FLOOD PLAN
COORDINATION
ORGANIZATION
(FPCO)

KREDITANSTALT FÜR
WIEDERAUFBAU (KfW)

CAISSE FRANÇAISE
DE DEVELOPPEMENT (CFD)

# BANK PROTECTION AND RIVER TRAINING (AFPM) PILOT PROJECT FAP 21/22



# COMMENTS TO DRAFT FINAL REPORT AND ANSWERS



MAY 07, 1993

CONSULTING CONSORTIUM FAP 21/22

RHEIN-RUHR ING.-GES.MBH, DORTMUND/GERMANY

COMPAGNIE NATIONALE DU RHONE, LYON/FRANCE
PROF.DR. LACKNER&PARTNERS, BREMEN/GERMANY
DELFT HYDRAULICS, DELFT/NETHERLANDS

In association with:

BANGLADESH ENGINEERING &
TECHNOLOGICAL SERVICES LTD.(BETS)
DESH UPODESH LIMITED (DUL)

GERMAN-FRENCH COOPERATION WITH BANGLADESH

# BANK PROTECTION AND RIVER TRAINING (AFPM) PILOT PROJECT FAP 21 / 22

FLOOD PLAN CO-ORDINATION ORGANIZATION (FPCO)

Project Office :
Consulting Consortium FAP 21/22
House 4, Road 125, Gulshan-1
Dhaka-1212, Bangladesh
Tel : (880-2) 600751, 881199
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The Chief Engineer
Flood Plan Coordination Organization
7, Green Road
Dhaka

Our Ref: CC/FPCO/L/93-195

May 13, 1993

Subj : **Comments to Draft Final Report**

Dear Sir,

Referring to your Memos No.

| | |
|---|---|
| 331/FPCO/A-021/22/90 | dated 01.03.93 |
| 390/FPCO/A-021/22/90 | dated 11.03.93 |
| 396(4)/FPCO/A-001/22/90 | dated 13.03.93 |
| 433/FPCO/A-021/22/90 | dated 16.03.93 |
| 541/FPCO/A-021/22/90 | dated 05.04.93 |
| 620/FPCO/A-021/22/90 | dated 15.04.93 |

we have pleasure in submitting you 35 copies of the report on the comments and our answers.

For easy reference we have included the comments and put them in italic.

As requested in your above letter we have answered the comments of category 1 and 2 only.

In case you should have further questions please do not hesitate to contact us.

Yours sincerely,

(Dr H Brühl)
Project Director



Encl: 35 copies of the Report on the Comments and Answers to the Draft Final Report.

CN/KA

FAP 21 / 22

GOVERNMENT OF
THE PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF
IRRIGATION, WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN CO-ORDINATION ORGANIZATION
7, GREEN ROAD, DHAKA-1215
BANGLADESH.

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| No. 146 | 03.03.93 |
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03/03/93

PHONE : 324460
TELEX : 632215 JRC BJ
FAX : 00-880-2-813169

Memo. No. 331 /FPCO/A-021/22/90 Dated- 1-3-93

To

Dr. H. Bruhl
Project Director, FAP 21/22
House No-4, Road No-125
Gulshan, Dhaka.

(Atten: Mr. Mohiuddin Mansur)

Sub: Comments on the Draft Final Report of FAP-21.

Dear Dr. Bruhl,

We received the Draft Final Report of FAP-21, Bank Protection Pilot Project in the last week of January, 1993 and have the pleasure to furnish herewith the comments of FPCO on the report. The comments received from CFD are also enclosed.

You are requested, to please submit your response on category I and category 2 comments and also on comments of CFD. If you wish we may discuss category 3 comments at a suitable time.

Thanking you,

Yours sincerely,

( M. H. Siddiqi )
Chief Engineer
FPCO.

Enclo: As stated.

8

1/29

GOVERNMENT OF
THE PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF
IRRIGATION, WATER DEVELOPMENT & FLOOD CONTROL
FLOOD PLAN CO-ORDINATION ORGANIZATION
7, GREEN ROAD, DHAKA-1215
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PHONE : 324460
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FAX : 00-880-2-813169

Memo No. 390 /FPCO/A-021/22/90 Dated- 11-3-93

To
The Project Director
FAP-21/22
House No-4, Road No-125
Gulshan, Dhaka.

(Atten: M. Mohiuddin Mansur)

Sub: Comments on the Draft Final Report of FAP-22.

Dear Sir,

We received the Draft Final Report of FAP-22, River Training/AFPM Pilot Project in the month of December 1992 and have the pleasure to furnish herewith the comments of FPCO on the report.

You are requested to please submit your response on Category 1 and Category 2 comments. If you wish we may discuss Category 3 comments at a suitable time.

Thanking you,

Yours sincerely,

( M. H. Siddiqi )
Chief Engineer
FPCO.

FAP 21 / 22

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15/03/93

25/29

GOVERNMENT OF
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FLOOD PLAN CO-ORDINATION ORGANIZATION
7, GREEN ROAD, DHAKA-1215
BANGLADESH.

PHONE : 324460
TELEX : 632215 JRC BJ
FAX : 00-880-2-813169

Sub: Comments of Prof. W.F.T.Van Ellen on Draft Final Report of FAP-1.

Enclosed please find comments of Prof. Van Ellen on the draft final report of FAP-1 for your information and necessary action.

A meeting would be arranged to resolve the issue of different scour depths, resulting from the model tests of FAP-1 and FAP-21/22.

Enclo: As stated.

( M. H. Siddiqi )
Chief Engineer.

Memo No. 396(4) /FPCO/A-001/90 Dated- 13-3-93

Distribution:-

1) Director Planning (General), WDB, Dhaka.
2) Superintending Engineer-IV, FPCO, Dhaka.
3) Team Leader, FAP-1, Dhaka.
4) Team Leader, FAP-21/22, Dhaka.

FAP 21/22 14/3/93

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THE PEOPLE'S REPUBLIC OF BANGLADESH
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7, GREEN ROAD, DHAKA-1215
BANGLADESH.

PHONE : 324460
TELEX : 632215 JRC BJ
FAX : 00-880-2-813169

Memo No. 433 /FPCO/A-021/22/90 Dated- 16-3-93

To

The Project Director
FAP 21/22
House No. 4, Road No. 125
Gulshan, Dhaka.

**(Attention: Mr. S. M. Mansur, D.P.M)**

**Subject: Comments on the Draft Final Report of FAP 21**

**Reference: T.O. No. 331/FPCO/A-021/22/90 Dated-01-03-93**

Dear Sir,

In continuation to the above memo some more comments on the subject report received from Mr. A.K. Ataur Rahman, Director, Directorate of Fisheries, Dhaka and from Mr. Md. Afazuddin, Chief Engineer, Design-II, BWDB, Dhaka are forwarded herewith.

You are requested to please consider those comments and respond where necessary. If you feel, you may also discuss with us.

Thanking you,

Yours sincerely

(M. H. Siddiqi)
Chief Engineer

Enclo: Comments-2 Nos.

FAP 21/22 17/3/93

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17/03/93

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FLOOD PLAN CO-ORDINATION ORGANIZATION
7, GREEN ROAD, DHAKA-1215
BANGLADESH.

PHONE : 324460
TELEX : 632215 JRC BJ
FAX : 00-880-2-813169

Memo No.541 /FPCO/A-021/22/90 Dated-05-04-93

To

Mr. C. Netzeband,
Project Manager,
FAP-21/22
Gulshan, Dhaka.

**Subject: Comments on the Draft Final Report of FAP-21**

**Reference: T.O. No. 331/FPCO/A-021/22/90 Dated-01-03-93 & 433/FPCO/A-021/22/90 Dated-16-03-93**

Dear Sir,

In continuation to the above memo enclosed please find one more comment on the subject report as received from Mr. SK. Mostofa Hussain, Chief Engineer, River Research Institute, Faridpur for taking necessary action from your end.

Thanking you.

Yours sincerely,

(M. H. Siddiqi)
Chief Engineer

Enclo: As stated.

FAP 21 / 22

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06/04/93

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FLOOD PLAN CO-ORDINATION ORGANIZATION
7, GREEN ROAD, DHAKA-1215
BANGLADESH.

PHONE : 324460
TELEX : 632215 JRC BJ
FAX : 00-880-2-813169

Memo No. 620 /FPCO/A-021/22/90 Dated- 15-4-93

To
The Project Manager
FAP 21/22
Gulshan, Dhaka.

**Subject: Comments on the Draft Final Report of FAP 21/22 (Executive Summary)**

Dear Sir,

Enclosed please find comments on the subject report as received from the Secretary, WARPO, Dhaka and Mr. Abinash Chandra Sarker, Additional Chief Engineer, Design-I, BWDB, Dhaka for taking necessary action from your end.

Thanking you,

Yours sincerely,

(M. H. Siddiqi)
Chief Engineer

Enclo: As stated.



FAP 21/22

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16-4-93

# COMMENTS ON
# DRAFT FINAL REPORT OF FAP 21
# BY CFD

20

# GENERAL COMMENTS BY CFD

## 1. *GENERAL REMARKS ABOUT THE FORMULAS*

*In the body of the report formulas and factors have to be checked very carefully to correct errors and/or non appropriated dimension of the parameters; for example:*

*The Chézy coefficient is not dimensionless, as indicated in the report, but is expressed as ($m^{1/2}/s$).*

*The formula 7.4.7 seems to be erroneous:*
*..... etc.*

*Such a preliminary checking is important because a summary of recommended formulas, for design purpose, will constitute part of the "Guide-Lines" (manual) the Consultant is intending to supply after achievement of the evaluation process for serving as reference for future works.*

Answer:
The Consultant agrees that there are some printing errors left in the draft. They will be corrected in the final text. The recommendation which formula to use will be given in the guidelines and manuals at the end of the Project, after incorporating the experiences gained in the monitoring and adaptation phase. Before that one must, however, take into consideration the fact that the application of different formulas will result in different thickness of cover layers. Insufficient dimensions of protection units can lead to damages of revetments. Hence, it is also one of the tasks of the Project in accordance with the design philosophy to test the applicability of all well-known equations. Appropriate application of the formulas/equations recommended in ANNEX 16 out of which only some are shown in the Main Report, Volume I A, will be further investigated during the Test and Implementation Phase.

The dimension of the Chézy-coefficient is of course $m^{\frac{1}{2}}/s$.

The formula for the slope factor

$$k_s = \cos\alpha \sqrt{\frac{1-\tan^2\alpha}{\tan^2\varepsilon_s}}$$

is taken from PIANC (1987a), page 94.

The alternative formula under 7.4.7 of the Main Report.

$$k_s = \sqrt{1-\frac{\sin^2\alpha}{\sin^2\varepsilon_s}}$$

is given by Pilarczyk.

However, the application of both formulas shows the same result.

## 2. *ABOUT SCOUR EVALUATION (Chapter 2.3.7)*

*The Consultant observes that maximum scour depths are the result of a combination of bend scour and local scour:*
*bend scour can be approached by some realistic calculations whereas*

*local scour can only be determined, within acceptable limits, by means of physical model tests.*

***We agree with such a conclusion but on the condition that the calibration of the physical model proves, without doubts, its reliability. Further we shall insist again on the necessity to dispose of a reliable tool for simulating the complex scouring process occurring in a huge river with very fine sediment and suspension load transport mode. The "feed-back" between the prototype surveys in the vicinity of the test structures and the scale model stimulation is therefore very important and its results are basic for improvement of both physical model technics and general knowledge of the scour process.***

Answer:
In this type of physical model a traditional calibration is not possible due to dynamic behaviour of the channels of the Jamuna river and due to the absence of local scour holes near river training structures in the model area. Therefore the measured maximum local scour depths are compared with the scour depths which are predicted by some formulas, see attached note on the evaluation of the scour depths (APPENDIX 1). The reasonable confirmation of the measured scour depths by information from literature is considered as a calibration of the model. In the evaluation of the measured local scour depths in FAP 1 and in FAP 21/22, see APPENDIX 2, it is concluded that no serious inconsistency in the results of both projects exists. These confirmations are a strong indication that the physical model tests are a reliable tool for the design of river training structures and for the analysis of complex scouring processes.

The prototype surveys in the vicinity of the test structures will increase the understanding of the morphologic processes in the Jamuna river, and may be the analysis of these surveys can contribute to an improvement of the physical model technics.

## 3. *PRESENT SITUATION - OTHER EXPERIENCES (Chapter 3.3)*

***It would be useful to redact a comprehensive report on the study tour made in China and USA by the Consultant; the topics would not only be about technics and material used for bank protection but also, if available, on the long term morphological evolution observed in the rivers (mainly in China) induced by local structures and embankments in view to serve as a reference for FAP 22 and also for the fore seen morphological study, component of an interregional study.***

Answer:
The Consultant has made a report on the braided rivers study tour giving the details of the activities and presenting the main findings. In depth comments on the morphological aspects are additionally given in ANNEX 1 "River Training and Morphological Response" and ANNEX 2 "River Morphology".

## 4. *DESIGN METHODS (Chapter 6)*

***In the list of loads which may lead to damage or failure, the human factors are quoted and among them: the faulty design;***

***In the list of faulty designs we suggest to add the possible wrong basic informations supplied from both models tests and/or formula such as "Pilarczyk's" used by the Consultant for designing the characteristics of the revetment under current and/or wave attacks.***

***The Consultant intends to analyse systematically the eventual failure mechanism***

*on the basis of a "fault tree", and to calculate the probability of its occurrence in review to optimize the future standard design; due to the complexity of the phenomena, the difficulty to observe them, in detail, during the flood period onside, the insufficient statistical data of all the relevant variables and like the interdependence of these variables we, therefore, doubt such a probabilistic approach may be realistic and reliable.*

Answer:
The possibility that wrong basic informations are supplied from the physical model tests is very unlikely since the evaluation of the scour depths resulted in a tentative calibration of the physical model. The validation of Pilarczyk's formula has been done quite extensively, therefore the formula itself will not supply wrong basic information. The Consultant agrees that in general a small risk exists that a faulty design is based on the application of a formula outside the range of its validity.

At this moment insufficient statistical data of all relevant variables are available for a complete probabilistic approach for the design of bank protection structures along the Jamuna river. The Consultant plans to investigate if and to which extent probabilistic design methods may be applied for the design of river training structures.

However, some examples of the application of a probabilistic design method are presented in the Meghna River Bank Protection Short Term Study (FAP 9B) and the Jamuna Bridge design. Probabilistic design methods could be used for a sensitivity analysis of the different parameters, and this could result in recommendations for the required accuracy of the measurements during the monitoring phase of the project. Improved measurements will increase the availability of sufficient statistical data of all relevant variables in future.

## 5. *DESIGN OF BANK PROTECTION WORKS (Chapter 7)*

***About the design flow velocity for the series of groynes near Kamarjani: The Table 7.2.5 gives the flow velocities calculated with the mathematical model as a function of the return period:***

***2.6 m/s is the maximum velocity calculated for 100 years return period when the current velocities measured in July 1992 are always overpassing 3 m/s, 3.2 m/s on 21.07.1992 (Chapter 8.5). Is there some explanation for such a discrepancy?***

Answer:
The flow velocities in nature were measured in three locations at 1.5 m below the water surface at 21st July 1992: 3.2, 3.1 and 2.9 m/s. The calculated flow velocities are depth averaged flow velocities. The difference between the surface flow velocity and the depth averaged flow velocity is estimated at 0.5 to 0.7 m/s. This value depends on the assumed hydraulic roughness of the river bed: C = 60 to 70 $m^{0.5}/s$, $k_s$ = 0.02 to 0.05 m.

The fixed point flow measurements were located at a distance of 220 to 250 m from the bank line. In the design of the permeable groynes the head of these groynes protrudes only 60 m into the channel. The head is much closer to the bank then the location of the flow measurements. This difference in horizontal location accounts for about 0.5 m/s difference in flow velocity.

The combination of both effects results that a given 3 to 3.2 m/s corresponds with a 2 to 2.2 m/s depth averaged flow velocity near the head of the groyne with a low return period for example 2 years 2.1 m/s in that table. These effects explain the apparent discrepancy mentioned in the question.

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6. *TECHNICAL INVESTIGATIONS (Chapter 8), Page 8-1*

*About the mathematical modelling:*
*The 2D model computes the flow field which is used to determine:*
*The discharge distribution at the inflow of the physical model,*
*The lateral boundary limit as a flow line;*

*The 2D model takes into account an eventual bank line modification and different return periods 2,10,50,100 years but it is supposed that the channel topography is unchanged, so it would not be useless to test the influence of a possible topographic channel change combined with a bank line modification.*

*About the two physical models performed in Faridpur for studying groynes on the Kamarjani site and bank revetment on the Bahadurabad site;*

*We note:*
*The size of sand in the models is the same than in the prototype;*
*Each test is divided in two parts:*
- *High discharge for the simulation of scour pattern;*
- *Discharge according to Froude condition to measure the flow velocities;*

*Although the Consultant asserts the similar grain size and the relatively high discharge have likely a negligible influence on the model results we think this assertion has to be very carefully checked; so, we agree with the usefulness of additional tests the Consultant intends to perform before the implementation of the works (October 1993) but also and especially after the monitoring phase (See the hereafter Chapter 9).*

Answer:
The 2 dimensional mathematical model takes into account an eventual bank line modification and different return periods for the discharge and the water levels. This interesting comment points to the relationship between an extreme flood (high water levels and high discharges) and bankline modifications. From satellite images it can be seen that after the extreme flood of 1988 the channel pattern in the Jamuna river was influenced. However it was not clear from those satellite images that the radius of the curvature of the bank in outflanking bends over a length of 2 to 5 km had changed. Bank line modifications are developed in a period of several floods. The model tests represent a relatively short length of the bankline of 2 to 5 km. This was the reason that the Consultant assumed that such a relationship does not affect the curvature of the bankline in the physical model tests.

The assertion that the similar grain size and the relatively high model discharge have likely a negligible influence on the model results has been checked carefully in APPENDIX 1 and 2.

7. *PROGRAM OF ACTION (Chapter 11), Part D*

*Additional studies and investigations are scheduled by the Consultant in such a way that results may be available in time for incorporating in the designs works before implementation;*

*Very important topics are:*
- *Development of improved methodology for prediction of planform changes,*
- *Topographic and hydrographic surveys,*
- *Additional model tests investigations for the falling apron designs which would be undertaken in a Consultant's European Laboratory.*

*We think it is a good opportunity to define which is lacking in the Faridpur laboratory equipment to improve its facilities.*

Answer:
A lack on modern equipment is only one of the bottle-necks for a successful development of the River Research Institute and may be not the most severe one. Therefore the preparation of an inventory for new equipment has a low priority at this moment. The Consultant plans in cooperation with FAP 1 to prepare a programme for physical model tests additional to the executed physical model investigations by FAP 21/22 and FAP 1.

