8. OPERATION AND MAINTENANCE

8.1 O&M Organization in GIP Area

In Bangladesh, two governmental organization are concerned with the operation and maintenance (O&M) for the completed FCD/I projects and other related infrastructures such as public roads, namely; Bangladesh Water Development Board (BWDB) and Local Government Engineering Department (LGED). The other agencies which are influenced directly or indirectly by O&M of FCD/I projects in terms of their ordinary activities are the Department of Fisheries, the Department of Agricultural Extension, the Bangladesh Rural Development Board and Non-Governmental Organizations (NGOs).

8.1.1 Gaibandha O & M Division of BWDB

The BWDB is responsible for planning, design, operation and maintenance of FCD/I projects, as well as urban protection. At present, BWDB set up the O & M field divisions in the respective regions, all of which are under jurisdiction of the four zonal chief engineers, in order to undertake the following works;

- Operation and maintenance of completed schemes
- Rehabilitation of deteriorated schemes
- Survey and investigation for new small scheme initiated by the O&M organization.
- Implementations of small schemes.

At the field level, the above works are practiced by section officers, sub-divisional engineers and executive engineers in the O&M Division office. In the GIP area, the Gaibandha O&M Division under the jurisdiction of the Chief Engineer, North Western Zone, Rajshahi is responsible for supervision and coordination of O&M works. It is concerned mainly with the following components of the FCD/I projects completed in the GIP area;

- Main flood embankment along BRE and TRE (retirements, strengthening).
- Bank protection works and river training works like Groyne, Permeable Spur Dyke, etc.
- Water management involving drainage improvements (Satdamua Katler Beel project).
- Operation and maintenance of the regulators provided under FCD project

Of the completed FCD works in the GIP area, the Gaibandha O & M Division concentrates on monitoring and maintaining TRE and BRE through provision of the retired embankments and/or river training works to cope with the river bank erosions. As far as the Gaibandha O&M division is concerned, it appears that the monitoring and maintenance works are proceeded in the positive way. At present, there are a lot of yards for manufacturing concrete blocks to be used for outer shell of the groyne along the Teesta and the periodic rehabilitation works have been gone on during the dry season in the recent years.

8.1.2 LGED's O & M activity in the GIP area

The Local Government Engineering Bureau was established under the Local Government Division, Ministry of Local Government Rural Development and Cooperatives in the year 1984. In primary, its main functions are to provide technical support to Zila parisads or Thana parisads (local government office in district and sub-district, respectively), Pourshavas (municipality office) and other agencies when necessary in the construction, operation and maintenance of local civil infrastructure. In addition

thereto, they were responsible for implementation, operation and maintenance of small water management schemes and rural roads and structures. LGED is presently involved in the construction of the Class B feeder roads, bridges and culverts.

There have been the directives that small to medium size of FCD/I projects constructed under BWDB be handed over to LGED. In actuality, however, it is rare for the time being that LGED has practiced the O&M of completed small FCD/I schemes in the substantial term, which are transferred from the jurisdiction of BWDB at Zila and Thana levels. In addition, LGED sets up no definite O & M organization in the structure to maintain the completed works like road, bridge and culvert at Zila and Thana level and is carrying out the rehabilitation works thereof with NGO such as CARE (Concern for American Relife Everywhere). Besides, Thana Rarizad implements the rehabilitation works with fund of Zila Parizad when those rehabilitation works are demanded through the union members of Thana.

The GIP comprises not only the FCD works on the major outer rivers but also those for compartmentalisation utilising existing rural and municipality roads. Thus, it is considered essential for the local government offices be involved in the O&M of the GIP components. Moreover, it needs to involve the aforesaid agencies concerned with fishery, agriculture and rural development, since its development would have an influence on the present activities in those sectors. Therefore, the organization for operation and maintenance of GIP will need to involve a member of these agencies so as to attain the objective of the project, although the components of GIP are commissioned to BWDB after completion of construction substantially as the BWDB's asset.

