FAP24

Government of the People's Republic of Bangladesh

Water Resources Planning Organization

European Commission

Delft Hydraulics

Danish Hydraulic Institute

Hydroland
Approtech
Osiris

RIVER SURVEY PROJECT

Special Report No.14

Mineralogical and physical properties of river sediments

July 1996

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Acronyms and abbreviations

ARPA	:Assistant Resident Project Adviser
BIWTA	:Bangladesh Inland Waterways Transport Authority
BoQ	:Bill of Quantities
BUET	:Bangladesh University of Engineering and Technology
BWDA	:Bangladesh Waterways Development Authority
BWDB	:Bangladesh Water Development Board
CEC	:Commission of the European Communities
FPCO	:Flood Plan Coordination Organization
GoB	:Government of Bangladesh
MIWDFC	:Ministry of Irrigation, Water Development and Flood Control
PA	:Project Adviser
PMU	:Project Management Unit
PoE	:Panel of Experts
RPA	:Resident Project Adviser
RRI	:River Research Institute
SE	:Superintending Engineer
SoB	:Survey of Bangladesh
SWMC	:Surface Water Modelling Centre
ToR	:Terms of Reference
TS	:Technical Specifications
UoL	:University of Leeds
UoN	:University of Nottingham
WRIS	:Water Resources Information System

1 Introduction

The River Survey Project (FAP24) was initiated on June 9, 1992, and executed by the Flood Plan Coordination Organisation (FPCO) under the Ministry of Irrigation, Water Development, and Flood Protection with funding from the Commission of the European Communities. Consultants Delft Hydraulics/Danish Hydraulic Institute (DELFT-DHI) undertook the joint venture in association with Osiris, Hydroland and Approtech. The project is supervised by a Project Management Unit with participation by FPCO, a Project Advisor, and a Resident Project Advisor.

The objective of the project is to establish detailed, accurate field data for Flood Action Plan (FAP) projects, and for any planning, impact evaluation, or design activities within national water resource and river engineering activities.

The scope of the project comprises:

- A survey component, comprising a comprehensive field survey programme of river hydrology, sediment transport, and morphology;
- A study component, comprising investigations of processes and effects within river hydrology, sediment transport, and morphology; and
- A training component.

The study programme was developed with the client and the Project Advisor. Please refer to the Study Programme (February 1995) for details of the objectives and the programme scope.

This report describes mineralogical and physical properties of river sediments. The study was carried out by Abu Muhammod Ibrahim, Mohammed Mamun, and Maminul Haque Sarker. Professor Md. Badrul Imam and Dr. Syed Humayun Akhter of Geology Department, Dhaka University performed the mineralogical and physical sediment analyses in their laboratory. They helped in many ways throughout the study. Dr. Mahbub Ahmed, Soil Science Department of Dhaka University carried out the density analyses in his laboratory. Dr. D.K.Barua made initial contributions and framed the study programme together with Pieter van Groen.

A preliminary version of the report was submitted as RSP Study Report 14 in April, 1996. Several comments were received from WARPO and from the PA. These comments have been incorporated in the present edition.

The project expresses its sincere gratitude to Prof. J. J. Peters, PA, for initiating this study and for critical technical advise during its execution and reporting.

2 Background and study objective

2.1 Background

Studying the physical properties of river-borne sediments is important in understanding the geologic characteristics of watersheds, the geomorphological response of rivers, and the engineering properties. According to genetic origins, sediments can be divided into three categories:

- lithogenous sediments
- biogenous sediments
- hydrogenous sediments

River-borne sediments are mostly lithogeneous—detrital products of disintegrated pre-existing rocks. Biogeneous sediments, or the remains of organisms, also may be present in certain amounts. Hydrogenous sediments—precipitates from dissolved chemicals—are mostly found in sea-water.

The Ganges, Brahmaputra, and Teesta Rivers, draining the Himalayan mountain ranges of the subcontinent, carry sediments from areas of a varying geology to Bangladesh. Ganges, Brahmaputra, and Teesta sediments are characterized by large amounts of mica (both muscovite and biotite), while sediment from the northern and eastern hill areas of Bangladesh are generally less micaceous (especially with respect to biotite). In addition, alluvium from the Ganges River is calcareous.

These major rivers contain between 15 and 30 percent feldspars, and between five and 30 percent micas. The amount of mica varies with the size fraction; some silty deposits contain as much as 80 percent micas. The heavy mineral content ranges between two and nine percent, while the content of easily weatherable minerals is between 25 and 40 percent (FAO, 1971).

Sediments of the Brahmaputra and Meghna rivers are characterised by the amphibole-epidote heavy mineral association. Ganges River sediment is characterised by the amphibole-garnet and amphibole-garnet-epidote heavy mineral associations, diagnostically supplied by dolomite. The Teesta and Atrai rivers contain high levels of biotite in the heavy fractions (Huizing, 1971). Sediments also vary with their textural properties, and grain sizes vary in the upstream and downstream portions of the rivers.

Analysis of Brahmaputra-Jamuna river sand shows that grains are angular to sub-angular in shape. The samples are composed primarily of unstable minerals like feldspar, pyroxene, and amphibole, and contain only 46 to 53 percent quartz. These quartz grains have fresh, unworn conchoidal fractured surfaces, indicating that the sand bars and point bars of the Brahmaputra within Bangladesh are immature and that the source area of the sand deposits is not far from the depositional area (Moonira, 1989).

Floodplain sedimentation studies along the left bank of Jamuna River showed that during normal and high flood years, the river water carried the sediments onto the adjacent floodplain. Sediment rates determined by ^{137}Cs analysis found that more than 1.3 cm/year of river sediments were deposited on the active Jamuna floodplain and 1.24 cm/year on the young Jamuna floodplain (ISPAN, 1995). These sediments were sandy loam to silt loam in texture, and held more plant nutrients than the adjacent soils.

Sediment textural properties are commonly used to describe the physical characteristics of sediments. Although grain size is routinely determined in FAP 24's laboratory, mineralogical properties of river-borne sediments in Bangladesh is virtually unknown. The grain size, moisture content, and angle of repose of the sub-soil of the deltaic alluvial plains of Bangladesh was assessed by Mollah (1993). The importance of determining other properties, however, was recently stressed in a technical communication by Peters (1994). The physical properties indicated in the Bill of Quantities (Remark 26A to Table 5.2. f(2)) are:

- Mineralogy
- Major minerals
- Trace minerals
- Rock fragments
- Shape variables
- Angularity
- Density of sediments

Other properties to be considered (but not included in the unit rates of Table 5.2 f (2)) are:

- Other shape variables
- Sphericity
- Shape factor
- Rollability
- Angle of repose
- Porosity of sediments
- Organic content

2.2 Description of the physical properties to be determined

A mineral is a naturally occurring inorganic crystalline material with a unique chemical composition. In Figure 2.1 (Raymond and Warkenin, 1975), a scheme is presented to show the mineralogical analyses of soil samples. Practically all sediments carried by water originate from rock material, and constituents of the parent material usually are found in the sediment. For example, Figure 2.2 shows the main rock types of the Ganges-Brahmaputra river basin (Sarin et al, 1989). Due to weathering and abrasion, material sorting is highest for fine material, while all the constituents of the original rock material can be found in coarse material. Because of its stability, quartz is the most common mineral found in sediments.

Mineralogical analysis involves identifying minerals, including the heavy ones, and determining the percentage of each mineral of each size in the total sample. Comparing similar studies of upstream bed-sediment sources may indicate major sediment sources. Following the scheme in Figure 2.1, the textural qualities of the following minerals are discussed:

Quartz is the single-most abundant *sand-sized* mineral. Depending on the presence of other minerals, sands usually are identified as silicate sands, carbonate sands, or gypsum sands. Silicate sands primarily contain quartz and feldspar minerals.

Relatively, *mica* is the most abundant *silt-sized* mineral in Bangladesh rivers. Granulometric analysis of Jamuna river-bed material samples by RPT-NEDECO-BCL (1988) showed that the flake-shaped, black mica content is about 2-5 percent by volume. The presence of mica is critical to the stability of engineering structures, as it is neither granular like quartz particles that display frictional resistance, nor cohesive like clay.

The different *clay-sized* minerals found in Bangladesh are *illite, kaolinite, chlorite, clay-mica,* and *smectite*. Kaolinite is common in tropical and subtropical areas, and represents highly weathered soils with good drainage. Chlorite is common in marine and sedimentary rocks. According to Sarin, et. al. (1989), the percentage of clay minerals found in the Brahmaputra River is 61 percent illite, 18 percent kaolinite, 16 percent chlorite, and five percent smectite. In the Ganges River, smectite is 42 percent, illite is 43 percent, chlorite is eight percent, and kaolinite is seven percent. However, these values were determined from samples taken in India and do not describe the regional effects of Bangladesh.

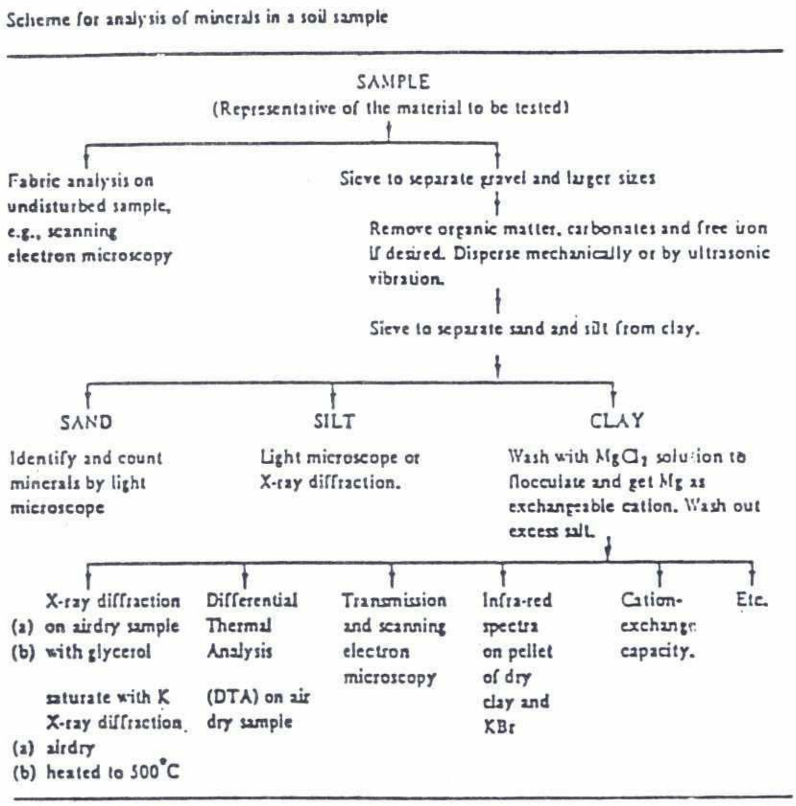

Figure 2.1: Analysis of minerals in a sample (Source : Raymond and Warkentin, 1975)

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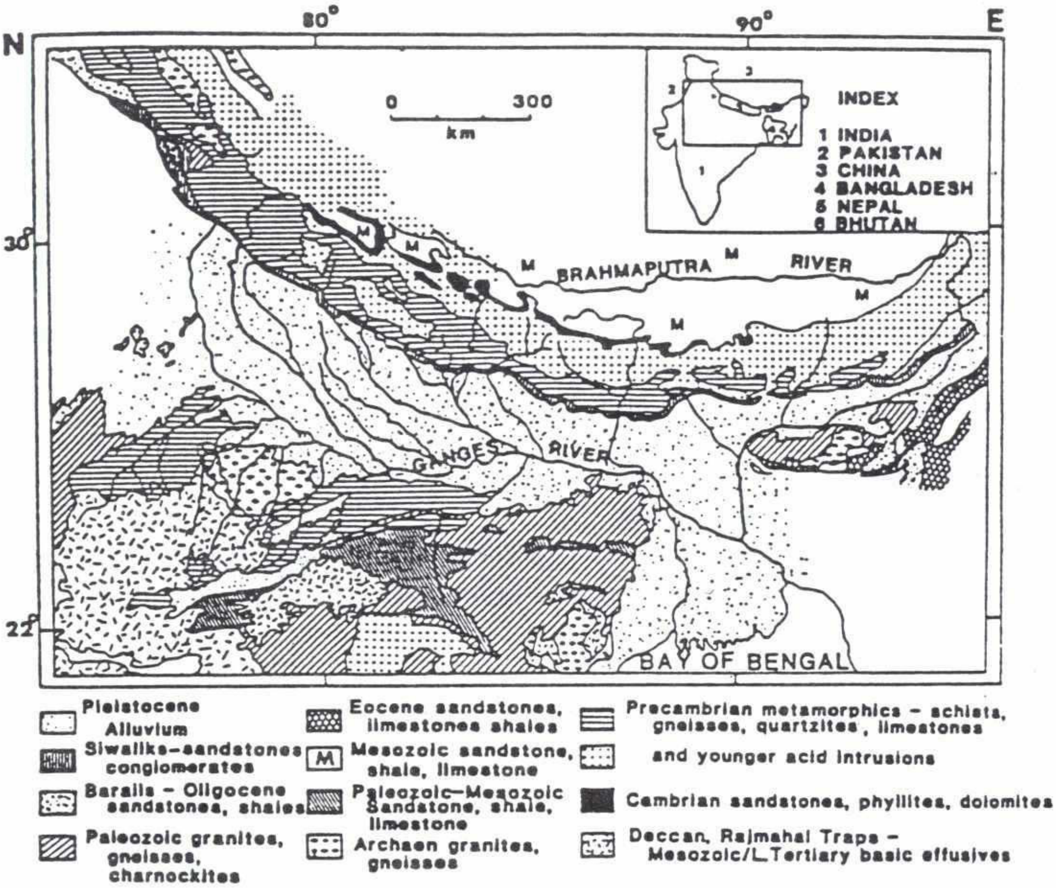

Figure 2.2: Rock type in Ganges - Brahmaputra river basin (Source : Sarin, et al 1989)

A generally accepted method to classify grain physical property is to separate the shape variables into two parts: (1) the gross shape or *sphericity*, and (2) the relatively smaller scale directional changes of the grain surface known as *roundness* or *angularity*. In addition, shapes are defined by the ratio of some axial measurements. The abrasion that occurs during transport is unlikely to make much change in grain sphericity, consequently making sphericity a fairly consistent property. On the other hand, the roundness can alter significantly during transport.

An interesting alternative way of determining shape variations in sand-sized sediment is by *"rolling"* the grain (Winkelmolen,1969). This is done by passing the various sieve fractions through a rotating drum whose axis is inclined at an 2°30' horizontal angle. As the grains cascade within the drum, the most rollable are sorted out and drop first in the collector. There is a reasonable correlation between rollability and shape, with the near-spherical grains being the most rollable.

In studying the fall velocity of geometric shapes (McNown and Malaika, 1950) and sand grains (Albertson, 1953), *particle shapes* were defined by some orthogonal axial measurements, such as:

$$SF = c/(a*b)^{0.5}$$

known as a Corey factor, where

a = length along longest axis perpendicular to the other two axes
b = length along intermediate axis perpendicular to the other two axes
c = length along short axis perpendicular to the other two axes.

The shape factor can be determined from the fall velocity (details in Vanoni, 1975). Experience in other countries has shown that the shape factor of quartz particles usually are taken as 0.7. The shape factor, however, has not been defined for Bangladesh environmental conditions.

2.3 Objective of the study

The major objective of this study was to prepare a data base for the physical properties of sediments found in the major rivers of Bangladesh. More specifically, the objectives were:

- To understand the mineralogical and physical properties of river sediment in relation to the different environments of the river, notably river bed sediments, near bed sediments, and suspended sediments;
- To correlate the relationship between grain size distribution and mineralogical properties of river sediments;
- To determine the role of physical and mineralogical properties of river sediments on river morphological behaviour;
- To estimate the variation in river mineralogical properties in relation to geographical occurrence; and
- To study the mineralogical characteristics of floodplain sediment, and to estimate the variation from river sediment.

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3 The study area

The study area included the major rivers of Bangladesh and one floodplain site along the left bank of the Jamuna River.

3.1 River sites

Sediment samples were collected in eight spots on the Teesta, Jamuna, Ganges, Gorai, Padma, and Meghna Rivers (Figure 3.1). The sampling sites are described below. Details about sampling locations, dates, sample depths, and sample types are given in Appendix II, together with the physical characteristics.

3.1.1 Teesta River

Two sites in the Teesta River were selected for sampling. One near the confluence of the Jamuna River was sampled before and after the flood season. Sample 1 was collected 35 m from the left bank, and sample 3 at 10 m from the right bank (Figure 3.2a). The remaining samples were collected from the middle of the river channels.

The upstream Teesta River site (Figure 3.2b) was sampled after the flood season. The sampling points ran across the river to cover different geographical locations.

3.1.2 Jamuna River

Three sampling areas on the Jamuna River were included in the study. Samples 6 through 10 were collected north of the confluence of Teesta River, and samples 11 through 15 were taken near the confluence (Figure 3.2a). These sampling points ran across the main stream of the river at regular intervals, covering the unstable char (island) and river beds.

The Jamuna also was sampled near Bahadurabad: One site on the left bank and one near Fulchari Ghat on the right bank (Figure 3.3). There were also some sampling points south of Bahadurabad along the left bank.

The Jamuna's third sampling area was at Sirajganj (Figure 3.4). All the sampling points were located along the left bank near Bhuapur Ghat, covering mid-stream, the bank, and the unstable sand bars.

3.1.3 Padma River

Two sampling sites were selected on the Padma River. One site near Mawa (Figure 3.5a) was first sampled before the flood season. The sampling points ran across the river and covered bank points, unstable sand bars, and the mid-stream area. Some of the points near the bank and mid-stream were sampled again after the flood.

Kamargaon, another Padma River site, was sampled after the flood season (Figure 3.5b). This site covered stable and unstable sand bars, mid-stream areas, and the river banks.

3.1.4 Ganges and Gorai Rivers

The Ganges River sampling site occupied a large area from Hardinge Bridge to south of the Gorai off-take (Figure 3.6). Most of the sampling points were on the right bank. The Gorai River sampling area was located at the off-take (Figure 3.7). The sampling points were distributed along the right bank.

3.1.5 Meghna River

This Meghna River sampling site was south of the Meghna Railway Bridge at Bhairab Bazar (Figure 3.8).

3.1.6 Jim's and Roy's Bars

Jim's sand bar, an unstable char in the left channel of the Jamuna River, is located about 10 km north of Bahadurabad Ghat. The head, tail, and mid-section of this bar were sampled (Figure 3.9).

Roy's bar, a big sand bar comprised of both stable and unstable charland, is located 5 km south of Bahadurabad Ghat near the left bank of the Jamuna. The sampling points covered the head, tail, and mid-section of the bar (Figure 3.9).

3.1.7 River bank

Two sampling sites were selected off a vertical wall of the eroded left bank of the Jamuna River. One of the sites was located two kilometres south of Bahadurabad Ghat. The other site was one km north of Bahadurabad Ghat (Figure.3.9). It was an established area supporting agricultural crops, homesteads, and roads. A soil profile was developed, about one m deep. The last two layers above the water level were gleyed and unaltered by soil-forming factors. Four layers were sampled in between the water level and the topsoil of the river bank profiles.

3.2 Floodplain sites

Six floodplain sampling sites were selected along the left bank of Jamuna River (Figure 3.10). The areas are located in Sharishabari Thana of Jamalpur District and Kazipur Thana of Sirajganj District, and do not have flood protection embankments. Two of the sites (numbers 5 and 6) were located on the active Jamuna floodplain and the remaining sites were on the young Jamuna floodplain. All the sites, more or less, followed a straight line east to west from Sharishabari town.

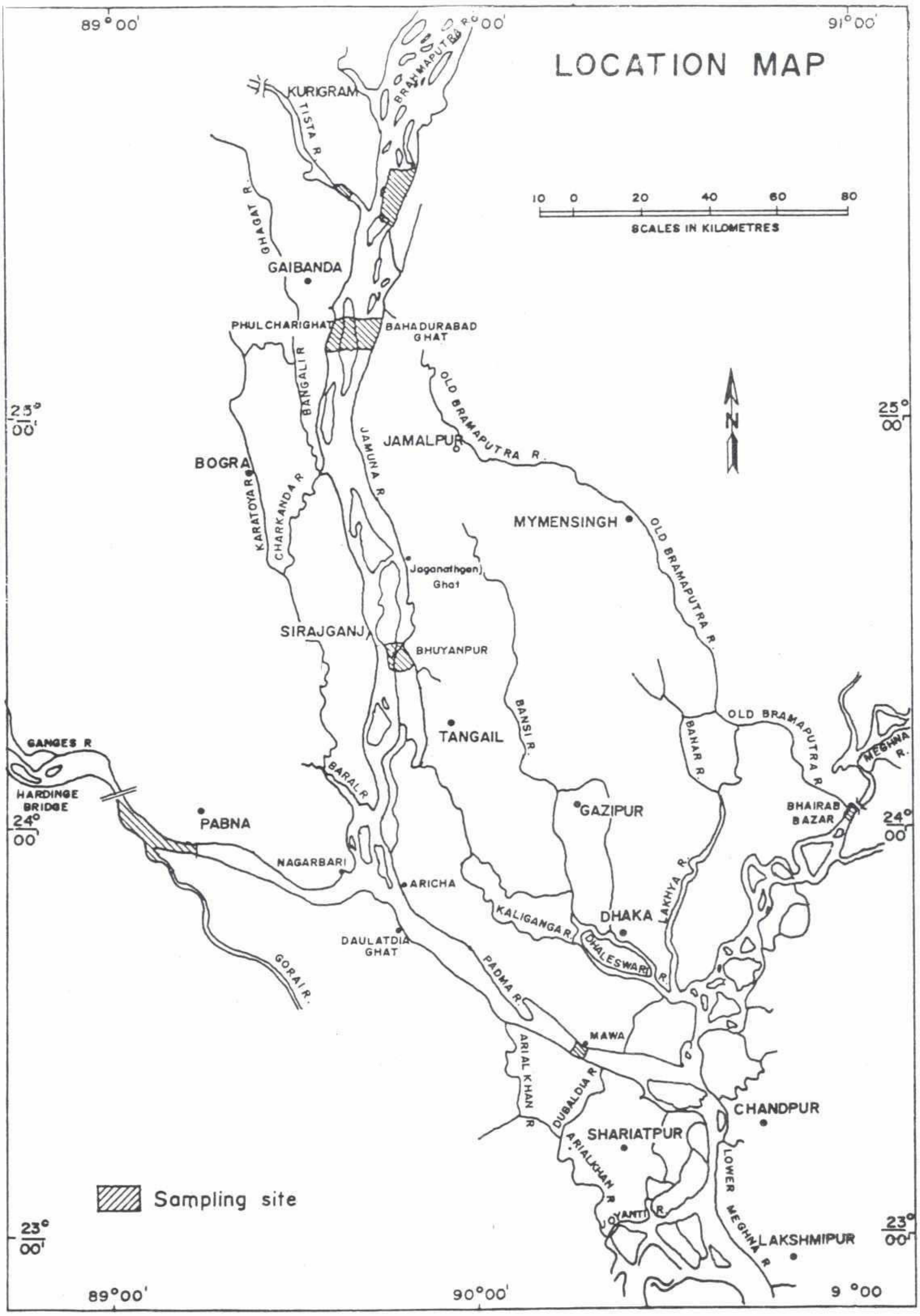

Figure 3.1: Location map for sampling areas

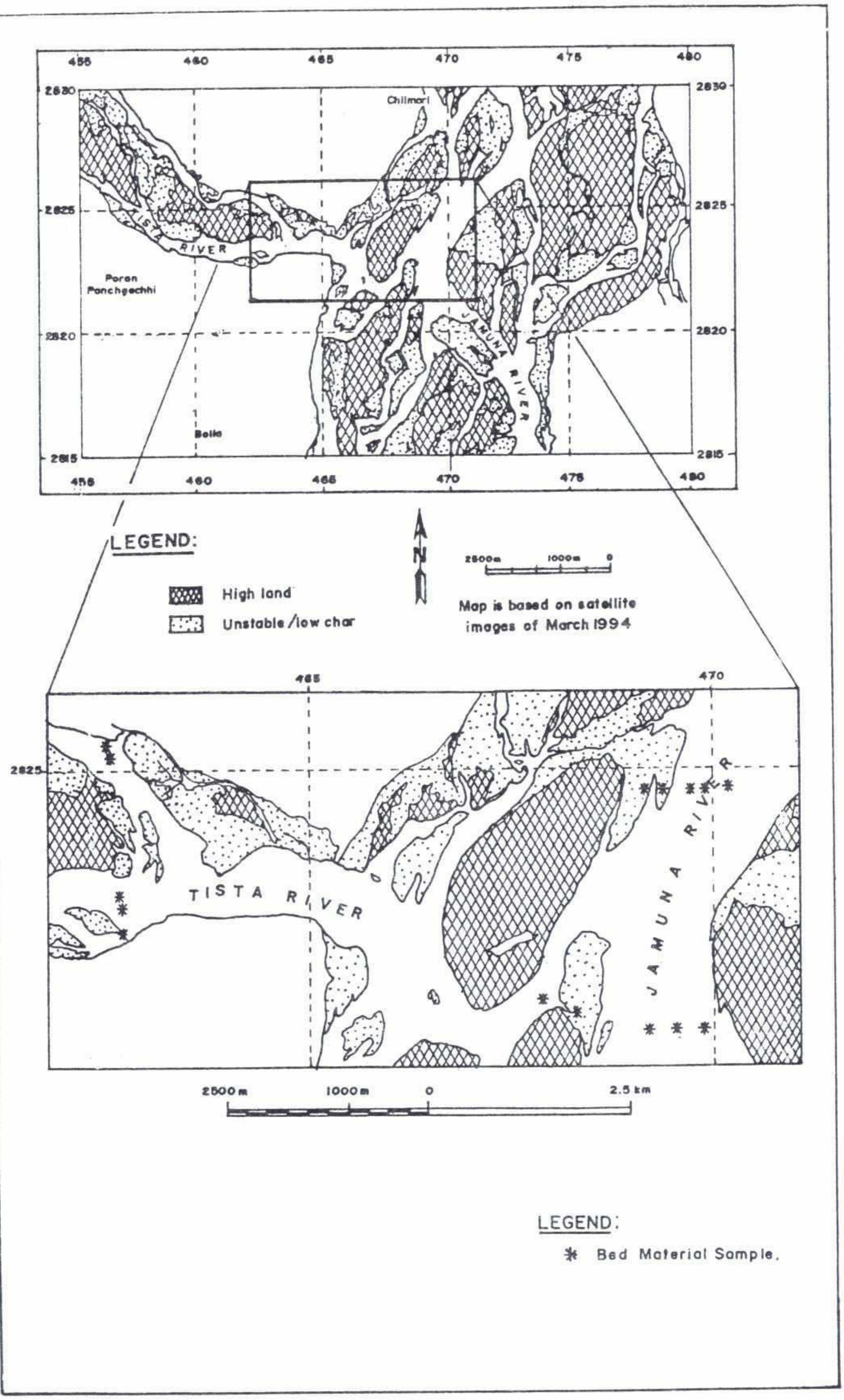

Figure 3.2a: Teesta and Upper Jamuna River

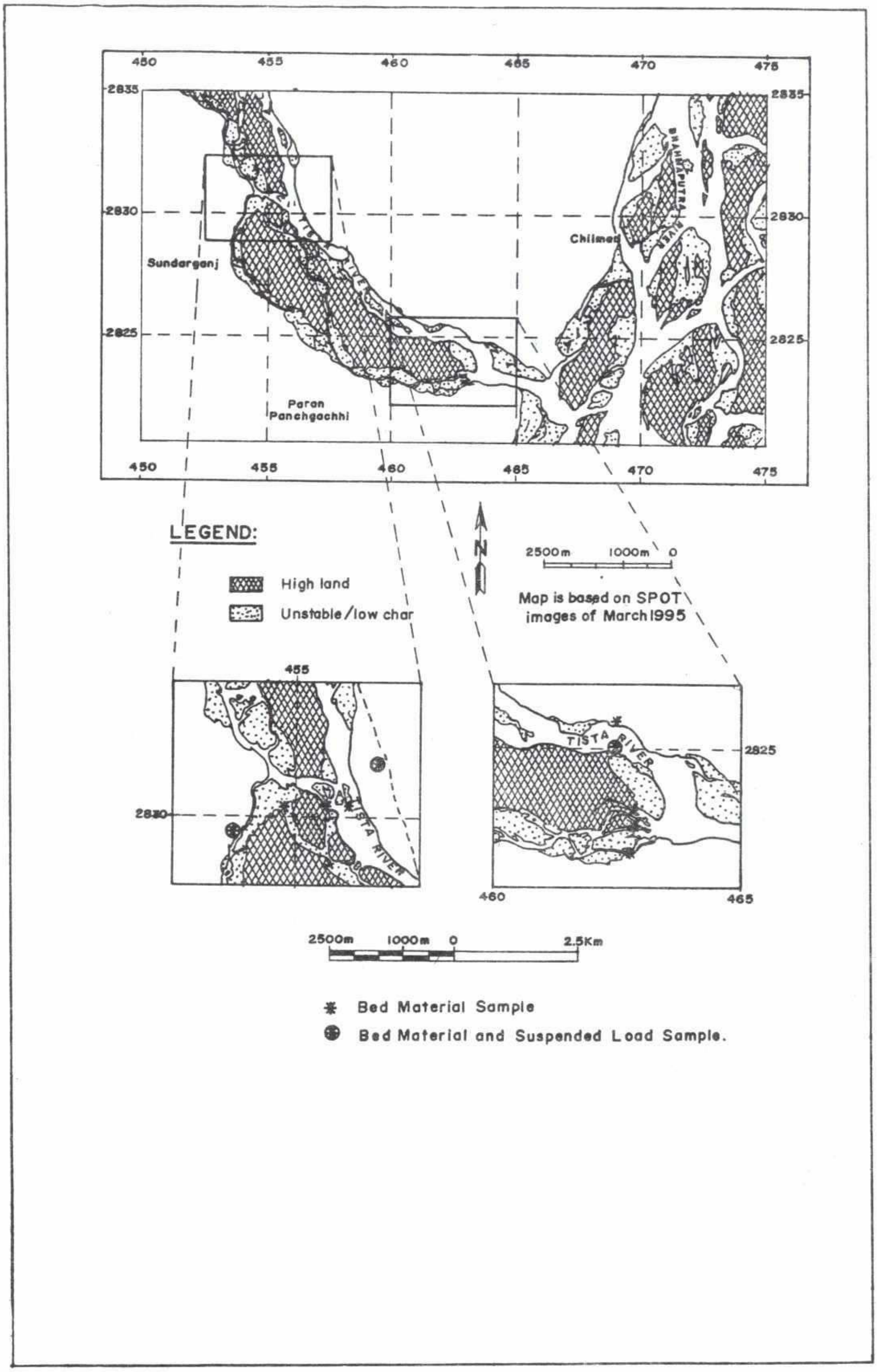

Figure 3.2b: Teesta River (after Flood)

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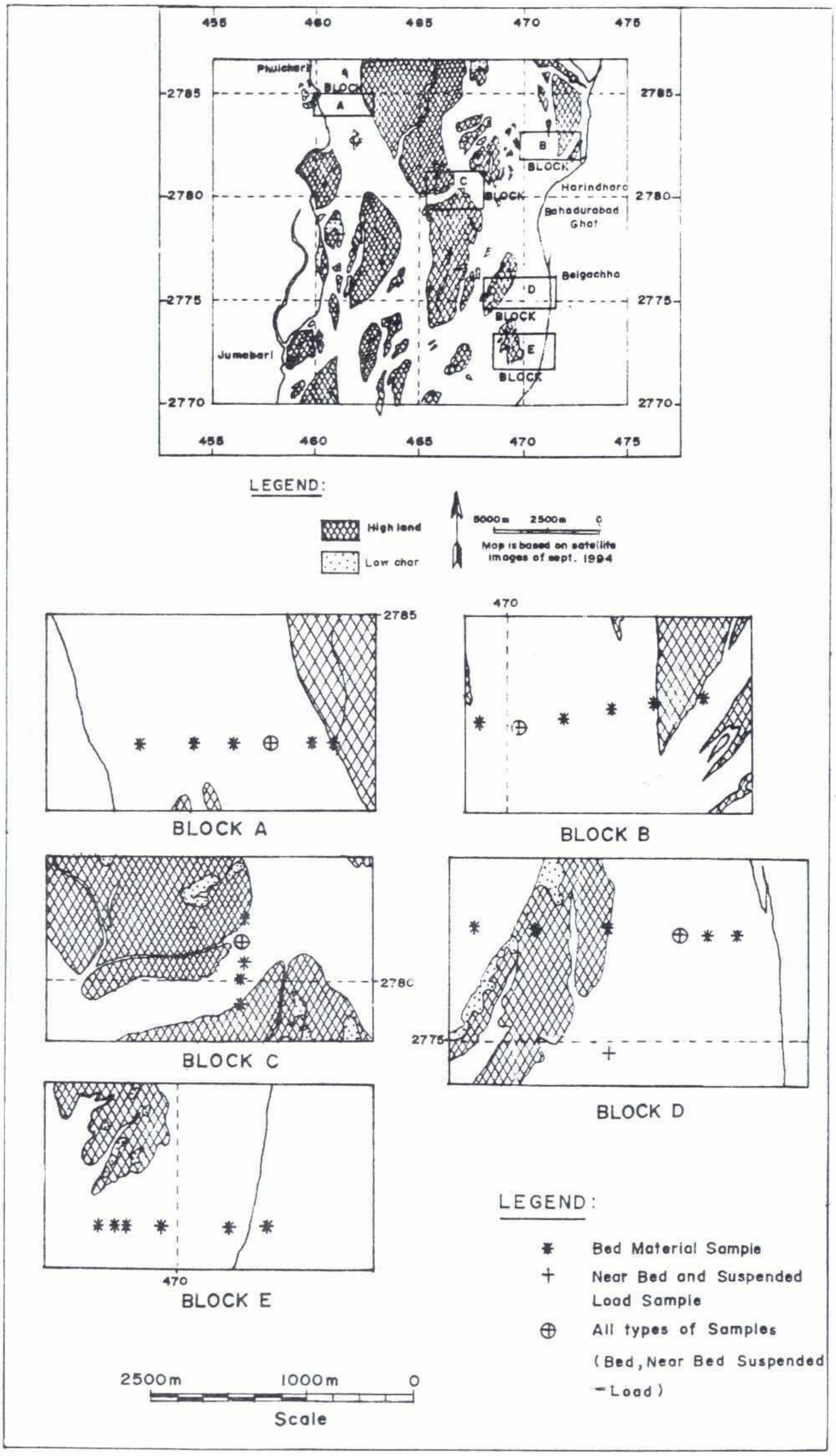

Figure 3.3: Jamuna River (Near Bahadurabad)

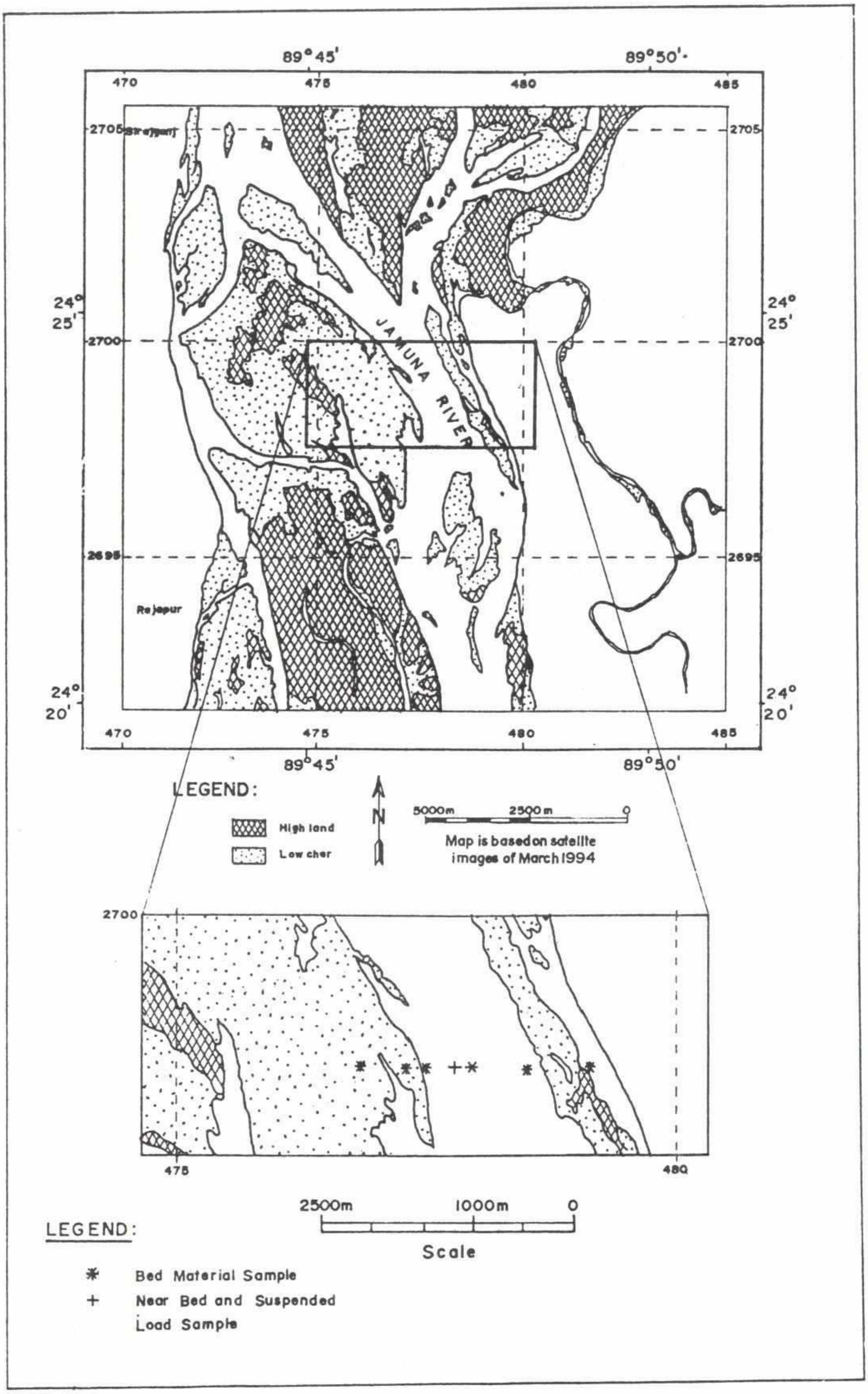

Figure 3.4: Jamuna River (Near Sirajganj)

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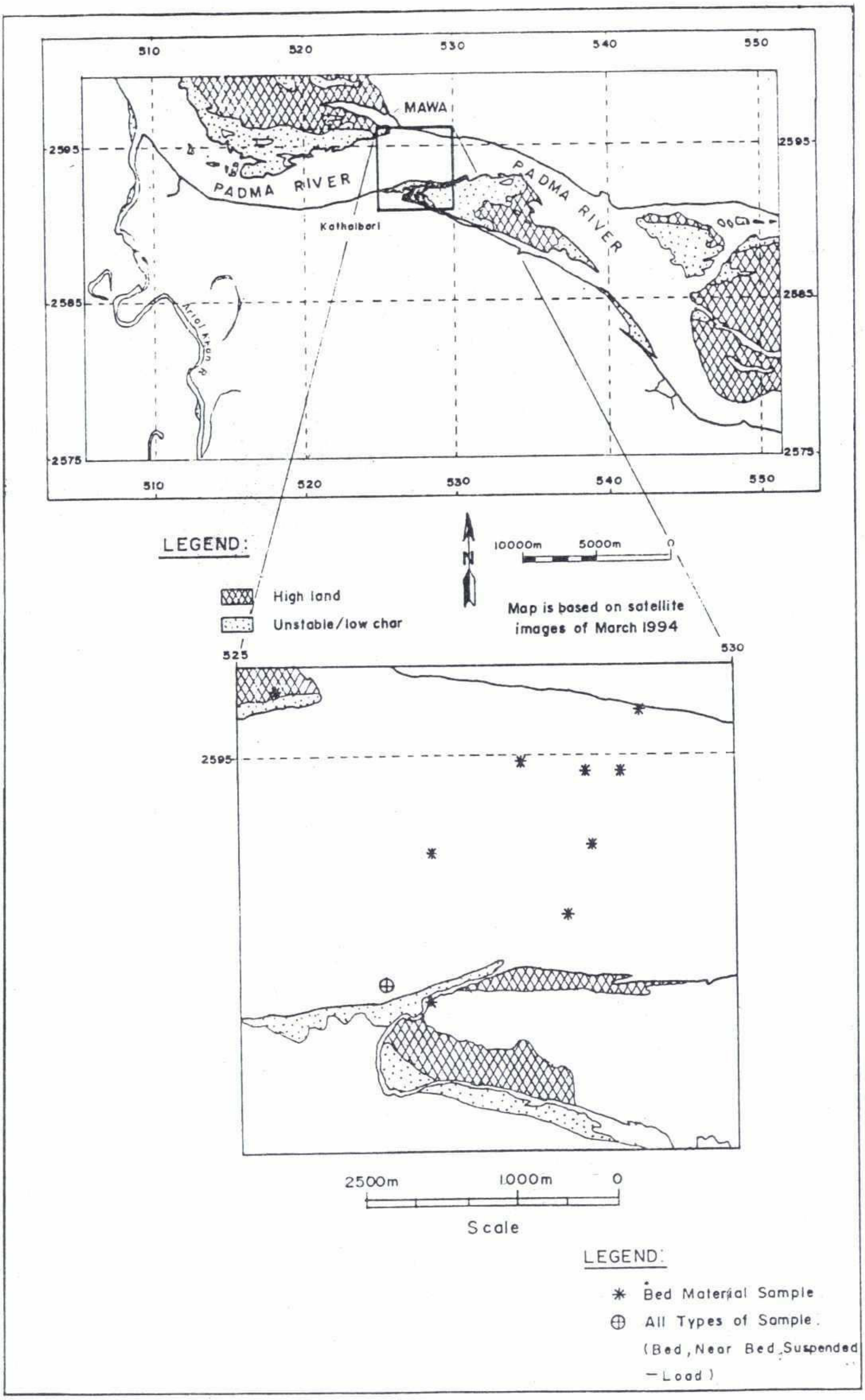

