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Development of a methodology for drought frequency analysis using sub-catchments in Zimbabwe

Nyabeze, Washington Rueben Rudo

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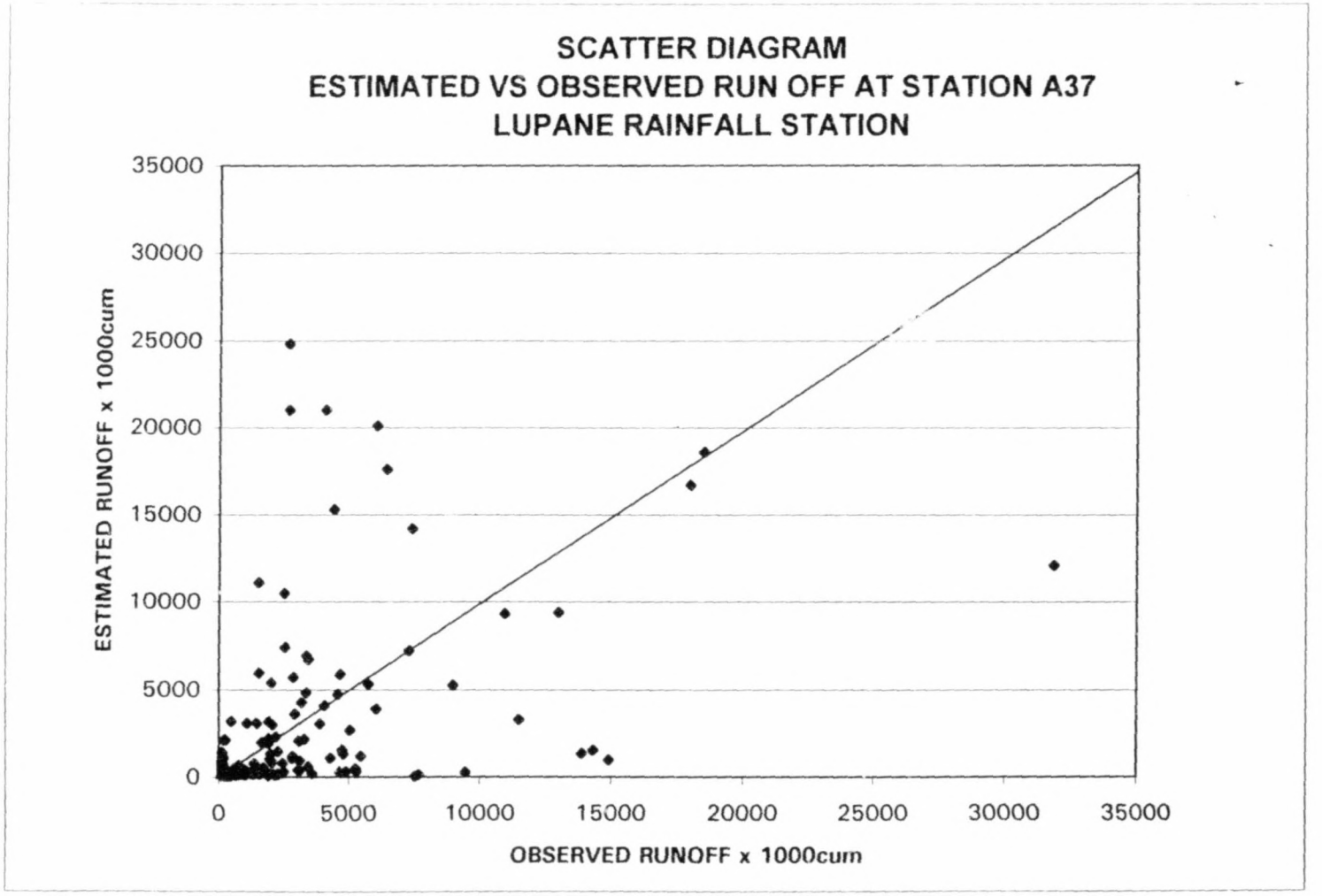

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUN OFF AT STATION A37
LUPANE RAINFALL STATION
ESTIMATED RUNOFF x 1000cum
OBSERVED RUNOFF x 1000cum
0
5000
10000
15000
20000
25000
30000
35000

Figure 10.1

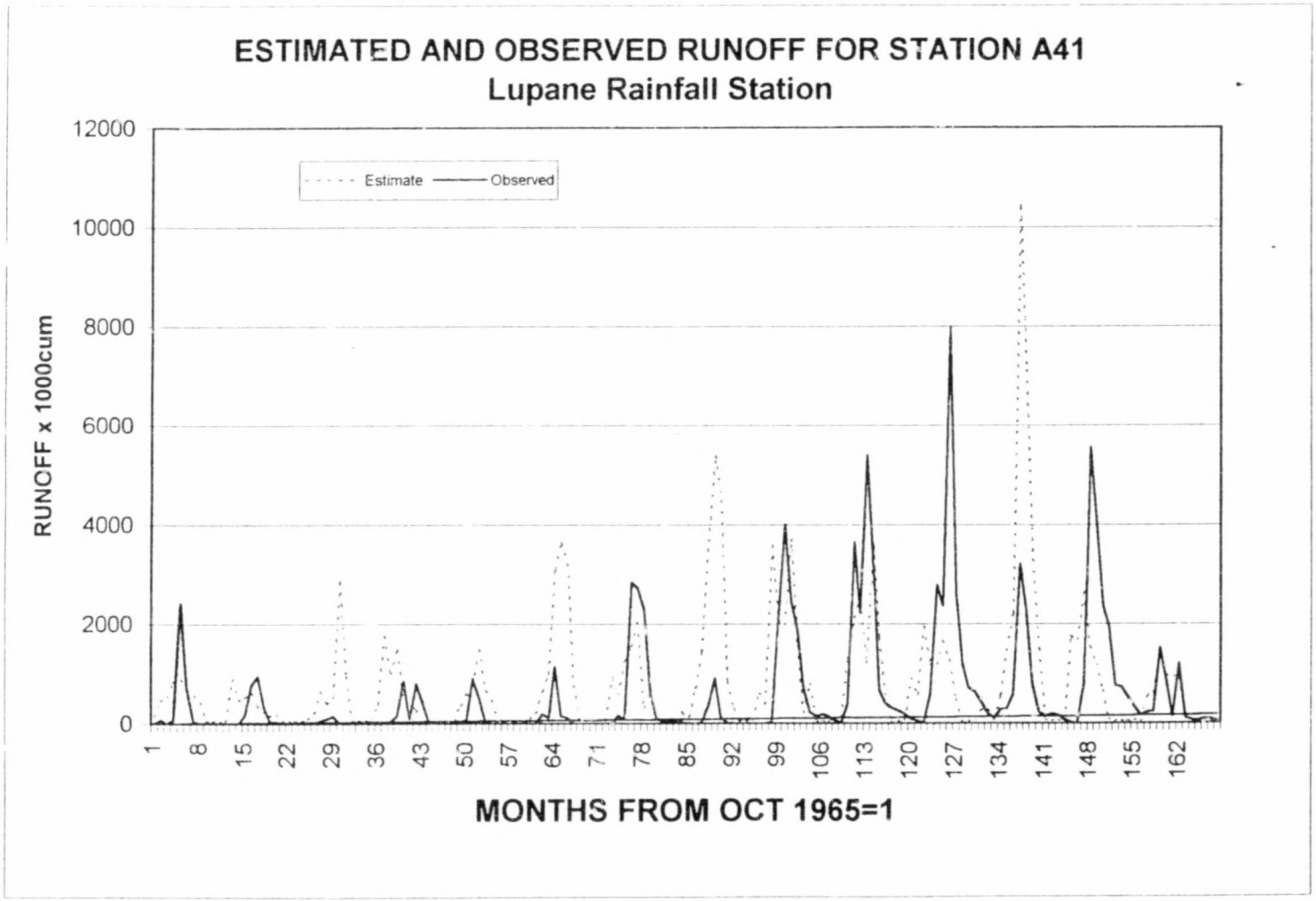

ESTIMATED AND OBSERVED RUNOFF FOR STATION A41
Lupane Rainfall Station
Estimate
Observed
RUNOFF x 1000cum
12000
10000
8000
6000
4000
2000
0
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
127
134
141
148
155
162
MONTHS FROM OCT 1965=1