*8. MONITORING (Chapter 13), Page 13-1*

*The monitoring is obviously a very basic phase for checking the designs or for the adaptation of works which have to be seen "in a different context than simple repairs works".*

*The Consultant writes in the report that "If required, also further physical model tests may be executed ....":*

*We think that in any case additional model tests have to be performed with the exact prototype conditions as flow pastern, water levels ... as surveyed during the monitoring campaigns in view to compare, for example, the local scour evolution both on model and prototype and therefore to be able to improve the physical simulation technics.*

*Collaboration with FAP 24 is especially important for prototype surveys and mainly for scour surveys. As concerns scour surveys it is not useless to underline the difficulties to perform them during the flood period around the heads of groynes and even to interpret the results keeping in mind the important suspension load and high concentration of the sediments close to the bottom, especially at the toe of the structures.*

Answer:
In Phase II of the FAP 21 component additional physical model investigations will be carried out for fine tuning the layouts of the test sites. The results will be used in the detailed design. The Consultant is further considering to perform model tests after the construction, during the monitoring and adaptation period, to simulate certain events that have occurred on the prototype test structures.

A close cooperation with FAP 24 is arranged on several working levels, including the project management.

# COMMENTS ON
# DRAFT FINAL REPORT OF FAP 21
# BY FPCO

## GENERAL COMMENTS BY FPCO

*The comments relate to the Main Report on Bank Protection FAP 21, which has been issued in January 1993. Earlier the consultants submitted their Preliminary FAP 21 Investment Report and Draft Final Report Planning Study, on which the PoE made their comments meanwhile.*

*The present report gives a good account of the progress of the study and of the results obtained. It also presents detailed proposals for the further programme of the study.*

*The latter has been overtaken by events in the mean time: a recent KfW and CFD mission appraised the progress of the study and concluded that the risks associated with a start of construction in the 1993/94 season would be too large and that construction would have to be postponed by one year. This opinion has been conferred to FPCO in the mean time and in a joint meeting, at which also the PoE was represented, this conclusion of the mission has been accepted.*

*The incurred delay will have a number of implications for the project and for some associated issues, some of which have been recorded in the Minutes of Meeting, signed by FPCO and the mission, dated 7 February 1993.*

*Important morphological changes could take place at both selected construction sites, possibly even to the extent that one or both of them would no longer be considered suitable. This underlines the earlier expressed necessity to keep some additional sites under surveyance, as possible fall-back options. The consultants are to be instructed to report whether they consider it advisable that the number of such sites is to be increased, taking also into account the important morphological changes that apparently are already taking place, e.g. at Bahadurabad and Sirajganj.*

*The morphological developments may also make it advisable to change the sequence of the construction operations: whereas it is presently planned to start with the Kamarjani site and to take up Bahadurabad the year thereafter, it may appear better to start with the latter. This option should be kept open.*

*The Minutes of Meeting referred to above record that at Kamarjani permeable groynes are proposed to be built, apparently excluding the option of impermeable groynes, which up to then were included in the programme. While the model tests support this choice, it would be premature to abandon the option of impermeable groynes altogether at this stage. The possibility to include them in a later stage of the project is kept open in the Minutes and this should be made clear to the consultants also.*

*Another issue that deserves closer attention is the matter of risks, associated with the implementation of the project. There are different categories of risks:*

- *The construction of the works, and probably notably the groynes, may cause concentrated currents downstream and as a result erosion. This possibility is also apparent from the drawings that depict currents during the model tests. While there is no doubt that without the project, erosion would be even more destructive, those who lose their land and property may neverless blame the project and demand compensation. The consultants could be asked to give a prediction about the possible extent of the downstream erosion.*

- *Usually such "consequential damage" is considered a risk to be borne by the Client. It is advised that FPCO studies this subject; it may consider*

*to acquire some extra land downstream, in accordance with the prediction of the consultant.*

- *The test structures are designed to be "risky" structures, that is a possibility of failure is built in, to maximize the "learning" aspect of the project. This may entail risks to third parties, e.g. including possible damage to vessels caused by obstacles under water. Such risks ought to be borne by the consultants; they may, of course, pass (part of) these risks to sub-contractors.*

Answer:
The concerns expressed in this comment are shared by the Consultant, as can be seen in the Draft Final Report. As to the number of tentative fall-back options, the consultant should like to make the following remarks:
(1) Spare sites have been investigated at Sariakandi and Kazipur, the details of the investigations, including the preliminary design, being presented in ANNEX 23. Previously, site investigations (topographic and hydrographic) had been carried out at Chandanbaisa and Nakalia.
(2) Since additional site investigations require additional time and funds, the decision whether or not to increase the number of spare sites, is to be made by FPCO.

Finally, as to the sequence of the implementation of the test structure, i.e. to begin either at Kamarjani or at Bahadurabad, there is a certain preference for Kamarjani as the first site, but that may be changed by FPCO, if necessary.

Referring to the type o groynes to be constructed, notably permeable or impermeable ones, the Consultant took note of the Minutes of Meeting of FPCO and KfW and is prepared to add an impermeable groyne, funds and time permitting.

One of the aspects of the influence of a series of short groynes on the flow field and the morphologic developments is the influence on the bank erosion downstream of the series of groynes.

This erosion downstream of the series of groynes depends to a large extent on the morphologic development of the outflanking channel by the river itself. A series of 100 % permeable groynes stimulates the sedimentation downstream of the groynes and does not increase the bank erosion in that area. A series of impermeable groynes can induce some additional bank erosion downstream of the series of groynes, especially if the centre line of these groynes point in downstream direction. And the influence of a series of hybrid (that is half permeable and half impermeable) groynes is between these extreme cases. The length of the bank line and the rate of the induced bank erosion cannot be predicted on the basis of the performed investigations, therefore additional investigations are required if this aspect is important. The Consultant will discuss this aspect in more detail with FPCO when preparing the test programme at the beginning of Phase II.

The Consultant agrees with the proposal to acquire some land downstream of the test site, both for the reason given in the comment and for providing some flexibility for modified design and adaptation.

Although the Consultant is designing and constructing "risky" test structures this is being done on behalf of GOB, FPCO who are the client. It is common and legal practice that all risks attributable to the type, the character and the function of a construction are borne by the client.

# CATEGORY 1 COMMENTS BY FPCO

1. *Main Report (MR), Page 8-5, Section 8.1.2.3 and 8.2*

***This may have to be reviewed now that construction has been postponed by one year. Although the selection criteria may still hold, the outcome may be different in the course of time.***

Answer:

The assessment of preselected areas (Section 8.1.2.3) and the selection of test sites within the selected areas (Section 8.2) are planned to be reviewed each year after the flood to anticipate new morphologic developments and to include the most recent results and knowledge in the selection criteria.

2. *Main Report, Page 8-17, Section 8.2, Fig. 8.2-1 and Fig. 8.6-1*

***While the figure shows the predicted erosion near the Manos regulator, the actual site selected by the consultants is more upstream. So, even if the regulator may not be a permanent structure in FAP 21, if it would still be there at the time when the tests are being done, the criterion "something-to-defend" could be a reason to move the test site to the south. As proposed now by the consultants, no value can be given to this criterion in Table 8.1-2 and consequently the site would not qualify for selection at all. It seems that also the model tests have been done at a different site than eventually selected.***

Answer:
While executing the studies for the preliminary design including the preselection of the site at Kamarjani, the Consultant tried to take account of the morphological changes that took place in the flood season 1992. Hence, there are some discrepancies between the exact locations. This is not serious since the final location will anyhow only be determined after the 1993 flood.

3. *Main Report, Page 8-51, Section 8.7*

***The model tests indicate a very severe erosion for the impermeable groynes. These results should be compared with those of similar tests performed under FAP 1. Whereas the tests performed under FAP 1 relate to a 1:100 years flood, against a 1:2 years for FAP 21, the erosion depths for the latter generally seem nevertheless to be appreciably less. As the decision to restrict the tests to permeable groynes only, is built on the observed scouring depths in the models tests, the consultants are requested to investigate this point thoroughly, in consultation with FAP 1.***

Answer:

The evaluation of the measured scour depths in the physical model investigation has been reported in a separate note, which has been prepared by FAP 1 and FAP 21/22 together, see APPENDIX 2.

4. *Main Report, Page 9-3, Section 9.2*

***Although the consultancy contract apparently does not require FPCO to give prior agreement with respect to contractual aspects of the construction of the works, the consultants should nevertheless be requested to submit the***

*arrangements with sub-contractors and in particular with local ones, to FPCO, giving it the opportunity to give its comments.*

Answer:
According to the Consulting Agreement, the Consultant has full and unreservable responsibility for all the services which he is committed to render under this agreement. This responsibility includes the subcontracted construction services.

It is understood that the arrangements with local subcontractors and suppliers will be done according to the rules as laid down in the Consulting Agreement and the Letter to Proceed. Further, all steps and decisions will be duly documented for future auditing by FPCO and/or KfW.

5. *Main Report, Page 12-4, Section 12.5.1, Para 6*

***The number of groynes to be built should be discussed in due course with FPCO, particularly with respect to the retained option of impermeable groyne(s).***

Answer:
The Consultant agrees with that suggestion.

6. *Volume VI, Page A14-7, Para 1*

***Does this statement also hold in case the model is partly provided with a fixed bed, and partly with a movable one? One would expect that a possible "under-nourishment" of the flow could cause extra erosion in the movable part, which would lead to an over-estimation of the erosion. This could impact more heavily on the impermeable groynes, where the opportunity of the flow to satisfy any possible under-nourishment is more restricted than in the case of the permeable groyne, where a larger part of the movable bed is touched by the current. Could this contribute to the answer to pt. 3 above?***

Answer:
The statement that no further increase in scour depths is expected once the conditions of general sediment motion have been established holds also for a model with a fixed inflow section and a movable mid-section, because of the following:

- During the test a possible under-nourishment was checked. This under-nourishment causes bed erosion just downstream the transition from the fixed bed part to the movable bed part.
- The sediment transport intensity in the model was rather low, much lower than required for a full movable bed model of the Jamuna river.
- This bed erosion had no influence on the scour depths because the distance between this transition and the first upstream groyne was sufficient.

It is true that in the tests with the impermeable groynes this distance was close to the minimum value. The maximum scour depths, which were measured in the model tests, are most probably not affected by a possible under-nourishment. See also the comparison of the measured scour depths with the Amad formula in APPENDIX 1.

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## CATEGORY 2 COMMENTS BY FPCO

*1. Page S-1, 2nd Para, last 3 lines*

*"The observations were ..... will become available".*

***Are the observations based only on satellite images? Unless the observations are related to river morphology, the prediction can not be expected to agree with real situation.***

Answer:
This comment is not quite understood since, according to the Consultant's understanding, the satellite images are representing the "real situation" because they are geocorrected and hence equivalent to topographical maps. As to the predictions, one can of course not be sure that the actual situation will develop as per the forecast because too many variables are involved in the processes. The Consultant hopes that the repeated forecast, check of forecast, investigation of deviations, new forecast etc. will lead to a substantial improvement of the understanding of the physical processes involved and of the methods of prediction.

*2. Page S-2, Para 1, last two lines*

*"The design velocities .....at Kamarjani".*

***How the design velocities were determined? It is generally expected that higher velocity will be associated with groynes. Discuss the justification of design velocities.***

Answer:
The design flow velocities were determined in an analysis of the available prototype measurements, of the 2-dimensional mathematical model simulations and of the physical model tests. The design flow velocities for the groynes near Kamarjani are site specific, that means based on the characteristics of the channel near Kamarjani. The same holds for the design flow velocities near the other test site near Bahadurabad. Therefore no direct comparison of the design flow velocities near groynes and near revetments is possible. More information on this analysis is given in Subsection 7.2.3.

In general it is right that higher design flow velocities are expected near impermeable groynes than near a revetment, but in this summary the designed permeable groynes are meant, and the lower design flow velocity near a permeable groyne confirms the general experience with these groynes.

*3. Page S-3, 3rd Para, 1st 3 lines*

*"Based on detailed ..... will be tested".*

***From stability analysis the scope of revetment works below and above water level have been recommended. It is not clear whether the water level refers to low water level or high water level. Have you done the stability analysis of vertical wall of wire mesh gabions? Before we go for test, stability, advantages & disadvantages must be discussed to justify the test.***

Answer:
The recommended revetment slopes of 1:3 below and 1:2 above the ground water level are based on extensive stability analyses taking into account low and high

river water levels as well. The results of such stability investigations can be shown at the end of the Final Design Phase.

The stability of vertical walls of wire mesh gabions has not been analyzed in detail and is only based on rough calculations. Detailed investigations to optimize the dimensions of the vertical walls are planned during the Final Design Phase.

*4. Main Report, Page 2-8*

***Noting the expressed doubts about the accuracy of available data on sediment transport, the consultants should give an impression about the sensitivity of the conclusions and recommendations of the study with respect to these data. Presumable also the model tests take into account the available data.***

Answer:
It is felt that the accuracy of the sediment transport data has only a minor effect, because of the way these data were handled. The investigations in the local scour model were not based on the sediment transport relations, but the scaling in combination with the bed material selection was such that initiation of motion of the bed material was just achieved (as is normally done for these type of models).

*5. Volume IA, Page 6-5, Para 3*

***It has been mentioned that values for loading variables are usually selected with an extremely low exceedance probability whereas for the strength properties average values are assumed. But in both cases, a probability of 5% has been considered. Is it not contradictory?***

Answer:
In this study the preliminary design of river training structures is based on a deterministic and/or quasi-probabilisitc design method. The description of the probabilistic design method in section 6.3 is an outline, which the Consultant considers to apply in the final design of these structures. This means that the mentioned probabilities of 5 % are a very preliminar figure which has to be detailed during the Final Design Phase.

*6. Volume IA, Page 7-1, Last Para*

***For a permanent river training structure, a return period of 100 years has been recommended. The selection of return period should not be arbitrary. There should be a basis behind the selection. It can be based upon risk analysis.***

Answer:
The recommendation of a return period of 100 years refers only to the design of permanent river training/bank protection structures. This is not applicable to the design of test structures. According to the design philosophy of the Project test structure are to be designed with such a level of safety that certain damage of the structures shall be allowed to identify the limits and to design new standards. Since, however, on the other hand the test structures should also "protect something", the selected return period of 25 years was regarded to be appropriate. In this regard see also answer to comment No. 10 on page 13.

7. *Volume IA, Page 7-2, Line-7*

***It has been assumed that observed water level was not influenced by wind set-up and transverse gradients in a cross-section. Has the validity of this assumption been checked?***

Answer:
The validity of this assumption has not been checked because no sufficient prototype data is available for the analysis of wind set-up and transverse gradients in the Jamuna river. However it can be mentioned that the computed water levels with the 2-dimensional mathematical model (see ANNEX 6, Part B) show that a transverse gradient can result in water level differences of about 0.1 m in a cross-section. In extreme cases a difference of 0.2 m seems possible.

8. *Volume IA, Page 7-5, Table 7.2-4*

***The table shows average flow velocity corresponding to 100-year discharge which is several times larger than the bank full or dominant discharge. Is the regime equation (7.2-1) applicable in such condition?***

Answer:
The regime equations are determined for discharges smaller than the bankfull discharge of a channel. The extrapolation of the regime equation and including about 20 % of the flood plain cross-sectional area in the considered cross-section are suggested from the simulations with the 1-dimensional mathematical model. Because this extrapolation has not been verified formally with prototype data, the calculated average flow velocities in Table 7.2-4 should be considered as good estimations, which are supported by the average flow velocities given by FAP 1.

9. *Volume IA, Page 8-25, Para 1*

***The vertical acceleration, the vertical component of flow velocity and sudden variations in the bottom topography have a dominant effect upon the flow field near the groynes. The two dimensional model cannot simulate these processes. What is the reliability (or representativeness) of the results of the mathematical model study given in sec. 8.6.2?***

Answer:
The flow field close to the groynes is influenced by the vertical acceleration of the flow over a distance of about a 10 times the water depth. In the Jamuna river the water depth varies roughly between 10 and 20 m. In this area the results of the mathematical model are not reliable. In that area the flow velocities measured in the physical model are used for analysis instead of those of the mathematical model. It should be realised that this area of 300 by 400 m is only a small portion of the modelled area of 5 by 3 km. In Subsection 8.6.2 some results of the mathematical model are presented in figures 8.6-2 and 8.6-3. The results in the first two grid cells adjacent to the schematized groynes are not accurate, because of the mentioned influence of the vertical acceleration.

10. *Annex 5, Page A5-12, Para 2*

***It is expected that the return period of the maximum discharge and that of the maximum water level would not be same. The discharge has a strong correlation with the depth of flow while the water level is not strongly correlated with the depth of flow.***

Answer:
The strong correlation of the discharge with the water depth means that the average bed level is changing permanently. The absence of strong correlation of the water level with the water depth indicates that for a certain situation the return period of maximum discharge is not the same as that of the maximum water level. For the design of the bank protections the Consultant selected the design water level with a return period of 25 years and the design discharge with a return period of 25 years. It should be realized that probably these design parameters will not be observed simultaneously in an extreme situation.

*11. Annex 6, Page A6-15, Para 2*

***Since the roughness co-efficient and the surface water level gradient are constant along the width, the distribution of discharge in a cross-section becomes function of the water depth when the Manning equation (or Chézy equation) is used. Some assessment of the representativeness of this simplification with the real situation is necessary. This is because the computed discharge distributions given in Tables 6-3, 6-4, 7-3 and 7-4 are highly dependent on the specified discharge distribution along the boundary of the mathematical model.***

Answer:
Along the upper boundary of the model the water level gradient in the flow direction is constant, but the roughness coefficient can be calculated as a function of the local water depth. The representativeness of this simplification is checked from the computed flow field. If this simplification creates strong curvatures in the flow lines near the upper boundary, then this simplication affects the representativeness of the computed flow field. These type of curvatures cannot be observed in the computed flow fields and therefore this simplification had a neglectable influence on the representativeness of the computed flow field. Indeed the computed discharge distribution depends slightly (not highly) on the computed discharge distribution at the upstream boundary of the mathematical model.

*12. Annex 7, General/C-1*

***The GPA issued by FPCO has not apparently been taken into consideration in the preparation process of this report. Any reason, thereof.***

Answer:
The GPA has been used as a guideline in the socio-economic investigations whenever applicable for the special type of project. It should, however, be borne in mind that the GPA has been elaborated for FCD-I projects and regional development projects, whereas the FAP 21 component is dealing with very small scale and local test works of individual constructions which the local population is immediately benefitting from. Hence also the socio-economic investigations are to be on the local level.

*13. Volume VI, Page A11-53, Subsection (ii)*

***The impact of geological activity may be under-estimated, in that it may be one of the main agents in sediment supply to the upper stretches of the Brahmaputra.***

Answer:
It is acknowledged that earthquakes and landslides may cause a non-steady input of sediment into the main stem and the tributaries of the Brahmaputra

river. The unsteady inputs however are dampened while they travel through the river system. In the Consultant's opinion their influence in Bangladesh is fairly small. It is felt however that tectonic effects (mainly faults) may be an important agent for planform development in the Jamuna river. Hopefully this will be studied by FAP 24.

*14. Volume VI, Page A11-53, Subsection (iv)*

***The importance of human interference can be inferred also from Fig. 3.5-1, which suggests that thanks to this, there has been a water bearing channel in front of Sirajganj for at least the last 15 years.***

Answer:
The Consultant agrees with this statement which confirms the thesis that human interference generally improves the predictability, or reduces the unpredictability.

*15. Volume VI, Page A11-56, Section 4.3*

***In analyzing the morphology of the test areas, the superimposed persistent westward trend may have to be included in the analysis.***

Answer:
The supposed westward movement in the upper reaches of the Jamuna river was taken into account and it favours locations along the right bank of the river. This is one of the reasons why possible test structures south of Bahadurabad may not be attractive, particularly if Scenario 3 for River Training/AFPM shall remain a possible alternative.

