No. 02

PEOPLE'S REPUBLIC OF BANGLADESH
BANGLADESH WATER DEVELOPMENT BOARD

# FEASIBILITY STUDY ON THE KURIGRAM IRRIGATION AND FLOOD CONTROL PROJECT - SOUTH UNIT

VOLUME II

# APPENDIXES

MARCH, 1993

Japan International Cooperation Agency
Tokyo, Japan

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# VOLUME II APPENDIXES

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# Abbrebiation

| | |
|---|---|
| AED | Agro-Ecological Division |
| BADC | Bangladesh Agricultural Development Corporation |
| BBS | Bangladesh Bureau of Statistics |
| BKB | Bangladesh Krishi (agricultural) Bank |
| BRDB | Bangladesh Rural Development Board |
| BWDB | Bangladesh Water Development Board |
| CAD | Command Area Development |
| CIDA | Canadian International Development Agency |
| DAE | Department of Agricultural Extension |
| DOF | Department of Fisheries |
| DOL | Department of Livestock |
| DTW | Deep Tubewell (with positive displacement pump) |
| EE | Executive Engineer |
| EIRR | Economic Internal Rate of Return |
| GDP | Gross Domestic Product |
| GOB | Government of Bangladesh |
| FAP | Flood Action Plan |
| FAO | Food and Agriculture Organization |
| FFW | Food-For-Works |
| FPCO | Flood Plan Coordination Organization |
| FCD | Flood Control and Drainage |
| FCD/I | Flood control, Drainage and Irrigation |
| IBRD | International Bank for Reconstruction and Development (world Bank) |
| IDA | International Development Association (World Bank) |
| IFAD | International Fund For Agricultural Development |
| HYV | High Yielding Variety |
| JICA | Japan International Cooperation Agency |
| LCS | Landless Contracting Society |
| LGED | Local Government Engineering Department (former LGEB) |
| LLP | Low Lift Pump |
| MPO | Master Plan Organization |
| NGO | Non-governmental Organization |
| NPV | Net Present Value |
| NPVR | Net Present Value Ratio |
| NWP | National Water Plan |
| O&M | Operation and Maintenance |
| PBC | Project Beneficiary Committee |
| PCC | Project Coordination Committee |
| PIE | Project Impact Evaluation |
| PIO | Project Implementation Office |
| STW | Shallow Tubewell (with suction pump) |
| S/W | Scope of Work |
| SCF | Standard Conversion Factor |
| SE | Superintending Engineer |
| UCCA | Upazila Central Cooperative Association |
| UNDP | United Nations Development Programme |
| UNO | Upazila Nirbahi Officer (principal staff officer of Upazila Parishad) |
| WARPO | Water Resources Planning Organization (formerly MPO) |
| WFP | World Food Programme |
| WHO | World Health Organization |

# Glossary

| | |
|---|---|
| Aman | Main monsoon season paddy crop (Aug./Sept. - Nov/Dec.) |
| Aus | Late dry season/early monsoon paddy crop (Mar./Apr. - July/Aug.) |
| Beel, Bil | Small lake, swamp or body of year-round standing water |
| Boro | Winter (dry) season paddy crop (Dec./Jan. - Apr.) |
| Bundh | Earthen embankment |
| Chhatak | 290 - 350 grammes |
| Chain | 100 feet |
| Cropping intensity | Ratio of acreage of crops cultivated in a year to the total acreage under cultivation |
| Crore | Ten million (10,000,000) |
| Ghog | Animal burrow in embankment |
| Ghee | Edible oild made from milk |
| Khal | Natural channel/minor river/tidal creek |
| Khalashis | "Cleaner" (actually guard) of regulator/sluice |
| Khas | Government owned |
| Kharif | Summer (wet) season |
| Kutcha | Locally made, not manufactured; earthen (of roads, structures) |
| Lakh | Hundred thousand (100,000) |
| Maund | 37.3 kg |
| Mauza | Revenue village (comprise several physical settlements) |
| Nala | Excavated canals |
| Parishad | Elected council of Upazila or Union |
| Rabi | Winter (dry) season |
| Thana | New Administrative unit between Union and Zila |
| Union | Administrative level below Upazila, typically 10 per Upazila |
| Upazila | Former Administrative unit between Union and Zila |
| Zila | District, main sub-regional administrative unit |

# Abbreviation of Measurements

### Length

| | | | |
|---|---|---|---|
| mm | = millimeter | | |
| cm | = centimeter | = | 0.39 in. |
| m | = meter | = | 1.09 yd. |
| km | = kilometer | = | 0.62 ml. |
| in. | = inch | = | 2.54 cm |
| ft. | = foot | = | 30.48 cm |
| yd. | = yard | = | 91.44 cm |
| ml. | = mile | = | 1.61 km |

### Volume

| | | | |
|---|---|---|---|
| lit. | = liter | | |
| m3 | = cubic meter | = | 1,000 lit. |
| MCM | = million m3 | | |
| ft3 | = cubic feet | = | 0.028 m3 |
| ac-in | = acre-inch | = | 102.80 m3 |
| ac-ft | = acre-feet | = | 1,234 m3 |

### Area

| | | | |
|---|---|---|---|
| m2 | = square meter | = | 10.76 ft2 |
| km2 | = square kilometer | = | 100 ha |
| ha | = hectare | = | 2.47 ac |
| ac | = acre | = | 0.405 ha |
| ft2 | = square feet | = | 0.09 m2 |
| mile2 | = square mile | = | 2.59 km2 |

### Weight

| | | | |
|---|---|---|---|
| kg | = kilogram | = | 2.20 lb |
| ton | = ton | = | 1,000 kg |
| lb | = pound | = | 0.454 kg |
| md | = maund | = | 37.32 kg |
| Ck. | = Chhatak | = | 0.30 kg |

### Time

| | |
|---|---|
| sec. | = second |
| min. | = minute |
| hr. | = hour |
| day | = 84,600 sec. |
| yr. | = year |

### Electric Measures

| | | | |
|---|---|---|---|
| kW | = kilowatt | = | 1,000 watt |
| MW | = Megawatt | = | 1,000 kW |
| GW | = Gigawatt | = | 1,000 MW |
| kV | = Kilovolt | = | 1,000 volt |

### Other Measures

| | | |
|---|---|---|
| % | = percent | |
| lakh | = ten thousand | |
| crore | = 10 million | |
| HP | = horse power | = 0.746 kW |
| TPH | = ton per hour | |

### Derived Measures

| | | | |
|---|---|---|---|
| m3/sec | = 35.31 ft3/sec | | |
| ft3/sec | = 0.028 m3/sec | | |
| md/ac | = 92.23 kg/ha | = | 0.092 ton/ha |
| ton/ha | = 2.47 tons/acre | = | 10.84 md/ac |
| ton/acre | = 0.405 ton/ha | = | 4.39 md/ac |

### Currency

| | | |
|---|---|---|
| Tk | = Taka | (US$1.0 = Tk38.8 = ¥125, as of February, 1992) |
| US$ | = US dollar | |
| ¥ | = Japanese Yen | |

# APPENDIX - I

# TOPOGRAPHIC SURVEY

FEASIBILITY STUDY ON

KURIGRAM IRRIGATION AND FLOOD CONTROL PROJECT (SOUTH UNIT)

## APPENDIX - I TOPOGRAPHIC SURVEY

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# APPENDIX - I TOPOGRAPHIC SURVEY

## 1. Activities of Topographic Survey

Topographic survey was carried out by the Survey Corporation (641/1, Bara Moghbazar Dhaka - 1217, Phone : 415130) under the JICA Study Team during the period from January 6 to March 7, 1992 in Phase I, and the period from July 28 to October, 1992 in Phase II.

### 1.1 Survey Works in Phase I

The following survey works were carried out along the Dharla river during the period of phase I. Chart of the surveyed location is shown in Fig. I.1.

1) Longitudinal surveys was carried out on the right bank of flood embankment, and also was tied to WAPDA BM No.77 in another 6km. Total 34.5km was surveyed with back cheking,
2) Cross Sectional surveys across the Dharla river, 30 sections were carried out with an average length of 3,000m at the interval of 500 to 1,000m, from the right bank upto the left bank which is existed,
3) 12 numbers of new Bench Mark(BM), named JKS(JICA Kurigram South) were established along the right bank. Description of the BM is shown in Fig. I.3. As the control elevtion point for the JKS-BMs, WAPDA BM No.77 was used. Values and location of JKS-BMS are shown in Table I.3, and
4) Drawings which were Described, based on the above surveys, are shown in Table I.2.

### 1.2 Survey Works in Phase II

The following survey works were carried out along the existing rivers and drainage canals (named Main Channel-A to F), and route of proposed Ratnai Diversion Channel. Chart of the surveyed location is shown in Fig. I.2, and quantities of canal survey are shown in Table I.1.

1) Longitudinal surveys, in total 190.5km were carried out along the each Main Channel with back cheking,
2) Cross sectional surveys across the Channels, in total 759 sections, were carried out with an average length of 150m at the interval of 200 to 400,
3) 27 numbers of plane table survey, in total area 397,000m$^2$, were carried out at the proposed structure site (for Irrigation Regulators, Check Gates, Bridges), in scale of 1/200 to 1/1,000,
4) 24 numbers of JKS Bench Mark, Whuch are same specification of Phase I, were established along the Main Channels. Values and locations are shown in TableI.3,

| Name of Location | | | Main | | Area |
| --- | --- | --- | --- | --- | --- |
| Thana | Union | Mauza | Channel | Station | (ha) |
| Lalmonirhat | Kulaghat | Banagram | A | 3+300 | 140 |
| Kurigram | Kathalbari | Pratap | A | 32+000 | 100 |
| Ulipur | Ulipur | Narikelbari | B | 41+000 | 110 |

5) For proposed Demonstration Farm, Level surveys and land use surveys were carried out at the following three(3) sites, on scale of 1/2,500, to revise the Mauza Maps, and

6) Drawings which were Described, based on the above surveys, are shown in Table I.2.

## 2. Availability of Topographic Map of the Study Area

In the Study area, the following scaled topographic maps prepared during the time of Pakistan, are available. These maps are based on the aerial photographs taken by Hessrs Air Survey Co.,Ltd.,London in 1953 and the ground control survey in 1960/61. The maps have not been revised since that time. The maps are generally accurate,however, geographical features, especially the river courses, shapes and widths, are drastically changed already.

| | | |
| --- | --- | --- |
| 1) | Scaled 1/15,840 | Printed in two(2) colors, with contour interval of one(1) foot shown few BM values in PWD |
| 2) | Scaled 1/50,000 | Printed in six(6) colors |

## 3. Availabilitiy of Bench Marks of the Study Area

In Bangladesh, the datum for leveling is known as GTS(the Great Trigonometrical Survey), basedon Mean See Level(MSL) as determined from the period tidal records along the coast of Indo-Pakistan Sub-Continent(1958 to 1909). Other widely used datum is PWD(the Public Works Department). The relative height between GTS and PWD is "PWD = GTS + 1.509 feet".

As Bench Mark(BM) of the Study area, three(3) WAPDA BMs are available. These BMs have been established in 1962/62, the time of East Pakistan, based on PWD datum, by WAPDA. The purpose are maintenance a system of river gauge elevation control, and once used for planning of the regulators by BWDB. Original values of these BMs are as follows.

| BM No. | Station | E.L.in feet | E.L.in meter | Remarks |
|---|---|---|---|---|
| No.45.5 | Chilmari | 77.22 ft | 23.437 m | Not available |
| No.76 | Taluk Simulbari | 101.13 ft | 30.824 m | Not available |
| No.77 | Kurigram | 87.92 ft | 26.798 m | Available |

However, BMs of No.45.5 and No.76 are not available at presence, due to eroding the river coast. in case of No.76 BM, according to the river gauge master, the BM have been sifted to the Temporary Bench Mark(TBM) valued in 30.750 m, before the BM damaged. But the reliable result of leveling surveys, to be tied to WAPDA BM No.77, which was carried out by Survey Corporation in this time, height of this TBM is 30.160 m, for information.

And also, BM values are shown on the topographic maps scaled 1/15,840, however, most of the those BMs of the Study area have been damaged or missing and not reliable any more.

## Table 1.1 Quantities of Canal Survey

| Main Channel | Longitudinal (km) | Cross Sectional (Nos.) | Plane Table (Nos.) | Plane Table (sq.m) | JAS-BM (Nos.) |
|---|---|---|---|---|---|
| A | 64.4 | 302 | 11 | 207,000 | 6 |
| B | 55.9 | 261 | 6 | 60,000 | 8 |
| C | 35.9 | 146 | 5 | 70,000 | 4 |
| D | 13.2 | 3 | 1 | 20,000 | 1 |
| E | 10.0 | 3 | 2 | 20,000 | 0 |
| F | 7.8 | 27 | 2 | 20,000 | 2 |
| Ratnai Diversion | 3.3 | 17 | 0 | 0 | 1 |
| **Total** | **190.5** | **759** | **27** | **397,000** | **22** |

## Table I.2 List of Drawings

| Phase I / II | Surveys | Drawing No. | Scale | Numbers |
|---|---|---|---|---|
| I | (River Survey) | | | |
| | 1.Longitudinal | RLS | H=1/5,000 V=1/500 | 10 |
| | | RLL | H=1/1,000 V=1/100 | 48 |
| | 2.Cross Sectional | RCS | H=1/5,000 V=1/500 | 13 |
| | | RCL | H=1/1,000 V=1/100 | 60 |
| | **Sub-total** | | | **131** |
| II | (Canal Survey) | | | |
| | 1.Longitudinal | | | |
| | Clannel - A | AL | H=1/5,000 V=1/500 | 19 |
| | | | H=1/1,000 V=1/100 | 93 |
| | Clannel - B | BL | H=1/5,000 V=1/500 | 16 |
| | | | H=1/1,000 V=1/100 | 80 |
| | Clannel - C | CL | H=1/5,000 V=1/500 | 11 |
| | | | H=1/1,000 V=1/100 | 52 |
| | Clannel - D,E | DEL | H=1/50,000 V=1/500 | 1 |
| | Clannel - F | FL | H=1/5,000 V=1/500 | 3 |
| | | | H=1/1,000 V=1/100 | 15 |
| | Ratnai Diversion | HL | H=1/5,000 V=1/500 | 1 |
| | | | H=1/1,000 V=1/100 | 5 |
| | 2.Cross Sectional | | | |
| | Clannel - A | AC | H=1/500 V=1/100 | 43 |
| | Clannel - B | BC | H=1/500 V=1/100 | 36 |
| | Clannel - C | CC | H=1/500 V=1/100 | 19 |
| | Clannel - D | DC | H=1/500 V=1/100 | 1 |
| | Clannel - E | EC | H=1/500 V=1/100 | 1 |
| | Clannel - F | FC | H=1/500 V=1/100 | 5 |
| | Ratnai Diversion | HC | | 3 |
| | 3.Plane Table | | | |
| | Clannel - A | AS | S=1/1,000 ~ 1/200 | 11 |
| | Clannel - B | BS | S=1/1,000 ~ 1/200 | 6 |
| | Clannel - C | CS | S=1/1,000 ~ 1/200 | 5 |
| | Clannel - D | DS | S=1/1,000 ~ 1/200 | 1 |
| | Clannel - E | ES | S=1/1,000 ~ 1/200 | 2 |
| | Clannel - F | FS | S=1/1,000 ~ 1/200 | 2 |
| | 4.Demonstration Farm | MA | S=1/2,500 | 3 |
| | **Sub-total** | | | **434** |
| | **Total** | | | **565** |

# Table I.3 List of JKS Bench-Marks

| Phase | No. of JKS-BM | Station (m) | Value (m) | Latitude | Longitude | Name of Location: Thana | Union | Mauza |
|---|---|---|---|---|---|---|---|---|
| Phase - I | 1 | 3+420 | 30.907 | 25° 58.4' | 89° 28.3' | Lalmonirhat | Mohalhat | Bumka |
| | 2 | 6+000 | 30.821 | 25° 57.2' | 89° 29.0' | Lalmonirhat | Kulaghat | Banagram |
| | 3 | 8+500 | 30.989 | 25° 56.2' | 89° 30.0' | Lalmonirhat | Kulaghat | Banagram |
| | 4 | 10+900 | 30.915 | 25° 55.2' | 89° 30.8' | Lalmonirhat | Kulaghat | Kulaghat |
| | 5 | 13+100 | 30.217 | 25° 54.2' | 89° 31.3' | Lalmonirhat | Kulaghat | Khatamari |
| | 6 | 15+500 | 31.274 | 25° 52.7' | 89° 33.1' | Lalmonirhat | Barobari | Baliram |
| | 7 | 18+100 | 27.795 | 25° 52.9' | 89° 31.8' | Lalmonirhat | Barobari | Barabasuria |
| | 8 | 20+600 | 27.093 | 25° 52.7' | 89° 33.1' | Rajarhat | Chhinai | Kulua |
| | 9 | 23+300 | 29.087 | 25° 51.4' | 89° 35.4' | Kurigram | Holokhana | Sanyasi |
| | 10 | 26+200 | 27.681 | 25° 51.5' | 89° 37.0' | Kurigram | Holokhana | Holokhana |
| | 11 | 27+640 | 29.054 | 25° 51.9' | 89° 37.6' | Kurigram | Holokhana | Bher Bheri |
| | 12 | --- | 28.006 | 25° 51.0' | 89° 38.7' | Kurigram | Holokhana | Subharkuthi |
| Phase - II | Channel - A | | | | | | | |
| | A1 | 10+624 | 31.577 | 25° 55.7' | 89° 30.2' | Lalmonirhat | Kulaghat | Kulaghat |
| | A2 | 15+358 | 30.854 | 25° 53.8' | 89° 31.5' | Lalmonirhat | Kulaghat | Baribanamari |
| | A3 | 22+820 | 28.542 | 25° 51.9' | 89° 34.2' | Rajarhat | Chhinai | Kalua |
| | A4 | 28+185 | 29.168 | 25° 50.5' | 89° 36.1' | Kurigram | Khatalbari | Sibram |
| | A5 | 33+855 | 28.677 | 25° 48.5' | 89° 36.2' | Kurigram | Khatalbari | Jat Gobardhan |
| | A6 | 63+387 | 27.372 | 25° 41.1' | 89° 41.7' | Kurigram | Hatia | Anantapur |
| | Channel - B | | | | | | | |
| | B1 | 3+780 | 28.157 | 25° 49.2' | 89° 33.9' | Rajarhat | Rajarhat | Paikpara |
| | B2 | 8+414 | 29.005 | 25° 47.8' | 89° 32.5' | Rajarhat | Rajarhat | Kismat Punker |
| | B3 | 12+745 | 28.359 | 25° 46.3' | 89° 31.4' | Rajarhat | Rajarhat | Chandamari |
| | B4 | 21+745 | 27.781 | 25° 43.8' | 89° 33.3' | Rajarhat | Nazim Khan | Manarkuti |
| | B5 | 31+200 | 28.115 | 25° 40.5' | 89° 32.9' | Ulipur | Thetrai | Gorai Piar |
| | B6 | 43+967 | 26.025 | 25° 39.3' | 89° 37.1' | Ulipur | Gunaigach | Ramdas Dheniram |
| | B7 | 51+714 | 26.129 | 25° 37.9' | 89° 39.6' | Ulipur | Tabakpur | Boru Tabakpur |
| | B8 | 55+776 | 26.380 | 25° 37.1' | 89° 41.4' | Chilmari | Ranigonj | Dakshin Udri |
| | Channel - C | | | | | | | |
| | C1 | 5+562 | 27.691 | 25° 46.9' | 89° 34.5' | Rajarhat | Chairpashar | Taluk Asharu |
| | C2 | 11+370 | 27.609 | 25° 44.9' | 89° 35.5' | Rajarhat | Umarmojid | Balakandi |
| | C3 | 22+412 | 26.228 | 25° 41.3' | 89° 37.1' | Ulipur | Dharanibari | Kismat Malatibari |
| | C4 | 29+033 | 25.448 | 25° 39.7' | 89° 40.1' | Ulipur | Dhamsrani | Naora |
| | Channel - D | | | | | | | |
| | D1 | 0+325 | 27.333 | 25° 45.7' | 89° 37.7' | Kurigram | Durgapur | Gorai |
| | Channel - E | | | | | | | |
| | F1 | 4+731 | 27.466 | 25° 50.7' | 89° 37.5' | Kurigram | Kathalbari | Khalisa Kalua |
| | F2 | 10+305 | 28.536 | 25° 48.6' | 89° 37.3' | Kurigram | Balgachha | Kale |
| | Channel - H | | | | | | | |
| | H1 | 0+000 | 32.449 | 25° 58.1' | 89° 26.7' | Lalmonirhat | Mogalhat | Durakuti |

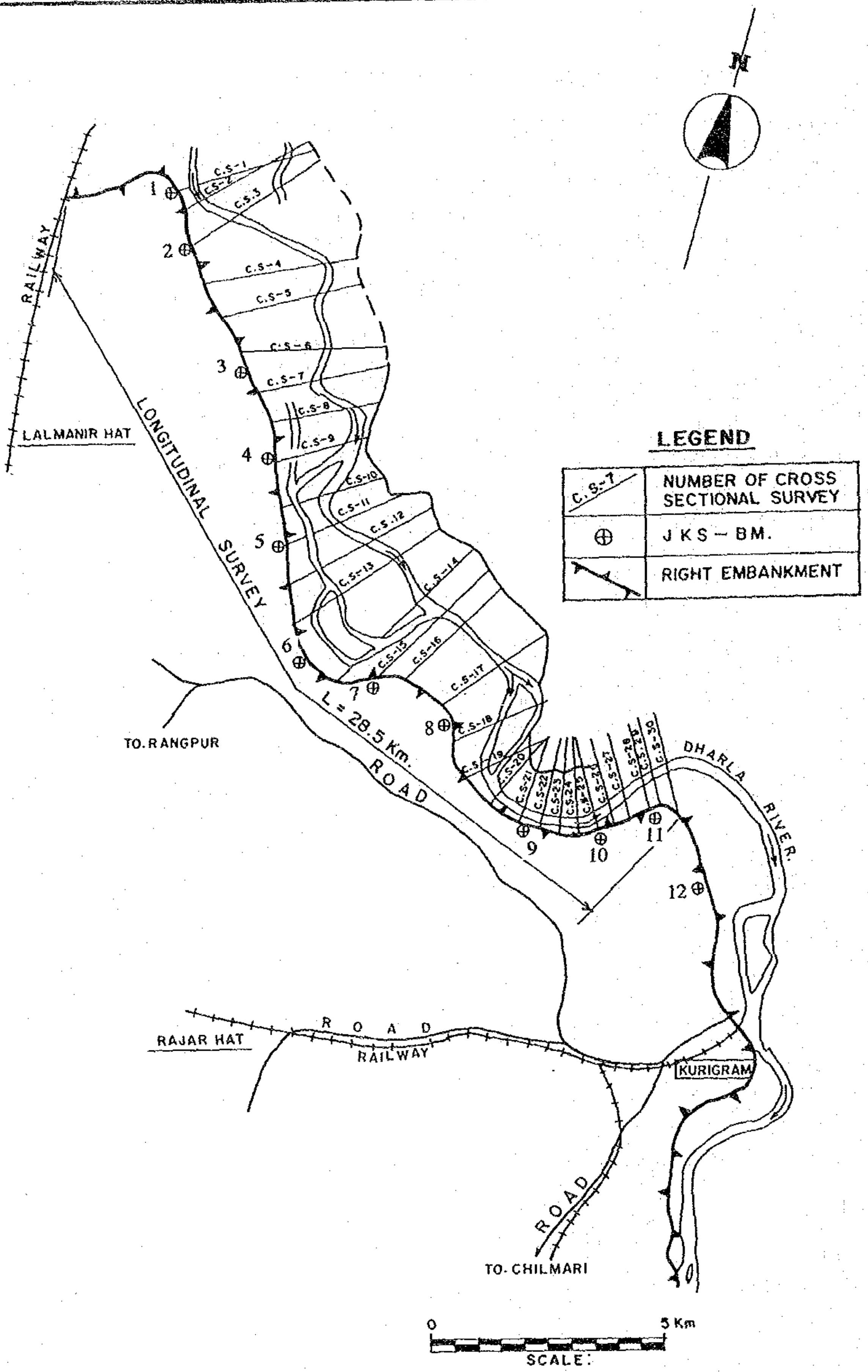


**Fig. 1.1 Chart of the Surveyed Location (Phase I)**

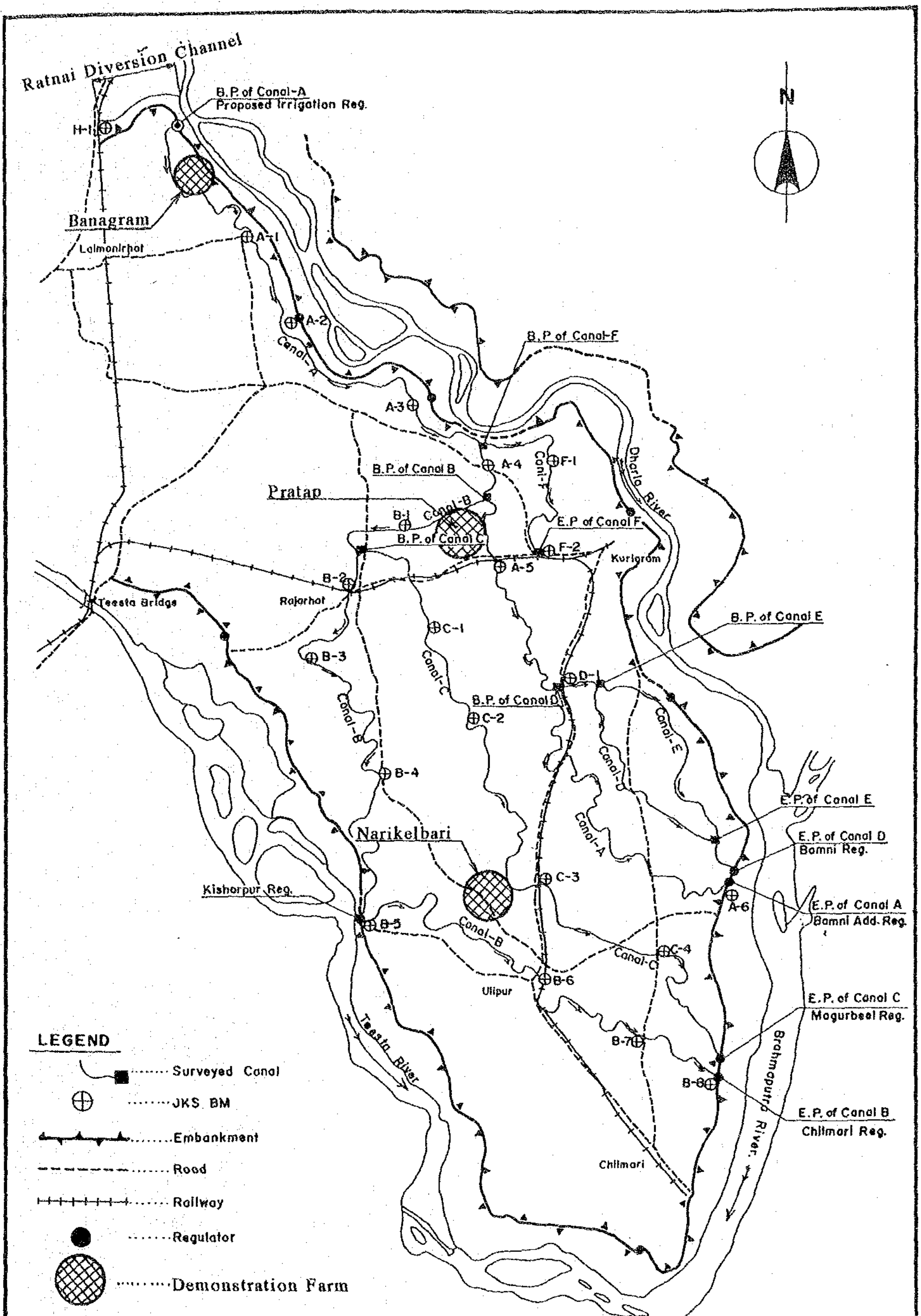


**Fig. I.2 Chart of the Surveyed Location (phase II)**

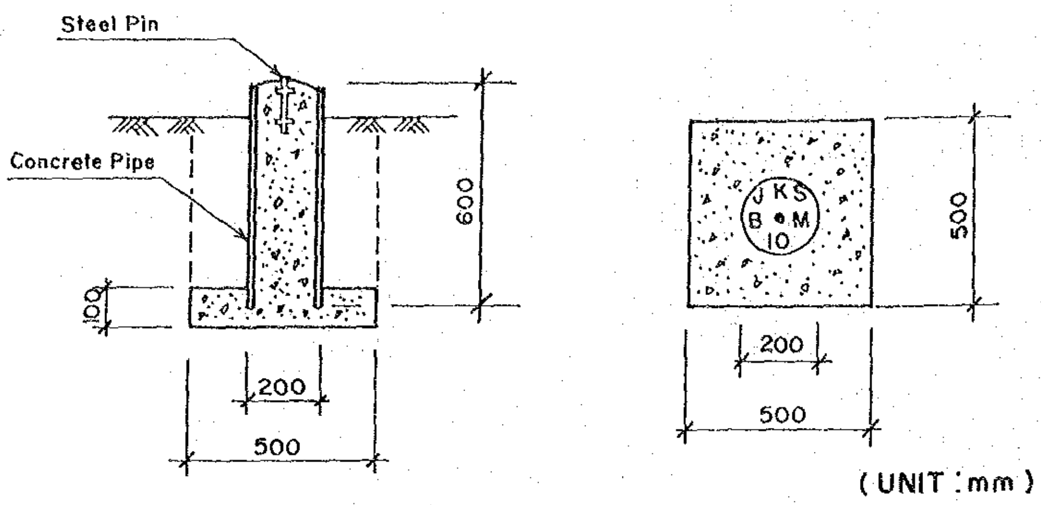


**Fig. I.3 Description of JKS-BM**

# APPENDIX - II

# METEOROLOGY AND HYDROLOGY

FEASIBILITY STUDY ON

KURIGRAM IRRIGATION AND FLOOD CONTROL PROJECT (SOUTH UNIT)

# APPENDIX - II METEOROLOGY AND HYDROLOGY

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# APPENDIX II METEOROLOGY AND HYDROLOGY

## 1. Introduction

### 1.1 Objectives

The objective of the meteorological and hydrological study is to grasp the meteorological and hydrological characteristics of the Study area, to provide useful information necessary for the formulation of the irrigation and drainage plan.

### 1.2 Meteorological and Hydrological Data

#### 1.2.1 Meteorological Data

The meteorological data at the Rangpur Station (Station No. P10208) located 40km west from Kurigram were obtained from Meteorological Department, because no meteorological data except rainfall is available in the Study area. The collected data cover the daily data series of maximum, minimum and mean temperatures, relative humidity, sunshine hours, wind speed and evaporation. Available data are shown in Table II.1.1.

#### 1.2.2 Rainfall Data

There are seven(7) rainfall stations in and around the Study area. From the Thiessen Polygon analysis, the following six(6) stations except Pirgacha(202) were selected for data analysis.

All the rainfall data of these stations were collected from the Surface Water Hydrology Section-2 of BWDB for the period of about 30 years from 1960 to 1990.

Available data are shown in Table II.1.2.

| Station | (No.) | Coefficient of Thiessen Polygon |
|---|---|---|
| Chilmari | (163) | 0.16 |
| Kaunia | (178) | 0.09 |
| Kurigram | (182) | 0.28 |
| Lalmanirhat | (183) | 0.15 |
| Sundarganj | (218) | 0.01 |
| Ulipur | (222) | 0.31 |

#### 1.2.3 Water Level Data

There are total seven(7) water level ganging stations in and around the Study area; two(2) for the Dharla river , two(2) for the Teesta river and three(3) for the Brahmaputra river. All daily data were collected from Surface Water Hydrology Section-2 of the BWDB for the period of about 30 years from 1960 to 1990 (except Haripur and Bahadurabad). Available data are shown in Table II.1.3.

