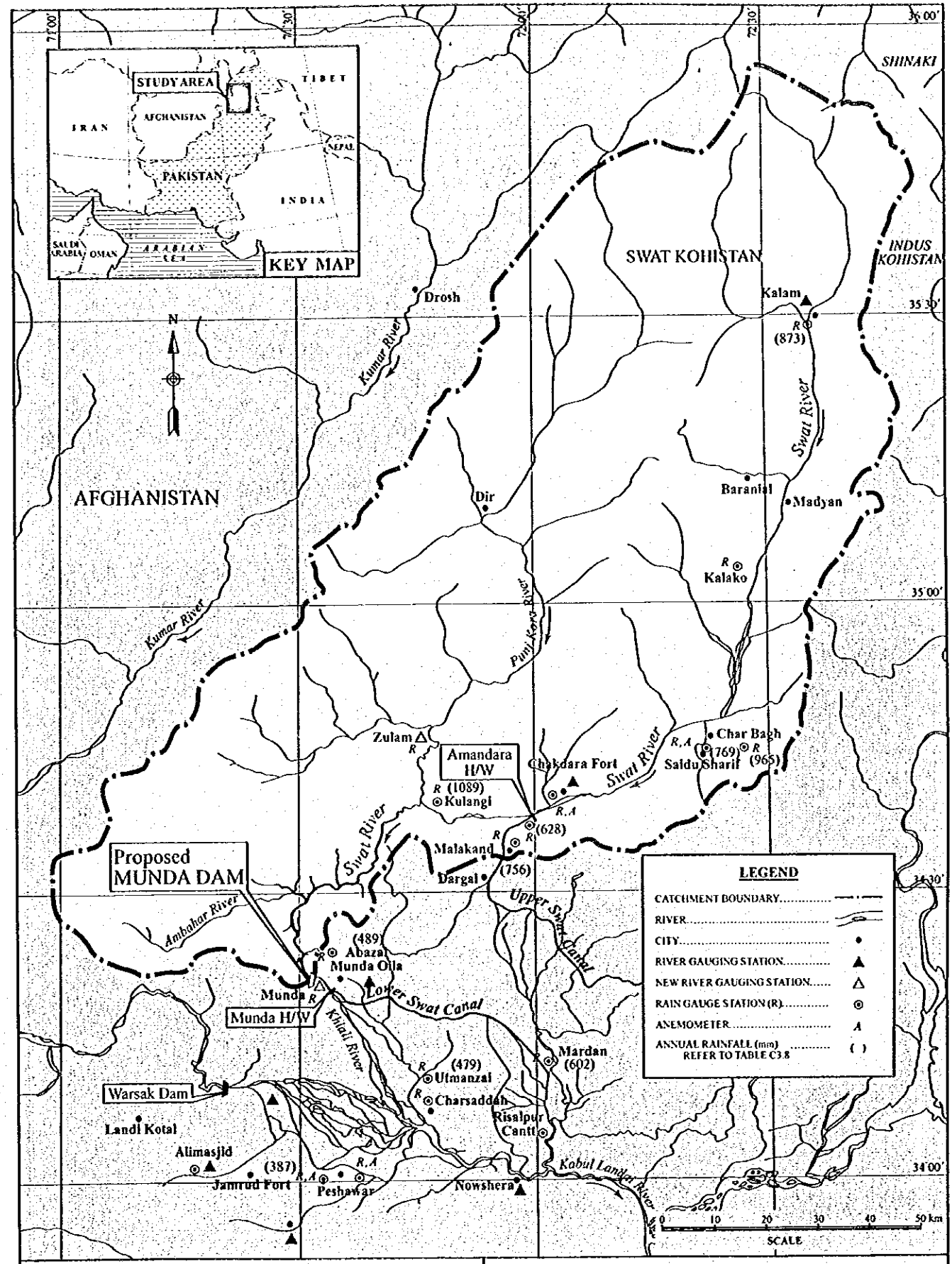
APPENDIX C

FIGURES



FEASIBILITY STUDY
ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT
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Figure C1.1
Existing Hydrometeorological Stations along Swat River

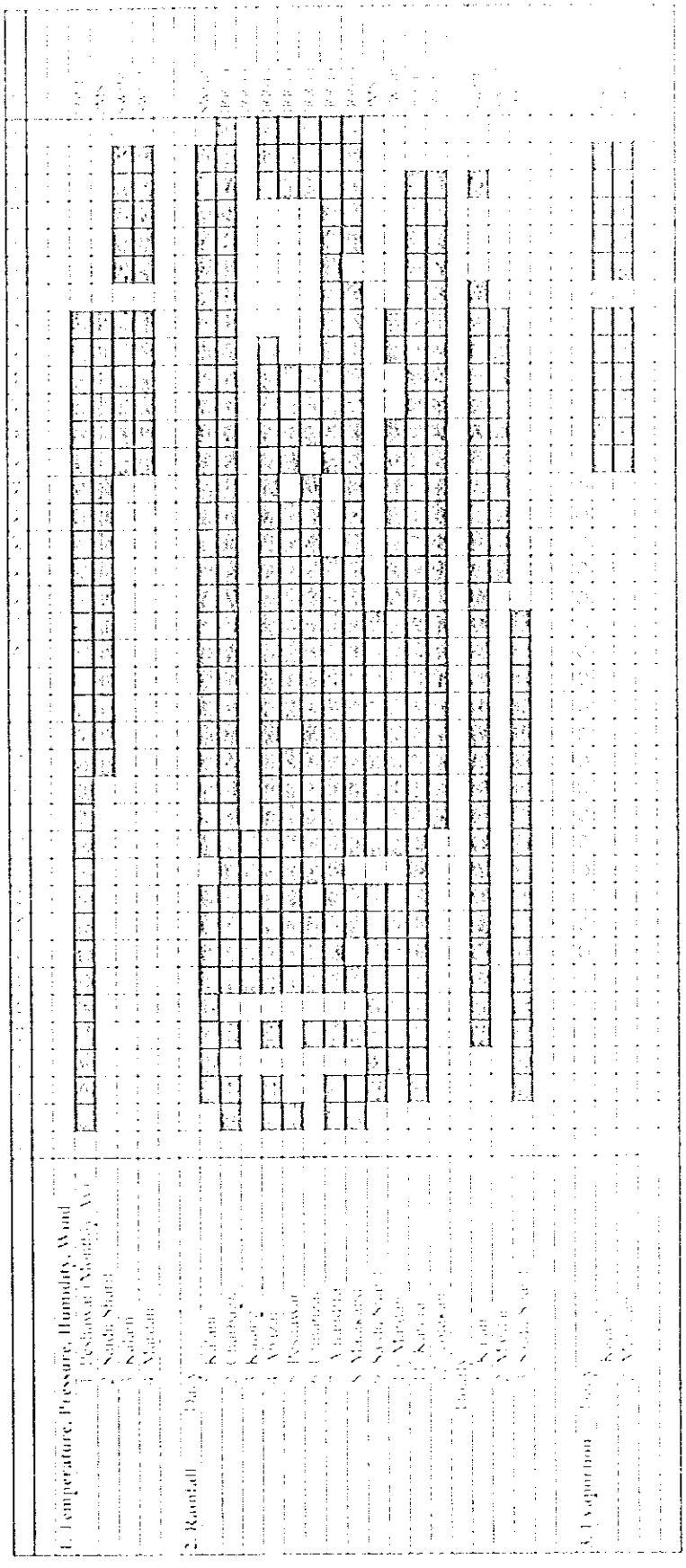
FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C1.2** **Satellite Image Map of Munda Dam Basin** **(November 1976)**

Figure C 1.2

Satellite Image Map of Munda Dam Basin
(November 1976)

FEASIBILITY STUDY
ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT
IN ISLAMIC REPUBLIC OF PAKISTAN
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure C2.1
Inventory of the Meteorological Data Collected During Field Investigation Stage



FEASIBILITY STUDY
ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT
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Figure C 2.1
Inventory of the Meteorological Data Collected During Field Investigation Stage

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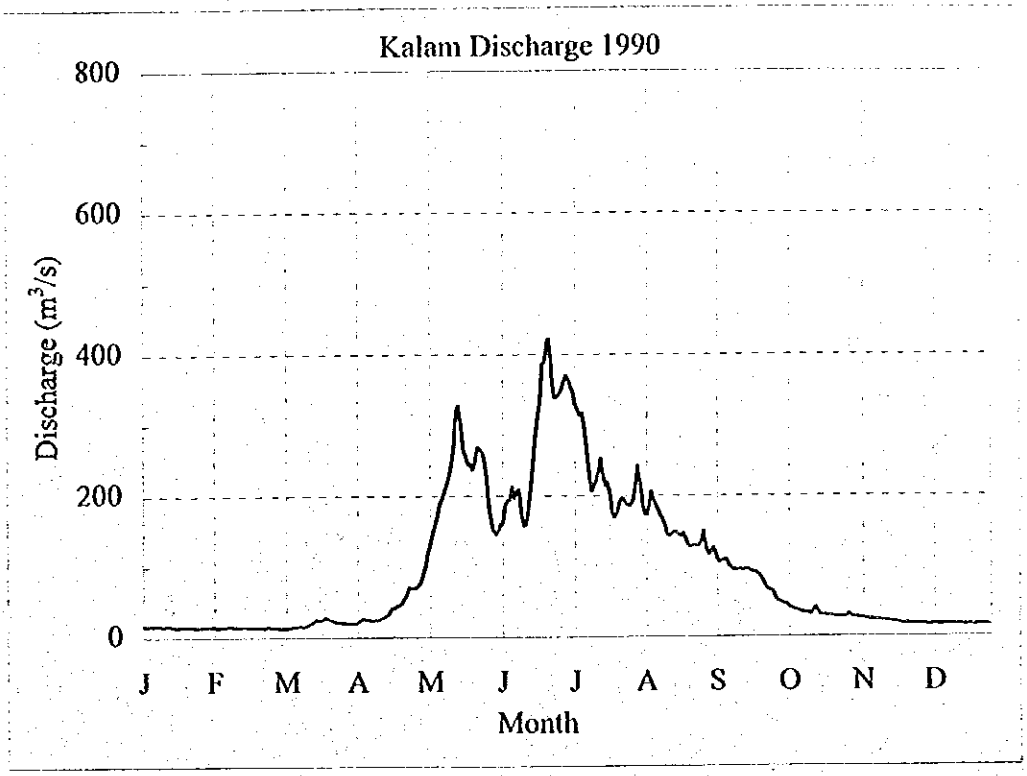
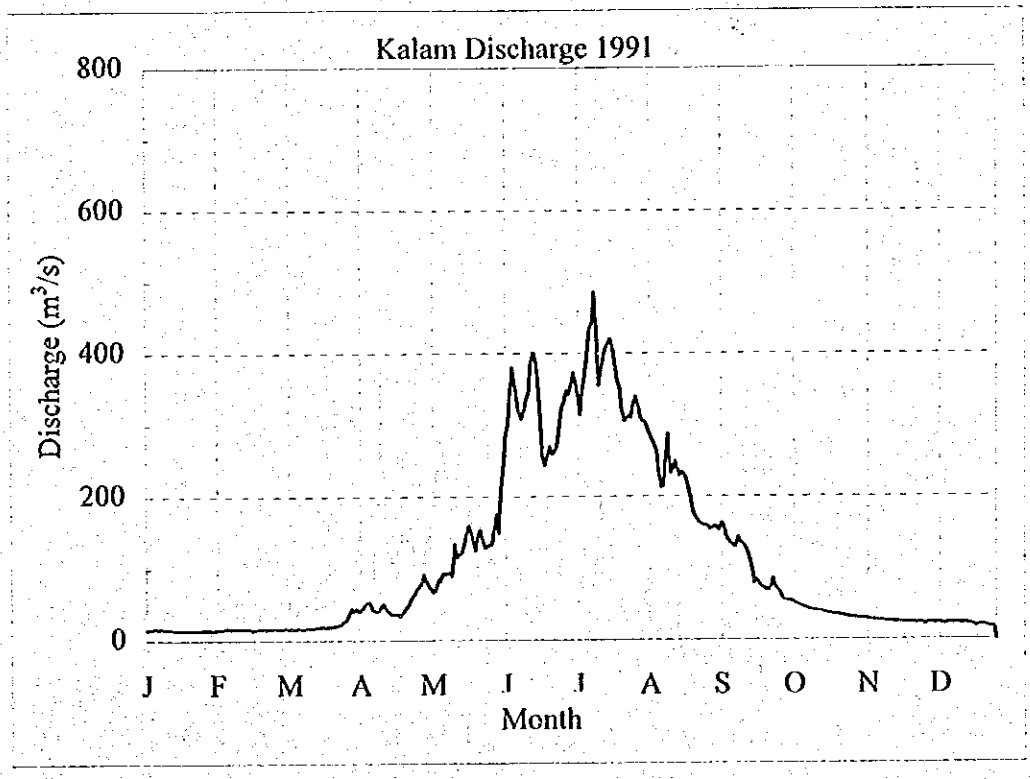
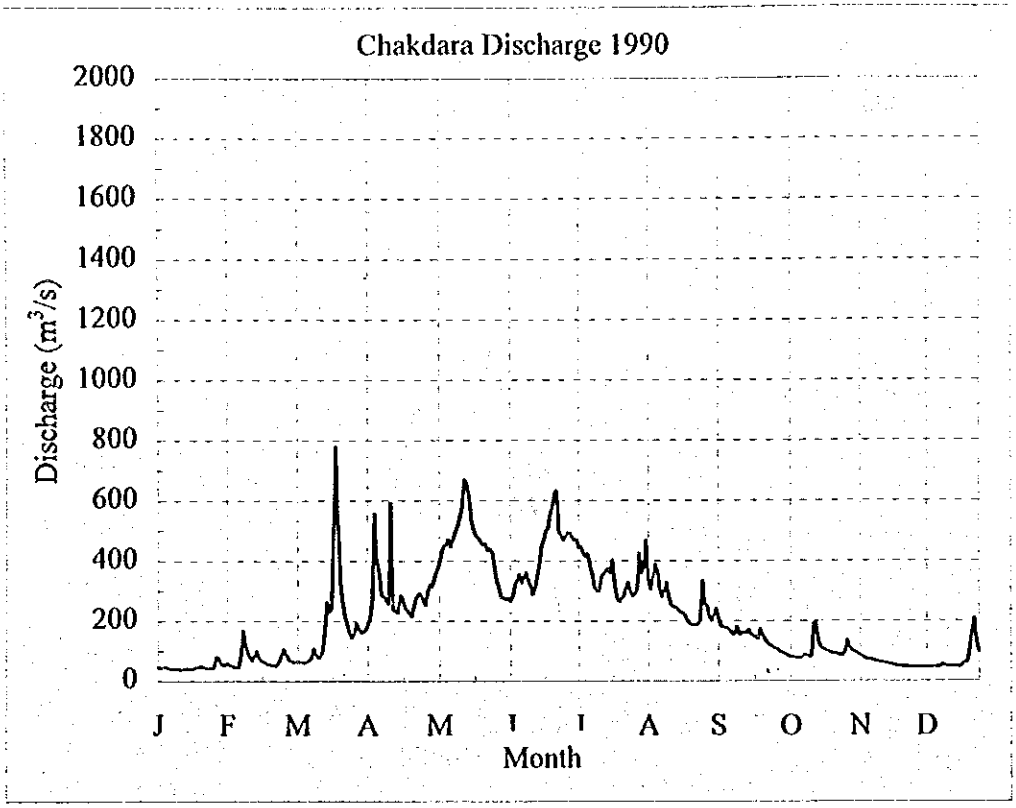
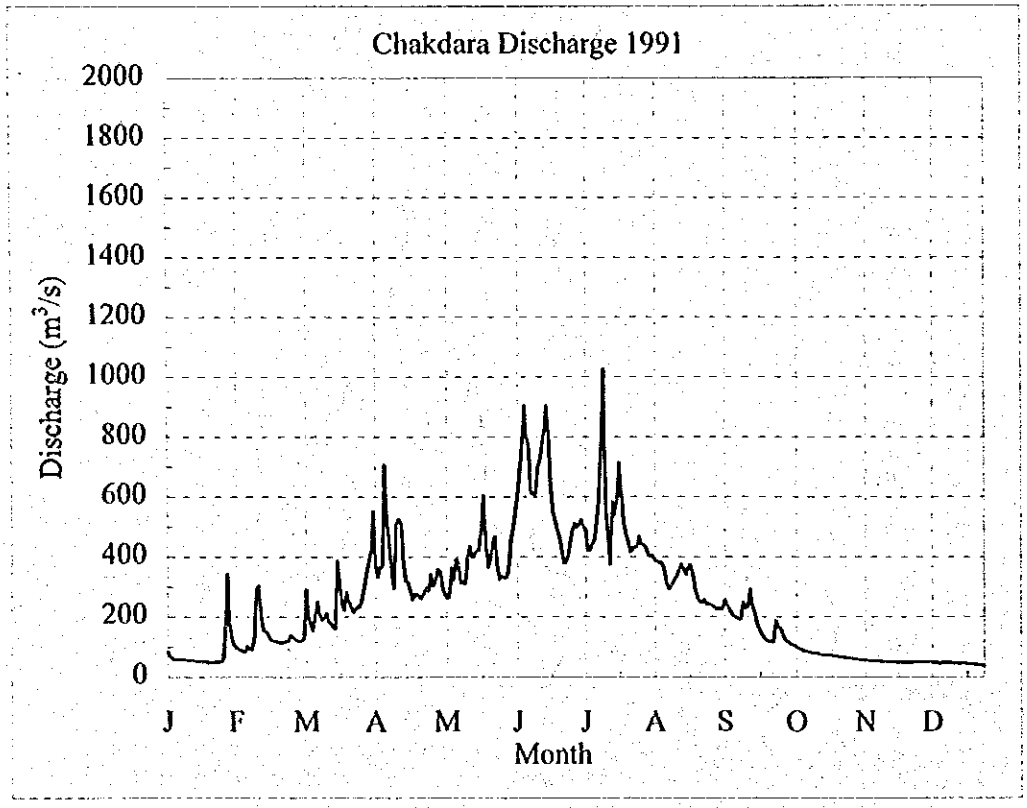
Figure C2.2
Inventory of the Hydrological Data Collected During Field Investigation Stage



