CHAPTER 7 FEASIBILITY DESIGN

7.1 Optimum Scheme Subject to Feasibility Study

The proposed optimum scheme is presented in **Figure 7.1.1**, and summarized below:

Control System

a) Central Control System: Dhaka

b) Regional Control System:

- Northeastern (NE) Region (Control Station: Sylhet)
- Northwestern (NW) Region (Control Station: Rangpur)
- Southeastern (SE) Region (Control Station: Chittagong)
- Southwestern (SW) Region (Control Station: Barisal)
- North-central (NC) Region (Control Station: Dhaka)

Manual-Telemeter Combined Observation System

The number of manual and telemetric hydrometeorological gauging stations to be assigned to each region is tabulated below:

Number of Hydrometeorological Gauges by Region

Region	NE	NW	SE	SW	NC	Total
Control Station	Sylhet	Rangpur	Chittagong	Barisal	Dhaka	
Water Level	***18***	***22***	***9***	***17***	***25***	***91***
Manual	11	17	7	12	21	68
Telemeter	7	5	2	5	4	23
Rainfall	***14***	***15***	***11***	***15***	***13***	***68***
Manual	7	10	9	10	9	45
Telemeter	7	5	2	5	4	23
Total	**32**	**37**	**20**	**32**	**38**	**159**

7.2 Observation System

7.2.1 Exact Locations of Proposed Telemetric Gauging Stations

The reconnaissance survey at the sites of the 23 proposed telemetric gauging stations was conducted by the Study Team and counterpart personnel and their exact locations selected. In evaluating the preferred locations the following factors were considered:

- The location should coincide with or be close to the existing FFWC observatories to maintain continuity between the records of the existing and proposed gauges.
- The location should not be influenced by wave action if possible.
- The location should have a suitable structure (bridge, revetment, etc.) to which the automatic water level gauging equipment could be properly attached.
- The location should have sufficient space for the installation of the gauge house in which the recording equipment is set.
- The location should have sufficient clearance for proper rainfall observation.

Since such information was mostly collected during the inventory survey conducted in the First Study Works in Bangladesh, the main purpose of the reconnaissance was to gather more detailed information for design of the gauging stations during the feasibility study.

Information on locations of the proposed telemetric stations is listed in **Table 7.2.1**.

7.2.2 Proposed Types of Gauging Equipment

Rainfall Gauging Equipment

The tipping bucket type rainfall gauges should, in principle, be installed on the rooftop of the gauge house.

Water Level Gauging Equipment

Conventional float-well type gauging stations have been constructed at the majority of sites of automatic water level gauging stations of BWDB. Although this requires rather extensive civil construction works, they are sustainable and reliable if the gauge is installed at stable or hard points in the river course. However, due to severe course shifting of many of the rivers in Bangladesh, a significant number of automatic water level gauging stations are currently not operational.

Following consultation with counterpart personnel, the sensing pole float equipment was selected as the most suitable for those sites with severe river course shifting.

For locations with suitable structures such as bridges, supersonic sensor (sonar) type gauging equipment is recommended.

Schematic sketches of the layout plans of both sensing pole type and supersonic sensor (sonar) type automatic water level gauging equipment/facilities are shown in **Figures 7.2.1** and **7.2.2**, respectively.

For data transmission between water level sensor and gauge house, the application of a wireless data transmission system using a solar battery with a power saving function is proposed. Since the allowable maximum direct distance between sensor pole and gauge house is about 1 km, this will prove useful for sites subject to frequent shifting of the river course.

For observatories using the supersonic sensor (sonar) type, the relocation range of the sensor is likely to be limited to within 40 ~ 50 m (one span of bridge pier) along the bridge superstructure. Data and power transmission using cables is therefore possible. Based on a preliminary comparison of cost effectiveness, the following criteria were established:

- The cable transmission system is applied if the required cable length is 500m or less.
- The wireless transmission system is applied if the required cable length is more than 500m.

Selection and Preliminary Design of Gauging Facilities

Based on the above considerations, the selection and preliminary design of the gauging facilities was carried out for each site. The sketches of the layout plans of facilities and equipment for the 23 proposed telemetric gauging stations are presented in **ANNEX-V**. The selected type of hydrometeorological gauge and method of data transmission from gauge to telemeter house are summarized in **Table 7.2.2**.

7.3 Data Transmission System

7.3.1 General

The adopted data transmission system for the flood forecasting and warning system should take into consideration the various components of the FFWS including observation, analysis, dissemination and response as well as the control systems. The overall communication network is shown in **Figure 7.3.1**.

(1) Basic Strategy of Transmitting Technology

Observation System

a) From Gauging Station to Regional Office
   - VHF Radio for telemeter observation system
   - Mobile communication (Digital HF Radio) for manual observation system
b) Between regional office and central office
   - Digital HF Radio for data communication with T&T public line

Dissemination System

a) From Central and Regional office to receiving office (Warning Message Dissemination)
   - Fax or E-mail using T&T public line
b) From Telemeter gauging station to objective O&M office and Upazilla office (Point-to-Point Direct Data Dissemination)
   - VHF Radio for telemeter dissemination system

Control System in Central and Regional Offices

   - Local Area Network (LAN) with Ethernet

(2) Requirement for Data Transmission System

Succession of Existing Analysis System

The existing analysis system has been developed for ease of use. All software is packaged on platform software and is able to operate on personal computers. This analysis system is connected to an Ethernet LAN in the FFWC, providing a convenient environment for FFWC staff to confirm and modify the analysis system using any computer connected to the LAN. As the FFWC staff were trained on using this network, the proposed analysis system (both for central and regional control) will be comparable to the existing configuration.

Common Database

A common database will sit between the interface equipment and MIKE11 analysis software. The interface software linking the software and input equipment will be simple and by using a common database no problems are anticipated to arise. Furthermore, with an open and common interface, the database will be readily accessible to other systems.

Capability to Cope with Different Collection Interval

The analysis system should be able to cope flexibly with different data recording intervals of telemeter and manual gauging stations. It should also have inbuilt software for the checking and modification of any erroneous data and be capable of operation even if observed data from manual gauging stations are not available.

Regional System

The Regional system should forward reports where and when they are required. Regional system will essentially operate using the Regional forecasting model for more detailed analysis. For the effective use of this system during emergency periods, monitoring of observed data and preparation of warning report should be carried out automatically.

Point-to-Point Direct Data Dissemination

For warning in flash flood areas, telemeter data (water level and rainfall data) from telemeter gauging stations will be forwarded directly to objective O&M divisional offices and Upazilla offices where such information is needed.

Improvement of Information System

a) Interagency Network

Flood forecasting and warning information should be transmitted to objective government agencies to ensure effective and quick action against flood disaster. The Government has a responsibility for maintaining public safety and operation of interagency networks for transmission of such information.

In line with this concept, an IT (Information Technology) policy was established in Bangladesh. BTTB is expected to assume leadership for coordination with other public utility sectors (PDB, Railway, Gas, etc) and BWDB should discuss this with them to establish the appropriate interagency network.

b) BWDB Network

Apart from the interagency network, a specific BWDB network connecting the various offices of BWDB should be established to improve business effectiveness, allow quick action during emergencies and provide full access and use of all information resources. Emergency information should be transmitted quickly between central, divisional and field offices and should be exchanged between related sections such as O&M and hydrology section within BWDB.

For this proposed system, an HF wireless network with BTTB public lines is planned between regional offices and central office. Although at present it is not considered to be a high-level information network, it would be BWDB-exclusive and could be easily maintained by BWDB.

The current HF wireless network is considered most effective for BWDB at present. However, in the future when Regional systems are fully active and many types of information are to be transmitted between central office and regional office, new information technology such as microwave, which can transmit huge volumes of data quickly, will be required. If a microwave network can be confidently maintained by BWDB, the Study team proposes this type of system for its network.

(3) Basic Design Concept

The data transmission flow is shown in **Figure 7.3.2**.

a) Data from Gauging Station
   - Observed data from telemeter gauging stations are transmitted with VHF telemeter radio line automatically to the database in the regional office at hourly intervals as a minimum.
   - Observed data from manual gauging stations are transmitted with mobile line or Digital HF Radio line automatically to the common database in the regional office at least once a day.
   - Regional warning reports are made by the regional system using observed data from telemeter gauging stations.

b) Data from Regional Office
   - Observed data stored in the common database in the regional office are transmitted to central office with Digital HF Radio line at least once a day.
   - Model boundary data for regional systems are derived using the supermodel in Central office using transmitted observed data from Regional offices.

c) Data from Central Office
   - Model boundary data for regional systems, derived using the Supermodel in Central office, are transmitted to Regional offices with Digital HF Radio line at least once a day.

d) Model Operation at Regional Office
   - The regional model is processed by Regional offices using observed data and other required model boundary data.
   - Regional forecasting reports are made by regional systems using observed data and model boundary data.

e) Dissemination from Central /Regional Offices
   - Regional warning and Regional forecasting reports are made by regional systems and disseminated to relevant agencies such as O&M divisional offices of BWDB, District offices and Upazilla offices.
   - A Central forecasting report is made by the central system and disseminated to relevant central agencies such as DMB, EOC, PMO, TV, and newspapers.
   - Dissemination is done using e-mail and fax by T&T public line.

f) Point-to-Point Direct Data Dissemination
  - For warning in flash flood areas, telemeter data (water level and rainfall data) from relevant telemeter gauging stations are sent directly to objective O&M divisional offices and Upazilla offices.
  - At these O&M divisional offices and Upazilla offices, there will be a monitor panel displaying water level and rainfall data.

7.3.2 Data Observation System

(1) General

In **Section 4.2.3**, alternative plans for transmission of recorded data were outlined.

Of these plans, it was concluded that VHF radio was the optimum method for data transmission from gauging station to regional office, and HF data transmission was the optimum method from regional office to central FFWC.

In this section, basic concepts for developing the data transmission system are provided. Descriptions of frequency management in Bangladesh and radio tests conducted by the Study Team are also mentioned. Preliminary specifications of equipment are discussed in **Section 7.7**.

(2) From Gauging Station to Regional Office

A combined system of telemeter and mobile network are proposed for data transmission from the gauging station to the regional office.

The proposed telemeter station network will incorporate 23 telemeter stations (see **Section 4.2.2**). Manual observations at the remaining 85 gauging stations of the existing FFWC hydrometeorological network will continue. At the manual stations, gauge readers will transmit the observed data via the mobile network.

The telemeter and manual systems are outlined below.

<u>Telemeter System</u>

Data from the telemeter gauging stations will be transmitted directly to the regional offices. In some cases topographic conditions and long distances would result in difficulties in direct transmission of data and repeater stations will be provided.

a. Basic Concept

Use of BWDB's existing Frequencies: Existing BWDB's frequencies (149.250MHz and 166.075MHz) will be used for the VHF telemeter system.

Location of Repeater Station: In principal, repeater stations are installed at the BWDB O&M offices located throughout the country. The available land is suitable for the erection of the high antenna towers and maintenance of the equipment is easily undertaken. Furthermore, staff at the O&M offices can obtain the observed data directly from the display panels. If O&M offices are not available the repeater stations will be installed at a site in the local Upazilla office.

Antenna Height: At the telemeter station, the standard antenna pole is proposed as 10m in height. At the repeater station, a higher antenna height of 20 to 40m was considered due to availability of land.

Stored Repeater System: To avoid deterioration in the Signal to Noise (S/N) ratio caused by long distance transmission, a stored repeater system is proposed in which transmitted data are stored and re-transmitted at every repeater station.

Power Supply System: At the telemeter station, although commercial power will be unavailable, solar power with battery will be effective.

At the repeater station in the O&M office, commercial power with battery will be utilized. The battery will be used in case of disruption to commercial power.

Where the repeater station is to be installed at a site other than the O&M office, solar power with battery will be adopted, as commercial power is likely to be unavailable at some locations.

Criteria of Signal to Noise (S/N) Ratio: There is no international criteria on radio circuit design for a telemeter system at 150MHz band. Therefore, based on criteria established by the Ministry of Land, Infrastructure and Transport, Japan, an S/N ratio of 34.5dB or more for one interval is proposed.

b. Result of Design

As outlined above a telemeter system network was designed as shown in **Figure 7.3.3**. This resulted in the need for a total of 28 repeater stations.