Figure 11

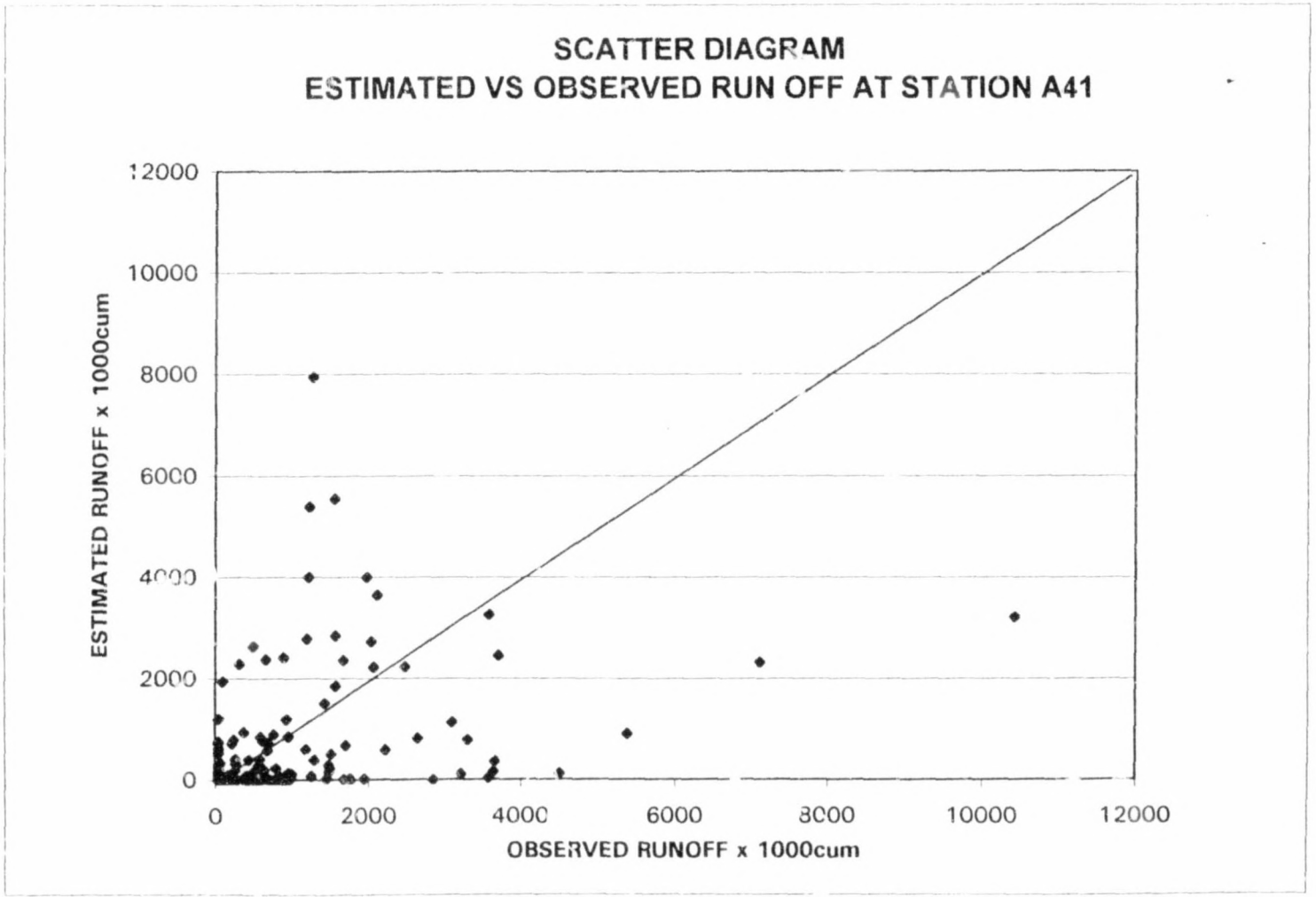

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUN OFF AT STATION A41
ESTIMATED RUNOFF x 1000cum
OBSERVED RUNOFF x 1000cum
0
2000
4000
6000
8000
10000
12000

Figure 11.1

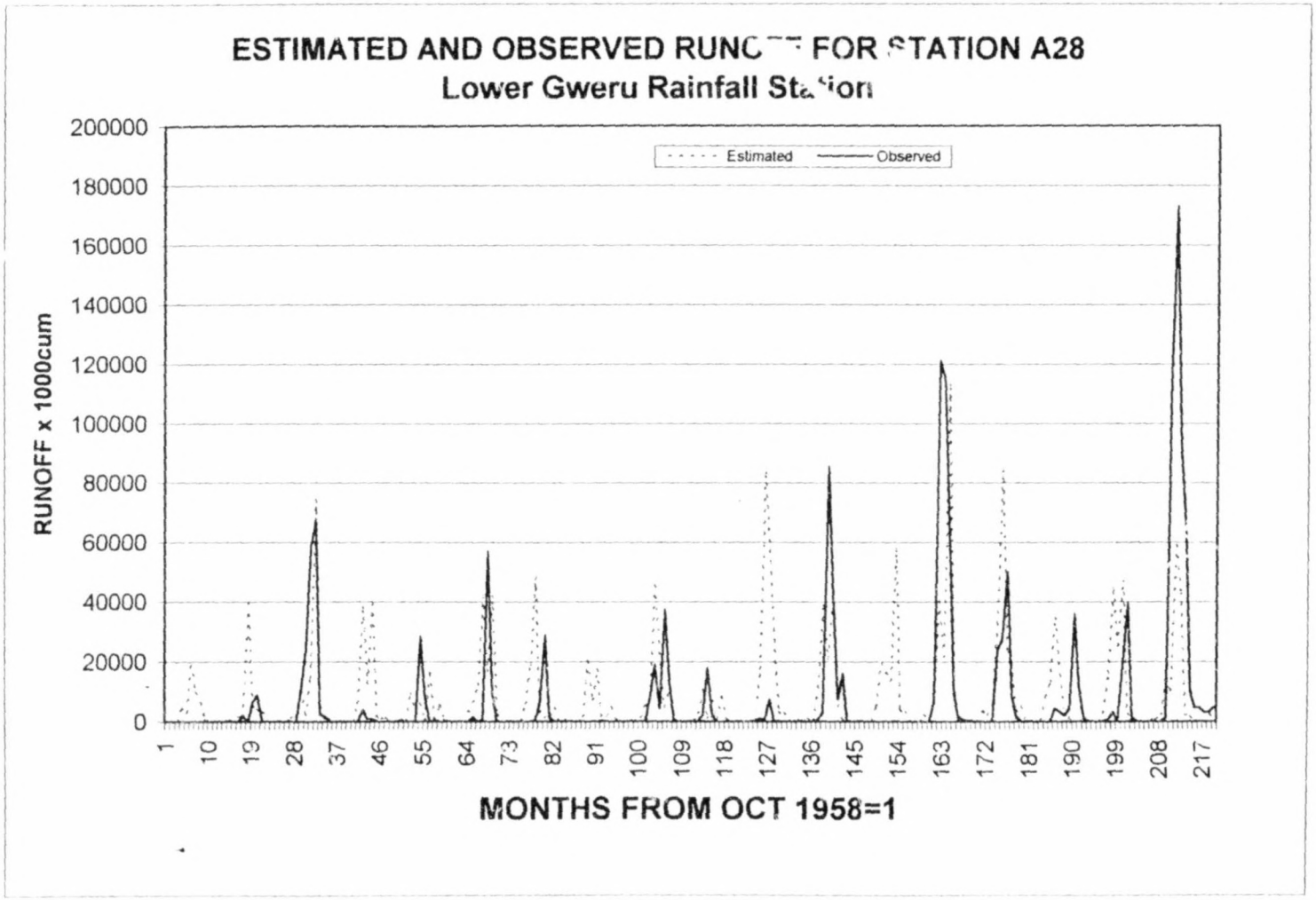

ESTIMATED AND OBSERVED RUNOFF FOR STATION A28
Lower Gweru Rainfall Station
Estimated
Observed
RUNOFF x 1000cum
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1
10
19
28
37
46
55
64
73
82
91
100
109
118
127
136
145
154
163
172
181
190
199
208
217
MONTHS FROM OCT 1958=1

Figure 12

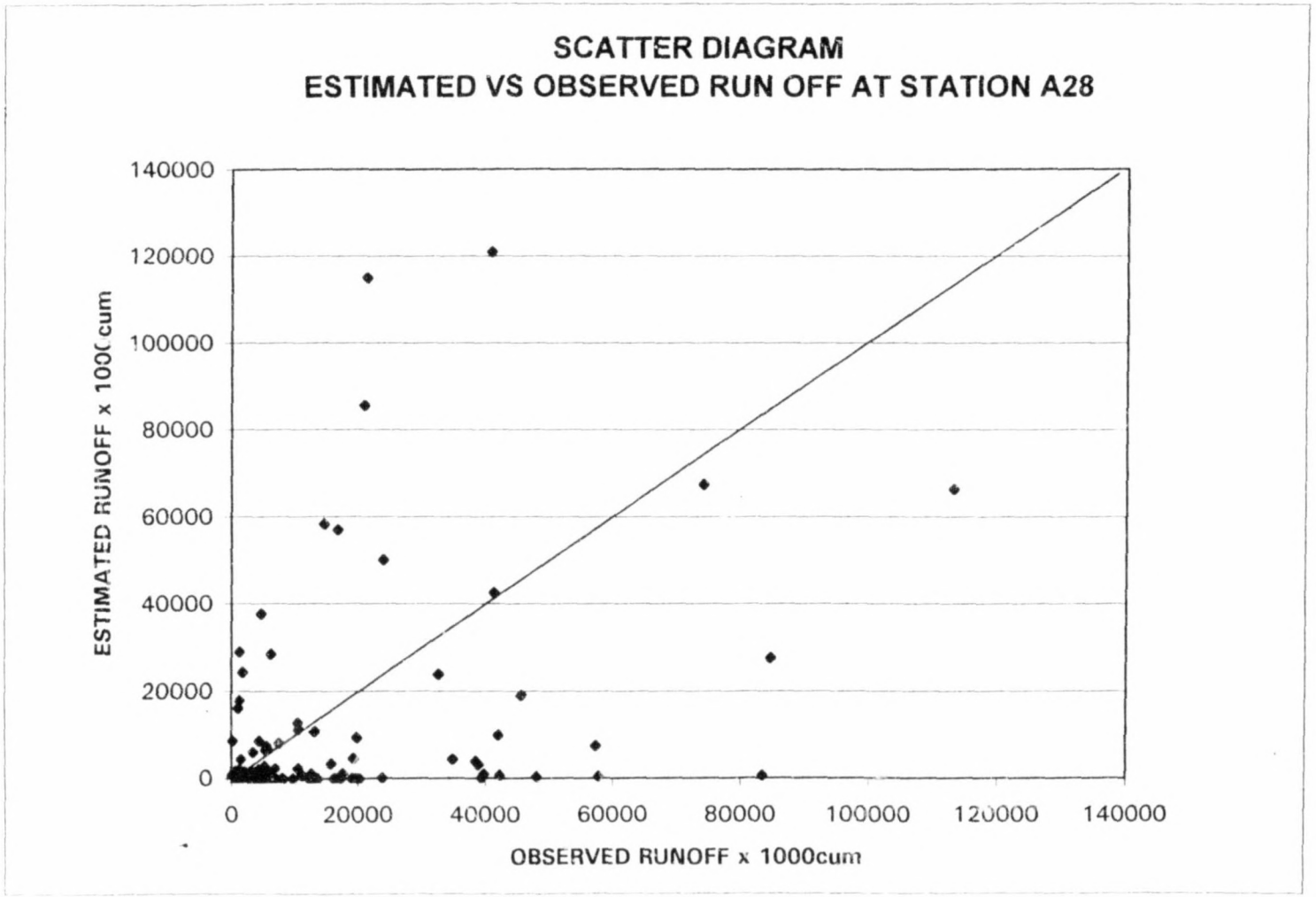

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUN OFF AT STATION A28
ESTIMATED RUNOFF x 1000cum
OBSERVED RUNOFF x 1000cum
0
20000
40000
60000
80000
100000
120000
140000