Figure 3.5a: Padma River (Near Mawa)

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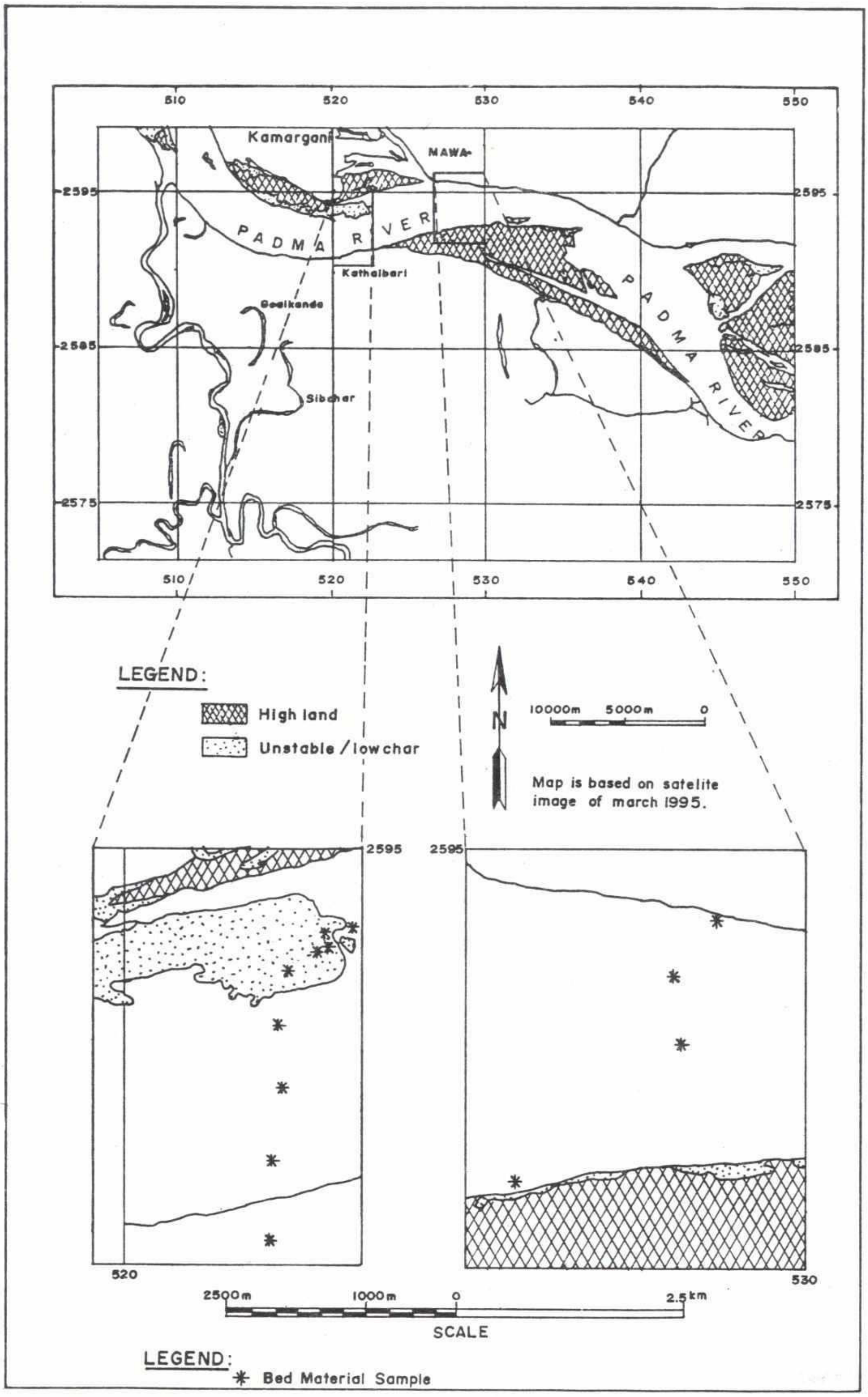

Figure 3.5b: Padma River (Near Kamargaon)

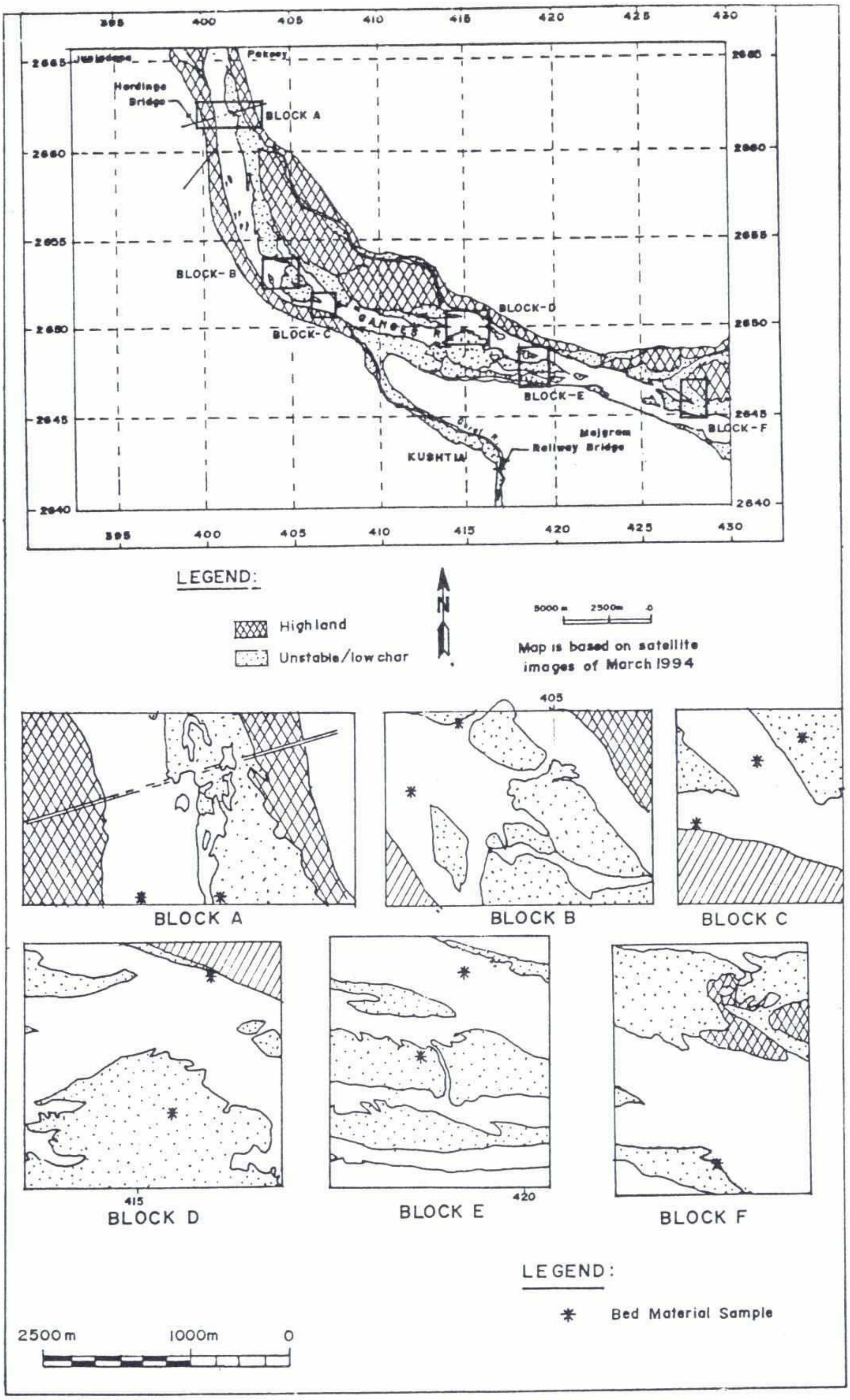

Figure 3.6: Ganges River

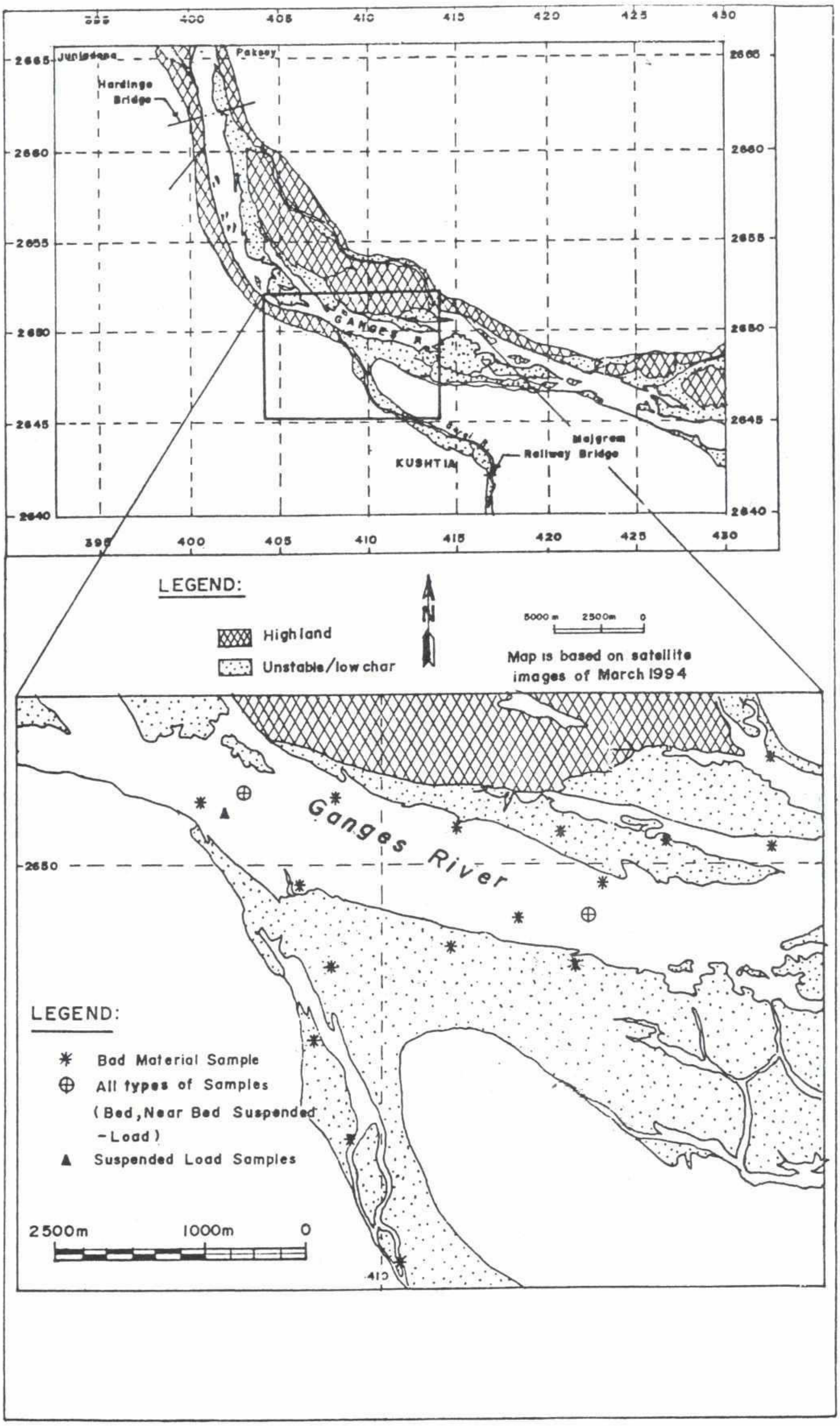

Figure 3.7: Ganges and Gorai Rivers (near Gorai Off-take)

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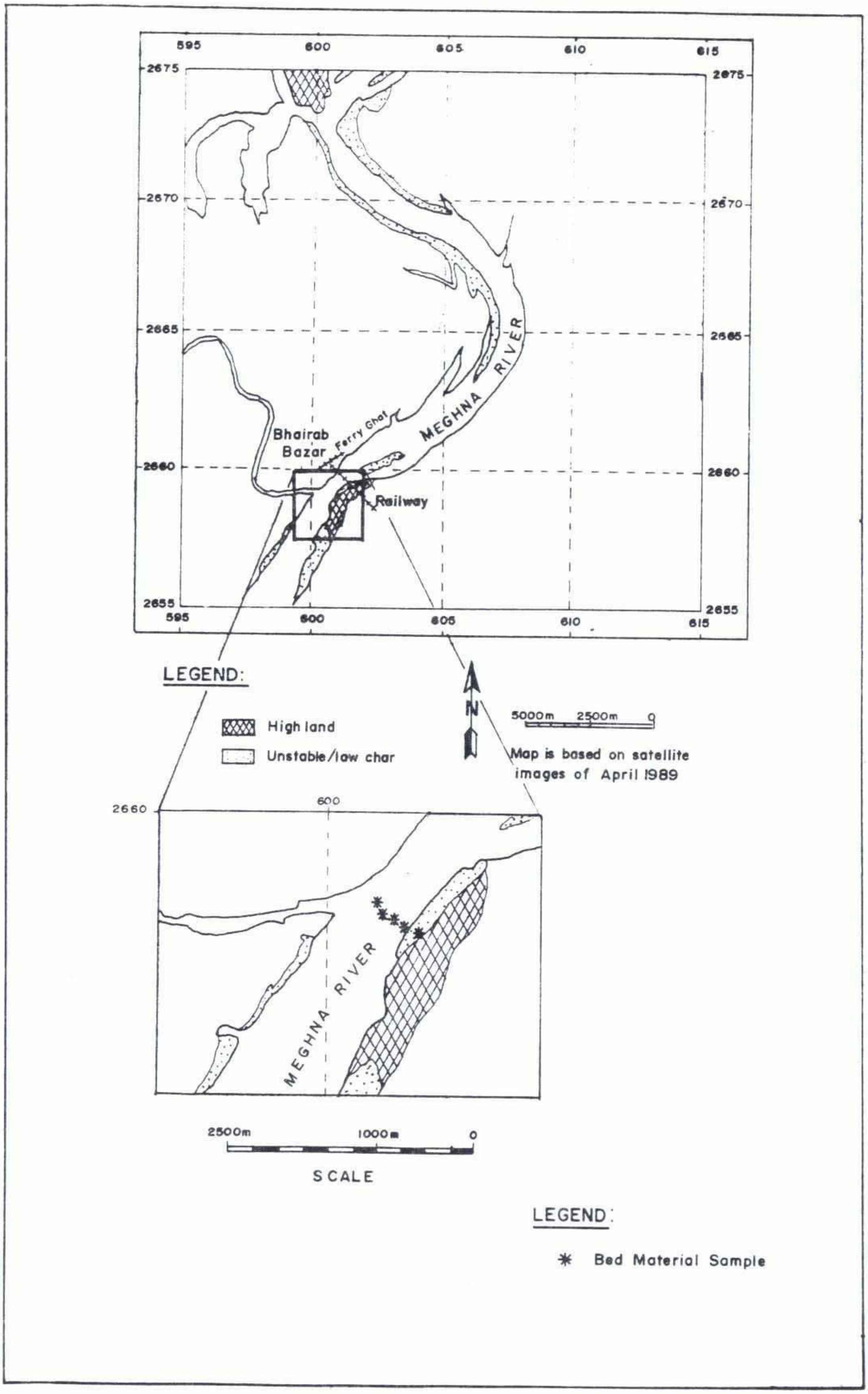

Figure 3.8: Meghna River (Near Bhairab bazar)

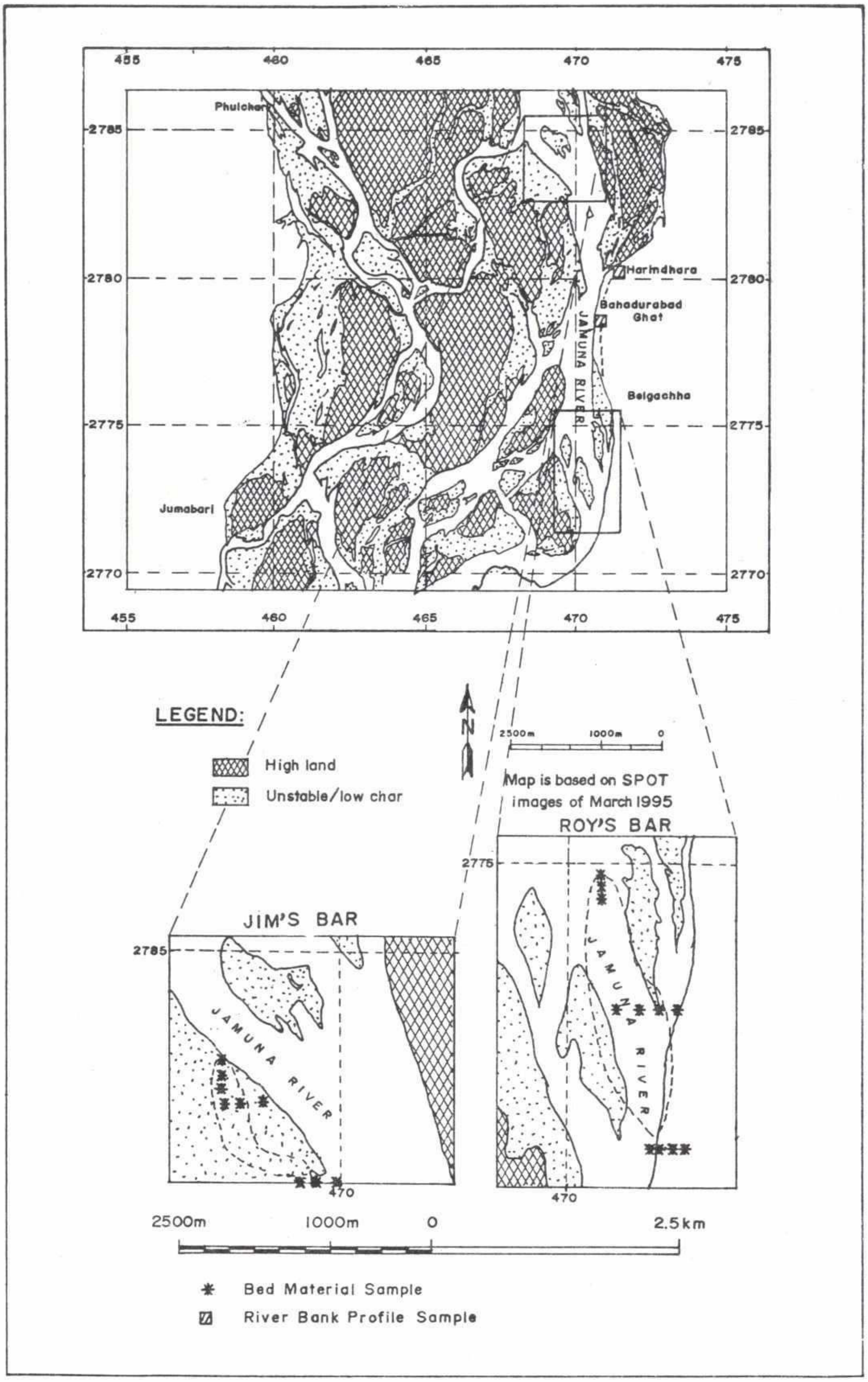

Figure 3.9: Jim's Bar, Roy's Bar and River bank profile sites

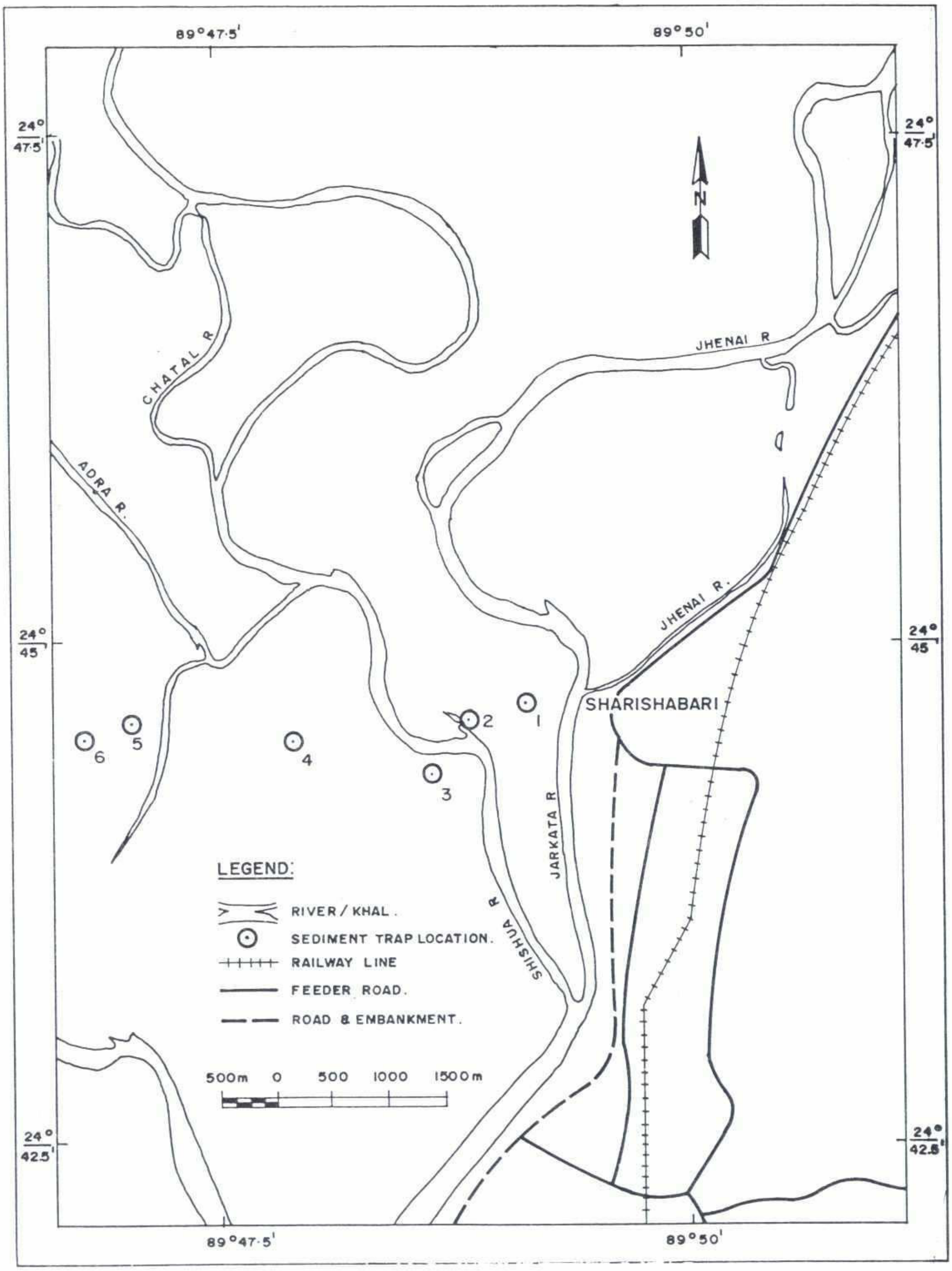

Figure 3.10: Floodplain sampling sites in Jamuna River floodplain

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4 Methodology

4.1 River sediment sampling

Sediment samples were collected in and near the river beds, and suspended loads were taken from the river profiles. USBM 54, Van Veen, and Scooping drag samplers were used for collecting bed samples. The near-bed samples were collected five centimetres above the river bed by Delft bottle or by pumping. Pumps were used to collect mid-depth suspended load samples.

Sediment sampling was taken before and after the flood season. The first samples were taken between 26 May and 29 June, 1995. The Teesta and the upper reaches of the Jamuna River were sampled on 26 May; the rest of the Jamuna River was sampled between 29 May and 8 June, the Meghna River on 7 June, the Padma River on 23 and 24 June, and the Ganges and Gorai rivers on 28 and 29 June. A total of 115 samples were collected.

The second sampling was made between 5 October and 10 November, 1995. The Teesta River was sampled between 5 October and 3 November; the Padma River between 6 and 31 October; and Jim's bar, Roy's bar, and the river bank profiles were sampled between 8 and 10 November. A total of 55 samples were collected.

4.2 Floodplain sediment sampling

Each sampling site was 10 m by 10 m and represented the major flood and sedimentation regimes of the area. A bamboo-covered fence was constructed to keep people, livestock, and floating vegetation out of the area. One person per sampling site was hired for security and to collect flood water samples and information on inundation depths.

Traps and mats were placed at the sampling sites between 8 and 11 June, 1995.

Each site received a 2 m by 2 m *permeable jute mat* on which three 50 cm by 50 cm permeable cloths were secured with iron nails (Fig.4.1).

Three *sediment traps* were set in each of the six sites (Fig.4.1). Each trap was initially filled with clean tubewell water and covered by a funnel cover. The covers were removed when flood water entered the sites and covered again when flood waters receded.

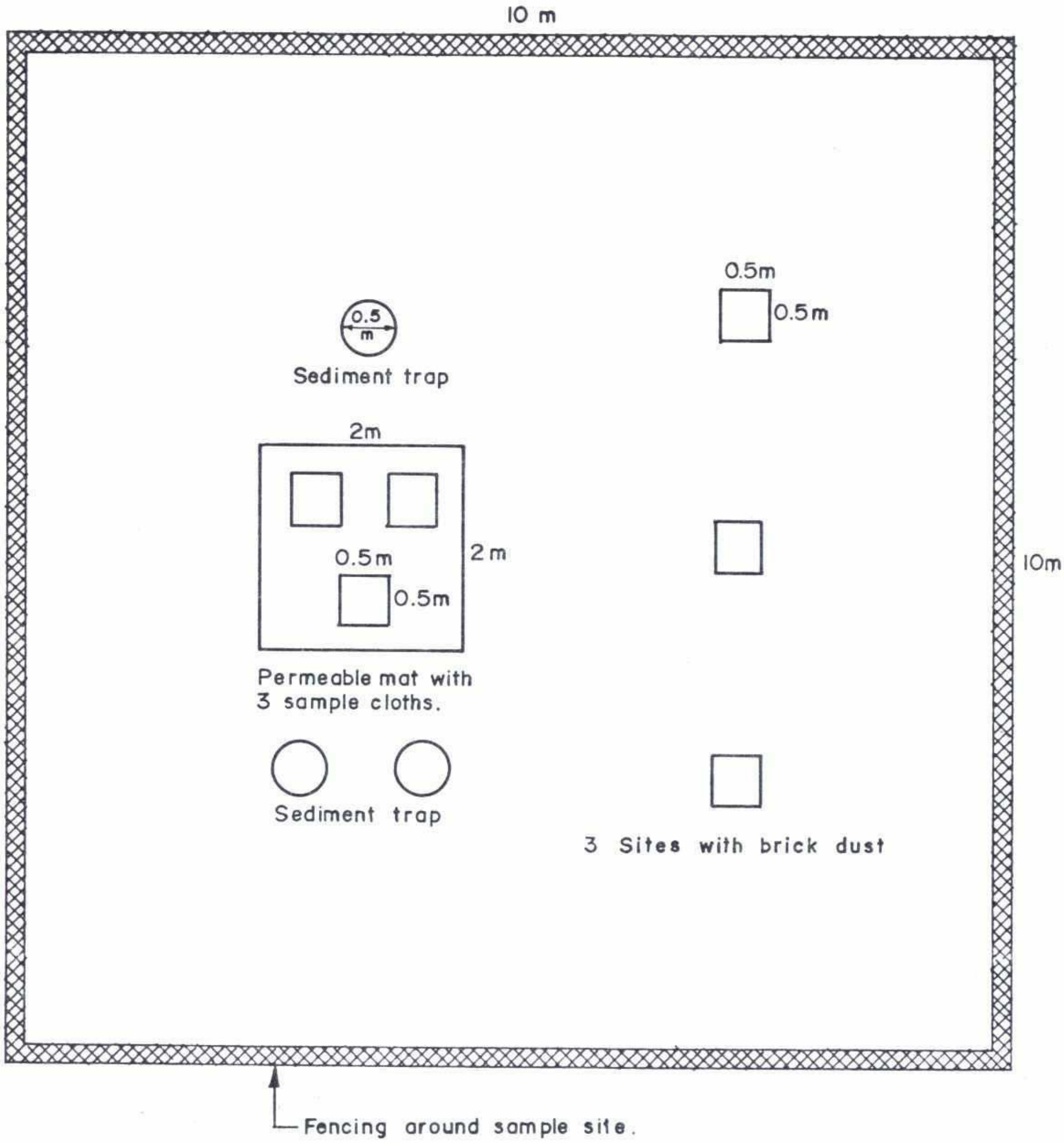

Figure 4.1: Layout of floodplain sampling site

At each site, a thin layer of *brick dust* was spread over the soil surface in three 50 cm by 50 cm sub-plots to measure the sediment layer overlying the topsoil of the area.

The traps, mats, cloths, and brick dust were left at each sampling site for the entire field season. Sediment deposited on the cloth and traps were collected after flood waters receded. Sediments from the higher sites (numbers 3, 4, and 5) were sampled between 25 and 26 September, and from the lower sites (numbers 1, 2, and 6) between 22 and 23 October, 1995.

4.3 Laboratory analysis

Sediment samples were analyzed for mineralogical and physical properties at Dhaka University's Geology and Soil Science Department laboratory. Grain-size analysis, for all the samples, was carried out at the FAP24 laboratory. Fifty-two samples were selected for full analysis; the remaining samples had a limited analysis. Parameters for the full and limited analyses are given in Table 4.1. Also, please refer to Figure 2.1.

Physical properties	Method of analysis	Full analyses	Limited analyses
Mineralogy			
- Sand-size minerals	Light microscope	+	+
- Silt-size minerals	Light microscope and XRD, resp.	+	+
- Silt-size minerals	XRD	+	-
- Clay-size minerals	XRD	+	-
- Trace minerals	Light microscope	+	+
- Rock fragments	Light microscope	+	+
Shape variables			
- Angularity	Microscope + shape chart	+	+
- Sphericity	Microscope + shape chart	+	-
- Shape factor	Microscope	+	-
Density	Pycnometer	+	+
Grain size	Sieving/settling tube	+	+
+ : Selected analyses			
- : Not selected			

Table 4.1: Analysis parameters

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4.3.1 Sand mineralogy

The sand-size sample were washed with clean water to remove any dust, then oven dried at 60 °C. Using a quartering procedure, a 15 g segment was taken from each sand fraction. All the samples were then impregnated individually with araldite resin and blue dye. A tablet measuring 35 mm by 25 mm by 5 mm was made from each sample and left 24 hours for complete consolidation. The impregnated tablet was then mounted on a glass slide and grounded to an appropriate thickness in an Ingram Thin Section Grinder (Model 400ts). Finally, it was polished with carborundum powder to a thickness of 0.03 mm, as determined by quartz interference colour, and studied under a polarizing petrographic research microscope (MEIJI-ML-POL). Using an automatic point counter attached to the microscope, a quantitative estimation of the identified minerals was made. Micro-photographs were taken on a representative thin section of sand mineralogy. During preparation of a sample, a bias might be introduced by large mica flakes because of their preferential orientation. Measures were taken to minimize the effect during the interpretation of results.

4.3.2 Silt mineralogy

The silt and clay fractions, along with distilled water, were placed in a 250 ml beaker and kept 15 minutes in an ultrasonic cleaning bath (Decon, Model FS 100 b) to completely disperse the clay particles. Of course, there is a risk of breaking some particles (such as mica flakes) into smaller pieces if the ultrasonic waves are too powerful. The silt and clay fractions were separated from the silt-clay mixture by the gravity method following Stokes' law of particle settling velocity.

Both microscopic and XRD studies were carried out to determine silt mineralogy. In the microscopic study, grains of silt fractions were mounted on a glass slide with Canada balsam. To prepare an oriented mount of silt for XRD analysis, five grams of silt were gently ground to a fine powder in an agate mortar. The powder was then packed into the cavity of a plastic disc to X-ray in an air dry state; a JEOL X-ray diffractometer with a Ni-filtered Cuka radiation source at 30 kV and 20 mÅ was used. Full analysis for all the samples ran from 2°2Θ to 65°2Θ at a scanning speed of 2°2Θ per minute.

4.3.3 Clay mineralogy

To prepare an oriented mount of clay fraction for X-ray analysis, a pipette was used to withdraw 10 ml of a clay suspension from a measuring cylinder. The sample was placed in a small beaker at 60°C for 24 hours to make a concentrated clay slurry. The concentrated slurry was then deposited onto a ceramic disc by a glass dropper and left overnight to dry. The resulting oriented clay sample was run in an air dry and glycolated state in a X-ray diffractometer from 2°2Θ to 30°2Θ using a Ni-filtered Cuka radiation source at 30 kV and 20 mÅ at a scanning speed of 2°2Θ per minute.

4.3.4 Shape variables

The sphericity and angularity of the sand grains were determined by a visual comparison of the grains under a microscope with a standard sphericity-angularity chart of Powers (1982) (Figure 4.2). The shape factor of the sand fractions was determined by measuring the long, intermediate, and short axes, which are mutually perpendicular to each other, under the microscope with an attached micrometer. Five sand quartz grains were measured for each full analysis sample, and the shape factor was obtained from the equation: $SF = c/(a * b)^{0.5}$.

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4.3.5 Grain sizes

The grain size distribution of the samples that contained large amounts of sand (>0.063 mm) was performed by dry sieving, while samples that contained a large amount of silt and clay (<0.063 mm) were analyzed by the wet sieving and fall velocity method. All the bed, near-bed, and suspended load samples were separated into sand, silt, and clay fractions.

For the sieving analysis, sieves with aperture sizes at 1/2 phi, ranging from 63 microns to 1,000 microns, were used. In the fall velocity method, an Andreasen Tube and a 50 ml pipet withdrawal tube were used.

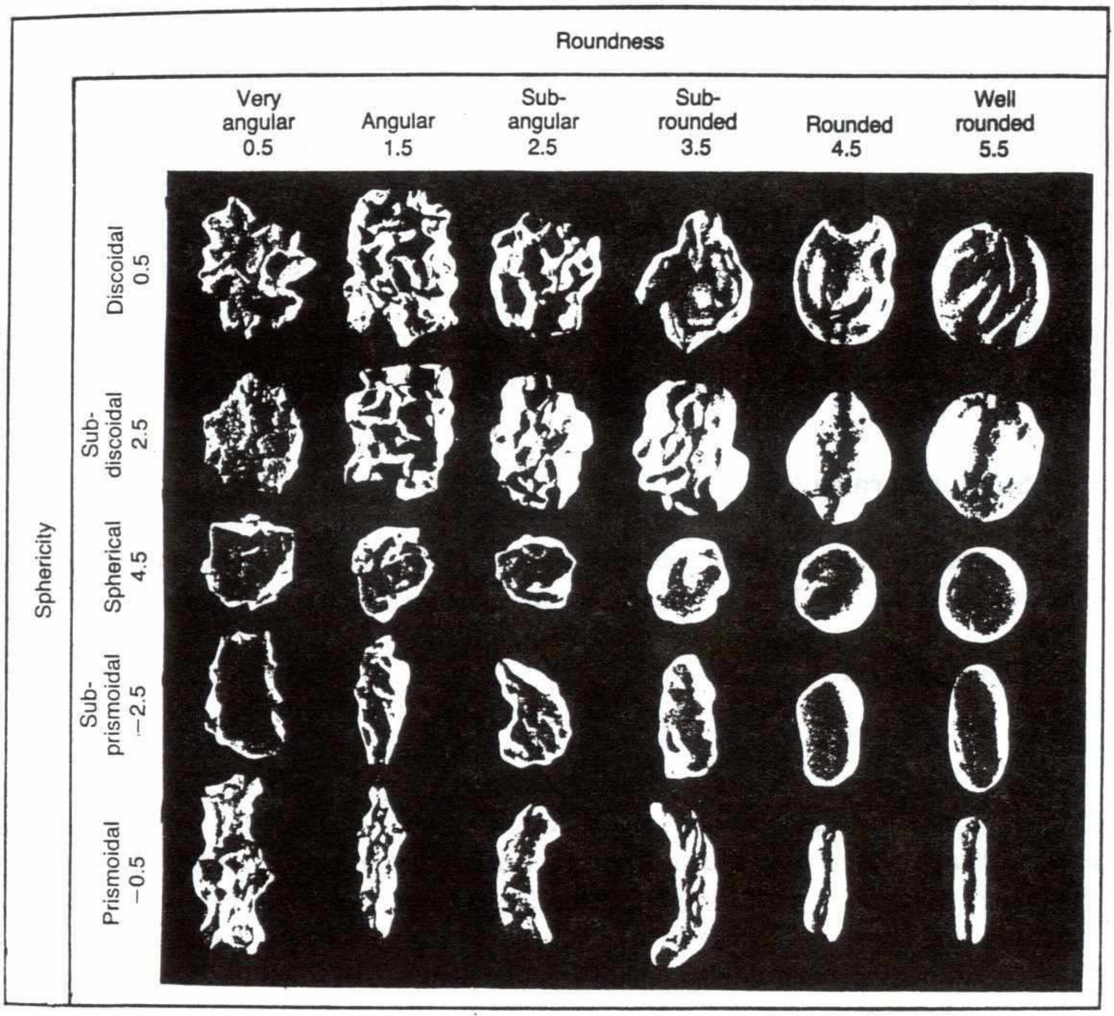

Figure 4.2 Visual comparison chart for estimating roundness and sphericity (from Powers, 1982). (Reproduced by permission of American Geologic Institute)

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5 Data and results

Maps showing the sampling locations were presented in Chapter 3. For each sampling location, a single parameter may vary widely or hardly at all. Therefore, a mean value with a standard deviation was determined for a single parameter. Please refer to Appendix II for detailed information on the total number of samples collected, the date of collection, and results for each sample.

Data from different locations on the rivers were grouped into two sections. Sand fractions from bed materials, near-bed materials, and suspended load materials taken before the flood season on the major rivers locations are tabulated in Tables 5.1.1a; 5.1.1b and 5.1.1c. Similarly, silt fractions are tabulated in Tables 5.2.1a, 5.2.1b and 5.2.1c. Data on clay mineralogy are presented in Tables 5.3.1a, 5.3.1b and 5.3.1c, while shape variables data for the sand fractions are listed in Table 5.4.1.

Data on the sand fractions of bed samples collected after the flood season (in Teesta and Nawa Rivers, and Jim's Bar and Roy's Bar) are presented in Table 5.1.2a. Sand fractions of suspended load material of Teesta River are presented in Table 5.1.2b, and of river bank profiles in Table 5.1.2c. Corresponding silt fractions are given in Table 5.2.2a-c. Clay fractions of Jim's and Roy's Bars are presented in Table 5.3.2a, and of river bank profiles in Table 5.3.2b. Shape variables data for the sand fractions after the flood season are listed in Table 5.4.2.