<u>Manual System</u>

Apart from those locations at which telemeter stations will be installed, all remaining gauging stations in the FFWC network will remain manually observed using a gauge reader. For the manual system, there are two options for data transmission between the gauging station and regional office. One is based on a mobile network system and the other on an HF data transmission system. A comparison of the advantages and disadvantages of each is given below.

The mobile network system has an advantage that apparatus for data transmission is small and light. In future, the network area will be widely distributed and the mobile network will be effective as a method of data transmission from the gauging station. HF data transmission is less reliable and a backup system such as BTTB public line is necessary. However, a BTTB public line is sometimes not available at gauging stations. For that reason, in principal, a mobile network system is proposed for data transmission from manual gauging stations. Only if a manual gauging station is located outside the mobile network will HF data transmission be used.

Comparison between Mobile Network and HF Data Transmission Systems

	Mobile network	HF data transmission
Advantage	Apparatus for data transmission is small and light Mobile network is more reliable than HF data transmission	Data transmission is conducted within BWDB's own network
Disadvantage	If outside mobile network, data cannot be transmitted	It is necessary to familiarize the gauge reader with the use of a personal computer for operation of HF data transmission HF wireless stations are not appropriate for proper installation of a personal computer

Basic concepts of a mobile network system are shown below and details of HF data transmission are discussed in sub-clause (3) "From Regional Office to Central FFWC"

[Mobile Network System]

In Bangladesh the mobile network is becoming increasingly more widespread and gaining in popularity, therefore being more effective At manual gauging stations, observations will be continued by the gauge reader In order to transmit the observed data, one mobile apparatus will be provided to the gauge reader at each station and he/she will input the data into the mobile apparatus The gauge reader will then transmit the data to the data server at the regional office for analysis

The basic concept to build up the mobile network effectively is summarized below

a Basic Concept of Mobile Data Transmission

Easy operation: Some gauge readers are not familiar with the mobile apparatus. It is necessary for every gauge reader to use it easily and instantly.

Precise data input: Wrong data should not be sent to the regional office Since inputting the data is done by the gauge reader manually, it is necessary to prepare a system that will prevent the gauge reader from transmitting the wrong data.

b Selection of Mobile Apparatus

There are two types of mobile apparatus for data transmission One is a mobile phone and the other is a PDA (Personal Digital Assistant)

It is easier to input the data into a PDA and it has a larger display than a mobile phone Therefore, operationally, a PDA is considered to be better However, the mobile phone network is currently spread more widely throughout the country (and will be in the future). Therefore, the mobile phone has been selected for data transmission from the manually observed stations c Necessary Function of Mobile Data Transmission

Input data checking system: The mobile apparatus should have a function for the gauge reader to check the input data before transmitting

Sending acknowledgment system: After data are transmitted and input to the data server at the regional office correctly, the mobile apparatus should acknowledge receipt of data

(3) From Regional Office to Central FFWC

HF Data Transmission System

BWDB currently uses HF radio for voice communication between FFWC at Dhaka and its network of wireless stations Staff of BWDB are therefore familiar with its application. HF data transmission is also on BWDB's own network and it can more easily maintain the equipment. Based on the result of HF data transmission tests conducted in this Study, HF data transmission is considered feasible provided a backup system is available should transmission failure occur

a Basic Concept of HF Data Transmission System

Use of existing BWDB's frequencies: At present, BWDB pays loyalty fees to BTRC for use of six frequencies (3 305MHz, 4 442MHz, 4 490MHz, 5 089MHz, 8 157MHz and 8 188MHz) In order to utilize these BWDB frequencies effectively, they should be used as much as possible

Preparation of Backup system: As seen from the results of HF data transmission testing (outlined below in sub-clause 5), data transmission from the regional office to the central FFWC was not always successful Therefore, to improve reliability of HF data transmission, a BTTB public line should also be used as a backup

b. Necessary Function of HF Data Transmission System

ALE (Automatic Link Establishment): To reduce the load on the HF operator and save time, HF radio should, prior to data transmission, have a function to automatically select a channel of optimum frequency from the existing BWDB frequencies

BTTB public line for backup: In case of failure of data transmission by HF, data transmission should be conducted through a BTTB public line Accordingly, HF radio equipment should have a function for automatic line changeover

Error Check Function: Error checking is necessary for precise data transmission. In addition to the data checking function installed in the modem, another error check function should be provided for the HF data transmission system to prevent transmission of garbled data

(4) Frequency Management

The management of the frequency is essential for implementation of the telecommunication network as well as the radio communication network. A discussion and recommendations on management of frequencies in Bangladesh are presented below.

Entire Area of Bangladesh

With reference to the study of telemeter system design, the Study Team investigated the allocation of frequency at BTRC. BTRC is in charge of the management of frequency use under the Ministry of Post and Telecommunication. For the allocation of new frequencies, applications are forwarded from BTRC to NSMC (National Spectrum Management Committee) which consists of 20 members from BTTB, Ministry of Defence, PDB, Grameen Phone and so on. After internal consultation, NSMC gives the recommendation of the frequency allocation to BTRC whose staff subsequently approve its allocation. As mentioned above, the fair allocation of the frequency is made based on a mutual consent among members of NSMC. Overall, frequencies in Bangladesh are managed competently by BTRC.

According to BTRC, application for new frequencies from a governmental organization is prioritized so that BWDB may obtain a new frequency if necessary.

BWDB

BWDB's existing VHF frequency is officially allocated for transmitting telemeter data. However, this frequency has also been used at a pump station in Chandpur irrigation project, also managed by BWDB. This implies management of the frequency in BWDB is not adequate. Considering radio interference and future extension of BWDB's communication network, it is necessary to organize a division or a section that will manage not only frequencies but also the whole communication network in BWDB.

(5) Radio Test

The Study Team conducted HF data transmission tests and VHF interference radio measurements during the Second Works in Bangladesh. An outline of the objectives, contents and evaluation of these is presented below.

HF Data Transmission Test

i) Objective of Test

The objective of the HF Data Transmission Test was to assess the feasibility of data transmission between the regional and central office based on the system currently operated by BWDB and also to determine the necessity of applying a new frequency. The testing was conducted between Dhaka, where the central FFWC is located, and Sylhet, the site of one of the regional offices proposed to improve the existing FFWS.

ii) Outline and Result of Test

[Outline of Test]

Text data were transmitted from one test site to another test site alternately under 16 conditions These included various frequencies, data sizes and baud rates outlined below (Details of the 16 conditions are described more fully in **ANNEX-VII**.)

- Frequency 3 305MHz, 4 442MHz, 5 089MHz, 8 188MHz
- Data size 100byte, 1kbyte
- Baud rate 1200baud, 2400baud

The data transmission was attempted three times for each condition and was conducted in the morning, around midday and evening

[Test Items]

Test items included.

- Checking the success or failure of data transmission
- Checking the time when data were transmitted

[Results of Test]

The results of the tests indicated

- Data transmission at 8.188MHz frequency was better than at the other three frequencies tested (3 305MHz, 4 442MHz, 5 089MHz) regardless of time
- Reliability of HF data transmission was variable, the average of total successful transmission at 8 188MHz being 53%.
- The success and failure of data transmission did not depend on baud rate and data size
- Antenna input level of the receiver side at successful transmission was about 30 to 45 dBμV. Garbled data were transmitted twice at these input levels.

Test results are listed in **Table 7.3.1.** Data measured at the test site are presented in **ANNEX-VII**

iii) Evaluation

Based on the HF data transmission test

- Data transmission from the regional office to the central office using HF is possible However reliability of data transmission is not particularly high
- In order to reliably transmit data to the central office (in case of failure of data transmission by HF), a BTTB public line is necessary as a backup to the HF data transmission system
- A system that can automatically select an optimum frequency should be installed on HF radio equipment

VHF Radio Interference Measurement

i) Objective of Test

The objective of the VHF Radio Interference Measurement was to check the existence of radio interference at 13 telemeter stations (Amalshid, Kanaighat, Sarighat, Durgapur, Nakuagaon, Kurigram, Noonkhawa, Dalia, Panchagarh, Pankha, Comilla, Laurergarh and Bhairab Bazar) near the Indian border in order to check incoming radio interference from India.

ii) Outline and Results of Test

[Outline of Test]

The Study Team measured radio interference waves at 2 frequencies (149.250MHz and 166.075MHz) at those test sites mentioned above using a measuring receiver. Measurement of the radio interference waves at all frequencies was continued for 3 hours.

[Result of Test]

No radio interference waves were found at the above 13 stations. The results of the tests are presented in **Table 7.3.2**. Data measured at the test sites are presented in detail in **ANNEX-VII**.

iii) Evaluation

For the thirteen 13 telemeter stations at which testing was undertaken, radio circuit design using BWDB's two frequencies (149.250MHz and 166.075MHz) for the telemeter system is feasible. However, new radio stations may be installed near these sites before implementation of the project. It is therefore recommended that radio interference again be checked at the actual sites during implementation.

(6) Subject

Institutional Matter

BWDB's existing VHF is officially assigned to be used for transmitting telemeter data. However, this frequency is used at the pump station in Chandpur managed by BWDB. To avoid any impacts on the proposed telemeter system, it is necessary to organize a division or section within BWDB that manages not only the frequencies but also the whole communication network of the organisation.

Technical Matters

i) Land Acquisition for Repeater Stations

BWDB has to make the necessary preparations regarding land acquisition to install VHF repeater stations in Upazillas where O&M offices are not located.

ii) Error Detecting System for HF Data Transmission

In HF data transmission tests, some garbled data were received at the receiver site. This phenomenon probably results because missed and garbled letters are beyond the existing error detection system associated with the modem of the HF radio. Therefore a more sophisticated system should be added to the HF data transmission system proposed.

7.4 Analysis System

7.4.1 General

To improve the existing flood forecasting system operated by FFWC plus provide warning of flood conditions to those areas with very short time for preparedness, the following approach is proposed:

i) Telemetry stations are to be installed at 23 key locations in the country to obtain real-time data on water levels and rainfalls.

ii) The analysis system will continue to be based on the MIKE11 modeling system. This will be supplemented with regionally-based systems installed at each of the five regional centers including:
   - North-east region at Sylhet
   - North-west region at Rangpur
   - North-central region at Dhaka (at existing central FFWC office)
   - South-west region at Barisal
   - South-east region at Chittagong.

iii) In the vicinity of the borders of those areas subject to flash flooding, substantial changes in water levels can occur in periods of less than 3 to 4 hours. It is therefore proposed that the real-time data from the local telemetry stations be disseminated directly to these areas.

7.4.2 Proposed Analysis System for Areas with Sufficient Time for Preparedness

Supermodel (Nationwide Model)

Flood forecasting using the Supermodel should be continued by the FFWC in its current form. To accommodate the proposed telemetry network and digital transmission of data from the manually-observed stations, system upgrades at the FFWC will be required. These include:

- An interface for direct access to the hydrometeorological database for storage of data transmitted from both telemetry and manually operated stations,
- Development of software for the automatic checking and verification of data once stored on the database, and
- An interface within the Supermodel for the automatic retrieval of data from the hydrometeorological database.

The Supermodel would be operated on a daily basis. The flood forecasts for 24 and 48 hour intervals will be used by the FFWC to issue Daily Bulletins for the following 24 and 48 hour periods (comparable to the current situation).

For the proposed analysis system, the simulation results of the Supermodel must be transmitted to the regional centers on a daily basis. In addition, the hourly forecasts made by the FFWC for flash flood areas should define peak flood forecasts and their times of occurrence for stations in these areas in addition to the current approach of simply disseminating 24 and 48 hour forecasts.

Regional Models

To complement the Supermodel, regional flood models are to be installed at the five regional centers. These will be based on regional surface water analysis models developed for six areas of the country as part of the "Surface Water Simulation Modelling Programme (SWSMP)" study. The models and proposed locations of the regional centers are outlined below.