From the condition of available data, the following five(5) stations except Haripur (294.5) and Bahadurabad (46.9) were selected for data analysis.

| Station | (No.) | River |
|---|---|---|
| Talukshimulbari | (76) | Dharla |
| Kurigram | (77) | Dharla |
| Kaunia | (294) | Teesta |
| Noonkawa | (45) | Brahmaputra |
| Chilmari | (45.5) | Brahmaputra |

#### 1.2.4 Discharge Data

Discharge data at the Talukshimulbari and Kurigram stations of the Dharla river and at the Kaunia of the Teesta river are also available. Available discharge data period is about 18 years from 1973 to 1990 at Kurigram, but discharge data at Talukshimulbari have many lacking. Available data are shown in Table II.1.4.

Location of meteorological and hydrological stations are shown in Fig.II.1.1.

## 2. Meteorological and Hydrological Conditions

### 2.1 Climate

#### 2.1.1 Temperature

Maximum temperatures vary from about 24 to 34°C, minimum temperature range between about 10 to 26°C and mean temperature range between about 17 to 29°C.

#### 2.1.2 Humidity

The relative Humidity is high through the year with average humidity varying from 68 to 87 percent. The humidity is highest during monsoon period June to September.

#### 2.1.3 Sunshine Hours

Sunshine hours of average monthly ranges between 4.1 to 5.5 hrs/day during the monsoon period and 6.5 to 8.5 hrs/day during the other months.

#### 2.1.4 Wind Speed

The wind speed are relatively low and the average speed of monthly are 2 to 4 m/sec.

#### 2.1.5 Evaporation

Maximum evaporation of average monthly ranges between 2.3 to 6.0 mm. The summary data of above mentioned is shown in Table II.2.1 to II.2.8. All of meteorological data are collected as daily format and arranged as 10-days period for the purpose of irrigation calculation.

## 2.2 Rainfall

All of rainfall data are collected by daily format, however data requirement for the Study analysis have generally related to 10-daily total. Hence 10-daily series rainfall have been tabulated for six(6) main stations. Annual rainfall for each stations are from 1975 to 2582 mm/year (listed in Table II.2.9). Annual maximum daily rainfall and 5-day period rainfall are listed in Table II.2.10 and II.2.11 respectively.

Isohyetal map with Thiessen polygon is shown in Figure II.2.1. It's shown that monthly rainfall distribution is concentrated in Monsoon season from June to September and there is few rainfall in Non-Monsoon season from November to March. Areal distribution in the Study area is shown that yearly rainfall is gradually reducing from northern part (2500mm/year) to southern part (2000mm/year) in Figure II.2.1.

Correlation coefficient of 10-daily total rainfall is tabulated in Table II.2.12. Monthly and annual rainfall at each stations are listed in Table II.2.13 to II.2.18.

## 2.3 Water Level

All of water level data are collected by daily format, however, data requirement for he Study analysis have generally related to 10-daily mean. Hence 10-daily mean water level have been tabulated for five(5) water level gauging stations. Annual maximum and minimum water level are shown in Table II.19 and II.2.20. The highest water level was recorded at Taluksimulbari in Dharla river 32.76m/PWD in 1966 and lowest water level was 25.64m/PWD in 1982. And the highest water level was recorded at Kurigram in Dharla river 27.500m/PWD in 1987 and lowest water level was 21.75m/PWD in 1960. Monthly mean water level for each stations are listed in Table II.2.21 to II.2.25.

## 2.4 Discharge

Discharge data are needed on the irrigation intake and flood control design. Discharge data at Kurigram gauging station in the Dharla river is available about 18-years from 1973 to 1990. Annual rating curve at Kurigram gauging station is calculated by Least square method, and result is shown in Table II.2.26. But discharge observation data in 1976 and 1977 is not available, so rating curve in these years are calculated by using the data in 1975 and 1978.

Annual maximum and minimum discharge at Kurigram are calculated from annual maximum and minimum water level (listed Table II.2.27) by using rating formula (listed Table II.2.26). Monthly mean discharge at Kurigram is listed in Table II.2.28.

Monthly pattern for climatological, rainfall and water level are shown in Fig.II.2.2 to II.2.4.

# 3 Hydrological Probability Analysis

## 3.1 Methodology

Gumbel-Chow method and Thomas plotting are adopted for hydrological probability analysis in this Study.

Formula of Gumbel-Chow method is as follow.

$$X = s\,K + Xm$$

where, $Xm$ : mean
$s$ : standard deviation

$$K = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \log_e\left(\log_e \frac{T}{T-1}\right)\right\}$$

| T (years) | 200 | 100 | 50 | 25 | 20 | 10 | 5 | 2 |
|---|---|---|---|---|---|---|---|---|
| K | 3.683 | 3.137 | 2.592 | 2.043 | 1.867 | 1.304 | 0.72 | -0.164 |

## 3.2 Probability

### 3.2.1 Rainfall

Probability analysis of rainfall was carried out for duration of 1-day, 5-days and yearly rainfall to produce estimates of the annual frequency. Yearly, daily and 5-day period rainfall probability on each period at main six(6) stations are tabulated in Table II.3.1 to II.3.3.

### 3.2.2 Water Level

Water level data are collected from 1960 to 1990. Twenty eight(28) data at Kurigram and twenty six(26) data at Talukshimulbari are available on annual maximum water level.

And twenty nine(29) data at Kurigram and twenty eight(28) data at Talukshimulbari are available on annual minimum water level. Water level probability on main six(6) gauging stations are tabulated in Table II.3.4 and II.3.5.

### 3.2.3 Discharge

Discharge frequency analysis is done at Kurigram gauging station that is objective river for irrigation intake and having long period data.

Flood maximum, minimum and droughty discharge frequency at Kurigram is tabulated in Table II.3.6 to II.3.8.

## Table II.1.1 Meteorological Data Availability

```
Item                 1960      1970      1980      1990
                     |    |    |    |    |    |    |    |
------------------------------------------------------------
Temperatur Max.     +*******++*+++    +++++*********+
           Min.     +*******+++*+++   +**++*********+
           Ave.     +*******+++*+++   +++++*********+
Humidity            +*******++*++++++*++***+*********+
Sunshine Hours                          +*++++++++*+**+
Wind Speed          +********* +++++* +++*++++++++*+
Evaporation                                +++*******+
------------------------------------------------------------
```

## Table II.1.2 Rainfall Data Availability

```
Station              1960      1970      1980      1990
 (No.)               |    |    |    |    |    |    |    |
------------------------------------------------------------
Chilmari(163)          ++ *****+++**********+********
Kaunia(178)            *+*******+++**********+********
Kurigram(182)         ++ ******+ *******************
Lalmanirhat(183)       +****+ **+ *************** **
Pirgacha(202)          ++*******+*********** +*******
Sundarganj(218)        *+*******++*********   ********
Ulipur(222)            *********+ +*****************
------------------------------------------------------------
```

## Table II.1.3 Water Level Data Availability

```
Station              1960      1970      1980      1990
 (No.)               |    |    |    |    |    |    |    |
------------------------------------------------------------
Noonkawa(45)           ++*******+***********  ********
Chilmari(45.5)         +   ************** *   ********
Bahadurabad(46.9)    ***   *************************
Talukshimulbari(76)  + +   *****+ ******************
Kurigram(77)         * + ***+***+*************+*******
Kaunia(294)          ***** *+***+ ++*+**+*************
Haripur(294.5)                       ***          *
------------------------------------------------------------
```

## Table II.1.4 Discharge Data Availability

```
Station              1960      1970      1980      1990
 (No.)               |    |    |    |    |    |    |    |
------------------------------------------------------------
Talukshimulbari(76)            **** ****          ******
Kurigram(77)                         ***++***************
Kaunia(294)                      ** ***   ** **** ******
------------------------------------------------------------
   *) data complete        +)  not complete
```

## Table II.2.1 Monthly Mean Meteorological Data at Rangpur

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Set. | Oct. | Nov. | Dec. | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (_C ) | | | | | | | | | | | | | |
| Maximum | 24.2 | 26.7 | 31.0 | 33.4 | 32.4 | 32.1 | 31.6 | 32.0 | 31.6 | 30.8 | 28.5 | 25.3 | 30.0 |
| Minimum | 10.2 | 12.2 | 16.0 | 20.3 | 22.5 | 24.7 | 25.6 | 26.3 | 25.2 | 22.3 | 16.9 | 12.2 | 19.5 |
| Average | 17.3 | 19.4 | 23.5 | 26.9 | 27.5 | 28.4 | 28.6 | 29.2 | 28.4 | 26.6 | 22.7 | 18.8 | 24.8 |
| Humidity ( % ) | 81.8 | 76.0 | 67.9 | 71.1 | 79.8 | 85.0 | 87.0 | 85.8 | 87.0 | 85.0 | 82.5 | 83.4 | 81.0 |
| Sunshine (hrs) | 7.73 | 7.98 | 7.83 | 7.39 | 6.51 | 5.48 | 4.09 | 5.15 | 4.92 | 7.32 | 8.51 | 7.72 | 6.72 |
| Wind (knot) | 2.7 | 3.0 | 3.9 | 4.0 | 3.5 | 3.4 | 3.3 | 3.4 | 3.1 | 2.7 | 3.0 | 2.7 | 3.2 |
| Evaporation (mm/day) | 2.3 | 4.0 | 5.3 | 6.0 | 5.2 | 4.6 | 4.4 | 4.5 | 3.5 | 3.5 | 3.1 | 2.3 | 4.1 |

## Table II.2.2 Monthly Mean Maximum Temperature at Rangpur

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959 | - | - | - | - | - | - | - | - | - | 24.7 | 29.3 | 29.4 |
| 1960 | 37.7 | 36.0 | 31.8 | 31.3 | 32.2 | 30.8 | 31.4 | 28.6 | 26.6 | 25.5 | 24.6 | 32.0 |
| 1961 | 34.6 | 32.5 | 31.2 | 32.3 | 32.3 | 31.7 | 30.6 | 27.1 | 23.5 | 23.4 | 27.4 | 32.5 |
| 1962 | 36.5 | 30.8 | 31.6 | 32.3 | 31.3 | 32.9 | 30.9 | 28.8 | 25.7 | 24.9 | 29.7 | 30.4 |
| 1963 | 32.6 | 30.9 | 32.3 | 31.2 | 31.8 | 33.0 | 31.1 | 27.3 | 25.9 | 23.5 | 27.8 | 32.5 |
| 1964 | 32.5 | 32.1 | 31.6 | 30.7 | 32.2 | 31.9 | 30.9 | 29.0 | 24.9 | 25.7 | 27.2 | 31.2 |
| 1965 | 31.8 | 32.8 | 31.3 | 31.1 | 30.6 | 31.2 | 30.9 | 27.0 | 25.6 | 24.9 | 29.7 | 34.1 |
| 1966 | 38.1 | 35.2 | 31.8 | 32.0 | 31.6 | 31.9 | 30.0 | 27.8 | 25.4 | 25.1 | 28.8 | 30.6 |
| 1967 | 32.4 | 33.1 | 33.8 | 31.8 | 34.2 | 32.3 | 30.5 | 29.1 | 27.3 | - | - | - |
| 1968 | - | - | - | - | - | - | - | - | - | 25.4 | 28.6 | 31.9 |
| 1969 | 34.9 | 33.3 | 33.5 | 32.7 | 32.6 | 32.7 | 31.0 | 28.0 | 25.7 | 24.1 | 26.8 | 32.8 |
| 1970 | 37.5 | 36.6 | 31.6 | 31.6 | 32.5 | 32.6 | 31.7 | 30.2 | 26.1 | 25.3 | 27.0 | - |
| 1971 | - | - | 31.9 | 33.1 | 32.6 | 32.4 | 31.9 | 30.2 | - | 26.1 | 25.5 | 30.5 |
| 1972 | 34.3 | 38.0 | 35.8 | 34.2 | - | 33.6 | 33.0 | 32.2 | 28.6 | - | - | - |
| 1973 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1974 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1975 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1976 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1977 | - | - | - | - | - | - | - | - | - | 27.4 | 27.6 | 31.4 |
| 1978 | 33.2 | 30.4 | 30.7 | 30.9 | 32.7 | 30.8 | 31.5 | 27.5 | - | 17.0 | 19.5 | - |
| 1979 | - | - | - | - | 32.0 | 30.8 | 29.6 | 27.3 | 23.3 | 23.2 | 25.8 | 30.3 |
| 1980 | 33.2 | 29.5 | 31.4 | 31.1 | 30.5 | 31.4 | 29.2 | 28.3 | 25.7 | - | 26.3 | 30.4 |
| 1981 | 29.9 | 30.5 | 33.1 | - | - | - | 32.1 | 28.7 | 24.2 | 25.0 | 26.1 | 29.6 |
| 1982 | 31.2 | 33.3 | 31.0 | 31.7 | 31.5 | 31.8 | 30.8 | 27.2 | 24.0 | 22.7 | 25.5 | 30.5 |
| 1983 | 31.9 | 30.0 | 32.3 | 31.7 | 31.4 | 30.3 | 30.3 | 28.8 | 23.7 | 22.4 | 25.5 | 31.7 |
| 1984 | 33.9 | 29.9 | 31.1 | 30.9 | 32.3 | 30.5 | 31.0 | 28.2 | 24.4 | 23.7 | 25.6 | 31.9 |
| 1985 | 33.2 | 31.3 | 32.2 | 30.5 | 32.3 | 30.9 | 30.8 | 28.1 | 25.5 | 23.7 | 26.7 | 32.2 |
| 1986 | 30.3 | 31.6 | 32.4 | 31.5 | 32.6 | 30.1 | 28.9 | 27.9 | 24.4 | 24.1 | 27.6 | 29.7 |
| 1987 | 32.1 | 33.1 | 32.5 | 30.4 | 30.7 | 30.9 | 30.5 | 28.2 | 25.7 | 24.9 | 27.7 | 30.1 |
| 1988 | 32.3 | 31.0 | 31.7 | 31.8 | 31.5 | 31.8 | 31.4 | 28.6 | 26.0 | 23.1 | 25.4 | 30.3 |
| 1989 | 34.6 | 32.6 | 32.0 | 31.0 | 32.5 | 30.7 | 31.4 | 28.0 | 23.7 | 24.2 | 25.4 | 27.9 |
| 1990 | 29.5 | 31.8 | 31.8 | 31.8 | 32.4 | 31.5 | 28.7 | 29.5 | 26.1 | - | - | - |
| mean | 33.4 | 32.4 | 32.1 | 31.6 | 32.0 | 31.6 | 30.8 | 28.5 | 25.3 | 24.2 | 26.7 | 31.0 |

## Table II.2.3 Monthly Mean Minimum Temperature at Rangpur

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959 | - | - | - | - | - | - | - | - | - | 9.8 | 13.4 | 16.5 |
| 1960 | 20.8 | 24.0 | 25.0 | 25.9 | 26.5 | 25.7 | 23.0 | 16.0 | 13.5 | 11.8 | 11.4 | 17.0 |
| 1961 | 21.3 | 23.3 | 25.2 | 26.2 | 26.4 | 25.6 | 21.9 | 16.2 | 10.1 | 8.9 | 13.1 | 15.6 |
| 1962 | 21.8 | 22.2 | 24.3 | 26.2 | 25.8 | 25.9 | 21.8 | 15.6 | 11.7 | 9.8 | 12.4 | 16.3 |
| 1963 | 20.5 | 22.4 | 25.2 | 26.1 | 26.5 | 26.3 | 22.5 | 16.3 | 13.0 | 9.0 | 12.5 | 18.1 |
| 1964 | 20.8 | 22.7 | 24.8 | 25.5 | 26.1 | 25.6 | 23.8 | 17.0 | 10.8 | 10.0 | 11.1 | 13.7 |
| 1965 | 20.0 | 22.7 | 25.2 | 25.8 | 26.0 | 25.3 | 22.0 | 15.9 | 11.0 | 11.1 | 13.8 | 16.5 |
| 1966 | 21.2 | 23.3 | 24.3 | 25.5 | - | 25.0 | 20.8 | 16.0 | 11.7 | 9.4 | 11.3 | 14.0 |
| 1967 | 17.1 | 22.0 | 25.0 | 25.8 | 27.7 | 26.1 | 22.4 | 17.1 | 12.5 | - | - | - |
| 1968 | - | - | - | - | - | - | - | - | - | 7.3 | 9.7 | 12.3 |
| 1969 | 18.1 | 21.4 | 21.2 | 26.2 | 26.3 | 25.5 | 21.4 | 17.1 | 11.7 | 9.6 | 12.0 | 15.3 |
| 1970 | 19.6 | 22.8 | 23.9 | 24.7 | 25.5 | 25.3 | 21.5 | 17.0 | 9.7 | 9.7 | 9.6 | - |
| 1971 | - | - | - | - | 25.7 | 24.4 | 22.0 | 17.5 | - | 9.4 | 10.6 | 12.6 |
| 1972 | 13.7 | 14.3 | 16.7 | 21.3 | - | 21.9 | 21.3 | 18.8 | 12.4 | - | - | - |
| 1973 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1974 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1975 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1976 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1977 | - | - | - | - | - | - | - | - | - | 10.6 | 13.5 | - |
| 1978 | 20.7 | 23.8 | 25.9 | 26.1 | 27.1 | 25.2 | 23.1 | 18.2 | 11.8 | 12.6 | 12.5 | 15.8 |
| 1979 | 20.5 | 24.3 | 25.6 | 25.0 | 26.0 | 25.5 | 22.5 | 19.2 | 13.1 | 10.2 | 14.0 | 17.6 |
| 1980 | 23.8 | 22.3 | 25.9 | 26.8 | 26.3 | 26.2 | 22.5 | 17.3 | 14.0 | - | 13.3 | 16.8 |
| 1981 | 20.0 | 22.4 | 25.8 | - | - | - | 22.9 | 16.2 | 12.6 | 11.5 | 12.4 | 16.2 |
| 1982 | 20.8 | 23.8 | 25.4 | 26.1 | 26.6 | 25.8 | 22.5 | 16.6 | 12.3 | 10.1 | 10.6 | 16.1 |
| 1983 | 19.3 | 22.3 | 25.0 | 26.2 | 26.4 | 25.3 | 23.3 | 16.8 | 11.8 | 10.3 | 12.1 | 16.5 |
| 1984 | 21.6 | 22.8 | 25.7 | 25.3 | 26.2 | 24.2 | 22.7 | 15.4 | 12.0 | 10.1 | 12.2 | 17.6 |
| 1985 | 21.7 | 22.7 | 25.2 | 25.2 | 26.3 | 24.8 | 21.9 | 15.7 | 12.6 | 10.8 | 11.4 | 15.4 |
| 1986 | 20.2 | 21.6 | 25.0 | 25.3 | 25.8 | 23.7 | 20.5 | 16.9 | 12.9 | 11.1 | 13.4 | 17.4 |
| 1987 | 21.3 | 23.0 | 25.6 | 25.9 | 25.9 | 25.4 | 22.6 | 17.7 | 13.6 | 11.4 | 14.0 | 17.9 |
| 1988 | 21.7 | 23.7 | 25.6 | 26.1 | 26.2 | 25.4 | 22.7 | 17.5 | 14.1 | 10.0 | 11.5 | 16.2 |
| 1989 | 20.8 | 23.7 | 25.1 | 25.4 | 26.4 | 25.1 | 23.3 | 16.7 | 11.8 | 11.6 | 13.9 | 16.5 |
| 1990 | 20.5 | 23.7 | 25.6 | 26.1 | 26.3 | 25.2 | 21.3 | 17.3 | 12.6 | - | - | - |
| mean | 20.3 | 22.5 | 24.7 | 25.6 | 26.3 | 25.2 | 22.3 | 16.9 | 12.2 | 10.2 | 12.2 | 16.0 |

## Table II.2.4 Monthly Mean Temperature at Rangpur

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959 | - | - | - | - | - | - | - | - | - | 17.4 | 21.4 | 23.0 |
| 1960 | 29.3 | 30.0 | 28.4 | 28.6 | 29.4 | 28.3 | 27.2 | 22.3 | 19.6 | 18.7 | 18.1 | 24.5 |
| 1961 | 28.1 | 28.0 | 28.3 | 29.3 | 29.4 | 28.7 | 26.6 | 21.7 | 16.9 | 16.2 | 20.2 | 24.1 |
| 1962 | 29.2 | 26.5 | 28.3 | 29.2 | 28.6 | 29.4 | 26.5 | 22.2 | 18.8 | 17.4 | 21.1 | 23.4 |
| 1963 | 26.6 | 26.9 | 28.8 | 28.7 | 29.1 | 29.6 | 26.8 | 21.9 | 19.5 | 16.5 | 20.1 | 25.3 |
| 1964 | 26.7 | 27.4 | 28.2 | 28.1 | 29.2 | 28.8 | 27.4 | 23.2 | 17.9 | 17.9 | 19.2 | 22.5 |
| 1965 | 25.9 | 27.9 | 28.3 | 28.5 | 28.2 | 28.3 | 26.5 | 21.5 | 18.3 | 17.9 | 21.8 | 25.3 |
| 1966 | 29.8 | 29.2 | 28.1 | 28.8 | 28.9 | 28.5 | 25.5 | 21.9 | 18.5 | 17.3 | 20.0 | 22.3 |
| 1967 | 24.8 | 27.6 | 29.4 | 28.8 | 30.9 | 29.2 | 26.6 | 23.1 | 19.9 | - | - | - |
| 1968 | - | - | - | - | - | - | - | - | - | 16.4 | 18.5 | 22.1 |
| 1969 | 26.6 | 27.4 | 27.3 | 29.5 | 29.5 | 29.1 | 26.3 | 22.5 | 18.8 | 16.9 | 19.4 | 24.0 |
| 1970 | 28.5 | 29.6 | 27.8 | 28.2 | 29.1 | 29.0 | 26.6 | 23.5 | 18.2 | 17.5 | 18.4 | - |
| 1971 | - | - | - | - | 29.2 | 28.4 | 26.9 | 23.9 | - | 17.8 | 18.1 | 21.6 |
| 1972 | 23.9 | 26.2 | 26.2 | 27.7 | - | 27.8 | 27.2 | 25.5 | 20.5 | - | - | - |
| 1973 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1974 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1975 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1976 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1977 | - | - | - | - | - | - | - | - | - | 19.0 | 20.6 | - |
| 1978 | 27.1 | 27.2 | 28.3 | 28.5 | 29.9 | 28.0 | 27.4 | 22.7 | - | 15.2 | 15.9 | - |
| 1979 | - | - | - | - | 29.0 | 28.2 | 25.6 | 23.2 | 18.6 | 16.7 | 19.7 | 24.0 |
| 1980 | 28.6 | 26.0 | 28.7 | 28.9 | 28.5 | 29.0 | 25.9 | 22.8 | 19.8 | - | 19.8 | 23.6 |
| 1981 | 25.0 | 26.4 | 29.3 | - | - | - | 27.5 | 22.5 | 18.3 | 18.3 | 19.3 | 23.0 |
| 1982 | 26.0 | 28.6 | 28.2 | 29.0 | 29.1 | 28.8 | 26.7 | 22.0 | 18.2 | 16.4 | 18.1 | 23.3 |
| 1983 | 25.9 | 26.1 | 28.7 | 29.0 | 28.9 | 27.8 | 26.8 | 22.8 | 17.6 | 16.3 | 18.8 | 24.1 |
| 1984 | 27.8 | 26.4 | 28.4 | 28.1 | 29.3 | 27.4 | 26.9 | 21.8 | 18.2 | 17.0 | 18.9 | 24.8 |
| 1985 | 27.5 | 27.1 | 28.6 | 27.9 | 29.3 | 27.9 | 26.4 | 21.9 | 19.1 | 17.2 | 19.0 | 23.8 |
| 1986 | 25.3 | 26.6 | 28.8 | 28.5 | 29.2 | 26.9 | 24.8 | 22.5 | 18.7 | 17.6 | 20.5 | 23.5 |
| 1987 | 26.7 | 28.1 | 29.1 | 28.2 | 28.3 | 28.1 | 26.6 | 23.0 | 19.7 | 18.2 | 20.9 | 24.1 |
| 1988 | 27.0 | 27.3 | 28.7 | 29.0 | 28.8 | 28.7 | 27.1 | 22.9 | 20.1 | 16.7 | 18.5 | 23.3 |
| 1989 | 27.8 | 28.1 | 28.8 | 28.4 | 29.5 | 28.0 | 27.4 | 22.4 | 17.7 | 17.9 | 19.7 | 22.3 |
| 1990 | 25.0 | 27.8 | 28.7 | 28.9 | 29.4 | 28.3 | 25.1 | 23.4 | 19.4 | - | - | - |
| mean | 26.9 | 27.5 | 28.4 | 28.6 | 29.2 | 28.4 | 26.6 | 22.7 | 18.8 | 17.3 | 19.4 | 23.5 |

## Table II.2.5 Monthly Mean Humidity at Rangpur

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959 | - | - | - | - | - | - | - | - | - | 77.3 | 72.9 | 67.8 |
| 1960 | 50.4 | 69.9 | 86.5 | 87.5 | 86.6 | 89.6 | 83.3 | 83.0 | 87.8 | 83.5 | 76.0 | 62.7 |
| 1961 | 63.1 | 80.1 | 86.4 | 85.6 | 87.6 | 85.8 | 87.0 | 83.3 | 85.2 | 81.7 | 74.5 | 61.1 |
| 1962 | 60.2 | 82.7 | 87.5 | 85.9 | 88.6 | 86.9 | 83.1 | 82.0 | 82.9 | 77.6 | 65.8 | 66.7 |
| 1963 | 71.6 | 80.9 | 86.0 | 89.2 | 87.9 | 85.1 | 84.8 | 80.6 | 79.9 | 74.2 | 71.5 | 65.0 |
| 1964 | 75.1 | 82.0 | 86.9 | 89.4 | 85.4 | 85.9 | 85.4 | 80.1 | 77.7 | 76.5 | 72.0 | 67.3 |
| 1965 | 70.2 | 79.1 | 86.7 | 85.5 | 87.2 | 85.7 | 81.3 | 82.3 | 79.5 | 81.2 | 74.1 | 61.0 |
| 1966 | 67.0 | 73.3 | 86.9 | 88.2 | 89.1 | 87.2 | 84.6 | 86.1 | 83.1 | 81.0 | 76.6 | 75.9 |
| 1967 | 72.8 | 76.8 | 79.0 | 84.0 | 79.1 | 83.7 | 85.7 | 84.9 | 85.1 | - | - | - |
| 1968 | - | - | - | - | - | - | - | - | - | 82.3 | 77.7 | 75.4 |
| 1969 | 76.5 | 78.3 | 79.2 | 85.7 | 84.4 | 84.3 | 84.1 | 83.7 | 83.6 | 85.5 | 83.6 | 78.0 |
| 1970 | 75.2 | 79.0 | 85.7 | 87.0 | 85.3 | 87.2 | 89.0 | 84.5 | 84.0 | 86.7 | 83.7 | - |
| 1971 | - | - | 89.3 | 86.8 | 87.8 | 87.2 | 87.8 | 88.3 | 97.5 | 86.2 | 87.6 | 80.9 |
| 1972 | 78.8 | 80.1 | 82.7 | 85.8 | - | 86.3 | 87.3 | 88.0 | 88.6 | 89.0 | 84.7 | 84.7 |
| 1973 | 83.3 | 84.5 | 85.4 | 83.7 | 82.7 | 86.7 | 85.3 | 86.1 | 87.7 | - | - | - |
| 1974 | - | - | - | - | - | - | - | - | - | 88.2 | 87.8 | 87.5 |
| 1975 | 83.8 | 85.5 | 85.2 | 87.9 | 89.0 | 90.9 | 92.0 | 91.8 | 91.7 | 91.0 | 90.8 | 88.0 |
| 1976 | 88.3 | 87.4 | 89.4 | 91.1 | 89.5 | 86.7 | 89.3 | 92.0 | 91.7 | 90.8 | - | - |
| 1977 | 81.8 | 80.0 | 83.7 | 85.3 | 86.9 | 87.2 | 90.2 | - | 90.6 | 88.7 | 88.2 | 40.3 |
| 1978 | 62.2 | 82.1 | 87.1 | 88.1 | 81.3 | 85.2 | 75.5 | 76.4 | 70.1 | 69.3 | 61.7 | 46.4 |
| 1979 | 56.6 | 65.9 | 78.4 | 86.2 | 81.3 | 82.1 | 80.7 | 79.6 | 78.7 | 73.2 | 67.6 | 61.9 |
| 1980 | 66.5 | 79.4 | 84.0 | 84.1 | 85.6 | 85.9 | 82.5 | 72.7 | 73.3 | 77.2 | 68.9 | 61.0 |
| 1981 | 73.0 | 80.8 | 81.1 | - | - | - | 75.4 | 71.2 | 74.5 | 73.7 | 64.4 | 63.2 |
| 1982 | 69.6 | 74.1 | 84.1 | 84.7 | 82.8 | 85.2 | 80.0 | 76.9 | 77.5 | 75.6 | 65.9 | 57.3 |
| 1983 | 63.2 | 81.2 | 82.2 | 85.3 | 83.8 | 87.1 | 85.6 | 80.2 | 85.9 | 84.3 | 73.7 | 65.2 |
| 1984 | 66.5 | 85.7 | 85.8 | 88.7 | 84.5 | 88.7 | 87.2 | 79.3 | 84.3 | 81.6 | 77.3 | 67.0 |
| 1985 | 70.4 | 80.7 | 85.1 | 89.1 | 85.0 | 88.0 | 85.8 | 82.0 | 82.6 | 83.5 | 71.3 | 56.0 |
| 1986 | 74.8 | 78.3 | 84.7 | 86.8 | 84.8 | 89.7 | 87.2 | 84.4 | 83.3 | 85.0 | 82.8 | 76.1 |
| 1987 | 76.1 | 80.0 | 88.1 | 91.5 | 88.5 | 90.5 | 87.9 | 86.5 | 87.5 | 84.6 | 78.1 | 72.0 |
| 1988 | 74.7 | 83.9 | 85.4 | 87.5 | 89.4 | 87.9 | 84.8 | 80.6 | 82.6 | 79.6 | 71.3 | 71.3 |
| 1989 | 60.6 | 78.5 | 84.3 | 88.6 | 84.6 | 90.3 | 85.8 | 84.1 | 82.5 | 84.5 | 76.8 | 72.9 |
| 1990 | 79.7 | 83.6 | 86.8 | 87.9 | 86.5 | 88.3 | 87.7 | 79.2 | 80.2 | - | - | - |
| mean | 71.1 | 79.8 | 85.0 | 87.0 | 85.8 | 87.0 | 85.0 | 82.5 | 83.4 | 81.8 | 76.0 | 67.9 |

## Table II.2.6 Monthly Mean Sunshine Hours at Rangpur

| Year | Apr. | May. | Jun | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | - | - | - | - | 48.5 | 64.1 | 71.4 | - | 66.7 | 81.7 | 66.2 | 70.0 |
| 1980 | 75.2 | 63.4 | 60.6 | 53.9 | 50.9 | 54.4 | 82.4 | 96.8 | 88.9 | 82.5 | 91.8 | 78.9 |
| 1981 | 77.3 | 77.3 | 84.6 | - | - | - | 107.8 | 102.1 | 83.0 | 90.9 | 93.3 | 93.1 |
| 1982 | 77.8 | 92.2 | 39.7 | 43.5 | 60.9 | 59.2 | 84.4 | 75.8 | 67.6 | - | 85.8 | 90.6 |
| 1983 | 67.1 | 66.0 | 68.4 | 53.4 | - | - | 62.7 | 91.5 | 71.6 | - | - | 83.7 |
| 1984 | 86.6 | 39.4 | 56.4 | 31.0 | 56.7 | 45.9 | 59.7 | - | 77.0 | - | - | 61.5 |
| 1985 | 70.2 | - | 51.4 | - | - | 55.3 | 80.1 | 86.6 | 70.4 | 76.4 | 83.5 | 77.2 |
| 1986 | - | - | - | - | - | 37.2 | - | - | 92.4 | 78.7 | 84.8 | 74.8 |
| 1987 | 78.3 | 91.2 | 47.6 | 27.4 | 44.5 | 38.2 | 68.5 | 73.9 | 82.6 | 76.1 | 71.9 | 81.6 |
| 1988 | - | 63.7 | 53.5 | 41.5 | 30.2 | 49.2 | 78.5 | 81.1 | 79.7 | 76.2 | 79.1 | 76.4 |
| 1989 | 74.9 | 64.2 | 58.4 | 35.4 | 65.2 | 34.7 | 72.2 | 79.4 | 69.4 | 62.0 | 65.8 | 72.3 |
| 1990 | 62.6 | 68.1 | 48.2 | 39.0 | 59.7 | 53.8 | 51.7 | 84.8 | 77.3 | 71.1 | 76.0 | 79.3 |
| 1991 | 68.9 | 25.2 | 33.8 | 42.9 | 46.8 | - | 59.3 | 78.9 | - | - | - | - |
| mean | 73.9 | 65.1 | 54.8 | 40.9 | 51.5 | 49.2 | 73.2 | 85.1 | 77.2 | 77.3 | 79.8 | 78.3 |

