

# APPENDIX L

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19/03/91

## Vava'u well monitoring

(from dbase file VAVWELLS.DBF)

Well No	Date	Depth to water (m)	Electrical Conductivity (uS/cm)	Temperature (degrees C)	pH	Pump stat (T=on, F=off)
1	26/09/90	17.97	0	0.0	0.00	.F.
2	26/09/90	18.81	985	26.5	0.00	.F.
3	05/03/90	0.00	890	0.0	0.00	.F.
3	26/09/90	0.00	800	27.0	0.00	.F.
4	05/03/90	0.00	800	0.0	0.00	.F.
4	26/09/90	0.00	756	29.7	0.00	.F.
5	05/03/90	0.00	1030	0.0	0.00	.F.
5	26/09/90	32.60	983	27.2	0.00	.F.
6	26/09/90	4.94	1096	26.0	0.00	.F.
7	05/03/90	0.00	1105	0.0	0.00	.F.
7	26/09/90	7.90	1065	25.9	0.00	.F.
8	05/03/90	0.00	4130	0.0	0.00	.F.
8	26/09/90	29.52	4820	26.4	0.00	.F.
9	05/03/90	0.00	590	0.0	0.00	.F.
9	26/09/90	0.00	410	0.0	0.00	.F.
10	07/03/90	0.00	900	0.0	0.00	.F.
10	26/09/90	49.80	824	26.0	0.00	.F.
11	26/09/90	60.45	0	0.0	0.00	.F.
12	26/09/90	54.27	0	0.0	0.00	.F.
13	26/09/90	0.00	1274	0.0	0.00	.F.
14	05/03/90	0.00	1120	0.0	0.00	.F.
14	26/09/90	22.26	773	26.9	0.00	.F.
15	05/03/90	0.00	1610	0.0	0.00	.F.
15	26/09/90	0.00	1628	26.2	0.00	.F.
16	05/03/90	0.00	1360	0.0	0.00	.F.
16	26/09/90	48.69	1462	0.0	0.00	.F.
17	05/03/90	0.00	3200	0.0	0.00	.F.
17	26/09/90	12.36	2030	25.4	0.00	.F.
18	26/09/90	0.00	0	0.0	0.00	.F.
19	26/09/90	0.00	1377	26.5	0.00	.F.
20	26/09/90	46.59	0	0.0	0.00	.F.
22	26/09/90	22.25	639	26.7	0.00	.F.
23	05/03/90	0.00	1370	0.0	0.00	.T.
23	26/09/90	25.26	1638	26.9	0.00	.F.
24	05/03/90	0.00	1270	0.0	0.00	.T.
24	26/09/90	24.70	0	0.0	0.00	.F.
25	05/03/90	0.00	760	0.0	0.00	.F.
25	26/09/90	24.00	1942	26.3	0.00	.F.
26	26/09/90	24.09	1362	26.2	0.00	.F.
27	26/09/90	0.00	1731	26.1	0.00	.F.
28	05/03/90	0.00	1860	0.0	0.00	.F.
28	26/09/90	0.00	1593	26.4	0.00	.F.
35	06/03/90	0.00	3000	0.0	0.00	.F.
36	06/03/90	0.00	540	0.0	0.00	.F.
37	06/03/90	0.00	920	0.0	0.00	.F.
38	06/03/90	0.00	700	0.0	0.00	.F.
39	06/03/90	0.00	780	0.0	0.00	.F.

# APPENDIX M

## PROGRAM WATBAL.6

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Water Balance Program to Compute Recharge to Groundwater  
using MONTHLY Rainfall Data and either Evaporation Data  
or a Relationship between Rainfall and Evapotranspiration

- allows for interception losses
- assumes linear relation between ratio EA/ET and  
soil moisture content (field capacity-wilting point)

### RAINFALL/EVAP DATA USED IN WATER BALANCE:

Name of Rainfall File : VAVAU.RAI  
Title of Rainfall Data : Monthly rainfall data: Vava'u: Tonga: 1947-90

Name of Evaporation File : VAVAU.EVA  
Title of Evaporation Data :  
Monthly evap (Penman): Vava'u: (from Thompson, 1986)

No. of Years of Record : 44  
First Year of Record : 1947  
Last Year of Record : 1990

### INPUT SOIL AND VEGETATION PARAMETERS

Maximum Interception Store (ISMAX) in mm = 90  
Initial Interception Store (IIS) in mm = 50  
Soil Moisture Zone Thickness(SMZ) in mm = 1000  
Field Capacity(FC)= .55  
Wilting Point(WP)= .4  
Initial Soil Moisture Content(ISMC) in mm = 500  
Deep Rooted Vegetation(eg Coconut Trees) Ratio(DRVR)= .5  
Ratio of these roots reaching water table(DRWT)= 0  
Crop Factor for Deep Rooted Vegetation(CROPPD)= .8  
Crop Factor for Shallow Rooted Vegetation(CROPPS)= 1

### YEAR 1947

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
316	151	90	500	37	239	50	550	189	0	127	189	+0.60
103	134	90	550	40	-27	0	523	0	0	130	0	+0.00
657	135	90	523	33	534	27	550	507	0	123	507	+0.77
55	112	55	550	51	-51	0	499	0	0	106	0	+0.00
161	103	90	499	8	63	51	550	12	0	98	12	+0.07
287	90	90	550	0	197	0	550	197	0	90	197	+0.69
134	99	90	550	8	36	0	550	36	0	98	36	+0.27
73	108	73	550	32	-32	0	519	0	0	105	0	+0.00
90	117	90	519	19	-19	32	499	0	0	109	0	+0.00
172	142	90	499	31	51	51	550	0	0	121	0	+0.00
65	151	65	550	77	-77	0	473	0	0	142	0	+0.00
312	159	90	473	30	192	77	550	115	0	120	115	+0.37
2425	1501	1003		366				1056	0	1369	1056	+0.44

### YEAR 1948

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
463	151	90	550	55	318	0	550	318	0	145	318	+0.69
360	134	90	550	40	230	0	550	230	0	130	230	+0.64
329	135	90	550	41	199	0	550	199	0	131	199	+0.60
183	112	90	550	20	73	0	550	73	0	110	73	+0.40
61	103	61	550	38	-38	0	512	0	0	99	0	+0.00
115	90	90	512	0	25	38	537	0	0	90	0	+0.00
51	99	51	537	40	-40	13	498	0	0	91	0	+0.00
17	108	17	498	53	-53	52	444	0	0	70	0	+0.00
65	117	65	444	14	-14	106	431	0	0	79	0	+0.00
113	142	90	431	10	13	119	444	0	0	100	0	+0.00
503	151	90	444	16	397	106	550	291	0	106	291	+0.58
490	159	90	550	62	338	0	550	338	0	152	338	+0.69
2750	1501	914		387				1449	0	1301	1449	+0.53

YEAR 1949

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
199	151	90	550	55	54	0	550	54	0	145	54	+0.27
98	134	90	550	40	-32	0	518	0	0	130	0	+0.00
364	135	90	518	32	242	32	550	210	0	122	210	+0.58
133	112	90	550	20	23	0	550	23	0	110	23	+0.17
47	103	47	550	50	-50	0	500	0	0	97	0	+0.00
14	90	14	500	45	-45	50	454	0	0	59	0	+0.00
103	99	90	454	3	10	96	464	0	0	93	0	+0.00
148	108	90	464	7	51	86	515	0	0	97	0	+0.00
192	117	90	515	19	83	35	550	49	0	109	49	+0.25
148	142	90	550	47	11	0	550	11	0	137	11	+0.08
39	151	39	550	101	-101	0	449	0	0	140	0	+0.00
363	159	90	449	20	253	101	550	152	0	110	152	+0.42
1848	1501	910		439				499	0	1349	499	+0.27

YEAR 1950

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
313	151	90	550	55	168	0	550	168	0	145	168	+0.54
238	134	90	550	40	108	0	550	108	0	130	108	+0.46
466	135	90	550	41	336	0	550	336	0	131	336	+0.72
366	112	90	550	20	256	0	550	256	0	110	256	+0.70
68	103	68	550	32	-32	0	519	0	0	100	0	+0.00
65	90	65	519	18	-18	32	501	0	0	83	0	+0.00
252	99	90	501	5	157	49	550	107	0	95	107	+0.43
112	108	90	550	16	6	0	550	6	0	106	6	+0.05
177	117	90	550	24	63	0	550	63	0	114	63	+0.35
258	142	90	550	47	121	0	550	121	0	137	121	+0.47
312	151	90	550	55	167	0	550	167	0	145	167	+0.54
393	159	90	550	62	241	0	550	241	0	152	241	+0.61

3020 1501 1033 414 1573 0 1447 1573 +0.52

YEAR 1951

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
255	151	90	550	55	110	0	550	110	0	145	110	+0.43
277	134	90	550	40	147	0	550	147	0	130	147	+0.53
457	135	90	550	41	327	0	550	327	0	131	327	+0.71
129	112	90	550	20	19	0	550	19	0	110	19	+0.15
116	103	90	550	12	14	0	550	14	0	102	14	+0.12
114	90	90	550	0	24	0	550	24	0	90	24	+0.21
42	99	42	550	51	-51	0	499	0	0	93	0	+0.00
28	108	28	499	47	-47	51	451	0	0	75	0	+0.00
330	117	90	451	8	232	99	550	133	0	98	133	+0.40
59	142	59	550	75	-75	0	475	0	0	134	0	+0.00
29	151	29	475	55	-55	75	420	0	0	84	0	+0.00
58	159	58	420	12	-12	130	408	0	0	70	0	+0.00

1894 1501 846 416 775 0 1262 775 +0.41

YEAR 1952

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
239	151	90	408	3	146	142	550	4	0	93	4	+0.02
117	134	90	550	40	-13	0	537	0	0	130	0	+0.00
222	135	90	537	37	95	13	550	82	0	127	82	+0.37
62	112	62	550	45	-45	0	505	0	0	107	0	+0.00
66	103	66	505	23	-23	45	482	0	0	89	0	+0.00
103	90	90	482	0	13	68	495	0	0	90	0	+0.00
66	99	66	495	19	-19	55	476	0	0	85	0	+0.00
81	108	81	476	12	-12	74	464	0	0	93	0	+0.00
139	117	90	464	10	39	86	502	0	0	100	0	+0.00
165	142	90	502	32	43	48	545	0	0	122	0	+0.00
84	151	84	545	58	-58	5	487	0	0	142	0	+0.00
96	159	90	487	36	-30	63	457	0	0	126	0	+0.00

1440 1501 989 316 86 0 1305 86 +0.06

YEAR 1953

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
126	151	90	457	21	15	93	472	0	0	111	0	+0.00
134	134	90	472	19	25	78	497	0	0	109	0	+0.00
252	135	90	497	26	136	53	550	83	0	116	83	+0.33
300	112	90	550	20	190	0	550	190	0	110	190	+0.63
53	103	53	550	45	-45	0	505	0	0	98	0	+0.00
92	90	90	505	0	2	45	507	0	0	90	0	+0.00
111	99	90	507	6	15	43	522	0	0	96	0	+0.00
14	108	14	522	69	-69	28	453	0	0	83	0	+0.00