Regions and Associated Regional Models

Region	Regional Centre	SWSMP Regional Model Installed at Regional Centre
North-east	Sylhet	North-East
North-west	Rangpur	North-West
North-central	Dhaka	North-Central, South-East
South-west	Barisal	South-West
South-east	Chittagong	Chittagong Hills

A comparison of river networks in the Supermodel and regional models indicates the following:

i) The river networks for the North-East (NE), North-West and North-Central models are marginally more detailed than for the comparable regions in the Supermodel.
ii) The South-East and South-West regional models have more detailed river networks.
iii) The South-East region in the present study covers the area around Chittagong and the Chittagong Hill Tracts. This region is not currently included in the Supermodel.

For flood forecasting, the results of the Supermodel must be used to define all external boundary conditions for all regions apart from the south-east region (Chittagong Hills model). Boundary conditions for the latter will need to be estimated by the FFWC personnel as this region is not included in the current Supermodel.

The major benefit of combined operation of the Supermodel and regional model is that the latter can be run more frequently whenever large increases in flood levels are monitored on the borders (particularly in flash flood regions). This combined operation of the Supermodel and regional model (termed intermediate operation) should improve flood forecasts in the region at least in the 12 to 24 hours after ToF_{REG} when compared to those based on the Supermodel.

For intermediate operation, it is proposed that the same internal stations as used in the

Supermodel also be adopted for the regional model in the updating process applied in the MIKE11 model. There will be a period extending from 0600 (ToF for Supermodel) to the ToF for the regional model when water level data are unavailable for relevant internal stations. During this period, hourly forecasts as derived using the Supermodel would be included in the hindcast period. This should have negligible impact on the accuracy of flood forecasting as discussed in **Section 7.4.4.**

7.4.3 Proposed Analysis System for Areas with Insufficient Time for Preparedness

Quantitative forecasting of future water levels or discharges with sufficient accuracy is not possible at present for the boundaries of the flash flood areas. This reflects a lack of hydrometeorological data in the upstream catchments outside Bangladesh. With the proposed telemetry network located in the border areas, observed flood levels and rainfalls can, however, be disseminated to authorities and end users directly. These data would at least provide an indication of the direction of future immediate changes in local flood levels.

It is therefore proposed that data from each local telemetry station be disseminated directly to the local authorities. The data should be linked to a rudimentary system with warnings issued based on actual flood level, rate of change in water levels over the preceding 2 to 3 hours and/or recent rainfalls if defined intensities are exceeded.

7.4.4 Assessment of the Improvement of Accuracy Obtained from Proposed System

(1) General

Prior to finalizing the recommended analysis system, forecasting was undertaken using the Supermodel to identify the primary causes of inaccurate flood forecasting. The modeling assumed:

i) Boundary conditions for the following 72 hours were as recorded, that is no errors occurred in their estimation, with model updating undertaken using all internal boundary stations (27) as currently adopted.
ii) Boundary conditions for the following 72 hours were as recorded but the number of internal boundary stations used for model updating was limited to the three stations proposed for installation of the telemetry network.
iii) Boundary conditions for the following 72 hours were as recorded, that is no errors occurred in their estimation, but no model updating was undertaken.

Comparison of FFWC flood forecasts with those of case i) quantified the likely level of improvement achieved with improved accuracy in boundary estimation. Any remaining errors in flood forecasts could only be minimized through ongoing model calibration, continued updating of river network characteristics, and improved estimation of rainfall.

Comparison of cases i) and ii) defined the likely reduction in forecast accuracy when the number of updating stations is reduced. Comparison of cases i) and iii) defined the likely reduction in forecast accuracy when no model updating is applied.

(2) Statistical Comparison of the Result

A summary of the results is presented in **Table 7.4.1**. The following observations are made:

- Errors are less than the MAE (Mean Absolute Error) for a relatively large percentage of the period analyzed, but larger errors occur periodically.
- Improved boundary estimation will reduce forecasting errors in the monsoonal flood areas, but only marginally.
- For those stations in flash flood areas, the accuracy of the 24 hour forecasts only improved marginally when applying 'as recorded' boundary conditions, although the errors remained significant.
- The limited improvement with 'as observed' boundary conditions in the flash flood areas therefore reflects limitations in model calibration, inaccuracies in current runoff estimation and the impacts of likely changes in hydraulic characteristics for the river network.
- Excluding the updating procedure from the analyses resulted in negligible impact on the errors in flood forecasting in the monsoonal flood areas. For the flash flood areas, the updating has negligible effect.

Although the inclusion of updating does not appear to provide any substantial improvement in flood forecasting, it is proposed that the existing number of internal stations (27) be retained in the Supermodel.

(3) *Graphical Comparison of the Result*

The two floods that occurred in early and late June, 2003 were evaluated. These represent the largest events that occurred in 2003 after flood forecasting using the Supermodel was commenced by the FFWC. The following observations are made (refer to the **Supporting Report** for detailed information):

- There are generally only minor differences in flood forecasts over the 24 hour period if updating is included for the current 27 stations applied by FFWC or limited to a small number.
- For those stations located in the flash flood areas, namely Moulvi Bazar and Jariajangail (north-east region), the flood forecasts when based on 'as observed' boundary estimates better match the observed hydrograph. The results overall, however, remained generally poor during the initial hydrograph rises.
- Application of the combined approach using the Supermodel in conjunction with the relevant regional model, when large changes in flood levels are observed, should result in improved flood forecasts over the immediate 12 to 24 hours.
- The rainfalls must be based on more representative hourly rainfall patterns. These can only be provided with automatic stations (through telemetry) or use of radar images as discussed below.

7.4.5 Estimation of Forecast Boundary Conditions

(1) Utilization of Indian Hydrometeorological Data

For the monsoonal flood areas, one possible approach is to derive relationships for the boundary stations on the Jamuna and Padma Rivers with stations upstream in India. At present only limited data are available to the FFWC from India. A comparison of water levels for Noonkhawa and Goalpara (some 105km upstream) is shown on **Figure 7.4.1**. This indicates a reasonable relationship could be developed between these sites but there is still some scatter in the data even though the distance between the sites (and travel time) is relatively small. Comparison of the water levels for Pankha and Farraka Barrage is also shown on **Figure 7.4.1**. The distance between the stations is only around 30km. Hence the good relationship is hardly surprising. However, the comparison highlights the need to continually review the data to ensure changes in channel sections and/or datums at one or both sites included in such relationships are quickly identified.

Forecasting of 48 and 72 hour boundary water levels for both Jamuna and Padma Rivers would require comparisons to be made with stations in India a considerably greater distance upstream of the border, probably of the order of 400 km. Relevant stations upstream of Pankha on the Padma River include Mongyr (265 km upstream) and Patna (405 km upstream). On the Brahmaputra River upstream of Noonkhawa, Tejpur (335 km upstream) and Debrugarh (580 km upstream) would be suitable. Errors in the relationships could be significant at such distances. Nonetheless, relevant data should be obtained by the FFWC from Indian authorities and the comparisons made.

(2) Coordination with Ongoing CFAB Project

To provide flood forecasts with longer lead time in excess of the currently adopted 72 hours, alternative approaches will be required. One promising technique is the Climate Forecasting in Bangladesh (CFAB) project, a joint approach currently being undertaken by the Georgia Institute of Technology in conjunction with the BWDB. The basic variables to be forecast are the discharges of the Jamuna and Padma Rivers at the borders with India. Three forecasting timeframes are being developed, namely, short period (1 to 6 days), medium range (20-25 days) and long range (1 to 6 months).

The results to date appear promising and further studies are now ongoing with the aim of transferring the software to Bangladesh in the near future. These approaches do not, however, derive flood forecasts at these timescales for the flash flood areas. The results would therefore be used in conjunction with the Supermodel for flood forecasting in the monsoonal areas. The probable inaccuracies in defining boundary estimates for the flash flood areas at such long periods in advance should not have any significant impact on forecasting accuracy for stations in the monsoonal areas.

Prior to issuing flood warnings based on such long-term forecasts, it would be essential to confirm their accuracy. Issuing warnings that are subsequently found to be significantly in error could lead to a lack of confidence in future forecasts.

(3) Application of the Information of BMD Radar Network

For the flash flood areas, upstream stations in India are limited. Those existing are close to the borders and travel times are too short to allow any meaningful use to be made of the data even if they could be transmitted to the FFWC in real-time.

Improved estimation of boundary forecasts is likely to be possible only with better definition of rainfall defining both spatial and temporal distribution. This would require cloud intensity information obtained from BMD radar or NOAA satellite data. A preliminary concept for this analysis is illustrated in **Figure 7.4.2**.

In conjunction with rainfall estimation, an areally distributed rainfall-flood routing model would be required to simulate associated flood discharges. The support of BMD staff is essential, since the result can also highlight the effectiveness of BMD's existing radar network. This could add weight to the establishment of a doppler radar at Moulvi Bazar as currently proposed by BMD.

7.4.6 Comments on Proposed Analysis System

Establishing regional flood models will ensure simulations can be undertaken as required at regional offices, also allowing early dissemination of flood warnings and quicker local verification of model performance through comparison with observed water levels.

The availability of water level data from stations on the major rivers in India will allow the development of relationships to define boundary forecasts for Noonkhawa and Pankha. As a minimum, this will provide a reliable approach to be followed by FFWC. Relationships developed would have to be continually updated to ensure changes in conditions at the various water level stations used were incorporated.

The application of the model using 'observed' boundary forecasts has indicated that further calibration of the model, particularly in the flash flood areas, is essential to minimize forecasting errors. Recent calibration of the Supermodel has occurred and FFWC should use this model prior the next wet season to assess its accuracy in forecasting in the flash flood areas based on data recorded.

Flood forecasting beyond 72 hours is currently not undertaken. The workshops and interviews indicated warnings of 4-5 days would be required to allow early harvesting of crops prior to inundation due to future flooding. For this to be implemented, the use of short and medium-term weather forecasting techniques such as that currently being developed as part of said CFAB project should be investigated. Flood forecasting would be applicable to the monsoonal flood areas. Errors in the estimation of 'long-term' boundary conditions in the flash flood areas should have negligible impact based on the analyses undertaken using the Supermodel in the current study.

The primary benefits for the analysis system associated with the proposed telemetry network will be improved short-term flood forecasting in the flash flood areas. The FFWC must therefore be prepared to apply the regional models immediately changes in boundary conditions are observed or risk the possibility of not providing flood warnings with sufficient lead time. It is therefore necessary that the regional centers remain operational on a generally continuous basis throughout the period in which flash flooding occurs.

7.5 Dissemination System

7.5.1 Basic Strategy

(1) Objective of FFWS

As explained in **Section 3.6**, the flood warning dissemination system is not working properly. It is clear that without a functioning dissemination system, the overall FFWS may not provide any benefits. **The objective of the FFWS is ultimately to disseminate flood warning to the end beneficiaries**, so that they can take necessary actions accordingly.

The FFWS is not only aimed at calculating the possible flood. The most important action is to disseminate warnings to the people, surely, accurately, in a timely and official manner under the responsibility of the government. Hydrological and meteorological conditions may change from time to time. Therefore flood forecasting and warning should be disseminated in a timely manner to reflect the real situation of weather and flood conditions.

Flood warning may be divided into 1) ***forecasting***, 2) ***warning***, and 3) ***evacuation order*** according to the situation. The ***warning*** may be divided further such as, for example, Signal No.1, No.2, No.3, etc. This would depend on the severity of the possible flood. For instance, Signal No.1 may indicate to people the possibility of flooding, Signal No.2 may indicate the need to close schools, and so on and Signal No.3 to provide advice to the public to prepare for evacuation. Such information can be issued with more surety by the regional office than the central office. The former generally has greater knowledge of existing conditions in the area regarding levels of flooding, preparations of the local public regarding flood awareness and so on.

(2) Regional Disaster Management

Disaster management is commonly undertaken by concerned agencies in most countries at a local rather than central level. As noted above, flood warnings should generally be issued by the regional office due to its greater knowledge of local conditions, that is the 'real situation'.

FFWS is one of the most important and essential supporting measures for the regional disaster management. Central Office can and should take actions to assist / support emergency countermeasures including financial arrangements, supply of emergency goods, etc.