Floodplain sand, silt, and clay fractions data are given in Tables 5.1.3, 5.2.3 and 5.3.3. Shape variables are presented in Table 5.4.3.

The following sections describe the amount of individual minerals in sand, silt, and clay. Results are obtained on total sand and silt fractions. Physical and chemical characteristics of these minerals are given in Appendix I.

5.1 Sand mineralogy

This section deals with the mineraological characteristics of the sand fractions of the sediment samples. Hereby, the river and the floodplain sediments are describes in separate sections.

5.1.1 River sediment

Quartz

Quartz found in Bangladesh rivers is predominantly mono-crystalline, but a few grains are poly-crystalline. Quartz was the most abundant mineral found in all the study rivers (Plate 1). After the flood season, the percentages of quart increased in the Teesta River at its confluence with the Jamuna. The amount of quartz found in the Padma River was the same both before and after flood season. There were no significant variation of quartz in different sections of Jim's and Roy's bars.

River bank profiles contained between 43 and 59 percent quartz.

Feldspar

Of the entire study area, Jim's and Roy's bars had the highest level of feldspar (22 percent). Of the rivers, however, the Gorai had the highest level of feldspar (11 percent) and the Teesta had the lowest

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(five percent) (Plate 2). There was little variation in all categories (bed, near-bed, or suspended). Both the Teesta and Padma rivers showed little variation in feldspar before and after flood season.

The feldspar included two common types: potash feldspar and plagioclase feldspar.

Mica

In river-bed samples, the amount of mica varied widely between rivers. The Teesta River contained 41 percent mica at all sampling sites (Plate 3). While that amount was greatly reduced after the flood season at the confluence, the upstream sites continued to show a high level (27 percent) (Plate 4). The Padma and Meghna rivers contained overall low levels of mica (7 percent), but the Padma's level rose to 13 percent after flood season. Generally, in most locations, mica was more abundant in the near-bed and suspended samples than in the bed samples. Jim's bar samples had only three to five percent mica, while Roy's bar contained between 14 and 16 percent. Water level samples of river bank profile 2 had the lowest levels of mica (two percent), while samples taken at the same depth in profile 1 showed the highest levels (42 percent).

The most predominant types of mica were muscovite and biotite; chlorite was present in smaller amounts.

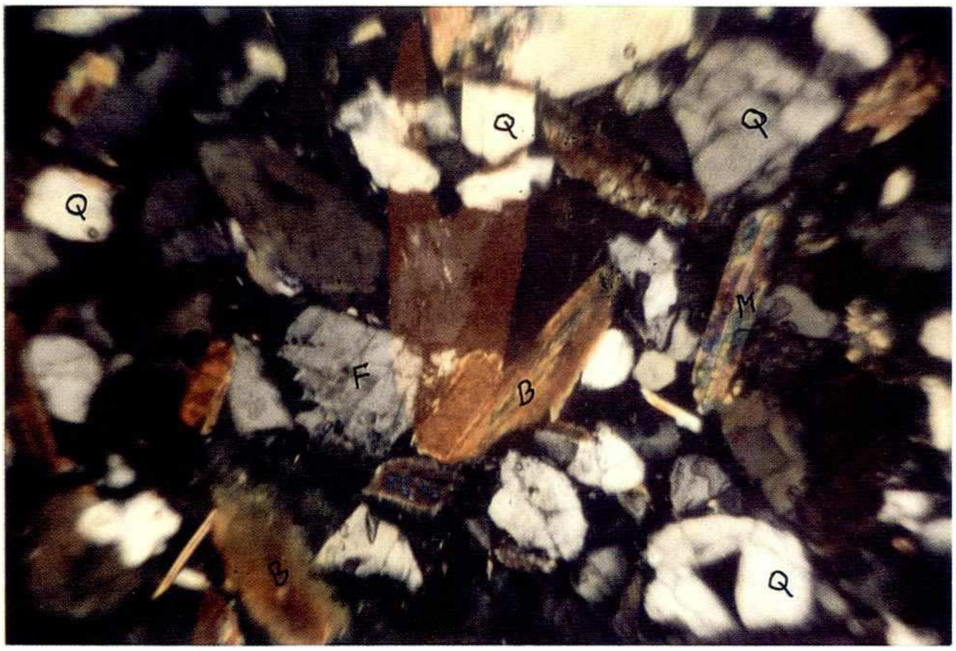

Plate 1: Jamuna (Sirajganj) general normal mineralogy:
M = muscovite and B = biotite, both are mica,
F = feldspar, Q = quartz
(vertical height of photograph : 0.8 mm)

Plate 2: Jamuna (Bahadurabad) general mineralogy:
Quartz + feldspar
(vertical height of photograph : 0.8 mm)

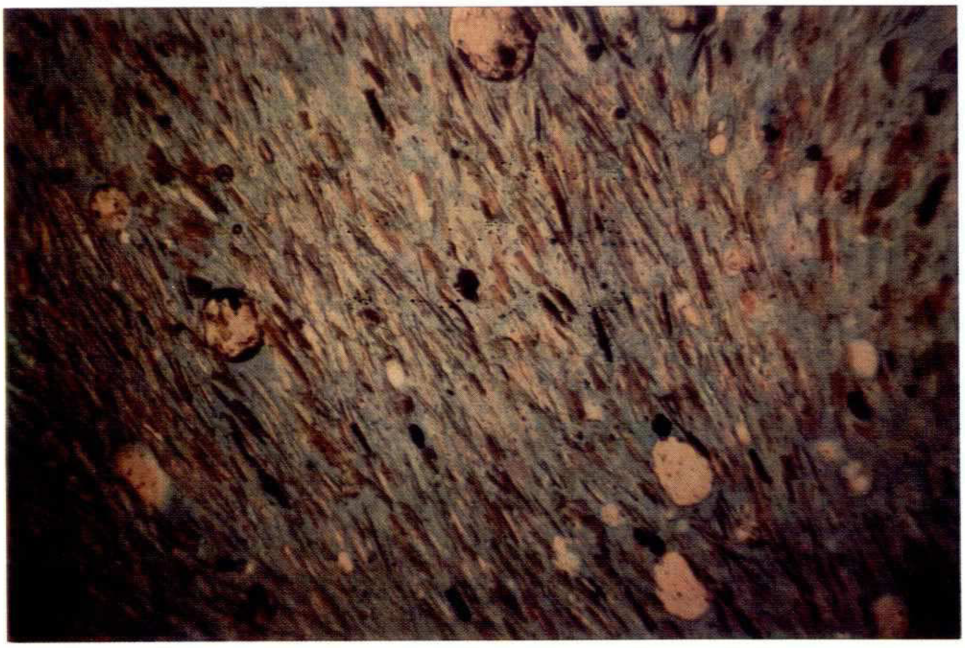

Plate 3 : Teesta River. Very high concentration of mica (white muscovite + brown biotite + green chlorite) in the sample. Only a few quartz grains are seen (vertical height of photograph : 2.0 mm)

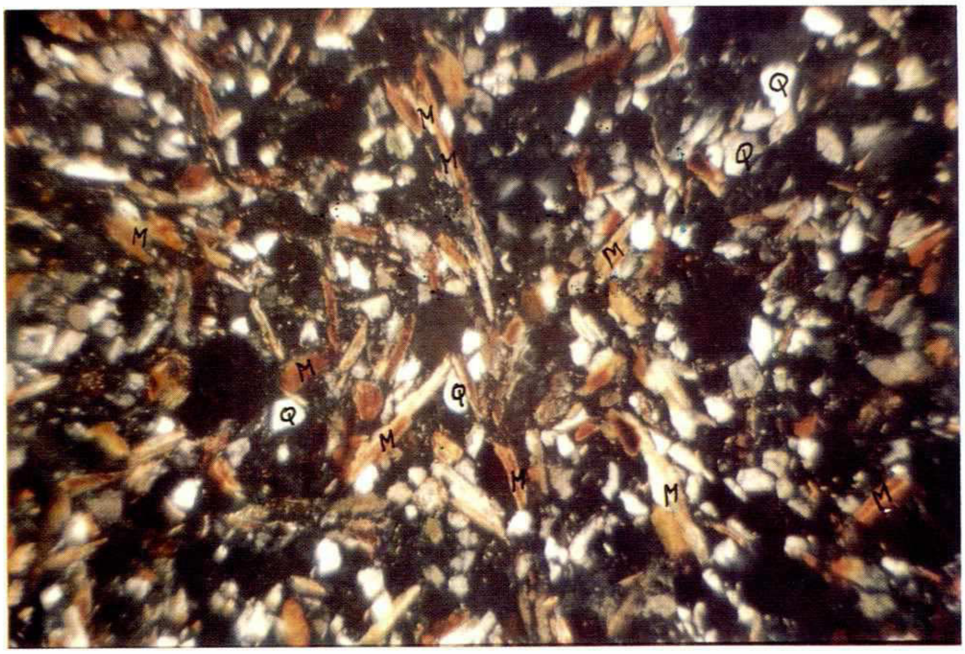

Plate 4: High mica content in upstream part of Teesta River (vertical height of photograph : 2.0 mm)

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Rock fragments

Rock fragments make up a significant part of the sand fractions. In the rivers, the largest amount (22 percent) was observed in bed samples from the upper Jamuna River, while the lowest (10 percent) was found in the Teesta River. After the flood season, however, rock fragments increased to 15 percent in the Teesta. Rock fragment content remained the same both before and after flood season in the Padma River. Jim's and Roy's bars contained between 20 and 38 percent rock fragments (Plates 5 and 6).

River bank profile number 2 had the largest amount (41 percent) of rock fragments at water level, while profile 1 had the lowest (10 percent) at the same depth. The amount varied between 12 and 17 percent in surface layers.

The most common rock fragments found were schist (metamorphic), chert (sedimentary), and argillaceous (sedimentary) varieties (Plates 7 and 8). Plutonic (igneous) rock fragments also were found, as were quartzite, siltstone, and sandstone.

Heavy minerals

The concentration of heavy minerals was higher in bed samples than in near-bed or suspended load samples. In the bed samples, the Padma River had the highest level (22 percent) (Plate 9), while the Teesta and Ganges rivers had the lowest (four percent). After the flood season, these minerals increased to 10 percent in the Teesta (Plate 10) and decreased to eight percent in the Padma except near Kamargaon where the amount rose to 25 percent (Plate 11).

Heavy mineral content was low (two to five percent) in all layers of river bank profiles, except in one layer of profile 1.

The three categories of heavy minerals found in the sand fraction are:

- Amphibole and pyroxene: Amphibole was more common than pyroxene (Plate 12), with Hornblende (Plate 13) being the most abundant variety. Also present were augite, diopside, tremolite, and actinolite

- Other nonopaque heavies: The most common types in this group were garnet and epidote (Plate 14). Others included zircon, tourmaline, apatite, sillimanite, zoisite, rutile, spinel, and sphene

- Black opaque: This group included magnetite and other iron and titanium minerals. In some samples, an exceptional abundance of black opaque minerals were observed

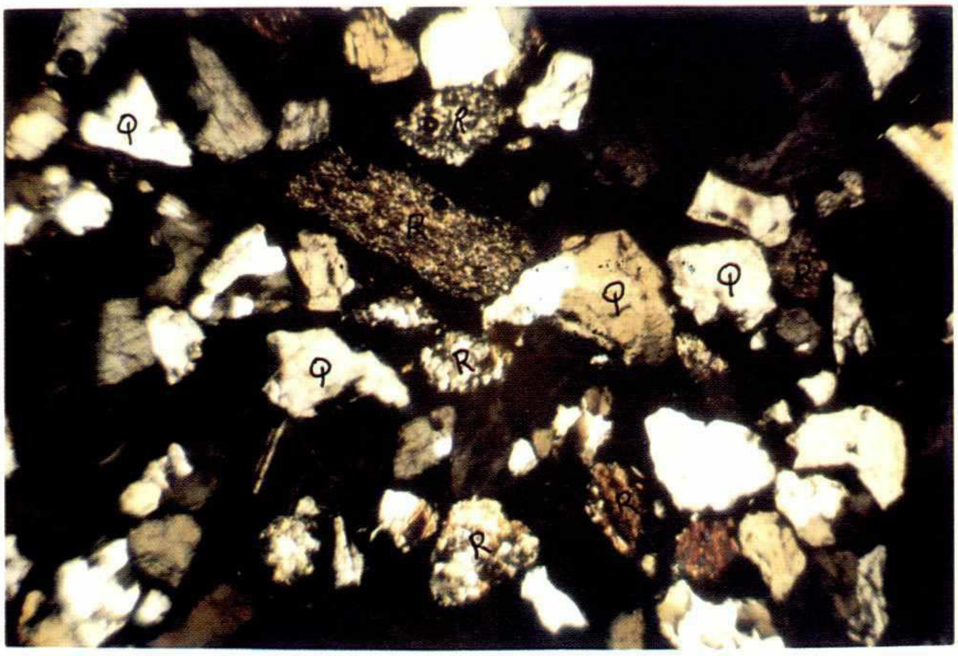

Plate 5 : Abundant rock fragments in Jim's Bar
R = Rock fragments, Q = Quartz
(vertical height of photograph : 2.0 mm)

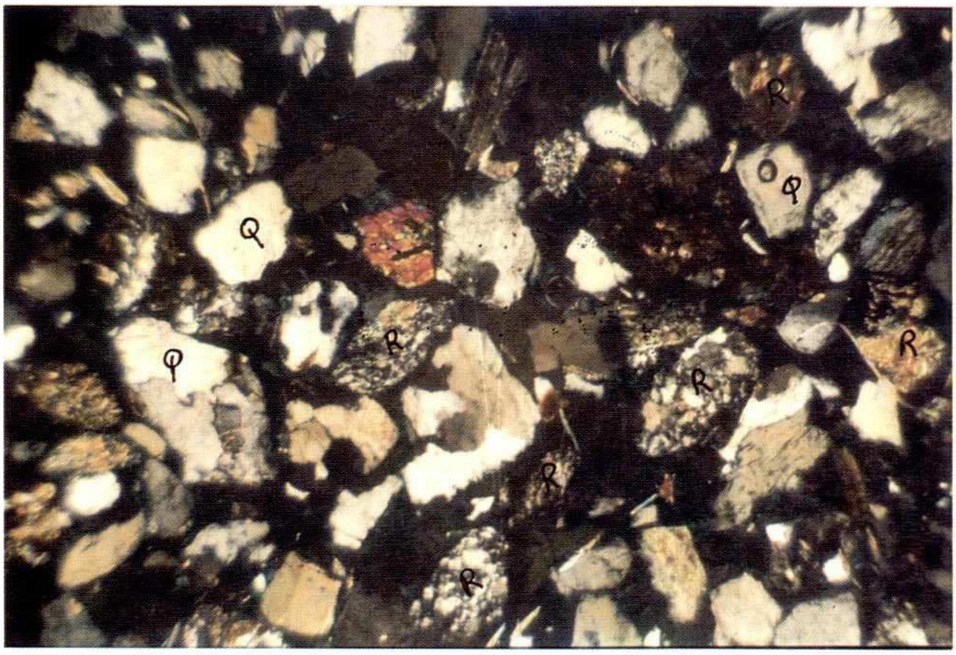

Plate 6 : Abundant rock fragments in Roy's Bar
R = Rock fragments, Q = Quartz
(vertical height of photograph : 2.0 mm)

Plate 7 : Jamuna (Sirajganj) MS = mica schist lithic grain
(vertical height of photograph : 0.8 mm)

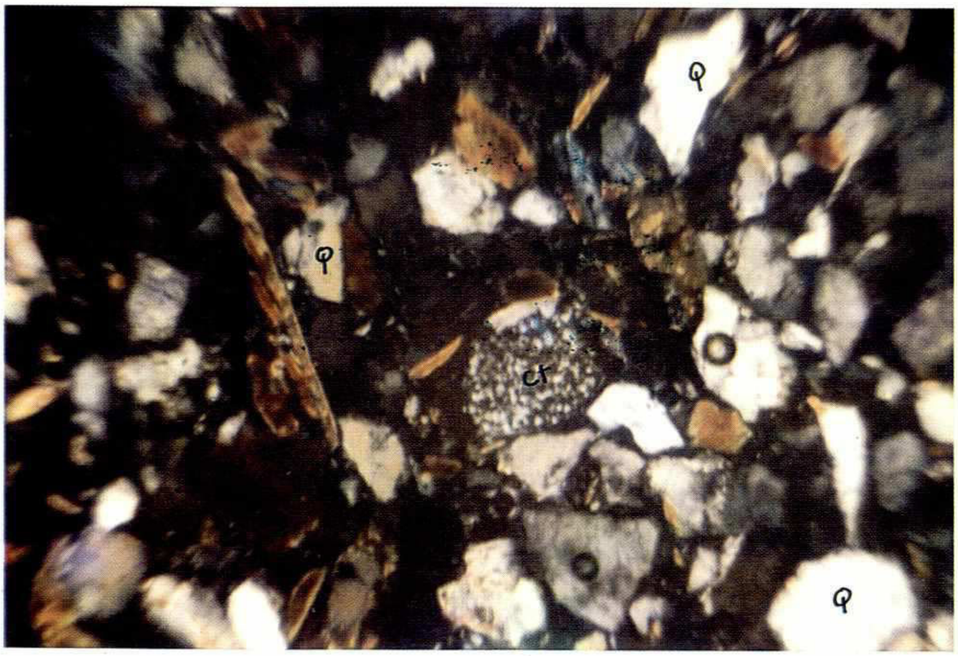

Plate 8 : Jamuna (Sirajganj) Ct = chart lithic grain
(vertical height of photograph : 0.8 mm)

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Carbonates

Carbonates were found in the Ganges and Gorai Rivers in all samples, but only trace amounts or none at all were found in the other rivers. Calcite and dolomite were the most common minerals of this group (Plate 15).

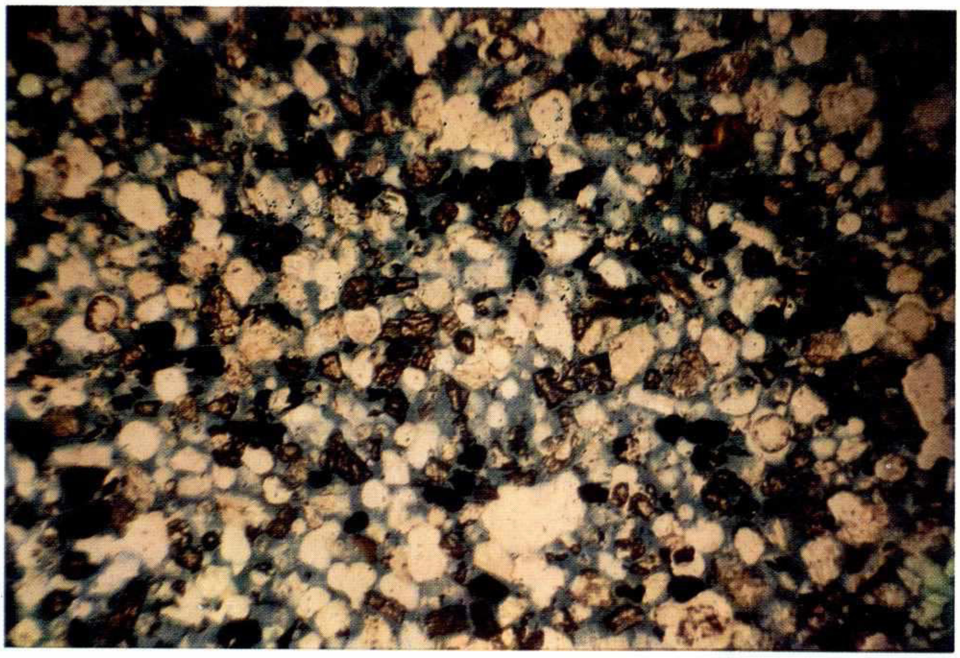

Plate 9 : Padma River (Mawa): A high concentration of heavy minerals including black opaque mineral is seen in the sample. The nonopaque grains with high relief are heavy minerals: Garnet, zircon, epidote, amphibole and pyroxene. The black opaque heavy mineral are mostly magnetite

(vertical height of photograph : 2.0 mm)

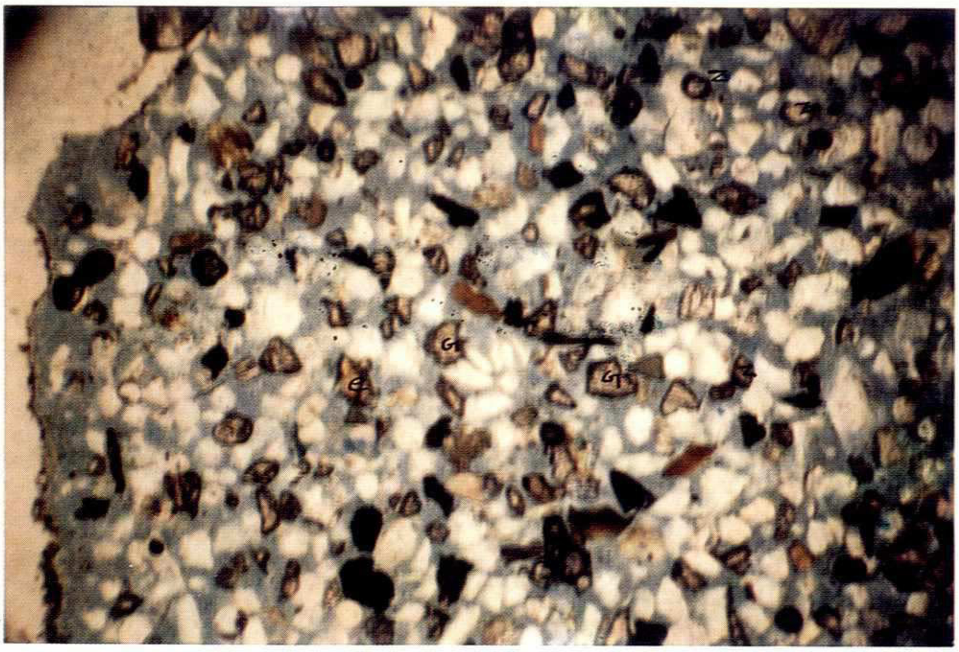

Plate 10 : Heavy minerals in Teesta confluence after flood season
G = Garnet , E = Epidot , Z = Zircon
(vertical height of photograph : 2.0 mm)

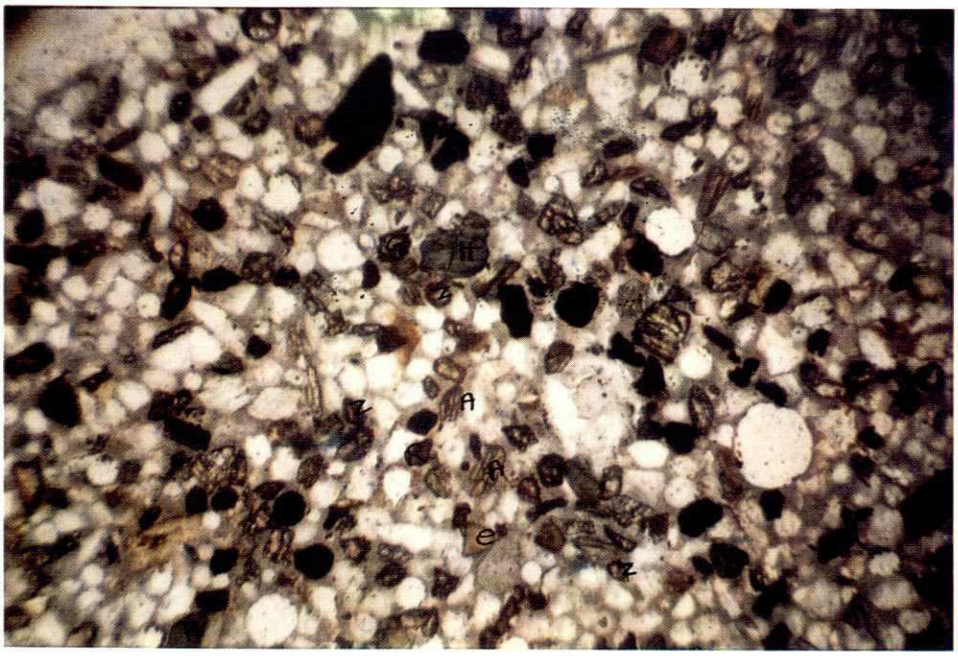

Plate 11 : A high concentration of heavy minerals in Padma river near Kamargaon
H = Hornblende , Z = Zircon , G = Garnet
(vertical height of photograph : 2.0 mm)

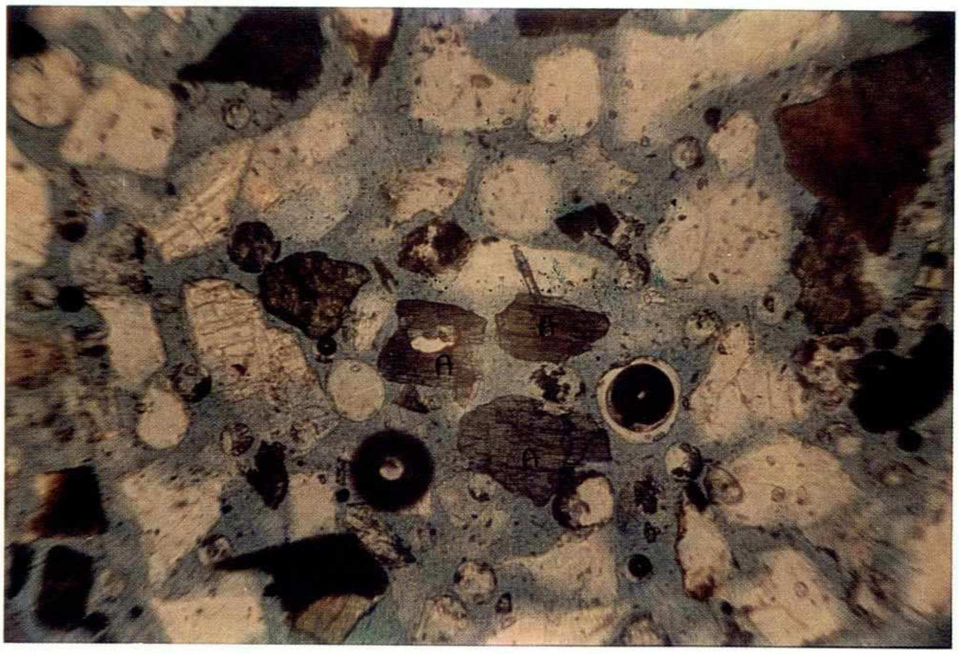

Plate 12 : Jamuna (Bahadurabad) heavy minerals:
A = amphibole (hornblende), G = garnet
(vertical height of photograph : 0.8 mm)

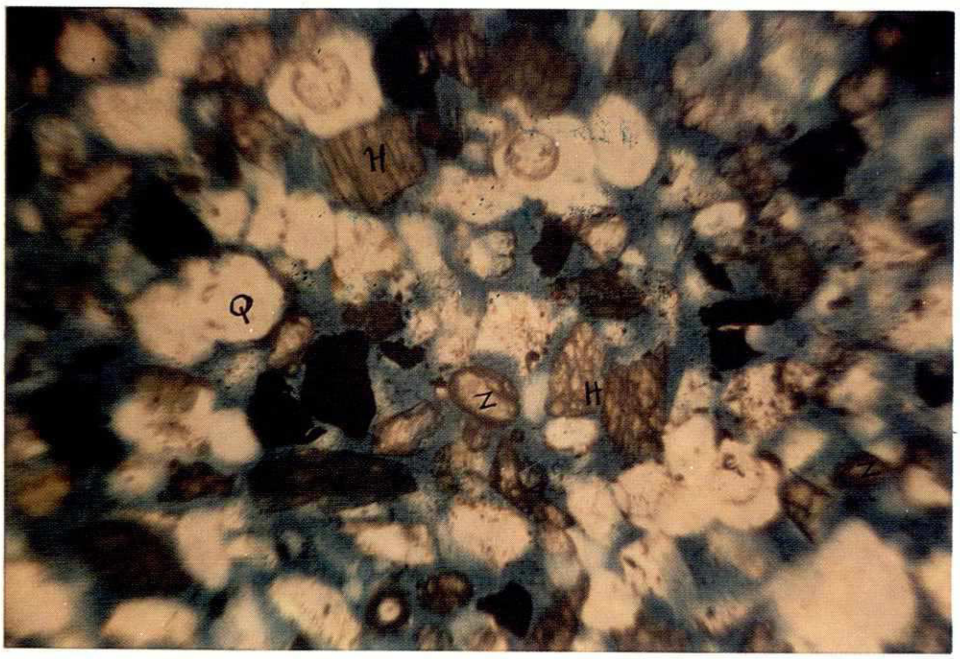

Plate 13 : Padma (Mawa) heavy minerals: H = Hornblende, Z = zircon
(vertical height of photograph : 0.8 mm)

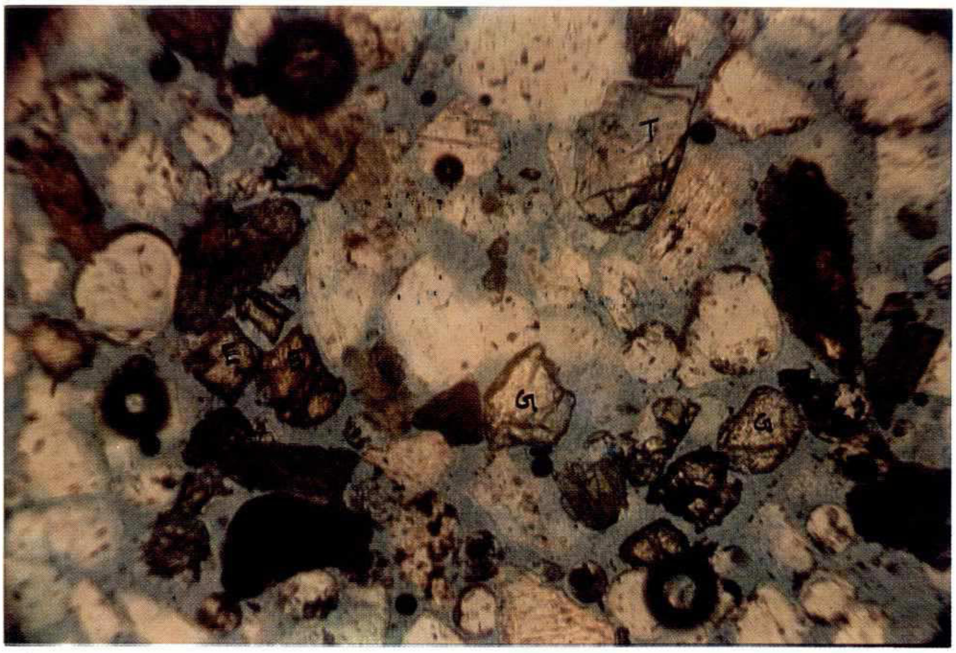

Plate 14 : Jamuna (Bahadurabad) heavy minerals: G = garnet, E = epidote, T = tourmaline, Z = zircon, H = hornblende
(vertical height of photograph : 0.8 mm)

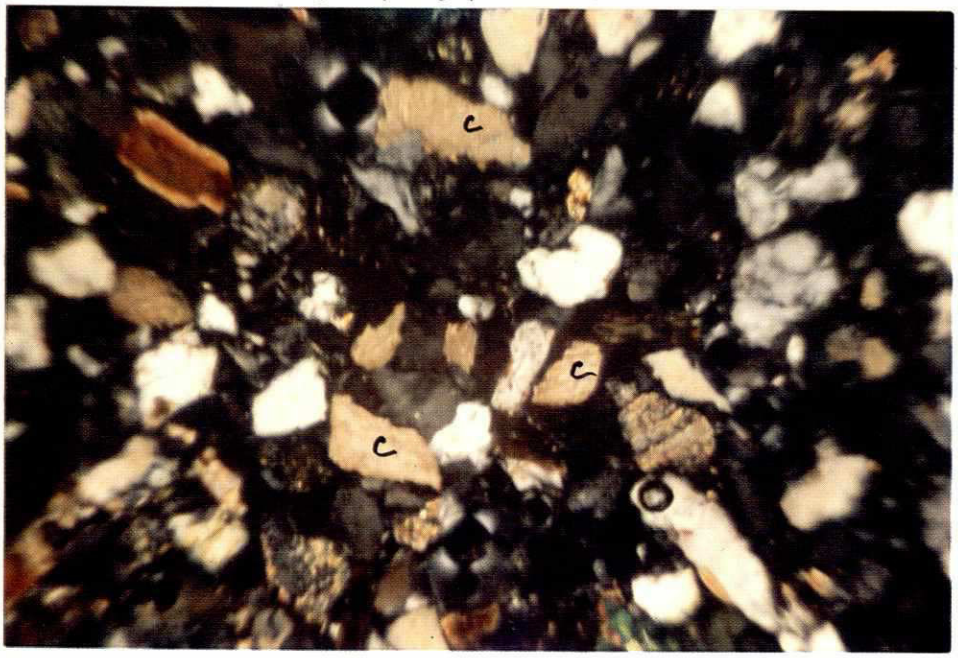

Plate 15 : Ganges River: C = calcite grain
(vertical height of photograph : 0.8 mm)

Location	Quartz %	Feldspar %	Rock fragment %	Mica %	Heavy minerals			Carbonates %	Grain size		
					Am-phiboles Pyroxene %	Non-opaque %	Opaque %		<63 micron %	>63 micron %	D_{50} mm
Teesta	40 ± 17	5 ± 3	10 ± 8	41 ± 28	2 ± 1	2 ± 1	traces	traces	43.82 ± 27	56.18 ± 27	0.077 ± .033
Jamuna (Upstream)	47 ± 5	8 ± 3	22 ± 3	10 ± 3	6 ± 2	5 ± 2	2 ± 2	traces	1.93 ± 3	98.07 ± 3	0.187 ± .066
Jamuna (Bahad-urabad)	42 ± 9	7 ± 3	16 ± 7	26 ± 19	4 ± 3	4 ± 3	1 ± 2	traces	26.24 ± 34	73.76 ± 34	0.135 ± .088
Jamuna (Sirajganj)	41 ± 11	9 ± 3	16 ± 5	20 ± 23	6 ± 2	6 ± 3	2 ± 3	traces	19.22 ± 35	80.78 ± 35	0.152 ± .069
Padma (Mawa)	46 ± 8	8 ± 3	17 ± 5	7 ± 6	8 ± 4	7 ± 4	7 ± 9	traces	3.25 ± 3	96.75 ± 3	0.132 ± .035
Ganges	44 ± 9	8 ± 3	17 ± 5	18 ± 15	3 ± 2	4 ± 2	1	5	20.00 ± 33	80.00 ± 33	0.132 ± .064
Gorai Off-take	53 ± 4	11 ± 1	19 ± 1	11 ± 3	2 ± 1	2 ± 1	traces	2	0.25 ± .044	99.75 ± .044	0.176 ± .007
Meghna (Bhairab)	48 ± 4	10 ± 3	20 ± 3	9 ± 5	6 ± 2	5 ± 2	2 ± 2	traces	26.56 ± 23	73.44 ± 23	0.130 ± .066

Table 5.1.1a: Mineralogical and physical properties of sand for bed material samples before the flood season

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Location	Quartz %	Feldspar %	Rock fragment %	Mica %	Heavy minerals			Carbonates %	Grain size		
					Amphiboles Pyroxene %	Non-opaque %	Opaque %		<63 micron %	>63 micron %	D_{50} mm
Jamuna (Bahadurabad)	40 ± 4	9 ± 4	16 ± 5	26 ± (10)	5 ± (0.6)	4 ± 1	traces	nil	6.58 ± 7	93.42 ± 7	0.190 ± .079
Jamuna (Sirajganj)	40	4	10	39	3	3	traces	traces	1.12	98.88	0.163
Padma (Mawa)	46	7	15	25	2	2	traces	2	47.20	52.80	0.067
Ganges	40 ± 1	6 ± 5	16 ± (0.5)	27 ± 3	2 ± (0.5)	2 ± 1	traces	7	85.13 ± 3	14.87 ± 3	0.010

Table 5.1.1b: Mineralogical and physical properties of sand for near bed material samples before the flood season

Location	Quartz %	Feldspar %	Rock fragment %	Mica %	Heavy minerals			Carbonates %	Grain size		
					Amphiboles Pyroxene %	Non-opaque %	Opaque %		<63 micron %	>63 micron %	D_{50} mm
Jamuna (Bahadurabad)	36 ± 9	5 ± 2	14 ± 2	40 ± 12	2 ± 2	2 ± 1	1	nil	71.18 ± 13	28.82 ± 13	0.042 ± .009
Jamuna (Sirajganj)	47	6	15	27	2	2	1	nil	52.23	46.77	0.058
Padma (Mawa)	49	7	14	23	2	2	3	nil	78.20	21.80	0.036
Ganges	46 ± 0.5	8 ± 2	18 ± 1	23 ± 3	1 ± 0.5	1	traces	2	90.27 ± 5	9.73 ± 5	0.012 ± .002

Table 5.1.1c: Mineralogical and physical properties of sand for suspended load samples before the flood season

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Location	Quartz %	Feldspar %	Rock Fragment %	Mica %	Heavy minerals			Carbonates %	Grain size		
					Amphiboles pyroxene %	Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D 50 mm
Teesta (Upstream)	42 ± 8	6 ± 2	10 ± 2	27 ± 19	3 ± 2	8 ± 9	3 ± 5	Traces	24.49 ± 24	75.51 ± 24	0.093 ± 0.034
Teesta (Confluence)	53 ± 5	8 ± 1	15 ± 2	14 ± 6	4 ± 1	5 ± 1	1 ± 2	Nil	3.85 ± 3	96.15 ± 3	0.137 ± 0.029
Padma (Mawa)	49 ± 4	10 ± 1	19 ± 3	13 ± 9	4 ± 1	3 ± 1	1 ± 1	1 ± 1	6.63 ± 5	93.37 ± 5	0.134 ± 0.041
Padma(Kamergan) On charland	40 ± 4	9 ± 1	16 ± 1	25 ± 4	4 ± 1	3 ± 1	Nil	3 ± 1	39.20 ± 9	60.80 ± 9	0.072 ± 0.006
Padma (Kamergan) on river bed	44 ± 7	8 ± 2	13 ± 3	8 ± 9	8 ± 3	11 ± 5	6 ± 5	2 ± 1	14.18 ± 20	85,82 ± 20	0.119 ± 0.042
Jim's bar (head)	38 ± 1	14 ± 4	38 ± 3	3 ± 1	4 ± 2	3 ± 1	Nil	Nil	2.29 ± 1	97.71 ± 1	0.337 ± 0.006
Jim's bar (middle)	36 ± 3	22 ± 5	35 ± 1	4 ± 4	2 ± 1	1	Nil	Nil	8.41 ± 11	91.59 ± 11	0.295 ± 0.032
Jim's bar (tail)	40 ± 4	20 ± 1	32 ± 2	5 ± 1	2 ± 1	1	Nil	Nil	12.91 ± 12	87.09 ± 12	0.227 ± 0.049
Roy's bar (head)	40 ± 2	15 ± 5	27 ± 9	14 ± 12	3 ± 1	1	Nil	1	35.72 ± 19	64.28 ± 19	0.116 0.056
Roy's bar (middle)	46 ± 4	9 ± 2	20 ± 4	16 ± 9	6 ± 1	3	Trace	Trace	13.59 ± 8	86.41 ± 8	0.120 ± 0.030
Roy's bar (tail)	45 ± 2	12 ± 3	21 ± 4	16 ± 8	4 ± 1	2 ± 1	Nil	Trace	18.27 ± 21	81.73 ± 21	0.100 ± 0.028

Table 5.1.2a : Mineralogical and Physical properties of sand for bed material samples after flood season

Location	Quartz %	Feldspar %	Rock Fragment %	Mica %	Heavy minerals			Carbonates %	Grain size		
					Amphiboles Pyroxene %	Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D - 50 mm
Teesta river (Upstream)	37 ± 5	5 ± 1	8	22 ± 10	3 ± 2	19 ± 18	6 ± 6	Nil	93.33 ± 1	6.67 ± 1	0.019 ± 0.002
Teesta river (Confluence)	43 ± 1	6 ± 2	11 ± 1	32 ± 2	3 ± 1	4	1	Nil	59.76 ± 15	40.24 ± 15	0.050 ± 0.019

Table : 5.1.2b Mineralogical and Physical properties of sand for suspended load after flood season

Location	Depth from surface(m)	Quartz %	Feldspar %	Rock Fragment %	Mica %	Heavy minerals			Carbonates %	Grain size		
						Amphiboles pyroxene %	Non-opaque %	Opaque %		<63 micron %	>63 micron %	D - 50 mm
River bank (south of Bahadurabad ghat) Profile - 1	0.20	59	8	17	12	3	1	Nil	Nil	76.07	23.93	0.032
	0.70	38	7	12	39	3	1	Nil	Nil	85.90	14.10	0.031
	2.50	55	9	20	2	5	6	2	Nil	99.65	0.35	0.006
	5.5	38	7	10	42	1	1	Nil	Trace	94.75	5.25	0.020
River bank (North of Bahadurabad ghat) Profile - 2	0.30	43	7	12	35	1	1	Trace	Trace	52.53	47.47	0.060
	2.40	70	8	12	6	2	1	1	Nil	98.19	1.81	-
	3.90	41	5	11	40	2	1	Nil	Nil	95.03	4.97	0.019
	4.90	43	9	41	2	3	2	Nil	Nil	99.55	0.45	0.006

Table : 5.1.2c: Mineralogical and Physical properties of sand for river bank profiles

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5.1.2 Floodplain sediment

Between 3,000 and 4,000 tons/ha of sediment were deposited at site numbers 1 and 3. At the other sites, however, the sediment deposition varied from 14 to 60 tons/ha. From field observations it was concluded that sites 1 and 3 received sediments primarily from nearby eroded river bank materials. The other sites received sediment as suspended load materials from distant sources.