Figure 12.1

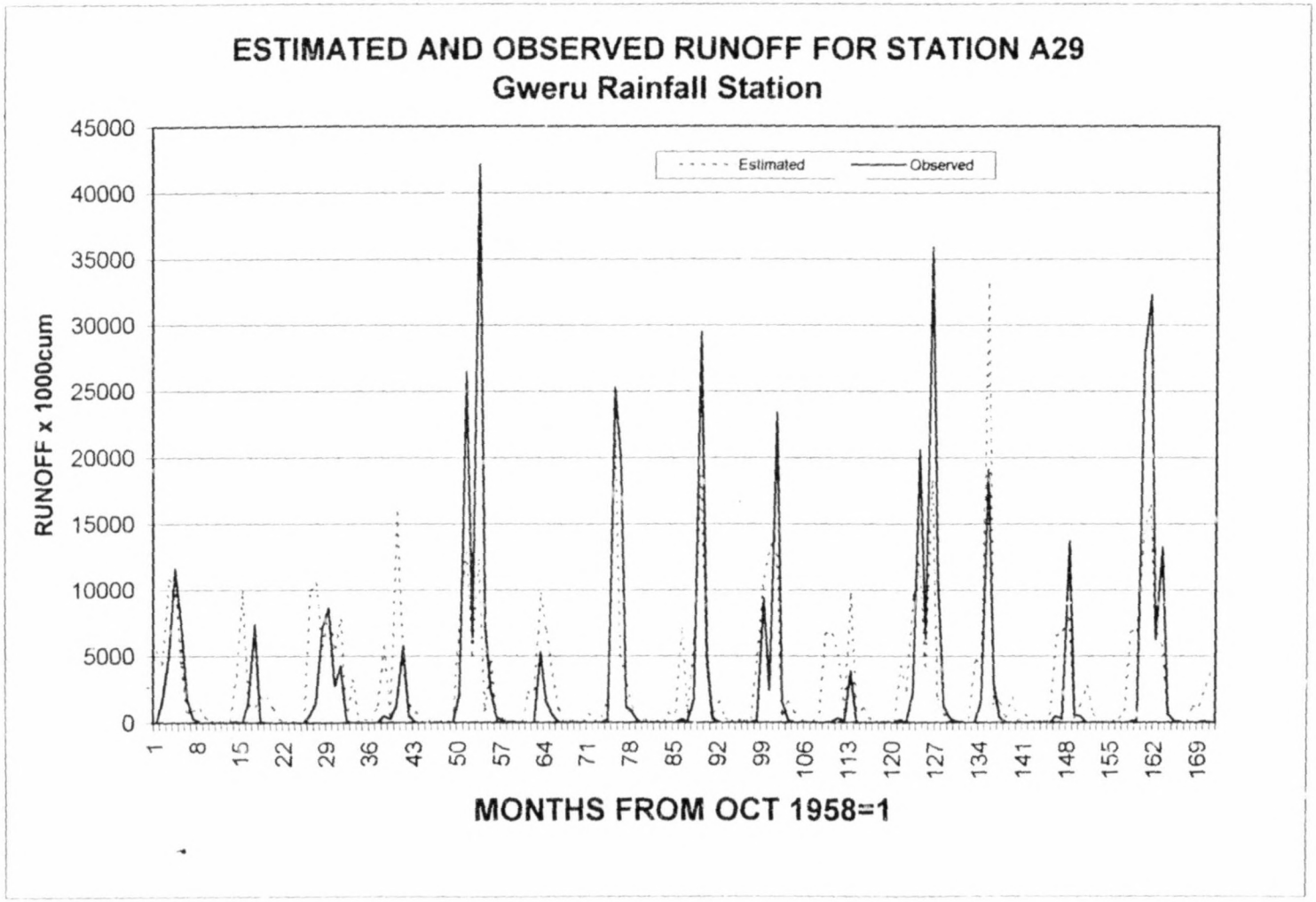

ESTIMATED AND OBSERVED RUNOFF FOR STATION A29
Gweru Rainfall Station
Estimated
Observed
RUNOFF x 1000cum
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
127
134
141
148
155
162
169
MONTHS FROM OCT 1958=1

Figure 13

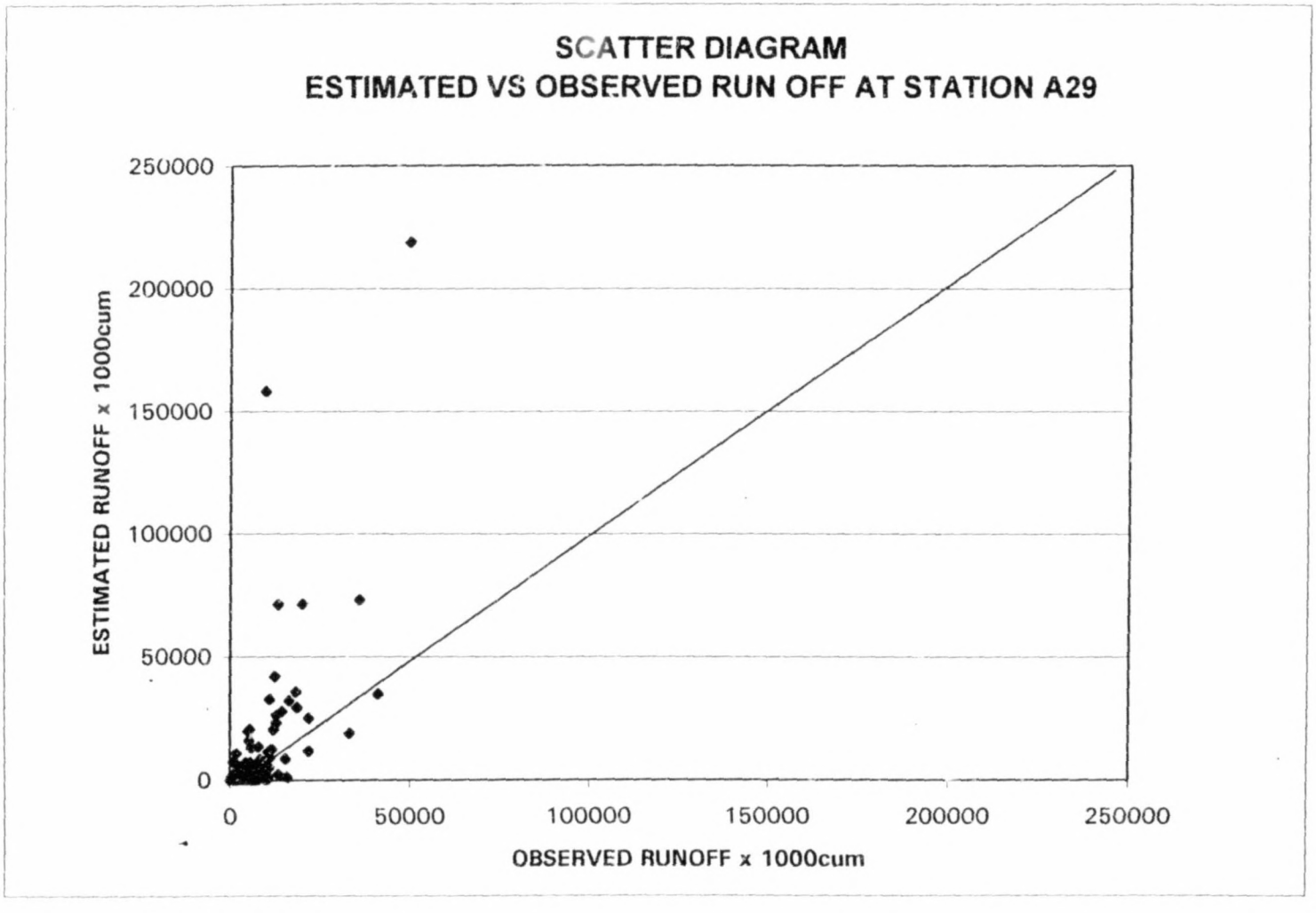

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUN OFF AT STATION A29
ESTIMATED RUNOFF x 1000cum
250000
200000
150000
100000
50000
0
0
50000
100000
150000
200000
250000
OBSERVED RUNOFF x 1000cum

Figure 13.1

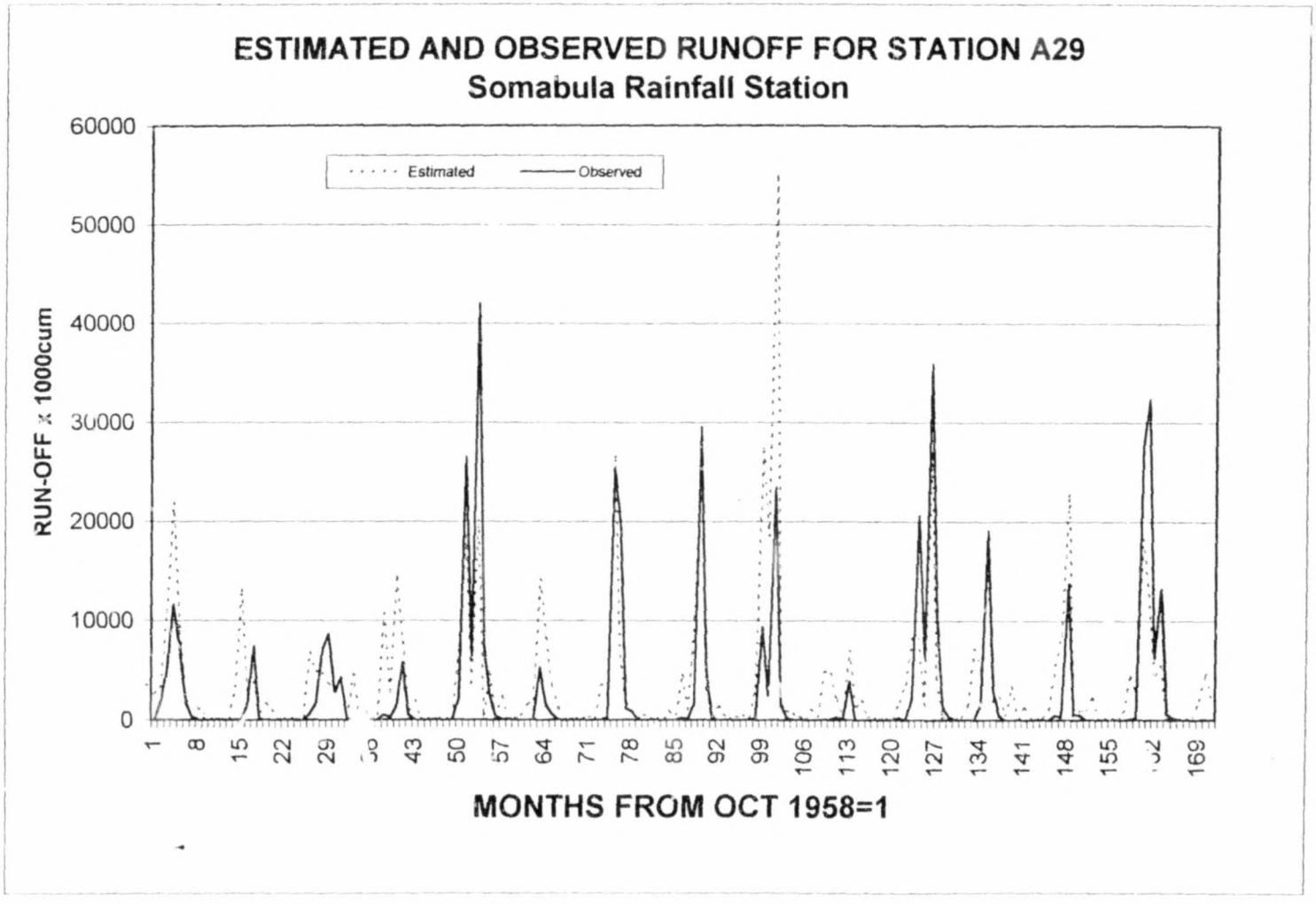

ESTIMATED AND OBSERVED RUNOFF FOR STATION A29
Somabula Rainfall Station
Estimated
Observed
RUN-OFF x 1000cum
60000
50000
40000
30000
20000
10000
0
1
8
15
22
29
43
50
57
64
71
78
85
92
99
106
113
120
127
134
141
148
155
169
MONTHS FROM OCT 1958=1