(3) O&M Divisional Office's Initiatives for FFWS

Operation and Maintenance Divisional Offices (O&M DO) have undertaken:

a) Emergency countermeasures to prevent flood damages at river structures,
b) Flood forecasting and warning services based on their own hydrological observations at the river structures (often driven by necessity as warnings from the FFWC are not received), and
c) Flood warning message dissemination to the local population.

Thus, O&M DOs are familiar with flood forecasting and warning activities. Most importantly, O&M DOs need FFWS for the operation and maintenance of their river structures but sometimes must reply on local people for information on flood conditions. These actions can therefore also be taken at local level by the O&M DOs surely, accurately, timely and officially as they have many branch offices distributed over the country. Therefore, FFWC (and specifically the proposed FHC) should coordinate with O&M DO.

(4) Request to UNDP and DMB

As explained in **Section 3.6**, responsibility for the warning dissemination system lies with BWDB, DMB and Local Government Institution. According to the BWDB Act, 2000, BWDB is only responsible for warning preparation. This is to be provided to various central government agencies and district administration. DMB is responsible for pre-disaster preparedness. According to the Standing Orders on Disaster, 1999, warning dissemination to the grass root level is a responsibility of District, Upazilla and Union Disaster Management Committee. There is no provision for warning dissemination to the various river structures.

Because of this legal status, the present Study has divided the proposed Project into components, part of which is to be executed by BWDB and the rest to be given serious consideration for uptake by DMB and Local Authorities. As mentioned in **Section 3.8.1**, UNDP will soon implement a Comprehensive Disaster Management Project (CDMP). It is therefore strongly requested that UNDP and DMB take up part of the warning dissemination component in this project.

(5) Point-to-Point Dissemination

During the field investigation by the Study Team, it was found through discussion that in some border areas lead time is very short between flood warning and occurrence of the event. In such cases, the Upazilla administration attempts to obtain water level data from nearby gauging stations. Based on that information, they also attempt to disseminate warnings and arrange response systems. It was strongly suggested by the local community during these discussions that if they could obtain water level data sooner, actions could be implemented to provide warnings, mitigate flood damage and so on even before the warnings from FFWC are received.

In addition to the warning information provided after application of the hydraulic model (as part of the FFWC procedure), it is therefore proposed that real time water level data be transmitted directly to Upazilla administrations in those areas where lead time is as low as 4 hours or less. This system, referred to as point-to-point dissemination, will be implemented using a special terminal located in the offices of the local administration. This would indicate current water levels and could also be programmed to set off alarms if water levels reached predefined targets.

7.5.2 Required Components

(1) Inhabitants

Required components related to flood warning dissemination for the inhabitants are as follows:

- After preparation of the flood bulletin, the Flood Hydrology Circle (FHC) will provide the information to all district administrations, all BWDB O&M zonal offices and all relevant central government agencies. For speedy dissemination, use of email, internet website and auto-dial fax should be implemented.
- Area specific warnings with inundation maps should be prepared by FHC.
- Until there is a proper area specific warning, gauges should be fixed at village level and correlated with the nearest danger level. This must be done by the Union DMC in close collaboration with local people.
- Danger levels should be reviewed periodically by BWDB.
- New topographic maps should be prepared by BWDB.
- Lead time should be increased by FHC. This lead time can be different based on the flood type. In flash flood areas, at least 4 hours is required for evacuation. In other flood areas, at least 4 days is required to minimise agricultural and other economic losses.
- Local BWDB staff, who are members of District DMC, should help to interpret the warning messages in a local context.
- District DMC will send the interpreted and area specific warnings to Upazilla by phone, fax, email or police wireless.
- Upazilla DMC will provide this information to union by phone or mobile. If there is no telephone connection in a union or it is not covered by mobile network, a SSB wireless set is to be provided to those unions. Operational costs of mobile or wireless should be arranged on a participating basis.
- NGOs should be involved in the Union DMC.
- The Union DMC will take responsibility of informing all people by means such as drum beating, hoisting a flag, signaling with a red light, using mosque loud-speakers or personal communication.
- BWDB staff, who are members of the District DMC, will monitor the dissemination process in the lower tiers of the administration and assist District DMC to ensure dissemination.
- A feedback system should be introduced. For example, once the Union DMC

receives information, this is to be confirmed to the Upazilla DMC.

- A Flood Preparedness Program (FPP) should be introduced similar to that in operation in the CPP. This can be initiated under DMB through UNDP's CDMP project.
- Volunteers should be trained under FPP for warning dissemination.
- In some border areas, actual water levels in the nearby river will be informed to Upazilla administration for point-to-point dissemination. A terminal will be installed by the BWDB at the Upazilla administration to provide information of present water levels as recorded by the nearby telemetric stations. There are 32 Upazillas to be provided with terminals in the project. These include Tetulia, Panchagarh Sadar, Boda, Debiganj, Dimla, Jaldhaka, Kishoreganj, Khansama, Patgram and Hatibandha in the north-west region; Jhinaigati, Nalitabari, Durgapur, Kalmakanda, Tahirpur, Jamalganj, Bisambharpur, Sunamganj Sadar, Doarabazar, Chhatak, Goainghat, Jaintipur, Kanaighat, Zakiganj, Beani Bazar and Kamalganj in the north-east region; Brahmanpara, Burichang and Comilla Sadar in the Comilla area and Fatikchhari, Rauzan and Hathazari in the Chittagong area (see **Figure 7.5.1** for their locations).
- BWDB will undertake periodic maintenance of terminals placed at the Upazillas.

(2) River Structures

Required components related to flood warning dissemination for the river structures include the following:

- After preparation of the flood bulletin, the Flood Hydrology Circle (FHC) will provide this information to all BWDB OM zonal offices and central offices of all relevant agencies operating various river structures. These would include Roads and Highways (RHD), Bangladesh Inland Water Transport Authority (BIWTA), Bangladesh Inland Water Transport Corporation (BIWTC), Bangladesh Agricultural Development Corporation (BADC), etc. For speedy dissemination, use of email, internet website and auto-dial fax should be implemented.
- For major facilities such as ports, bridges, major highways and major ferry terminals, flood warnings will be given directly by FHC to the field operation offices.
- FHC should prepare specific warnings for major structures including national highways, ports, ferry terminals, barrages, bridges and major embankments.
- BWDB O&M zonal offices will convey the warning to all divisional offices and directly to the major structures themselves.
- BWDB O&M divisional offices will inform all field operation offices of the warning.
- Flood warnings received by relevant agencies will be passed on to their respective field operation offices.

7.5.3 Implementation Demarcation

As explained in **Section 7.5.1**, a major part of the flood warning dissemination system is not within BWDB's mandate. Required components described in **Section 7.5.2** clearly state the responsible authority. Of these, the items for which BWDB should be responsible will be included in the present Project. For the other items, it is strongly recommended that they be included in the CDMP study being undertaken by the UNDP. After that project they should be implemented by DMB and local government institutions.

7.6 Response System

7.6.1 Basic Strategy

As explained in **Section 3.7**, the response system is not functioning properly. It is obvious that without an adequate response system, the overall FFWS may not provide the required benefit. Of the various aspects of the response system shown in **Section 3.7.1**, the most important is evacuation to minimize the loss of human life. However, as also discussed in **Section 3.7**, responsibility for this sub-sector lies with the Local Government Institutions. According to the Standing Orders on Disaster, 1999, evacuation is a responsibility of District, Upazilla and Union Disaster Management Committees.

At present, there are only 95 flood shelters, of which 58 were donated by an NGO and 37 were constructed by different district administrations. The list is presented in **Table 7.6.1**. However, it is noted that people often take shelter in any available high rise structures such as schools and offices. As this is not done in an organized manner and proper facilities are generally unavailable in these shelters, people are often uncertain about moving to them during flooding. Therefore, flood shelters should be designated and if required, new ones constructed.

It is noted that there is no provision for a response system for the operation of various river structures. This should be initiated.

Because of the present legal status, the present Study divided the proposed Project into two parts. One was the response system for river structures. This is to be executed by BWDB. The other is the evacuation system that is recommended to be implemented by local government institutions. Detailed study of the latter should be included in the CDMP study being undertaken by UNDP.

7.6.2 Required Components

(1) Public

Required components related to the response system for the public are as follows:

- DMB should prepare an evacuation manual so that a formal evacuation system can be established.
- DMB should initiate a campaign for awareness building. Local NGOs should be involved in this process.
- The proposed FPP should carry out flood drills for improved evacuation.

- Upazilla DMC should nominate flood shelters. These may include designated flood shelters, cyclone shelters, schools, colleges, high-rise buildings, roads, embankments, etc. Specific areas in each shelter should be clearly demarcated.
- New flood shelters should be prepared by DMB. These can be used for schools in normal times.
- Upazilla DMC should also nominate shelter areas for livestock.
- Upazilla DMC should monitor the evacuation process.
- Upazilla DMC should prepare a list of required facilities for each shelter to ensure proper living conditions can be maintained during floods. Before the start of the flood season, necessary arrangements should be made. There should be a prior plan to provide drinking water and sanitation facilities.
- Actual responsibility of evacuation should lie with the Union DMC.
- Volunteers should be trained under the proposed FPP to assist in the evacuation process.
- Union DMC should earmark transportation for evacuation. Since Union Councils do not always own enough vehicles and boats, they should prepare an inventory of possible means of transport available during emergencies from various agencies at Upazilla and even District level.
- Upazilla DMC should arrange security for evacuated houses. Assistance should be obtained from Police, Ansars, Village Defense Police (VDP) and volunteers.
- DMB should prepare response management guidelines for agriculture and fisheries.
- District DMC should issue response measures for agriculture and fisheries taking into consideration flood warnings, working closely with relevant agencies such as the Directorate of Agricultural Extension (DAE) and Fisheries Department.
- Union DMC should inform the public regarding measures related to agriculture and fisheries and also monitor the responses undertaken.

(2) River Structures

River structures of the country are managed by various organizations such as BWDB (embankments, barrages, etc.), RHD (bridges, highways, etc.), BIWTA (large ferry terminals), BIWTC (large ferries), Bangladesh Railway (rail line, bridges, etc.), BADC (small scale irrigation) and so on.

Required components related to a response system for river structures are as follows:

- Response management guidelines (emergency operational procedures) should be prepared by all concerned agencies.
- The O&M office of each agency should issue response directives for the individual river structures based on the flood warning.
- Field operation offices should undertake proper response measures as stipulated in the guidelines.
- The O&M office of each agency should monitor actions taken by the field offices.

7.6.3 Implementation Demarcation

As explained in **Section 7.6.1**, the evacuation-related response system is not within BWDB's mandate. Response systems for BWDB's river structures are, however, its responsibility. Required components described in **Section 7.6.2** clearly state the responsible authority. Of these, the items for which BWDB should be responsible will be included in the present Project.

For the evacuation-related response system, it is strongly recommended that this be included in the CDMP study being undertaken by UNDP. The findings should be implemented by DMB and local government institutions. For river structures of other agencies, DMB and BWDB should cooperate to implement the response system.

7.7 Overall Components

Based on the feasibility design outlined in **Sections 7.1** to **7.6**, the overall components of the proposed project are described below. Features of the proposed project are shown in **Figure 7.7.1**. The preliminary specifications of equipment are summarized based on requirements for (1) Central office (Dhaka), (2) Regional office, (3) Repeater station, (4) Telemeter station, (5) Manual gauging station and (6) Point-to-point dissemination. Block diagrams based on each are shown in **Figures 7.7.2** to **7.7.7.**

7.7.1 Central Office (Dhaka)

(1) Function

a. Analysis function
- The central office receives regional observed and forecast data. Analyzing the regional observed and forecast data by MIKE11, a central bulletin, hazard map and observation map should be produced.

b. Monitoring function
- The observed forecast data should be monitored on the monitoring computer.

c. Database function
- The observed and forecast data should be stored in the database server.

d. Dissemination function
- The bulletin should be disseminated to ministries and TV/radio stations via E-mail or fax and open to the public via the FFWC Internet website.

e. Input/output interface function
- Communications with the regional offices should be conducted through digital HF or T&T lines. T&T is used if a digital HF link is not established. Interfaces with digital HF and T&T should be provided.

f. Regional function
- The function of the regional offices, described in Section 7.7.2, should be provided for the analysis of the Dhaka region.