## Table II.2.7 Monthly Mean Evaporation at Rangpur

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | - | - | - | - | - | - | - | - | - | - | 7.4 | 5.4 |
| 1983 | - | - | 3.7 | 3.8 | - | - | - | 3.3 | 2.3 | 2.3 | 3.3 | 5.1 |
| 1984 | - | 4.7 | - | - | - | - | 3.8 | 3.4 | 2.1 | 2.3 | 3.1 | 5.7 |
| 1985 | 7.0 | 5.9 | 5.5 | 6.3 | 5.7 | 3.9 | 3.2 | 2.8 | 2.4 | 2.4 | 3.7 | 6.6 |
| 1986 | 5.5 | 5.6 | 5.0 | 4.5 | 4.8 | 3.6 | 3.2 | 2.6 | 2.4 | 2.4 | 3.5 | 4.8 |
| 1987 | 5.9 | 6.4 | 5.2 | 4.2 | 4.0 | 3.1 | 3.2 | 2.9 | 2.6 | 2.4 | 3.5 | 5.0 |
| 1988 | 5.9 | 5.5 | 4.0 | 4.3 | 2.8 | 3.7 | 3.8 | 3.4 | 2.4 | 2.2 | 4.4 | 5.8 |
| 1989 | 7.2 | 5.7 | 4.7 | 4.0 | 4.6 | 3.2 | 4.0 | 2.8 | 1.9 | 2.1 | 3.0 | 4.2 |
| 1990 | 4.5 | 3.9 | 4.4 | 4.1 | 4.8 | 3.5 | 3.2 | 3.2 | 2.4 | 2.2 | 3.7 | 5.2 |
| 1991 | 5.9 | 3.6 | 4.0 | 4.2 | - | - | - | - | - | - | - | - |
| mean | 6.0 | 5.2 | 4.6 | 4.4 | 4.5 | 3.5 | 3.5 | 3.1 | 2.3 | 2.3 | 4.0 | 5.3 |

## Table II.2.8 Monthly Mean Wind Velocity at Rangpur

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959 | - | - | - | - | - | - | - | - | - | 2.2 | 2.3 | 2.9 |
| 1960 | 3.6 | 3.3 | 2.7 | 2.9 | 2.8 | 2.4 | 2.3 | 2.4 | 2.0 | 2.0 | 2.4 | 3.4 |
| 1961 | 3.3 | 3.7 | 2.8 | 2.6 | 2.8 | 2.5 | 2.2 | 2.4 | 2.9 | 1.7 | 1.8 | 2.6 |
| 1962 | 3.8 | 3.1 | 2.5 | 2.5 | 2.8 | 2.4 | 2.2 | 2.0 | 2.0 | 2.2 | 2.4 | 3.0 |
| 1963 | 3.7 | 3.4 | 3.1 | 2.6 | 2.9 | 2.2 | 2.2 | 2.4 | 2.1 | 2.8 | 2.5 | 3.4 |
| 1964 | 3.2 | 2.7 | 3.6 | 3.2 | 3.2 | 2.7 | 2.9 | 2.5 | 2.4 | 2.1 | 2.2 | 2.5 |
| 1965 | 3.5 | 3.4 | 3.5 | 3.0 | 3.1 | 2.3 | 2.0 | 2.3 | 2.7 | 2.5 | 2.1 | 3.1 |
| 1966 | 2.9 | 3.1 | 3.9 | 2.5 | 2.6 | 2.4 | 2.4 | 2.1 | 2.3 | 2.3 | 2.8 | 3.3 |
| 1967 | 4.3 | 3.7 | 2.9 | 3.5 | 2.2 | 2.3 | 2.4 | 2.0 | 2.2 | 2.2 | 2.4 | 3.4 |
| 1968 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1969 | 2.9 | 2.3 | 2.6 | 2.6 | 2.8 | 2.8 | 2.4 | 2.5 | 2.2 | - | 2.6 | 4.4 |
| 1970 | 4.0 | 3.1 | 2.8 | 2.5 | 2.2 | 2.8 | 2.4 | 2.8 | - | 2.2 | 3.2 | - |
| 1971 | - | - | 2.5 | 2.7 | 3.3 | 3.2 | 2.4 | 3.7 | - | 2.0 | 2.2 | 2.8 |
| 1972 | 3.2 | 3.6 | 2.8 | 2.5 | - | 2.3 | 2.4 | 2.2 | 2.0 | 2.1 | 2.0 | 2.5 |
| 1973 | 3.3 | 2.2 | 2.1 | 2.8 | 2.1 | 2.3 | 2.2 | 2.4 | 2.1 | 2.0 | 2.0 | 2.3 |
| 1974 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1975 | 2.5 | 2.2 | 2.1 | 2.1 | 3.0 | 2.3 | 2.0 | 2.0 | - | - | 5.2 | 4.6 |
| 1976 | 2.9 | 2.7 | 2.9 | 2.4 | 2.8 | 2.2 | 2.2 | 2.0 | - | 2.1 | - | - |
| 1977 | 2.6 | 2.9 | 2.1 | 2.2 | 2.2 | 2.0 | 2.0 | - | 2.0 | 2.2 | 2.0 | 4.4 |
| 1978 | 4.3 | 4.2 | 3.3 | 2.8 | 3.0 | 3.4 | 3.1 | 3.1 | 3.0 | 3.4 | 4.2 | 5.6 |
| 1979 | 4.4 | - | 4.8 | 5.4 | 4.6 | 5.0 | 3.1 | 2.6 | 2.8 | - | 3.4 | |
| 1980 | 4.0 | 3.6 | 3.5 | 3.9 | 3.8 | 3.4 | 3.0 | 3.0 | 2.4 | - | 2.7 | 4.3 |
| 1981 | 3.8 | 3.1 | 3.4 | - | - | - | - | 3.7 | 2.9 | 3.7 | 4.5 | 4.8 |
| 1982 | 4.7 | 4.4 | 3.9 | 3.7 | 5.1 | 3.0 | 3.1 | - | - | 3.5 | 3.7 | 4.4 |
| 1983 | 4.7 | - | 3.6 | 3.5 | 4.2 | 3.5 | 3.8 | 4.1 | 3.4 | - | 3.8 | 4.8 |
| 1984 | 4.9 | 4.5 | 5.1 | 4.7 | 5.5 | 4.5 | - | 5.0 | 4.4 | 4.3 | 4.3 | 6.1 |
| 1985 | 5.7 | 5.9 | 4.6 | 4.9 | 5.1 | 4.4 | 3.8 | 4.2 | - | 4.0 | 4.8 | 5.7 |
| 1986 | 6.5 | 4.4 | 5.4 | 5.0 | 4.8 | 5.1 | 4.3 | 4.1 | - | 3.6 | 4.3 | 4.8 |
| 1987 | 5.6 | 4.4 | 4.2 | 4.6 | 4.6 | 3.8 | 3.3 | 3.8 | 4.0 | 3.5 | 3.5 | 4.5 |
| 1988 | 5.3 | 5.1 | 6.2 | 4.1 | 4.0 | 4.0 | 3.8 | 5.0 | 3.7 | - | - | - |
| mean | 4.0 | 3.5 | 3.4 | 3.3 | 3.4 | 3.1 | 2.7 | 3.0 | 2.7 | 2.7 | 3.0 | 3.9 |

**Table II.2.9 Annual Rainfall Data**

| Year | Chil mari | Kaunia | Kuri gram | Lalma nirhat | Pir gacha | Sundar ganj | Ulipur |
|---|---|---|---|---|---|---|---|
| 1962 | - | 2372 | - | - | - | 1612 | 1687 |
| 1963 | - | - | - | 2194 | - | - | 2717 |
| 1964 | - | 2216 | 2260 | 3195 | 2293 | 1974 | 3006 |
| 1965 | 1721 | 1434 | 2143 | 2183 | 1624 | 1729 | 2423 |
| 1966 | 1751 | 1817 | 1937 | - | 1799 | 1764 | 2178 |
| 1967 | 1695 | 2126 | 1891 | - | 1469 | 1614 | 1828 |
| 1968 | 2341 | 2374 | 2274 | 2961 | 2316 | 1867 | 2679 |
| 1969 | 2207 | 2459 | 2194 | 2677 | 2430 | 2003 | 2390 |
| 1970 | - | - | - | - | - | - | - |
| 1971 | - | - | - | - | 1483 | - | - |
| 1972 | - | - | 1864 | 1592 | 887 | 1483 | - |
| 1973 | 3358 | 3575 | 3249 | 3245 | 2730 | 2627 | 2671 |
| 1974 | 3838 | 4951 | 3355 | 4071 | 2779 | 2944 | 2978 |
| 1975 | 1771 | 2130 | 1690 | 2061 | 1674 | 1546 | 1499 |
| 1976 | 1943 | 1654 | 2228 | 1677 | 1964 | 1497 | 1765 |
| 1977 | 2275 | 2295 | 2145 | 2770 | 1985 | 2224 | 2199 |
| 1978 | 1784 | 1735 | 1707 | 2127 | 1888 | 1356 | 1591 |
| 1979 | 1812 | 2392 | 2446 | 2480 | 1770 | 1374 | 2054 |
| 1980 | 1729 | 1841 | 1835 | 1995 | 2228 | 2028 | 2002 |
| 1981 | 1421 | 2252 | 1609 | 2010 | 2378 | - | 1876 |
| 1982 | - | - | 2365 | 2453 | - | - | 1965 |
| 1983 | 2290 | 2267 | 2378 | 2107 | - | 2462 | 2052 |
| 1984 | 2778 | 3002 | 2861 | 3354 | 2502 | 2295 | 2666 |
| 1985 | 1810 | 2736 | 2450 | 2926 | 1789 | 2128 | 2111 |
| 1986 | 2559 | 2434 | 2487 | 2364 | 2013 | 2464 | 2572 |
| 1987 | 3231 | 3820 | 2980 | 3991 | 2941 | 3197 | 2857 |
| 1988 | 2989 | 2549 | 3173 | - | 2603 | 1777 | 3024 |
| 1989 | 2676 | 2803 | 2857 | 2294 | 2595 | 2196 | 2480 |
| 1990 | 2699 | 2526 | 2733 | 2657 | 2674 | 1759 | 2518 |
| Ave. | 2304 | 2478 | 2364 | 2582 | 2116 | 1997 | 2300 |

**Table II.2.10 Annual Maximum Daily Rainfall**

| Year | Chil mari | Kaunia | Kuri gram | Lalma nirhat | Pir gacha | Sundar ganj | Ulipur |
|---|---|---|---|---|---|---|---|
| 1961 | - | - | - | - | - | - | - |
| 1962 | - | 181.1 | 137.2 | 138.2 | - | 132.6 | 209.6 |
| 1963 | 168.9 | - | - | 161.5 | 195.6 | - | 138.9 |
| 1964 | - | 119.1 | 127.2 | 186.9 | 210.8 | 97.8 | 127.0 |
| 1965 | 139.7 | 101.6 | 115.6 | 142.7 | 148.6 | 81.3 | 118.1 |
| 1966 | 158.8 | 152.4 | 152.9 | 119.4 | 159.0 | 81.3 | 168.9 |
| 1967 | 91.2 | 251.2 | 108.2 | - | 96.5 | 241.3 | 79.8 |
| 1968 | 153.7 | 191.8 | 147.3 | 211.8 | 172.7 | 186.7 | 218.9 |
| 1969 | 222.2 | 174.0 | 176.0 | 234.7 | 175.3 | 157.5 | 304.8 |
| 1970 | 204.5 | 152.9 | 157.6 | 136.1 | 95.2 | 180.3 | 175.3 |
| 1971 | - | 234.5 | - | - | 109.2 | 133.4 | - |
| 1972 | - | - | 129.5 | 114.3 | 69.8 | 215.9 | - |
| 1973 | 219.7 | 321.3 | 235.0 | 238.8 | 223.5 | 208.3 | 292.1 |
| 1974 | 168.9 | 281.2 | 203.2 | 254.0 | 215.9 | 132.1 | 203.2 |
| 1975 | 86.4 | 194.6 | 88.9 | 137.2 | 81.8 | 101.6 | 117.3 |
| 1976 | 88.9 | 226.1 | 279.4 | 174.0 | 355.6 | 142.2 | 133.4 |
| 1977 | 102.9 | 121.4 | 119.4 | 196.6 | 127.0 | 114.3 | 83.8 |
| 1978 | 99.1 | 153.7 | 115.6 | 121.9 | 71.6 | 127.0 | 148.6 |
| 1979 | 141.0 | 260.3 | 284.5 | 150.6 | 245.9 | 88.9 | 177.8 |
| 1980 | 88.9 | 148.6 | 132.1 | 122.7 | 171.4 | 141.7 | 117.6 |
| 1981 | 121.9 | 185.4 | 134.6 | 154.2 | 185.4 | - | 159.5 |
| 1982 | - | 177.8 | 274.3 | 240.0 | - | - | 158.7 |
| 1983 | 116.3 | 165.1 | 215.9 | 139.7 | 157.5 | 157.0 | 114.3 |
| 1984 | 172.2 | 196.9 | 156.2 | 203.2 | 210.8 | 142.2 | 139.7 |
| 1985 | 165.1 | 218.4 | 138.4 | 161.3 | 151.1 | 190.5 | 139.7 |
| 1986 | 242.6 | 113.0 | 139.7 | 171.5 | 165.1 | 129.5 | 119.4 |
| 1987 | 306.1 | 228.6 | 180.3 | 216.4 | 226.1 | 228.6 | 228.6 |
| 1988 | 237.5 | 138.0 | 203.2 | - | 204.0 | 114.3 | 129.5 |
| 1989 | 255.0 | 210.0 | 220.0 | 252.0 | 200.0 | 200.0 | 300.0 |
| 1990 | 315.0 | 215.0 | 214.0 | 225.0 | 140.5 | 80.0 | 300.3 |

## Table II.2.11 Annual Maximum 5-day Period Rainfall

| Year | Chil mari | Kaunia | Kuri gram | Lalma nirhat | Pir gacha | Sundar ganj | Ulipur |
|---|---|---|---|---|---|---|---|
| 1962 | - | 515.2 | 316.3 | 213.8 | - | 241.8 | 275.9 |
| 1963 | 353.0 | - | - | 257.5 | 323.4 | - | 429.7 |
| 1964 | - | 307.1 | 289.0 | 342.4 | 339.1 | 266.7 | 350.6 |
| 1965 | 297.7 | 165.1 | 257.5 | 345.1 | 206.8 | 188.0 | 294.1 |
| 1966 | 405.4 | 258.5 | 314.4 | 282.2 | 368.0 | 350.3 | 340.3 |
| 1967 | 198.8 | 394.7 | 222.9 | - | 173.4 | 343.0 | 192.4 |
| 1968 | 393.0 | 309.7 | 311.2 | 432.8 | 351.5 | 280.7 | 401.2 |
| 1969 | 452.0 | 486.4 | 308.9 | 422.1 | 364.6 | 330.2 | 500.8 |
| 1970 | 393.7 | 279.6 | 305.1 | 294.3 | 200.7 | 340.4 | 300.1 |
| 1971 | - | 296.6 | - | - | 212.2 | 212.2 | - |
| 1972 | - | - | 286.1 | 200.7 | 197.3 | 283.3 | - |
| 1973 | 505.0 | 549.1 | 584.4 | 520.7 | 577.3 | - | 698.5 |
| 1974 | 582.4 | 474.8 | 460.8 | 462.3 | 399.0 | 411.4 | 432.4 |
| 1975 | 190.5 | 226.9 | 217.0 | 219.8 | 165.4 | 179.0 | 266.2 |
| 1976 | 243.9 | 288.3 | 604.5 | 457.2 | 870.0 | 266.7 | 335.9 |
| 1977 | 290.8 | 269.0 | 226.1 | 416.6 | 236.6 | 208.3 | 220.5 |
| 1978 | 266.0 | 278.7 | 248.9 | 257.1 | 332.3 | 177.8 | 282.1 |
| 1979 | 287.0 | 459.6 | 411.5 | 323.3 | 334.3 | 223.5 | 381.5 |
| 1980 | 213.4 | 279.4 | 209.5 | 264.7 | 245.1 | 271.0 | 179.8 |
| 1981 | 238.8 | 426.7 | 246.4 | 398.3 | 420.4 | - | 249.9 |
| 1982 | - | 317.8 | 391.2 | 397.7 | - | - | 271.5 |
| 1983 | 271.5 | 386.1 | 312.6 | 226.3 | 270.2 | 284.7 | 252.2 |
| 1984 | 314.5 | 431.9 | 328.0 | 381.4 | 393.7 | 272.3 | 333.3 |
| 1985 | 337.9 | 401.3 | 307.3 | 369.1 | 276.9 | 336.6 | 321.3 |
| 1986 | 593.9 | 255.3 | 279.4 | 338.5 | 301.0 | 349.2 | 377.2 |
| 1987 | 560.5 | 635.0 | 457.1 | 540.3 | 536.0 | 523.8 | 492.8 |
| 1988 | 442.7 | 458.0 | 448.0 | - | 332.9 | 285.9 | 396.3 |
| 1989 | 372.5 | 415.0 | 345.0 | 362.7 | 350.7 | 338.0 | 438.8 |
| 1990 | 426.0 | 259.5 | 322.0 | 425.6 | 281.5 | 195.0 | 387.6 |

**Table II.2.12 Correlation Coefficient of 10-daily Rainfall**

| | LAL | KAU | PIR | SUN | KUR | ULI | CHI |
|---|---|---|---|---|---|---|---|
| LAL | - | 0.838 | 0.822 | 0.808 | 0.855 | 0.841 | 0.796 |
| KAU | 0.838 | - | 0.825 | 0.820 | 0.856 | 0.839 | 0.818 |
| PIR | 0.822 | 0.825 | - | 0.823 | 0.839 | 0.858 | 0.804 |
| SUN | 0.808 | 0.820 | 0.823 | - | 0.842 | 0.876 | 0.839 |
| KUR | 0.855 | 0.856 | 0.839 | 0.842 | - | 0.900 | 0.869 |
| ULI | 0.841 | 0.839 | 0.858 | 0.876 | 0.900 | - | 0.905 |
| CHI | 0.796 | 0.818 | 0.804 | 0.839 | 0.869 | 0.905 | - |

LAL: Lalmanirhat
KAU: Kaunia
PIR: Pirgacha
SUN: Sundarganj
KUR: Kurigram
ULI: Ulipur
CHI: Chilmari

## Table II.2.13 Monthly and Annual Rainfall at Chilmari (163) mm.

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | - | - | - | - | - | - | - | - | - | 0.0 | 0.0 | 33.0 | - |
| 1963 | 104.1 | 76.8 | 755.8 | 474.9 | - | 218.5 | - | - | 0.0 | 0.0 | 0.0 | 6.4 | - |
| 1964 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1965 | 2.5 | 425.4 | 262.6 | 402.3 | 361.2 | 188.2 | 58.4 | 0.0 | 0.0 | 19.9 | 0.0 | 0.0 | 1720.5 |
| 1966 | 7.6 | 375.8 | 221.3 | 279.4 | 612.6 | 4.1 | 165.0 | 0.0 | 0.0 | 6.4 | 0.0 | 78.4 | 1750.6 |
| 1967 | 116.9 | 312.3 | 323.4 | 369.6 | 233.0 | 225.0 | 53.3 | 0.0 | 0.0 | 0.0 | 0.0 | 61.1 | 1694.6 |
| 1968 | 56.6 | 340.1 | 566.8 | 637.1 | 244.4 | 181.4 | 253.5 | 0.0 | 0.0 | 3.0 | 0.0 | 58.2 | 2341.1 |
| 1969 | 210.4 | 516.3 | 476.2 | 230.0 | 455.6 | 203.3 | 25.4 | 26.4 | 0.0 | 24.1 | 31.8 | 7.6 | 2207.1 |
| 1970 | 25.9 | 328.7 | 1025.5 | 655.2 | 20.9 | 230.6 | 271.7 | 0.0 | 0.0 | 11.4 | - | - | - |
| 1971 | 87.9 | 81.0 | 207.6 | - | - | - | - | - | - | - | - | - | - |
| 1972 | - | - | - | - | 121.0 | 239.3 | 84.9 | 2.5 | 0.0 | 5.9 | 29.5 | 11.0 | - |
| 1973 | 40.9 | 374.3 | 1139.0 | 358.9 | 387.1 | 683.0 | 304.1 | 10.2 | 3.8 | 3.8 | 0.5 | 52.8 | 3358.4 |
| 1974 | 140.3 | 469.8 | 612.6 | 1265.8 | 514.5 | 728.8 | 86.2 | 17.5 | 0.0 | 0.0 | 2.5 | 0.0 | 3838.0 |
| 1975 | 169.2 | 404.0 | 113.2 | 447.0 | 221.0 | 328.8 | 81.3 | 0.0 | 0.0 | 0.0 | 6.4 | 0.0 | 1770.9 |
| 1976 | 221.0 | 301.6 | 519.4 | 443.3 | 342.3 | 87.5 | 27.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1943.0 |
| 1977 | 200.7 | 296.3 | 745.0 | 292.7 | 177.7 | 147.4 | 367.8 | 33.6 | 7.6 | 0.0 | 4.5 | 2.1 | 2275.4 |
| 1978 | 71.9 | 487.6 | 486.3 | 320.2 | 105.7 | 239.0 | 57.9 | 11.2 | 0.0 | 0.0 | 4.3 | 0.0 | 1784.1 |
| 1979 | 32.3 | 101.3 | 137.6 | 631.8 | 394.4 | 340.3 | 104.1 | 8.9 | 40.6 | 0.0 | 17.8 | 2.5 | 1811.6 |
| 1980 | 77.9 | 380.7 | 415.8 | 220.5 | 197.5 | 280.5 | 110.5 | 0.0 | 0.0 | 15.3 | 22.9 | 7.6 | 1729.2 |
| 1981 | 118.1 | 486.4 | 52.6 | 460.9 | 147.3 | 116.9 | 8.9 | 0.0 | 22.9 | 0.0 | 0.0 | 7.4 | 1421.4 |
| 1982 | 159.3 | 60.6 | 326.0 | 278.2 | - | - | - | - | 0.0 | 0.0 | 0.0 | 30.5 | - |
| 1983 | 30.5 | 409.7 | 345.1 | 504.3 | 423.6 | 245.3 | 262.0 | 0.0 | 33.0 | 20.3 | 10.2 | 6.4 | 2290.4 |
| 1984 | 74.9 | 340.2 | 681.9 | 654.0 | 172.3 | 647.9 | 148.5 | 0.0 | 21.6 | 0.0 | 21.6 | 15.2 | 2778.1 |
| 1985 | 81.5 | 177.1 | 435.7 | 686.4 | 144.5 | 213.4 | 65.0 | 0.0 | 6.1 | 0.0 | 0.0 | 0.0 | 1809.7 |
| 1986 | 201.4 | 252.2 | 308.6 | 306.4 | 284.2 | 412.8 | 664.1 | 12.7 | 18.3 | 0.0 | 11.4 | 86.6 | 2558.7 |
| 1987 | 90.2 | 218.7 | 493.7 | 922.4 | 834.4 | 386.9 | 157.8 | 32.0 | 1.3 | 0.0 | 53.9 | 39.4 | 3230.7 |
| 1988 | 101.5 | 401.8 | 794.3 | 734.4 | 506.7 | 227.0 | 33.9 | 116.8 | 3.0 | 32.9 | 34.5 | 2.0 | 2988.8 |
| 1989 | 0.0 | 682.2 | 353.0 | 833.9 | 86.0 | 599.5 | 48.0 | 0.0 | 1.5 | 0.0 | 23.0 | 48.4 | 2675.5 |
| 1990 | 226.6 | 498.6 | 482.8 | 358.9 | 255.4 | 322.5 | 505.5 | 0.0 | 0.0 | 7.2 | 8.0 | 33.5 | 2699.0 |
| Ave. | 101.9 | 338.4 | 472.4 | 510.7 | 301.8 | 299.9 | 164.4 | 11.3 | 6.1 | 5.6 | 10.9 | 22.7 | 2303.5 |

## Table II.2.14 Monthly and Annual Rainfall at Kaunia (178) mm

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 0.0 | 467.1 | 652.6 | 211.1 | 618.1 | 232.2 | 175.6 | 0.0 | 0.0 | 0.0 | 0.0 | 15.2 | 2371.9 |
| 1963 | - | - | 870.1 | - | 238.1 | 340.3 | - | - | - | - | - | - | - |
| 1964 | 103.7 | 278.6 | 446.3 | 616.4 | 211.3 | 377.9 | 181.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2216.0 |
| 1965 | 79.2 | 345.9 | 142.2 | 302.2 | 412.5 | 88.9 | 47.0 | 0.0 | 0.0 | 16.2 | 0.0 | 0.0 | 1434.1 |
| 1966 | 7.6 | 514.9 | 268.0 | 316.1 | 365.5 | 156.1 | 27.5 | 3.8 | 0.0 | 21.6 | 0.0 | 135.9 | 1817.0 |
| 1967 | 3.8 | 164.7 | 517.9 | 692.8 | 421.7 | 234.9 | 77.9 | 0.0 | 0.0 | 4.3 | 4.8 | 3.3 | 2126.1 |
| 1968 | 16.3 | 237.0 | 633.3 | 630.5 | 191.3 | 414.3 | 192.8 | 0.0 | 0.0 | 18.8 | 0.0 | 39.4 | 2373.7 |
| 1969 | 168.6 | 559.6 | 423.8 | 505.4 | 370.9 | 286.8 | 44.1 | 54.1 | 0.0 | 24.9 | 10.9 | 9.9 | 2459.0 |
| 1970 | 80.5 | 236.5 | 651.2 | 607.6 | 167.7 | 465.0 | 101.1 | 6.1 | 0.0 | 8.9 | - | - | - |
| 1971 | 242.4 | 147.4 | 775.9 | 278.7 | 344.6 | 194.7 | 346.8 | - | 0.0 | 2.5 | 22.9 | 32.0 | - |
| 1972 | 47.7 | 131.3 | - | - | 201.6 | 159.7 | 118.0 | 1.8 | 0.0 | 17.8 | 24.9 | 11.5 | - |
| 1973 | 44.2 | 642.9 | 1155.7 | 329.3 | 144.0 | 616.2 | 215.8 | 51.4 | 0.0 | 21.3 | 0.0 | 54.6 | 3275.4 |
| 1974 | 189.5 | 795.1 | 668.2 | 1161.6 | 678.6 | 1046.0 | 402.9 | 0.0 | 0.0 | 0.0 | 8.9 | 0.0 | 4950.8 |
| 1975 | 215.4 | 445.2 | 98.1 | 640.1 | 105.4 | 424.6 | 189.8 | 0.0 | 0.0 | 0.0 | 10.9 | 0.0 | 2129.5 |
| 1976 | 332.5 | 236.3 | 422.2 | 531.1 | 101.9 | 26.4 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1653.7 |
| 1977 | 137.4 | 346.4 | 602.0 | 385.5 | 360.3 | 156.5 | 220.5 | 54.7 | 11.5 | 1.8 | 3.8 | 14.5 | 2294.9 |
| 1978 | 112.0 | 263.0 | 448.4 | 474.6 | 103.8 | 312.8 | 1.5 | 0.0 | 0.0 | 5.8 | 13.4 | 0.0 | 1735.3 |
| 1979 | 36.8 | 97.7 | 164.8 | 581.5 | 699.5 | 609.8 | 153.6 | 11.4 | 8.9 | 0.0 | 10.7 | 17.7 | 2392.4 |
| 1980 | 68.6 | 304.7 | 316.2 | 396.7 | 463.4 | 219.8 | 59.6 | 0.0 | 0.0 | 4.8 | 0.0 | 7.6 | 1841.4 |
| 1981 | 158.4 | 449.4 | 134.7 | 853.3 | 299.6 | 349.3 | 0.0 | 0.0 | 4.1 | 0.0 | 1.5 | 1.5 | 2251.8 |
| 1982 | - | 44.9 | 671.9 | 683.6 | 338.3 | 607.5 | 49.5 | - | - | - | - | - | - |
| 1983 | 41.8 | 390.0 | 170.8 | 821.6 | 261.6 | 303.3 | 251.4 | 0.0 | 20.3 | 5.1 | 0.0 | 1.3 | 2267.2 |
| 1984 | 90.2 | 238.9 | 872.7 | 835.6 | 242.6 | 574.3 | 120.7 | 0.0 | 1.3 | 0.0 | 5.1 | 20.3 | 3001.7 |
| 1985 | 153.6 | 350.5 | 817.9 | 793.7 | 250.0 | 272.0 | 90.2 | 0.0 | 7.6 | 0.0 | 0.0 | 0.0 | 2735.5 |
| 1986 | 212.1 | 229.8 | 240.3 | 424.3 | 245.1 | 673.1 | 325.2 | 0.0 | 33.0 | 0.0 | 0.0 | 50.8 | 2433.7 |
| 1987 | 100.5 | 342.8 | 628.7 | 1554.6 | 649.0 | 270.6 | 180.3 | 0.0 | 0.0 | 0.0 | 60.9 | 33.0 | 3820.4 |
| 1988 | 148.6 | 304.6 | 466.2 | 425.0 | 730.0 | 391.5 | 18.5 | 55.0 | 0.0 | 5.0 | 5.0 | 0.0 | 2549.4 |
| 1989 | 0.0 | 441.0 | 475.0 | 679.2 | 458.0 | 458.3 | 90.0 | 31.0 | 0.0 | 0.0 | 12.5 | 157.5 | 2802.5 |
| 1990 | 179.5 | 454.0 | 634.5 | 189.0 | 276.0 | 425.0 | 325.0 | 0.0 | 0.0 | 25.0 | 7.0 | 10.5 | 2525.5 |
| Ave. | 110.0 | 337.9 | 513.2 | 589.7 | 343.1 | 368.5 | 143.2 | 10.4 | 3.2 | 6.8 | 7.8 | 23.7 | 2477.5 |