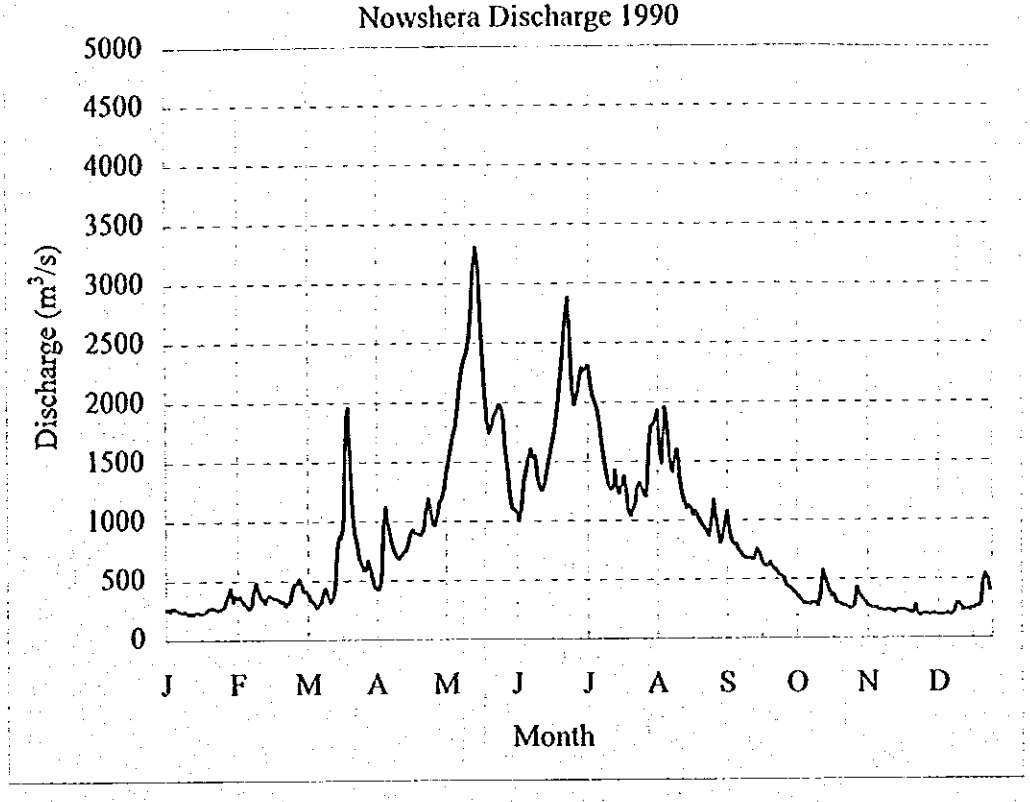


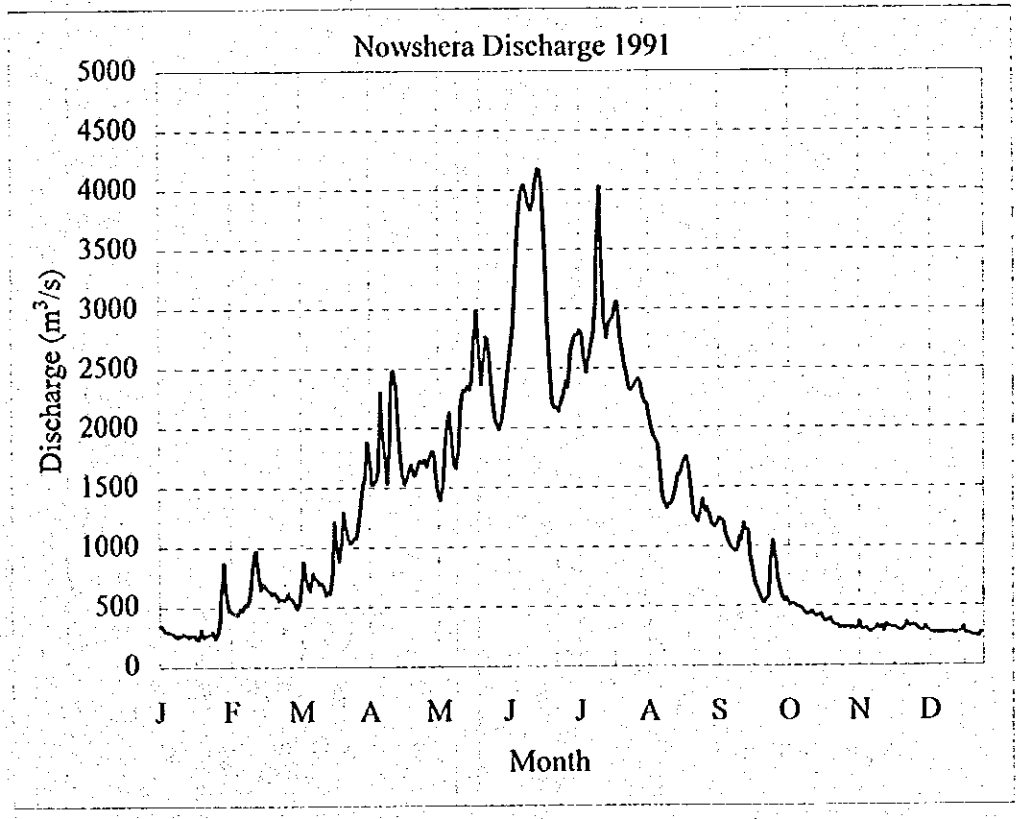
FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C2.3** **Daily Discharge at Kalam Water Level Station in 1990 - 1991**





FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C2.4** **Daily Discharge at Chakdara Water Level Station in 1990 - 1991**





FEASIBILITY STUDY
ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT
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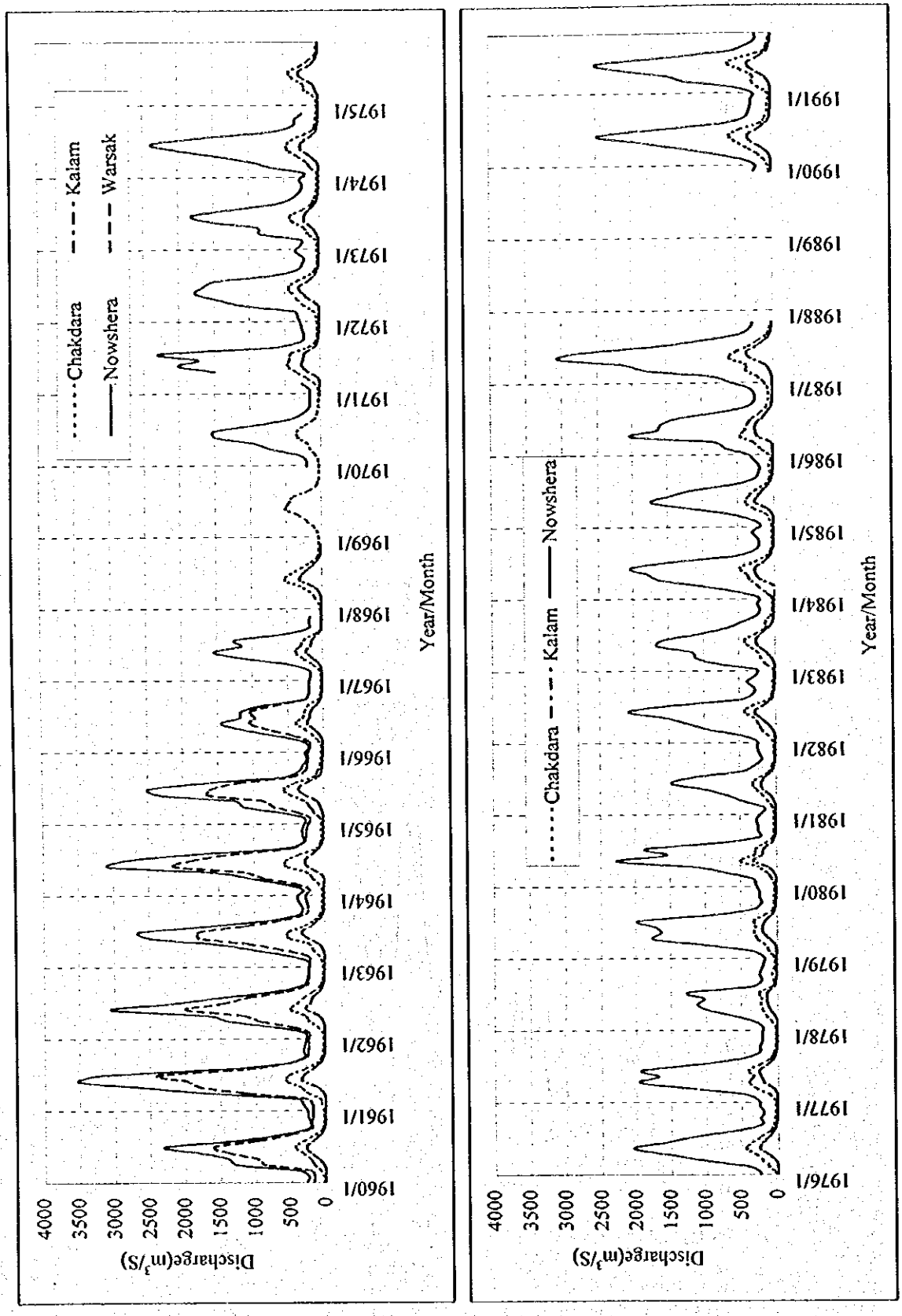
Figure C2.5
Daily Discharge at Nowshera Water Level Station in 1990 - 1991



FEASIBILITY STUDY
ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT
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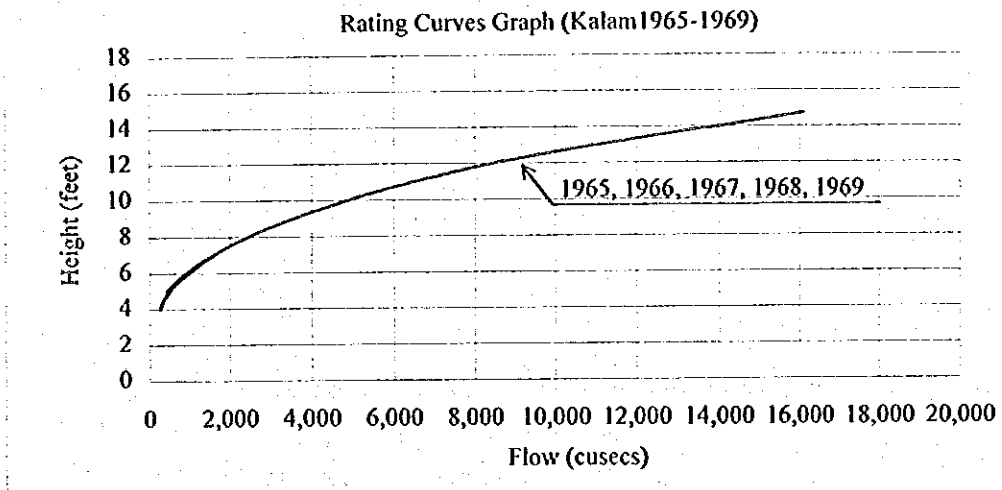
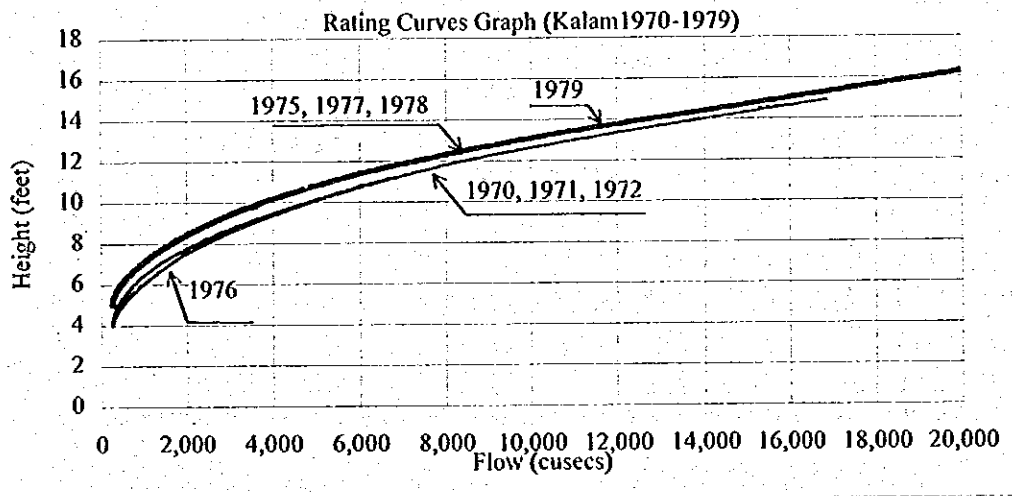
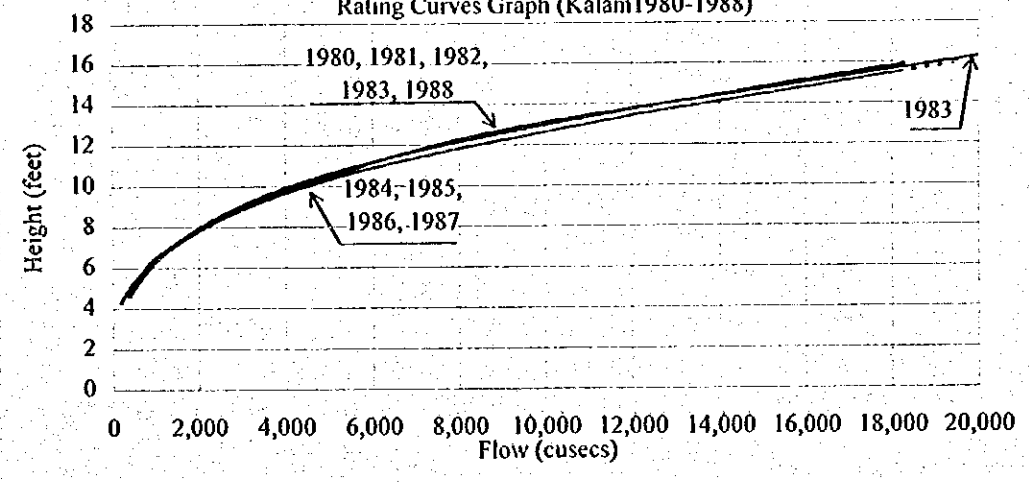
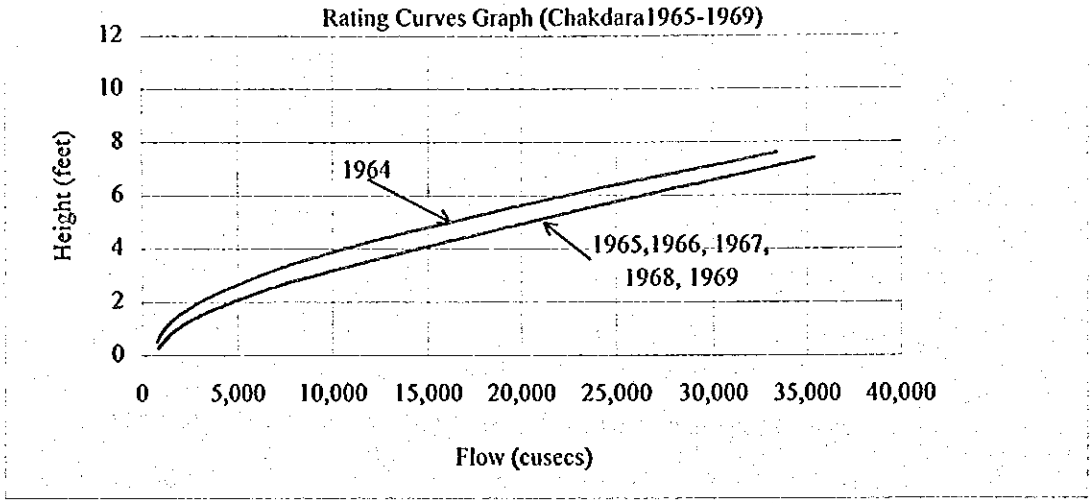
Figure C2.6
Monthly Average Discharge at Kalam, Chakdara, Warsak and Nowshera Stations

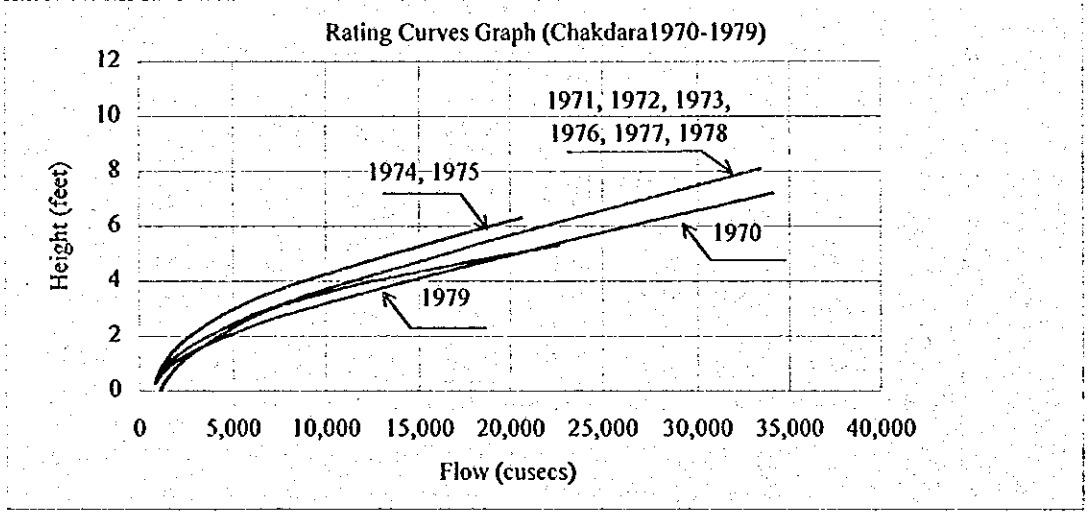


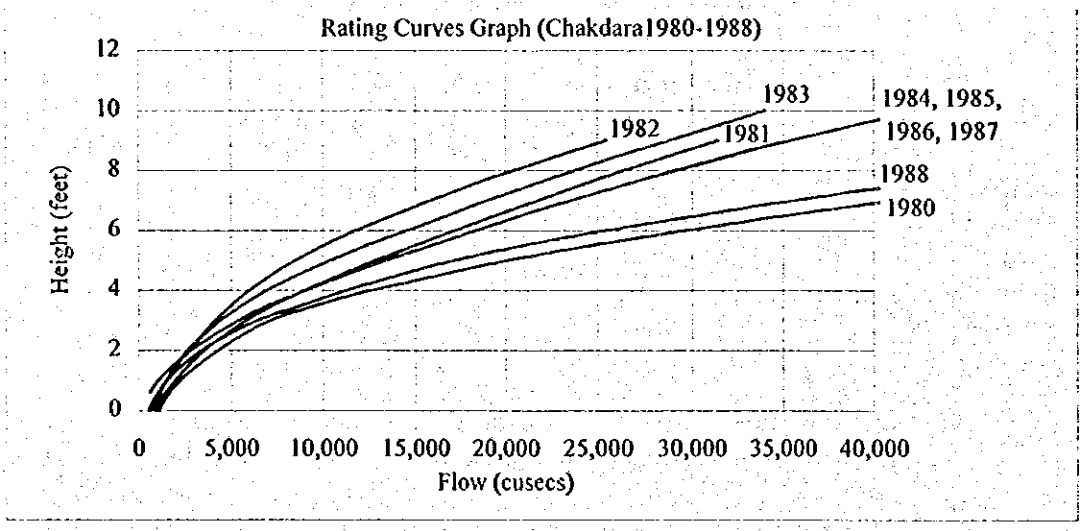




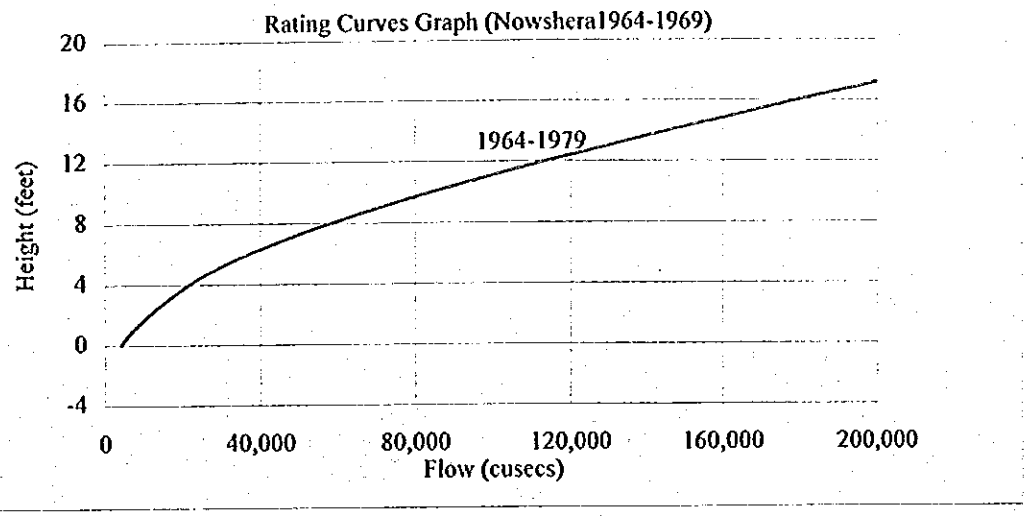
FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C2.7** **Rating Curves at Kalam Water Level Station**