8.2 Problems on Present O&M Practice

8.2.1 Overall O&M problems identified by FAP 13 Study

The operation and maintenance of flood control structures is generally seen as a major constraint to effective functioning of the structures. FAP 13, the operation and maintenance study, identified the following problems, constraints and difficulties in current O&M through assessment of 17 completed projects;

a) The main organization in the O&M of the projects is BWDB at the central level. In BWDB, O&M Division are responsible for repairs and rehabilitation of projects as well as for routine O&M. This organizational set up is construction oriented. As a result O&M is not given proper importance.

b) Funds for O&M mainly from the Revenue Budget, Food For Works, Development Budget and Cash Foreign Exchange Budget. The total of these funds is inadequate to allow effective O&M.

c) Operation problems includes;
   - inadequate design not taking operational requirements into account
   - weak institutional arrangement for operation
   - untrained operators of structures
   - frequent conflict of interest over operating practice, and no procedure for conflict resolution

d) Maintenance problems include;
   - lack of routine maintenance of structures

c) Other aspects;
   - lack of public consultation in planning and design stage, and during construction and commissioning, which has led to misunderstandings about projects and subsequent O&M problems
   - lack of O&M manual, especially for field staff
   - unclear tasks, responsibilities and accountabilities of staff involved in O&M

In addition to these problems, the following points are also significant;

(1) Lack of participation of the beneficiaries

The beneficiaries involvement in O&M of the project is important;

- to make the beneficiaries partners in the development of project
- to reduce Government burden of cost for O&M of the project
- to get actual information on field conditions for proper O&M planning
- to encourage the beneficiaries by giving training and other facilities to them
- to make the beneficiaries conscious of the O&M cost and thereby to pay the water rate

(2) Tendency of new construction

The tendency of almost all engineers seek to work for new project instead of working in O&M projects which is a vital reason for non development of improved O&M procedures of BWDB. As a result O&M of the completed projects have been neglected.

(3) Lack of interest for O&M

O&M is s difficult task moreover fund is short. Understandably, the engineers are not interested to work in O & M projects.

In the GIP area, on the other hand, the significant problems in connection with the O&M would be breaches of TRE and BRE as well as the deterioration of the flood embankments as mentioned below. As pointed out by the FAP 13 study, substantial O&M resources are being devoted to protecting embankments against erosion, repairing breaches or retiring eroded embankments. In case of the GIP area, these problems requiring periodic rehabilitation works and repairing are caused mainly by the insufficient design and construction practiced at the implementation stage.

8.2.2 Matters considered in design of GIP components with respect to improvement of O&M

(1) Maintenance problem of FCD structure

The maintenance works are distinguished into the following three categories in compliance with their frequency that will take place;

a) Preventive maintenance : This type of maintenance is to be done continuously throughout the year. It includes minor repairs of the embankment, structures, weed clearance, removal of silt and obstacles from the canal, cleaning of the hydraulic structures and culverts

b) Periodic maintenance : Periodic maintenance include resectioning of embankments, desiltation of canals, repair of canals and partial replacement of structures. The intention of periodic maintenance is to bring the system elements back to design standard.

c) Emergency maintenance : It is unforseen which is required to repair the manage caused by natural calamities. A separate provision may be kept in the budget to deal with the emergency maintenance.

At present, the GIP area is protected by the flood embankments from the floods of the Brahmaputra (BRE), Teesta (TRE) and Ghagot (Satdamua Katler Embankment), and the inland rainfall water is drained through regulators into these rivers. However, these existing flood control drainage structures require repair after every monsoon season, especially in TRE and BRE. Although at present the Gaibandha O&M Division is taking the necessary temporary measures therefor, the following problems have been taking place in every monsoon season concerning the maintenance of TRE and BRE.

Deterioration of embankment body

In most parts of the GIP area, the existing embankment bodies of TRE and BRE have been deteriorating due to uncompacted embankment body, lack of turfing, and partly use of inappropriate embankment material at the construction stage. The embankment slopes and crest surfaces are easily eroded by rainfall, wind, wave and animals as well as the human's activity settling on the embankment berms. Excepting the human's activity, it is considered that the problems are responsible partly for the inappropriate design of the flood embankments as well as adoption of construction methods not suited to the embankment material. Since the problems on maintenance of the FCD structures come from constraint of budget allocatable thereto, they need to be built with such a quality that the maintenance cost, as far as possible, become minimized after completion of the works. During the FAP 2 study, for instance, we have inspected that a lot of embankments in the NW region have been deteriorated. Especially, we encountered that the FCD structure constructed in the last year has been washed away in the next year's monsoon season in the escape structure in the SIRDP scheme and groyne on TRE. It has to be note that these were caused by the inappropriate planning and design rather than insufficient maintenance works.