Figure 14

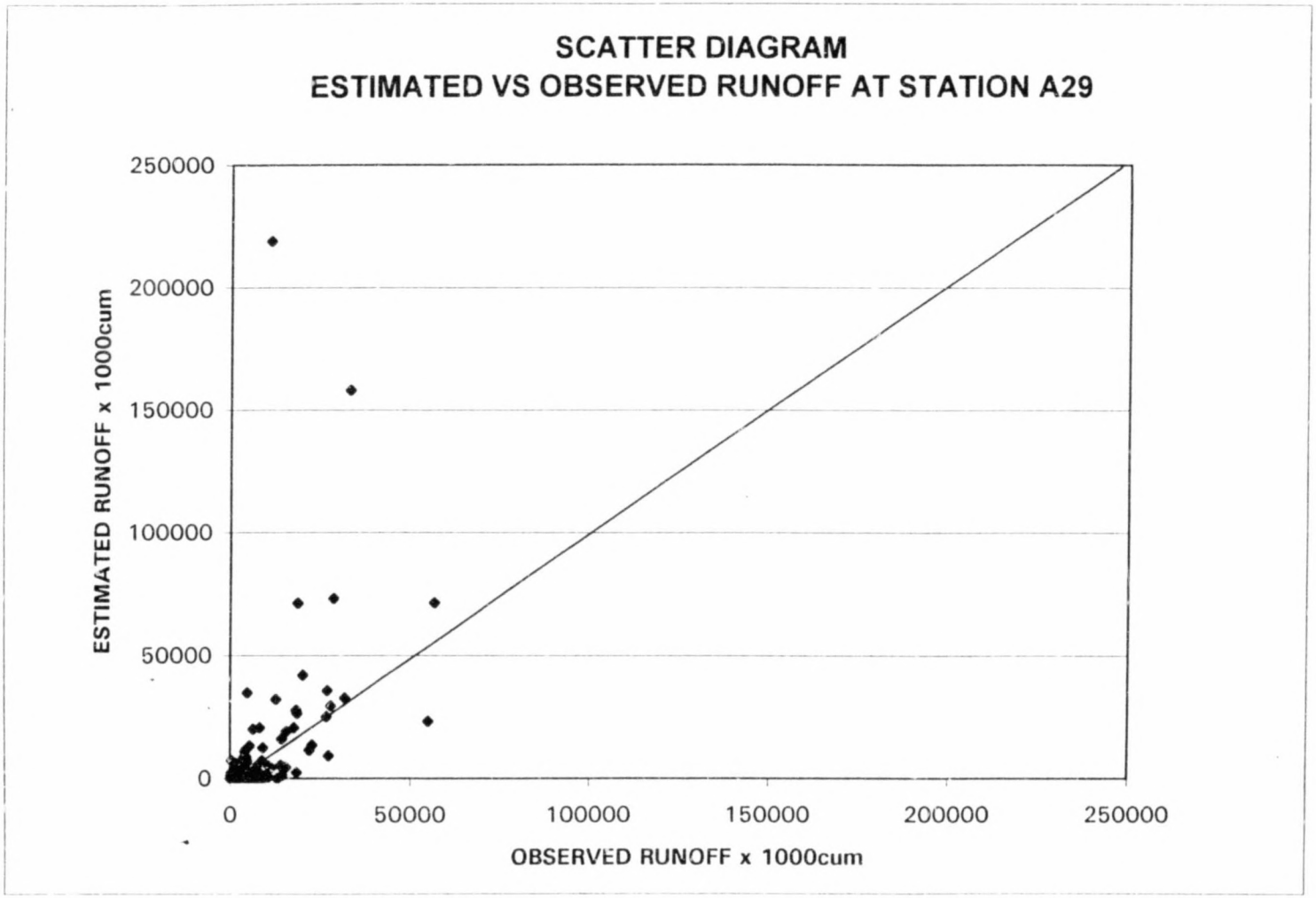

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUNOFF AT STATION A29
ESTIMATED RUNOFF x 1000cum
OBSERVED RUNOFF x 1000cum
250000
200000
150000
100000
50000
0
0
50000
100000
150000
200000
250000

Figure 14.1

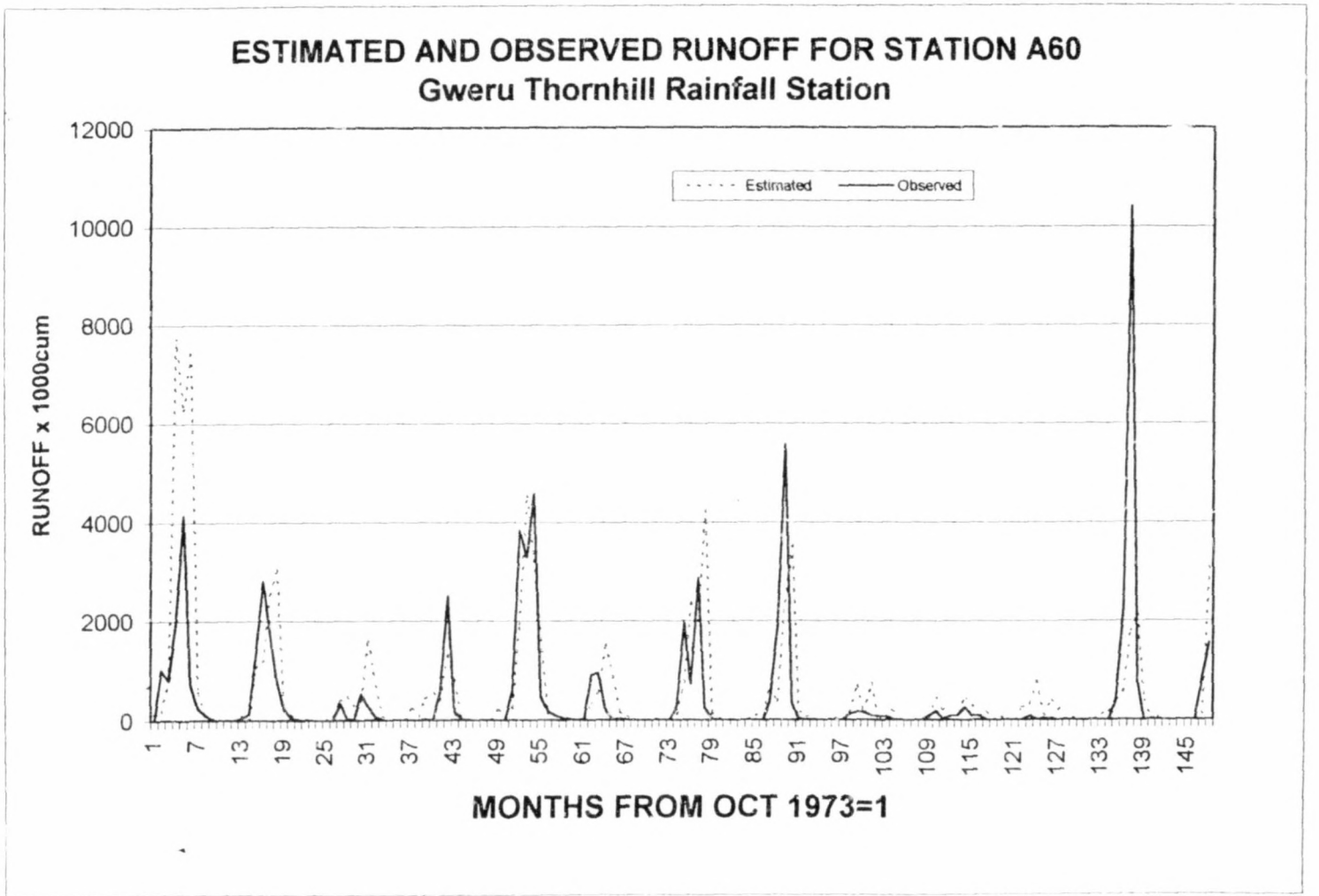

ESTIMATED AND OBSERVED RUNOFF FOR STATION A60
Gweru Thornhill Rainfall Station
Estimated
Observed
RUNOFF x 1000cum
12000
10000
8000
6000
4000
2000
0
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
103
109
115
121
127
133
139
145
MONTHS FROM OCT 1973=1