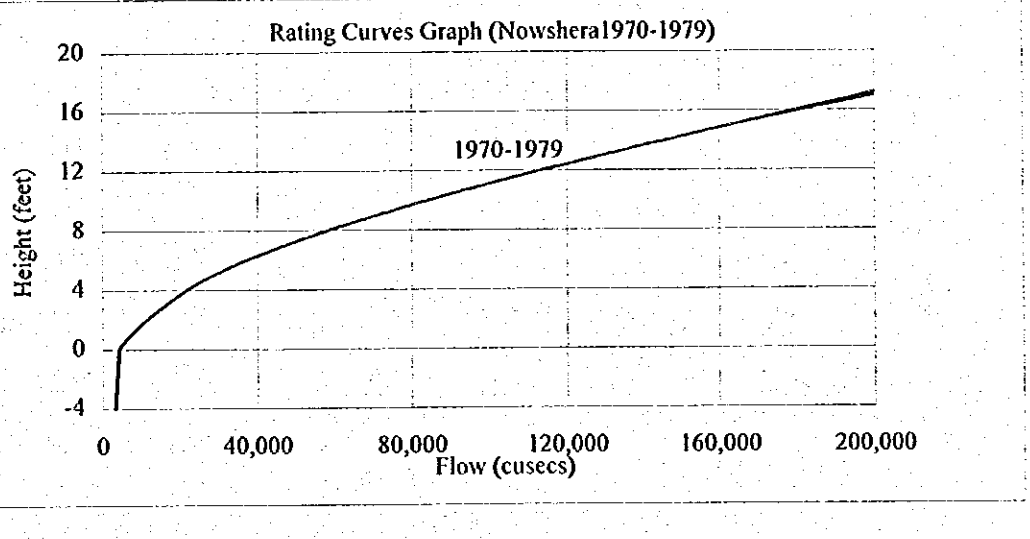


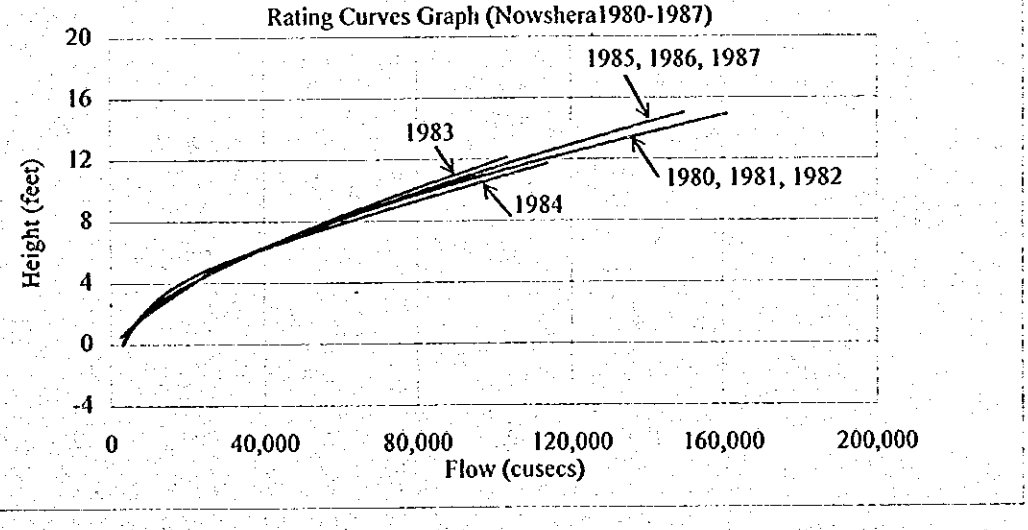




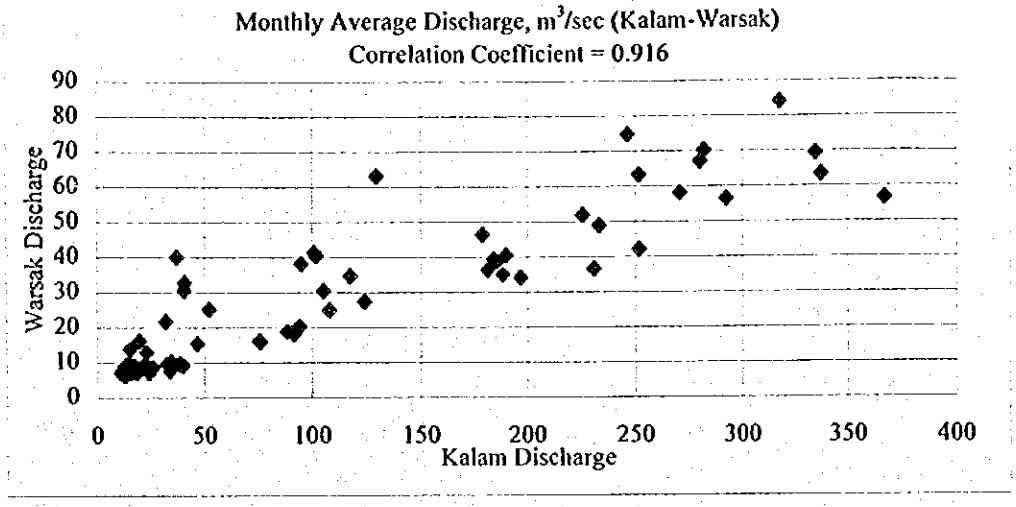
FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C2.8** **Rating Curves at Chakdara Water Level Station**

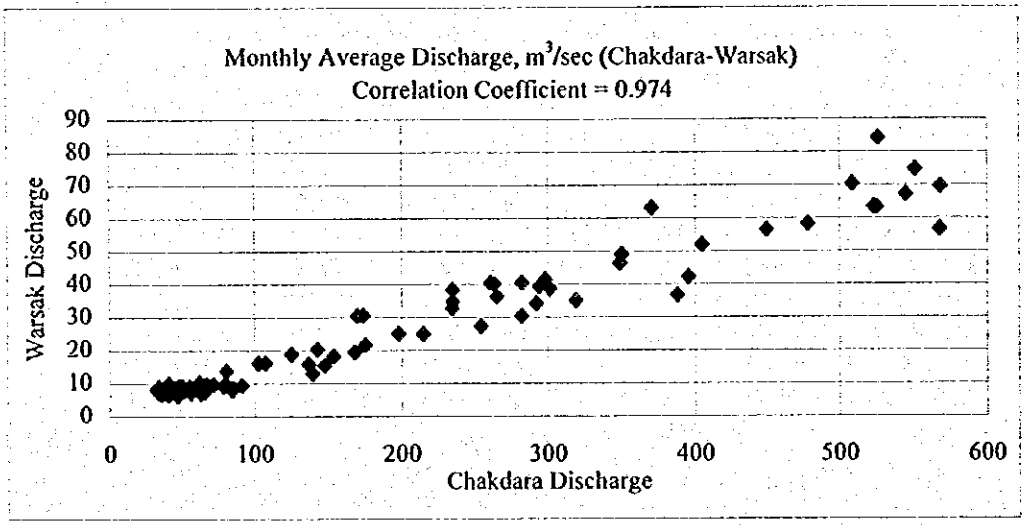


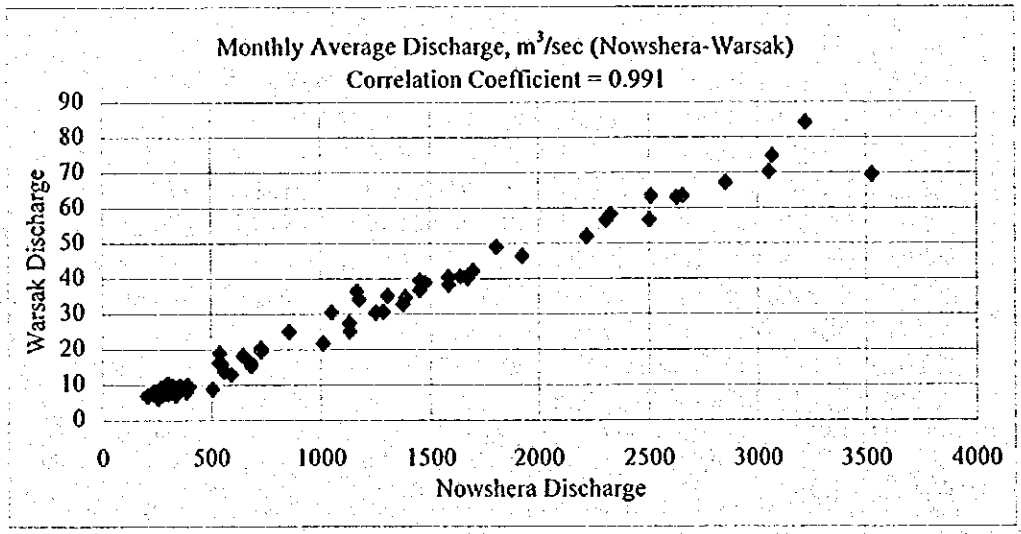




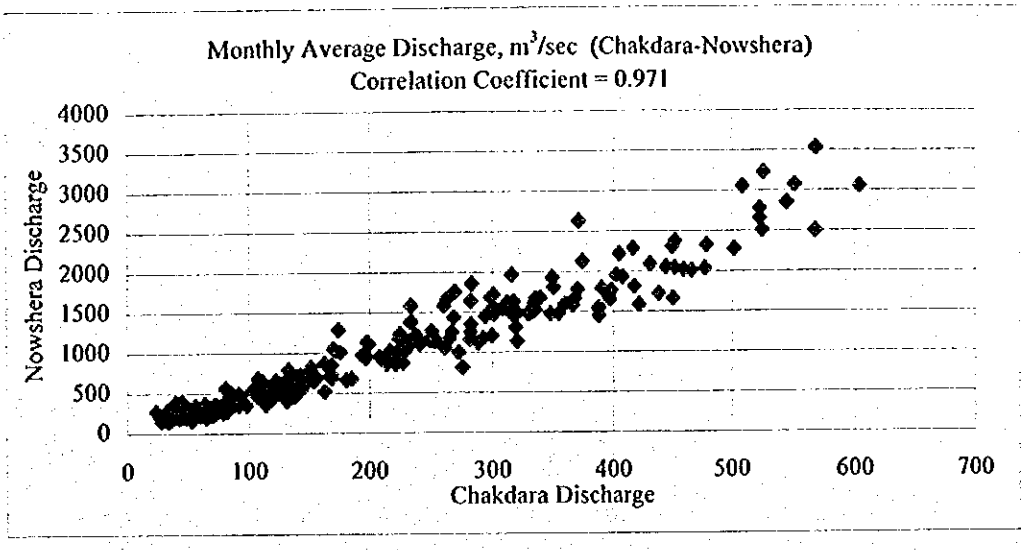
FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	Figure C2.9 Rating Curves at Nowshera Water Level Station

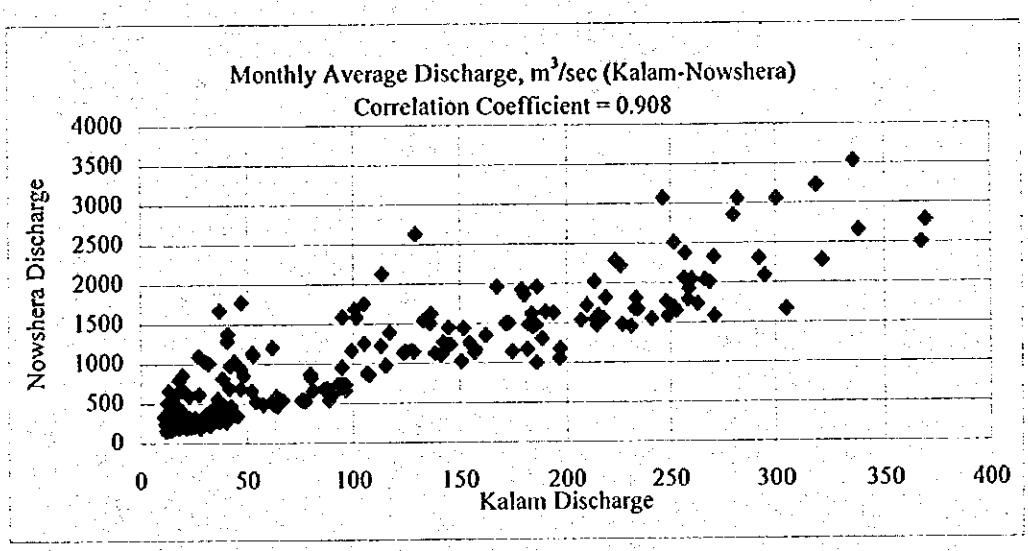


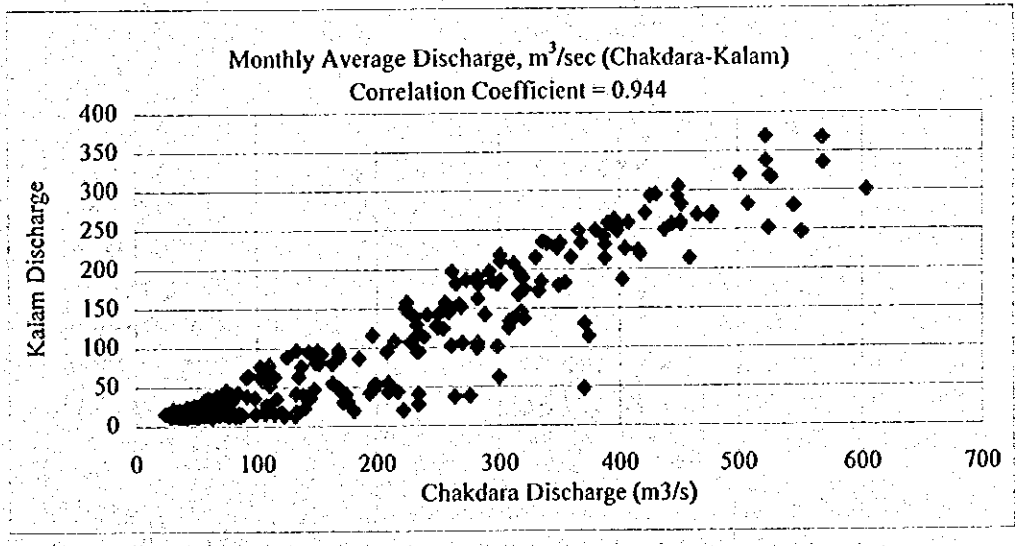




FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C2.10** **Correlation Coefficient of Monthly Discharge with Warsak Station**







FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C2.11** **Correlation Coefficient of Monthly Discharge with Nowshera and Kalam Stations**