12	117	12	453	34	-34	97	420	0	0	46	0	+0.00
54	142	54	420	10	-10	130	409	0	0	64	0	+0.00
75	151	75	409	4	-4	141	405	0	0	79	0	+0.00
58	159	58	405	3	-3	145	402	0	0	61	0	+0.00

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1281	1501	806		257				273	0	1063	273	+0.21
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YEAR 1954

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
256	151	90	402	1	165	148	550	17	0	91	17	+0.07
222	134	90	550	40	92	0	550	92	0	130	92	+0.42
495	135	90	550	41	365	0	550	365	0	131	365	+0.74
275	112	90	550	20	165	0	550	165	0	110	165	+0.60
83	103	83	550	18	-18	0	532	0	0	101	0	+0.00
167	90	90	532	0	77	18	550	59	0	90	59	+0.35
22	99	22	550	69	-69	0	481	0	0	91	0	+0.00
162	108	90	481	9	63	69	544	0	0	99	0	+0.00
79	117	79	544	33	-33	6	511	0	0	112	0	+0.00
177	142	90	511	35	52	39	550	13	0	125	13	+0.08
102	151	90	550	55	-43	0	507	0	0	145	0	+0.00
604	159	90	507	44	470	43	550	427	0	134	427	+0.71

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2644	1501	994		363				1139	0	1357	1139	+0.43
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YEAR 1955

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
109	151	90	550	55	-36	0	514	0	0	145	0	+0.00
193	134	90	514	30	73	36	550	37	0	120	37	+0.19
384	135	90	550	41	254	0	550	254	0	131	254	+0.66
91	112	90	550	20	-19	0	531	0	0	110	0	+0.00
139	103	90	531	10	39	19	550	20	0	100	20	+0.14
393	90	90	550	0	303	0	550	303	0	90	303	+0.77
322	99	90	550	8	224	0	550	224	0	98	224	+0.70
236	108	90	550	16	130	0	550	130	0	106	130	+0.55
188	117	90	550	24	74	0	550	74	0	114	74	+0.39
247	142	90	550	47	110	0	550	110	0	137	110	+0.45
224	151	90	550	55	79	0	550	79	0	145	79	+0.35
182	159	90	550	62	30	0	550	30	0	152	30	+0.16

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2708	1501	1080		368				1260	0	1448	1260	+0.47
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YEAR 1956

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
258	151	90	550	55	113	0	550	113	0	145	113	+0.44
168	134	90	550	40	38	0	550	38	0	130	38	+0.23
617	135	90	550	41	487	0	550	487	0	131	487	+0.79

235	112	90	550	20	125	0	550	125	0	110	125	+0.53
98	103	90	550	12	-4	0	546	0	0	102	0	+0.00
139	90	90	546	0	49	4	550	45	0	90	45	+0.33
110	99	90	550	8	12	0	550	12	0	98	12	+0.11
80	108	80	550	25	-25	0	525	0	0	105	0	+0.00
47	117	47	525	52	-52	25	472	0	0	99	0	+0.00
105	142	90	472	23	-8	78	465	0	0	113	0	+0.00
581	151	90	465	24	467	85	550	382	0	114	382	+0.66
90	159	90	550	62	-62	0	488	0	0	152	0	+0.00

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2528 1501 1027                      361                      1202                      0 1388 1202                      +0.48

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YEAR 1957

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
759	151	90	488	32	637	62	550	575	0	122	575	+0.76
491	134	90	550	40	361	0	550	361	0	130	361	+0.74
126	135	90	550	41	-5	0	546	0	0	131	0	+0.00
259	112	90	546	19	150	5	550	145	0	109	145	+0.56
65	103	65	550	34	-34	0	516	0	0	99	0	+0.00
173	90	90	516	0	83	34	550	49	0	90	49	+0.28
157	99	90	550	8	59	0	550	59	0	98	59	+0.38
99	108	90	550	16	-7	0	543	0	0	106	0	+0.00
44	117	44	543	63	-63	7	480	0	0	107	0	+0.00
11	142	11	480	63	-63	70	417	0	0	74	0	+0.00
108	151	90	417	6	12	133	429	0	0	96	0	+0.00
346	159	90	429	12	244	121	550	123	0	102	123	+0.36

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2638 1501 930                      334                      1312                      0 1264 1312                      +0.50

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YEAR 1958

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
60	151	60	550	82	-82	0	468	0	0	142	0	+0.00
408	134	90	468	18	300	82	550	218	0	108	218	+0.53
358	135	90	550	41	228	0	550	228	0	131	228	+0.64
243	112	90	550	20	133	0	550	133	0	110	133	+0.55
158	103	90	550	12	56	0	550	56	0	102	56	+0.36
9	90	9	550	73	-73	0	477	0	0	82	0	+0.00
70	99	70	477	13	-13	73	464	0	0	83	0	+0.00
146	108	90	464	7	49	86	513	0	0	97	0	+0.00
66	117	66	513	35	-35	37	478	0	0	101	0	+0.00
217	142	90	478	24	103	72	550	31	0	114	31	+0.14
283	151	90	550	55	138	0	550	138	0	145	138	+0.49
14	159	14	550	131	-131	0	420	0	0	145	0	+0.00

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2032 1501 849                      509                      804                      0 1358 804                      +0.40

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YEAR 1959

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RAIN	ET	EI	SMC1	ES	XCESS	SMDEF	SMC2	GWR	TL	EA	NETR	RECHARGE
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(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	RATIO
191	151	90	420	7	94	131	513	0	0	97	0	+0.00
128	134	90	513	30	8	37	521	0	0	120	0	+0.00
610	135	90	521	33	487	29	550	459	0	123	459	+0.75
231	112	90	550	20	121	0	550	121	0	110	121	+0.52
129	103	90	550	12	27	0	550	27	0	102	27	+0.21
101	90	90	550	0	11	0	550	11	0	90	11	+0.11
66	99	66	550	30	-30	0	520	0	0	96	0	+0.00
68	108	68	520	29	-29	30	491	0	0	97	0	+0.00
456	117	90	491	15	351	59	550	293	0	105	293	+0.64
251	142	90	550	47	114	0	550	114	0	137	114	+0.45
60	151	60	550	82	-82	0	468	0	0	142	0	+0.00
50	159	50	468	45	-45	82	424	0	0	95	0	+0.00
2341	1501	964		348				1025	0	1312	1025	+0.44

YEAR 1960

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
239	151	90	424	9	140	126	550	14	0	99	14	+0.06
211	134	90	550	40	81	0	550	81	0	130	81	+0.39
711	135	90	550	41	581	0	550	581	0	131	581	+0.82
296	112	90	550	20	186	0	550	186	0	110	186	+0.63
70	103	70	550	30	-30	0	520	0	0	100	0	+0.00
48	90	48	520	30	-30	30	490	0	0	78	0	+0.00
208	99	90	490	5	113	60	550	53	0	95	53	+0.26
273	108	90	550	16	167	0	550	167	0	106	167	+0.61
94	117	90	550	24	-20	0	530	0	0	114	0	+0.00
34	142	34	530	84	-84	20	446	0	0	118	0	+0.00
56	151	56	446	26	-26	104	420	0	0	82	0	+0.00
211	159	90	420	8	113	130	533	0	0	98	0	+0.00
2451	1501	928		332				1082	0	1260	1082	+0.44

YEAR 1961

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
470	151	90	533	48	332	17	550	314	0	138	314	+0.67
127	134	90	550	40	-3	0	547	0	0	130	0	+0.00
799	135	90	547	40	669	3	550	667	0	130	667	+0.83
144	112	90	550	20	34	0	550	34	0	110	34	+0.24
176	103	90	550	12	74	0	550	74	0	102	74	+0.42
67	90	67	550	21	-21	0	529	0	0	88	0	+0.00
102	99	90	529	7	5	21	534	0	0	97	0	+0.00
138	108	90	534	15	33	16	550	18	0	105	18	+0.13
119	117	90	550	24	5	0	550	5	0	114	5	+0.04
118	142	90	550	47	-19	0	531	0	0	137	0	+0.00
218	151	90	531	48	80	19	550	61	0	138	61	+0.28
415	159	90	550	62	263	0	550	263	0	152	263	+0.63
2893	1501	1057		383				1436	0	1440	1436	+0.50

YEAR 1962

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
324	151	90	550	55	179	0	550	179	0	145	179	+0.55
320	134	90	550	40	190	0	550	190	0	130	190	+0.60
237	135	90	550	41	107	0	550	107	0	131	107	+0.45
509	112	90	550	20	399	0	550	399	0	110	399	+0.78
131	103	90	550	12	29	0	550	29	0	102	29	+0.22
196	90	90	550	0	106	0	550	106	0	90	106	+0.54
78	99	78	550	19	-19	0	531	0	0	97	0	+0.00
27	108	27	531	64	-64	19	467	0	0	91	0	+0.00
150	117	90	467	11	49	83	516	0	0	101	0	+0.00
84	142	84	516	41	-41	34	476	0	0	125	0	+0.00
473	151	90	476	28	355	74	550	281	0	118	281	+0.59
231	159	90	550	62	79	0	550	79	0	152	79	+0.34
2760	1501	999		390				1371	0	1389	1371	+0.50

YEAR 1963

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
105	151	90	550	55	-40	0	510	0	0	145	0	+0.00
438	134	90	510	29	319	40	550	279	0	119	279	+0.64
359	135	90	550	41	229	0	550	229	0	131	229	+0.64
200	112	90	550	20	90	0	550	90	0	110	90	+0.45
202	103	90	550	12	100	0	550	100	0	102	100	+0.50
20	90	20	550	63	-63	0	487	0	0	83	0	+0.00
118	99	90	487	5	23	63	510	0	0	95	0	+0.00
177	108	90	510	12	75	40	550	35	0	102	35	+0.20
78	117	78	550	35	-35	0	515	0	0	113	0	+0.00
112	142	90	515	36	-14	35	501	0	0	126	0	+0.00
75	151	75	501	46	-46	49	455	0	0	121	0	+0.00
186	159	90	455	23	73	95	528	0	0	113	0	+0.00
2070	1501	983		375				733	0	1358	733	+0.35

YEAR 1964

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
50	151	50	528	78	-78	22	451	0	0	128	0	+0.00
224	134	90	451	13	121	99	550	21	0	103	21	+0.09
680	135	90	550	41	550	0	550	550	0	131	550	+0.81
117	112	90	550	20	7	0	550	7	0	110	7	+0.06
91	103	90	550	12	-11	0	539	0	0	102	0	+0.00
44	90	44	539	38	-38	11	501	0	0	82	0	+0.00
266	99	90	501	5	171	49	550	121	0	95	121	+0.46
50	108	50	550	52	-52	0	498	0	0	102	0	+0.00
187	117	90	498	16	81	52	550	29	0	106	29	+0.15
100	142	90	550	47	-37	0	513	0	0	137	0	+0.00
258	151	90	513	41	127	37	550	90	0	131	90	+0.35



