第５章　環境予備調査結果

５－１　環境配慮実施の背景

JICAプロジェクトにおける環境配慮とは「開発プロジェクトにより著しい環境インパクトが生じるか否かを調査し、その結果を評価し、必要に応じ、環境インパクトを回避又は軽減するような対策を講じることである」と定義されている。JICAが推進する開発は、持続可能なものでなくてはならず、環境配慮は開発の持続性を確保するための必須の要件である。

バングラデシュ国のような開発途上国における環境配慮実施に際しては、対象国における環境配慮のための政策、体制が必ずしもよく整備されているわけではない現状を認識しつつ、先方関係諸機関の問題意識を把握したうえで、十分な協議を重ねていくことが重要である。したがって環境配慮は、対象国の意向に基づき、生活向上のための持続的な開発の推進と、適切な環境との調和に役立てることを基本方針として実施されるべきである。

５－２　環境法制度と行政組織の現状

(1) 国の政策

国家レベルの環境政策の方向性を規定した国家環境政策（National Environmental Policy）をはじめとして以下の政策がある。

1) 国家環境政策

1992年に制定された国家環境政策（National Environmental Policy 1992）は分野ごとの行動ガイドラインとともに、バングラデシュ国家の環境施策の枠組みを規定するものである。

この国家環境政策ではその目標として以下をあげている。

・環境保全及び改良により、生態系バランスの維持と国家全体の進歩と発展を図る。

・自然災害からの国土及び国民生活を守る。

・環境を悪化させるすべての活動を特定し、管理統制を図る。

・すべての天然資源の持続可能な利用を図る。

・環境関連の国際的先進機関と積極的な協調を図る。

この国家環境政策では、各産業セクターに対し、以下のような方針を示している。

例えば、工業セクターに対しては以下があげられる。

・生産活動において、環境汚染を引き起こす場合は、そのすべての段階で改善手段を講じること。

・すべての新しい公営・私営の生産事業に対し、環境影響評価を行うこと。

・環境汚染を引き起こす品物を製造するプラントの設立を禁止し、環境的に健全なプラ

ントの設置・開発を進めること。
・原材料の持続可能な利用と浪費の防止に心がけること。

エネルギー･燃料セクターに対しては以下があげられる。
・環境汚染を引き起こすような燃料の使用を避け、環境的に健全なあるいは環境負荷の小さい燃料の使用を進めること。
・燃料として木材や農業廃棄物の使用を避け、代替燃料の使用を進めること。
・バングラデシュ国に現存する回復可能なエネルギー源を保全すること。
・エネルギー資源や鉱物資源の採掘に関連するプロジェクトを遂行する前に環境影響評価を実施すること。

さらに、生態系保全を進める見地から、以下の方針も合わせ示している。
・野生生物をはじめとして生物多様性の保護、及び生態系保全に関連する研究の推進、及び関連するエリアの知識の普及と交換を推進すること。
・湿地帯の保護と開発及び渡り鳥の保護に努めること。

また、行政上の体制として以下があげられる。
・すべての環境影響評価は環境局（Department of Environment：DOE）が検討し、承認する。

この国家環境政策を受けて、以下の各政策が制定されている。
・工業政策1991（Industrial Policy, 1991）
・工業政策1999（Industrial Policy，1999）
・国家水資源政策1998（National Water Policy，1998）
・国家エネルギー政策1995（National Energy Policy，1995）
・電力政策1995（Power Policy，1995）
・私営電力政策（Private Power Policy）
・石油政策（Petroleum Policy）
・国家森林政策1994（National Forest Policy，1994）
・国家観光政策1992（National Tourism Policy，1992）
・国家保健政策1999（National Health Policy，1999）

(2) 行政組織

環境森林省(Ministry of Environment and Forest：MoEF)は、国家経済政策を決定する国家経済会議の執行委員会常任メンバーとして、バングラデシュ国の環境政策及び環境関連法に関するすべての問題に最終責任を負う体制になっており、以下の実施機関、専門機関を監督している。

- 環境局（Department of Environment：DOE）
- 森林局（Department of Forest：DOF）
- バングラデシュ林業開発公社（Bangladesh Forest Industries Development Corporation：BFIDC）
- 森林研究所（Bangladesh Forest Research Institute, FRI, and Institute of Forest）
- 農業研究委員会の森林部（Bangladesh Agricultural Research Council：BARI）
- 国立植物博物館（National Herbarium）

図５－１から図５－３にはDOEの組織図、活動内容、人員及び予算を示した。

５－３　初期環境調査、環境影響評価の実施体制

初期環境調査と環境影響評価は、日本人専門家の監督の下、ローカルコンサルタントに再委託して実施する。なお、ローカルコンサルタントへ再委託する際のTORについては、森林環境省及びJMBAの環境部とよく協議して決定するものとする。

初期環境調査については、Pre-F／Sにおいて小規模ながら行っている。本格調査における初期環境調査ではその結果を踏まえながら調査対象を広げ、全体像を捕らえるべく調査を進めるよう留意しなければならない。

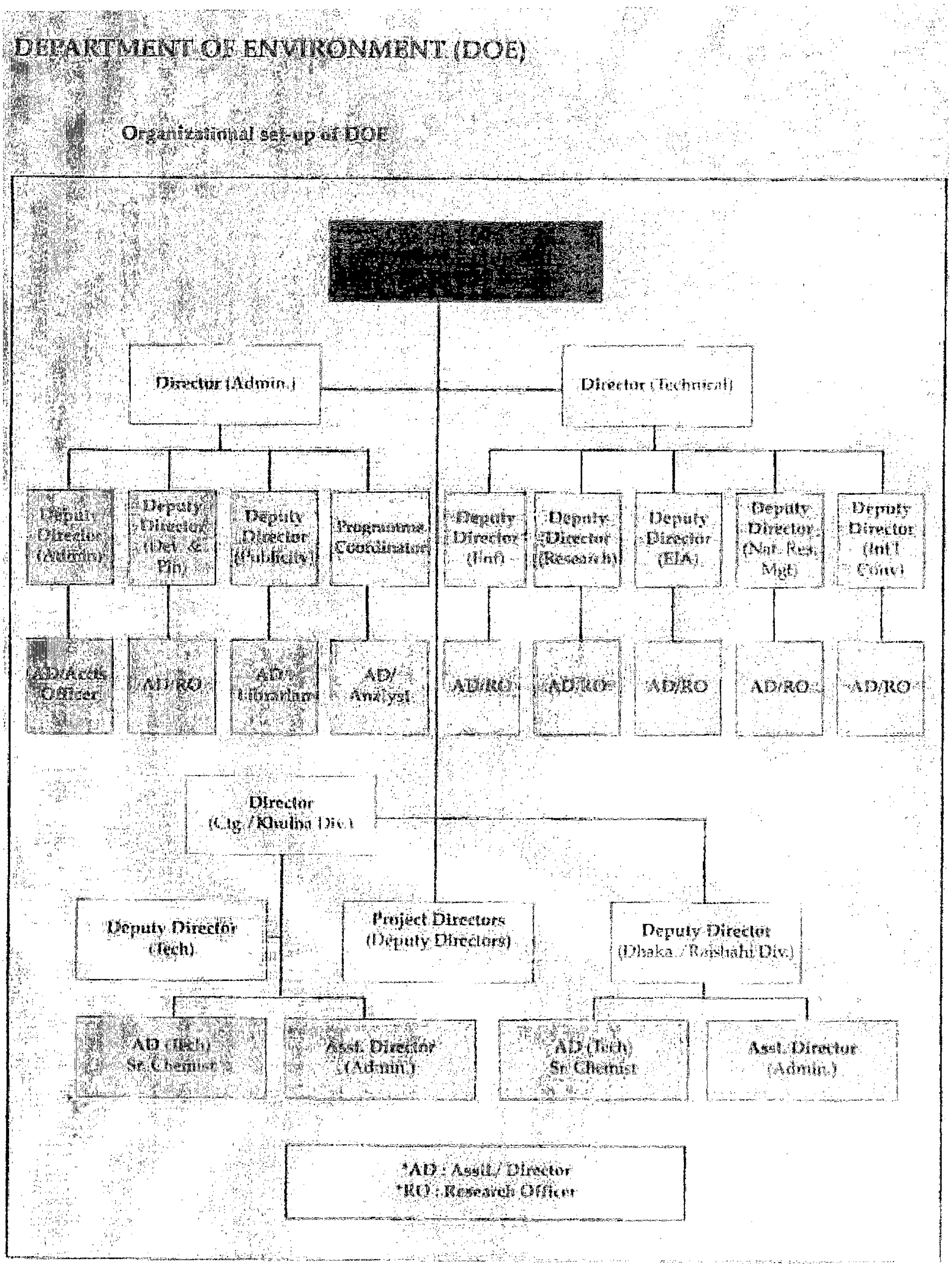
DEPARTMENT OF ENVIRONMENT (DOE)
Organizational set-up of DOE
Director (Admin.)
Director (Technical)
Deputy Director (Admin)
Deputy Director (Publicity)
Programme Coordinator
Deputy Director (Research)
Deputy Director (EIA)
Deputy Director (Nat. Res. Mgt)
Deputy Director (Int'l Conv)
AD/Accts Officer
AD/RO
AD/ Librarian
AD/ Analyst
AD/RO
AD/RO
AD/RO
AD/RO
AD/RO
Director (Ctg./Khulna Div.)
Deputy Director (Tech)
Project Directors (Deputy Directors)
Deputy Director (Dhaka./Rajshahi Div.)
AD (Tech) Sr. Chemist
Asst. Director (Admin.)
AD (Tech) Sr. Chemist
Asst. Director (Admin.)
*AD : Asstt./ Director
*RO : Research Officer

図５－１　DOEの組織図

DOE ACTIVITIES

Figure-2: Principal Activities of DOE

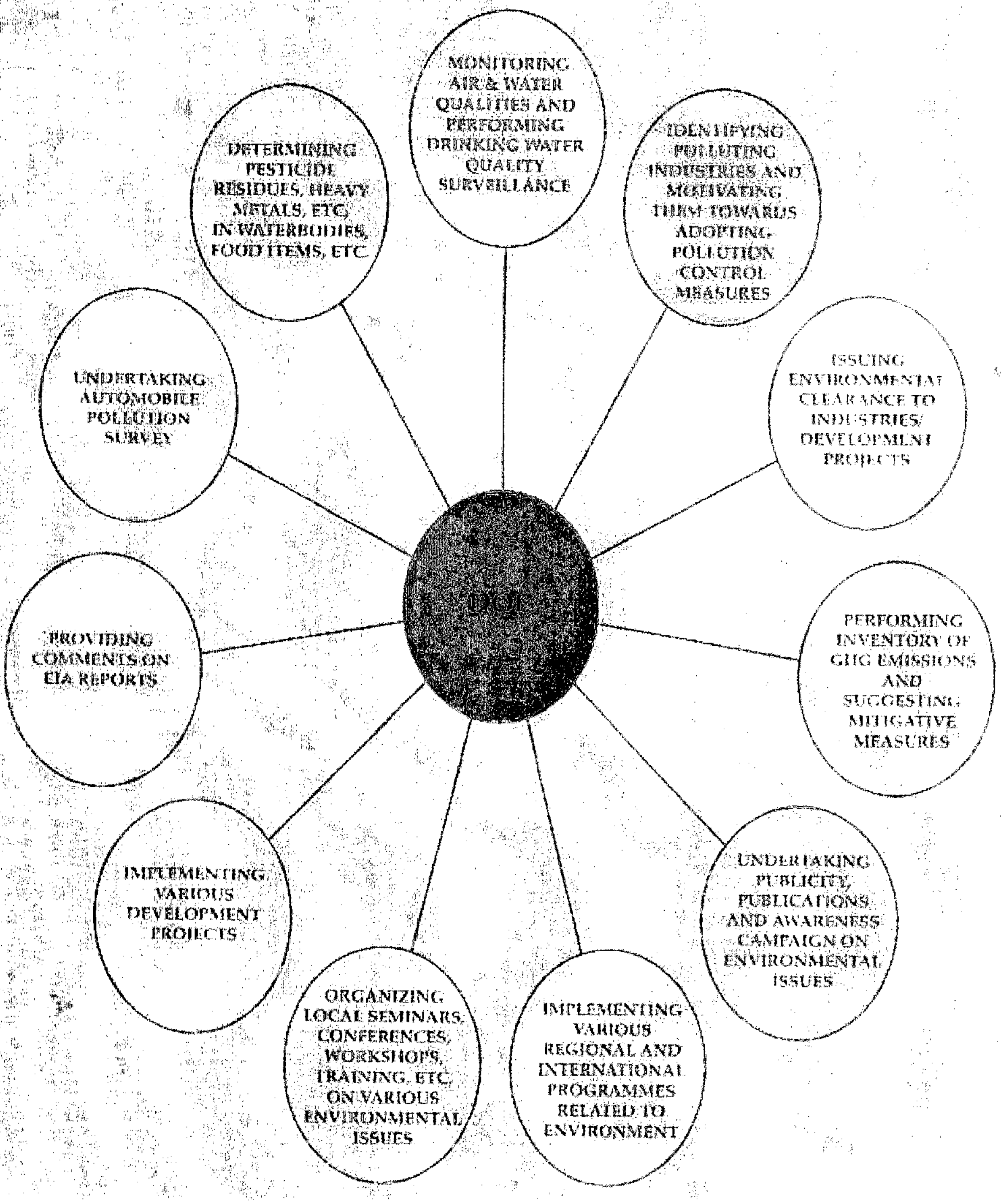

図５－２　DOEの活動内容

Table -2 : Existing manpower of DOE according to designations

Sl No.	Name of Post	Number of Posts
	Class -I	
1.	Director General	1
2.	Director	1
3.	Deputy Director	12
4.	Programme Coordinator	1
5.	Administrative Officer	1
6.	Asstt. Director (Technical)	15
7.	Asstt. Director (Admin.)	2
8.	Asstt. Director (Pub.)	3
9.	Senior Chemist	6
10.	Research Officer	7
11.	Analyst	3
12.	Accounts Officer	1
13.	Librarian	1
		Total=57
	Class-II	
14	Junior Chemist	6
15.	Asstt. Bio-Chemist	1
16.	Inspector	12
17.	Senior Technician	6
18.	Draftsman	3
		Total =28
19.	**Class-III**	62
20.	**Class-IV**	26
		Grand Total =173

Table -4 : Year-wise Revenue Budget of the Department of Environment since 1991-92

Financial Year	Allocation
1996-97	Tk. 1,34,45,000.00
1995-96	Tk. 1,19,65,000.00
1994-95	Tk. 91,00,000.00
1993-94	Tk. 86,20,000.00
1992-93	Tk. 69,65,000.00
1991-92	Tk. 79,15,000.00

Table -5: Year-wise Development Budget of the Department of Environment since 1991-92

Financial Year	Allocation
1996-97	Tk. 3,79,27,000.00
1995-96	Tk. 6,11,74,000.00
1994-95	Tk. 4,89,00,000.00
1993-94	Tk. 3,21,25,000.00
1992-93	Tk. 4,61,00,000.00
1991-92	Tk. 3,72,00,000.00

Table -3 : Break-up of Manpower at Headquarters and Divisional Offices

Serial No.	Class of Officers/ Employees	Head Quarters	Dhaka Division	Chittagong Division	[illegible] Division	Rajshahi Division	Total
1	Class-I	35	06	06	[illegible]	02	[illegible]
2	Class-II	04	08	06	[illegible]	01	28
3	Class-III	22	12	10	[illegible]	08	62
4	CLASS-IV	09	04	05	[illegible]	[illegible]	[illegible]
Total number of Officers/Employees		70	30	27	[illegible]	[illegible]	[illegible]

図５－３　DOEの人員及び予算

５－４　スクリーニング、スコーピング結果

調査団は、陸上現地踏査をマワ周辺で２回、アリチャ周辺で１回、更に航空機からの上空調査を両サイトについて１回行った。これら現地踏査及び上空調査やPre-F／Ｓレポートの初期環境調査の結果も参考にして、マワ周辺のサイトを前提に、JICAガイドラインの定型フォーマットにプロジェクト概要、プロジェクト立地環境を記入した。また、それらをベースにして、環境要素のスクリーニング、スコーピングを行った。現地踏査に使用した地図は、フェリー乗り場移設前の１/50,000地形図のみで、情報量が乏しくあまり役には立たなかった。表５－２から表５－６にプロジェクト概要、プロジェクト立地環境、環境要素のスクリーニング、スコーピングの結果を示す。

マワ周辺の集落は大きなものではないが、旧フェリー乗り場を中心として、川沿いにそれなりの農漁村集落を形成している。旧フェリー乗り場の脇には、レンガ工場が稼働していた。集落の住民は漁業にも従事しているようではあるが、生活の糧のほとんどは農業から得ているということであった。村落住民の生活のレベルは、バングラデシュ国の中では平均以上ではないかと思われ、村の子どもは、学校の制服を着ているものも見受けられた。レンガ工場の労働や、フェリー乗り場周辺での小商い等を生活の足しにしている住民も少なからずいるものと思われた。

Pre-F／Ｓでは、小規模な初期環境調査における社会経済状況調査の結果として、マワ付近の集落について以下が述べられている。

- 架橋プロジェクトで影響を受けるのは、左岸側（マワ側）では商工業者が多く、右岸側（マワの対岸側）では農業従事者が多い。
- 右岸側の農業は二期作、三期作を行っているのに対し、左岸側では一期作のみである。
- 左岸側の住民は右岸側の住民より豊かであるらしく、煉瓦製の耐久便所を持つ家の比率が左岸側で68%であるのに対し、右岸側では22%である。
- 耕作及び魚やエビを獲るために使っている池は左岸側の方が多い。
- 両岸ともに80～85%の住民が飲用水として井戸水を使っている。
- このあたりの主な農産物は、米、南京豆、野菜、ジュート、唐辛子等である。

なお、調査団が踏査に訪れたときには、マワの村落内に立派なモスクが建設中であった。

アリチャフェリーターミナルは、マワフェリーターミナルに比してかなり規模が大きい。また運航されているフェリーはその過半数が、船体の前後に昇降口のある乗降効率の良いものであり、船体もマワのフェリーより二回りほど大きいものであった。フェリーの船着場は、確認できただけでも５か所あり、１㎞くらいの範囲に広がっていた。フェリーターミナル周辺に集まっている商店街もマワに比して大きく、活気があるように感じられた。