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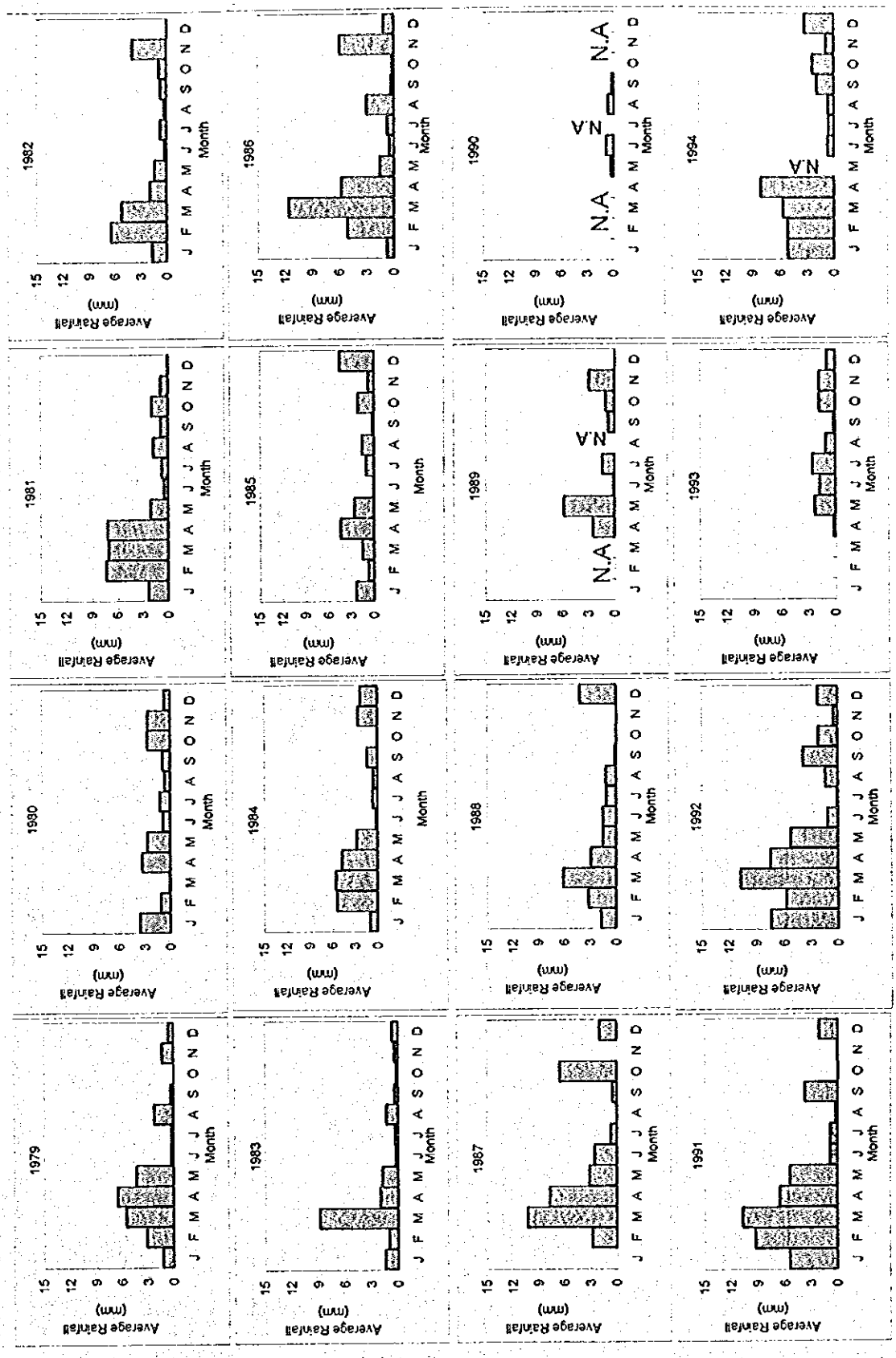
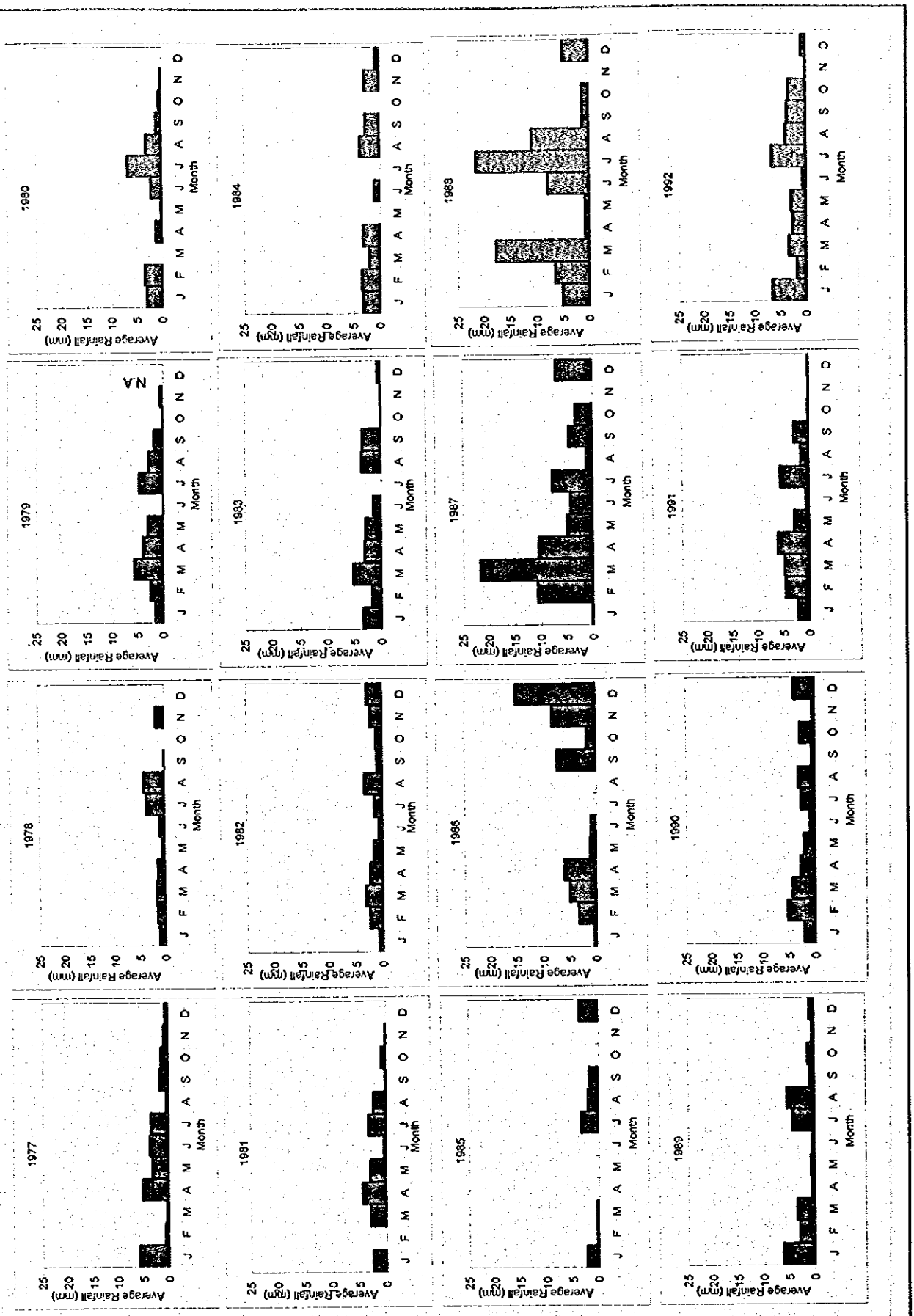
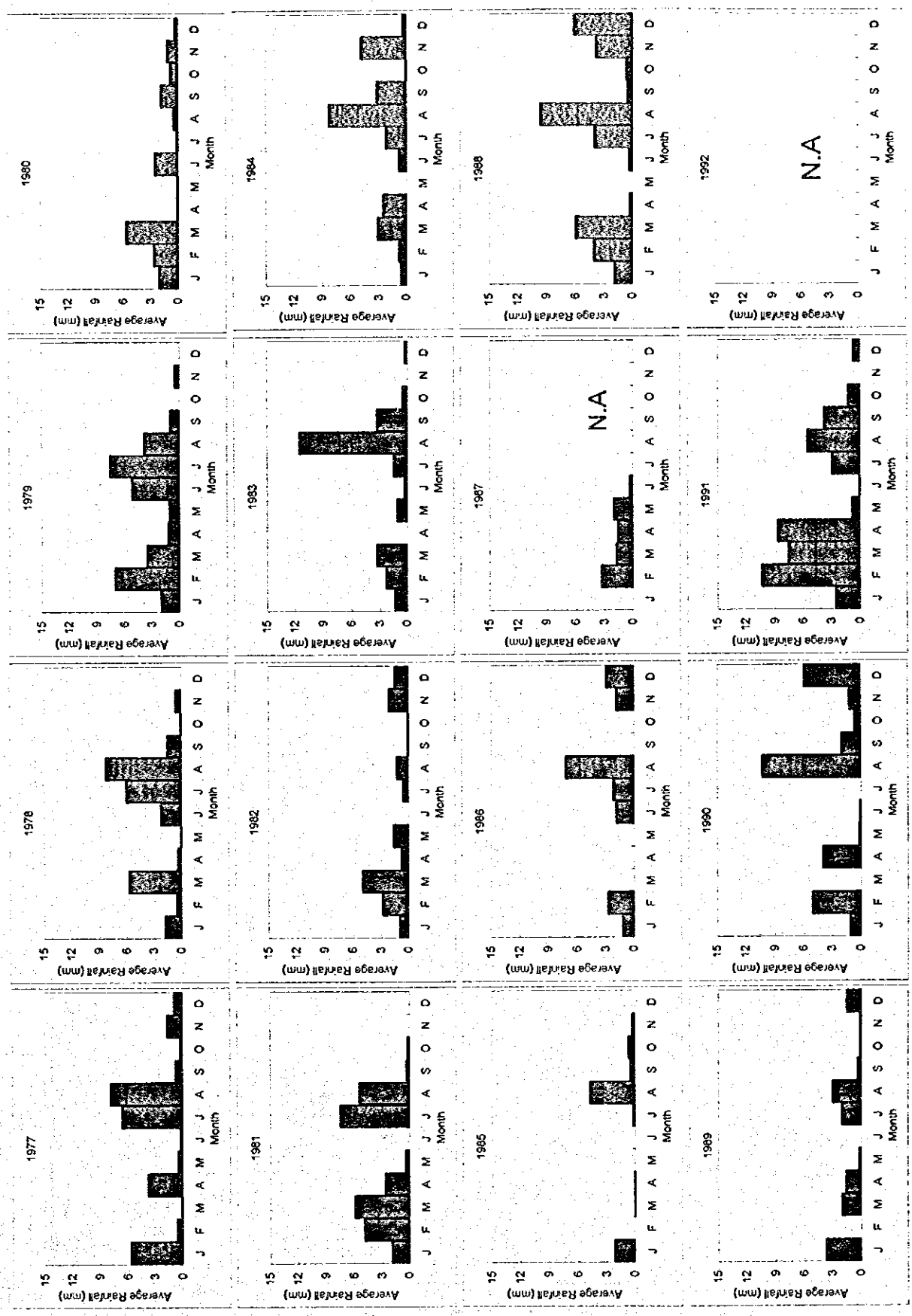
Figure C2.12
Correlation Coefficient of Monthly Discharge with Munda Headworks



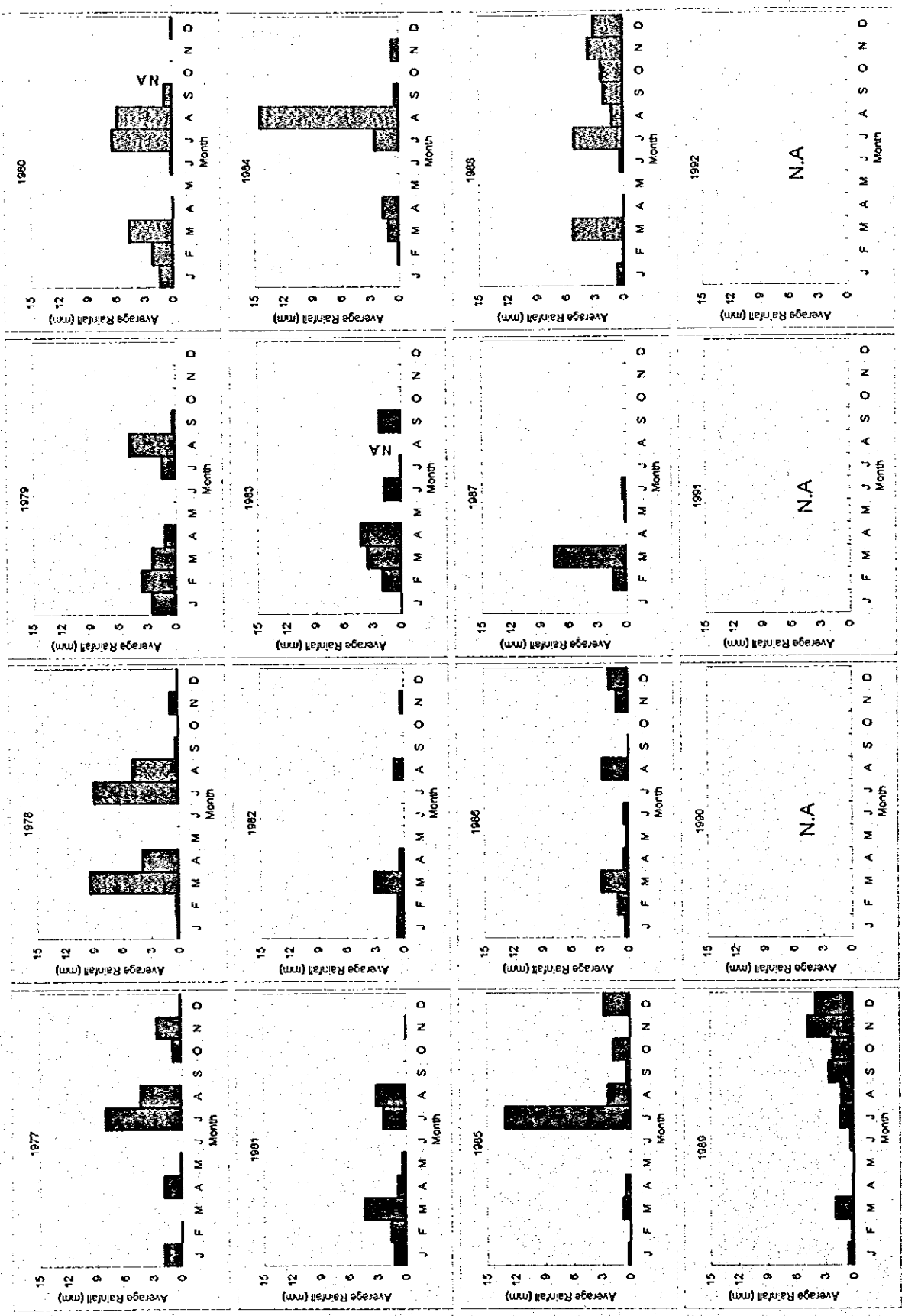
FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C3.1** **Monthly Rainfall at Kalam Gauging Station**



FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C3.2** **Monthly Rainfall at Charbagh Gauging Station**



FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C3.3** **Monthly Rainfall at Malakand Gauging Station**



FEASIBILITY STUDY
ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT
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Figure C3.4

Monthly Rainfall at Abazai Gauging Station

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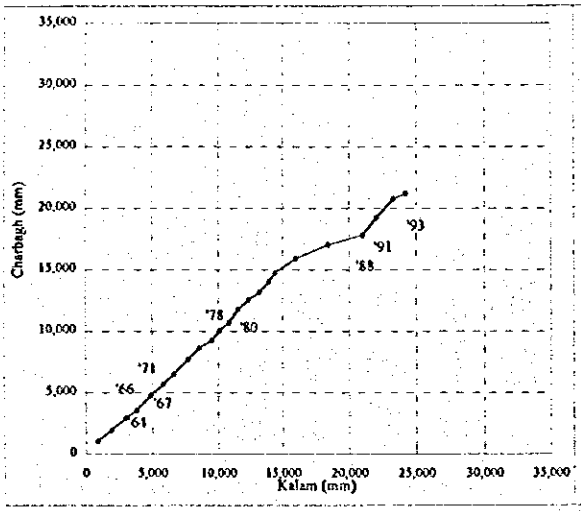
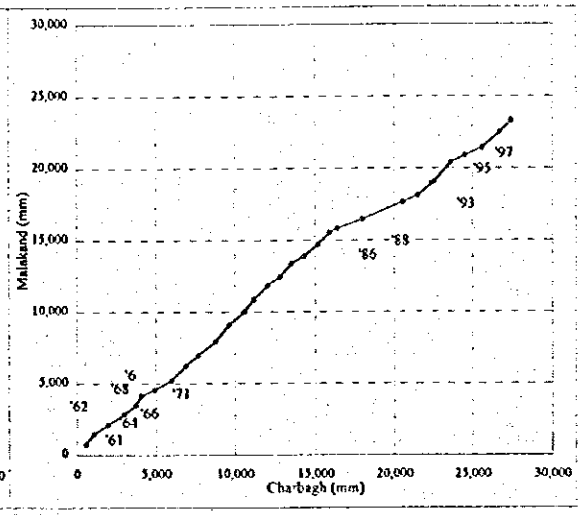
Figure C3.5

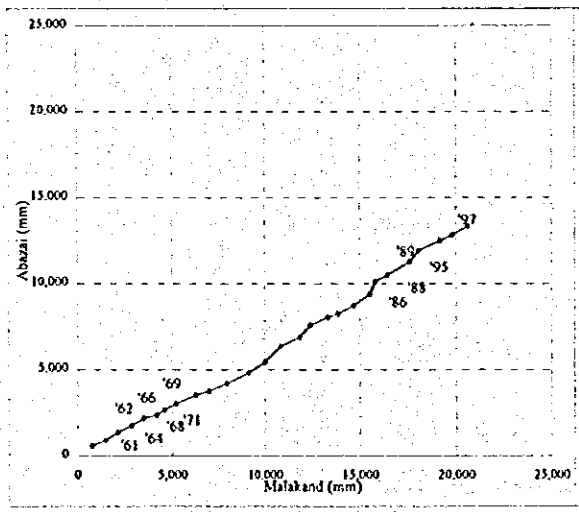
Average Monthly Rainfall for the period 1961 - 1997



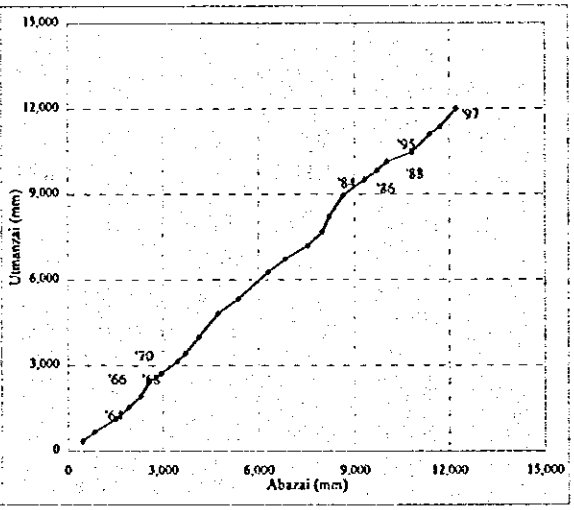
(a) Kalam and Charbagh



(b) Charbagh and Malakand

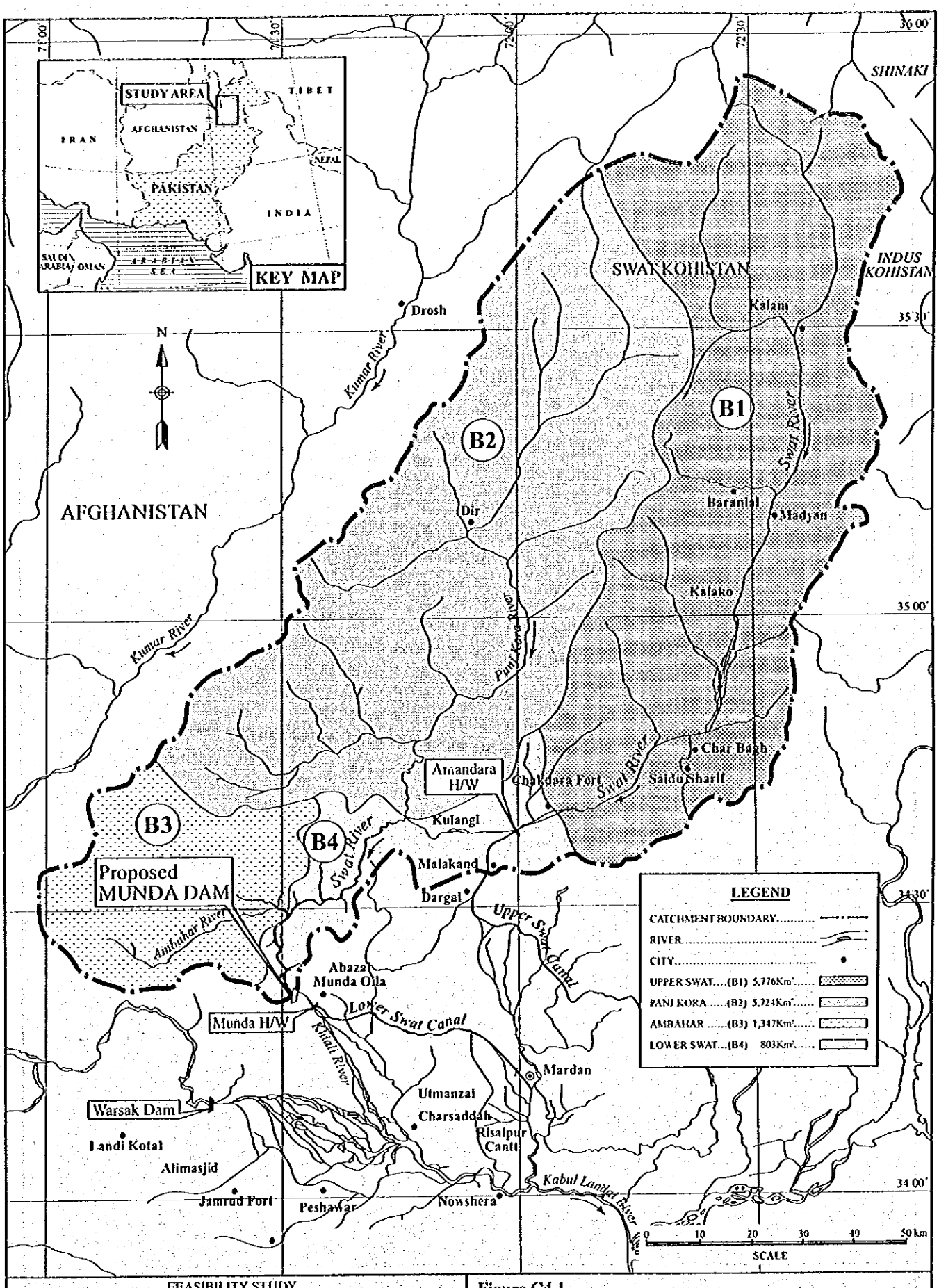


(c) Malakand and Abazai



(d) Abazai and Utmanzai

FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C3.6** **Double Mass Curve of Annual Rainfall**