# COMMENTS ON DRAFT FINAL REPORT OF FAP 22 BY FPCO

# GENERAL COMMENTS BY FPCO

1. *The volumes IB, II, III and IV contain a large amount of ideas and considerations and it is not the aim in this short review to analyze them in all details.*

   *A preliminary, general comment, which was already present in the Annex IV to the report on the first mission of the FAP 24 Project Advisor concerns the approach used by FAP 21/22. Although the Annex 2 "River Morphology" may be considered as an excellent first draft with many useful quotations of past Bangladesh river studies and references made to some currently accepted theories, it sometimes lacks criticism about the theories and outcome of past calculation and measurements. It is obviously one of the goals of FAP 24 River Survey Project to gather the information necessary for understanding the processes and so allow the validation of theories.*

   *Three examples may be presented here to support this statement both related to the FAP 24 River Survey Project.*

   - *The validity of the "roughness" concept e.g. derived from the Chezy formulation is not proven for this kind of extremely large alluvial with small slopes, where the water surface slopes probably do not correspond to the concept of "uniform flow".*

   - *The importance of the two-dimensional approach of the bed load (and of its variation with stage) in the interpretation and prediction of morphologic changes is not recognized. The measurement of the distribution of velocity, discharge and sediment transport must be part of the studies on which test will be based.*

   *The whole approach is based on a too narrow "one-dimensional picture" (instead of a two-or three-dimensional) of the sediment transport problem and a two-dimensional concept (instead of a three-dimensional) in the morphological studies.*

   *These studies do not account for the processes really at the basis of bar and char formation (also lacking in FAP 3) and of bed and bank scour. It is obvious that only little experience exist in this field, but the question is if the present theories can help or if it is not advisable to reconsider the accepted concepts.*

2. *The reports will be discussed separately hereafter. Both give a very good account of progress made so far and contain clear proposals for the continuation of the project in the coming year.*

   *For both project components, bank protection and Rriver Ttraining/AFPM Pilot Project studies have been conducted and innovative proposals are put forward.*

   *The next stage for FAP 21 is the construction of some pilot works, comprising groynes and bank protection, resp. at Kamarjani and Bahadurabad. The nature of the works is as such acceptable, especially with regards to the emphasis on the application of indigenous materials and contractor-capacity. The replicability of the works and construction method is an important point and in this respect the test works have to prove the point.*

*The time schedule that the consultants present, is very tight, and possibly even optimistic to some extent. Quick decision making is necessary, but that should not go at the expense of thorough preparations, also on the side of the guest country. This applies, for instance, to the approval of the proposed works and of the intended procedures for implementation. Attention is to be given to the question of responsibility for the control of operation of the proposed structure does not allow for any interruption due to uncertainties in this respect.*

*Also FAP 22 has some innovative proposals; it seems that surface screens have excellent potentials for the management and eventual narrowing of the braided river bed of the Jamuna. It could eventually result in a considerable gain in new land within the wide bed of the Jamuna. However, there are places where the refreshing enthusiasm and optimism could be tempered by caution. For instance, it seems that the proposed application of surface screens mounted on barges, still has to prove its practicality. In the next stage efforts should concentrate on this points. In the mean time it is worthwhile not to lose sight of other options as well, such as 'intelligent' dredging.*

3. *The report has been prepared on a comprehensive proposal of diverting the flow of Jamuna river from the banks vulnerable to severe erosion and make it flow through some selected stable channels. The implementation of the ideas will definitely have effects on socio economic, ecologic and environmental fields of the country. These aspects have elaborately been described in the report. The morphological changes of the river vis-a-vis historical background and characteristic conditions test in mathematical models have been broadly presented in the report.*

*Two different methods have been mentioned in the report for stabilizing the Jamuna river. These are (a) the classical groyne/revetment construction termed as "hard measures" and (b) "soft recurrent measures" by floating screens and artificial channel cut offs. This technique for sediment laden flows through selected channels of braided river like Jamuna will create interest in the minds of concerned scientists and technocrats. The device has been termed as "vertical screen" and it has different areas of opening in different depths. This device should be well tested before placing in the gigantic river like Jamuna.*

*Of the two alternatives the "soft measures" by which the river can be narrowed and diverted through selected channels seems to be better. Again these stabilized narrowed channels must be able to carry the huge amount of sediment brought in from outside of the country. Scour and accretion is the natural behaviour of a sediment-laden channel in alluvial beds. When this behaviour is artificially changed or disturbed, unpredictable and detrimental phenomena may be resulted in the long run. This aspect needs to be studied in all possible ways for a considerable period before implementation. This invites tenacious research.*

4. *For training of Jamuna river the report has given priority to recurrent "Soft measures" such as surface screen. This concept seems to be new and yet to be seen successful in any big braided river of the World. Whereas the 'Anabranched flood channel using hard measure' have been successfully adapted in case of Yellow River and the Yangtze Kiang river of China. The Chinese consider Jamuna more complex than Yellow River or Yangtze Kiang river and rightly believe that a "hard point" concept should be applicable to the Jamuna. (Ref. Art.4.3.2, page 4-4 of the Main Report).*

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*By the use of surface screens it may be possible to silt up an outflanking channel. But due to the tendency of the river to attain dynamic equilibrium the newly developed channel will soon subject to serious bank erosion. A new outflanking channel may likely to develop again necessitating to be silted up. In this manner, through out the entire length of the river, surface screens have to be installed at numerous places same time requiring huge cost and manpower mobilisation. But in anabranched flood channel method hard points may be developed in 15 to 20 years time with lesser cost.*

Answer:
The indication that ANNEX 2 "River Morphology" sometimes lacks criticism is a result of the character of the activity which was more a compilation of an inventory of the state of the art than an in-depth theoretical analysis.

The mentioned three examples regarding the validity of the roughness concept, the two-dimensional character of the sediment transport (including bed load transport), and the valididty of the two-dimensional concept in the morphologic study are considered more in detail. It is obvious that formally in no reach in the Jamuna river uniform flow is present. Always backwater and drawdown effects will be noticeable, while the variation in discharge induces many time-dependent phenomena, like changes in roughness over time due to bedform adaptation and changes in cross-section due to differential sediment transport. Where assumptions as to uniform flow and other schematizations were made they were either justified by the pre-feasibility character of the present studies or a more detailed study is not possible at this moment.

In engineering it is common practice to schematize the very complicated (time dependent and 3-d) conditions in nature. In itself this can be dangerous, because it may lead to a too simplified appraoch, as suggested by the remarks. The Consultant feels however that the approach taken has not resulted in biased results. They would appreciate that the remarks were specified in more detail, concentrating on how and where the simplified approaches may have resulted in "mistakes".

The Consultant does not agree that "the importance of the two-dimensional approach ... is not recognized" (by him). See further the request before.

Again the Consultant does not agree that **in this stage** "the whole approach is based on a too narrow "one-dimensional" picture. He agrees that in later stages it may be necessary to consider the more complicated picture, as is shown in their suggestions for the next phases of the project. It has to be realized that the study was not meant to present an accurate simulation of the actual phenomena but was executed to assess the relative impact of different river training measures in order to decide on the feasibility of more detailed investigations.

As to the 5th para of point 2, it is clear that surface screens mounted on barges still have to prove their practicality. That is exactly the reason why the Consultant proposed further model tests and investigations before starting proptotype tests in the river itself. Other options making use of dredging (e.g. channel cutoffs) are already proposed in the report.

As to the last para of point 3, it is understood that more research is required before the "soft measures" are going to be implemented. However, considerable research has already been undertaken (e.g. Jamuna Bridge Study, FAP 1 and FAP 21/22) and is still going on (FAP 24). With its obtained knowledge and expertice FAP 22 could make a considerable contribution to the already ongoing research, which will improve the understanding of the phenomena that might be a result of the measures.

As to the first para of point 4, the statement that the concept of "hard points" is applicable for the Jamuna should be doubted. During the study tour it became clear that in China there is a surplus of material required for "hard measures". The tendering of the river training works for the Jamuna Bridge made clear that hard measures are extremely expensive for the Bangladesh situation.

As to the first para of point 4, the validity of the statement "in anabranched flood channel method hard points may be developed in 15 to 20 years time with lesser cost" is doubtful. First of all the works will take much more time than 20 years and the lesser cost might not be valid as already indicated in the previous paragrah. At this moment it is not necessary to make a decission whether "hard" or "soft" measures should be applied. Such a decission should be the result of a thorough feasibility study and depends also on the future economic development in Bangladesh. This question will be discussed in detail in the Experts Discussion on River Training/AFPM planned for end October, 1993.

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# CATEGORY 1 COMMENTS BY FPCO

1. *Volume IB, Page 3-8, Section 3.4.4*

***Fisheries should be given more prominence.***

Answer:
Although FAP 22 is not an FCD-I project let alone a rural development project, the Consultant has put much effort in assessing fishery aspects. Even own site investigations were carried out although no such studies were asked for in the ToR. The Consultant firmly believes that basic investigations on fishery should be the subject of specialized fishery projects or at least fishery related programme(s) of FAP 16.

2. *Taming the river: Review of Measures (Volume IB, Part B, Section 4.4, Page 4-5)*

***Some of the structural solutions proposed in "the most promising recurrent measures" in table 4.4-1 (page 4-6) are not sufficiently justified and some probably very risky. The presentations and discussions (this remark is valid in general, for all reports) is too theoretical, like in state of the art books. It is not always clear how some structures would be applied, especially their position relatively to the channel, bank or char geometry, and if it is indicated, too simplistic, not taking into account the way sediment transport acts effectively in the morphologic changes.***

***It should have been useful to present at least a sketch on an existing river stretch, with plan view and cross-sections.***

***The conditions of success for short-cut of outflanking bends are not sufficient in terms of morphology and are more than the dimensioning of a pilot channel to be dredged, as described in Annex 1, page 75 to 78, applicable in rivers not of the type of the Jamuna.***

***The use of floating vanes, although the idea is interesting, will have serious limitations due to the large drag, the system being difficult to anchor, and the probably uncontrollable erosion/scouring processes if not assessing properly the morphologic process (e.g. risk of outflanking, not accounted for in the modelling). The prediction of the behaviour of the screens and of their effect with scale model is at least doubtful.***

Answer:
A detailed justification of the preliminary selection of recurent measures in Table 4.4-1 can be found in ANNEX 1, Part A "State-of-the-Art" in river training and in Part B "Preliminary selection of recurrent measures". From the comment it is not clear why in general some of these measures are probably very risky.

The theoretical character is an automatic consequence of the fact that the project was formulated in such a way that the study had to be executed as a desk study based on ready available means and knowledge. In a prefeasibility study of river training measures a simplistic and theoretical approach has been selected, because it is expected that the main principles and the main effects can be studied with such an approach for a first order relative impact assessment. And such main principles and effects are important criteria for a first estimation of the possible effectivity of such measures. No sufficient detailed reports of the practical experiences in rivers comparable with the Jamuna river are available for a selection of a river training measure. It is agreed that for a complete feasibility study also the practical aspects should be studied in detail in a follow-up study.

Because of the theoretic and simplistic approach, the sketch was considered to give sufficient information for the moment. In aspects of the implementation, 10 examples with plan views of bifurcations are presented in ANNEX III, Chapter 6, as possible locations for placement of surface screens. These plan views are based on satellite images. For these examples no measured cross-sections are available. The Consultant agrees that a more realistic configuration would have been useful, but indicates that the sketch was made considering real river dimensions.

The description of artificial cutoffs in ANNEX 1, page 75 to 78 is mainly based on a review of the available literature and this is not a sufficient description of this river training measure. Therefore additional studies were carried out. In ANNEX 11, "Remote Sensing Study of Morphological Processes" especially Subsection 3.3.2 "Abandonment of bifurcated channels", the characteristics of the natural cutoffs in the Jamuna river were studied. A theoretical approach for dimensioning the pilot channel is presented in ANNEX 4, Part C "Morphological response due to Cutoffs" based on theoretical computations.

During extreme conditions the large drag on surface screens mounted on barges is probably one of the limiting factors. In the preliminary ideas regarding the construction of the surface screens the screens are allowed to swing away automaticly if the dragforce reaches a maximum force, to guarantee sufficient safety of the anchored barges. As a consequence it has to be accepted that during extreme conditions the effectivity of the screens is reduced. This system of automatic swinging screens also limits the forces on the anchors. The character of the erosion and scouring processes in nature can be tested with a pilot project. For the special conditions on the Jamuna river a special suitable type of anchor should be selected in a follow-up study.

It is considered as a big advantage that the floating surface screens can be moved to a new location if unexpected and unwanted erosion or scouring processes start to develop. In this way the erosion and scouring processes are fully controllable and to a large extent reversible.

The basic understanding of the erosion or scouring processes can be studied best under controlled boundary conditions, which can be realized only in a physical model. This basic understanding forms a basis for the guidelines for the design and the operation of the surface screens. For a detailed prediction of the behaviour of the surface screens a pilot project in nature is proposed.

*3. Volume IB, Page 5-5-6, Section 5.1.3*

***Are the discussed alternatives equivalent in their sediment transporting capacity. It could be that the river 'needs' a certain sinuosity, or braiding to accommodate the amount of sediment supplied at the upstream end. See also pt. 14 hereafter. For such and other reasons the statement on page 5-11, that no decision with respect to any of the 3 scenario's has to be taken yet, is supported.***

Answer:
It is obvious that "for equilibrium conditions" the river has to transport the quantities of sediment that are supplied at the upstream boundary. This holds for all three alternatives. To do so the river has possibly to adjust its slope and other dependent parameters. The Consultant has attempted to make a first estimate of the way the river will react and some results are given in Chapter 7 of ANNEX 1. These are the basis for the impact assessment. In the Consultant's view this aspect is therefore not the main reason for not selecting one of the 3 scenarios at this moment.

4. *Volume IB, Page 5-11, Section 5.2.1, para 2*

***It could be that it is easier for the Jamuna to accommodate to dispose of 'too much' sediment, than to pick up more sediment, heavily loaded as it is already. In other works an equilibrium involving aggradation may earlier be reached than one involving degradation.***

Answer:
The Consultants does not concur with this statement. The time scale of aggradation processes may be smaller, the same and longer than that of degradational processes, depending on the boundary conditions imposed. Furthermore the Consultant does not agree with the statement that the Jamuna river is "heavily loaded". Many rivers in the world carry much larger loads and have concentrations of sediment 1 to 2 orders of magnitude larger than the Jamuna river (Milliman & Mead, 1983). Of course a river can carry only more bed material if the velocity increases, but due to the strongly non-linear relationship between sediment transport capacity and velocity only relatively minor increases of the velocity are needed to transport much more bed material load.

5. *Volume IB, Page 5-13, para 2, bullet 2*

***It should be explained why the assumption of the maximization of the number of channels is reasonable.***

Answer:
As discussed in Chapter 7 of ANNEX 1 of the FAP 22 report, some authors have proposed that a river, given a certain valley slope and other imposed parameters, tends to maximise its number of channels. There is however no proof that a river actually does show this behaviour. At present the Consultant assumes that this statement is not generally true. It could well be that the number of channels is determined also (and may be even only!) by the ease with which cutoffs take place. In the Jamuna river cutoffs take place at very low cutoff values (generally below 1.6) while for many meandering rivers a much larger value is required. This can be explained by the character of the topsoil through which the cutoff has to be "cut". In the Jamuna river the topsoil consists of sand with some clay and the occurring of a cutoff depend mostly on the difference between the incoming sediment and the transporting capacity (Klaassen & van Zanten, 1989). In meandering rivers the topsoil is very often very cohesive and may have dense vegetation, making the occurence of a cutoff much more difficult. For the time being it is assumed by the Consultant that the maximization of the number of channels is a good working hypothesis for the Jamuna river, but this should be studied. The Consultant has proposed to FAP 24 to include this topic in their study topics.

6. *Volume IB, Page 5-14, Fig. 5.2-1 and Volume II, Page A-1-126 ff*

***The figure raises a number of questions: How can it physically be explained that an increasing number of channels is associated with a decreasing total channel width and a decreasing depth? Is there not a contradiction with Fig. 2.3-2. The latter gives for 3 channels a total width of channels and bars of 10 and Fig. 5.2-1(b) a width of the channels of about 17 km. For 3 channels Figure (d) gives a half meander length of about 13 km; how does that compare with half the wave length of 30 km, as established by FAP 1?***

Answer:
An increasing number of channels for given imposed Q, V (volume yearly to be transported), and valley slope results in more channels each with smaller dimensions (width and depth) and increased slope. Due to the increased slope

the sinuosity will be lower and hence the total width (sum of the channel widths plus the additional width due to the curves) may be less. This explains the tendency in the indicated figure.

The discrepencies observed in the other questions are acknowledged. In this respect it should be realized that the Consultant does not claim to have developed a theory that fits to all available data. The available time under the present project and also the stage the project is in, did not allow to make more detailed studies. Furthermore, it should be realized that some aspects that could be of importance (like the possibility of clayey banks with more resistance and the influence of tectonics) are not included and have also not been studied extensively up till now. It is hoped that FAP 24 will take up studies that may at least partly clarify the observed discrepancies.

7. *Volume IB, Page 5-18, para 2*

***The impact on the internal water management on the left bank should be assessed.***

Answer:
Further to the impact on both sides, the combined impact on the environment of the different projects should be assessed in the next phases.

8. *Volume IB, Page 5-20, Table 5.3-1*

***The table may not entirely be suitable for this type of projects; other categories would have to be added to do justice to scenario 3. Moreover, the applied ratings are rather subjective. Although it may be true that scenario 3 could induce erosion, and even disappearance of some of the inhabited chars, there will be gains in new land along the left bank. By a well designed system of colmatage the upper layers of the new land could be made to be reasonably fertile. Contrary to most of the chars, it probably would be possible to introduce irrigation on the new land. There will be other, very significant advantages for people living there, compared to their life on isolated char land; they have much better access to all kinds of services, health, water supply, education, industrial development, etc. There should be no doubt that in sum scenario 3 has many advantages above any of the others.***

Answer:
The Consultant tends to agree that not full justice has been done to Scenario 3. In later stages of the project, when benefits and disadvantages of the different scenarios can be assessed in more detail, this should be taken up again. It underlines that in this stage a decision as to which scenario is preferable cannot be taken. The procedures may be dealt with at the Experts Discussion on FAP 22, in October 1993.

9. *The Investigations, Simplified Calculation Method (Volume IB, Part C, Section 6.2.1 (i), Page 6-2*

***There is no evidence given about the validity of the calculation method for the efficiency of the proposed surface screens, and no results of present or past experiences in similar alluvial rivers are presented.***

***The schematization used for the calculation is possibly valid for a theoretical study, but irrelevant for designing the experiment.***

*The hypotheses made about*
- *calculation of channel width and depth determined with empirical regime equations and the conditions of equilibrium sediment transport, and*
- *the dynamic equilibrium of the river bed at the start of the experiment*

*are more than questionable.*

*The hypotheses on the uniform distribution (over the width of the cross-section of flow and sediment) as well as the choice of the equilibrium sediment concentration vertical in the approach flow is not proven and most unlikely.*

*The method does not account for possible bank erosion in channel 1, opposite to the screen.*

*The choice of the sediment transport equation (no thorough analysis of interaction between bedload and suspended load; use of Engelund-Hansen formula with multiplication coefficient equal to 4, Van Rijn distribution, etc.) is too much arbitrary; one aspect to be considered urgently (possibly in collaboration with FAP 24) is the assessment of the relative importance of bedload and suspended load in the experiments, and this for the different stages of the flow.*

Answer:
The simplified calculation method for estimating the effectivity of the proposed surface screens has not been validated because no sufficient data from nature or physical model investigations are available for such a validation.

