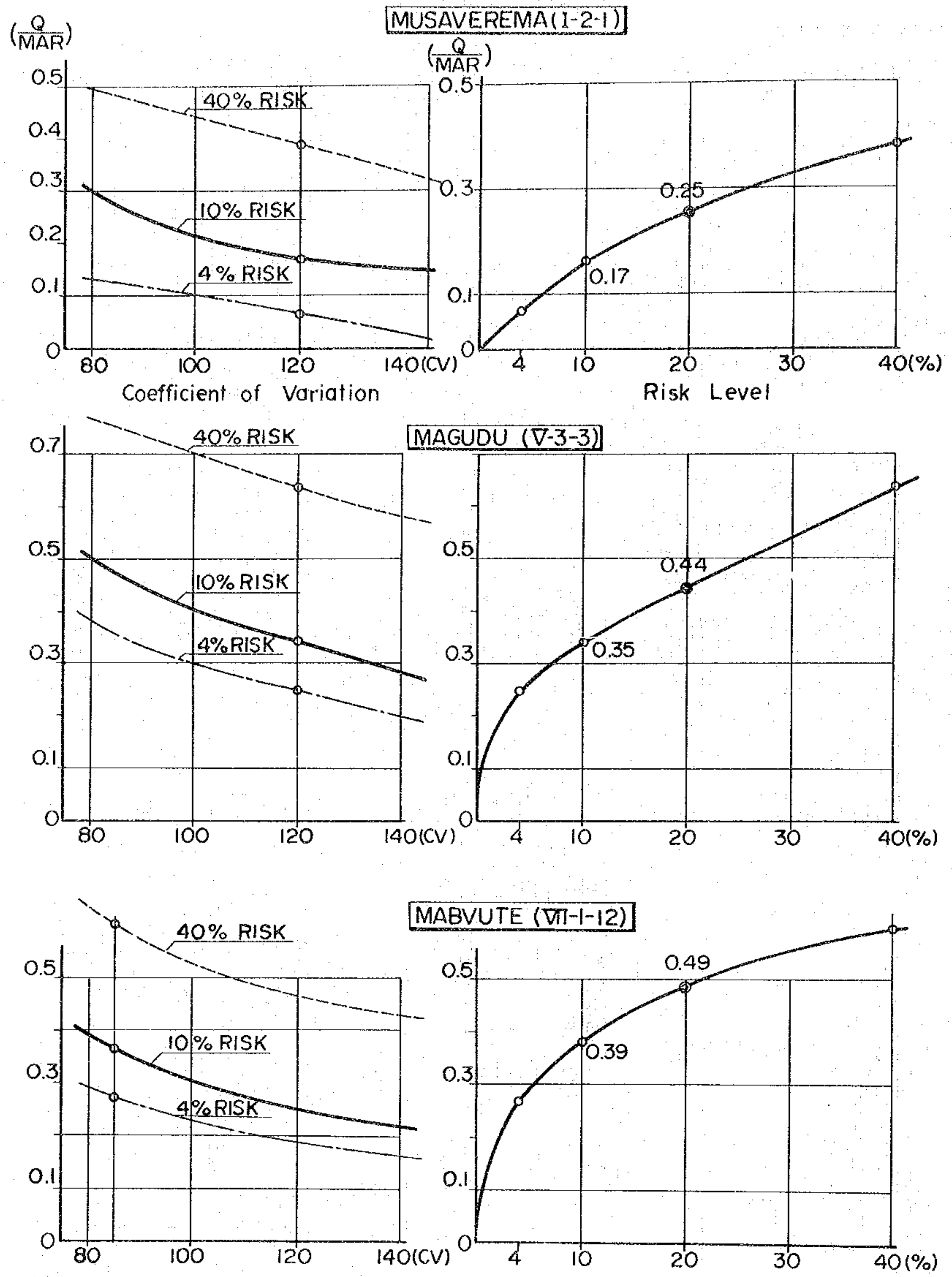
Figure B-5 (1) INTERPORATION OF 20% RISK LEVEL



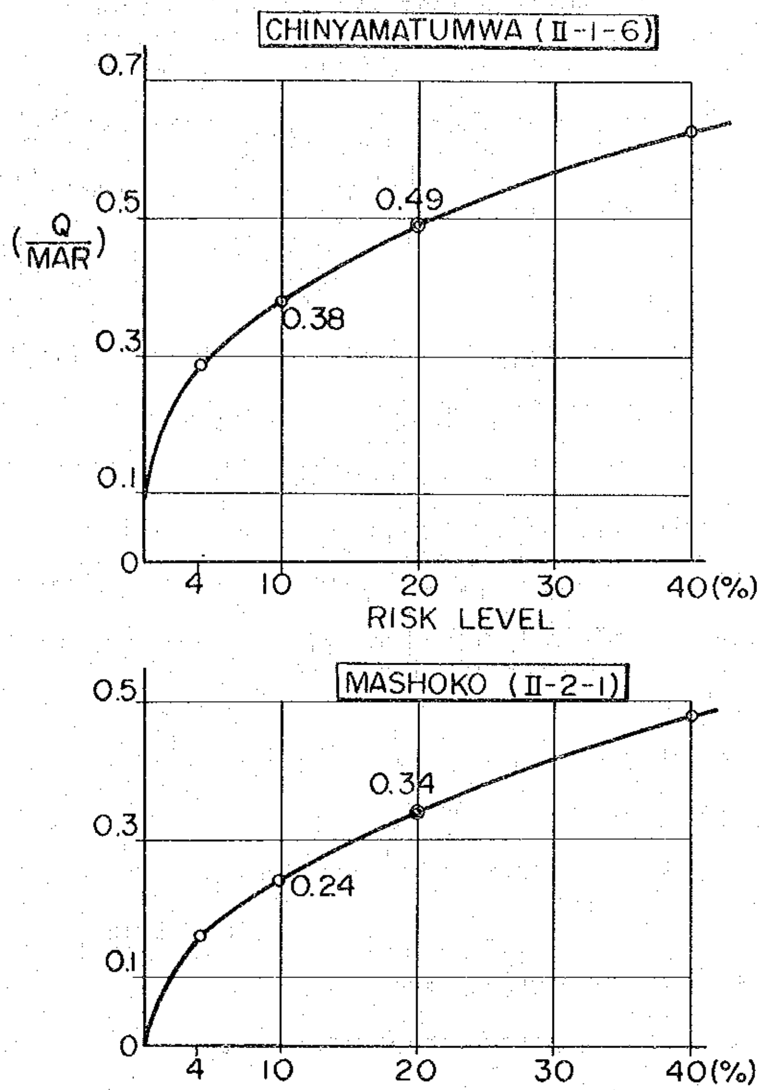
NOTE

Q······Reservoir Yield

MAR···Mean Annual Inflow into Dam

CV······Coefficient of Variation

Figure B-5 (2) INTERPORATION OF 20% RISK LEVEL



NOTE

Q ------ Reservoir Yield

MAR ---- Mean Annual Inflow into Dam

CV ----- Coefficient of Variation

Table B-6 (1) Erosion Classes

Class I: No Apparent Erosion There should be no visible sign of erosion, such as sheet, rill or gully erosion identifiable on aerial photographs. The typical lands distinguished in Class I are mentioned as follows: - Grazing land under good management - Woodland with a good cover of trees - Woodland of bare soil or alluvial sand deposit without any sign of erosion visible on the photograph.
Class II/S: Slight Sheet Erosion There should be noticeable sheet erosion causing uniform removal of soil from the area without development of conspicuous water channels. The typical lands involved in Class II are mentioned as follows: - Lands with poor plant cover - Grazing land of discernible plant pedestals and alluvial deposits - Rill erosion of short distance - Cropping areas of good management on steep slopes
Class II/SR: Slight Sheet and Rill Erosion There should be small but conspicuous water channels or tiny rivulets that are minor concentrations of runoff, in addition to the sheet erosion mentioned in Class II/S.

NOTE : Summerized from the Report of "Soil and Water Conservation", Appendix 32

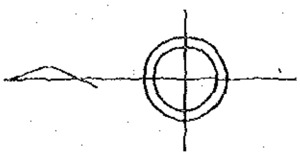
Table B-6 (2) Erosion Classes

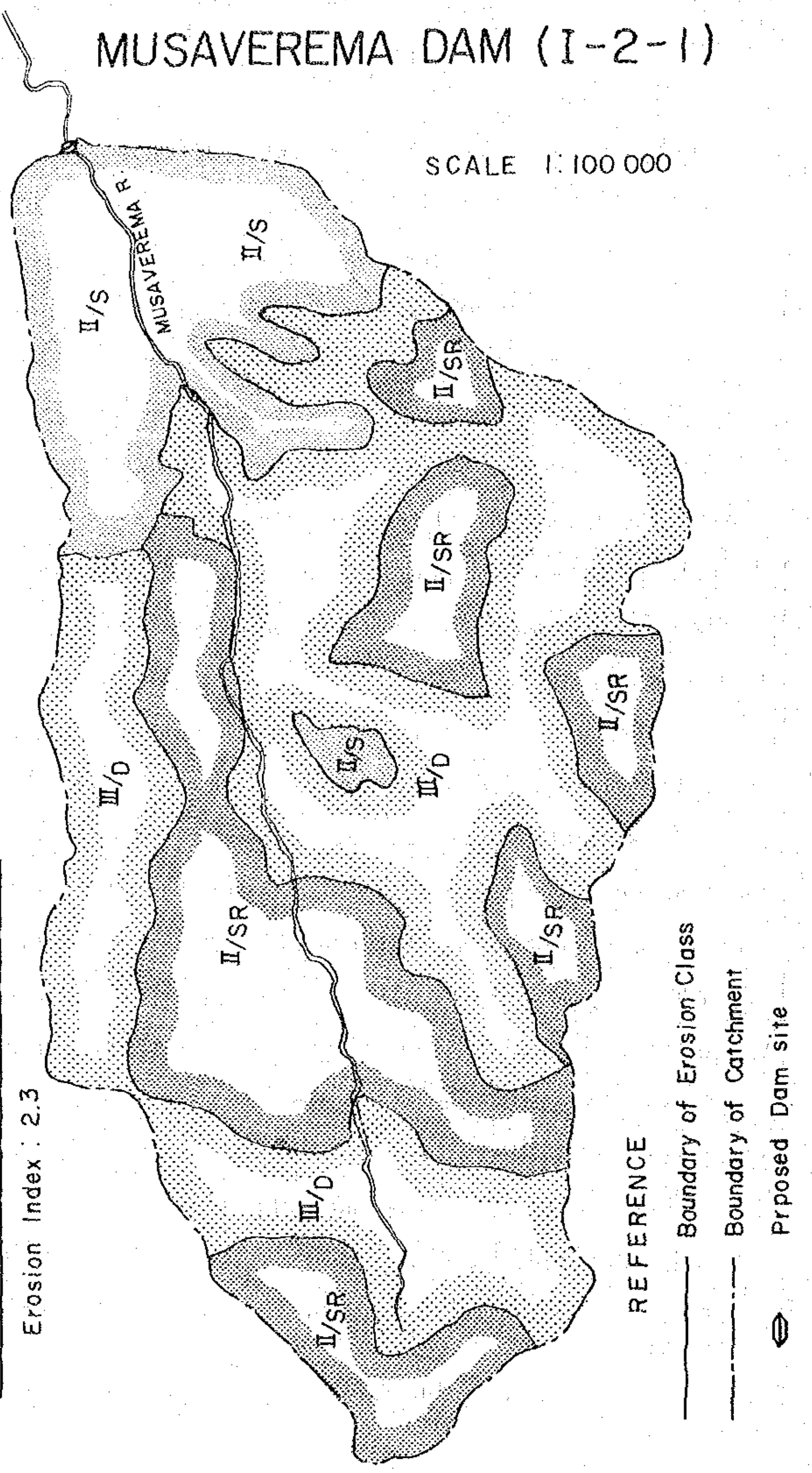
Class III/SR: Moderate Sheet and Rill Erosion There should be more severe degree of sheet and rill erosion in comparison with the Class II/SR. The gullies that are clearly not active or very rare occurrence of active gullies, should be allowed within the class. Considerable areas involved in Unit III/SR are listed as follows: - Area of base soil - Area of cattle tracks clearly visible - Area of actively eroding in grazing land
Class III/RG: Moderate Rill and Gully Erosion There should be active gully erosion discernible in aerial photographs. Removal of soil by formation of relatively large channels, forming barriers not crossable with farm machinery, hinders tillage operations and reduces crop livestock production significantly.
Class III/D: Erosion along Drainage Lines There should be erosion along rivers, streams and waterways, all sorts of erosion taking place along such drainage lines, This class extends to include all gullies within the area, active or not active, so that the yield of the soil by the Class III/D erosion may vary largely.
Class IV: Severe Erosion There should be marked and widespread dissection of the land by rill and gully erosion; 20 - 25% of the land severely affected by erosion, which is of little value for crop or livestock production.

NOTE : Summerized from the Report of "Soil and Water Conservation", Appendix 32

Figure B-6(I) Classification Map of Soil Erosion

MUSAVEREMA DAM (I-2-1)



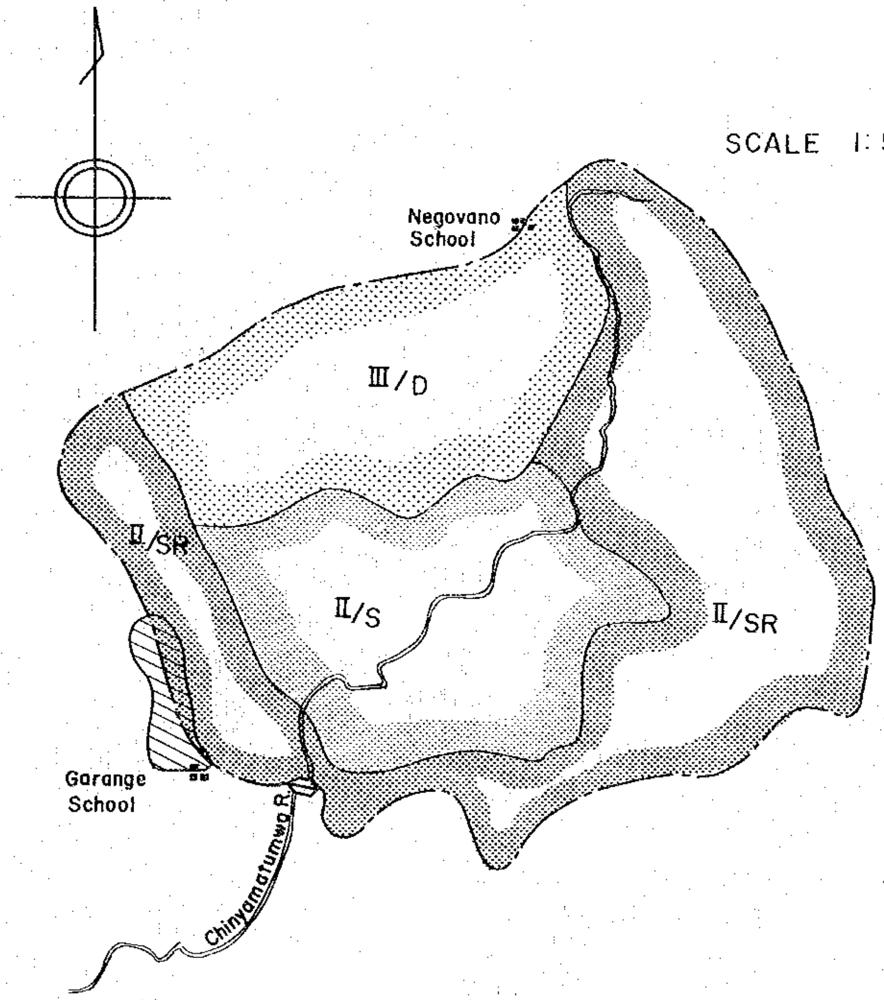


Class	Area (ha)	%	Weighted
II/S	20.9	16	16
II/SR	46.4	35	70
III/D	63.7	49	147
Total	131.0	100	233

Erosion Index : 2.3

Figure B-6 (2) Classification Map of Soil Erosion

CHINYAMATUMWA DAM (II-1-6)



REFERENCE

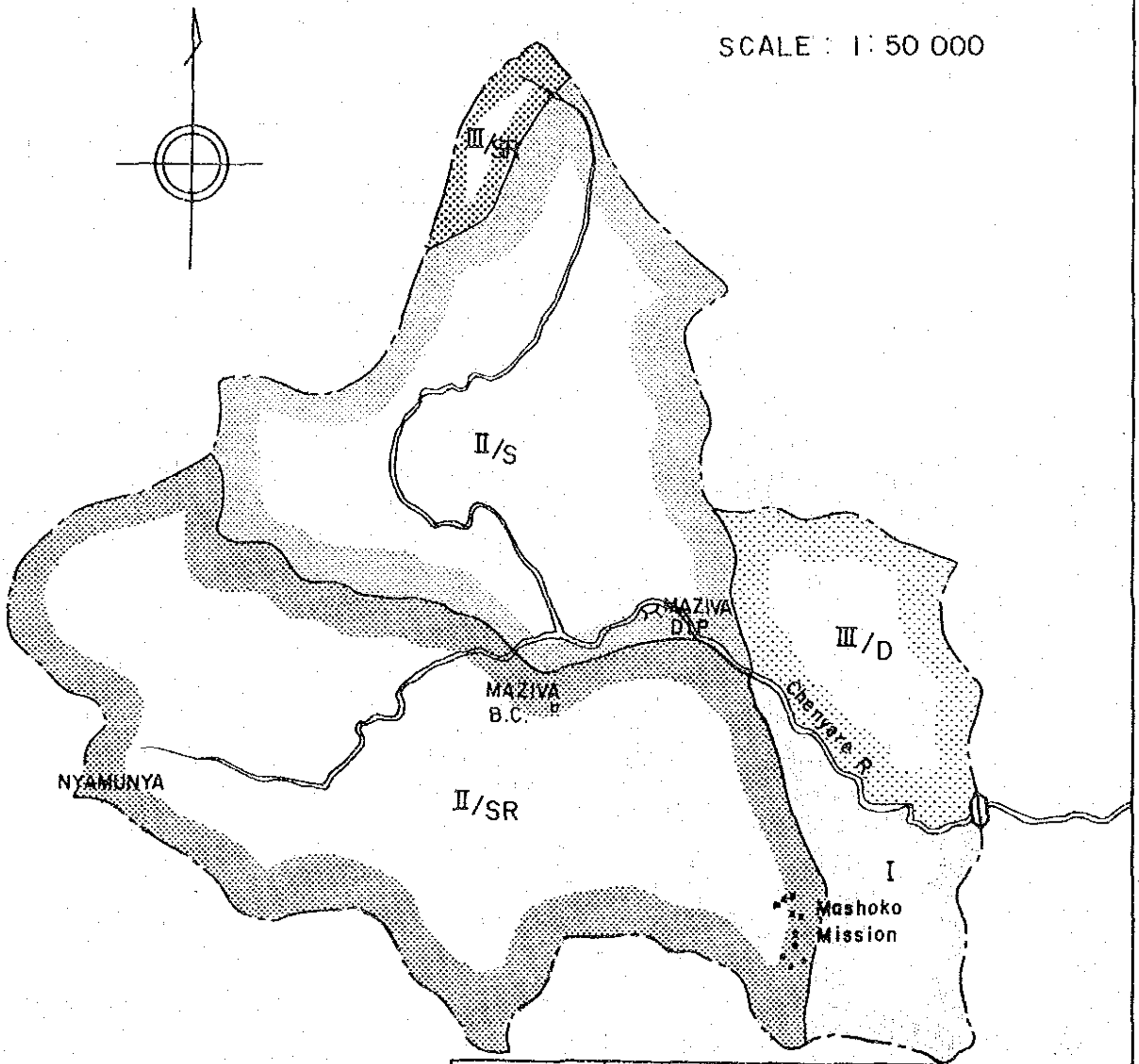
- Boundary of Catchment
- Boundary of Erosion Class
- Proposed Dam site
- Irrigable Area

Class	Area (ha)	%	Weighted
II/S	4.3	26	26
II/SR	8.2	50	100
III/D	3.9	24	72
Total	16.4	100	198

Soil Erosion Index : 2.0

Figure B-6(3) Classification Map of Soil Erosion

MASHOKO DAM (II-2-1)



REFERENCE

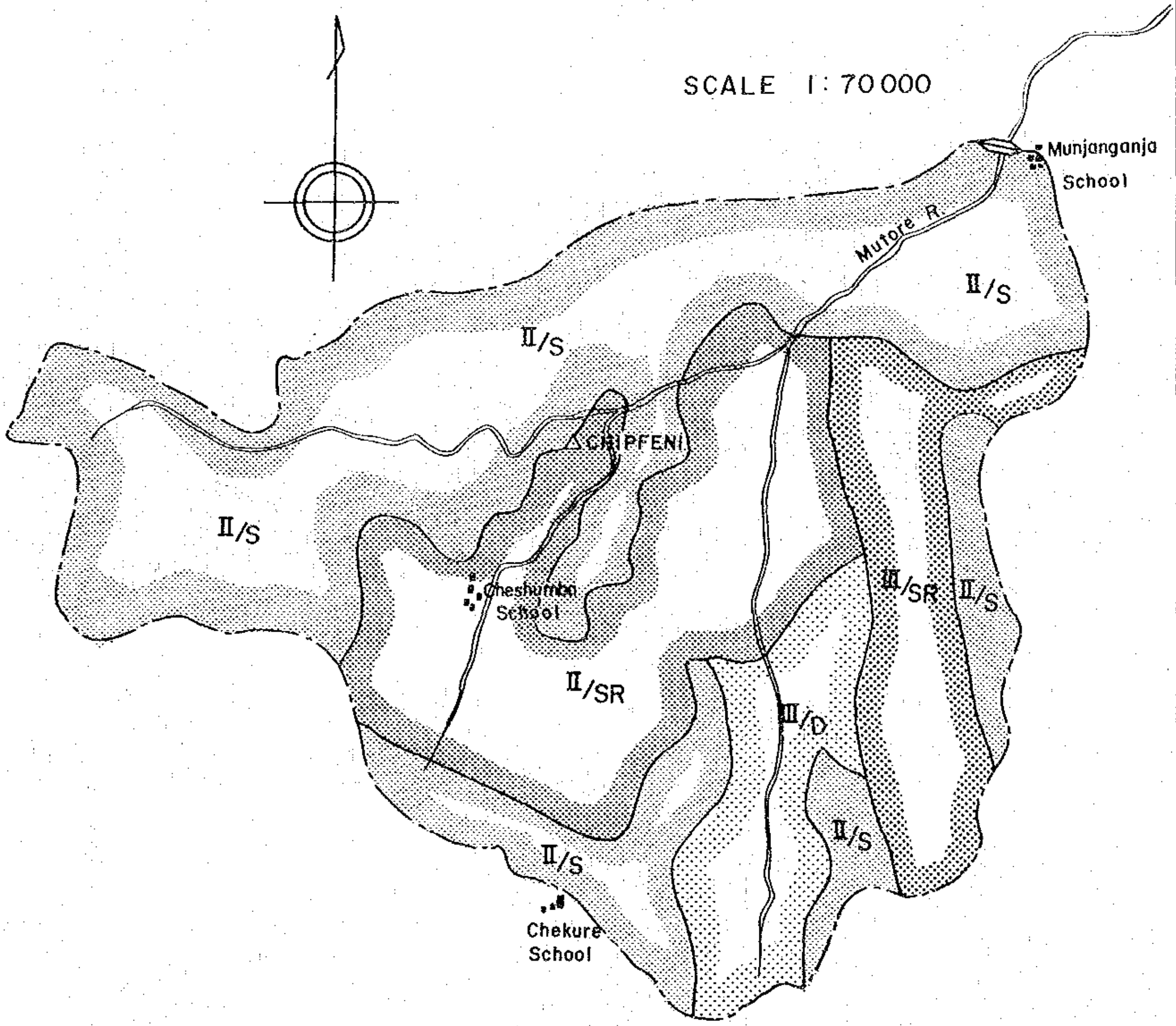
- - - - - Boundary of Catchment
——— Boundary of Erosion Class
⊖ Proposed Dam site

Class	Area (ha)	%	Weighted
I	2.3	8	0
II/S	8.7	32	32
II/SR	12.8	47	94
III/D	2.7	10	30
III/SR	0.7	3	12
Total	27.2	100	168

Erosion Index : 1.7

Figure B-6(4) Classification Map of Soil Erosion

MUNJANGANJA DAM (Ⅳ-4-10)