FEASIBILITY STUDY
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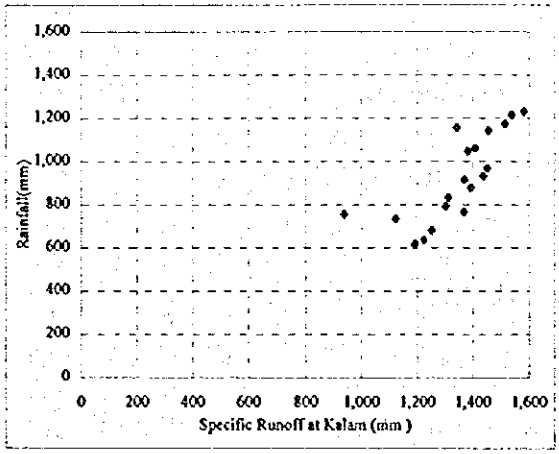
Figure C4.1

Catchment Areas and Subbasins up to Munda Dam Site

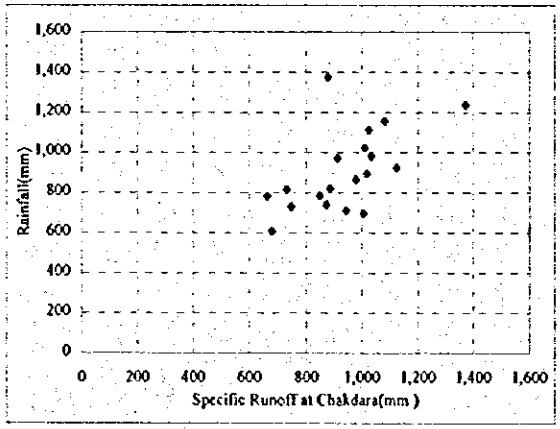
Year	Specific Flow (mm)	Rainfall at Kalam (mm)	Runoff Coefficient
1964	1,408	1,060	1.33
1965	1,580	1,231	1.28
1966	1,370	915	1.50
1967	1,452	968	1.50
1969	1,647	998	1.65
1971	1,223	635	1.93
1972	1,513	1,173	1.29
1975	1,537	1,215	1.27
1976	1,437	934	1.54
1977	1,190	614	1.94
1978	1,302	792	1.64
1979	1,312	834	1.57
1980	1,252	681	1.84
1981	1,383	1,047	1.32
1982	938	756	1.24
1983	1,194	621	1.92
1984	1,394	878	1.59
1985	1,123	734	1.53
1986	1,343	1,156	1.16
1987	1,455	1,142	1.27
1988	1,369	765	1.79
1991	1,727	1,416	1.22
Total	30,151	20,564	1.47

Kalam



Year	Specific Flow (mm)	Rainfall at Kalam mm	Rainfall Charbagh mm	Average Rainfall (mm)	Runoff Coefficient
1964	913	1,060	884	972	0.94
1966	1,034	915	1,047	981	1.05
1967	1,011	968	1,079	1,023	0.99
1969	748	635	822	728	1.03
1971	1,025	1,173	1,052	1,112	0.92
1972	1,124	906	943	924	1.22
1975	732	839	792	815	0.90
1976	1,081	1,215	1,096	1,155	0.94
1977	1,018	934	853	893	1.14
1978	849	614	953	784	1.08
1979	1,006	792	599	696	1.45
1980	944	681	739	710	1.33
1981	979	1,047	682	865	1.13
1982	665	756	809	782	0.85
1983	872	621	857	739	1.18
1984	886	878	759	819	1.08
1985	681	734	481	608	1.12
1986	878	1,156	1,591	1,373	0.64
1991	1,373	1,416	1,055	1,236	1.11
Total	17,818			17,217	1.03

Chakdara



FEASIBILITY STUDY
ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT
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Figure C4.2

Specific Runoff and Rainfall at Kalam and Chakdara

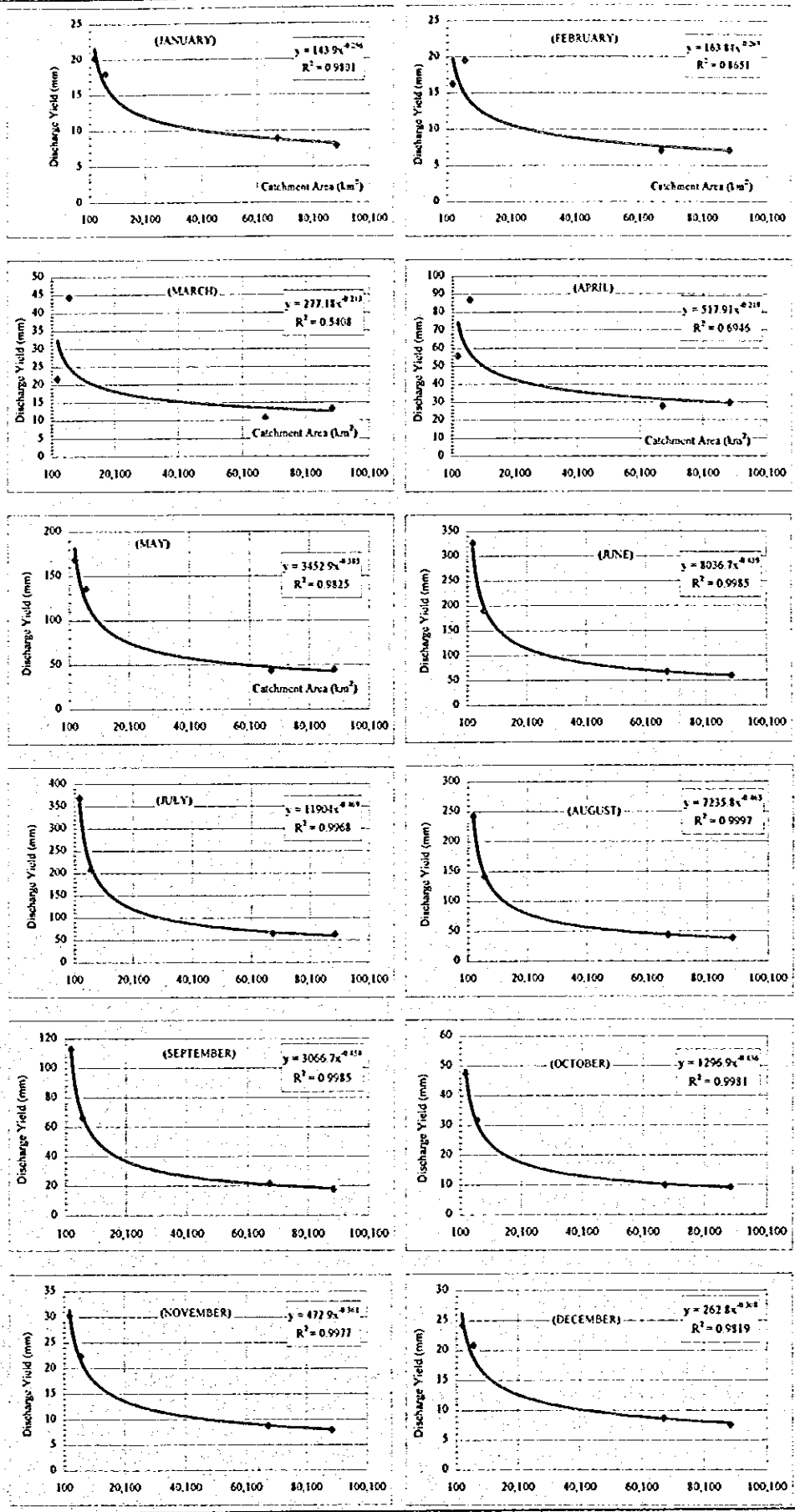

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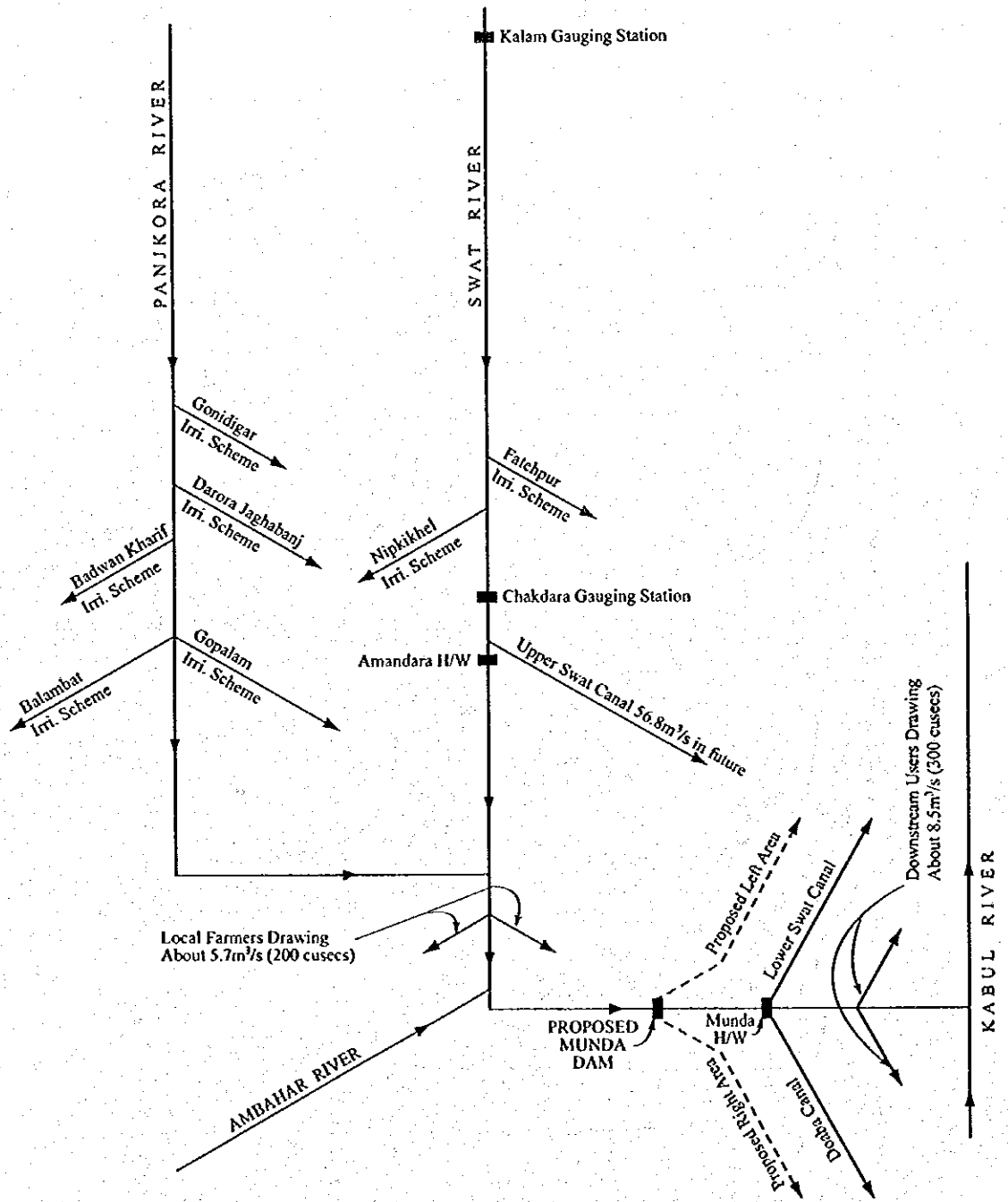
Figure C4.4

Discharge Yield vs. Catchment Area



Notes : 1) Intake discharges for the about irrigation schemes and canals are presented in Tables C4.1, C4.4 and C4.6.
2) Future intake discharge for both of LSC and Doaba canal is 37.4m³/s on annual averaage.

FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C4.5** **Irrigation Schemes of Swat River Basin**

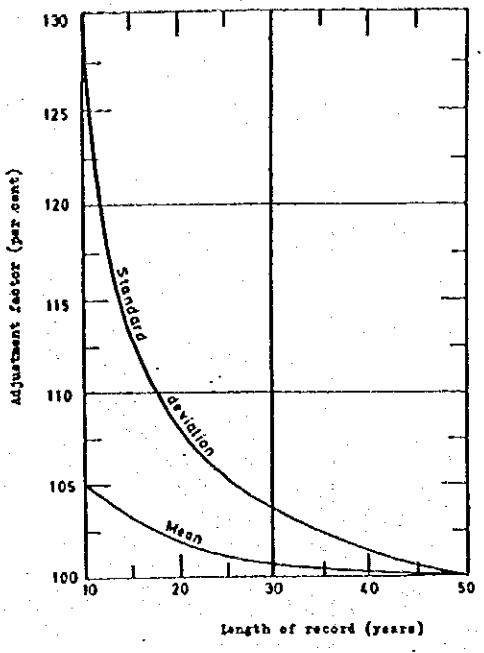


Figure 4.4 - Adjustment of mean and standard deviation of annual series for length of record (after Hershfield [3])

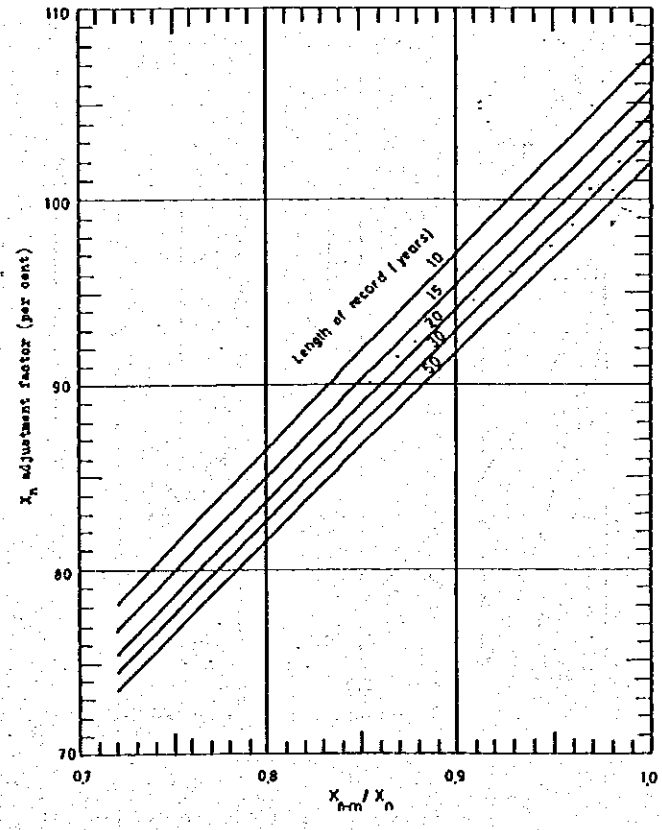


Figure 4.2 - Adjustment of mean of annual series for maximum observed rainfall

(Source: WMO-332)

FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C5.2** **Adjustment of Mean and Standard Deviation and Mean of Annual Series**

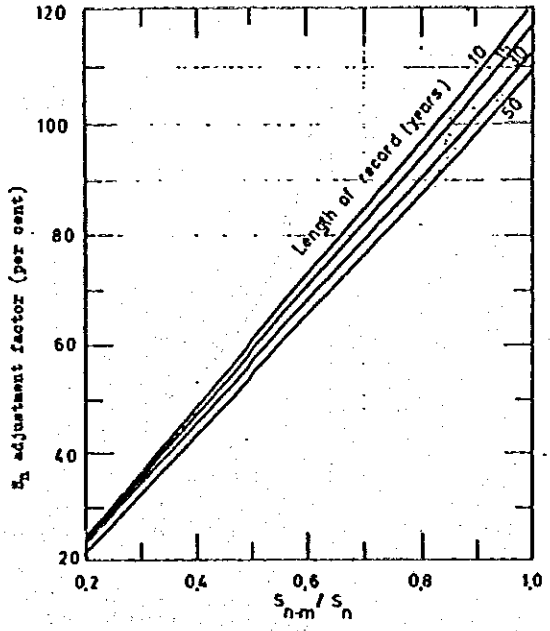


Figure 4.3 - Adjustment of standard deviation of annual series for maximum observed rainfall