81	159	81	550	70	-70	0	480	0	0	151	0	+0.00
2148	1501	945		433				818	0	1378	818	+0.38

YEAR 1965

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
362	151	90	480	29	243	70	550	173	0	119	173	+0.48
261	134	90	550	40	131	0	550	131	0	130	131	+0.50
327	135	90	550	41	197	0	550	197	0	131	197	+0.60
204	112	90	550	20	94	0	550	94	0	110	94	+0.46
206	103	90	550	12	104	0	550	104	0	102	104	+0.51
56	90	56	550	31	-31	0	519	0	0	87	0	+0.00
42	99	42	519	41	-41	31	479	0	0	83	0	+0.00
60	108	60	479	23	-23	71	456	0	0	83	0	+0.00
109	117	90	456	9	10	94	466	0	0	99	0	+0.00
247	142	90	466	21	136	84	550	52	0	111	52	+0.21
80	151	80	550	64	-64	0	486	0	0	144	0	+0.00
29	159	29	486	67	-67	64	419	0	0	96	0	+0.00
1983	1501	897		396				751	0	1293	751	+0.38

YEAR 1966

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
244	151	90	419	7	147	131	550	16	0	97	16	+0.07
15	134	15	550	107	-107	0	443	0	0	122	0	+0.00
176	135	90	443	12	74	107	517	0	0	102	0	+0.00
155	112	90	517	15	50	33	550	17	0	105	17	+0.11
33	103	33	550	63	-63	0	487	0	0	96	0	+0.00
57	90	57	487	17	-17	63	470	0	0	74	0	+0.00
153	99	90	470	4	59	80	529	0	0	94	0	+0.00
78	108	78	529	23	-23	21	506	0	0	101	0	+0.00
178	117	90	506	17	71	44	550	27	0	107	27	+0.15
281	142	90	550	47	144	0	550	144	0	137	144	+0.51
134	151	90	550	55	-11	0	539	0	0	145	0	+0.00
165	159	90	539	58	17	11	550	7	0	148	7	+0.04
1669	1501	903		425				210	0	1328	210	+0.13

YEAR 1967

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
1009	151	90	550	55	864	0	550	864	0	145	864	+0.86
311	134	90	550	40	181	0	550	181	0	130	181	+0.58
213	135	90	550	41	83	0	550	83	0	131	83	+0.39
438	112	90	550	20	328	0	550	328	0	110	328	+0.75
240	103	90	550	12	138	0	550	138	0	102	138	+0.58
97	90	90	550	0	7	0	550	7	0	90	7	+0.07

61	99	61	550	34	-34	0	516	0	0	95	0	+0.00
44	108	44	516	44	-44	34	471	0	0	88	0	+0.00
81	117	81	471	15	-15	79	456	0	0	96	0	+0.00
314	142	90	456	17	207	94	550	112	0	107	112	+0.36
81	151	81	550	63	-63	0	487	0	0	144	0	+0.00
65	159	65	487	49	-49	63	438	0	0	114	0	+0.00

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2954	1501	962		390				1714	0	1352	1714	+0.58
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YEAR 1968

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
546	151	90	438	14	442	112	550	330	0	104	330	+0.60
74	134	74	550	54	-54	0	496	0	0	128	0	+0.00
175	135	90	496	26	59	54	550	5	0	116	5	+0.03
104	112	90	550	20	-6	0	544	0	0	110	0	+0.00
150	103	90	544	11	49	6	550	43	0	101	43	+0.29
102	90	90	550	0	12	0	550	12	0	90	12	+0.12
34	99	34	550	59	-59	0	492	0	0	93	0	+0.00
114	108	90	492	10	14	59	506	0	0	100	0	+0.00
107	117	90	506	17	-0	44	506	0	0	107	0	+0.00
109	142	90	506	33	-14	44	492	0	0	123	0	+0.00
152	151	90	492	34	28	58	520	0	0	124	0	+0.00
122	159	90	520	50	-18	30	502	0	0	140	0	+0.00

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1789	1501	1008		326				390	0	1334	390	+0.22
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YEAR 1969

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
132	151	90	502	37	5	48	507	0	0	127	0	+0.00
248	134	90	507	28	130	43	550	87	0	118	87	+0.35
284	135	90	550	41	154	0	550	154	0	131	154	+0.54
267	112	90	550	20	157	0	550	157	0	110	157	+0.59
7	103	7	550	86	-86	0	464	0	0	93	0	+0.00
16	90	16	464	28	-28	86	435	0	0	44	0	+0.00
78	99	78	435	4	-4	115	431	0	0	82	0	+0.00
12	108	12	431	18	-18	119	413	0	0	30	0	+0.00
158	117	90	413	2	66	137	479	0	0	92	0	+0.00
192	142	90	479	25	77	71	550	6	0	115	6	+0.03
38	151	38	550	102	-102	0	448	0	0	140	0	+0.00
178	159	90	448	20	68	102	516	0	0	110	0	+0.00

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1610	1501	781		411				404	0	1192	404	+0.25
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YEAR 1970

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
122	151	90	516	43	-11	34	506	0	0	133	0	+0.00

210	134	90	506	28	92	44	550	48	0	118	48	+0.23
200	135	90	550	41	70	0	550	70	0	131	70	+0.35
266	112	90	550	20	156	0	550	156	0	110	156	+0.59
122	103	90	550	12	20	0	550	20	0	102	20	+0.17
199	90	90	550	0	109	0	550	109	0	90	109	+0.55
54	99	54	550	41	-41	0	510	0	0	95	0	+0.00
62	108	62	510	30	-30	41	479	0	0	92	0	+0.00
51	117	51	479	31	-31	71	448	0	0	82	0	+0.00
53	142	53	448	26	-26	102	422	0	0	79	0	+0.00
329	151	90	422	8	231	128	550	103	0	98	103	+0.31
468	159	90	550	62	316	0	550	316	0	152	316	+0.68

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2136	1501	940		340				822	0	1280	822	+0.38
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YEAR 1971

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
173	151	90	550	55	28	0	550	28	0	145	28	+0.16
415	134	90	550	40	285	0	550	285	0	130	285	+0.69
189	135	90	550	41	59	0	550	59	0	131	59	+0.31
251	112	90	550	20	141	0	550	141	0	110	141	+0.56
370	103	90	550	12	268	0	550	268	0	102	268	+0.73
49	90	49	550	37	-37	0	513	0	0	86	0	+0.00
80	99	80	513	13	-13	37	500	0	0	93	0	+0.00
125	108	90	500	11	24	50	524	0	0	101	0	+0.00
174	117	90	524	20	64	26	550	38	0	110	38	+0.22
206	142	90	550	47	69	0	550	69	0	137	69	+0.34
169	151	90	550	55	24	0	550	24	0	145	24	+0.14
456	159	90	550	62	304	0	550	304	0	152	304	+0.67

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2657	1501	1029		411				1217	0	1440	1217	+0.46
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YEAR 1972

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
293	151	90	550	55	148	0	550	148	0	145	148	+0.51
172	134	90	550	40	42	0	550	42	0	130	42	+0.25
257	135	90	550	41	127	0	550	127	0	131	127	+0.49
136	112	90	550	20	26	0	550	26	0	110	26	+0.19
104	103	90	550	12	2	0	550	2	0	102	2	+0.02
38	90	38	550	47	-47	0	503	0	0	85	0	+0.00
159	99	90	503	6	63	47	550	17	0	96	17	+0.10
156	108	90	550	16	50	0	550	50	0	106	50	+0.32
167	117	90	550	24	53	0	550	53	0	114	53	+0.32
163	142	90	550	47	26	0	550	26	0	137	26	+0.16
44	151	44	550	96	-96	0	454	0	0	140	0	+0.00
44	159	44	454	37	-37	96	417	0	0	81	0	+0.00

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1733	1501	936		440				491	0	1376	491	+0.28
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YEAR 1973

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
159	151	90	417	6	63	133	480	0	0	96	0	+0.00
443	134	90	480	21	332	70	550	262	0	111	262	+0.59
393	135	90	550	41	263	0	550	263	0	131	263	+0.67
304	112	90	550	20	194	0	550	194	0	110	194	+0.64
31	103	31	550	65	-65	0	485	0	0	96	0	+0.00
57	90	57	485	17	-17	65	468	0	0	74	0	+0.00
467	99	90	468	4	373	82	550	292	0	94	292	+0.62
109	108	90	550	16	3	0	550	3	0	106	3	+0.03
197	117	90	550	24	83	0	550	83	0	114	83	+0.42
115	142	90	550	47	-22	0	528	0	0	137	0	+0.00
333	151	90	528	47	196	22	550	174	0	137	174	+0.52
310	159	90	550	62	158	0	550	158	0	152	158	+0.51
2918	1501	988		369				1428	0	1357	1428	+0.49

YEAR 1974

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
178	151	90	550	55	33	0	550	33	0	145	33	+0.19
642	134	90	550	40	512	0	550	512	0	130	512	+0.80
229	135	90	550	41	99	0	550	99	0	131	99	+0.43
363	112	90	550	20	253	0	550	253	0	110	253	+0.70
425	103	90	550	12	323	0	550	323	0	102	323	+0.76
163	90	90	550	0	73	0	550	73	0	90	73	+0.45
71	99	71	550	25	-25	0	525	0	0	96	0	+0.00
108	108	90	525	13	5	25	529	0	0	103	0	+0.00
80	117	80	529	29	-29	21	501	0	0	109	0	+0.00
83	142	83	501	36	-36	49	465	0	0	119	0	+0.00
313	151	90	465	24	199	85	550	114	0	114	114	+0.36
164	159	90	550	62	12	0	550	12	0	152	12	+0.07
2819	1501	1044		355				1420	0	1399	1420	+0.50

YEAR 1975

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
495	151	90	550	55	350	0	550	350	0	145	350	+0.71
344	134	90	550	40	214	0	550	214	0	130	214	+0.62
303	135	90	550	41	173	0	550	173	0	131	173	+0.57
120	112	90	550	20	10	0	550	10	0	110	10	+0.09
91	103	90	550	12	-11	0	539	0	0	102	0	+0.00
158	90	90	539	0	68	11	550	57	0	90	57	+0.36
300	99	90	550	8	202	0	550	202	0	98	202	+0.67
228	108	90	550	16	122	0	550	122	0	106	122	+0.53
105	117	90	550	24	-9	0	541	0	0	114	0	+0.00
66	142	66	541	64	-64	9	477	0	0	130	0	+0.00
483	151	90	477	28	365	73	550	292	0	118	292	+0.60
269	159	90	550	62	117	0	550	117	0	152	117	+0.43
2962	1501	1056		369				1537	0	1425	1537	+0.52