REFERENCE

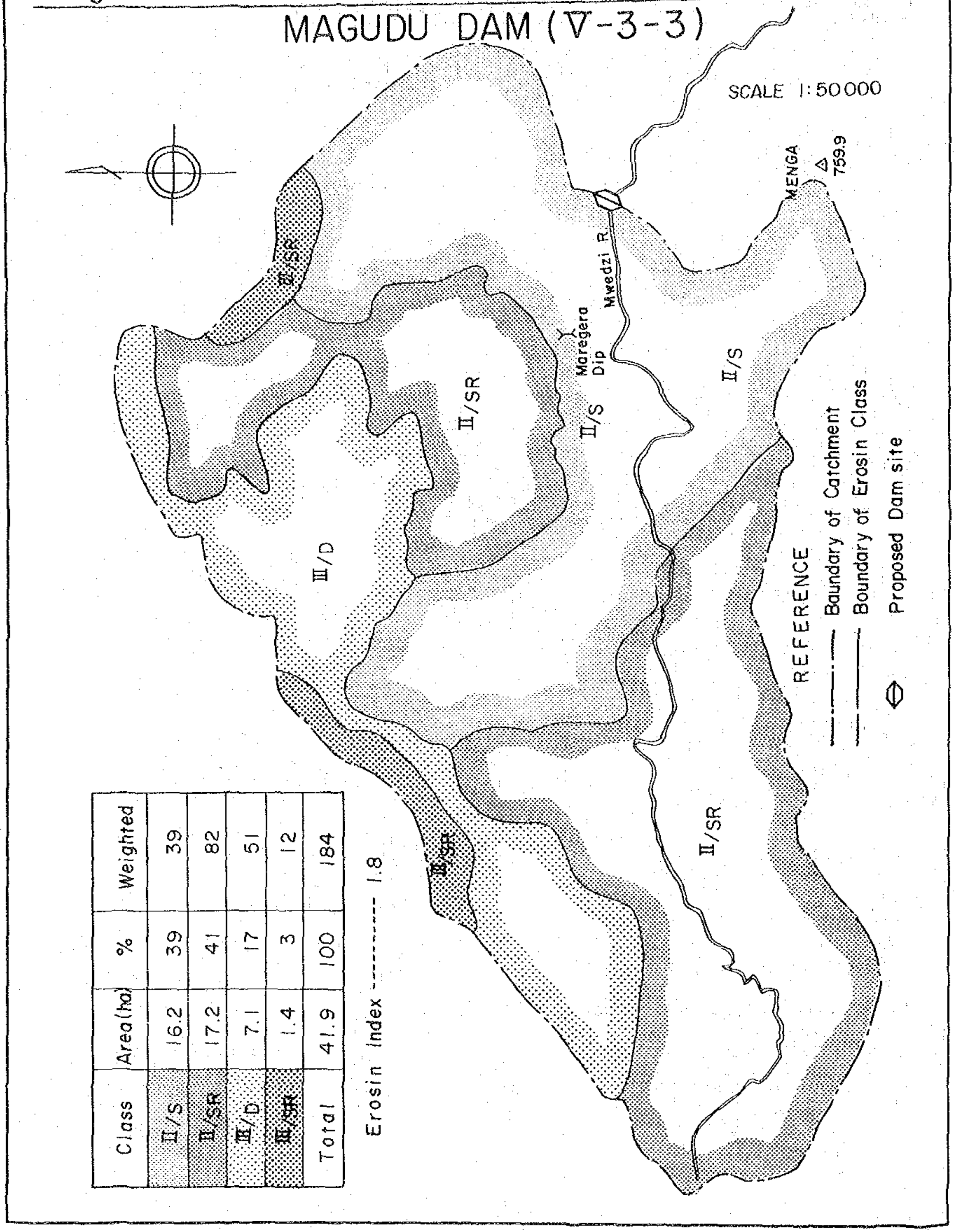
- — - — Boundary of Catchment
- ——— Boundary of Erosion Class
- Proposed Dam site

Class	Area (ha)	%	Weighted
Ⅱ/S	26.7	50	50
Ⅱ/SR	14.2	27	54
Ⅲ/D	5.2	10	30
Ⅲ/SR	6.7	13	52
Total	52.8	100	186

Erosion Index : 1.9

Figure B-6(5) Classification Map of Soil Erosion

MAGUDU DAM (V-3-3)

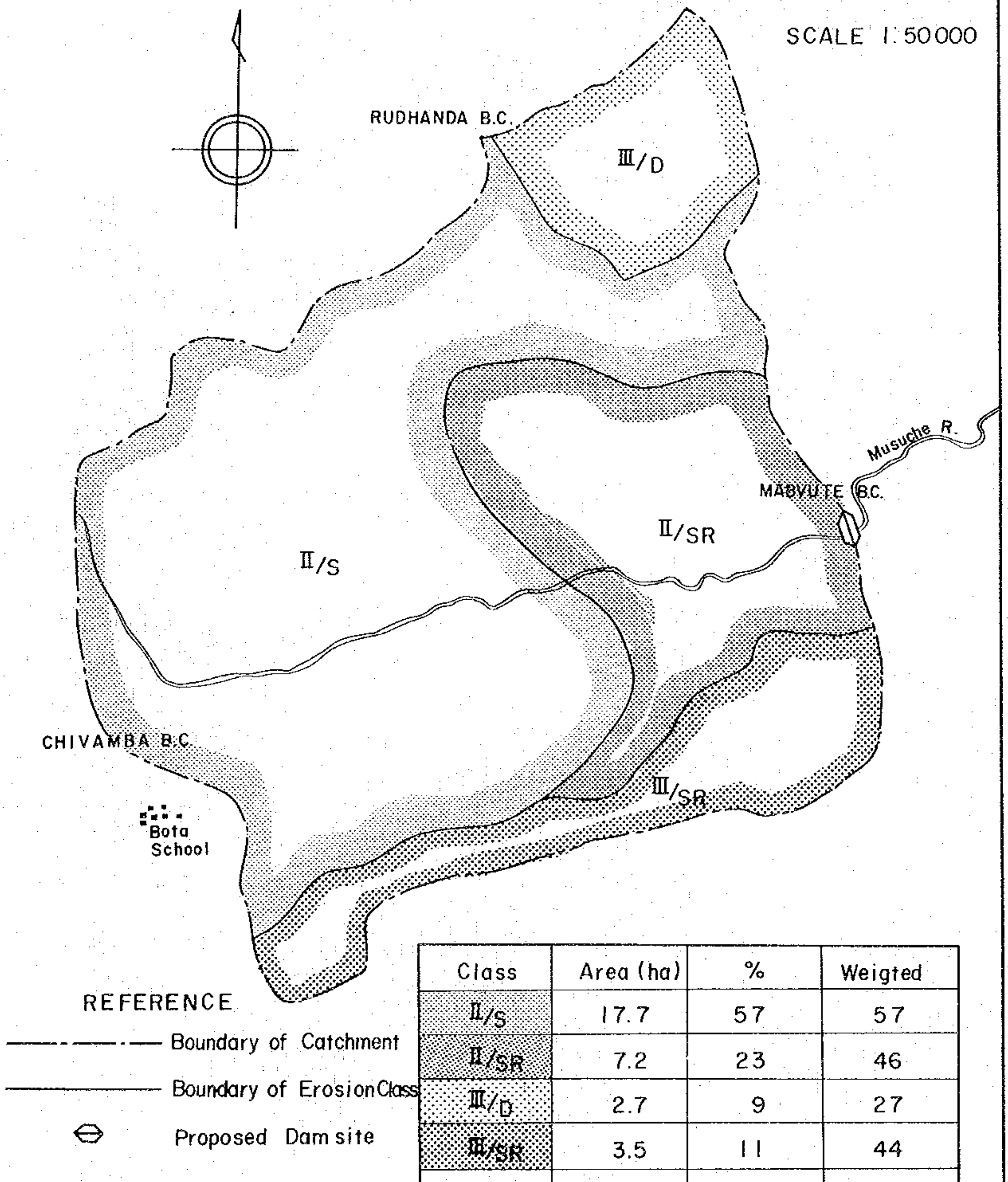


Class	Area(ha)	%	Weighted
II/S	16.2	39	39
II/SR	17.2	41	82
III/D	7.1	17	51
III/SR	1.4	3	12
Total	41.9	100	184

Erosin Index ---------- 1.8

Figure B-6(6) Classification Map of Soil Erosion

MABVUTE DAM (VII-1-12)



Class	Area (ha)	%	Weigted
II/S	17.7	57	57
II/SR	7.2	23	46
III/D	2.7	9	27
III/SR	3.5	11	44
Total	31.1	100	174

Erosion Index : 1.7

ANNEX C. SOIL, LAND USE AND AGRICULTURE

Contents		Page

Table C-1 Yield Results in MAPANZURE Irrigation Scheme

unit: tonne/hectare

	1981/82	82/83	83/84	84/85	85/86
Maize	6.4	2.3	7.3	9.6	5.9
Groundnuts (unshelled)	1.0	1.3	1.8	2.1	!.8
Sugar beans	0.3	0.6	0.9	1.4	0.9
Tomatoes	10	20	10	30	15

Table C-2 Crop Production in ARDA ESTATE

	Unit	1980	1981	1982	1983
Maize	ha	36	480	1228	690
	t	6	2654	5378	2541
	kg	167	5529	4380	3683
Groundnuts	ha	178	195	143	273
(unshelled)	t	299	373	458	1206
	kg	1680	1913	3203	4418
Wheat	ha	2277	1868	5041	1267
	t	7630	7854	18556	5441
	kg	3351	4204	3681	4294

Source:
"AGRICULTRAL PRODUCTION IN COMMUNAL LAND IRRIGATION SCHEMES AND ARDA ESTATES 1983"

Table C-3 Crop Yield per Hectare in the Districts (Unit: tonne/ha)

District / Year / Crop	GAZA, KOMANAI			BIKITA			GUTU			MASVINGO			ZAKA		
	83/84	84/85	85/86	83/84	84/85	85/86	83/84	84/85	85/86	83/84	84/85	85/86	83/84	84/85	85/86
Maize	N.A	0.9	-	1.0	1.6	1.0	0.7	1.4	N.A	0.5	1.4	0.8	0.5	0.9	0.9
Rapoko		0.6	0.3	0.7	1.0	0.9	0.7	0.8		0.6	0.7	0.7	-	0.3	0.5
Mhunga		0.7	0.2	0.7	1.0	0.7	0.5	0.7		0.5	0.9	0.7	-	0.4	0.4
Sorghum		1.1	0.2	0.8	1.2	0.8	0.6	0.9		0.6	0.9	1.1	0.5	0.5	0.6
Groundnuts		0.8	0.2	0.4	0.6	0.6	-	-		0.3	0.4	0.4	0.1	0.1	0.1
Cotton		0.9	0.3	0.7	0.8	0.7	0.4	0.9		0.9	1.1	0.9	0.7	0.7	0.9
Sunflower		0.3	0.2	0.4	0.6	0.5	0.2	0.4		0.4	0.4	0.4	0.1	0.2	0.2

Table C-4 Crop Yield per Hectare in the Wards

(Unit: tonne/ha)

Crop	MATIBI.I Ward 9 (I-2-1)	BIKITA Ward 6 (II-1-6)	MATSAI Ward 2 (II-2-1)	GUTU Ward 26 (IV-4-10)	NAJENA Dowa 6 (V-3-3)	NDANGA Dzoro North (VII-1-12)
Maize	0.9	1.0	0.6	0.9	1.1	0.7
Rapoko	-	0.9	0.5	0.5	0.7	0.5
Mhunga	0.6	0.7	0.5	0.5	0.6	0.7
Sorghum	0.7	0.8	0.6	0.7	0.7	0.4
Groundnuts	0.4	0.5	0.5	0.3	0.6	0.3
Cotton	0.6	0.6	1.3	-	1.0	0.7
Sunflower	-	0.5	0.6	0.1	0.6	0.2

Table C-5 The Yield of Maize per Hectare in Each Project Area

Project Area	Farmers Interviewed											
	A			B			C			D		
	B.	O.	P.	B.	O.	P.	B.	O.	P.	B.	O.	P.
I-2-1	2.2	1.1	0	2.7	1.0	0	2.8	0.4	0	2.3	1.0	0
II-1-6	2.7	1.2	0.1	0.9	0.4	0.2	3.6	1.3	0.9	2.2	0.6	0.5
II-2-1	4.5	1.0	0	2.0	1.0	0	2.0	1.0	0	0.8	0.6	0.4
IV-4-10	1.2	0.9	0.6	2.7	0.9	0	2.7	0.9	0.5	2.7	0.9	0.5
V-3-3	2.2	0.9	0.2	0.6	0.3	0	1.6	0.8	0	1.3	0.7	0.1
VII-1-12	2.7	1.4	0.7	4.6	2.2	1.4	4.6	0.4	0.1	2.0	1.0	0.8

Note) B: Bumper year, O: Ordinary year, P: Poor year

Table C-6(1) **SOIL ANALYTICAL DATA**

Site No.	M - 1				M-2			M - 3	
Depth (cm)	0-13	14-40	41-		0-10	11-40		0-10	
Sample No.	M-1A	M-1B	M-1C		M-2A	M-2B		M-3A	
Dry Matter %	98.5	96.3	96.4		99.5	99.3		99.4	
Organic Matter %	0.64	0.84			0.62				
Gravel %	1	6	6		18	39		10	
Texture	CoSCL	CoSL	CoSC		FLS	FSL		mLS	
Coarse sand %	22.2	21.3	19.2		17.1	14.8		18.9	
Medium sand %	12.1	20.2	8.5		19.5	11.5		21.1	
Fine sand %	29.3	37.2	17.0		51.2	57.3		43.3	
Silt %	9.1	7.5	8.5		7.3	6.6		7.8	
Clay %	27.3	13.8	46.8		4.9	9.8		8.9	
1) Ec (m℧)	0.0279	0.0233			0.0263	0.0138			
PH ($CaCl_2$)	4.7	5.1			4.5	4.4			
PH (H_2O)									
2)Ex. Ca (me%)	3.26	7.88			0.12	0.88			
Ex. Mg (me%)	1.86	2.80			0.84	1.14			
Ex. Na (me%)	0.05	0.06			0.03	0.04			
Ex. K (me%)	0.47	0.10			0.51	0.38			
Ex. bases (me%)	5.64	10.84			1.50	2.44			
3)Ex. Cap. (me%)	6.32	11.16			2.75	3.06			
Base saturation %	89	97			55	80			
4) E/C value	23	81			56	31			
5) S/C value	21	79			31	25			
Total nitrogen %	0.045				0.020				
Available P O (p.p.m.)	13.8				11.4				

Notes
1) EC : Electrical Conductivity 2) Ex. : Exchangeable 3) Ex. Cap. : Exchange Capacity
4) E/C : Exchange capacity per 100gms clay 5) S/C : Exchangeable bases per 100gms clay

Table C-6(2) **SOIL ANALYTICAL DATA**

Site No	B − 1			B−2		B − 3			B − 4
Depth (cm)	0−10	11−40	41−	0−15	16−	0−15	16−30	31−60	0−10
Sample No	B−1A	B−1B	B−1C	B−2A	B−2B	B−3A	B−3B	B−3C	B−4A
Dry Matter %	98.4	98.7	78.3	99.6	98.5	99.7	99.3	99.8	99.0
Organic Matter %	0.42	0.30				0.53	0.45		
Gravel %	1	3	9	2	10	2	3	8	3
Texture	FSCL	mSC	C	CoSL	CoSC	CoSL	CoSL	CoSCL	CoS
Coarse sand %	10	10.3	10.9	27.6	22.2	21.4	20.6	25.0	29.9
Medium sand %	18	12.4	8.7	23.5	10.0	18.4	17.5	14.1	22.7
Fine sand %	43	30.9	15.2	31.6	13.3	42.9	41.2	22.8	39.2
Silt %	9	8.2	7.6	6.1	10.0	9.2	9.3	6.5	3.1
Clay %	20	38.2	57.6	11.2	44.5	8.1	11.4	31.5	5.1
1) Ec (m℧)	0.0476	0.0197				0.0482	0.0166		
PH ($CaCl_2$)	5.1	5.1				5.3	5.1		
PH (H_2O)									
2)Ex. Ca (me%)	0.68	1.26				0.18	0.06		
Ex. Mg (me%)	0.74	1.30				0.50	0.50		
Ex. Na (me%)	0.04	0.08				0.04	0.03		
Ex. K (me%)	0.37	0.39				0.42	0.25		
Ex. bases (me%)	1.83	3.03				1.14	0.84		
3)Ex. Cap. (me%)	3.07	4.62				1.19	2.10		
Base saturation %	60	66				57	40		
4) E/C value	15	12				15	18		
5) S/C value	9	8				14	7		
Total nitrogen %	0.037					0.045			
Available P O (p.p.m.)	7.0					25.5			

Notes 1) EC : Electrical Conductivity 2) Ex. : Exchangeable 3) Ex. Cap. : Exchange Capacity
4) E/C : Exchange capacity per 100gms clay 5) S/C : Exchangeable bases per 100gms clay

Table C-6(3) **SOIL ANALYTICAL DATA**

Site No.	BM-1				BM-2				
Depth (cm)	0-20	21-55	56-		0-10	10-35	36-60		
Sample No.	BM-1A	BM-1B	BM-1C		BM-2A	BM-2B	BM-2C		
Dry Matter %	99.4	98.5	98.4		99.0	99.0	98.1		
Organic Matter %	0.54	0.33			0.68	0.43			
Gravel %	1	2	4		1	7	13		
Texture	FSL	FSL	CoSCL		FSL	FSL	FSCL		
Coarse sand %	6.1	9.2	20.8		3.0	5.4	6.9		
Medium sand %	13.1	17.3	13.6		9.1	11.8	11.5		
Fine sand %	62.6	52.0	33.3		60.6	58.1	37.9		
Silt %	10.1	7.2	7.3		19.2	17.2	19.6		
Clay %	8.1	14.3	25.0		8.1	7.5	24.1		
1) Ec (m℧)	0.0241	0.0154			0.0262	0.0252			
PH ($CaCl_2$)	4.9	5.6			4.4	5.4			
PH (H_2O)									
2)Ex. Ca (me%)	2.42	3.00			2.62	2.88			
Ex. Mg (me%)	0.80	1.26			1.36	1.86			
Ex. Na (me%)	0.03	0.05			0.05	0.13			
Ex. K (me%)	0.34	0.19			0.19	0.07			
Ex. bases (me%)	3.59	4.50			4.22	4.94			
3)Ex. Cap. (me%)	4.09	4.82			4.88	5.29			
Base saturation %	88	93			87	93			
4) E/C value	50	34			60	70			
5) S/C value	44	31			52	66			
Total nitrogen %	0.025				0.053				
Available P O (p.p.m.)	9.0				12.5				

Notes
1) EC : Electrical Conductivity 2) Ex. : Exchangeable 3) Ex. Cap. : Exchange Capacity
4) E/C : Exchange capacity per 100gms clay 5) S/C : Exchangeable bases per 100gms clay

Table C-6(4) **SOIL ANALYTICAL DATA** AREA IV-4-10

Site No.	G - 1			G - 2			G - 3	G - 4	
Depth (cm)	0-20	21-50	51-	0-15	16-50	51-	0-10	0-10	
Sample No.	G-1A	G-1B	G-1C	G-2A	G-2B	G-2C	G-3A	G-4A	
Dry Matter %	96.5	95.6	96.2	95.3	91.4	95.5	97.1	99.7	
Organic Matter %	0.86	0.61		0.95	0.68				
Gravel %	1	2	23	1	5	7	4	8	
Texture	CoSCL	CoSCL	CoSC	CoSCL	CoSCL	C	CoSCL	CoS	
Coarse sand %	16.2	26.5	23.4	18	18.9	10.8	16.7	43.5	
Medium sand %	12.1	10.2	10.4	12	9.5	6.4	12.5	25.0	
Fine sand %	25.2	20.4	18.2	23	25.3	12.9	25.0	19.6	
Silt %	18.2	12.3	11.7	22	15.8	22.6	17.7	6.5	
Clay %	28.3	30.6	36.3	25	30.5	47.3	28.2	5.4	
1) Ec (m℧)	0.0458	0.0323		0.0449	0.0265				
PH ($CaCl_2$)	6.1	5.8		4.6	5.3				
PH (H_2O)									
2)Ex. Ca (me%)	16.26	9.00		7.00	4.62				
Ex. Mg (me%)	7.36	5.50		4.34	3.70				
Ex. Na (me%)	0.08	0.09		0.30	1.10				
Ex. K (me%)	0.38	0.12		0.49	0.09				
Ex. bases (me%)	24.08	14.71		12.13	9.51				
3)Ex. Cap. (me%)	21.74	14.47		11.49	11.25				
Base saturation %	100	100		100	85				
4) E/C value	77	48		46	37				
5) S/C value	85	48		49	31				
Total nitrogen %	0.046			0.094					
Available P O (p.p.m.)	11.5			9.25					

Notes
1) EC : Electrical Conductivity 2) Ex. : Exchangeable 3) Ex. Cap. : Exchange Capacity
4) E/C : Exchange capacity per 100gms clay 5) S/C : Exchangeable bases per 100gms clay

Table C-6 (5) **SOIL ANALYTICAL DATA** AREA V-3-3

Site No.	N - 1				N - 2				
Depth (cm)	0-10	11-35	36-		0-10	11-35	36-90		
Sample No.	N-1A	N-1B	N-1C		N-2A	N-2B	N-2C		
Dry Matter %	97.9	96.5	96.3		98.6	93.8	97.8		
Organic Matter %	0.99	1.01			0.70	0.69			
Gravel %	2	2	2		3	4	7		
Texture	CoSCL	C	C		FSCL	mSCL	CoSC		
Coarse sand %	15.3	14.3	17.0		10.3	11.5	15.1		
Medium sand %	14.3	10.2	7.0		14.4	16.7	10.7		
Fine sand %	28.6	19.4	16.0		39.2	34.4	19.4		
Silt %	14.3	15.3	14.0		10.3	13.5	7.5		
Clay %	27.5	40.8	46.0		25.8	24.0	47.3		
1) Ec (m℧)	0.0456	0.0231			0.0378	0.0156			
PH ($CaCl_2$)	5.2	5.4			4.2	4.3			
PH (H_2O)									
2)Ex. Ca (me%)	5.12	6.26			1.76	1.18			
Ex. Mg (me%)	3.66	4.24			2.76	2.78			
Ex. Na (me%)	0.06	0.06			0.04	0.11			
Ex. K (me%)	1.41	0.43			0.46	0.08			
Ex. bases (me%)	10.25	11.49			5.03	4.15			
3)Ex. Cap. (me%)	10.87	13.63			6.28	7.29			
Base saturation %	94	84			80	57			
4) E/C value	40	33			24	30			
5) S/C value	37	28			19	17			
Total nitrogen %	0.102				0.071				
Available P O (p.p.m.)	14				7.5				

Notes
1) EC : Electrical Conductivity 2) Ex. : Exchangeable 3) Ex. Cap. : Exchange Capacity
4) E/C : Exchange capacity per 100gms clay 5) S/C : Exchangeable bases per 100gms clay

Table C-6(6) SOIL ANALYTICAL DATA

Site No.	Z - 1			Z - 2			Z - 3		
Depth (cm)	0-10	11-25	26-	0-10	11-35	36-	0-18	19-47	48-90
Sample No.	Z-1A	Z-1B	Z-1C	Z-2A	Z-2B	Z-2C	Z-3A	Z-3B	Z-3C
Dry Matter %	99. 0	96. 7	97. 8	99. 1	96. 9	99. 1	99. 4	98. 7	98. 2
Organic Matter %	0. 68	0. 74		0. 72	0. 52		0. 56	0. 46	
Gravel %	1	6	6	3	5	8	16	12	11
Texture	FSL	FSC	C	FSL	CoSCL	CoSC	CoSL	mSL	CoSL
Coarse sand %	12. 1	10. 6	8. 5	14. 4	21. 1	26. 1	21. 4	19. 3	22. 5
Medium sand %	14. 1	7. 4	4. 2	15. 5	12. 6	6. 5	20. 3	20. 5	18. 0
Fine sand %	47. 5	30. 9	16. 0	48. 4	33. 7	21. 7	39. 3	39. 8	31. 4
Silt %	9. 1	8. 5	14. 9	9. 3	10. 5	7. 6	9. 5	10. 2	13. 5
Clay %	17. 2	42. 6	56. 4	12. 4	22. 1	38. 1	9. 5	10. 2	14. 6
1) Ec (m℧)	0. 0587	0. 0216		0. 0454	0. 0272		0. 0190	0. 0146	
PH ($CaCl_2$)	4. 7	5. 2		4. 9	5. 4		4. 7		
PH (H_2O)									
2)Ex. Ca (me%)	0. 05	1. 76		1. 62	2. 38		0. 12	0. 38	
Ex. Mg (me%)	0. 72	1. 40		1. 16	2. 20		0. 50	0. 68	
Ex. Na (me%)	0. 04	0. 04		0. 04	0. 05		0. 04	0. 02	
Ex. K (me%)	0. 43	0. 43		0. 62	0. 21		0. 32	0. 25	
Ex. bases (me%)	1. 24	3. 63		3. 44	4. 84		0. 98	1. 33	
3)Ex. Cap. (me%)	2. 84	5. 42		3. 92	5. 34		2. 60	2. 31	
Base saturation %	35	67		88	91		38	58	
4) E/C value	17	13		32	24		27	23	
5) S/C value	7	9		28	22		10	13	
Total nitrogen %	0. 058			0. 065			0. 031		
Available P O (p.p.m.)	14. 5			13. 5			4. 5		