(2) Equipment Specification

Central Part

a. Regional I/F

HF antenna	:	With antenna tuner
HF transceiver	:	Automatic link establishment
T & T Modem	:	For backup line
I/F equipment	:	Computer (24hour operation) Hard disk Display Ethernet I/F T&T modem I/F (RS-232C) Transceiver I/F (RS-232C) (Software) Automatic line change Database access

b. Database Sever (central)

Database server	:	Computer (24hour operation) Storage device (CD, MO) Hard disk Display Ethernet I/F (Software) Database index (water level, rainfall) Data collection interval (10min. max.) Data storage period (5years) Accessibility (open database access)

c. Supermodel Analysis System

Analysis server	:	Computer (24hour operation) Storage device (CD, MO) Hard disk Display Ethernet I/F (Software) Arc-View platform (existing) MIKE11 (existing) MIKE11 database (existing) MIKE Flood Watch (existing) for preparation of bulletin and web contents Database access

d. Printer : Color laser printer

			Ethernet I/F
e.	Monitor Computer	:	Computer (24hour operation) Storage device (CD, MO) Hard disk Display Ethernet I/F (Software) Database access
f.	T&T interface	:	Ethernet I/F T&T I/F E-mail and fax sending function
g.	Power Equipment	:	UPS

Regional Part

a.	Telemeter I/F		
	VHF antenna	:	3 element collinear type
	Telemeter supervisory equipment	:	Transmitter and receiver (150MHz band)
		:	Ethernet I/F
b.	Manual I/F		
	HF antenna	:	With antenna tuner
	HF transceiver	:	Automatic link establishment
	Mobile modem	:	For data receiving from mobile phone
	I/F equipment	:	Computer (24hour operation) Hard disk Display Ethernet I/F Mobile modem I/F (RS-232C) Transceiver I/F (RS-232C) (Software) Automatic data input function
c.	Database Server (regional)		
	Database server	:	Computer (24hour operation) Storage device (CD, MO) Hard disk Display Ethernet I/F (Software) Database index (water level, rainfall) Data collecting interval (10min. max.)

			Data storage period (5years) Accessibility (open database access)
d.	Regional Analysis System Analysis server	:	Computer (24hour operation) Storage device (CD, MO) Hard disk Display Ethernet I/F (Software) Arc-View platform (existing) MIKE11 (existing) MIKE11 database (existing) MIKE Flood Watch (existing) for preparation of bulletin and web contents Database access
e.	Printer	:	Color laser printer Ethernet I/F
f.	Monitor Computer	:	Computer (24hour operation) Storage device (CD, MO) Hard disk Display Ethernet I/F (Software) Database access
g.	T&T interface	:	Ethernet I/F T&T I/F E-mail and fax sending function
h.	Power Equipment	:	UPS

7.7.2 Regional Office

(1) Function

a. Analysis function
- The regional offices receive observed data from each gauging station. Analysing observed data by regional MIKE11, a regional report should be made.

b. Monitoring function
- The observed and forecast data should be monitored on the monitor computer.

c. Database function
- The observed and forecast data should be stored in the database server.

d. Dissemination function
- Regional warning and forecasting messages should be disseminated to O&M divisional offices and district offices via E-mail or fax.

e. Input/output interface function
- Communications with the central office should be conducted through digital HF or T&T. T&T is used as a backup in case a digital HF link is not established. Interfaces with digital HF and T&T should be provided.
- Observed data at each gauging station should be transmitted to the regional offices via VHF telemeter, mobile phone or digital HF. Interfaces with VHF telemeter and mobile phone and digital HF should be provided.

(2) Equipment Specification

a. Telemeter I/F

VHF antenna	:	3 element collinear type
Telemeter supervisory equipment	:	Transmitter and receiver (150MHz band)
	:	Ethernet I/F

b. Manual I/F

HF antenna	:	With antenna tuner
HF transceiver	:	Automatic link establishment
Mobile modem	:	For data receiving from mobile phone
I/F equipment	:	Computer (24hour operation) Hard disk Display Ethernet I/F Mobile modem I/F (RS-232C) Transceiver I/F (RS-232C) (Software) Automatic data input function

c. Central I/F

HF antenna	:	With antenna tuner
HF transceiver	:	Automatic link establishment
T & T Modem	:	Backup line
I/F equipment	:	Computer (24hour operation) Hard disk Display Ethernet I/F T&T modem I/F (RS-232C) Transceiver I/F (RS-232C) (Software) Automatic line change Database access

d. Database Server (regional)

Database server	:	Computer (24hour operation) Storage device (CD, MO)

			Hard disk Display Ethernet I/F (Software) Database index (water level, rainfall) Data collecting interval (10min. max.) Data storage period (5years) Accessibility (open database access)
e.	Regional Analysis System Analysis server	:	Computer (24hour operation) Storage device (CD, MO) Hard disk Display Ethernet I/F (Software) Arc-View platform (existing) MIKE11 (existing) MIKE11 data base (existing) MIKE Flood Watch (existing) for preparation of bulletin and web contents Database access
f.	Printer	:	Color laser printer Ethernet I/F
g.	Monitor	:	Computer (24hour operation) Storage device (CD, MO) Hard disk Display Ethernet I/F (Software) Database access
h.	T&T interface	:	Ethernet I/F T&T I/F E-mail and fax sending function
i.	Power Equipment	:	UPS

7.7.3 Repeater Station

Repeater Station in O&M Office

(1) Function

a. Repeater function
- At repeater stations, received data should be stored and retransmitted to a regional office or next repeater station in order to avoid attenuation of signal level of radio.

b. Monitoring function
- Observed data should be monitored at O&M offices.

(2) Equipment Specification

a.	Repeater equipment	: Transmitter and receiver Stored repeater system
b.	Antenna	: 3 element collinear type
c.	Monitoring equipment	: With monitoring panel
d.	Power equipment	: Isolation transformer, DC power supply unit
e.	Antenna tower	: Approx: 20-40m height

Repeater Station in Upazilla without O&M Office (not Upazilla office)

(1) Function

a. Repeater function
- At repeater stations, received data should be stored and retransmitted to a regional office or next repeater station in order to avoid attenuation of signal level of radio.

b. Monitoring function
- Observed data should be monitored at Upazilla office.

(2) Equipment Specification

a.	Repeater equipment	: Transmitter and receiver Stored repeater system
b.	Antenna	: 3 element collinear type
c.	Power equipment	: Solar cells panel, Power distribution board, Battery
d.	Antenna tower	: Approx: 20-40m height

7.7.4 Telemeter Station

(1) Function

a. Gauging function
- Water level or rainfall level should be observed and sent to telemeter equipment.

b. Telemeter function
- Observed data should be transmitted to the regional office by VHF radio.

(2) Equipment Specification

a.	Telemeter equipment	:	Transmitter and receiver
b.	Antenna	:	Yagi antenna or 3 element collinear type
c.	Raingauge	:	Raingauge, coder, data recorder
d.	Water level gauge		
	(Sensing pole type)	:	Data recorder, sensing pole, transmitter, receiver,
	(Sonar type)	:	Data recorder, sonar type water level gauge, temperature sensor, connection board, coder
	(Either sensing pole type or sonar type is applied.)		
e.	Power equipment	:	Solar cells panel, Power distribution board, Battery
f.	Antenna tower	:	Approx: 20-40m height

7.7.5 Manual Gauging Station

Manual Gauging Station (by HF)

(1) Function

a. Data transmission function
- Observed data input by a gauge reader should be transmitted to the regional office through digital HF.

(2) Equipment Specification

a.	HF terminal I/F	:	Computer
b.	HF transceiver	:	Automatic link establishment
c.	HF antenna	:	With antenna tuner
d.	Power equipment	:	Isolation transformer, DC power supply unit

Manual Gauging Station (by mobile)

(1) Function

a. Data transmission function
- Input data checking system. (Mobile apparatus should have a function to check the input data with the gauge reader before its transmission.)
- Sending acknowledgement system. (After data are transmitted and input to the data server at the divisional office correctly, the mobile apparatus should acknowledge receipt of data to the gauge reader.)

(2) Equipment Specification

a.	Mobile phone	:	Commonly used mobile phone (Grameen etc.)

7.7.6 Point-to-Point Direct Dissemination (O&M office, Upa-zilla)

(1) Function

a. Monitoring function
  - Point-to-point dissemination will be conducted at O&M and Upazilla offices to provide warning to the O&M offices and Upazilla officers. Telemeter data (water level and rainfall data) should be directly received at those locations where such data are needed.
  - Telemeter data should be monitored through a monitoring panel in the O&M and Upazilla offices.

(2) Equipment Specification

a.	Monitoring equipment	: Receiver, monitoring panel
b.	Antenna	: Yagi antenna
c.	Power equipment	: DC Power supply unit, Isolation Transformer
d.	Antenna tower	: Approx: 20-40m height

CHAPTER 8 INSTITUTIONAL ARRANGEMENT

8.1 General

In **Section 3.8**, present institutional matters were discussed in detail and associated problems identified. Among these, two major concerns were identified as centralized, top-down administration and segregation of job responsibility. For better coordination, efficient functioning, cost reduction and proper management, establishment of regional offices of BWDB is considered the most appropriate. In this setup, the regional offices of BWDB will be responsible for all activities like planning, design, implementation, operation and maintenance, and hydrology including flood and low flow forecasting. Logistical facilities can be better utilized and field level coordination among various sections ensured. The benefits obtained from this system include:

- it is possible to execute works in a more coordinated manner,
- it will make maximum utilization of manpower and equipment,
- it is possible to take into account the local condition in all activities,
- it will reduce administrative procedure,
- Hydrology and O&M can assist each other as and when required, and
- it is possible to prepare localized flood warnings and assist in warning dissemination.

Figure 8.1.1 shows the divisions and sub-divisions of BWDB. It is apparent the number of O&M divisions and sub-divisions are rather large compared to those of Hydrology. Merging these will give better efficiency and optimum use of manpower and resources.

However, it appeared from the discussion with BWDB officials, counterparts, and Steering Committee meetings that it would be rather difficult to implement this without detailed in-depth study. It may be mentioned here that the present centralized system was introduced in the late 1980s. BWDB suggested that another change may not be possible now. It would also be subject to GOB's policy decisions and major change has a direct influence on budget allocation and operational modality.

Though the Study Team is not selecting the regional offices of BWDB as part of the present Project, it is believed that this is the best option and recommends BWDB undertake a detailed Study to assess the feasibility of regional offices.

Under the above circumstances, the Study Team proposes the regional system of Hydrology as described in **Sections 4.4.2** and **4.4.4**. In addition to data collection, compilation and relevant maintenance, these offices can also provide regional flood warning. Working from central office, it is not always possible to fully comprehend and interact with the local context. Moreover, divisions and sub-divisions of Hydrology at field levels are under different circles of Hydrology. As a result, there are duplications of work. Divisions and sub-divisions of Hydrology are shown in **Figure 8.1.1**. It can be seen that there are two sub-divisions each at Dhaka, Comilla, Faridpur, Pabna, Jessore, Dinajpur and Mymensingh.

Comparative merits of the centralized and decentralized administration of Hydrology service in respect of the FFWS service are given in **Table 3.8.2**. This clearly highlights the relative advantages of the regional system over the central system.

This concept of regional offices is also proposed in line with the understanding of BWDB (**Section 6.3**), World Bank (WSIP project, **Section 3.8.1**) and other development partners.

8.2 Organizational Setup

8.2.1 Basic Strategy

The Study Team proposes regional offices of Hydrology as the basis of the organizational setup along with some major changes in the central office.

8.2.2 Reorganization of Central Hydrology

Even in the regional setup, reorganization of the central Hydrology is required to avoid duplication of responsibility, streamlining job functions and better coordination.