YEAR 1976

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
357	151	90	550	55	212	0	550	212	0	145	212	+0.59
334	134	90	550	40	204	0	550	204	0	130	204	+0.61
207	135	90	550	41	77	0	550	77	0	131	77	+0.37
208	112	90	550	20	98	0	550	98	0	110	98	+0.47
91	103	90	550	12	-11	0	539	0	0	102	0	+0.00
16	90	16	539	62	-62	11	477	0	0	78	0	+0.00
47	99	47	477	24	-24	73	453	0	0	71	0	+0.00
87	108	87	453	7	-7	97	447	0	0	94	0	+0.00
75	117	75	447	12	-12	103	435	0	0	87	0	+0.00
62	142	62	435	17	-17	115	418	0	0	79	0	+0.00
255	151	90	418	7	158	132	550	26	0	97	26	+0.10
133	159	90	550	62	-19	0	531	0	0	152	0	+0.00
1872	1501	917		356				618	0	1273	618	+0.33

YEAR 1977

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
239	151	90	531	48	101	19	550	82	0	138	82	+0.34
297	134	90	550	40	167	0	550	167	0	130	167	+0.56
493	135	90	550	41	363	0	550	363	0	131	363	+0.74
71	112	71	550	37	-37	0	513	0	0	108	0	+0.00
134	103	90	513	9	35	37	548	0	0	99	0	+0.00
36	90	36	548	48	-48	2	500	0	0	84	0	+0.00
218	99	90	500	5	123	50	550	73	0	95	73	+0.33
127	108	90	550	16	21	0	550	21	0	106	21	+0.16
39	117	39	550	70	-70	0	480	0	0	109	0	+0.00
35	142	35	480	51	-51	70	429	0	0	86	0	+0.00
12	151	12	429	24	-24	121	405	0	0	36	0	+0.00
65	159	65	405	3	-3	145	402	0	0	68	0	+0.00
1766	1501	798		391				706	0	1189	706	+0.40

YEAR 1978

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
472	151	90	402	1	381	148	550	233	0	91	233	+0.49
204	134	90	550	40	74	0	550	74	0	130	74	+0.36
418	135	90	550	41	288	0	550	288	0	131	288	+0.69
178	112	90	550	20	68	0	550	68	0	110	68	+0.38
224	103	90	550	12	122	0	550	122	0	102	122	+0.55
77	90	77	550	12	-12	0	538	0	0	89	0	+0.00
11	99	11	538	73	-73	12	465	0	0	84	0	+0.00
267	108	90	465	7	170	85	550	85	0	97	85	+0.32
173	117	90	550	24	59	0	550	59	0	114	59	+0.34

215	142	90	550	47	78	0	550	78	0	137	78	+0.36
112	151	90	550	55	-33	0	517	0	0	145	0	+0.00
217	159	90	517	48	79	33	550	46	0	138	46	+0.21
2568	1501	988		379				1053	0	1367	1053	+0.41

YEAR 1979

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
135	151	90	550	55	-10	0	540	0	0	145	0	+0.00
215	134	90	540	37	88	10	550	78	0	127	78	+0.36
395	135	90	550	41	265	0	550	265	0	131	265	+0.67
270	112	90	550	20	160	0	550	160	0	110	160	+0.59
209	103	90	550	12	107	0	550	107	0	102	107	+0.51
288	90	90	550	0	198	0	550	198	0	90	198	+0.69
51	99	51	550	43	-43	0	507	0	0	94	0	+0.00
133	108	90	507	12	31	43	538	0	0	102	0	+0.00
70	117	70	538	39	-39	12	499	0	0	109	0	+0.00
359	142	90	499	31	238	51	550	187	0	121	187	+0.52
149	151	90	550	55	4	0	550	4	0	145	4	+0.03
154	159	90	550	62	2	0	550	2	0	152	2	+0.01
2428	1501	1021		406				1001	0	1427	1001	+0.41

YEAR 1980

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
162	151	90	550	55	17	0	550	17	0	145	17	+0.11
161	134	90	550	40	31	0	550	31	0	130	31	+0.20
343	135	90	550	41	213	0	550	213	0	131	213	+0.62
368	112	90	550	20	258	0	550	258	0	110	258	+0.70
69	103	69	550	31	-31	0	519	0	0	100	0	+0.00
84	90	84	519	4	-4	31	515	0	0	88	0	+0.00
84	99	84	515	10	-10	35	505	0	0	94	0	+0.00
202	108	90	505	11	101	45	550	55	0	101	55	+0.27
197	117	90	550	24	83	0	550	83	0	114	83	+0.42
76	142	76	550	59	-59	0	491	0	0	135	0	+0.00
91	151	90	491	33	-32	59	458	0	0	123	0	+0.00
104	159	90	458	24	-10	92	448	0	0	114	0	+0.00
1941	1501	1033		352				657	0	1385	657	+0.34

YEAR 1981

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
138	151	90	448	18	30	102	479	0	0	108	0	+0.00
461	134	90	479	21	350	71	550	279	0	111	279	+0.60
312	135	90	550	41	182	0	550	182	0	131	182	+0.58
210	112	90	550	20	100	0	550	100	0	110	100	+0.48

314	103	90	550	12	212	0	550	212	0	102	212	+0.68
83	90	83	550	6	-6	0	544	0	0	89	0	+0.00
61	99	61	544	33	-33	6	511	0	0	94	0	+0.00
75	108	75	511	22	-22	39	489	0	0	97	0	+0.00
91	117	90	489	14	-13	61	476	0	0	104	0	+0.00
120	142	90	476	24	6	74	482	0	0	114	0	+0.00
117	151	90	482	30	-3	68	479	0	0	120	0	+0.00
146	159	90	479	33	23	71	502	0	0	123	0	+0.00

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2128 1501 1029                      272                                      773                      0 1301 773                      +0.36

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YEAR 1982

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
611	151	90	502	37	484	48	550	436	0	127	436	+0.71
420	134	90	550	40	290	0	550	290	0	130	290	+0.69
368	135	90	550	41	238	0	550	238	0	131	238	+0.65
473	112	90	550	20	363	0	550	363	0	110	363	+0.77
177	103	90	550	12	75	0	550	75	0	102	75	+0.43
56	90	56	550	31	-31	0	519	0	0	87	0	+0.00
73	99	73	519	19	-19	31	501	0	0	92	0	+0.00
199	108	90	501	11	98	49	550	49	0	101	49	+0.25
151	117	90	550	24	37	0	550	37	0	114	37	+0.24
17	142	17	550	113	-113	0	438	0	0	130	0	+0.00
115	151	90	438	14	11	113	449	0	0	104	0	+0.00
213	159	90	449	20	103	101	550	2	0	110	2	+0.01

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2873 1501 956                      380                                      1489                      0 1336 1489                      +0.52

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YEAR 1983

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
173	151	90	550	55	28	0	550	28	0	145	28	+0.16
218	134	90	550	40	88	0	550	88	0	130	88	+0.41
480	135	90	550	41	350	0	550	350	0	131	350	+0.73
42	112	42	550	63	-63	0	487	0	0	105	0	+0.00
78	103	78	487	13	-13	63	474	0	0	91	0	+0.00
20	90	20	474	31	-31	76	443	0	0	51	0	+0.00
34	99	34	443	17	-17	107	426	0	0	51	0	+0.00
21	108	21	426	14	-14	124	413	0	0	35	0	+0.00
51	117	51	413	5	-5	137	408	0	0	56	0	+0.00
42	142	42	408	5	-5	142	403	0	0	47	0	+0.00
86	151	86	403	1	-1	147	402	0	0	87	0	+0.00
520	159	90	402	1	429	148	550	281	0	91	281	+0.54

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1765 1501 734                      284                                      747                      0 1018 747                      +0.42

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YEAR 1984

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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
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172	151	90	550	55	27	0	550	27	0	145	27	+0.16
276	134	90	550	40	146	0	550	146	0	130	146	+0.53
126	135	90	550	41	-5	0	546	0	0	131	0	+0.00
410	112	90	546	19	301	5	550	296	0	109	296	+0.72
56	103	56	550	42	-42	0	508	0	0	98	0	+0.00
34	90	34	508	36	-36	42	472	0	0	70	0	+0.00
71	99	71	472	12	-12	78	459	0	0	83	0	+0.00
77	108	77	459	11	-11	91	448	0	0	88	0	+0.00
199	117	90	448	8	101	102	550	0	0	98	0	+0.00
28	142	28	550	102	-102	0	447	0	0	130	0	+0.00
42	151	42	447	31	-31	103	416	0	0	73	0	+0.00
308	159	90	416	7	211	134	550	78	0	97	78	+0.25
1799	1501	848		404				547	0	1252	547	+0.30

YEAR 1985

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
143	151	90	550	55	-2	0	548	0	0	145	0	+0.00
340	134	90	548	39	211	2	550	209	0	129	209	+0.61
408	135	90	550	41	278	0	550	278	0	131	278	+0.68
206	112	90	550	20	96	0	550	96	0	110	96	+0.47
124	103	90	550	12	22	0	550	22	0	102	22	+0.18
81	90	81	550	8	-8	0	542	0	0	89	0	+0.00
160	99	90	542	8	62	8	550	54	0	98	54	+0.34
30	108	30	550	70	-70	0	480	0	0	100	0	+0.00
36	117	36	480	39	-39	70	441	0	0	75	0	+0.00
38	142	38	441	26	-26	109	415	0	0	64	0	+0.00
16	151	16	415	12	-12	135	403	0	0	28	0	+0.00
147	159	90	403	1	56	147	459	0	0	91	0	+0.00
1729	1501	831		330				659	0	1161	659	+0.38

YEAR 1986

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
92	151	90	459	21	-19	91	439	0	0	111	0	+0.00
80	134	80	439	13	-13	111	427	0	0	93	0	+0.00
186	135	90	427	7	89	123	515	0	0	97	0	+0.00
277	112	90	515	15	172	35	550	137	0	105	137	+0.50
80	103	80	550	21	-21	0	529	0	0	101	0	+0.00
451	90	90	529	0	361	21	550	340	0	90	340	+0.75
99	99	90	550	8	1	0	550	1	0	98	1	+0.01
66	108	66	550	38	-38	0	512	0	0	104	0	+0.00
189	117	90	512	18	81	38	550	43	0	108	43	+0.23
159	142	90	550	47	22	0	550	22	0	137	22	+0.14
18	151	18	550	120	-120	0	430	0	0	138	0	+0.00
60	159	60	430	18	-18	120	412	0	0	78	0	+0.00
1757	1501	934		326				544	0	1260	544	+0.31



## YEAR 1987

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
5	151	5	412	11	-11	138	402	0	0	16	0	+0.00
224	134	90	402	0	134	148	535	0	0	90	0	+0.00
152	135	90	535	36	26	15	550	11	0	126	11	+0.07
27	112	27	550	77	-77	0	474	0	0	104	0	+0.00
298	103	90	474	6	202	77	550	126	0	96	126	+0.42
135	90	90	550	0	45	0	550	45	0	90	45	+0.33
49	99	49	550	45	-45	0	505	0	0	94	0	+0.00
127	108	90	505	11	26	45	531	0	0	101	0	+0.00
25	117	25	531	72	-72	19	459	0	0	97	0	+0.00
26	142	26	459	41	-41	91	418	0	0	67	0	+0.00
72	151	72	418	8	-8	132	409	0	0	80	0	+0.00
586	159	90	409	4	492	141	550	351	0	94	351	+0.60
1726	1501	744		311				533	0	1055	533	+0.31