The available results of present or past experiences with bandals in alluvial rivers are often a description of the increased sedimentation and increased erosion of the river bed downstream of several rows of bandals. This type of description is not sufficient to estimate the values of all the relevant parameters of the simplified calculation method for a calibration of this method.

This simplified calculation method is based on a schematization to a one-dimensional calculation of the complicated flow field near surface screens at a bifurcation. This type of schematization has been applied also for the schematization of the flow field and the sediment transport near intakes at river banks. The applied schematization is not only possibly valid for a theoretical study but is also valid for a pre-feasibility study to estimate roughly the possible effectivity of the proposed surface screens. For designing an experiment in a physical model or in the prototype the results of the simplified calculation method should be combined with data of field surveys of bifurcations, and with the practical aspects of the implementation of these screens.

It is true that in a real situation the observed channel width and depth, the observed sediment transport and the dynamic equilibrium will most likely deviate from the channel width and depth calculated with the regime equations, the equilibrium sediment transport and the assumed dynamic equilibrium. These deviating values can be substituted in the simplified calculation without any problem and in this way this simplified calculation method can be applied for a specific situation, e.g. the considered bifurcation. This means also that this simplified calculation method can be used for a detailed sensitivity analysis of all parameters. The general conclusions regarding the effectivity of the proposed surface screens are not expected to change if these deviating values were substituted in the simplified calculation method, because the calculated values are fair estimations of the average value of these parameters in the Jamuna river.

The assumption of a uniform distribution of flow velocities and sediment transport intensity over the width of a cross-section is very common in one-dimensional calculations, see for example the General Model made with MIKE 11, and this assumption has proved to be very useful in many situations if a proper

interpretation of the results is made. The non-uniform distribution of the flow velocities and the sediment transport are important for designing a pilot test in nature and may be also for designing a physical model test. If required the simplified calculation method can be extended later in a schematic way with this non-uniform distribution of the flow velocities and the sediment transport over the width of a channel.

The formula of the assumed equilibrium concentration vertical according to Van Rijn can be replaced by any other formula describing the concentration vertical in this simplified calculation method. The Consultant expects that the results of FAP 24, River Survey Project, will contribute to a more accurate description of the sediment concentration vertical as a function of the discharge in the channels of the Jamuna river. An accurate formula for the concentration vertical will be an improvement of the simplified calculation method. It is suggested to study this in a next phase of the Project.

What is mentioned for the sediment concentration vertical holds also for the sediment transport formula. These aspects are topics for a study of the basic morphologic characteristics of the Jamuna river and such a study will be covered probably by the tasks of the River Survey Project, FAP 24. The scope of work of FAP 21/22 does not include such a study and therefore some available and widely accepted formulas in previous studies of the Jamuna river have been applied.

Some preliminary calculations as a start of a sensitivity analysis indicated that changes in the sediment transport formula and in the sediment concentration vertical will not change the general conclusions regarding the effectivity of the proposed surface screens in a dramatic way.

The method has been developed starting with one row of surface screens which is connected with the bank. To prevent serious bank erosion in channel 1 it is considered to split the row in two separate rows with each one connected with a bank to prevent bank erosion. These two rows do not change the results and conclusions of the simplified calculation method.

Summarizing the Consultant agrees in general with most of the comments but would like to indicate that these comments do not change the Consultant's view that floating and fixed surface screens are a most promising measure for river training in the Jamuna.

*10. Volume IB, Page 6-18, Section 6.3.2, Fig. 6.3-1*

***The presented example of the cutoff channel may not be fully representative for the Jamuna. Quite frequently it occurs that two of the braiding channels, one of which is an outflanking eroding channel, come very close to each other at some point. With relatively little effort it seems to be possible that the flow of the eroding channel is diverted into the other one. This is probably easier than the case discussed here. Has the effect of the dredged spoil being pumped into the channel to be closed been taken into consideration.***

Answer:
The idea to create a short-cut between two parallel braiding channels, one of which is an 'outflanking' channel, is considered as a valuable comment and the Consultant plans the study the possibilities for these short-cuts in the next phase of the remote sensing study. These short-cuts are indeed different from the presented cutoff channel. In the natural development of the braiding channels of the Jamuna river these cutoff channels are observed also.

The Consultant has indeed concentrated on a cutoff of one channel, and he does agree that other types of cutoffs may also be possible and even be attractive. The difficulty with the example quoted is that it is not certain that the dredged pilot channel will actually develop into a full-fledge cutoff as no information is available on the relative water levels. In addition it is remarked that studies are needed into the water level differences in the river in transverse direction. Also this topic has been suggested to FAP 24 for futher study.

*11. Volume IB, Page 8-6, Section 8.4-1*

***The following activities could be incorporated in or added to the schedule of activities:***

- ***Review of reports, data, proposals etc. of relevant activities (FAP 1's master plan, FAP 3.1 charlands proposals, FAP 24 results etc.).***

- ***Programme of Public Participation - This is an essential component which should be initiated at the outset, and not left till the workshop. It should cover identification, planning and design, and include appropriate staged consultation within JAFP residents, NGO's local and central government concerned departments, universities etc.***

- ***Continued monitoring of satellite imagery and other data to keep up the work on planform prediction etc. This is seen as a continuous activity which should not be interrupted.***

Answer:

- All relevant reports that were available at the time of undertaking the study were evaluated and taken care of by the Consultant. FAP 1 Master Plan, FAP 24 results will be taken care of after being available during the next phase of the Project.
- The study on River Training/AFPM of the Jamuna river concentrated first on the basic technical viability and on general socio-economic, economic and environmental aspects. A reasonable public participation requires at least a possible basic concept, that is hoped to be the result of the Experts Discussion in October 1993.
- The Consultant fully agrees with the statement that it is important to continue with the planform prediction, both for short term use for the selection of the test sites and for the development of a methodology to be used later. Therefore, some funds are included in Phase II of the Project for regularly buying, processing and interpretation of satellite images to this effect. This will be done in close cooperation with FAP 19 and FAP 24.

*12. Volume IB, Page 8-8, Subsection (4)*

***Sociologist, add: - assist in public participation programme Subsection (5); Environmental Expert, add- identify and evaluate impacts of the pilot project.***

Answer:

As a matter of course the Consultant will include environmental and socio-economic aspects when possible pilot areas for River Training/AFPM will be identified.

*13. Volume IB, Page 8-10, Table 8.4-2 and Page 8-4-8*

*Reference inputs 4.1, 5.1, 4.2, 5.2, 6.2 and 7.2, there should be more emphasis on the development of JAFP, in relation to the potential changes under the various scenario's. The proposals of FAP 3.1 and others will be concerned more with flood proofing rather than development per se. Items to be covered in the extended planning study should include:*

- *agriculture*
- *fisheries*
- *navigation*
- *social aspects*
- *environment*
- *local institutions (incl. public health, education, public admin, etc.).*

*Although some of these aspects are covered by the present study, the extended study will update and refine the impact evaluations, assess the possibilities for comprehensive JAFP management and address the specific impacts in the prototype trial areas.*

Answer:
It is fully agreed that once the technical, economic and administrative viability be proven in the Experts Discussion of October, 1993 the above items will be included in all further investigations.

*14. Volume IB, Chapter 9*

*The suggestions developed here have not fully matured yet. First of all the contention that research and investigations should be separated from implementation is not convincing and is contradicted by Volume III, page A3-65 where a combined team of morphologists, river engineers, surveyors etc. is proposed. Certainly during the stage of testing and experimentation, research and investigations should not be separated from implementation, because of the close linkages and necessary feed back, and possibly not even thereafter. Secondly the suggestion for an IRMI is rather far-fetched: who would be the controlling agency; who would finance; what would be its responsibilities and authority. Thirdly the case of the Jamuna River Authority has not been argued at all. In general one should be careful with non-income-generating authorities; especially in developing countries, with a relatively weak administration, authorities may soon grow out of control and become a burden rather than an asset. The recommendation that before Phase II will start, institutional (re-) arrangements have to take place, is premature. Unless the institutional study is incorporated in the extended planning study, the former should not be implemented before January 1994, when also other activities in this field are expected to have developed some realistic concept. The consultants are advised to liaise closely with FAP 24 (and FAP 5B-MES once it starts), since they also have institutional development in their brief.*

Answer:
The Consultant fully agrees that the suggestions presented in Chapter 9 are all but fully matured. It was, on the contrary, the Consultant's intention to trigger the discussion on organizational and administrative aspects and to stress the importance of that issue for any River Training/AFPM on the Jamuna river.

In fact, due to the requirements of a very long term commitment for planning and funding such a century-project and, at the same time of extremely short-term decisions for where to invest the yearly invstments, the Consultant firmly believes that some basic administrative-organizational decisions by GOB would be necessary prior to continue into the next phase of investigation. It is expected that important aspects on that topic will be presented by the Experts Opinion end 1993.

As to separate the research and investigation from the implementation the Consultant thinks that there are quite some good arguments for this proposal, for example:

- research and investigation requires scientists and engineers whereas the decisions on implementation need to be taken by polititions, managers, etc.
- research and investigations should be done free of any interest for implementation
- since the decisions on the yearly investments have to be done within about 2 weeks only, the respective body should be as small as possible to ensure the effectivity.

It is agreed that non-income-generating authorities should be avoided as far as possible. Therefore in due time, may be starting with the Experts Discussion on FAP 22, the possibilities of income generation of a river training authority should be discussed.

Finally, the Consultant should like to confirm his already existing liaison with FAP 24 also on institutional aspects.

*15. Volume IB, Page 10-8, 7, Section 10.4*

***Public participation {Subsection (3)} should have taken place well before implementation starts. NGO's should be mentioned, as they can make an important contribution.***

Answer:
The Consultant does not think that public participation in the generally understood sense - i.e. grass roots' participation - is feasible on an issue that is technically and scientifically not yet understood. To put it in other words, the technical viability of training the Jamuna should first be assured or at least be probable. Once that stage was arrived at, as is hoped to be the result of the Experts Discussion, the concerned public including the relevant NGOs should be involved in the discussion from the onset.

*16. Volume II, Page A1-112, Subsection 7.3.4.2*

***One wonders whether not also the sediment supply is a factor that should be taken into account. In a sense a true delta may be considered as a braiding system: it has an abundant sediment supply and apparently the most effective way for the river to handle that is developing a number of channels. This appears to be in agreement with the contention of White and Bettess (Section 7.3.4.3) that the river tries to maximize its stream power. In this respect one should also be aware of the fact that this and other studies of the Jamuna just consider a discrete section of the entire river, which in principle is wrong for drawing solid conclusions. One would have to consider the entire river, at least from the point where it breaks through the Himalayas. Up to that point it probably had a steep slope and it is heavily loaded with sediment, i.e. caused by the frequent earthquakes and landslides. Thereafter the slope presumably decreases and the only option for the river to handle the abundant amount of sediment is by developing a number of braided channels. In this connection it would be interesting to try to relate the intensity of braiding to an increase in sediment supply e.g. as a result of earthquakes in the Himalayas. If this theory is correct, it sets some boundary conditions to what one can do with mitigating the braiding character of the Jamuna.***

Answer:
It is agreed that more studies are needed to fully understand the characteristics of the Jamuna river and their dependence on factors like the sediment supply and the valley slope.

17. *Volume II, Page A1-118 and Fig. 7.4-5*

***A point somewhat related to the foregoing is that there probably is no such thing as a 'theoretical' width of a braided river: If there were not river banks, there is no reason why braiding channels should rejoin after some time. This means that the actual width of the braided bed is a function of the level of the banks in relation to the flow regime and these two may be interrelated through the concept of 'dominant' discharge.***

Answer:
It seems that the course of a river ultimately is determined by geological controls. It is logic that the braided Brahmaputra "starts" where it breaks through the Himalayas and that it "ends" in the Bay of Bengal. Its actual course depends on these geologic controls. A too wide river would have channels that deviate too much from the "direct" distance (which is not a straight line due to the geologic controls!). Hence the width of a braided river cannot become infinite even if there is no influence from the banks. In line with the comment it is felt that the total width is a minimum width and that the river may be much wider, especially if "permanent" islands develop as e.g. is the case at Bahadurabad.

18. *Volume II, Page A2-15, Section 3.3, para 4*

***One wonders how representative dune tracking can be for the determination of bed load. It is well known that the bed topography is related to the velocity of the water, to the extent that at some point there may be a flat bed (see Page A2-14, para 1), or even anti-dunes. Dune tracking would then give zero bed load in the first case and negative bed load in the second one, none of which would be correct.***

Answer:
Dune tracking can only be done in the case that dunes are present, and even then there is some doubt in the presence of much suspended load. In the Jamuna river also flat bed occurs (see e.g. Klaassen et al, 1988), and under those conditions the method cannot be used. Anti-dunes occur only for a Froude number in the order of 1 and more, and this occurs only in steep rivers and hence not in the Jamuna river. The relevance of the dune-tracking method has been proposed to FAP 24 as one of the study topics to be taken up.

19. *Existing Experiences with Surface Vanes (Annex 3, Section 1.1 Page 3-1)*

***A general remark about all the methods presented including the surface vanes, is that the criteria for selection are not sufficient.***

***The french experience with scouring barge placed in a channel - a different technique than the one proposed for the Jamuna - was tested in shallow rivers on crossings with depths of the order of one or two meters.***

***Bandals is a proven - although not evident nor simple - method. These structures are usually placed along channels, on the bars, and are fixed in the bed. They work at lower stages, in shallow depths.***

*The comment made (Annex 3, Section 1.1, page A3-1) "the present use of bandals in Bangladesh is focused on the improvement of the fairway depth for ferries and inland navigation on the Jamuna river" denotes a misunderstanding; the bandals have also a definite effect on the morphology of the whole system, as their effect on the navigation channel is by increasing the natural "self-dredging capacity" of the flow through a re-alignment of this flow. This re-alignment is obtained by modifying the bar and char morphology: channel and bar/char geometry interact continuously. A thorough discussion of this aspect is needed, and no reference had been made to the papers published by B. Winkles in a bulletin of the Permanent Association for Navigation Congresses on the relationship in large US alluvial rivers between morphology and flow distribution.*

Answer:
The criteria for selection a river training measure are not described in ANNEX 3 but these are described in detail in ANNEX 1 "River Training and Morphological Response", see especially Section 1.2, Limitations and Set up. If well understood, this comment suggests to extend the criteria which were used for the selection of river training methods and which were based on the main principles of flow and sediment distribution with more practical criteria related to the construction and the operation of the surface screens. The elaboration of practical aspects requires a detailed determination of all conditions and this is planned to be studied in a next phase of a complete feasibility study.

The Consultant is interested in articles and literature regarding the French experience with the scouring barge.

Bandals are proven in practice, but a validated theoretical description and prediction of its effectiveness is missing in the existing literature. If these small scale measures are upgraded to a larger scale the effectivity on flow and sediment transport will change probably considerably.

The experiences described by Winkley with the training of the Mississippi river are reflected less detailed in the results of the study tour. Especially during the development of a long term strategy for training the Jamuna river with hard points, the experiences in the Mississippi river with creating an optimal final plan form are interesting. If necessary the experiences described by Winkley will be included in a next phase of the Project.

## *20. Volume III, Page A3-7, Equation 2.3-2*

*How can be refer to the bankful width of a channel ? Fig. 2.3-1 is not well understood for the same reason. The Jamuna has only one bankful width and that is what Equation 2.3-2 is believed to refer to and that is how the equation is being used elsewhere in the report.*

Answer:
Each channel in the Jamuna river has its own bankfull width. The relationships show that these formulas are also valid for discharges below the bankfull width, see article of Klaassen and Vermeer, "Channel characteristics of the braiding Jamuna river".

## *21. Comments about the proposed Tests on Floating Vanes (Section 6.1, Page A3-48)*

*One important shortcoming, which appears from the morphologic analysis of the proposed tests, is the lack of integration in the overall morphologic changes of the considered area. The upstream conditions will make the experiment*

*successful or worthless. The assumption made about the stability of the channel pattern of the Jamuna (Section 6.1, page A3-48) is not relevant as the intervention concerns a restricted are where morphologic changes were important at that scale, also with stage.*

Answer:
In this prefeasibility study the analysis of the 10 examples of the application of surface screens as a river training measure is based only on the available satellite images, see ANNEX 3, Section 6.3. These examples were meant to stimulate the understanding of the possible, complicated effects of the proposed surface screens. In the next phase of this Project this type of examples should be studied more in detail, including an integration in the specific morphologic characteristics of the considered area.

The success of a test in the prototype depends partly on the upstream conditions. The flexibility of the floating surface screens to shift them regularly (for example each two months) to the optimal location in a bifurcation reduces the influence of the upstream conditions on the success of the test.

Because the overall characteristics of the Jamuna river were not changed during the last decades it is assumed that the average local characteristics were not changed also. In case the average local characteristics of all the channels and the bifurcations were changed during the last few decades one should be careful with analyzing examples of the past. The validity of these examples for future situations could have been reduced.

The comment underlines the importance of working "with" the river, rather than working "against" it. The changes upstream should be anticipated (and for this a tool for predicting planform changes is needed!) and the decision on which measures should be taken where should be based on this assessment.

*22. Volume III, Page A3-61, Section 6.4 last sentence*

*The contention that erosion takes place only during 1-1.5 months per year is not correct. In fact erosion can occur even during low stages of the river.*

Answer:
This comment is correct and this sentence should be read as:

In a schematization of the complicated physical process of bank erosion it is assumed that the eroded area along the bank is a function of the maximum discharge during a flood. A characteristic value of this discharge is the discharge which passes Bahadurabad and which is exceeded during 30 to 45 days per flood. This does not mean that all the bank erosion per year occurs during these 30 to 45 days. In fact erosion can occur even during low stages of the river. The Consultant plans to study the relationship between the bank erosion and the discharge in the Jamuna river more in detail during the next phase of the Project.

*23. Volume III, Part B, Chapter 8*

*The discussion in this chapter shows that the idea of the floating screens has not yet been brought to the stage of practicality. A number of important aspects has not been looked into, or not to the full depth: the velocity may be higher than 2 m/s. Fig. 8.4-2 suggests that some channel will be fully closed, which may not be accepted by country boats and fishermen; how about floating debris, the question of anchoring the barges has not been solved; there probably will be vibrations; the calculated forces do not account for the pressure on the barges*

***themselves; the forces on the shore anchors and on the connection in between the barges are entirely unmanageable. Unless practical solutions are found, the floating barge may never exceed the stage of a bright but unpractical idea. The consultants should therefore concentrate in the next phase all attention on this point. At the same time other options, e.g. "Intelligent" dredging should be explored further, so as to develop a number of alternative tools for AFPM.***

Answer:
The scope of this prefeasibility study of river training measures and AFPM is focussed on the technical feasibility of recurrent river training measures as a first phase of a complete feasibility study including all other practical aspects. A preliminary answer can be given to the aspects mentioned in the comment to indicate a possible solution for each aspect, which has to be studied in full depth in a later stage of the project.