Notes
1) EC : Electrical Conductivity 2) Ex. : Exchangeable 3) Ex. Cap. : Exchange Capacity
4) E/C : Exchange capacity per 100gms clay 5) S/C : Exchangeable bases per 100gms clay

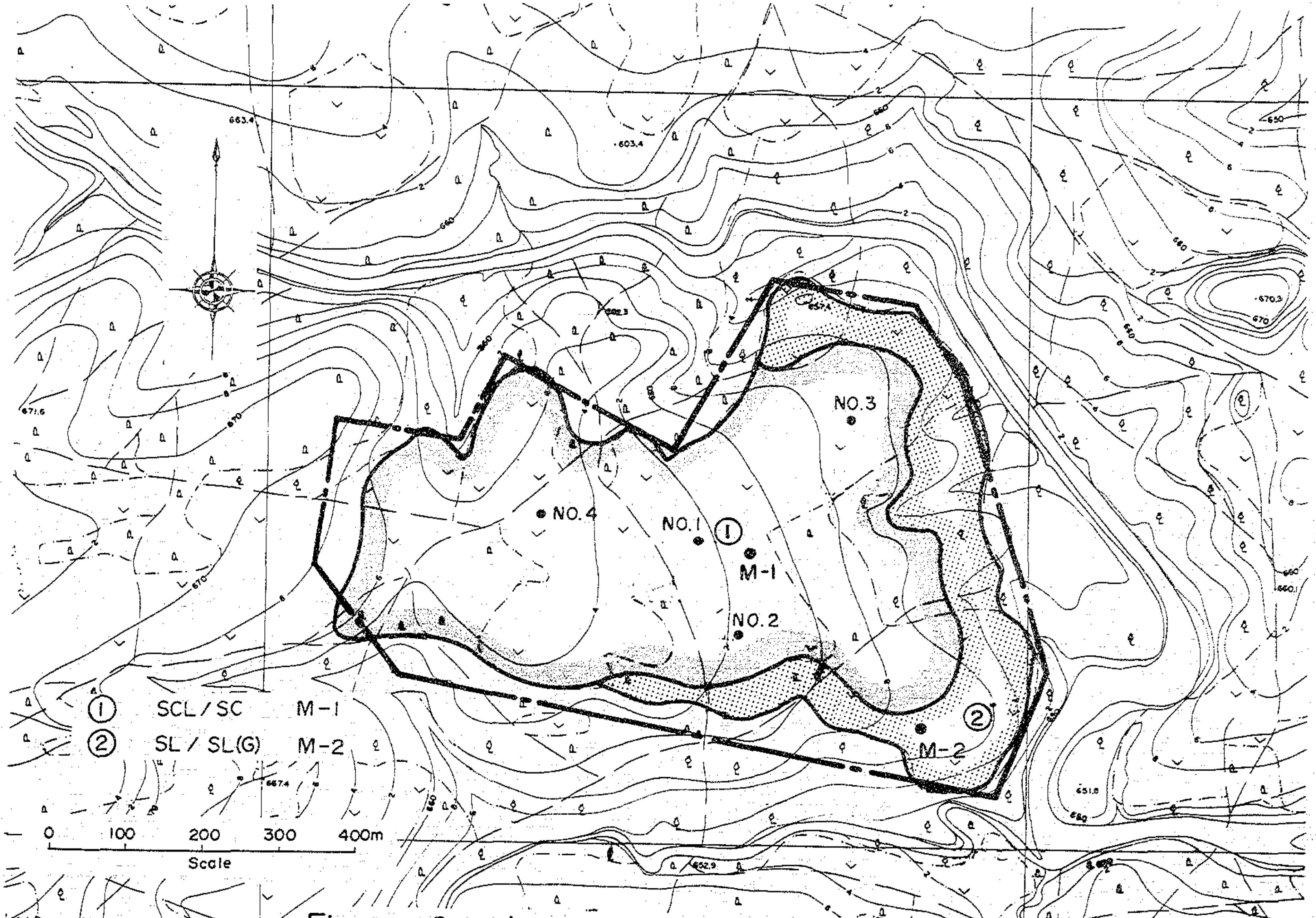


Figure C-1 (I) Soil Map of Musaverema (I-2-1)

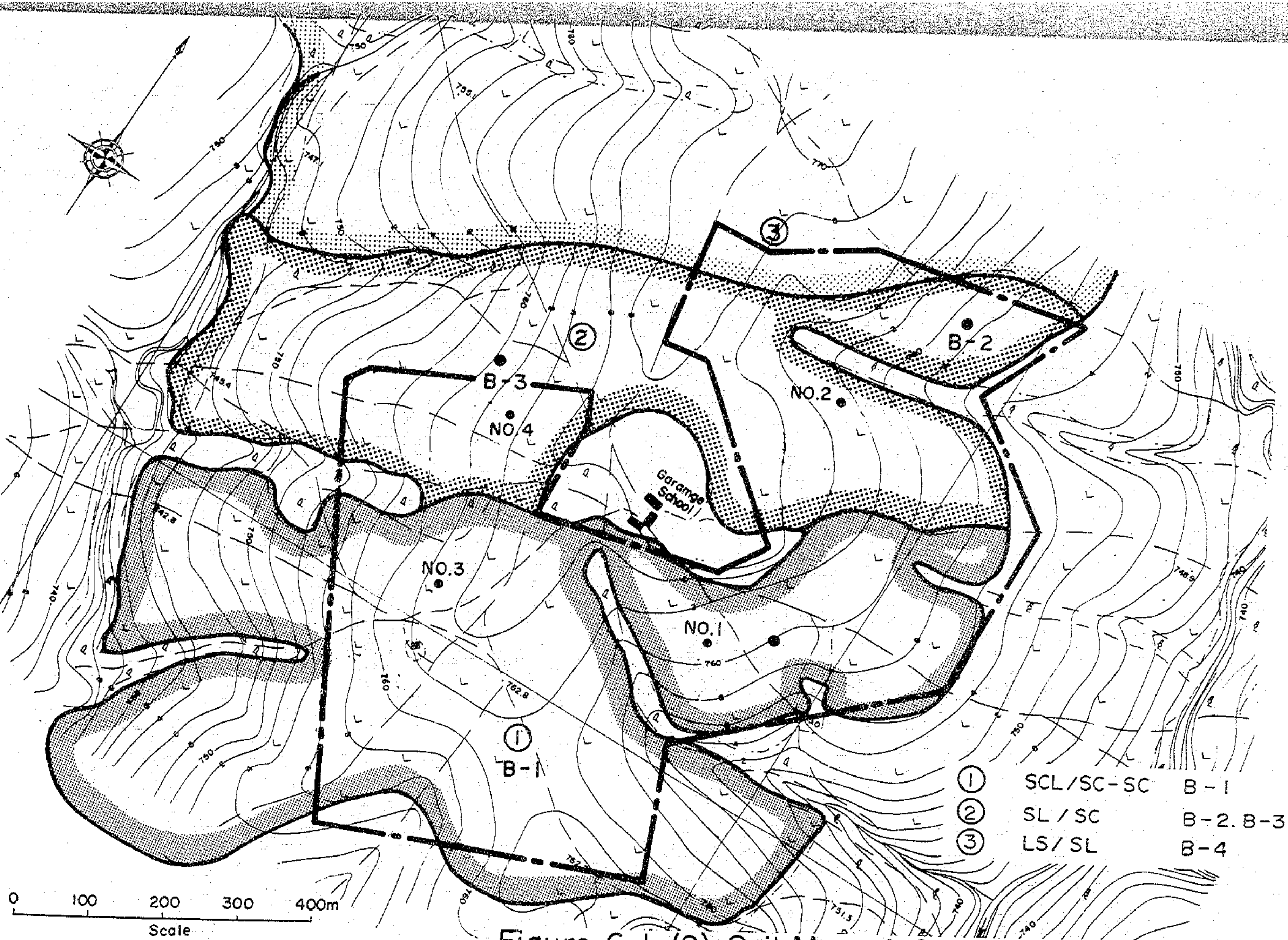


Figure C-1 (2) Soil Map of Chiyamatumwa (II-1-6)

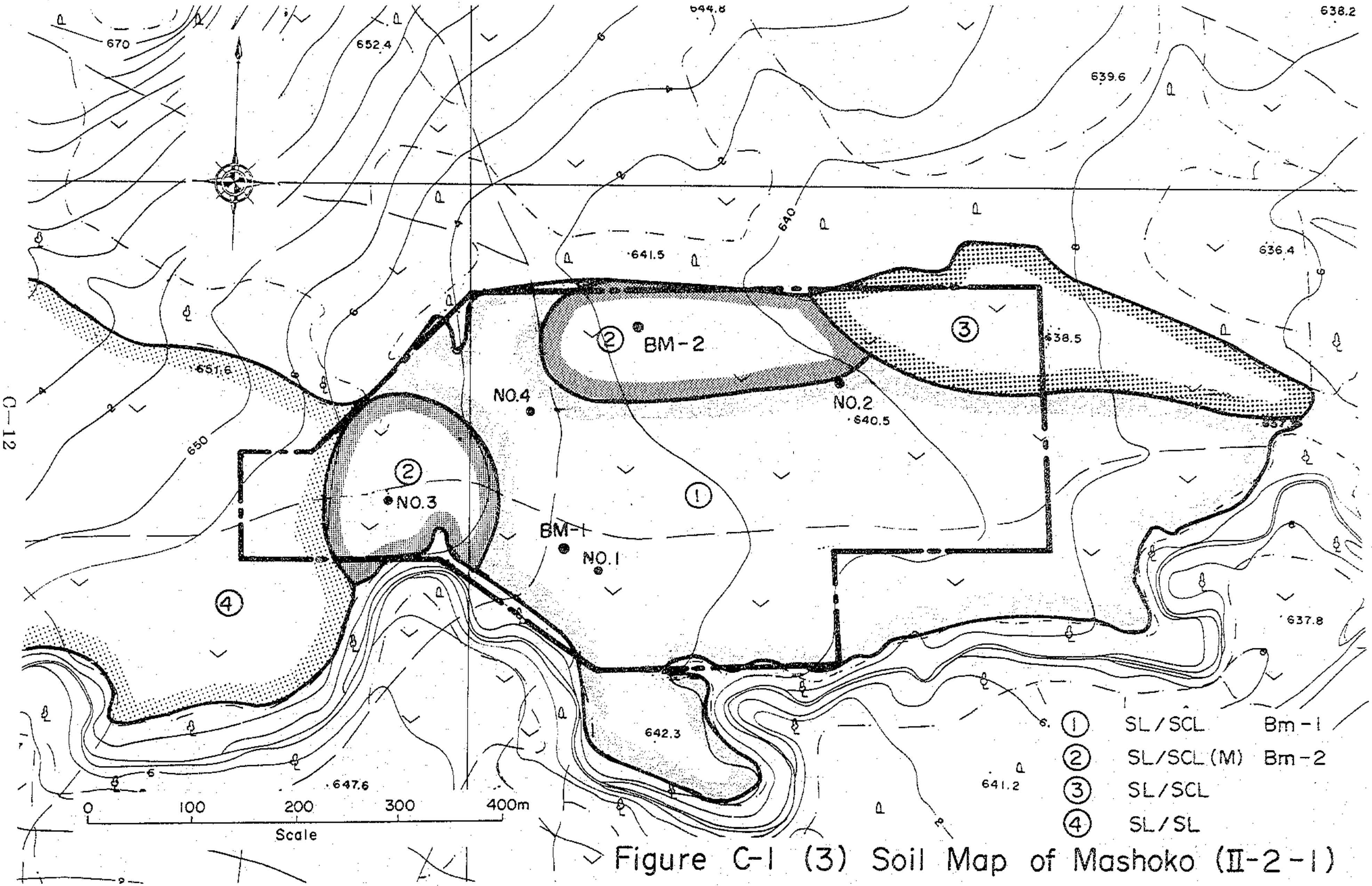


Figure C-1 (3) Soil Map of Mashoko (II-2-1)

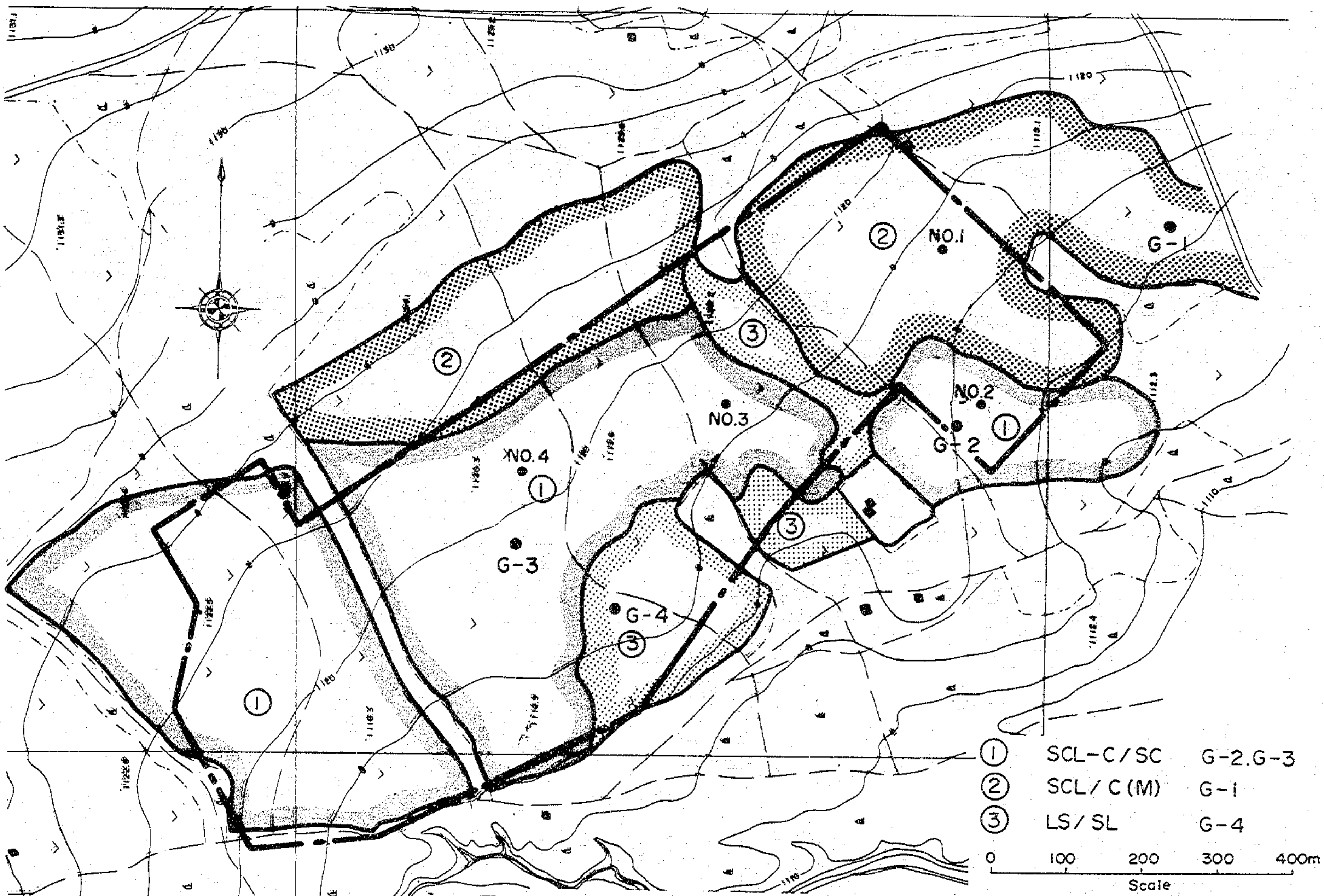


Figure C-1 (4) Soil Map of Munjanganja (Ⅳ-4-10)

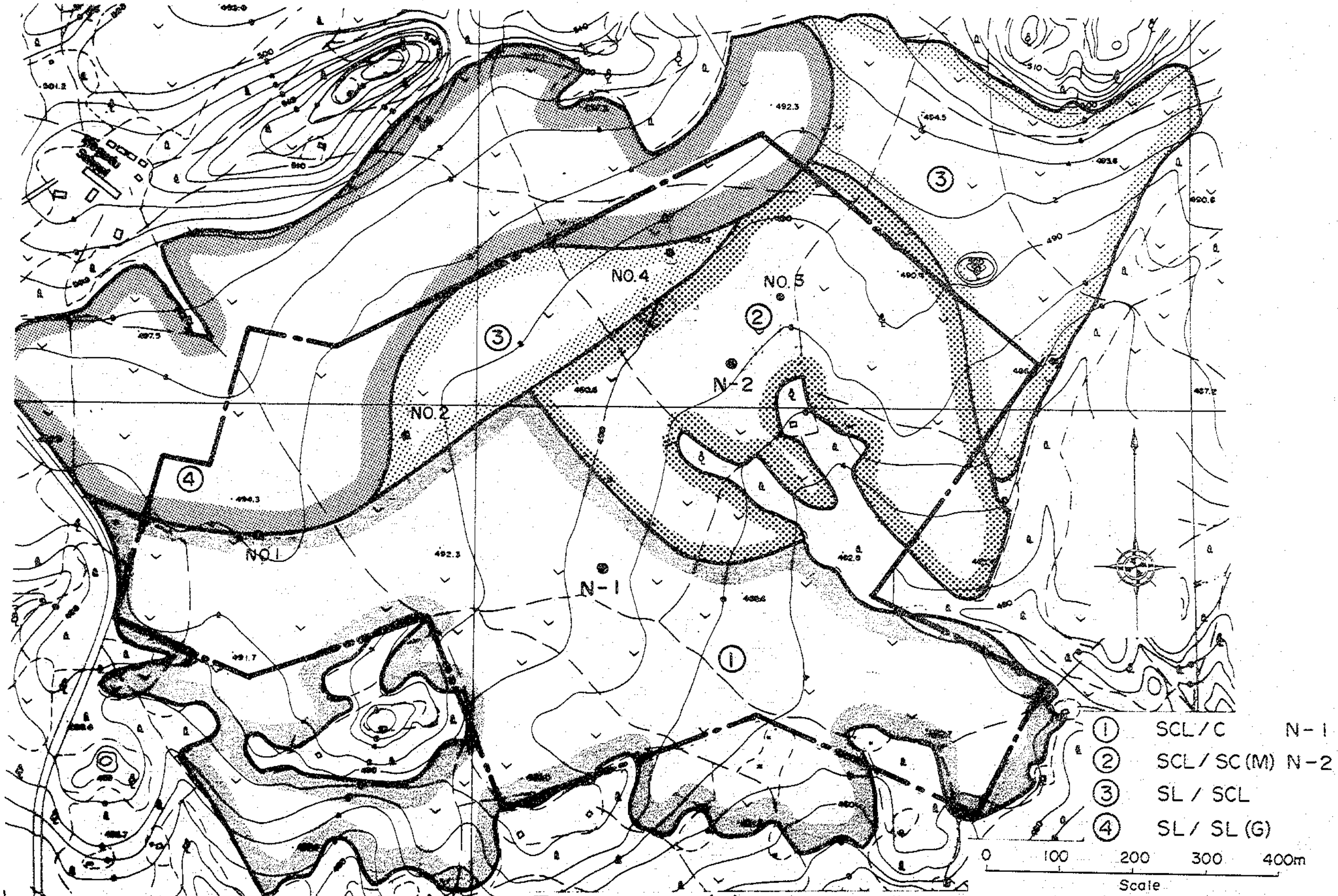


Figure C-1 (5) Soil Map of Magudu (V-3-3)

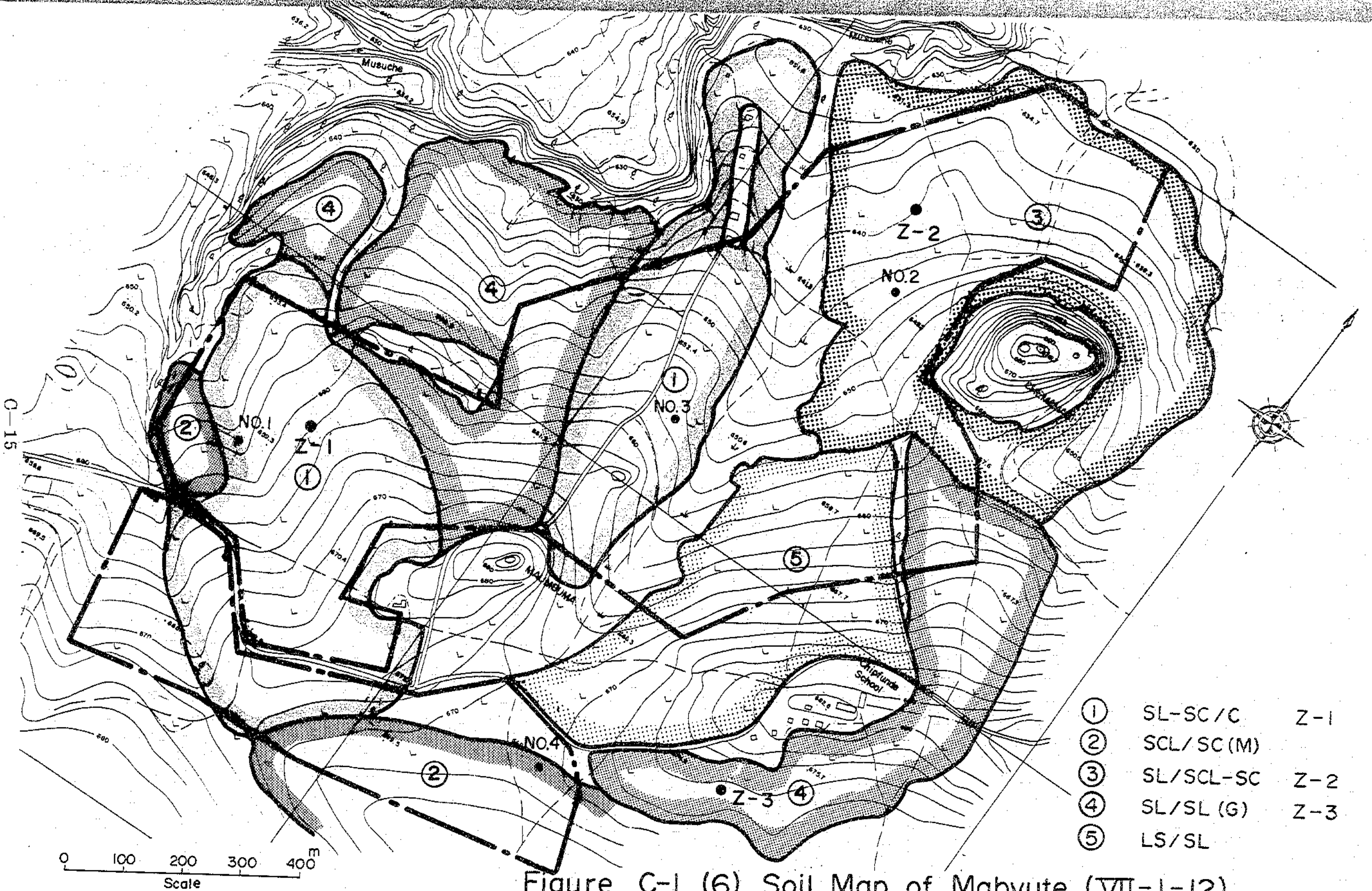


Figure C-1 (6) Soil Map of Mabvute (VII-1-12)

ANNEX D. IRRIGATION

Contents

D.1. Reference Crop Evapotranspiration

Reference crop evapotranspiration (ETo) was estimated on the monthly basis, by applying the method of modified Penman method, based on the climatological data observed at Masvingo Meteorological Station.