Quartz

Quartz was the most common mineral found in all floodplain samples. Between 43 and 55 percent quartz was found in sampling sites 3, 4, and 5, while between 11 and 55 percent was found in sites 1,2, and 6. In all except site 2, the cloths contained more minerals than the traps.

Feldspar

Between 5 and 13 percent feldspar was found in higher sites and between three and nine percent was found in lower sites. As with quartz, cloth samples contained more mineral than trap samples, except in site 2.

Mica

More mica was found in higher sites (16 to 41 percent) than in lower sites, with the lowest (five percent) being recorded at site.2. More mica was collected in traps rather than on cloths.

Rock fragments

Unlike other minerals, rock fragments concentrated more (eight to 81 percent) in lower sites than in higher sites (five to 19 percent). In most places, cloths contained more fragments than the traps.

Heavy minerals

The higher sites recorded more (three to 12 percent) heavy minerals than the lower sites. No heavy minerals were present in site 2.

Site no.	Type of Sample	Collection Zone	Quartz %	Feldspar %	Rock Fragment %	Mica %	Heavy minerals			Carbonates %	Grain size		
							Amphiboles Pyroxene %	Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D - 50 mm
1	Trap	Upper layer	36	9	15	32	2	5	1	Nil	43.06	56.94	0.063
1	Trap	Lower layer	47	7	16	19	6	4	1	Nil	50.01	49.99	0.063
1	Cloth	Upper layer	47	8	13	24	4	3	1	Nil	44.20	55.80	0.064
1	Cloth	Lower layer	42	9	12	31	5	1	Nil	Nil	54.28	45.72	0.058
2	Trap	-	56 ± 5	7	16 ± 3	19 ± 4	2	1	Nil	Nil	99.92	0.08	0.006 ± 0.002
2	Cloth	-	11 ± 1	3	81 ± 3	5 ± 3	Nil	Nil	Nil	Nil	99.95	0.05	0.007
3	Trap	Upper layer	48	5	19	16	6	5	1	Nil	15.46	84.54	0.094
3	Trap	Lower layer	43	9	11	30	4	2	1	Nil	76.32	23.68	0.041
3	Cloth	Upper layer	44	13	18	16	4	4	1	Nil	13.95	86.05	0.096
3	Cloth	Lower layer	45	6	10	33	3	2	1	Nil	76.50	23.50	0.042
4	Trap	-	51 ± 4	5	5 ± 3	38 ± 2	1	Nil	Nil	Nil	99.15	0.85	0.010
4	Cloth	-	55 ± 9	7	12	18 ± 6	5 ± 1	4	1	Nil	98.91	1.09	0.013
5	Trap	-	44 ± 2	5	8 ± 2	41	2	1	Nil	Nil	99.08	0.92	0.010
5	Cloth	-	47 ± 3	5 ± 2	11 ± 4	28 ± 10	5	5 ± 2	1	Nil	99.48	0.52	0.016
6	Trap	-	42 ± 2	4	8	39 ± 8	4	3 ± 3	Nil	Nil	98.95	1.05	0.010
6	Cloth	-	53 ± 5	7 ± 2	9 ± 2	27 ± 10	4 ± 1	2 ± 1	Nil	Nil	99.25	0.75	0.015

Table 5.1.3 : Mineralogical and Physical properties of Sand for flood plain sediment

5.2 Silt mineralogy

Although the mineralogical compositions of the sand and silt fractions are similar, the relative percentages of the individual minerals in the latter deviate significantly from those of the former.

5.2.1 River sediment

Quartz and feldspar

Because of the fine grained nature of silts, it was sometimes difficult to distinguish quartz from K-feldspar. One exception was that the twinning behaviour of plagioclase feldspar easily distinguished it from quartz. Because of the distinguishing difficulty, quartz and feldspar were grouped together for the quantitative estimate. Since the physical properties of these two minerals are similar, the grouping did not conflict with the purpose of the mineralogical results. (It is noted, however, that feldspar can undergo a significant metamorphosis, and can change into clay in the process, while quartz will undergo a negligible change).

There were some variations between the samples. Bed samples from the Padma and Jamuna rivers at Sirajganj had a lower quartz and feldspar content (41 percent) than the near-bed and suspended samples from the same river. Conversely, in the Ganges River, the bed samples contained more quartz and feldspar (55 percent) than the near-bed and suspended samples.

The quartz and feldspar content remained the same in the Teesta River after the flood season, but it increased in the Padma to 55 percent. The two minerals are the most commonly found in Jim's and Roy's bars and they are found at a uniformly high level (53 to 65 percent) in all layers of river bank profiles.

Mica

The bed samples of the Teesta River had a higher content (21 percent) of mica than all other places. The lowest amount of mica (five percent) was observed in the Padma River. In general, the suspended load samples showed a higher amount of mica than the bed and near-bed samples.

The mica content in the Teesta River bed samples collected dropped to 15 percent after the flood season, while it rose to 10 percent in the Padma. In Teesta River suspended load samples, however, the mica content rose to between 22 and 40 percent. Jim's bar had more mica (17 percent) than Roy's bar (nine percent).

In river bank profiles, more mica (five to 12 percent) was found in the silt fractions than in the sand fractions. Mica distribution was more or less uniform.

Rock fragments

In bed samples, the Teesta River contained a small amount (three percent) of rock fragments; 11 percent was recorded in the Gorai and Meghna rivers. Little variation was observed between the samples types at different locations.

After the flood season, the rock fragment content in the Teesta dropped to two percent. There was little difference in rock fragment content between Jim and Roy's bars.

The amount present in both river bank profiles was uniform, ranging from seven to 13 percent.

Heavy minerals

Of the bed samples, the silt fractions contained more heavy minerals than the sand fractions. The Padma River had the highest percentage (48 percent) of heavy minerals of all the rivers; the Teesta River had 17 percent. In the near-bed and suspended samples, however, the Padma River did not have more heavy mineral content than the other rivers. There was little difference in results between sample types at most sites.

After the flood season, the heavy mineral content rose to 36 percent in the bed samples of the Teesta, but fell to 28 percent in the Padma. In the suspended load samples of the Teesta, there was higher heavy mineral content upstream (40 percent) than at the confluence (22 percent). In both river bank profiles, the surface layer had more heavy minerals (27 to 31 percent) than the other profile layers.

In the silt fractions, amphiboles and pyroxene were present in amounts similar to many other heavy minerals, making it impossible, and unnecessary, to separate the two from other heavy minerals. In the sand fractions, however, the abundance and colour characteristics made amphiboles and pyroxene easily distinguishable from other nonopaque heavy minerals.

Carbonates

Appreciable amounts of carbonates were found only in the Ganges and Padma rivers.

Location	Quartz + feldspar %	Rock fragment %	Mica %	Heavy minerals		Carbonates %	Grain size		
				Non-opaque %	Black opaque %		< 63 micron %	> 63 micron %	D_{50} mm
Teesta	53 ± 9	3 ± 3	27 ± 15	15 ± 7	2 ± 1	nil	43.82 ± 27	56.18 ± 27	0.077 ± .033
Jamuna (Upstream)	51 ± 6	5 ± 2	5 ± 2	32 ± (4)	6 ± 2	nil	1.93 ± 3	98.07 ± 3	0.187 ± .066
Jamuna (Bahad-urabad)	53 ± 7	7 ± 2	11 ± 10	26 ± (8)	3 ± 2	nil	26.24 ± 34	73.76 ± 34	0.135 ± .088
Jamuna (Sirajg-anj)	49 ± 7	8 ± 2	14 ± 12	26 ± 8	3 ± 3	nil	19.22 ± 35	80.78 ± 35	0.152 ± .069
Padma (Mawa)	41 ± 8	5 ± 1	5 ± 3	33 ± (5)	15 ± 9	1	3.25 ± 3	96.75 ± 3	0.132 ± .035
Ganges	55 ± 7	9 ± 3	11 ± 6	19 ± 6	4 ± 5	2	20.00 ± 33	80.00 ± 33	0.132 ± .064
Gorai Off-take	58 ± 4	11 ± 3	6 ± 4	19 ± 8	5 ± 2	1	0.25 ± .044	99.75 ± .044	0.176 ± .007
Meghna (Bhai-rab)	52 ± 4	11 ± 2	14 ± 10	20 ± 7	3 ± 2	nil	26.56 ± 23	73.44 ± 23	0.130 ± .066

Table 5.2.1a: Mineralogical and physical properties of silt for bed material samples before the flood season

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Location	Quartz + feldspar %	Rock fragment %	Mica %	Heavy minerals		Carbonates %	Grain size		
				Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D_{50} mm
Jamuna (Bahadurabad)	52 ± 8	7 ± 3	9 ± 7	28 ± 7	4 ± 5	nil	6.58 ± 7	93.42 ± 7	0.191 ± .079
Jamuna (Sirajganj)	55	5	13	25	2	nil	1.12	98.88	0.163
Padma (Mawa)	65	8	10	15 ± 5	1	1	47.20	52.80	0.067
Ganges	49 ± 4	10 ± 4	21 ± 5	14 ± 2	2 ± 0.5	4	85.13 ± 3	14.87 ± 3	0.013

Table 5.2.1b: Mineralogical and physical properties of silt for near bed samples before the flood season

Location	Quartz + feldspar %	Rock fragment %	Mica %	Heavy minerals		Carbonates %	Grain size		
				Non-opaque %	Black opaque %		<63 micron %	>63 micron %	D - 50 mm
Jamuna (Bahadurabad)	56 ± 6	6 ± 6	14 ± 8	22 ± 4	1 ± 0.5	nil	71.18 ± 13	28.82 ± 13	0.042 ± .009
Jamuna (Sirajganj)	54	5	19	21	1	nil	52.23	46.77	0.058
Padma (Mawa)	62	5	18	13	1	traces	78.20	21.80	0.036
Ganges	52 ± 3	8 ± 0.5	19 ± 7	18 ± 7	2 ± 2	1	90.27 ± 5	9.73 ± 5	0.012 ± .002

Table 5.2.1c: Mineralogical and physical properties of silt for suspended load samples before the flood season

Location	Quartz + Feldspar %	Rock Fragment %	Mica %	Heavy minerals		Carbonates %	Grain size		
				Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D - 50 mm
Teesta (Upstream)	50 ± 8	2 ± 1	15 ± 10	26 ± 10	6 ± 6	1 ± 1	24.49 ± 24	75.51 ± 24	0.093 ± 0.034
Teesta (Confluence)	53 ± 6	2 ± 1	9 ± 2	30 ± 5	6 ± 3	Trace	3.85 ± 3	96.15 ± 3	0.137 ± 0.029
Padma (Mawa)	55 ± 6	5 ± 1	10 ± 6	24 ± 8	4 ± 3	2 ± 1	6.63 ± 5	93.37 ± 5	0.134 ± 0.041
Padma(Kamargaon) On charland	53 ± 3	9 ± 1	10 ± 3	25 ± 1	2 ± 1	1	39.20 ± 9	60.80 ± 9	0.072 ± 0.006
Padma (Kamargaon) on river bed	45 ± 7	9 ± 3	18 ± 10	21 ± 11	5 ± 5	2 ± 2	14.18 ± 20	85.82 ± 20	0.119 ± 0.042
Jim's bar (head)	56 ± 2	6 ± 1	17 ± 2	19 ± 1	1	1	2.29 ± 1	97.71 ± 1	0.337 ± 0.006
Jim's bar (middle)	54 ± 6	7 ± 2	9 ± 4	27 ± 3	3 ± 1	Trace	8.41 ± 11	91.59 ± 11	0.295 ± 0.032
Jim's bar (tail)	59 ± 7	10 ± 1	11 ± 2	18 ± 4	1 ± 1	1	12.91 ± 12	87.09 ± 12	0.227 ± 0.049
Roy's bar (head)	58 ± 3	8 ± 2	6 ± 2	24 ± 4	2 ± 1	Trace	35.72 ± 19	64.28 ± 19	0.116 0.056
Roy's bar (middle)	51 ± 6	7 ± 1	9 ± 2	30 ± 7	2 ± 2	1	13.59 ± 8	86.41 ± 8	0.120 ± 0.030
Roy's bar (tail)	47 ± 9	6 ± 2	5 ± 1	35 ± 9	7 ± 3	Traces	18.27 ± 21	81.73 ± 21	0.100 ± 0.028

Table 5.2.2a : Mineralogical and Physical properties of Silt for Bed Materials after flood season

Location	Quartz + Feldspar %	Rock Fragment %	Mica %	Heavy minerals		Carbonates %	Grain size		
				Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D - 50 mm
Teesta river (upstream)	44 ± 6	4	11 ± 9	31 ± 6	9 ± 9	1	93.33 ± 1	6.67 ± 1	0.019 ± 0.002
Teesta river (confluence)	61 ± 7	5	11 ± 5	21 ± 1	2	Nil	59.76 ± 15	40.24 ± 15	0.050 ± 0.019

Table 5.2.2b : Mineralogical and Physical properties of Silt for suspended load after flood season

Location	Depth from surface (m)	Quartz + Feldspar %	Rock Fragment %	Mica %	Heavy minerals		Carbonates %	Grain size		
					Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D - 50 mm
River bank (South of Bahadurabad ghat) Profile-1	0.20	55	8	10	26	1	Nil	76.07	23.93	0.032
	0.70	62	10	7	20	Nil	1	85.90	14.10	0.031
	2.50	59	12	9	19	1	Nil	99.65	0.35	0.006
	5.5	62	7	12	18	1	Nil	94.75	5.25	0.020
River bank (North of Bahadurabad ghat) Profile-2	0.30	53	8	8	29	2	Nil	52.53	47.47	0.060
	2.40	64	11	7	17	1	Nil	98.19	1.81	-
	3.90	61	13	12	10	4	Nil	95.03	4.97	0.019
	4.90	65	13	5	16	1	Nil	99.55	0.45	0.006

Table 5.2.2c : Mineralogical and Physical properties of Silt for river bank profiles

5.2.2 Floodplain sediment

Quartz and feldspar

Lower floodplain sites held more quartz and feldspar (44 to 63 percent) than higher sites, although the lowest amount (35 percent) was recorded at one low sampling site. At some sites, there were content variations between sample types. More quartz and feldspar was recorded in traps than on cloths, except at site 1.

Mica

Higher sampling sites contained the most mica (28 percent), while the smallest amount (four percent) was recorded at a low site. There was little variation between sample types at most sites.

Rock fragments

Rock fragments were more concentrated (six to 22 percent) in lower topographical sites than higher ones (three to 17 percent). There was little variation between sample types.

Heavy minerals

Heavy minerals were more associated with silt fractions than sand fractions. The largest amount (39 percent) was recorded in the top layers of site 3 and smallest amount (18 percent) was recorded in a trap sample in site 4. Otherwise, the amount of heavy minerals did not significantly vary between sites or sample types.

5.3 Clay mineralogy

Illite was the most common mineral found in the clay fraction; kaolinite and chlorite were the next most abundant. Montmorillonite appeared only in the Ganges River, where at one site it represented six percent of the total minerals.

Variations in clay mineralogy was not apparent in either the rivers or floodplain sampling sites.

Site no.	Type of Sample	Collection Zone	Quartz + Feldspar %	Rock Fragment %	Mica %	Heavy minerals		Carbonates %	Grain size		
						Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D - 50 mm
1	Trap	Upper layer	48	11	9	31	1	nil	43.06	56.94	0.063
1	Trap	Lower layer	63	8	7	21	1		50.01	49.99	0.063
1	Cloth	Upper layer	57	7	6	30	nil	nil	44.20	55.80	0.064
1	Cloth	Lower layer	53	8	11	25	2	1	54.28	45.72	0.058
2	Trap	-	46 ± 8	17 ± 8	9	28	Trace	Trace	99.92	0.08	0.006 ± 0.002
2	Cloth	-	44 ± 5	22 ± 5	7 ± 1	27 ± 1	Trace	Nil	99.95	0.05	0.007
3	Trap	Upper layer	49	5	6	32	7	1	15.46	84.54	0.094
3	Trap	Lower layer	53	7	9	30	1	Trace	76.32	23.68	0.041
3	Cloth	Upper layer	47	3	10	37	2	1	13.95	86.05	0.096
3	Cloth	Lower layer	62	11	5	18	2	2	76.50	23.50	0.042
4	Trap	-	53 ± 13	17 ± 12	12 ± 4	18 ± 3	Trace	Trace	99.15	0.85	0.010
4	Cloth	-	35 ± 4	15 ± 4	28 ± 2	22 ± 2	Trace	Trace	98.91	1.09	0.013
5	Trap	-	57 ± 6	9	7 ± 1	27 ± 7	Trace	Nil	99.08	0.92	0.010
5	Cloth	-	55 ± 6	8 ± 3	7	27 ± 4	2	1	99.48	0.52	0.016
6	Trap	-	61 ± 3	11 ± 1	4	24	Trace	Trace	98.95	1.05	0.010
6	Cloth	-	52 ± 5	6	11 ± 5	27 ± 10	2	2	99.25	0.75	0.015

Table 5.2.3 : Mineralogical and Physical properties of Silt for flood plain sediment

Location	Illite %	Kaolinite + chlorite %	Montmorillonite %
Teesta	73	27	nil
Jamuna (Upstream)	72	28	nil
Jamuna (Bahadurabad)	70	30	nil
Jamuna (Sirajganj)	71	29	nil
Padma (Mawa)	73	27	nil
Ganges	74	24	2
Gorai	72	28	nil
Meghna (Bhairab Bazar)	69	31	nil

Table 5.3.1a: Physical properties of clay for bed material samples

Location	Illite %	Kaolinite + chlorite %	Montmorillonite %
Jamuna (Bahadurabad)	78	22	nil
Jamuna (Sirajganj)	73	27	nil
Padma (Mawa)	76	24	nil
Ganges	71	29	nil

Table 5.3.1b: Physical properties of clay for near bed material samples

Location	Illite %	Kaocinite + chlorite %	Montmorillonite %
Jamuna (Bahadurabad)	72	28	nil
Jamuna (Sirajganj)	64	36	nil
Padma (Mawa)	67	33	nil
Ganges	71	29	nil

Table 5.3.1c: Physical properties of clay for suspended load samples

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Location	Illite %	Kaocinite + chlorite %	Montmorillonite %
Jim's bar	65	35	nil
Roy's bar	64	36	nil

Table 5.3.2a: Physical properties of clay for Jim's bar and Roy's bar

Location	Depth from surface (m)	Illite %	Kaolinite + chlorite %	Montmorillonite %
River bank (South of bahadurabad ghat) Profile-1	0.20	66	34	nil
	0.70	79	21	nil
	2.50	63	37	nil
	5.50	64	36	nil
River bank (North of Bahadurabad ghat) Profile-2	0.30)	77	23	nil
	2.40	74	26	2
	3.90	64	36	nil
	4.90	67	33	nil

Table 5.3.2b: Physical properties of clay of river bank profiles

Sampling Site no.	Illite %	Kaocinite + chlorite %	Montmorillonite %
1	69	31	nil
2	68	32	nil
3	74	26	nil
4	70	30	nil
5	69	31	nil
6	70	30	nil

Table 5.3.3: Physical properties of clay for Floodplain sediment

5.4 Grain sizes

5.4.1 Grain sizes of river sediment

Bed samples contain more sand than silt and clay particles at all sampling sites. The most sand (99 percent) was recorded in the upper Jamuna and Gorai rivers; the least (56 percent) was recorded in the Teesta River. After flood season, however, sand in the Teesta samples increased to 96 percent. Near-bed samples were similar to the bed samples, except in the Ganges where silt and clay dominate sand. Silt and clay particles were more common than sand in suspended load samples, with the Ganges and Padma rivers containing the most.

There was more sand than silt and clay at both Jim's and Roy's bars: 97 percent at Jim's bar; 64 percent at Roy's bar. River bank profiles, however, were dominated by silt and clay.

5.4.2 Grain sizes of floodplain sediment

Silt and clay particles were found in 99 percent of all sampling sites, except in sites 1 and 3. As previously mentioned in section 4.1.2, sediments from these sites are transported with eroded river bank materials. Therefore, the grain sizes were predominantly sand in the upper layers (57 to 84 percent), but were predominantly silt and clay (50 to 76 percent) in the lower levels. These lower level grains were believed to be mixed with suspended load materials.

5.5 Shape variables

5.5.1 Shape variables of river sediment

Sphericity

Bed sample sand fractions from the upper Jamuna, Bahadurabad, and the Meghna River, were spherical (index 4.5). At other sites, the fractions were sub-prismoidal (index -2.5). In the near-bed and suspended samples, the sand was mostly sub-prismoidal. All the samples from Jim's bar were spherical. The head and tail section of Roy's bar had sub-prismoidal fractions, but spherical fractions were found in the middle section. Sand fractions from river bank profiles were spherical in most layers.

Angularity

All bed and near-bed samples were similar in roundness characteristics. Most were sub-rounded (index 3.5), but some were sub-angular (index 2.5). In the suspended samples, the angularity ranged between sub-angular and sub-rounded. The sub-rounded characteristics of the samples did not change after the flood season in the Teesta and Padma rivers. Sand fractions of all river bank profile layers were sub-angular.

5.5.2 Shape variables of floodplain sediment

Sphericity

The sand fractions at all sampling sites were sub-prismoidal, except at site 2 where they were spherical.

Angularity

The sand fractions of all sediment samples were sub-angular.

Location	Density (g/cm^3)	Sphericity	Angularity	Shape factor	Grain size		
					< 63 micron %	> 63 micron %	D_{50} mm
Teesta	2.74	- 2.5	2.5 - 3.5	0.712	43.82 ± 27	56.18 ± 27	0.077 ± .033
Jamuna (Upstream)	2.78	4.5	3.5	0.737	1.93 ± 3	98.07 ± 3	0.187 ± .066
Jamuna (Bahadurabad)	2.79	4.5	2.5 - 3.5	0.737	26.24 ± 34	73.76 ± 34	0.135 ± .088
Jamuna (Sirajganj)	2.78	- 2.5	2.5 - 3.5	0.699	19.22 ± 35	80.78 ± 35	0.152 ± .069
Padma (Mawa)	2.93	- 2.5 - 4.5	2.5 - 3.5	0.724	3.25 ± 3	96.75 ± 3	0.132 ± .035
Ganges	2.75	-2.5	2.5 - 3.5	0.705	20.00 ± 33	80.00 ± 33	0.132 ± .064
Gorai	2.74	--	3.5	--	0.25 ± .044	99.75 ± .044	0.176 ± .007
Meghna (Bhairab Bazar)	2.79	4.5	2.5 - 3.5	0.709	26.56 ± 23	73.44 ± 23	0.130 ± .066

Table 5.4.1a: Physical properties of bed material samples

Location	Density (g/cm^3)	Sphericity	Angularity	Shape factor	Grain size		
					< 63 micron %	> 63 micron %	D_{50} mm
Jamuna (Bahadurabad)	2.77	4.5	3.5	0.753	6.58 (± 7)	93.42 ± 7	0.190 ± .079
Jamuna (Sirajganj)	2.75	- 2.5	2.5	0.674	1.12	98.88	0.163
Padma (Mawa)	--	- 2.5	3.5	0.710	47.20	52.80	0.067
Ganges	--	- 2.5	3.5	0.698	85.13 (± 3)	14.87 ± 3	.010

Table 5.4.1b: Physical properties of near-bed samples

Location	Density (g/cm^3)	Sphericity	Angularity	Shape factor	Grain size		
					< 63 micron %	> 63 micron %	D_{50} mm
Jamuna (Bahadurabad)	--	2.5	2.5 - 3.5	0.763	71.18 ± 13	28.82 ± 13	0.042 ± .009
Jamuna (Sirajganj)	--	- 2.5	3.5	0.717	52.23	46.77	0.058
Padma (Mawa)	--	- 2.5	2.5	0.713	78.20	21.80	0.036
Ganges	--	--	2.5 - 3.5	--	90.27 ± 5	9.73 ± 5	0.012 ± .002

Table 5.4.1c: Physical properties of suspended load samples

Location	Density (g/cm^3)	Sphericity %	Angularity	Shape sector	Grain size		
					<63 micron %	>63 micron %	D - 50 mm
Teesta (Upstream)	2.86	-	2.5 - 3.5	-	24.49 ± 24	75.51 ± 24	0.093 ± 0.034
Teesta (Confluence)	2.73	-	2.5	-	3.85 ± 3	96.15 ± 3	0.137 ± 0.029
Padma (Mawa)	2.70	-	2.5 - 3.5	-	6.63 ± 5	93.37 ± 5	0.134 ± 0.041
Padma(Kamargaon) On charland	2.73	-	2.5	-	39.20 ± 9	60.80 ± 9	0.072 ± 0.006
Padma (Kamargaon) On river bed	2.82	-	2.5	-	14.18 ± 20	85,82 ± 20	0.119 ± 0.042
Jim's bar (head)	2.70	4.5	2.5	0.706 ± 0.031	2.29 ± 1	97.71 ± 1	0.337 ± 0.006
Jim's bar (middle)	2.70	4.5	2.5	0.707 ± 0.021	8.41 ± 11	91.59 ± 11	0.295 ± 0.032
Jim's bar (tail)	2.75	4.5	2.5	0.708 ± 0.017	12.91 ± 12	87.09 ± 12	0.227 ± 0.049
Roy's bar (head)	2.72	-2.5	2.5	0.706 ± 0.013	35.72 ± 19	64.28 ± 19	0.116 0.056
Roy's bar (middle)	2.72	4.5	2.5	0.710 ± 0.013	13.59 ± 8	86.41 ± 8	0.120 ± 0.030
Roy's bar (tail)	2.72	-2.5	2.5	0.701 ± 0.022	18.27 ± 21	81.73 ± 21	0.100 ± 0.028

Table 5.4.2a : Physical properties of bed material samples of rivers after flood season

Location	Density (g/cm³)	Sphericity	Angularity	Shape factor	Grain size		
					<63 micron %	>63 micron %	D - 50 mm
Teesta river (Upstream)			2.5		93.33 ± 1	6.67 ± 1	0.019 ± 0.002
Teesta river (Confluence)			2.5		59.76 ± 15	40.24 ± 15	0.050 ± 0.019

Table 5.4.2b : Physical properties of suspended load samples

Location	Depth from surface(m)	Density (g/cm³)	Sphericity	Augularity	Shape factor	Grain size		
						<63 micron %	>63 micron %	D - 50 mm
River bank (south of Bahadurabad ghat) Profile - 1	0.20	2.73	4.5	2.5	0.717 ±0.031	76.07	23.93	0.032
	0.70	2.78	4.5	2.5	0.713 ± 0.023	85.90	14.10	0.031
	2.50	2.78	4.5	2.5	0.711 ± 0.042	99.65	0.35	0.006
	5.5	2.77	4.5	2.5	0.069 ± 0.019	94.75	5.25	0.020
River bank (North of Bahadurabad ghat) Profile - 2	0.30	2.70	4.5	2.5	0.720 ± 0.041	52.53	47.47	0.060
	2.40	2.72	-2.5	2.5	0.713 ± 0.011	98.19	1.81	
	3.90	2.76	4.5	2.5	0.710 ± 0.010	95.03	4.97	0.019
	4.90	2.65	4.5		0.713 ± 0.027	99.55	0.45	0.006

Table 5.4.2c : Physical properties of river bank profiles

Site no.	Type of Sample	Collection Zone	Density (g/cm^3)	Sphericity	Angularity	Shape factor	Grain size		
							<63 micron %	>63 micron %	D - 50 mm
1	Trap	Upper layer	2.72	-	2.5	-	43.06	56.94	0.063
1	Trap	Lower layer	2.75	-	2.5	-	50.01	49.99	0.063
1	Cloth	Upper layer	2.74	-2.5	2.5	0.716 ± 0.04	44.20	55.80	0.064
1	Cloth	Lower layer	2.77	-2.5	2.5	0.719 ± 0.034	54.28	45.72	0.058
2	Trap	-	-	4.5	2.5	0.710 ± 0.021	99.92	0.08	0.006 ± 0.002
2	Cloth	-	2.68	4.5	2.5	0.704 ± 0.053	99.95	0.05	0.007
3	Trap	Upper layer	2.74	-	2.5	-	15.46	84.54	0.094
3	Trap	Lower layer	2.75	-	2.5	30	76.32	23.68	0.041
3	Cloth	Upper layer	2.76	-2.5	2.5	0.717 ± 0.021	13.95	86.05	0.096
3	Cloth	Lower layer	2.78	-2.5	2.5	0.709 ± 0.021	76.50	23.50	0.042
4	Trap	-	2.69	2.5	2.5	0.713 ± 0.011	99.15	0.85	0.010
4	Cloth	-	2.71	-2.5	2.5	0.699 ± 0.016	98.91	1.09	0.013
5	Trap	-	-	-2.5	2.5	0.703 ± 0.019	99.08	0.92	0.010
5	Cloth	-	2.67	-2.5	2.5	0.701 ± 0.027	99.48	0.52	0.016
6	Trap	-	-	2.5	2.5	0.719 ± 0.031	98.95	1.05	0.010
6	Cloth	-	2.70	-2.5	2.5	0.697 ± 0.031	99.25	0.75	0.015

Table 5.4.3 : Physical properties of floodplain sediment

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6 Discussion and interpretation

The differences found in sediment properties of the major rivers should be considered when evaluating the morphological behaviour of these rivers.

Grain size analyses of river sites showed that sand dominated silt and clay at most sites on the rivers, except in sediments deposited on the floodplain. The mineralogical composition of sand and silt is more or less similar, but clay particles hold completely different types of minerals. Minerals in clay particles are chemically sensitive, but physically more stable. Sand and silt minerals are supposed to be more physically active than the clay minerals. Little variation in the mineralogical characteristics of clay was observed on the major rivers.

6.1 Linkages between physical and mineralogical properties

It was found that the physical properties of sediments are related to the mineralogical properties. Of all the rivers, the Teesta, Jamuna, Padma, and Ganges rivers had more mica and heavy minerals in the finer fraction particles (i.e., with a low value of D_{50}) (Figures 6.1 and 6.2). Rock fragments and quartz increased toward higher D_{50} values in all rivers except the Gorai (Figures 6.3 and 6.4).

Due to a high level of heavy minerals, the Padma River showed an exceptionally high sediment density as compared with other rivers. Similarly, a high sediment density was observed in connection with a high heavy minerals content in the Jamuna, Padma, and Meghna rivers sampling areas (Figure 6.5a). It was observed that the density ranges from 2.7 to 2.9 g/cm^3 when sediment contains up to 30 percent of heavy minerals (Figure 6.5b).

Only in the Teesta River did rock fragments and quartz values show a trend toward increasing higher densities (Figure 6.6a). Conversely, samples from the upper reaches of the Jamuna, Sirajganj, and Padma Rivers showed a decreasing trend toward a higher density (Figure 6.6b). In other rivers, the relationship is not understood and warrants further investigation.