The human activity by increasing landless people resettling on TRE due to the bank erosion mentioned below would be one of the causes that these flood embankments are being deteriorated. Concerning TRE, it is proposed in the present study to secure a space for accommodating the landless people through provision of subdike in the country side to solve the problem. However, this would not be effective for the long term point of view as long as the bank erosion continues from now on with creation of new landless people. The present study contemplates to provide the river training works at the breached portions along the Teesta in order to avoid the further aggravation of the present situation.

Breaches of embankment due to bank erosion

The river channel of the Brahmaputra has been shifting to the west eroding the river banks in the GIP area so that retirement of BRE has been repeated. The existing Manas regulator is likely to be lost in near future.

TRE also is subject to severe bank erosion for sections between Noahali and Godowrghat and between Poriraghat and Sundarganj. This has led to retirement of TRE.

Although BWDB provided several groynes along the river stretch, some of these were washed away by the flood flow since 1987 because of insufficient number of groynes and use of poor construction material of their bodies and insufficient construction method. On the other hand, the design of the river training and bank protection works require the elaborated studies and/or experiments through its pilot construction from the hydraulic and river morphological point of view, associated with a lot of unkown factors. It appears that it is hardly possible to solve the bank erosion problem with such a temporary measure with limited budget allocated thereto. The river training works would need to be implemented under the formulated project as early as possible which allows allocation of budget sufficient for realization of the permanent measures. Therefore, it appears that the permanent measures to cope with the bank erosion will have to be worked out through the subsequent detailed study of GIP and/or FAP 21 and 22. Concerning BRE, retirement of existing flood embankments would have to be adopted until the economical permanent measures on these major rivers be established through FAP 21 and 22 being now underway.

(2) Operation of Regulator

The regulators planned in the present study are designed to enable the manual operation taking into account higher maintenance cost of the electric-operated type of gate, although some of them are preferred to be designed of the latter type from the scale merit in view of construction cost of regulator itself. It is judged that the present electric supply in the GIP area could not meet the operation in the emergency case, and moreover the automatic operation would require larger operation cost.

(3) Public perception in connection with operation and maintenance

Concerning the public participation in relation to the O&M, one general important comment that comes out from the GIP public consultation is that existing projects like EIP projects named Satdamua Katler Beel, Sonail Embankment etc. had been planned with no consultation in villages or communities and as a result some problems have been taking place. In the GIP area, the existing Satdamua embankment has been constructed along the left bank of Ghagot river to protect inside area without providing alternative major drainage provision. Consequently, people living in the opposite bank of the river has been suffering from severe drainage congestion. The similar problems had been created in the Sonail Embankment Scheme located downstream of the GIP area after completion thereof.

8.3 Consideration on Future O & M System

8.3.1 Overall recommendations for improving O&M

FAP 13's overall recommendations for improving O&M are;

- improved institutional arrangement,
- public participation and consultation,
- changing of planning and design of some project components to facilitate O&M,
- establishment of specific operating rules for individual structures and preparation of project-specific O&M manuals,
- establishment of water management procedures, involving increased farmer participation where appropriate and including contingency plans for managing floods,
- resource mobilisation, e.g. introduction of value-related land taxes in flood-protected areas, and multi-purpose use of FCD/I infrastructure for resource generation,
- undertaking of routine maintenance,

- monitoring of O&M costs and resource estimates based on clear guidelines,
- staff training.

Some of these recommendations require action at national level, and most of them require further elaboration and trials at field level.

8.3.2 Suggestion for improving O&M in the GIP area

(1) Institutional set-up

After completion of the Gaibandha Improvement Project, the BWDB O&M division is to be responsible and to act as the managing organization for monitoring, operating and maintaining the completed works of GIP in substantial term. On the other hand, it would be essential for the BWDB structure to have an adequate linkage with the field level, and moreover it is recommended to set up the local communities which are to be organized by the Gaibandha O&M Division and other local members of the concerned agencies. In the present study, we held the public participation by involving those local staffs and farmers in the GIP area to listen to their perceptions to the GIP FCD plans. In the subsequent detailed design stage, the local communities will need to be established to make the local staffs participate in the project and reflect the local perception in more concrete form. Figure 8.1 shows a possible organization at field level, suggested by the FAP 2 Study Team for the time being, which comprise two local committees, namely the Zila Project Coordination Committees at the district level and Thana Project Coordination Committees at the sub-district level.