アリチャにはインドから運ばれてくる牛が数多く見られ、船から下ろした牛をトラックに載せ

表５－２　プロジェクト概要のフォーマット、道路

項　目	内　　容
プロジェクト名	バングラデシュ国　パドマ橋建設計画調査
背　景	パドマ橋の建設により、国土の南西部と中央部が結ばれ、全国的な道路網が連結することとなる。
目　的	マワにおけるパドマ川橋梁の建設
位　置	マワ
実施機関	Jamuna Multipurpose Bridge Authority, Ministry of Communications
裨益人口	南西部諸県の人口2,900万人
計画諸元	４車線の道路橋、送電線、ガスパイプラインへのリザーブも視野に入れる。鉄道併用橋の代替案も考慮する。
計画の種類	新設
計画道路の性格	一般道路（橋梁部は有料）、農漁村、平地部
計画年次／交通量	1999年　5,200台／日
延長／幅員／車線数	橋長６km／幅員17.2m／４車線
道路構造	盛り土、高架及び橋梁
付属施設	鉄道、ガスパイプ、送電線、通信線
その他特記すべき事項	

注：記述は既存資料により分かる範囲内とする。

表５－３プロジェクト立地環境のフォーマット（道路）

項　目		内　　容
プロジェクト名		バングラデシュ国　パドマ橋建設計画調査
社会環境	地域住民（居住者／先住民／計画に対する意識等）	川沿いに点在する農漁村の村落住民、計画に対してはおおむね好意的。
	土地利用（都市／農村／史跡／景勝地／病院等）	農業が主の農漁村。村落部もあり。近くにレンガ工場、モスク、学校がある。
	経済／交通（商業･農漁業・工業団地／バスターミナル等）	村落住民の生活は、漁業も行ってはいるもののあくまで農業が中心の様子。フェリーターミナル周辺での小商い、レンガ工場での労働に従事しているものもあり。
自然環境	地形・地質（急傾斜地・軟弱地盤・湿地／断層等）	低地、洪水の危険性あり。砂質シルトからシルト質砂の地盤。
	貴重な動植物（自然公園･指定種の生息域等）	JMBA及び村民への聴取では特にない。
公害	苦情の発生状況（関心の高い公害等）	特になし
	対応の状況（制度的な対策／補償等）	特にないと思われるが不明
その他特記すべき事項		特になし

表５－４　スクリーニングのフォーマット（道路）

環境項目			内　　容	評　定	備　考（根拠）
社会環境	1	住民移転	用地占有に伴う移転（居住権、土地所有権の転換	有･無･不明	小さいながらも農漁業を中心とした村落共同体を形成している。
	2	経済活動	土地等の生産機会の喪失、社会構造の変化	有･無･不明	計画地に農地、住宅地、船どまりなどがある。またレンガ工場もある。
	3	交通・生活施設	渋滞・事故等既存交通や学校・病院への影響、舟運等既存交通への影響	有･無･不明	フェリー交通は影響を受ける。近くにモスク、学校はあるが、病院は不明
	4	地域分断	交通の阻害による地域社会の分断	有･無･不明	計画道路が村を分断する可能性が高い。
	5	遺跡・文化財	寺院仏閣・埋蔵文化財等の損失や価値の減少	有･無･不明	モスクがあるが、計画地に入るかどうかは微妙。
	6	水利権・入会権	漁業権、水利権、山林入会権等の阻害	有･無･不明	特に建設中には漁業に影響が出ると思われるが、権利関係は不明
	7	保健衛生	ゴミや衛生害虫の発生等衛生環境の悪化	有･無･不明	ゴミ等の発生はない。
	8	廃棄物	建設廃材･残土･一般廃棄物等の発生	有･無･不明	建設廃材、残土等の発生は考えられる。
	9	災害(リスク)	地盤崩壊･落盤、事故等危険性の増大	有･無･不明	洪水の発生、川岸の侵食に影響が出る可能性がある。
自然環境	10	地形・地質	掘削・盛土等による価値のある地形・地質の改変	有･無･不明	川の護岸工事で川岸の位置等が変わる可能性あり。
	11	土壌浸食	土地造成・森林伐採後の雨水による表土流出	有･無･不明	川岸の侵食、土砂の堆積等の可能性あり。
	12	地下水	掘削に伴う排水等による涸渇、過剰揚水や涵養能力の低下による涸渇、浸出水による汚染	有･無･不明	地下水揚水はないと思われる。
	13	湖沼・河川流況	埋め立て、排水の流入、放水路による流量、流速、河床の変化	有･無･不明	河川に橋脚が立つので、流路、流速、河床の侵食に変化が生じる可能性がある。
	14	海岸・海域	埋め立て、沿岸漂砂の変化、海況の変化による海岸侵食や堆積	有･無･不明	海岸地域ではない。
	15	動植物	生息条件の変化による繁殖阻害、種の絶滅	有･無･不明	野生動植物の生息地域ではない。
	16	気象	大規模造成や建築物による気温、風況等の変化	有･無･不明	気象変化を引き起こす行為はない。
	17	景観	造成による地形変化、構造物による調和の阻害	有･無･不明	景観阻害を引き起こすおそれは少ない。
公　害	18	大気汚染	車両や工場からの排出ガス、有害ガスによる汚染	有･無･不明	供用開始後に自動車排気ガスによる大気汚染が考えられる。
	19	水質汚濁	土砂や工場排水の流入、水量の減少による水質の汚濁	有･無･不明	重大な水質汚濁を引き起こすような行為はないが、建設中に若干の水質汚濁の可能性がある。
	20	土壌汚染	粉じん、農薬、アスファルト乳剤等による汚染、排水・有害物質等の流出・拡散等による汚染	有･無･不明	土壌汚染物質の発生はない。
	21	騒音・振動	車両の走行、ポンプの稼働等による騒音･振動の発生	有･無･不明	自動車騒音、振動の影響はある。
	22	地盤沈下	地盤変状や地下水位低下に伴う地表面の沈下	有･無･不明	地下水揚水はないと思われる。
	23	悪臭	排気ガス・悪臭物質の発生	有･無･不明	悪臭の発生要因はない。
総合評価：IEE あるいは EIA の実施が必要となる開発プロジェクトか				要・不要	影響の考えられる項目が複数ある。

表５－５　スコーピングチェックリスト

環境項目			評定	根　　拠
社会環境	1	住民移転	A	計画路線が農漁村の中を通る。
	2	経済活動	B	計画路線は農地、住宅地及びレンガ工場を通る。
	3	交通･生活施設	B	計画路線が学校の近くを通過するおそれあり。
	4	地域分断	B	アプローチ部が村を分断する可能性あり。
	5	遺跡・文化財	C	計画路線がモスク近くを通過する可能性がある。
	6	水利権･入会権	C	漁業に影響があるものと考えられるが漁業権については不明。
	7	保健衛生	D	保健衛生状況は悪化しない。
	8	廃棄物	B	建設廃材の発生が考えられる。
	9	災害(リスク)	C	洪水の発生、川岸の侵食に影響が出るかもしれない。
自然環境	10	地形・地質	A	川岸の位置が変わるおそれがある。
	11	土壌浸食	A	川岸で侵食、土砂の堆積が起こる可能性あり。
	12	地下水	D	地下掘削はなく、地下水への影響はない。
	13	湖沼・河川流況	A	河川中に橋脚が立つので流況が変化するおそれがある。
	14	海岸・海域	D	海岸・海域ではない。
	15	動植物	D	貴重な動植物の生息地は存在しない。
	16	気　象	D	気象への影響は考えられない。
	17	景　観	D	景観阻害を起こすおそれはない。
公　害	18	大気汚染	A	供用後の通過交通による排気ガスにより､影響が出る可能性がある。
	19	水質汚濁	B	工事中にのみ水質汚濁の可能性がある。
	20	土壌汚染	D	土壌汚染物質の使用、発生はない。
	21	騒音・振動	B	供用後の通過交通による騒音振動の影響は若干出る可能性がある。
	22	地盤沈下	D	地下水の汲み上げはない。
	23	悪　臭	D	悪臭の発生はない。

注１：評定の区分

Ａ：重大なインパクトが見込まれる。

Ｂ：多少のインパクトが見込まれる。

Ｃ：不明（検討をする必要はあり、調査が進むにつれて明らかになる場合も十分に考慮に入れておくものとする。

Ｄ：ほとんどインパクトは考えられないためIEEあるいはEIAの対象としない。

注２：評定にあたっては、該当する項目別解説書を参照し、判断の参考とすること。

表５－６　総合評価

環境項目	評定	今後の調査方針	備　考
１．住民移転	A	移転対象地域の現況調査、移転候補地の現況調査	
10. 地形・地質	A	過去の流路の変遷を調査、河道変動のシミュレーション	
11. 土壌侵食	A	河岸侵食のシミュレーション	
13. 湖沼･河川流	A	流況のシミュレーション	
18. 大気汚染	A	大気の現況調査、大気汚染予測	
２．経済活動	B	レンガ工場現況調査、農地・住宅地の現況調査、世帯収入の調査	
３．交通・生活施設	B	学校・病院等、生活施設の分布調査、現況調査	
４．地域分断	B	コミュニティーの分布調査	
８．廃棄物	B	廃棄物の種類、量の予測	
19. 水質汚濁	B	水質の現況調査、汚濁予測	
21. 騒音・振動	B	騒音・振動の現況調査、騒音･振動の予測	
５．遺跡・文化財	C	計画路線近傍の宗教施設、遺跡･文化財の現況調査	
６．水利権・入会権	C	漁業権の実情調査	
９．災害（リスク）	C	洪水のシミュレーション	

る前に休憩させるための広場が、船着場に隣接して２か所もあった。また、港に隣接してコンクリートの電柱を作る大きな工場があり、実際に稼働していた。その工場は川に製品積み出しのための専用ジェティを建設していたようであるが、我々が踏査したときには既に壊れていた。我々が踏査したときには、船着場のすぐ先の川を航路確保のため、浚渫していた。また、船着場のある川岸が侵食されており、くい打ちとサンドバッグにて護岸工事が行われていた。フェリーターミナル背後の集落はマワのものに比して大きいと見受けられたが、その住民の生活形態等を確認することはできなかった。

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第６章　本格調査への提言

６－１　調査の基本方針

(1) 調査の背景

バングラデシュ国の国土は大河川により４地域（東部、北央部、北西部、南西部）に分割されており、国内道路交通網も各地域と首都ダッカのある北央部とを結ぶ形で発達してきた。これらの地域を結ぶ道路幹線網のうち、北央部と北西部、北西部と南西部及び北央部と東部を結ぶ渡河橋梁は順次整備されてきているが、北央部と南西部を結ぶ道路はいまだパドマ川で分断されている。北央部と南西部を結ぶ幹線国道である国道７号線、８号線はともにフェリーによる渡河に頼っており、このパドマ川による道路の分断はバングラデシュ南西部の道路交通網構築のネックとなっている。バングラデシュ南西部には、第３の都市クルナや第２の海港モングラ港があり、道路網整備の遅れは南西部だけでなく、バングラデシュ国全体における社会・経済発展の阻害要因となっている。

また、バングラデシュ国の南北を縦断するアジアハイウェイA-１はダッカを通りインド国カルカッタ市につながる対インド貿易の重要な道路である。国道８号線のダッカからパドマ川を渡りバンガに至る区間は、このアジアハイウェイA-１を構成する道路で、アジア開発銀行（ADB）の支援の基に1999年より改良・拡幅工事が行われているが、パドマ川の架橋は含まれておらず、道路網整備の課題解決には至っていない。

上記の背景から、1998年バングラデシュ国政府は、国道８号線の渡河地点（マワ付近）のパドマ川に架かる橋梁建設計画策定に係る協力を我が国に対し要請してきた。2001年、我が国は調査を円滑に実施するため事前調査団を派遣した。要請書における橋梁計画案は道路、鉄道及び公共物添架を含む多目的橋梁であったが、鉄道網の将来計画が定かでないため、調査は道路橋（公共物添架を含む）として実施することで合意し、S／Wを署名・交換した。

(2) 調査の目的

本調査はバングラデシュ国政府の要請に基づき、以下を目的とする。

1) ダッカ－クルナ間のパドマ川において建設予定の橋梁（以下、「パドマ橋」と記す）のF／S調査を実施すること

2) 調査の実施を通じて、バングラデシュ側C／Pへの技術移転を行うこと

６－２　調査対象範囲

アリチャーマワ間のパドマ川周辺地域を調査対象地域とする。ただし、パドマ橋建設に伴う広域的な社会経済的インパクトの検討は、インド、ネパール、ブータン、ミャンマーも調査対象地域とする。

６－３　調査項目とその内容、範囲

本件調査の内容は、次のとおりとする。

なお、本件調査にあたっては、バングラデシュ国側への技術移転に配慮することとし、調査業務の計画・実施はC／Pと十分な協議、打合せを基に行うこととする。

また、調査において使用される各種のデータ及び、その手法が調査終了後にバングラデシュ国側で活用可能となるように調査方法を工夫するとともに、調査期間中の技術移転のために必要となるプログラムを調査工程に含めることとする。

(1) 関連データ・情報の収集及びレビュー

下記の項目について、関係諸機関(C／P機関のみではなく、バングラデシュ国政府機関や民間会社等も含む) に働きかけ、既存資料･データ･図面･情報の収集･分析を行う。

1) 社会・経済・産業関連資料

社会・経済フレームワークを策定するために必要なバングラデシュ国の社会・経済資料（人口、GDP、貿易、産業構造、投資配分、自動車登録台数等）を調査する。

2) 関連開発計画及びレポート

既存の交通計画、道路計画、土地利用計画等の関連開発計画をレビューする。また、バングラデシュ国又は他のドナーが実施した、あるいは実施中の関連調査結果等のレビューを行う。

3) 財務資料

道路予算、財源、外国からの資金援助等の財務資料

4) パドマ橋関連組織の現況把握

パドマ橋建設計画及び維持管理計画の検討のため、組織の構成、意思決定方法、責任体制、予算等を調査する。

5) 道路整備計画

パドマ橋建設の効果促進に寄与する道路整備を検討するため、バングラデシュ国の全土における道路整備状況につき整備完了、実施中及び将来の整備が見込まれる道路を含め調査する。

6) 交通関連資料

南西地域と他の地域間の道路、鉄道、フェリー内陸水運による旅客及び貨物交通量のデータを収集・分析する。

7) 周辺諸国との交易資料

インド、ネパール、ブータン及びミャンマー等の周辺諸国との交易の現状と国境通過交通量。

8）道路、鉄道、橋梁に関する資料

下記の項目に関する基礎データを収集し、分析する。

・設計基準等の技術資料

・主要河川に架かる（建設中を含む）橋梁の設計、施工及び維持管理に関する資料

9）設計単価（材料・労務・機械の国内／輸入市場及び経済価格、国外調達先、調達可能量、国内輸送費等）に関する資料

10）自然・環境条件

・自然条件（土質・地質、測量、水文、気象、地震等）に関する資料

・環境に対する法律、規制及び環境基準等に関する資料

11）住民移転・用地買収等に対する法律、事例に関する資料

12）その他関連するデータ・情報

必要に応じその他関連するデータ・情報を収集・分析する。

(2) 現況交通調査・分析

1）既存交通調査の分析

既存交通データを用いて交通現況を把握するとともに補足交通調査の実施資料とする。

2）補足交通調査

ダッカのある北東地域とクルナのある南西地域間の現況交通状況を把握するとともに、将来交通量推計モデル構築資料にするため、パドマ川をスクリーンラインとした交通調査を実施する。また、南西地域はクルナ市を中心とするゾーンと、バリサル市を中心とするゾーンに大別されるため、両ゾーンへの交通を調査する。

a）断面交通量調査

① 断面交通量調査を実施し、以下の内容を把握する。

・上下線車種別交通量

・大型車混入率

② 観測地点

アリチャ及びマワのフェリー渡河地点、ファリドプル・ジャンクション、タケルハット・ジャンクションの計４地点において24時間、３日間実施する。

b）路側OD調査

アリチャ及びマワのフェリー渡河２地点において24時間、３日間実施し、以下の内容を把握する。

・車種別OD

・車種別乗車人員

・貨物OD

・貨物積載量

c）ダッカ市サダルハット港での交通量調査

サダルハット港と南西地域間を往来するフェリーの南西地域の発着港別乗客数と、便数について24時間、３日間実施する。

(3) 需要予測（目標年次2025年）

1）周辺国家を含んだゾーニングと社会経済フレームの設定

2）現在の旅客及び貨物のOD表の作成

3）道路、鉄道、内陸水運等の各交通モードの機関分担を分析する。

4）将来OD表の作成

5）交通量配分（将来の旅客及び貨物量の配分を予測する）

6）橋梁の交通量の予測（パドマ橋を通過すると想定される旅客及び貨物の交通量を予測する）

7）周辺諸国のインド、ネパール、ブータン、ミャンマーとの国境通過交通の予測

(4) 架橋位置と線形の検討

過去の河岸線の移動履歴と河岸侵食速度等のデータから河道の安定性を調査し、設計耐用年数である100年間、十分にその機能を供用できる架橋地点を検討する。さらに、河道の安定性の調査結果に基づく複数の線形代替案を検討し、最適な架橋位置を選定する。検討対象渡河地点は、最初に主として河川･水文の条件、及び道路網整備計画との関連から最初に２地点に絞るものとする。この２地点に対して行われる自然条件、環境、交通調査結果を踏まえ、概略橋梁形式、護岸工、施工計画等を検討し、建設コスト、社会経済分析結果を基に、総合的に最適な架橋位置の提案を行う。