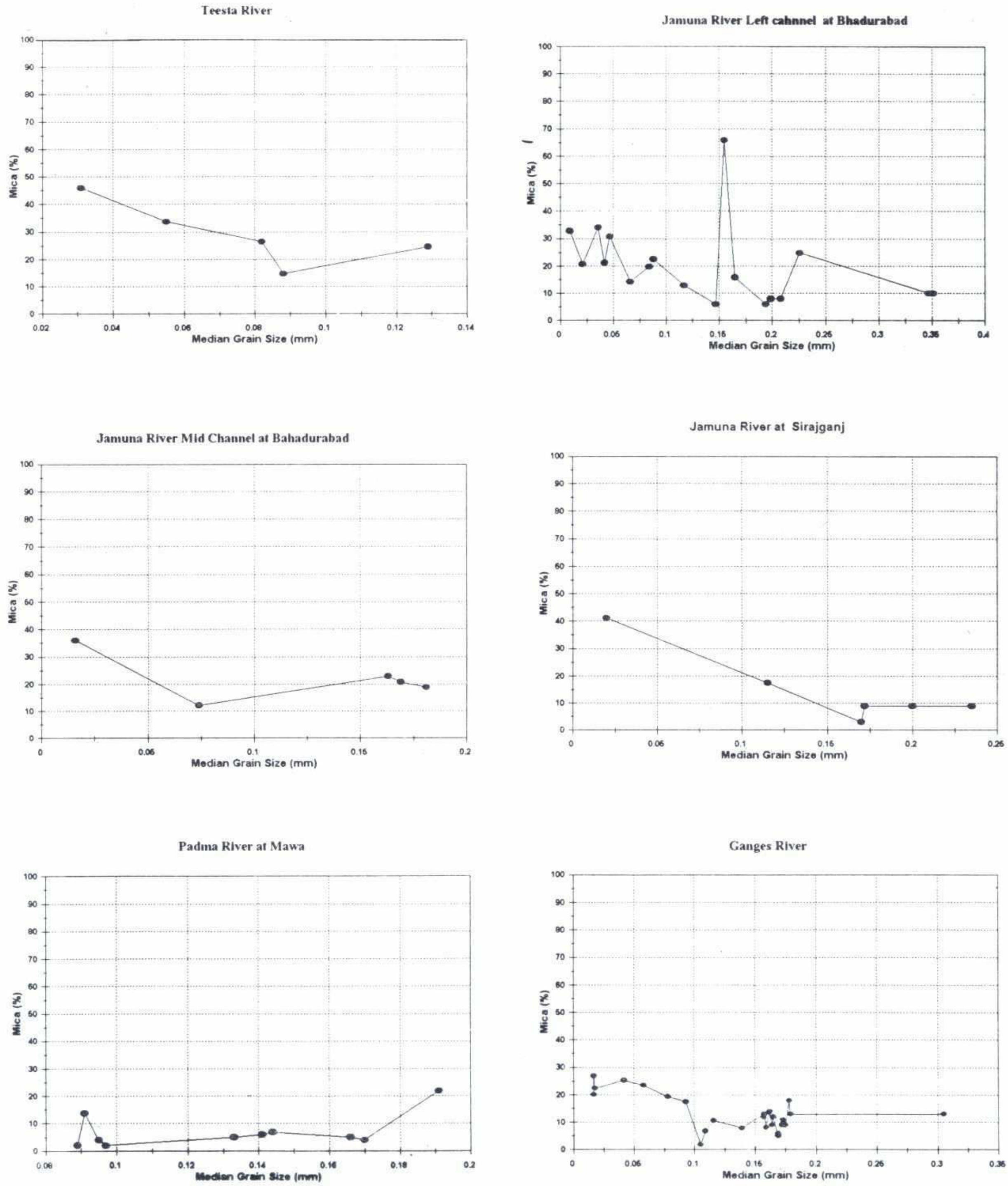

Figure 6.1: Median grain size versus mica

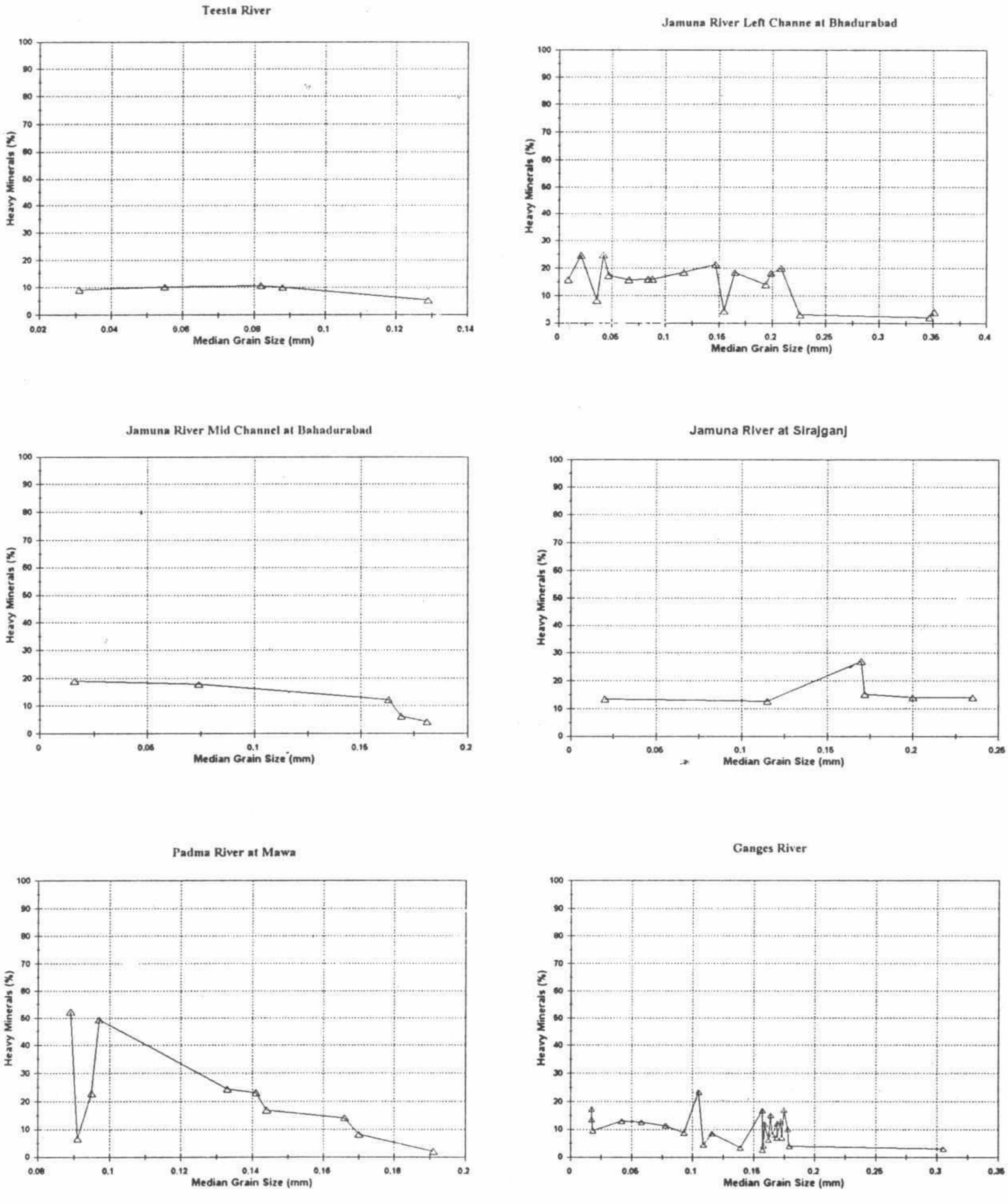

Figure 6.2: Median grain size versus heavy minerals

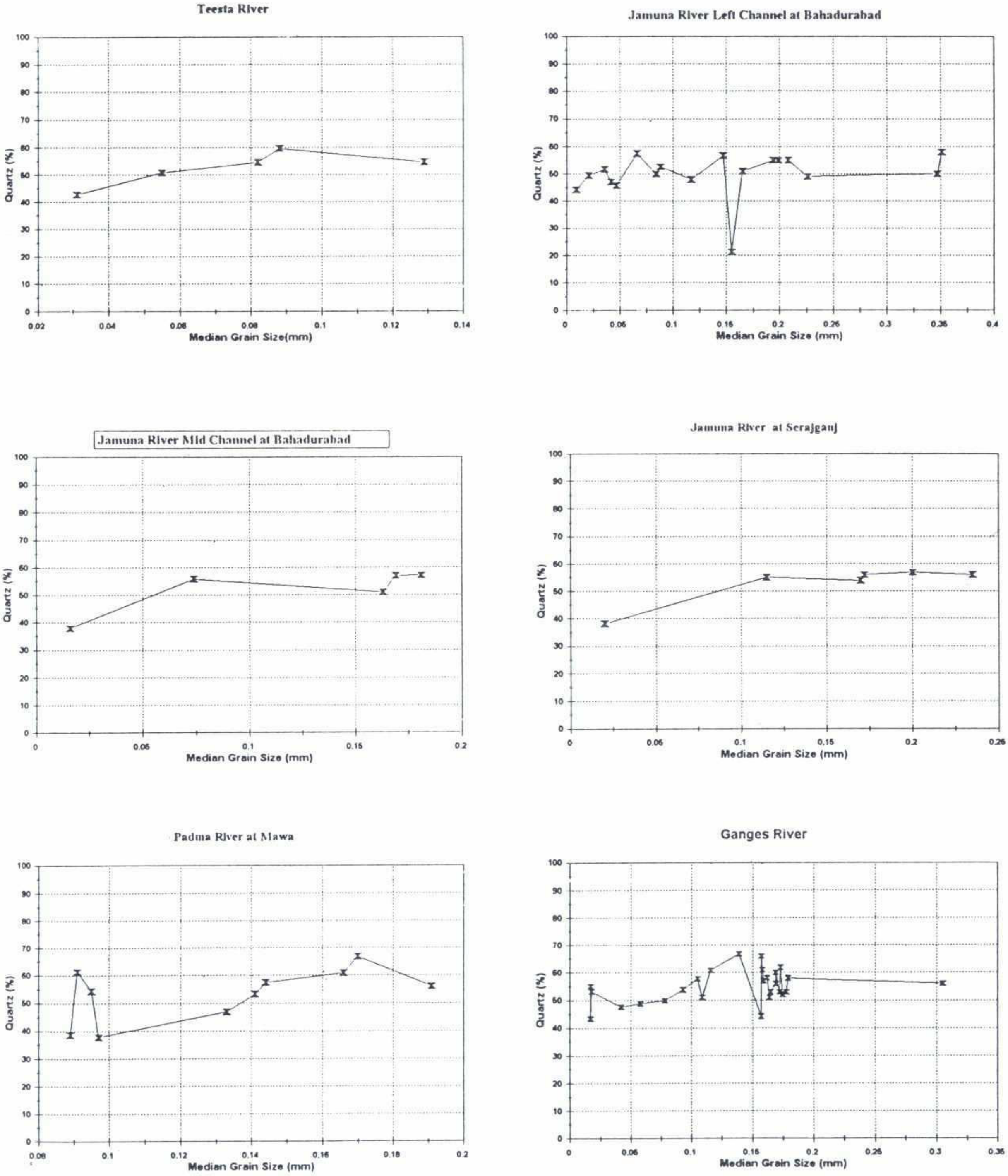

Figure 6.3: Median grain size versus quartz

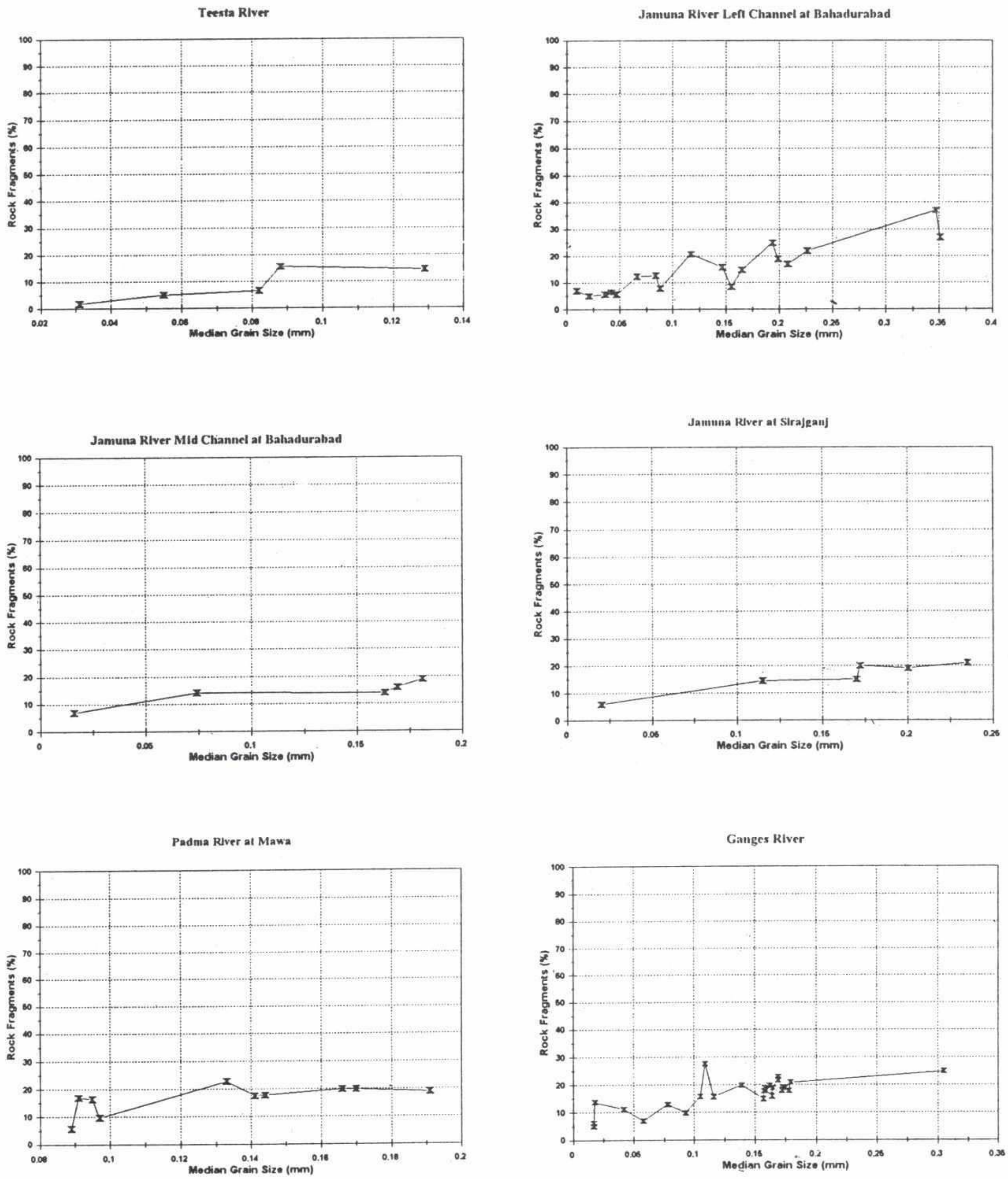

Figure 6.4: Median grain size versus rock fragments

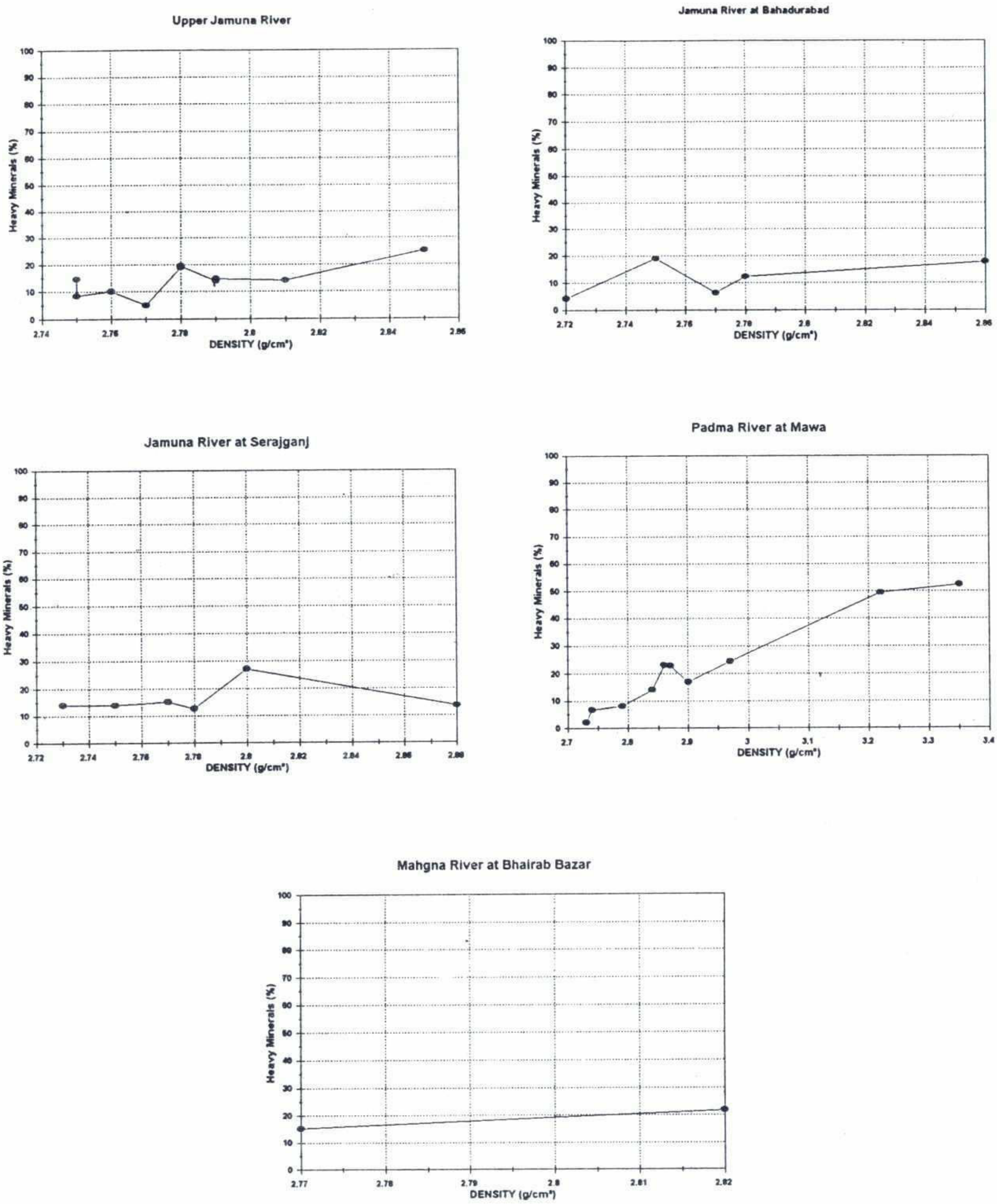

Figure 6.5a: Density versus heavy minerals

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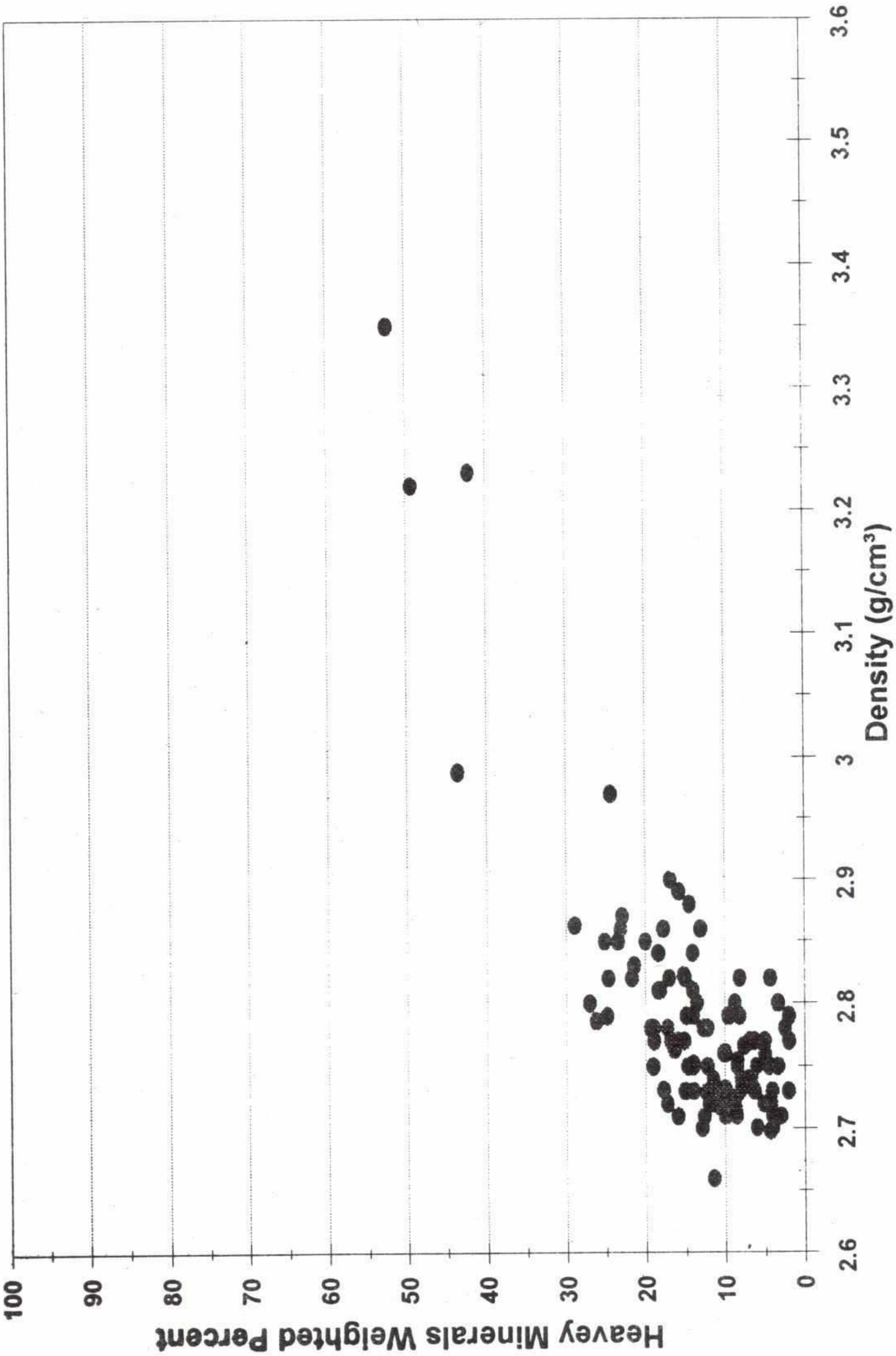

Figure 6.5b: Relation between heavy minerals and density of the sediment samples

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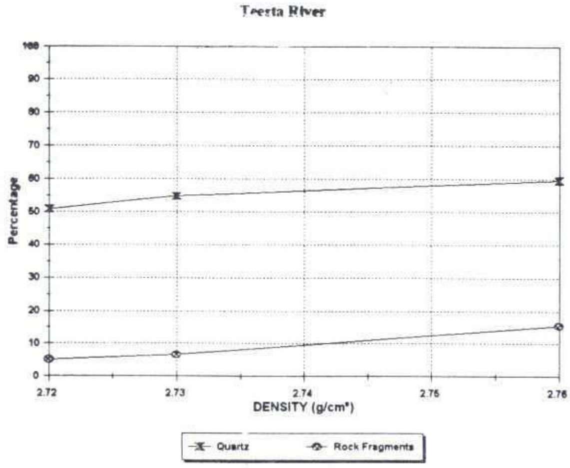

Figure 6.6a: Density versus quartz and rock fragments

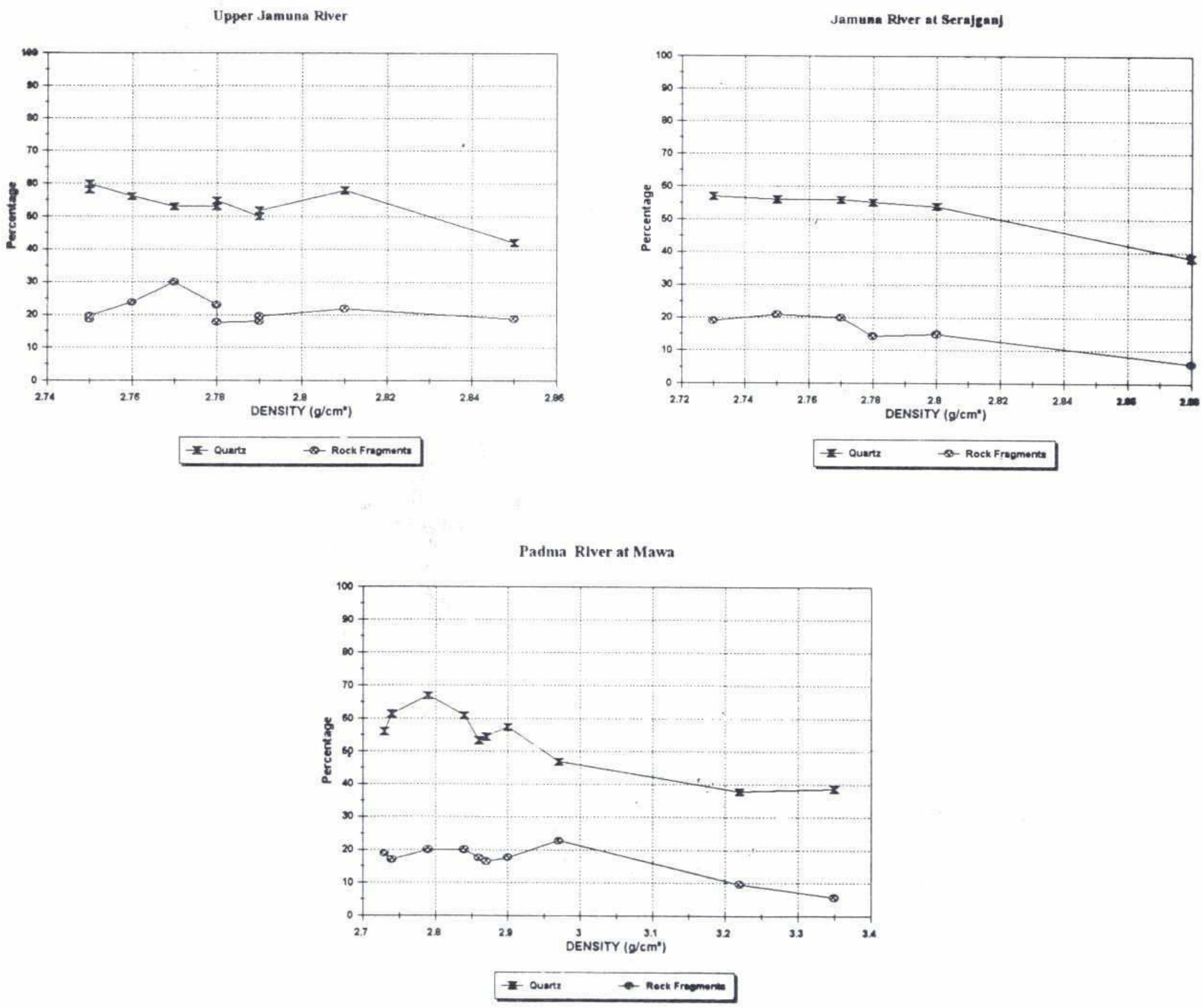

Figure 6.6b: Density versus quartz and rock fragments

6.2 Relationship between mica and heavy minerals

High concentrations of mica were found in the Teesta River, as were high concentrations of heavy minerals found in the Padma River. The mica content was low in upstream reaches of the Jamuna River, but the amount increased immediately below its confluence with the Teesta, indicating that the Teesta is a major source of mica to the Jamuna.

The concentration of heavy minerals in the Padma River needs further examination. Both the Jamuna and the Ganges rivers carry heavy minerals. The cumulative behaviour of these two rivers may be responsible for the higher values. Reversely, the mica content was less in the Padma River.

In the preceding chapter, it was noted that mica and heavy minerals were mostly associated with finer particles. The presence of mica tended to lower the sediment density, whereas heavy minerals contributed to an increase in sample densities.

An attempt was made to establish a relationship between mica and heavy minerals in the total sample volumes, but no meaningful relationship appeared. In the sand fractions, however, a relationship was derived that showed that the mica content decreased as the heavy minerals content increased.(Figures 6.7a and 6.7b).

6.3 Seasonal variation of physical properties in rivers

Sediments were collected from the Teesta and Padma rivers before and after the flood season. The sediment collected before the flood clearly showed highest concentrations of mica in the Teesta and heavy minerals in the Padma.

Sediment samples collected after the flood season, from the same sites, showed that both the mica in the Teesta and the heavy minerals in the Padma decreased significantly (Tables 6.1 and 6.2). It was interesting to note that both rivers had similar high concentrations of these minerals in their upstream reaches (see section 5.1.1). It is likely that these upstream concentrations would move further down to the rivers' confluences. This concept may be applied in the case of other minerals, because, in most cases, there is a mineral content variation before and after the flood season. Grain size distribution also showed an increase in sand content in the Teesta River.

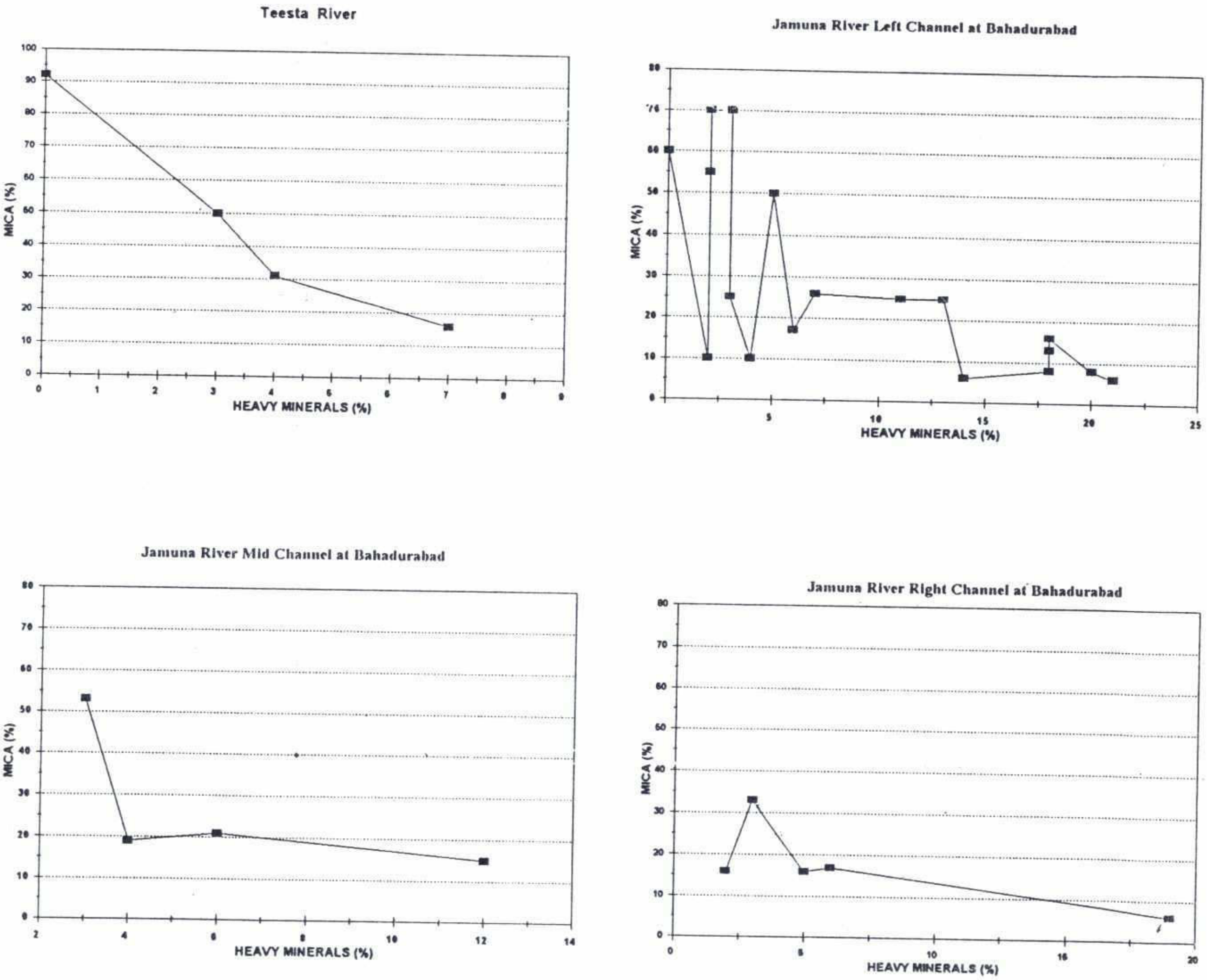

Figure 6.7a: Heavy minerals versus mica in sand mineralogy

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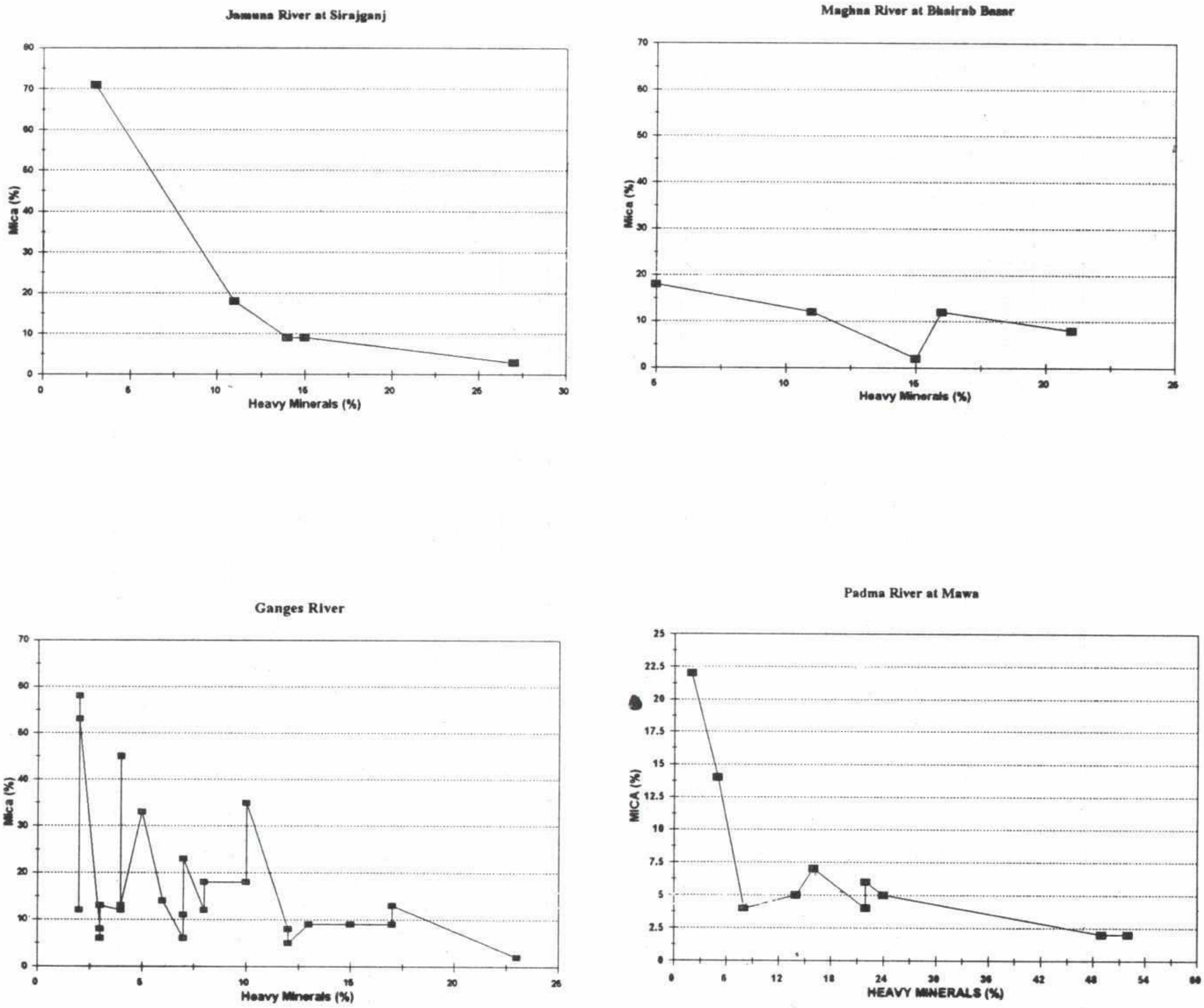

Figure 6.7b: Heavy minerals versus mica in sand mineralogy

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Location	Quartz %	Feldspar %	Rock Fragment %	Mica %	Heavy minerals			Grain size		
					Amphiboles %	Non-opaque %	Opaque %	<63 micron %	>63 micron %	D - 50 mm
Teesta river before flood season	40 ± 17	5 ± 3	10 ± 8	41 ± 28	2 ± 1	2 ± 1	traces	43.82 ± 27	56.18 ± 27	0.077 ± .033
Teesta river after flood season	53 ± 5	8 ± 1	15 ± 2	14 ± 6	4 ± 1	5 ± 1	1 ± 2	3.85 ± 3	96.15 ± 3	0.137 ± .029
Padma river before flood season	46 ± 8	8 ± 3	17 ± 5	7 ± 6	8 ± 4	7 ± 4	7 ± 9	3.25 ± 3	96.75 ± 3	0.132 ± .035
Padma river after flood season	49 ± 4	10 ± 1	19 ± 3	13 ± 9	4 ± 1	3 ± 1	1 ± 1	6.63 ± 5	93.37 ± 5	0.134 ± .041

Table 6.1 Seasonal variation of physical properties of sand of Teesta and Padma rivers

Location	Quartz + Feldsper %	Rock Fregments %	Mica %	Heavy minerals		Grain size		
				Non-opaque %	Opeque	<63 microns %	>63 microns %	D - 50 mm
Teesta river before flood season	53 ± 9	3 ± 3	27 ± 15	15 ± 7	2 ± 1	43.82 ± 27	56.18 ± 27	0.077 ± .033
Teesta river after flood season	53 ± 6	2 ± 1	9 ± 2	30 ± 5	6 ± 3	3.85 ± 3	96.15 ± 3	0.137 ± .029
Padma river before flood season	41 ± 8	5 ± 1	5 ± 3	33 ± 5	15 ± 9	3.25 ± 33	96.75 ± 3	0.132 ± .035
Padma river before flood season	55 ± 6	5 ± 1	10 ± 6	24 ± 8	4 ± 3	6.63 ± 5	93.37 ± 5	0.134 ± .041

Table 6.2 Seasonal variation of physical properties of silt of Teesta and Padma rivers

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6.4 Spatial variation of the sand fraction mineralogical properties of river sediment

Four types of analyses were conducted to determine the spatial variation of sediment mineralogical properties (sand fraction). These analyses considered the variation of properties (1) among the different locations, (2) in the downstream direction, (3) in the vertical direction, and (4) contribution by individual channels to the mineralogical properties downstream of a confluence. Bed samples from banks and chars were excluded in these analyses.

The mineralogical properties were categorised into four groups according to their chemical composition and physical properties, such as heavy minerals, carbonates, quartz/feldspar/rocks, and mica. The analyses and results are discussed below:

6.4.1 Variation among the different locations

Sediment samples from the Teesta, the Brahmaputra upstream of the Teesta confluence, Bahadurabad, Sirajganj, the Ganges, the Gorai, and the Mawa were considered for the analyses. The mineralogical properties of the samples from these locations were similar (Figure 6.8), except for the Teesta samples where mica was significantly higher. In most locations, quartz/feldspar/rocks dominated the samples, averaging 69 to 82 percent. For comparison, the Teesta samples contained only 56 percent quartz/feldspar/rocks. Teesta samples had the highest percentage of mica (41 percent), and the Mawa River samples contained the highest percentage of heavy minerals (22 percent).

Subsequent sediment sampling in May 1995 in the Teesta River showed a considerable reduction of the percentage of mica in the samples. The average mica contents in the samples collected in November 1995 was 21 %. The probable explanation of the presence of a higher percentage (41%) of mica in the samples collected in May 1995 is that during the sampling period there was almost no flow in the Teesta River, which, together with the backwater effect from the Jamuna River, made the sampling location a deposition area. It is highly possible that mica is deposited along with the silt and clay fractions at that area. This argument is supported by the fact that the average percentage of silt in those samples is comparatively very high, and the samples which have a higher percentage of silt also contain a higher percentage of mica in the sand fraction.

6.4.2 Variation in downstream direction

The downstream analyses were performed on three river systems: (1) the Brahmaputra-Jamuna-Padma system that included sampling in the Brahmaputra upstream of the Teesta confluence, Bahadurabad, Sirajganj, and Mawa; (2) the Ganges-Padma system that included sampling in the Ganges near the Gorai off-take and Mawa; and (3) the Ganges-Gorai system.

It appeared that mica was decreasing while heavy minerals were increasing in the downstream stretches of the Brahmaputra-Jamuna-Padma and the Ganges-Padma systems (Figure 6.9). The quartz/feldspar/rocks content was fairly constant in both downstream systems. In the Ganges-Gorai system, the percentage of heavy minerals, carbonates, and mica in the Gorai River was less than in the Ganges River.

It was difficult to conclude whether there were any increasing or decreasing mineralogical property trends in the sediments because the data were high in scatter (Figure 6.9), and because there were only a small number of samples representing the various properties per location. Nevertheless, it was

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evident that the Mawa River samples contained more heavy minerals (Figure 6.8), possibly because of the accumulation of heavier sediment particles.

6.4.3 Vertical direction

A few vertical near-bed and suspended samples were collected for mineralogical analysis. Among those, five pairs of near-bed and suspended samples were from Bahadurabad, one pair from Sirajganj, two from the Ganges River, and one from the Mawa River. Usually a bed sample also was taken from the same near-bed and suspended sediment sampling point. The exception was at Sirajganj, where bed samples were not taken at the same point.

The average mineral percentage in bed, near-bed, and suspended samples, taken from the same point, were compared to determine the vertical variation in mineralogical properties. In particular, the average mineral percentage from all bed samples were compared with the one pair of near-bed and suspended samples, except for the samples taken at Sirajganj (Figure 6.10). Some common characteristics emerged for vertical mineral distribution: there were few heavy minerals, carbonates, and quartz/feldspar/rocks, and mica content was highest in near-bed and suspended samples. The sample numbers, however, were too small on which to base solid conclusions.

The vertical variation of individual minerals is shown in Figure 6.11. The average percentage of individual minerals in near-bed and suspended sediment samples was compared with the bed samples from the same points (Figure 6.11). The comparison indicated that the percent of heavy minerals, carbonates, and quartz/feldspar/rocks was higher in bed samples while lighter minerals made up more of the near-bed and suspended samples. These vertical variations were rather expected and seem logical because of the differences in density and shape.

6.4.4 Contribution of individual channels downstream of a confluence

The mineralogical property samples from Bahadurabad and the Mawa River were compared with the predicted mineralogical properties based on the following assumption:

$$p=\frac{V_1 p_1 + V_2 p_2}{V_1 + V_2} \qquad (1)$$

where p is the predicted percentage of a certain mineral in bed samples, and p_1 and p_2 are the measured percentage of that mineral upstream in the two confluencing channels in which V_1 and V_2 are the respective yearly average sediment transport capacity.

In order to predict the mineralogical properties of sediments at Bahadurabad, the Teesta and the Brahmaputra Rivers are considered as confluencing, and the sediment samples from those rivers are used for the prediction. The average annual sediment volume of the Teesta River is estimated at 10 % of the volume of the Jamuna. Similarly, prediction of the mineralogical properties at Mawa can be based on the confluencing rivers of Ganges and Jamuna. Hereby, the mineralogical properties of the sediments at the Sirajganj sampling location are taken as representative for the Jamuna, because this location is nearer to the confluence. The average yearly sediment volumes of the Ganges and Jamuna Rivers were estimated from FAP24 Study Report 19: 'Sediment balances and rating curves'.

The predicted mineral percentage for Bahadurabad, which was dominated by properties of the Brahmaputra samples upstream of the Teesta confluence, showed similar deviations as those discussed with the downstream situation in Figure 6.9. The predicted mineral percentage for the Mawa River agreed with the measured mineral percentage in bed sediment samples (Figure 6.12b). The heavy minerals, however, deviated significantly, probably because of the accumulation of heavier minerals as discussed above.

6.5 Correlation between river and floodplain sediment

An attempt was made to correlate the mineralogical and physical properties of river and floodplain sediment (Tables 6.3 and 6.4). The Jamuna floodplain site, located between the Bahadurabad and Sirajganj sites, most likely received spill-over river water at Bahadurabad. The Sirajganj site is downstream of the study floodplain. The Bahadurabad data were compared to the floodplain data. With sand fractions, the mineralogical data of the different river sample types were similar to the floodplain data, with the river bed data showing the most similarities to the floodplain data and river suspended loads showing the largest difference (mica content: 40 percent in rivers to 26 percent in floodplains).

Silt fractions showed correlations similar to that of the sand fractions and the grain size floodplain data were similar to the rivers' suspended load samples. The only real difference between the rivers and floodplain was that rock fragments made up 11 percent more of the floodplain sample.