The modified Penman method applied in the Project was quoted from the book of "Crop Water Requirement, FAO Irrigation and Drainage Paper, No. 24".

The form of the equation used in this method is:

$$ETo = c[\underbrace{W.Rn}_{\text{radiation term}} + \underbrace{(1-W).f(u).(ea-ed)}_{\text{aerodynamic term}}]$$

where:

- ETo = reference crop evapotranspiration in mm/day
- W = temperature-related weighting factor
- Rn = net radiation in equivalent evaporation in mm/day
- f(u) = wind-related function
- (ea-ed) = difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air, both in mbar
- c = adjustment factor to compensate for the effect of day and night weather conditions

Table D-1 Summary of Reference Crop Evapotranspiration (Modified Penman Method)

(mm/day)

STATION : MASVINGO

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	5.9	5.4	4.1	3.8	2.8	2.6	3.1	4.0	5.8	6.1	6.3	6.2
1977	7.2	3.7	3.8	4.5	3.6	2.9	3.0	3.8	5.1	6.9	6.5	5.1
1978	5.0	4.9	4.4	3.7	3.2	2.4	2.7	4.7	5.9	5.3	6.1	4.6
1979	5.9	6.2	4.9	4.9	3.3	2.8	3.2	4.4	5.8	6.1	5.3	5.3
1980	6.6	5.7	5.0	4.5	3.8	3.0	3.0	4.4	4.7	6.4	5.7	6.0
1981	5.2	4.0	5.0	4.0	3.0	2.9	3.4	4.5	5.4	5.6	6.7	6.7
1982	6.7	6.2	6.1	4.8	3.6	3.2	3.1	4.7	5.8	5.9	6.8	8.0
1983	8.7	7.2	6.4	5.3	4.2	3.3	3.1	4.4	6.7	6.8	7.9	6.8
1984	7.7	6.3	5.2	4.5	3.9	2.9	3.0	4.7	5.9	6.5	5.7	6.2
1985	5.2	5.4	5.4	4.8	3.5	2.8	3.0	4.7	5.1	7.3	7.0	5.4
Mean	6.4	5.5	5.0	4.5	3.5	2.9	3.1	4.4	5.6	6.3	6.4	6.0

STATION : ZAKA (For reference)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	6.0	5.5	4.2	3.9	2.9	2.9	3.2	4.0	5.7	6.2	6.7	6.8
1977	7.1	4.0	3.9	4.6	4.0	3.3	3.2	4.0	5.2	6.9	5.8	5.4
1978	5.0	5.1	4.4	3.8	3.5	2.6	2.9	4.9	6.0	5.4	6.0	5.2
1979	6.1	6.2	4.7	5.0	3.7	3.0	3.2	4.2	5.4	5.7	5.5	5.9
1980	6.9	6.0	5.2	4.9	4.3	3.2	3.2	4.3	4.8	6.3	6.2	6.4
1981	5.6	4.1	5.1	4.2	3.0	2.9	3.1	4.0	4.9	5.2	6.6	6.9
1982	6.6	5.7	5.9	4.9	3.8	3.3	3.2	4.5	5.4	6.0	6.8	8.1
1983	8.4	7.2	6.4	5.4	4.5	3.1	3.4	4.4	6.2	6.6	7.8	7.2
1984	7.5	6.2	5.0	4.3	4.0	2.8	3.1	4.5	5.7	6.5	5.5	6.2
1985	5.4	5.2	5.3	4.8	3.6	2.9	3.2	4.6	5.0	6.7	6.8	6.2
Mean	6.5	5.5	5.0	4.6	3.7	3.0	3.2	4.3	5.4	6.2	6.4	6.4

STATION : BUFFALO RANGE (For reference)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	6.6	5.9	4.4	3.9	2.9	2.9	3.2	4.1	6.2	7.8	6.7	7.2
1977	8.2	4.5	4.0	4.3	4.0	3.1	3.6	4.3	5.5	7.2	7.2	5.7
1978	5.2	5.3	4.7	3.9	3.2	2.6	2.9	4.5	6.5	5.5	6.3	5.6
1979	6.4	7.4	5.1	5.0	3.6	3.2	3.5	4.3	5.9	6.7	5.7	6.3
1980	7.3	6.6	5.3	4.4	3.8	3.1	3.3	4.6	4.9	6.6	6.8	6.8
1981	6.3	4.5	5.3	4.5	2.9	2.8	3.1	4.0	4.7	5.6	7.2	7.7
1982	7.3	5.6	6.4	5.5	3.9	3.7	3.6	5.3	6.5	7.6	7.6	8.2
1983	8.8	7.4	6.7	5.8	4.5	3.3	3.5	4.7	7.4	7.5	9.1	7.6
1984	8.0	7.1	5.8	4.8	3.9	3.1	3.4	5.0	5.9	7.3	5.8	6.5
1985	6.1	5.3	6.1	5.5	3.7	3.3	3.4	5.1	5.4	7.7	7.5	6.7
Mean	7.0	6.0	5.4	4.8	3.6	3.1	3.4	4.6	5.9	7.0	7.0	6.8

Table D－2(1) Computation of Reference Crop Evapotranspiration

* PROJECT NAME		- MEDIUM SIZE DAMS
* METEOROLOGICAL STATION		- MASVINGO -
* LATITUDE (-:SOUTHERN HEMISPHERE)		-20.00
* ALTITUDE	(M)	1094.00
* METHOD OF COMPUTATION		PENMAN
		ET=C*<W*RN+(1-W)*F(U)*(EA-ED)> MM/DAY
* HEIGHT OF WIND MEASURMENT	(M)	2.00
CORRECTION FACTOR OF WIND-SPEED		1.00
* RATIO OF UDAY/UDAILY		1.30
* RATIO OF UDAY/UNIGHT		1.50

		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MAXIMUM RERATIVE HUMIDITY	(%)	95.0	95.0	95.0	95.0	95.0	90.0	90.0	85.0	85.0	85.0	90.0	90.0
RADIATION AT LATITUDE	(MM/DAY)	17.3	16.5	15.0	13.0	11.0	10.0	10.4	12.0	13.9	15.8	17.0	17.4
MAXIMUM POSSIBLE SUNSHINE	(HOUR)	13.2	12.8	12.3	11.7	11.2	10.9	11.0	11.5	12.0	12.6	13.1	13.3

YEAR OF 1976		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	21.8	21.7	21.1	18.5	15.0	14.1	12.9	13.5	19.6	21.4	23.8	23.7
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	7.7	7.3	5.9	7.1	6.5	7.1	9.3	9.4	9.6	7.8	8.0	7.4
* MEAN RERATIVE HUMIDTY		(%)	75.0	79.0	83.0	78.0	78.0	72.0	64.0	58.0	54.0	61.0	66.0	68.0
* MEAN WIND-SPEED		(KM/DAY)	190.0	190.0	170.0	153.0	150.0	138.0	132.0	158.0	179.0	210.0	144.0	167.0
VAPOUR PRESSUR	EA	(MBAR)	26.10	25.95	25.05	21.30	17.00	16.19	14.90	15.55	22.84	25.50	29.46	29.29
	ED	(MBAR)	19.57	20.50	20.79	16.61	13.26	11.66	9.54	9.02	12.33	15.55	19.44	19.92
WIND FUNCTION	F(U)		0.78	0.78	0.73	0.68	0.67	0.64	0.63	0.70	0.75	0.84	0.66	0.72
WEIGHTING FACTOR	W		0.73	0.73	0.72	0.70	0.65	0.64	0.63	0.63	0.71	0.73	0.75	0.75
SOLAR RADIATION	RS	(MM/DAY)	9.37	8.83	7.35	7.19	5.94	5.76	7.00	7.90	9.03	8.84	9.44	9.19
NET RADIATION	RN	(MM/DAY)	5.67	5.33	4.41	3.91	2.93	2.56	2.91	3.60	4.57	5.00	5.62	5.57
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.86	2.86	2.56	2.30	2.26	2.08	1.99	2.38	2.69	3.16	2.17	2.51
ADJUSTMENT FACTOR	C		1.08	1.07	1.02	1.02	0.99	0.98	1.01	1.02	1.05	1.03	1.07	1.06
EVAPO-TRANSPIRATION	ET	(MM/DAY)	5.90	5.40	4.10	3.80	2.80	2.60	3.10	4.00	5.80	6.10	6.30	6.20

YEAR OF 1977		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	24.0	22.0	20.5	18.3	16.5	13.6	13.2	15.6	20.0	22.6	23.1	23.2
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	9.3	3.6	5.4	10.0	9.8	9.2	8.2	7.9	8.3	10.2	8.3	5.9
* MEAN RERATIVE HUMIDTY		(%)	62.0	86.0	85.0	74.0	66.0	65.0	66.0	62.0	60.0	53.0	63.0	78.0
* MEAN WIND-SPEED		(KM/DAY)	161.0	164.0	138.0	132.0	104.0	107.0	132.0	156.0	161.0	158.0	156.0	156.0
VAPOUR PRESSUR	EA	(MBAR)	29.80	26.40	24.15	21.02	18.80	15.66	15.22	17.72	23.40	27.42	28.27	28.44
	ED	(MBAR)	18.48	22.70	20.53	15.55	12.41	10.18	10.05	10.99	14.04	14.53	17.81	22.18
WIND FUNCTION	F(U)		0.70	0.71	0.64	0.63	0.55	0.56	0.63	0.69	0.70	0.70	0.69	0.69
WEIGHTING FACTOR	W		0.75	0.73	0.72	0.69	0.67	0.64	0.63	0.66	0.71	0.74	0.74	0.74
SOLAR RADIATION	RS	(MM/DAY)	10.42	6.45	7.04	8.81	7.56	6.72	6.48	7.12	8.28	10.35	9.64	8.21
NET RADIATION	RN	(MM/DAY)	6.11	4.14	4.26	4.54	3.39	2.74	2.79	3.43	4.36	5.60	5.65	5.15
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.42	2.47	2.08	1.99	1.56	1.61	1.99	2.35	2.42	2.38	2.35	2.35
ADJUSTMENT FACTOR	C		1.09	1.00	1.03	1.08	1.05	1.02	1.00	1.00	1.03	1.07	1.07	1.04
EVAPO-TRANSPIRATION	ET	(MM/DAY)	7.20	3.70	3.80	4.50	3.60	2.90	3.00	3.80	5.10	6.90	6.50	5.10

Table D−2(2) Computation of Reference Crop Evapotranspiration

YEAR OF 1978		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	22.7	22.4	21.6	18.7	16.0	12.5	12.2	18.0	20.6	21.9	21.2	20.7
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	5.9	6.4	6.5	7.0	8.6	7.3	8.5	10.5	9.2	6.8	8.1	5.5
* MEAN RERATIVE HUMIDTY		(%)	82.0	82.0	82.0	79.0	74.0	75.0	72.0	55.0	53.0	69.0	69.0	81.0
* MEAN WIND-SPEED		(KM/DAY)	170.0	147.0	153.0	127.0	104.0	124.0	127.0	147.0	183.0	179.0	187.0	164.0
VAPOUR PRESSUR	EA	(MBAR)	27.59	27.08	26.10	21.58	18.20	14.50	14.20	20.60	24.30	26.25	25.20	24.45
	ED	(MBAR)	22.62	22.21	21.40	17.05	13.47	10.88	10.22	11.33	12.88	18.11	17.39	19.80
WIND FUNCTION	F(U)		0.73	0.67	0.68	0.61	0.55	0.60	0.61	0.67	0.76	0.75	0.77	0.71
WEIGHTING FACTOR	W		0.74	0.74	0.73	0.70	0.66	0.62	0.62	0.69	0.72	0.73	0.72	0.72
SOLAR RADIATION	RS	(MM/DAY)	8.19	8.25	7.71	7.14	6.97	5.85	6.62	8.48	8.80	8.21	9.51	7.95
NET RADIATION	RN	(MM/DAY)	5.15	5.09	4.61	3.90	3.28	2.58	2.88	3.85	4.48	4.82	5.60	4.96
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.56	2.21	2.30	1.91	1.56	1.87	1.91	2.21	2.75	2.69	2.81	2.47
ADJUSTMENT FACTOR	C		1.05	1.06	1.04	1.03	1.04	0.99	1.01	1.04	1.04	1.02	1.06	1.03
EVAPO-TRANSPIRATION	ET	(MM/DAY)	5.00	4.90	4.40	3.70	3.20	2.40	2.70	4.70	5.90	5.30	6.10	4.60

YEAR OF 1979		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	21.6	22.3	21.1	19.3	15.9	13.6	13.2	17.2	20.2	22.6	21.7	21.3
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	7.8	9.1	7.1	10.1	8.3	7.8	8.3	9.0	9.0	7.6	6.7	6.6
* MEAN RERATIVE HUMIDTY		(%)	74.0	71.0	75.0	69.0	70.0	69.0	64.0	59.0	55.0	61.0	75.0	75.0
* MEAN WIND-SPEED		(KM/DAY)	167.0	158.0	170.0	150.0	130.0	156.0	164.0	167.0	199.0	202.0	170.0	161.0
VAPOUR PRESSUR	EA	(MBAR)	25.80	26.91	25.05	22.42	18.08	15.66	15.22	19.64	23.70	27.42	25.95	25.35
	ED	(MBAR)	19.09	19.11	18.79	15.47	12.66	10.81	9.74	11.59	13.03	16.73	19.46	19.01
WIND FUNCTION	F(U)		0.72	0.70	0.73	0.67	0.62	0.69	0.71	0.72	0.81	0.82	0.73	0.70
WEIGHTING FACTOR	W		0.73	0.73	0.72	0.70	0.66	0.64	0.63	0.68	0.71	0.74	0.73	0.72
SOLAR RADIATION	RS	(MM/DAY)	9.44	9.99	8.08	8.86	6.83	6.08	6.52	7.70	8.69	8.72	8.60	8.67
NET RADIATION	RN	(MM/DAY)	5.68	5.85	4.69	4.53	3.18	2.61	2.79	3.62	4.46	4.98	5.23	5.30
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.51	2.38	2.56	2.26	1.96	2.35	2.47	2.51	2.99	3.04	2.56	2.42
ADJUSTMENT FACTOR	C		1.08	1.09	1.05	1.08	1.02	0.98	0.99	1.01	1.03	1.03	1.05	1.05
EVAPO-TRANSPIRATION	ET	(MM/DAY)	5.90	6.20	4.90	4.90	3.30	2.80	3.20	4.40	5.80	6.10	5.30	5.30

YEAR OF 1980		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	22.0	23.7	20.5	19.4	16.2	12.8	12.2	15.7	18.7	21.1	23.5	22.8
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	9.5	6.9	7.8	8.5	9.3	8.7	8.5	8.6	7.3	8.8	6.0	7.6
* MEAN RERATIVE HUMIDTY		(%)	70.0	73.0	77.0	70.0	64.0	64.0	67.0	56.0	66.0	59.0	69.0	76.0
* MEAN WIND-SPEED		(KM/DAY)	161.0	167.0	179.0	153.0	147.0	150.0	167.0	202.0	193.0	207.0	207.0	207.0
VAPOUR PRESSUR	EA	(MBAR)	26.40	29.29	24.15	22.56	18.44	14.80	14.20	17.84	21.58	25.05	28.95	27.76
	ED	(MBAR)	18.48	21.38	18.60	15.79	11.80	9.47	9.51	9.99	14.24	14.78	19.98	21.10
WIND FUNCTION	F(U)		0.70	0.72	0.75	0.68	0.67	0.67	0.72	0.82	0.79	0.83	0.83	0.83
WEIGHTING FACTOR	W		0.73	0.75	0.72	0.71	0.67	0.62	0.62	0.66	0.70	0.72	0.75	0.74
SOLAR RADIATION	RS	(MM/DAY)	10.55	8.57	8.51	7.97	7.32	6.49	6.62	7.49	7.70	9.47	8.14	9.32
NET RADIATION	RN	(MM/DAY)	6.22	5.20	4.90	4.18	3.27	2.65	2.83	3.48	4.16	5.26	4.98	5.71
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.42	2.51	2.69	2.30	2.21	2.26	2.51	3.04	2.90	3.11	3.11	3.11
ADJUSTMENT FACTOR	C		1.09	1.06	1.06	1.05	1.03	0.99	0.99	0.99	1.00	1.04	1.02	1.06
EVAPO-TRANSPIRATION	ET	(MM/DAY)	6.60	5.70	5.00	4.50	3.80	3.00	3.00	4.40	4.70	6.40	5.70	6.00

Table D−2(3) Computation of Reference Crop Evapotranspiration

YEAR OF 1981		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	23.8	22.0	21.3	18.2	15.3	12.7	13.2	16.5	18.4	19.2	23.7	22.3
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	6.1	4.4	7.8	7.8	7.4	9.2	9.4	9.0	8.0	7.3	7.5	8.6
* MEAN RERATIVE HUMIDTY		(%)	80.0	86.0	76.0	75.0	79.0	69.0	66.0	61.0	59.0	67.0	63.0	68.0
* MEAN WIND-SPEED		(KM/DAY)	147.0	188.0	164.0	153.0	193.0	170.0	202.0	228.0	242.0	274.0	216.0	213.0
VAPOUR PRESSUR	EA	(MBAR)	29.46	26.40	25.35	20.88	17.36	14.70	15.22	18.80	21.16	22.28	29.29	26.91
	ED	(MBAR)	23.57	22.70	19.27	15.66	13.71	10.14	10.05	11.47	12.48	14.93	18.45	18.30
WIND FUNCTION	F(U)		0.67	0.78	0.71	0.68	0.79	0.73	0.82	0.89	0.92	1.01	0.85	0.85
WEIGHTING FACTOR	W		0.75	0.73	0.72	0.69	0.66	0.62	0.63	0.67	0.70	0.70	0.75	0.73
SOLAR RADIATION	RS	(MM/DAY)	8.32	6.96	8.51	7.58	6.38	6.72	7.04	7.70	8.11	8.53	9.12	9.98
NET RADIATION	RN	(MM/DAY)	5.24	4.42	4.92	4.03	3.10	2.77	2.96	3.64	4.24	4.87	5.41	5.92
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.21	2.83	2.47	2.30	2.90	2.56	3.04	3.43	3.64	4.12	3.25	3.20
ADJUSTMENT FACTOR	C		1.06	1.00	1.06	1.04	0.98	0.99	0.99	0.99	1.00	1.00	1.05	1.06
EVAPO-TRANSPIRATION	ET	(MM/DAY)	5.20	4.00	5.00	4.00	3.00	2.90	3.40	4.50	5.40	5.60	6.70	6.70

YEAR OF 1982		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	23.2	22.2	21.3	20.3	15.7	14.6	14.1	16.1	18.5	20.8	23.6	24.9
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	9.2	8.3	9.6	8.2	8.8	8.8	7.4	9.5	9.0	7.4	7.2	9.3
* MEAN RERATIVE HUMIDTY		(%)	72.0	73.0	66.0	67.0	64.0	61.0	63.0	55.0	55.0	63.0	59.0	57.0
* MEAN WIND-SPEED		(KM/DAY)	184.0	216.0	184.0	187.0	147.0	135.0	153.0	204.0	239.0	233.0	222.0	230.0
VAPOUR PRESSUR	EA	(MBAR)	28.44	26.74	25.35	23.85	17.84	16.64	16.19	18.32	21.30	24.60	29.12	31.51
	ED	(MBAR)	20.48	19.52	16.73	15.98	11.42	10.15	10.20	10.08	11.72	15.50	17.18	17.96
WIND FUNCTION	F(U)		0.77	0.85	0.77	0.77	0.67	0.63	0.68	0.82	0.92	0.90	0.87	0.89
WEIGHTING FACTOR	W		0.74	0.73	0.72	0.71	0.66	0.65	0.64	0.66	0.70	0.72	0.75	0.76
SOLAR RADIATION	RS	(MM/DAY)	10.35	9.47	9.60	7.81	7.07	6.54	6.10	7.96	8.69	8.59	8.92	10.43
NET RADIATION	RN	(MM/DAY)	6.20	5.61	5.29	4.10	3.18	2.66	2.67	3.63	4.42	4.89	5.26	6.08
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.77	3.25	2.77	2.81	2.21	2.03	2.30	3.07	3.60	3.51	3.34	3.46
ADJUSTMENT FACTOR	C		1.09	1.07	1.08	1.03	1.02	1.00	0.98	1.00	1.02	1.02	1.05	1.07
EVAPO-TRANSPIRATION	ET	(MM/DAY)	6.70	6.20	6.10	4.80	3.60	3.20	3.10	4.70	5.80	5.90	6.80	8.00

YEAR OF 1983		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	26.0	24.3	23.6	21.5	19.4	15.9	15.1	14.8	21.3	21.6	25.3	23.8
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	9.3	8.7	8.3	8.0	9.0	9.1	8.0	9.8	10.5	8.6	9.0	8.3
* MEAN RERATIVE HUMIDTY		(%)	52.0	64.0	64.0	57.0	59.0	63.0	66.0	59.0	45.0	55.0	52.0	64.0
* MEAN WIND-SPEED		(KM/DAY)	248.0	230.0	225.0	179.0	147.0	130.0	147.0	193.0	193.0	236.0	199.0	176.0
VAPOUR PRESSUR	EA	(MBAR)	33.60	30.37	29.12	25.65	22.56	18.08	17.12	16.82	25.35	25.80	32.27	29.46
	ED	(MBAR)	17.47	19.44	18.64	14.62	13.31	11.39	11.30	9.92	11.41	14.19	16.78	18.85
WIND FUNCTION	F(U)		0.94	0.89	0.88	0.75	0.67	0.62	0.67	0.79	0.79	0.91	0.81	0.75
WEIGHTING FACTOR	W		0.77	0.75	0.75	0.73	0.71	0.66	0.65	0.65	0.72	0.73	0.76	0.75
SOLAR RADIATION	RS	(MM/DAY)	10.42	9.73	8.81	7.69	7.17	6.67	6.38	8.11	9.56	9.34	10.09	9.78
NET RADIATION	RN	(MM/DAY)	5.99	5.69	4.98	3.94	3.24	2.76	2.81	3.71	4.64	5.15	5.76	5.82
DAYTIME WIND-SPEED	UDAY	(M/SEC)	3.73	3.46	3.39	2.69	2.21	1.96	2.21	2.90	2.90	3.55	2.99	2.65
ADJUSTMENT FACTOR	C		1.08	1.07	1.06	1.03	1.03	1.01	0.99	1.01	1.05	1.03	1.07	1.07
EVAPO-TRANSPIRATION	ET	(MM/DAY)	8.70	7.20	6.40	5.30	4.20	3.30	3.10	4.40	6.70	6.80	7.90	6.80

Table D−2 (4) Computation of Reference Crop Evapotranspiration

YEAR OF 1984		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	24.0	22.4	22.0	19.3	17.7	14.1	14.8	16.1	20.9	22.7	21.7	22.7
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	9.7	8.3	7.0	8.4	8.6	7.5	7.2	10.2	9.0	8.4	6.9	8.0
* MEAN RERATIVE HUMIDTY		(%)	60.0	70.0	71.0	73.0	63.0	69.0	67.0	55.0	54.0	57.0	72.0	73.0
* MEAN WIND-SPEED		(KM/DAY)	199.0	196.0	187.0	179.0	164.0	167.0	153.0	184.0	196.0	184.0	207.0	196.0
VAPOUR PRESSUR	EA	(MBAR)	29.80	27.08	26.40	22.42	20.24	16.19	16.82	18.32	24.75	27.59	25.95	27.59
	ED	(MBAR)	17.88	18.96	18.74	16.37	12.75	11.17	11.27	10.08	13.36	15.73	18.68	20.14
WIND FUNCTION	F(U)		0.81	0.80	0.77	0.75	0.71	0.72	0.68	0.77	0.80	0.77	0.83	0.80
WEIGHTING FACTOR	W		0.75	0.74	0.73	0.70	0.69	0.64	0.65	0.66	0.72	0.74	0.73	0.74
SOLAR RADIATION	RS	(MM/DAY)	10.68	9.47	8.02	7.92	6.97	5.94	6.00	8.32	8.69	9.22	8.73	9.58
NET RADIATION	RN	(MM/DAY)	6.21	5.58	4.64	4.19	3.18	2.58	2.70	3.75	4.46	5.16	5.26	5.80
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.99	2.95	2.81	2.69	2.47	2.51	2.30	2.77	2.95	2.77	3.11	2.95
ADJUSTMENT FACTOR	C		1.09	1.08	1.04	1.04	1.01	0.97	0.98	1.02	1.03	1.05	1.04	1.06
EVAPO-TRANSPIRATION	ET	(MM/DAY)	7.70	6.30	5.20	4.50	3.90	2.90	3.00	4.70	5.90	6.50	5.70	6.20

YEAR OF 1985		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
* MEAN AIR TEMPERATURE		(°C)	23.1	21.7	21.9	18.9	16.2	13.2	14.1	15.8	19.4	21.7	21.9	22.6
* ACTUAL DAY LIGHT HOURS		(HR/DAY)	6.2	7.8	8.4	8.9	8.4	7.8	8.0	9.6	7.8	9.6	8.6	5.9
* MEAN RERATIVE HUMIDTY		(%)	80.0	82.0	75.0	67.0	67.0	66.0	66.0	54.0	61.0	54.0	60.0	72.0
* MEAN WIND-SPEED		(KM/DAY)	153.0	173.0	170.0	173.0	153.0	138.0	141.0	199.0	204.0	253.0	228.0	179.0
VAPOUR PRESSUR	EA	(MBAR)	28.27	25.95	26.25	21.86	18.44	15.22	16.19	17.96	22.56	25.95	26.25	27.42
	ED	(MBAR)	22.62	21.28	19.69	14.65	12.35	10.05	10.69	9.70	13.76	14.01	15.75	19.74
WIND FUNCTION	F(U)		0.68	0.74	0.73	0.74	0.68	0.64	0.65	0.81	0.82	0.95	0.89	0.75
WEIGHTING FACTOR	W		0.74	0.73	0.73	0.70	0.67	0.63	0.64	0.66	0.71	0.73	0.73	0.74
SOLAR RADIATION	RS	(MM/DAY)	8.39	9.15	8.87	8.19	6.87	6.08	6.38	8.01	7.99	9.97	9.83	8.21
NET RADIATION	RN	(MM/DAY)	5.25	5.54	5.10	4.21	3.17	2.57	2.79	3.63	4.24	5.42	5.06	5.07
DAYTIME WIND-SPEED	UDAY	(M/SEC)	2.30	2.60	2.56	2.60	2.30	2.08	2.12	2.99	3.07	3.81	3.43	2.69
ADJUSTMENT FACTOR	C		1.06	1.08	1.07	1.05	1.01	0.99	0.99	1.01	1.00	1.04	1.06	1.03
EVAPO-TRANSPIRATION	ET	(MM/DAY)	5.20	5.40	5.40	4.80	3.50	2.80	3.00	4.70	5.10	7.30	7.00	5.40

D.2. Net Irrigation Water Requirements

D.2.1. Crop Evapotranspiration

Crop evapotranspiration (ETc)(consumptive use of crops) of proposed crops has been estimated by multiplying the estimated ETo values by crop coefficients which express the relationship between ETo and the actual evapotranspiration during the vegetative stage of the crops. Crop coefficient was quoted from the book of "FAO Irrigation and Drainage Paper, No. 24".