The proposed organization is given in **Figure 8.2.1**. The salient features are as follows:

- In this proposal, the present mandate of PFFC is divided based on similar work features.
- It is proposed to create Flood Hydrology Circle (FHC) instead of PFFC as shown in **Figure 8.2.1**.
- The other three circles remain unchanged from the current setup.
- A newly proposed Processing Division will be placed directly under the Hydrology service and will include three of the branches now under the PFFC, namely Processing Branch, Index and Publication Branch and Management and Services Branch (see **Figure 3.2.1**). Because of its strategic location, it will be easy for this division to coordinate with the other three data collection circles.
- There will be three divisions under FHC.
- The present FFWC will become the Forecasting division with a mandate for flood forecasting, model updating, model validation and low flow forecasting.
- A new division will be created named Data Collection Division by transferring some personnel from the Surface Water Hydrology circle.
- Since C&I division is the single electro-mechanical division of Hydrology, it should function independently of PFFC.
- Part of the present C&I will become Data Transmission division and will be placed under FHC.
- Part of the C&I division will become Instrumentation division placed directly under Hydrology Service, and will be responsible for maintaining electro-mechanical equipment of the three data collection circles.
- Mandate of the Flood Hydrology Circle (FHC) will be:

- Collection of all observation data
- Transmission of data to regional office
- Operation of the Supermodel
- Issuing of flood forecasts with regard to local context
- Become a member of the national disaster management committee
- Monitor the warning dissemination process
- Help in the evacuation and other response management
- Undertake dry season monitoring

8.2.3 The Regional Setup

In this setup, there will be a number of regional offices of Hydrology. Each regional office will have all functions of Hydrology headed by a Superintending Engineer. To a certain extent these offices will run independently. Head office will supervise, monitor and provide assistance. There will be four divisions in each regional office, namely Surface water hydrology division, Ground water hydrology division, Flood hydrology division and River morphology division. The mandate of the regional office will be similar to the central office.

There are many approaches to dividing the regions, including river basin, flood type, administrative division, logistic facilities availability, existing hydrology divisions, etc. Considering all these factors along with technical, hydrological, financial, and organizational issues, and maximum utilization of present facilities, it is proposed to create five regions of Hydrology. These are Northwest (NW), North Central (NC), Northeast (NE), Southwest (SW) and Southeast (SE). The proposed regional boundaries can be seen schematically on **Figure 7.3.3**.

The following steps are considered in the regional selection process.

1. Regional boundaries were principally defined along the three major rivers (Padma, Jamuna and Meghna). Since water level fluctuations in those rivers is rather small (day-to-day), it is suitable to set river points in those major rivers as 'boundary points'. From this viewpoint, three regions were extracted, that is NW, SW and the eastern part (group of NE, NC, and SE).
2. Since the eastern part was still rather large, it was further divided according to the basin division line. Three regions were defined for the eastern part, that is NE, NC and SE.

It may be noted that these regions are almost similar to those defined for the setup of the "Regional Models" under FAP 25 and Surface Water Simulation Modelling Programme (SWMC, 1996).

Regional office location should consider availability of various logistical facilities and activities for river management. Based on these, the regional offices are proposed to be established in Dhaka, Chittagong, Barisal, Rangpur and Sylhet.

8.3 Regulation on New Set-up

Any major change of BWDB can be only done by MOWR in consultation with Ministry of Establishment and Ministry of Finance. The proposals that must be implemented immediately are re-organization of Hydrology central office and establishment of Sylhet Regional Hydrology Office. After necessary consultation, MOWR should issue an order to implement these.

MOWR should act promptly to commence an institutional reform study and recommendations coming from it should also be implemented urgently. The mandate of such a re-organization should also be clearly stated.

8.4 Manpower Requirement for Improved FFWS

The Study Team proposes the regional operation system with some major change in the central structure. There will be five regional offices of Hydrology. Each regional office will carry out all work of Hydrology including data collection, processing, maintenance of equipment, operation of the regional model, localized flood warning, informing local authorities of the warning, and assisting in warning dissemination and response.

Manpower requirements are one of the major items of the feasibility design from the institutional aspect.

8.4.1 Manpower Requirement for Improved FFWS

The staffing of the present FFWS is shown in **Table 8.4.1** while manpower requirements for the proposed FFWS system are given in **Table 4.5.2**. Work items were identified initially from the two broad classifications, namely operation task and maintenance task.

The present strength is 294 and with this the optimum service should be delivered properly. However, required manpower for optimum service is 231. To determine the manpower requirement, jobs were identified both for operational task and maintenance task. Class-wise position was then determined for the regional offices and central offices. For the telemeter stations, one staff member is allotted for a number of stations for periodic rating and regular inspection. For the manual stations, one gauge reader is assigned, who will work from 09:00 to 18:00. And for telemeter stations, one gauge reader for each region is assigned to calibrate the telemeter observation system.

It is also proposed that for important manual observation stations there will be continuous data collection, even during the night through the flood season. For this purpose, extra gauge readers will be appointed by out-sourcing.

One Superintending Engineer (SE) will head the Flood Hydrology Circle. There will be three Executive Engineers (XEN) for the three divisions at central office.

Each regional office will be headed by one XEN. In this set up, there are 45 managerial level staff, 51 technical staff, 47 support staff and 90 gauge readers.

The gauge readers of FFWS (under Data Collection Division) require skills differing to those of the gauge readers of the Surface water hydrology circle. While the responsibilities of gauge readers of the SWHC are taking the observations, entering the data in a ledger and periodically mailing it to the central or regional offices, the manual gauge readers of the FHC require more technical skills. After taking the observations, the gauge readers will need knowledge of the operation of the special data input mobile devices proposed for real-time data transmission.

8.4.2 Manpower Requirement for Improved Hydrology

The Study Team proposes the regional operation system of Hydrology. Reorganization of central hydrology and set up of each regional office will be required for this purpose.

The staffing of present Hydrology is shown in **Table 8.4.2**. Preliminary manpower requirements for improved Hydrology are given in **Table 8.4.3**. The work items were identified initially from the two broad classifications. However, for a more accurate assessment, an institutional reform study is necessary.

Central office will be headed by a Chief Engineer. There will be four Superintending Engineers (SE) for the four circles, that is FHC, Ground Water Hydrology Circle, Surface Water Hydrology Circle and River Morphology & Research Circle at central office and two Executive Engineers (XEN) for the two divisions, namely Instrumentation Division and Processing Division. As most of the activities are to be carried out in the field, there will be only one XEN each under the three data collection circles, namely SW, GW and RM for central office administration and coordination purposes. However, since the central FHC has to operate the Supermodel for flood forecasting and prepare nationwide forecasting, there will be three XENs for the three divisions.

One Superintending Engineer (SE) will head the Regional Hydrology office. There will be four Executive Engineers (XEN) for the four divisions, namely Regional FH, Ground Water Hydrology, Surface Water Hydrology and River Morphology and Research Divisions at each regional office. In the Regional FH, there will be three SDEs for the three sub-divisions collecting, transmitting and preparing the regional forecasts. Sub-divisions for the other three data collection divisions were estimated based on the work volume.

The required manpower for FHC was estimated in detail as outlined above but for other circles was evaluated to maintain staff numbers at comparable levels. Exact staffing should be determined through an Institutional Review Study.

CHAPTER 9 COST ESTIMATE

9.1 Basic Conditions

(1) Estimation of Project Cost

In previous Chapters of the Report, a detailed description of the proposed feasibility design for improvement of the existing FFWS has been presented. Based on the proposal, costs estimates have been derived outlining both associated Investment Cost and Annual Operation and Maintenance Cost. These are described in the following sections including a summary of the various price and exchange rates also used in the analyses.

(2) Price Rate

Equipment price rates were based on price levels in Japan as at July 2003.

The price rates of all works in Bangladesh were based on the "Standard Schedule of Rates Manual", published by BWDB in July 2002.

(3) Exchange Rate

The exchange rate used in deriving project costs was determined using the rate for May 2003, that is Taka 1.0 = JPY 2.00.

(4) Currency

The project costs are divided into foreign and local currencies. As the monetary unit for each currency, the Bangladesh Taka is employed.

(5) Price Increase Rate

Price increase rate was not considered in this cost estimate.

9.2 Investment Cost

9.2.1 Conditions of Estimation of Investment Cost

(1) Scope of Estimation

The scope for cost estimation covered the four sub-systems: 1) Observation system, 2) Data transmission system, 3) Forecasting analysis system, and 4) Warning dissemination system. The scope is shown **Figure7.7.1**.

(2) Components

Investment costs were divided into direct installation costs and indirect costs. The direct installation costs were mainly estimated based on quantities and current price rates of equipment. The indirect costs were divided into administration, engineering, training and contingency components each based on a nominated percentage of the total direct installation costs (both foreign and local). The respective components are described in more detail below:

a) Direct Installation Cost

- Equipment
- Civil works
- Installation
- Maintenance tools
- Spare parts
- Ocean and inland transportation
- Office equipment

b) Indirect Installation Cost

- Administration
- Engineering
- Training
- Contingency
- Price Escalation

The following components were estimated in local currency:

- All civil works (including design and materials)
- Domestic labor cost for installation of automatic water level gauging stations
- Materials for installation of automatic water level gauging stations
- Administration cost
- Engineering assumed to be around 10% of the foreign cost
- Training assumed to be around 10% of the foreign cost
- Contingency assumed to be around 10% of the foreign cost

(3) Direct Installation Cost

Direct installation cost consisted of labor, materials, contractor's profit, tools, temporary structures and other components required for the execution of the works.

a) Equipment

- Observatory equipment: water level gauging and rainfall gauging systems for each station
- Data transmission equipment: antenna systems, radio equipment, interface systems and mobile equipment for each facility
- Analysis systems: computer software, hardware and monitoring systems both in Central and Regional offices
- Warning systems: interface computers in each divisional O&M office, FFWC Website
- Power supply for each facility

b) Civil Works

- New building construction including control rooms in Regional Offices, repeater stations in Upazillas and station houses at each telemeter gauging station
- Antenna tower construction: required at each facility
- Others included new road construction or similar at each facility

c) Installation

- Labor costs and material costs to fit and fix all equipment plus testing for material properties and machine performances.

d) Maintenance Tools

- All tools for maintenance of all equipment
- Maintenance tool costs were estimated by referring to existing FFWC and other similar facilities.

e) Spare Parts

- All spare parts for equipment
- Spare parts costs were estimated as 20% of all equipment costs

f) Ocean and Inland Transportation

- All transportation costs from supply country to demand place
- Ocean transportation costs were estimated as 9% of all equipment costs in foreign currency
- Inland transportation costs were estimated as 1% of all equipment costs in local currency

g) Office Equipment

- All office accessories: personal computers, printers, telephones, faxes and so on at each new control center
- Office equipment costs were estimated by referring to existing FFWC and other similar facilities

(4) Administration Cost

Government administrative costs were estimated as 1% of total direct installation costs expressed in local currency.

(5) Engineering

Foreign and local engineering costs for detailed engineering and procurement assistance were estimated as 14% and 1% respectively of total direct installation costs.

(6) Training

Foreign and local staff training costs were estimated as 0.9% and 0.1% respectively of total equipment and installation costs.

(7) Contingency

Foreign contingency costs were estimated as 14% of total civil works plus 4.5% of total equipment costs including installation. Local contingency costs were 1% of total civil works plus 0.5% of total equipment costs including installation.