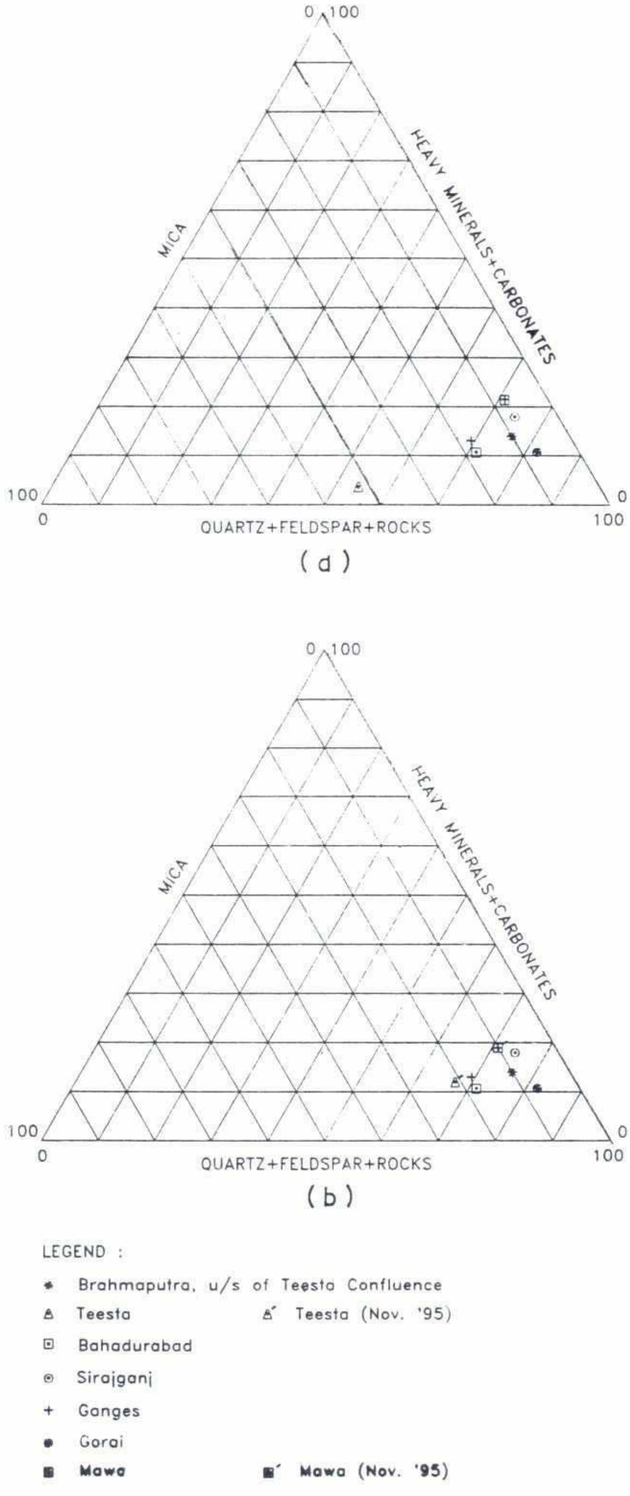

Figure 6.8: Variation of minerals of river bed sediment among the different location

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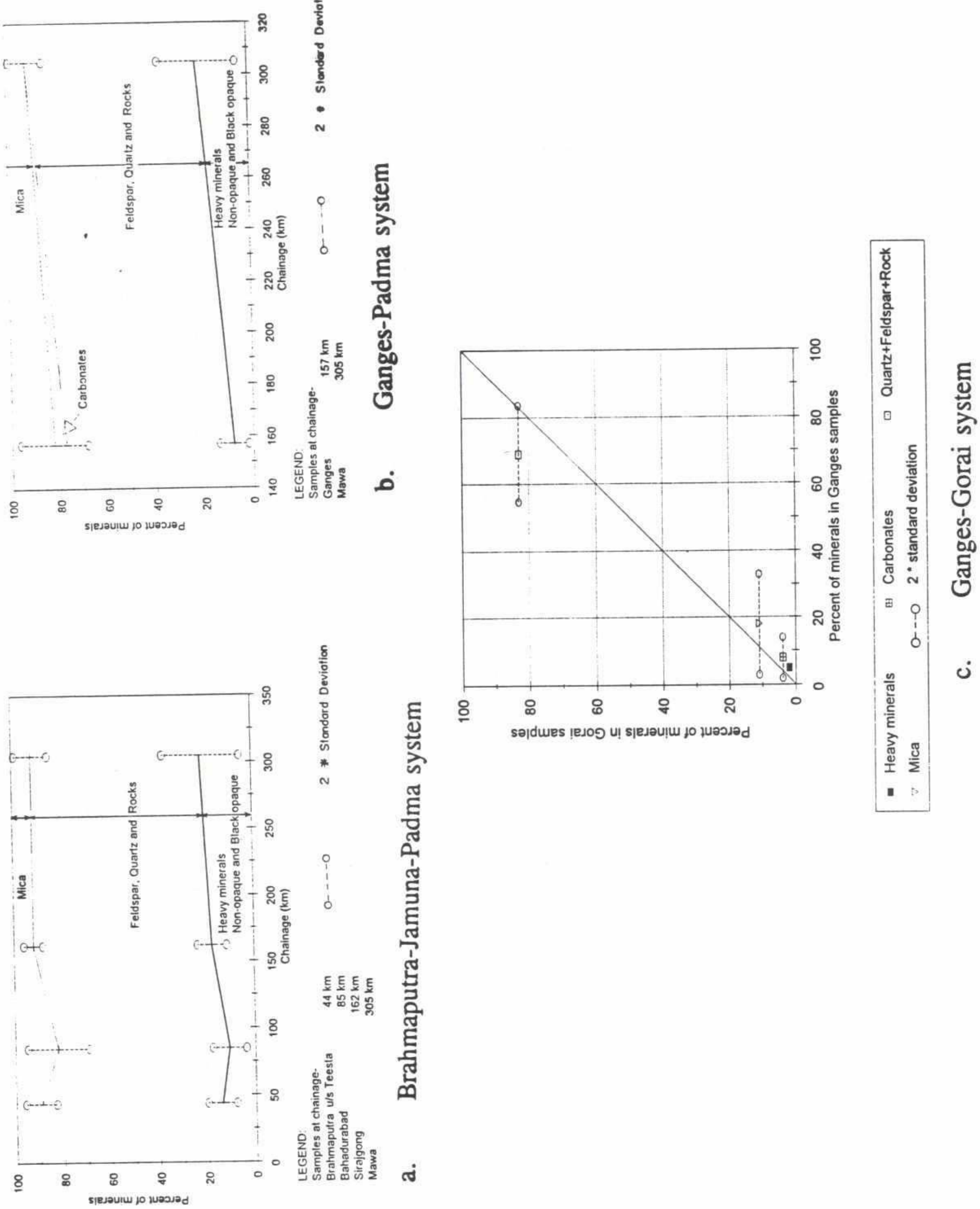

Figure 6.9: Variation of mineralogical properties in downstream direction

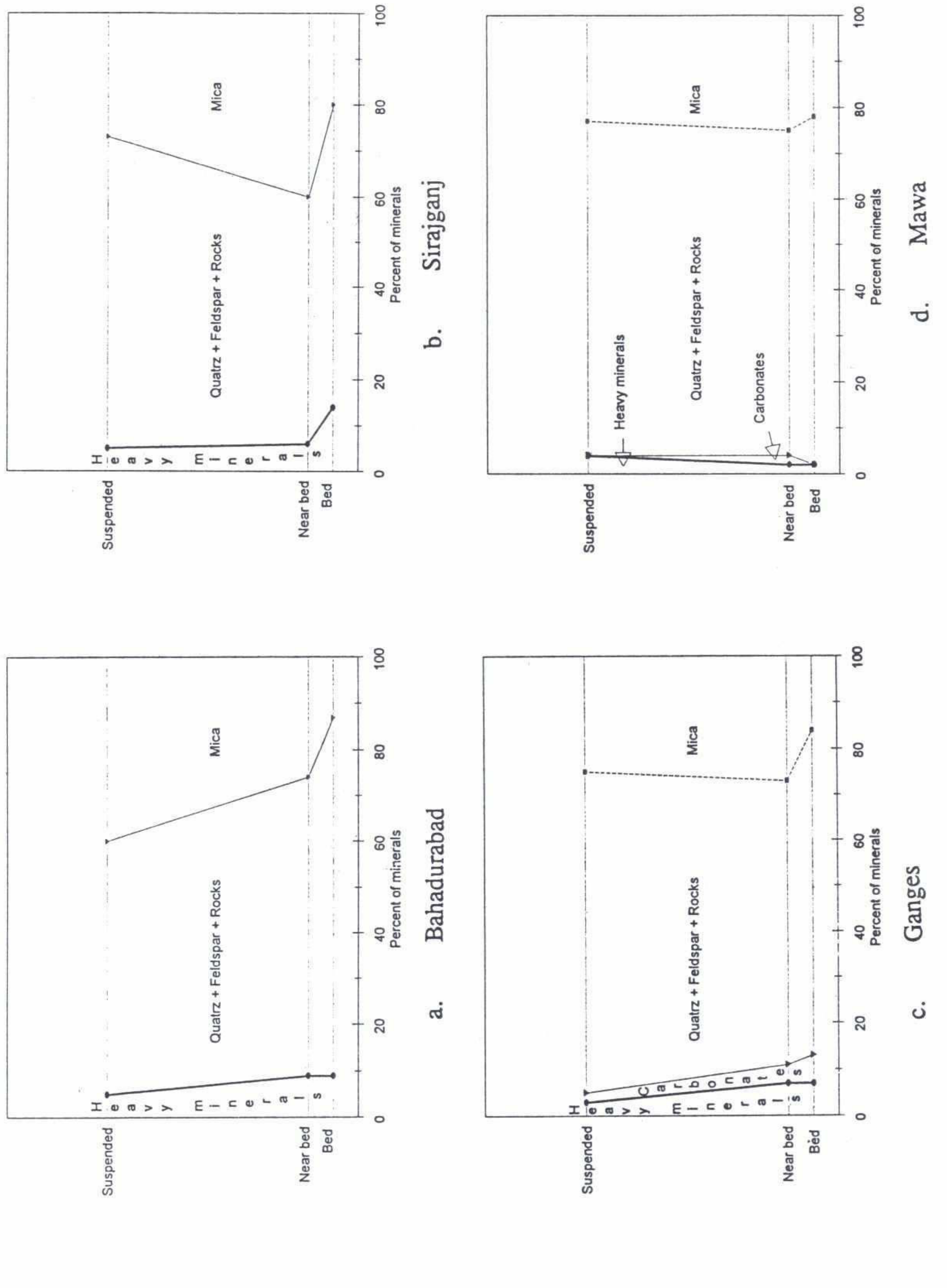

Figure 6.10: Variation of mineralogical properties among bed, near bed and suspended samples at different locations

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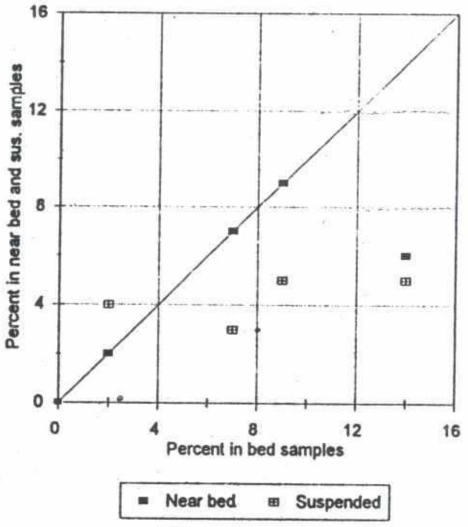
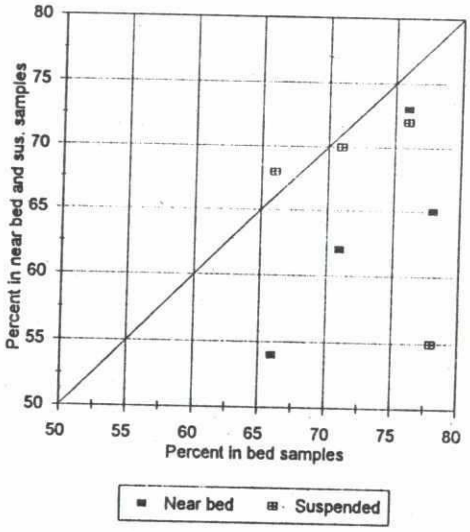
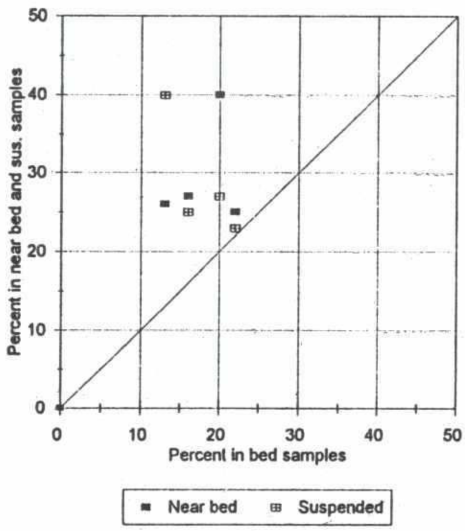


a. Heavy minerals

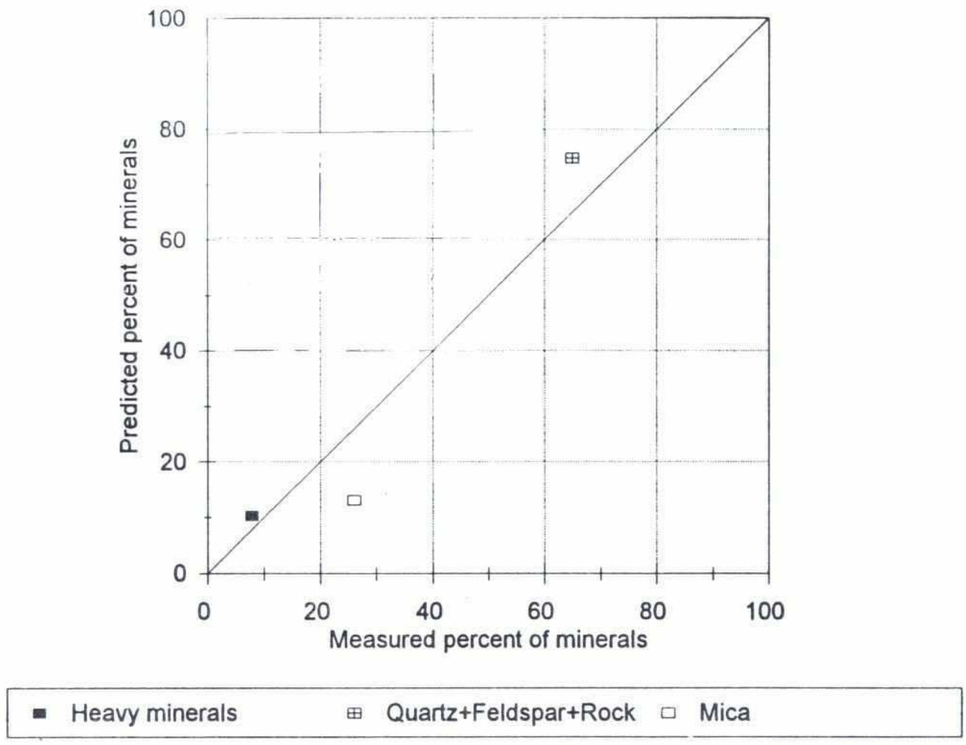


b. Quartz+feldspar+Rock

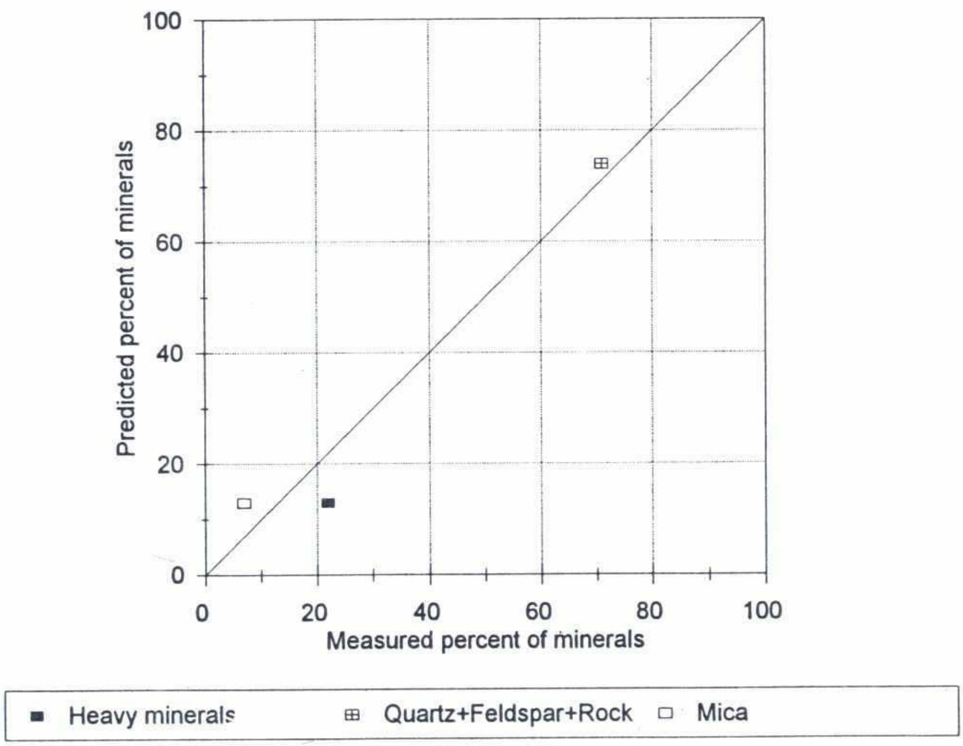


c. Mica

Figure 6.11: Variation of minerals among bed, near bed and suspended samples



a. Bhadurabad



b. Mawa

Figure 6.12: Comparison between measured and predicted minerals of river bed sediments

Location	Quartz %	Feldspar %	Rock fragments %	Mica %	Heavy minerals			Carbonates %	Grain size		
					Amphiboles Pyroxene	Non-opaque %	Black Opaque %		<63 micron %	>63 micron %	D - 50 mm
Jamuna River, Bed	42 ± 9	7 ± 3	16 ± 7	26 ± 19	4 ± 3	4 ± 3	1 ± 2	trace	26.24 ± 34	73.76 ± 34	0.135 ± .088
Jamuna River Near-bed	40 ± 4	9 ± 4	16 ± 5	26 ± 10	5 ± 0.6	4 ± 1	Trace	Nil	6.58 ± 7	93.42 ± 7	0.190 ± .079
Jamuna River, Suspended load	36 ± 9	5 ± 2	14 ± 2	40 ± 12	2 ± 2	2 ± 1	1	Nil	71.18 ± 13	28.82 ± 13	0.042 ± .009
Jamuna River, Flood plain Sediment	44 ± 12	6 ± 3	17 ± 20	26 ± 12	3 ± 2	2 ± 2	Trace	Nil	81.80 ± 28	18.20 ± 28	0.029 ± 0.028

Table 6.3 : Mineralogical and Physical characteristics of sand fractions of Jamuna river (Bahadurabad) and Jamuna flood plain

Location	Quartz + Feldspar %	Rock Fragment %	Mica %	Heavy minerals		Carbonates %	Grain size		
				Non-opaque %	Opaque %		<63 micron %	>63 micron %	D - 50 mm
Jamuna River, Bed	53 ± 7	7 ± 2	11 ± 10	26 ± 8	3 ± 2	Nil	26.24 ± 34	73.76 ± 34	0.135 ± .088
Jamuna River, Near-bed	52 ± 8	7 ± 3	9 ± 7	28 ± 7	4 ± 5	Nil	6.58 ± 7	93.42 ± 7	0.190 ± .079
Jamuna River, Suspended load	56 ± 6	6 ± 6	14 ± 8	22 ± 4	1 ± 0.5	Nil	71.18 ± 13	28.82 ± 13	0.042 ± .009
Jamuna River Flood plain Sediment	51 ± 9	11 ± 7	10 ± 6	26 ± 6	1 ± 1	Trace	81.80 ± 28	18.20 ± 28	0.029

Table 6.4 : Mineralogical and Physical characteristics of silt fractions of Jamuna river (Bahadurabad) and Jamuna flood plain

6.6 Topographical variation of physical properties in floodplain sediment

Floodplain sampling sites were located both on higher and lower topographical sites. The higher topographical sites (sites 3, 4, and 5) were inundated by flood water for 40 to 58 days, and maximum land surface flood depth reached 180 to 200 cm. The lower sites (sites 1, 2, and 7) remained under flood waters for 64 to 99 days. Maximum land surface flood depth measured 200 to 285 cm.

The variation in inundation periods and flood depth did not made a significant difference in mineralogical properties at the different topographical sites. But, in both sand and silt fractions, minor variations were observed (Tables 6.5 and 6.6). Quartz and mica were more abundant at higher sites, while rock fragments were more abundant at lower sites. The heavy minerals content and grain sizes were similar at the higher and lower sites.

6.7 Variation of mineralogical properties within river bank profiles

Of the two river bank profiles that were studied, some of the mineralogical characteristics within the profiles were not uniform (see Section 5.1.1). Quartz varied between 41 and 70 percent in profile 2, and between 38 and 59 percent in profile 1. Mica varied between two and 40 percent among all profiles. But, feldspar, heavy minerals, and rock fragments showed reasonable variations. Silt and clay particles dominated sand in all profile layers.

The profiles represented more of the floodplain characteristics than of the various river profiles. The profile topsoil was made of similar mineral and physical floodplain sediment.

Sampling site	Quartz %	Feldspar %	Rock Fragment %	Mica %	Heavy minerals			Grain size		
					Amphiboles Pyroxene %	Non-opaque %	Opaque %	<63 micron %	>63 micron %	D - 50 mm
Higher site	48 ± 6	6 ± 2	11 ± 5	29 ± 10	3 ± 2	3 ± 2	Traces	81 ± 31	19 ± 31	0.031 ± .031
Lower site	41 ± 15	6 ± 2	24 ± 26	24 ± 12	3 ± 2	2 ± 2	Traces	82 ± 24	18 ± 24	0.027 ± .025

Table 6.5 Topographical variation of mineralogical and physical properties of sand in flood plain sediment

Sampling site	Quartz + Feldspar %	Rock Fragments %	Mica %	Heavy minerals		Grain size		
				Non-opaque %	Opaque	<63 microns %	>63 microns %	D 50 mm
Higher site	51 ± 10	10 ± 7	12 ± 8	25 ± 7	1	81 ± 31	19 ± 31	0.031 ± .031
Lower site	52 ± 8	12 ± 7	8 ± 3	26 ± 5	1	82 ± 24	18 ± 24	0.027 ± .025

Table 6.6 Topographical variation of mineralogical and physical properties of silt in flood plain sediment

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7 Conclusion and recommendations

7.1 Conclusion

This study aids the understanding of the physical and mineralogical characteristics of the river sediments of Bangladesh's major rivers. The mineralogical compositions of these sediments indicate that they originate from different sources. The Ganges River system is characterised by significant amounts of carbonate minerals, whereas other rivers have only traces or no carbonate minerals. Montmorillonite clay was present only in the Ganges system. The Teesta River contained more mica than the other rivers, and had a small heavy minerals and rock fragment content. The Meghna River contained less mica than the Ganges, Jamuna or Teesta rivers, but had a significant amount of rock fragments.

It was observed that, within the same river, different mineralogical characteristics existed between stable and unstable sand bars. Unstable sand bars (Jim's Bar) comprised more rock fragments and less mica than stable sand bars (Roy's Bar).

The study also examined the variations in physical and mineralogical characteristics between the upper and lower reaches of the major rivers. In all cases it was observed that the percentage of quartz and rock fragments was constant in the downstream direction of the main rivers. Trends of an increasing occurrence of heavy minerals, and a decreasing occurrence of mica in the downstream direction were observed, but the hydraulic and morphological processes liable for these trends were not clear. The data also indicated that the particle fineness increased in the lower reaches of the Jamuna River.

The mineralogical properties of bed sediment samples (sand fraction) varied significantly both temporally and spatially, although the average sediment properties at different location was similar.

The percentage of heavy minerals in bed sediment samples is higher, and the percentage of mica is less, as compared with near-bed and suspended samples.

The study demonstrated that a high concentration of precious heavy minerals like garnet, zircon, and epidote exist in the Padma River (Plates 9 and 11). If these minerals occur over a large area in this river, commercial extraction could be considered. Two sediment samplings in the Padma River showed that the percentage of heavy minerals was distinctively higher than in other locations, probably due to an environment favourable to such accumulation.

As most of the river sediments were collected before the arrival of the flood season, the findings may be regarded as characteristic of the pre-monsoon season. Unless the sediments are carefully examined during the monsoon and the dry season, this study should be regarded as indicative only, and caution should be used when extrapolating the findings to other parts of the river and other seasons of the year.

Comparative study between river and floodplain sediments helps to conclude that the mineralogical characteristics of river sediments have a similarity with the mineralogical composition of adjacent floodplains. Grain size characteristics of floodplain sediment are similar to river suspended load materials, but are different from bed and near-bed materials.

This study did not correlate the data with the geomorphological regimes of the different rivers sections. Due to an inadequate description of the sampling locations in most cases, the findings could not be

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referred to an exact feature of the river (e.g., point bar, sand bar). A dry season sampling programme would help detail the sampling sites.

7.2 Recommendations

It is recommended that:

- The river sediment sampling programme be continued at the same sampling sites during the monsoon and dry seasons;

- Consideration be given to more sampling sites in the lower parts of the Jamuna River (immediately north of the confluence with the Ganges River), the Meghna River at the estuary and at its upper reaches, and the Gorai/Madhumati rivers in their saline tidal zones;

- Further investigations be made in the Teesta and Padma rivers to examine the upstream to downstream shifting of mica and heavy minerals, respectively;

- Floodplain sediment of the Ganges and Meghna rivers be checked for mineralogical properties and compared with their respective river sediment characteristics;

- Further XRD analyses of silt and clay are not necessary as optical microscope analysis is better suited for the determination of the silt mineralogy. Unlike sand and silt mineralogy, clay mineralogy does not contribute significantly to understanding the river morphology; and

- An improved technique be developed for this kind of study. For example, prior to selection of sampling sites, an aerial photo interpretation should be carried out with recent photographs. River morphologists could be assigned to make a full description of the sampling sites.

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APPENDIX - I
Short description of minerals of river sediments of Bangladesh

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Short description of minerals of river sediments of Bangladesh

Sand, silt, and clay minerals found in the major rivers of Bangladesh are described briefly in this section in an effort to understand mineral behaviour in river environments as well as their characteristics and occurrences.

1 Physical behaviour of minerals

1.1 Abrasion resistance

It seems highly probable that the residues produced by disintegration and decomposition of source rocks would undergo further alteration during transport from the place of release to the place of ultimate deposition. Downstream changes in river gravel composition has long been noted. The rocks show rather rapid elimination of less durable components (limestone, shale, friable sand-stones) with resulting enrichment in more stable rock types (quartzite, chert). It seems that the softer and more cleavable species would be destroyed by abrasion, with a complementary enrichment in harder and more durable components.

Some experiments have been made to determine the resistance of mineral grains to wear. Friese (1931) determined the durability of a several minerals. For example, he assigned a numerical value to the abrasion resistance of each mineral studied, with crystalline haematite being assigned 100 (Table 1).

Thiel (1940) experimentally determined the relative abrasion resistance of common minerals. According to Thiel, the order of resistance is (beginning with the least resistance) : (1) apatite, (2) hornblende, (3) microcline, (4) garnet, (5) tourmaline, and (6) quartz. Later, in 1945, he added several other minerals to the list. Although differing in some important particulars, the order is consistent with the results of Friese (Table 1).

After Friese (1931)	**After Thiel (1945)**
Haematite (100) [b]	Barite
Monazite (117, av.)	Siderite
Orthoclase (150)	Fluorite
Diopside (160)	Goethite
Andalusite (220)	Enstatite
Kyanite (260)	*Kyanite*
Apatite (275)	Bronzite
Common olivine (290)	*Haematite*
Epidote (320)	*Augite*
Ilmenite (325)	*Apatite*
Garnet (378, av.)	Spodumene
Magnetite (380)	Hypersthene
Topaz (390)	Diallage
Common augite (420)	Rutile
Staurolite (420)	Hornblende
Cordierite (480)	Zircon
Pyrite (500)	*Epidote*
Tourmaline (817, av)	*Garnet*
	Titanite
	Staurolite
	Microcline
	Tourmaline
	Quartz

Note : a) Minerals common to two lists are italicized to facilitate comparison.

b) "Transportwiderstand" haematite arbitrarily taken as 100.

Table 1 : Abrasion resistance of minerals (in order of increasing resistance)[a].

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1.2 Hardness

Mineral hardness is generally defined by its resistance to scratching, and relative hardness has been employed as a useful diagnostic property since the beginning of systematic mineralogy. It was given qualitative precision by the Austrian mineralogist Mohs, who, in 1822, proposed the following scale of relative hardness :

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Topaz
9. Corundum
10. Diamond

Apparently, the durability index and Mohs scale of hardness are closely related, at least for minerals less hard than quartz. The exact function was not worked out fully., although it appears to be of the type $y = (x / a^n)$, where y is the durability index, x is the Mohs hardness, a is the hardness of quartz (7), and n is an exponent (near 4). Erratic values were frequent and may be the result of size reduction processes other than abrasion, of the nonuniform nature of the hardness scale, and of other mineral properties (such as elasticity).

2 Characteristics and occurrence of minerals

2.1 Sand and silt minerals

2.1.1 Quartz

Chemical formula : Sio_2

Density : 2.65 Hardness : 7

Occurrence : Quartz is stable over almost the entire range of geological conditions and because it is the most abundant oxide in the earth's crust. It is a common mineral, present both in igneous and metamorphic rocks, such as granite, gneiss, schist, and quartzite.

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2.1.2 Feldspar group

Microcline and orthoclase

Chemical formula : $KALSi_3O_8$

Density : 2.56 Hardness : 6

Occurrence : Orthoclase occurs in large quantities as a constituent of granite and gneiss rocks.

Plagioclase series

Chemical formula :

Albite : $NaALSi_3O_8$

Labradorite : $NaCaAL_2Si_6O_{16}$

Anorthite : $CaAL_2Si_2O_8$

Density : 2.62 - 2.76 Hardness : 6

Occurrence : Sodium and calcium feldspars form part of many crystalline rocks such as basalt, diabase, gabbro, and diorite. The feldspars decompose fairly readily in the presence of H_2O and CO_2. Calcium feldspars decompose much easier than do sodium and potassium.

2.1.3 Mica group

There are various type of micas. Commonly they are muscovite, biotite, and chlorite.

Muscovite (white)

Chemical formula : $KAl_2(AlSi_3O_{10})(OH)_2$

Density : 2.8 - 2.9 Hardness : 2.5(on cleavage),
cleavage)

Occurrence : In igneous rocks, muscovite is confined to some granites. It is a common, abundant mineral in schists and gneiss metamorphic rocks. It is resistant to weathering and, thus, occurs as a detrital mineral in clastic sediments.

Biotite (dark)

Chemical formula : $K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$

Density : 2.8 - 3.4, increasing with iron content. Hardness : 25(on cleavage).

Occurrence : Biotite is found in many igneous rocks; it also is an important constituent of metamorphic rocks, especially schists, gneisses, and hornfels. When much iron is present, it decomposes readily; otherwise, it breaks up quite easily, but chemically decomposes slowly.

Chlorite

Chemical formula : $(Mg,Fe,Al)_6(Al,Si)_4O_{10}(OH)_8$

Density : 2.6 - 3.3, increasing with iron content.

Occurrence : Chlorite is an important mineral in low grade schists, and is also common in igneous rocks as an alteration product of biotite and other ferro-magnesian minerals. Hydrothermal alteration of pre-existing rocks often resulted in the formation of large amounts of chlorite. Chlorite also is present in the clay mineral fraction of many sediments.

2.1.4 Heavy mineral group

Amphiboles series

Hornblende :

Chemical formula : $NaCa_2(Mg,Fe,Al)_5(Si,Al)_8 O_{22}(OH)_9$

Density : 3.0 - 3.4, increasing with iron content.

Occurrence : Hornblende is common in medium grade metamorphic rocks (schist), and in igneous plutonic rocks. Hornblende decomposes fairly readily because of its easy cleavage and high ferrous iron content. It produces a rust-coloured clay mineral when decomposing.

Tremolite - Actinolite

Chemical formula : $Ca_2(Mg,Fe)_5Si_8O_{22} (OH)_2$

Density : 2.98 -3.46

Occurrence : Tremolite and actinolite are common minerals of low and medium grade metamorphic rocks.

Pyroxene series

Augite :

Chemical formula : $Ca(Mg,Fe,Al)(Al,Si)_2 O_6$

Density : 3.25 -3.55 Hardness : 6

Occurrence : Augite is the most important ferromagnesian mineral of igneous rocks; it is especially abundant in basic and ultrabasic rocks such as gabbros and basalts, and occurs in many sites.

Diopside :

Chemical formula : $CaMgSi_2O_6$

Density : 3.25 -3.55 Hardness : 6

Occurrence : Diopside occurs in medium and high grade metamorphic rocks, especially those rich in calcium. White and light green diopsides characteristically occur in metamorphosed dolomitic limestone.

Non-opaque heavies

Zircon :

Chemical formula : $ZrSiO_4$

Density : 4.6 -4.7 Hardness : 7.5

Occurrence : Zircon is a common accessory mineral of igneous rocks and pegmatites of the granite, syenite, and nepheline syenite families. The presence of uranium and thorium make it a useful mineral for determining the age of such rocks. Because zircon is resistant to mechanical and chemical disintegration, it appears as a detrital in river and beach sands. This mineral is frequently radioactive due to Th and U replacing Zr in the structure.

Tourmaline :

Chemical formula : $Na(Mg,Fe)_3Al_6(Bo_3)_3$ (Si_6O_{18}) (OH)4

Density : 3.0 -3.2 Hardness : 7.5

Occurrence : Tourmaline occurs in granite pegmatites. It is also common as an accessory mineral in metamorphic rocks, especially in schists and gneisses. Brown, Mg-rich tourmaline is found in metamorphosed limestone.

Apatite :

Chemical formula : $Ca_5(Po_4)_3$ (F,Cl,OH)

Density : 3.1 -3.2 Hardness : 5

Occurrence : Apatite occurs extensively as massive crypto crystalline material which constitutes the bulk of phosphate rock and fossil bone.

Sillimanite :

Chemical formula : Al_2SiO_5

Density : 3.24 Hardness : 7

Occurrence : Sillimanite is formed in aluminium-rich rocks under conditions of high grade regional metamorphism, and is found in schists and gneisses.

Zoisite :

Chemical formula : $Ca_2Al_3Si_3O_{12}$ (OH)

Density : 3.3 Hardness : 6.5

Occurrence : Zoisite occurs as constituent of schists and gneisses.

Rutile :

Chemical formula : TiO_2

Occurrence : Rutile is often found as an alteration product of other titanium minerals, especially sphene and ilmenite.

Spinel :

Chemical formula : $MgAl_2O_4$

Density : 3.6

Occurrence : The spinels are usually high temperature minerals, found as accessory minerals in basic igneous rocks and highly aluminium metamorphic rocks.

Sphene :

Chemical formula : $CaTiSiO_5$

Density : 3.5 Hardness : 6

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Occurrence : Sphene is widely distributed both igneous and metamorphic rocks, and is commonly found in gneiss and schist rocks.

Black opaque heavies

Magnetite :

Chemical formula : Fe_3O_4

Occurrence : Magnetite is commonly found as accessory mineral in igneous rocks.

2.1.5 Carbonate group

Calcite :

Chemical formula : $CaCo_3$

Density : 2.71(pure), increases with substitution of Fe, Mn or Zn

Occurrence : Calcite is a common and widely distributed mineral in the earth's crust. It is an important rock forming mineral in sedimentary and metamorphosed sedimentary rocks. It occurs in nearly pure form, in great thickness of chalk and limestone, and as a cementing material in other sedimentary rocks.

Dolomite :

Chemical formula : $CaMg(Co_3)$

Density : 2.85 for pure dolomite, increasing to about 3.02 for a mineral with Mg:Fe = 1:1

Occurrence : Dolomite is widely occurs in sedimentary strata. In this form, it is believed to have originated through transformation of limestone or coral (dolomitization) by magnesium-bearing solution.

2.2 Clay minerals

Clay minerals are not mineral fragments of parent material, but have definite crystals structures. The climatic conditions under which weathering occurs has much to do with the relative proportions of the different clay minerals developed from weathering. For example, under warm, humid conditions, more minerals from the kaolinite and illite group are developed than from the montmorillonite group. In cool, moist climates, the condition is reversed.

The clay mineral have many physical features in common. They do not occur as macroscopic or, except for the kaolin minerals, as microscopic crystals; instead they occur as earthy masses. As a result, hardness is not a diagnostic property, since all of them appear very soft (the hardness of these minerals is about 2- 3).

These plate-shaped minerals are made up of plates Al_2O_3 and SiO_2 and expose a large amount of surface area per unit of weight.

Kaolinite :

Chemical formula : $Al_4Si_4O_{10}(OH)_8$

Density : 2.6 Hardness : 2

Occurrence : Kaolinite is formed by the decomposition of other alumina-silicates, especially the feldspars, either by weathering or by hydrothermal activities. It is low in silica, but fairly high in the OH group.

Illite :

Chemical formula : $(OH)_4K_x(Al_4.Fe_4.Mg_4Mg_6)$ $(Si_8$ - $x.Al_x)$ O_{20}

The characteristics of illite are similar to white micas (muscovite), but differs, perhaps, in that it contains less potash and more water than do the micas proper.

Montmorillonite :

Chemical formula : $Al_2Si_4O_{10}(OH)_2.xH_2O$

Density : 2.0 -2.7 Hardness : 2 - 2.5

Occurrence: Bentonite is a rock consisting largely of montmorillonite. This mineral is high in SiO_2, but low in the OH group.

Chlorite :

Chemical formula : $(Mg,Fe,Al)_6$ $(Al,Si)_4O_{10}$ $(OH)_8$

Density : 2.6 - 3.3 Hardness : 2.5(on cleavage)

Occurrence : Chlorite is an important mineral in low grade schist, and is also common in igneous rocks as an alteration product of biotite and other ferro-magnesian minerals.