## Table II.2.15 Monthly and Annual Rainfall at Kurigram (182) mm

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961 | - | - | 415.0 | 329.5 | 56.2 | 228.7 | 158.5 | 0.0 | 1.3 | 12.7 | 27.9 | 0.0 | - |
| 1962 | 2.3 | 505.8 | 297.0 | 175.1 | 528.2 | 138.9 | 79.2 | 0.0 | - | - | 0.0 | - | - |
| 1963 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1964 | 69.1 | 434.0 | 474.6 | 483.5 | 141.4 | 251.8 | 310.9 | 0.0 | 0.0 | 0.0 | 19.7 | 75.2 | 2260.2 |
| 1965 | 94.5 | 419.4 | 454.1 | 443.8 | 410.1 | 235.3 | 47.7 | 32.0 | 0.0 | 5.8 | 0.0 | 0.0 | 2142.7 |
| 1966 | 24.6 | 528.7 | 263.2 | 300.3 | 383.8 | 180.7 | 32.4 | 41.7 | 11.7 | 1.0 | 0.0 | 168.9 | 1937.0 |
| 1967 | 127.7 | 417.6 | 292.0 | 367.1 | 236.6 | 305.9 | 108.4 | 0.0 | 0.0 | 3.8 | 0.0 | 32.2 | 1891.3 |
| 1968 | 40.6 | 241.0 | 577.6 | 546.9 | 228.6 | 365.3 | 242.8 | 0.0 | 0.0 | 11.4 | 0.0 | 19.6 | 2273.8 |
| 1969 | 163.1 | 394.8 | 457.3 | 390.9 | 431.8 | 194.3 | 36.1 | 56.9 | 0.0 | 61.4 | 0.0 | 7.8 | 2194.4 |
| 1970 | 63.8 | 290.8 | 739.1 | 511.2 | 115.9 | 314.9 | 183.6 | 0.0 | 0.0 | 0.0 | - | - | - |
| 1971 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1972 | 112.1 | 208.3 | 578.0 | 373.8 | 154.8 | 213.3 | 114.8 | 63.5 | 0.0 | 0.0 | 17.8 | 27.9 | 1864.3 |
| 1973 | 63.0 | 401.5 | 1433.7 | 229.7 | 288.5 | 597.1 | 62.8 | 61.0 | 7.4 | 19.0 | 0.0 | 85.6 | 3249.3 |
| 1974 | 282.5 | 312.6 | 665.0 | 969.5 | 251.3 | 583.1 | 287.0 | 0.0 | 0.0 | 0.0 | 1.3 | 2.5 | 3354.8 |
| 1975 | 161.9 | 473.5 | 102.7 | 384.0 | 137.3 | 256.0 | 174.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1689.5 |
| 1976 | 63.9 | 313.5 | 688.3 | 767.6 | 295.3 | 81.3 | 0.0 | 0.0 | 0.0 | 0.0 | 12.7 | 5.1 | 2227.7 |
| 1977 | 257.8 | 208.1 | 591.7 | 236.4 | 439.4 | 149.9 | 213.3 | 35.6 | 2.5 | 0.0 | 0.0 | 0.0 | 2134.7 |
| 1978 | 127.0 | 227.1 | 540.9 | 299.7 | 44.5 | 457.2 | 6.3 | 0.0 | 0.0 | 0.0 | 3.8 | 0.0 | 1706.5 |
| 1979 | 14.0 | 86.9 | 278.6 | 786.1 | 657.8 | 416.3 | 157.6 | 1.3 | 2.5 | 0.0 | 17.8 | 26.7 | 2445.6 |
| 1980 | 116.8 | 425.3 | 239.9 | 309.8 | 233.7 | 380.9 | 60.9 | 0.0 | 0.0 | 8.9 | 17.8 | 40.6 | 1834.6 |
| 1981 | 82.4 | 368.3 | 115.5 | 471.2 | 274.3 | 210.7 | 0.0 | 0.0 | 52.1 | 0.0 | 0.0 | 34.3 | 1608.8 |
| 1982 | 63.6 | 219.6 | 624.7 | 403.6 | 285.6 | 635.0 | 62.3 | 3.8 | 0.0 | 3.1 | 21.6 | 41.9 | 2364.8 |
| 1983 | 101.3 | 300.7 | 350.4 | 745.5 | 308.9 | 354.6 | 186.6 | 0.0 | 25.4 | 2.5 | 0.0 | 2.5 | 2378.4 |
| 1984 | 78.8 | 378.8 | 761.6 | 751.9 | 144.6 | 592.5 | 116.7 | 0.0 | 0.0 | 0.0 | 14.7 | 21.8 | 2861.4 |
| 1985 | 146.0 | 309.6 | 627.2 | 695.6 | 194.5 | 383.8 | 73.4 | 0.0 | 20.3 | 0.0 | 0.0 | 0.0 | 2450.4 |
| 1986 | 120.8 | 229.8 | 333.1 | 583.5 | 210.0 | 562.3 | 371.9 | 7.6 | 12.7 | 0.0 | 0.0 | 55.3 | 2487.0 |
| 1987 | 124.5 | 165.0 | 491.2 | 870.2 | 606.9 | 312.4 | 305.7 | 0.0 | 0.0 | 0.0 | 67.4 | 36.6 | 2979.9 |
| 1988 | 150.8 | 488.6 | 666.7 | 686.3 | 702.1 | 332.7 | 16.0 | 81.0 | 0.0 | 13.5 | 35.0 | 0.0 | 3172.7 |
| 1989 | 0.0 | 503.0 | 492.8 | 890.8 | 93.6 | 672.6 | 24.0 | 0.0 | 0.0 | 0.0 | 33.5 | 146.5 | 2856.8 |
| 1990 | 228.0 | 399.4 | 816.1 | 156.5 | 289.0 | 459.8 | 352.0 | 0.0 | 0.0 | 7.0 | 0.0 | 25.0 | 2732.8 |
| Ave. | 106.7 | 342.7 | 513.1 | 505.7 | 290.9 | 352.4 | 135.2 | 13.7 | 5.0 | 5.6 | 10.8 | 32.9 | 2364.0 |

## Table II.2.16 Monthly and Annual Rainfall at Lalmonirhat (183) mm

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | - | 469.4 | 485.0 | 211.9 | 545.4 | 191.3 | 49.8 | 0.0 | 0.0 | 0.0 | - | 21.6 | - |
| 1963 | 203.1 | 280.9 | 427.5 | 596.4 | 331.7 | 235.3 | 70.0 | 20.3 | 0.0 | 0.0 | 0.0 | 29.0 | 2194.2 |
| 1964 | 78.4 | 464.9 | 650.5 | 864.7 | 322.1 | 515.6 | 237.3 | 0.0 | 0.0 | 0.0 | 24.6 | 36.8 | 3194.9 |
| 1965 | 50.8 | 410.3 | 291.8 | 573.1 | 621.8 | 191.7 | 25.0 | 0.0 | 0.0 | 18.1 | 0.0 | 0.0 | 2182.6 |
| 1966 | 0.8 | - | 306.0 | 414.9 | 421.0 | 244.2 | 73.1 | 19.8 | 0.0 | 0.0 | 0.0 | 147.5 | - |
| 1967 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1968 | 29.0 | 186.0 | 797.9 | 596.9 | 566.4 | 475.0 | 273.2 | 0.0 | 0.0 | 9.6 | 0.0 | 27.1 | 2961.1 |
| 1969 | 160.7 | 531.9 | 545.0 | 675.0 | 362.0 | 275.9 | 21.3 | 56.4 | 0.0 | 33.3 | 15.5 | 0.0 | 2677.0 |
| 1970 | 116.5 | 314.2 | 548.5 | 749.7 | 143.5 | 286.3 | 109.2 | 0.0 | 0.0 | 4.5 | - | - | - |
| 1971 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1972 | 70.0 | 119.9 | 343.1 | 707.2 | 144.8 | 63.5 | 77.0 | 0.0 | 0.0 | 25.4 | 2.5 | 38.5 | 1591.9 |
| 1973 | 64.6 | 405.2 | 1253.5 | 208.3 | 243.8 | 665.5 | 226.1 | 63.5 | 0.0 | 0.0 | 0.0 | 114.3 | 3244.8 |
| 1974 | 215.9 | 533.5 | 670.6 | 990.7 | 984.2 | 527.2 | 105.4 | 15.2 | 0.0 | 0.0 | 0.0 | 27.9 | 4070.6 |
| 1975 | 294.6 | 473.7 | 228.7 | 618.5 | 217.5 | 195.9 | 31.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2060.8 |
| 1976 | 41.9 | 41.8 | 349.8 | 756.2 | 397.3 | 74.7 | 15.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1676.9 |
| 1977 | 169.5 | 212.5 | 659.9 | 474.8 | 602.6 | 187.8 | 383.1 | 53.3 | 3.3 | 0.0 | 5.1 | 17.8 | 2769.7 |
| 1978 | 173.5 | 364.6 | 530.0 | 595.9 | 88.6 | 372.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 1.0 | 2127.0 |
| 1979 | 16.3 | 112.4 | 312.2 | 621.9 | 594.1 | 561.1 | 199.4 | 21.6 | 0.0 | 0.0 | 3.8 | 37.6 | 2480.4 |
| 1980 | 104.9 | 330.7 | 263.5 | 212.5 | 645.4 | 293.5 | 90.5 | 0.0 | 0.0 | 5.5 | 34.8 | 13.2 | 1994.5 |
| 1981 | 102.4 | 507.2 | 104.8 | 584.5 | 358.6 | 245.4 | 0.0 | 0.0 | 44.7 | 0.0 | 0.0 | 62.0 | 2009.6 |
| 1982 | 67.8 | 198.5 | 474.4 | 657.6 | 296.7 | 678.2 | 54.6 | 0.0 | 0.0 | 0.8 | 6.9 | 17.5 | 2453.0 |
| 1983 | 96.7 | 464.2 | 224.3 | 518.9 | 247.6 | 265.2 | 235.4 | 0.0 | 23.6 | 10.1 | 0.0 | 20.8 | 2106.8 |
| 1984 | 152.9 | 387.1 | 737.4 | 585.4 | 203.1 | 922.6 | 301.0 | 0.0 | 5.6 | 0.0 | 30.1 | 28.7 | 3353.9 |
| 1985 | 278.2 | 417.4 | 447.9 | 963.5 | 368.1 | 357.7 | 74.5 | 0.0 | 18.3 | 0.0 | 0.0 | 0.0 | 2925.6 |
| 1986 | 102.8 | 265.2 | 377.8 | 482.6 | 452.8 | 299.4 | 265.8 | 14.8 | 22.1 | 0.0 | 13.2 | 67.9 | 2364.4 |
| 1987 | 95.3 | 309.8 | 859.3 | 1107.3 | 834.8 | 232.4 | 436.1 | 8.4 | 0.0 | 0.0 | 69.8 | 37.6 | 3990.8 |
| 1988 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1989 | 0.0 | 443.4 | 408.9 | 637.0 | 252.0 | 431.0 | 16.0 | 15.0 | 10.2 | 0.0 | 0.3 | 80.0 | 2293.8 |
| 1990 | 115.4 | 305.6 | 739.5 | 208.3 | 345.0 | 434.8 | 382.3 | 0.0 | 0.0 | 29.0 | 22.2 | 75.0 | 2657.1 |
| Ave. | 112.1 | 342.0 | 501.5 | 600.5 | 407.3 | 354.8 | 144.4 | 11.1 | 4.9 | 5.2 | 9.6 | 36.1 | 2581.8 |

## Table II.2.17 Monthly and Annual Rainfall at Sundarganj (178) mm

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 3.0 | 414.3 | 419.1 | 324.7 | 205.5 | 125.7 | 75.0 | 0.0 | 0.0 | 0.0 | 0.0 | 44.4 | 1611.7 |
| 1963 | 92.0 | 317.6 | 565.3 | - | 176.5 | 167.7 | 137.9 | 17.8 | 0.0 | 0.0 | 8.9 | 8.9 | - |
| 1964 | 54.6 | 276.2 | 458.5 | 511.6 | 217.2 | 179.0 | 276.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1974.0 |
| 1965 | 0.0 | 315.0 | 274.3 | 280.7 | 514.5 | 313.7 | 30.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1728.7 |
| 1966 | 50.8 | 517.8 | 175.7 | 310.8 | 532.0 | 24.1 | 2.5 | 4.3 | 0.0 | 0.0 | 0.0 | 145.8 | 1763.8 |
| 1967 | 25.4 | 383.6 | 260.4 | 256.5 | 235.0 | 364.5 | 55.9 | 0.0 | 0.0 | 0.0 | 0.0 | 33.0 | 1614.3 |
| 1968 | 62.2 | 389.8 | 488.8 | 448.1 | 0.0 | 389.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 88.8 | 1867.2 |
| 1969 | 127.0 | 397.5 | 496.3 | 373.6 | 356.6 | 216.0 | 0.0 | 2.5 | 0.0 | 21.6 | 11.4 | 0.0 | 2002.5 |
| 1970 | 29.3 | 340.2 | 784.5 | 723.1 | 141.0 | 360.6 | 264.2 | 2.5 | - | - | - | - | - |
| 1971 | 188.4 | 394.9 | 445.8 | 220.9 | 103.8 | 293.4 | 181.7 | - | - | - | - | 40.6 | - |
| 1972 | 20.3 | 48.4 | 425.8 | 450.9 | 168.9 | 290.6 | 28.0 | 0.0 | 0.0 | 0.0 | 31.8 | 17.8 | 1482.5 |
| 1973 | 144.9 | 416.6 | 868.7 | 143.0 | 290.9 | 683.2 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2627.3 |
| 1974 | 152.4 | 408.8 | 487.7 | 950.9 | 347.8 | 438.2 | 158.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2944.5 |
| 1975 | 202.0 | 371.0 | 135.9 | 374.6 | 139.7 | 297.2 | 15.3 | 0.0 | 0.0 | 0.0 | 10.0 | 0.0 | 1545.7 |
| 1976 | 114.3 | 133.4 | 441.8 | 396.3 | 239.9 | 171.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1497.2 |
| 1977 | 159.3 | 425.9 | 562.6 | 299.1 | 346.6 | 129.6 | 298.4 | 1.3 | 1.3 | 0.0 | 0.0 | 0.0 | 2224.1 |
| 1978 | 110.4 | 341.6 | 426.7 | 278.1 | 12.8 | 186.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1356.2 |
| 1979 | 1.3 | 124.4 | 133.3 | 470.9 | 336.3 | 272.8 | 0.0 | 0.0 | 31.7 | 0.0 | 0.0 | 3.3 | 1374.0 |
| 1980 | 81.0 | 288.0 | 504.6 | 240.7 | 442.8 | 272.7 | 111.8 | 0.0 | 0.0 | 44.4 | 11.4 | 30.5 | 2027.9 |
| 1981 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1982 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1983 | 0.0 | 375.0 | 503.0 | 515.7 | 361.6 | 389.0 | 302.2 | 0.0 | 15.2 | 0.0 | 0.0 | 0.0 | 2461.7 |
| 1984 | 53.3 | 335.3 | 525.1 | 617.4 | 72.6 | 495.4 | 175.3 | 0.0 | 5.1 | 0.0 | 2.5 | 12.7 | 2294.7 |
| 1985 | 35.5 | 226.0 | 366.5 | 783.1 | 368.4 | 236.5 | 110.6 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 2127.9 |
| 1986 | 240.1 | 246.0 | 334.2 | 362.0 | 299.7 | 410.3 | 486.0 | 0.0 | 38.1 | 0.0 | 10.2 | 36.9 | 2463.5 |
| 1987 | 63.5 | 146.1 | 423.1 | 956.3 | 873.0 | 398.7 | 214.8 | 19.1 | 0.0 | 0.0 | 53.8 | 48.8 | 3197.2 |
| 1988 | 55.9 | 101.1 | 432.9 | 341.8 | 457.3 | 261.8 | 0.0 | 103.3 | 0.0 | 0.7 | 22.0 | 0.0 | 1776.8 |
| 1989 | 0.0 | 513.5 | 313.5 | 920.0 | 72.0 | 347.3 | 13.0 | 0.0 | 0.0 | 0.0 | 0.7 | 16.0 | 2196.0 |
| 1990 | 136.0 | 348.0 | 356.0 | 187.0 | 300.0 | 202.2 | 230.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1759.2 |
| Ave. | 81.6 | 318.4 | 430.0 | 451.5 | 281.9 | 293.3 | 120.3 | 5.8 | 3.7 | 2.7 | 6.5 | 20.3 | 1996.6 |

**Table II.2.18 Monthly and Annual Rainfall at Ulipur (222) mm**

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 0.3 | 463.4 | 443.1 | 198.5 | 343.3 | 91.4 | 72.1 | 0.0 | 0.0 | 0.0 | 0.0 | 74.8 | 1686.9 |
| 1963 | 176.9 | 459.1 | 593.2 | 877.2 | 338.4 | 138.9 | 82.3 | 22.6 | 0.0 | 0.0 | 25.4 | 2.5 | 2716.5 |
| 1964 | 66.0 | 354.0 | 762.4 | 694.2 | 344.5 | 350.1 | 381.5 | 0.0 | 0.0 | 0.0 | 19.5 | 34.2 | 3006.4 |
| 1965 | 86.9 | 466.3 | 258.8 | 501.4 | 611.5 | 330.9 | 75.7 | 14.0 | 10.2 | 61.2 | 0.0 | 5.9 | 2422.8 |
| 1966 | 0.0 | 605.7 | 203.8 | 450.3 | 544.8 | 110.1 | 108.5 | 50.8 | 0.0 | 5.3 | 0.0 | 98.6 | 2177.9 |
| 1967 | 140.9 | 353.5 | 272.3 | 336.6 | 317.5 | 304.3 | 74.1 | 0.0 | 0.0 | 0.0 | 0.0 | 28.4 | 1827.6 |
| 1968 | 47.0 | 213.2 | 670.9 | 727.6 | 289.6 | 353.3 | 305.8 | 0.0 | 0.0 | 8.1 | 0.0 | 63.3 | 2678.8 |
| 1969 | 171.2 | 583.5 | 597.6 | 395.6 | 430.9 | 171.6 | 22.6 | 0.0 | 0.0 | 12.2 | 4.6 | 0.0 | 2389.8 |
| 1970 | 79.7 | 285.6 | 803.1 | 563.9 | 169.5 | 209.5 | 221.2 | 11.0 | 0.0 | 15.4 | 0.0 | - | - |
| 1971 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1972 | - | - | 514.0 | 562.9 | 88.0 | 231.9 | 99.9 | 0.0 | 0.0 | 8.6 | 19.8 | 21.8 | - |
| 1973 | 39.6 | 326.6 | 763.4 | 273.0 | 249.2 | 774.0 | 78.8 | 6.6 | 6.9 | 20.3 | 0.0 | 132.1 | 2670.5 |
| 1974 | 243.4 | 264.9 | 704.7 | 1023.0 | 240.2 | 354.7 | 146.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2977.5 |
| 1975 | 140.2 | 399.4 | 87.1 | 380.2 | 116.1 | 312.6 | 54.4 | 0.0 | 0.0 | 0.0 | 9.1 | 0.0 | 1499.1 |
| 1976 | 55.4 | 186.5 | 453.3 | 656.6 | 323.1 | 85.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.3 | 0.0 | 1765.2 |
| 1977 | 163.3 | 276.8 | 684.4 | 293.0 | 239.2 | 182.6 | 311.7 | 30.5 | 5.1 | 0.0 | 0.0 | 12.7 | 2199.3 |
| 1978 | 99.5 | 278.0 | 428.5 | 421.8 | 108.6 | 235.2 | 5.6 | 0.0 | 0.0 | 4.1 | 7.1 | 3.0 | 1591.4 |
| 1979 | 52.8 | 109.2 | 142.6 | 720.6 | 451.7 | 412.4 | 62.0 | 14.0 | 44.5 | 0.0 | 19.0 | 24.7 | 2053.5 |
| 1980 | 142.0 | 419.8 | 340.9 | 299.5 | 310.3 | 290.1 | 119.9 | 0.0 | 0.0 | 7.7 | 33.5 | 38.1 | 2001.8 |
| 1981 | 98.3 | 471.6 | 52.9 | 573.5 | 289.9 | 297.0 | 0.0 | 0.0 | 31.7 | 0.0 | 0.0 | 61.5 | 1876.4 |
| 1982 | 168.7 | 129.7 | 492.3 | 413.7 | 341.3 | 334.4 | 59.7 | 3.0 | 0.0 | 4.1 | 0.0 | 17.8 | 1964.7 |
| 1983 | 29.8 | 316.8 | 332.8 | 507.4 | 318.2 | 264.3 | 227.4 | 0.0 | 41.9 | 7.9 | 0.0 | 5.3 | 2051.8 |
| 1984 | 75.7 | 289.6 | 684.6 | 790.0 | 124.9 | 517.3 | 153.9 | 0.0 | 8.9 | 0.0 | 0.0 | 21.0 | 2665.9 |
| 1985 | 131.3 | 170.6 | 504.9 | 683.1 | 215.8 | 302.6 | 94.7 | 0.0 | 7.6 | 0.0 | 0.0 | 0.0 | 2110.6 |
| 1986 | 123.4 | 227.3 | 399.8 | 355.9 | 356.1 | 524.4 | 441.4 | 20.3 | 14.0 | 0.0 | 3.8 | 105.6 | 2572.0 |
| 1987 | 88.1 | 248.6 | 357.8 | 917.4 | 652.1 | 274.5 | 191.0 | 8.1 | 0.0 | 0.0 | 83.1 | 36.6 | 2857.3 |
| 1988 | 124.2 | 303.2 | 698.2 | 646.8 | 605.7 | 477.4 | 11.1 | 99.7 | 0.0 | 16.6 | 41.4 | 0.0 | 3024.3 |
| 1989 | 0.0 | 577.0 | 259.4 | 1005.1 | 66.0 | 504.0 | 17.0 | 0.0 | 0.0 | 0.0 | 9.8 | 41.2 | 2479.5 |
| 1990 | 182.8 | 421.1 | 392.9 | 285.5 | 308.3 | 476.6 | 430.8 | 0.0 | 0.0 | 3.2 | 14.0 | 3.2 | 2518.4 |
| Ave. | 101.0 | 340.8 | 460.7 | 555.5 | 314.1 | 318.3 | 137.5 | 10.0 | 6.1 | 6.2 | 10.6 | 30.8 | 2299.5 |

## Table II.2.19 Annual Maximum Water Level (m/PWD)

| Year | Noonkawa | Chilmari | Bahadura bad | Taluk Simulbari | Kurigram | Kaunia | Haripur |
|---|---|---|---|---|---|---|---|
| 1960 | - | - | 19.475 | - | 26.485 | 29.575 | - |
| 1961 | - | - | 18.905 | - | - | 29.362 | - |
| 1962 | 28.065 | 25.065 | 19.990 | 30.430 | 27.020 | 29.606 | - |
| 1963 | - | - | - | - | - | 29.438 | - |
| 1964 | 27.710 | - | 19.840 | - | 26.700 | 29.377 | - |
| 1965 | 27.585 | 23.245 | 19.690 | 30.575 | 26.610 | - | - |
| 1966 | 27.445 | 23.805 | 19.615 | 32.755 | 26.350 | 29.980 | - |
| 1967 | 27.385 | 23.965 | 19.495 | 30.648 | 26.320 | 29.529 | - |
| 1968 | 27.525 | 24.040 | 19.795 | 30.891 | 26.525 | 30.520 | - |
| 1969 | 27.580 | 23.785 | 19.840 | 29.962 | 25.870 | 29.444 | - |
| 1970 | 27.875 | 24.185 | 20.195 | 29.970 | 26.275 | 29.691 | - |
| 1971 | 27.110 | 24.075 | 18.745 | - | - | - | - |
| 1972 | 27.935 | 24.090 | 19.980 | 30.115 | 27.035 | 29.804 | - |
| 1973 | 27.790 | 23.880 | 19.880 | 30.410 | 26.195 | 30.145 | - |
| 1974 | 27.985 | 24.460 | 20.255 | 30.540 | 26.715 | 29.926 | - |
| 1975 | 27.545 | 23.775 | 19.600 | 31.135 | 26.515 | 30.017 | - |
| 1976 | 27.630 | 23.895 | 19.865 | 30.968 | 26.305 | 30.099 | - |
| 1977 | 27.768 | 24.110 | 19.990 | 30.937 | 26.182 | 30.136 | - |
| 1978 | 27.411 | 23.677 | 19.630 | 30.989 | 25.832 | 29.992 | 22.510 |
| 1979 | 27.315 | - | 19.782 | 30.617 | 26.365 | 30.225 | 23.090 |
| 1980 | 27.935 | 24.245 | 20.102 | 31.196 | 26.579 | 30.023 | 23.800 |
| 1981 | 27.295 | - | 19.480 | 30.785 | 26.579 | 30.157 | - |
| 1982 | - | - | 19.420 | 30.850 | 26.480 | 29.986 | - |
| 1983 | 26.710 | 24.105 | 19.930 | 31.440 | 26.620 | 30.130 | - |
| 1984 | 26.450 | 24.260 | 20.110 | 31.740 | 27.380 | 30.080 | - |
| 1985 | 26.510 | 23.925 | 19.620 | 31.130 | 26.745 | 30.050 | - |
| 1986 | 26.195 | 23.440 | 19.150 | 30.730 | 25.910 | 29.990 | - |
| 1987 | 26.700 | 24.560 | 19.710 | 32.050 | 27.500 | 30.470 | - |
| 1988 | 28.100 | 25.060 | 20.620 | 31.200 | 27.410 | 30.430 | - |
| 1989 | 26.110 | 23.575 | 19.580 | 30.970 | 26.330 | 30.200 | - |
| 1990 | 25.990 | 23.690 | 19.390 | 30.530 | 25.900 | 30.100 | - |

**Table II.2.20 Annual Minimum Water Level (m/PWD)**

| Year | Noonkawa | Chilmari | Bahadurabad | Taluk Simulbari | Kurigram | Kaunia | Haripur |
|---|---|---|---|---|---|---|---|
| 1960 | - | - | 12.220 | 26.575 | 21.775 | 26.436 | - |
| 1961 | - | - | 11.950 | - | - | 26.603 | - |
| 1962 | 21.640 | 16.425 | 12.405 | 26.850 | 22.035 | 26.722 | - |
| 1963 | - | - | - | - | - | 26.829 | - |
| 1964 | 21.900 | - | 12.970 | - | 22.325 | 27.045 | - |
| 1965 | 21.715 | 16.385 | 13.165 | 27.024 | 22.050 | - | - |
| 1966 | 21.730 | 16.595 | 13.235 | 26.775 | 21.960 | 27.195 | - |
| 1967 | 21.395 | 16.625 | 13.300 | 26.761 | 22.295 | 27.426 | - |
| 1968 | 21.580 | 16.795 | 13.410 | 26.899 | 22.235 | 27.304 | - |
| 1969 | 21.350 | 16.505 | 13.135 | 26.770 | 22.815 | 25.963 | - |
| 1970 | 21.275 | 16.580 | 13.030 | 26.740 | 22.370 | 27.243 | - |
| 1971 | 21.290 | 16.490 | 13.000 | - | 22.310 | - | - |
| 1972 | 21.320 | 16.915 | 13.045 | 27.438 | 22.310 | 27.789 | - |
| 1973 | 21.975 | 17.070 | 13.365 | 26.930 | 22.420 | 27.493 | - |
| 1974 | 21.775 | 16.915 | 13.350 | 27.005 | 22.615 | 27.594 | - |
| 1975 | 21.700 | 17.000 | 13.010 | 27.080 | 22.570 | 27.640 | - |
| 1976 | 21.870 | 16.720 | 12.885 | 26.868 | 22.235 | 27.752 | - |
| 1977 | 21.611 | 16.313 | 13.015 | 26.883 | 22.327 | 27.871 | - |
| 1978 | 20.970 | 16.017 | 13.015 | 27.280 | 22.311 | 27.859 | 20.102 |
| 1979 | 21.290 | - | 13.259 | 27.264 | 22.540 | 27.830 | 19.895 |
| 1980 | 21.710 | 17.175 | 13.244 | 27.233 | 22.189 | 27.789 | 19.825 |
| 1981 | 21.230 | - | 13.040 | 26.640 | 22.129 | 27.962 | - |
| 1982 | 20.700 | - | 13.120 | 27.215 | 22.570 | 27.270 | - |
| 1983 | 20.915 | 16.630 | 13.050 | 27.190 | 22.390 | 27.470 | - |
| 1984 | 20.350 | 17.345 | 13.480 | 27.820 | 22.360 | 27.560 | - |
| 1985 | 20.260 | 17.625 | 13.240 | 27.840 | 22.470 | 27.835 | - |
| 1986 | 20.260 | 17.265 | 13.150 | 27.530 | 22.195 | 27.480 | - |
| 1987 | 19.990 | 17.355 | 13.380 | 27.520 | 22.190 | 27.540 | - |
| 1988 | 20.170 | 17.650 | 13.680 | 27.380 | 22.115 | 27.370 | - |
| 1989 | 19.980 | 17.575 | 13.660 | 27.300 | 22.100 | 27.570 | - |
| 1990 | 20.020 | 17.610 | 13.350 | 27.250 | 21.980 | 27.670 | - |

**Table II.2.21 Monthly Mean Water Level at Kurigram (No.77) (m/PWD)**

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 21.923 | 22.103 | 23.570 | 25.105 | 24.359 | 25.233 | 23.545 | 22.484 | 22.169 | 21.999 | 21.913 | 21.825 |
| 1961 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1962 | 22.074 | 22.659 | 24.176 | 25.145 | 25.908 | 25.067 | 23.844 | 23.262 | 22.831 | - | - | - |
| 1963 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1964 | 22.629 | 22.987 | 24.251 | 25.711 | 25.383 | 25.122 | 23.865 | 23.141 | 22.776 | 22.569 | 22.465 | 22.356 |
| 1965 | 22.431 | 22.651 | 23.760 | 24.944 | 25.690 | 24.900 | 23.676 | 23.274 | 22.861 | 22.517 | 22.241 | 22.091 |
| 1966 | 22.009 | 22.271 | 24.111 | 25.254 | 25.442 | 25.236 | 23.652 | 23.167 | 23.062 | 22.940 | 22.813 | 22.798 |
| 1967 | 22.715 | 23.209 | 99 | 25.436 | 24.094 | 23.918 | 23.653 | 23.039 | 22.806 | 22.613 | 22.443 | 22.354 |
| 1968 | 22.275 | 22.791 | 23.997 | 25.444 | 24.622 | 24.468 | 24.646 | 24.104 | 23.407 | 23.176 | 23.029 | 22.942 |
| 1969 | 22.923 | 23.392 | 24.325 | 25.156 | 24.706 | 24.775 | 24.237 | 23.779 | 23.533 | 23.350 | 23.146 | 23.067 |
| 1970 | 23.091 | 23.242 | 24.613 | 25.338 | 25.017 | 24.815 | 24.106 | 22.978 | 22.603 | 22.497 | 22.448 | 22.402 |
| 1971 | - | - | - | - | - | - | - | - | - | 22.544 | 22.471 | - |
| 1972 | 22.449 | 23.191 | 24.577 | 25.346 | 24.916 | 24.641 | 23.867 | 23.295 | 23.002 | 22.876 | 22.765 | 22.727 |
| 1973 | 22.507 | 23.186 | 25.146 | 24.693 | 25.282 | 24.629 | 24.230 | 23.424 | 22.997 | 22.849 | 22.732 | 22.622 |
| 1974 | 22.978 | 23.802 | 24.581 | 25.744 | 25.085 | 25.619 | 24.646 | 23.307 | 23.026 | 22.877 | 22.746 | 22.665 |
| 1975 | 22.617 | 22.745 | 23.777 | 25.296 | 24.874 | 25.114 | 24.366 | 23.284 | 22.982 | 22.834 | 22.761 | 22.653 |
| 1976 | 22.613 | 23.258 | 24.452 | 25.527 | 25.255 | 24.227 | 23.434 | 22.913 | 22.746 | 22.534 | 22.394 | 22.287 |
| 1977 | 22.696 | 23.078 | 24.559 | 25.037 | 25.410 | 24.733 | 24.128 | 23.143 | 22.742 | 22.723 | 22.689 | 22.566 |
| 1978 | 22.484 | 22.841 | 23.847 | 28.306 | 24.630 | 24.691 | 24.002 | 23.364 | 23.077 | 22.928 | 22.827 | 22.692 |
| 1979 | 22.628 | 22.922 | 22.889 | 24.870 | 25.105 | 25.419 | 24.756 | 23.432 | 23.205 | 22.869 | 22.702 | 22.651 |
| 1980 | 22.543 | 22.940 | 24.177 | 25.052 | 25.757 | 24.978 | 24.056 | 23.125 | 22.723 | 22.512 | 22.388 | 22.252 |
| 1981 | 22.299 | 22.687 | 23.160 | 25.613 | 25.720 | 25.285 | 23.785 | 23.106 | 22.872 | 22.712 | 22.602 | 22.555 |
| 1982 | 22.677 | 22.800 | 23.877 | 25.831 | 24.581 | 24.808 | 23.759 | 23.247 | 22.992 | 22.819 | 22.720 | 22.642 |
| 1983 | 22.503 | 23.217 | 24.169 | - | 24.892 | 25.585 | 24.172 | 23.172 | 22.862 | - | - | 22.438 |
| 1984 | 22.468 | 23.553 | 25.110 | 26.030 | 24.965 | 25.805 | 24.488 | 23.790 | 23.421 | 23.150 | 22.985 | 22.852 |
| 1985 | 22.660 | 23.087 | 24.664 | 25.899 | 24.920 | 25.127 | 24.181 | 23.219 | 22.957 | 22.867 | 22.658 | 22.534 |
| 1986 | 22.505 | 22.867 | 23.670 | 24.875 | 24.541 | 24.911 | 23.919 | 22.802 | 22.489 | 22.288 | 22.216 | 22.295 |
| 1987 | 22.312 | 22.673 | 23.698 | 25.523 | 25.556 | 24.905 | 23.935 | 22.936 | 22.547 | 22.380 | 22.288 | 22.274 |
| 1988 | 22.264 | 22.762 | 23.571 | 25.206 | 25.647 | 25.119 | 23.487 | 22.556 | 22.441 | 22.298 | 22.273 | 22.207 |
| 1989 | 22.134 | 22.568 | 24.429 | 25.273 | 24.567 | 25.067 | 23.943 | 22.823 | 22.486 | 22.361 | 22.289 | 22.245 |
| 1990 | 22.376 | 23.061 | 24.666 | 25.213 | 25.025 | 24.879 | 24.423 | 22.888 | 22.462 | 22.308 | 22.133 | 22.028 |
| Mean | 22.492 | 22.948 | 24.142 | 25.440 | 25.070 | 24.967 | 24.029 | 23.180 | 22.860 | 22.681 | 22.561 | 22.482 |