(5) パドマ橋への接続道路計画

調査対象地域の既存道路及び道路計画を調査し、最適な接続道路計画を検討する。

(6) 自然条件調査１

検討対象渡河地点を２か所に絞り込み、それぞれに対して測量、土質･地質調査を行う。

1）測　量

a）ベンチマークの設置

GPSを用い、両渡河地点とも、パドマ川両岸に１か所ずつベンチマークを設置し、SOB

基準点とリンクさせる。

b) 中心線及び縦断測量

路線中心線及び縦断測量を行う。縦断測量については、陸上部は水準測量、河川部は深浅測量を行う。

2) 土質・地質調査

a) ボーリング調査

両渡河地点とも、パドマ川両岸で以下のボーリング調査を行い、室内土質試験もともに行う。

・アバットメント位置を念頭に120m程度の深度まで１本ずつ

・取り付け盛り土を念頭に40m程度の深度まで１本ずつ

・橋梁予定地点からやや離れた地点（２km以内）で、ハードポイントとなる可能性のある場所をねらい40m程度の深度まで２本ずつ

3) 水文調査

調査対象地域のパドマ川の流速、流量、河床変動、年間水位、洗掘、河岸侵食等のデータの収集・分析を行い、最適渡河地点選定の資料とする。

(7) 初期環境調査

1) 初期環境影響調査（IEE）

架橋予定地点において影響の見込まれる環境項目について現況調査を行い、初期環境調査を実施する。

2) 初期社会影響調査（ISIE）

家屋・住民移転、民間水運業者への影響、フェリー利用者への影響、農地の減少等、本プロジェクトにより影響を受けると想定される項目について現況調査を行い、初期社会環境調査を行う。

(8) 公共添架物の検討

パドマ橋に添加されるガスパイプライン､送電線､通信線等につき将来計画を含め調査し、橋梁の設計に考慮すべき重量、専有空間及び添架方法を検討する。

(9) 設計基準の設定

バングラデシュ国側の現地基準やニーズを踏まえて設計基準を設定する。また、航路の位置、ナビゲーションクリアランス、洗掘・侵食等に関する技術的条件を設定する。

(10) 自然条件調査２

１か所に絞った最適渡河地点において、測量、土質･地質調査、水文調査を行う。

1) 測　量

a) 中心線及び縦断測量

路線中心線を出し、中心線上の地盤標高を50mごとに測定する。

b) 路線沿いの現況・地形測量

路線沿いに幅100mで現況・地形測量を行う。

c) 路線横断測量

路線横断面を中心線上50mごとに測定し、横断図を作成する。

d) 川岸の現況・地形測量

渡河地点から上下流方向にそれぞれ４kmにわたり、幅200mで川岸の現況・地形測量を行う。

e) 川岸の横断図作成

渡河地点から上下流方向にそれぞれ４kmの区間で、川岸の横断面を100mごとに作成する。作成にあたっては、上記の川岸の現況・地形測量及び後述する河川部の深浅測量の結果を使い、陸上側200m、川側200mの範囲をカバーするものとする。

f) 深浅測量

渡河地点から上下流それぞれ４kmの区間で行う。水深の測定にあたっては、水位標を設けて、標高とのキャリブレーションを常に行うものとする。

2) 土質・地質調査

a) ボーリング調査

最適渡河地点候補地において以下のボーリング調査、室内土質試験を行う。

- アバットメントと中洲における橋脚を念頭に深度120m程度までのボーリングを計４か所
- 取り付け盛り土、高架部を念頭に深度40m程度までのボーリングを計８か所
- 護岸工事、ハードポイント候補地を念頭に深度40m程度までのボーリングを計８か所
- 盛り土材用土質試験

3) 水文調査

a) 流速測定

架橋予定地点の上流と下流で各１断面、合計２断面で行う。測定は雨期に２回、乾期に２回（満潮時、干潮時）行うものとする。測定は、流速計かADCPを用いて行い、河川断面、水位のデータとともに検討し、水量を求める。

(11) 構造形式の比較検討

複数の構造形式代替案について予備的設計を行い、施工性、維持管理性、経済性等を考慮し、最適な構造形式を選定する。

(12) 概略設計

橋梁、接続道路、河川改修、護岸等の概略設計を行う。概略設計図は、事業費概略積算に必要なすべての図面を作成する。また、用地取得と移転補償費算出のため、用地取得図（永久占用）を作成する。

(13) 施工計画の検討

概略設計を基に資材計画、施工方法、施工機械・設備、架設工、及び工事工程の概略施工計画を策定する。また、架設占用面積の算出のための用地取得図を作成する。

(14) 環境影響評価（EIA）

IEEにて特定された社会環境・自然環境要因について、調査・測定し、結果を分析する。

・社会環境影響

・自然環境影響

・住民移転計画の作成

・環境管理計画の作成

(15) 維持管理計画、運営計画の検討

維持管理項目を選定し、項目ごとに頻度・内容を整理した維持管理計画を作成する。運営組織、要員数を設定する。

(16) 事業費の概略積算

事業費概略積算には以下の費目を含める。

・建設工事費

・設計監理費（入札手続き、工事管理等）

・用地取得費及び移転補償費、税金、予備費

(17) 経済分析・財務分析

・国内及び周辺国を含んだ社会経済インパクト分析

・経済評価（国内及び周辺国を含んだ社会経済インパクト分析結果を考慮）

・料金体系の検討

・資金調達方法の検討

・民間セクター参入に係る検討

・国家財政への影響の検討

(18) 事業実施計画の検討

事業実施に向けてバングラデシュ国政府が今後、検討すべき事項について明確にする。

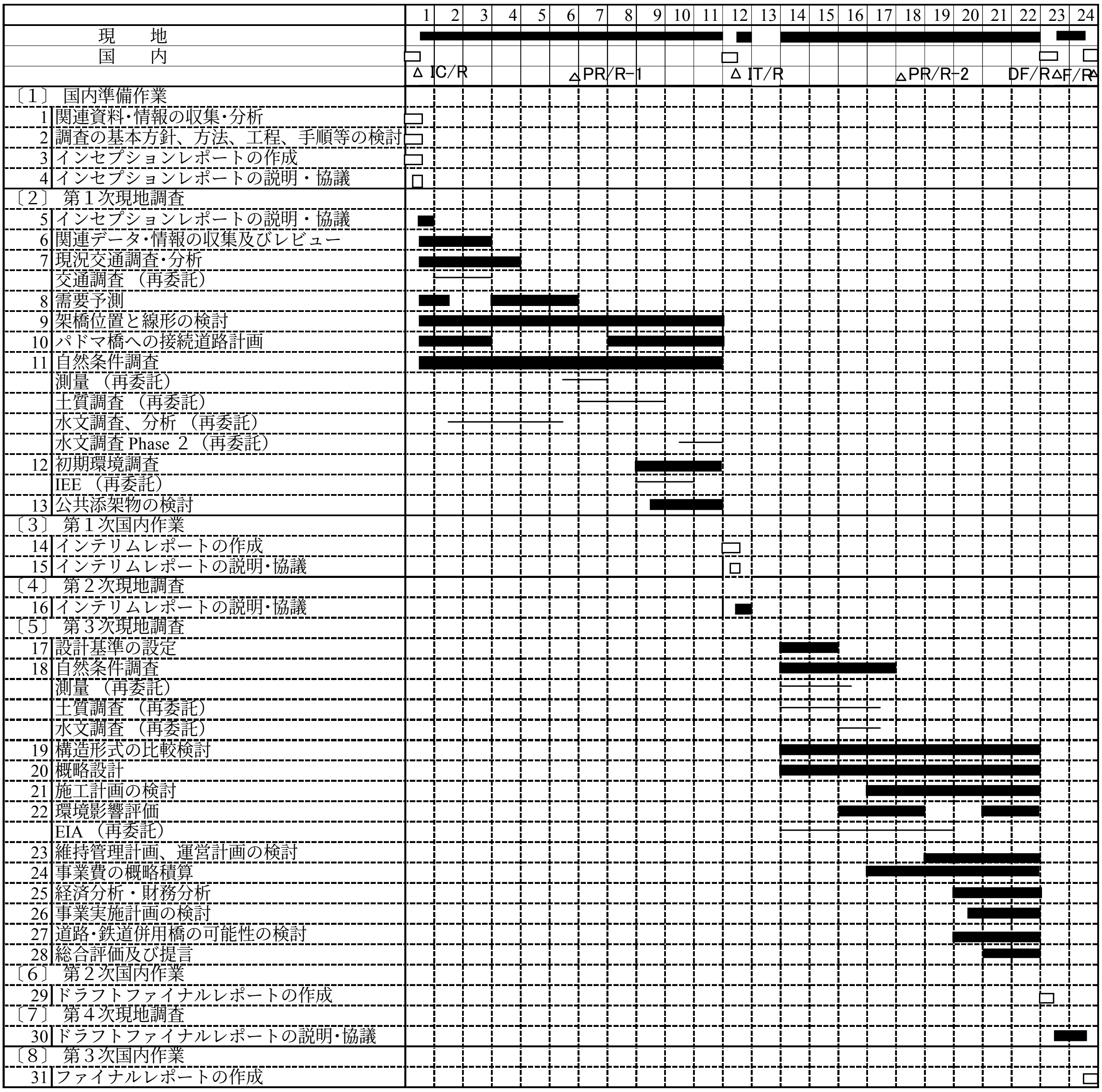
(19) 道路・鉄道併用橋の可能性の検討

道路橋の概略設計を基に、パドマ川渡河部分の構造（橋梁部）のみ単線の鉄道（軌間1,676㎜）が載荷する道路・鉄道併用橋について検討する。概略設計では、橋梁部に鉄道単線及び道路が載荷した場合の橋梁の断面構成を決定し、構造（上下部工）の安定計算を行う。概算積算は、橋梁部について道路・鉄道併用橋の建設費、アプローチ部は道路のみの建設費を用いて算出し、経済・財務分析を実施する。

(20) 総合評価及び提言

事業実施計画、維持管理・運営計画、環境影響、住民移転等の社会影響を総合し、プロジェクトに対する総合的な評価を行う。

６－４　調査スケジュール



IC/R：　Inception Report

PR/R-１：Progress Report １

IT/R：　Interim Report

PR/R-２：Progress Report ２

DF/R：　Draft Final Report

F/R：　Final Report

６－５　調査実施上の留意点

(1) パドマ橋の主機能

パドマ橋は道路橋として調査･計画されるものの､将来の接続鉄道整備を整備を考慮して、道路橋としての調査・計画終了後に、鉄道利用の可能性の検討を実施する（鉄道が利用できる空間を確保した断面形状にて､列車荷重を考慮した構造計算及び橋梁のコスト積算を行い、経済・財務評価を実施する）。

(2) パドマ橋の架橋地点選定

1) 事前調査にて入手した既存データでは、マワはパドマ橋架橋地点のひとつの候補だと考えられるものの、現時点でマワを最適地点だと結論づけることはできない。

2) パドマ橋の設計耐用年数である100年の間、十分にその機能を供用できるよう､架橋地点は慎重に検討がなされるべきである。

3) 架橋位置選定手法については、現地調査報告を参考とする。

(3) パドマ橋の社会経済インパクト

ジャムナ橋建設時には、住民移転計画の移転世帯数が実際にはかなり膨れ上がったことを考慮し、本格調査では慎重な検討が必要である。

６－６　調査実施体制

(1) ステアリングコミッティ

ステアリングコミッティは、大蔵省経済協力局（ERD)、計画委員会、運輸省ジャムナ多目的橋公団（JMBA)、運輸省道路局（RHD)、バングラデシュ国鉄（BR)、バングラデシュ水資源開発委員会（BWDB）等で組織する。

(2) C／P人員

C／P人員は、道路技術者、橋梁技術者、鉄道技術者、河川技術者、地質技術者、運輸経済専門家、社会開発専門家、環境専門家、地域開発専門家、財政専門家、積算専門家から構成される。

付　属　資　料

１．要請書

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

ROADS & RAILWAYS DIVISION

MINISTRY OF COMMUNICATIONS

ROADS AND HIGHWAYS DEPARTMENT

TECHNICAL ASSISTANCE PROJECT PROFORMA (TAPP)

(RECAST)

FEASIBILITY STUDY OF PADMA BRIDGE ON DHAKA-
MAWA-BHANGA ROAD OVER THE RIVER PADMA (PHASE-I).

ESTIMATED COST : TK. 427.00 Lacs.

FEBRUARY/1998.

TAPP FORMAT

PART-A PROJECT ID(1)	PROJECT NO.(2)	TAPP DATE	REVISED(3)
	TA	February/1998	-

PROJECT TITLE(4): FEASIBILITY STUDY OF PADMA BRIDGE ON DHAKA-MAWA ROAD OVER THE RIVER PADMA.

ADMN.MINISTRY/DIVISION (5)
ROADS & RAILWAYS DIVN.
MINISTRY OF COMMUNICATIONS.

EXEC AGENCY (6)
ROADS & HIGHWAYS DEPARTMENT(RHD)

SECTOR ROAD & ROAD TRANSPORT(7)

PROJECT MANAGER (8)
EXECUTIVE ENGINEER(RHD)
BRIDGE DESIGN DIVN.-3,
WESTERN ZONE, DHAKA.

TAPP PREPARED BY (9)
EXECUTIVE ENGINEER(RHD)
PLANNING DIVISION /ADDRESS 281490
SARAK BHABAN, RAMNA, DHAKA.

PART B PROJECT DATES PLANNED START MM YY(10) 03 1998 PLANNED COMPLETION MM YY (11) 09 1998

PART C PROJECT FINANCING Probable donor (12) IDA, ADB, ODA, JICA, DUTCH, KUWAIT FUND, SAUDI FUND, CHINA GRANT ETC.

LOCAL COST SOURCE (13) GOB
FOREIGN EXCHANGE SOURCE (14) Selected donor
CURRENCY/RATE (15) 1 US$= Tk. 44/-

PROJECT COST	TOTAL COST (16)	F/E COST (17)	TK. COST (18)	GOB COST (19)	PROJECT AID(20)	RPA (21)	CDST (22)
F/Y-1	256.00	179.20	76.80	-	256.00	76.80	-
F/Y-2	171.00	119.70	51.30	-	171.00	51.30	-
TOTAL	427.00	298.90	128.10	-	427.00	128.10	-

RE TACC/MIS

FINANCIAL ARRANGEMENTS WITH DONOR (23) NONE [ ] DISCUSSED [ ]

NAME/DESIGNATION OF DONOR CONTACT (24)

FINANCING AFTER COMPLETION OF THE PROJECT FUNDS REQUIRED YEAR (25)

MODE OF FINANCING DONOR (26)
LOAN: No. GRANT: Yes GOB ADP BUDGET: Yes REVENUE BUDGET: No.

SELF FINANCING % NIL (27)

PART D-I PROJECT DESCRIPTION (28)

A TA Project has been included in the current years Annual Development Programme of GOB. For a long time the construction of a bridge across the river Padma near Mawa has been a widely felt need of the people living to the south western part of the country. It will establish second crossing between east and west parts ~~[illegible]~~ through southern part of the country. The first crossing will be established soon by complition of the construction of Jamuna Multipurpose Bridge by 1998. Suitable doners should be searched for the purpose in due course.

T A P P F O R M A T

The TAPP has been prepared for feasibility study of Padma bridge on Dhaka-Mawa-Bhanga Road. The construction of the bridge will improve the efficiency of the existing transportation through shorter and more reliable journey. It will increase the viability of freight import through Mongal Port by providing a direct route to the Capital City Dhaka. It will stimulate the regional economy in the South Western Zone. It will help to increase foreign trade with Bangladesh. It will establish a direct link for transit traffic as part of the "Trans Asian Highway " concept.It will also carry utility services viz. Electrical Interconnector,Gas Pipe lines, Telecommunications etc.

PART. D-2 PROJECT OBJECTIVES (29)

The main Objective of the Consultancy Services described herein is to carryout detailed Engineering services for feasibility study for the construction of a bridge over the Padma near Mawa on Dhaka-Mawa-Bhanga Road.

CONSEQUENCES IF NOT APPROVED (30)If the project is not approved,appropriate steps for construction of the bridge can not be taken up.As such the viability of establishment of an efficient and reliable road communication in the south-western zone of the country can not be implemented.

LINKAGE TO OTHER PROJECT/ORGANIZATIONS (31) NIL

PART-E PROJECT OUTPUT (IN QUANTITATIVE OR QUALITATIVE TERMS) (32)

PREPARATORY ASSISTANCE : The project study reports will be utilized in formulating a scheme for detailed design and construction of the bridge over the river Padma near Mawa.

TECHNOLOGY TRANSFER : The GOB Counterpart officials being associated with foreign experts and local professionals, will get training to conduct such studies independently in future.

TRAINING : NIL

MANAGEMENT IMPROVEMENT : Same as technology Transfer

INSTITUTIONAL SUPPORT : NIL

T A P P F O R M A T

ACTION EXPECTED AFTER COMPLETION OF THE PROJECT (33)
Based on satisfactory result of the study, a Project may emerge suitable for financing fordetailed design and construction of the bridge.

PART-F-1 PROJECT INPUT PERSONNEL

EXPATRIATE CONSULTANTS(34)	MAN-MONTHS	NO OF CONSULTANT	COST/MM
	42	23	Tk. 6.00 Lacs.

TASKS AND QUALIFICATION REQUIRED (35):Mainning schedule and TOR for the services attached as Annexure-A&B respectively.

JUSTIFICATION : Engagement of expatriate consultants will be required to cover up the skill gaps of local experts in such type of complicated project and will enable to take up such projects independently in future by technology transfer.

LOCAL CONSULTANT (36)	MAN-MONTH	NO OF CONSULTANT	COST/MAN-MONTH
	20	8	Tk. 1.00 Lacs.

SKS AND QUALIFICATIONS REQUIRED (37): As Item 35

PART-F-1 PROJECT INPUT PERSONNEL,

PROJECT PERSONNEL GOB(38)	MAN-MONTH	NO OF PERSONNEL	COST/MAN-MONTH
Existing RHD Setup	will be	utilized	Tk. Nil

NO. OF STAFF AVAILABLE (39) FULL TIME	NO.OF STAFF AVAILABLE PART-TIME (40)	NO.OF STAFF OF DE(41)
Existing RHD	Setup with be utilized	

TASKS AND QUALIFICATION REQUIRED (42):

Supervision and co-ordination of consultants activities for proper and timely completion and implementation of the project. Will actas Counterpart of the Consultant and help them in Transfer of Technology.

FCT PERSONNEL OTHERS(43)	MAN-MONTH	NO OFPERSONNEL	COST/MM
-	-	-	-

TASKS AND QUALIFICATIONS REQUIRED:

Designation and qualification of different support staff from various deciplines will be proposed by the consultant during negotiation.