APPENDIX - II

Results of laboratory analyses of river and floodplain sediment samples

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth	Sampling Depth	Sand Minarology								
			Easting (m)	Northing (m)	(m)	(m)	Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
1	BED	05.10.95	456653	830270	5.65	5.65	32	4	8	53	1	1	tr	-	-
2	BED	05.10.95	456018	829891	1.20	1.20	52	8	13	20	2	4	1	-	-
3	BED	05.10.95	455605	829819	2.00	2.00	50	7	12	15	7	8	tr	-	tr
4	BED	05.10.95	454726	829710	1.80	1.80	39	3	8	45	1	1	tr	2	-
5	BED	05.10.95	453739	829120	3.60	3.60	38	6	10	4	5	25	12	-	-
A1063	SUS-LOAD	05.10.95	453739	829120	5.65	2.80	32	4	8	2	5	37	12	-	-
A455	SUS-LOAD	05.10.95	456653	830270	3.60	1.80	42	6	9	41	1	1	-	-	-

Table 1. Sand Mineralogy of Sediments of Teesta River Up Stream (Location Fig 3.2b)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth	Sampling Depth	Sand Minarology								
			Easting (m)	Northing (m)	(m)	(m)	Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
DHE-1	BED	26/05/95	462640	824853	1.70	1.70	6	1	tr	92	-	tr	tr	-	-
DHE-2	BED	26/05/95	462461	824800	1.25	1.25	40	3	4	50	1	1	1	-	-
DHE-3	BED	26/05/95	462730	822513	2.55	2.55	49	10	18	18	2	2	tr	-	tr
DHE-4	BED	26/05/95	462730	823093	2.05	2.05	51	4	8	31	2	2	1	tr	tr
DHE-5	BED	26/05/95	462725	823012	2.00	2.00	53	5	19	16	3	3	1	-	-
1	BED	03.11.95	462640	824580	3.10	3.10	50	10	12	12	5	6	5	-	-
2	BED	03.11.95	462461	824645	1.50	1.50	56	9	15	12	2	5	1	-	-
3	BED	03.11.95	462730	822560	0.30	0.30	56	8	18	13	2	2	tr	-	tr
4	BED	03.11.95	462730	823110	0.40	0.40	44	8	13	24	5	6	-	-	-
5	BED	03.11.95	462780	822950	1.50	1.50	58	7	18	7	4	5	tr	-	-
A935	SUS-LOAD	03.11.95	462640	824580	3.10	1.55	42	8	12	30	4	4	-	-	-
A851	SUS-LOAD	03.11.95	462780	822950	1.50	0.75	45	5	10	34	2	3	1	-	-

Table 2. Sand Mineralogy of Sediments of Teesta River near Jamuna Confluence (Location Fig 3.2a)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth	Sampling Depth	Sand Minarology								
			Easting (m)	Northing (m)	(m)	(m)	Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
DHE-6	BED	26/05/95	469147	824187	2.03	2.03	51	9	20	12	4	3	1	-	-
DHE-7	BED	26/05/95	469261	824187	3.90	3.90	46	6	20	14	9	4	1	-	-
DHE-8	BED	26/05/95	469523	824099	5.31	5.31	37	5	19	14	9	8	8	-	-
DHE-9	BED	26/05/95	469739	824140	11.50	11.50	50	8	22	6	6	6	2	-	-
DHE-10	BED	26/05/95	469890	824150	4.40	4.40	48	7	18	8	8	7	4	-	-
DHE-11	BED	26/05/95	469924	82192	4.70	4.70	52	7	20	9	5	6	1	-	-
DHE-12	BED	26/05/95	469630	821280	12.24	12.24	37	16	30	11	4	1	tr	-	tr
DHE-13	BED	26/05/95	469367	821285	10.24	10.24	45	8	23	5	8	8	3	-	-
DHE-14	BED	26/05/95	468335	821453	4.30	4.30	50	6	24	10	4	5	1	-	-
DHE-15	BED	26/05/95	467908	821716	3.85	3.85	44	6	18	10	7	6	1	8	-

Table 3. Sand Mineralogy of Sediments of upstream of Jamuna River near Teesta confluence (Location Fig 3.2a)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sand Minarology: Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
DHA-1	BED	29/05/95	469538	770930	-	-	45	10	25	6	7	6	1	-	-
DHA-2	BED	29/05/95	469442	770930	-	-	35	15	37	10	1	1	tr	-	tr
DHA-3	BED	29/05/95	469300	770930	-	-	26	5	8	60	-	-	tr	-	tr
DHA-4	BED	29/05/95	470900	770930	-	-	50	7	10	26	3	3	1	-	-
DHA-5	BED	29/05/95	469884	770930	-	-	47	8	17	8	6	7	7	-	-
DHA-6	BED	29/05/95	470400	770930	-	-	44	7	15	16	6	6	6	-	-
DHA-1	BED	30/05/95	470296	775506	-	-	45	13	27	10	2	2	tr	-	tr
DHA-2	BED	30/05/95	470546	775506	-	-	14	4	9	70	1	1	1	-	-
DHA-3	BED	30/05/95	470796	775506	-	-	20	2	5	70	1	1	tr	-	tr
DHA-4	BED	30/05/95	468296	775506	-	-	42	5	15	25	7	4	tr	1	tr
DHA-5	BED	30/05/95	468900	775506	-	-	48	5	8	25	6	6	1	1	-
DHA-6	BED	30/05/95	469600	775506	-	-	48	9	16	6	10	9	2	-	-
DHA-1	BED	31/05/95	461938	783238	-	-	45	10	22	17	3	2	1	tr	-
DHA-2	BED	31/05/95	461540	783250	-	-	42	5	17	33	1	1	1	-	-
DHA-3	BED	31/05/95	462307	783254	-	-	52	8	18	16	3	2	tr	-	tr
DHA-4	BED	31/05/95	462512	783282	-	-	40	11	30	16	1	1	tr	-	tr
DHA-5	BED	31/05/95	460640	783250	-	-	38	5	10	28	8	8	3	-	-
DHA-6	BED	31/05/95	461140	783250	-	-	47	10	18	6	7	7	5	-	-
DHA-7	BED	31/05/95	466286	779883	-	-	48	9	19	19	2	2	tr	tr	-
DHA-8	BED	31/05/95	466316	779521	-	-	49	8	16	21	2	3	1	-	-
DHA-9	BED	31/05/95	466310	779664	-	-	44	7	14	23	6	5	1	-	-
DHA-10	BED	31/05/95	466300	780100	-	-	33	3	7	53	2	1	tr	-	tr
DHA-11	BED	31/05/95	466300	779300	-	-	45	8	20	15	7	4	1	-	-
DHA-1	BED	01/06/95	470076	781430	-	-	42	6	21	13	8	7	3	-	-
DHA-2	BED	01/06/95	469710	781380	-	-	30	4	8	55	1	1	tr	-	tr
DHA-3	BED	01/06/95	470530	781480	-	-	51	8	18	17	3	2	1	-	-
DHA-4	BED	01/06/95	470980	781550	-	-	36	13	22	25	2	1	tr	-	tr
DHA-5	BED	01/06/95	471430	781610	-	-	47	8	19	8	7	7	4	-	-
DHA-6	BED	01/06/95	471880	781680	-	-	36	3	5	50	2	3	tr	tr	-
A338	SUS-LOAD	28/05/95	469546	774930	10.40	5.00	49	8	17	23	1	1	tr	-	tr
A698	SUS-LOAD	30/05/95	470295	777497	13.90	7.00	36	3	16	37	5	2	1	-	-
C126	SUS-LOAD	31/05/95	461938	783238	5.20	2.60	20	4	13	59	1	2	1	-	-
A1362	SUS-LOAD	31/05/95	466286	779883	6.00	3.00	34	4	13	46	1	1	1	-	-
C118	SUS-LOAD	01/06/95	470077	781430	12.00	6.00	41	4	11	37	2	4	1	-	-
A4037	NEAR BED	27/05/95	469577	774934	10.00	9.95	41	12	21	16	5	4	tr	-	tr
A167	NEAR BED	30/05/95	470295	777497	13.90	13.85	40	16	21	15	5	2	tr	-	tr
C019	NEAR BED	31/05/95	461938	783238	5.20	5.15	40	6	11	35	4	3	1	-	-
C144	NEAR BED	31/05/95	466286	779883	6.00	5.95	32	5	10	40	6	6	tr	-	tr
B483	NEAR BED	01/06/95	470077	781430	12.00	11.95	42	6	16	25	5	5	tr	-	tr

Table 4. Sand Mineralogy of Sediments of Jamuna River near Bahadurabad (Location Fig 3.3)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Sand Minarology								
			Easting (m)	Northing (m)			Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals			Carbonates (%)	Others (%)
											Amphibole (%)	Non opaque (%)	Black opaque (%)		
DHA-1	BED	08/06/95	479100	698500	-	-	16	3	5	71	1	1	1	-	2
DHA-2	BED	08/06/95	478500	698500	-	-	44	12	20	9	8	6	1	-	-
DHA-3	BED	08/06/95	477950	698500	-	-	44	10	15	3	8	10	9	-	tr
DHA-4	BED	08/06/95	477550	698500	-	-	44	13	19	9	7	7	tr	-	tr
DHA-5	BED	08/06/95	477400	698500	-	-	47	9	21	9	6	6	2	-	-
DHA-6	BED	08/06/95	476830	698500	-	-	49	6	16	18	5	5	1	-	-
C131	SUS-LOAD	08/06/95	477772	698480	9.20	4.60	47	6	15	27	2	2	1	-	-
A444	NEAR BED	08/06/95	477772	698480	9.20	9.15	40	4	10	39	3	3	tr	tr	-

Table 5. Sand Mineralogy of Sediments of Jamuna River near Sirajganj (Location Fig 3.4)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Sand Minarology								
			Easting (m)	Northing (m)			Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals			Carbonates (%)	Others (%)
											Amphibole (%)	Non opaque (%)	Black opaque (%)		
DHE-1	BED	29/06/95	422722	645512	-	-	50	7	18	8	5	6	1	5	-
DHE-2	BED	29/06/95	419335	647770	-	-	49	7	22	5	3	7	2	5	-
DHE-3	BED	29/06/95	418912	646922	-	-	44	8	19	9	7	8	2	3	-
DHE-4	BED	29/06/95	415351	648600	-	-	38	18	25	13	2	1	tr	2	tr
DHE-5	BED	29/05/95	415850	649940	-	-	41	7	14	23	4	3	tr	7	tr
DHE-6	BED	29/05/95	413848	650420	-	-	30	5	10	45	2	2	tr	5	tr
DHE-10	BED	28/06/95	408519	650065	8.90	8.90	54	7	17	11	3	3	1	4	-
DHE-11	BED	28/06/95	409135	649220	6.50	6.50	50	16	18	12	1	1	tr	1	tr
DHE-17	BED	29/06/95	408155	650018	-	-	59	8	20	8	1	2	tr	1	tr
DHC-1	BED	28/05/95	402155	660646	1.70	1.70	51	10	22	12	2	2	tr	-	tr
DHC-3	BED	28/05/95	401346	660648	21.80	21.80	20	5	9	58	1	1	tr	5	tr
DHC-4	BED	28/06/95	406250	650600	2.80	2.80	54	7	19	13	2	2	tr	2	tr
DHC-5	BED	28/06/95	406892	651221	5.80	5.80	52	6	16	2	8	9	6	tr	tr
DHC-6	BED	28/05/95	407350	651411	1.50	1.50	28	6	10	53	1	1	tr	tr	-
DHC-7	BED	28/06/95	404000	653470	2.30	2.30	51	7	20	14	2	3	1	2	-
DHC-8	BED	28/06/95	403504	652924	6.50	6.50	52	8	23	6	3	4	tr	3	tr
DHC-10	BED	29/06/95	410552	649970	10.30	10.30	40	4	10	33	1	2	2	8	-
DHC-12	BED	29/06/95	412561	649814	3.60	3.60	44	7	30	6	2	1	tr	9	tr
DHC-13	BED	29/06/95	413704	649747	5.40	5.40	41	12	19	12	4	3	1	8	-
DHC-15	BED	29/06/95	411962	649394	4.70	4.70	46	7	18	18	7	3	tr	-	tr
DHC-16	BED	29/06/95	411181	649060	6.90	6.90	43	10	18	9	5	7	1	7	-
DHC-17	BED	29/05/95	410486	648764	1.50	1.50	32	6	9	35	5	4	1	8	-
DHC-20	BED	29/06/95	411938	649798	4.10	4.10	36	8	15	13	6	8	3	11	-
DHC-23	BED	29/06/95	408380	650331	15.70	15.70	48	6	10	18	4	3	1	10	-
DHC-26	BED	29/06/95	411862	649040	8.20	8.20	50	8	21	13	2	2	-	4	-
DHC-27	BED	29/06/95	411721	648607	6.20	6.20	44	7	16	9	7	7	1	9	-
A734	SUS-LOAD	29/06/95	408380	650331	15.70	7.85	46	7	16	24	2	1	tr	3	tr
A1069	SUS-LOAD	29/06/95	408192	650065	16.00	8.00	45	11	19	19	1	1	tr	3	tr
A933	SUS-LOAD	29/06/95	411862	649040	8.20	4.10	46	6	19	25	1	1	tr	1	tr
A738	NEAR BED	29/06/95	408380	650331	15.70	15.20	42	5	16	24	1	1	1	10	-
A457	NEAR BED	29/06/95	411862	649040	8.20	6.58	39	6	15	30	2	3	tr	4	tr

Table 6. Sand Mineralogy of Sediments of Ganges River (Location Fig 3.6 &3.7)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sand Minarology Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Amphibole (%)	Heavy Minerals Non opaque (%)	Heavy Minerals Black opaque (%)	Carbonates (%)	Others (%)
DHE-13	BED	28/06/95	409500	648410	1.20	1.20	51	12	17	11	3	4	1	1	-
DHE-14	BED	28/06/95	409300	647700	1.10	1.10	51	11	19	15	1	1	tr	1	tr
DHE-15	BED	29/06/95	409680	646720	-	-	58	10	21	6	2	2	1	-	-
DHE-16	BED	29/06/95	410117	645435	-	-	47	12	19	11	2	2	tr	6	tr

Table 7. Sand Mineralogy of Sediments of Gorai River (Location Fig 3.7)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sand Minarology Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Amphibole (%)	Heavy Minerals Non opaque (%)	Heavy Minerals Black opaque (%)	Carbonates (%)	Others (%)
DHC-1	BED	23/06/95	528340	592935	7.10	7.10	58	9	20	4	6	2	tr	-	tr
DHC-2	BED	23/06/95	528569	593625	12.00	12.00	48	10	18	7	7	7	2	tr	tr
DHC-3	BED	23/06/95	528865	594345	10.00	10.00	49	6	17	4	7	9	6	2	-
DHC-4	BED	23/06/95	529078	595023	14.60	14.60	44	10	18	6	11	8	3	-	-
DHC-5	BED	23/06/95	528541	594361	9.10	9.10	36	3	6	2	13	14	25	1	-
DHC-6	BED	23/06/95	527850	594458	7.70	7.70	32	6	10	2	12	14	23	tr	tr
DHC-7	BED	24/06/95	526456	592246	15.70	15.70	47	9	19	22	1	1	tr	-	tr
DHC-8	BED	24/06/95	526938	592056	7.20	7.20	41	6	23	5	7	7	10	1	-
DHC-9	BED	24/06/95	526979	593592	7.70	7.70	48	13	20	5	8	5	1	-	-
DHC-10	BED	24/06/95	525401	595159	2.30	2.30	57	5	18	14	3	2	tr	tr	-
2	BED	31/10/95	528581	593624	10.20	10.20	52	11	21	9	3	3	tr	tr	-
4	BED	31/10/95	529076	595020	10.20	10.20	42	10	14	27	3	2	tr	1	tr
5	BED	31/10/95	528561	594363	8.60	8.60	52	9	22	5	5	5	1	1	-
8	BED	31/10/95	526938	592052	15.60	15.60	51	11	18	9	5	2	tr	3	tr
A21	SUS-LOAD	24/06/95	526456	592247	15.70	8.20	49	7	14	23	2	2	3	-	-
A27	NEAR-BED	24/06/95	526456	592247	15.70	25.20	46	7	15	25	2	2	tr	2	tr

Table 8. Sand Mineralogy of Sediments of Padma River near Mawa (Location Fig 3.5a)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sand Minarology Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Amphibole (%)	Heavy Minerals Non opaque (%)	Heavy Minerals Black opaque (%)	Carbonates (%)	Others (%)
DHE-1	BED	06/10/95	522252	593581	ON CHAR	ON CHAR	34	9	14	31	4	4	tr	3	-
DHE-2	BED	06/10/95	522179	593487	ON CHAR	ON CHAR	44	8	16	20	4	4	tr	3	tr
DHE-3	BED	06/10/95	822118	593373	ON CHAR	ON CHAR	40	9	17	25	3	3	tr	2	tr
DHE-4	BED	06/10/95	522131	593350	ON CHAR	ON CHAR	40	8	16	25	3	3	tr	4	tr
DHE-5	BED	06/10/95	521813	593154	-	-	39	8	13	26	6	5	2	1	tr
DHE-6	BED	06/10/95	521773	592580	6.30	6.30	35	6	7	6	10	17	15	4	-
DHE-7	BED	06/10/95	521738	591864	11.30	11.30	46	7	14	4	8	12	7	2	-
DHE-8	BED	06/10/95	521703	591160	9.73	9.73	44	9	16	1	12	13	4	1	-
DHE-9	BED	06/10/95	521636	590222	11.30	11.30	56	11	17	1	5	6	3	1	-

Table 9. Sand Mineralogy of Sediments of Padma River near Kamargaon (Location Fig 3.5b)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
							Sand Minarology								
DHB-1	BED	07/06/95	600565	658562	27.20	27.20	52	9	22	12	5	5	1	-	-
DHB-2	BED	07/06/95	600511	658596	22.20	22.20	45	6	21	12	5	5	6	-	-
DHB-3	BED	07/06/95	600986	658280	-	-	45	8	18	8	10	8	3	-	-
DHB-4	BED	07/06/95	600825	658349	12.80	12.80	42	11	23	18	3	2	tr	-	tr
DHB-5	BED	07/06/95	600706	658464	24.80	24.80	53	16	14	2	7	7	1	-	-

Table 10. Sand Mineralogy of Sediments of Meghna River near Bhairab Bazar (Location Fig 3.8)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
							Sand Minarology								
2	Head	08/11/95	468879	783524	-	-	39	10	43	3	2	3	-	-	tr
3	Head	08/11/95	468879	783474	-	-	35	20	36	3	3	2	tr	-	-
4	Head	08/11/95	468879	783424	-	-	37	12	36	4	6	5	-	-	-
6	Tail	08/11/95	469618	782268	-	-	36	20	35	6	2	1	-	-	-
7	Tail	08/11/95	469668	782268	-	-	45	18	30	4	2	1	-	-	-
8	Tail	08/11/95	469718	782268	-	-	39	21	30	6	3	1	-	-	-
9	Middle	10/11/95	469279	785134	-	-	39	15	35	9	1	1	-	-	-
11	Middle	10/11/95	469064	783131	-	-	34	27	35	1	2	1	-	-	-
12	Middle	10/11/95	468914	783131	-	-	33	25	36	1	4	1	-	-	-

Table 11. Sand Mineralogy of Sediments of Jim's Bar (location Fig 3.9)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
							Sand Minarology								
2	Head	09/11/95	470308	774375	-	-	35	21	35	5	2	1	-	-	-
3	Head	09/11/95	470308	774315	-	-	40	17	33	6	3	1	-	-	-
4	Head	09/11/95	470308	774265	-	-	40	8	14	32	3	1	-	2	-
5	Tail	09/11/95	471002	771572	-	-	46	16	20	13	4	1	-	-	-
6	Tail	09/11/95	471052	771572	-	-	43	7	15	29	3	2	-	1	-
7	Tail	09/11/95	470948	771572	-	-	45	14	21	16	3	1	-	-	-
8	Tail	09/11/95	471898	771572	-	-	47	12	26	7	6	2	-	-	-
9	Middle	09/11/95	471080	772950	-	-	44	8	15	23	5	4	tr	tr	-
10	Middle	09/11/95	470880	772950	-	-	48	11	24	8	6	3	-	-	-
11	Middle	09/11/95	470460	772950	-	-	50	10	24	6	6	3	-	-	tr
12	Middle	09/11/95	470660	772950	-	-	41	7	16	26	7	3	-	-	-

Table 12. Sand Mineralogy of Sediments of Roy's Bar (Location Fig 3.9)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Profile Depth (m)	Depth From Surface (m)	Sand Minarology: Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
A1	A	09/11/95	470988	778421	5.50	5.50	38	7	10	42	1	1	-	tr	tr
A2	A	09/11/95	470988	778421	5.50	2.50	55	9	20	2	5	6	2	1	-
A3	A	09/11/95	470988	778421	5.50	0.70	38	7	12	39	3	1	-	-	-
A4	A	09/11/95	470988	778421	5.50	0.20	59	8	17	12	3	1	-	-	-
C1	C	09/11/95	471178	779649	4.90	4.90	43	9	41	2	3	1	-	-	tr
C2	C	09/11/95	471178	779649	4.90	3.90	41	5	11	40	2	1	-	-	-
C3	C	09/11/95	471178	779649	4.90	2.40	70	8	12	6	1	1	1	-	-
C4	C	09/11/95	471178	779649	4.90	0.30	43	7	12	35	1	1	tr	tr	-

Table 13. Sand Mineralogy of Sediments of River Bank Profile (Location Fig 3.9)

Site No.	Sample Type	Collection Date	Sampling Position Longitude East	Sampling Position Latitude North	Total Depth (m)	Sampling Depth (m)	Sand Minarology: Quartz (%)	Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Amphibole (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Others (%)
1	CLOTH	22/10/95	89°49.1633'	24°44.7183'	0.0-0.15	0.0-0.15	47	8	13	24	4	3	tr	-	tr
1	CLOTH	22/10/95	89°49.1633'	24°44.7183'	0.15-0.25	0.15-0.25	42	9	12	31	5	1	-	-	-
1	TRAP	22/10/95	89°49.1633'	24°44.7183'	Above Funnel	Above Funnel	36	9	15	32	2	5	1	-	-
1	TRAP	22/10/95	89°49.1633'	24°44.7183'	Inside Trap	Inside Trap	47	7	16	19	6	4	1	-	-
2	CLOTH	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	10	3	84	2	tr	-	tr	-	-
2	CLOTH	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	12	2	78	7	-	-	-	-	tr
2	TRAP	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	51	6	18	23	1	1	-	-	-
2	TRAP	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	61	8	13	15	2	1	-	-	-
3	CLOTH	25/09/95	89°48.6271'	24°44.3766'	0.0-0.18	0.0-0.18	44	13	18	16	4	4	tr	-	tr
3	CLOTH	25/09/95	89°48.6271'	24°44.3766'	0.18-0.26	0.18-0.26	45	6	10	33	3	2	tr	-	tr
3	TRAP	25/09/95	89°48.6271'	24°44.3766'	Above Funnel	Above Funnel	48	5	19	16	6	5	tr	-	-
3	TRAP	25/09/95	89°48.6271'	24°44.3766'	Inside Trap	Inside Trap	43	9	11	30	4	2	tr	-	-
4	CLOTH	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	46	7	12	24	6	4	1	-	-
4	CLOTH	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	63	6	11	12	4	3	1	-	-
4	TRAP	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	47	3	8	40	1	tr	-	-	tr
4	TRAP	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	55	7	2	36	-	-	-	-	-
5	CLOTH	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	44	3	7	38	4	3	tr	-	tr
5	CLOTH	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	49	6	15	18	5	6	1	-	-
5	TRAP	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	42	5	10	40	1	1	-	-	1
5	TRAP	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	46	4	6	41	2	1	-	-	-
6	CLOTH	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	57	8	10	17	5	3	-	-	-
6	CLOTH	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	48	5	7	36	3	1	-	-	-
6	TRAP	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	40	3	8	47	1	tr	-	-	tr
6	TRAP	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	43	5	8	31	7	6	-	-	-

Table 14. Sand Mineralogy of Flood Plain Sediments (Location Fig 3.10)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Silt Minarology						Clay Minarology		
			Easting (m)	Northing (m)			Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
1	BED	05.10.95	456653	830270	5.65	5.65	59	5	13	19	4	-	-	-	-
2	BED	05.10.95	456018	829891	1.20	1.20	37	1	6	38	18	-	-	-	-
3	BED	05.10.95	455605	829819	2.00	2.00	57	2	14	24	3	-	-	-	-
4	BED	05.10.95	454726	829710	1.80	1.80	51	2	35	11	tr	-	-	-	-
5	BED	05.10.95	453739	829120	3.60	3.60	48	1	8	37	6	-	-	-	-
A1063	SUS-LOAD	05.10.95	453739	829120	5.65	2.80	38	4	3	36	17	2	-	-	-
A455	SUS-LOAD	05.10.95	456653	830270	3.60	1.80	50	5	20	25	tr	tr	-	-	-

Table 15. Silt and Clay Mineralogy of Sediments of Teesta River Up Stream (Location Fig 3.2b)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Silt Minarology						Clay Minarology		
			Easting (m)	Northing (m)			Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
DHE-1	BED	26/05/95	462640	824853	1.70	1.70	46	2	42	8	2	-	-	-	-
DHE-2.	BED	26/05/95	462461	824800	1.25	1.25	57	6	21	14	2	-	-	-	-
DHE-3	BED	26/05/95	462730	822513	2.55	2.55	41	3	46	9	1	-	-	-	-
DHE-4	BED	26/05/95	462730	823093	2.05	2.05	54	3	14	26	3	-	73	27	-
DHE-5	BED	26/05/95	462725	823012	2.00	2.00	66	2	10	20	2	-	-	-	-
1	BED	03.11.95	462640	824580	3.10	3.10	53	2	10	27	8	-	-	-	-
2	BED	03.11.95	462461	824645	1.50	1.50	60	1	11	27	1	-	-	-	-
3	BED	03.11.95	462730	822560	0.30	0.30	50	1	8	33	8	-	-	-	-
4	BED	03.11.95	462730	823110	0.40	0.40	59	3	7	25	5	1	-	-	-
5	BED	03.11.95	462780	822950	1.50	1.50	45	2	8	38	7	-	-	-	-
A935	SUS-LOAD	03.11.95	462640	824580	3.10	1.55	68	4	6	20	2	-	-	-	-
A851	SUS-LOAD	03.11.95	462780	822950	1.50	0.75	55	5	15	22	2	tr	-	-	-

Table 16. Silt and Clay Mineralogy of Sediments of Teesta River near Jamuna Confluence (Location Fig 3.2a)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Silt Minarology						Clay Minarology		
			Easting (m)	Northing (m)			Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals: Non opaque (%)	Heavy Minerals: Black opaque (%)	Carbonates (%)	Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
DHE-6	BED	26/05/95	469147	824187	2.03	2.03	53	4	5	28	10	-	-	-	-
DHE-7	BED	26/05/95	469261	824187	3.90	3.90	44	5	3	40	7	tr	-	-	-
DHE-8	BED	26/05/95	469523	824099	5.31	5.31	50	5	7	32	6	-	-	-	-
DHE-9	BED	26/05/95	469739	824140	11.50	11.50	48	8	5	32	6	tr	-	-	-
DHE-10	BED	26/05/95	469890	824150	4.40	4.40	45	3	9	35	8	-	-	-	-
DHE-11	BED	26/05/95	469924	82192	4.70	4.70	50	4	4	34	8	tr	72	28	-
DHE-12	BED	26/05/95	469630	821280	12.24	12.24	49	8	6	33	4	-	-	-	-
DHE-13	BED	26/05/95	469367	821285	10.24	10.24	57	7	2	30	4	-	-	-	-
DHE-14	BED	26/05/95	468335	821453	4.30	4.30	62	3	6	25	4	-	-	-	-
DHE-15	BED	26/05/95	467908	821716	3.85	3.85	61	6	6	25	2	-	-	-	-

Table 17. Silt and Clay Mineralogy of Sediments of upstream of Jamuna River near Teesta Confluence (Location Fig 3.2a)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Silt Minarology						Clay Minarology		
			Easting (m)	Northing (m)			Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Non opaque (%)	Heavy Minerals Black opaque (%)	Carbonates (%)	Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
DHA-1	BED	29/05/95	469538	770930	-	-	49	4	5	37	5	-	-	-	-
DHA-2	BED	29/05/95	469442	770930	-	-	50	12	5	29	4	-	-	-	-
DHA-3	BED	29/05/95	469300	770930	-	-	53	6	7	32	2	-	-	-	-
DHA-4	BED	29/05/95	470900	770930	-	-	44	7	33	15	1	-	69	31	-
DHA-5	BED	29/05/95	469884	770930	-	-	50	8	6	30	5	-	-	-	-
DHA-6	BED	29/05/95	470400	770930	-	-	50	5	6	34	4	tr	-	-	-
DHA-1	BED	30/05/95	470296	775506	-	-	52	6	6	33	3	-	-	-	-
DHA-2	BED	30/05/95	470546	775506	-	-	42	5	40	12	1	tr	68	32	-
DHA-3	BED	30/05/95	470796	775506	-	-	51	5	18	25	1	-	-	-	-
DHA-4	BED	30/05/95	468296	775506	-	-	59	6	4	29	2	-	-	-	-
DHA-5	BED	30/05/95	468900	775506	-	-	50	7	4	35	4	-	-	-	-
DHA-6	BED	30/05/95	469600	775506	-	-	42	4	4	42	8	-	-	-	-
DHA-1	BED	31/05/95	461938	783238	-	-	52	11	10	25	2	-	-	-	-
DHA-2	BED	31/05/95	461540	783250	-	-	55	6	15	23	1	-	64	35	tr
DHA-3	BED	31/05/95	462307	783254	-	-	60	5	6	25	4	-	-	-	-
DHA-4	BED	31/05/95	462512	783282	-	-	65	6	7	20	2	-	-	-	-
DHA-5	BED	31/05/95	460640	783250	-	-	68	8	10	12	2	-	-	-	-
DHA-6	BED	31/05/95	461140	783250	-	-	58	13	4	24	1	-	-	-	-
DHA-7	BED	31/05/95	466286	779883	-	-	64	5	4	25	2	-	-	-	-
DHA-8	BED	31/05/95	466316	779521	-	-	55	7	6	31	1	-	-	-	-
DHA-9	BED	31/05/95	466310	779664	-	-	46	10	7	29	8	-	-	-	-
DHA-10	BED	31/05/95	466300	780100	-	-	38	7	35	19	1	-	77	23	-
DHA-11	BED	31/05/95	466300	779300	-	-	60	6	8	23	3	-	-	-	-
DHA-1	BED	01/06/95	470076	781430	-	-	45	4	4	37	10	-	-	-	-
DHA-2	BED	01/06/95	469710	781380	-	-	57	5	28	9	1	-	-	-	-
DHA-3	BED	01/06/95	470530	781480	-	-	56	6	11	26	1	-	74	26	-
DHA-4	BED	01/06/95	470980	781550	-	-	56	8	6	29	1	-	-	-	-
DHA-5	BED	01/06/95	471430	781610	-	-	51	7	6	35	1	-	-	-	-
DHA-6	BED	01/06/95	471880	781680	-	-	50	6	19	24	1	-	68	32	-
A338	SUS-LOAD	28/05/95	469546	774930	10.40	5.00	57	7	6	28	2	-	-	-	-
A698	SUS-LOAD	30/05/95	470295	777497	13.90	7.00	46	6	27	20	1	tr	72	28	-
C126	SUS-LOAD	31/05/95	461938	783238	5.20	2.60	54	6	21	18	1	-	-	-	-
A1362	SUS-LOAD	31/05/95	466286	779883	6.00	3.00	58	4	10	27	1	-	-	-	-
C118	SUS-LOAD	01/06/95	470077	781430	12.00	6.00	65	6	8	19	2	tr	-	-	-
A4037	NEAR BED	27/05/95	469577	774934	10.00	9.95	48	11	7	31	3	-	-	-	-
A167	NEAR BED	30/05/95	470295	777497	13.90	13.85	63	5	4	27	1	-	-	-	-
C019	NEAR BED	31/05/95	461938	783238	5.20	5.15	54	4	20	21	1	-	78	22	-
C144	NEAR BED	31/05/95	466286	779883	6.00	5.95	53	10	14	22	1	-	-	-	-
B483	NEAR BED	01/06/95	470077	781430	12.00	11.95	40	5	2	39	14	-	-	-	-

Table 18. Silt and Clay Mineralogy of Sediments of Jamuna River near Bahadurabad (Location Fig 3.3)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Silt Minarology: Quartz+ Feldspar (%)	Silt Minarology: Rock Fragments (%)	Silt Minarology: Mica (%)	Silt Minarology: Heavy Minerals Non opaque (%)	Silt Minarology: Heavy Minerals Black opaque (%)	Silt Minarology: Carbonates (%)	Clay Minarology: Illite (%)	Clay Minarology: Kaolinote + Chlorite (%)	Clay Minarology: Montmorillonite (%)
DHA-1	BED	08/06/95	479100	698500	-	-	39	6	40	14	1	-	76	24	-
DHA-2	BED	08/06/95	478500	698500	-	-	51	12	5	30	2	-	-	-	-
DHA-3	BED	08/06/95	477950	698500	-	-	42	6	5	37	10	-	-	-	-
DHA-4	BED	08/06/95	477550	698500	-	-	45	10	12	31	2	-	-	-	-
DHA-5	BED	08/06/95	477400	698500	-	-	59	6	8	24	3	-	-	-	-
DHA-6	BED	08/06/95	476830	698500	-	-	56	7	15	20	1	tr	66	34	-
C131	SUS-LOAD	08/06/95	477772	698480	9.20	4.60	53	5	19	22	1	-	64	36	-
A444	NEAR BED	08/06/95	477772	698480	9.20	9.15	55	5	13	25	2	-	73	27	-

Table 19. Silt and Clay Mineralogy of Sediments of Jamuna River near Sirajganj (Location Fig 3.4)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Silt Minarology: Quartz+ Feldspar (%)	Silt Minarology: Rock Fragments (%)	Silt Minarology: Mica (%)	Silt Minarology: Heavy Minerals Non opaque (%)	Silt Minarology: Heavy Minerals Black opaque (%)	Silt Minarology: Carbonates (%)	Clay Minarology: Illite (%)	Clay Minarology: Kaolinote + Chlorite (%)	Clay Minarology: Montmorillonite (%)
DHE-1	BED	29/06/95	422722	645512	-	-	57	8	15	15	3	2	-	-	-
DHE-2	BED	29/06/95	419335	647770	-	-	51	14	5	25	4	1	-	-	-
DHE-3	BED	29/06/95	418912	646922	-	-	56	14	6	20	2	2	-	-	-
DHE-4	BED	29/06/95	415351	648600	-	-	62	12	6	17	2	1	-	-	-
DHE-5	BED	29/05/95	415850	649940	-	-	55	10	10	18	5	2	-	-	-
DHE-6	BED	29/05/95	413848	650420	-	-	56	6	19	16	2	1	-	-	-
DHE-10	BED	28/06/95	408519	650065	8.90	8.90	60	6	8	18	3	5	71	28	tr
DHE-11	BED	28/06/95	409135	649220	6.50	6.50	64	5	4	20	7	-	-	-	-
DHE-17	BED	29/06/95	408155	650018	-	-	49	6	2	35	7	tr	-	-	-
DHC-1	BED	28/05/95	402155	660646	1.70	1.70	64	12	8	13	2	1	-	-	-
DHC-3	BED	28/05/95	401346	660648	21.80	21.80	44	5	26	13	1	11	70	24	6
DHC-4	BED	28/06/95	406250	650600	2.80	2.80	57	10	7	24	1	1	-	-	-
DHC-5	BED	28/06/95	406892	651221	5.80	5.80	35	4	2	30	28	1	-	-	-
DHC-6	BED	28/05/95	407350	651411	1.50	1.50	54	14	21	8	2	1	-	-	-
DHC-7	BED	28/06/95	404000	653470	2.30	2.30	65	8	4	20	2	tr	-	-	-
DHC-8	BED	28/06/95	403504	652924	6.50	6.50	62	9	8	18	2	tr	-	-	-
DHC-10	BED	29/06/95	410552	649970	10.30	10.30	52	5	17	14	4	8	78	21	1
DHC-12	BED	29/06/95	412561	649814	3.60	3.60	52	7	14	16	2	9	75	24	tr
DHC-13	BED	29/06/95	413704	649747	5.40	5.40	54	9	6	23	8	-	-	-	-
DHC-15	BED	29/06/95	411962	649394	4.70	4.70	61	4	11	21	1	tr	-	-	-
DHC-16	BED	29/06/95	411181	649060	6.90	6.90	46	10	7	24	13	tr	-	-	-
DHC-17	BED	29/05/95	410486	648764	1.50	1.50	51	12	22	12	2	1	-	-	-
DHC-20	BED	29/06/95	411938	649798	4.10	4.10	68	6	12	11	2	1	-	-	-
DHC-23	BED	29/06/95	408380	650331	15.70	15.70	51	9	12	16	4	8	73	26	1
DHC-26	BED	29/06/95	411862	649040	8.20	8.20	56	9	10	20	4	1	-	-	-
DHC-27	BED	29/06/95	411721	648607	6.20	6.20	50	7	8	33	2	-	-	-	-
A734	SUS-LOAD	29/06/95	408380	650331	15.70	7.85	49	8	10	29	3	1	-	-	-
A1069	SUS-LOAD	29/06/95	408192	650065	16.00	8.00	56	8	20	13	2	1	-	-	-
A933	SUS-LOAD	29/06/95	411862	649040	8.20	4.10	50	9	26	14	1	-	-	-	-
A738	NEAR BED	29/06/95	408380	650331	15.70	15.20	52	6	16	16	1	9	71	29	-
A457	NEAR BED	29/06/95	411862	649040	8.20	6.58	45	15	25	12	2	tr	-	-	-

Table 20. Silt and Clay Mineralogy of Sediments of Ganges River (Location Fig 3.6 &3.7)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Silt Minarology						Clay Minarology		
			Easting (m)	Northing (m)			Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Non opaque (%)	Heavy Minerals Black opaque (%)	Carbonates (%)	Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
DHE-13	BED	28/06/95	409500	648410	1.20	1.20	57	11	3	22	6	1	-	-	-
DHE-14	BED	28/06/95	409300	647700	1.10	1.10	64	16	5	9	6	tr	-	-	-
DHE-15	BED	29/06/95	409680	646720	-	-	53	7	3	30	6	1	-	-	-
DHE-16	BED	29/06/95	410117	645435	-	-	59	10	13	15	2	1	-	-	-

Table 21. Silt and Clay Mineralogy of Sediments of Gorai River (Location Fig 3.7)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Silt Minarology						Clay Minarology		
			Easting (m)	Northing (m)			Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Non opaque (%)	Heavy Minerals Black opaque (%)	Carbonates (%)	Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
DHC-1	BED	23/06/95	528340	592935	7.10	7.10	35	5	4	37	18	1	-	-	-
DHC-2	BED	23/06/95	528569	593625	12.00	12.00	36	6	4	35	19	tr	-	-	-
DHC-3	BED	23/06/95	528865	594345	10.00	10.00	42	5	5	31	14	3	64	35	tr
DHC-4	BED	23/06/95	529078	595023	14.60	14.60	33	5	4	44	13	tr	-	-	-
DHC-5	BED	23/06/95	528541	594361	9.10	9.10	34	3	4	34	23	2	71	29	-
DHC-6	BED	23/06/95	527850	594458	7.70	7.70	34	4	3	35	24	-	-	-	-
DHC-7	BED	24/06/95	526456	592246	15.70	15.70	52	7	8	29	3	tr	-	-	-
DHC-8	BED	24/06/95	526938	592056	7.20	7.20	36	4	2	32	26	-	-	-	-
DHC-9	BED	24/06/95	526979	593592	7.70	7.70	49	6	8	33	3	tr	-	-	-
DHC-10	BED	24/06/95	525401	595159	2.30	2.30	55	6	12	24	2	1	83	17	-
2	BED	31/10/95	528581	593624	10.20	10.20	56	7	20	14	2	1	-	-	-
4	BED	31/10/95	529076	595020	10.20	10.20	47	5	8	36	2	2	-	-	-
5	BED	31/10/95	528561	594363	8.60	8.60	64	5	7	21	2	1	-	-	-
8	BED	31/10/95	526938	592052	15.60	15.60	52	4	7	26	8	3	-	-	-
A21	SUS-LOAD	24/06/95	526456	592247	15.70	8.20	62	5	18	13	1	tr	66	33	tr
A27	NEAR-BED	24/06/95	526456	592247	15.70	25.20	65	8	10	15	1	1	76	24	-

Table 22. Silt and Clay Mineralogy of Sediments of Padma River near Mawa (Location Fig 3.5a)

Sample No.	Sample Type	Collection Date	Sampling Position		Total Depth (m)	Sampling Depth (m)	Silt Minarology						Clay Minarology		
			Easting (m)	Northing (m)			Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Non opaque (%)	Heavy Minerals Black opaque (%)	Carbonates (%)	Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
DHE-1	BED	06/10/95	522252	593581	ON CHAR	ON CHAR	56	7	8	27	tr	1	-	-	-
DHE-2	BED	06/10/95	522179	593487	ON CHAR	ON CHAR	52	11	10	24	2	1	-	-	-
DHE-3	BED	06/10/95	822118	593373	ON CHAR	ON CHAR	54	9	8	25	2	2	-	-	-
DHE-4	BED	06/10/95	522131	593350	ON CHAR	ON CHAR	48	8	15	26	2	1	-	-	-
DHE-5	BED	06/10/95	521813	593154	-	-	48	10	17	22	tr	2	-	-	-
DHE-6	BED	06/10/95	521773	592580	6.30	6.30	31	6	6	41	15	tr	-	-	-
DHE-7	BED	06/10/95	521738	591864	11.30	11.30	47	7	34	11	tr	-	-	-	-
DHE-8	BED	06/10/95	521703	591160	9.73	9.73	51	13	9	18	4	5	-	-	-
DHE-9	BED	06/10/95	521636	590222	11.30	11.30	49	7	25	13	3	3	-	-	-

Table 23. Silt and Clay Mineralogy of Sediments of Padma River near Kamargaon (Location Fig 3.5b)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Silt Minarology: Quartz+ Feldspar (%)	Silt Minarology: Rock Fragments (%)	Silt Minarology: Mica (%)	Silt Minarology: Heavy Minerals Non opaque (%)	Silt Minarology: Heavy Minerals Black opaque (%)	Silt Minarology: Carbonates (%)	Clay Minarology: Illite (%)	Clay Minarology: Kaolinote + Chlorite (%)	Clay Minarology: Montmorillonite (%)
DHB-1	BED	07/06/95	600565	658562	27.20	27.20	46	15	18	20	1	-	-	-	-
DHB-2	BED	07/06/95	600511	658596	22.20	22.20	58	10	16	16	tr	-	69	31	-
DHB-3	BED	07/06/95	600986	658280	-	-	54	13	5	23	5	-	-	-	-
DHB-4	BED	07/06/95	600825	658349	12.80	12.80	48	9	30	10	3	-	-	-	-
DHB-5	BED	07/06/95	600706	658464	24.80	24.80	51	10	3	31	5	-	-	-	-

Table 24. Silt and Clay Mineralogy of Sediments of Meghna River near Bhairab Bazar (Location Fig 3.8)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Silt Minarology: Quartz+ Feldspar (%)	Silt Minarology: Rock Fragments (%)	Silt Minarology: Mica (%)	Silt Minarology: Heavy Minerals Non opaque (%)	Silt Minarology: Heavy Minerals Black opaque (%)	Silt Minarology: Carbonates (%)	Clay Minarology: Illite (%)	Clay Minarology: Kaolinote + Chlorite (%)	Clay Minarology: Montmorillonite (%)
2	Head	08/11/95	468879	783524	-	-	59	5	14	20	1	1	-	-	-
3	Head	08/11/95	468879	783474	-	-	56	7	18	17	1	1	66	34	-
4	Head	08/11/95	468879	783424	-	-	54	7	18	20	1	-	-	-	-
6	Tail	08/11/95	469618	782268	-	-	69	8	9	13	-	-	-	-	-
7	Tail	08/11/95	469668	782268	-	-	56	10	13	18	2	1	64	36	-
8	Tail	08/11/95	469718	782268	-	-	52	10	10	24	2	2	-	-	-
9	Middle	10/11/95	469279	785134	-	-	54	9	12	23	1	Tr	65	35	-
11	Middle	10/11/95	469064	783131	-	-	48	7	10	30	4	-	-	-	-
12	Middle	10/11/95	468914	783131	-	-	61	4	3	29	3	-	-	-	-

Table 25. Silt and Clay Mineralogy of Sediments of Jim's Bar (Location Fig 3.9)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Silt Minarology: Quartz+ Feldspar (%)	Silt Minarology: Rock Fragments (%)	Silt Minarology: Mica (%)	Silt Minarology: Heavy Minerals Non opaque (%)	Silt Minarology: Heavy Minerals Black opaque (%)	Silt Minarology: Carbonates (%)	Clay Minarology: Illite (%)	Clay Minarology: Kaolinote + Chlorite (%)	Clay Minarology: Montmorillonite (%)
2	Head	09/11/95	470308	774375	-	-	60	10	8	20	tr	1	-	-	-
3	Head	09/11/95	470308	774315	-	-	60	6	7	24	2	tr	-	-	-
4	Head	09/11/95	470308	774265	-	-	54	9	4	29	3	1	74	26	-
5	Tail	09/11/95	471002	771572	-	-	42	6	3	41	7	tr	-	-	-
6	Tail	09/11/95	471052	771572	-	-	60	9	6	22	2	1	59	41	-
7	Tail	09/11/95	470948	771572	-	-	35	5	4	44	10	2	-	-	-
8	Tail	09/11/95	471898	771572	-	-	49	5	4	33	8	tr	-	-	-
9	Middle	09/11/95	471080	772950	-	-	52	9	12	24	Tr	2	59	41	-
10	Middle	09/11/95	470880	772950	-	-	57	7	10	24	1	1	-	-	-
11	Middle	09/11/95	470460	772950	-	-	41	7	6	40	6	-	-	-	-
12	Middle	09/11/95	470660	772950	-	-	54	6	7	32	-	1	-	-	-