**Table II.2.22 Monthly Mean Water Level at Talkshimulbari (No.76) (m/PWD)**

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | - | - | - | - | - | - | - | - | 26.863 | 26.747 | 26.683 | 26.631 |
| 1961 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1962 | 26.872 | 27.330 | 28.404 | 28.297 | 28.921 | 28.425 | 27.409 | 27.029 | 26.918 | - | - | - |
| 1963 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1964 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1965 | 27.132 | 27.412 | 28.165 | 28.981 | 29.655 | 28.810 | 27.635 | 27.406 | 27.183 | 27.106 | 27.061 | 27.044 |
| 1966 | 27.049 | 27.050 | 28.279 | 29.368 | 29.524 | 28.900 | 27.624 | 27.155 | 27.019 | 26.932 | 26.842 | 26.844 |
| 1967 | 26.812 | 27.223 | 28.637 | 29.436 | 28.322 | 28.381 | 28.071 | 27.356 | 27.216 | 27.102 | 27.031 | 26.992 |
| 1968 | 26.940 | 27.456 | 28.228 | 29.526 | 28.934 | 28.948 | 28.728 | 27.778 | 27.603 | 27.483 | 27.409 | 27.396 |
| 1969 | 27.396 | 27.773 | 28.538 | 29.094 | 28.518 | 28.284 | 27.543 | 27.150 | 27.035 | 26.962 | 26.902 | 26.818 |
| 1970 | 26.835 | 27.089 | 28.197 | 28.876 | 28.623 | 28.455 | 28.077 | 27.415 | 27.241 | 27.165 | - | - |
| 1971 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1972 | 27.698 | 28.028 | 28.909 | 29.421 | 28.641 | 28.791 | 28.140 | 27.701 | 27.605 | 27.547 | 27.504 | 27.470 |
| 1973 | 27.452 | 27.836 | 29.045 | 28.623 | 29.013 | 28.278 | 27.980 | 27.503 | 27.288 | 27.220 | 27.100 | 26.986 |
| 1974 | 27.132 | 27.725 | 28.003 | 29.066 | 28.940 | 28.827 | 27.943 | 27.685 | 27.434 | 27.354 | 27.269 | 27.158 |
| 1975 | 27.165 | 27.485 | 28.730 | 29.749 | 29.060 | 29.533 | 28.680 | 27.865 | 27.566 | 27.455 | 27.438 | 27.334 |
| 1976 | 27.321 | 28.122 | 29.055 | 29.653 | 29.554 | 28.889 | 28.147 | 27.500 | 27.211 | 27.047 | 26.946 | 26.889 |
| 1977 | 27.394 | 27.952 | 28.965 | 29.385 | 29.862 | 29.089 | 28.592 | 27.768 | 27.480 | 27.443 | 27.467 | 27.458 |
| 1978 | 27.558 | 28.046 | 28.952 | 29.750 | 28.914 | 28.968 | 28.307 | 27.819 | 27.533 | 27.412 | 27.383 | 27.321 |
| 1979 | 27.331 | 27.764 | 27.726 | 29.086 | 29.289 | 29.525 | 28.901 | 27.833 | 27.800 | 27.629 | 27.539 | 27.451 |
| 1980 | 27.438 | 27.790 | 28.787 | 29.324 | 29.800 | 29.097 | 28.375 | 27.788 | 27.532 | 27.410 | 27.324 | 27.236 |
| 1981 | 27.359 | 27.747 | 28.375 | 29.764 | 29.535 | 29.133 | 27.666 | 27.119 | 26.981 | 26.944 | 26.869 | 26.700 |
| 1982 | 26.866 | 27.088 | 28.303 | 30.047 | 28.819 | 29.171 | 28.181 | 27.811 | 27.700 | 27.479 | 27.316 | 27.237 |
| 1983 | 27.235 | 28.134 | 28.995 | 30.310 | 29.356 | 30.197 | 28.809 | 28.240 | 28.104 | 28.041 | 27.955 | 27.870 |
| 1984 | 27.911 | 28.534 | 29.310 | 30.342 | 29.506 | 30.372 | 29.388 | 28.787 | 28.453 | 28.352 | 28.311 | 28.223 |
| 1985 | 28.238 | 28.506 | 29.515 | 30.395 | 29.558 | 29.640 | 29.032 | 28.451 | 28.204 | 28.080 | 27.969 | 27.886 |
| 1986 | 27.880 | 28.151 | 28.780 | 29.573 | 29.448 | 29.690 | 28.855 | 28.088 | 27.811 | 27.681 | 27.591 | 27.609 |
| 1987 | 27.616 | 27.944 | 28.741 | 30.090 | 30.008 | 29.493 | 28.689 | 28.064 | 27.776 | 27.648 | 27.587 | 27.565 |
| 1988 | 27.590 | 27.904 | 28.348 | 29.676 | 29.962 | 29.664 | 28.500 | 27.661 | 27.530 | 27.498 | 27.460 | 27.414 |
| 1989 | 27.344 | 27.780 | 29.514 | 29.745 | 29.246 | 29.708 | 28.720 | 28.089 | 27.674 | 27.514 | 27.432 | 27.444 |
| 1990 | 27.594 | 28.119 | 29.089 | 29.471 | 29.481 | 29.353 | 28.851 | 28.044 | 27.838 | 27.782 | 27.588 | 27.327 |
| Mean | 27.352 | 27.769 | 28.676 | 29.502 | 29.250 | 29.139 | 28.340 | 27.735 | 27.504 | 27.424 | 27.359 | 27.292 |

## Table II.2.23 Monthly Mean Water Level at Kaunia (No.294) (m/PWD)

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 26.722 | 27.137 | 28.294 | 28.876 | 28.522 | 28.759 | 27.977 | 27.046 | 26.720 | 26.590 | 25.588 | 26.619 |
| 1961 | 26.816 | 27.332 | 28.285 | 28.564 | 28.917 | 28.586 | 28.116 | 27.208 | 26.896 | 26.721 | 26.733 | 26.819 |
| 1962 | 26.997 | 27.523 | 28.503 | 28.769 | 29.165 | 28.710 | 27.931 | 27.389 | 27.140 | 26.939 | 26.765 | 26.864 |
| 1963 | 27.129 | 27.679 | 28.591 | 29.040 | 28.942 | 28.516 | 28.196 | 27.728 | 27.368 | 27.169 | 27.177 | 27.163 |
| 1964 | 27.532 | 27.869 | 28.478 | 28.991 | 28.806 | 28.687 | 28.167 | 27.527 | 27.262 | 27.125 | 27.080 | 27.184 |
| 1965 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1966 | 27.416 | 27.863 | 28.610 | 28.980 | 29.304 | 29.059 | 28.242 | 27.607 | 27.300 | 27.263 | 27.275 | 27.450 |
| 1967 | 27.613 | 28.158 | - | 28.929 | 28.805 | 28.786 | 28.403 | 27.846 | 27.728 | 27.647 | 27.540 | 27.721 |
| 1968 | 27.841 | 28.176 | 28.653 | 29.138 | 29.037 | 28.992 | 28.722 | 27.833 | 27.600 | 27.499 | 27.369 | 27.421 |
| 1969 | 27.594 | 28.028 | 28.819 | 29.041 | 28.946 | 28.683 | 27.328 | 26.506 | 26.156 | 26.017 | 26.860 | 27.187 |
| 1970 | 27.569 | 28.076 | 28.963 | 29.328 | 29.066 | 28.890 | 28.515 | 28.042 | 27.835 | 27.669 | 27.690 | |
| 1971 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1972 | - | 28.707 | 28.934 | 29.117 | 29.154 | 28.990 | 28.609 | 28.259 | 27.986 | 27.898 | 27.819 | 27.973 |
| 1973 | 28.215 | 28.555 | 29.175 | 28.986 | 29.260 | 29.057 | - | - | 27.727 | 27.615 | 27.521 | 27.583 |
| 1974 | 27.954 | 28.498 | 28.970 | 29.502 | 29.255 | 29.222 | 28.998 | 28.085 | 27.741 | 27.640 | 27.710 | 27.740 |
| 1975 | 27.911 | 28.514 | 29.092 | 29.518 | 29.283 | 29.531 | 28.890 | 28.177 | 27.927 | 27.792 | - | - |
| 1976 | 28.190 | 28.677 | 29.293 | 29.571 | 29.684 | 29.260 | 28.816 | 28.317 | 28.104 | 27.989 | 27.808 | 27.850 |
| 1977 | 28.395 | 28.766 | 29.377 | 29.628 | 29.790 | 29.440 | 29.145 | - | 28.146 | 28.003 | 27.925 | 27.923 |
| 1978 | 28.290 | 28.886 | 29.504 | 29.653 | 29.525 | 29.362 | 28.824 | 28.315 | 28.162 | 28.013 | 27.955 | 27.918 |
| 1979 | 28.163 | 28.606 | 28.905 | 29.616 | 29.582 | 29.371 | 28.992 | 28.236 | 28.177 | 27.909 | 27.883 | 28.074 |
| 1980 | 28.380 | 28.689 | 29.314 | 29.569 | 29.602 | 29.379 | 28.805 | 28.254 | 28.021 | 27.903 | 27.863 | 27.927 |
| 1981 | 28.177 | 28.634 | 28.955 | 29.549 | 29.495 | 29.286 | 28.660 | 28.317 | 28.137 | 28.036 | 28.055 | 28.181 |
| 1982 | 28.467 | 28.610 | 29.212 | 29.627 | 29.352 | 29.264 | 28.304 | 27.700 | 27.486 | 27.365 | 27.325 | 27.487 |
| 1983 | 27.932 | 28.647 | 29.051 | 29.509 | 29.164 | 29.394 | 28.520 | 27.814 | 27.604 | 27.574 | 27.531 | 27.582 |
| 1984 | 27.724 | 28.411 | 29.153 | 29.557 | 29.078 | 29.371 | 28.587 | 28.142 | 29.492 | 27.756 | 27.808 | 27.948 |
| 1985 | 28.155 | 28.390 | 29.133 | 29.606 | 29.160 | 29.298 | 28.745 | 28.266 | 28.004 | 27.917 | 27.849 | 27.881 |
| 1986 | 28.075 | 28.342 | 28.840 | 29.335 | 29.080 | 29.222 | 28.728 | 28.074 | 27.885 | 27.736 | 27.662 | 27.823 |
| 1987 | 28.079 | 28.348 | 28.908 | 29.415 | 29.431 | 29.366 | 28.777 | 28.276 | 27.890 | 27.670 | 27.608 | 27.760 |
| 1988 | 27.986 | 28.450 | 28.819 | 29.411 | 29.702 | 29.200 | 28.415 | 27.757 | 27.554 | 27.453 | 27.426 | 27.531 |
| 1989 | 27.741 | 28.287 | 29.084 | 29.333 | 29.119 | 29.300 | 28.620 | 28.064 | 27.744 | 27.663 | 27.661 | 26.918 |
| 1990 | 28.054 | 28.425 | 29.137 | 29.370 | 29.123 | 29.118 | 28.746 | 28.148 | 27.915 | 27.893 | 27.805 | 27.857 |
| Mean | 27.826 | 28.286 | 28.930 | 29.294 | 29.219 | 29.107 | 28.528 | 27.886 | 27.714 | 27.533 | 27.475 | 27.570 |

**Table II.2.24 Monthly Mean Water Level at Noonkawa (No.45) (m/PWD)**

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 22.137 | 23.531 | 25.469 | 26.364 | 27.133 | 26.210 | 24.134 | 22.882 | 22.233 | - | - | - |
| 1963 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1964 | 22.778 | 23.430 | 25.093 | 26.849 | 26.562 | 25.998 | 24.468 | 23.195 | 22.442 | 28.511 | 21.978 | 21.959 |
| 1965 | 22.603 | 23.793 | 25.347 | 26.332 | 26.729 | 25.849 | 23.898 | 23.061 | 22.207 | 21.946 | 21.796 | 21.951 |
| 1966 | 22.626 | 23.426 | 25.640 | 26.316 | 26.697 | 26.269 | 24.062 | 22.612 | 22.278 | 21.922 | 21.769 | 22.021 |
| 1967 | 22.294 | 23.311 | 25.011 | 26.723 | 25.475 | 25.148 | 24.705 | 22.806 | 22.089 | 21.693 | 21.462 | 21.687 |
| 1968 | 22.388 | 23.752 | 25.782 | 27.030 | 25.907 | 25.780 | 24.944 | 22.872 | 22.180 | 21.836 | 21.664 | 21.742 |
| 1969 | 22.214 | 23.326 | 25.339 | 26.885 | 26.194 | 25.918 | 23.665 | 22.368 | 21.782 | 21.445 | 21.391 | 21.829 |
| 1970 | 22.731 | 24.429 | 25.821 | 26.958 | 26.751 | 25.751 | 25.081 | 22.754 | 21.539 | 21.330 | 21.294 | 21.305 |
| 1971 | 21.878 | 23.440 | 25.715 | 26.471 | 26.437 | 25.070 | - | - | - | - | 21.404 | 21.369 |
| 1972 | 22.041 | 24.093 | 25.652 | 26.489 | 26.191 | 25.911 | 24.485 | 22.838 | 21.987 | 21.616 | 21.407 | 21.874 |
| 1973 | 22.894 | 24.479 | 26.260 | 25.788 | 26.495 | 25.319 | 24.523 | 23.066 | 22.544 | 22.304 | 22.120 | 22.325 |
| 1974 | 22.972 | 24.501 | 25.816 | 27.486 | 26.814 | 26.866 | 24.983 | 23.492 | 22.712 | 21.835 | 21.871 | 21.966 |
| 1975 | 22.746 | 23.850 | 25.195 | 26.688 | 26.482 | 26.461 | 25.422 | 23.613 | 22.677 | 22.113 | 21.937 | 22.093 |
| 1976 | 22.274 | 23.307 | 25.368 | 26.669 | 26.253 | 25.654 | 24.266 | 23.266 | 22.765 | 22.297 | 22.070 | 22.509 |
| 1977 | 23.737 | 25.075 | 26.720 | 26.955 | 27.437 | 26.394 | 25.169 | 23.172 | 22.190 | 21.743 | 21.656 | 21.701 |
| 1978 | 22.230 | 23.256 | 25.313 | 26.518 | 26.288 | 25.524 | 24.248 | 22.574 | 21.958 | 21.402 | 21.123 | 21.112 |
| 1979 | 22.022 | 23.551 | 23.849 | 26.553 | 26.273 | 26.140 | 25.647 | 23.498 | 22.873 | 22.244 | 22.123 | 22.367 |
| 1980 | 23.199 | 24.547 | 25.687 | 26.536 | 27.113 | 26.078 | 25.122 | 23.254 | 22.488 | 22.035 | 21.869 | 21.913 |
| 1981 | 22.558 | 23.352 | 24.511 | 26.886 | 26.468 | 26.060 | 24.377 | 22.585 | 21.803 | 21.450 | 21.268 | 21.364 |
| 1982 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1983 | 22.496 | 23.465 | 24.074 | 25.780 | 24.862 | 25.481 | 23.966 | 21.845 | 21.055 | 20.942 | 20.927 | 20.851 |
| 1984 | 21.545 | 22.947 | 24.499 | 25.406 | 24.541 | 24.910 | 23.362 | 22.062 | 21.587 | 21.502 | 21.416 | 21.740 |
| 1985 | 22.584 | 23.014 | 24.363 | 26.002 | 24.977 | 25.082 | 23.439 | 21.559 | 20.882 | 20.539 | 20.398 | 20.607 |
| 1986 | 21.452 | 22.350 | 23.414 | 25.045 | 24.680 | 25.326 | 23.847 | 21.885 | 21.135 | 20.628 | 20.345 | 20.627 |
| 1987 | 21.701 | 22.256 | 23.809 | 25.737 | 25.808 | 25.241 | 23.812 | 21.645 | 20.754 | 20.240 | 20.086 | 20.044 |
| 1988 | 21.443 | 23.001 | 24.652 | 25.901 | 26.107 | 25.553 | 24.519 | 21.782 | 20.924 | 20.306 | 20.346 | 20.584 |
| 1989 | 21.543 | 22.827 | 24.445 | 25.416 | 24.342 | 24.574 | 23.092 | 21.595 | 15.884 | 20.111 | 20.252 | 20.445 |
| 1990 | 21.748 | 22.945 | 24.966 | 25.507 | 24.947 | 24.855 | 24.541 | 21.900 | 20.988 | 20.447 | 20.198 | 20.478 |
| Mean | 22.327 | 23.528 | 25.104 | 26.344 | 26.073 | 25.682 | 24.376 | 22.622 | 21.691 | 21.697 | 21.314 | 21.479 |

## Table II.2.25 Monthly Mean Water Level at Chilmari (No.45.5) (m/PWD)

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 18.089 | 19.847 | 22.223 | 23.445 | 24.192 | 23.462 | 20.776 | 18.255 | 16.829 | - | - | - |
| 1963 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1964 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1965 | 17.837 | 19.547 | 21.111 | 22.112 | 22.706 | 21.746 | 20.041 | 19.056 | 17.821 | 17.180 | 16.676 | 16.575 |
| 1966 | 17.384 | 18.614 | 21.678 | 23.021 | 23.394 | 22.931 | 20.926 | 18.741 | 17.488 | 17.273 | 16.709 | 16.808 |
| 1967 | 17.111 | 18.662 | 20.992 | 23.153 | 22.033 | 21.549 | 20.992 | 18.416 | 17.389 | 16.932 | 16.714 | 16.935 |
| 1968 | 17.867 | 19.434 | 21.940 | 23.294 | 22.378 | 22.179 | 21.379 | 18.958 | 17.642 | 17.139 | 16.907 | 17.035 |
| 1969 | 17.668 | 19.145 | 21.648 | 23.135 | 22.427 | 22.262 | 19.963 | 18.182 | 17.384 | 16.823 | 16.619 | 17.045 |
| 1970 | 13.877 | 20.518 | 22.169 | 23.243 | 23.060 | 22.159 | 21.509 | 18.908 | 17.429 | 16.859 | - | - |
| 1971 | 17.819 | 20.110 | 21.982 | 23.490 | 23.207 | 22.000 | 21.862 | - | - | - | 16.683 | 17.124 |
| 1972 | 18.280 | 20.507 | 21.930 | 22.648 | 22.514 | 22.139 | 20.571 | 18.779 | 17.716 | 17.217 | 17.003 | 17.317 |
| 1973 | 18.315 | 19.786 | 22.020 | 22.054 | 22.915 | 21.863 | 20.749 | 18.822 | 17.979 | 17.398 | 17.200 | 17.328 |
| 1974 | 18.137 | 20.705 | 22.091 | 23.824 | 23.267 | 23.317 | 21.337 | 19.108 | 17.980 | 17.260 | 17.056 | 17.118 |
| 1975 | 18.011 | 19.465 | 21.286 | 23.084 | 22.641 | 22.549 | 21.747 | 19.273 | 18.138 | 17.438 | 17.136 | 17.539 |
| 1976 | 18.287 | 19.380 | 21.598 | 22.999 | 22.728 | 22.105 | 20.382 | 18.735 | 17.965 | 17.209 | 16.885 | 17.404 |
| 1977 | 19.002 | 20.773 | 22.879 | 23.021 | 23.626 | 22.871 | 21.449 | 19.128 | 17.903 | 17.034 | 16.639 | 16.447 |
| 1978 | 17.287 | 19.088 | 21.591 | 22.775 | 22.420 | 21.884 | 20.368 | 18.395 | 17.523 | 16.616 | 16.238 | 16.212 |
| 1979 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1980 | 18.405 | 20.332 | 21.570 | 22.777 | 23.563 | 22.270 | 21.346 | 19.087 | 17.890 | 17.429 | 17.235 | 17.711 |
| 1981 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1982 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1983 | 18.471 | 20.097 | 21.656 | 23.086 | 22.576 | 23.210 | 21.476 | 18.925 | 18.186 | 17.532 | 17.101 | 17.068 |
| 1984 | 18.547 | 20.328 | 22.214 | 23.372 | 22.736 | 23.132 | 21.356 | 19.600 | 18.559 | 17.890 | 17.644 | 18.173 |
| 1985 | 19.400 | 20.156 | 22.339 | 23.463 | 22.647 | 22.803 | 21.347 | 19.513 | 18.558 | 18.093 | 17.737 | 17.843 |
| 1986 | 18.884 | 19.919 | 20.902 | 22.660 | 22.338 | 22.875 | 21.668 | 19.738 | 18.481 | 17.792 | 17.375 | 17.752 |
| 1987 | 19.149 | 19.826 | 21.477 | 23.487 | 23.639 | 23.127 | 21.752 | 18.900 | 18.291 | 17.801 | 17.505 | 18.100 |
| 1988 | 18.803 | 20.238 | 21.961 | 23.228 | 23.493 | 23.081 | 22.057 | 19.456 | 18.569 | 17.903 | 17.793 | 17.877 |
| 1989 | 18.614 | 20.013 | 21.897 | 23.113 | 22.503 | 22.694 | 21.765 | 19.557 | 18.262 | 17.731 | 17.794 | 17.906 |
| 1990 | 19.168 | 20.514 | 22.640 | 23.107 | 22.847 | 22.749 | 22.477 | 19.587 | 18.468 | 18.110 | 17.837 | 17.967 |
| Mean | 18.101 | 19.875 | 21.825 | 23.066 | 22.910 | 22.540 | 21.221 | 19.005 | 17.933 | 17.394 | 17.113 | 17.331 |

## Table II.2.26 Rating Curve Formula for Kurigram Gauging Station

| YEAR | Formula | Nos.of data available | correlation coefficient |
|---|---|---|---|
| 1973 | Q= 63.8(H-21)^1.540 | 12 | 0.774 |
| 1974 | Q= 17.3(H-21)^3.158 | 11 | 0.983 |
| 1975 | Q= 24.8(H-21)^2.804 | 11 | 0.990 |
| 1976 | *Q= 29.8(H-21)^2.530 | - | - |
| 1977 | *Q= 29.8(H-21)^2.530 | - | - |
| 1978 | Q= 32.3(H-21)^2.435 | 17 | 0.911 |
| 1979 | Q= 38.2(H-21)^1.938 | 13 | 0.954 |
| 1980 | Q= 46.5(H-21)^2.073 | 11 | 0.948 |
| 1981 | Q= 32.6(H-21)^2.206 | 11 | 0.965 |
| 1982 | Q= 19.7(H-21)^2.795 | 25 | 0.988 |
| 1983 | Q= 29.4(H-21)^2.479 | 24 | 0.977 |
| 1984 | Q= 18.2(H-21)^2.424 | 9 | 0.863 |
| 1985 | Q= 25.0(H-21)^2.615 | 33 | 0.968 |
| 1986 | Q= 45.0(H-21)^2.273 | 48 | 0.986 |
| 1987 | Q= 38.6(H-21)^2.398 | 41 | 0.989 |
| 1988 | Q= 37.4(H-21)^2.544 | 27 | 0.992 |
| 1989 | Q= 39.1(H-21)^2.422 | 26 | 0.992 |
| 1990 | Q= 47.1(H-21)^2.383 | 25 | 0.992 |

Those Formula are derived from Observed Discharge and Water level Data using Least squares.

remark *) using 28 data in 1975 and 1978

## Table II.2.27 Flow Regime at Kurigram (cu.m)

| Year | Discharge(cu.m) | | | | | |
|---|---|---|---|---|---|---|
| | Max. | 95day | 125day | 275day | 355day | Min. |
| 1973 | 3563 | 865 | 260 | 100 | 51 | 48 |
| 1974 | 4253 | 1211 | 295 | 125 | 83 | 78 |
| 1975 | 2976 | 942 | 175 | 120 | 92 | 87 |
| 1976 | 2030 | 592 | 167 | 93 | 55 | 50 |
| 1977 | 1913 | 743 | 192 | 118 | 84 | 60 |
| 1978 | 1496 | 607 | 222 | 136 | 81 | 62 |
| 1979 | 990 | 419 | 165 | 107 | 93 | 89 |
| 1980 | 1640 | 654 | 192 | 111 | 73 | 66 |
| 1981 | 1413 | 494 | 137 | 94 | 53 | 43 |
| 1982 | 2254 | 492 | 142 | 94 | 73 | 69 |
| 1983 | 2080 | 649 | 191 | 91 | | 67 |
| 1984 | 1594 | 504 | 199 | 98 | 43 | 38 |
| 1985 | 2363 | 750 | 180 | 111 | 75 | 68 |
| 1986 | 1641 | 632 | 175 | 92 | 69 | 67 |
| 1987 | 3377 | 825 | 150 | 81 | 64 | 59 |
| 1988 | 4128 | 683 | 119 | 71 | 53 | 49 |
| 1989 | 2147 | 797 | 133 | 73 | 51 | 49 |
| 1990 | 2046 | 1090 | 219 | 92 | 48 | 45 |

**Table II.2.28 Monthly Mean Discharge at Kurigram (No.77) (cu.m)**

| Year | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 120.1 | 214.8 | 578.8 | 480.1 | 606.6 | 468.5 | 389.3 | 250.0 | 185.2 | 164.4 | 148.7 | 134.4 |
| 1974 | 156.7 | 472.1 | 1074.8 | 2431.8 | 1670.3 | 2225.2 | 1078.4 | 245.8 | 161.1 | 126.7 | 100.7 | 86.7 |
| 1975 | 95.5 | 119.3 | 526.5 | 1531.6 | 1156.6 | 1329.3 | 779.3 | 256.6 | 169.2 | 136.0 | 121.4 | 101.6 |
| 1976 | 100.2 | 236.1 | 718.8 | 1386.9 | 1184.5 | 583.1 | 291.8 | 154.0 | 122.7 | 88.1 | 69.2 | 56.4 |
| 1977 | 115.9 | 194.4 | 754.2 | 1034.3 | 1314.1 | 854.8 | 567.5 | 207.1 | 121.8 | 118.2 | 112.2 | 92.8 |
| 1978 | 85.5 | 151.5 | 447.2 | 1004.5 | 755.5 | 789.9 | 479.2 | 263.0 | 191.8 | 159.8 | 140.2 | 116.3 |
| 1979 | 98.3 | 137.1 | 133.4 | 545.5 | 597.3 | 695.6 | 512.5 | 214.4 | 177.3 | 128.6 | 107.1 | 101.1 |
| 1980 | 169.4 | 343.3 | 1639.2 | 3226.8 | 4908.1 | 2842.1 | 1354.7 | 445.9 | 235.9 | 159.2 | 123.7 | 90.9 |
| 1981 | 58.5 | 105.3 | 189.5 | 962.7 | 1003.2 | 826.9 | 320.9 | 168.9 | 130.0 | 106.9 | 92.3 | 86.4 |
| 1982 | 84.2 | 102.5 | 448.2 | 1641.7 | 757.2 | 867.9 | 342.4 | 190.7 | 135.6 | 105.0 | 90.0 | 79.0 |
| 1983 | 80.8 | 216.0 | 545.3 | - | 869.2 | 1303.2 | 529.4 | 202.7 | 137.4 | - | - | 72.4 |
| 1984 | 46.3 | 202.7 | 575.2 | 931.0 | 530.7 | 845.1 | 380.1 | 220.1 | 155.4 | 116.9 | 96.0 | 81.2 |
| 1985 | 95.2 | 177.5 | 766.9 | 1621.9 | 910.2 | 1034.9 | 538.8 | 202.9 | 144.7 | 128.5 | 93.9 | 76.7 |
| 1986 | 114.4 | 186.4 | 451.9 | 981.4 | 830.9 | 1014.4 | 531.5 | 172.5 | 111.6 | 80.2 | 70.3 | 81.1 |
| 1987 | 74.8 | 133.2 | 475.2 | 1464.2 | 1570.6 | 1018.8 | 540.3 | 190.3 | 110.4 | 83.6 | 70.9 | 69.2 |
| 1988 | 69.8 | 177.8 | 453.9 | 1528.1 | 2015.0 | 1510.2 | 409.9 | 115.8 | 94.8 | 72.7 | 69.2 | 60.3 |
| 1989 | 53.0 | 157.0 | 794.6 | 1339.6 | 865.0 | 1191.8 | 564.0 | 169.9 | 102.2 | 82.5 | 72.3 | 66.6 |
| 1990 | 102.3 | 271.5 | 1075.9 | 1465.2 | 1328.5 | 1209.8 | 948.0 | 217.1 | 117.3 | 90.0 | 63.6 | 50.4 |
| Mean | 95.6 | 199.9 | 647.2 | 1386.9 | 1270.8 | 1145.1 | 586.6 | 216.0 | 144.7 | 114.5 | 96.6 | 83.5 |

## Table II.3.1 Yearly Rainfall Frequencies

| Station | Ave. | S | Yearly Rainfall Frequencies(mm/yr) 2 yr | 5 yr | 10 yr | 20 yr | 25 yr | 50 yr | 100yr |
|---|---|---|---|---|---|---|---|---|---|
| Chilmari | 2303.14 | 628.42 | 2200 | 2756 | 3123 | 3476 | 3587 | 3932 | 4275 |
| Kaunia | 2481.52 | 720.80 | 2363 | 3000 | 3421 | 3827 | 3954 | 4350 | 4743 |
| Kurigram | 2362.23 | 478.02 | 2284 | 2706 | 2986 | 3254 | 3389 | 3601 | 3862 |
| Lalmanir hat | 2581.87 | 645.02 | 2476 | 3046 | 3423 | 3786 | 3900 | 4254 | 4605 |
| Pirgacha | 2117.25 | 494.66 | 2036 | 2473 | 2762 | 3041 | 3128 | 3399 | 3669 |
| Sundar ganj | 1984.22 | 459.25 | 1909 | 2315 | 2583 | 2842 | 2922 | 3175 | 3425 |
| Ulipur | 2298.89 | 444.84 | 2226 | 2619 | 2879 | 3129 | 3208 | 3452 | 3694 |