(8) Price Escalation

Price escalations were calculated under the assumption that equipment would be installed at the end of 2005. The total of the direct installation costs both of foreign and local currency portions was subject to the price escalation. The applied price escalation rates both for foreign and local portions are shown below:

- Foreign currency portion: 0.25 %/year
- Local currency portion: 4.3 %/year

9.2.2 Investment Cost

The investment costs are estimated at 1,148.2 million Taka as shown in the table below. The foreign currency component is approximately 942.2 million Taka and the local component 206.0 million Taka. The detailed breakdown is presented in the **Supporting Report.**

Investment Cost

(Unit: Million Taka)

Item	Currency Portion		Total
	Foreign	Local	
A Direct Installation Cost			
A-1 Equipment	494.6	0.0	494.6
A-2 Civil works	0.0	144.0	144.0
A-3 Installation	93.8	0.6	94.4
A-4 Maintenance tools	25.0	0.0	25.0
A-5 Spare parts	98.9	0.0	98.9
A-6 Ocean and inland transportation	44.5	4.9	49.5
A-7 Office Equipment	0.0	18.4	18.4
Sub Total	756.8	167.9	924.8
B Administration Cost	0.0	9.2	9.2
C Engineering	129.5	9.2	138.7
D Training	5.3	0.6	5.9
E Contingency	46.7	4.4	51.1
F Price Escalation	3.8	14.7	18.5
Total	**942.2**	**206.0**	**1,148.2**

9.3 Annual Operation and Maintenance Cost

9.3.1 General

As mention in previous sections, the existing telemeter system does not function well. One of the main reasons is that the budget allocated to operation and maintenance is insufficient. To make the FFWS more effective, a greater allocation to operation and maintenance should be allowed. Therefore in this section, in addition to estimation of project O&M cost, actual O&M cost and required O&M cost for effective management of the existing FFWS are calculated as a reference. The cases considered are indicated below:

1) Actual O&M cost (for existing FFWS)

Actual O&M cost for the existing FFWS was estimated by the Study Team based on the result of discussions with BWDB staff. These revealed that the repair and maintenance budget is insufficient to ensure the FFWS functions effectively.

2) Required O&M cost (for existing FFWS)

Repair and maintenance costs for equipment, depreciation cost and other O&M costs required for effective functioning of the FFWS were estimated by the Study Team.

3) Project O&M cost (for proposed FFWS)

This is outlined in the following section.

9.3.2 Conditions for Evaluation of Operation and Maintenance Cost

(1) Scope of Estimation

The scope of the proposed project covers the FFWS. Therefore, sections associated with the FFWS in the existing Hydrology service were only selected for the purpose of cost estimation.

(2) Components

The operation and maintenance costs include staff personnel, operating and management and depreciation costs.

(3) Staffing

The number of staff for the existing FFWS and required number for proper operation and maintenance of the improved FFWS are presented in **Tables 8.4.1** and **4.5.2** respectively.

(4) Operation and Maintenance Cost

The operation and maintenance costs are classified into the following components:

Components of O&M Cost

Item	Details
a) Transportation cost	- business trip costs
b) Communication cost	- BTTB, mobile, courier, post, etc.
c) Vehicle operation cost	- driver's wages, fuel and oil, repairs
d) Boat operation cost	- driver's wages, fuel and oil, repairs
e) Repair and maintenance cost	- for telemeter equipment (0.5% of total telemeter equipment costs) - for computer equipment (10% of total computer equipment costs) - for civil construction (2% of total civil works and 5% existing gauging stations)
f) Light, fuel and water cost	(5% of total office staff costs)
g) Consumables	(3% of total office staff costs)
h) Advertising	(2% of total office staff costs)
i) Social costs	(2% of total office staff costs)
j) Social welfare	(1% of total office staff costs)
k) House and land rental	- for public space: not necessary - for rental space: necessary (Dhaka Region)
l) Training cost	- for each official staff member
m) Insurance	(1% of total of "a) ~l)")
n) Sundry	(5% of total of "a) ~ l)")

(5) Depreciation Cost

For replacement of the system, depreciation cost should be considered and budgeted for by the Bangladesh government. However, depreciation is usually not included in annual O&M costs for most infrastructure projects in Bangladesh.

In the case of estimation of required O&M cost for the existing FFWS and project O&M cost, depreciation costs have been included in O&M cost. Depreciation cost was estimated assuming a 5 year replacement (20% annual rate of depreciation) for hardware and mobiles, 10 year replacement (10% annual rate of depreciation) for other equipment, and 30 year replacement (3.3% annual rate of depreciation) for civil construction items.

9.3.3 Annual Operation and Maintenance Cost

The O&M cost for the project is estimated at around 202.4 million Taka, required O&M cost for existing FFWS is 70.6 million Taka and actual O&M cost is 34.1 million Taka. These are summarized below. Excluding depreciation cost, the project O&M cost is 65.6 million Taka, an increase of 21.5 million Taka annually over the required O&M cost. As shown in the results, the repair and maintenance cost will be higher to operate and maintain the existing FFWS and improve its effectiveness. In terms of staffing cost, project O&M cost is 1.4 million Taka lower than actual O&M cost reflecting the reduction in staff numbers. A detailed breakdown of the estimation of annual O&M cost is presented in the **Supporting Report**.

Comparison of Annual O&M Costs

(Unit: Million Taka/year)

Items	Actual O&M cost (for existing FFWS)	Required O&M cost (for existing FFWS)	Project O&M Cost (for proposed FFWS)
Staff	24.4	24.4	23.0
Repair, Maintenance	1.7	10.5	27.1
Other O&Ms	8.0	9.4	15.5
Subtotal	*34.1*	*44.3*	*65.6*
Depreciation	0.0	26.3	136.8
Total	**34.1**	**70.6**	**202.4**

CHAPTER 10 PROJECT EVALUATION

10.1 General

10.1.1 Contents of Evaluation

Project evaluation is indispensable when evaluating overall feasibility of the proposed plan. In this Study, the evaluation was conducted covering three aspects: (i) economic impact, (ii) social impact and (iii) environmental impact.

10.1.2 Financial Evaluation and Affordability Evaluation

The financial evaluation to judge financial viability of a project is usually conducted if it will generate financial revenue. In the case of the FFWS, no financial revenue will result from its implementation as the beneficiaries of the project will not pay for the service provided through the improved systems. Therefore, such a financial evaluation was not undertaken in this Study.

Financial affordability is other aspect of financial evaluation. It depends on the scale of operating and maintenance cost associated with the project, the development policy of the GOB, the scale of the BWDB's budget, the priority or degree of urgency of policy or project as judged by the GOB, and so on. The Study Team was not able to obtain data and information to evaluate the financial affordability of this project. As a result, the evaluation of the financial affordability of the project was not executed in this Study.

10.2 Economic Evaluation

10.2.1 Preconditions of Economic Evaluation

(1) Project Life

The project life of this project was adopted as eleven years including one year for implementation. This assumed a 10 year economic life for telemeter stations.

(2) Conditions of Economic Development

The economic benefits usually take into account future socio-economic development plans including the population, land use, products by industrial sector and so on. For this study the economic evaluation of this project was conducted on the basis of the present conditions of economic development.

(3) Project Costs for Evaluation

The proposed project will be implemented by utilizing the existing equipment and facilities of FFWS. The project costs also included existing assets for equipment and facilities and their maintenance cost.

Furthermore, the FFWS will mitigate flood damage by evacuation not only through flood warning but also with supporting works such as well-organized dissemination and response systems including relief and rescue works by the NGOs and other regional inhabitants. The supporting costs are included in the project costs.

(4) Opportunity Cost of Capital

The opportunity cost of capital (OCC) is the cut-off ratio of EIRR to judge the viability of the project. In Bangladesh, the OCC is assumed to be 15% for water resources development projects. However, for disaster management development projects such as flood warning, the OCC is assumed to be lower than 15%. This is because tangible benefits of this kind of project would be less than those associated with other types of water resources development projects but the intangible benefits are assumed to be relatively greater. For this project the OCC was assumed to be 12%.

10.2.2 Economic Benefits

(1) Classification of Avoidable Damage

The benefit of this project is considered to be the avoidable flood damage resulting from the implementation of the improved FFWS. The reductions in flood damage can be classified into that associated with (i) structural measures such as embankments and (ii) evacuation or protective measures for infrastructure after receiving the flood warnings from the FFWS. Basically the flood damage of movables assets could be avoided (or minimized) but infrastructure damage could not be reduced. However, if suitable protective measures could be implemented, the cost for rehabilitation or maintenance would also be reduced.

(2) Potential Avoidable Damage Due to the Improved FFWS

The potential avoidable damage due to the improved FFWS is, under ideal conditions, assumed to be the maximum avoidable damage. Under these conditions most of the constraints to evacuation from the floodplain after receiving flood warnings are eliminated. Major constraints would include the following:

- Insufficient financial funds to protect infrastructure.
- Insufficient modes of transport such as vehicles, boats and rafts for evacuation.
- Poor condition of roads for evacuation.
- Poorly organized communication network for dissemination of flood warning.
- Poorly established response system for evacuation after receiving the flood warning.
- Insufficient time to evacuate after receiving the flood warning.

But even if most of these are eliminated, there are still constraints including physical conditions. Therefore the potential avoidable damage is not equal to the total damage to be avoided under ideal conditions.

(3) Practically Avoidable Damage Due to the Improved FFWS

The practically avoidable damage due to the improved FFWS reflects the project benefits. They exclude those components of the potential avoidable damage mentioned above that cannot be eliminated due to the FFWS.

Practically avoidable damage does, however, include the damage to be avoided by the improved or existing FFWS because the avoidance of damage could be accelerated as a result of synergy effects between the exiting and improved FFWS.

(4) Survey of Residents and Staff of BWDB

A "Residents-Household Survey" was conducted by the Study Team during the first field works in Bangladesh as part of the "Survey on Evacuation Condition and Awareness of Flood Victims". In this survey, the rate of potential avoidable damage to total damage, apart from damage for infrastructure, ranged from 50% to 99% for the various categories for which damage estimates were obtained.

The Study Team also conducted an interview survey with staff of the BWDB with regard to potentially avoidable and practically avoidable damage outlined above. In total 29 staff members of BWDB were interviewed including 23 from Divisional O&M Offices, 2 from Ground Water Hydrology Department, 2 from Mapping Center and 2 others. The questions on potential and practically avoidable damage were expressed as a percentage of the total flood damage. The result of the interview survey indicated that the ratio of potential avoidable damage to the total damage by category (house, agriculture etc.) varied from 50% to 88% apart from damage to infrastructure.

The avoidable damage of the Residents-Household Survey is considered to reflect the potential avoidable damage and so is equivalent to the potential avoidable damage category obtained in the Interview Survey. This would suggest the results from the Residents-Household Survey are reliable with regard to all potential avoidable damage except infrastructure.

The Study Team adopted conservative (low) estimates for potential practically avoidable damage based on the minimum percentages obtained from the Interview Survey of BWDB. This was appropriate because economic benefits (that is the practically avoidable damage) were far greater than the project costs. Also understandings and conditions with regard to the potential avoidable damage varied between interviewees, reflecting differences in experiences during flooding, the inherent characteristics of flood types and the forms of evacuation in the areas where they lived. Their responses were generally seen as being rather optimistic.

Based on the estimates for minimum avoidable damage, the potential and practically avoidable damage was calculated for the 1998 flood. The potential avoidable damage and practically avoidable damage were estimated to be 30,954 million Taka and 20,688 million Taka respectively. Based on these estimates and the total flood damage estimates for 1998 of 115,735 million Taka (see **Section 2.6.3**) the rate of practically avoidable to total damage was estimated as 13.3%.

The practically avoidable damage was estimated for various return periods by applying the 13.3% rate of practically avoidable damage to total damage estimated for each respective return period. The results of the calculations are shown in the following table.

Estimated Probable Practically Avoidable Flood Damage

Return Period (Years)	2	5	10	25	50	100
Flood Affected Area(km^2)	30,000	39,900	49,100	89,500	100,250	103,700
Flood Damage (Million Taka)	6,040	13,136	23,644	51,424	155,735	166,603
Practically Avoidable Flood Damage (Million Taka)	802	1,745	3,141	6,831	20,688	22,131

(5) Average Annual Practically Avoidable Damage by the Improved FFWS

The average annual practically avoidable damage was estimated on the basis of the practically avoidable damage by return period. The result of calculation is shown in the following table. The average annual practically avoidable damage was estimated to be around 1,615 million Taka.

10.2.3 Economic Cost

The economic costs were derived by conversion factors estimated by the Study Team (refer to the **Supporting Report** for detail) to the project cost at the financial prices. The total economic cost of this project is estimated as 1,122.3 million Taka. The local currency portion is 184.1 million Taka and the foreign currency portion 938.1 million Taka.

10.2.4 Economic Evaluation

The economic evaluation was conducted with regard to EIRR (Economic Internal Rate of Return), NPV (Net Present Value) and B/C (Benefit Cost ratio) by comparing cash flow of the economic benefits and costs during the project life. The discount rate of 12% was applied to the calculation of NPV and B/C. The EIRR is estimated to be 26.4%, significantly higher than the 12% opportunity cost of capital. NPV and B/C are calculated as 708 million Taka and 1.1, respectively. Hence this project could be judged as satisfactorily viable.