## YEAR 1988

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
292	151	90	550	55	147	0	550	147	0	145	147	+0.50
99	134	90	550	40	-31	0	519	0	0	130	0	+0.00
142	135	90	519	32	20	31	539	0	0	122	0	+0.00
187	112	90	539	18	79	11	550	68	0	108	68	+0.36
191	103	90	550	12	89	0	550	89	0	102	89	+0.47
115	90	90	550	0	25	0	550	25	0	90	25	+0.22
58	99	58	550	37	-37	0	513	0	0	95	0	+0.00
25	108	25	513	56	-56	37	457	0	0	81	0	+0.00
332	117	90	457	9	233	93	550	140	0	99	140	+0.42
145	142	90	550	47	8	0	550	8	0	137	8	+0.06
319	151	90	550	55	174	0	550	174	0	145	174	+0.55
230	159	90	550	62	78	0	550	78	0	152	78	+0.34
2135	1501	983		423				729	0	1406	729	+0.34

## YEAR 1989

RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
367	151	90	550	55	222	0	550	222	0	145	222	+0.61
630	134	90	550	40	500	0	550	500	0	130	500	+0.79
283	135	90	550	41	153	0	550	153	0	131	153	+0.54
127	112	90	550	20	17	0	550	17	0	110	17	+0.14
213	103	90	550	12	111	0	550	111	0	102	111	+0.52
28	90	28	550	56	-56	0	494	0	0	84	0	+0.00
28	99	28	494	40	-40	56	454	0	0	68	0	+0.00
9	108	9	454	32	-32	96	422	0	0	41	0	+0.00
81	117	81	422	5	-5	128	417	0	0	86	0	+0.00
166	142	90	417	5	71	133	488	0	0	95	0	+0.00
188	151	90	488	32	66	62	550	4	0	122	4	+0.02
658	159	90	550	62	506	0	550	506	0	152	506	+0.77

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 2778 1501 866 399 1513 0 1265 1513 +0.54  
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YEAR 1990  
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RAIN (mm)	ET (mm)	EI (mm)	SMC1 (mm)	ES (mm)	XCESS (mm)	SMDEF (mm)	SMC2 (mm)	GWR (mm)	TL (mm)	EA (mm)	NETR (mm)	RECHARGE RATIO
255	151	90	550	55	110	0	550	110	0	145	110	+0.43
159	134	90	550	40	29	0	550	29	0	130	29	+0.18
82	135	82	550	48	-48	0	502	0	0	130	0	+0.00
192	112	90	502	14	88	48	550	41	0	104	41	+0.21
210	103	90	550	12	108	0	550	108	0	102	108	+0.52
262	90	90	550	0	172	0	550	172	0	90	172	+0.66
160	99	90	550	8	62	0	550	62	0	98	62	+0.39
18	108	18	550	81	-81	0	469	0	0	99	0	+0.00
167	117	90	469	11	66	81	535	0	0	101	0	+0.00
84	142	84	535	47	-47	15	488	0	0	131	0	+0.00
29	151	29	488	64	-64	62	424	0	0	93	0	+0.00
202	159	90	424	10	102	126	526	0	0	100	0	+0.00

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 1820 1501 933 389 522 0 1322 522 +0.29  
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44 YEAR AVERAGES  
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2232 1501 941 373 917 0 1315 917 +0.41

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Monthly recharge (mm) on Vava'u for period 1947-90

Year	J	F	M	A	M	J	J	A	S	O	N	D	Annual Recharge	Annual Rainfall
1947	189	0	507	0	12	197	36	0	0	0	0	115	1056	2425
1948	318	230	199	73	0	0	0	0	0	0	291	338	1449	2750
1949	54	0	210	23	0	0	0	0	49	11	0	152	499	1848
1950	168	108	336	256	0	0	107	6	63	121	167	241	1573	3020
1951	110	147	327	19	14	24	0	0	133	0	0	0	775	1894
1952	4	0	82	0	0	0	0	0	0	0	0	0	86	1440
1953	0	0	83	190	0	0	0	0	0	0	0	0	273	1281
1954	17	92	365	165	0	59	0	0	0	13	0	427	1139	2644
1955	0	37	254	0	20	303	224	130	74	110	79	30	1260	2708
1956	113	38	487	125	0	45	12	0	0	0	382	0	1202	2528
1957	575	361	0	145	0	49	59	0	0	0	0	123	1312	2638
1958	0	218	228	133	56	0	0	0	0	31	138	0	804	2032
1959	0	0	459	121	27	11	0	0	293	114	0	0	1025	2341
1960	14	81	581	186	0	0	53	167	0	0	0	0	1082	2451
1961	314	0	667	34	74	0	0	18	5	0	61	263	1436	2893
1962	179	190	107	399	29	106	0	0	0	0	281	79	1371	2760
1963	0	279	229	90	100	0	0	35	0	0	0	0	733	2070
1964	0	21	550	7	0	0	121	0	29	0	90	0	818	2148
1965	173	131	197	94	104	0	0	0	0	52	0	0	751	1983
1966	16	0	0	17	0	0	0	0	27	144	0	7	210	1669
1967	864	181	83	328	138	7	0	0	0	112	0	0	1714	2954
1968	330	0	5	0	43	12	0	0	0	0	0	0	390	1789
1969	0	87	154	157	0	0	0	0	0	6	0	0	404	1610
1970	0	48	70	156	20	109	0	0	0	0	103	316	822	2136
1971	28	285	59	141	268	0	0	0	38	69	24	304	1217	2657
1972	148	42	127	26	2	0	17	50	53	26	0	0	491	1733
1973	0	262	263	194	0	0	292	3	83	0	174	158	1428	2918
1974	33	512	99	253	323	73	0	0	0	0	114	12	1420	2819
1975	350	214	173	10	0	57	202	122	0	0	292	117	1537	2962
1976	212	204	77	98	0	0	0	0	0	0	26	0	618	1872
1977	82	167	363	0	0	0	73	21	0	0	0	0	706	1766
1978	233	74	288	68	122	0	0	85	59	78	0	46	1053	2568
1979	0	78	265	160	107	198	0	0	0	187	4	2	1001	2428
1980	17	31	213	258	0	0	0	55	83	0	0	0	657	1941
1981	0	279	182	100	212	0	0	0	0	0	0	0	773	2128
1982	436	290	238	363	75	0	0	49	37	0	0	2	1489	2873
1983	28	88	350	0	0	0	0	0	0	0	0	281	747	1765
1984	27	146	0	296	0	0	0	0	0	0	0	78	547	1799
1985	0	209	278	96	22	0	54	0	0	0	0	0	659	1729
1986	0	0	0	137	0	340	1	0	43	22	0	0	544	1757
1987	0	0	11	0	126	45	0	0	0	0	0	351	533	1726
1988	147	0	0	68	89	25	0	0	140	8	174	78	729	2135
1989	222	500	153	17	111	0	0	0	0	0	4	506	1513	2778
1990	110	29	0	41	108	172	62	0	0	0	0	0	522	1820

## Appendix N

### List of hydrogeological equipment

The Hydrogeology Unit of the Ministry of Lands, Survey and Natural Resources was provided with the following equipment during the course of the Master Plan study. Funds for the equipment were provided from the Master Plan study.

Item Number	Item	Make/Model	Quantity
1.	Portable conductivity, salinity and temperature meter with 2m cable	TPS LC843	
2.	Portable pH meter	TPS LC803	
3.	Portable conductivity meter with 100 m cable	Beta 8001	
4.	PVC bailer	Islex5	
5.	Portable water depth probe (electric contact type) with 60m cable	HS 67-8144	
6.	Electronic data loggers (64 kb capacity) with environmental enclosures and software	Unidata 60035	
7.	Electric pressure transducers (a) 5m range, 10m cable (b) 1m range, 15m cable (c) 1m range, 25m cable	Unidata 6508C1 Unidata 6508A4 Unidata 6508A1	
8.	Tipping bucket rain gauge	Unidata 6506A5	
9.	Barograph	Unidata 6522A1	
10.	Electrical resistivity equipment complete with cables, reels, probes, software and spare parts	ABEM SAS 3001	
11.	Electromagnetic equipment complete with data logger and software	Gconics EM341	
12.	Automatic survey level, tripod (GSTO5) and two staffs (MYZOG)	Wild NA281	

Item Number	Item	Make/Model	Quantity
13.	Potable computer (386SX, 40 Mb hard disk) with maths coprocessor and remote VGA colour monitor	Mitac 3030D1	
14.	Plotter (A3 size with 8 pens)	Houston Instruments Image Maker HI1117E1	
15.	Digitiser tablet	Wintime KD-50001	
16.	Software		
	(a) Microsoft Works	1	
	(b) dBaseIII+	1	
	(c) other software	#	
17.	Chemical test equipment	#	
	(a) field kit for chloride tests	1	
	(b) 1 litre brown glass bottles with caps	3	
	(c) 28 g (1 oz) brown dropper bottle	1	
	(d) 5 ml pipettes graduated in 0.1 ml	2	
	(e) 100 ml porcelain mixing casseroles	2	
	(f) 25 ml plastic measuring cylinder	1	
	(g) glass stirring rods	2	
	(h) silver nitrate	500g	
	(i) potassium chromate	250g	
18.	Four wheel drive vehicle	Toyota Hilux Dual Cab	

Notes:

- \* : 2 off 60m cables were modified on site to 1 off 40m cables and 1 off 80m cable  
# : yet to be ordered