## Table II.3.2 Daily Rainfall Frequencies

| Station | Ave. | S | Daily Rainfall Frequencies(mm ) 5 yr | 10 yr | 20 yr | 50 yr | 100yr |
|---|---|---|---|---|---|---|---|
| Chilmari | 169.44 | 66.53 | 217.3 | 256.2 | 293.7 | 341.9 | 378.2 |
| Kaunia | 189.41 | 52.67 | 227.1 | 257.7 | 287.2 | 325.1 | 353.7 |
| Kurigram | 169.86 | 53.84 | 208.6 | 240.1 | 270.4 | 309.4 | 338.7 |
| Lalmanir hat | 177.10 | 44.38 | 209.1 | 235.0 | 260.0 | 292.1 | 316.3 |
| Pirgacha | 169.11 | 61.06 | 213.1 | 248.7 | 283.1 | 327.4 | 360.6 |
| Rangpur | 171.75 | 47.86 | 206.2 | 234.2 | 261.1 | 295.8 | 321.9 |
| Sundar ganj | 146.40 | 46.47 | 179.9 | 207.0 | 233.2 | 266.9 | 292.2 |
| Ulipur | 169.44 | 65.06 | 216.3 | 254.3 | 290.9 | 338.1 | 373.5 |

## Table II.3.3 5-days Period Rainfall Frequencies

| Station | Ave. | S | Daily Rainfall Frequencies(mm ) 5 yr | 10 yr | 20 yr | 50 yr | 100yr |
|---|---|---|---|---|---|---|---|
| Chilmari | 359.62 | 116.75 | 443.7 | 511.9 | 577.6 | 662.2 | 725.9 |
| Kaunia | 363.90 | 110.75 | 443.6 | 508.3 | 570.7 | 651.0 | 711.3 |
| Kurigram | 333.74 | 100.88 | 406.4 | 465.3 | 522.1 | 595.2 | 650.2 |
| Lalmanir hat | 352.02 | 92.79 | 418.8 | 473.0 | 525.3 | 592.5 | 643.1 |
| Pirgacha | 335.57 | 143.44 | 438.8 | 522.6 | 603.4 | 707.4 | 785.6 |
| Rangpur | 326.42 | 118.77 | 411.9 | 481.3 | 548.2 | 634.3 | 699.0 |
| Sundar ganj | 286.39 | 78.33 | 342.8 | 388.5 | 432.6 | 489.4 | 532.1 |
| Ulipur | 348.26 | 107.82 | 425.9 | 488.9 | 549.6 | 627.7 | 686.5 |

Ave.:Average S:Standard deviation

## Table II.3.4 Flood Water Level Frequencies for Each Gauging Stations

| Station | River | Ave. | S | Flood Peak Frequencies(m/PWD) 2 yr | 5 yr | 10 yr | 20 yr | 25 yr | 50 yr | 100yr | 200yr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Noonkawa | Brahmaputra | 27.321 | 0.618 | 27.219 | 27.766 | 28.127 | 28.475 | 28.583 | 28.923 | 29.260 | 29.597 |
| Chilmari | Brahmaputra | 24.038 | 0.427 | 23.968 | 24.345 | 24.594 | 24.835 | 24.911 | 25.145 | 25.377 | 25.611 |
| Bahadura bad | Brahmaputra | 19.723 | 0.380 | 19.660 | 19.997 | 20.219 | 20.432 | 20.499 | 20.708 | 20.915 | 21.122 |
| Talukshi mulbari | Dharla | 30.815 | 0.494 | 30.807 | 31.171 | 31.459 | 31.737 | 32.138 | 32.095 | 32.365 | 33.126 |
| Kurigram | Dharla | 26.526 | 0.434 | 26.454 | 26.838 | 27.092 | 27.336 | 27.412 | 27.651 | 27.887 | 28.124 |
| Kaunia | Teesta | 29.948 | 0.317 | 29.896 | 30.176 | 30.361 | 30.540 | 30.595 | 30.770 | 30.942 | 31.116 |

by Gumbel-Chow Method

## Table II.3.5 Minimum Water Level Frequencies for Each Gauging Station

| Station | River | Flood Peak Frequencies(m/PWD) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2 yr | 3 yr | 5 yr | 10 yr | 20 yr | 50 yr | 100yr |
| Talukshi mulbari | Dharla | 27.10 | 26.97 | 26.86 | 26.74 | 26.65 | 26.56 | 26.50 |
| Kurigram | Dharla | 22.23 | 22.14 | 22.05 | 21.96 | 21.88 | 21.80 | 21.75 |

by Thomas Plotting

## Table II.3.6 Flood Discharge Frequencies at Kurigram (cu.m)

| Return Period | Discharge(cub.m) Maximum |
|---|---|
| 2 | 2049 |
| 5 | 2883 |
| 10 | 3434 |
| 20 | 3965 |
| 25 | 4130 |
| 50 | 4628 |
| 100 | 5162 |
| 200 | 5677 |
| Ave. | 2204 |
| S. | 943 |

Ave. : average
S. : standard deviation

**Table II.3.7 Minimum Discharge Frequencies at Kurigram (cu.m)**

| Return Period | Discharge(cub.m) Minimum |
|---|---|
| 2 | 66 |
| 3 | 58 |
| 5 | 52 |
| 10 | 46 |
| 20 | 41 |
| 50 | 37 |
| 100 | 34 |

by Thomas plotting

**Table II.3.8 Droughty Discharge (355 days) Frequencies at Kurigram (cu.m)**

| Return Period | Discharge (cu.m/sec) |
|---|---|
| 2 | 67 |
| 3 | 64 |
| 5 | 55 |
| 10 | 50 |
| 20 | 45 |
| 50 | 41 |
| 100 | 38 |


| | |
|---|---|
| 2 | 67 |
| 3 | 64 |
| 5 | 55 |
| 10 | 50 |
| 20 | 45 |
| 50 | 41 |
| 100 | 38 |

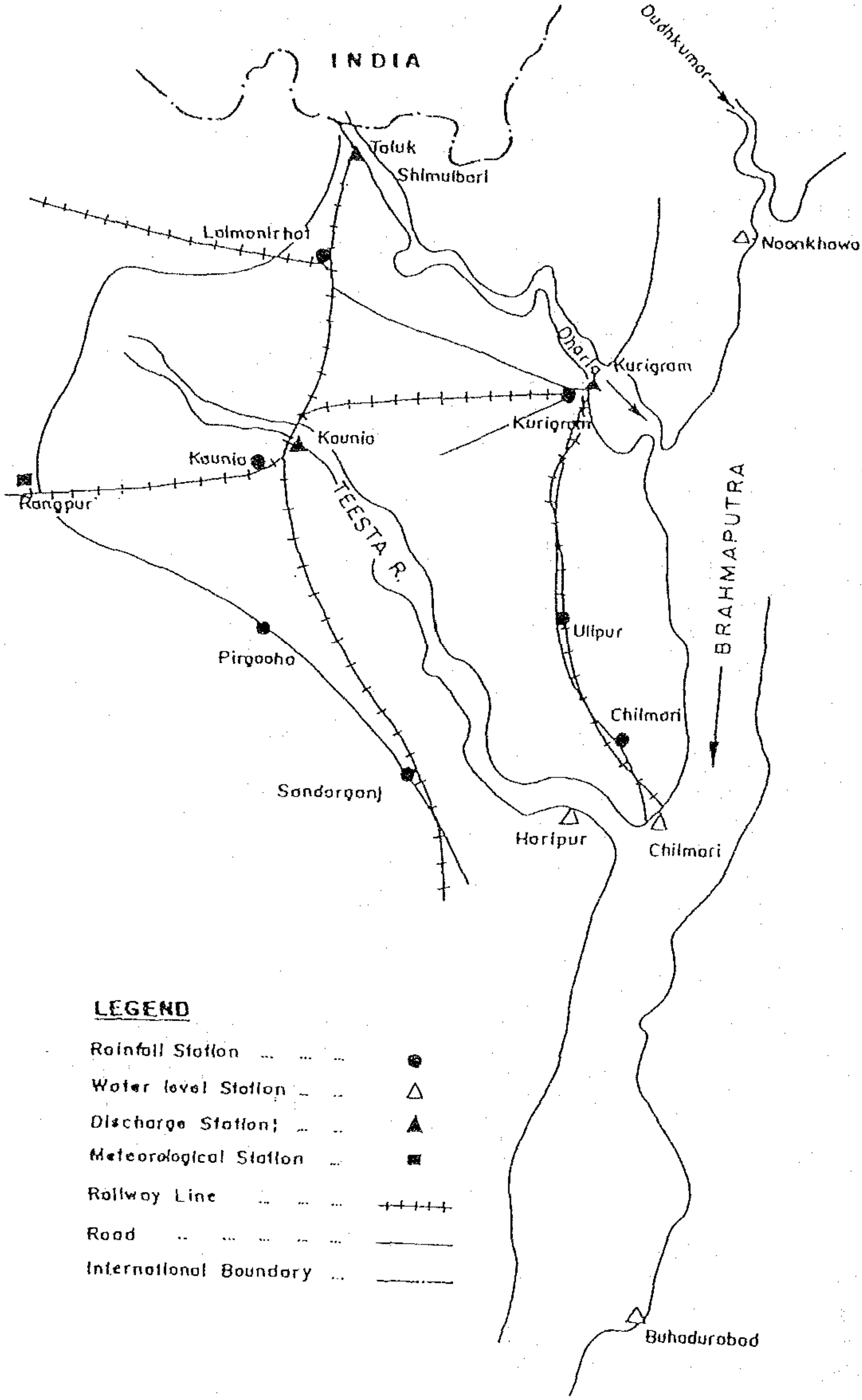


**Fig. II.1.1 Location of Meteorological and Hydrological Stations**

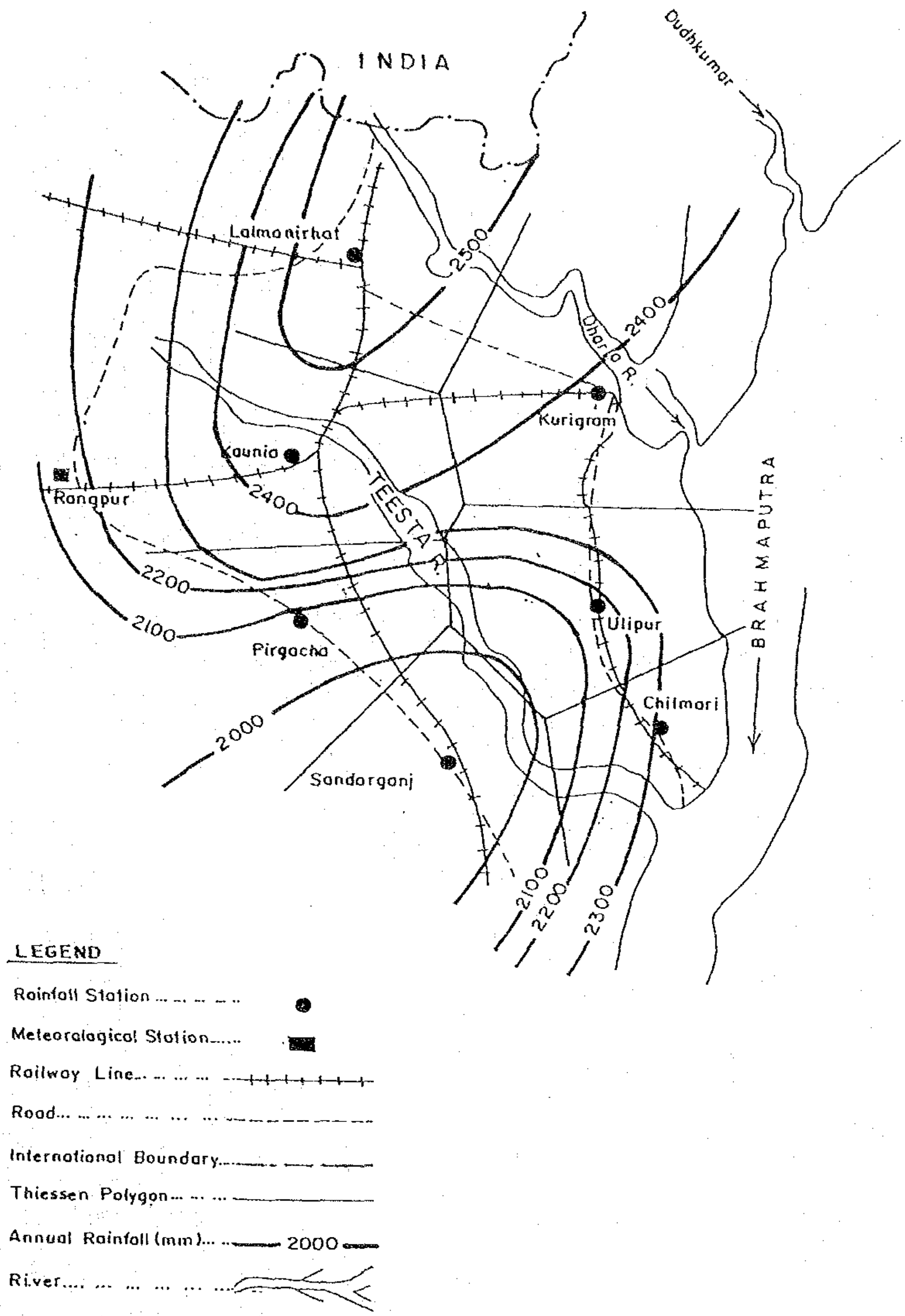


**Fig. II.2.1 Thiessen Polygon and Isohyetal Map**

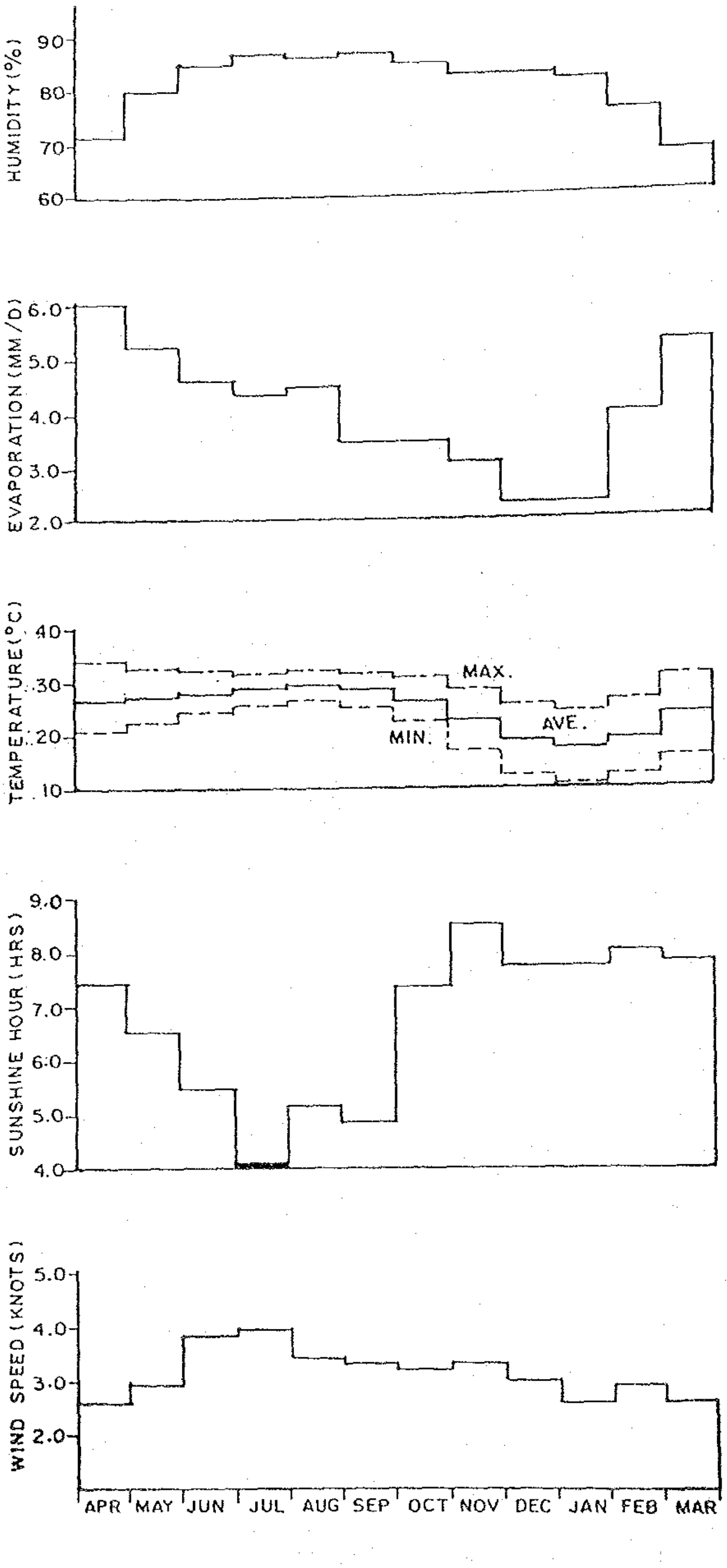


**Fig. II.2.2 Monthly Climatological Variations at Rangpur**

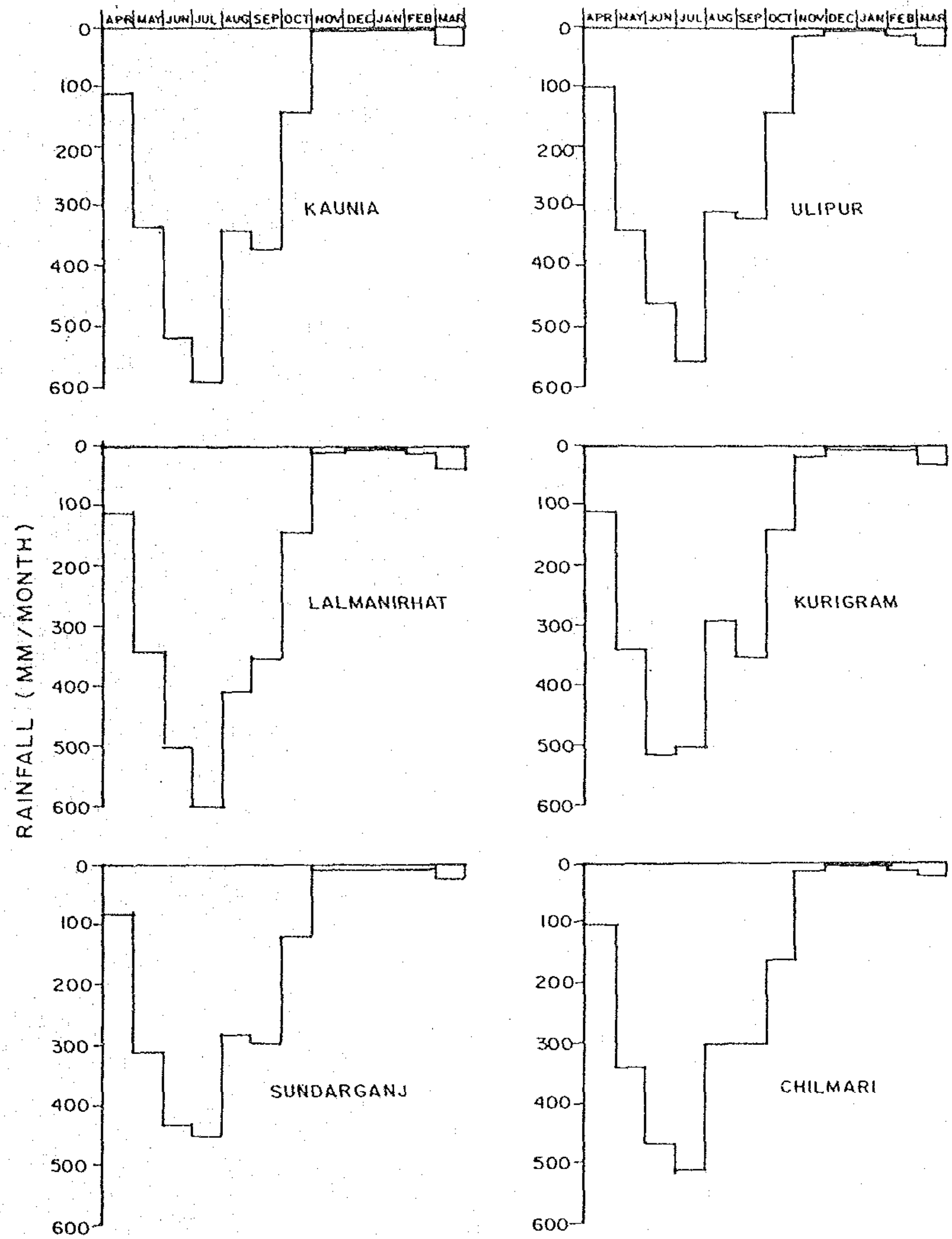


**Fig. II.2.3 Monthly Rainfall Pattern**

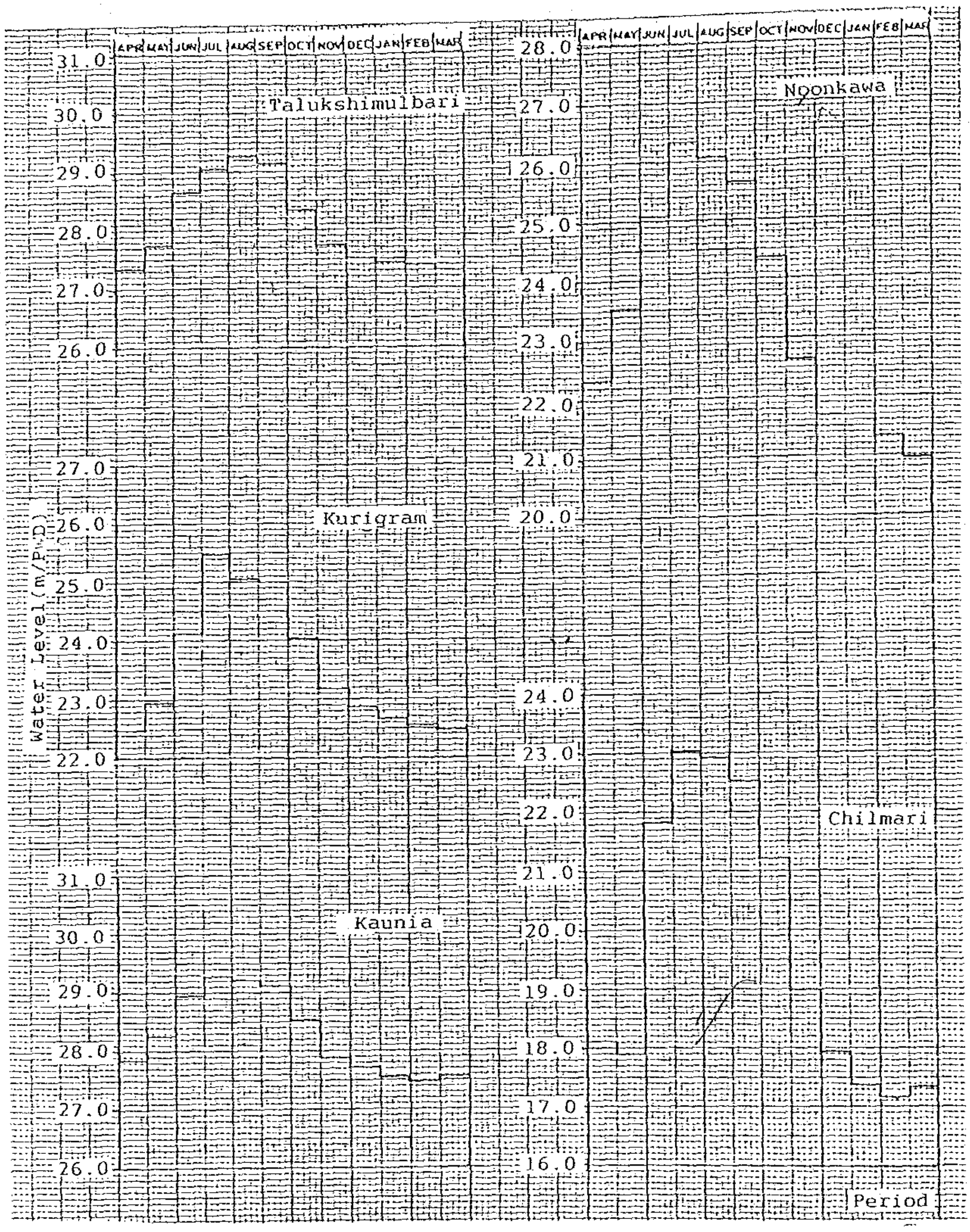


**Fig. II.2.4 Monthly Water Level Pattern**

## APPENDIX - III

# GEOLOGY AND SOIL MECHANICS

FEASIBILITY STUDY ON

KURIGRAM IRRIGATION AND FLOOD CONTROL PROJECT (SOUTH UNIT)

# APPENDIX - III GEOLOGY AND SOIL MECHANICS

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# APPENDIX-III GEOLOGY AND SOIL MECHANICS

## 1. Introduction

Geotechnical investigation of the Feasibility Study on the Kurigram Irrigation and Flood Control Project -South Unit was conducted in order to clarify the surface geological condition of the Study area and to obtain basic data for foundation design of the structures by the execution of test boring as well as field reconnaissance and review of the existing data.

The main items conducted in geotechnical investigation are as follows:

- To collect and review of the existing data and reports from government agencies concerned,
- To carry out field reconnaissance survey for general soil condition of the Study area,
- To execute the test boring works including standard penetration test (SPT) at 1 m interval at the 4 selected major structure sites, and
- To study on seismicity, bearing capacity of foundation, slope stability, erosion resistance and liquefaction.

## 2. Data Collection and Review

During the field work of investigation in the Phase I Stage, the Study Team visited various governmental offices concerned, exchanged the views on the geotechnical matters with the officials and collected data.

The collected data regarding to the topographical, geological and soil mechanical information are shown in Table III.2.1, List of References.

## 3. Topography and Geology

### 3.1 General Topography and Geology

The entire land of Bangladesh is referred as a part of the Bengal Basin filled in the Tertiary to Quaternary period. Bangladesh is been generally described as a delta or a flat alluvial plain formed by the continued process of erosion and deposition of the detritus carried by the several ancient and recent rivers. The three major rivers in the country are the Ganges, the Brahmaputra and the Megna. These rivers originate from the glaciers of the Himalayas. The thickness of sediment cover over the basement rocks, is about 180 meters along the Rangpur-Dinajpur axis and increases southeastward to over 3,600 meters in the eastern part of the country.

The landform of Bangladesh is physiographically divided into 3 categories of Tertiary Hills, Pleistocene Uplands and Recent Plain corresponding to the geological features which consist of pre-Tertiary rocks, Tertiary sedimentary rocks, Pleistocene deposits and alluvial deposits.

The Tertiary Hills are distributed in the southeastern part of the country, the only region that experienced upheaval contemporaneously with Himalayan Orogeny, whereas the rocks of pre-Tertiary and Tertiary ages are subsided in the depth influenced by Himalayan Orogeny throughout the country except this area. The Tertiary Hills formed mainly of sandstones and shales occupy about 18 % of the country.Their average height is around 300 m above the sea level having the highest peak of 1,003 m at Mowduk Mual on the Bangladesh-Myanmar Border.

The Pleistocene Uplands are developed mainly in the Madhupur tract, north of the Dhaka city, and the Barind tract in the northwest of the country. These Uplands rise like islands above the flood plains. The upland covers an area of about 10 % of the country. The height of the Madhupur tract varies from 9 m to 18 m. The Barind Upland attains a height of about 40 m in places. Pleistocene deposit of the Uplands overlying pre-Tertiary and Tertiary rocks settles in the depth of scores or more meters in the part. However, the parts of them crop out locally in the quite limited areas where the Pleistocene deposit was eroded away in the lowering time of sea level (i.e the sea regression) from Pleistocene to lower Holocene time.

The Recent Plains consisting of the alluvial deposits occupy about 72 % of the country. The alluvial deposits are distributed almost allover the country, filling the valleys of the glacial epoch. The Recent Plains are divided into Piedmont Plain, Floodplain, Deltaic Plain, Tidal Plain and Coastal Plain.

The Piedmont Plain in the northwest area rolls down from north to south. The Floodplains of continental deposits are further sub-divided as the Teesta floodplain, Brahmaputra floodplain, Ganges river floodplain, Meghna river floodplain, Meghna estuarine floodplain and Surma-Kusiyara floodplain. The Deltaic Plains is built up by both marine and continental deposits. The Tidal Plains are composed predominantly of marine deposits. The most of them are situated in the very low land area less than 3 m above the sea level.

The physiographic landform in Bangladesh is shown on Fig.III.2.1.

Structurally, on a geological time scale, the northern Indian plate is sliding under the South-East Asian Plate, forming the Himalayas and warping/shearing the adjoining geological structures. Along the eastern border of the country, the 2 plates are rubbing each other similarly warping/shearing the adjoining geological structures. Accordingly the northern and eastern sides the country are an active tectonic area.

In Bangladesh, the principal tectonic units are divided into 2 parts bounded by the Calcutta-Mymensingh Hinge. The hinge line runs southwest from Mymensingh, about 50 km north of Dhaka, to Culcutta, the capital of West Bengal in India. The northwest of the hinge line is the Precambrian Platform, and the southeast is the Bengal Foredeep. However, no active seismic movement has been related to the above mentioned tectonic element.

The Tectonic Plates in the South to Southeast Asia and Generalized Tectonic Map of Bangladesh and Adjoining Area are shown on Figs.III.3.1 and III.3.2 respectively.

## 3.2 Topography and Geology of the Study Area

The Study area is situated in the most northern part of Bangladesh, and is encircled by a ring levee located in the Kurigram and Lalmonirhat districts. The area is bounded by the Dharla river in the north, Teesta river in the south, Brahmaputra river in the east and railway embankment in the west as shown on the Location Map.

Phisiographically, as shown on Fig.III.3.3, the most of Study area extends on the lower Teesta floodplain, but the old Teesta meander floodplain is developed partially in the northern part, the active and young Teesta meander floodplain is developed on the northeastern periphery along the Dharla river, the active and young Brahmaputra flood plain is developed locally on the right bank of the Brahmaputra river at the southeastern part, and the active and young Teesta meander flood plain is developed along the Teesta river in the southwestern periphery.

The elevation of land surface of the area varies from about 34 m above the sea level in the north and about 21 m in the south. The land has a very gentle slope of about 1/5,300 from northwest to southeast. In the nearly flat land, some undulations with irregular relief due to low pockets, gullies and depressions are sporadically found.

Physiographic units of the Study area is shown on Fig.III.3.3.

The Study area is geologically underlain by alluvium which have formed by the interstream and meander deposits of the rivers Teesta, Brahmaputra and Dharla. The alluvium in the Study area consists of the silt and clay in the upper most portion, the fine sand, the fine to medium sand with gravel and the medium to coarse sand with gravel in the deeper portion.

The geological condition in the Study area is shown on Fig.III.3.4 as panel diagram.

## 4. Seismicity

### 4.1 Tectonic Features

As shown on the Tectonic Map (Fig.III.3.2), there are major fault systems: the Main Boundary Thrust and the Disang Thrust in the northeastern region of India, and the Arakan Yoma Suture along the India-Myanmar Ranges. These regions are known as high seismic activity zones where major earthquakes frequently occur. Although not many significant earthquakes have occurred in Bangladesh, the land particularly in the northern and eastern parts have been affected by the earthquakes occurred in the adjacent regions mentioned above.

### 4.2 Past Earthquake Damages in Bangladesh

Major earthquakes affected Bangladesh have been summarized by F.H.Khan (1991) as below:

(1) Bengal Earthquake of 1885

The earthquake of July 14,1885 severely rocked the central and northwestern parts of Bangladesh causing considerable damages.

(2) Great Assam Earthquake of 1897

The earthquake occurred in the afternoon of July 12, 1897 in northeastern India and having a magnitude of 8.7 in the Richter scale, has been classed as one of the greatest in history. The Shillong Plateau in Assam region was the epicentral tract of this earthquake. It caused severe damages over a large area of Assam, Bengal and Bihar, and was felt over an area of 600,000 $km^2$. The earthquake was followed aftershocks continuing a number of years.

(3) Srimangal Earthquake of 1918

This is a major earthquake with epicenter in Bangladesh. It occurred at 16:21 on July 8, 1918. It had a magnitude 7.6 in the Richter scale and the epicenter was in the Bbalisera valley just south of Srimangal of Sylhet district.