D.2.2 Effective Rainfall

Reliable rainfall was defined as amount of rainfall exceeded in 4 years out of 5 in following rainfall stations.

Project Name	No.	Name of Rainfall Station
Musaverema (I-2-1)	460	Chendebvu Dam
Chinyamatumwa (II-1-6)	680	Makoro
Mashoko (II-2-1)	682	Chiremwaremwa
Munjanganja (IV-4-10)	642	Mukaro
Magudu (V-3-3)	627	Faversham
Mabvute (VII-1-12)	632	Svuure

Effective reliable rainfall was estimated by the evapotranspiration/precipitation ratio method (USDA 1969).

Table D−3(1) Irrigation Water Requirements Musaverema(I -2-1)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Reference Crop Evapotranspiration, mm	198	154	155	135	109	87	96	136	168	195	192	186	1811
Reliable Rainfall, mm	93	77	47	24	11	4	3	3	8	16	52	76	414
Crop Coefficients													
(Summer)													
Sugar Beans	—	0.5	0.9	1.05	0.7	—	—	—	—	—	—	—	
Tomatoes	0.65	1.0	1.05	0.9	0.65	—	—	—	—	—	—	0.4	
Groundnuts	0.85	0.95	0.9	0.65	—	—	—	—	—	—	0.4	0.55	
Vegetables	0.95	0.95	0.95	0.9	0.8	—	—	—	—	0.4	0.5	0.9	
(Winter)													
Maize	0.75	—	—	—	—	—	—	0.5	0.55	0.9	1.05	1.0	
Vegetables	—	—	—	—	—	0.55	0.7	0.95	0.95	0.95	0.85	—	
Early Maize	—	—	—	—	—	0.55	0.7	1.0	1.05	0.95	0.65	—	
Wheat	—	—	—	—	0.55	0.75	1.05	1.05	1.0	0.55	—	—	
Crop Evapotranspiration, mm													
(Summer)													
Sugar Beans	—	77	140	142	76	—	—	—	—	—	—	—	435
Tomatoes	129	154	163	122	24	—	—	—	—	—	—	74	666
Groundnuts	168	146	140	59	—	—	—	—	—	—	77	102	692
Vegetables	188	146	147	122	29	—	—	—	—	52	96	167	947
(Winter)													
Maize	149	—	—	—	—	—	—	45	92	176	202	186	850
Vegetables	—	—	—	—	—	48	67	129	160	185	163	—	752
Early Maize	—	—	—	—	—	48	67	136	176	185	83	—	695
Wheat	—	—	—	—	20	65	101	143	168	107	—	—	604
Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	—	50	37	19	7	—	—	—	—	—	—	—	113
Tomatoes	67	59	39	18	2	—	—	—	—	—	—	48	233
Groundnuts	72	58	37	12	—	—	—	—	—	—	35	53	267
Vegetables	75	58	38	18	2	—	—	—	—	7	36	60	294
(Winter)													
Maize	69	—	—	—	—	—	—	0	0	14	52	64	199
Vegetables	—	—	—	—	—	0	0	0	0	15	42	—	57
Early Maize	—	—	—	—	—	0	0	0	0	15	25	—	40
Wheat	—	—	—	—	2	0	0	0	0	12	—	—	14
Net IWR with Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	—	27	103	123	69	—	—	—	—	—	—	—	322
Tomatoes	62	95	124	104	22	—	—	—	—	—	—	26	433
Groundnuts	96	88	103	47	—	—	—	—	—	—	42	49	425
Vegetables	113	88	109	104	27	—	—	—	—	45	60	107	653
(Winter)													
Maize	80	—	—	—	—	—	—	45	92	162	150	122	651
Vegetables	—	—	—	—	—	48	67	129	160	170	121	—	695
Early Maize	—	—	—	—	—	48	67	136	176	170	58	—	655
Wheat	—	—	—	—	18	65	101	143	168	95	—	—	590

Table D−3(2) Irrigation Water Requirements Chinyamatumwa(II-1-6)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Reference Crop Evapotranspiration, mm	198	154	155	135	109	87	96	136	168	195	192	186	1811
Reliable Rainfall, mm	108	112	54	24	12	9	4	5	9	20	73	130	560
Crop Coefficients													
(Summer)													
Sugar Beans	0.4	0.65	1.05	1.0	0.5	—	—	—	—	—	—	—	
Tomatoes	0.65	1.0	1.05	0.9	0.65	—	—	—	—	—	—	0.4	
Groundnuts	0.95	0.95	0.7	—	—	—	—	—	—	0.4	0.4	0.7	
Vegetables	0.95	0.95	0.95	0.9	0.8	—	—	—	—	0.4	0.5	0.9	
(Winter)													
Maize	0.6	—	—	—	—	—	0.55	0.55	0.85	1.05	1.05	0.85	
Vegetables	—	—	—	—	—	0.55	0.7	0.95	0.95	0.95	0.85	—	
Early Maize	—	—	—	—	—	0.55	0.7	1.0	1.05	0.95	0.65	—	
Wheat	—	—	—	—	0.6	0.95	1.05	1.05	0.75	0.35	—	—	
Crop Evapotranspiration, mm													
(Summer)													
Sugar Beans	40	100	163	135	27	—	—	—	—	—	—	—	465
Tomatoes	129	154	163	122	24	—	—	—	—	—	—	74	666
Groundnuts	188	146	109	—	—	—	—	—	—	39	77	130	689
Vegetables	188	146	147	122	29	—	—	—	—	52	96	167	947
(Winter)													
Maize	40	—	—	—	—	—	18	75	143	205	202	158	841
Vegetables	—	—	—	—	—	48	67	129	160	185	163	—	752
Early Maize	—	—	—	—	—	48	67	136	176	185	83	—	695
Wheat	—	—	—	—	65	83	101	143	126	23	—	—	541
Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	34	74	44	19	4	—	—	—	—	—	—	—	175
Tomatoes	75	82	44	19	3	—	—	—	—	—	—	74	297
Groundnuts	85	80	39	—	—	—	—	—	—	7	48	89	348
Vegetables	85	80	42	19	3	—	—	—	—	9	50	96	384
(Winter)													
Maize	24	—	—	—	—	—	0	0	5	19	63	94	205
Vegetables	—	—	—	—	—	5	0	0	5	18	58	—	86
Early Maize	—	—	—	—	—	5	0	0	5	18	35	—	63
Wheat	—	—	—	—	8	5	0	0	5	4	—	—	22
Net IWR with Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	6	26	119	116	23	—	—	—	—	—	—	—	290
Tomatoes	54	72	119	103	21	—	—	—	—	—	—	0	369
Groundnuts	103	66	70	—	—	—	—	—	—	32	29	41	341
Vegetables	103	66	105	103	26	—	—	—	—	43	46	71	563
(Winter)													
Maize	16	—	—	—	—	—	18	75	138	186	139	64	636
Vegetables	—	—	—	—	—	43	67	129	155	167	105	—	666
Early Maize	—	—	—	—	—	43	67	136	171	167	48	—	632
Wheat	—	—	—	—	57	78	101	143	121	19	—	—	519

Table D-3(3) Irrigation Water Requirements Mashoko(II-2-1)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Reference Crop Evapotranspiration, mm	198	154	155	135	109	87	96	136	168	195	192	186	1811
Reliable Rainfall, mm	83	91	46	19	11	7	3	4	6	17	57	98	442
Crop Coefficients													
(Summer)													
Sugar Beans	—	0.5	0.9	1.05	0.7	—	—	—	—	—	—	—	
Tomatoes	0.65	1.0	1.05	0.9	0.65	—	—	—	—	—	—	0.4	
Groundnuts	0.85	0.95	0.9	0.65	—	—	—	—	—	—	0.4	0.55	
Vegetables	0.95	0.95	0.95	0.9	0.8	—	—	—	—	0.4	0.5	0.9	
(Winter)													
Maize	0.75	—	—	—	—	—	—	0.5	0.55	0.9	1.05	1.0	
Vegetables	—	—	—	—	—	0.55	0.7	0.95	0.95	0.95	0.85	—	
Early Maize	—	—	—	—	—	0.55	0.7	1.0	1.05	0.95	0.65	—	
Wheat	—	—	—	—	0.55	0.75	1.05	1.05	1.0	0.55	—	—	
Crop Evapotranspiration, mm													
(Summer)													
Sugar Beans	—	77	140	142	76	—	—	—	—	—	—	—	435
Tomatoes	129	154	163	122	24	—	—	—	—	—	—	74	666
Groundnuts	168	146	140	59	—	—	—	—	—	—	77	102	692
Vegetables	188	146	147	122	29	—	—	—	—	52	96	167	947
(Winter)													
Maize	149	—	—	—	—	—	—	45	92	176	202	186	850
Vegetables	—	—	—	—	—	48	67	129	160	185	163	—	752
Early Maize	—	—	—	—	—	48	67	136	176	185	83	—	695
Wheat	—	—	—	—	20	65	101	143	168	107	—	—	604
Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	—	58	37	16	7	—	—	—	—	—	—	—	118
Tomatoes	60	68	38	15	2	—	—	—	—	—	—	61	244
Groundnuts	65	67	37	9	—	—	—	—	—	—	38	65	281
Vegetables	68	67	37	15	2	—	—	—	—	8	39	75	311
(Winter)													
Maize	62	—	—	—	—	—	—	0	0	15	50	79	206
Vegetables	—	—	—	—	—	0	0	0	0	15	46	—	61
Early Maize	—	—	—	—	—	0	0	0	0	15	28	—	43
Wheat	—	—	—	—	2	0	0	0	0	13	—	—	15
Net IWR with Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	—	19	103	126	69	—	—	—	—	—	—	—	317
Tomatoes	69	86	125	107	22	—	—	—	—	—	—	13	442
Groundnuts	103	79	103	50	—	—	—	—	—	—	39	37	411
Vegetables	120	79	110	107	27	—	—	—	—	44	57	92	636
(Winter)													
Maize	87	—	—	—	—	—	—	45	92	161	152	107	644
Vegetables	—	—	—	—	—	48	67	129	160	170	117	—	691
Early Maize	—	—	—	—	—	48	67	136	176	170	55	—	652
Wheat	—	—	—	—	18	65	101	143	168	94	—	—	589

Table D-3(4) Irrigation Water Requirements Munjanganja(Ⅳ-4-10)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Reference Crop Evapotranspiration, mm	198	154	155	135	109	87	96	136	168	195	192	186	1811
Reliable Rainfall, mm	110	96	43	20	8	4	1	1	8	25	73	131	520
Crop Coefficients													
(Summer)													
Sugar Beans	0.4	0.65	1.05	1.0	0.5	—	—	—	—	—	—	—	
Tomatoes	0.65	1.0	1.05	0.9	0.65	—	—	—	—	—	—	0.4	
Groundnuts	0.95	0.95	0.7	—	—	—	—	—	—	0.4	0.4	0.7	
Vegetables	0.95	0.95	0.95	0.9	0.8	—	—	—	—	0.4	0.5	0.9	
(Winter)													
Maize	0.6	—	—	—	—	—	0.55	0.55	0.85	1.05	1.05	0.85	
Vegetables	—	—	—	—	—	0.55	0.7	0.95	0.95	0.95	0.85	—	
Early Maize	—	—	—	—	—	0.55	0.7	1.0	1.05	0.95	0.65	—	
Wheat	—	—	—	—	0.6	0.95	1.05	1.05	0.75	0.35	—	—	
Crop Evapotranspiration, mm													
(Summer)													
Sugar Beans	40	100	163	135	27	—	—	—	—	—	—	—	465
Tomatoes	129	154	163	122	24	—	—	—	—	—	—	74	666
Groundnuts	188	146	109	—	—	—	—	—	—	39	77	130	689
Vegetables	188	146	147	122	29	—	—	—	—	52	96	167	947
(Winter)													
Maize	40	—	—	—	—	—	18	75	143	205	202	158	841
Vegetables	—	—	—	—	—	48	67	129	160	185	163	—	752
Early Maize	—	—	—	—	—	48	67	136	176	185	83	—	695
Wheat	—	—	—	—	65	83	101	143	126	23	—	—	541
Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	35	64	36	16	0	—	—	—	—	—	—	—	151
Tomatoes	75	72	36	15	0	—	—	—	—	—	—	74	272
Groundnuts	88	71	32	—	—	—	—	—	—	9	48	90	338
Vegetables	88	71	35	15	0	—	—	—	—	12	50	95	366
(Winter)													
Maize	25	—	—	—	—	—	0	0	0	24	63	94	206
Vegetables	—	—	—	—	—	0	0	0	0	23	57	—	80
Early Maize	—	—	—	—	—	0	0	0	0	23	38	—	61
Wheat	—	—	—	—	0	0	0	0	0	6	—	—	6
Net IWR with Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	5	36	127	119	27	—	—	—	—	—	—	—	314
Tomatoes	54	82	127	107	24	—	—	—	—	—	—	0	394
Groundnuts	100	75	77	—	—	—	—	—	—	30	29	40	351
Vegetables	100	75	112	107	29	—	—	—	—	40	46	72	581
(Winter)													
Maize	15	—	—	—	—	—	18	75	143	181	139	64	635
Vegetables	—	—	—	—	—	48	67	129	160	162	106	—	672
Early Maize	—	—	—	—	—	48	67	136	176	162	45	—	634
Wheat	—	—	—	—	65	83	101	143	126	17	—	—	535

Table D-3(5) Irrigation Water Requirements Magudu(V-3-3)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Reference Crop Evapotranspiration, mm	198	154	155	135	109	87	96	136	168	195	192	186	1811
Reliable Rainfall, mm	98	100	54	26	9	8	3	7	10	22	64	97	498
Crop Coefficients													
(Summer)													
Sugar Beans	—	0.5	0.9	1.05	0.7	—	—	—	—	—	—	—	
Tomatoes	0.65	1.0	1.05	0.9	0.65	—	—	—	—	—	—	0.4	
Groundnuts	0.85	0.95	0.9	0.65	—	—	—	—	—	—	0.4	0.55	
Vegetables	0.95	0.95	0.95	0.9	0.8	—	—	—	—	0.4	0.5	0.9	
(Winter)													
Maize	0.75	—	—	—	—	—	—	0.5	0.55	0.9	1.05	1.0	
Vegetables	—	—	—	—	—	0.55	0.7	0.95	0.95	0.95	0.85	—	
Early Maize	—	—	—	—	—	0.55	0.7	1.0	1.05	0.95	0.65	—	
Wheat	—	—	—	—	0.55	0.75	1.05	1.05	1.0	0.55	—	—	
Crop Evapotranspiration, mm													
(Summer)													
Sugar Beans	—	77	140	142	76	—	—	—	—	—	—	—	435
Tomatoes	129	154	163	122	24	—	—	—	—	—	—	74	666
Groundnuts	168	146	140	59	—	—	—	—	—	—	77	102	692
Vegetables	188	146	147	122	29	—	—	—	—	52	96	167	947
(Winter)													
Maize	149	—	—	—	—	—	—	45	92	176	202	186	850
Vegetables	—	—	—	—	—	48	67	129	160	185	163	—	752
Early Maize	—	—	—	—	—	48	67	136	176	185	83	—	695
Wheat	—	—	—	—	20	65	101	143	168	107	—	—	604
Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	—	63	41	22	5	—	—	—	—	—	—	—	131
Tomatoes	69	74	44	21	5	—	—	—	—	—	—	60	273
Groundnuts	80	73	41	13	—	—	—	—	—	—	42	64	313
Vegetables	80	73	42	20	5	—	—	—	—	10	43	74	347
(Winter)													
Maize	72	—	—	—	—	—	—	0	6	20	55	79	232
Vegetables	—	—	—	—	—	0	0	0	6	20	52	—	78
Early Maize	—	—	—	—	—	0	0	0	6	20	31	—	57
Wheat	—	—	—	—	5	0	0	0	6	17	—	—	28
Net IWR with Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	—	14	99	120	71	—	—	—	—	—	—	—	304
Tomatoes	60	80	119	101	19	—	—	—	—	—	—	14	393
Groundnuts	88	73	99	46	—	—	—	—	—	—	35	38	379
Vegetables	108	73	105	102	24	—	—	—	—	42	53	93	600
(Winter)													
Maize	77	—	—	—	—	—	—	45	86	156	147	107	618
Vegetables	—	—	—	—	—	48	67	129	154	165	111	—	674
Early Maize	—	—	—	—	—	48	67	136	170	165	52	—	638
Wheat	—	—	—	—	15	65	101	143	162	90	—	—	576

Table D-3(6) Irrigation Water Requirements Mabvute(Ⅷ-1-12)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Reference Crop Evapotranspiration, mm	198	154	155	135	109	87	96	136	168	195	192	186	1811
Reliable Rainfall, mm	114	126	66	27	15	9	6	6	8	26	60	111	574
Crop Coefficients													
(Summer)													
Sugar Beans	0.4	0.65	1.05	1.0	0.5	—	—	—	—	—	—	—	
Tomatoes	0.65	1.0	1.05	0.9	0.65	—	—	—	—	—	—	0.4	
Groundnuts	0.95	0.95	0.7	—	—	—	—	—	—	0.4	0.4	0.7	
Vegetables	0.95	0.95	0.95	0.9	0.8	—	—	—	—	0.4	0.5	0.9	
(Winter)													
Maize	0.6	—	—	—	—	—	0.55	0.55	0.85	1.05	1.05	0.85	
Vegetables	—	—	—	—	—	0.55	0.7	0.95	0.95	0.95	0.85	—	
Early Maize	—	—	—	—	—	0.55	0.7	1.0	1.05	0.95	0.65	—	
Wheat	—	—	—	—	0.6	0.95	1.05	1.05	0.75	0.35	—	—	
Crop Evapotranspiration, mm													
(Summer)													
Sugar Beans	40	100	163	135	27	—	—	—	—	—	—	—	465
Tomatoes	129	154	163	122	24	—	—	—	—	—	—	74	666
Groundnuts	188	146	109	—	—	—	—	—	—	39	77	130	689
Vegetables	188	146	147	122	29	—	—	—	—	52	96	167	947
(Winter)													
Maize	40	—	—	—	—	—	18	75	143	205	202	158	841
Vegetables	—	—	—	—	—	48	67	129	160	185	163	—	752
Early Maize	—	—	—	—	—	48	67	136	176	185	83	—	695
Wheat	—	—	—	—	65	83	101	143	126	23	—	—	541
Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	36	81	53	22	5	—	—	—	—	—	—	—	197
Tomatoes	78	91	53	21	4	—	—	—	—	—	—	68	315
Groundnuts	90	89	46	—	—	—	—	—	—	10	40	77	352
Vegetables	90	89	51	21	4	—	—	—	—	13	41	83	392
(Winter)													
Maize	25	—	—	—	—	—	0	0	0	24	52	82	183
Vegetables	—	—	—	—	—	5	0	0	0	23	48	—	76
Early Maize	—	—	—	—	—	5	0	0	0	23	32	—	60
Wheat	—	—	—	—	10	5	0	0	0	6	—	—	21
Net IWR with Effective Reliable Rainfall, mm													
(Summer)													
Sugar Beans	4	19	110	113	22	—	—	—	—	—	—	—	268
Tomatoes	51	63	110	101	20	—	—	—	—	—	—	6	351
Groundnuts	98	57	63	—	—	—	—	—	—	29	37	53	337
Vegetables	98	57	96	101	25	—	—	—	—	39	55	84	555
(Winter)													
Maize	15	—	—	—	—	—	18	75	143	181	150	76	658
Vegetables	—	—	—	—	—	43	67	129	160	162	115	—	676
Early Maize	—	—	—	—	—	43	67	136	176	162	51	—	635
Wheat	—	—	—	—	55	78	101	143	126	17	—	—	520

Table D-4(1) Irrigation Interval — Musaverema(I-2-1), Mashoko(II-2-1), Magudu(III-3-3)

Items	Summer				Winter			
	Sugar Beans	Tomatoes	Groundnuts	Vegetable	Maize	Vegetable	Early Maize	Wheat
Month	Apr.	Mar.	Jan.	Jan.	Nov.	Oct.	Oct.	Sep.
Available soil water, mm/m	100	100	100	100	100	100	100	100
Fraction of available soil water	0.45	0.4	0.4	0.45	0.6	0.45	0.6	0.55
Readily available soil water, mm/m	45	40	40	45	60	45	60	55
ETcrop, mm/day	4.7 (4.5×1.05)	5.3 (5.0×1.05)	5.4 (6.4×0.85)	6.1 (6.4×0.95)	6.7 (6.4×1.05)	6.0 (6.3×0.95)	6.0 (6.3×0.95)	5.6 (5.6×1.0)
Rooting depth, m	0.5	0.7	0.5	0.4	1.0	0.4	1.0	1.0
Readily available soil water in root zone, mm	22.5	28.0	20.0	18.0	60.0	18.0	60.0	55.0
Irrigation interval, days	4.8	5.3	3.7	3.0	9.0	3.0	10.0	9.8

Table D-4(2) Irrigation Interval — Chinyamatumwa(II-1-6), Munjanganja(IV-4-10), Mabvute(VII-1-12)

Items	Summer				Winter			
	Sugra Beans	Tomatoes	Groundnuts	Vegetable	Maize	Vegetable	Early Maize	Wheat
Month	Apr.	Mar.	Jan.	Jan.	Oct.	Oct.	Oct.	Aug.
Available soil water, mm/m	100	100	100	100	100	100	100	100
Fraction of available soil water	0.45	0.4	0.4	0.45	0.6	0.45	0.6	0.55
Readily available soil water, mm/m	45	40	40	45	60	45	60	55
ETcrop, mm/day	5.3 (5.0×1.05)	5.3 (5.0×1.05)	6.1 (6.4×0.95)	6.1 (6.4×0.95)	6.6 (6.3×1.05)	6.0 (6.3×0.95)	6.0 (6.3×0.95)	4.6 (4.4×1.05)
Rooting depth, m	0.5	0.7	0.5	0.4	1.0	0.4	1.0	1.0
Readily available soil water in root zone, mm	22.5	28.0	20.0	18.0	60.0	18.0	60.0	55.0
Irrigation interval, days	4.2	5.3	3.3	3.0	9.1	3.0	10.0	12.0

D.3. Measurement of Intake Rate

During the field survey, intake rate measurements were made at four sites in each project area (see Figure D-1), under wet conditions, in order to pursue an adequate irrigation method. The wet conditions mean the field keeping the water holding capacity after 24 hours of soil saturation.