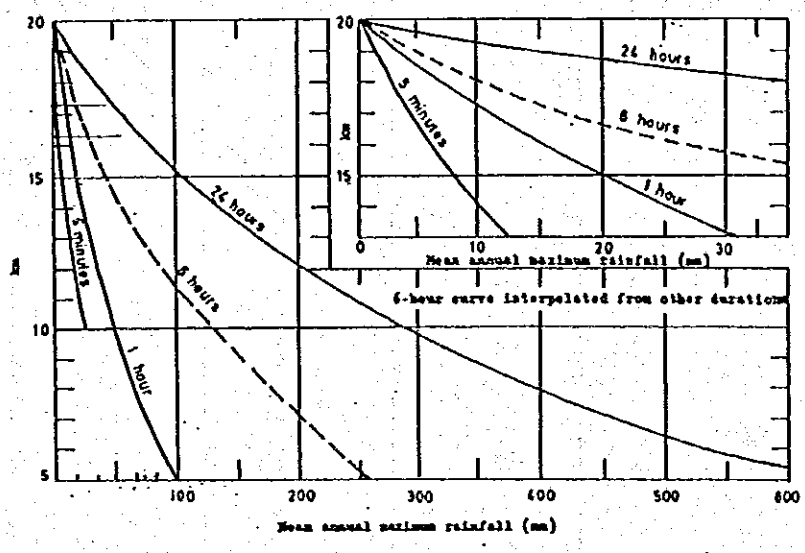


Figure 4.1 - K_m as a function of rainfall duration and mean of annual series (after Hershfield [4])

(Source: WMO-332)

FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C5.3** **Adjustment of Standard Deviation and Parameter *km* as a Function of Rainfall Duration**

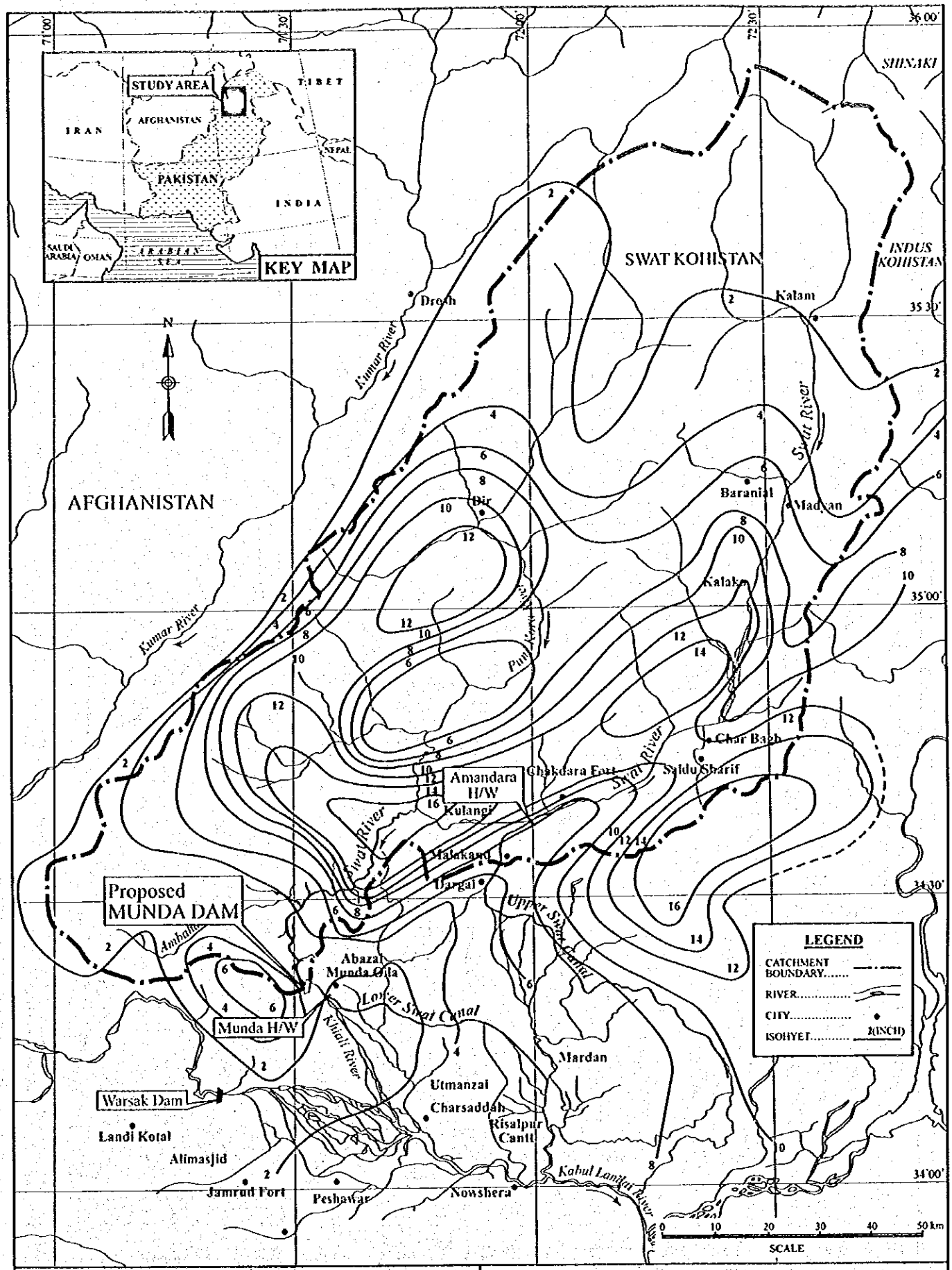


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Figure C5.4
Isohyetal Map of the 26 - 29 August 1929 Storm, Adopted from Ref. 1

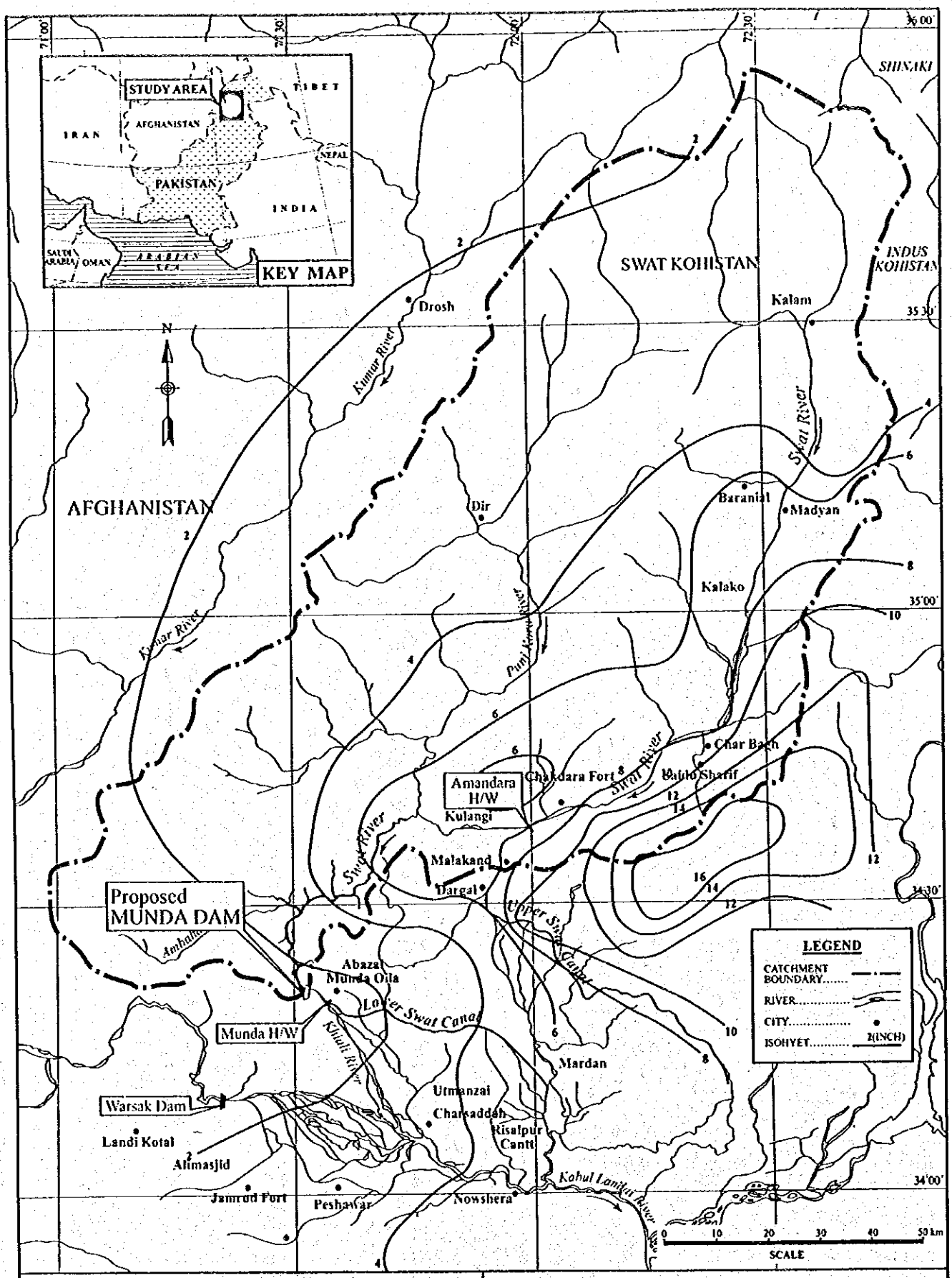

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Figure C5.5
Isohyetal Map of the 26 - 29 August 1929 Storm, Adopted from Ref. 5

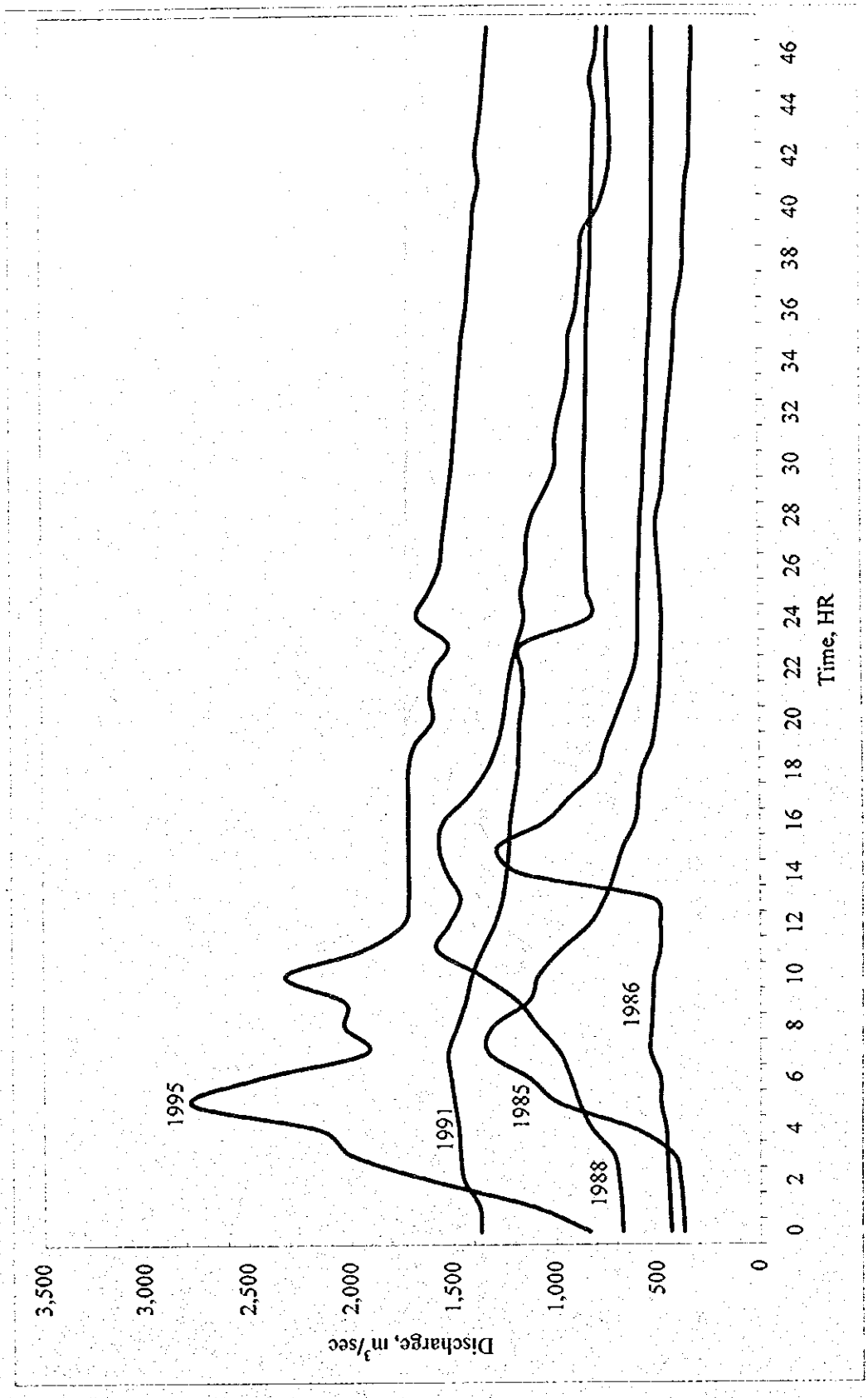

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Figure C5.6

48-hours Flood Hydrographs at Chakdara

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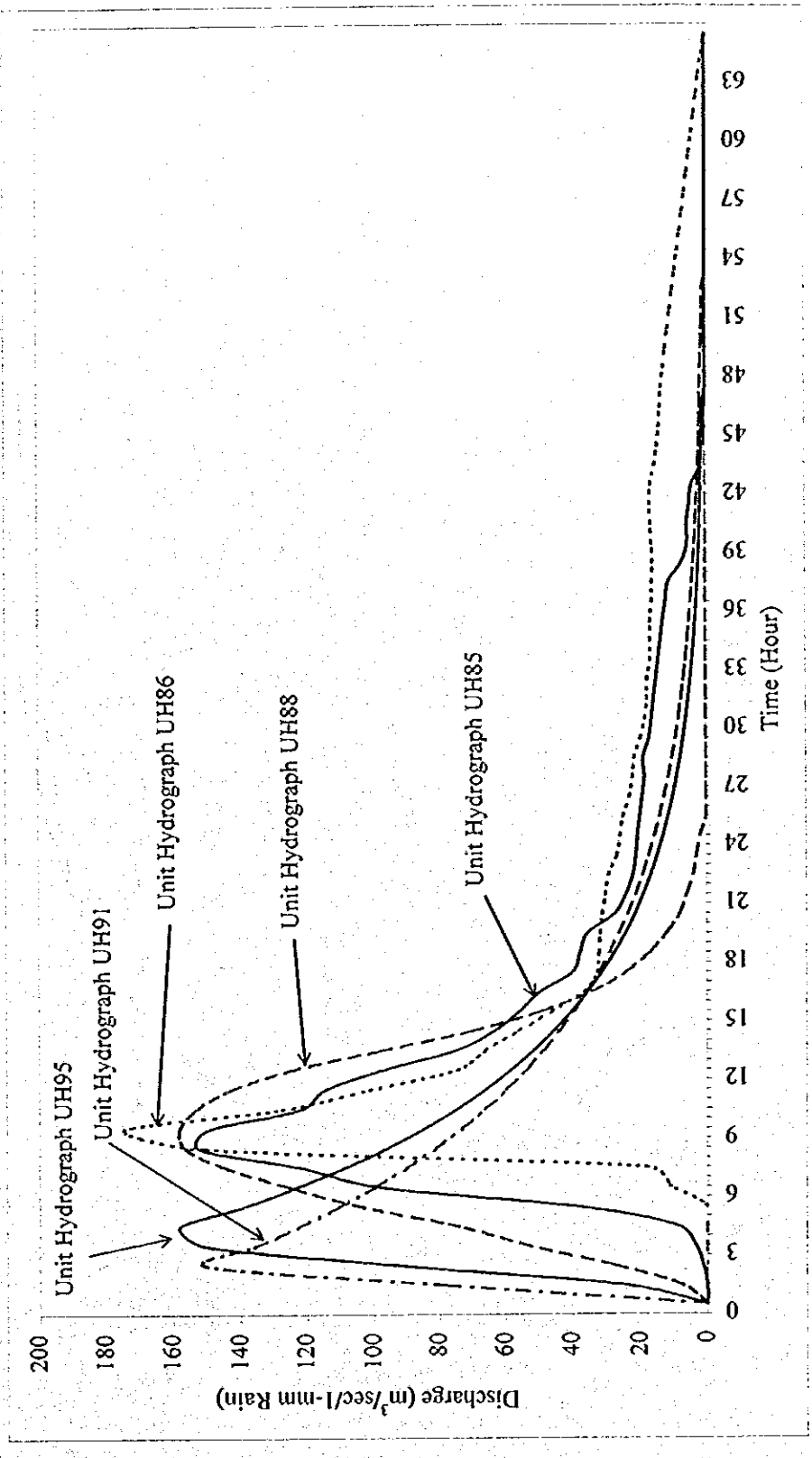
Figure C5.7

Estimated vs. Observed Hydrograph for 1995 Flood



FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C5.8** **Unit Hydrograph Ordinates for the Five Flood Events**