Table 26. Silt and Clay Mineralogy of Sediments of Roy's Bar (Location Fig 3.9)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Northing (m)	Total Profile Depth (m)	Depth From Surface (m)	Silt Minarology Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Non opaque (%)	Black opaque (%)	Carbonates (%)	Clay Minarology Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
A1	A	09/11/95	470988	778421	5.50	5.50	62	7	12	18	Tr	-	64	36	-
A2	A	09/11/95	470988	778421	5.50	2.50	59	12	9	19	1	-	63	37	-
A3	A	09/11/95	470988	778421	5.50	0.70	62	10	7	20	-	1	79	21	-
A4	A	09/11/95	470988	778421	5.50	0.20	55	8	10	26	1	-	66	34	-
C1	C	09/11/95	471178	779649	4.90	4.90	65	13	5	16	1	-	67	33	-
C2	C	09/11/95	471178	779649	4.90	3.90	61	13	12	10	4	-	64	36	-
C3	C	09/11/95	471178	779649	4.90	2.40	64	11	7	17	Tr	-	74	26	-
C4	C	09/11/95	471178	779649	4.90	0.30	53	8	8	29	2	-	77	23	-

Table 27. Silt and Clay Mineralogy of Sediments of River Bank Profile (Location Fig 3.9)

Site No.	Sample Type	Collection Date	Sampling Position Longitude East	Latitude North	Total Depth (m)	Sampling Depth (m)	Silt Minarology Quartz+ Feldspar (%)	Rock Fragments (%)	Mica (%)	Heavy Minerals Non opaque (%)	Black opaque (%)	Carbonates (%)	Clay Minarology Illite (%)	Kaolinote + Chlorite (%)	Montmorillonite (%)
1	CLOTH	22/10/95	89°49.1633'	24°44.7183'	0.0-0.15	0.0-0.15	57	7	6	30	-	-	69	31	-
1	CLOTH	22/10/95	89°49.1633'	24°44.7183'	0.15-0.25	0.15-0.25	53	8	11	25	2	1	69	31	-
1	TRAP	22/10/95	89°49.1633'	24°44.7183'	Above Funnel	Above Funnel	63	8	7	21	tr	-	-	-	-
1	TRAP	22/10/95	89°49.1633'	24°44.7183'	Inside Trap	Inside Trap	48	11	9	31	tr	-	-	-	-
2	CLOTH	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	48	17	6	28	Tr	-	72	28	-
2	CLOTH	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	39	26	8	26	1	-	-	-	-
2	TRAP	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	53	9	9	28	1	Tr	65	35	-
2	TRAP	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	39	25	8	27	-	tr	-	-	-
3	CLOTH	25/09/95	89°48.6271'	24°44.3766'	0.0-0.18	0.0-0.18	47	3	10	37	2	1	74	26	-
3	CLOTH	25/09/95	89°48.6271'	24°44.3766'	0.18-0.26	0.18-0.26	62	11	5	18	2	2	70	30	-
3	TRAP	25/09/95	89°48.6271'	24°44.3766'	Above Funnel	Above Funnel	53	7	9	30	tr	tr	-	-	-
3	TRAP	25/09/95	89°48.6271'	24°44.3766'	Inside Trap	Inside Trap	49	5	6	32	7	1	-	-	-
4	CLOTH	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	39	11	29	20	-	Tr	70	30	-
4	CLOTH	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	31	19	26	23	1	-	-	-	-
4	TRAP	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	65	5	8	20	1	Tr	70	30	-
4	TRAP	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	40	28	16	15	tr	-	-	-	-
5	CLOTH	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	61	5	8	23	2	1	71	29	-
5	CLOTH	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	49	11	7	31	1	1	-	-	-
5	TRAP	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	62	10	8	20	-	-	67	33	-
5	TRAP	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	51	9	6	33	tr	tr	-	-	-
6	CLOTH	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	47	6	6	37	1	3	-	-	-
6	CLOTH	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	57	7	16	17	2	1	65	35	-
6	TRAP	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	58	12	4	24	1	Tr	74	26	-
6	TRAP	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	63	10	4	23	-	-	-	-	-

Table 28. Silt and Clay Mineralogy of Flood Plain Sediments (Location Fig 3.10)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density (g/cm³)	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
1	BED	05.10.95	456653	830270	5.65	5.65	-	-	-	2.718	0.031	0.052	0.070	0.086	0.122	42.787	57.213	1.936
2	BED	05.10.95	456018	829891	1.20	1.20	-	-	-	2.755	0.076	0.101	0.126	0.156	0.225	2.999	97.001	1.646
3	BED	05.10.95	455605	829819	2.00	2.00	-	-	-	2.822	0.079	0.107	0.134	0.163	0.225	1.766	98.234	1.624
4	BED	05.10.95	454726	829710	1.80	1.80	-	-	-	2.766	0.025	0.036	0.044	0.059	0.110	63.170	36.830	1.960
5	BED	05.10.95	453739	829120	3.60	3.60	-	-	-	3.231	0.066	0.079	0.091	0.104	0.162	11.707	88.293	1.376
A1063	SUS-LOAD	05.10.95	453739	829120	5.65	2.80	-	-	-	-	0.005	0.014	0.021	0.027	0.045	94.53	5.47	3.005
A455	SUS-LOAD	05.10.95	456653	830270	3.60	1.80	-	-	-	-	0.004	0.010	0.017	0.024	0.057	92.14	7.86	3.419

Table 29. Physical Properties of Sediments of Teesta River Up Stream (Location Fig 3.2b)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density (g/cm³)	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHE-1	BED	26/05/95	462640	824853	1.70	1.70	-	2.50	-	-	0.015	0.025	0.031	0.039	0.061	91.968	8.032	1.920
DHE-2	BED	26/05/95	462461	824800	1.25	1.25	-	3.50	-	2.72	0.026	0.041	0.055	0.075	0.120	56.116	43.884	2.030
DHE-3	BED	26/05/95	462730	822513	2.55	2.55	-	3.50	-	-	0.014	0.078	0.129	0.158	0.222	23.659	76.341	5.398
DHE-4	BED	26/05/95	462730	823093	2.05	2.05	-2.5	2.50	0.712±0.027	2.73	0.039	0.069	0.082	0.096	0.140	26.917	73.083	1.777
DHE-5	BED	26/05/95	462725	823012	2.00	2.00	-	3.50	-	2.76	0.045	0.074	0.088	0.104	0.174	20.432	79.568	1.762
1	BED	03.11.95	462640	824580	3.10	3.10	-	-	-	2.763	0.083	0.124	0.148	0.176	0.236	2.43	97.57	1.635
2	BED	03.11.95	462461	824645	1.50	1.50	-	-	-	2.715	0.073	0.091	0.109	0.133	0.211	3.66	96.34	1.614
3	BED	03.11.95	462730	822560	0.30	0.30	-	-	-	2.698	0.131	0.155	0.177	0.201	0.254	1.02	98.98	1.348
4	BED	03.11.95	462730	823110	0.40	0.40	-	-	-	2.739	0.085	0.128	0.151	0.178	0.236	2.75	97.25	1.617
5	BED	03.11.95	462780	822950	1.50	1.50	-	-	-	2.729	0.068	0.084	0.099	0.118	0.200	9.37	90.63	1.602
A935	SUS-LOAD	03.11.95	462640	824580	3.10	1.55	-	-	-	-	0.017	0.040	0.068	0.084	0.120	44.28	55.72	2.809
A851	SUS-LOAD	03.11.95	462780	822950	1.50	0.75	-	-	-	-	0.013	0.023	0.031	0.044	0.100	75.24	24.76	2.515

Table 30. Physical Properties of Sediments of Teesta River near Jamuna Confluence (Location Fig 3.2a)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHE-6	BED	26/05/95	469147	824187	2.03	2.03		3.50		2.75	0.081	0.113	0.139	0.166	0.223	1.892	98.108	1.606
DHE-7	BED	26/05/95	469261	824187	3.90	3.90		3.50		2.79	0.083	0.124	0.146	0.172	0.226	2.608	97.392	1.606
DHE-8	BED	26/05/95	469523	824099	5.31	5.31		2.50		2.85	0.116	0.145	0.165	0.188	0.233	1.176	98.824	1.384
DHE-9	BED	26/05/95	469739	824140	11.50	11.50		2.50		2.81	0.134	0.162	0.188	0.218	0.359	0.544	99.456	1.483
DHE-10	BED	26/05/95	469890	824150	4.40	4.40		3.50		2.78	0.107	0.143	0.163	0.186	0.233	1.798	98.202	1.440
DHE-11	BED	26/05/95	469924	82192	4.70	4.70	4.5	2.50	0.737±0.017	2.75	0.067	0.079	0.091	0.104	0.156	9.134	90.866	1.355
DHE-12	BED	26/05/95	469630	821280	12.24	12.24		3.50		2.77	0.186	0.275	0.319	0.370	0.473	0.235	99.765	1.557
DHE-13	BED	26/05/95	469367	821285	10.24	10.24		3.50		2.78	0.168	0.252	0.296	0.347	0.452	0.242	99.758	1.597
DHE-14	BED	26/05/95	468335	821453	4.30	4.30		3.50		2.76	0.128	0.151	0.172	0.196	0.244	1.180	98.820	1.343
DHE-15	BED	26/05/95	467908	821716	3.85	3.85		3.50		2.79	0.139	0.168	0.194	0.225	0.377	0.447	99.553	1.517

Table 31. Physical Properties of Sediments of upstream of Jamuna River near Teesta Confluence (Location Fig 3.2a)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHA-1	BED	29/05/95	469538	770930	-	-		2.50			0.14	0.17	0.19	0.23	0.38	0.37	99.63	1.53
DHA-2	BED	29/05/95	469442	770930	-	-		2.50		2.79	0.25	0.30	0.35	0.40	0.57	0.12	99.88	1.38
DHA-3	BED	29/05/95	469300	770930	-	-		2.50		2.79	0.01	0.03	0.04	0.05	0.11	73.24	26.76	2.83
DHA-4	BED	29/05/95	470900	770930	-	-	4.5	3.50	0.743±0.026		-	0.01	0.01	0.01	0.03	98.02	1.98	-
DHA-5	BED	29/05/95	469884	770930	-	-		3.50		2.85	0.14	0.18	0.21	0.25	0.41	0.42	99.58	1.60
DHA-6	BED	29/05/95	470400	770930	-	-		3.50		2.84	0.10	0.14	0.17	0.19	0.24	2.17	97.83	1.49
DHA-1	BED	30/05/95	470296	775506	-	-		3.50		2.70	0.25	0.31	0.35	0.41	0.59	0.17	99.83	1.38
DHA-2	BED	30/05/95	470546	775506	-	-	-2.5	3.50	0.722±0.033	2.82	0.07	0.12	0.16	0.20	0.38	13.71	86.29	2.18
DHA-3	BED	30/05/95	470796	775506	-	-		2.50		2.82	0.01	0.02	0.02	0.03	0.06	94.75	5.25	2.77
DHA-4	BED	30/05/95	468296	775506	-	-		3.50		2.71	-	0.07	0.08	0.10	0.19	24.93	75.07	-
DHA-5	BED	30/05/95	468900	775506	-	-		3.50		2.77	0.07	0.08	0.09	0.10	0.13	11.73	88.27	1.35
DHA-6	BED	30/05/95	469600	775506	-	-		2.50		2.83	0.09	0.13	0.15	0.17	0.23	1.62	98.38	1.59
DHA-1	BED	31/05/95	461938	783238	-	-		2.50		2.73	0.12	0.16	0.19	0.23	0.40	1.65	98.35	1.66
DHA-2	BED	31/05/95	461540	783250	-	-	2.5	2.50	0.740±0.021		-	0.07	0.08	0.10	0.14	23.70	76.30	-
DHA-3	BED	31/05/95	462307	783254	-	-		3.50		2.72	0.11	0.15	0.18	0.21	0.35	0.90	99.10	1.58
DHA-4	BED	31/05/95	462512	783282	-	-		3.50		2.80	0.09	0.14	0.16	0.19	0.24	6.79	93.21	1.59
DHA-5	BED	31/05/95	460640	783250	-	-		2.50		2.82	0.01	0.02	0.03	0.04	0.13	78.10	21.90	3.09
DHA-6	BED	31/05/95	461140	783250	-	-		3.50		2.77	0.14	0.16	0.18	0.21	0.30	0.28	99.72	1.33
DHA-7	BED	31/05/95	466286	779883	-	-		2.50		2.72	0.13	0.16	0.18	0.21	0.31	1.23	98.77	1.36
DHA-8	BED	31/05/95	466316	779521	-	-		3.50		2.77	0.12	0.15	0.17	0.19	0.24	1.38	98.62	1.39
DHA-9	BED	31/05/95	466310	779664	-	-		3.50		2.78	0.11	0.14	0.16	0.19	0.24	0.97	99.03	1.46
DHA-10	BED	31/05/95	466300	780100	-	-	4.5	3.50	0.736±0.043	2.75	0.01	0.01	0.02	0.02	0.04	94.75	5.25	2.60
DHA-11	BED	31/05/95	466300	779300	-	-		3.50		2.86	0.03	0.05	0.07	0.10	0.19	41.36	58.64	2.48
DHA-1	BED	01/06/95	470076	781430	-	-		3.50		2.81	0.08	0.10	0.12	0.15	0.22	1.45	98.55	1.61
DHA-2	BED	01/06/95	469710	781380	-	-		3.50		2.82	0.01	0.03	0.04	0.05	0.10	77.36	22.64	2.47
DHA-3	BED	01/06/95	470530	781480	-	-	4.5	3.50	0.729±0.019	2.89			0.07	0.08	0.12	46.97	53.03	
DHA-4	BED	01/06/95	470980	781550	-	-		1.50			0.15	0.19	0.23	0.28	0.43	0.27	99.73	1.62
DHA-5	BED	01/06/95	471430	781610	-	-		2.50		2.81	0.14	0.17	0.20	0.24	0.40	1.01	98.99	1.59
DHA-6	BED	01/06/95	471880	781680	-	-	4.5	3.50	0.753±0.032	2.78	0.02	0.04	0.05	0.07	0.11	61.64	38.36	2.00
A338	SUS-LOAD	28/05/95	469546	774930	10.40	5.00		2.50			0.01	0.03	0.06	0.08	0.17	55.02	44.98	3.32
A698	SUS-LOAD	30/05/95	470295	777497	13.90	7.00	2.5	2.50	0.763±0.032		0.02	0.03	0.05	0.07	0.19	59.51	40.49	3.04
C126	SUS-LOAD	31/05/95	461938	783238	5.20	2.60		2.50			0.01	0.02	0.03	0.04	0.07	89.57	10.43	2.20
A1362	SUS-LOAD	31/05/95	466286	779883	6.00	3.00		3.50			0.01	0.03	0.04	0.05	0.11	75.02	24.98	2.48
C118	SUS-LOAD	01/06/95	470077	781430	12.00	6.00		3.50			0.00	0.03	0.04	0.05	0.10	76.78	23.22	2.50
A4037	NEAR BED	27/05/95	469577	774934	10.00	9.95		3.50		2.77	0.14	0.18	0.21	0.25	0.42	0.46	99.54	1.62
A167	NEAR BED	30/05/95	470295	777497	13.90	13.85		3.50		2.70	0.19	0.29	0.34	0.40	0.61	1.83	98.17	1.63
C019	NEAR BED	31/05/95	461938	783238	5.20	5.15	4.5	3.50	0.753±0.047		-	0.09	0.12	0.15	0.24	17.77	82.23	-
C144	NEAR BED	31/05/95	466286	779883	6.00	5.95		3.50			0.07	0.10	0.13	0.16	0.24	12.63	87.37	1.80
B483	NEAR BED	01/06/95	470077	781430	12.00	11.95		2.50			0.10	0.14	0.16	0.19	0.25	0.23	99.77	1.55

Table 32. Physical Properties of Sediments of Jamuna River near Bahadurabad (Location Fig 3.3)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHA-1	BED	08/06/95	479100	698500	-	-	-2.50	1.50	0.700±0.012	2.88	0.004	0.013	0.020	0.026	0.045	96.136	3.864	3.475
DHA-2	BED	08/06/95	478500	698500	-	-		2.50		2.77	0.130	0.152	0.172	0.194	0.237	1.104	98.896	1.319
DHA-3	BED	08/06/95	477950	698500	-	-		3.50		2.8	0.127	0.150	0.170	0.194	0.240	0.414	99.586	1.340
DHA-4	BED	08/06/95	477550	698500	-	-		3.50		2.73	0.143	0.172	0.200	0.232	0.389	0.215	99.785	1.534
DHA-5	BED	08/06/95	477400	698500	-	-		3.50		2.75	0.149	0.192	0.235	0.293	0.430	0.182	99.818	1.623
DHA-6	BED	08/06/95	476830	698500	-	-	-2.5	3.50	0.699±0.011	2.78	0.060	0.087	0.115	0.147	0.218	17.243	82.757	1.819
C131	SUS-LOAD	08/06/95	477772	698480	9.20	4.60	-2.5	3.50	0.717±0.016		0.016	0.033	0.058	0.082	0.165	53.230	46.770	2.890
A444	NEAR BED	08/06/95	477772	698480	9.20	9.15	-2.5	2.50	0.674±0.025	2.75	0.103	0.142	0.163	0.188	0.238	1.124	98.876	1.481

Table 33. Physical Properties of Sediments of Jamuna River near Sirajganj (Location Fig 3.4)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHE-1	BED	29/06/95	422722	645512	-	-		3.50		2.72	0.100	0.139	0.159	0.183	0.230	0.785	99.215	1.481
DHE-2	BED	29/06/95	419335	647770	-	-		3.50		2.75	0.128	0.150	0.169	0.191	0.234	1.458	98.542	1.320
DHE-3	BED	29/06/95	418912	646922	-	-		3.50		2.82	0.132	0.155	0.175	0.198	0.244	1.824	98.176	1.326
DHE-4	BED	29/06/95	415351	648600	-	-		2.50		2.71	0.173	0.257	0.305	0.361	0.480	0.199	99.801	1.616
DHE-5	BED	29/05/95	415850	649940	-	-		3.50		2.73	0.031	0.062	0.078	0.099	0.180	27.644	72.356	2.194
DHE-6	BED	29/05/95	413848	650420	-	-		3.50		2.72	0.005	0.013	0.017	0.022	0.046	95.460	4.540	2.671
DHE-10	BED	28/06/95	408519	650065	8.90	8.90	-2.5	3.50	0.700±0.019	2.71	0.068	0.092	0.116	0.149	0.229	11.444	88.556	1.745
DHE-11	BED	28/06/95	409135	649220	6.50	6.50		2.50		2.78	0.091	0.134	0.157	0.184	0.240	2.153	97.847	1.579
DHE-17	BED	29/06/95	408155	650018	-	-		3.50		2.75	0.081	0.112	0.139	0.166	0.225	0.993	99.007	1.610
DHC-1	BED	28/05/95	402155	660646	1.70	1.70		2.50		2.74	0.016	0.136	0.173	0.220	0.391	28.388	71.612	6.372
DHC-3	BED	28/05/95	401346	660648	21.80	21.80	-2.5	3.50	0.702±0.019	2.80	0.004	0.012	0.017	0.022	0.042	96.931	3.069	3.096
DHC-4	BED	28/06/95	406250	650600	2.80	2.80		3.50		2.73	0.097	0.137	0.158	0.182	0.230	0.690	99.310	1.501
DHC-5	BED	28/06/95	406892	651221	5.80	5.80		2.50		2.85	0.073	0.089	0.105	0.122	0.203	1.269	98.731	1.572
DHC-6	BED	28/05/95	407350	651411	1.50	1.50		2.50		2.79	0.006	0.013	0.018	0.024	0.042	95.668	4.332	2.444
DHC-7	BED	28/06/95	404000	653470	2.30	2.30		3.50		2.75	0.106	0.142	0.162	0.185	0.231	1.069	98.931	1.440
DHC-8	BED	28/06/95	403504	652924	6.50	6.50		2.50		2.77	0.129	0.150	0.169	0.191	0.233	0.183	99.817	1.312
DHC-10	BED	29/06/95	410552	649970	10.30	10.30	-2.5	2.50	0.706±0.001	2.71	0.037	0.051	0.058	0.070	0.108	59.247	40.753	1.620
DHC-12	BED	29/06/95	412561	649814	3.60	3.60	-2.5	3.50	0.720±0.038	2.75	0.068	0.089	0.109	0.139	0.242	10.010	89.990	1.774
DHC-13	BED	29/06/95	413704	649747	5.40	5.40		3.50		2.73	0.116	0.145	0.165	0.187	0.232	0.656	99.344	1.378
DHC-15	BED	29/06/95	411962	649394	4.70	4.70		3.50		2.71	0.138	0.159	0.178	0.200	0.241	0.330	99.670	1.294
DHC-16	BED	29/06/95	411181	649060	6.90	6.90		3.50		2.86	0.131	0.153	0.172	0.195	0.239	0.321	99.679	1.316
DHC-17	BED	29/05/95	410486	648764	1.50	1.50		3.50		2.70	0.017	0.034	0.042	0.054	0.125	74.152	25.848	2.473
DHC-20	BED	29/06/95	411938	649798	4.10	4.10		3.50		2.77	0.093	0.135	0.157	0.182	0.234	1.181	98.819	1.545
DHC-23	BED	29/06/95	408380	650331	15.70	15.70	-2.5	2.50	0.699±0.038	2.80	0.068	0.081	0.093	0.107	0.172	7.005	92.995	1.415
DHC-26	BED	29/06/95	411862	649040	8.20	8.20		2.50		2.71	0.136	0.158	0.179	0.201	0.246	0.340	99.660	1.315
DHC-27	BED	29/06/95	411721	648607	6.20	6.20		3.50		2.73	0.113	0.144	0.164	0.186	0.231	0.582	99.418	1.396
A734	SUS-LOAD	29/06/95	408380	650331	15.70	7.85		3.50			-	0.004	0.009	0.016	0.047	92.447	7.553	-
A1069	SUS-LOAD	29/06/95	408192	650065	16.00	8.00		2.50			-	0.007	0.015	0.034	0.088	83.949	16.051	-
A933	SUS-LOAD	29/06/95	411862	649040	8.20	4.10		3.50			-	0.007	0.012	0.020	0.046	94.410	5.590	-
A738	NEAR BED	29/06/95	408380	650331	15.70	15.20	-2.5	3.50	0.698±0.019		-	0.006	0.013	0.024	0.089	81.665	18.335	-
A457	NEAR BED	29/06/95	411862	649040	8.20	6.58		3.50			-	0.007	0.013	0.021	0.072	88.589	11.411	-

Table 34. Physical Properties of Sediments of Ganges River (Location Fig 3.6 & 3.7)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHE-13	BED	28/06/95	409500	648410	1.20	1.20		3.50		2.74	0.138	0.160	0.181	0.204	0.248	0.265	99.735	1.310
DHE-14	BED	28/06/95	409300	647700	1.10	1.10		3.50		2.77	0.139	0.162	0.184	0.208	0.291	0.181	99.819	1.322
DHE-15	BED	29/06/95	409680	646720	-	-		3.50		2.76	0.125	0.147	0.166	0.188	0.231	0.302	99.698	1.327
DHE-16	BED	29/06/95	410117	645435	-	-		3.50		2.71	0.132	0.153	0.173	0.195	0.238	0.266	99.734	1.311

Table 35. Physical Properties of Sediments of Gorai River (Location Fig 3.7)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHC-1	BED	23/06/95	528340	592935	7.10	7.10		3.50		2.79	0.129	0.150	0.170	0.192	0.235	0.419	99.581	1.318
DHC-2	BED	23/06/95	528569	593625	12.00	12.00		2.50		2.90	0.082	0.120	0.144	0.170	0.225	2.564	97.436	1.607
DHC-3	BED	23/06/95	528865	594345	10.00	10.00	4.5	3.50	0.735±0.023	2.87	0.070	0.083	0.095	0.109	0.175	4.172	95.828	1.421
DHC-4	BED	23/06/95	529078	595023	14.60	14.60		3.50		2.86	0.080	0.115	0.141	0.168	0.224	3.298	96.702	1.622
DHC-5	BED	23/06/95	528541	594361	9.10	9.10	4.5	3.50	0.738±0.032	3.35	0.067	0.079	0.089	0.101	0.124	7.799	92.201	1.327
DHC-6	BED	23/06/95	527850	594458	7.70	7.70		3.50		3.22	0.071	0.084	0.097	0.111	0.183	3.658	96.342	1.467
DHC-7	BED	24/06/95	526456	592246	15.70	15.70		2.50		2.73	0.137	0.165	0.191	0.221	0.372	0.285	99.715	1.501
DHC-8	BED	24/06/95	526938	592056	7.20	7.20		2.50		2.97	0.079	0.106	0.133	0.160	0.221	1.240	98.760	1.609
DHC-9	BED	24/06/95	526979	593592	7.70	7.70		3.50		2.84	0.125	0.147	0.166	0.188	0.231	0.563	99.437	1.327
DHC-10	BED	24/06/95	525401	595159	2.30	2.30	-2.5	2.50	0.698±0.024	2.74	0.067	0.080	0.091	0.105	0.159	8.459	91.541	1.360
2	BED	31/10/95	528581	593624	10.20	10.20		2.5-->3.5		2.701	0.138	0.160	0.181	0.203	0.248	0.51	99.49	1.308
4	BED	31/10/95	529076	595020	10.20	10.20		2.5		2.732	0.063	0.075	0.085	0.097	0.121	15.25	84.75	1.351
5	BED	31/10/95	528561	594363	8.60	8.60		2.5-->3.5		2.660	0.127	0.148	0.167	0.189	0.231	4.07	95.93	1.316
8	BED	31/10/95	526938	592052	15.60	15.60		2.5		2.725	0.070	0.086	0.101	0.118	0.199	6.68	93.32	1.578
A21	SUS-LOAD	24/06/95	526456	592247	15.70	8.20	-2.5	2.50	0.713±0.020		0.008	0.020	0.036	0.050	0.098	78.199	21.801	3.333
A27	NEAR-BED	24/06/95	526456	592247	15.70	25.20	-2.5	3.50	0.710±0.025		0.017	0.043	0.067	0.089	0.171	47.203	52.797	2.963

Table 36. Physical Properties of Sediments of Padma River near Mawa (Location Fig 3.5a)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHE-1	BED	06/10/95	522252	593581	ON CHAR	ON CHAR		2.5		2.748	0.036	0.052	0.065	0.080	0.114	47.67	52.33	1.710
DHE-2	BED	06/10/95	522179	593487	ON CHAR	ON CHAR		2.5		2.728	0.038	0.057	0.069	0.084	0.115	42.53	57.47	1.676
DHE-3	BED	06/10/95	822118	593373	ON CHAR	ON CHAR		2.5		2.734	0.039	0.057	0.070	0.087	0.123	42.29	57.71	1.705
DHE-4	BED	06/10/95	522131	593350	ON CHAR	ON CHAR		2.5-->3.5		2.724	0.054	0.070	0.082	0.095	0.122	24.30	75.70	1.460
DHE-5	BED	06/10/95	521813	593154	-	-		2.5		2.731	0.034	0.050	0.061	0.078	0.120	52.93	47.07	1.782
DHE-6	BED	06/10/95	521773	592580	6.30	6.30		2.5		2.988	0.065	0.078	0.089	0.102	0.142	11.79	88.21	1.364
DHE-7	BED	06/10/95	521738	591864	11.30	11.30		2.5		2.786	0.073	0.092	0.112	0.139	0.212	4.71	95.29	1.620
DHE-8	BED	06/10/95	521703	591160	9.73	9.73		2.5-->3.5		2.863	0.128	0.149	0.168	0.190	0.232	0.88	99.12	1.314
DHE-9	BED	06/10/95	521636	590222	11.30	11.30		2.5		2.752	0.127	0.148	0.167	0.188	0.231	0.57	99.43	1.316

Table 37. Physical Properties of Sediments of Padma River near Kamargaon (Location Fig 3.5b)

Sample No.	Sample Type	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
DHB-1	BED	07/06/95	600565	658562	27.20	27.20		3.50			0.008	0.111	0.202	0.286	0.427	33.016	66.984	13.585
DHB-2	BED	07/06/95	600511	658596	22.20	22.20	4.5	2.50	0.709±0.039		-	0.008	0.019	0.048	0.234	68.355	31.645	-
DHB-3	BED	07/06/95	600986	658280	-	-		3.50		2.82	0.055	0.075	0.096	0.123	0.204	11.064	88.936	1.815
DHB-4	BED	07/06/95	600825	658349	12.80	12.80		3.50			0.022	0.133	0.155	0.181	0.233	19.464	80.536	4.229
DHB-5	BED	07/06/95	600706	658464	24.80	24.80		2.50		2.77	0.138	0.159	0.178	0.199	0.239	0.888	99.112	1.285

Table 38. Physical Properties of Sediments of Meghna River near Bhairab Bazar (Location Fig 3.8)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
2	Head	08/11/95	468879	783524	-	-		2.5		2.691	0.261	0.303	0.342	0.384	0.468	1.58	98.42	1.307
3	Head	08/11/95	468879	783474	-	-	4.5	2.5	0.706±0.031	2.685	0.259	0.302	0.340	0.382	0.466	1.93	98.07	1.309
4	Head	08/11/95	468879	783424	-	-		2.5		2.740	0.222	0.288	0.328	0.373	0.462	3.37	96.63	1.408
6	Tail	08/11/95	469618	782268	-	-		2.5		2.738	0.146	0.197	0.251	0.309	0.437	4.69	95.31	1.660
7	Tail	08/11/95	469668	782268	-	-	4.5	2.5	0.708±0.017	2.782	0.039	0.089	0.158	0.222	0.397	30.19	69.81	3.117
8	Tail	08/11/95	469718	782268	-	-		2.5		2.721	0.148	0.212	0.271	0.326	0.444	3.87	96.13	1.676
9	Middle	10/11/95	469279	785134	-	-	4.5	2.5	0.707±0.021	2.726	0.038	0.130	0.260	0.317	0.440	23.72	76.28	4.204
11	Middle	10/11/95	469064	783131	-	-		2.5		2.671	0.259	0.300	0.338	0.380	0.463	0.05	99.95	1.306
12	Middle	10/11/95	468914	783131	-	-		2.5		2.719	0.155	0.234	0.286	0.338	0.448	1.46	98.54	1.653

Table 39. Physical Properties of Sediments of Jim's Bar (Location Fig 3.9)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
2	Head	09/11/95	470308	774375	-	-		2.5		2.717	0.035	0.067	0.106	0.173	0.377	33.26	66.74	3.005
3	Head	09/11/95	470308	774315	-	-		2.5		2.681	0.068	0.142	0.189	0.251	0.413	14.37	85.63	2.358
4	Head	09/11/95	470308	774265	-	-	-2.5	2.5	0.706±0.013	2.751	0.025	0.040	0.054	0.070	0.117	59.53	40.47	2.034
5	Tail	09/11/95	471002	771572	-	-		2.5		2.731	0.066	0.081	0.096	0.113	0.193	12.11	87.89	1.581
6	Tail	09/11/95	471052	771572	-	-	-2.5	2.5	0.701±0.022	2.734	0.024	0.044	0.056	0.076	0.112	54.73	45.27	2.077
7	Tail	09/11/95	470948	771572	-	-		2.5		2.726	0.075	0.099	0.122	0.152	0.220	3.68	96.32	1.637
8	Tail	09/11/95	471898	771572	-	-		2.5		2.682	0.077	0.101	0.125	0.154	0.219	2.54	97.46	1.620
9	Middle	09/11/95	471080	772950	-	-	4.5	2.5	0.710±0.013	2.680	0.064	0.083	0.102	0.127	0.210	14.96	85.04	1.709
10	Middle	09/11/95	470880	772950	-	-		2.5		2.720	0.079	0.129	0.150	0.176	0.228	8.18	91.82	1.663
11	Middle	09/11/95	470460	772950	-	-		2.5		2.732	0.081	0.125	0.147	0.173	0.227	4.86	95.14	1.632
12	Middle	09/11/95	470660	772950	-	-		2.5		2.749	0.046	0.069	0.080	0.094	-0.122	26.35	73.65	1.582

Table 40. Physical Properties of Sediments of Roy's Bar (Location Fig 3.9)

Sample No.	Sampling Location In The Bar	Collection Date	Sampling Position Easting (m)	Sampling Position Northing (m)	Total Profile Depth (m)	Depth From Surface (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
A1	A	09/11/95	470988	778421	5.50	5.50	4.5	2.5	0.069±0.019	2.769	0.006	0.014	0.020	0.027	0.049	94.75	5.25	2.717
A2	A	09/11/95	470988	778421	5.50	2.50	4.5	2.5	0.711±0.042	2.785	-	-	0.006	0.009	0.017	99.65	0.35	-
A3	A	09/11/95	470988	778421	5.50	0.70	4.5	2.5	0.713±0.023	2.771	0.010	0.022	0.031	0.041	0.086	85.90	14.10	2.534
A4	A	09/11/95	470988	778421	5.50	0.20	4.5	2.5	0.717±0.031	2.727	0.005	0.020	0.032	0.049	0.109	76.07	23.93	4.606
C1	C	09/11/95	471178	779649	4.90	4.90	4.5	2.5	0.713±0.027	2.647	-	0.004	0.006	0.008	0.024	99.55	0.45	-
C2	C	09/11/95	471178	779649	4.90	3.90	4.5	2.5	0.710±0.010	2.763	0.005	0.014	0.019	0.026	0.048	95.03	4.97	2.953
C3	C	09/11/95	471178	779649	4.90	2.40	-2.5	2.5	0.713±0.011	2.716	-	-	-	0.008	0.030	98.19	1.81	-
C4	C	09/11/95	471178	779649	4.90	0.30	4.5	2.5	0.720±0.041	2.691	0.031	0.046	0.060	0.079	0.113	52.53	47.47	1.826

Table 41. Physical Properties of Sediments of River Bank Profile (Location Fig 3.9)

Site No.	Sample Type	Collection Date	Sampling Position Longitude East	Sampling Position Latitude North	Total Depth (m)	Sampling Depth (m)	Sphericity	Angularity	Shape Factor	Particle Density g/cm³	Particle Size D16 (mm)	D35 (mm)	D50 (mm)	D65 (mm)	D90 (mm)	Weight Percent <0.063(mm)	Weight Percent >0.063(mm)	Geometric Standard Deviation
1	CLOTH	22/10/95	89°49.1633'	24°44.7183'	0.0-0.15	0.0-0.15	-2.5	2.5	0.716±0.041	2.735	0.028	0.050	0.064	0.080	0.114	44.20	55.80	1.963
1	CLOTH	22/10/95	89°49.1633'	24°44.7183'	0.15-0.25	0.15-0.25	-2.5	2.5	0.719±0.034	2.766	0.026	0.045	0.058	0.075	0.112	54.28	45.72	1.995
1	TRAP	22/10/95	89°49.1633'	24°44.7183'	Above Funnel	Above Funnel		2.5		2.725	0.024	0.045	0.063	0.078	0.116	50.01	49.99	2.146
1	TRAP	22/10/95	89°49.1633'	24°44.7183'	Inside Trap	Inside Trap		2.5		2.751	0.026	0.050	0.063	0.079	0.114	43.06	56.94	2.037
2	CLOTH	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	4.5	1.5	0.704±0.053	2.705	-	-	0.007	0.013	0.028	99.93	0.07	-
2	CLOTH	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00		2.5		2.658	-	-	0.007	0.011	0.022	99.96	0.04	-
2	TRAP	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00	4.5	2.5	0.710±0.021	-	-	-	0.004	0.007	0.019	99.91	0.09	-
2	TRAP	22/10/95	89°48.7811'	24°44.6419'	0.00	0.00		2.5		-	-	-	0.007	0.013	0.028	99.93	0.07	-
3	CLOTH	25/09/95	89°48.6271'	24°44.3766'	0.0-0.18	0.0-0.18	-2.5	2.5	0.717±0.021	2.761	0.065	0.081	0.096	0.114	0.198	13.95	86.05	1.619
3	CLOTH	25/09/95	89°48.6271'	24°44.3766'	0.18-0.26	0.18-0.26	-2.5	2.5	0.709±0.013	2.779	0.019	0.034	0.042	0.053	0.102	76.50	23.50	2.153
3	TRAP	25/09/95	89°48.6271'	24°44.3766'	Above Funnel	Above Funnel		2.5		2.756	0.063	0.079	0.094	0.112	0.192	15.46	84.54	1.613
3	TRAP	25/09/95	89°48.6271'	24°44.3766'	Inside Trap	Inside Trap		2.5		2.741	0.017	0.031	0.041	0.052	0.100	76.32	23.68	2.255
4	CLOTH	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	-2.5	2.5	0.699±0.016	2.706	-	0.008	0.013	0.020	0.042	98.41	1.59	-
4	CLOTH	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00		2.5		2.707	-	0.008	0.013	0.019	0.032	99.41	0.59	-
4	TRAP	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00	2.5	2.5	0.713±0.011	2.686	-	0.008	0.013	0.020	0.042	98.41	1.59	-
4	TRAP	25/09/95	89°47.8445'	24°44.4959'	0.00	0.00		2.5		2.693	-	0.002	0.007	0.012	0.030	99.88	0.12	-
5	CLOTH	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	-2.5	2.5	0.701±0.027	-	-	0.008	0.012	0.020	0.036	99.40	0.60	-
5	CLOTH	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00		2.5		2.681	-	0.010	0.019	0.029	0.047	99.56	0.44	-
5	TRAP	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00	-2.5	2.5	0.703±0.019	-	-	0.008	0.012	0.020	0.036	99.40	0.60	-
5	TRAP	26/09/95	89°47.0274'	24°44.6031'	0.00	0.00		2.5		-	-	0.005	0.008	0.014	0.031	98.76	1.24	-
6	CLOTH	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00		2.5		2.694	0.005	0.009	0.013	0.018	0.036	99.22	0.78	2.415
6	CLOTH	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	-2.5	2.5	0.697±0.031	2.705	0.004	0.010	0.017	0.022	0.033	99.28	0.72	3.007
6	TRAP	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00	2.5	2.5	0.719±0.031	-	0.005	0.009	0.013	0.018	0.036	99.22	0.78	2.415
6	TRAP	23/10/95	89°46.7434'	24°44.5193'	0.00	0.00		2.5		-	-	0.005	0.007	0.011	0.022	98.68	1.32	-

Table 42. Physical Properties of Flood Plain Sediments (Location Fig 3.10)

APPENDIX – III

Glossary

Angularity : A term often used for the property of sedimentary particles now commonly known as roundness.

Bed material : The material of which the bed of a stream is composed. It may originally have been the material of suspended load or of bed load, or, in some cases, of partial residual.

Clay mineral : One of a complex and loosely defined group of finely crystalline, amorphous hydrous silicates. Clay minerals are formed chiefly by alteration or weathering of primary silicate minerals such as feldspar, pyroxenes, and amphiboles that have a diameter of less than four microns.

Heavy mineral : A rock forming mineral generally having a specific gravity greater than 2.9.

Igneous rock : A rock that solidified from molten or partly molten material, i.e., from magma. It constitutes one of the three main classes into which rocks are divided, the others being sedimentary and metamorphic rocks.

Igneous metamorphism : A high temperature metamorphic process that includes the effects of magma on adjacent rocks as well as those due to injection pegmatitization.

Mineral : A naturally occurring inorganic element or compound having an orderly internal structure and a characteristically chemical composition, crystal form, and physical properties.

Metamorphic rock : A rock derived from pre-existing rocks by mineralogical, chemical, and structural changes. It is generally found deep in the earth's crust in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment.

Sand : A rock fragment or detrital particle smaller than a granule and larger than a coarse silt grain, with a diameter range of 63 to 2,000 microns.

Silt : A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, with a diameter range of four to 63 microns.

Sphericity : The relation of the various diameters (length, width, thickness) of a particle, specifically the degree to which the shape of a sedimentary particle approaches that of a sphere.

Sedimentary rock : A rock resulting from the consolidation of loose sediment that has accumulated in layers, e.g., a clastic rock consisting of mechanically formed fragments of older rock transported from its source, ice, or air, and deposited in water. Or, it may be formed chemically by precipitation from solution, or from an organic secretion of plants and animals.

Suspended load : The part of the total stream load that is carried for a considerable period of time in suspension, free from contact with the stream bed.