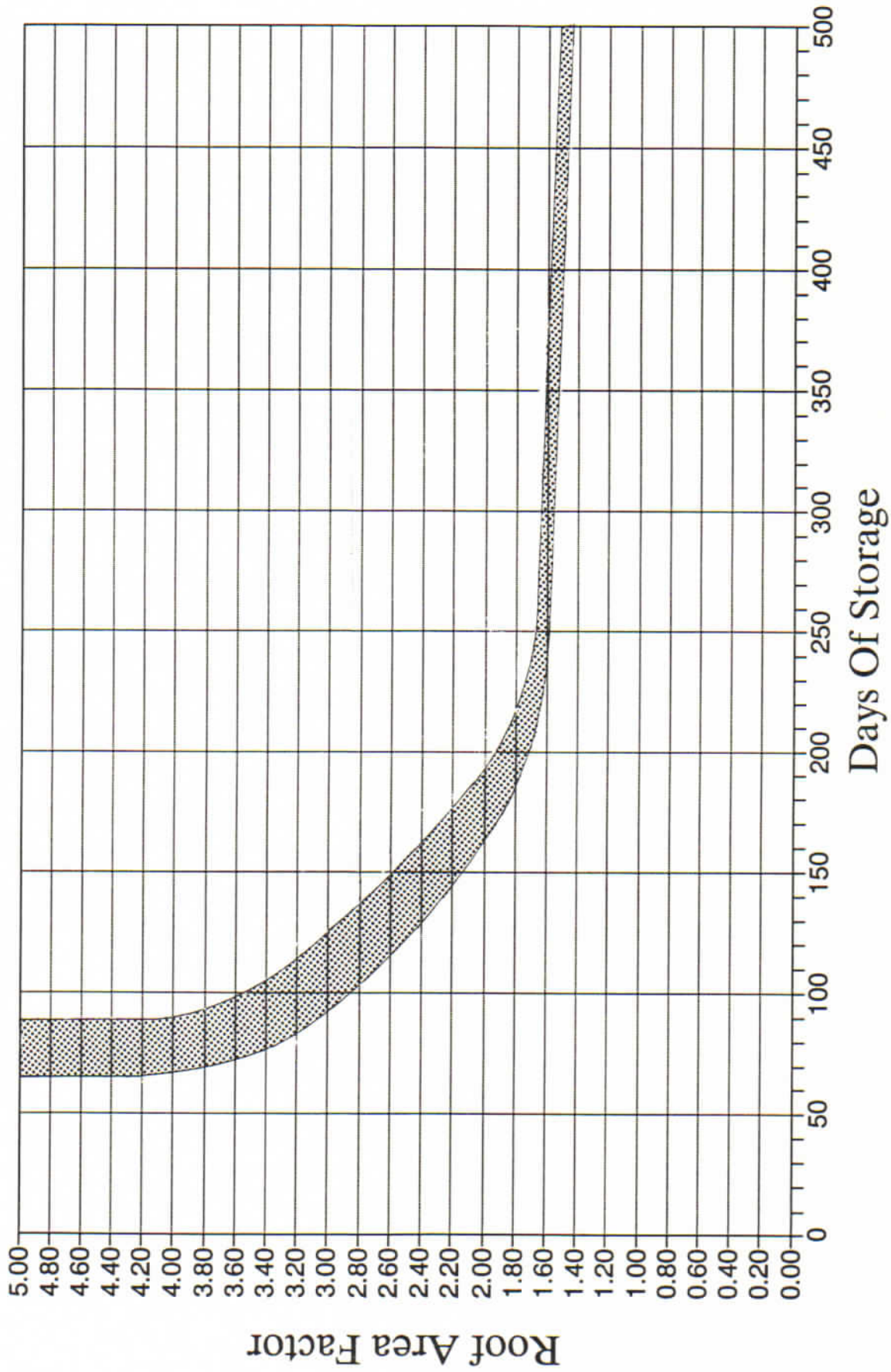
Suppliers' names, addresses and contact numbers are listed below:

Item Number(s)	Supplier name and address	Contact numbers
1,2	TB Pty Ltd 4 Jamberoo Street Springwood Brisbane QLD 4127 Australia	phone(07)2088447 fax(07)8084871

Item Number(s)	Supplier name and addressContact numbers
3	CHK Engineering 24 Fred Street Lilyfield NSW 2040 Australia phone(02)8184555 fax(02)8107908
4	Islex Pty Ltd PO Box 122 Darra QLD 4076 Australia phone(07)3768488 fax(07)3762959
5	Hydrological Services Pty Ltd PO Box 322 Liverpool NSW 2170 Australia phone(02)6012022 fax(02)6026971
6,7,8,9	Unidata 3 Whalla Street Willetton WA 6155 Australia phone(09)4571499 fax(09)4575224
10	Richard Foot Pty. Ltd. PO Box 245 Terrey Hills NSW 2084 Australia phone(02)4502133 fax(02)4502569
11	Geoterrex 13 Whiting Street Artarmon NSW 2064 Australia phone(02)4383866 fax(02)4375917
12	Leica Instruments Pty Ltd PO Box 21 North Ryde NSW 2116 phone(02)8887122 fax(02)8887526
13,14,15,16	PATCO Hala Taufu'ahaufax23120 Nuku'alofa Tongatapu Kingdom of Tonga phone21320
17	Not yet ordered
18	Burns Philp Toyotaphone23500 Nuku'alofa Tongatapu Kingdom of Tonga

# Rainwater Catchment Graph Ha'apai

Annual RainFall  
= 1591 mm

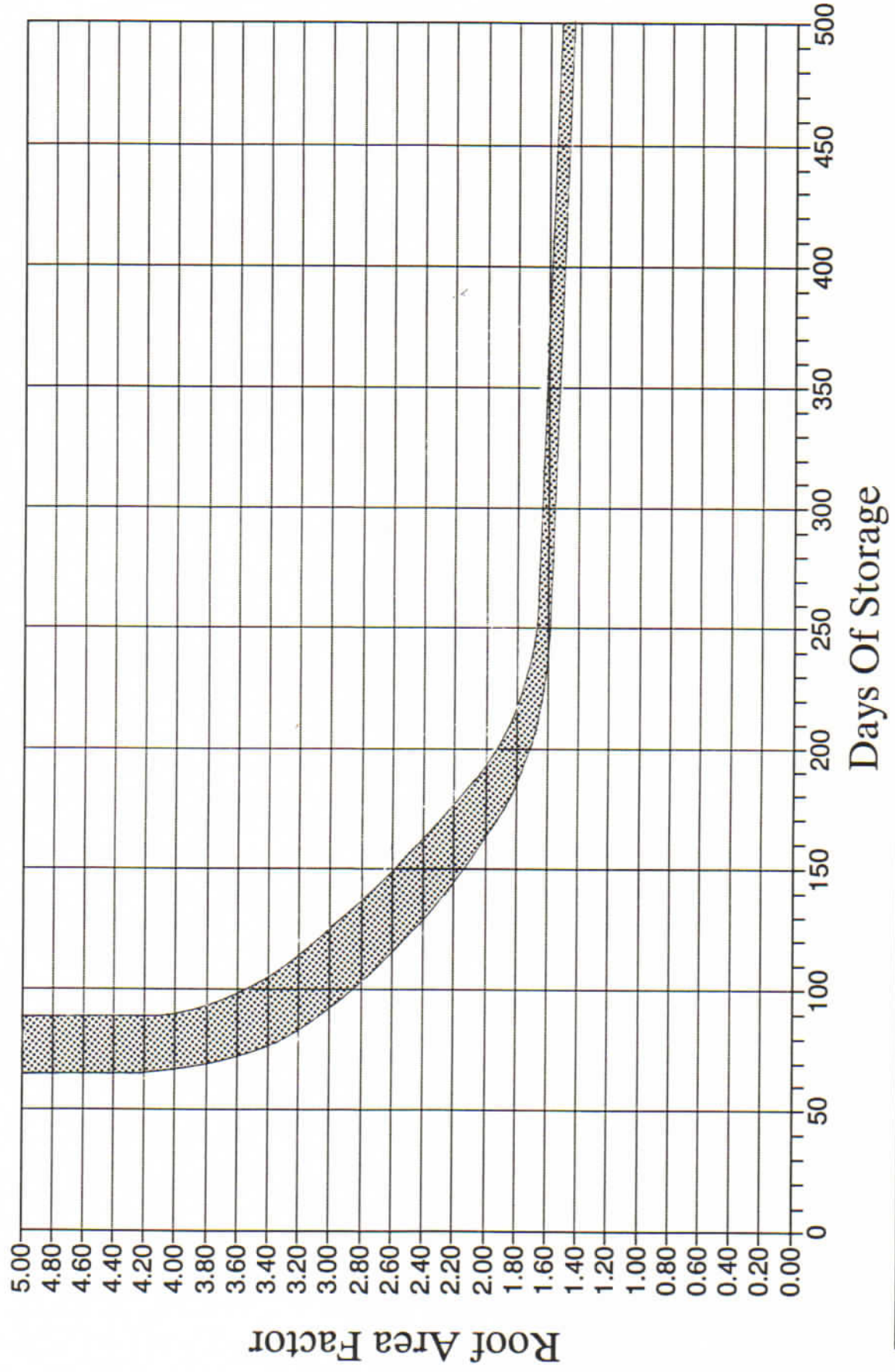


Base Area(m<sup>2</sup>) = Demand (L/Day) X 365 / Annual Rainfall (mm)

Required Roof Area = Base Area X Roof Area Factor

# Rainwater Catchment Graph Ha'apai

Annual Rain Fall  
= 1591 mm



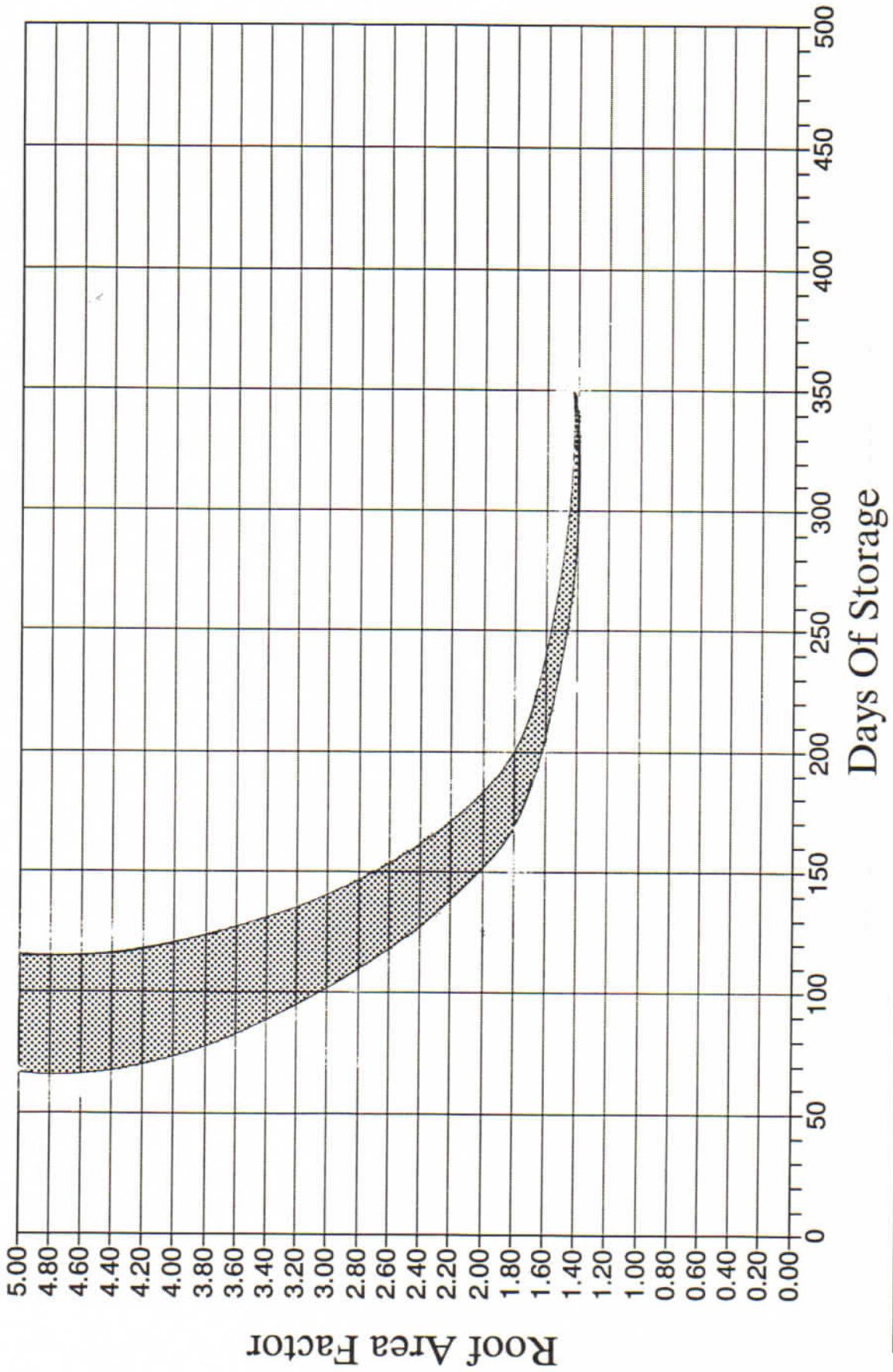
Base Area(m<sup>2</sup>) = Demand (L/Day) X 365 / Annual Rainfall (mm)