T A P P F O R M A T

(Taka in lac)

ESTIMATED (44) PERSONNEL COST	EXPATRIATE CONSULTANTS	LOCAL CONSULTANT	PROJECT PERSONNEL GOB	PROJ. PERSONNEL OTHERS
F/Y-1	151.00	12.00	-	-
F/Y-2	101.00	8.00	-	-
F/Y-3	-	-	-	-
TOTAL =	252.00	20.00	-	-

(Taka in lac)

PART-F-2	PROJECT INPUT EQUIPMENT	
SPECIFICATION OF TERMS (15)	**QUANTITY**	**COST**
Equipment Rental charges		
1. Air Conditioner (6 Nos.)	Tk. 6,000/-	
2. Telex, Fax, Telephone	" 20,000/-	
3. Photo copping & Printing	" 20,000/-	
	Tk.46,000/-X7 months	Tk.3.22 Lacs
4. Hire of Vehicles, Car-4 Nos. for 5 months with drivers.		Tk. 8.00 Lacs
5. Hire of survey launch with crews for 1 month		" 0.55 "
6. Hire of survey equipments		" 1.00 "
7. Hire of vessel for soil investigation/ bore holes.		" 3.20 "
8. Local laboratory charge for soil testing report		" 4.00 "

ANNUAL PHASING OF ESTIMATED COSTS (46) Total= Tk. 19.97 Lacs.

F/Y-1	F/Y-2	F/Y-3	F/Y-4	F/Y-5	F/Y-6	F/Y-7	F/Y-8	F/Y-9	F/Y-10
12.00	7.97	-	-	-	-	-	-	-	-

PART-F-3 PROJECT INPUT TRAINING

ECIFICATION (17)	INSTITUTION (48)	NO.OF (49) PARTICIP	COST(50)
	NIL		

ANNUAL PHASING OF ESTIMATED COSTS (51)

F/Y-1	F/Y-2	F/Y-3	F/Y-4	F/Y-5	F/Y-6	F/Y-7	F/Y-8	F/Y-9	F/Y-10
-	-	-	-	-	-	-	-	-	-

TAPP FORMAT

PART-F-4 PROJECT INPUT OTHERS

SPECIFICATION (52)	COSTS (Taka in lac)
International Expencess:	
1. Air tickets & subsistance allowances	Tk. 42.00 Lacs.
2. Miscelleneous-a) Internatiol communications	" 3.00 "
b) Reports	" 3.00 "
c) Computer allowance	" 13.00 "
d) Site investigation	" 21.00 "
e) Soil laboratory investigation allowance	" 6.00 "
f) Freight of documents allowance	3.00 "
Local Expenses :-	
1. Living allowances for overseas staffs	" 34.00 "
2. Supporting staffs-Tech.Asstt.,Surveyors, Draftsman etc.	" 1.24 "
3. Local Air travels	" 0.28 "
4. Printing and binding of interim & draft report	2.15 "
5. Office,utilities,maintenance etc.for 7 month "	1.19 "
6. Office furniture,equipments,supplies for 7 " "	0.91 "
7. Office administration & Back up staffs for 7 " "	1.61 "
8. Freight of Cocuments for Bangladesh to home office.	" 1.00 "
9. Contigency for support services.	" 1.65 "
Total :	135.03 Lacs.

ANNUAL PHASING OF ESTIMATED COSTS (53)

F/Y-1	F/Y-2	F/Y-3	F/Y-4	F/Y-5	F/Y-6	F/Y-7	F/Y-8	F/Y-9	F/Y-10
81.00	54.03	-	-	-	-	-	-	-	-

PROVISION IN FIVE YEAR (54) | PROVISION IN ADP Included.

NO.OF ENCLOSURES | SIGNATURE OF RECOMMENDING AUTHORITY (56)

22/2/9?

(Md.Abdullahel Kafi)
Executive Engineer(RHD)
Planning Division (P&D)
Sarak Bhabah,Ramna,Dhaka.

22/2/92

(M.M.Masudul Huque)
Superintending Engineer(RHD)
Planning & Programming Circle
Sarak Bhaban,Ramna,Dhaka.

22/2/9?

(Md. Serajul Islam)
Addl.Chief Engineer(RHD)
Planning & Development
Sarak Bhaban,Ramna,Dhaka.

22/2/9?

(Md. Abdul Wadud)
Chief Engineer
Roads & Highways Department
Sarak Bhaban,Ramna,Dhaka.

Abstract of Cost

(Taka in lacs)

1.	Expatriate Consultants, 23 Nos.=42 MM @Tk.6 lacs, per MM.	=Tk.252.00
2.	Local Consultants, 8 Nos.=20 MM @Tk.1 lacs, per MM.	=Tk. 20.00
3.	Project Input Equipment Rental Charges (Detailed in TAPP item 45).	=Tk. 19.97
4.	Project Input others(Detailed in TAPP item 52).	=Tk.135.03
	Total	=Tk.427.00 lacs.

MANNING SCHEDULE

A. Expatriate Consultants :-

Sl.No.	Position	Estimated M.M.	
		Country	Home
1.	Project Director	1.00	0.30
2.	Project Manager	5.00	0.15
3.	Transport Economist	1.50	-
4.	Development Economist	1.50	0.30
5.	Energy Economist	1.00	-
6.	Transport Engineer	2.50	0.15
7.	Bridge Engineer-1	3.00	0.15
8.	Bridge Engineer-2	2.50	0.15
9.	Bridge Engineer-3	1.00	0.15
10.	Foundation Specilist	1.50	0.15
11.	Cost Engineer	1.50	0.15
12.	Transport Planner	2.50	0.30
13.	System Analyst	2.00	-
14.	River Engineer-1	4.00	-
15.	Geotechnical Engineer	2.50	0.15
16.	Hydrologist	1.00	0.30
17.	River Morphologist	1.50	0.15
18.	River Engineer-1	1.00	0.15
19.	Expert Soil Mech.	0.50	-
20.	Expert Hydrodynamics	0.50	-
21.	Specialist(Various)	-	0.30
22.	Experts (Various)	-	0.30
23.	Home Office support(Various)	-	1.20
		37.50 +	4.50

Total = 42 Man months.

B. Local Consultants :-

Sl.No.	Position	Estimated MM
1.	Hydrologist	1.00
2.	Transport Economist	4.00
3.	Development Economist	2.00
4.	Transport Engineer	3.00
5.	Geotechnical Engineer	2.00
6.	Bridge Engineer	3.00
7.	River Engineer	3.00
8.	Cost Engineer	2.00
	Total	20.00 Man Months.

TERMS OF REFERENCE FOR FEASIBILITY STUDY OF A BRIDGE ACROSS THE PADMA RIVER NEAR MAWA.

PHASE - I

CHARACTERISTICS AND CONFIGURATION STUDY

Introduction :

1. The Government of Bangladesh has set as one of its highest priorities the integration of the western and eastern regions of the country, by the construction of major crossing of the Jamuna-Padma River System. It therefore has taken up the Jamuna Multipurpose Bridge construction work across the river Jamuna for carrying road, rail, a power interconnector, a gas pipeline and telecommunication cable near Bhuapur & Sirajgonj. But it could not serve much benefit for peoples of south-western zone of the country. So a second bridge across the river Padma near Mawa on Dhaka - Mawa - Bhanga road has been also a widely felt need of the people. The bridge could enable to carry road as well as utility services viz. an Electrical Intercomector, a gas pipeline, telecommunication line, etc. It is contemplated that the crossing will consists of a bridge, approaches and associated river training works.

2. It is contemplated that the study should started in March 1998 and be completed November 1998. Because of the short time available it is expected that this study will require an intensive effort on the part of the selected consultant. On the basis of the site and characteristics determined by Phase - I of the Feasibility Study, Phase - II (Preliminary Engineering, Economic Evaluation and Detailed Design) will than be carried out separately.

Main objective of the study :

3. *The objectives of the study are fourfold -*

a) where should the bridge be located ?;
b) what traffic will move over it, including transfers of electric power and gas between the two regions?;
c) what characteristics and configuration does the bridge require in order to handle the projected traffic? ; and
d) what are the incremental costs associated with alternative solutions?

Background :

4 . The Government of Bangladesh wishes to provide improved transportation between the eastern and western regions of the country by constructing major river crossings, suitable for multipurpose uses, including potential road traffic and electric power and gas transfers. GOB has already taken up the construction work of Jamuna Multipurpose Bridge across the river Jamuna near Bhuapur & Sirajgonj for carrying road, rail, second electrical interconnection, gas pipe line and telecommunication cables. But it could not serve much benefit for the people of south-west zone of the country. So a second bridge across the river Padma near Mawa on Dhaka - Mawa - Bhanga road has been also a widely felt need of the people for a long time. The bridge could enable to carry road and different utility services viz. third Electrical Interconnetor, Second gas pipe line crossing and telecommunication cables.

5 It is mentioned here that the GOB has taken up Dhaka - Khulna road via Mawa, Bhanga as national highway standard road to shorten the existing road distance of south-western Divisions/Districts and Mongla Port with the capital city Dhaka to a remarkable extend.

6 . The existing transportation system is by means of ferries, presently of limited capacity and the operation of which is frequently interrupted both by low water during dry season and by floods, with high current flows, resulting in significant delays to traffic. The ferry is situated on Dhaka - Mawa - Bhanga Road and operated by IWTA/IWTC.

7 . The Jamuna - Padma River system is one of the greatest in the world, with very large flood discharges during the monsoon season, and heavy bed loads and suspended sediment loads, During flood periods, high velocities lead to scouring erosion and moving sand waves. It is a braided river, with many course changes and major shifts in the river channel having occurred during previous years.

8 . The potential crossing area is underlead by thick sediments. It is a seismically active area, with a regional history of four strong earthquakes of long duration during the past century.

9 . There is a considerable all season river navigation in the Padma River.

10. Materials for construction are scarce, except for sand and clay. Cement is produced locally, but supplies may be limited. There appears to be no source of rock or stone within reasonable distance of the crossing area other than by deep mining.

11. The Government of Bangladesh believes that significant developments could take place in the northwest and that commerce with and between the rest of Bangladesh will grow as a result of a direct land connection by a bridge.

12. A factor which may have an influence on the proposed bridge is the existing railroad crossing, the Hardinge Bridge, across the Ganges. There is currently a proposal under consideration to deck this bridge to accommodate road traffic as well.

13. In 1981, an overhead interconnector for power transmission was constructed across the Jamuna, just above its confluence with the Ganges. A second power connector is under consideration for the early 1990s. This connector could be carried by the proposed bridge. The Consultant should estimate the incremental cost of carrying a 230-kV transmission line together with the cost of linking this line to the grid systems in the eastern and western regions.

14. There are plans to expand the gas transmission system to the western part of Bangladesh. If this plan is feasible, a gas pipeline could be carried by the proposed bridge.

15. Many reports have been prepared over past years, that are relevant to the proposed study. These include, but are not necessarily limited to the following:

(a) Petrobangla: Techno Economic Study for Gas Supply to Western Zone, August 1983, by Rendel Palmer and Tritton and Pencol Consultants, plus "Appendices".

(b) Jamuna River Bridge Construction Report Volumes I - VIII incl. Japan International Cooperation Agency, August 1976.

(c) Intermodal Transport Study, "Interim Report" for Asian Development Bank by Pacific Consultants International, Pan Development Consultants Ltd., and Development Design Consultants, Ltd.

(d) Bangladesh Transport Study 1974, Economic Intelligence Unit.

(e) Brahmaputra (Jamuna) River Crossing Feasibility Study. Freeman, Fox and Partners, et al.

(f) Brahmaputra Multipurpose Barrage Report, Sir William Halcrow, October 1984.

(g) Design and Construction of East-West Electrical Interconnector Bangladesh Power Development Board, 1982.

(h) Bangladesh Energy Planning Project, Interim Report, Sir William Halcrow and Partners et al., prepared for the Asian Development Bank, December 1984 (Final Report is expected to be available by June 1985).

(i) Jamuna Bridge Feasibility study phase I & II by RPT-NEDECO JV. for World Bank.

(j) Design and construction of Jamuna Multipurpose Bridge under Jamuna Bridge Authority of GOB, now under implementation.

(i) Power System Master Plan, Draft Report, Acres International, prepared for the Asian Development Bank, August 1984.

The consultant shall become familiar with these and other relevant studies but is expected to exercise independent judgment as to their data and conclusions.

16. General Seismic Criteria for the site have been prepared by Professor Bruce Bolt. Local seismic reports are also available in Bangladesh. These reports will be made available to the consultant.

Scope of Service

17. The consultant shall identify the most favorable corridor (general location) for the crossing and shall present the rationale for its evaluation.

In this evaluation, the consultants should consider, but be limited to, the following corridors:

(-) On [illegible] Dhaka-[illegible]-Bhanga Road or nearby the road, suits suitable to accommodate with the existing highway.

(j) crossing below the confluence of Ganges with the Jamuna

18. The consultant will make projections of commodity and passenger traffic in five year increments to the year 2020. These projections shall include traffic presently or potentially using road, electric power lines and gas pipelines. Due to the necessity to make a wide range of assumptions concerning future economic conditions, projections must be formulated in terms of minimum and maximum flows of commodities and passengers. Projections will be predicated on financial costs.

19. Commodity flows and passenger movements based on existing road should include an analysis of diverted and generated traffic including potential intermodal diversions. The maximum demand for electi power and natural gas shall be predicated on the basis of projected demai and supply considerations, including the possible construction of gas-fi power statio s and other gas-based industries in the western region.

20. The consultant will need to conduct appropriate origin and destination studies and traffic counts to support the limited data base necessary to estimate existing and potential traffic. While the consul will not be required to make a toll bridge study per se it will be nece to make and detail assumptions on toll rates to the extent they are cr to traffic forecasts.

21. In conjunction with the traffic projections, the consultant sh consider a range of bridge characteristics and configurations which w satisfy the requirements such as but not limited to:

(a) two lane road and turnouts;

(b) Two lane road with breakdown lane(s);

(c) two lane road and turnouts with provision for future expansion to four-lane road;

(d) two lane road and turnouts with provision for future expansion,

(e) two lane road and turnouts,

and

(f) two-lane road and turnouts

The consultant shall consider incremental expansion and stage construction to satisfy these requirements.

12. The consultant will consider but not be limited to the following bridge schemes:

(a) cable stayed;

(b) continuous truss;

(c) prestressed concrete "I" and box girder;

(d) steel box girder and trestle-type; and

(e) tied arch truss.

The latter two (c) and (d) should be considered both as simple and continuous spans.

23. Foundation types to be considered shall include but not necessarily be limited to wells, caissons, and large diameter cylinder piles of steel and/or concrete.

24. For the purpose of this study, the consultant may assume the following:

(a) Earthquake Criteria. (As per report prepared by Prof. Bruce Bolt and local seismic reports.)

(b) Applicable Highway Standards.

(c) Navigation clearance as required to satisfy existing and future standards for river navigation.

(d) Discount rate (opportunity cost of capital) of 10% and 15%.

25. For purposes of this study, the consultant will critically review existing data and use the most appropriate values for river discharge, velocity, and suspended and bed load sediment quantities, sand waves and potential scour depths, and wind velocity.

26. The consultant shall utilize such methods as he feels necessary to determine the critical parameters affecting the study including review of existing reports, use of geophysical (seismic) techniques such as sparker (boomer) surveys, or similar means, limited additional borings and/or probings, and review of geological and hydrological data. The Government of Bangladesh will endeavour to make available all previous reports and studies which are relevant.

27. The consultant shall specifically address the following physical items in order to determine their impact on costs and technical feasibility of the crossing:

(a) river discharge velocities and water levels;

(b) current velocities;

(c) suspended sediment quantities;

(d) water levels;

(e) sand waves;

(f) navigation clearances;

(g) geotechnical conditions;

(h) scour potential;

(i) crossing alignment and profile;

(j) potential alignments for approaches;

(k) construction loads and stages;

(l) materials availability;

(m) river channel changes, historically, and over geologic times;

(n) upstream and downstream effects of new construction; and

(o) boat and barge traffic with potential for impact with piers.

Note that the level of investigation should be only that which is appropriate to this study.

28. In developing appropriate characteristics and configurations, the consultant will be expected to provide an incremental cost analysis to

determine which bridge schemes and construction methods can potentially provide a minimum cost solution. In this context the potential maintenance costs over the period of analysis should be considered. Also, the consultant will be expected to determine optimum trade-offs between alternative bridge characteristics and configurations including bridge length vs. river training investments and approaches. Order of magnitude cost estimates essentially may be essentially divided into four components:

(a) foundations;

(b) superstructure;

(c) river training; and

(d) approaches.

29. Foundations for the bridge are believed to be especially critical in view of deep sediments, depth to a suitable founding stratum, potential for severe scour, sand waves, flood discharges, and seismicity. In examining this matter, the consultant should consider both the well techniques used for the recently constructed power interconnector transmission-line piers, and large diameter tubular piles of steel or prestressed concrete. Fendering may be needed to protect from boat/barge impact. Sand abrasion and its interaction with corrosion should be considered.

30. The consultant shall estimate the incremental cost of alternative characteristics and configuration of the bridge superstructure and any related foundation costs. Depending on traffic forecasts this should include

but not necessarily be limited to two lanes with ~~or without~~ breakdown lane or turnouts; four-lane road; with and without rail track; and support for power cable and gas pipeline. This analysis also should be based on optimum stage construction taking into consideration projected traffic and discounted cost estimates.

31. River training works are also considered to be especially important because of the flood velocities, character of the soils, lack of conventional dike materials, instability of the river channels, and consequences due to any failure of training works. The consultant should become familiar with the history of prior techniques and methods, in similar environments, and the failures which have occurred, and should investigate modern methods of dike construction including but not limited to filter fabrics, brick, asphalt, including sand asphalt, gabions, sand/filled mattresses, articulated mattresses, cement treatment, sand/cement blocks, etc.

32. Cost estimates of necessary approaches for road, rail, gas and electric power are those necessary to connect the proposed bridge with the existing infrastructure for these facilities. In addition, the consultant should determine the cost of alternative intermodal connections (e.g. road to rail, rail to road) that would significantly affect the cost of the proposed bridge and its approaches. In considering approaches the consultant should consider protection from erosion from floods, the effect on existing secondary river channels such as the Dhaiwari and any necessary mitigation

measures to limit adverse effects. In this context modern techniques as well as those historically applied in Bangladesh should be considered.

33. Following the technical analysis of the crossing characteristics, the consultant shall carry out a risk analysis, evaluating the potential for major river changes, damage to or undermining of bridge piers, breach of dikes, earthquake damage, flood damage, or vessel collision with the bridge piers and/or superstructure, etc.