The Executive Engineer will, in conjunction with different government organisation like Bangladesh Rural Development Board, Local Government Engineering Bureau, Bangladesh Agricultural Development Corporation, Department of Agricultural Extension, Development of Livestock, Fisheries and Forestry and with a few number of representative from farmers and fishermen, organise and form Project Coordination Committees at district level for proper organizing of operation and maintenance. The Thana project coordination committee at each subdistrict will be managed by the Sub-Divisional Engineer of BWDB under the directions of the Zila Project Coordination Committees. The aim of the committee is as follows:

- to ensure the smooth and effective operation and maintenance of the GIP components,
- to arrange the gate operation of regulators taking into account the productivity in all sectors, such as agriculture, fishery, etc.,
- to provide the efficient use of irrigation water in connection with operation of regulators,
- to arrange for FFW programmes, when become necessary,
- to arrange for the collection of tolls and rates, when such an institutional system is likely to be realized, and
- to ensure effective flood emergency procedure and disaster relief facilities.

The Thana Project Coordination Committees will establish, motivate and monitor the Regulator and Sluice committees and act as liaison between the farmer and all other concerned government and non-government agencies.

(2) Other conceivable procedures for improving O&M

The other procedures for improving O&M than aforesaid which are to be formulated in the subsequent

detailed design and construction stages and to be proceeded under the Committees at the O&M stage will be as follows;

(i) Increased local involvement in O&M: Element of this could include;
- landless groups employed as contracting societies involved in initial earthworks construction (LGED has also had experience in involving groups in culvert construction: this may have relevance in the context of Gaibandha's localised drainage problems);
- routine maintenance of embankments undertaken by poor women living on or adjacent to the embankments;
- embankment protection works (involving placing of concrete blocks or brick mattressing) also to be carried out by landless contracting societies where possible;
- sluice committees formed including different beneficiaries/interest groups;
- similar committees formed to take action in the case of emergencies, i.e. threatened embankment failure.)

(ii) Training of different personnel involved in O&M: This is an important component. Proposals on the nature of training required will be developed consistent with the proposed organisational structure.

(iii) Budgeting O&M cost; The sources of O&M funds will need to be considered: while in principle cost recovery may be desirable, such an approach would probably have to be developed as part of national policy. The use of landless contracting societies and greater involvement of beneficiaries could, however, be expected to reduce O&M costs compared with present arrangements.

(iv) A report is to be prepared with ,maps for the year, mentioned the possible causes on non-fulfilment of the target by field, which are;
- poor field layout
- insufficient canal
- faulty operation system of regulators
- Obstruction in the canal for fisheries, road crossing, culverts
- silting up of canals
- poor embankment condition.

(v) The maintenance programme of the last year is to be discussed with the field offices and a draft work plan is to be prepared for the year considering the inspected condition of canals, condition of embankment, condition of structures.

(vi) Periodic and preventive maintenance work plan is chalked out alongwith a programme of rehabilitation,(if any required). The work should be discussed with the field officials, the consultants and the beneficiaries.

(vii) The final draft plan and budget are to be sent to the Board for final approval.

(xiii) Water management section: Under this concept the position of the Sectional Officer will be strengthened. He will be the nearest to the farmers. He will update the scheme maps and inventories. This should be done every year to support the planning of maintenance and cost recovery. After consultation with the farmers, the Sectional Officer will ascertain the system needs, communicate relevant information to decisions makers set operation schedule, prepare

and submit maintenance plan.

With the improved feeding of information, period visit to the different elements meeting with the system users, the Sub-Divisional Engineer can coordinate the work of the Sectional Officer and report to the Executive Engineer.

(ix) Follow-up at higher level: With updated information and work plan, the Executive Engineer will take up the selected issue to other agencies at his level or at BWDB's headquarters as and when required and the work plan is approved for implementation.

8.3.3 Operation and Maintenance items for components of GIP

The major FCD components included in GIP are Drainage regulator, flushing sluice, embankment, and groyne and revetment works. Out of these, the groyne and revetment works will require the intensive monitoring during the monsoon season and maintenance works in the post monsoon season. The periodic monitoring and maintenance are expected to be practiced by the Gaibandha O&M division in consultation with the Project Coordination Committees. The maintenance works require for each of the components are summarized below;