Required Roof Area = Base Area X Roof Area Factor



# Rainwater Catchment Graph Vava'u

Annual RainFall  
= 2135 mm

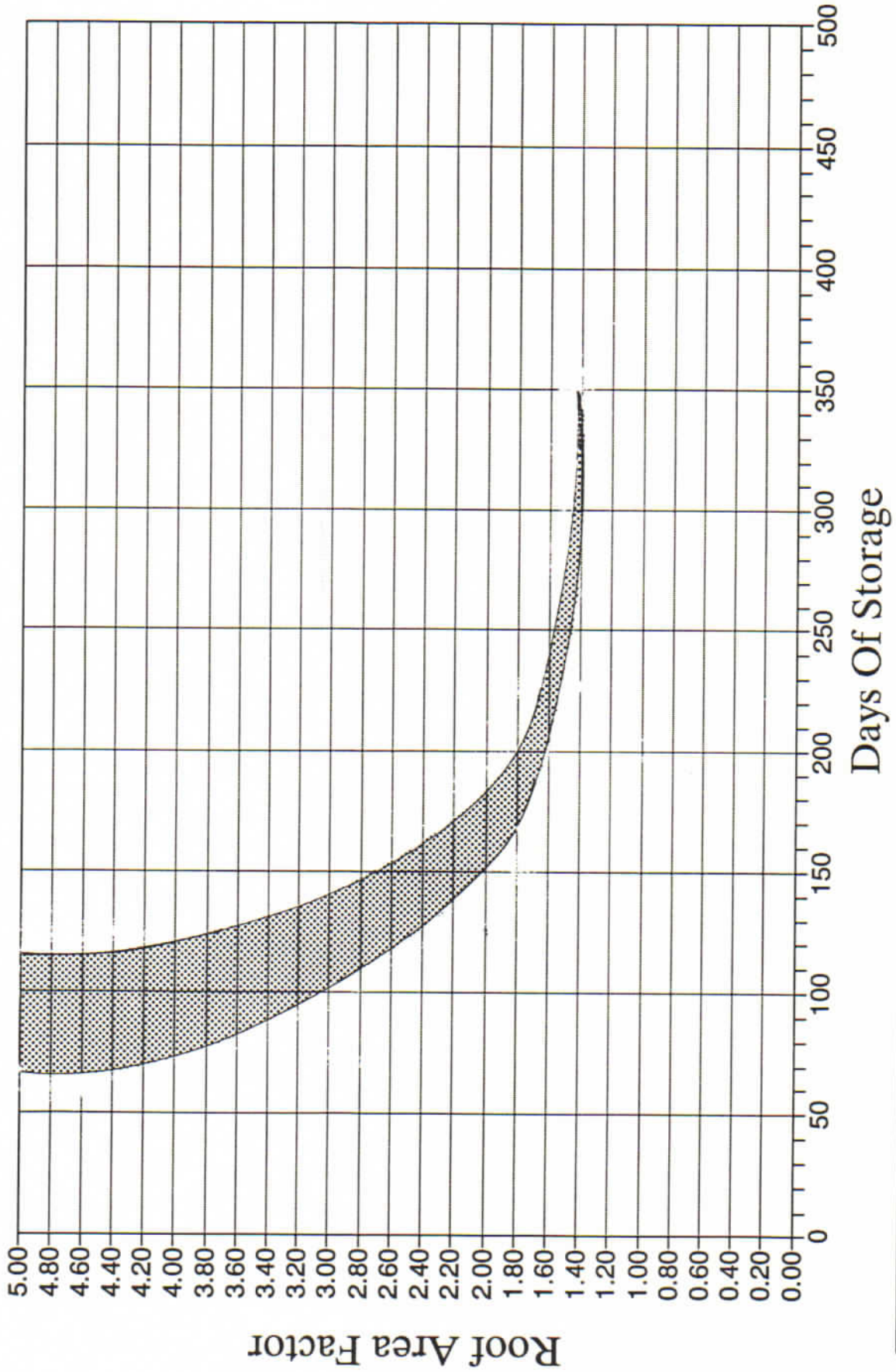


Base Area(m<sup>2</sup>) = Demand (L/Day) X 365 / Annual Rainfall (mm)

Required Roof Area = Base Area X Roof Area Factor

# Rainwater Catchment Graph Vava'u

Annual RainFall  
= 2135 mm

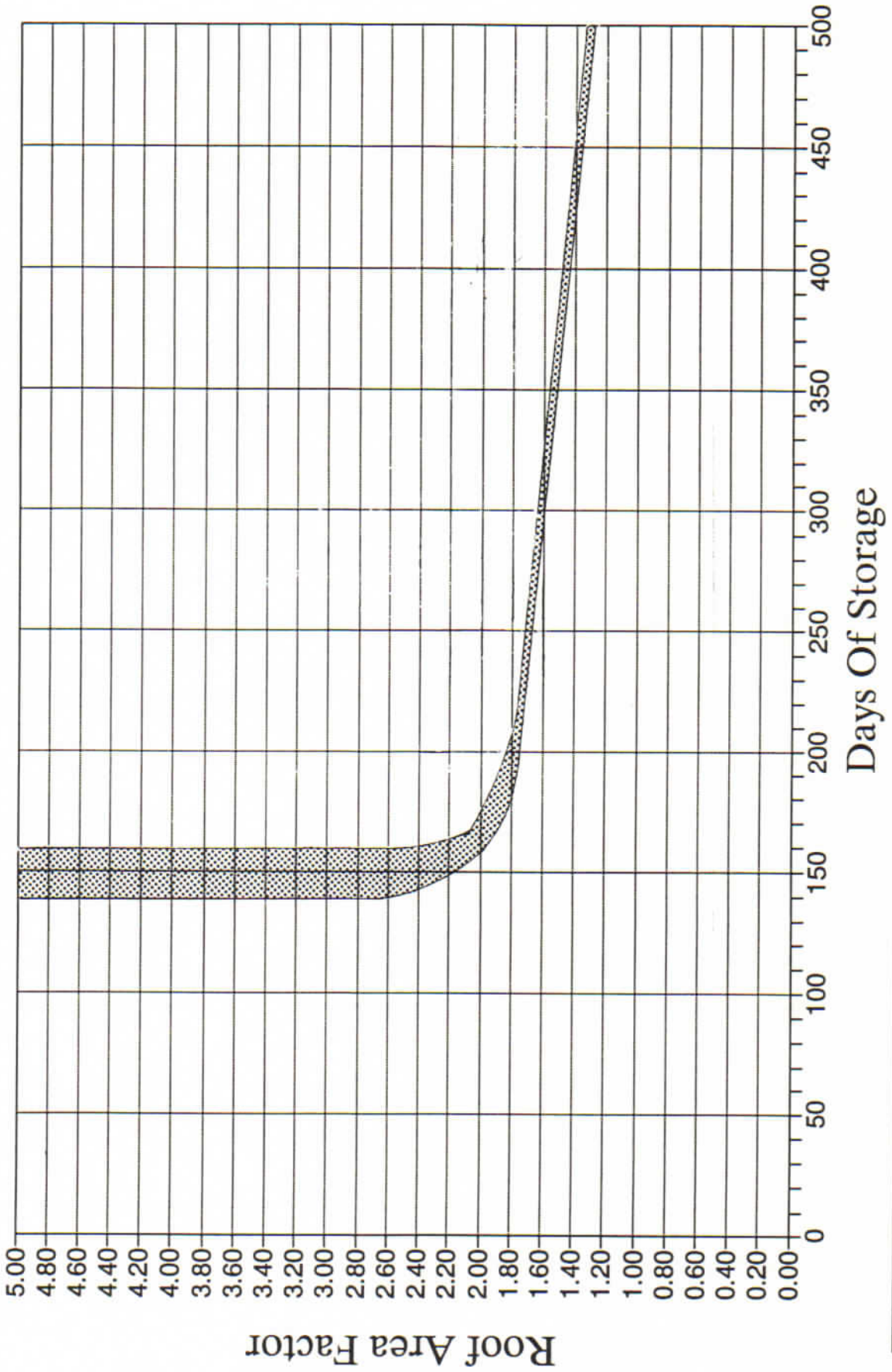


Base Area(m<sup>2</sup>) = Demand (L/Day) X 365 / Annual Rainfall (mm)