Figure 15

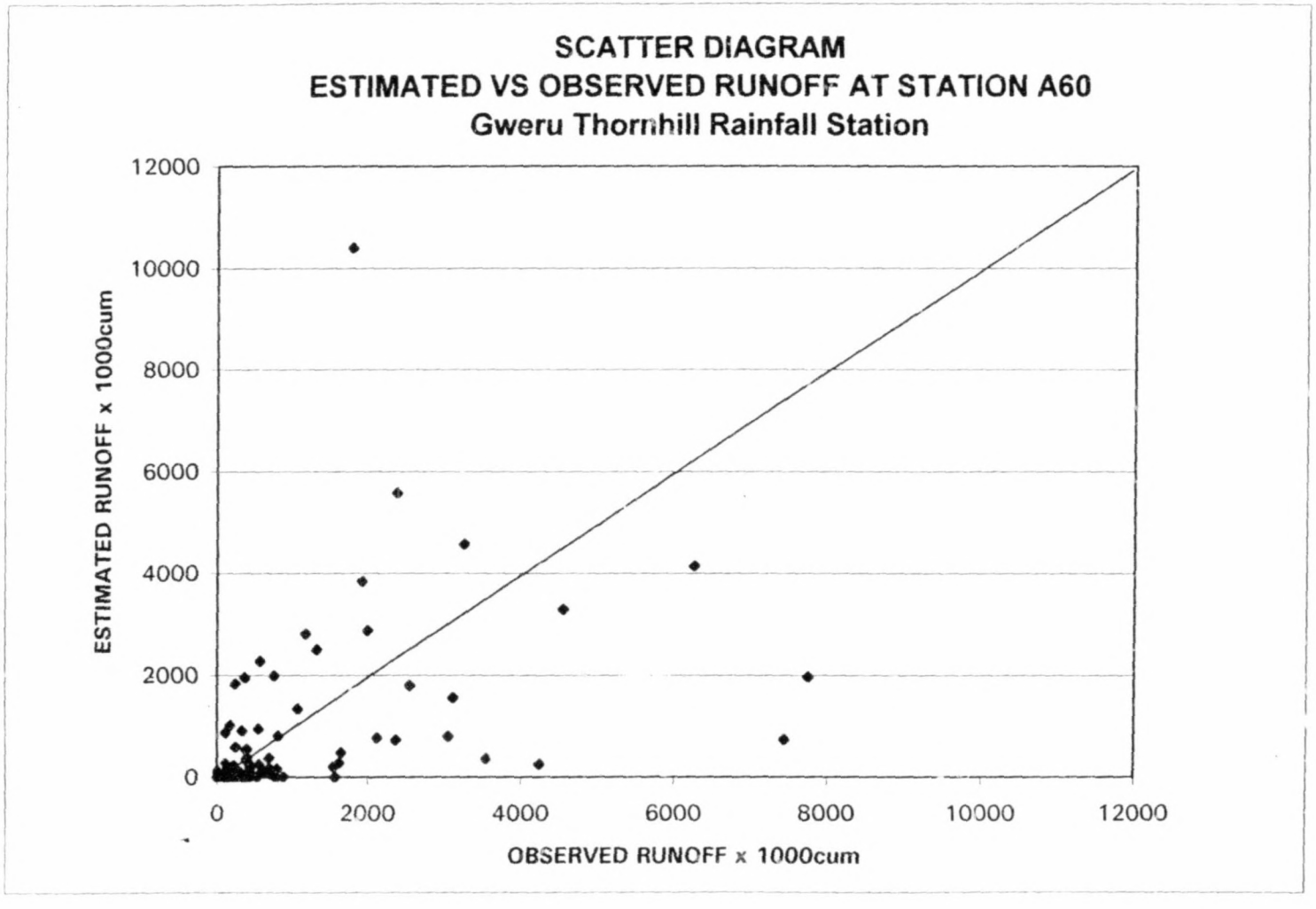

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUNOFF AT STATION A60
Gweru Thornhill Rainfall Station
ESTIMATED RUNOFF x 1000cum
OBSERVED RUNOFF x 1000cum
0
2000
4000
6000
8000
10000
12000

Figure 15.1

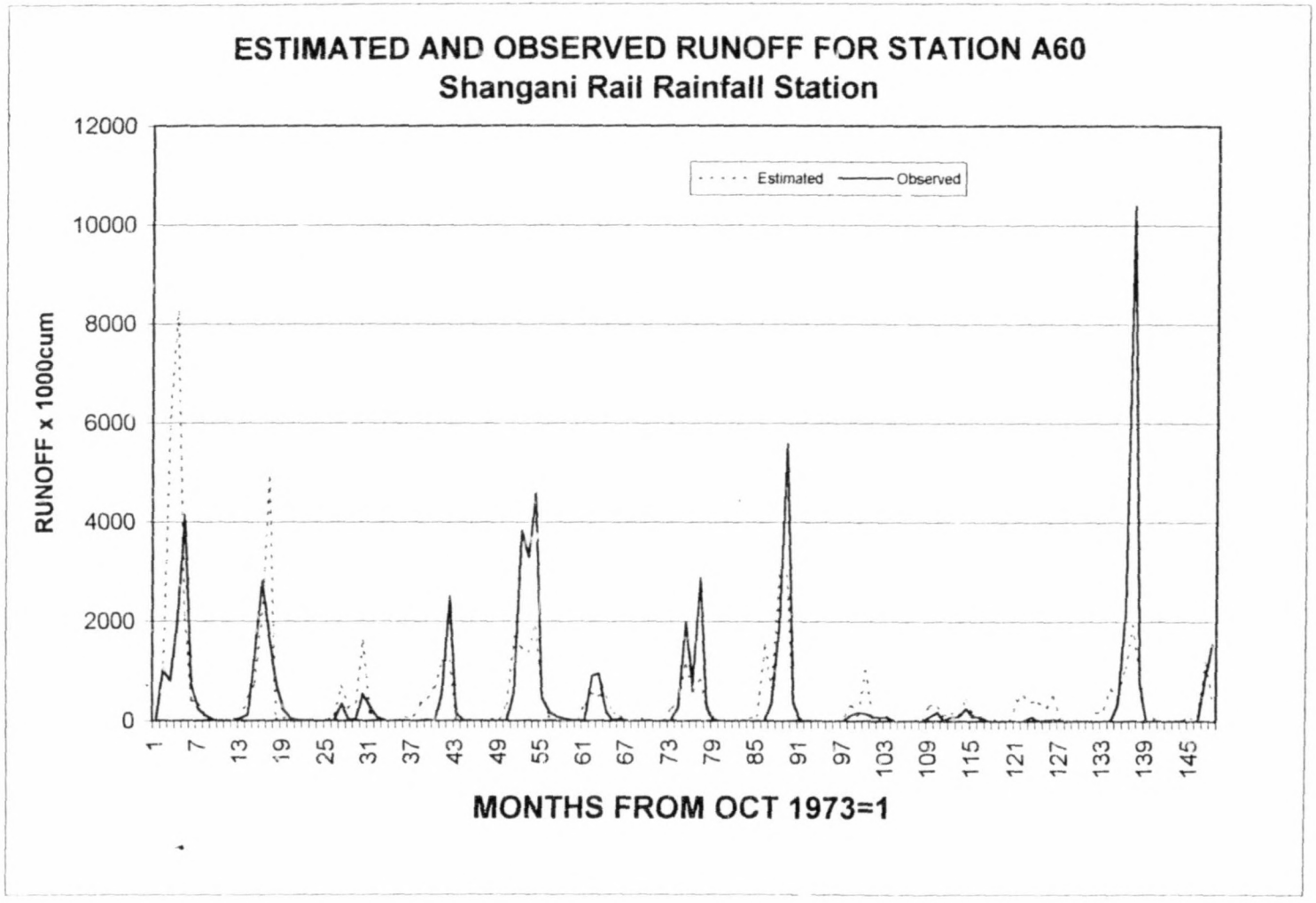

ESTIMATED AND OBSERVED RUNOFF FOR STATION A60
Shangani Rail Rainfall Station
Estimated
Observed
RUNOFF x 1000cum
12000
10000
8000
6000
4000
2000
0
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
103
109
115
121
127
133
139
145
MONTHS FROM OCT 1973=1

Figure 16

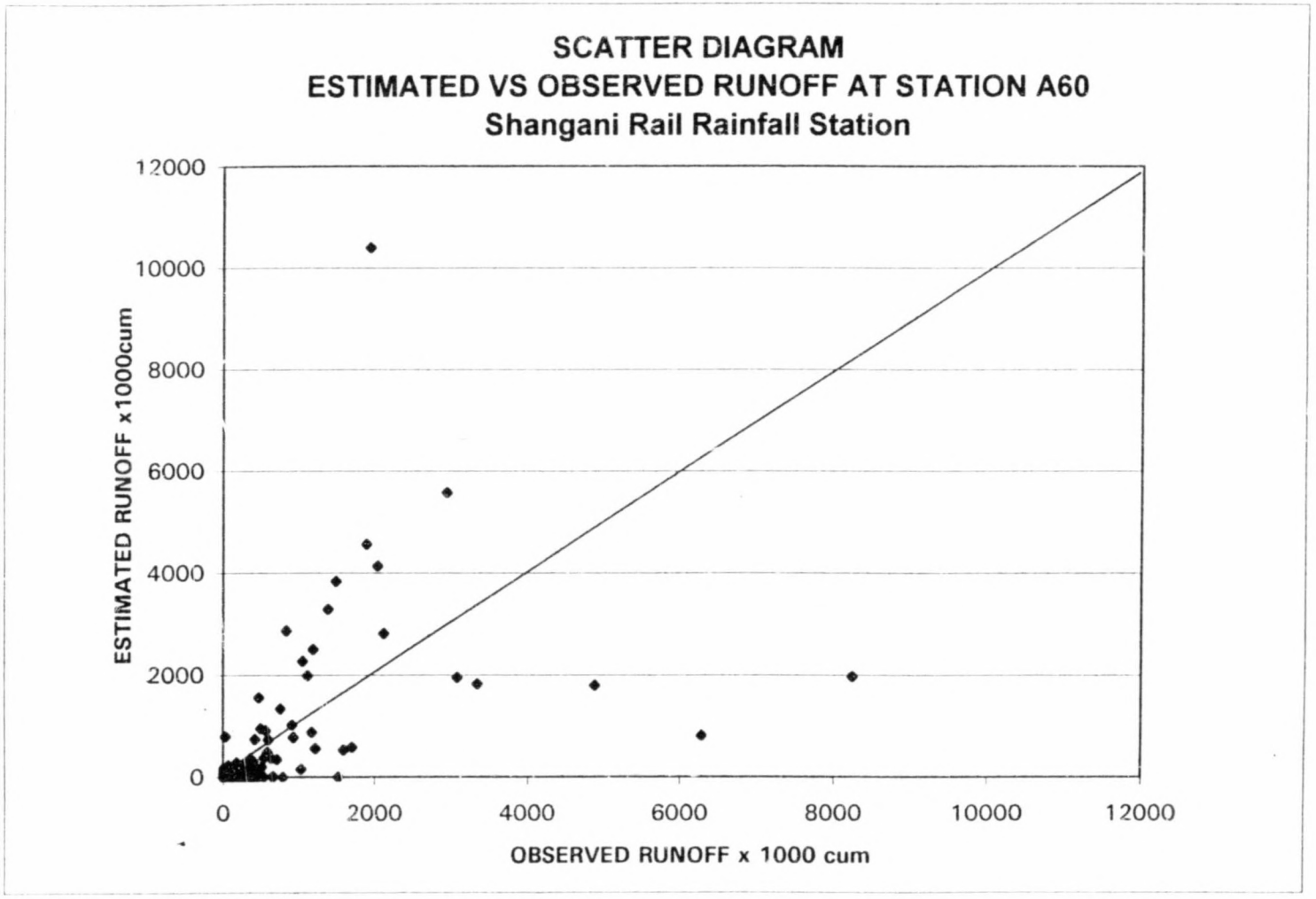

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUNOFF AT STATION A60
Shangani Rail Rainfall Station
ESTIMATED RUNOFF x1000cum
OBSERVED RUNOFF x 1000 cum
0
2000
4000
6000
8000
10000
12000