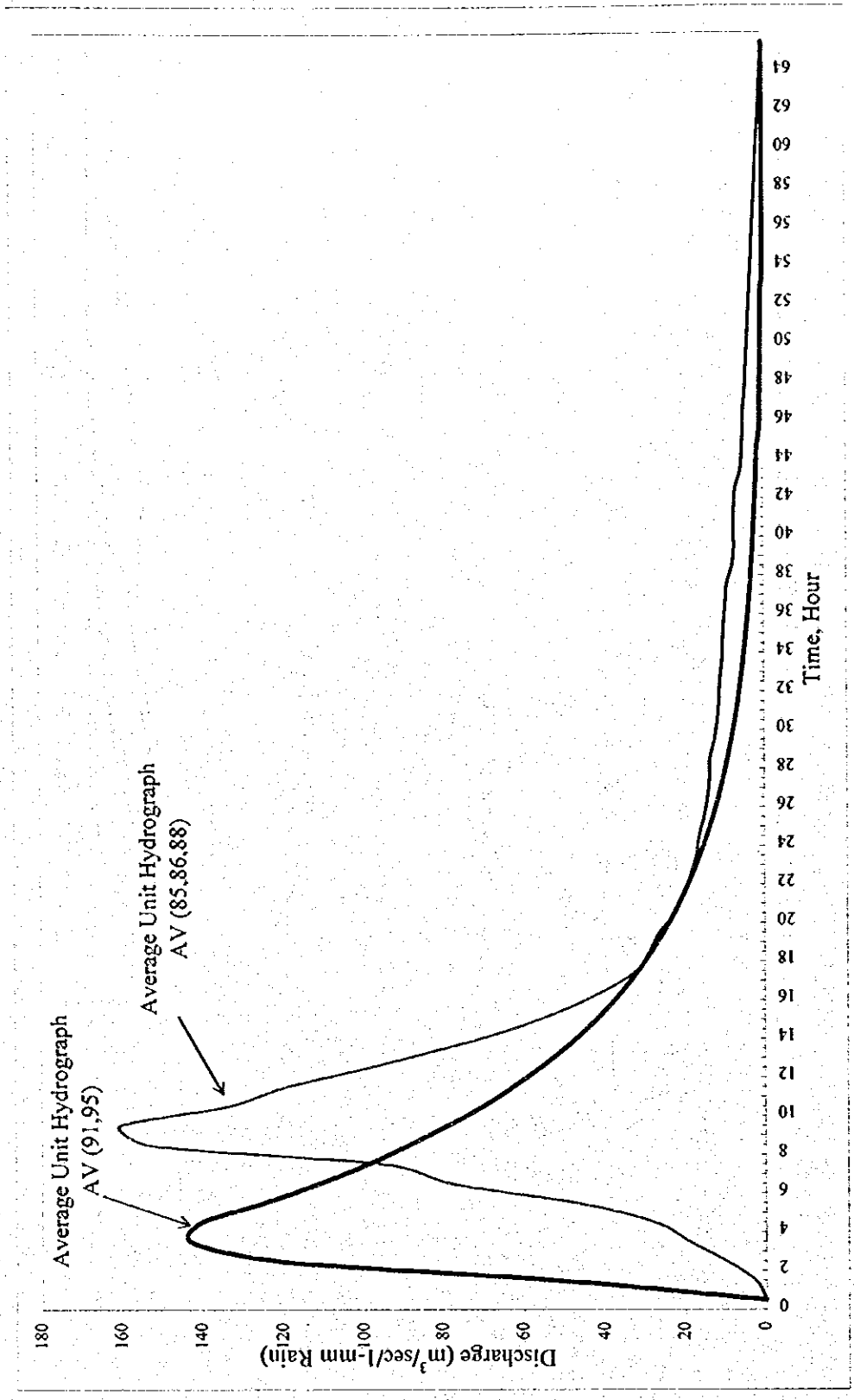


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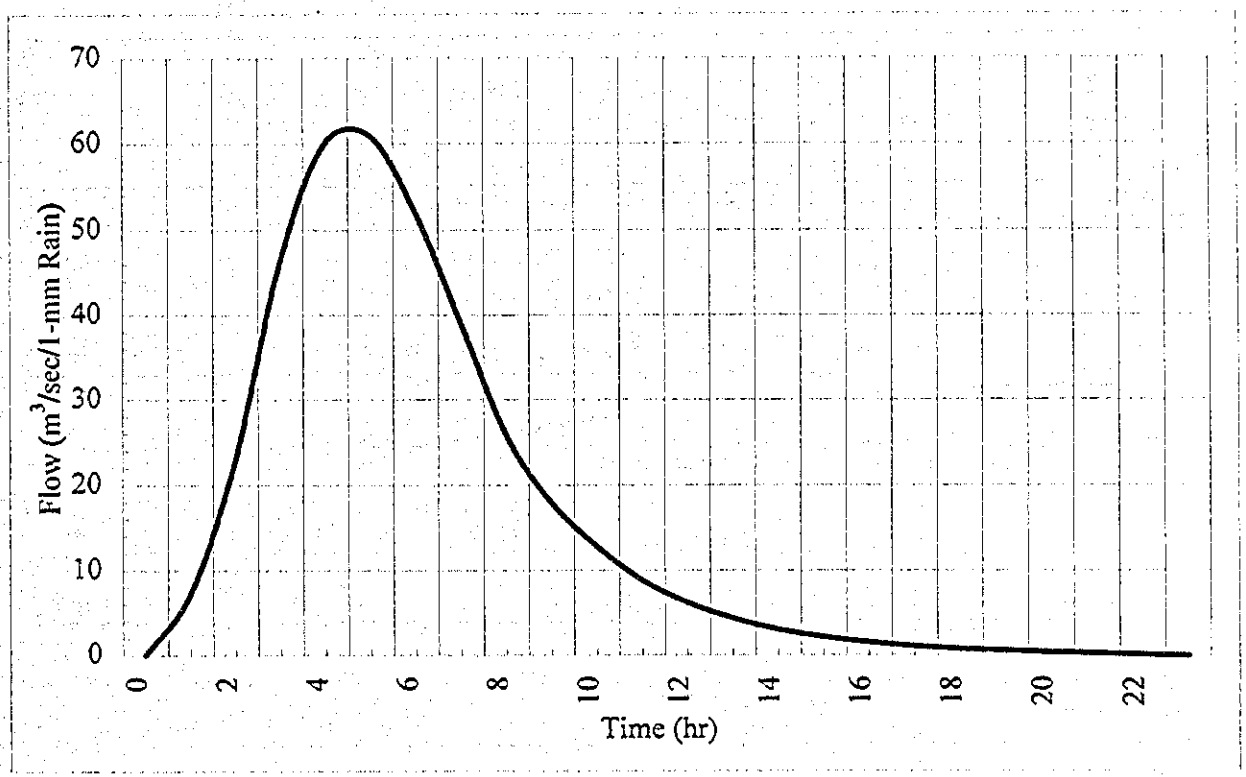
Figure C5.9

Adopted Unit Hydrographs for the Study

TIME	UHAmb
0.00	0
1.00	7.24
2.00	22.95
3.00	46.42
4.00	60.11
5.00	60.88
6.00	51.96
7.00	38.98
8.00	25.78
9.00	17.89
10.00	12.78
11.00	8.82
12.00	6.24
13.00	4.35
14.00	3.03
15.00	2.13
16.00	1.50
17.00	1.04
18.00	0.73
19.00	0.55
20.00	0.38
21.00	0.24
22.00	0.10
23.00	0.00



Time to Concentration	4.05 hour
Time to Peak	4.55 hour
Peak flow	61.67 m^3/sec/1-mm Rain

Figure C5.10

Ambahar Synthesized Unit Hydrograph

Case	Unit Hydrograpgh Condition	PMP	Qp	Tp
1	Average Unit Hydrograph 1991 and 1995	24-PMP	18,169	11
2	Average Unit Hydrograph 1985, 1986 and 1988	24-PMP	19,393	16
3	Average Unit Hydrograph 1991 and 1995	72-PMP	15,988	13
4	Average Unit Hydrograph 1985, 1986 and 1988	72-PMP	16,706	18

Qp Peak Flow, m^3/sec

Tp Time to Peak, hours

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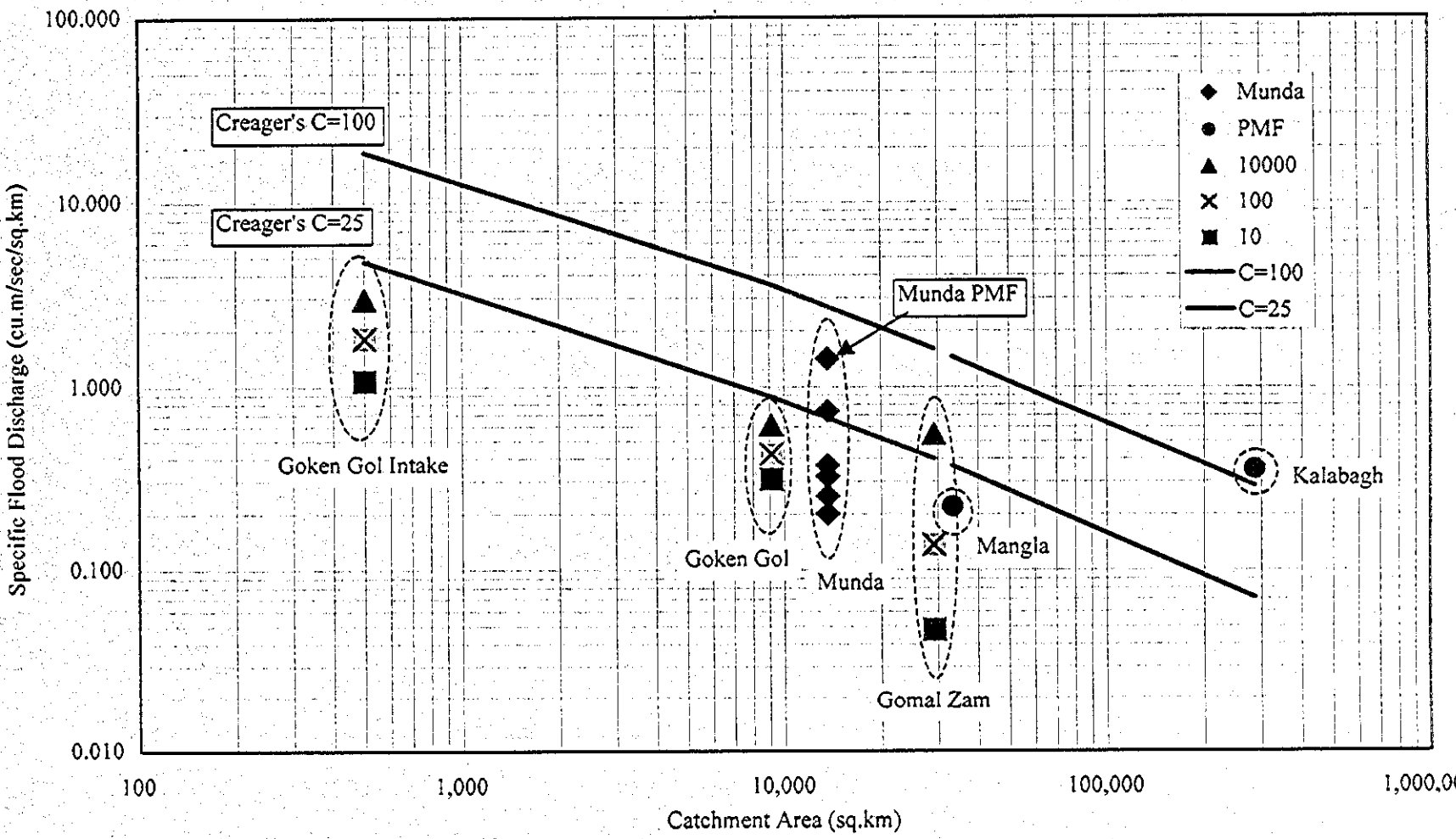
Figure C5.11

Estimated Composite PMF at Munda Dam Site



Sources: Project planning report for Kalabagh Dam, Volume IV, Technical morandum 23, 1984
Completion report for Mangla Dam Project, Volume III, 1971
PC-I Proforma, Gomal Zam Dam Project, 1996
Main report of feasibility study (Updated) for Golen Gol project, Volume 2 of 5, 1997

Figure C5.12
Specific Design Floods for Various Projects

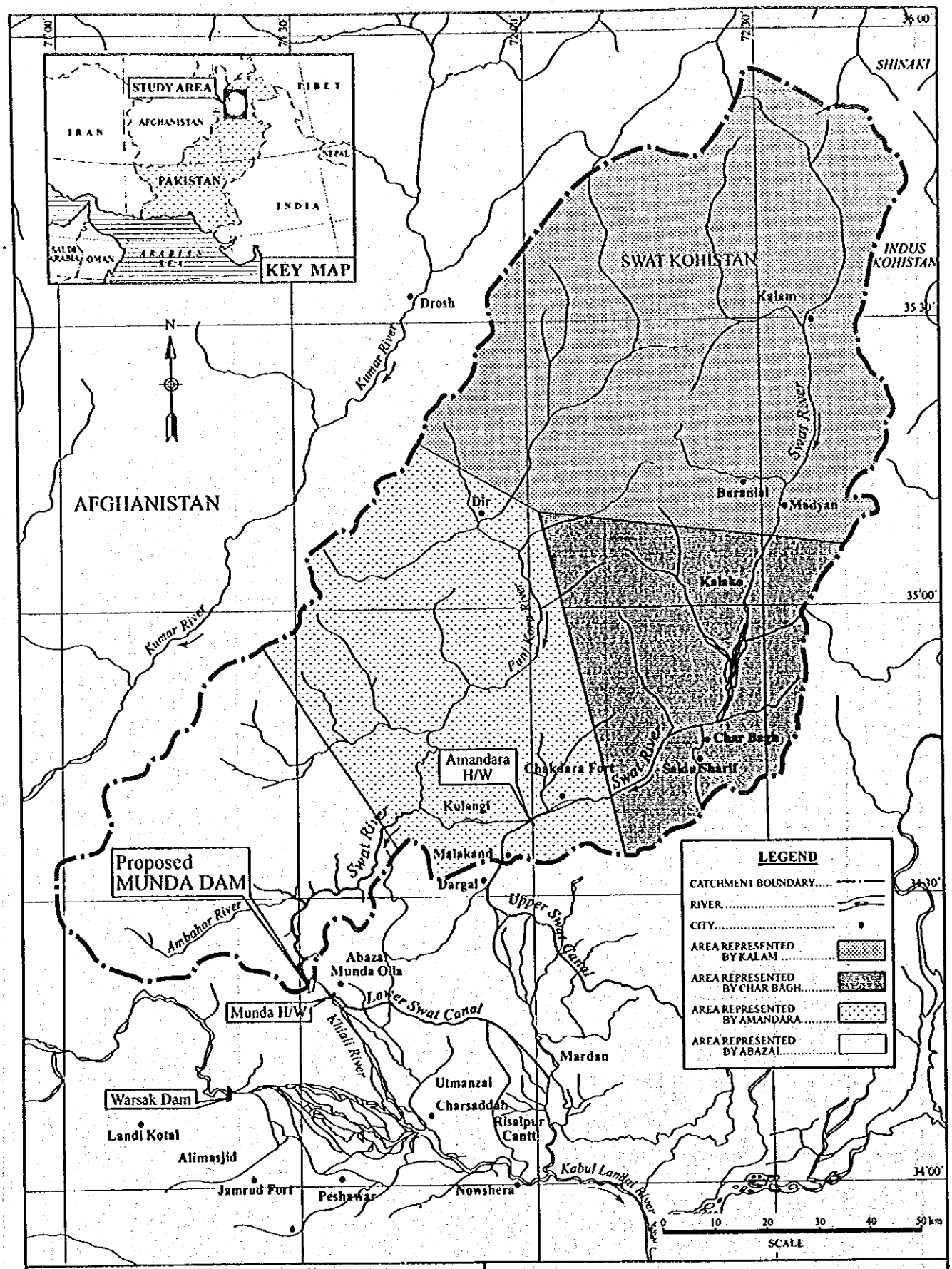


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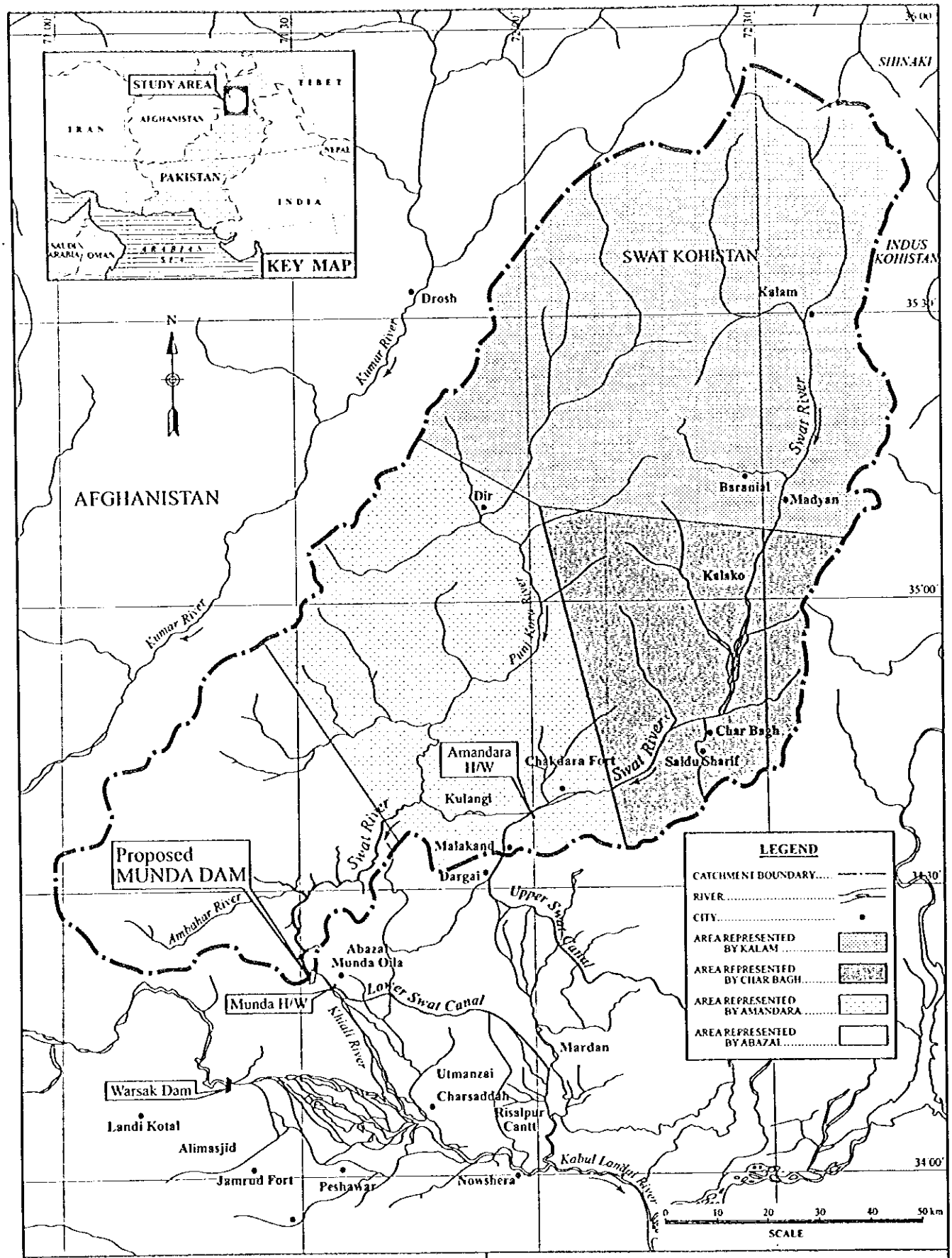
Figure C5.13
Thiessen Polygon for Basin Rainfall Calculation