To measure the intake rate, a cylinder infiltrometer was used and the reading of water depth within the cylinder was made at the interval of every five to 10 minutes.

Results of intake rate measurements are plotted on a logarithmic paper. The intake rate approaches a constant value as time increases. The constant rate is referred to as basic intake rate. The following table gives the obtained basic intake rate.

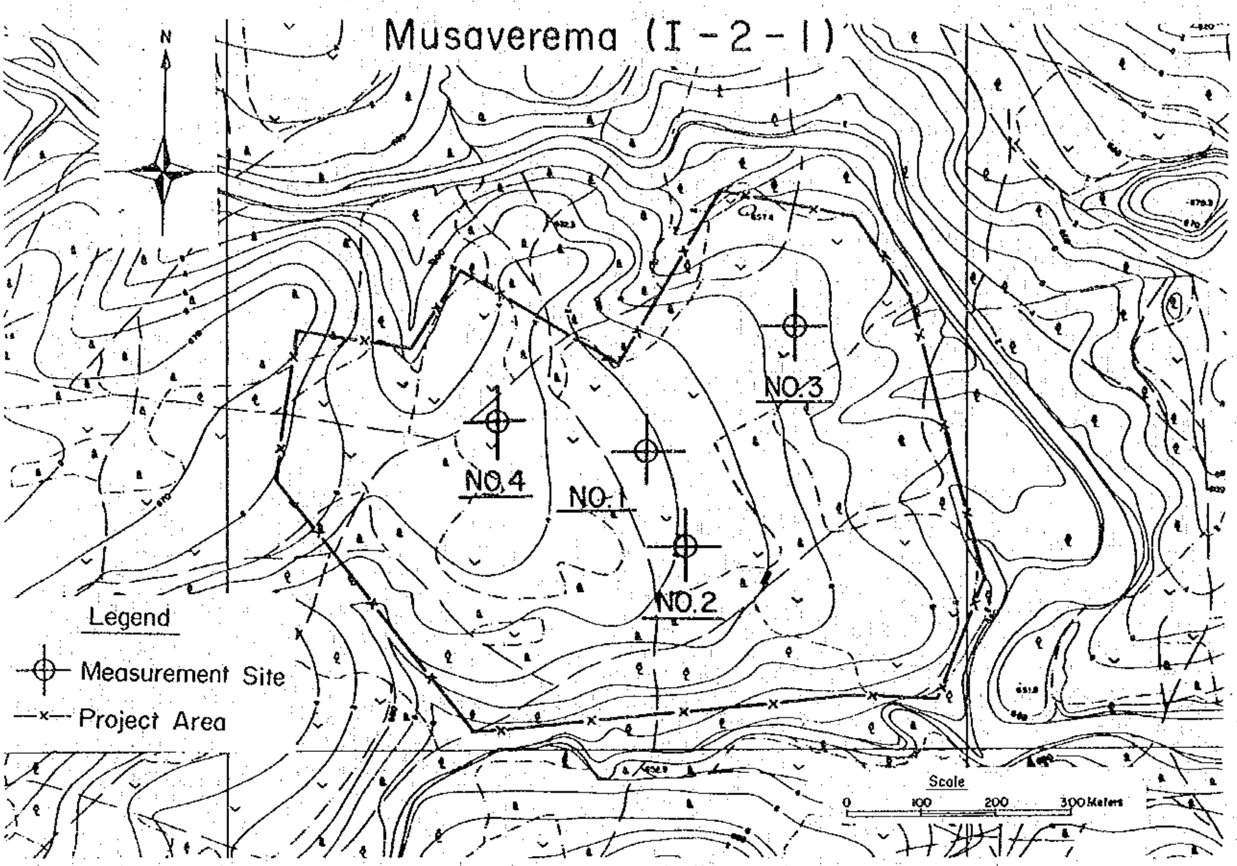
Table D-5 Obtained Basic Intake Rate

(mm/hr)

Name of Project	Measurement Site No.				Average
	No. 1	No. 2	No. 3	No. 4	
Musaverema (I-2-1)	18.7	5.9	2.7	15.8	10.8
Chinyamatumwa (II-1-6)	20.0	28.3	(71.6)	11.9	20.1
Mashoko (II-2-1)	15.7	7.0	16.8	9.6	12.3
Munjanganja (IV-4-10)	4.1	17.3	15.2	18.4	13.8
Magudu (V-3-3)	4.9	6.0	4.0	5.0	5.0
Mabvute (VII-1-12)	18.0	21.5	12.6	19.1	17.8

Figure D-1 (1) Location Map of Intake Rate Measurement

Musaverema (I-2-1)



Chinyamatumwa (II-1-6)

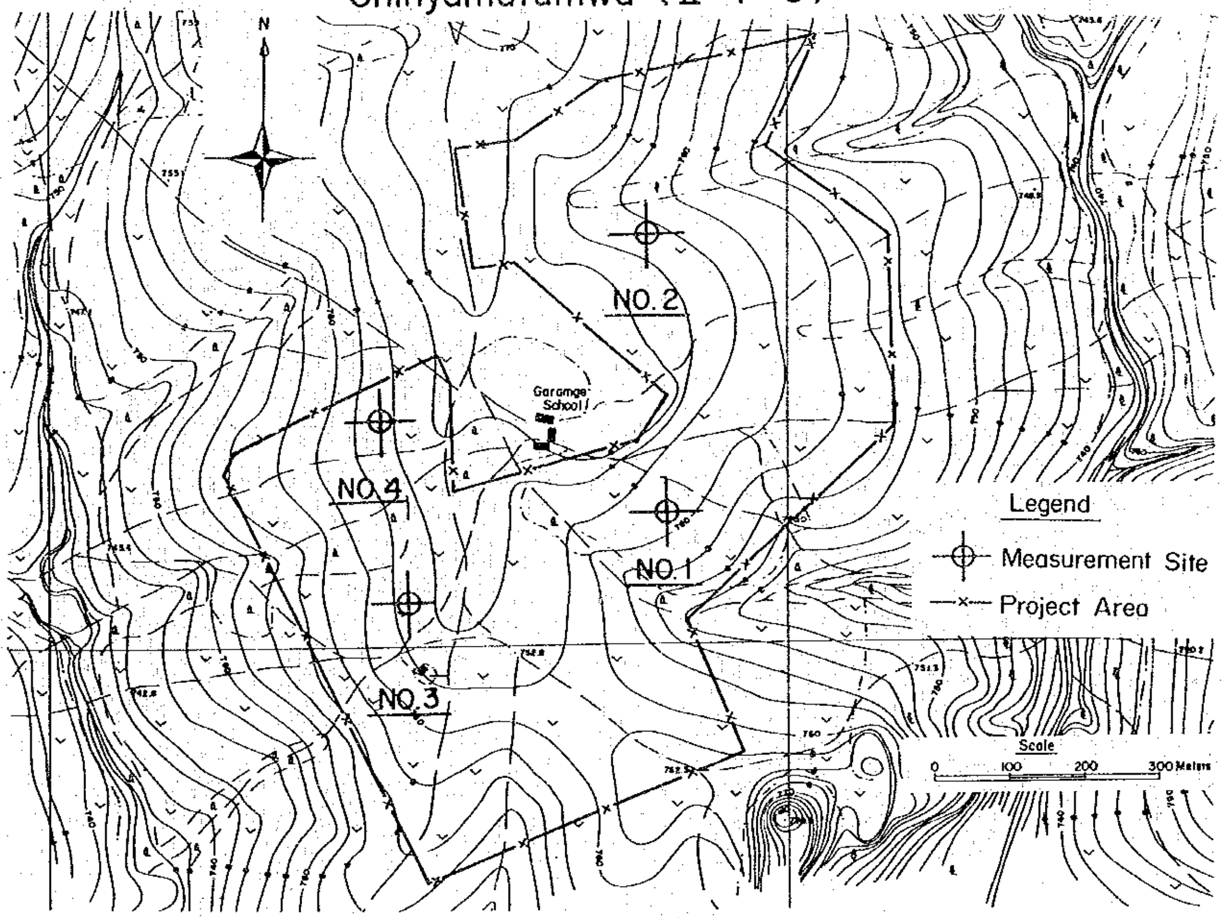
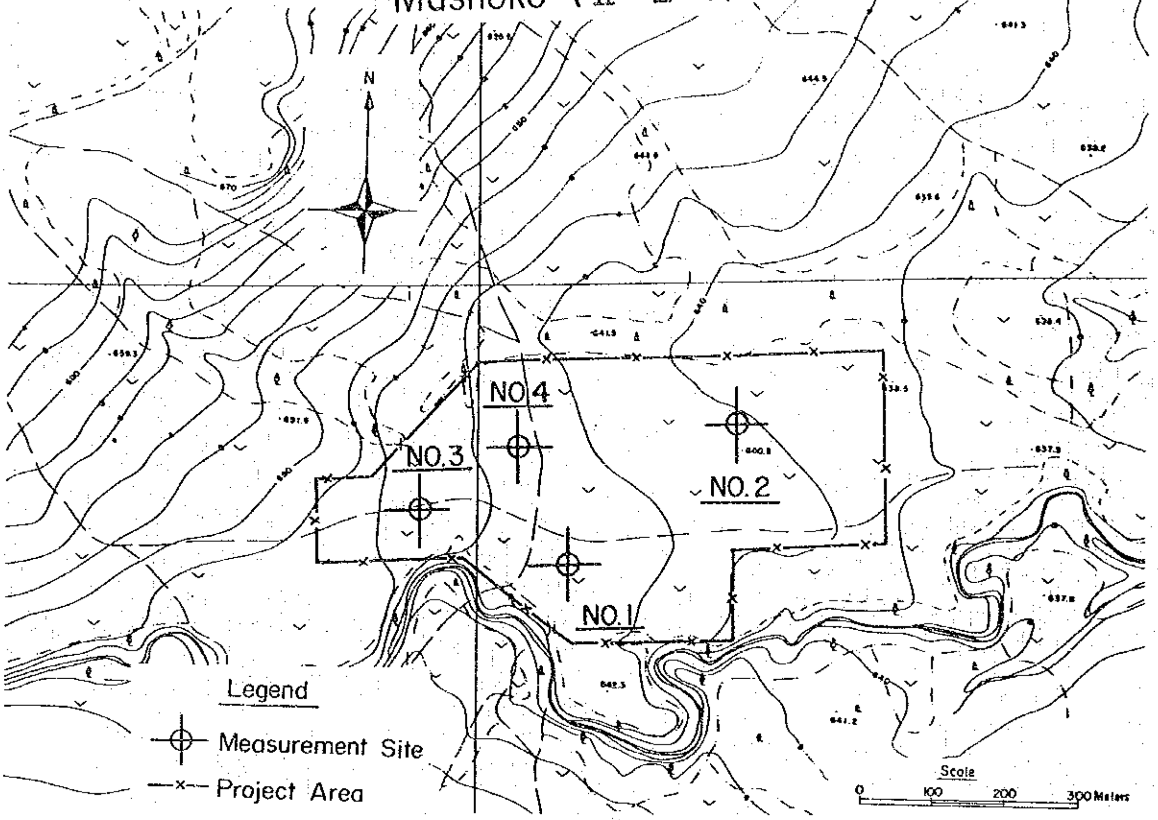


Figure D-1 (2) Location Map of Intake Rate Measurement

Mashoko (II-2-1)



Munjanganja (IV-4-10)

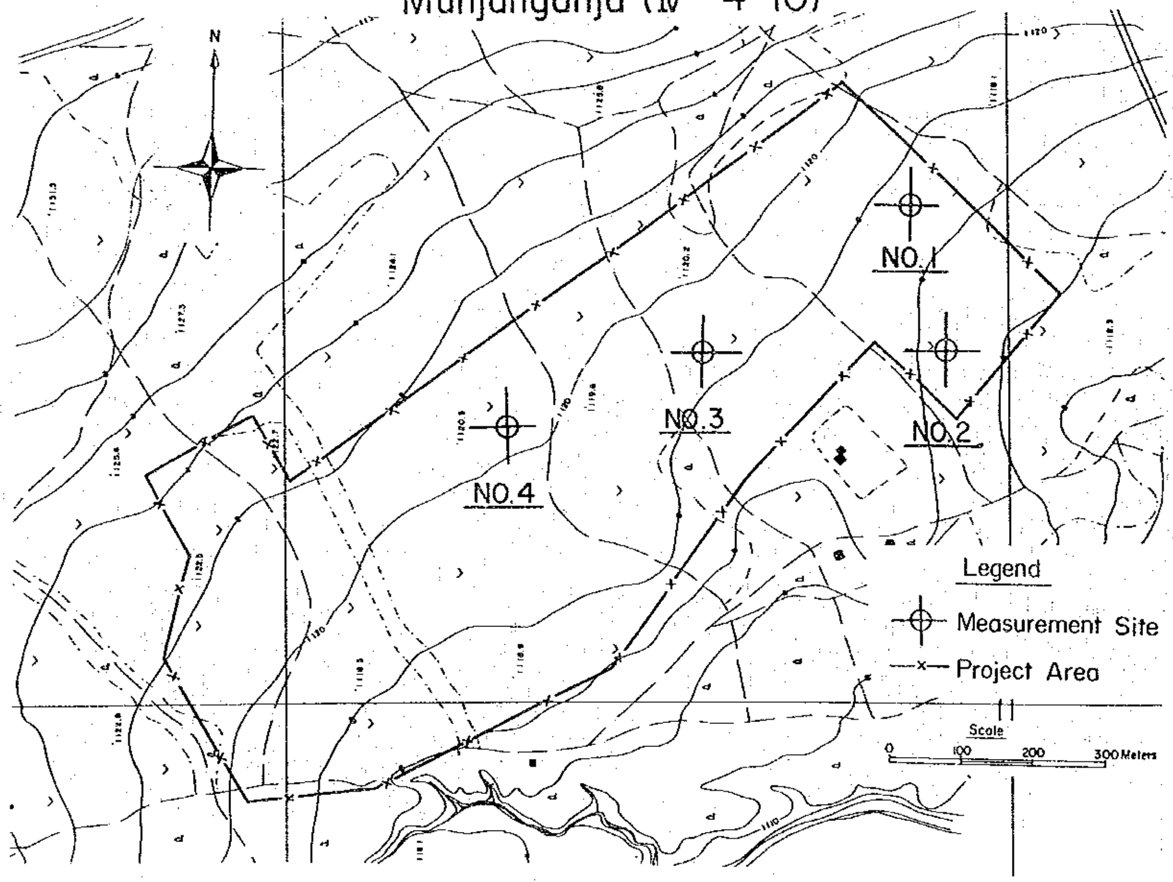
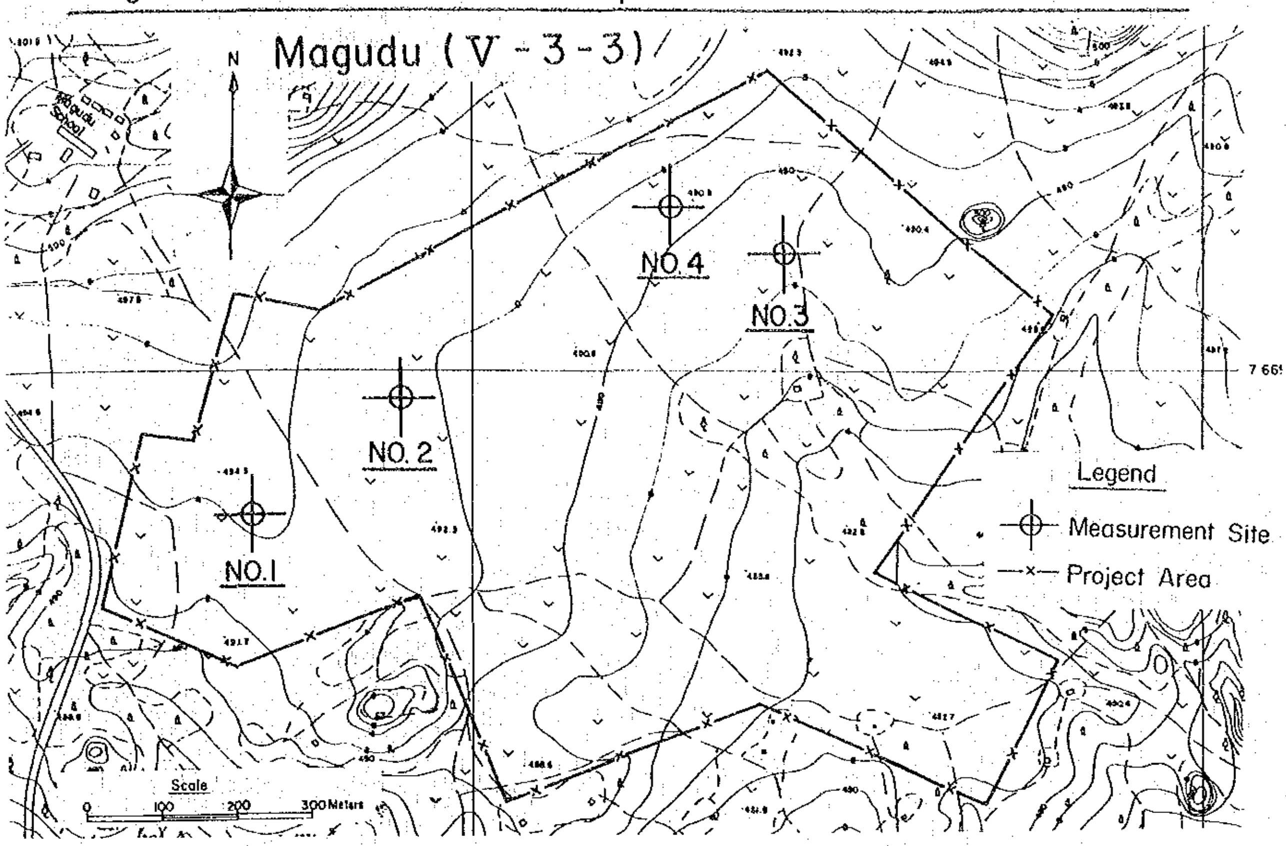


Figure D-1 (3) Location Map of Intake Rate Measurement



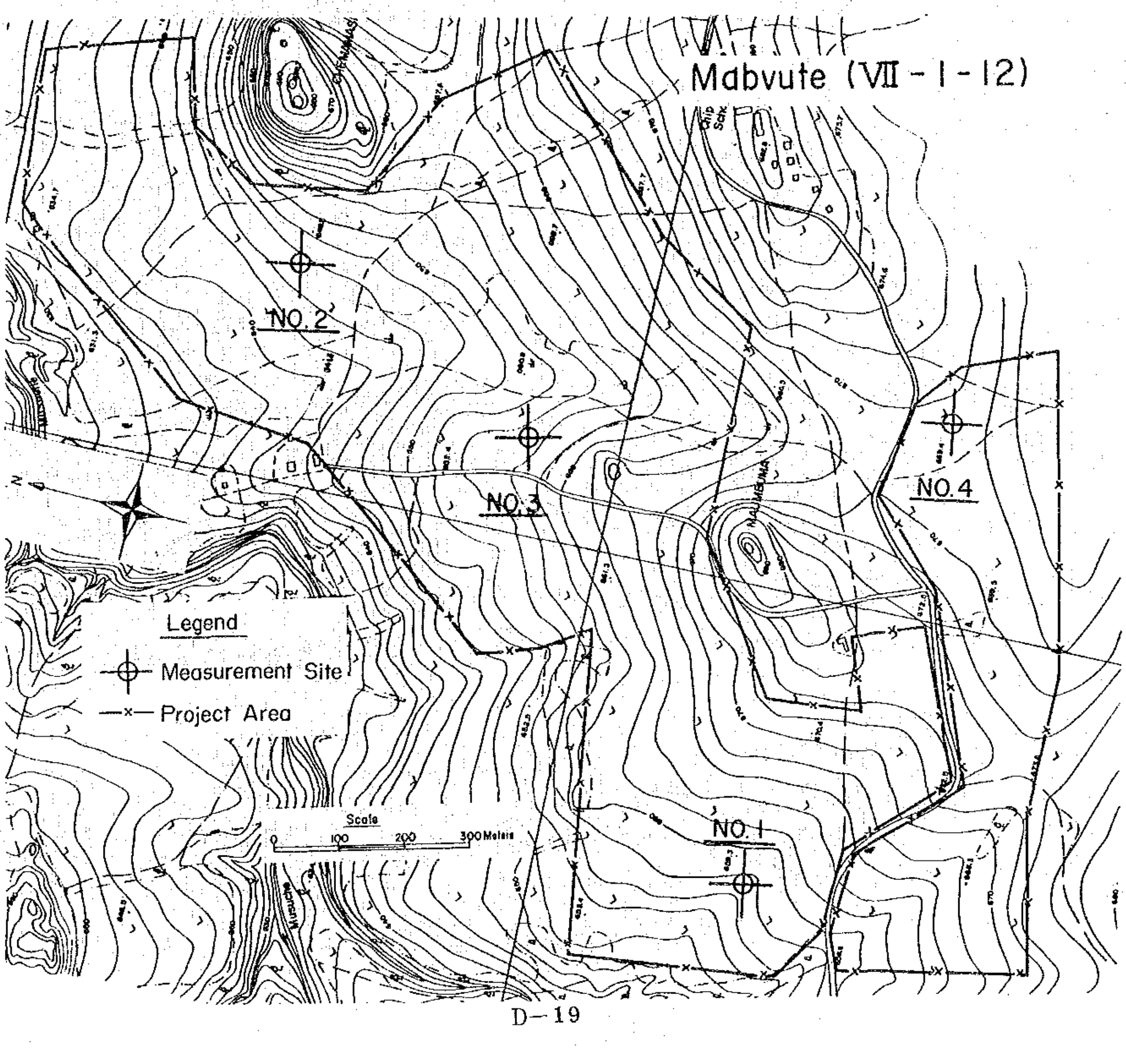
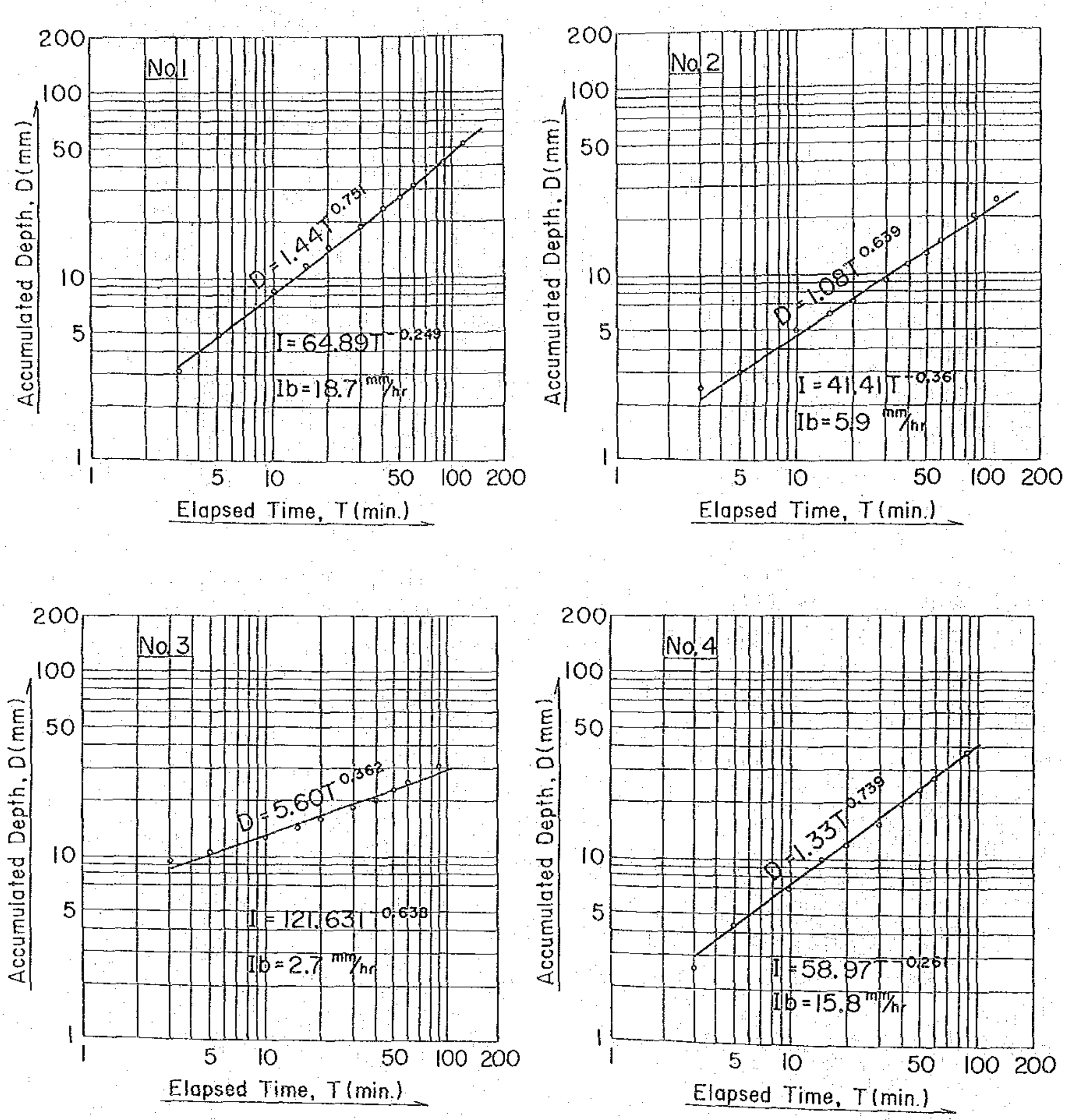