(4) Assam Earthquake of 1950

This is another great earthquake and had a magnitude of 8.5 in the Richter scale. It occurred in the afternoon of August 15,1950 with epicenter in the extreme northeast corner of India. This earthquake caused great destruction and killed 532 persons in northeastern India. Aftershocks of this earthquake also continuous over a long period.

In addition to the above, according to B.L.C.Johnson (1982), the Teesta river, flowing southern boundary of the Study area, has been changed its river course from a tributary of the Ganges to existing tributary of the Brahmaputra by the Great Assam Earthquake of 1897.

## 4.3 Seismic Zoning of Bangladesh

The report to prepare a seismic zoning map of Bangladesh and to suggest a code for earthquake resistant design of structures has been published in 1979 by the Committee of Experts / the Geological Survey of Bangladesh. The report recommended Bangladesh to be sub-divided into three zones I, II and III, and suggests the basic horizontal seismic coefficient of 0.08 for zone I, 0.05 for zone II and 0.04 for zone III. Zone I covers northeast Bangladesh including the Study area and is designated as the most active seismic zone. Zone II runs from northwest to southeast covering the central part of Bangladesh. Zone III covers the southeast part of Bangladesh and is designated as the least active seismic zone.

The Seismic Zoning Map of Bangladesh is shown on Fig.III.4.1.

## 4.4 Seismicity of the Study Area

### 4.4.1 Used Data for Seismicity Analysis

Seismicity analysis for the Study area was carried out based on the data of past earthquake covering the period from September 1833 to June 1971. According to the collected data, earthquakes likely affecting to the Study area were 92 events over a period of 138 years.The data cover the recorded earthquakes with epicenters located within at least 500 km distance from major structure site in the Study area at N 25.9°/ E.89.6°. The data were obtained from the report of Seismic Zoning Map of Bangladesh published by the Geological Survey of Bangladesh.

Within the recorded period of 138 years, the maximum magnitude was 8.7 of the Great Assam Earthquake in 1897, and its epicenter was 295 km away from the Study area. The nearest earthquake occurred 63 km away from the site in 1949 with the magnitude of 6.0.

The earthquakes likely to affect the Study area are shown in Table III.4.1.

### 4.4.2 Intensity and Acceleration Analysis

The effective intensity and acceleration at the Study area caused by each event of the recorded earthquakes were estimated by the several method. The formulae used for the study are as follows:

(1) Intensity

1) Cornell's method (1968)

$Imm = 8.0+1.5M-2.5Ln(d^2+h^2+400)^{0.5}$

2) Kawasumi's method (1951)

$Ij = 2M-4.6052\log d-0.00183d-0.307$ (When d>100 km)

$Ij = 2(M-\log r)-0.01688r-3.9916$ (When d<100 km)

Where, Imm : Intensity in Modified Mercalli (MM) Scale
Ij : Intensity in Japan Meteorological Agency (JMA) Scale
M : Magnitude of earthquake in Richter Scale
Ln : Natural logarithm
d : Distance from epicenter to the site in km
h : Depth of focus in km
r : Distance from focus to the site in km

(2) Acceleration

1) Richter's method (1942)

$\log \alpha = Imm/3 - 0.5$

2) Kawasumi's method (1951)

$\alpha = 0.45 \times 10^{(Ij/2)}$ (When Ij<5.5)

$\alpha = 20 \times 10^{(Ij/5)}$ (When 5.5<Ij<7.0)

3) Cornell's method (1968)

$\alpha = 2000\ e^{0.8\ M}/(d^2+h^2+400)$

4) Esteva's method (1976)

$\alpha = 5000\ e^{0.8M}/(r+40)^2$

5) Katayama's method (1974)

$\alpha = 980(0.203\ e^{0.9464M}(r+30)^{-1.637})$

Where, $\alpha$ : Peak ground acceleration in gal or $cm/sec^2$
e : The exponential constant

Intensities and accelerations likely to affect the Study area, estimated through the above methods, are shown in Table III.4.2.

### 4.4.3 Frequency Analysis

Plotting the cumulative number of converted frequency in 100 years (Nc) and the intensity (I) on a logarithm-normal graph, the following formulae were obtained by the minimum square method as shown on Fig.III.4.2.

$\log Nc = -0.227I+2.041$ (I : MM Scale)

$\log Nc = -0.221I+1.393$ (I : JMA Scale)

The expected maximum intensities in a probable return period of 50 years and 100 years were obtained from above formulae. Furthermore, the maximum ground accelerations ($\alpha$) corresponding to the maximum intensities were also obtained by the Richter's and Kawasumi's methods as follows.

50 years return period ($Nc=2.0$)

$I = 7.67$ in MM Scale $\alpha=114$ gal (Richter)

$I = 4.94$ in JMA Scale $\alpha=133$ gal (Kawasumi)

100 years return period ($Nc=1.0$)

$I = 8.99$ in MM Scale $\alpha=314$ gal (Richter)

$I = 6.30$ in JMA Scale $\alpha=364$ gal (Kawasumi)

On the other hand, the maximum ground accelerations to be expected in the same probable return periods were directly obtained by plotting the recurrence interval (Tr) and peak ground acceleration on a log-log graph as shown on Fig.II- 8. The recurrence interval of Tr was computed by the following equation.

$$Tr = P/n$$

Where, P : The observatory period (Years)

n : The serial number of an earthquake in observatory period (Nos.)

Relationship between the recurrence interval (Tr) and the maximum ground acceleration ($\alpha$) is obtained as below.

$\log(\alpha)=1.322\log(Tr)-0.308$ (Cornell)

$\log(\alpha)=1.616\log(Tr)+0.056$ (Esteva)

$\log(\alpha)=1.129\log(Tr)-0.029$ (Katayama)

The maximum ground accelerations for the 50 and 100 years return period obtained from above formulae are as follows.

50 years return period

90 gal (Cornell) 107 gal (Esteva) 77 gal (Katayama)

100 years return period

227 gal (Cornell) 239 gal (Esteva) 169 gal (Katayama)

### 4.4.4 Design Seismicity

Design seismic coefficient for the the Study area, which is obtained by dividing the maximum acceleration (gal or cm/sec$^2$) by g or 980 cm/sec$^2$ varies from 0.08 to 0.14 on the basis of 50 years return period and from 0.17 to 0.37 on the basis of 100 years return period.

However, the design seismic coefficient has been generally taken lower than the return period of 100 years even the case in the area of high seismicity. Such modification is based on consideration that the horizontal component of acceleration can be less than the estimated maximum value and the duration of the peak acceleration to act upon structures is very limited. Furthermore, based on the scale and importance of proposed structures, the available return period for determination of the seismic coefficient in the Study area will be adopted in 50 years.

Consequently conditions, the horizontal seismic coefficient of 0.08, the same value as the Bangladesh standard, is recommended for the design criteria of the structures in the Study area.

## 5. Soil Mechanical Condition

In the Project area, consisting of both Kurigram South and North units, the soil mechanical laboratory tests of total 195 samples have been previously made through the following 3 stages. Sampling depths varies from 0.5 m to 98.2 m from the ground surface.

### (1) Original F/S Stage

The test was made in 1968 for 72 samples taken from auger holes (South unit 29 holes, North unit 2 holes) which bored along the existing embankment alignment, and in 1969 for 22 samples taken from exploratory borings at the proposed pumping station (1 hole) and the proposed barrage sites(3 holes). The laboratory test had been made by the Hydraulic Research Laboratory.

### (2) Revised and Updated F/S Stage

The test for 51 soil samples obtained from exploratory borings (South unit 8 holes, North unit 3 holes) was done in 1974 by the same Laboratory as the test of original F/S stage.

### (3) North Unit F/S Stage

In the feasibility study of the North Unit, the laboratory soil test had been carried out in 1989 by the JICA study team.In this study, 30 samples from augerborings (15 holes) and 20 samples taken from 1 exploratory boring at the proposed pumping station site were tested.

The sampling locations for the previous laboratory tests and the test results are shown in Fig.III.5.1. According to the grain size of this table, about a half of samples in the upper portion was classified as silty materials, and the remainings were sandy materials.

Mean values of silty and sandy materials aresummarized as follows.

| Test item | | | Silty Materials | | Sandy materials | |
|---|---|---|---|---|---|---|
| | | | 0 - 5 m | below 5 m | 0 - 5 m | below 5 m |
| Natural moisture content | | (%) | 33.15 | 22.03 | 21.72 | |
| Wet density | $\gamma_w$ | (t/m$^2$) | 1.634 | | 1.675 | 1.924 |
| Dry density | $\gamma_d$ | (t/m$^2$) | 1.295 | | 1.375 | 1.581 |
| Grain size | $D_{10}$ | (mm) | 0.0108 | 0.0077 | 0.0469 | 0.1144 |
| | $D_{30}$ | (mm) | 0.0227 | 0.0280 | 0.0999 | 0.2403 |
| | $D_{50}$ | (mm) | 0.0341 | 0.0535 | 0.1343 | 0.4663 |
| | $D_{60}$ | (mm) | 0.0491 | 0.0705 | 0.1492 | 0.7626 |
| Uniformity coefficient | Cu | | 7.9 | 10.6 | 3.4 | 7.8 |
| Curvature coefficient | Cz | | 1.4 | 1.5 | 1.4 | 1.7 |
| Liquid limit | LL | (%) | 41.4 | | 38.4 | |
| Plasticity limit | PL | (%) | 27.9 | | 27.4 | |
| Plasticity index | PI | | 13.5 | | 11.0 | |
| Direct shear test | C | (t/m$^2$) | 0.74 | | 0.43 | 0.10 |
| | $\phi$ | (°) | 16.6 | | 25.9 | 33.8 |
| Triaxial compresion test | C | (t/m$^2$) | 0.70 | | 0.64 | 0.50 |
| | $\phi$ | (°) | 16.0 | | 25.8 | 31.8 |

## 6. Test Boring Works

### 6.1 Site Selection of the Test Borings

Through the preparatory work of the Study, 2 major structure sites, the proposed pumping station and barrage sites, were selected as the first priority sites. Based on the field reconnaissance and review of the existing data, 2 regulator sites, Ratnai and Harichari regulator sites, were newly added.

Location map of the selected test boring sites are shown on Fig.III.6.1.

### 6.2 Locations and Present Condition of the Selected Boring Sites

#### 6.2.1 Proposed Pumping Station Site

Proposed pumping station is located at Bumka village in Lalmonirhat district, and is about 3 km distant along the main embankment from its starting point of the northernmost of the Study area. The site is nearly flat on the old Teesta meander floodplain. The ground height of the site is about 32 m above the sea level.

Two (2) test borings including SPT, BB-1 and BB-2, were sunk to the depth of 20 m each. THe location of the boring holes are just inside of the main levee. Other than the above, one exploratoly boring with SPT had been carried out to a depth of about 22 m (72 ft) in November 1969. The previous boring point is about 300 m south of proposed pump station site.

#### 6.2.2 Proposed Barrage Site

Proposed barrage is planned at Holokhana village in Kurigram district across the Dharla river. The site is located about 30 km downstream from the northernmost of the Study area and is about 6 km north of Kurigram town.

Through the previous feasibility study, 3 borings had been sunk at Surer Kuthi village, about 3 km south of the proposed barrage site, in December,1968. According to this, N-values more than 30 appear at the depth of 20 m below the ground surface. Therefore the boring depths were changed from 20 m to 30 m in 3 holes.

Total 4 test borings with SPT, BI-1, BI-2, BI-3 and BI-4, were conducted along the proposed barrage axis; three holes on the right bank of the main stream of the Dharla river and the rest one, BI-4, on the left bank.

#### 6.2.3 Ratnai Regulator Site

Ratnai regulator, having 8 gates, had been constructed on he Ratnai river at Bari Bonomali villagein Lalmonirhat district in late June, 1982. It is located on the old Teesta meander floodplain, and at about 14 km along the main embankment from its starting point.

The Ratnai regulator was severely damaged by the flood occurred in June, 1983. The river course of the Ratnai has also been shifted to the south due to this flood. Accordingly the Ratnai regulator has been abandoned since 1983. Existing river course of the Ratnai flows about 40 m south from the previous river course at the crossing section with the main embankment. Considering the present situation mentioned above, it is recommended that the Ratnai regulator shall be newly constructed.

According to the information by BWDB, every foundation of the existing regulators had been designed based on the N-values obtained from SPT at its design stage. However the record of previous borings could not found.

One (1) test boring, BR-1, was sunk to 20 m at the spot just outside of the main embankment on the right bank of the existing Ratnai river.

### 6.2.4 Harichari Regulator Site

The Harichari regulator has 12 gates and has been constructed in late December, 1979. It is located at the southernmost of the Study area near the confluence of the Brahmaputra and the Teesta rivers where the active and young Teesta meander floodplain is distributed.

Foundation of the apron portion and a part of side wall of the regulator have been damaged by the flood in September, 1991. Accordingly the rehabilitation of the Ratnai regulator shall be required as soon as possible.
Although there are the previous boring records made in 1976, in order to clarify the further detailed geological condition of the apron portion, 1 test boring was made at the right bank of the canal.

The schematic location maps of each selected test boring spots are shown on Fig.III.6.2.

## 6.3 Work Items and Quantities of the Test Borings

The test boring work consists of core boring and standard penetration test (SPT) at 1 m interval. For 3 holes among 4 in total in the proposed barrage site, the scheduled boring length was changed from 20 m each to 30 m each according to the previous boring records. The selected boring sites and their quantities are as follows:

(1) Proposed pump station site
Core boring 20 m/hole x 2 holes = 40 m
SPT (1 m interval) 40 nos.

(2) Proposed barrage site
Core boring 30 m/hole x 3 holes = 90 m
20 m/hole x 1 hole = 20 m
SPT 110 nos.

(3) Ratnai regulator site
Core boring 20 m/hole x 1 hole = 20 m
SPT 20 nos.

(4) Harichari regulator site
Core boring 20 m/hole x 1 hole = 20 m
SPT 20 nos.

## 6.4 Operation of the Test Boring Works

After preparation of the Technical Specifications by he JICA Study Team, the test boring works including SPT were carried out at the four selected major structure sites in the period from mid January to early March, 1992. The field operation was done during the period from January 25 to February 20. 1992, by the local contractor, Aqua Soil Engineers, under supervision of the JICA Study Team.

## 6.5 Geotechnical Condition

The geotechnical condition of all the test boring sites are quite similar, although the sites are apart each other within the distance from 10 to 40 km. The surface geological materials of the boring sites are underlain by alluvium which is principally composed of sandy strata intercalated with thin silty layers in the shalower portion. The sandy strata generally consist of very fine to fine sand in the upper section and medium to coarse sand in the deeper section. A small quantity of pebbles are partially found in the deeper section. The groundwater levels observed in the boreholes are generally shallow with the depth of 0.60 to 4.90 m from the ground surface, although it was later half of the dry season. The N-values at each site obtained from SPT vary from 1 to 49. The layers having more than 20 of average N-values appear in the depth of below 16 to 21 m except the Ratnai regulator site. More than 30 of average N-values appear only proposed barrage site at the depth below 29 m.

Summarized boring logs and of each hole are shown on Figs.III.6.3 and III.6.4.

## 7. Bearing Capacity of Foundation Ground

The bearing capacity of foundation bed at the proposed Bumka pumping station, Holokhana barrage and Ratnai regulator sites was calculated based on the SPT.

The test borings revealed that the foundation beds of the proposed structures consist of sandy strata. On the relationship between the N-value and internal friction angle of sandy strata, several formulae have been proposed by Terzaghi-Peck, Meyehof, Dunham and Osaki as shown on Fig.II-14. As the foundation beds of the proposed structures consist of uniform size paticles, the following Dunham's formula was adopted to determine the design internal friction angle.

$$\phi = \sqrt{12N} + 15$$

The long term allowable bearing capacity having a safety factor of 3.0 on the sandy ground was calculated by the following Terzaghi's formula (1963) for a rectangular type shallow foundation.

$$q_a = 1/3((0.5-0.1 \times B/L) \times B \times \gamma_1 \times Nr + \gamma_2 \times Df \times Nq)$$

where,

| | | |
|---|---|---|
| qa | : | Allowable bearing capacity ($t/m^2$) |
| $\gamma 1$ | : | Unit weight ($t/m^3$) of foundation bed below the footing bottom base, subtracting 1.0 under water level ($\gamma_1'$) |
| $\gamma 2$ | : | unit weight of overlying foundation bed (or backfill) above the footing bottom, subtracting 1.0 below groundwater level ($\gamma 2'$) |
| Nr, Nq | : | Bearing capacity factor, see Fig.III.7.2 |
| B | : | Shorter side length of foundation base (m) |
| L | : | Longer side length of foundation base (m) |
| Df | : | Depth of foundation bottom (m) |

Based on the general design criteria for each structure, the design values and estimated allowable bearing capacities are calculated as follows:

| | | Pump House (Bumka) | Barrage (Holokhana) | Ratnai Regulator (Bari Bonomali) |
|---|---|---|---|---|
| $\gamma_1, \gamma_2$ | ($t/m^3$) | 1.7 | 1.7 | 1.7 |
| $\gamma_1', \gamma_2'$ | ($t/m^3$) | 0.7 | 0.7 | 0.7 |
| Df | (m) | 15 | 2 | 4 |
| B | (m) | 16 | 689 | 7 |
| L | (m) | 29 | 22 | 17 |
| N-value | | 20 | 10 | 8 |
| $\phi$ | (°) | 30 | 26 | 25 |
| Nr | | 6.5 | 3.6 | 3.2 |
| Nq | | 12 | 8.0 | 7.7 |
| qa | ($t/m^2$) | 52.8 | 12.9 | 9.6 |

## 8. Recommendation for the Harichari Regulator Rehabilitation

According to the results of the test boring of BH-1 carried out at downstream side of the existing Harichari regulator, the surface stratum consist of very loose fine sand and its N-values were only 2 to 6. From this geotechnical condition, it can be said that the risk of scoring or piping at the downstream side of the regulator is high. Therefore, sheet piling as countermeasures against scoring or piping is recommended in the rehabilitation work of the regulator.

## 9. Stability Analysis of Embankment Slopes

As the embankment materials for the flood levees, irrigation canals and approach roads to the structures, both the sandy and silty soil strata destributed in the shallow portion of the Study area shall be used. Accordingly the stability analysis was made on both the embankments of silty and sandy soil materials. The embankment are assumed to have a slope of 1:3 and a 4.2 m wide crest width to match the existing levees. The required safety factors of embankment was determined at not less than 1.5 against the normal condition and not less than 1.2 against the seismic condition.

The analysis for the sandy soil embankments was made by the linear sliding method. The safety factors were calculated by the following formulae against the normal and seismic conditions.

$$Fs = \tan \phi / \tan \theta \quad \text{(Normal condition)}$$

$$Fs = (1-k \tan \theta)\tan \phi / (\tan \theta + k) \quad \text{(Seismic condition)}$$

where,
- Fs : Safety factor
- $\theta$ : Slope angle 1:3 = 18.4°
- $\phi$ : Internal friction angle = 30°
- k : Seismic coefficient = 0.08

The design internal friction angle was empirically selected based on the results of previous laboratory tests.

The calculated safety factors were as follows:

(1) Normal condition

Fs=tan30° / tan18.4°=0.577 / 0.333=1.73 > 1.5..............................ok

(2) Seismic condition

Fs=(1-0.08 x tan30°)tan18.4°/(tan30°+0.08)=1.65 > 1.2...................ok

On the other hand, the stability analysis for the silty soil embankment was carried out assuming the embankment height from 5 to 10 m. The analysis was made by using the Janbu's slope stability chart as shown on Fig.III.9.1.

The safety factor was calculated with the stability chart and the following formula.

$$Fs = N \times C / \gamma / H$$

where,

| | | |
|---|---|---|
| N | : | Stability factor = 5.53 |
| C | : | Cohesion of materials, means undrained shearstrength (Cu) in the chart = 3.0 $t/m^2$ |
| $\gamma$ | : | Density of materials, means saturated density($\gamma_{sat}$) in the chart = 1.339 $t/m^3$. The value was obtained by the following relation.<br>$\gamma_{sat}=\gamma_d+e/(1+e)$<br>$\gamma_d$ (dry density) =1.295 $t/m^3$<br>e (void ratio) = $(Gs/\gamma_d)-1$<br>Gs (specific gravity) = 2.66 $t/m^3$ |
| H | : | Slope height (m) |

The design values of C and $\gamma$for the analysis were empirically selected based on the previous laboratory tests.

The safety factors against the various embankment heights are calculated as follows:

| | | |
|---|---|---|
| H = 5 m | Fs = 5.53 x 3.0/1.339/5 = 2.48 > 1.5 | ...ok |
| H = 6 m | Fs = 5.53 x 3.0/1.339/6 = 2.07 > 1.5 | ...ok |
| H = 7 m | Fs = 5.53 x 3.0/1.339/7 = 1.77 > 1.5 | ...ok |
| H = 8 m | Fs = 5.53 x 3.0/1.339/8 = 1.55 > 1.5 | ...ok |
| H = 9 m | Fs = 5.53 x 3.0/1.339/9 = 1.38 < 1.5 | ...no |
| H =10 m | Fs = 5.53 x 3.0/1.339/10= 1.23 < 1.5 | ..no |

From the stability analysis results, it can be judged that the embankment height with slope of 1:3 must not be more than 8 m to have a safety factor not less than 1.5. For the embankment of 1:3 slope heigher than 8 m, counterweight berms are recommended to secure the stability.

## 10. Resistance against Erosion

The embankment materials of surface layers consist of the silty layer and the poorly-graded fine sand. Their uniformity coefficient was 7.9 of the silty layer and 3.4 of the sand layer. These materials have an extremely small erosion resistance. It is known that the surface layers in the Study area are easily eroded in the river bank of the Dharla, Teesta and Brahmaputra rivers. The existing flood embankment also is found to have been damaged by the erosion due to stream flow and rainfall in many places.

Accordingly the slope protection works such as the concrete lining, earth lining or sod facing should be furnished even in stable condition against the sliding failure.

## 11. Possibility of Liquefaction

In general, the sand layer foundation which conforms to the following conditions is considered to have risk of being liquefied by an earthquake.

a) The layer within the depth of 15 to 20 m from the ground surface
b) Pure sand layer consisting of uniform medium-sized particles
c) Layer saturated below the groundwater table
d) Poor compacted

The possibility of lipuefaction is judged to be high under the following conditions.

1) The content of silt and clay is less than 10% and the average grain size D50=0.075-2.0 mm. Particularly, the sand layer with D50=0.12-1.0 mm and a uniformity coefficient (Cu) of below 10 has a large risk of becoming lipuefied. For the sand layer with a uniformity coefficient less than 5, the risk is considered extremely high.

2) The N-values of SPT fall within the range of "C" in Fig.II-17.

The average grain size, Cu and percentage of N-nalue in the range"C" for each 5 m are summarized below:

| Depth | D50 | Cu | N-value in the range "C" (%) |
|---|---|---|---|
| Up to 5 m | 0.143 | 3.4 | 52.5 |
| 6 m - 10 m | 0.131 | 3.1 | 35.0 |
| 11 m - 15 m | 0.187 | 2.6 | 17.5 |
| 16 m - 20 m | 0.249 | 6.8 | 5.0 |
| Average | 0.178 | 4.0 | 28.8 |

As seen from the above table, D50s of sandy materials up to the depth of 20 m fall between 0.12 and 1.0 mm. Particularly the size up to the depth of 15 m was very fine. While the uniformity coefficients of them were less than 10.

The N-values of SPT for sand layers at the all test boring sites were plotted against the depth in Fig.II-17. The results show that about 29 % of the testing values falls within the range "C" and most of all the remaining samples are plotted within the range "B". Of which the rate of first 5 m shows more than 50 %.

As mentioned in the section of seismic analysis, the ground acceleration during the earthquakes of 50 years return period is estimated at about 80 gal in the Study area. This acceleration is not judged to be so high.

The foundation basement of the major proposed structures were planned at comparative deep portion which located below the most risky section of up to 5 m, i.e. in the depth of 15 m at the pumping station and in the depth of 8 m at the barrage site.

It is judged from above consideration that the sand layer foundation in the Study area has no high risk of being liquefied during earthquake. However, considering the possibility of liquefaction, carefully compaction such as heavy tamping which adopted during construction of the existing Teesta barrage will be required for the large-scale and important structeres.

Table III.2.1 LIST OF REFERENCES

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| II-03 | Geography of Bangladesh | Haroun & Rashid | 1991 |
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| II-17 | Kurigram Irrigation & Flood Control Project North Unit F/S Final Report, Vol.I, II | JICA | Oct.1990 |
| II-18 | Flood Action Plan North West Regional Study (FAP-2) Interim Report, Vol.I, II | UK-ODA/JICA | Oct.1991 |

## Table III.4.1 Earthquakes Likely Affecting to the Study Area (1/2)

| No. | Date Day | /Mon. | /Yr. | Epicenter Latitude(N) | Longitude(E) | Magnitude (Richter) | Depth* (km) | Distance** (km) |
|---|---|---|---|---|---|---|---|---|
| 1 | 26 | Aug. | 1833 | 27.5 | 86.5 | 7.5 | 0 | 362 |
| 2 | 10 | Jan. | 1869 | 24.3 | 92.2 | 7.5 | 0 | 316 |
| 3 | 12 | Jun. | 1897 | 25.8 | 90.9 | 8.7 | 0 | 134 |
| 4 | 17 | Feb. | 1909 | 27.0 | 87.0 | 5.0 | 0 | 291 |
| 5 | 8 | Jul. | 1918 | 24.3 | 91.7 | 7.6 | 0 | 275 |
| 6 | 9 | Sep. | 1923 | 25.3 | 91.0 | 7.1 | 0 | 159 |
| 7 | 30 | Jan. | 1924 | 25.0 | 93.0 | 6.0 | 0 | 361 |
| 8 | 23 | Oct. | 1926 | 25.0 | 93.0 | 5.5 | 0 | 361 |
| 9 | 2 | Jul. | 1930 | 25.8 | 90.2 | 7.1 | 0 | 63 |
| 10 | 3 | Jul. | 1930 | 25.8 | 90.2 | 5.5 | 0 | 63 |
| 11 | 4 | Jul. | 1930 | 25.8 | 90.2 | 5.5 | 0 | 63 |
| 12 | 8 | Jul. | 1930 | 25.8 | 90.8 | 5.5 | 0 | 124 |
| 13 | 11 | Jul. | 1930 | 25.0 | 93.8 | 5.5 | 0 | 440 |
| 14 | 13 | Jul. | 1930 | 25.8 | 90.8 | 5.5 | 0 | 124 |
| 15 | 6 | Mar. | 1932 | 25.5 | 92.5 | 5.0 | 0 | 300 |
| 16 | 24 | Mar. | 1932 | 25.8 | 90.2 | 5.5 | 0 | 63 |
| 17 | 27 | Mar. | 1932 | 25.5 | 92.5 | 5.5 | 0 | 300 |
| 18 | 9 | Nov. | 1932 | 26.5 | 92.0 | 5.5 | 0 | 255 |
| 19 | 6 | Mar. | 1932 | 25.7 | 90.5 | 5.8 | 0 | 95 |
| 20 | 15 | Jan. | 1934 | 26.6 | 86.8 | 8.3 | 0 | 295 |
| 21 | 21 | May | 1935 | 29.0 | 89.2 | 6.0 | 0 | 343 |
| 22 | 18 | Jun. | 1936 | 26.6 | 90.3 | 5.5 | 0 | 108 |
| 23 | 7 | Sep. | 1936 | 27.5 | 87.0 | 5.1 | 0 | 318 |
| 24 | 9 | Mar. | 1937 | 27.0 | 92.0 | 5.5 | 0 | 275 |
| 25 | 21 | Mar. | 1937 | 25.5 | 94.0 | 5.5 | 0 | 452 |
| 26 | 29 | Jan. | 1938 | 27.5 | 87.0 | 6.0 | 0 | 318 |
| 27 | 26 | Feb. | 1938 | 28.0 | 90.5 | 5.5 | 0 | 250 |
| 28 | 27 | May | 1939 | 24.3 | 94.1 | 6.8 | 0 | 491 |
| 29 | 4 | Jan. | 1939 | 28.5 | 86.5 | 5.5 | 0 | 426 |
| 30 | 13 | Feb. | 1939 | 27.0 | 92.0 | 5.5 | 0 | 275 |
| 31 | 11 | May | 1940 | 24.9 | 94.1 | 6.0 | 0 | 472 |
| 32 | 2 | Aug. | 1940 | 28.0 | 90.5 | 5.5 | 0 | 250 |
| 33 | 21 | Jan. | 1941 | 27.2 | 92.0 | 6.3 | 0 | 285 |
| 34 | 23 | Jan. | 1941 | 27.0 | 92.8 | 6.3 | 0 | 350 |
| 35 | 6 | Sep. | 1941 | 27.0 | 92.0 | 5.5 | 0 | 275 |
| 36 | 8 | Feb. | 1943 | 27.0 | 92.0 | 5.5 | 0 | 275 |
| 37 | 23 | Oct. | 1943 | 26.8 | 94.0 | 7.2 | 0 | 461 |
| 38 | 24 | Dec. | 1944 | 24.7 | 92.2 | 6.0 | 0 | 295 |
| 39 | 19 | May | 1945 | 25.1 | 90.9 | 6.0 | 0 | 158 |
| 40 | 16 | Mar. | 1946 | 26.4 | 92.6 | 6.0 | 0 | 312 |
| 41 | 29 | Nov. | 1947 | 27.9 | 92.9 | 5.5 | 0 | 404 |
| 42 | 1 | Mar. | 1948 | 26.8 | 94.0 | 5.5 | 0 | 461 |
| 43 | 10 | Dec. | 1949 | 26.0 | 89.0 | 6.0 | 0 | 62 |
| 44 | 26 | Feb. | 1950 | 28.0 | 90.5 | 6.0 | 0 | 250 |
| 45 | 16 | Aug. | 1950 | 27.9 | 91.9 | 5.5 | 0 | 323 |
| 46 | 16 | Aug. | 1950 | 27.5 | 92.5 | 6.5 | 0 | 346 |

Note * : No records
** : from epicenter to project site (25.9N, 89.6E)
Source : II- 08