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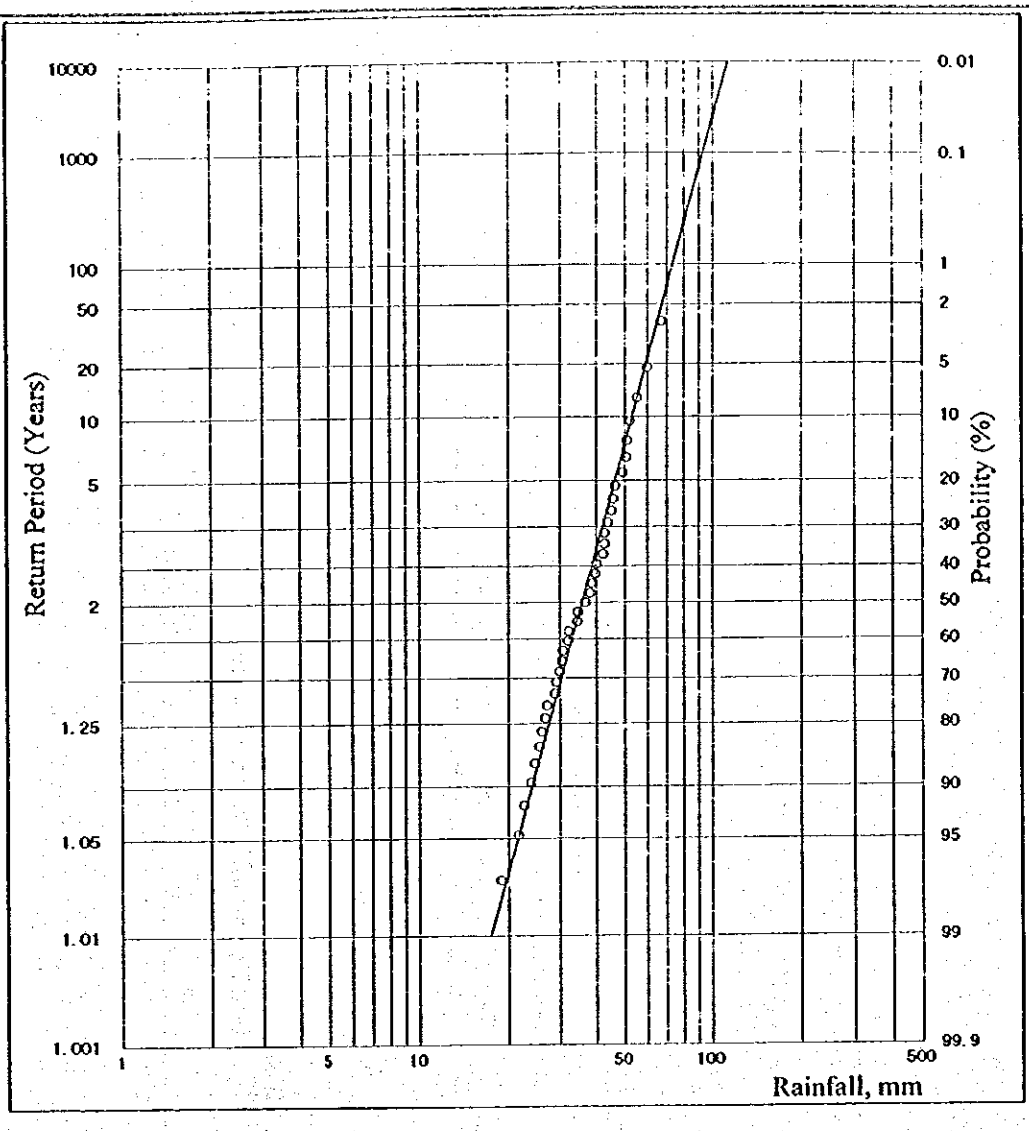
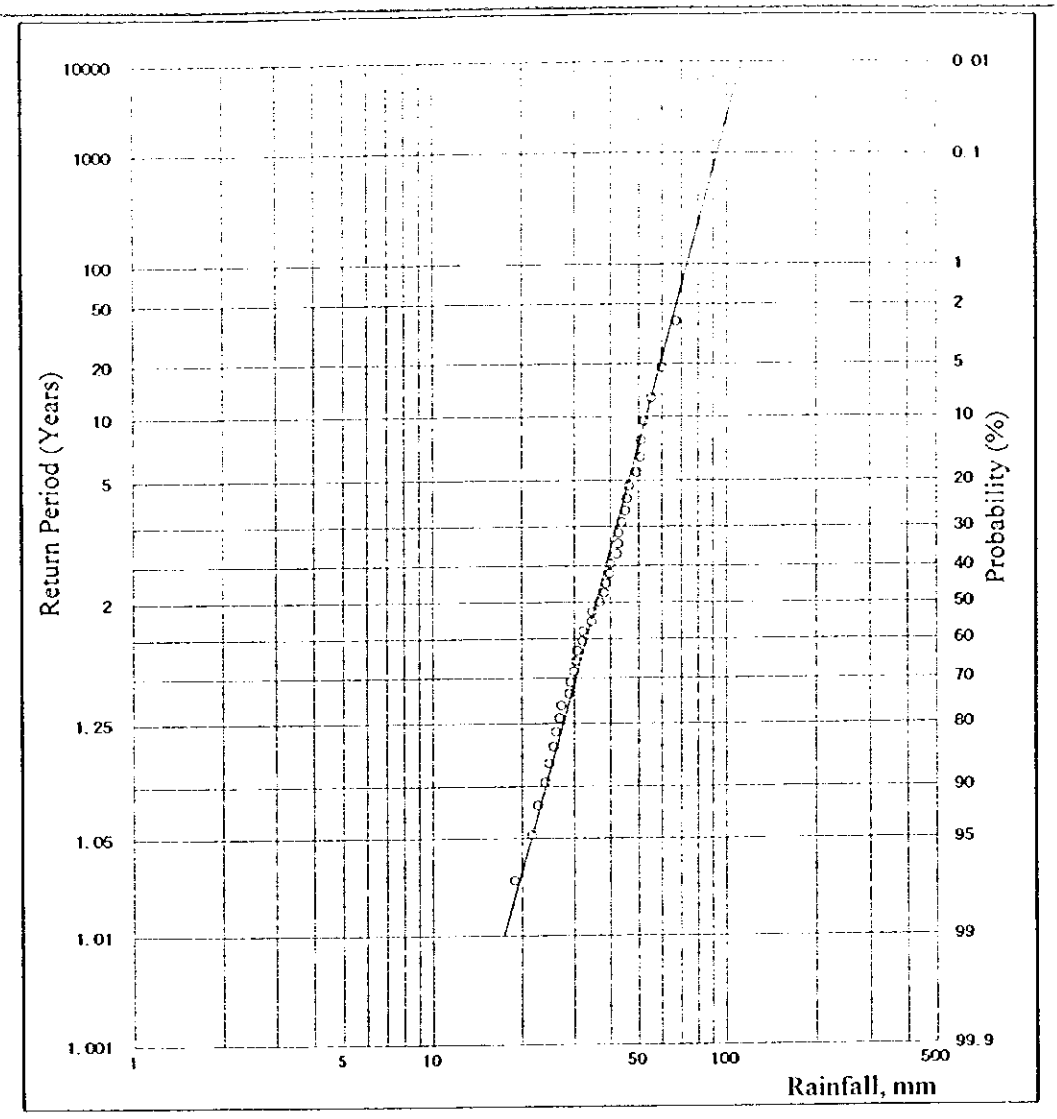


Return Period (Year)	Probability	Probable Rainfall (mm)
2	0.5000	35.74
5	0.2000	46.34
10	0.1000	53.07
20	0.0500	59.37
25	0.0333	61.15
50	0.0200	67.35
100	0.0100	73.26
200	0.0050	79.12
300	0.0033	82.54
500	0.0020	86.85
1000	0.0010	92.73
2000	0.0005	98.64
5000	0.0002	106.53
10000	0.0001	112.58

Figure C5.14
Frequency Curve for Basin Annual Maximum 24-hours Rainfall (Pearson Type III)



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500	0.0020	86.85
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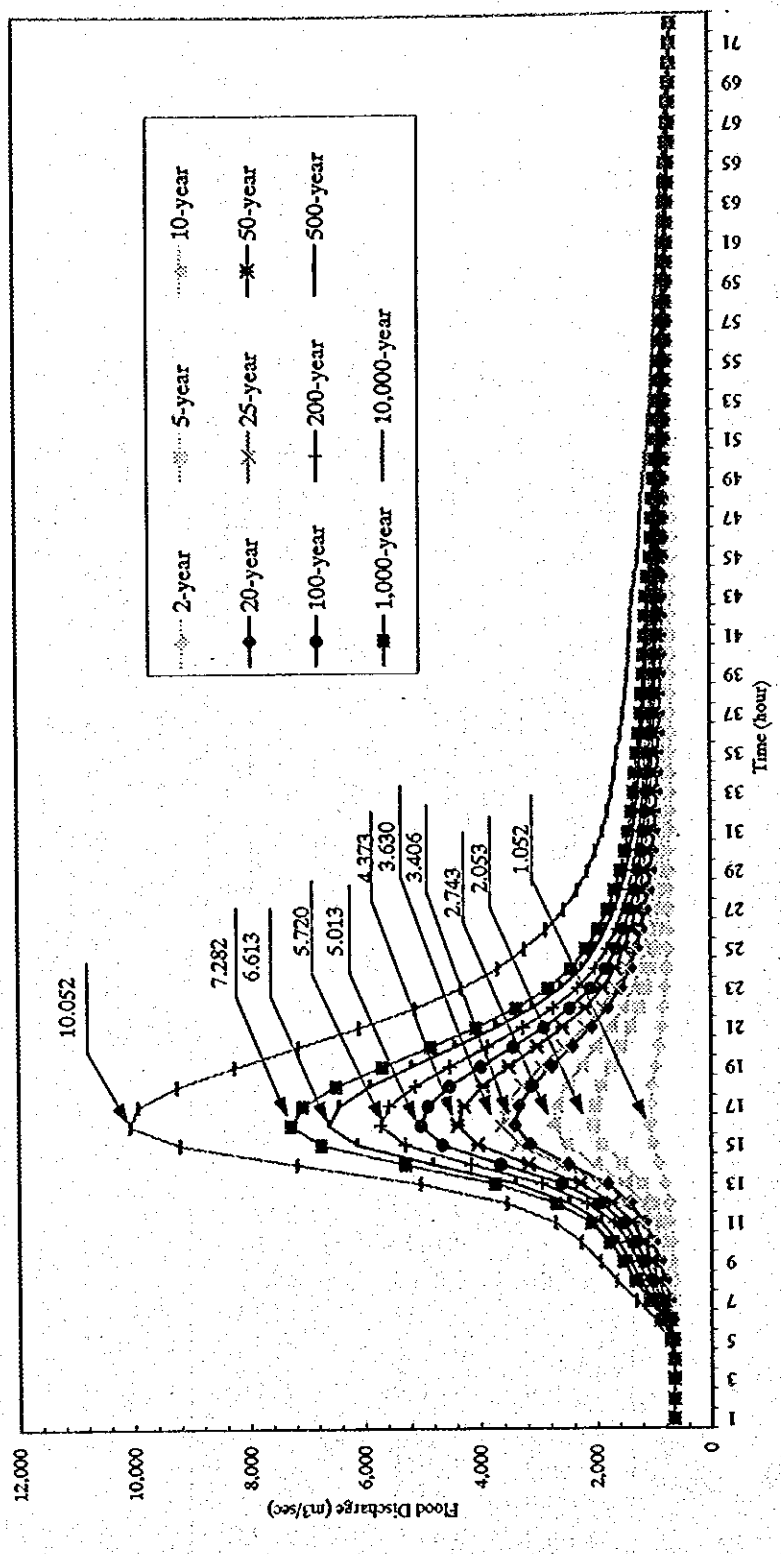
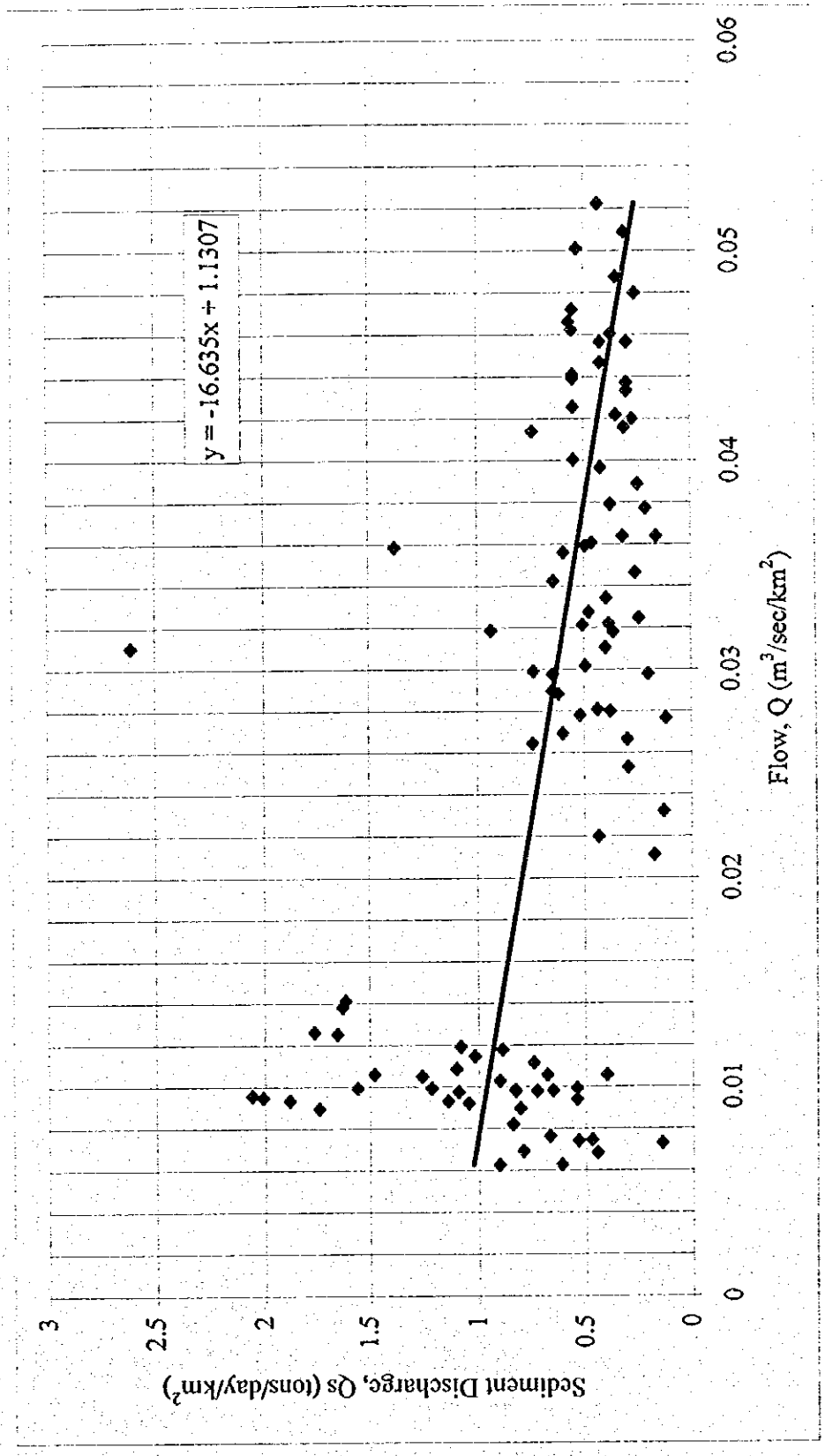
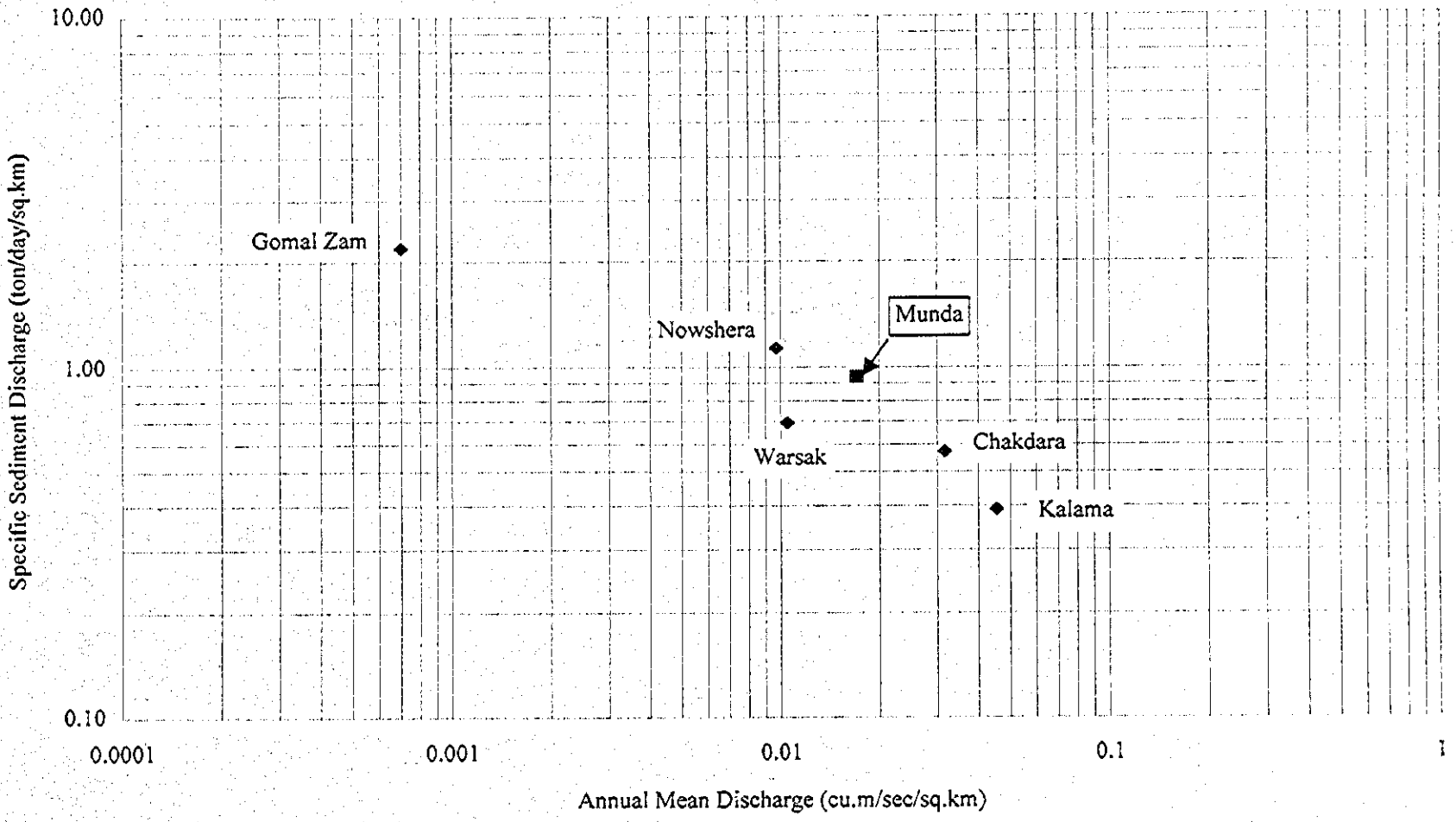


FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C5.15** **Flood Frequencies for Different Return Periods at Munda Dam Site**



FEASIBILITY STUDY ON THE DEVELOPMENT OF MUNDA DAM MULTIPURPOSE PROJECT IN ISLAMIC REPUBLIC OF PAKISTAN JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure C6.1** **Sediment Yield vs. Water Yield**



Sources: Suspended sediment data of at Kalam and Chakdara
Annual sediment loading records for Kalam, Chakdara and Nowshera stations (1961-1990)
Annual sediment loading records for Warsak station (1961-1970)
PC-I Proforma, Gomal Zam Dam Project, 1996

Figure C6.2
Specific Sediment Discharge for Various Projects