34. The consultant will be expected to make recommendations on the optimum crossing scheme based on an analysis of incremental costs. This can be done by comparing the costs of alternative bridge, river works, and approach configurations carrying the projected commodity flows and passenger traffic. The analysis shall be predicated on economic costs. The incremental cost analyst must consider three basic factors:

(a) which bridge characteristics and configurations considering incremental expansion/staged construction results in the lowest net present economic costs?;

(b) which alternative transport modes result in the lowest net present economic costs?; and

(c) in making the trade-off between (a) and (b) above, which scheme results in the lowest overall transport systems economic costs?

35. It is expected that the consultants will develop computer programs at least for traffic simulation and the incremental cost analysis. Use of a computer program will enable the consultant to prepare a sensitivity analysis to support its recommended crossing solution and give some indication of its comparative advantages in comparison with other alternatives.

Reports and Timing

36. The consultant shall submit the following reports, in English:

(a) An Inception Report within two months of the study starting date. This report shall detail the general inputs, methodology and analysis to be used in the study, and, if practicable, the selection of the optimum corridor for the crossing. Twenty copies of the report should be submitted to the client.

(b) Two Progress Reports at six weeks intervals after the Inception Report, briefly describing the work carried out in the previous six weeks and the proposed work program for the following six week period. The report should highlight any problems and/or delays and proposed remedial action. These reports shall include details on the consultant's staff on the project including a current and projected staff bar chart. These reports should be separate and generally short. Progress Report No. 1 will include initial traffic projections for commodities and passengers. Progress

Report No. 2 will include incremental cost estimates of alternative crossing characteristics and configuration. Twenty copies of report should be submitted to the client.

IBRD.

(c) A Draft Final Report at the end of month six of the study. This report should be a complete document, with an initial executive summary of the findings and recommendations of the consultant, and should only be considered "draft" in the context of being subject to review. The Draft Final Report will contain:

(i) a discussion of the analysis and methodological techniques used in determining the optimum corridor for the proposed crossing;

(ii) detailed description of the methodology, data, assumptions and computer programs used to generate minimum and maximum commodity and passenger traffic projections;

(iii) a discussion of the basis for developing the incremental cost estimates of the various alternative solutions; and

(iv) an incremental cost analysis to support the recommendations for the minimum cost crossing solution.

Twenty four copies of report should be submitted to the client.

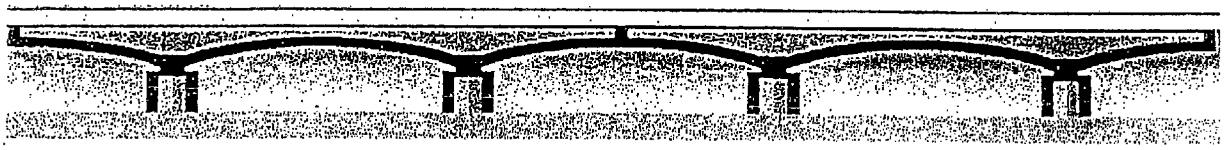
(d) A Final Report, within one month of receipt of comments from the Panel of Experts, incorporating all revisions deemed appropriate <u>by the consultant.</u> Thirty Two copies of report should be submitted to the client.

Peoples Republic of Bangladesh

JAMUNA MULTIPURPOSE BRIDGE AUTHORITY

PADMA BRIDGE STUDY

PHASE I **PREFEASIBILITY**



DRAFT FINAL REPORT

EXECUTIVE SUMMARY

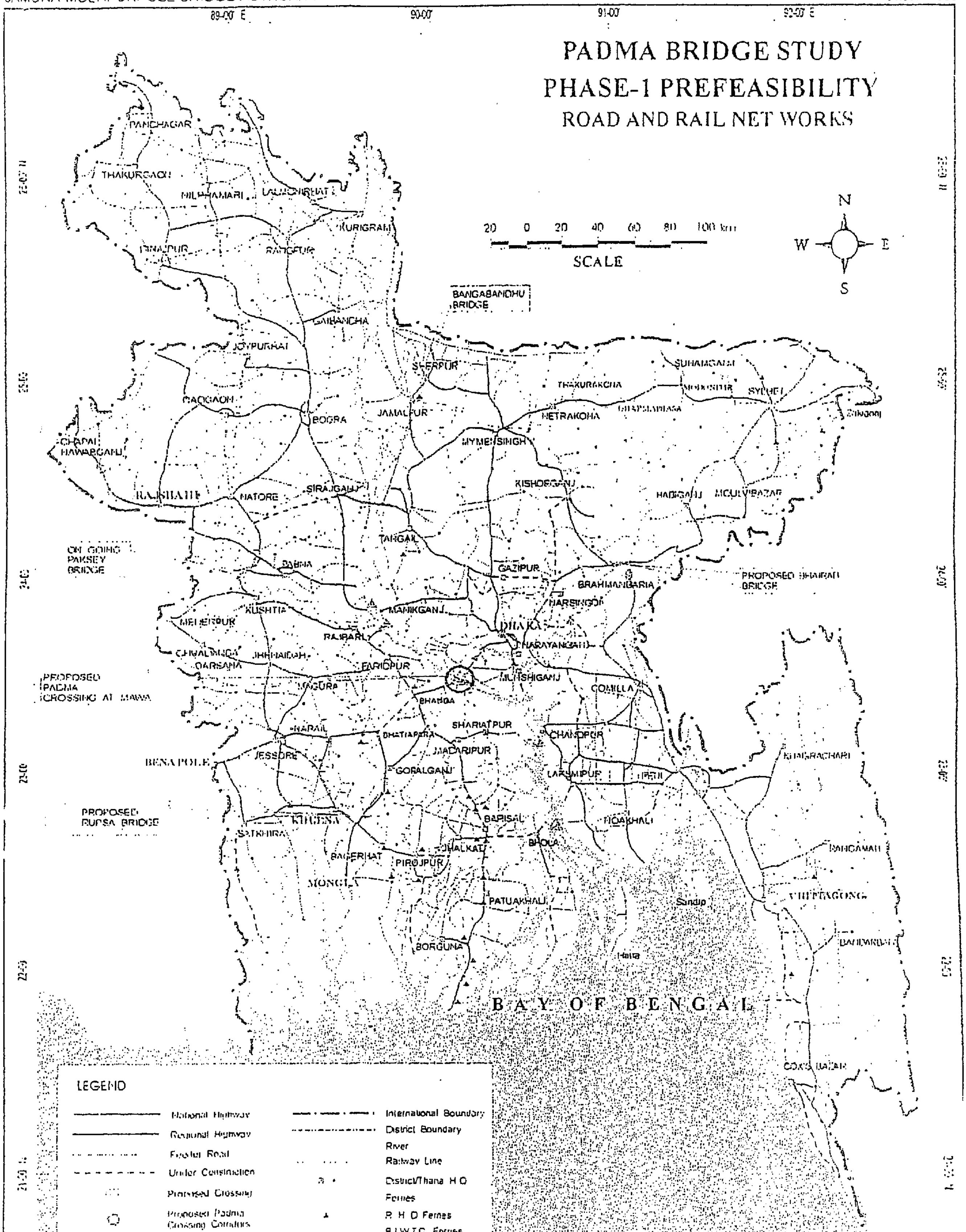
Rendel Palmer & Tritton

nedeco

In association with

Bangladesh Consultants Ltd.

OCTOBER 1999


PADMA BRIDGE STUDY
PHASE-1 PREFEASIBILITY
ROAD AND RAIL NET WORKS
SCALE
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THAKURGAON
NILPHAMARI
KURIGRAM
DINAJPUR
RANGPUR
BANGABANDHU BRIDGE
GAIBANDHA
JOYPURHAT
SHERPUR
NAOGAON
BOGRA
JAMALPUR
NETRAKONA
SYLHET
SUNAMGANJ
CHAPAI NAWABGANJ
MYMENSINGH
KISHOREGANJ
RAJSHAHI
NATORE
SIRAJGANJ
HABIGANJ
ON GOING PAKSEY BRIDGE
TANGAIL
PABNA
GAZIPUR
BRAHMANBARIA
PROPOSED BHAIRAB BRIDGE
KUSHTIA
MANIKGANJ
NARSINGDI
MEHERPUR
RAJBARI
DHAKA
NARAYANGANJ
CHUADANGA
JHENAIDAH
DARSANA
FARIDPUR
MUNSHIGANJ
PROPOSED PADMA CROSSING AT MAWA
MAGURA
COMILLA
BHANGA
NARAIL
SHARIATPUR
CHANDPUR
BENAPOLE
JESSORE
MADARIPUR
GOPALGANJ
LAKSHMIPUR
KHAGRACHARI
PROPOSED RUPSA BRIDGE
KHULNA
BARISAL
NOAKHALI
SATKHIRA
BHOLA
BAGERHAT
JHALKATI
PIROJPUR
RANGAMATI
MONGLA
PATUAKHALI
Sandip
CHITTAGONG
BORGUNA
BANDARBAN
Hatia
BAY OF BENGAL
COX'S BAZAR
LEGEND
National Highway
Regional Highway
Feeder Road
Under Construction
Proposed Crossing
Proposed Padma Crossing Corridors
International Boundary
District Boundary
River
Railway Line
District/Thana H Q
Ferries
R H D Ferries
B I W T C Ferries

EXECUTIVE SUMMARY

1. INTRODUCTION

The South Western region of Bangladesh is separated from the capital region and other parts of the country by the Padma, one of the mightiest rivers in the world. The Government of Bangladesh has set as one of it highest priorities the integration of the country by the construction of a long Multipurpose Bridge across the Padma River.

The proposed fixed crossing over the Padma would help physically unite the country and provide rapid and secure connections between the East Zone and Mongla, the country's second sea port, and Benapole, the largest land port. As has been shown by the success of the Bangabandhu Bridge over the Jamuna, the consequent reductions in transport costs would stimulate traffic, trade and economic development.

This Draft Final Report describes the surveys, studies, preliminary designs, cost estimating, economic and traffic evaluation carried out during the period 16 May–16 October 1999 as part of the Phase I Prefeasibility Study of the proposed bridge.

Funding of this study has been provided within the 3rd Amendment to the Contract between Jamuna Multipurpose Bridge Authority (JMBA), and the Consultants Rendel Palmer & Tritton (RPT) and Netherlands Engineering Consultants (NEDECO) in association with Bangladesh Consultants Ltd (BCL). The contract for the Phase I study was signed on 5 May 1999. Mobilisation of the expatriate and local team started on 16 May 1999, and this Draft Final Report was submitted in late October 1999.

The primary objectives of the Prefeasibility Study are:

- to locate the bridge;
- to estimate the volume of expected traffic including gas and electricity transfers, and rail if applicable;
- to assess appropriate characteristics and configurations of the bridge. to handle the projected road and rail traffic, gas and electricity transfers:
- to consider the merits of a tunnel alternative; and
- to estimate the relative costs of alternative solutions.

The location of the bridge was a clear and necessary requirement to allow the remaining objectives to be achieved. This was decided to be at Mawa in an Inception Report Workshop on 29 August 1999, and confirmed by the work carried out up to the October Report. The characteristics of the bridge are defined in four main aspects: type of foundations, extent of river training works, length of bridge, and type of superstructure. It is not intended that these features be finally fixed at this stage as this could reduce technical competition at tender. However they need sufficient development to allow confidence in achievement and reliability of pricing appropriate to this Prefeasibility Stage.

In addition to the bridge crossing, the Consultants were requested to consider a tunnel crossing as an alternative to the bridge. It became clear at the Inception Stage that the tunnel option was neither economically nor technically realistic.

The study has been broadly divided into two periods. During the first period, the first eight weeks labelled the Site Identification Phase, the team concentrated on locating alternative sites for the bridge and producing the Inception Report. This period was followed by a workshop where the Client's invitees and the Consultants' experts were invited to discuss the initial findings, and to debate in some depth the selected crossing site, the river engineering and bridge engineering problems, and potential solutions.

The second period formed the main part of the study. During this period, labelled the Scheme Selection Phase, the Consultants concentrated their efforts on a single site, towards generating the necessary information for the incremental cost evaluation, towards developing recommendations for the preferred bridge characteristics, and producing the Draft Final Report.

As specified in the Terms of Reference, the information presented in the present Report comprises the activities mentioned in the scope of the work, which components are related to:

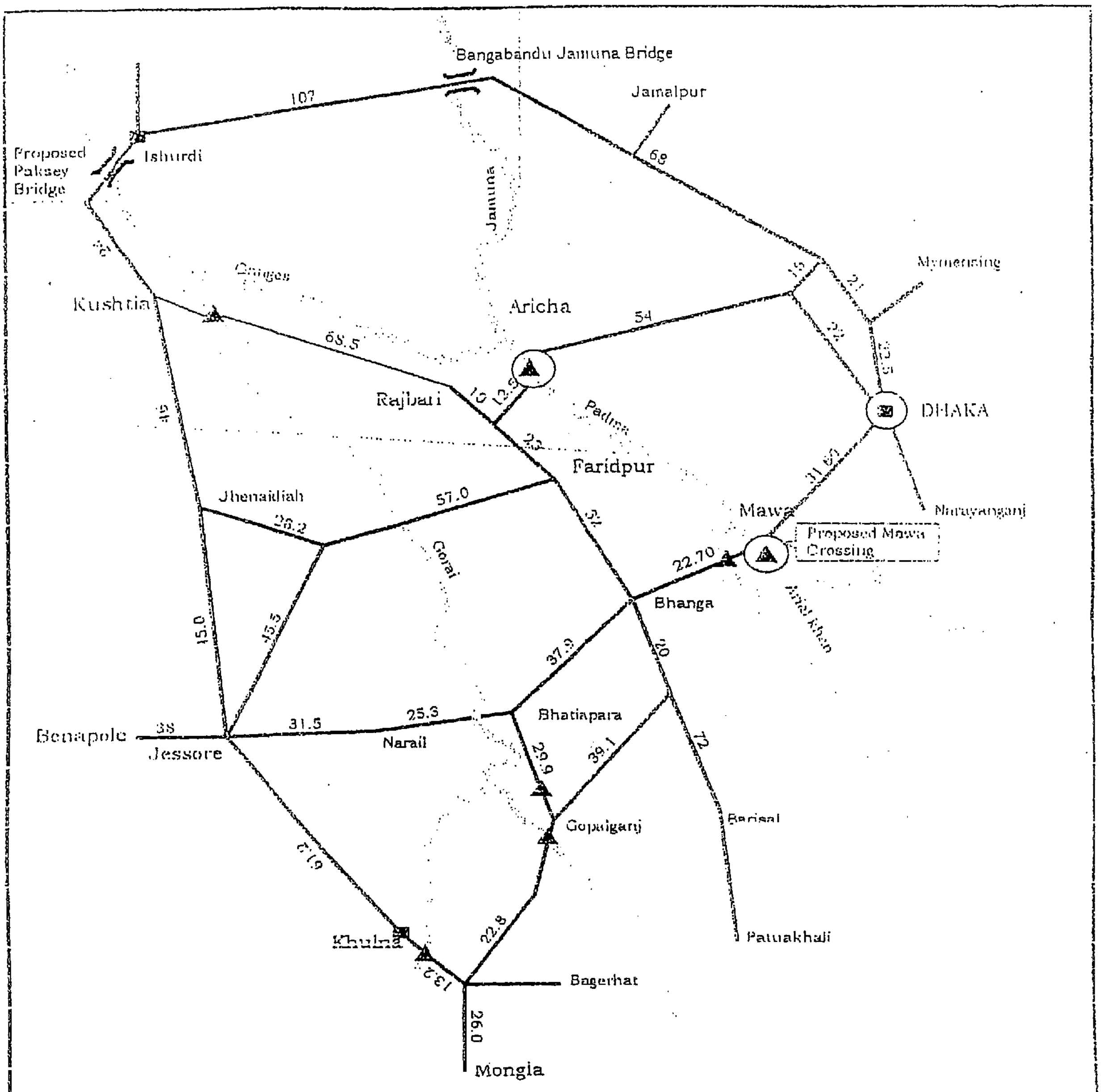
- Engineering surveys, investigations and data collection;
- Methodology for the study;
- Data analysis and engineering studies;
- Confirmation of the preferred crossing site;
- Indicative configurations for the crossing, river training works, approach roads, environmental protection and resettlement; and
- Incremental cost analyses of the alternatives.

This Document reports the work done during the 5 month study period, as specified in the TOR. Furthermore, the submission of this Prefeasibility Report provides the foundations of a full Feasibility Study if is decided to take the project forward.

The documents are presented in a Main Report plus Annexes and this Executive Summary.

The Study is not required, at this stage, to carry out a formal cost benefit analysis of building the bridge. This should form part of a future Feasibility Study, as it did for the corresponding Jamuna study. The objective at this stage is to assess what the configuration (what services the bridge should carry and in what form) and location of the bridge should preferably be, if it were built. These questions are complex and closely interrelated. In principle, it is not possible to decide location and configuration independently.

In deciding these issues, it was necessary to take account of the effect of the bridge, in whichever location, on the total costs of the transport, energy and communications systems of Bangladesh. The optimum configuration and location will depend on the balance, for all bridge users, between the capital and environmental costs of capacity on the bridge and of access to the bridge, in relation to wider transport system operating cost savings; any additional transport benefits, such as generated traffic; and energy system operating and cost savings.



Destination	Distance from Dhaka (km)	
	Via Goalanda	Via Mawa
Faridpur	112	86
Kushtia	167	198
Jhenaidaha	197	171
Magura	169	143
Narail	207	117
Jessore	215	149
Gopalgong	312	132
Khulna	276	158
Benapole	253	187
Mongla	315	170
Barisal	236	146

Diagrammatic of Road Network with Distances from Dhaka to SW major Centres

RPT - NEDECO - BCL .

2. THE TRANSPORT BACKGROUND

The mighty Padma River is formed by the confluence of the Ganges and Jamuna Rivers. It is the shortest and newest component of the Delta of the Ganges-Jamuna-Meghna system. It flows in a South West to South East direction with a length of approximately 120 km down to its confluence with the Upper Meghna. In its short trajectory, the Padma has an average discharge of 88,000 m^3/s and carries a high sediment load. The river can be characterised as a braided river with a number of distinctive channels, from one to three, with sandbars (chars) in between.