Figure 16.1

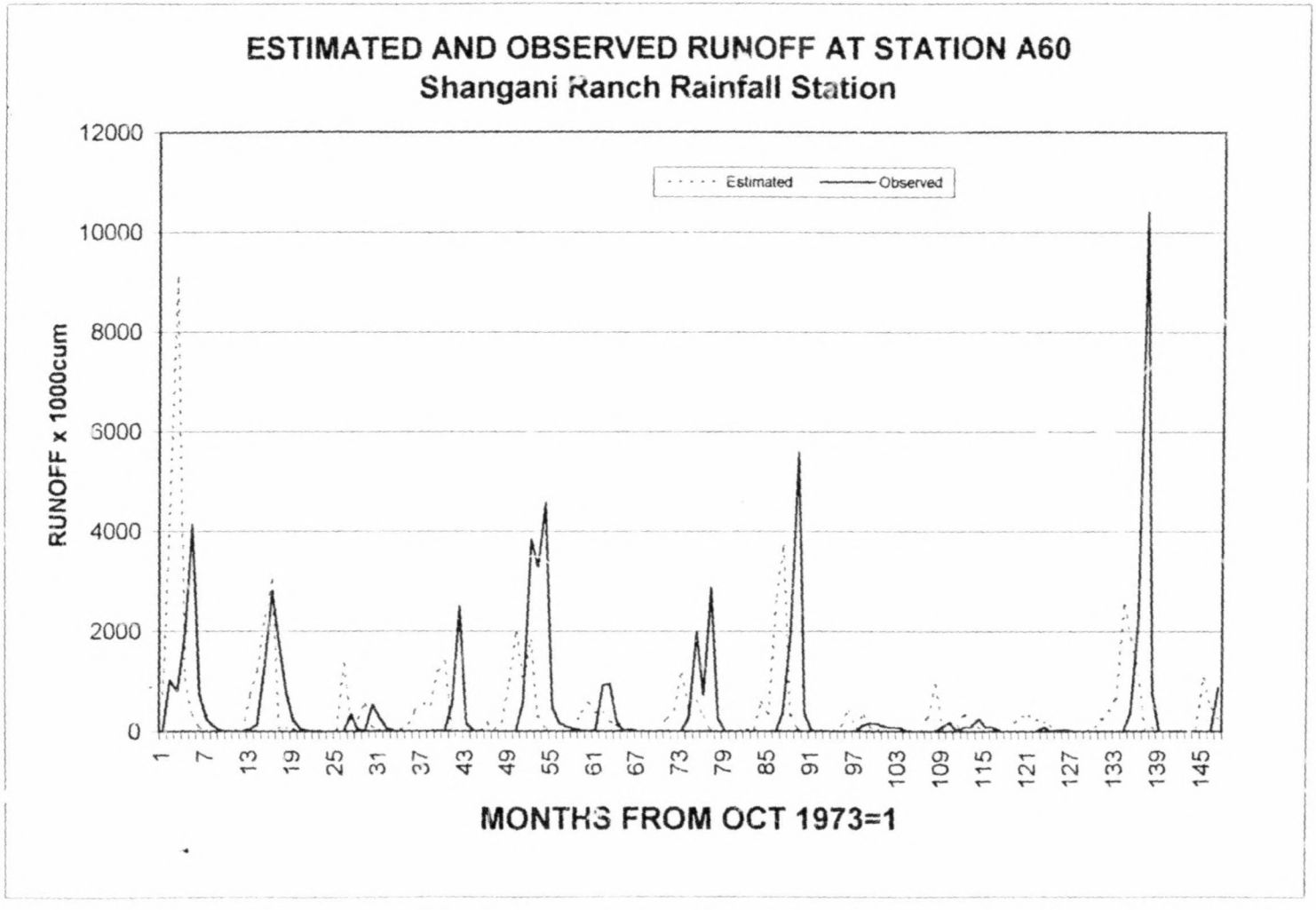

ESTIMATED AND OBSERVED RUNOFF AT STATION A60
Shangani Ranch Rainfall Station
Estimated
Observed
RUNOFF x 1000cum
12000
10000
8000
6000
4000
2000
0
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
103
109
115
121
127
133
139
145
MONTHS FROM OCT 1973=1

Figure 17

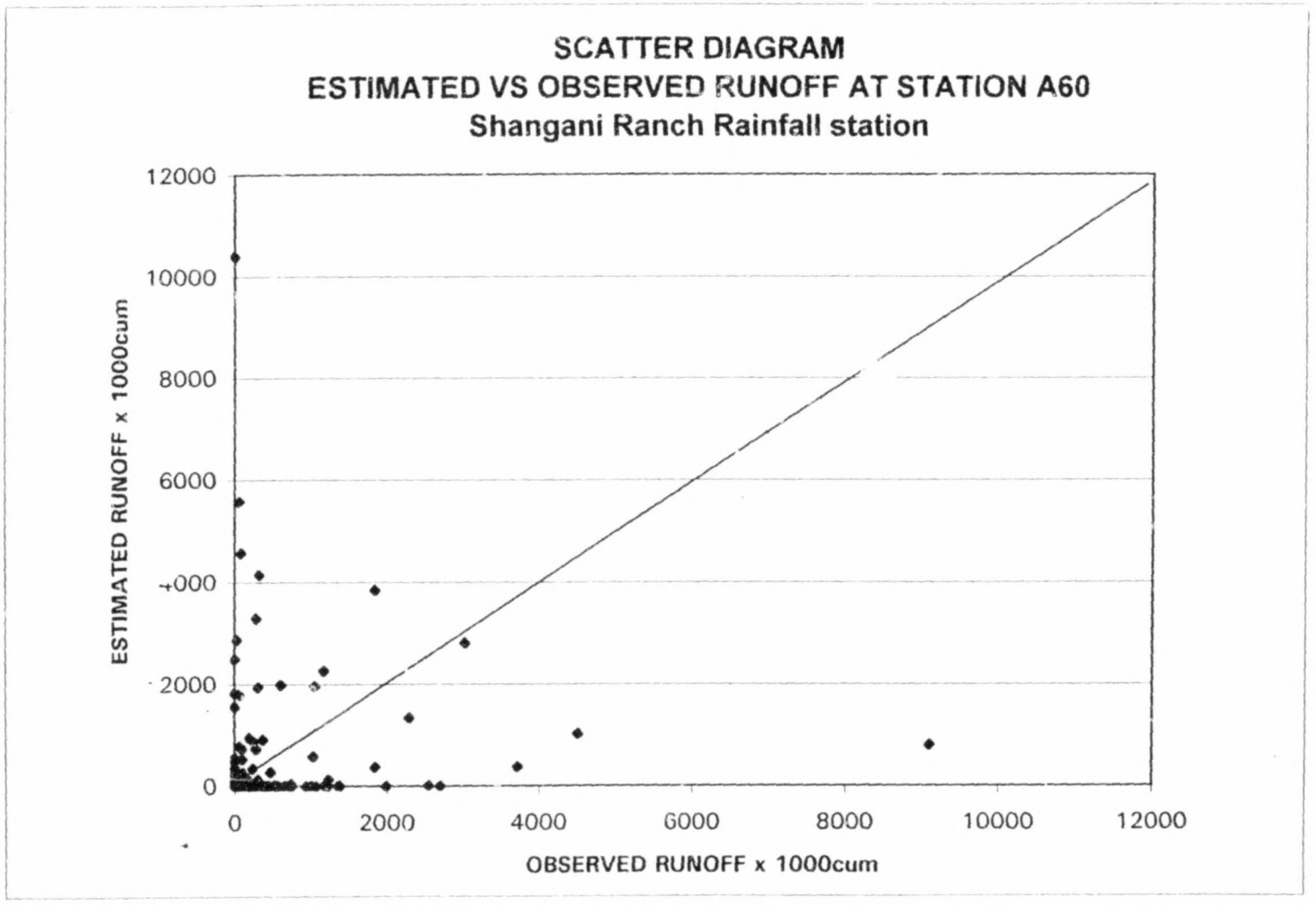

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUNOFF AT STATION A60
Shangani Ranch Rainfall station
ESTIMATED RUNOFF x 1000cum
OBSERVED RUNOFF x 1000cum
0
2000
4000
6000
8000
10000
12000