In a bifurcation the flow velocity can be higher than the assumed 2 m/s in extreme situations during a flood. If the anchoring of the barges with surface screens does not allow the high forces induced by these flow velocities > 2 m/s, then a possible solution is to swing the screen if the winch slips the rope after measuring the maximum allowed force. Or to swing the barge unit with the vertical screens to a position more parallel to the flow direction. This action will reduce the projected area of the screens to the flow and consequently will prevent a further increase of the forces, if they are close to the maximum allowed forces. It means that the efficiency of the screens are temporarily less than the possible efficiency with the screens in their original position. The extra costs for a stronger system have to be compared with the benefits of a temporary higher efficiency during floods.

One of the objectives of river training and active flood plain management is to be able to close a carefully selected channel completely with an appropriate closing technique. During the selection of channel the interests of for example fishermen, of traffic by country boats, the local people will be weighed as part of the public participation in river training and active flood plain management. This aspect is not specific for river training with surface screens.

It should be realized that in the Jamuna river not much floating debris is observed. Normally the upperflow along the row of screens will transport the debris to the opening or to channel 2. But if floating debris is stacked upstream of the barges with the screens, then one unit of the row should be released from one side, the barges swing open to a position parallel to the flow direction and all debris can pass without resistance. After the debris has passed, the barge is pulled back to its position in the row.

A full range of different types of anchors for special situations have been developed integrating the results of applied research in laboratories with practical experiences in for example the dredging industry. Such an anchoring system is technically feasible, but the combination of a technically feasible anchor system with an operationally and financially feasible system needs to be investigated in later stages of the Project.

For the vibrations of the barges and the screens by the flow and by wind waves a solution is possible. The barges are rather large and stable.

The comment that the forces on the shore anchors and on the connection in between the barges are entirely unmanageable may be valid for extreme situations. During the design of the anchor system not only the required strength of the system parts will be determined but also how to operate the system without unacceptable risks in difficult situations. The idea of shore anchors is very preliminary and may be dropped during the design of the anchor system.

The Consultant agrees fully that for all these aspects practical and sound solutions have to be found. And once again this is planned for a next phase of the Project after the planned Experts Discussion on this report. The capabilities of other river training measures like dredging and short-cuts, will be developed in such a next phase as an alternative tool for AFPM.

*24. Volume IV, Page A 7-43, Para 1*

*Does any of the listed conceptual framework include public participation?*

Answer:
Public participation to the project implementation will be included and is scheduled in a later stage as it is proposed on page A7-64 Para (iii).

*25. Volume IV, Page A 7-53, Section 8.3*

*It is not understood as to what is intended in this section in terms of the objective of the project.*

*Does the secondary source of data cover the whole project area, particularly when the data as available and used here are generated by two studies ? Which are:*

> *FAP 3.1 only covers approximately (?) of the study area of FAP 22 and REIS 1985 is an outdated data, and deals with only one Char Tekani case study: a very small one.*

*Under these serious limitations of the data it is difficult to rely on the report as presented here.*

*Some Recommendations*

- *To give priority to a comprehensive analysis of morphologic changes at bifurcations and confluences on the basis of charts (e.g. BIWTA and BWDB observations) and not only on satellite images.*
- *To organize the collection of basic data on one bifurcation/confluence, required for assessment and design of structures (including surface flow fields and detailed slope measurements).*
- *Prior to all test, to assess and try out in the field the feasibility of an anchored barge/vane across the flow in the Jamuna in a range of flow slopes and channel conditions.*
- *To replace as much as possible the model tests and calculations by limited field tests.*
- *To consider the alternative or complementary use of bandals or similar measures for influencing morphologic changes acting on bar/char formation.*
- *To consider the use dredging as a morphologic agent, especially in the case of cutoffs.*
- *To avoid as much as possible the use of fixed surface vanes like presented in combination with the floating surface vanes, because the risk of bank caving would be to important.*

Answer:
The limitations due to the lack of quantitative socio-economic data, the objective and methodology applied for the socio-economic assessment have been presented in detail in the report, in particular in paragraph 1 (boundary conditions for the assessment) and 7 (methodological basis of the assessment).

On the other hand the socio-economic assessment presented in a multicriteria qualitative one and its limits - which does not mean that it does not present any interest - are again recalled in paragraph 9, page A7-63.

**Some Recommendations**

- A comprehensive analysis of morphologic changes of 'promising' bifurcations on the basis of satellite images, sounding charts of BIWTA and additional surveys is planned. At that time it should be checked if the data of the surveys by FAP 24 can be used for this analysis. A start with such a comprehensive analysis has already been made in the Remote Sensing Study (ANNEX 11, Section 3.3, Bifurcation Analysis) using only satellite images. The Consultant fully agrees that satellite images provide only limited information, and that for a better understanding also data on levels are needed. Water and bed level data, however, are only available to a limited extent. During his investigations under the Jamuna Bridge studies and under the present study the Consultant has done his best to utilize the BWDB cross-sectional soundings and the BIWTA charts in addition to the satellite images, but it was found that these data are of limited use only. See also Annex 11, where an attempt was made to improve the understanding of bank erosion by using BIWTA data, but the results were not encouraging. An important aspect to consider that for predictive purposes satellite images are relatively easy to obtain and usually will be available in time. For the other type of data much more effort has to be invested and much elaboration is needed, let alone their rather late availability.

- "The collection of basic data ..." will be part of the monitoring phase once the use of surface screens or any other type of measure will be investigated.

- The reasons to recommend a replacement of the proposed physical model tests and theoretical calculations by limited field tests as much as possible are not clear. Physical model tests are a valuable tool because all effects are measured under controlled circumstances. In the analysis of the test results an in-depth analysis of possible scale effects is required. Theoretical calculations contribute to the conceptual understanding of these complex flow fields around surface screens at bifurcations. For example these calculations show which parameters are important and which parameters should be measured in nature and in the model. Therefore the Consultant's approach considers a well balanced mix between model tests, calculations and field tests.

- The use of bandals complementary to the rows of surface screens at a bifurcation is considered as a valuable comment. This use of bandals can be tested best in a pilot test in nature, and may be also in a physical model test during a next phase of the Project.

- In the simplified mathematical models described in ANNEX 4 a combination of dredging a cutoff channel with surface screens at the bifurcation of the cutoff channel and the outflanking channel is mentioned. Another combination is dredging a cutoff channel combined with active dredging at the bifurcation to accelerate the sedimentation process in the outflanking channel. This interesting suggestion will be considered in the study of other river training measures.

- At bifurcations the banks are often gently sloped, in general only small vertical cavings are observed. In case of gentle-sloped banks fixed bamboo surface vanes can be useful. In case the water depth is not too deep in front of a caved bank at a bifurcation, some bamboo surface vanes can reduce or stop the caving process. If the water depth is deep the floating surface vanes can be connected directly to this caving bank. For a selection of various types of surface vanes sufficient knowledge should be available to predict the future development of bank caving.

# CATEGORY 2 COMMENTS BY FPCO

## 1. *Surface Screen as a Recurrent Measure (Page S-3, Volume IB)*

***For Active Flood Plain Management (AFPM) of Jamuna river by reducing the flood channel width (i.e. reducing the number of parallel braids) the report has suggested for the use of surface screens. Surface screens work on the same principle as bandalling which is practiced in this sub-continent since long to confine the low water flow in a single Channel with a view to maintain suitable depth for navigation. It is concluded in the report that out of seven types of surface screens the floating surface screen is very attractive with respect to their technical capabilities, their flexibility and relatively low costs, (ref. page 5-3 of the Main Report). But during high flow when the silt concentration is maximum, it will be very difficult to keep the screens in position due to high velocity.***

Answer:
This comment points to an important aspect also touched in other comments. For an answer see comment 2, Category 1 of FPCO on page 19 and comment 23, Category 1 of FPCO on page 31 of this report.

## 2. *Artificial Cutoffs*

***It is mentioned that a cutoff is a specific river training measure compared to permanent and recurrent measures. But a braided river like Jamuna rarely forms adequate horse shoe bends as to facilitate artificial cutoffs. Moreover cutoffs often result in 'violent changes' in river regime, steepening of slope, inducing erosion in the stretch above the cutoff, and lowering the water level upstream.***

Answer:
Indeed extreme bends with high cutoff ratios seldom form in the Jamuna river (see also answer on Category 1 of FPCO comment 5, page 21 of this report). Extreme cutoff ratios are also not needed in a braided sand bed river like the Jamuna river. It may well be that an appropriate selection and design of the offtake in combination with a lead channel of fairly minor dimensions is already enough. The indicated effects are indeed connected with cutoffs, but here because of the low cutoff ratios these effects may be less serious. Furthermore it is intended only to accelerate a cutoff which probably otherwise would occur anyhow after a few more years.

## 3. *Institutional Aspects*

***The training of major rivers like Jamuna 'require the relentless, continuously adjusted and updated efforts of several generations'. Therefore it is suggested in the report to set up a separate institutional set-up to decide on the scenario of river training strategy and also to implement the strategy. For a developing country like Bangladesh it is difficult to create a big and separate institutional set-up at present or in near future. In view of the above fact the report should suggest how to implement the task with the available set-up.***

Answer:
Reference is made to the answer to comment 14 on page 26/27.

4. *Volume IB, Page 1-5 et seq. Section 1.3*

***This section should also include non-FAP activities e.g. Jamuna Bridge, BIWTA, BWDB etc.. It could also include a subsection on potential coordination on JAFP charland development with FAP 10/11, FAP 3.1, FAP 3.2 etc.***

Answer:
Section 1.3 has been included to highlight specifically the reciprocal interactions of various FAP components. This cannot be achieved with activities outside of FAP particularly those which have already been concluded. The relations to other institutions are mentioned at the respective locations in the report. It is a matter of course that close connection will be held with future FAP components like FAP 3.2.

5. *Volume IB, Page 2-2, Subsection 2.1.3, Population displacement and resettlement*

***Historically human habitations have been developed along the river banks. Every year sizeable population is affected by bank erosion. There is a common belief among the local people that erosion rate has been increased due to construction of embankments. Also erosion is attracted by the structural measures that have been taken so far.***

***We share the opinion stated in Art. 2.1.2, Para 2 that people as well as the Government should be motivated about the effective non-structural measures. The non-structural measures should be included in the whole of 'Flood Action Plan'.***

Answer:
The Consultant agrees to the suggestion given in this comment.

6. *Volume IB, Page 2-3, para 1*

***Potentials for the reclamation of land in the wide bed of the Jamuna should be mentioned.***

Answer:
This was mentioned as a potential benefit. As already stated in the scope of works potential land reclamation should be considered as a welcome positive by product of not as an objective for River Training/AFPM.

7. *Volume IB, Page 2-5, Para 2*

***It has been mentioned that in 1988 the maximum discharge had a return period of 100 years but the maximum water level had a return period of 60 years only. The reason behind this aspect is to be explained. It may be mentioned that the water level and the depth of flow are completely different parameters.***

Answer:
See answer on comment 10 on FAP 21 of Category 2 of FPCO, (page 12/13 of this report).

8. *Volume IB, Page 2-5, Table 2.2-2*

***Why the discharge at Nakalia is so low compared to those at Kamarjani and Bahadurabad?***

Answer:

Downstream of Kamarjani the first and most upstream distributary is the Old Brahmaputra river. Further downstream an other important distributary is the Dhaleswari river, off-take of which is between Bahadurabad and Nakalia. The discharges through these distributaries reduce the discharge at Nakalia.

*9. Volume IB, Page 2-10, Fig.2.3-2*

***Are the points in the graph discrete points? Connecting them by lines, as done in the figure, is misleading in that case.***

Answer:
The points in Figure 2.3-2 of Volume IB should indeed be drawn as discrete points.

*10. Volume IB, Page 2-13, Fig. 2.3-5*

***Presumably the 1977 and 1989 images were taken about the same time during the dry season, but how has the width of islands dropped so dramatically (the width of rivers increased by about one third, while the islands decreased by about one half)?***

Answer:
The 1977 and 1989 images were taken about the same time during the dry season but the water levels were different at those dates ( see table 2.2-2 of ANNEX 11): in 1977 the water level at Sirajganj was 6.62 m + PWD and in 1989 the water level at Sirajganj was 7.84 m and 7.69 m + PWD. This means the water levels differed about 1 m which results in an average difference of the channel width of about 800 m. This is estimated by differentiating the regime equations at a station.

*11. Volume IB, Page 2-14, Para 2*

***The prediction method for planform changes should not only depend upon historical planform data but also upon hydrologic and hydraulic parameters. Does the prediction method include the maximum discharge of previous year and the channel alignment (not near field) as input parameters?***

Answer:
The prediction method uses as a basis the planform near the potential site over a reach upstream as far as considered relevant. Furthermore the future discharges are taken into account in a probabilistic way. For more details see a recent paper related to the subject (Klaassen, Mosselman & Brühl, 1993).

*12. Volume IB, Page 2-21, para 2*

***The distinction between low chars and mega-chars is not very distinct. Could the ground level be related to dominant discharge(s), see FAP 1?***

Answer:
It is felt that a distinction between these two types of bars can indeed be made on the basis of their level. This has not been explored fully. This topic possibly should be taken up by FAP 24.

*13. Volume IB, Page 2-23, Art 2.3.8 2nd para, 5th to 7th line*

*"Therefore, it is also not very realistic..... than 2 to 3 years".*

*It is to be kept in mind that there may be sufficient natural development not related to river training measures even in one year.*

Answer:
No answer needed.

*14. Volume IB, Page 2-23, last para, last three lines*

*"This model could not be verified .....level".*

***Please discuss why it is felt that the simple model developed can predict morphological processes sufficiently for use at prefeasibility level.***

Answer:
This simple model was verified versus the Jamuna river data, see Volume IB, page 5-13. The predictions calculated with this simple model are fairly in line with the conditions observed in the Jamuna river (see Section 2.3 and ANNEX 2). This is the reason why it is felt that the simple model developed can predict morphological processes sufficiently for use at prefeasibility level.

*15. Volume IB, Page 3-7 and Volume IV Page A 7-5-7*

***The secondary data used may have to be handled with care. Against an average density of about 760 for the whole of Bangladesh, the densities for (vulnerable) charland, as established by FAP 3.1, seem to be rather high. The consultant should check this.***

Answer:
In the present stage of the Project the real population density figures are not of primary importance, this will become decisive once a river training programme would come into a more concrete state of decision.

*16. Volume IB, Page 4-7*

***In the first line it is stated that surface vanes or surface screens are probably effective..... Then how do you state in the fifth line of the following paragraph that surface screens are considered to be most promising.***

Answer:
The Consultant judges the floating surface screen as most promising (compare to other methods investigated) because of the expected efficiency which was proven by the simplified mathematical models (see ANNEX 4).

*17. No comment made under this number*

*18. Volume IB, Page 5-15, last para, last three lines*

*"Scenario 1 is the.....less drastic".*

*It is desirable to go for less drastic scenario.*

Answer:
The Consultant is not sure if such a decision should already be made at the present stage. Reference is made to comments No. 8. of Category 1 by FPCO, page 22 which is giving Scenario 3 the preference.

*19. Volume IB, Page 5-17, para 2*

***Do the scenarios take into account the 'with' and 'without' embankments and the Jamuna Bridge ? In which case can one assume that a decrease in bed levels and water levels may apply in the high flood situation ? Another negative effect of lowering water levels concerns the flow into all left bank distributaries: fish migration, navigation could be seriously impacted.***

Answer:
For each of the scenarios it was assumed that embankments would be present, hence for a mutual comparison this would be less relevant. Generally speaking it was assumed also that the effect of these embankments would be minor. The effect of the Jamuna Bridge was included as one of the hard points. The Consultant agrees that the effect on the distributaries needs to be included in a later stage of the Project.

*20. Volume IB, Page 5-17, 1st paragraph*

***Fig. 5.2-2 has been referred again but this is missing. Reference has been made also to Fig. 2.3-2. Fig. 2.3-2 shows width increase as number of channels increase. Fig. 5.2-1 (b) however, shows total width to decrease with increase of number of channels. These figures need to be discussed for clarification.***

Answer:
Will be corrected in final version.

*21. Volume IB, Page 6-2, Art. 6-2.1*

***"Surface screens have been selected ..... of this measure".***

***It seems selection of surface screen is based on a simplified calculation method. In the paragraph under title "simplified calculation method" it is mentioned that regime equation has been used and it has been assumed that river bed is in a dynamic equilibrium without erosion and sedimentation. Is it reasonably justified to use regime equation and to assume dynamic equilibrium in the calculation? Besides many assumptions are mentioned. Unless these assumptions are reasonably correct, the analysis will not give a correct picture. Besides practical considerations regarding proper placement of surface screens should be given due consideration. However, physical model tests followed by a pilot test has been strongly recommended to verify the preliminary results of effectivity.***

Answer:
Surface screens have been selected as a first promising measure in an evaluation of an inventory of recurrent river training measures with emphasis on the technical feasibility, see ANNEX 1 "River Training and Morphological Response". This measure has not been selected on the basis of the results of the simplified calculation method. These results are more specific than the general expectations from the 'state-of-the-art' report in ANNEX 1.

It should be clear that the used regime equation, the assumed dynamic equilibrium of the river bed are not essential for this calculation method. These

assumptions are made to obtain some representative results and because sufficient data on channel dimensions and sediment transport intensities were missing. If sufficient data are available from specific bifurcations the regime equation can be replaced, and the assumption on dynamic equilibrium can be dropped in this calculation method, see also answer on comment 9, Category 1 of FPCO, page 22/23 of this report.

The presented calculation method can be used for a sensitivity analysis regarding these assumptions of the regime equation and the dynamic equilibrium of the sediment transport to demonstrate the influence of these assumptions on the calculated effectivity of surface screens.

It is true that the results of this analysis depend on a number of assumptions, which should be reasonably correct. Therefore further study is required and possibly some assumptions can be verified with the results of FAP 24. It seems to be logic first to test the efficiency of surface screens in a physical model test and next to verify the results in a pilot test in the Jamuna river. However, the plan of action for a next phase of this project will be decided upon after an Experts Discussion during which also these assumptions will be evaluated.

*22. Volume IB, Page 6-8, Section 6.2.2*

***Difficulties with anchorage should be mentioned here. ANNEX 3 shows that this could be a real problem.***

Answer:
The anchoring of the floating surface screens has no effect on the effectivity of the screens and not on the short term river response. This anchoring can limit the conditions up to which surface screens can be used. Therefore the method of anchoring should be optimized.

A logical sequence is first discussing the sketchy designs of different types of surface screens and next to discuss the anchoring of the floating types of surface screens. Therefore anchoring is not mentioned in the introduction of section 6.2.2, but it is only mentioned at page 6-13. See also the answer on comment 2, Category 1 of FPCO, page 19 of this report.

*23. Volume IB, Page 7-6,7*

***There may be cases where erosion is not a function of discharge. Progressive erosion is noted along relatively small anabranches where unstable material slumps (probably through groundwater gradient). Presumably the channel velocities have to be sufficient to remove the slumped material, at least over some distance. See also pt. 18, category 1, above.***

Answer:
In this example of the bank erosion which is caused by a groundwater flow and channel discharge together, the resulting erosion can be a function of the discharge. Essential is that the supplied sand in the channel has to be transported by the channel discharge. If not the channel will silt up and finally the channel is closed and the bank erosion is stopped. Therefore all types of bank erosion by the river are also a function of the channel discharge and often the channel discharge is a limiting factor for the bank erosion. Other factors governing the bank erosion are the soil properties and, indeed, the ground water flow. The latter is interalia a function of the soil properties and of the rising and - mainly - falling velocity of the hydrograph governing the ground water gradient close to the bank.