As one of the world's greatest deltas, this river system has historically split Bangladesh into separate sections. Since independence in 1971, Bangladesh has been divided into three principal parts:
- the North West zone, bordered by the Ganges and Jamuna Rivers;
- the South West zone, isolated by the Padma and the Ganges Rivers; and
- the East zone, including the economic and industrial centres of Dhaka and Chittagong.

With the completion of the Jamuna Bridge in June 1998, the Government of Bangladesh opened up the North West to the economic development of Eastern Bangladesh. The Government has simultaneously demonstrated its ability to manage the preparation and construction of major infrastructure works. This has set a precedent for the further linking of the various parts of the country.

With the Paksey Bridge the Government is planning to connect North West Bangladesh with South West Bangladesh.

The construction of a bridge across the Padma to connect South West Bangladesh to Eastern Bangladesh is the last defining step in the unification of the country. This bridge would stimulate the economic and social development of the South West, and the growth of the nation's second major port at Mongla.

Two possible locations on the Padma were considered in the preliminary studies for the Jamuna Bridge, both existing ferry crossings. These locations, Aricha (for a river crossing towards Goalundo); and at Mawa, were investigated again in the present study, in greater detail.

Road traffic, particularly across the major Jamuna and Padma river crossings, has been increasing rapidly in recent years, in response to economic and population growth; changes in the patterns of production; and diversion from other modes. Rail traffic, after a long period of stagnation, has shown some recent signs of recovery in response to efforts to improve efficiency. Nationally IWT carries around a third of all freight traffic and has grown steadily, if undramatically, in line with economic growth.

Cross River Traffic Growth (percent p.a.)

Period	Bus	Truck	Subtotal Heavy Vehicles	Light Vehicles	Total Traffic
Cross-Jamuna					
1979 – 98			10.9	7.9	10.3
1983 – 98			9.5	11.4	9.8
1992 – 98	11.3	6.8	8.1	11.1	8.5
Cross-Padma					
1979 – 98			13.5	12.5	13.2
1983 – 98			12.6	15.5	13.3
1992 – 98	17.4	9.2	11.2	22.5	13.7

Source: JBS, BTSS, BIWTC

Substantial volumes of freight and passenger traffic move across the Padma River, by road ferry and by inland waterway transport (IWT). A Padma Bridge would reduce the time and costs of road traffic very significantly and, as the experience of the Jamuna Bridge has shown, would lead to large increases in road traffic, some of it diverted from IWT. If a rail link were provided on the bridge, it could also expect to divert traffic from IWT and, to a lesser degree, from road. The balance of traffic between the three modes will depend on the location and configuration of the bridge and on the pricing of transport services, particularly any tolls imposed on the bridge.

Both freight and passenger traffic is currently split between two modes: road and IWT. The construction of a road bridge would increase the attractiveness of road very greatly. Provided no tolls are charged, most passenger traffic can be expected to divert from IWT to road, even if over an extended period, as riverside village feeder roads are introduced. Considerable volumes of IWT freight might also transfer to road. The imposition of tolls at the levels currently levied on the Jamuna Bridge, however, would reduce the degree of diversion for both freight and passengers considerably.

Road Traffic Forecasts by Bridge Location (vehicles per day)

Year	Goalundo				Mawa			
	Trucks	Buses	Light Vehicles	Total	Trucks	Buses	Light Vehicles	Total
1999	*1,225*	*1,017*	*436*	*2,667*	*1,757*	*2.706*	*715*	*5,178*
Ratio: Bridge to Ferry/ Launch								
	1.18	0.66	0.85	0.86	1.70	1.75	1.40	1.68
2005	2.054	1.943	833	4.830	2.947	5.171	1.367	9.485
2010	3,047	3.033	1.288	7.337	4,370	7.993	2.113	14,476
2015	4.293	4.392	1.883	10.568	6.158	11.691	3.090	20.938
2020	6.050	6.423	2.754	15,227	8,677	17.093	4.519	30,294
2025	8.525	9.394	4.029	21.948	12.227	25.007	6.609	43.842
2030	12.012	13.740	5.892	31.644	17.229	36.573	9.666	63.468

A road/rail bridge would introduce competition for the IWT freight traffic from rail, particularly for low value and bulk traffics. The railway might also attract some freight traffic from road. The railway's success in attracting such traffic will depend on tariff policy and operational efficiency. The railway might also compete for some of the bus passenger traffic, depending on the kinds of service BR chose to operate.

There are large volumes of IWT freight moving into and out of the SW. Most of this traffic is of low value or bulk commodities, such as jute, construction materials and petroleum products. Information was collected from port authorities and IWT operators in the main river ports of Dhaka, Barisal, Chandpur, Khulna and Mongla to identify the principal movements. This was supplemented by further interviews with port and shipping companies in other locations to provide a picture of freight movements by type of commodity, and the results are included in the report.

The main new investment in the road network that will alter significantly the potential of the Padma bridge, is the improvement with ADB assistance of Route N8 between Dhaka and Khulna via Mawa and Bhanga. This road is now at the stage of preparation of detail designs, and it is planned to move to implementation during 2000. These improvements will be completed well before the Padma bridge could be built.

With completion of the improvements to Route N8, it is anticipated that the ferry service between Mawa and Char Janajat would be upgraded to equal that now provided between Aricha and Daulatdia. Simultaneously the service at Aricha would be likely to reduce to a level similar to that now provided between Mawa and Char Janajat.

The development of Mongla port is included in the FFYP. New container handling equipment is planned and maintenance dredging will be implemented.

The situation for rail connections is less clear. There is a functioning Broad Gauge connection to Daulatdia Ghat, which would permit easy connection to a bridge at Aricha. Connecting to Dhaka would then involve the construction of approximately 110 km of new BG line, involving bridges over three sizeable rivers.

Rail connections to Mawa on the south side of the river would involve new line. There is a closed line terminating at Talma. If this were still usable, only 71 km of new construction would be required, although it would be necessary to bridge two major rivers. Otherwise, it would be necessary to build a new line as far as Faridpur, a distance of 86 km. North of the river, the connections would be shorter, as the line could link to the existing Metre Gauge line at Narayanganj. It would then be necessary to dual the Metre Gauge line to Dhaka.

There is little or no rail traffic between the SW and the NE at present. Connections are difficult as the planned rail link between Dhaka and the Jamuna Bridge has not yet been completed. There is scope for attracting bulk traffics currently moving by inland waterways and there may possibly be some traffic currently moving by road which could use rail. There is also potential for Indian transit traffic and other international traffic as part of the Trans/Asia Rail Corridor, though the likely volumes are currently the subject of estimates rather than analysis.

The Padma Bridge proposal comes at a critical stage in the evolution of the transport network in South West Bangladesh. Dominated by the river delta, transport in the region has historically been by inland waterway vessels. This IWT network is now gradually being replaced by road transport, as the road and the bridges network develops through the delta region. The Padma Bridge will release the growing potential of this road system to link up with Dhaka and with the remainder of the East and North of the country. The bridge traffic forecasts recognise this phenomenon, and reflect not just the conventional road to road potential but the ongoing switch of traffic from longitudinal water transport to the road network.

3. THE ENERGY BACKGROUND

The Terms of Reference were set out in the belief that the SW did not have natural fuel resources and that the objective of including energy interconnectors on the Padma bridge was to provide less expensive supplies of energy to the SW. It is likely that this situation has been altered by the discovery, and proposal to exploit, gas resources at Bhola Island in the division of Barisal, in the SW. The Consultants received verbal confirmation of this development.

The supply of gas in Bangladesh was studied in the Gas System Development Plan in 1995/96 and the expansion of the total power sector was considered in the Power Sector Master Plan in 1995. Both of these studies were completed prior to the confirmation of gas reserves at the fields of Shahbazpur and Sangu, the first off shore at Shangu Estuary in the Bay of Bengal and the second in the district of Bhola in the SW.

The assessment of demand and of incremental benefits for the energy sector were complex because the supply of natural gas and of electricity are interrelated, and because of the reports that a Public Sharing Contract (PSC) partner has submitted the unsolicited proposal to develop gas resources in Bhola District.

Natural gas is consumed to generate electricity and to produce fertilisers, and by other industrial, domestic and commercial customers. The annual consumption of gas in 1996/97 was some 6923 million cubic meters (MCM) or 245 BCF, which represents an increase of 267 percent ever 1984/85, or an annual growth rate of 8.6 percent.

Some 48 per cent of gas supplies are used to generate electricity (including distribution losses), while 32 per cent is used to produce fertilisers and 19 per cent is used by industrial, domestic; and commercial consumers.

All of these consumers are located in the Eastern zone of the country. It is planned to supply gas in 1999 to the NW via the Banghabandhu bridge for electricity generation and fertiliser production. There are no direct consumers of natural gas in the SW.

The annual growth rate of consumption by domestic consumers has been some 13 percent, while industrial users have increased consumption at an annual rate of 9.2 percent. The electricity sector has increased its consumption at an annual rate of 5.9 per cent, while fertiliser production has absorbed gas at a rate increasing annually by 4.8 per cent.

The role of a gas interconnector on the Padma bridge would be significant oif there are ample supplies of gas in the NE of Bangladesh and gas is not available in the SW. Alternatively a gas interconnector would play a secondary role of providing added security of supply to the system. The interconnector would not serve a useful purpose when gas supplies from the traditional fields are limited and gas is not developed in the SW.

The electricity network comprises an Eastern zone which includes all of the area East of the Jamuna, Padma and Meghna rivers, and a Western zone. The two zones are interconnected by one 230 kV transmission line which crosses the Jamuna River at Aricha. The Western zone is in turn made up by the NW and the SW regions which are also interconnected by one 230 kV line, on the Hardinge bridge.

Total sales of electricity recorded by BPDB in 1996/97 were 9447 GWh, reflecting a loss of 20.3 per cent with regard to electricity generated. Electricity sales are distributed 77.6 per cent in the East zone whilst 22.4 per cent in the West zone, and in the West zone sales are distributed approximately equally between the NW and the SW.

Some 2.4 million tons of petroleum products were commercialised in 1994/95, equivalent to 104.8 TBtu.

Domestic consumers absorbed 18 percent of this energy, while 11 percent was used for electricity generation, 48 percent was used by transport, 6 percent was used by industry, and the agricultural sector consumed 17 percent.

The role of a third electricity interconnector would be to provide additional security against failure of the two East West interconnectors and this is not seen to be required prior to 2015 at the earliest.

The Padma bridge interconnector could have advantages over a second interconnector at the Bangabandhu bridge. At the time the need for the second interconnector becomes clear these alternatives should be evaluated.

The only measures of petroleum product consumption in the SW are the records of imports via the ports of Khulna and Barisal. During 1996/97 some 770,000 tons were imported. This is equivalent to 33.6 TBtu.

Petroleum products were used to generate 661 GWh in the SW in 1996/97. At an average efficiency of 26 per cent this required a fuel input of 8.7 TBtu.

The remaining petroleum products, some 24.9 Tbtu, were consumed by domestic users, by the transport sector, by industry and by agricultural users.

4. THE PROJECT

The engineering aspects of each site have been evaluated by studying the available data on planform changes of the Padma River as a result of both historical and present day processes. Particular attention has been paid to bankline recession data and changes in channel patterns, particularly the thalweg, with time. The approach has been similar to that used earlier by the Consultants for the Jamuna Bridge Phase I and Phase II Studies; the Meghna River Bank Protection Study; and an analysis of river processes in the Ganges River near the Hardinge Bridge for the Paksey Bridge Project, supplemented by the study of the latest available SPOT satellite images of the Padma river. This has been complemented by the data collected in the framework of the FAP 24 River Survey Project and EGIS.

In addition, the geological conditions at the confluence of the Padma and Meghna were reviewed to evaluate the risk of changes in river planform as a consequence of background environmental (eg tectonic) influences, and their possible effects.

In combination these studies provided insight into possible changes in the course of the rivers at the sites of the corridors and assisted in selecting the most suitable corridor. A first outline of the river training works that are required for each corridor, has been determined and preliminary investment costs estimated. The crossing scheme used for the cost comparison between sites is based on minimum interference with the river and will use a bridge foundation and superstructure combination which could be considered to be the least sensitive to the particular site conditions.

The cost of approach links for road, rail, gas and electricity could have a significant influence on total construction costs and these have been given due consideration in the work of the study team. Preliminary considerations for each site regarding the risk attached to peak floods, earthquakes, and collision of river craft with bridge piers have also been taken into account.

All of these aspects together with the river and bridge engineering criteria were compared to identify the most favourable corridor.

In each of the study areas, the main risks have been identified, minimum acceptable levels have been set, threats to achieving the minimum acceptable levels identified, and mitigation measures proposed. Areas of residual risk which are not covered by this analysis were identified.

The ToR lists the following configurations to be considered:

a) 2 lane road and turnouts
b) 2 lane road with breakdown lane(s)
c) 2 lane road and turnouts with provision for rail
d) 4 lane road and turn outs
e) 4 lane road and turn outs with provision for rail
f) 4 lane road and turn outs with future provision for rail

Electricity (230kV) and gas (760mm diameter pipeline) were also to be considered. Furthermore there was a requirement to investigate the possibility of incremental expansion and stage construction to satisfy the above configurations.

From a bridge construction point of view, by the time the various operational and safety issues have been addressed, the cost of adding turnouts will exceed the cost of adding hard shoulders. The reason for this is that, although there might be some saving in materials, the construction complexities introduced by the varying width will lead to high cost penalties. For example, the varying width means that the precast or prefabricated elements of the bridge will have different weights. This means that the crane or other handling equipment will not be used consistently to its capacity. Also, the changes in width introduce design detailing problems which in turn will incur additional costs.

Therefore, for the reasons stated above, the "2 lanes + hard shoulders" configuration is adopted as the base case, and the turnout concept is not considered further. The alternatives to be considered then become:

1. 2 lane road and hard shoulders (or breakdown lane): [Base Case]
2. 2 lane road and hard shoulders (or breakdown lane) with provision for rail
3. 4 lane road
4. 4 lane road with provision for rail
5. 4 lane road with future provision for rail

In all road only cases a centre barrier has been provided. The rail clearance gauge has an overall width of 4.724m. The geometry for each case has been considered from a functional and safety viewpoint, and within the national and international context. Gas, electricity and telecommunication cables can be added to each, without any significant change to the road/rail configuration, as discussed and illustrated within Annex-D.

The Mawa and Goalundo corridors are situated on the active recent flood plain of the Padma River System that lies within part of the Bengal Basin.

The Bengal Basin is located in a seismically very active region and is surrounded by the Himalayan Arc and Shillong Plateau in the north, Burmese Arc and Aracan-Yoma anticlinorium in the east, and Naga-Disang thrust zone in the north-east. The Himalayan and Burmese mountain belts are especially interesting seismic regions because of being situated between two continental masses; the Indian and Eurasian plates.

The Consultants are aware of the possible impact of a heavy earthquake on the Padma bridge crossing, its foundation and the surrounding civil engineering works like river training works and embankments.

Bangladesh has experienced several large earthquakes in the last 130 years. Among them seven have had a magnitude greater than 7.0. Two of them, the Bengal earthquake in 1885 and the Srimangal earthquake in 1918, had their epicentres in Bangladesh territory. The major earthquakes that a effected Bangladesh were the Cachar earthquake in 1869, the Bengal earthquake in 1885, the great Assam earthquake in 1897, the Srimangal earthquake in 1918, the Dubri earthquake in 1930 and Bihar-Nepal earthquake in 1934.

A preliminary site-specific seismic study for the Padma crossing appropriate for pre-feasibility work has been commissioned by the Consultant from BRTC-BUET. The study report is included in Annex-B, Appendix-B. The estimated maximum horizontal accelerations for the bridge design have been assessed at 0.125g at Mawa and 0.15g at Goalundo.

As with most of the river deposits of Bangladesh, the soils of the Padma contain mica of varying proportions. The GOB FAP 24, River Survey Project: Mineralogical & Physical Properties of River Sediments, (Study Report 14, March 1996) showed the percentage mica content of river bed samples to range between 1% and 22% in the sand size fraction and between 2% and 16% in the silt size fraction. The pre-feasibility boreholes confirmed the presence of mica in the deposits, and was visually estimated during logging to range from a 'trace' to over 10%. However, this estimate would be a reflection of the sand sized mica particles only and would tend to underestimate the total mica content. Mica content of the sands at the Jamuna river crossing ranged from less than 5% to in excess of 25% by weight.

It is considered reasonable to assume for preliminary geotechnical design of the bridge crossing over the Padma that the properties of the Padma sands will not be that dissimilar from those found on the Jamuna, since;

- the Padma is partly fed by the Jamuna river system and the river deposits have the same origin;
- a visual qualitative assessment of the mica content of the samples obtained from the ground investigation suggests the soils to be similar;
- also because of the similarity of the grain size of the sand deposits of both Jamuna and Padma.

Therefore similar geotechnical design methods using relationships developed for the Jamuna crossing will be used. It is important however that a detailed assessment of the mica content, its grain size distribution and its effect on geotechnical properties is made during feasibility and detailed design.