## Table III.4.1 Earthquakes Likely Affecting to the Study Area (2/2)

| No. | Date Day | /Mon. | /Yr. | Epicenter Latitude(N) | Longitude(E) | Magnitude (Richter) | Depth* (km) | Distance** (km) |
|---|---|---|---|---|---|---|---|---|
| 47 | 17 | Aug. | 1950 | 27.9 | 91.9 | 6.0 | 0 | 323 |
| 48 | 24 | Dec. | 1950 | 24.4 | 91.7 | 6.3 | 0 | 268 |
| 49 | 7 | Apr. | 1951 | 25.8 | 90.4 | 6.8 | 0 | 83 |
| 50 | 18 | Oct. | 1951 | 28.3 | 93.7 | 6.0 | 0 | 496 |
| 51 | 7 | Nov. | 1952 | 25.5 | 94.0 | 6.0 | 0 | 452 |
| 52 | 23 | Feb. | 1954 | 27.8 | 91.7 | 6.5 | 0 | 301 |
| 53 | 12 | Jun. | 1956 | 24.8 | 90.9 | 6.0 | 0 | 177 |
| 54 | 1 | Jul. | 1957 | 24.4 | 93.8 | 7.3 | 0 | 458 |
| 55 | 9 | Feb. | 1958 | 24.9 | 90.9 | 5.0 | 0 | 170 |
| 56 | 13 | Feb. | 1958 | 27.5 | 92.5 | 5.5 | 0 | 346 |
| 57 | 23 | Nov. | 1958 | 28.8 | 86.9 | 5.5 | 0 | 421 |
| 58 | 22 | Feb. | 1959 | 28.5 | 91.5 | 5.7 | 0 | 347 |
| 59 | 7 | Jan. | 1959 | 24.0 | 94.0 | 5.5 | 0 | 494 |
| 60 | 2 | Nov. | 1959 | 28.0 | 93.0 | 5.0 | 0 | 418 |
| 61 | 26 | May | 1960 | 27.0 | 93.0 | 5.0 | 0 | 369 |
| 62 | 29 | Jul. | 1960 | 26.9 | 90.3 | 6.5 | 0 | 134 |
| 63 | 21 | Aug. | 1960 | 26.4 | 88.6 | 5.5 | 0 | 116 |
| 64 | 29 | Sep. | 1961 | 28.0 | 87.0 | 5.5 | 0 | 352 |
| 65 | 6 | Nov. | 1961 | 26.7 | 91.9 | 5.5 | 0 | 252 |
| 66 | 25 | Dec. | 1961 | 27.0 | 90.0 | 5.5 | 0 | 130 |
| 67 | 30 | Oct. | 1962 | 26.6 | 93.3 | 5.5 | 0 | 387 |
| 68 | 18 | Feb. | 1964 | 27.5 | 91.1 | 5.5 | 0 | 235 |
| 69 | 18 | Feb. | 1964 | 25.0 | 94.3 | 5.4 | 0 | 490 |
| 70 | 30 | Aug. | 1964 | 27.6 | 88.3 | 5.2 | 0 | 230 |
| 71 | 1 | Sep. | 1964 | 27.2 | 92.3 | 5.7 | 0 | 312 |
| 72 | 21 | Oct. | 1964 | 28.1 | 93.8 | 5.9 | 0 | 493 |
| 73 | 12 | Jan. | 1965 | 27.6 | 88.0 | 6.1 | 0 | 249 |
| 74 | 11 | Apr. | 1965 | 26.7 | 92.3 | 5.1 | 0 | 291 |
| 75 | 18 | Jun. | 1965 | 25.0 | 93.8 | 5.9 | 0 | 440 |
| 76 | 9 | Dec. | 1965 | 27.5 | 92.5 | 5.3 | 0 | 346 |
| 77 | 26 | Sep. | 1966 | 27.5 | 92.6 | 5.6 | 0 | 355 |
| 78 | 6 | Sep. | 1967 | 24.2 | 91.7 | 5.0 | 0 | 282 |
| 79 | 15 | Sep. | 1967 | 27.4 | 91.8 | 5.8 | 0 | 280 |
| 80 | 14 | Nov. | 1967 | 24.0 | 91.5 | 5.1 | 0 | 282 |
| 81 | 12 | Jun. | 1968 | 26.0 | 91.1 | 5.5 | 0 | 155 |
| 82 | 18 | Aug. | 1968 | 26.4 | 90.6 | 5.2 | 0 | 118 |
| 83 | 27 | Dec. | 1968 | 24.1 | 91.6 | 5.2 | 0 | 282 |
| 84 | 25 | Jan. | 1969 | 22.9 | 92.3 | 5.4 | 0 | 426 |
| 85 | 26 | Feb. | 1969 | 26.6 | 92.4 | 5.0 | 0 | 297 |
| 86 | 1 | Jun. | 1969 | 25.8 | 91.8 | 5.0 | 0 | 226 |
| 87 | 30 | Jun. | 1969 | 26.9 | 92.6 | 5.1 | 0 | 327 |
| 88 | 5 | Nov. | 1969 | 27.7 | 90.2 | 5.0 | 0 | 209 |
| 89 | 19 | Feb. | 1970 | 27.4 | 94.0 | 5.5 | 0 | 480 |
| 90 | 25 | Jul. | 1970 | 25.7 | 88.5 | 5.2 | 0 | 113 |
| 91 | 2 | Feb. | 1971 | 23.8 | 91.8 | 5.4 | 0 | 319 |
| 92 | 17 | Jul. | 1971 | 26.5 | 93.2 | 5.3 | 0 | 375 |

Note * : No records
** : from epicenter to project site (25.9N, 89.6E)
Source : II- 08

## Table III.4.2 Earthquake Intensity and Acceleration of the Project Area (1/2)

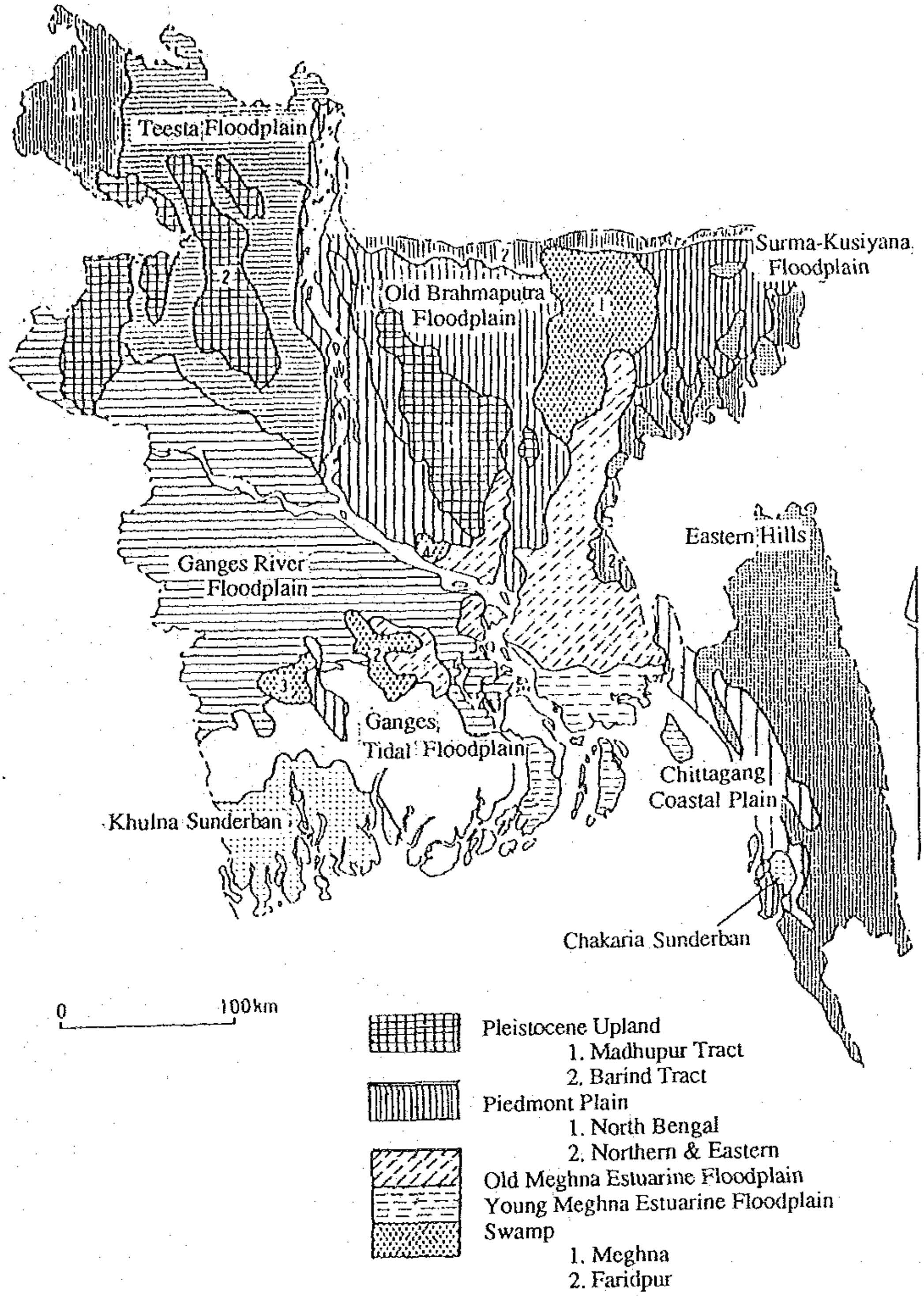
| No. | Date Day | /Mon. | /Yr. | Epicenter Latitude (N) | Epicenter Longitude (E) | Magnitude (Richter) | Depth (km) | Distance (km) | Intensity MMS | Intensity JMA | Peak Acceleration Richter (gal) | Kawasumi (gal) | Esteva (gal) | Katayama (gal) | Cornell (gal) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | Nov. | 1959 | 28.0 | 93.0 | 5.0 | 0 | 418 | 0.4 | 0.0 | 0 | 0 | 1 | 1 | 1 |
| 2 | 18 | Feb. | 1964 | 25.0 | 94.3 | 5.4 | 0 | 490 | 0.6 | 0.0 | 1 | 0 | 1 | 1 | 1 |
| 3 | 26 | May | 1960 | 27.0 | 93.0 | 5.0 | 0 | 369 | 0.7 | 0.0 | 1 | 0 | 2 | 1 | 1 |
| 4 | 7 | Jan. | 1959 | 24.0 | 94.0 | 5.5 | 0 | 494 | 0.7 | 0.0 | 1 | 0 | 1 | 1 | 1 |
| 5 | 19 | Feb. | 1970 | 27.4 | 94.0 | 5.5 | 0 | 480 | 0.8 | 0.0 | 1 | 0 | 2 | 1 | 1 |
| 6 | 1 | Mar. | 1948 | 26.8 | 94.0 | 5.5 | 0 | 461 | 0.9 | 0.0 | 1 | 0 | 2 | 1 | 1 |
| 7 | 25 | Jan. | 1969 | 22.9 | 92.3 | 5.4 | 0 | 426 | 1.0 | 0.0 | 1 | 0 | 2 | 1 | 1 |
| 8 | 21 | Mar. | 1937 | 25.5 | 94.0 | 5.5 | 0 | 452 | 1.0 | 0.0 | 1 | 0 | 2 | 1 | 1 |
| 9 | 11 | Jul. | 1930 | 25.0 | 93.8 | 5.5 | 0 | 440 | 1.0 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 10 | 4 | Jan. | 1939 | 28.5 | 86.5 | 5.5 | 0 | 426 | 1.1 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 11 | 17 | Jul. | 1971 | 26.5 | 93.2 | 5.3 | 0 | 375 | 1.1 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 12 | 23 | Nov. | 1958 | 28.8 | 86.9 | 5.5 | 0 | 421 | 1.1 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 13 | 30 | Jun. | 1969 | 26.9 | 92.6 | 5.1 | 0 | 327 | 1.2 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 14 | 7 | Sep. | 1936 | 27.5 | 87.0 | 5.1 | 0 | 318 | 1.2 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 15 | 6 | Mar. | 1932 | 25.5 | 92.5 | 5.0 | 0 | 300 | 1.2 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 16 | 29 | Nov. | 1947 | 27.9 | 92.9 | 5.5 | 0 | 404 | 1.2 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 17 | 26 | Feb. | 1969 | 26.6 | 92.4 | 5.0 | 0 | 297 | 1.3 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 18 | 17 | Feb. | 1909 | 27.0 | 87.0 | 5.0 | 0 | 291 | 1.3 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 19 | 9 | Dec. | 1965 | 27.5 | 92.5 | 5.3 | 0 | 346 | 1.3 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 20 | 21 | Oct. | 1964 | 28.1 | 93.8 | 5.9 | 0 | 493 | 1.3 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 21 | 30 | Oct. | 1962 | 26.6 | 93.3 | 5.5 | 0 | 387 | 1.4 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 22 | 6 | Sep. | 1967 | 24.2 | 91.7 | 5.0 | 0 | 282 | 1.4 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 23 | 11 | Apr. | 1965 | 26.7 | 92.3 | 5.1 | 0 | 291 | 1.5 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 24 | 18 | Oct. | 1951 | 28.3 | 93.7 | 6.0 | 0 | 496 | 1.5 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 25 | 23 | Oct. | 1926 | 25.0 | 93.0 | 5.5 | 0 | 361 | 1.5 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 26 | 14 | Nov. | 1967 | 24.0 | 91.5 | 5.1 | 0 | 282 | 1.5 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 27 | 29 | Sep. | 1961 | 28.0 | 87.0 | 5.5 | 0 | 352 | 1.6 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 28 | 11 | May | 1940 | 24.9 | 94.1 | 6.0 | 0 | 472 | 1.6 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 29 | 13 | Feb. | 1958 | 27.5 | 92.5 | 5.5 | 0 | 346 | 1.6 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 30 | 18 | Jun. | 1965 | 25.0 | 93.8 | 5.9 | 0 | 440 | 1.6 | 0.0 | 1 | 0 | 2 | 2 | 1 |
| 31 | 2 | Feb. | 1971 | 23.8 | 91.8 | 5.4 | 0 | 319 | 1.7 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 32 | 27 | Dec. | 1968 | 24.1 | 91.6 | 5.2 | 0 | 282 | 1.7 | 0.0 | 1 | 0 | 3 | 2 | 2 |
| 33 | 7 | Nov. | 1952 | 25.5 | 94.0 | 6.0 | 0 | 452 | 1.7 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 34 | 26 | Sep. | 1966 | 27.5 | 92.6 | 5.6 | 0 | 355 | 1.7 | 0.0 | 1 | 0 | 3 | 2 | 1 |
| 35 | 16 | Aug. | 1950 | 27.9 | 91.9 | 5.5 | 0 | 323 | 1.8 | 0.0 | 1 | 0 | 3 | 2 | 2 |
| 36 | 22 | Feb. | 1959 | 28.5 | 91.5 | 5.7 | 0 | 347 | 1.9 | 0.0 | 1 | 0 | 3 | 3 | 2 |
| 37 | 1 | Jun. | 1969 | 25.8 | 91.8 | 5.0 | 0 | 226 | 1.9 | 0.0 | 1 | 0 | 4 | 3 | 2 |
| 38 | 27 | Mar. | 1932 | 25.5 | 92.5 | 5.5 | 0 | 300 | 2.0 | 0.0 | 1 | 0 | 4 | 3 | 2 |
| 39 | 5 | Nov. | 1969 | 27.7 | 90.2 | 5.0 | 0 | 209 | 2.1 | 0.0 | 2 | 0 | 4 | 3 | 2 |
| 40 | 1 | Sep. | 1964 | 27.2 | 92.3 | 5.7 | 0 | 312 | 2.2 | 0.0 | 2 | 0 | 4 | 3 | 2 |
| 41 | 30 | Aug. | 1964 | 27.6 | 88.3 | 5.2 | 0 | 230 | 2.2 | 0.0 | 2 | 0 | 4 | 3 | 2 |
| 42 | 9 | Mar. | 1937 | 27.0 | 92.0 | 5.5 | 0 | 275 | 2.2 | 0.0 | 2 | 0 | 4 | 3 | 2 |
| 43 | 13 | Feb. | 1939 | 27.0 | 92.0 | 5.5 | 0 | 275 | 2.2 | 0.0 | 2 | 0 | 4 | 3 | 2 |
| 44 | 6 | Sep. | 1941 | 27.0 | 92.0 | 5.5 | 0 | 275 | 2.2 | 0.0 | 2 | 0 | 4 | 3 | 2 |
| 45 | 8 | Feb. | 1943 | 27.0 | 92.0 | 5.5 | 0 | 275 | 2.2 | 0.0 | 2 | 0 | 4 | 3 | 2 |
| 46 | 30 | Jan. | 1924 | 25.0 | 93.0 | 6.0 | 0 | 361 | 2.3 | 0.0 | 2 | 0 | 4 | 3 | 2 |
| 47 | 9 | Nov. | 1932 | 26.5 | 92.0 | 5.5 | 0 | 255 | 2.4 | 0.0 | 2 | 0 | 5 | 3 | 2 |
| 48 | 21 | May | 1935 | 29.0 | 89.2 | 6.0 | 0 | 343 | 2.4 | 0.0 | 2 | 0 | 4 | 4 | 2 |
| 49 | 6 | Nov. | 1961 | 26.7 | 91.9 | 5.5 | 0 | 252 | 2.4 | 0.0 | 2 | 0 | 5 | 4 | 3 |
| 50 | 26 | Feb. | 1938 | 28.0 | 90.5 | 5.5 | 0 | 250 | 2.4 | 0.0 | 2 | 0 | 5 | 4 | 3 |

Note, MMS : Modified Mercalli Scale
JMA : Japan Meteorilogical Agency Scale

## Table III.4.2 Earthquake Intensity and Acceleration of the Project Area (2/2)

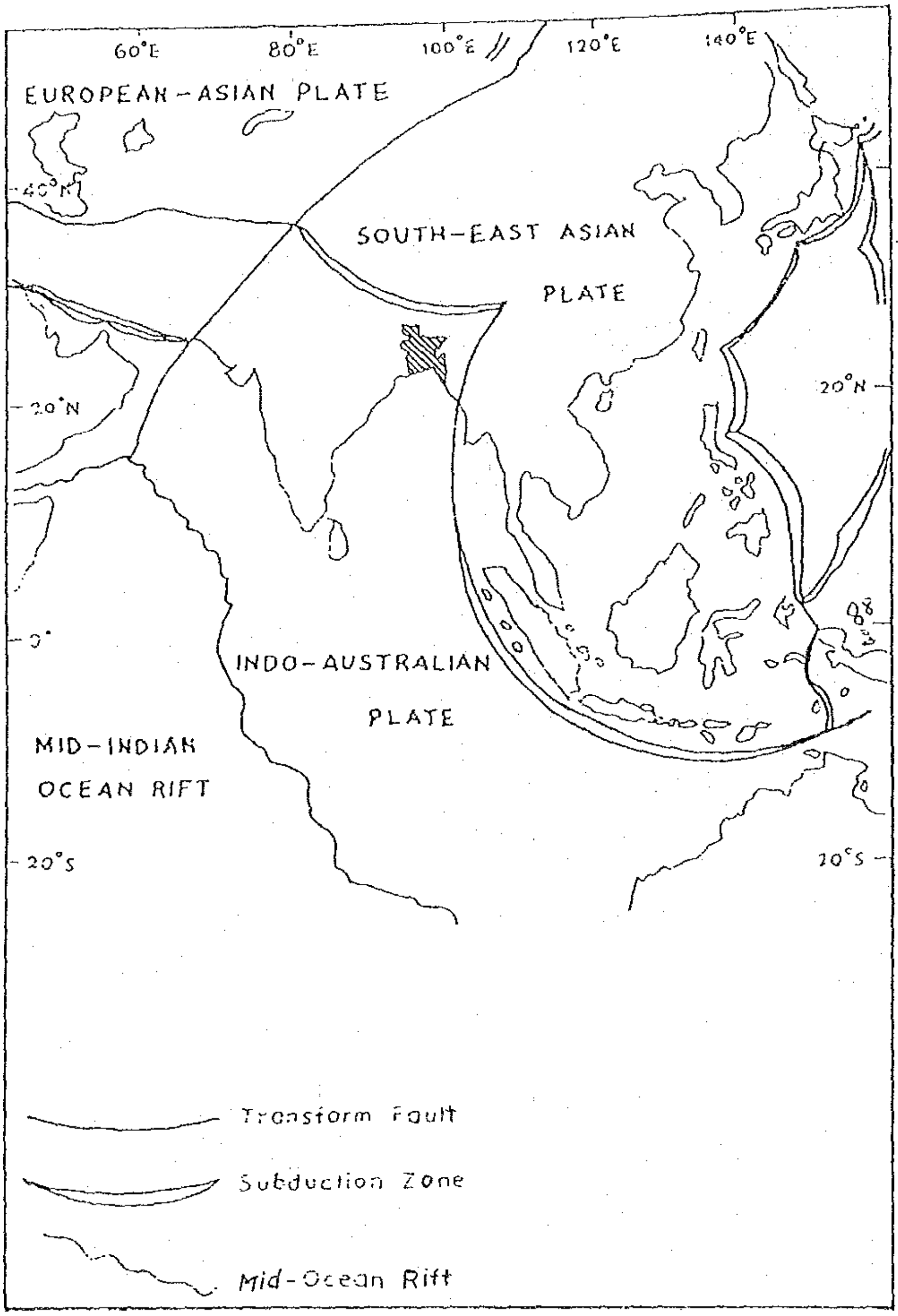
| No. | Date Day | /Mon. | /Yr. | Epicenter Latitude (N) | Epicenter Longitude (E) | Magnitude (Richter) | Depth (km) | Distance (km) | Intensity MMS | Intensity JMA | Peak Acceleration Richter (gal) | Peak Acceleration Kawasumi (gal) | Peak Acceleration Esteva (gal) | Peak Acceleration Katayama (gal) | Peak Acceleration Cornell (gal) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 2 | Aug. | 1940 | 28.0 | 90.5 | 5.5 | 0 | 250 | 2.4 | 0.0 | 2 | 0 | 5 | 4 | 3 |
| 52 | 17 | Aug. | 1950 | 27.9 | 91.9 | 6.0 | 0 | 323 | 2.5 | 0.0 | 2 | 0 | 5 | 4 | 2 |
| 53 | 29 | Jan. | 1938 | 27.5 | 87.0 | 6.0 | 0 | 318 | 2.6 | 0.0 | 2 | 0 | 5 | 4 | 2 |
| 54 | 18 | Feb. | 1964 | 27.5 | 91.1 | 5.5 | 0 | 235 | 2.6 | 0.0 | 2 | 0 | 5 | 4 | 3 |
| 55 | 15 | Sep. | 1967 | 27.4 | 91.8 | 5.8 | 0 | 280 | 2.6 | 0.0 | 2 | 0 | 5 | 4 | 3 |
| 56 | 27 | May | 1939 | 24.3 | 94.1 | 6.8 | 0 | 491 | 2.6 | 0.0 | 2 | 0 | 4 | 4 | 2 |
| 57 | 16 | Mar. | 1946 | 26.4 | 92.6 | 6.0 | 0 | 312 | 2.6 | 0.0 | 2 | 0 | 5 | 4 | 2 |
| 58 | 9 | Feb. | 1958 | 24.9 | 90.9 | 5.0 | 0 | 170 | 2.6 | 0.0 | 2 | 0 | 6 | 4 | 4 |
| 59 | 23 | Jan. | 1941 | 27.0 | 92.8 | 6.3 | 0 | 350 | 2.7 | 0.0 | 3 | 0 | 5 | 4 | 2 |
| 60 | 24 | Dec. | 1944 | 24.7 | 92.2 | 6.0 | 0 | 295 | 2.8 | 0.0 | 3 | 0 | 5 | 4 | 3 |
| 61 | 16 | Aug. | 1950 | 27.5 | 92.5 | 6.5 | 0 | 346 | 3.1 | 0.4 | 3 | 1 | 6 | 6 | 3 |
| 62 | 26 | Feb. | 1950 | 28.0 | 90.5 | 6.0 | 0 | 250 | 3.2 | 0.2 | 4 | 1 | 7 | 6 | 4 |
| 63 | 21 | Jan. | 1941 | 27.2 | 92.0 | 6.3 | 0 | 285 | 3.2 | 0.4 | 4 | 1 | 7 | 6 | 4 |
| 64 | 12 | Jan. | 1965 | 27.6 | 88.0 | 6.1 | 0 | 249 | 3.4 | 0.4 | 4 | 1 | 8 | 6 | 4 |
| 65 | 24 | Dec. | 1950 | 24.4 | 91.7 | 6.3 | 0 | 268 | 3.5 | 0.6 | 5 | 1 | 8 | 7 | 4 |
| 66 | 23 | Oct. | 1943 | 26.8 | 94.0 | 7.2 | 0 | 461 | 3.5 | 1.0 | 5 | 1 | 6 | 7 | 3 |
| 67 | 23 | Feb. | 1954 | 27.8 | 91.7 | 6.5 | 0 | 301 | 3.5 | 0.7 | 5 | 1 | 8 | 7 | 4 |
| 68 | 1 | Jul. | 1957 | 24.4 | 93.8 | 7.3 | 0 | 458 | 3.6 | 1.1 | 5 | 2 | 7 | 8 | 3 |
| 69 | 12 | Jun. | 1968 | 26.0 | 91.1 | 5.5 | 0 | 155 | 3.6 | 0.3 | 5 | 1 | 11 | 7 | 7 |
| 70 | 18 | Aug. | 1968 | 26.4 | 90.6 | 5.2 | 0 | 118 | 3.8 | 0.3 | 6 | 1 | 13 | 8 | 9 |
| 71 | 25 | Jul. | 1970 | 25.7 | 88.5 | 5.2 | 0 | 113 | 3.9 | 0.4 | 7 | 1 | 14 | 8 | 10 |
| 72 | 12 | Jun. | 1956 | 24.8 | 90.9 | 6.0 | 0 | 177 | 4.0 | 1.0 | 7 | 1 | 13 | 9 | 8 |
| 73 | 25 | Dec. | 1961 | 27.0 | 90.0 | 5.5 | 0 | 130 | 4.1 | 0.7 | 7 | 1 | 14 | 9 | 9 |
| 74 | 8 | Jul. | 1930 | 25.8 | 90.8 | 5.5 | 0 | 124 | 4.2 | 0.8 | 8 | 1 | 15 | 10 | 10 |
| 75 | 13 | Jul. | 1930 | 25.8 | 90.8 | 5.5 | 0 | 124 | 4.2 | 0.8 | 8 | 1 | 15 | 10 | 10 |
| 76 | 21 | Aug. | 1960 | 26.4 | 88.6 | 5.5 | 0 | 116 | 4.3 | 1.0 | 9 | 1 | 17 | 10 | 12 |
| 77 | 19 | May | 1945 | 25.1 | 90.9 | 6.0 | 0 | 158 | 4.3 | 1.3 | 9 | 2 | 16 | 11 | 10 |
| 78 | 18 | Jun. | 1936 | 26.6 | 90.3 | 5.5 | 0 | 108 | 4.5 | 1.1 | 10 | 2 | 19 | 11 | 14 |
| 79 | 26 | Aug. | 1833 | 27.5 | 86.5 | 7.5 | 0 | 362 | 4.5 | 2.2 | 10 | 6 | 12 | 14 | 6 |
| 80 | 10 | Jan. | 1869 | 24.3 | 92.2 | 7.5 | 0 | 316 | 4.9 | 2.6 | 13 | 9 | 16 | 17 | 8 |
| 81 | 6 | Mar. | 1932 | 25.7 | 90.5 | 5.8 | 0 | 95 | 5.3 | 2.1 | 18 | 5 | 29 | 18 | 22 |
| 82 | 8 | Jul. | 1918 | 24.3 | 91.7 | 7.6 | 0 | 275 | 5.4 | 3.2 | 19 | 17 | 22 | 23 | 11 |
| 83 | 29 | Jul. | 1960 | 26.9 | 90.3 | 6.5 | 0 | 134 | 5.5 | 2.7 | 21 | 10 | 30 | 22 | 20 |
| 84 | 3 | Jul. | 1930 | 25.8 | 90.2 | 5.5 | 0 | 63 | 5.8 | 2.4 | 27 | 7 | 39 | 22 | 38 |
| 85 | 4 | Jul. | 1930 | 25.8 | 90.2 | 5.5 | 0 | 63 | 5.8 | 2.4 | 27 | 7 | 39 | 22 | 38 |
| 86 | 24 | Mar. | 1932 | 25.8 | 90.2 | 5.5 | 0 | 63 | 5.8 | 2.4 | 27 | 7 | 39 | 22 | 38 |
| 87 | 9 | Sep. | 1923 | 25.3 | 91.0 | 7.1 | 0 | 159 | 6.0 | 3.5 | 31 | 24 | 37 | 31 | 23 |
| 88 | 15 | Jan. | 1934 | 26.6 | 86.8 | 8.3 | 0 | 295 | 6.1 | 4.3 | 35 | 62 | 33 | 38 | 17 |
| 89 | 10 | Dec. | 1949 | 26.0 | 89.0 | 6.0 | 0 | 62 | 6.6 | 3.4 | 49 | 22 | 59 | 36 | 58 |
| 90 | 7 | Apr. | 1951 | 25.8 | 90.4 | 6.8 | 0 | 83 | 7.1 | 4.4 | 73 | 70 | 76 | 54 | 63 |
| 91 | 2 | Jul. | 1930 | 25.8 | 90.2 | 7.1 | 0 | 63 | 8.2 | 5.6 | 169 | 260 | 139 | 99 | 135 |
| 92 | 12 | Jun. | 1897 | 25.8 | 90.9 | 8.7 | 0 | 134 | 8.8 | 7.1 | 267 | 515 | 174 | 178 | 115 |

Note, MMS : Modified Mercalli Scale
JMA : Japan Meteorilogical Agency Scale



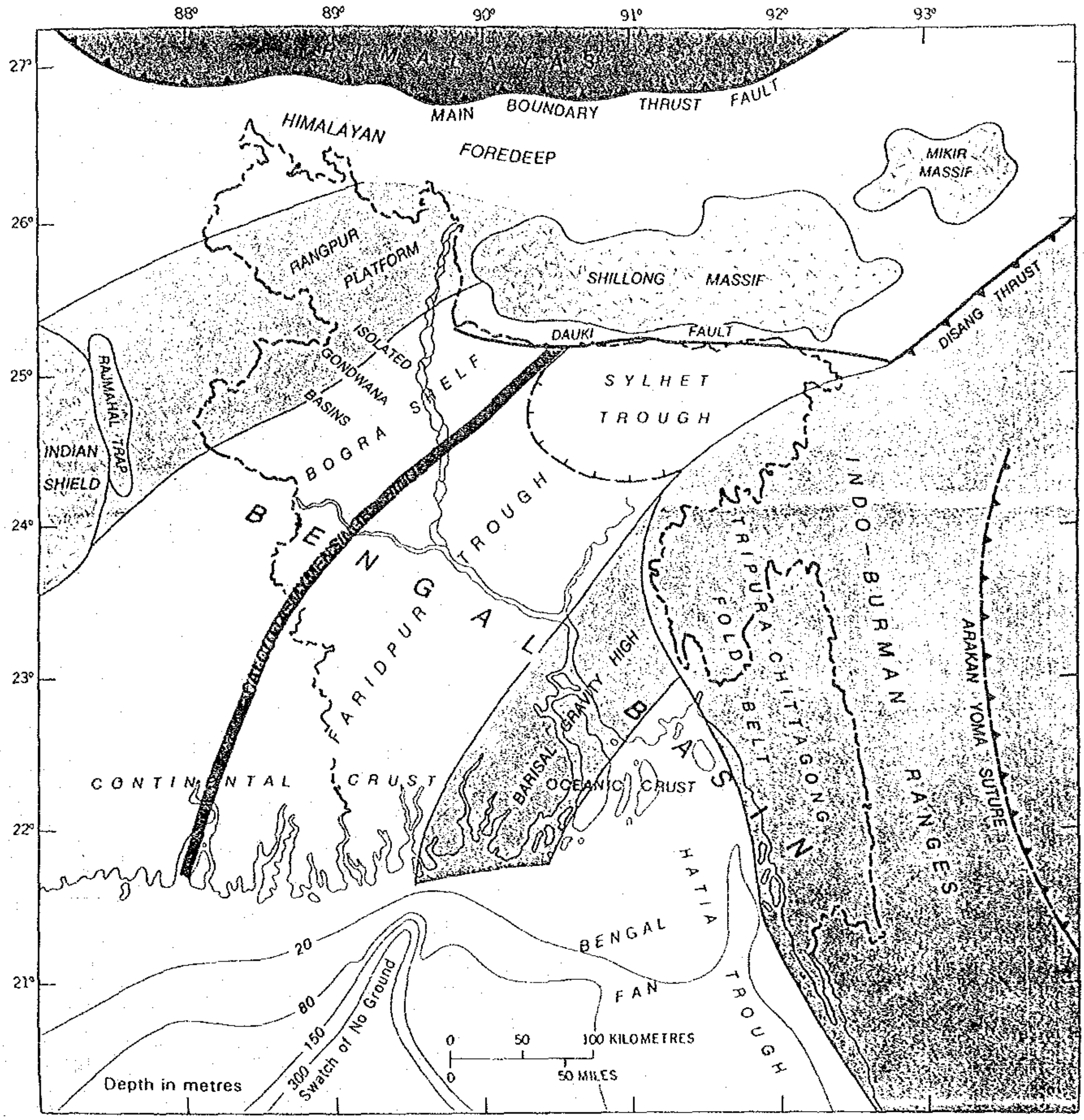

Source : II-04 & II-09

**Fig.III.2.1 PHYSICAL LANDFORM IN BANGLADESH**




Source : II-03

**Fig.III.3.1 TECTONIC PLATES IN THE SOUTH TO SOUTHEAST ASIA**




Source : II-01

**Fig.III.3.2 GENERALIZED TECTONIC MAP OF BANGLADESH AND ADJOINING AREA**