(1) Drainage Regulator

- Gauge readings should be recorded at least twice a day and in the flood season in particular.
- Anchorbolts holding hoisting system should be kept free from dust and rust and these should be provided with double nuts.
- All steel wire ropes should be cleaned and lubricated with grease at least twice a year. One before the advent of the floods and the other after the floods recede.
- Winches and lifting drums should be examined at least once a year to see if all gears and axles are clean and properly lubricated and ropes are fixed tight with adequate number of clips. All grease-fed bearing should be cleaned, old grease removed with kerosene oil and fresh grease applied. wires, stands and winding should be examined for their integrity invariably.
- The gate shutters should be cleaned and repainted as and when necessary.
- Gate grooves and their machined faces should be kept clean of debris and weeds.
- The fixed wheel rollers of vertical lift gates should be examined once a year. partially jammed rollers should be cleaned, freed and greased, bearings checked but totally jammed rollers should be replaced.
- Seals (pvc, rubber, brass or steel) of the gates should be checked for wear, tear and deterioration. These should be adjusted or replaced as and when necessary but well ahead of the advent of the flood.
- Stop logs in sufficient number of bulk heads in good condition with lowering and lifting devices should remain in stock in each sub-division.

(2) Flushing Sluice

- Structures should be examined by the Sub-divisional Engineer if defects are detected those should be reported to the Executive Engineer, who shall take immediate actions to mend the defect.
- Controlling device if by steel gate then it's maintenance procedure will be same as the drainage regulator.
- Controlling device if by stop-log then in off-season it should be stored in safe place. Stop logs

shall be in stock in sufficient number and price conditions.