*24. Volume IB, Page 5-5, Section 5.1.3, Selected Scenarios*

*Scenario 1: Under this scenario creating "nodal points" along both the bank so as to arrest further boundary shifting may be effective. Stabilization of mega-char (stable char) by hard materials may be effective but may not be economical.*

*Scenario 2: Nature of works in the form of recurrent measures within the hard points may be effective for arresting silt and stabilizing the river banks and shifting the thalweg.*

*Scenario 3: The concept of reducing the width and to gradual change of river geometry and river morphology may be a acceptable proposition to planners but may not to be acceptable to the river itself. The huge investment within the entire area of river system (240 km * 12 km (av.) and their O&M cost may not be helpful to the people for whom the huge investment is being proposed.*

*Detail theoretical investigations have been incorporated in the report. But model tests should be made with real situations, RRI, WDB, BUET may be grouped together for this type of studies under this project.*

Answer:
Model tests for final selection of the scenario may be required at a later stage. For final selection two-dimensional mathematical model test may be required. One should, however, be careful expecting too much of such model tests, since the reigning phenomena of braide sand bed rivers are extremely by complex and not yet fully understood, let alone mathematically formulated. Physical model test will have to be discarded due to scale problems.

*25. Volume IB, Page 9-2. Section 9.2 International Riverzone Management Institute*

*The recommendation of creation of a separate organization "International Riverzone Management Institute (IRMI)" may not be wise for the time being. RRI may be strengthened to the above standard and entrusted with the responsibilities for the present. WARPO may be brought in these activities. Creation of a new organization may confuse the responsibilities of RRI, WARPO and even of Water Development Board, all being in the same Ministry.*

*Project area in Figure 1.1-1 may be named as "Integrated Jamuna River Project" and be placed under a Chief Engineer for all short-term and long-term studies and works.*

Answer:
Proposing the creation of an international institute the Consultant had in mind to attract international scientists and hydraulic engineers to work on a long term basis on the problems related with training the Jamuna. This institute is not intended to substitute the existing institutions in Bangladesh which may be reorganized in such a way as to cope with the necessity of managing the river training programme through a Jamuna River Authority vested with the required competence and power.

One topic of the Experts Discussion on FAP 22 in October 1993 will be devoted to institutional and administrative aspects.

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*26. Volume II, Page A1-5, para 1*

***Erosion control should be added as one of the objectives of river engineering.***

Answer:
Erosion control has been mentioned as one of the objectives of FAP 21/22 and of AFPM.

*27. Volume II, Page A-10, 3rd para, last two lines*

*"However, as long as siltation ..... in channel 2".*

***The justification of this statement need to be given and discussed.***

Answer:
This statement is true as long as the discharge Q and the sediment transport S are constant. This assumption is not mentioned explicitly in this paragraph, because it was considered as self explaining. In nature this assumption is not true, because the discharge in the branches of the Jamuna river is changing almost continuously. This statement can be justified by basic morphologic calculations which are treated in textbooks.

*28. Volume II, Page A1-54, Section 4.2, para 3*

***The apparent linkage between the development of the administrative structure and the commencement of the implementation of a strategy has been noted.***

Answer:
The Consultant firmly believes that this linkage should be a precondition for continuing the activities on training the Jamuna river, also with regard to further studies. These studies would include morphological, technical, socio-economic, ecological and many more aspects and require significant funding which - unless the above linkage was missing - may better be utilized in other fields.

*29. Volume II, Page A2-53, Section 7.3*

***The observation that the Padma is a stable river, is not correct. The right bank is fairly stable, possibly as a result of some cohesive layers, but the right bank is not stable at all.***

Answer:
Agreed. Will be corrected in the final text.

*30. Volume III, Page A 3-4, 2nd para, 1st four lines*

*"The hydrodynamic ..... in the channels".*

***How about the validity of this assumption?***

Answer:
Reliable field data is missing to validate this assumption. If such data is available and if indicating the mentioned processes are not in equilibrium, then this non-equilibrium can be implemented in this simplified calculation easily. Probably this non-equilibrium is different for every bifurcation and this implies that the calculated results are valid only for the considered bifurcation. For a more general approach the assumed equilibrium is probably more suitable.

*31. Volume III, Page A 3-4, last para. 1st three lines*

*"The input data ..... sediment transport".*

*What geometry of the channel? How you fix equilibrium discharge and other data?*

Answer:
The considered geometric parameters of a channel are the center line which follows more or less the thalweg near the bifurcation, the average depth and the average width of a schematized rectangular cross-section.

In Section 2.3, equilibrium dimensions before placement of surface screens, a procedure to fix the equilibrium parameters are described.

*32. Volume III, Page A3-5, 1st para, 4th & 5th line*

*"In this description ..... fixed bed geometry".*

*How the use of fixed bed geometry will affect the result?*

Answer:
The use of a fixed bed affects the result in a sense that the results are valid for one situation, especially the initial situation. During the sedimentation process the calculation can be repeated with other bed geometries as many times as required. If the results of many calculations are presented as a function of time the influence of a variable dynamic river bed can be simulated.

*33. Volume III, Page A 3-5, 2nd para, 4th and 5th lines*

*"It is assumed that ..... in equilibrium".*

*How such assumptions will compare with the real field condition?*

Answer:
Up to now reliable field data are missing for an impression of the real field situation. Therefore it is necessary to make these assumptions. It is expected that the future results of FAP 24, River Survey Project, will provide at least some of the now missing data.

*34. Volume III, Page A 3-5, Art. 2.2*

*What is the chance of having a centric bifurcation in the field?*

Answer:
The appearance of symmetric and asymmetric bifurcations has been described in ANNEX 11, where, on page A-32, an analysis of bifurcations is presented. In that study all bifurcations were schematized in centric bifurcations. Therefore non-centric bifurcations seem to be rather rare.

*35. Volume III, Page A 3-5, Art. 2.3*

*The assumption relating to cross sections during low flow condition and during high stages should be made very carefully.*

Answer:
This assumption was verified for discharges below the bankfull discharge. The applied extrapolation to discharges above the bankfull discharge is not verified and therefore this extrapolation is tentative and it should be analyzed more in detail in a basic river study.

*36. Volume III, Page A 3-8, 1st para, 2nd and 3rd lines*

*"The differences between ..... relatively small, see Fig. 2.3-1".*

*What is the main purpose of this statement ? How the assumptions made are affecting the equations derived?*

Answer:
These equations can be used for a first estimation of the width and the depth of the channel cross-section. The derived equations will not change if these parameters are estimated in another way.

*37. Volume III, Annex 3, Page A3-7, last para*

*It has been assumed that the cross-section sounded during low flow conditions do not substantially differ in shape characteristics from cross-sections for higher stages. Is this assumption realistic for the Jamuna river?*

Answer:
The differences in the characteristic shapes of the cross-sections which were measured in the Jamuna river during low and high discharges are rather small.

*38. Volume III, Annex 3, Page A 3-8, Para 2*

*The computation of equilibrium dimensions has been made utilizing the Chézy equation (see Equation 2.3-5). The Chézy equation is a steady flow formula for clear water. What is the reliability of its application in the case of sediment laden water in the Jamuna?*

Answer:
The Chézy equation is not influenced by the sediment transport in the Jamuna river. The concentration of the sediment particles is too low for disturbing the turbulence structure of the flow as is observed in hyper-concentrated sediment flow.

*39. Volume III, Page A3-66, 67*

*The cost estimates do presumably not account for the costs (interest, depreciation, maintenance etc.) of the floating screens?*

Answer:
In the cost estimates it is assumed that the surface screens can be used during 5 years. The costs for normal maintenance costs were included in these cost estimates. It is true that these cost estimates do not account for interest costs.

*40. Volume III, Annex 4, page A4-1*

*The analysis has been done by considering the channels as independent of each other. Does this hold during bankful and high stage flows in the Jamuna ? How the MIKE-11 model has been schematized and calibrated in the Jamuna?*

Answer:
For the sake of simplicity no exchange between the two parallel channels over the separating char is modelled. Probably this can be considered as a simplification of nature and no calibration has been made. It is expected that this simplification does not affect seriously the results of this simplified model for a general situation.

For simulating a specific situation of an outflanking channel it may be necessary to include this exchange discharge during high discharges in the model. In that case sufficient data for calibration of the model are required.

*41. Volume IV, Page A-7-8, Age structure, Last sentence*

***Percentages do not add up to 100 percent.***

Answer:
Will be corrected in the final text.

*42. Volume IV, Page 7-10, section 3.2, para 1*

***How the anthropological information is related to the project?***

Answer:
The general qualitative anthropological information is related to the project from the two specific sources mentioned in that para, the oriental bibliography listed in the appendix "References" and the interviews and discussions hold during the field trips (see also the FAP 21 report, socio-economic and institutional aspects, ANNEX 7, Part C).

*43. Volume IV, Page A7-13, Table 3.3-2, Column 1*

***Where from the agricultural wage labour come, particularly in the mainland?***

Answer:
The figures reported are the ones given in the reference source (Elahi, 1992). The agricultural wage labour is most probably provided by occasional agricultural employment supplied by some medium or large landowners.

*44. Volume IV, Page A7-14, para 1*

***What is the basis of this conclusion?***

Answer:
The basis of this conclusion comes from the combined analysis of both Table 3.3-3 and Table 3.3-4.

*45. Volume IV, Page A7-15, Table 3.3-5*

***How land holding and land ownership is differentiated?***

Answer:
This differentiation is reported from the corresponding source (FAP 3.1, Char Study 1992). Land ownership corresponds legally to the property of the land, land holding corresponds to the tenancy of the land (its occupation and exploitation).

*46. Volume IV, Page 7-33 to 41, Section 5*

***The "conclusion" (page 40-41) does not adequately cover the information or data of prepages. Data should have been adequately explained and analyzed. In order words, the conclusion is not what it is expected. Further that the conclusion should have preceded with well knit analysis of required data base.***

Answer:
The "conclusion" (page 40-41) is as it is so called a "tentative overall synthetic conclusion" (Section 6) referring to all the information and analysis given above for the characterization of the Jamuna Active Flood Plain. The conclusion on specific topics are given in the respective chapters.

*47. The economic Annex-9 and Economic section of Main Report (Volume IB)*

***Need to be elaborated explaining clearly the assumptions and methodologies followed in carrying out the financial and economic analysis. More annexes (detailed analytical tables i.e. spreadsheets) in support of the summary results used in ranking the projects of different scenarios need to be annexed in Annex-9 for the Final Report.***

Answer:
The source of data used for financial and economic analysis is given with assumptions in A9-3.2.2. Basic data and calculations are shown in Tables A9-1 to A9-18.

*48. Volume IV, Annex 9 on Economic Assessment of the Report*

***An average conversion factor of 0.80 is used to convert project costs at financial price into economic prices. No explanation, however, of how this factor has been arrived at is provided in the Report; except monitoring that this has been taken from the FAP 1 Report. Even if it is accepted that this factor has been correctly estimated as weighted average of specific a conversion factor of different cost items using their cost shares as the relevant weights, there still remains the problem of updating this factor using the set of conversion factors of engg. cost items as provided in the GPA (April, 1992).***

Answer:
The conversion factor used in the report is taken from the more detailed studies of FAP 1 which followed GPA. According to the ToR the Project was to make maximum use of the findings of other, more specialized, FAP components. No basic economic investigations were asked for in FAP 21/22. The Consultant agrees, however, that the average estimate should be revised at a later stage, although the anticipated impact of this adjustment on the economic analysis will be obviously negligible and will not influence the selection of the optimum scenario.

*49. Volume IV, Annex 9, Table A9-16*

***Assessment of benefit in the Report seem to have been based on FAP 1 work in this respect. It is not clear, looking at Table A 9-16, whether such estimates though derived in terms of various category of losses (such as crop, property, infrastructure etc.) has been valued at economic prices using the appropriate conversion factors (specific as well as standard factor). If not done, then this will introduce an upward in the potential benefit estimates.***

Answer:
The assessment of benefits has been derived from the work done in FAP-1 for economic analysis. It is thus at economic prices.

*50. Volume IV, Annex 9, Table 3.3-1*

***It is not clear whether the inclusion of savings in BWDB expenditures in project benefits (Table 3.3-1) is justified.***

Answer:
The situation without project is assumed with the same investment policy by BWDB as at present. Project benefits include the impact of improved protection plus the saving of BWDB expenditures which will be replaced by project costs (capital and recurrent).

*51. Volume IV, Annex-9, Table A9-10, A9-12, A9-13 and A9-14, at page A9-24, 26, 27, and 28*

***In reference tables and in pages estimated investment cost presented but did not reflect any FEC involvement and land acquisition and resettlement cost at all. Consultants are requested to look in to the issue as proposed project implementation subject to imported materials like geotextiles and etc.***

Answer:
Land acquisition and resettlement costs may be considered as marginal for the envisaged works as they will not be done inland. The cost of imported material like geotextile as estimated in the Chinese-Bangladesh team report is given in Table A9-10. It may represent around 5% of total cost. Estimates may be also found in FAP 21, ANNEX 21. This does not appear to be a significant criterion for the selection of an optimum scenario when looking for a long term strategy.

*52. Volume IV, Annex 9, Page A 9-13*

***It is not clear how with same investment costs during Phase-I and lower investment costs during Phase-II, Scenario 1 returns lower EIRR for the combined Phase I and II run as compared to Scenario 2 and 3. Moreover, it is not clear how without presenting the results (e.g. EIRR, NPV etc.) separately, the consultants can arrive at specific conclusions as those made in page A9-13 in the Report.***

Answer:
Phase I is identical in all 3 scenarios. However, for Phase II, investment cost and maintenance costs are lower in Scenarios 2 and 3 than in Scenario 1. Please refer to Tables A9-12, A9-13, A9-14 and A9-15. Phase II is considered in sequence to Phase I. If analyzed separately it is necessary to assume that no counter effect will occur from the works made during Phase I and not followed by Phase II. This is not yet clearly established. Several runs of sensibility analysis were made to arrive at the comments made in page A9-13 of the report; they were not printed to avoid giving them too much importance.

*53. Volume IV, Annex 9*

***Attempts should be made to estimate, however, tentative those might be, the potential benefit to be occurred during Phase III. Without which the economic exercise remain essentially incomplete. This would also enable the consultants***

(12)

*to compute the economic return (EIRR) for each scenario for all three phases, both separately and combined together.*

Answer:
No data presently exist for the estimation of Phase III benefits. Decisions concerning Phase III are not required before the year 2015. Please refer to Section 5.6, "Recommended Strategy".

*54. Volume IV, Annex 9, Table 18, page A9-35, 36, 37 and 38*

*According to the reference table, Cost/Benefit analysis FAP-22, discounting period (economic life of project) assumed 57 years (1994 to 2051) in working out EIRR, PV and NPV which is deviation from the "Guidelines for Project Assessment" mentioned in para 22 at page-8. It seems discounting period has been confused with the estimated project phasing (implementation period). Consultants are requested to assume an independent discounting period for each phases under different scenarios (shown in Table 3.2-2, at page A 9-9 of Annex-9, Volume IV). Accordingly financial and economic analysis needs to be redone for the final report.*

Answer:
We agree that the discounting period in the FAP 21/22 cost/benefit analysis does not seem to follow GPA. This is due to the fact that, in any circumstances, investment will be spread over a very long period. That is investigated in a long term strategy and the methodology of economic analysis for individual project would not be appropriate in the present case. The comparison of the different scenarios is made on the same basis for each of them; the results of our analysis are thus valid. When individual projects will be identified, at a later stage, within the adopted strategy, the 30 years period will be used for comparison with other projects. It is suggested to include the question of the best discounting period for river training in the Experts Discussion on FAP 22, in October 1993.

*55. Volume IV, Annex 9, Table A9-15, Page A 9-29 to 32*

*The reference table needs to be recast in the light of the specific comment no.-2.*

Answer:
The Consultant presumes that comment 54 is meant and refers to the respective answer.

*56. Volume IV, Annex 9, Table 3.3-2, Page A9-13*

*As per above reference table and page only base case NPV and EIRR have been computed, sensitivity and switching value test had not been done. This is deviation from the GPA. This exercise needs to be done in final report and annexure should be furnished.*

Answer:
The subject of the study was the identification of a suitable strategy for river training and not the preparation of individual projects. At such a preliminary stage, cost and benefit estimated are based on extrapolation of available data. They are still very tentative and shall be supported later by pilot tests and pilot project still to be executed. Calculation runs were made to determine switching values of costs and benefits. The results are given in A9.3.3.3. The printing of spreadsheets justifying these calculations are considered to be misleading since they would suggest an accuracy which is not available.

57. *Volume IV, Annex 9, Table A9-16 and 17, at Page 33 and 34*

***Reference tables presented summary results of economic analysis (EIRR and average benefits) for different bank protection pilot projects, but detailed basis not explained in description, nor in Annexure. This needs careful look for final report.***

Answer:
As mentioned, Tables A9-16 and 17 were extracted from the FAP 1 and FAP 9B report. Both reports were considered reliable sources of data not requiring a detailed review, at the present stage of the Project, see also answer to comment 48, Category 2 by FPCO on page 46 of this report.

58. *Volume IV, Annex 10, Page A10-27, para 15*

***It is said that water-borne transport is not slower than road transport.***

***As per Master Plan of IWTA self propelled water transport is competitive with (road transport) only for distances exceeding 270 km. The Master Plan however reveals that the comparison assumed that the basic roads are already existing. While the cost of waterway include for an average of 20 km road feeder transport transhipment etc.***

***'Point to point' by country boat is then estimated that it is compatible at a distance exceeding around 92 km. However, the country boat may not be equipped with engine.***

***A public participation meeting indicated that rickshaw is preferable than country boats specially to avoid time.***

***It is therefore, suggested that the consultant make a proper comparative analysis between road transport and mechanical country boats.***

Answer:
The reference to the masterplan conclusion about preference of rickshaw transport over country boats, up to certain distances, is a valuable remark. However, since then the mechanization of the country boats has dramatically increased, which leads to a come-back of the same where earlier the competition was lost to the truck. The same may be true in respect of rickshaw transport. As the suggested analysis exceeds the present ToR it is suggested that such an in-depth analysis is included in the follow-up studies.

# FURTHER COMMENTS

# COMMENTS FROM DEPARTMENT OF FISHERIES
## (Received on 17.03.1993)

*1. Draft Final Report, Planning Study Volume 5 deals with the hydrological data, mathematical model test, socio-economic and administrative assessment of the project area. In this report most of the information of the fisheries resources in the project area appears to be collected from the secondary source mainly from Fisheries Resources Survey of the Department of Fisheries. These secondary data and information should be updated by collecting information of the field by the Consultant engaged in the project.*

Answer:
Looking to the ToR, only secondary source data were to be evaluated. However a sampling field data has been collected by the Consultant. Reference is made to ANNEX 8.