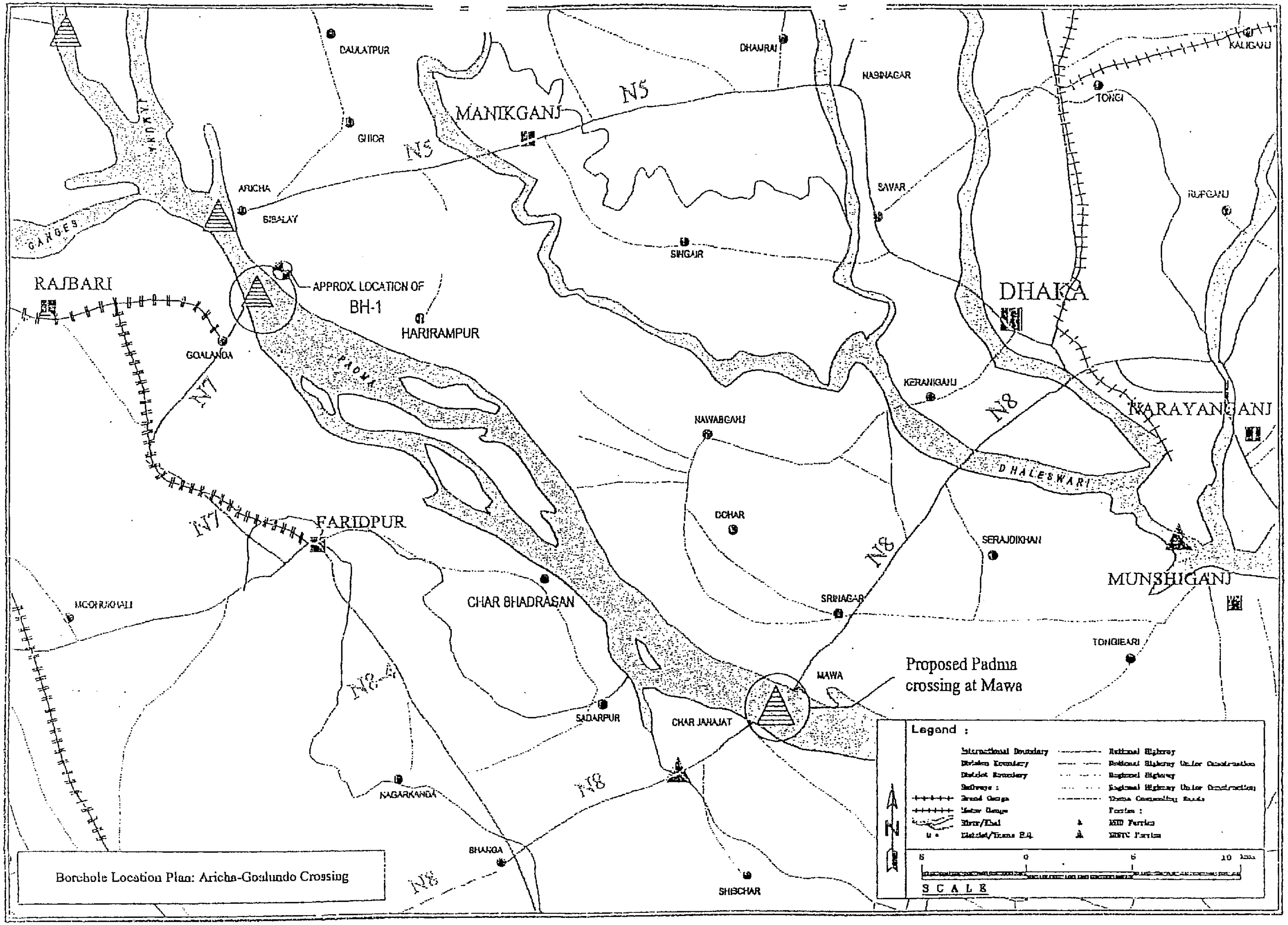
From the consultants' early work on the 1st Electrical Interconnector near Aricha it was clear that to avoid failure of foundations due to scour only deep foundations would suffice. There is no practical reliable way to prevent shallow foundations being undermined in such a large river with erodible bed material.

The geotechnical studies for the pre-feasibility study have comprised a number of interrelated activities

The scope of the investigation in the area of the Mawa corridor comprised three deep boreholes each of nominal 120m depth and five 40m deep boreholes. Following a review of the Padma River system it was decided that the Goalundo corridor should also be further investigated. A 120m deep borehole was drilled on the northeast bank of the Padma about 6.5km downstream of the Aricha ferry ghat to supplement existing borehole data in the area. The purpose of this is to investigate the alluvial deposits at depth and to enable a comparison to be made of the deposits with those located on the north river bank at Mawa and those at Aricha.

The ground investigation in the Mawa corridor comprised:

- one deep borehole at each river bank location at Mawa on the north bank (BH4) and Char Janajat on the south bank (BH3)
- one deep borehole on a mid-river char downstream of the Mawa corridor (BH 2)
- five 40m deep boreholes located on the river banks.



Borehole Location Plan: Aricha-Goalundo Crossing

The interpretation of the boreholes has shown that whilst detailed correlation of horizons between boreholes is not possible due to stratigraphic variation and the large distance between boreholes, there is broad stratigraphic agreement across the site. The ground conditions were generally found to be consistent with that expected from the geological survey map of the area.

The ground investigation showed the presence of extensive deposits of clayey SILT to depths of 39.0m and 31.5m on the north bank river approaches at and upstream of Mawa ferry ghat.

The stratigraphic sequence based on lithology and laboratory classification tests (particle size distribution and Atterberg limit tests) may be summarised as:

- Unit 1 - variable near surface deposits ranging from SILT of variable clay and sand content to very silty fine SAND. Occasional layers of silty CLAY were described. Generally this unit ranged between 3 and 10.5m in thickness.
- Unit 2 – predominantly a silty, occasionally very silty, fine SAND (typically <20% silt and <10% medium sand) with trace mica and occasional layers of clayey silt. In BH2 this unit could be divided into an upper very silty fine SAND unit with occasional deposits of very sandy SILT (Unit2a) down to -40.6m PWD underlain by a silty fine SAND (Unit 2b). Unit 2a in BH2 could possibly be a transition deposit fining upstream towards the deep Unit 1 deposits encountered in boreholes 6 and 7. The total thickness of Unit 2 was found to range between 64m and 80.5m.
- Unit 3 – predominantly a slightly silty fine and medium SAND with trace mica (typically with <10% silt and with traces of fine gravel). This was encountered in all 4 of the 120m deep boreholes.

It should be noted that the deposits include traces of mica, visually estimated during logging to be typically less than 10%. However, this estimate would be a reflection of the sand sized mica particles only and would tend to under estimate the total mica content. Very rarely, organic traces and remains were found in the deposits.

From the analysis of the liquefaction potential of the river bed materials it can be concluded that liquefaction could occur up to depths of 6m and 9m below scour level for the Mawa and Goalundo Corridors respectively. It is important that the structures will survive earthquakes and the detailed foundation design will therefore need to consider potential soil liquefaction and slope failure of the riverbanks.

Hence there are two fundamental options for foundations of a crossing of the River Padma: either piles or caissons. The conclusions reached during the Jamuna Bridge studies are equally valid for the Padma Crossing. Although the consultants used caisson foundations successfully for the power cable crossing at Aricha, the subsequent advances in large diameter piling changed the prospect for foundations of major bridges in Bangladesh. The cost comparisons made during the Jamuna studies all showed the raking steel pile options to be cheaper than caissons, and that conclusion still holds. Furthermore, caissons require more time to install, and the risk of major problems during installation is much greater. A fundamental characteristic of deep caissons in the micaceous soils of the Jamuna river was the lateral stiffness. This is of little consequence to a power line, but of immense importance to a road or rail link.

As demonstrated during the Jamuna studies, single or multiple vertical element foundations such as caissons or vertical piles are much more flexible when subject to lateral loads than raking pile groups. Raking piles embedded into a rigid pile cap at their head have much greater lateral stiffness than those same piles used as vertical elements. This is because a significant proportion of the horizontal load will be resisted by axial load in the piles which in turn is resisted by the stiff soils at depth. Vertical piles loaded horizontally depend for their stiffness on the stiffness of the surface layers of soil, and the typical loose micaceous bed material in the rivers in Bangladesh offers low resistance. A comparison in the Jamuna Phase II studies between a 2-pile bent of 2.5m diameter steel piles and a 7m diameter caisson showed the raked system to be at least six times stiffer than the caisson foundation.

The question of the preferred crossing location from the river engineering perspective is foremost related to:

- Measures required to keep the length of a bridge limited
- Measures required to ensure that the river will under all circumstances flow under the bridge or above the tunnel, without facing the risk that an outflanking river channel will attack and severe the approach to the bridge or the tunnel.

In 1987, when the concepts for crossing the Padma or the Jamuna had to be developed there were few reference projects. Now, in 1999, not only the Jamuna Bridge, including extensive river training works, has been completed, but also numerous other studies, particularly those in the context of the Flood Action Plan, have been carried out. The experience gained in making a design for the Jamuna Bridge and implementing it, along with the insights gained with the mentioned other studies will be used in this phase I study for the Padma Bridge.

While there are quite some similarities between the Jamuna and the Padma Rivers, there are also differences. Care should be taken in adopting the experience gained on the other projects and in other studies. It will always be necessary to verify that that experience or insight can also be applied to the Padma Bridge, and if so, whether some form of adjustment is necessary. While the Jamuna River can be characterised as a braiding river, the Padma River is said to be on the transition between meandering and braiding (wandering river). Its behaviour is somewhat less erratic than that of the Jamuna River, but that does not imply that drastic changes in the distribution of water between different river channels does not take place or that bank erosion rates are less spectacular. Comparison of satellite images taken in various years confirms this.

The cost of river training works is quite high: for the Jamuna Bridge project the cost of river training was higher than the cost for the bridge itself. If it is possible to avoid the need for the construction of river training works on one river bank, then this seems to be a potentially attractive location for a crossing site. Apart from avoiding the cost of river training works on one of the riverbanks, there are also advantages in terms of less land acquisition and resettlement of riverine inhabitants. Due attention should be given to physical possibilities to construct a river training work on the opposite bank. Construction of such a work in a main river channel should preferably be avoided. Instead a construction location on char land (whether or not connected to the main land) offers much more prospects. The length of the bridge will then be a function of the distance between the erosion resistant riverbank and the char on which the construction of a river training structure would take place.

In the phase I study for the Jamuna Bridge both the mentioned corridors were already considered. There was only a marginal difference between the scores for the Goalundo site and the Mawa site. Measured depths and potential scour depths near Mawa were then considered to be higher to be than for Goalundo. This may have been due to the very narrow (natural) width prevailing at that time near

Mawa. On the other hand however, near Goalundo one has to deal with the confluence of the Jamuna and the Ganges, which makes the training of the rivers towards the bridge opening more complicated.

At present there is a preference from a river engineering perspective to choose the Mawa corridor for situating the Padma Bridge. The preference for this crossing site is mainly based on:

- Presence of clay on the left bank at the Mawa site
- Less complicated current attack patterns at Mawa than at the confluence of the Jamuna and the Ganges near the Goalundo corridor.
- Negligible disturbance of the flow through the Arial Kahn River.
- Slightly more favourable seismic situation.

The preference for Mawa from a river engineering perspective coincides with the preferences from a transport economic point of view.

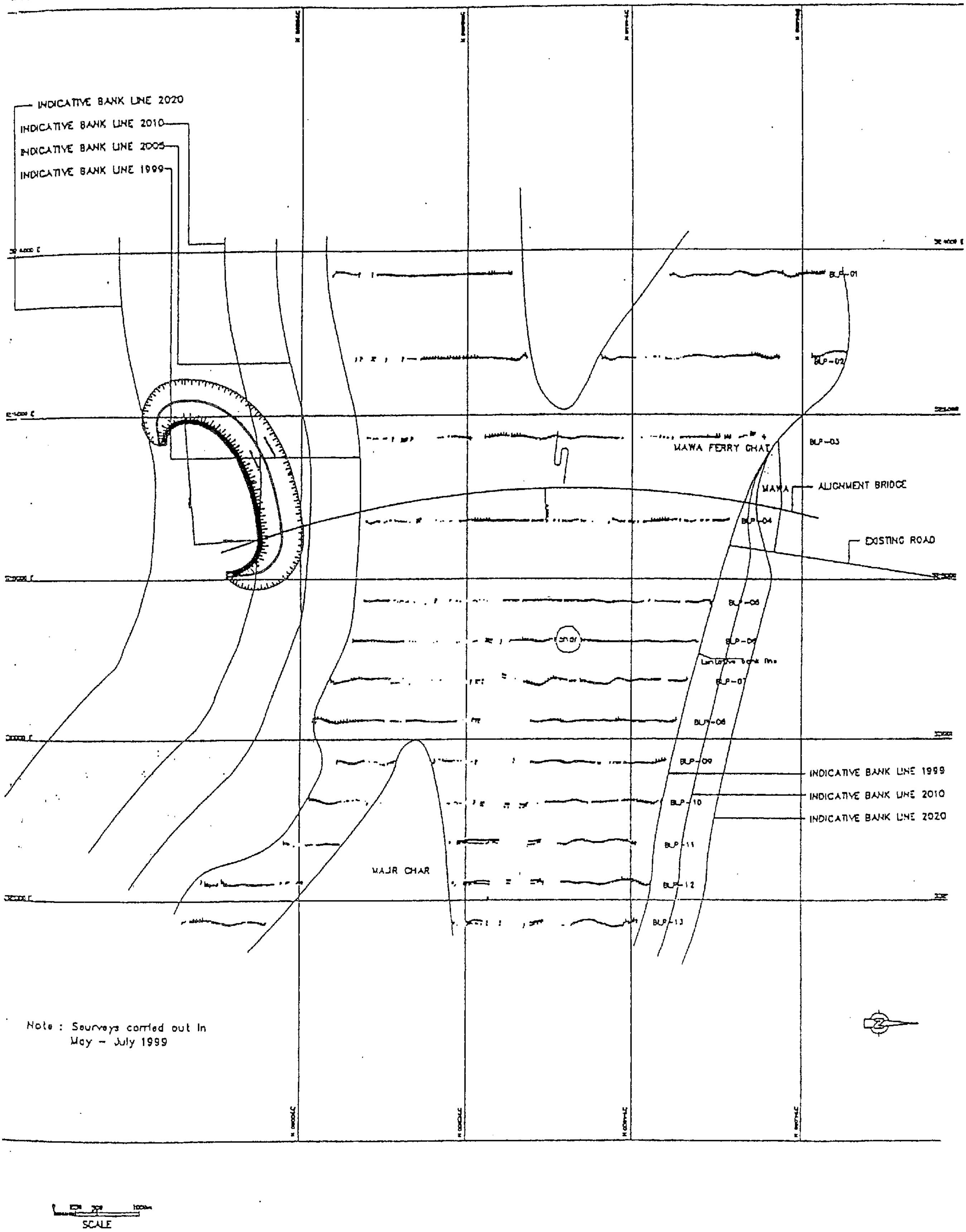
Tentative layouts for river training works at Mawa and Goalundo are indicated in the attached Figures. Note that on the left bank only protection at the approach road to the bridge is indicated. No guide bund is proposed here, as the river bank at Mawa is apparently not subject to heavy erosion. This is undoubtedly due to the presence of clayey [illegible] ...ch offers a natural erosion protection. Though the percentage of clay in the s[illegible] is not v[illegible] high, generally not more than 5 to 10 percent, this implies already a high ero[illegible] [illegible]tance when compared to soil that does not contain clay. A bridge opening of 6000m is ind[illegible] [illegible]his implies no or [illegible] [illegible]ackwater and constriction scour effects. Moreover this o[illegible] [illegible] ...he opening of the Jamuna Bridge (4800m), where the 1:100 years [illegible] ... Jamuna) is less (approx. 90,000 m^3/s versus approx. 125,000 m^3/s for Mawa.

Experience with disturbances due to dredging on the Jamuna River shows that a slope of 1V to 6H has sufficient tolerar[illegible] to undrained disturban[illegible] for [illegible] [illegible]ghts up to 30m provided that: the dredging is done in relatively thin laye[illegible] [illegible] no locally steep sections near the toe is produced; and ther[illegible] [illegible]ent time between successive cuts to prevent the build up of excess pore pressures. The s[illegible] upper Unit 1 at Padma are generally more silty than those at the Jamuna Bridge site and [illegible] [illegible]y, therefore to be more tolerant to undrained disturbance. On this basis it is considered that 1V to 6H slopes are acceptable from consideration of constructability, subject to review at detailed design stage, based on the results of further ground investigation and special testing.

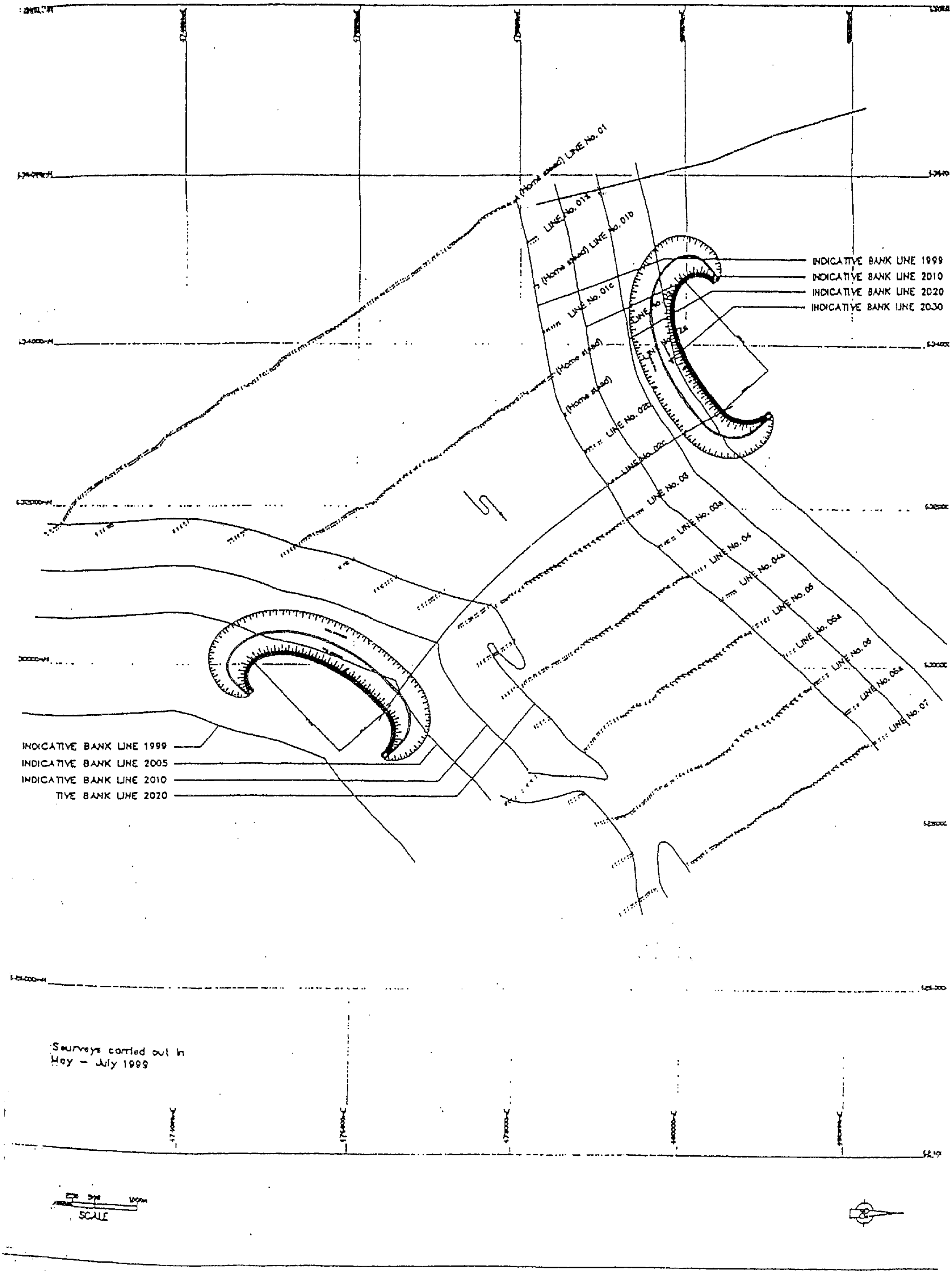
A steeper slope of 1V to 3.5H should be only acceptable above standard low water level.