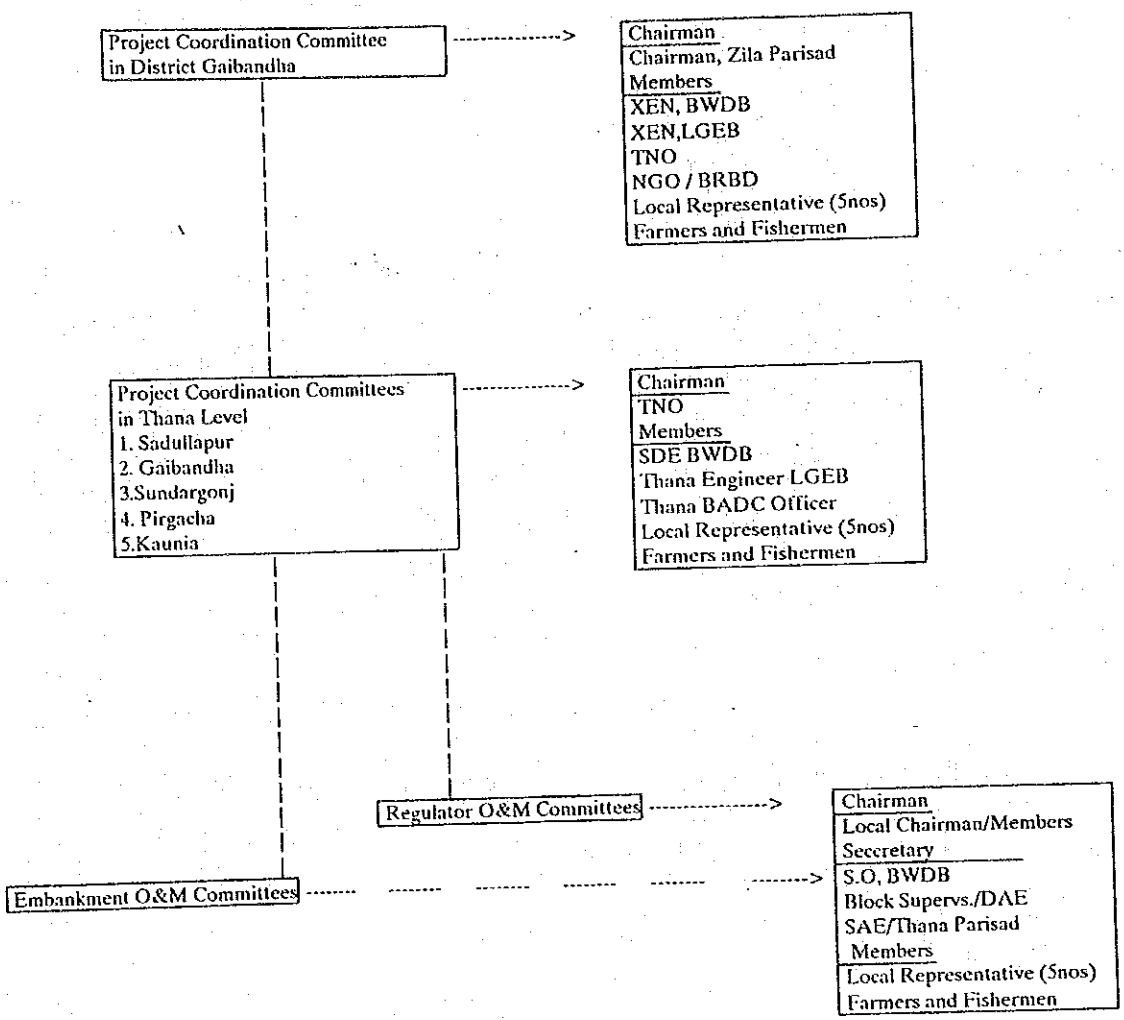
(3) Embankment

- The flood embankment should be maintained at full section and random check survey of cross section shall be conducted in every year.
- A thick turf should be maintained on the embankment slope and top. Grazing of cattle should be prevented.
- Use of embankment should not be allowed for any purpose other than flood control.
- Tree plantation should not be allowed on the embankment.
- All rain cuts, settlement and loss of turf should be mended immediately after the recession of the monsoon to allow repair works to set and turf to grow before the onset of monsoon. For repair purpose no earth be borrowed from berms.
- Piping in the embankment should be repaired by digging or boring through the embankment as soon as it is detected.
- Regular inspection should be made during flood season for detecting leakage in the embankment.
- Embankment close to river should be watched during flood season and if protective measures are required the same should be done in the following dry season.
- Rights of way should be kept free from all encumbrances at all time.

(4) Bank Revetment and Groyne

- The revetment work, spur, Groyne should be maintain at full section. Random check survey of cross section along with upstream and downstream toe and apron should be taken during flood period at 15 days interval.
- Regular inspection should be made during flood season for detecting erosion, settlement, leakage, scour near belt mouth etc.
- All rain cuts, settlement, displacement of blocks and mattressing works should be mended immediately after the recession of flood. For repair purpose material should be stock piled.
- Use of this part of embankment should not be allowed for any other purpose.

Figure 8.1 PROJECT COORDINATION COMMITTEES



Legend

BWDB Bangladesh Water Development Board
LGEB Local Government Engineering Bureau
XEN Executive Engineer
BADC Bangladesh Agricultural Development Corporation
TNO Thana Nirbahi Officer
BRDB Bangladesh Rural Development Board
SAE Sub-Assistant Engineer
DAE Department of Agricultural Extension

9. TECHNICAL NOTES

9.1 General

In consideration of the vast area of GIP, the Gaibandha Improvement Project is expected to be implemented with the following three phases as explained in the foregoing Chapter 6;

Phase-1 : Sealing of the Teesta with river training works
Phase-2 : Construction of backwater levee along the Ghagot and Gaibandha town protection
Phase-3 : Resectioning/heightening of existing Ghagot left embankment, provision thereof in the upstream reach and compartmentalization of the GIP area

Further, each phase comprises the detailed design including the survey and investigation to supplement those in the present project preparation stage, and construction supervision. This technical notes describe the engineering works to be carried in the detailed design stage of each phase as well as the expertised requirement for the implementation.

The major items of the engineering studies to be made in the implementation stage are as follows, although they differ phase by phase to some extent as itemized in the succeeding Section 9.2.

- To review the previous studies (project preparation study on GIP) based on the updated data and information,
- Additional topographic survey and geotechnical investigation to supplement those done in the present project preparation study,
- To carry out the test embankment with the manual construction method retained as the alternative construction method in the present study in order to verify the quality of the compaction works from the the geotechnical aspect,
- To carry out hydraulic modelling analyses through incorporation of the latest circumstances in the GIP area,
- To design the components of GIP at a level of the detailed design,
- To prepare the tender documents,
- To prepare operation and manuals, and
- To prepare training schedules for the local staffs who are to be engaged in the operation of the drainage structures after completion of construction.

9.2 Technical Notes on Each Phase

9.2.1 Detailed design in Phase-1 : Sealing of the Teesta with river training works

In the Phase-1 detailed design stage, an emphasis is to be placed on the design of river training works (groyne) along TRE and flood embankment (TRE), both of which are proposed for sealing the Teesta.

Groynes will have to be designed not only to function properly at the proposed locations against river bank erosion, but also not to cause the secondary bank erosion elsewhere after provision thereof. To confirm the morphological change along the Teesta right bank up- and downstream of the construction sites as well as the opposite left bank at which it might be caused by provision of the river training works, the hydraulic model test is planned to be carried out in the Phase-1. In case the physical modelling test exhibits that provision of the groynes might result in occurrence of such adverse effect elsewhere, alignment as well as dimensions of the groynes are to be revised. Thus, the best alignment

and dimensions of the groynes will be determined by the physical hydraulic model test. Besides, the morphological change along the Teesta will be monitored all over the implementation period, and the maintenance works will be provided in case an event that requires urgent maintenance works in the groynes due to unforseenable natural disaster takes place.