Figure 17.1

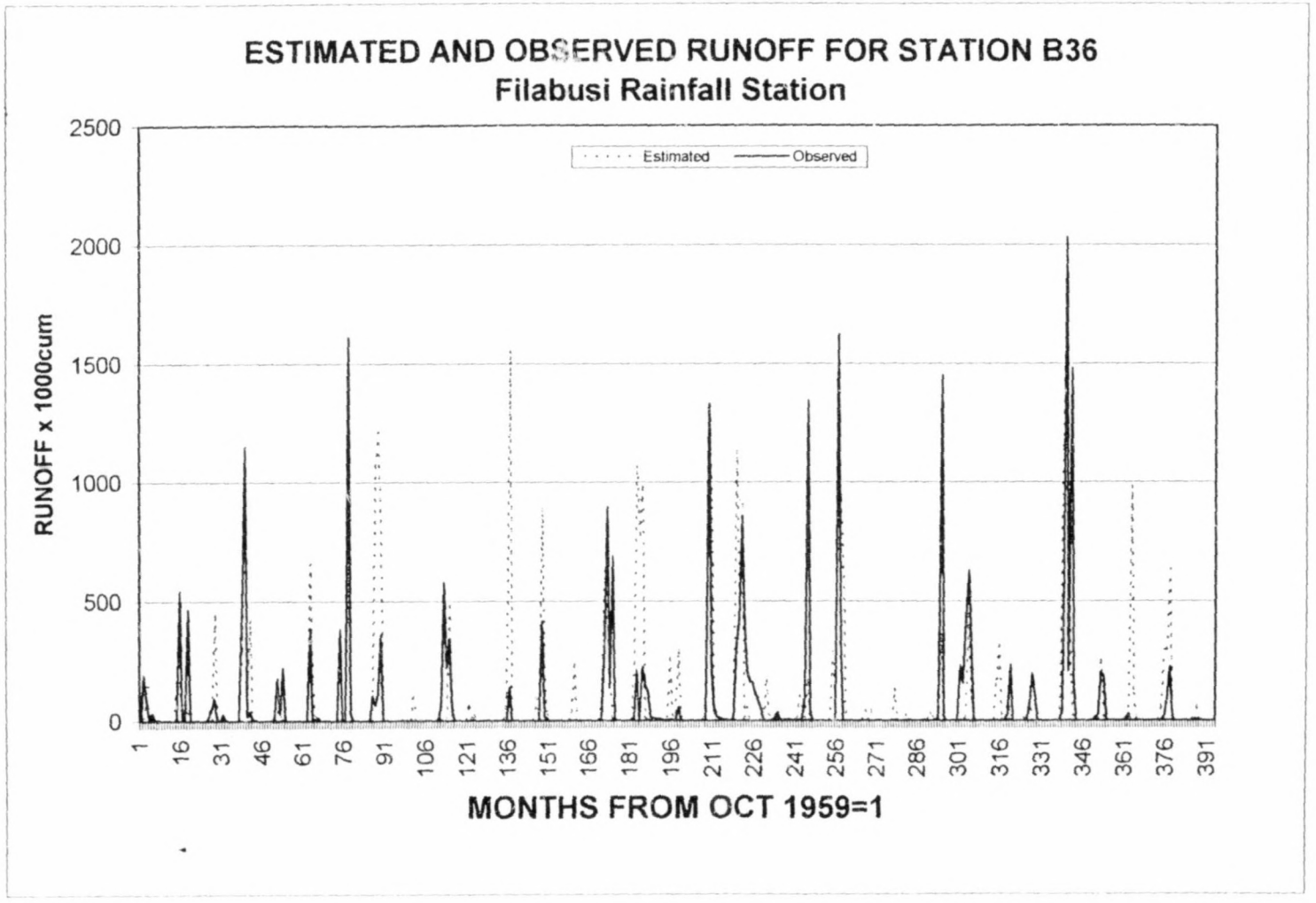

ESTIMATED AND OBSERVED RUNOFF FOR STATION B36
Filabusi Rainfall Station
Estimated
Observed
RUNOFF x 1000cum
2500
2000
1500
1000
500
0
1
16
31
46
61
76
91
106
121
136
151
166
181
196
211
226
241
256
271
286
301
316
331
346
361
376
391
MONTHS FROM OCT 1959=1

Figure 18

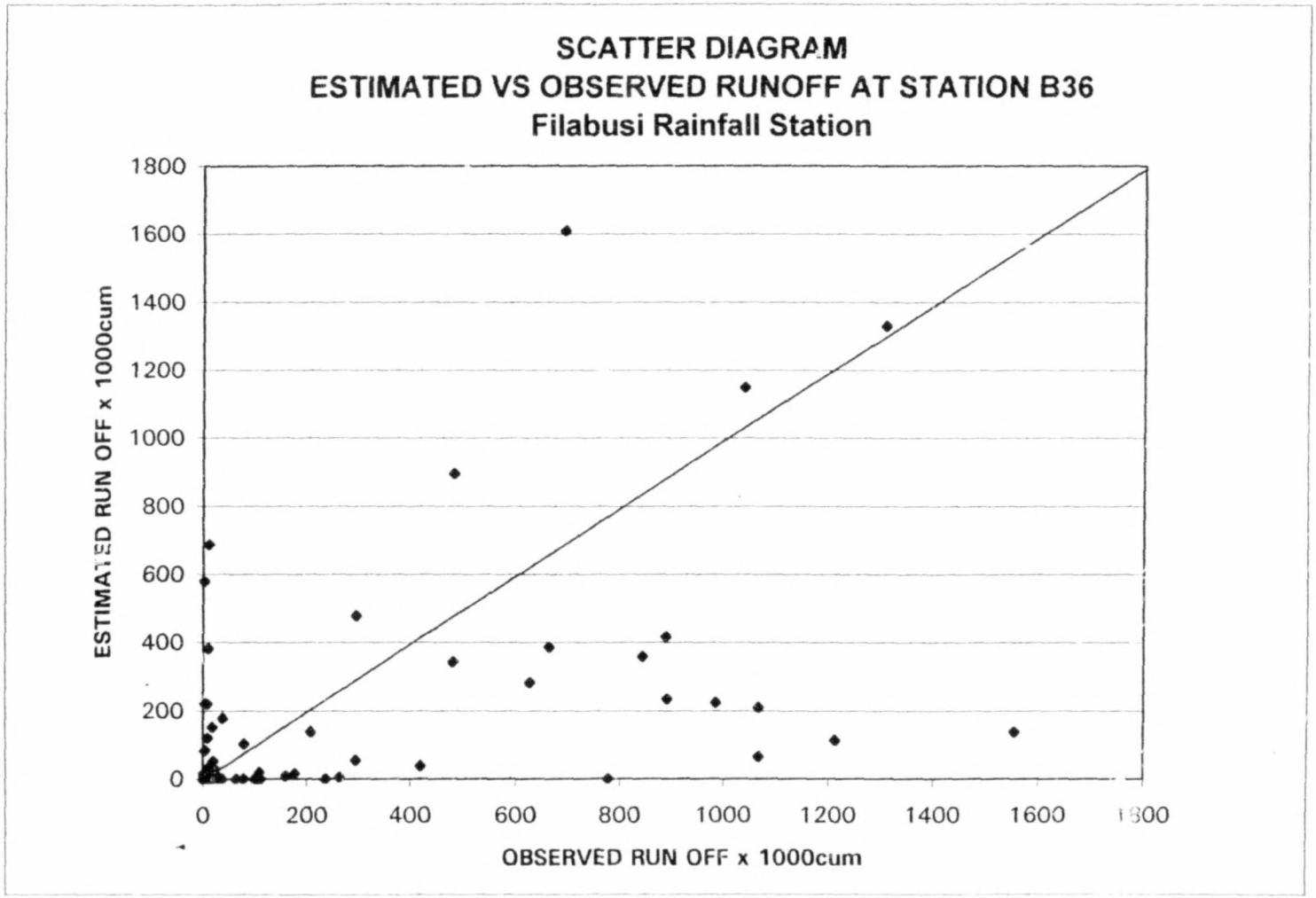

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUNOFF AT STATION B36
Filabusi Rainfall Station
ESTIMATED RUN OFF x 1000cum
OBSERVED RUN OFF x 1000cum
0
200
400
600
800
1000
1200
1400
1600
1800

Figure 18.1

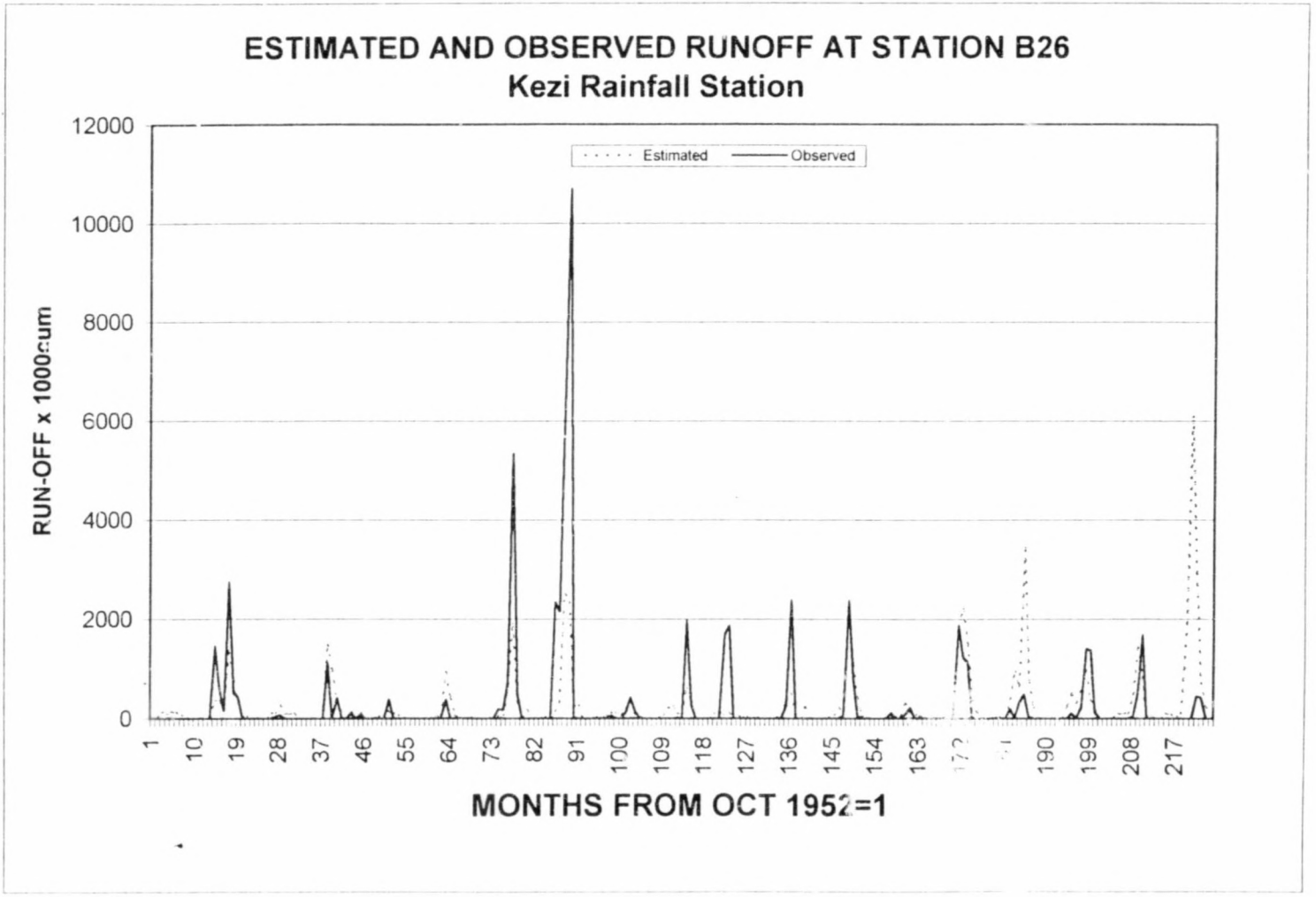

ESTIMATED AND OBSERVED RUNOFF AT STATION B26
Kezi Rainfall Station
Estimated
Observed
RUN-OFF x 1000cum
12000
10000
8000
6000
4000
2000
0
1
10
19
28
37
46
55
64
73
82
91
100
109
118
127
136
145
154
163
190
199
208
217
MONTHS FROM OCT 1952=1