Figure D-2 (1) Result of Cylinder Intake Rate Test

Musaverema (I-2-1)



Notes

$D = C \cdot T^{n}$

$I = 60 \cdot C \cdot n \cdot T^{n-1}$

$Ib = 60 \cdot C \cdot n \cdot \{600(n-1)\}^{n-1}$

D; Accumulated Depth (mm)

T; Elapsed Time (min)

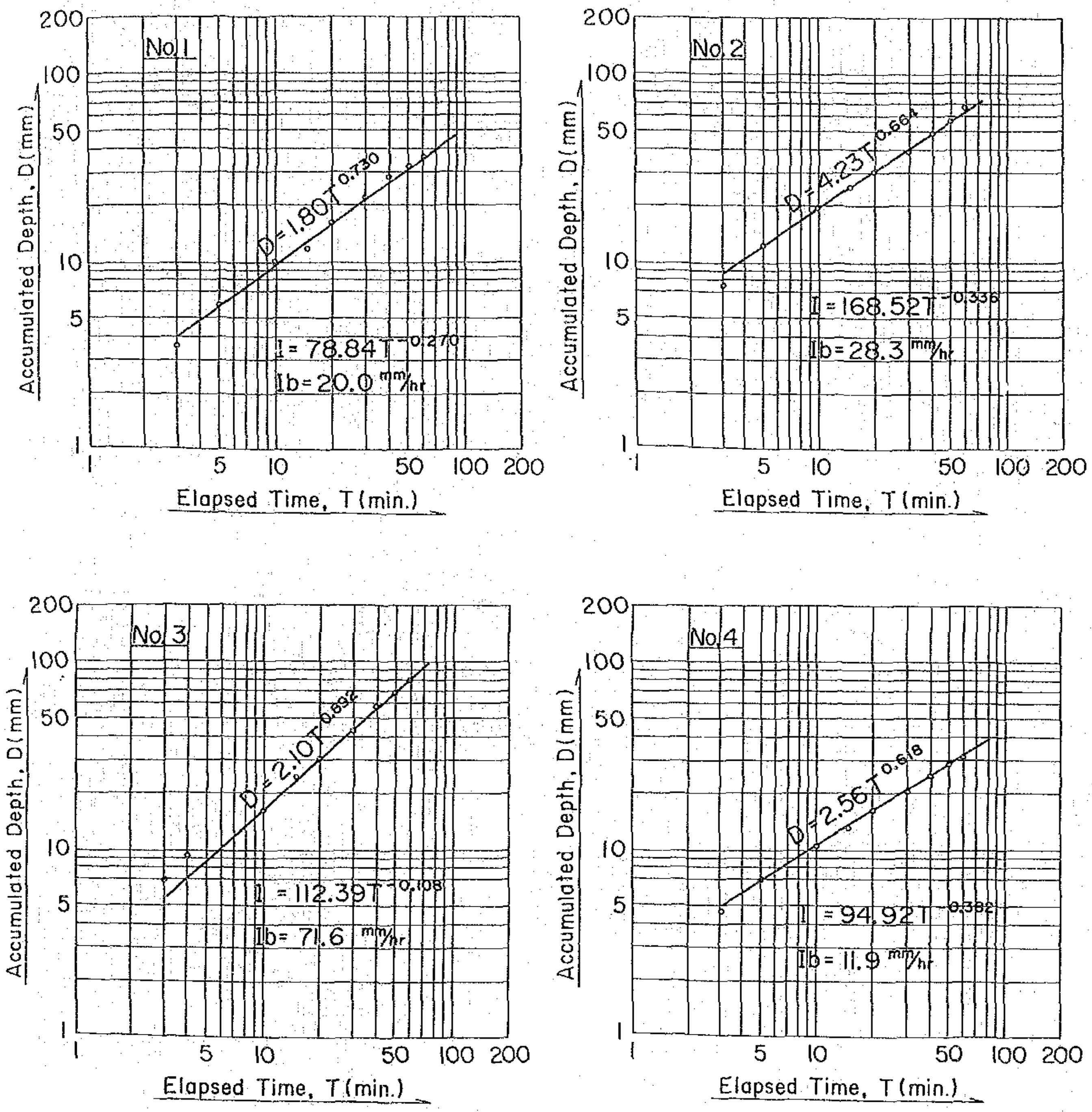
I; Intake Rate (mm/hr)

Ib; Basic Intake Rate (mm/hr)

C,n; Constant

Figure D - 2 (2) Result of Cylinder Intake Rate Test

Chinyamatumwa (II - 1 - 6)



Notes

$D=C\cdot T^{n}$

$I=60\cdot C\cdot n\cdot T^{n-1}$

$Ib=60\cdot C\cdot n\cdot \{600(n-1)\}^{n-1}$

D; Accumulated Depth (mm)

T; Elapsed Time (min)

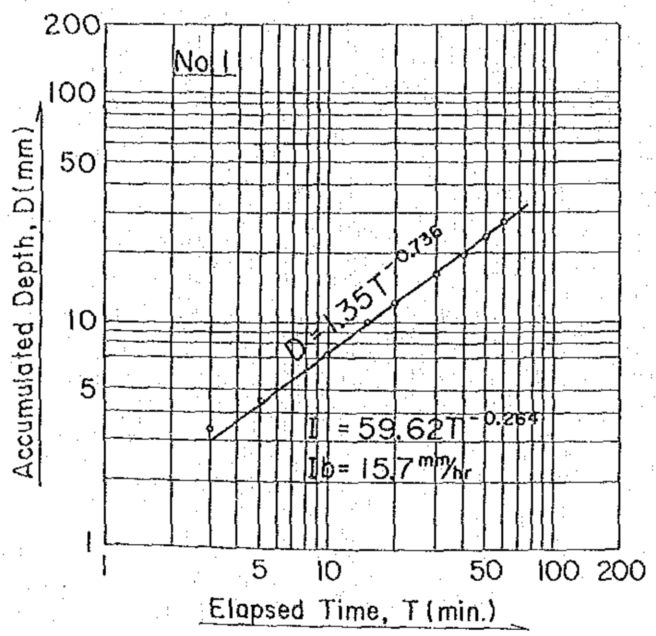
I; Intake Rate (mm/hr)

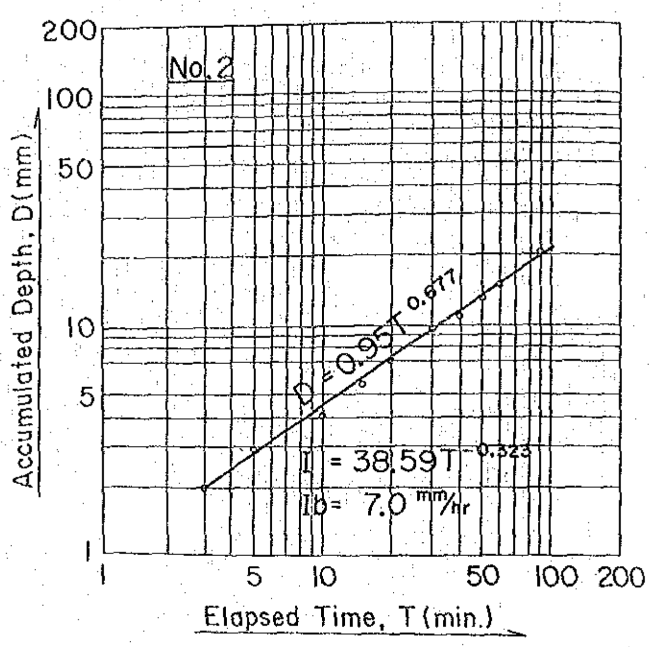
Ib; Basic Intake Rate (mm/hr)

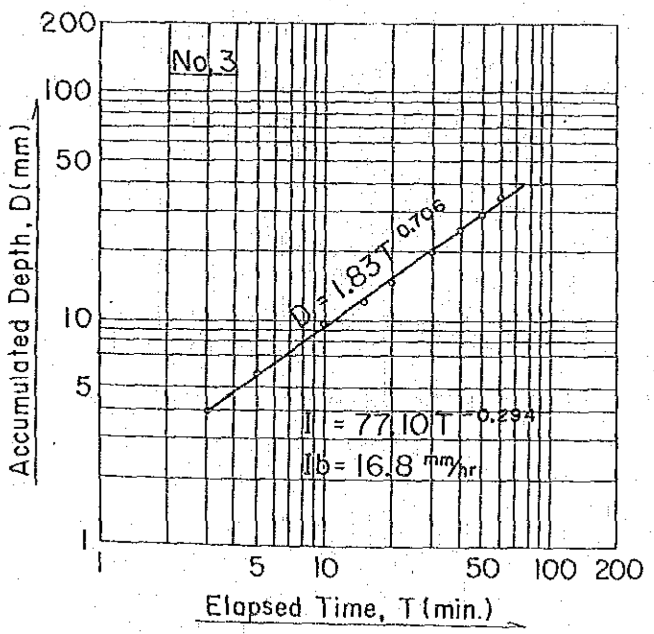
C,n; Constant

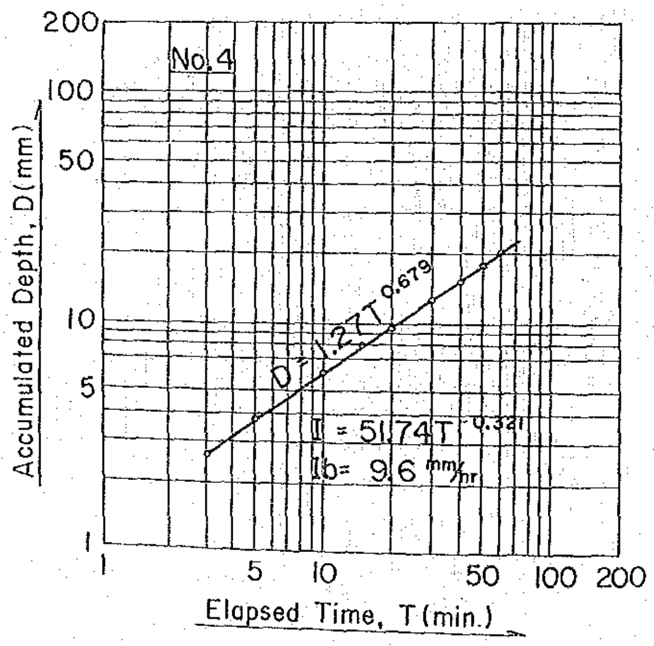
Figure D-2 (3) Result of Cylinder Intake Rate Test

Mashoko (II-2-1)









Notes

$D = C \cdot T^n$

$I = 60 \cdot C \cdot n \cdot T^{n-1}$

$Ib = 60 \cdot C \cdot n \cdot \{600(n-1)\}^{n-1}$

D; Accumulated Depth (mm)

T; Elapsed Time (min)

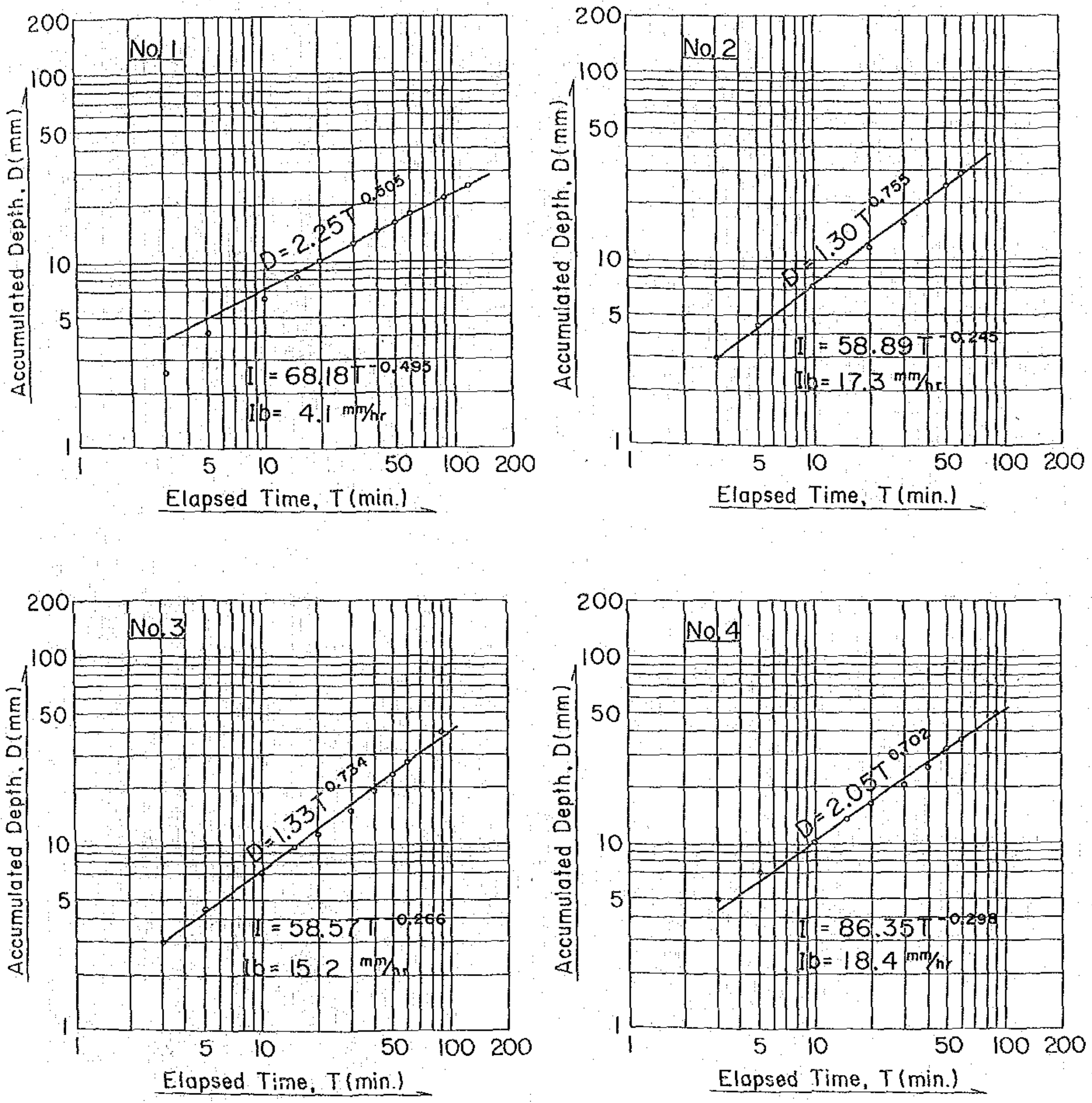
I; Intake Rate (mm/hr)

Ib; Basic Intake Rate (mm/hr)

C,n; Constant

Figure D-2 (4) Result of Cylinder Intake Rate Test

Munjanganja (Ⅳ-4-10)



Notes

$D = C \cdot T^{n}$

$I = 60 \cdot C \cdot n \cdot T^{n-1}$

$Ib = 60 \cdot C \cdot n \cdot \{600(n-1)\}^{n-1}$

D; Accumulated Depth (mm)

T; Elapsed Time (min)

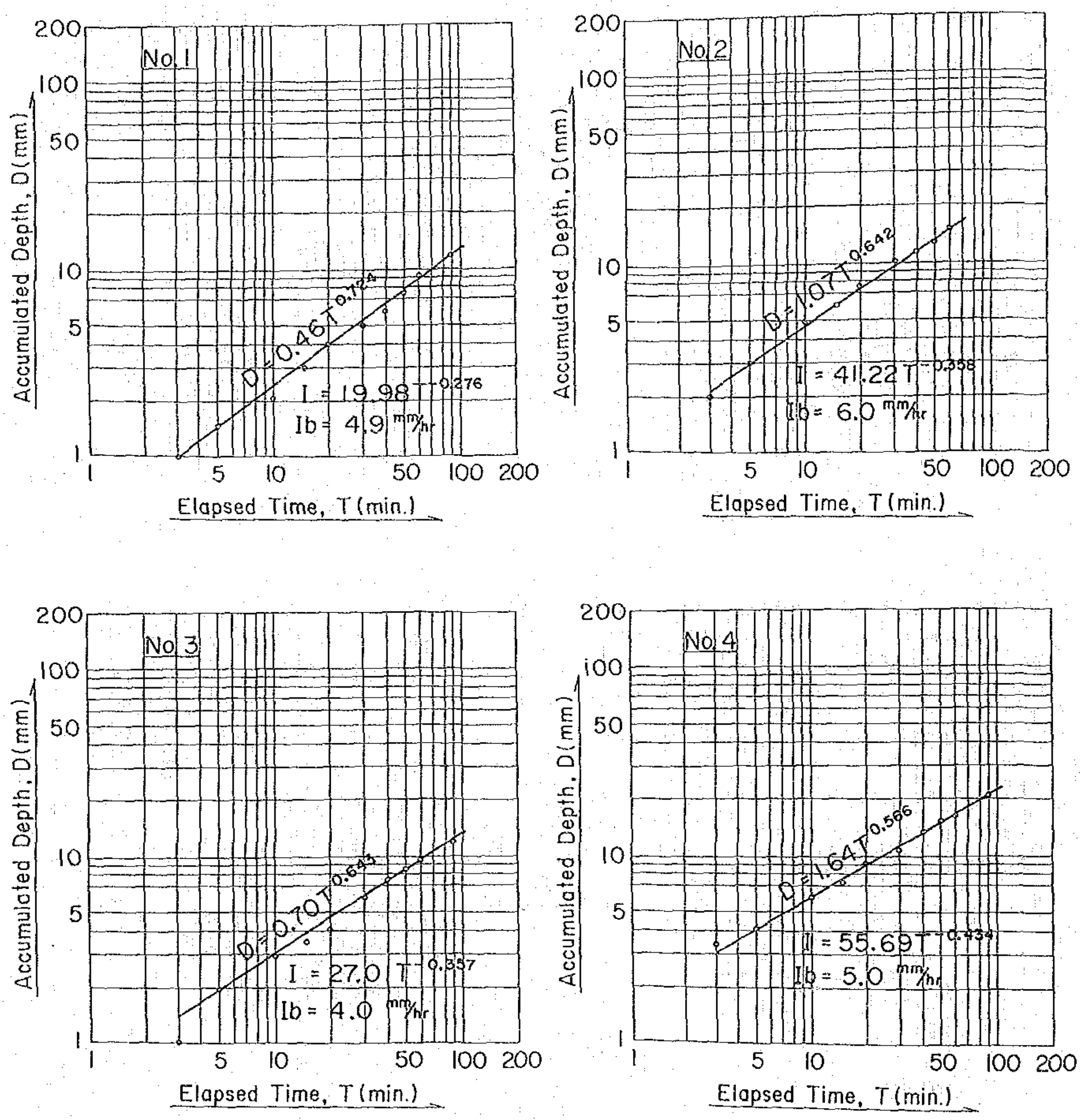
I; Intake Rate (mm/hr)

Ib; Basic Intake Rate (mm/hr)

C,n; Constant

Figure D-2 (5) Result of Cylinder Intake Rate Test

Magudu (V-3-3)



Notes

$D=C\cdot T^{n}$

$I=60\cdot C\cdot n\cdot T^{n-1}$

$Ib=60\cdot C\cdot n\cdot\{600(n-1)\}^{n-1}$

D; Accumulated Depth (mm)

T; Elapsed Time (min)

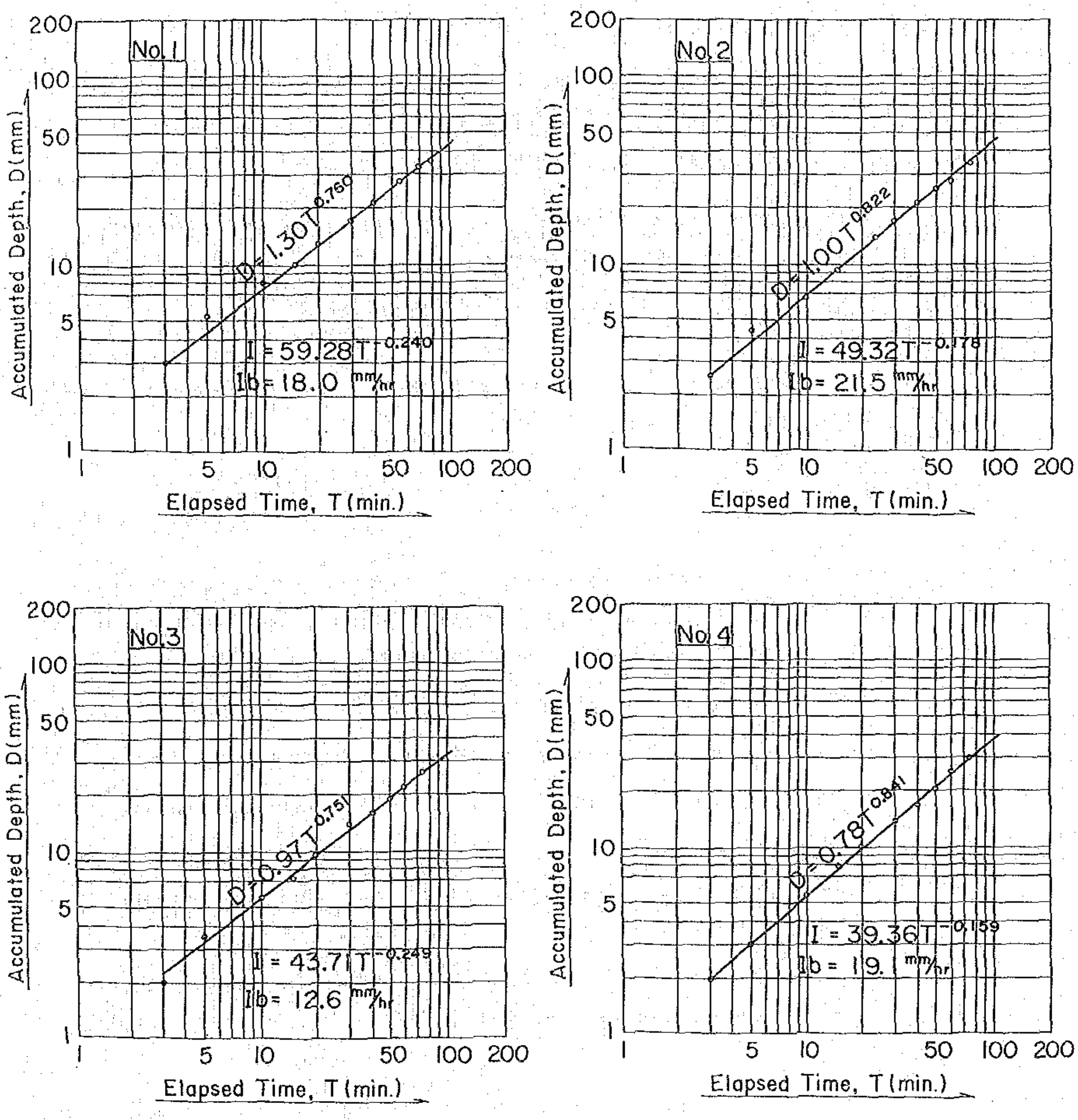
I; Intake Rate (mm/hr)

Ib; Basic Intake Rate (mm/hr)

C,n; Constant

Figure D-2 (6) Result of Cylinder Intake Rate Test

Mdbvute (VII - 1 - 12)



Notes

$D = C \cdot T^n$

$I = 60 \cdot C \cdot n \cdot T^{n-1}$

$Ib = 60 \cdot C \cdot n \cdot \{600(n-1)\}^{n-1}$

D; Accumulated Depth (mm)

T; Elapsed Time (min)

I; Intake Rate (mm/hr)

Ib; Basic Intake Rate (mm/hr)

C, n; Constant

D-4 Case study : Comparison of pump facilities between Motor driven and engine driven systems at II - 1 - 6 and VII - 1 - 12 sites.