In addition to the topographic condition as well as particle size of river bed material which will become available through the supplemental topographic survey and geotechnical investigation in more detail, the actual hydraulic conditions of flood flow at the construction sites such as distribution of flow velocity and direction of flow need to be investigated to make the physical model agreeable to the site conditions. For the purpose, current metering is proposed to be conducted at the proposed groyne sites.

To confirm the quality of embankment to be built with the manual construction method with improved compaction method, the test embankment which includes the laboratory tests for clarifying the engineering properties of soil materials compacted through the construction method is planned to be performed. Based on the test result, the adaptability of the manual construction method will be assessed from the engineering and economic point of view in order to determine the best construction method. The technical specifications for the embankment works as well as design criteria on the selected construction method will then be finalized based on the test embankment results. Those technical specifications and criteria will commonly be applied to the flood embankments involved in the Phases 2 and 3.

(1) Supplemental Investigation, Survey and Studies

a) To review the project preparation study based on the data and information newly made available for GIP

b) To carry out additional topographic survey to supplement those done in the present project preparation stage as itemized below;

- River cross sectional survey along the Teesta between Kaunia and the outfall to the Brahmaputra : An interval of those sections where the river training works are proposed will be about 1 Km and for the other portions it will be about 2 km.
- Aero-photo mapping at a scale of 1 to 5,000 for the area along the existing TRE and its realigned route using the latest aero photographies
- Plane table survey for spot areas proposed for regulators and sluices
- Cross sectional survey along TRE at interval of about 20 m

c) To carry out additional geotechnical investigations to supplement those done in the project preparation study, which include core boring and test pitting as well as insitu and laboratory testing of soil materials to be collected therefrom as well as the borrow sites of embankment material and spoil sites of excavated material

d) To carry out hydraulic analysis to update the design high water levels of the Teesta

e) To install a staff gauge in each of the compartments planned in the present project preparation study : Internal water level observation is required to be continued until the Phase-3 detailed design. These water level data will be applied to the inundation analysis scheduled to be made in the Phase-3.

(2) Hydraulic model test for detailed design of groynes and revetment works for TRE

a) To carry out current metering at the proposed groynes sites on the Teesta during the monsoon season: Flow velocities are to be measured along the cross sections surveyed in and near the portions where groynes are proposed to be provided, in order to clarify a tendency on the horizontal and vertical distributions of flow velocities during flood flow.
b) Hydraulic model test to clarify the morphological phenomenon after provision of the proposed groynes: It will aim to verify how provision of the groyne will influence on the down- and upstream portions as well as the Teesta left embankment. Based on the the results, dimensions and alignment of groynes are to be determined.

(3) Test embankment for design of flood embankment

(4) Detailed design

a) To determine design criteria
b) To design flood embankment, groyne and revetment works for river bank, drainage regulators and sluices, and other minor works
c) To make supplemental study of construction methods and schedule and estimate construction cost which is to be divided into local and foreign portions
d) To prepare a draft operation and maintenance manual

(5) Preparation of tender documents

The following documents required for the competitive tendering are to be prepared in the detailed design stage;

- Prequalification documents
- Tender documents which comprise the instruction to tenderers, conditions of contract, general and technical specifications, bill of quantities and tender drawings

9.2.2 Detailed design in Phase-2 : Construction of backwater levee along the Ghagot and Gaibandha town protection

In the Phase-2 detailed design, the alignment and dimensions of structures planned at the most downstream reach of the Ghagot including the shortcut channel will depend on how the existing Manas regulator is treated, abolished or maintained at the present location through the effective bank protection works, although for the time being it is too hard to foresee whether the existing Manas regulator threatened to the bank erosion could remain there until the commencement of the detailed design stage of the Phase-2. The engineering studies for the Phase-2 are prepared assuming that the policy on the treatment of the existing Manas regulator is set up, that is, it is determined by the concerned governmental agencies with reference to the FAP 21 and 22 studies prior to the commencement of the Phase-2 detailed design.