10.2.5 Conclusion

As already mentioned, the avoidable damages were based on the results of an Interview Survey of BWDB staff and adoption of conservatively low rates for assessing potential and practically avoidable damages. Taking this into consideration, it is concluded that this project is highly viable. The sensitivity analysis undertaken involving changing project benefits and costs also indicated it has high stability and credibility for the majority of cases assessed.

10.3 Social Impact Evaluation

10.3.1 General Impact

(1) Avoidance of Social Confusion

The avoidance of social confusion is the most direct social impact on the flooded community. The greater the lead time, the longer the time available for people to evacuate and maintain mental and physical well-being. This will minimize social confusion bringing about significant positive impact to the community. The people can avoid mental and physical situations of panic. Also traffic congestion will be mitigated with people having sufficient time to arrange basic facilities such as food and means of transport for safe passage in advance and at an acceptable pace. This will minimize traffic accidents. Overall, the avoidance of social confusion will contribute indirectly to avoid social disorder such as violence and robbery.

(2) Rescue of the Socially Weak

If there is sufficient time to evacuate, the possibility of rescuing the socially weak such as babies, the aged, the physically handicapped and the ill will improve. This will prevent the likelihood of health conditions associated with these people deteriorating.

(3) Strengthening of Social Solidarity

The necessity and importance of the dissemination and response systems will be recognized by the individual communities as indispensable for extracting the roles and functions of the FFWS. Solidarity among people in the community will be improved, increasing cooperation and providing more effective communication particularly regarding information on flood warning, safe evacuation procedures, and so on.

(4) Recovery of Socio-Economic Activities

After an evacuation, not only economic activities but also social activities such as education, medical treatment in hospitals, cultural activities, administrative works by the Government and so on are suspended temporarily. If the evacuation can be implemented far earlier, people can prepare to recover these temporally suspended social activities when normal conditions resume. As a result, negative impacts on these social activities could be minimized.

(5) Deepening of Understanding of the FFWS

As long as the dissemination and response system work effectively through close communication between the staff of BWDB and the people as the beneficiaries of the FFWS, the people's understanding of information from the flood warning will be deepened and effective evacuation will be accelerated.

10.3.2 Impact for Flood Warning

The "Residents-Household Survey", conducted as a part of the "Survey on Evacuation

Condition and Awareness of Flood Victims" during the project, was undertaken with 305 respondents at 15 locations in five regions at Dhaka, Rajshahi, Rangpur, Sylhet and Barisal. The following impacts summarise the results of the survey regarding indirect and direct social impact evaluation in relation to the FFWS.

(1) Receiving Flood Warning and Flood Warning Sources

In the survey, the two words 'flood warning' and 'flood status information/forecast' were considered as synonymous. Even awareness of the respondents through personal observation of flood situations and also information about floods obtained through personal communication from different sources including neighbors, villagers etc. were considered as warnings.

The results showed about 84 to 92% of respondents received flood warning (actually general flood situation information but not 'Warning' in the true sense of the word) in the different flood years of 1987, 1988, 1998 and 2000. It is important to note that the highest percentage of respondents mentioned the sources of flood 'warning' (or general flood information) as TV/Radio, personal observation and contact with neighbors, villagers and relatives. This implies that specific 'warning' was received by very few respondents from district, Upazilla or union level disaster management committees and NGOs. An organized effort in transmitting flood warning by these local organizations would result in less flood damages to the affected people as well as to the nation.

(2) Time of Receiving the Flood Warning Information

Timely receiving of advanced flood warning is a very important factor to the affected people in preparing for their evacuation and other activities to reduce flood damages.

Information on the time of receiving flood warning information by the respondents in different years showed from 24 to 37% of respondents received flood warning information in different flood years at least one week prior to their occurring, 17 to 20% at least 3 days prior, 13 to 28% at least 24 hours prior, 5 to 10% at least 12 hours prior, and 13 to 24 % within 12 hours of the flood.

(3) Receiving Evacuation Instruction Information and Their Sources

No organized and pre-planned 'evacuation' by any responsible Government/NGO agencies is practiced throughout the country. Rather, people take shelter on their own in different temporary shelters, such as schools, raised areas, embankments etc. The results showed 64 to 71% of respondents received some form of evacuation instruction. Regarding its sources, 57 to 68% stated TV/Radio, only 2 to 5% newspapers, 11 to 16% district/Upazilla administration, 16 to 31% Pourashava (Municipality)/Union Parishad (Counsel), 15 to 22% NGO/Voluntary organization, 2 to 5% teachers, imams (religious leaders) or social leaders and a large majority of 66 to 71% from neighbor, relative, villagers etc.

(4) Ways and Means of Receiving Flood Warning/Information

The result showed that 67% of respondents mentioned TV/Radio, 37% Pourashava/Union Parishad, 23% local Red Crescent Society/other NGOs, 15% newspaper, 14% announcement of district/upazilla administration, and 59% from other means including personal observation/contact with neighbors, relatives, villagers etc.

(5) Problems of Not Receiving Flood Warning

Different problems arise when not receiving flood warnings. Among the stated problems, 100% of 61 respondents stated the problems as "Could not shift household goods/furniture" and "Could not arrange food/cooking arrangements", 98% stated they "Could not shift family members" and "Could not arrange pure drinking water", and 95% mentioned they "Could not be prepared for evacuation".

Of these responses, the major problem faced when not receiving flood warnings in sufficient time (53% of respondents) was "Could not arrange food items and cooking arrangement". The second problem (21% of respondents) was "Could not shift household goods/furniture" while 14% of respondents stated "Could not shift family members".

(6) Benefits of Receiving Flood Warning in Advance

In terms of benefits of receiving flood warning in advance, 91% reported the benefit as "Could arrange food/cooking" during the period of inundation, followed by 68% as "Could shift family members", 67% as "Could be prepared for evacuation", and 65% as "Could shift household goods/furniture" etc. It is clear that those aspects considered indispensable for living are considered to be the benefits of a properly functioning FFWS.

10.3.3 Flood Warning/Evacuation Awareness Campaign

Regarding benefits accrued from observing/ participating in the campaign of flood warning evacuation awareness, 12 of the 14 interviewed stated in the affirmative. Of those 12, 10 respondents stated the benefit as finding a shelter, 8 mentioned the benefit of shifting family members, 7 referred to the arrangement of food/ cooking and 6 mentioned advantages of shifting household goods/ furniture etc.

10.3.4 Impact with Regard to Evacuation

(1) Preparatory Measures Adopted for Coping with Flood

On the question of various preparatory measures adopted by the respondents for coping with flooding after receiving flood warning/ information, 92% arranged food/ cooking, 62% organized shifting of family members, 60% arranged shelter, 53% organized both shifting of household goods/furniture and raising a platform in the house etc.

(2) Factors Considered to Take Decision for Evacuation

When deciding on evacuation, major factors considered by the respondents were high water level (90%), the problem of food/cooking arrangement (86%), living conditions being unsuitable in the house during flood (80%), the problems of sanitation facilities (76%) and communication problems (72%) etc.

(3) Evacuation of Respondents during Floods in Different Years

The highest ratio of evacuation during floods occurred in 1988 (65%), followed by 1998 (51%), 1987 (28%) and 2000 (26%). These evacuation rates are assumed to depend on the degree of awareness of flood warning and degree of dissemination of flood forecasting for the area where respondents lived.

The major places used for evacuation were houses of neighbors, relatives and other villagers (25%~38%), nearby educational institutions (25~36%), embankments, roads, high places, helipads (15~27%), etc.

(4) Routes of Evacuation and Means of Transportation

The major evacuation routes were waterways (70~80%) followed by roads (20~30%). The railway route was used by very few. As a means of transportation, most evacuees used boats and rafts on the waterways followed by foot/head loads. It was noticeable that evacuators did not use vehicles. This suggests vehicles are of limited use for transport during floods because roads are generally inundated by floodwaters.

(5) Support Provided to the Respondents during Floods

Support provided by agencies in different flood years were reported by the respondents. The agencies involved were Government, Semi-government and Local government agencies, NGOs, private organizations and individuals. Most are involved in relief work with very few in flood warning and evacuation.

(6) Problems Faced by Respondents during Evacuation as per Priority

Combining the 5 regions, 73% of respondents indicated their problems during evacuation included transport, 71% were financial, 58% were related to obtaining suitable shelter, 57% as damage of household goods and furniture and 14% as insecurity, problems of sanitation, etc.

In terms of priorities, transportation was the most critical problem (24%), followed by financial difficulties (22%).

These answers suggest the majority of those evacuating need to move to other places where they have better and safer conditions.

(7) Reasons for Not Evacuating During Floods

About 67% of respondents reported 'insecurity of properties at houses' as the reason for not evacuating, followed by 'evacuation place was not suitable' (50%), 'lack of nearby evacuation place' (38%), 'could not evacuate at short time' (20%), 'did not trust the warning' (16%) and 'did not receive any warning' (12%).

These answers suggest very important problems for the existing FFWS because if earlier, accurate and reliable flood warning could be given to the respondents, they could have evacuated with property in advance of the flood regardless of insecurity. There were some cases under the existing FFWS when immediate evacuation after flood warning did not occur because of unreliability of the flood warning. It was subsequently too late to evacuate with property when flooding actually occurred.

(8) Evacuation of Livestock in Different Flood Years

Some 25% to 46% of respondents evacuated their livestock. Of these, 31% to 45% moved animals to embankments, roads, high places, helipads etc, 20% to 28% to houses of neighbors, relatives/villagers, and 20% to 25% to educational institutions. The locations to which livestock were shifted were marginally different to the locations for evacuation of inhabitants (as discussed in (3)).

10.3.5 Life Condition during Flood

The respondents were asked about conditions of life during the floods. They stated various problems with 96% indicating difficulties with food, 91% isolation/ communication, 88% drinking water and sanitation, 84% sleeping, 74% diseases and damage of property etc. These answers suggest that support of those evacuating by providing food, medical aid, and similar is indispensable to save lives.

10.3.6 Conclusion

From the social viewpoint, it is predicted that this project would bring mostly positive and no negative impacts. It is therefore judged to be socially viable. But as the survey results show, there are many supporting conditions to ensure flood warnings can achieve their maximum impact. These conditions include the dissemination organization, response system including warning/evacuation awareness campaign, security of the community, supply of food, transport means and routes, financial support, and rescue and relief activities by many governmental and non-governmental groups and agencies.

10.4 Environmental Impact Evaluation

(1) Environmental Impact Due to Implementation of Proposed Project

The implementation of this project would be carried out by providing equipment in the offices of the flood forecasting and warning services for data processing, in the field for gauging the water level and rainfall, data transmission and so on. Therefore, serious environmental problems often associated with engineering projects such as contamination of water and negative impacts on the ecosystem will not occur.

(2) Protection of River Ecological Environment

If the flood warning is disseminated to the area to be flooded and there is sufficient time to protect the river structures by measures such as piling of sand bags on embankments, the latter could be protected against destruction. As a result, the river water will not flow over the embankment and the natural resources living in river water such as fish, larvae of insects, water micro-organisms and so on will be protected.

(3) Protection of Transport Environment

If the flood warning is effectively conducted and the lead time to evacuate is sufficient, traffic congestion could be minimized, fuel consumption could be reduced and traffic noise minimized. This project will contribute to a limited extent to mitigating traffic congestion and preventing air pollution and traffic noise.

(4) Protection of Water Contamination

The collapse of an embankment would result in overbank discharge and the remote possibility of the overflow mixing with contaminated water such as sewerage. If the river embankment is protected by measures after issuing flood warnings, such water contamination could be mitigated and contribute to preventing any deteriorating of people's health due to contamination.

(5) Conclusion

According to the brief study mentioned above, this project would bring mostly positive effects to the environment and no significant negative environmental impacts. It is therefore judged to be environmentally viable.

Overall, it is concluded that this project is judged to be comprehensively viable based on an integrated evaluation considering the economic, social and environmental viewpoints.