Required Roof Area = Base Area X Roof Area Factor

# Rainwater Catchment Graph Niuatoputapu

Annual RainFall  
= 2130 mm

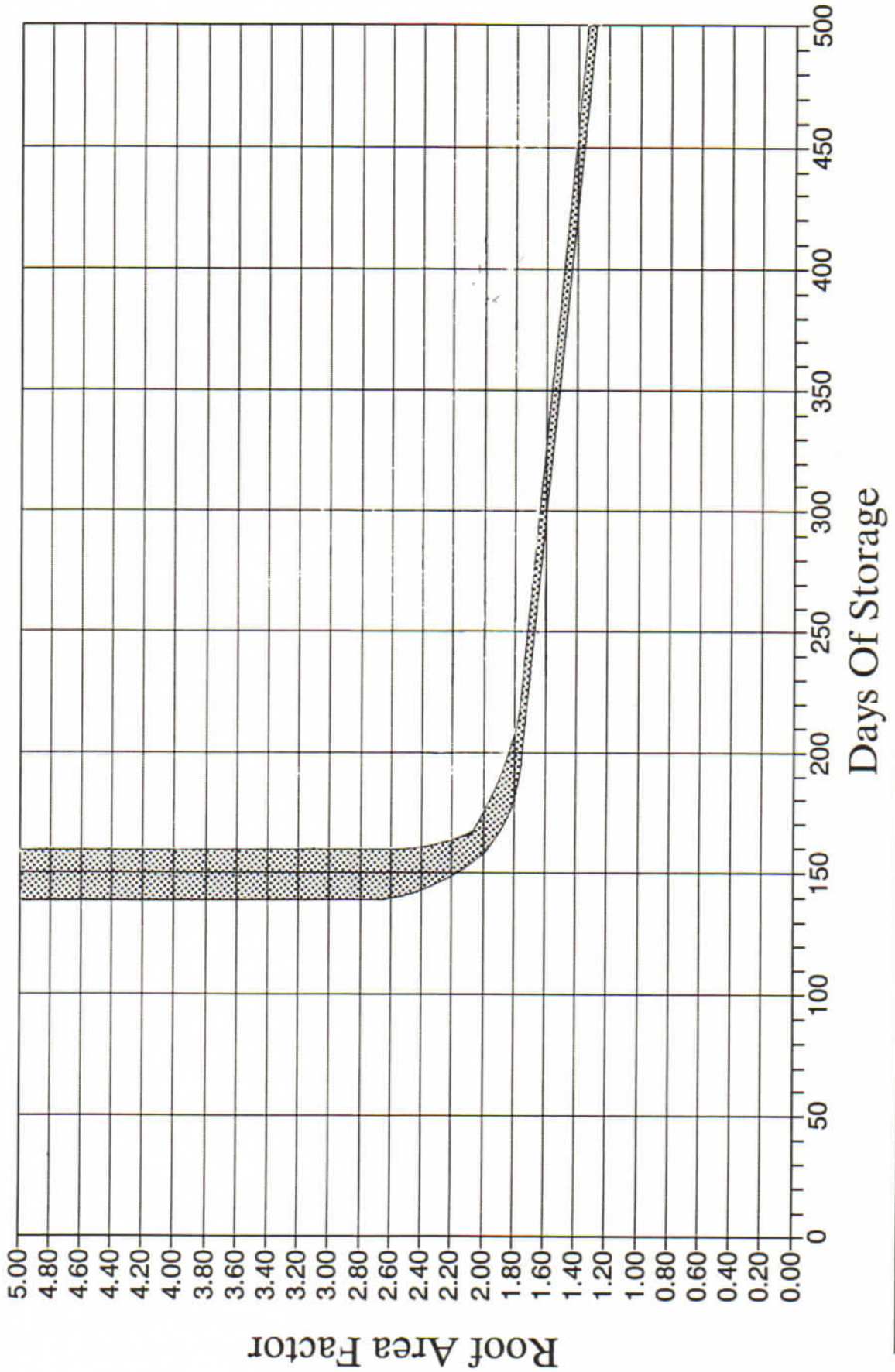


Base Area(m<sup>2</sup>) = Demand (L/Day) X 365 / Annual Rainfall (mm)

Required Roof Area = Base Area X Roof Area Factor

# Rainwater Catchment Graph Niuatoputapu

Annual RainFall  
= 2130 mm



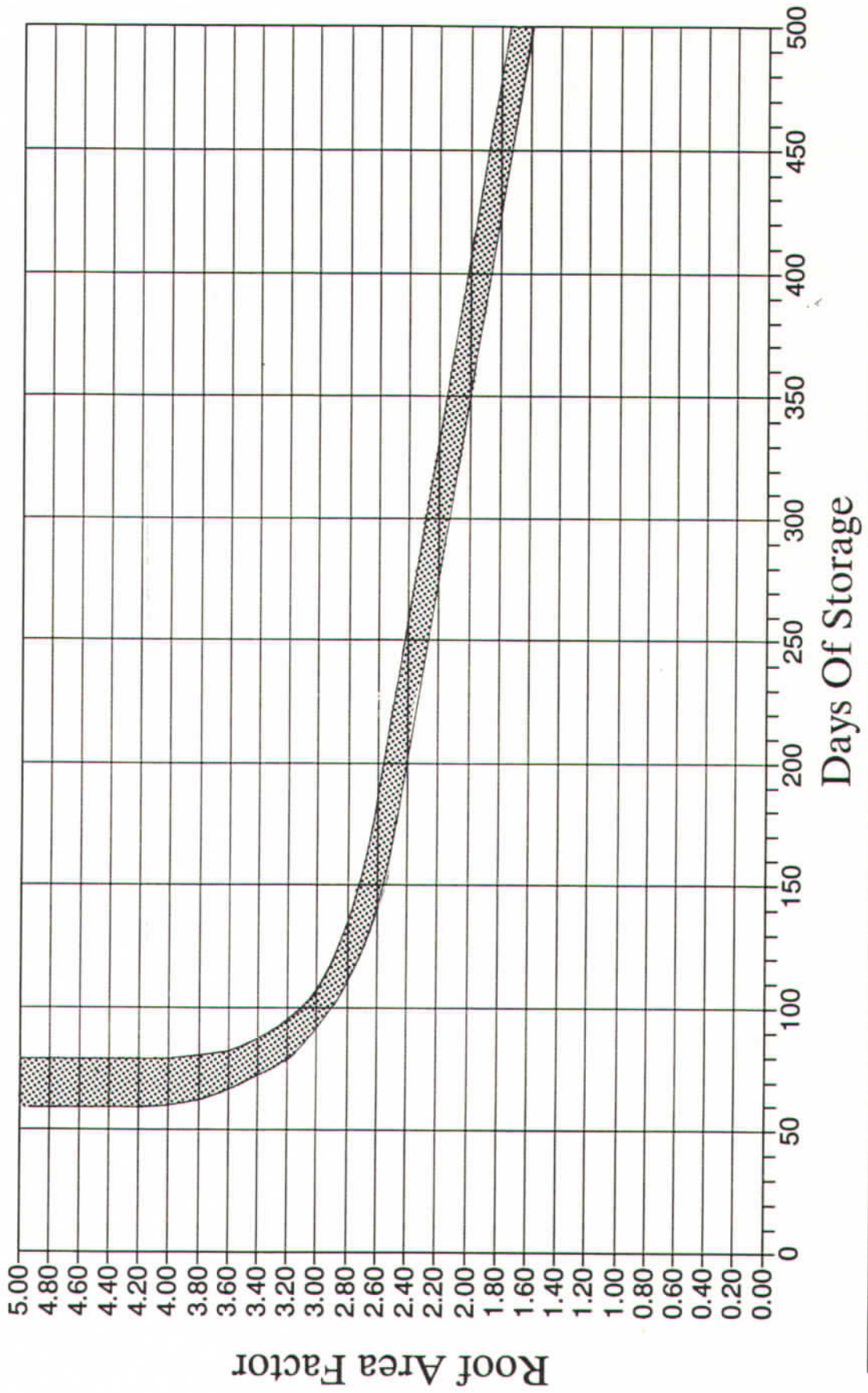
Base Area(m<sup>2</sup>) = Demand (L/Day) X 365 / Annual Rainfall (mm)

Required Roof Area = Base Area X Roof Area Factor

# Rainwater Catchment Graph

Niufo'ou

Annual RainFall  
= 2165 mm



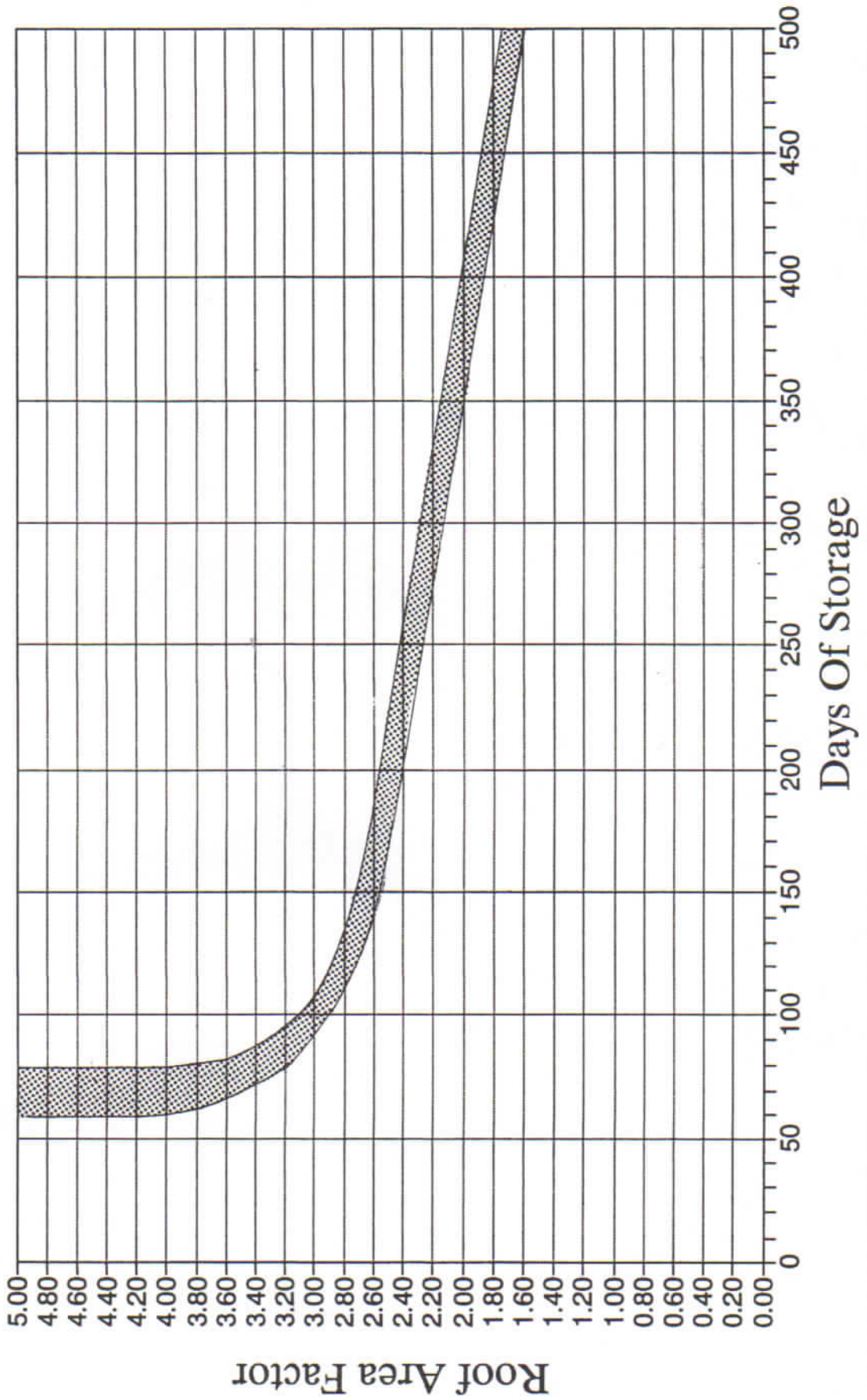
Base Area(m<sup>2</sup>) = Demand (L/Day) X 365 / Annual Rainfall (mm)

Required Roof Area = Base Area X Roof Area Factor

# Rainwater Catchment Graph

Niufo'ou

Annual RainFall  
= 2165 mm



Base Area(m<sup>2</sup>) = Demand (L/Day) X 365 / Annual Rainfall (mm)

Required Roof Area = Base Area X Roof Area Factor