(1) Supplemental Investigation, Survey and Studies

a) To carry out additional topographic survey as below;

- River cross sectional survey along the Ghagot and Manas at intervals of about 100 m, which

cover the existing Ghagot left embankment
- Aero-photo mapping at a scale of 1 to 5,000 for the area along the proposed route of the Ghagot left embankment using the latest aero photographies
- Plane table survey for spot areas proposed for short-cut channel, bridge, regulators and sluices
- Cross sectional survey along the existing GLE in lower reach and its proposed centerline in upper reach at interval of 20 m

b) To carry out additional geotechnical investigations to supplement those done in the project preparation study, which include core boring and test pitting as well as insitu and laboratory testing of soil materials to be collected therefrom as well as the borrow sites of embankment material and spoil sites of excavated material

(2) Detailed design

a) To determine the design criteria for flood embankment, short-cut channel, bridge and other components
b) To design flood embankment, short-cut channel, drainage regulators and sluices, and other minor works
c) To design for O&M works required for the river training works on the Teesta, to be provided in the Phase-1, if any
d) To make supplemental study of construction methods and schedule and estimate construction cost which is to be divided into local and foreign portions
e) To prepare a draft operation and maintenance manual

(3) Preparation of tender documents : The same sort of documents as those for the Phase-1 are to be prepared.

(4) To prepare the training schedule for the local staffs who are to be engaged in the maintenance of the regulators and sluices

9.2.3 Detailed Design in Phase-3 : Resectioning/heightening of existing Ghagot left embankment, provision thereof in the upstream reach and compartmentalization of the GIP area

There is a possibility that the present internal drainage pattern inside the GIP area will vary to a considerable extent because of provision of public roads and other infrastructures until the commencement of the Phase-3 detailed design. To verify the effectiveness of the compartmentalization as well as to look for the best alignment and dimensions of components for the compartmentalization under such a condition, the hydraulic modelling analysis to represent the inundation condition in the respective compartments are scheduled to be carried out in the Phase-3 detailed design. The hydraulic model to be used will be constructed through calibration based on the observed water levels in the respective compartments, of which observation are planned to commenced in the Phase-1 detailed design stage as aforesaid in the foregoing Sub-section 9.2.1.

(1) Supplemental Investigation and Survey

a) To carry out additional topographic survey as below;
- River cross sectional survey along the Ghagot at intervals of about 100 m, which except for

its stretch covered by that in the Phase-1
- Aero-photo mapping at a scale of 1 to 2,000 for the area along the proposed route of the Ghagot left embankment using the latest aero photographies
- Plane table survey for spot areas proposed for regulators and sluices

b) To carry out additional geotechnical investigations to supplement those done in the project preparation study, which include core boring and test pitting as well as insitu and laboratory testing of soil materials to be collected therefrom as well as the borrow sites of embankment material and spoil sites of excavated material

(2) Detailed design

a) To determine the design criteria for flood embankment, short-cut channel, bridge and other components
b) To design flood embankment, short-cut channel, drainage regulators and sluices, and other minor works
c) To design for O&M works required for the river training works on the Teesta, to be provided in the Phase-1, if any
d) To make supplemental study of construction methods and schedule and estimate construction cost which is to be divided into local and foreign portions
e) To prepare a final operation and maintenance manual

(3) Preparation of tender documents : The same sort of documents as those for the Phase-1 are to be prepared.

(4) To prepare the training schedule for the local staffs who are to be engaged in the maintenance of the regulators and sluices

9.3 Work Schedule and Expertize Requirement

It is estimated that the detailed design and construction supervision would take about 2 and 3 years for every phase, out of which the period required for the detailed design includes that for financial arrangement and tendering for construction. The prospective implementation schedule is established as shown in Figure 6.3, which shows that the implementation period of Phase-1 which will start in advance of other 2 Phases will overlap with that of the Phase-2, while the implementation of Phase-3 be commenced immediately after completion of the previous Phase-2 construction.

The expertised requirements for the implementation of GIP for the engineering works are listed below by discipline;

(1) Team Leader (Expatriate)
(2) Deputy Team Leader (Local)
(3) Hydrologist (Expatriate/Local)
(4) Hydraulic Engineer (Expatriate/Local)
(5) Hydraulic Model Test Expert (Expatriate/Local)
(6) Soil Mechanical Engineer (Expatriate/Local)
(7) Supervising Surveyor (Expatriate/Local)
(8) River Engineer (Expatriate)
(9) Design Engineer (Expatriate/Local)

(10) Contract/Specification Expert (Expatriate/Local)
(11) Construction Supervisor (Local)