Figure 19

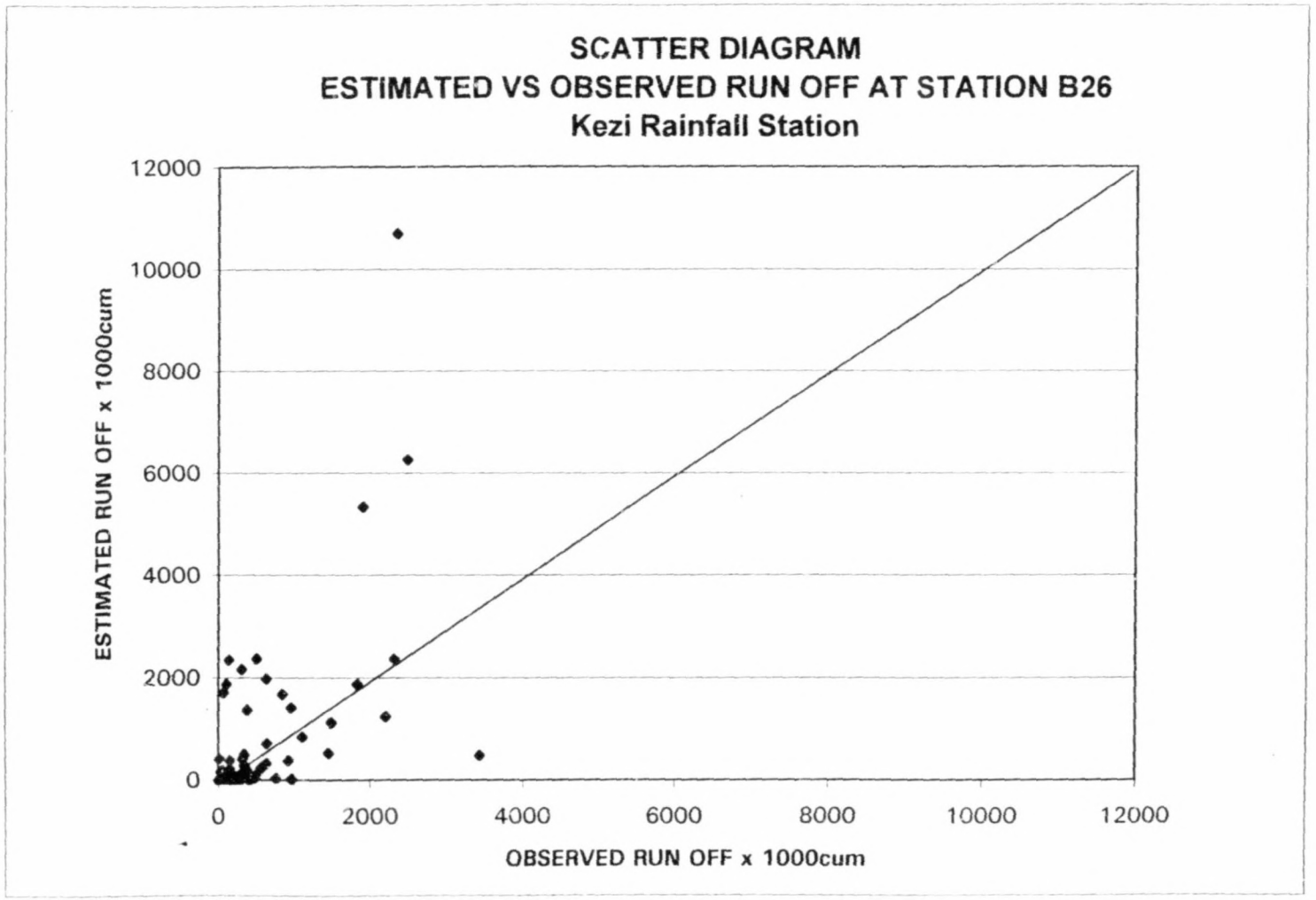

SCATTER DIAGRAM
ESTIMATED VS OBSERVED RUN OFF AT STATION B26
Kezi Rainfall Station
ESTIMATED RUN OFF x 1000cum
OBSERVED RUN OFF x 1000cum
0
2000
4000
6000
8000
10000
12000

Figure 19.1

APPENDIX II

Instructions for Microsoft Excel Spreadsheet

Instructions for Microsoft Excel Spreadsheet

A copy of the layout of the spreadsheet is attached. The letters A to AP refer to the columns on Microsoft Excel. Columns A to E have formula to derive the months in column F and the years in Column I. The first year of record is entered manually in the first cell of this column and the rest of the years are worked out automatically.

The following steps apply to micro catchment runoff analysis only. They should be followed in calibrating the spreadsheet for application on each sub-zone. Steps (b) to (f) and (q) to (s) are done only when step (a) is done for the first time. Steps (g) to (k) are for frequency analysis which is done only after the rainfall-runoff RAFLER has been calibrated to perform to the required accuracy.

a) Import output data from RAFLER on to Excel. Copy and paste data onto Column E the analysis spreadsheet (column E should have no entries before this step);
b) on the analysis spreadsheet, extend data references and formulae in columns A, B, C, D, F and G to match to range of data in column E;
c) extend data references and formulae in columns H and I to give correct reference to years of rainfall records for the estimated runoff;
d) extend column J to last year of record in column I;
e) import observed runoff data on to area bound at the top by entry A1 and AQ1. Do not import the annual totals;
f) extend data references and formulae in column AJ to cover all years of observed runoff data;
g) insert correct reference to annual totals of observed data into column U. Use column I to start entry in cell with correct year reference;
h) copy values only from column J and paste them in column V;
i) sort data in column V in ascending order;
j) extend column W to the same number of column entries as in column L;

k) enter the correct formula into Z16 and replicate to the same number of column entries as in column L. The formula for Z16 is of the form:

(1-W16/(WΦ+1)*100 where Φ is the raw reference of the last entry in Column W;

l) check month and year of first record of observed runoff and work out cell reference for the corresponding estimated runoff using columns A B,C, D and E. Enter this cell reference of column E into cell AG16, copy and replicate to extend data references and formulae down column AG;

m) copy AH16 and replicate down column AH to extend data references and formulae to the full length of data in column AG;

n) copy AI16 and replicate down column AI to extend data references and formulae to the full length of data in column AH;

o) extend formulae in column AJ to cover whole range of observed data. Check that every entry is correct;

p) correct cell references in column AN to read set of continuous observed data for use in comparative analysis;

q) correct cell references in column AO to read set of estimated data to match the set of continuous observed data in column AN;

r) modify cell references and titles on graphs.

SUB-ZONE AS1, RAINFALL-STATION LUPANE,RUNOFF STATION-A37

MICRO CATCHMENT CA (sq. km) 1370

A	B	C	D	E	F	G	H	I	J	K	L	M	N
				Input Values ↓									
← YEAR CALC →							← FREQUENCY ANALYSIS						
									D →		21		42
Month			Year	Estimate	Month	Estimate	Month	Year	Annual Est	An. E. mm	P=1	P=1	P=2
1	0	0	0	0.414967	1	0.414967	12	1939	31169	23	23	7	
2	0	0	0	2.90988	2	3.324847	24	1940	40142	29	29	7	52
3	0	0	0	9.732197	3	13.05704	36	1941	76669	56	56	7	85
4	0	0	0	2.978032	4	16.03508	48	1942	13419	10	10	7	66
5	0	0	0	2.029999	5	18.06508	60	1943	29450	21	21	8	31
6	0	0	0	0.171491	6	18.23657	72	1944	40174	29	29	8	51
7	0	0	0	0.171323	7	18.40789	84	1945	23758	17	17	9	47
8	0	0	0	0.683187	8	19.09108	96	1946	27837	20	20	9	38
9	0	0	0	1.236644	9	20.32772	108	1947	14987	11	11	9	31
10	0	0	0	1.153932	10	21.48165	120	1948	41267	30	30	10	41
11	0	0	0	3.593684	11	25.07534	132	1949	17016	12	12	10	43
12	1	1	0	6.093744	12	31.16908	144	1950	19372	14	14	10	27
13	0	1	1	2.270787	13	2.270787	156	1951	14425	11	11	10	25
14	0	1	1	4.638047	14	6.908834	168	1952	33076	24	24	10	35
15	0	1	1	12.84661	15	19.75544	180	1953	46814	34	34	11	58

O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB

	63		84								P=1	P=2
P=2	P=3	P=3	P=4	P=4	10yr RM	Annual Obs Est Sorted	Rank	Annual	Rank	Frequency	% on mean	% on mean
14		22		30		10671.44	1	10671	1	97	32	33
16		29		39		11416.96	2	11417	2	94	33	38
17	108	30		43		11454.61	3	11455	3	91	34	40
20	95	30	118	57		12142.49	4	12142	4	89	35	48
21	87	34	117	61		12792.13	5	12792	5	86	39	50
22	61	37	117	78		13287.83	6	13288	6	83	40	52
22	68	44	78	79		13737.23	7	13737	7	80	41	52
23	67	48	88			14281.74	8	14282	8	77	43	55
25	49	49	78			14649.39	9	14649	9	74	44	60
25	61	56	79		33887	14690.35	10	14690	10	71	45	60
26	53	61	74		32472	15523.5	11	15523	11	69	46	62
31	57		68		30395	16108.12	12	16108	12	66	47	74
31	37		67		24170	16382.33	13	16382	13	63	47	74
31	49		61		26136	16410.24	14	16410	14	60	49	74
31	69		83		27872	16645.35	15	16645	15	57	50	74

AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP

Input Values

P=3 % on mean	P=4 % on mean	mm	Frequency	Est Oct 64	Month	SCATTER TESTS Estimate	Observed
35	36	8	98	0.4576648	1	458	43
46	47	8	97	1.665809	2	1666	227
48	51	8	95	1.905674	3	1906	3160
48	68	9	93	4.065668	4	4066	4080
54	73	9	91	5.044245	5	5044	2680
59	93	10	90	3.111032	6	3111	405
70	94	10	88	2.266507	7	2267	192
76		10	86	1.564762	8	1565	151
78		11	84	0.1361772	9	136	218
89		11	83	0.1360917	10	136	279
97		11	81	0.1360032	11	136	266
		12	79	0.1358962	12	136	210
		12	78	3.042077	13	3042	394
		12	76	1.521083	14	1521	294
		12	74	1.666674	15	1667	380

RAFLER Input Parameters

Line 98	6
Line 100	16
Line 1860	
Line 1861	1,2,1,107858,12702,0.41,0.3,0.3,5,0.3,0,0.006

For Monthly Data

	Estimated	Observed
Mean	2570	2371
Variance	16597006	20967450.7
Standard Deviation	4074	4579
Maximum	31847	24800
Minimum	127	0

For Annual Data

	Estimated	Observed
Mean	27171	25601
Variance	1.72E+08	3.38E+08
Standard Deviation	13099	18375
Maximum	51677	60714
Minimum	9096	5697

Author Nyabeze W R R
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