*2. In this study data on fish stock assessment, number of fishermen involved in fishing, fish catch assessment, socio-economic condition of fishermen are not described specifically and impact on fisheries due to the project is not quantified.*

*3. Ongoing fisheries development activities of the DOF in the project area should be reviewed for prefeasibility/feasibility study of the future development programme.*

*4. Work plan for next phase of fisheries feasibility study should have been elaborately spelt out in the report.*

*5. Beneficiaries/benefits of the project area should be identified during next phase of the study for proper implementation of the future fisheries development programme.*

*6. Without fisheries mitigatory measures in the project area, fishermen house hold income may not increase but rather income of fishermen may decrease. Therefore, it is suggested to undertake fisheries development programme in the project area.*

Answer to points 2 to 6:
General comment: FAP 21 is a Bank Protection Test Work Project, not a fishery development (or regional development) project. Also FAP 22, in its present phase, was not asked to go into regional development assessment. Once the technical/economic feasibility of River Training/AFPM on the Jamuna be probably assured, fisheries would be a major concern for further investigations, after the Experts Discussion.

## COMMENTS FROM CHIEF ENGINEER DESIGN II, BWDB, DHAKA (Received on 17.03.1993)

1. *Annex 23, Subsection 3.6.2,*

***The Chézy C, Manning n were estimated on the basis of the discharge in one channel only rather than total discharge of Jamuna river, in the case the values of the coefficients would have been different.***

***In Table 3.6-2 and Table 3.6-3 the values of C, n and surface slopes should better be estimated for 50 years also as water development projects are generally designed considering a life time of 50 years.***

2. *Annex 23, Subsection 3.7.1*

***In case the test structures be Groynes the spacing of those is an important design parameter which has not been considered.***

3. *Annex 23, Subsection 3.7.3*

***There is lack of similarity between the surveyed cross-sections (Fig.A23-29) and the schematised (typical) cross-sections (Fig. A.23-30) of Jamuna at Kazipur site.***

4. *Annex 23, Subsection 3.7.4 (2)*

***Though the Design Values for slope revetment have been mentioned, no physical model test was described presumably to arrive at these values.***

Answer:
ANNEX 23 takes up the results as developed in the Main Report Volume IA and in the technical annexes (ANNEX 15 to 21) which cannot be repeated.

For the design of test structures other design criteria than for permanent bank protection structures have to be selected. Structures on the Jamuna may be lying high and dry after a few years and should therefore be designed for shorter life times and at lower safety levels which will allow certain damages.

As to Subsection 3.7.1, the Consultant agrees that the spacing of groynes is an important design parameter, the influence of which was however investigated in the model tests for Kamarjani and additional model tests for Kazipur/Sariakandi.

As to Subsection 3.7.3 it is to be mentioned that the surveyed cross-sections in nature show a complicated shape with one or more channels, see Fig.A23-29. In the physical model only a main channel as a part of the complete cross-section is reproduced. For a general similarity the width and the water depth of the channel should be reproduced. In the physical model a channel with a width of 400 m and a water depth of 15 m in cross-sections 4 to 7 is modelled. This width and this water depth shows a rather good similarity with the main channels in the surveyed cross-sections.

As to Subsection 3.7.4(2) the design criteria of slope revetments are based on the results of physical model tests performed for the test site at Bahadurabad and the additional test sites at Kazipur and Sariakandi.

## COMMENTS FROM RIVER RESEARCH INSTITUTE (RRI) (Received on 06.04.1993)

*The draft final report on Bank Protection of FAP 21 (Planning Study) is a study to find out some optimum design of bank protection devices of the Jamuna river and also other rivers of Bangladesh. Although this study has been done on two selected sites on the Jamuna river it is to some extent like a basic research to evolve some methods of design and construction of the bank protection devices which may be applied to all areas of Bangladesh.*

*The study is actually in its preliminary stage, because the findings of the model studies in the physical and mathematical models will be further tested in the prototype. With this idea the Consultants of FAP 21 have designed the protective devices with lower safety factors with a view to observing the extent of damage in the prototypes and keep the design criteria in the optimal range, so that no uneconomical and over designed structures are constructed.*

*In the physical model studies the impermeable straight groynes showed very deep scour at the toe. While the permeable groynes showed comparatively very less scour. This always happens because in case of straight impermeable groynes where the flow is hit back and produces a rolling/vortex at the toe of the groynes when it mixes with the undisturbed flows beyond the toe of the groynes. In the case of the permeable groynes comparatively less transverse flows mix with the direct flows and the phenomena of rolling is less and thereby scour also becomes less.*

*About the comparative study it may be mentioned that the individual members of the permeable groynes, which may be RCC piles, will entail more cost for construction than that for the impermeable groynes. On the other hand in case of impermeable groynes the scour at the toes will be vary deep and very costly foundation for the structures will be necessary. It may be also mentioned that groynes set at angles with the bank produce less scour at the toes. However, the test of the prototypes may reveal many unknown aspects which may be used for further construction and design.*

*For other parts of Bangladesh the soil conditions along the river banks are not exactly the same as that of the Jamuna river, so the findings of the prototype test on the Jamuna river banks may not be correctly, safely and economically applied to them.*

Answer:
The Consultant took note that the River Research Institute is on general terms agreeing with the findings of the study, particularly with the conclusions made from the physical model tests. The Consultant would like to take this opportunity to thank the direction and staff of RRI again for their services and the zeal they have worked on the tests.

# COMMENT FROM WARPO ON EXECUTIVE SUMMARY
# (Received on 18..04.1993)

*1. Section 1.2. Objectives of the Project, Page 2 to 7*

***It should be clearly stated that FAP 21 Bank Protection Pilot Project and FAP 22 River Training and Active Flood Plain Management Pilot Project are respectively to be confined to these Pilot Project only or to be phased out to total Jamuna Bank Protection and Jamuna River Training and Active Flood Plain Management as shown in Table 1 and 2 page 21 and 22 respectively.***

Answer:
The Consultant is not quite sure of the meaning of this comment. Referring to the objectives of the project components more details are given in the Main Reports Volume IA for the Bank Protection Pilot Project (FAP 21) and Volume IB for the River Training/AFPM Pilot Project (FAP 22).

*2. Chapter 3, Page 10 to 23, The Solutions Proposed*

***Two test sites one at Kamarjani and the other at Bahadurabad have been selected and in these two sites Bank Protection structures have been proposed.***

***But for River Training or Active Flood Plain Management, no test sites have been proposed as worked out in Scenario 1, 2 or 3. The proposed scenarios seem to be more effective for river training purposes like for the Jamuna river, but there is no proposal for execution of any scenario and or their combination.***

Answer:
It is correct that two test sites have been proposed for the Bank Protection Component (FAP 21) but none for the River Training/AFPM Component (FAP 22). The reason is that before proposing any river training test site, the basic decision is required on whether or not the Jamuna river shall be trained or stabilized. After that decision a series of detailed studies are to be made, as explained in detail in Chapter 8 and 10 of the Main Report, Volume IB. Only after a positive outcome of (at least some of) these studies and investigations, a pilot project would be carried out on the Jamuna river (test site).

*3. Institutional Aspects*

***It has been stated that a well defined Jamuna River Authority should be established.***

***It should be remembered that WARPO, FPCO, BWDB, RRI and Joint River Commission are separate bodies working on water related works. Setting up separate Jamuna River Authority may dilute the objectives of River Training works. Within Water Development Board one separate Chief Engineer and a panel of experts may be entrusted with the work. The panel may be formed with International and National experts.***

Answer:
In the Consultant's opinion the present distribution of responsibilities - and power for decision - as well as the present organization/administration does not allow the management of training the Jamuna river as stated in Chapter 9 of Volume IB. Reference is also made to comment and answer 25, Category 2 of FPCO, page 41 of this report.

## COMMENTS FROM ADD. CHIEF ENGINEER, DESIGN I, BWDB (Received on 18.04.1993)



*Chapter 2: Towards Developing New Solutions*

*Section 2.1 Basic Approach*

*Bank protection pilot project (FAP 21) is directed towards the practical design and actual implementation of test structures, the River Training and Active Flood Plain Management Pilot Project (FAP 22) is directed towards the preparation of medium and long term strategies.*

*The final objective of the River Training/AFPM component is to develop measures which would allow to control the Jamuna river in such a way that its outer channels would no longer threaten their outer banks by erosion.*

*But no approach for the basic problem, for making the river equilibrium which is the main reason for the erosion has been made in the study.*

*A rather important aspect of hydraulic engineering is the concern for the equilibrium, stability and fixation of the boundary between the media soil and water. Erosion and sedimentation are sign of a disturbed equilibrium. Equilibrium is always connected with the supply of solid material to a certain area and the transport of that material from the same area. If the supply and transport in the particular place become unbalanced, the equilibrium is disturbed and either erosion or sedimentation will occur. The erosion and sedimentation in Jamuna is due to unbalance in supply of solid material and transport of same.*

*In case no measure can be taken to provide balance between the supply and the transport capacity of sediments such erosion can be checked/prevented by fixation of the soil by revetment. In the study no approach has been made whether this balance can be made or not and no recommendation or remarks has been made in this respect. Study should be made to find out the way for making the balance between supply and transport of sediment and which will be permanent solution for the present problem of Jamuna river.*

*Section 3.2: Bank Protection Structures*

*In this report recommendation has been made to provide granular filter above water level and geotextile filter below water level due to uncontrollable construction of granular filter below the water.*

*According to "Design of low head hydraulic structure, water resources series no. 45, United Nations, New York, 1973:*
*Use of filters*

*(a) to prevent piping or erosion of fine soil particles (trespassing of subsoil particle) which is caused by excessive seepage force from the flow through the foundation soil.*

*(b)*

*Locations:*

*(a)*
*(b)*
*(c)*
*(d) Under riprap to prevent the loss of soil by seepage of ground water or erosion by external forces from flowing water.*
*(e)*

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*In the light of above our comments are stated below:*
*From the above test it is clear to understand that filter is provided to counter piping, suction and seepage under riprap only. The above phenomenon occurs in between highest and lowest water level which may be located as filter zone in protective work, where the placement of granular filter is very simple.*

*Since the placing of filter beyond riprap is not necessary hence due to uncontrollable construction of granular filter below the water level provision of Geotextile filter below water level is not require at all.*

*The launching apron (Toe protection) is provided only to protect/stabilize revetment (riprap) and it does not require any filter material.*

*According to "Hydraulic Design of Flood Control Channels" US Army Crops of Engineers. EM 1110-2-1601, 1 July, 1991. Engineers Manual, revetment toe protection has been described in the following language "Toe protection may be provided by two method:*

*(a) Extend to maximum scour depth*

*(b) Place launchable stone: Place sufficient launchable stone to stabilize erosion. Launchable stone is defined as stone that is placed along expected erosion areas at an elevation above the zone of attack. As the attack and resulting erosion occurs below the stone, the stone is undermined and rolls/slides down the slopes, stopping the erosion. This method has been widely used on sand bed streams. In the above text nothing mentioned about the filter below launching apron/Toe protection which clearly indicate no necessity of filter under toe protection.*

Answer:
As to Chapter 2, Section 2.1 the Consultant fully agrees that non-equilibrium is the result of an unbalance between supply and transport of bed material. Such an unbalance, however, is typically one of the characteristics of an untrained, braided river, causing that always some channels aggrade and some channels degrade, (in fact use of this will be made by introducing artificially unbalance via AFPM measures as studied under FAP 22). The unbalance in vertical sense would be eliminated if the river was transformed into a meandering channel with constant width (and constant floodplain width!), and this was studied as an extreme case. This would however not stop the river from eroding (in horizontal sense) via bank erosion. Hence, always bank protection would be needed (unless AFPM measures appear to be a good alternative).

As to Section 3.2, a revetment is to be constructed on a sloping river bank to protect and stabilize its surface against erosion by currents and wave action. It consists of a coverlayer and an underlayer. The coverlayer provides protection against the direct erosive forces of currents, waves and other external effects. The failure of revetments occurs most frequently due to failure of the underlayer as a result of hydraulic forces within it and inadequate provision for these forces in the design.

The functions of underlayers are as follows:
- to separate the coverlayer from the subsoil;
- to provide secondary protection in case of loss of the coverlayer or parts of it;
- to protect the subsoil from erosion by flow over its surface, parallel to the slope;
- to act as a filter allowing the movement of the water into and out of the subsoil, but to restrain at the same time movement of the subsoil;
- to provide a drainage zone for the underlayer and the subsoil parallel to the slope, and
- to dissipate energy of internal flow in the underlayer caused by current or wave attack.

The design of the underlayer must take realistic account of the fact that the flow in the underlayer may have components in any of 3 separate directions:

- along the slope in the direction of the river alignment;
- up or down the slope, and
- perpendicular to the slope into or out of the bank.

The above details show that the underlayer of a revetment has not only the function of a filter to prevent migration of the subsoil but interalia also of a separation layer to avoid penetration or loss of coverlayer material into the subsoil. It is common practice to place the coverlayer on a separation and regulating layer which functions at the same time as a filter. Hence, the underlayer is to be provided below the entire coverlayer down to the toe of the sloped river bank and not only between the highest and lowest water level.

As to the falling (launching) apron the Consultant agrees that in common practice no filter material is required. According to the preliminary design no filter material is planned to be installed with the falling aprons of the test structures (see ANNEX 21). Special falling apron model tests are planned for Phase II to obtain a better insight into physical processes involved.

# APPENDICES

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# APPENDIX 1

## EVALUATION OF THE MAXIMUM SCOUR DEPTH

### 1 INTRODUCTION

In the physical model investigation for FAP 21/22 in the River Research Institute a rather non-traditional scaling procedure for sand for the moveable model was used: the size of the model sand was the same as the size of the prototype sand. In the comments on the Draft Final Report of this project a justification or a verification was asked for this scaling procedure. In this note a verification of some results of the physical model is presented based on the scour formula of Ahmad.

### 2 ANALYSIS OF THE SCOUR FORMULA OF AHMAD

The maximum local scour depth near spurs and groynes has been analyzed in many laboratory studies. The most readily useful of the available studies are those of Ahmad (1953), see for example Vanoni (1977), who presented his results on the basis of an equation with the form:

$$h_0 + y_s = K \cdot q_c^{0.67} \qquad (1)$$

in which

| | | | |
|---|---|---|---|
| $h_0$ | = | undisturbed water depth upstream of the structure | (m) |
| $y_s$ | = | maximum local scour depth measured from the bed level | (m) |
| K | = | empirical coefficient for the geometry | (-) |
| $q_c$ | = | discharge intensity in the contraction in front of the head of the groyne | ($m^2/s$) |

The discharge intensity is defined as:

$$q_c = q_0 \cdot \frac{B}{B - b} \qquad (2)$$

in which

| | | | |
|---|---|---|---|
| B | = | total (flume) width upstream of the structure | (m) |
| b | = | width in the contraction by the groyne | (m) |
| $q_0$ | = | discharge intensity upstream of the groyne | ($m^2/s$) |

It means that $q_c$ represents the influence of
- the length of the groyne (B - b) and
- the upstream discharge intensity $q_0 = h_0 \cdot u_0$.

The upstream flow velocity determines the sediment transport intensity upstream of the groyne:
if $u_0 > u_{cr}$ then live bed scour and
if $u_0 < u_{cr}$ then clear water scour,
in which $u_{cr}$ is the critical flow velocity (m/s) for the initiation of the movement of the sand of the river bed. In all tests of Ahmad live bed scour was observed.

Recent investigations of bridge pier scour demonstrated that, see Figure 1, if $u_{cr} < u_0 < 2.5\ u_{cr}$ then the scour depth is a function of the sand size and flow velocity $u_0$, however,

if $u_0 > 2.5\ u_{cr}$ then the maximum scour is allmost independent of the sand size and of the flow velocity $u_0$ !

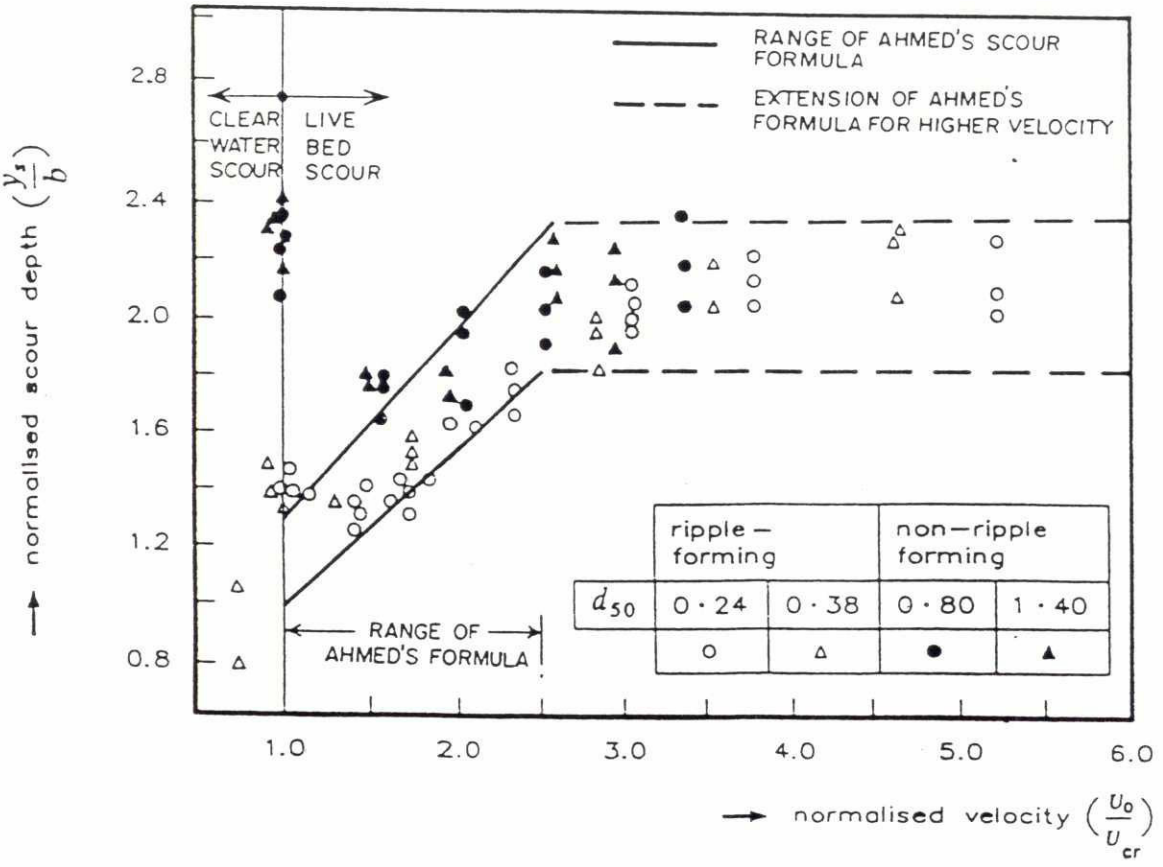


**Figure 1: Normalised scour depth around bridge piers as a function of the normalised flow velocity**

Data from a current research project (Kandasamy, 1989) showed that these tendencies are not only valid for bridge pier scour but also for scour near abutments ( Breusers and Raudkivi, pp 58, 1991). For the time being we assume that these tendencies are also applicable for the local scour near groynes on the basis of the similarities in the flow field around a groyne head and a bridge pier. A tentative tendency in the data of local scour near groynes suggests that the criteria $2.5\ u_{cr}$ for bridge piers should be replaced by $2\ u_{cr}$ for groynes.