The precedent of the Jamuna Multipurpose Bridge has provided a unique case history and an excellent experience base for the Padma Crossing. At the same time the consultants have remained alert to the differences in the prevailing factors. In particular, these differences include an increased ship impact load and reduced, but still important, seismic effects. The similarity to Jamuna should enhance confidence in, the conclusions derived for Padma.

During the study it became clear that a bridge at Goalundo would be the same length as, and so similar in other respects to, a bridge at Mawa and that there would be no essential difference in the cost of the bridge itself. Hence, for the purposes of illustration and design, the levels shown in Annex-D, Figures D4.1-5 correspond to the Mawa preferred site.



Layout Guide Bund Mawa



Layout Guide Bunds near Goalundo

For major bridges such as the Padma Crossing, design is inextricably linked to construction techniques. This is because the method of erection affects the distribution of loads in the permanent structure, and because the structure must be safe at all intermediate stages during construction. In the planning and procurement stages for the Jamuna Bridge the consultants took care to ensure that the reference designs were underpinned by thorough construction planning. This paid dividends in the form of sound method related cost estimates, and provided tenderers with a springboard from which to refine their designs. The successful construction of that crossing proved that the assumptions made by RPT-NEDECO-BCL were realistic. The same buildability and method related approach has been applied throughout the bridge engineering studies for the Padma Crossing. As the Padma Crossing corridors are downstream of the Jamuna/Ganges confluence, river access for equipment and materials will present a lower risk to tenderers; and the successful precedent of Jamuna should boost their confidence further.

The 230kV electricity interconnector, the 760mm diameter gas pipeline and the telecommunication cables can be added to any of the configurations, following the principles shown in the attached Figure.

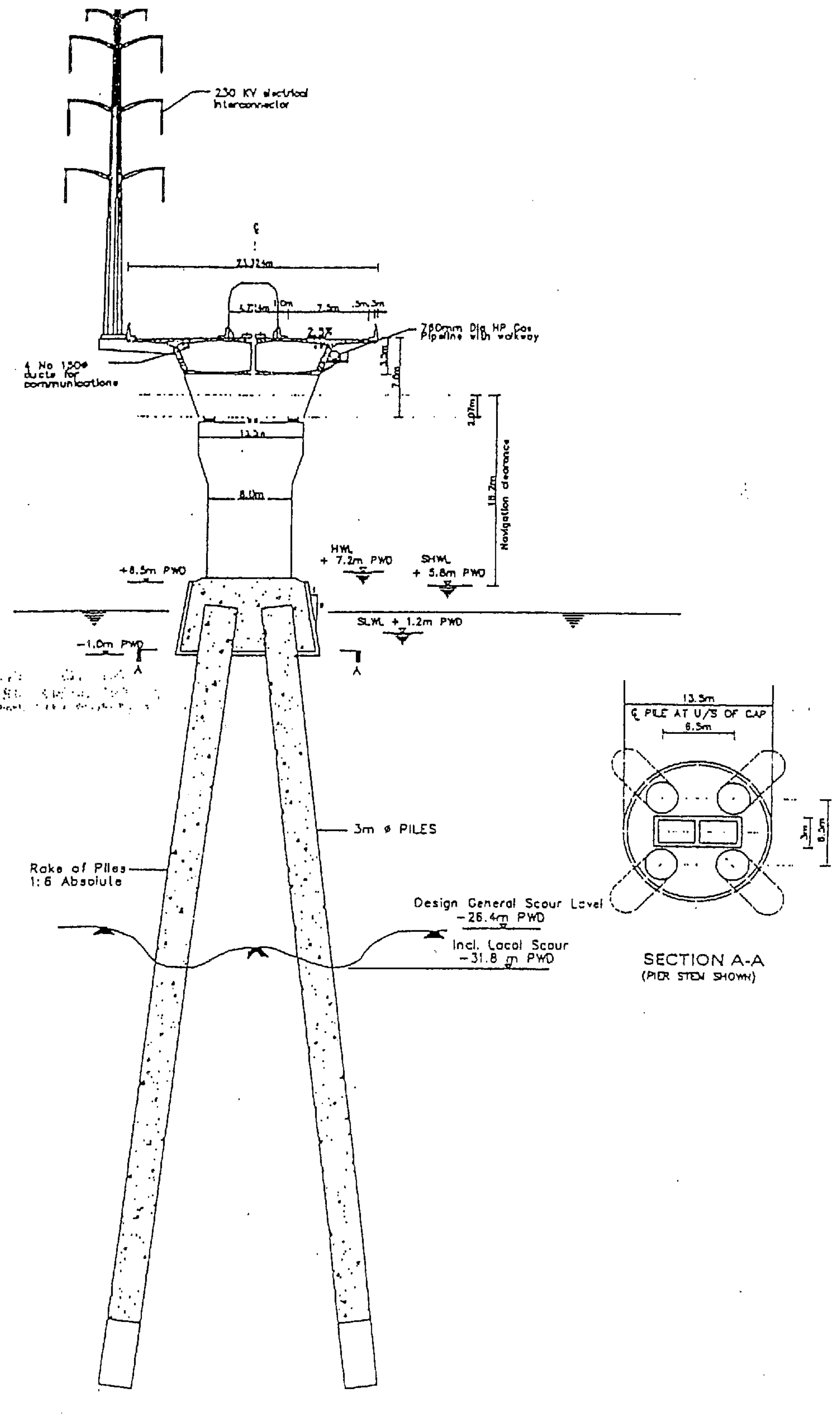
Discussions with Bangladesh Rail have established that the limiting gradient for Broad Gauge on the bridge is 0.5 percent as for MG rail on the Jamuna Bridge. This means that approaches to a bridge including rail will be considerably higher and longer than those for a road only crossing. In fact, the approach viaducts are approximately 20m high at the ends of the main bridge. Rail viaducts of length 1200m and road viaducts of 270m have been provided at both ends. At the abutments of both the road and rail viaducts the embankments are approximately 14m high. Diagrammatic elevations of the bridge end arrangement for options with rail are illustrated in Annex-D, Figure D4.10

A rigorous analysis of river patterns, similar to that carried out to establish the Jamuna Bridge vertical profile, will be particularly important for a rail bridge. For road-only cases where a maximum 2 percent gradient may be used, the final requirement for vertical profile will be more straightforward.

The substructure comprises piers founded on four large diameter raking piles. For costing, two alternatives were considered: firstly, steel piles with concrete plugs near the toe then compacted sand fill and concrete infill at the top; and secondly, reinforced concrete piles cast inside full-length steel sleeves. Recent work has indicated that reinforced concrete piles cast inside a steel tube are both structurally efficient and cost effective. This was confirmed during this study, and so the reinforced concrete piles with steel sleeves were adopted for the final costing.

A segmental prestressed concrete box girder has been adopted for the superstructure. The span length determined during the Inception stage on the basis of a greater scour depth was reexamined, but no reason was found to change from the 120m adopted previously. It was noted that the span vs cost curve was fairly flat in the range appropriate for the Jamuna Bridge, and it is of interest to note that the study of span length vs cost for the Oresund Bridge reflected the findings for the Jamuna Bridge. For the 7.85km long bridge portion of that 15.8km crossing, it was found that cost difference in the span range 100m to 140m was negligible.

It has been assumed for this Phase 1 study that the precast segments of the superstructure would be erected with a gantry using the balanced cantilever technique.



PROVISION FOR GAS,ELECTRICITY & COMMUNICATIONS

Steel/concrete composite box girders could readily be substituted for the PSC box structural form. In that case, full spans would be erected as simply supported units, subsequently made continuous. The concrete deck slab could be cast onto the open top steel box prior to erection. Alternatively, the steel box could be erected with temporary steel bracing in place. In this case, additional permanent steel flange material would be required over the central portion of the span to support the wet concrete in the temporary condition.

To get best value from the international construction market will require a set of design criteria which allows as much freedom as practicable to tenderers and their designers, but which imposes those constraints necessary to ensure a safe, durable and maintainable structure.

Incremental expansion from a 2 lane road bridge to a 4 lane road bridge could be achieved by extending the cantilevers and adding tubular steel or precast concrete props. Probably the most efficient way of constructing the extension to the cantilevers would be by precasting monolithic segments of deck and parapet. These precast units would be integrated with the stage one concrete using in situ concrete stitches both longitudinally and transversely. The extension could be prestressed onto the stage one deck by coupling to the stage one prestressing and reinforcement could also be connected using coulpers. Some prestressing could be applied longitudinally within the parapets if required to avoid cracking, especially over and adjacent to the piers.

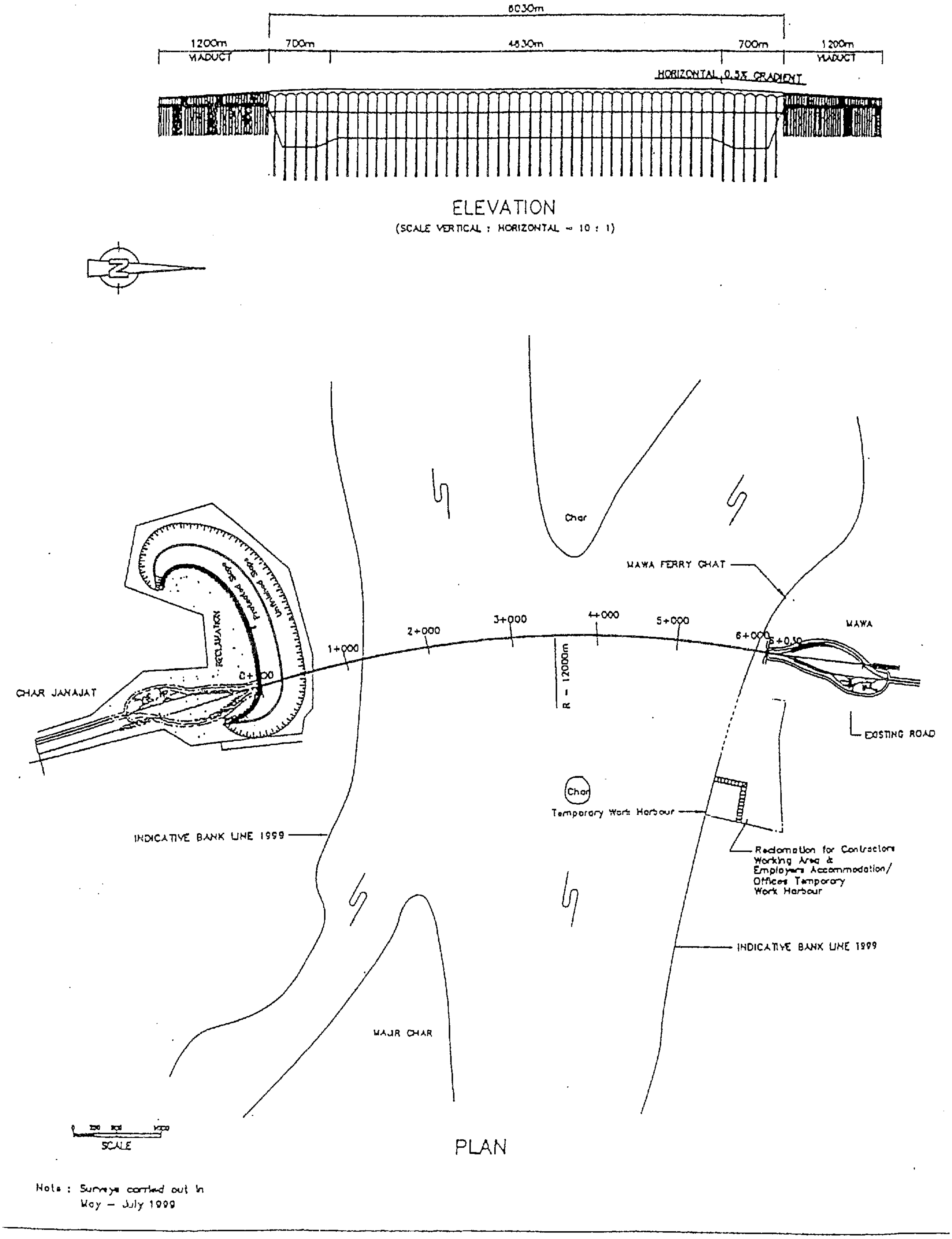
Certain day one provision would have to be made, including: a facility for adding longitudinal external prestressing to the box girder (ie anchorages and deviator blocks); thickening of the deck slab to accommodate couplers; and base supports cast and reinforced as protrusions on the face of the web of the box girder.

A similar approach could be adopted to move from the 2 lane road + BG rail to a 4 lane road + BG rail, but the need for development of this option has been precluded by system considerations alone.

The approach viaducts would be widened by adding piles, extending pilecaps, adding columns, extending the crosshead beams, adding a further prestressed beam and extending the deck slab.

Major sections of the national road network have been or are being rehabilitated/improved with the financial assistance of WB, ADB, OECF, DANIDA, DFID etc on both sides of the river Padma. More projects are in the pipeline for implementation in near future. One of the most relevant is the Third Road Improvement Project, now renamed as the South West Road Network Improvement Project, which is at detail design stage. The physical work is planned to start by April 2000 under ADB funding. This road once completed will provide a direct connection from the Mongla Port/Khulna & Barisal region to the capital city of Dhaka, via the Mawa crossing. The expected date of completion is June 2003. This single project will have a major influence on the transportation system in the SW region, and therefore needed to be considered with importance in planning any future road linkage to the Padma crossing or the location of the crossing itself.

The Base Case comprises a 2 lane road with hard shoulders and a centre barrier. For configurations 2 and 4 the cost estimate in relation to BG rail at day one includes the cost of the full strength in the main bridge substructure, superstructure, the approach viaducts and the track bed and the tracking. Beyond the approach viaducts, the cost of rail is included in rail approaches, not in the project cost. The layout of approach roads is consistent with the presence of rail at day one.



LAYOUT OF ROAD WITH RAILWAY CROSSING AT MAWA

The objective has been to connect the Bridge to the national highway network as economically as possible, consonant with minimum disruption to settlements and the environment. As the north bank is in close proximity to the ferry ghat, this entails a direct approach road connection of a little over 2km. The south approach is some 12km long, the ferry ghat being approximately 8km upstream of the Bridge end, and the alignment unfavourable to the desired direction of the road.

On the south bank there is sufficient space to provide a desirable flowing alignment, the only constraints being the waterways. However, the final alignment of the RJP III N-8 project and its crossing of the Arial Khan will determine the point at which the approach road joins the N-8, and the alignment shown is of a temporary nature. On the north bank there is limited room for manoeuvre due to the short connecting distance to the existing road.

In accordance with the Terms of Reference, a tunnel option alternative to a bridge has been investigated. The tunnel study has addressed the base case configuration of a 2-lane road with hard shoulders, with a kerb-to-kerb carriageway of 10.5m. An emergency walkway has also been provided for the use of stranded users in the case of vehicle breakdown or for access by operation and maintenance personnel.

Due to the highly variable bed profile of the Padma river, where the predicted general scour depth can go down to -38m PWD, ie.45m below water level, an immersed tube tunnel is not considered suitable and is not investigated further.

A single bored tunnel for two-way traffic with a minimum cover equal to one tunnel diameter is considered. For the predicted scour depth, the tunnel invert would need to be at a level of -64mPWD or below, and the tunnel length would be in excess of 13km. These parameters place a Padma tunnel beyond what has been constructed to date. The key issues of buildability, operation and maintenance, and safety of a 13km tunnel at a depth of -64mPWD are addressed.

With the precedent of the Trans-Tokyo Tunnel project, and the ground conditions at the Padma River Crossing being favourable for slurry shield tunnel technology, the construction of a tunnel is considered to be technically feasible.

The recent accidents in the European road tunnels have brought into focus the critical issue of safety in the operation of road tunnels. Under normal operating conditions the tunnel needs to be ventilated to remove the exhaust and poisonous gases and the same ventilation system can be used to control the spread of fire. Alternative ventilation systems are described in detail below. The risk of accidents and fire must be minimised and appropriate measures need to be put into place to allow evacuation to be effected with minimum loss of life. For an efficient and effective evacuation, discipline in the road user is essential if panic and chaos, which inevitably leads to loss of life, is to be avoided. The road users in Bangladesh are generally not accustomed to driving through tunnels and as such there is a serious risk of accidents occurring in the road tunnel.

For a Padma tunnel, the indicative lower-bound cost has been estimated as follows:

The all-in construction cost of $140M per km of a single bore (based on Tokyo Trans Bay out-turn cost) may be increased to allow for inflation to $150M/km for the Padma crossing. The river training works will be common to both bridge and tunnel schemes.

Out-turn cost for Tokyo Trans Bay Tunnel	US$ 140 million/km
Update for inflation	US$ 10 million/km
Allow for additional risk and mobilisation overseas (20%, say)	US$ 30 million/km
Total	US$ 180 million/km

Then capital cost for 13km Padma Tunnel Crossing (excluding river training works) would be:

13 x US$ 180 million = US$ 2,340 million

The consultants' cost estimate for the main bridge element (equivalent to the tunnel) for a 2-lane bridge scheme amounts to less than US$ 400m.

A coarse costing exercise indicates a large factor between the cost of a tunnel compared with that for a bridge. Even allowing for very large tolerances in these estimates (associated with, for example, inflation, changes in design parameters and design development) it is abundantly clear that a the cost of a tunnel will far exceed the cost of a bridge. This high cost premium, combined with the major construction, programme, operation and safety risks associated with a tunnel lead the consultants to recommend that this option should not be pursued further in this study.