(1) Site Investigation and Information

The electricity House (the Power Supply Authority) is positively proceeding with the extension of power supply network in Masvingo Province.

In accordance with the discussion held on June, 13th, 1987, the following advice were given.

(a) Electric power is more economical than diesel engine power taking into consideration the long term operation in this country, even though exclusive power line is extended from Zaka Sub-station to Mabvute (VII - 1 - 12), from BIKITA to Chinyamatumwa (II - 1 - 6).

(b) The maintenance of diesel engine and procurement of spare parts is difficult than that of electric motor.

(c) In case of introduction of diesel engine, it is recommended that generator be introduced to drive pump with motor so that it may easily cope with electric power supply in future.

(2) Result of Case study

(a) Design and Technical Aspect

Electric system is more advantageous by the following reasons.

- The system is simple and easily maintained after receiving power supply.
- Electric system will suffer far fewer break downs than diesel driven pumps.
- Easy countermeasure can be taken with fly wheel for water hammer phenomenon, on the other hand, the air chamber facilities with surge tank is required to cope with water hammer, if engine driven pump is adopted.
- Electricity is still required for automatic control and starting, stopping, warning system adopted between Pump House and N.S. reservoir as well as lighting in Pump House, even though main pumps are driven by engines.
- The generators used in short period for main pumps and automatic control system will still have quite large residual (remaining) values, and they can be re-used in other places and for other purposes.

(b) Initial Cost

Electric system is about 20% expensive comparing with engine system because the cost of generators which must be used until the electricity will be supplied by the power Authority. Cost estimate is made and shown afterward.

However, it is actually more economical than engine system because it is quite reasonable to evaluate the residual value of generators for main pumps and control system, which can be removed and re-used in other places or for other purposes after receiving electricity from Power Authority.

(c) Running Cost

Present tariff system of electricity is established in favor of large consumers. Energy cost of electricity equivalent to 1 liter of diesel oil lies around Z$ 0.11, whereas the tariff rate for balanced consumption after paying initial, basal tariff Z$ 0.206 is much cheaper, costing only Z$ 0.039. This benefit can be enjoyed by agricultural consumers whose consumption rate exceeds 4,000 kwh/month. Electrification requires additional installation costs, but even including these, electricity comes cheaper within 5~7 years if the proposed sites are located within the reach of 30 km from existing grids.

(d) Replacement Cost

Electric system incurs a little more replacement cost, than engine system, but when residual value of generators and future reduction in numbers of equipment to be replaced are taken into account, it turns out to be more economical.

In conclusion, over the project period, the cost of electricity system is estimated to be one fifth to one seventh cheaper than that of diesel engine system. Electrified System is not only economical, but maintenance trouble will be greatly reduced only if power supply is guaranteed, and it will bring another opportunity of development in other industries, such as processing.

Table D-6 Comparison of Design and Technical aspect of pump irrigation

II-1-6 : CHINYAMATUMWA
VII-1-12 : MABVUTE

	CASE-1 : Diesel Generator + Motor Pump		CASE-2 : Diesel Engine + Engine Pump
①	Main Pumps and accessories • The pumps are driven by motors • The power to drive the motors of pumps are supplied by Generators ⑤ • Attachments of simple flywheel can cope with water hammer		• The main pumps are driven by Engines • Slightly larger capacity of Engine power is required compared with Case-1 due to efficiency of power transmission even though the pump capacity is the same as Case-1. • Power transmission instead of Motor • Air chamber facilities (surge tank) is required to cope with water hammer.
②	Pump starter and accessories and ⑤ generator		Automatic control, starter and lighting system • Electric power is required to adopt the same system • Lighting is also required in pump house
⑥	• Automatic control system between pump house and N. S. reservoir is maintained by electricity • Lighting in pump house is required		
⑤	Generators for Main pumps • Diesel generators are required to supply electricity to motors of pump		No generator is required but diesel engines of slightly larger size as mentioned in ①
⑧	Electric cubicles and wiring materials • Power cable and the circuit are mainly required to drive main pumps, and other wiring and circuit system is required for Automatic control and starter as well as lighting in pump house		• Power cable and the circuit is not required. • automatic control & starting system and lighting in pump house are the same as Case-1
③	Valves	③	• The same system is adopted.
④	Pipes in Pump house	④	• The same system is adopted.
⑦	Fuel tanks and piping	⑦	• The same system is adopted.
⑨	Crane and accessories	⑨	• The same system is adopted.
⑩	Steps and cat walks in house	⑩	• The same system is adopted.
⑪	Pipeline and accessories	⑪	• The same system is adopted.

※ breakdovon in the following tables

Table D - 7 Cost Comparison Between Two Energy Sources

Site : Chinyamatumwa (II - 1 - 6)

Case 1, Diesel Grnerator plus Motor Pumps			Case 2, Diesel Engine plus Engine Pumps		
(A) Initial Cost (1st and 2nd year)	thous.Z$	740.0 *	(A) Initial Cost (1st and 2nd year)	thous.Z$	624.0 *
(B) Running Cost (3rd~40th year)	thous.Z$	763.2	(B) Running Cost (3rd~40th year)	thous.Z$	1,142.2
(1) Diesel Fuel Cost (3rd~5th year)	thous.Z$	69.6	(1) Diesel Fuel Cost (3rd~40th year)	thous.Z$	881.6
(2) Electricity Cost (6th~40th year)	thous.Z$	420.0	(2) Electrification Cost		0.0
(3) Electrification Cost (5th year)		48.0	(3) Replacement Cost (23rd year)	thous.Z$	260.6 *
(4) Replacement Cost (23rd year)	thous.Z$	286.8 *	(4) Residual Value of (generator)	thous.Z$	0.0
(5) Residual Value of Generator (6th year)	thous.Z$	−61.2	(C) Total Cost during Project Life	thous.Z$	1,766.2
(C) Total Cost during Project Life	thous.Z$	1503.2			

Case 1

(1) 3rd~5th year : Diesel Oil : thous.Z$ 23.0 = $2700^{hrs} \times (11^{l/hr} + 3^{l/hr}) \times 0.61^{Z\$/l}$

Lubricant : 0.2 = $2{,}700^{hrs} \times 6^{l}/300_{hr} \times 2.00^{Z\$/l} \times 2^{pcs}$

(23.0 + 0.2) × 3 = thous.Z$ 69.6

(2) 6th~40th year : Electricity : 90KVA = 77KW (h)

$2700^{hrs} \times 77^{kw} = 207{,}900^{kwh}/_{year}$

$207{,}900 \div 12 = 17{,}325^{kwh}/_{month}$

Surcharge for No.5 tariff (57%) and national (26%)

initial $(340^{kwh} + 10^{kwh} \times 90^{(KVA)}) \times$ Z$ 0.085 × 1.57 × 2.26

= Z$ 374.0

balance 17.325 − (340 + 10 × 90) = $16{,}085^{kwh}$

16085 × Z$ 0.011 × 1.57 × 2.26 = Z$ 627.8

total/month = 374 + 627.8 = 1001.8 total/year 1001.8 × 12 = thous.Z$12.0

total/35 years = 12.0 × 35 = thous.Z$ 420

(3) 5th year : highvoltage grid 6km × Z$ 6,600/m = thous.Z$ 39.6

receptor and transformer 1set : thous.Z$ 4.5

connection cost : thous.Z$ 1.2

each KVA × Z$ 30 × 90KVA : thous.Z$ 2.7

Total : 39.6 + 4.5 + 1.2 + 2.7 = thous.Z$ 48.0

(5) Life of generators : 20years

Period in use : 3years residual years 20 − 3 = 17 years

2 of 3 generators removed in 6th year

$$\left(106.5 \times \frac{9}{10}\right) \times \frac{2}{3} \times \frac{17}{20} = \text{thous.Z\$}54.4$$

1 of 2 startergenerators

$$\left(18.4 \times \frac{9}{10}\right) \times \frac{1}{2} \times \frac{17}{20} = \text{thous.Z\$ } 7.0$$

transportation cost for disposal $350^{km} \times 60^{¢}/_{km}$ = thous.Z$ 0.2

Total 54.4 + 7.0 − 0.2 = thous.Z$ 61.2

Case 2

(1) 3rd~40th year : Diesel Oil : thous.Z$ 23.0 = $2700^{hrs} \times (11^{l/hr} + 3^{l/hr}) \times 0.61^{Z\$}$

Lubricant : 0.2 = $2700^{hrs} \times 6^{l}/_{300hr} \times 2.00^{Z\$/l} \times 2$

(23.0 + 0.2) × 38 years = thous.Z$ 881.6

※ breakdovon in the following tables

Table D - 7 Cost Comparison Between Two Energy Sources

Site : Mavbute (Ⅶ - 1 - 12)

Case 1, Diesel Grnerator plus Motor Pumps

(A)	Initial Cost (1st and 2nd year)	thous.Z$	1,081.0 *
(B)	Running Cost (3rd~40th year)	thous.Z$	1,594.7
(1)	Diesel Fuel Cost (3rd~5th year)	thous.Z$	165.9
(2)	Electricity Cost (6th~40th year)	thous.Z$	966.0
(3)	Electrification Cost (5th year)	thous.Z$	179.3
(4)	Replacement Cost (23rd year)	thous.Z$	406.4
(5)	Residual Value of Generator (6th year)	thous.Z$	−122.9
(C)	Total Cost during Project Life	thous.Z$	2,675.7

(B) 3rd~5th year : Diesel Oil : 54.4thous.Z$ = 2700hrs × (27l/hr + 6l/hr) × 0.61Z$/l
Lubricant : 0.9 = 2,700hrs × 25l/300hr × 2.00Z$/l × 2pcs
(54.4 + 0.9) × 3 = thous.Z$ 165.9

6th~40th year : Electricity 220 KVA = 187KW (h)
2700hrs × 187kw = 504,900kwh/year
504,900 ÷ 12 = 42,075kwh/month

Surcharge : the same as above

initial (340kwh + 10kwh × 220(KVA)) × Z$ 0.085 × 1.57 × 2.26
= Z$ 766.0

balance 42,075 − (340 + 10 × 220) = 39,535kwh
39,535 × Z$ 0.011 × 1.57 × 2.26 = Z$ 1,543.0

total/month = 766 + 1543 = 2,309 total/year 2,309 × 12 = thous.Z$27.6
total/35 years = thous.Z$ 966.0

(C) 5th year highvoltage grid 25km × Z$ 6,600/m : thous.Z$ 165.0
receptor and transformer 1set (for 200KVA) : thous.Z$ 6.5
connection cost : thous.Z$ 1.2
each KVA × Z$ 30 × 220KVA : thous.Z$ 6.6
Total : 165.0 + 6.5 + 1.2 + 6.6 = thous.Z$ 179.3

(E) Life of generators : 20years
Period in use : 3years residual years 20 − 3 = 17 years
2 of 3 generators removed in 6th year

$$\left(228.1 \times \frac{9}{10}\right) \times \frac{2}{3} \times \frac{17}{20} = \text{thous.Z\$ } 116.3$$

1 of 2 startergeneratiors

$$\left(17.9 \times \frac{9}{10}\right) \times \frac{1}{2} \times \frac{17}{20} = \text{thous.Z\$ } 6.8$$

transportation cost for disposal 370 km × 60 $/km = thous.Z$ 0.2
Total 116.3 + 6.8 − 0.2 = 122.9

Case 2, Diesel Engine plus Engine Pumps

(A)	Initial Cost (1st and 2nd year)	thous.Z$	854.0 *
(B)	Running Cost (3rd~40th year)	thous.Z$	2,457.5
(1)	Diesel Fuel Cost (3rd~40th year)	thous.Z$	2,101.4
(2)	Electrification Cost		0.0
(3)	Replacement Cost (23rd year)	thous.Z$	356.1
(4)	Residual Value of (generator)	thous.Z$	0.0
(C)	Total Cost during Project Life	thous.Z$	3,311.5

(B) 3rd~40th year : Diesel Oil : 54.4 = 2,700hrs × (27l/hr + 6l/hr) × 0.61Z$
Lubricant : 0.9 = 2,700hrs × 25l/300hr × 2.00Z$/l × 2pcs
(54.4 + 0.9) × 38 years = thous.Z$ 2101.4

Table D-7 (contd.) Comparison of Cost

II-1-6 : CHINYAMATUMWA

CASE-1 Diesel : Generator + Motor Pump

Item	Description, Spec.	Q'ty	Cost	Remarks
			(1,000Z$)	
(A)	INITIAL COST (at Construction)			
①	Main Pumps and accessories	L. S.	72.7	to be replaced in the 23rd year
	• Double suction volute pumps 150 × 100 CJNM 2.22m³/min × 40 m × 1450 rpm × 30 kw	3 sets		
	• Flywheel with coupling 20 kg · m²			
	• Electric fan 30 kw × 380 V × 4 poles × 50 Hz			
②	Pump starter and accessories	L. S.	8.1	d. o.
	(Automatic control system between Pump station and N. S. Reservoir)			
	• Water level senser (Electro-rod)	3 sets		
	• Electro-Mognetic valve	3 sets		
	• Y-strainer	3 sets		
	• Manual stop valve	3 sets		
	• Check valve	3 sets		
	• Manometer, pitot-meter	3 sets		
	• Vacuum pump with tank 25 NVD	2 sets		
	• Small piping φ 25 mm × 20 m (SGP)	1 set		
③	Valves	L. S.	12.9	
	• Electric driven sluice valve φ 150	3 sets		
	• Manual sluice valve φ 150	3 sets		
	• Check valve (auto. close) φ 150	3 sets		
④	Pipes in pump house	L. S.	19.3	
	• Delivery pipe φ 150 × 3 m (STPG)	3 sets		
	• Delivery pipe φ 300 × 12 m (STPG)	1 set		
	• Suction pipe φ 200 × 8 m (STPG)	3 sets		
	• Expansion joint φ 150	3 sets		
	• Expansion joint φ 200	3 sets		

CASE-2 : Diesel Engine + Engine Pump

Item	Description, Spec.	Q'ty	Cost	Remarks
			(1,000Z$)	
(A)	INITIAL COST (at Construction)			
①	Main Pumps and accessories	L. S.	206.5	to be replaced in the 23rd year
	• Double suction volute pumps 150 × 100 CJNE 2.22 m³/min × 40 m × 1500 rpm × 42 ps	3 sets		(fuel consumption 11 ℓ/hr)
	• Engine 42 ps × 1500 rpm radiator cooling, manual start centrifugal clutch, battery			
	• Air chamber facilities with 2.0 cu · m tank			
②	Pump starter and accessories	L. S.	8.1	d. o.
	(Automatic control system between Pump station and N. S. Reservoir)			
	• the same as left	3 sets		
	• the same as left	3 sets		
	• the same as left	3 sets		
	• the same as left	3 sets		
	• the same as left	3 sets		
	• the same as left	3 sets		
	• the same as left	2 sets		
	• the same as left	1 set		
③	Valves	L. S.	3.3	
	• Manual sluice valve φ 150	3 sets		
	• Check valve (auto. Close) φ 150	3 sets		
④	Pipes in pump house	L. S.	19.3	
	• the same as left	3 sets		
	• the same as left	1 set		
	• the same as left	3 sets		
	• the same as left	3 sets		
	• the same as left	3 sets		

II-1-6 : CHINYAMATUMWA

CASE-1 : Diesel Generator + Motor Pump					CASE-2 : Diesel Engine + Engine Pump				
Item	Description, Spec.	Q'ty	Cost	Remarks	Item	Description, Spec.	Q'ty	Cost	Remarks
			(1,000Z&)						
⑤	Generators for Main Pumps	L. S.	106.5	only one set replaced in the 23rd year (fuel consumption 11 ℓ/hr)	⑤	NOT REQUIRED	—	—	
	• Diesel generator 42 KVA 380 V, 3 pH, 50 Hz with starter panel board radiator cooling	3 sets							
⑥	Generators for Automatic Control, starter and lighting in Pump house	L. S.	18.4	d. o. (fuel consumption for 1 set 3 ℓ/hr)	⑥	Generators for Automatic Control, starter and lighting in Pump house	L. S.	18.4	2 sets to be replaced in the 23rd year (fuel consumption 3 ℓ/hr)
	• Diesel generator 15 KVA 380 V, 3 pH, 50Hz with starter panel board radiator cooling	2 sets				• the same as left	2 sets		
⑦	Fuel tank and piping	L. S.	11.3		⑦	Fuel tank and piping	L. S.	11.3	
	• Fuel tank (outdoor) 5 m³	1 set				• Fuel tank (outdoor) 5 m³	1 set		
	• Service tank (indoor) 500 ℓ	1 set				• Service tank (indoor) 500 ℓ	1 set		
	• Piping for fuel supply	1 set				• Piping for fuel supply	1 set		
⑧	Electric cubicle and wiring materials	L. S.	161.3	to be replaced in the 23rd year	⑧	Electric cubicle and wiring materials	L. S.	27.6	to be replaced in the 23rd year
	• Pump panel 30 kw × 380 V × 50 Hz	1 pc				• Generator panel for item ⑥	1 pc		
	• Sub panel	1 pc				• Sub panel	1 pc		
	• Relay panel	1 pc				• Wiring of Power cable	1 set		
	• Generator panel for item ⑤ and ⑥	1 pc				• Wiring of Control cable	1 set		
	• Wiring of Power cable	1 set							
	• Wiring of Control cable	1 set							
⑨	Crane and accessories	L. S.	32.1		⑨	Crane and accessories	L. S.	32.1	
	• Manual ceiling crane 4 t 7.5 m span, 19 m run, 4 m high (for Generator)					• the same as left (for Engine)			
	• Manual Ceiling crane 2 t 7.0 m span, 19 m run, 4 m high (for Pump)					• the same as left (for Pump)			
⑩	Steps and cat walks in house	L. S.	16.1		⑩	Steps and cat walks in house	L. S.	16.1	
⑪	Pipe and accessories φ 300 mm for pipeline ℓ=870 m	L. S.	281.3			Pipe and accessories φ 300 mm for pipeline ℓ=870m	L. S.	281.3	
	Total of INITIAL COST		740.0	①~⑪		Total of INITIAL COST		624.0	①~⑪
	Total of REPLACEMENT COST		286.8			Total of REPLACEMENT COST		260.6	

Table D-7 (contd.) Comparison of Cost

VII-1-12 : MABVUTE

CASE-1 : Diesel Generator + Motor Pump

Item	Description, Spec.	Q'ty	Cost (1,000Z$)	Remarks
(A)	INITIAL COST (at Construction)			
①	Main Pumps and accessories	L. S.	94.1	to be replaced in the 23rd year
	● Double suction volute pumps 200 × 100 CJNM 4.53m³/min × 55 m × 1450 rpm × 75 kw	3 sets		
	● Flywheel with coupling, 31.5 kg · m²			
	● Electric fan 75 kw × 380 V × 4 poles × 50 Hz			
②	Pump starter and accessories	L. S.	7.9	d. o.
	(Automatic control system between Pump station and N. S. Reservoir)			
	● Water level senser (Electro-rod)	3 sets		
	● Electro-Mognetic valve	3 sets		
	● Y-strainer	3 sets		
	● Manual stop valve	3 sets		
	● Check valve	3 sets		
	● Manometer, pilot-meter	3 sets		
	● Vacuum pump with tank 25 NVD	2 sets		
	● Small piping φ 25 mm × 20 m (SGP)	1 set		
③	Valves	L. S.	22.8	
	● Electric driven sluice valve φ 200	3 sets		
	● Manual sluice valve φ 200	3 sets		
	● Check valve (auto. close) φ 200	3 sets		
④	Pipes in pump house	L. S.	23.5	
	● Delivery pipe φ 200 × 3 m (STPG)	3 sets		
	● Delivery pipe φ 400 × 12 m (STPG)	1 set		
	● Suction pipe φ 300 × 8 m (STPG)	3 sets		
	● Expansion joint φ 200	3 sets		
	● Expansion joint φ 300	3 sets		

CASE-2 : Diesel Engine + Engine Pump

Item	Description, Spec.	Q'ty	Cost (1,000Z$)	Remarks
(A)	INITIAL COST (at Construction)			
①	Main Pumps and accessories	L. S.	301.1	to be replaced in the 23rd year
	● Double suction volute pumps 200 × 100 CJNE 4.53m³/min × 55m × 1500rpm × 115ps	3 sets		
	● Engine 115 ps × 1500 rpm radiator cooling, manual start centrifugal clutch, battery			(fuel consumption 27 ℓ/hr)
	● Air chamber facilities with 3.0 cu · m tank			
②	Pump starter and accessories	L. S.	7.9	d. o.
	(Automatic control system between Pump station and N. S. Reservoir)			
	● the same as left	3 sets		
	● the same as left	3 sets		
	● the same as left	3 sets		
	● the same as left	3 sets		
	● the same as left	3 sets		
	● the same as left	3 sets		
	● the same as left	2 sets		
	● the same as left	1 set		
③	Valves	L. S.	7.2	
	● Manual sluice valve φ 200	3 sets		
	● Check valve (auto. Close) φ 200	3 sets		
④	Pipes in pump house	L. S.	23.5	
	● the same as left	3 sets		
	● the same as left	1 set		
	● the same as left	3 sets		
	● the same as left	3 sets		
	● the same as left	3 sets		

Comparison of Cost

VII-1-12 : MABVUTE

CASE-1 : Diesel Generator + Motor Pump

Item	Description, Spec.	Q'ty	Cost	Remarks
			(1,000Z&)	
⑤	Generators for Main Pumps • Diesel generator 42 KVA 380 V, 3 pH, 50 Hz with starter panel board radiator cooling	L. S. 3 sets	228.1	only one set replaced in the 23rd year (fuel consumption 27 ℓ/hr)
⑥	Generators for Automatic Control, starter and lighting in Pump house • Diesel generator 15 KVA 380 V, 3 pH, 50Hz with starter panel board radiator cooling	L. S. 2 sets	17.9	d. o. (fuel consumption for 1 set 3 ℓ/hr)
⑦	Fuel tank and piping • Fuel tank (outdoor) 10 m³ • Service tank (indoor) 1,000 ℓ • Piping for fuel supply	L. S. 1 set 1 set 1 set	15.6	
⑧	Electric cubicle and wiring materials • Pump panel 75 kw × 380 V × 50 Hz • Sub panel • Relay panel • Generator panel for item ⑤ and ⑥ • Wiring of Power cable • Wiring of Control cable	L. S. 1 pc 1 pc 1 pc 1 pc 1 set 1 set	219.5	to be replaced in the 23rd year
⑨	Crane and accessories • Manual ceiling crane 4 t 7.5 m span, 19 m run, 4 m high (for Generator) • Manual Ceiling crane 2 t 7.0 m span, 19 m run, 4 m high (for Pump)	L. S.	31.3	
⑩	Steps and cat walks in house	L. S.	15.6	
⑪	Pipe and accessories φ 400 mm for pipeline ℓ=860 m	L. S.	404.7	
	Total of INITIAL COST		1,081.0	①~⑪
	Total of REPLACEMENT COST		406.4	

CASE-2 : Diesel Engine + Engine Pump

Item	Description, Spec.	Q'ty	Cost	Remarks
⑤	NOT REQUIRED	—	—	
⑥	Generators for Automatic Control, starter and lighting in Pump house • the same as left	L. S. 2 sets	17.9	2 sets to be replaced in the 23rd year (fuel consumption 6 ℓ/hr)
⑦	Fuel tank and piping • Fuel tank (outdoor) 10 m³ • Service tank (indoor) 1,000 ℓ • Piping for fuel supply	L. S. 1 set 1 set 1 set	15.6	
⑧	Electric cubicle and wiring materials • Generator panel for item ⑥ • Sub panel • Wiring of Power cable • Wiring of Control cable	L. S. 1 pc 1 pc 1 set 1 set	29.2	to be replaced in the 23rd year
⑨	Crane and accessories • the same as left (for Engine) • the same as left (for Pump)	L. S.	31.3	
⑩	Steps and cat walks in house	L. S.	15.6	
	Pipe and accessories φ 300 mm for pipeline ℓ=870m	L. S.	404.7	
	Total of INITIAL COST		854.0	①~⑪
	Total of REPLACEMENT COST		356.1	

ANNEX E. DAM AND RESERVOIR

Contents