In FAP 21/22 model investigations the model discharge has been selected to fulfill $u_0 \geq 2\ u_{cr}$ and therefore the local scour depth is allmost independent of the type of sand or the model discharge. It means that if $u_0 > 2\ u_{cr}$ the maximum local scour depth in the formula of Ahmad is a function of geometric parameters $h_0$ and B/(B–b) only, see Figure 2.

$$q_c = q_0 \cdot \frac{B}{B - b} \tag{3}$$

$$q_0 = h_0 \cdot u_0 \tag{4}$$

$$u_0 = 2 \cdot u_{cr} \tag{5}$$

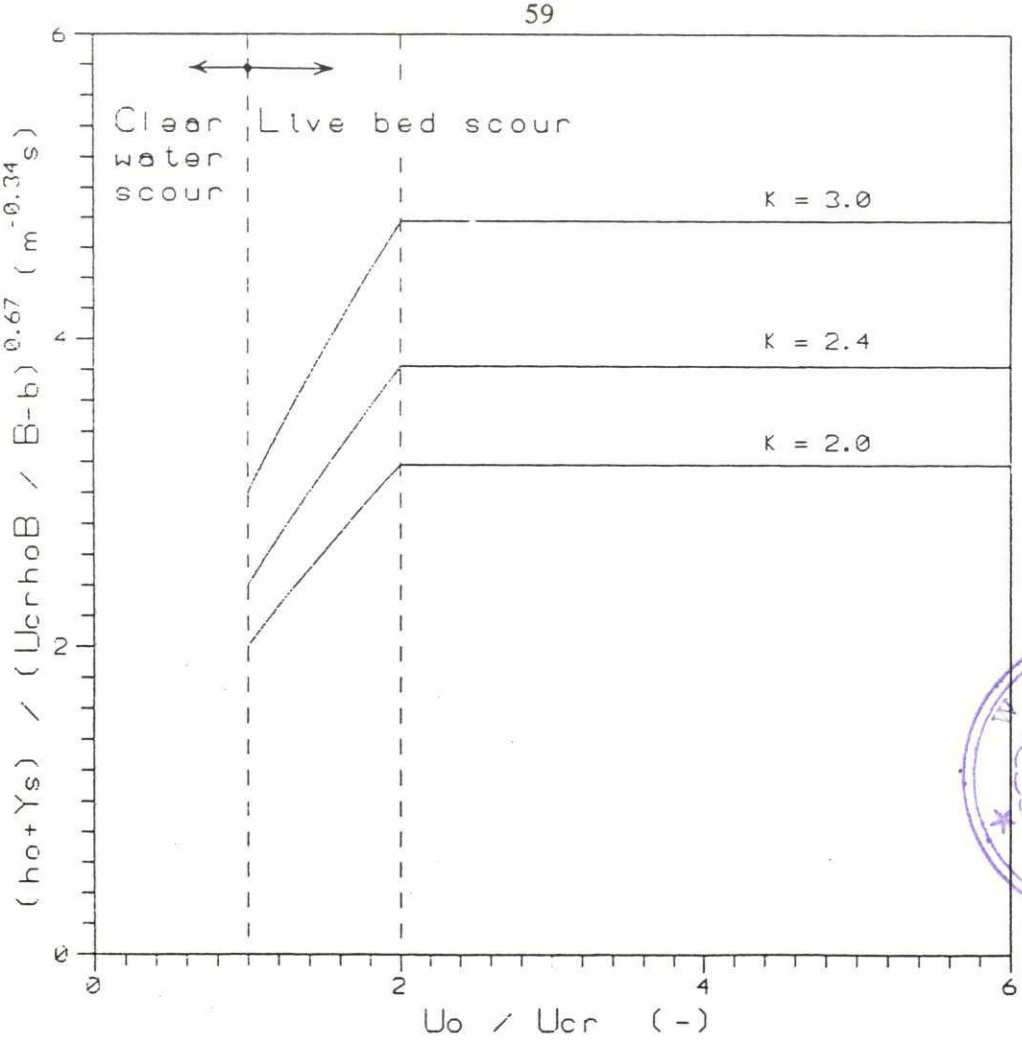




**Figure 2: Maximum scour depth near groynes as a function of the flow velocity**

Substitution of the above formulas in formula (1):

$$h_0 + y_s = K * (2\ u_{cr})^{0.67} * \left( \frac{h_0 * B}{(B - b)} \right)^{0.67} \qquad (6)$$

In the prototype the critical flow velocity is often rather low: for the Jamuna river about 0.6 m/s depending on the water depth. In design conditions for this river the flow velocity $u_0$ is always more than 2 $u_{cr}$.

## 3 VALUE OF COEFFICIENT K

Ahmad used in his physical model tests two types of sand with $D_{50}$ = 0.35 mm and 0.695 mm. He concluded that the sand type had no influence on the local scour depths. Probably this statement is based on an inaccurate extrapolation of the curve through his data-points to determine the equilibrium scour depth, because the measurements were made only during a short period of 2 or 3 hours after the start of the test. This means that probably Ahmad did not measure the equilibrium scour depth accurately. For comparison in FAP 21/22 model investigation the scour measurements were made during a period of 16 hours after the start of the test to determine the equilibrium scour depth and a new estimated extrapolation curve is made. The equilibrium scour depths determined by these extrapolated curves indicate that a coarse sand results in deeper scour holes and this effect was observed also in the studies of bridge pier

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scour, especially if
$1 < u/u_* < 2.5$, see Figure 1 (Breusers, 1991).
This means that the values for K recommended by Ahmad are too low and these values should be increased by approximately 20 %. For a single groyne of a vertical plate and perpendicular to a straight bank line K = 2 is recommended (Breusers and Raudkivi, 1991) and this value becomes: 2 * 1.2 = 2.4. In a recent investigation of DELFT HYDRAULICS, 1991 the local scour depth was measured near the head of a groyne made of a plate in a flume with a movable sand bed $D_{50}$ = 0.220 mm. The scour measurements were made during a period of 24 hours. Two tests in which $1 < u/u_* < 2$ confirmed this value of K, see Table 1.

| Test | $h_0 + y_s$ | $u_c$ | B - b | $q_c$ | K |
|---|---|---|---|---|---|
| - | m | m/s | m | $m^2/s$ | - |
| T5 | 0.29 to 0.34 | 0.30 | 1.05 | 0.042 | 2.4 to 2.8 |
| T7 | 0.35 to 0.40 | 0.39 | 1.35 | 0.058 | 2.3 to 2.6 |

**Table 1: Results of physical model tests by DELFT HYDRAULICS**

The investigated bend in Kamarjani model of FAP 21/22 is a rather sharp bend with K = 1.3. The influence of bends on the recommended values of K varies from K = 1.1 for a moderate bend to K = 1.4 for a sharp bend, see Breusers and Raudkivi, 1991. This is rather simple method to include the bend scour in the total local scour depth, but it is sufficient for this evaluation. In the Draft Final Report FAP 21/22, ANNEX 15, Special scour investigations, a more detailed method to calculate the influence of the bend scour is described.

Breusers and Raudkivi do not recommend a special value of K for a series of groynes, therefore each groyne of a series of groynes can be considered as independent of other groynes.

| Situation | K value |
|---|---|
| single groyne of a vertical plate, straight bankline | 2.0 * 1.2 = 2.4 |
| single groyne of a vertical plate, curved bend | 2.4 * 1.3 = 3.1 |

All groynes are perpendicular to the bank line

**Table 2: Recommended values of coefficient K**

In the next section these values of coefficient K are compared with the values of K determined from the results of the physical model tests.

## 4 VERIFICATION OF FAP 21/22 INVESTIGATIONS

In the Kamarjani model of FAP 21/22 one test, T5, has been performed with a series of three groynes made from plates and a vertical head. In all other tests more realistic permeable and impermeable groynes were built in. Based on the measurements of that test the value of coefficient K is estimated as accurate as possible with the following formula:

$$h_0 + y_s = K * (2u_{cr})^{0.67} * \left( \frac{h_0 * B}{(B - b)} \right)^{0.67} \qquad (7)$$

in which $h_0$ = 0.202 m, $u_{cr}$ = 0.18 to 0.20 m/s, B = 6.0 m and b = 0.80 m are substituted.

The approach flow velocity is estimated by:

$$u_0 = \frac{Q}{B * h_0} \qquad (8)$$

With Q = 0.420 $m^3/s$ and 0.480 $m^3/s$ it comes to

$$u_o = \frac{0.420}{6.0 * 0.202} = 0.35 \quad m/s \qquad (8.a)$$

and

$$u_o = \frac{0.480}{6.0 * 0.202} = 0.40 \quad m/s \qquad (8.b)$$

This approach flow velocity is just equal to 2 $u_{cr}$ and therefore it is expected that a further increase of the model discharge will not result in an increase of the scour depths.

| Test, groyne | $h_0 + y_s$ | K |
|---|---|---|
| - | m | - |
| T5, 1 | 0.62 | 3.0 to 3.3 |
| T5, 2 | 0.67 | 3.2 to 3.6 |
| T5, 3 | 0.595 | 2.9 to 3.2 |

**Table 3: Estimation of the value of K in test T5**

The value of K in test T5 varies between 2.9 and 3.6 and these values confirm K = 3.1 which is determined from the literature, Table 2. This can be considered as a reasonably good verification of the maximum scour depths measured in the physical model.

It can be concluded that the measured maximum scour depths in the physical model investigation for FAP 21/22 in the River Research Institute confirm the results of other investigations reported in the different literature. This is a strong indication that the physical model tests of FAP 21/22 are a reliable tool for the determination of the design scour depths.

## References


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# APPENDIX 2

## COMPARISON OF DESIGN FLOW PARAMETERS OF BRTS, FAP 1 AND FAP 21/22

### 1 INTRODUCTION

Both projects Brahmaputra River Training Studies (BRTS and FAP 1) and the Bank Protection and River Training (AFPM) Pilot project (FAP 21/22) have designed river training structures along the Jamuna river. A review of the design parameters regarding the design flow velocities and the design scour depths in the draft final reports of both projects have revealed the following.

### 2 APPROACH

Both projects used data of field surveys, literature, mathematical models and physical models to determine design parameters for river training structures. In principle this allows to compare the results of the physical models tests separately. This comparison is not presented for the flow velocities because a fair comparison is really complicated because of differences in set-up of the model testing, different definitions of parameters and a different analysis and interpretation of the physical model results. To a large extent these differences compensate each other and do not accumulate.

### 3 DESIGN PRINCIPLE

The basic design principle for river training structures along the Jamuna river as applied in both projects, differs significantly.

FAP 1 has selected to design permanent river training structures with a high safety level and expected low maintenance costs during the life time of the structure. Each river training structure is designed as non site specific and as a stand alone structure: its stability is not dependent on other river training structures in the vicinity. FAP 1 assumes that the worst condition can reproduce itself at any section of the river within the lifetime of the structure. The design life time of the structure is 30 years and the slope protection should resist a rare 100 year flow velocity. Owing to the morphological conditions the structure will be under severe attack during some periods and lesser attack at other times.

FAP 21/22 has selected to design a river training structure as a test structure with a relatively low level of safety and low maintenance costs during a possible life time of 10 to 15 years. After the monitoring phase of 3 to 5 years it is expected with a relatively high probability that the test structure will not be exposed to attack, during a couple of years. After this life time it is probable that the test structure needs extra reinforcement or protection by neighbouring river training structures to be upgraded to a permanent hard point. The toplayer should resist a 25 year flow velocity.

During the monitoring phase of the project the maintenance costs will be low. An important design criteria is that the test structure will be attacked by the flow during this monitoring phase and does not lay idle. This and other design criteria made the design of the test structures a site specific design which cannot be applied directly to other locations.

These different basic design principles were already implied by the Terms of Reference of both projects and these differences have resulted in different design flow velocities and design scour depths.

## 4 DESIGN FLOW VELOCITIES

The design flow velocities of FAP 1 are presented in Table 1 (see Section 9.3 Draft Main Report):

| Type of structure | Amplification factor | Design flow velocity (m/s) |
|---|---|---|
| Revetment: straight section | 1.1 | 3.7 |
| Revetment: upstream termination | 1.3 | 4.4 |
| Impermeable groyne: head of groyne | 1.4 | 4.8 |

**Table 1: Design flow velocities of FAP 1**

This assessment is based on evaluations and processes subjected to an integrated analysis giving probability functions of design flow velocities for a number of cases.

The design flow velocities FAP 21/22 are presented in Table 2 (see Section 9.4, Alternative designs of Draft Main Report):

| Type of structure | Design flow velocity (m/s) |
|---|---|
| Revetment: | |
| upstream termination | 3.5 |
| straight section | 3.5 |
| Permeable groyne: | |
| bed protection | 3.0 |
| pile structure | 2.5 |

**Table 2: Design flow velocities of FAP 21/22**

A comparison of the design flow velocities in both projects shows that the design flow velocities for revetments in FAP 1 are higher than the design flow velocities in FAP 21/22. This difference can be explained by the following reasons:

- The different design principles regarding the life time of the structures combined with the different safety levels results in the selection of different probabilities of exceedence for the design flow velocities.
- **The size of the design channel:**
  FAP 1 determined an extreme wide and deep channel in the worst case approach, with a water depth of about 20 m and steep side slopes after an analysis of the measured cross-sections along the whole Jamuna river.

  FAP 21/22 determined the average cross-section in the present channel near the test structures on the basis of a morphologic analysis of these channels. This cross-section does not have extreme side slopes nor extreme depths.
- **The size of the river training structures:**
  FAP 1 designed hard points which can be exposed to and resist extreme flow attack, and water depth after scour not less than the maximum naturally occurring water depth in the river.

FAP 21/22 test structures have a relatively smaller size and are designed as part of the bank with only a small embayments upstream and downstream of the test structure. This resulted in less extreme flow attack compared with the flow attack on FAP 1 river training structures.

- **A slightly different definition of the maximum flow velocity:**
  FAP 1 defined the design or maximum flow velocity as the extreme flow velocity somewhere above the toe of the bank protection or near the head of the groyne.

  FAP 21/22 defined the design flow velocity as the depth averaged flow velocity above the toe of the bank protection or near the head of the groyne. The difference between the two definitions is 10 to 15%.

These reasons explain the difference in the design flow velocities for the revetment sufficiently. The difference between the design flow velocities for the permeable and impermeable groyne, respectively 3.0 m/s and 4.8 m/s, can be explained by the difference between permeable and impermeable type of groynes and by the above mentioned reasons.

## 5 DESIGN SCOUR DEPTHS

The design scour depths of FAP 1 are presented in Table 3 (see Section 9.6 of Draft Main Report):

| Type of structure | Initial water depth (m) | Design scour depth related to the water level (m) |
|---|---|---|
| Revetment: straight section | 20 | 29 |
| Revetment: upstream termination | 20 | 33 |
| Impermeable groyne | 20 | 33 |

**Table 3: Design scour depths of FAP 1**

The design scour depths of FAP 21/22 are presented in Table 4 (see Section 9.4 of the Draft Main Report)

| Type of structure | Initial water depth (m) | Design scour depth related to the water level (m) |
|---|---|---|
| Revetment: straight section upstream termination | 17.3 | 22.3 to 28.3 |
| Hybrid permeable groyne: | 17.7 | 23.7 |

**Table 4: Design scour depths of FAP 21/22**

A comparison of the design scour depths in both projects shows that the design scour depths in FAP 1 are higher than the design scour depths in FAP 21/22. This difference can be explained by the same reasons as mentioned for the flow velocity. In addition it is mentioned that:

- the local scour depth near a hybrid permeable groyne is less than the local scour depth near an impermeable groyne.
- The relatively small difference in the scour depth near the termination and a straight section of a revetment found in FAP 1 is not specified in the design scour depths of FAP 21/22. This small difference can be caused by the small differences in geometry of both revetments.

It should be realized that the inaccuracy of these maximum scour depths is expected to be at least 1 to 2 m.

These reasons explain the difference in the design scour depths for a groyne and a revetment sufficiently.

## 6 MODEL TEST RESULTS

The measured maximum scour depths in the physical model testing can be compared more easily than the maximum flow velocities because the local scour depth near river training structures is mainly a function of the geometry. The main characteristics of some comparable tests are presented in Table 5.

| Project | Test No. | Type of Groyne | $h_o$(m) | L (m) | Total depth including Scour (m) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Groyne 1 | Groyne 2 | Groyne 3 |
| FAP 1 | 13A-/13B | Vertical | 15 | 80 | 42.5 | 43.5 | |
| FAP 1 | 17 | Sloping 1:3.5 | 20 | 152 | 40.5 | 32.2 | |
| FAP 21/22 | T2 | Sloping1: 4,3.5 & 3 | 12.8 | 80 | 43.0 | 35.6 | 30.6 |
| FAP 21/22 | T2 | Vertical | 12.8 | 80 | 46.6 | 48.6 | 45.6 |

L = length of the groyne (m)
$h_o$ = initial water depth (m)

**Table 5: Comparison of measured scour depths near groynes in the physical model testing of both projects**

The maximum scour depths near a vertical side caisson type groyne in Test T13 A and B can be compared with the maximum scour depths near a vertical sided plate type groyne in test T5 and the small difference can be caused by the different widths of the groynes.

In the same way a comparison can be made between groynes with a side slope 1:3.5 in test T17 and in test T2 and the small difference in scour depths cannot be explained by the difference in water depth, but may be differences in the layout of the approach channel have had some influence.

The result that the maximum scour depth near a vertical sided groyne is more than the maximum scour depth near a groyne with side slopes 1:3.5 confirms the observations in many other investigations.

The comparison shows that the measured maximum scour depths in the physical model testing of both projects are comparable.

In FAP 1 permeable groynes without bed protection were tested. The maximum scour depths were observed closed to the piles. In FAP 21/22 hybrid type groynes were tested with a bed protection and the maximum scour depth was measured downstream of the edge of the bed protection near the head of the groyne. This explains why the local scour depth near the hybrid permeable groynes in FAP 21/22 is rather small compared with the local scour depth near the permeable groynes tested by FAP 1.

It is mentioned that the scour depth measured near revetments in FAP 21/22 cannot be compared, because no comparable tests of FAP 1 were carried out. FAP 1 measured the local scour depth near a revetment with deep water upstream, simulating a deep embayment.

FAP 21/22 measured the local scour depth near a revetment with the normal water depth of the considered channel, because deep embayment upstream of the revetment is very unlikely during the life time of the test structure. This was a result of a morphologic analysis of channel patterns part of the selection of the location of the test structure. With this result the shape of the upstream termination of the revetment in FAP 21/22 has been optimized: a flow separation near the upstream termination of the test structure can be prevented by increasing the radius of the termination from 50 m to 450 m. This is only valid with a small embayment upstream of the revetment.

## 7 CONCLUSIONS

(a) Both projects FAP 1 and FAP 21/22 have used different design principles for the design of river training structures along the Jamuna river. FAP 21/22 design being site specific, but FAP 1 design being applicable to any location. These different basic design principles were the consequence of the different Terms of Reference of each project and these differences have resulted in different design flow velocities and different design scour depths.

(b) The difference in the design flow velocities and in the design scour depths can be explained almost completely. It is concluded that no serious inconsistency in the design values for flow velocities and scour depths can be observed from the Draft Final Report of the both projects.