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Government of the People's Republic of Bangladesh
Bangladesh Water Development Board

River Training Studies of the Brahmaputra River

Master Plan Report

May 1993

Technical Annexes
Annex 2
Economic Assessment

Sir William Halcrow & Partners Ltd.
in association with

Danish Hydraulic Institute
Engineering & Planning Consultants Ltd.
Design Innovations Group

HALCROW

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RIVER TRAINING STUDIES OF THE BRAHMAPUTRA RIVER

MASTER PLAN REPORT

GENERAL CONTENTS

8

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
BANGLADESH WATER DEVELOPMENT BOARD

RIVER TRAINING STUDIES OF THE BRAHMAPUTRA RIVER
MASTER PLAN REPORT: ANNEX 2

ECONOMIC ASSESSMENT

CONTENTS

TABLES

* Table at end of text

FIGURES

APPENDICES

* Table at end of text

GLOSSARY

Aman	-	Rice planted before or during the monsoon and harvested in November or December
Aus	-	Rice planted during March-April and harvested during June and July
B Aman	-	Broadcast Deep-Water Aman
Bil	-	Broad depression, usually with standing water in all seasons
Boro	-	Rice transplanted in December or January and harvested in April to May.
Char	-	Either a remnant of former floodplain or formed by deposition
District	-	Administrative unit in the care of a Deputy Commissioner
FW	-	With project - economic evaluation of the future situation with the proposed project
FWO	-	Without project - economic evaluation of the future situation without the proposed project
F0	-	Highland (Flood Depth <0.3 m)
F1	-	Medium Highland (Flood Depth 0.3 m - 0.6 m)
F2	-	Medium Lowland (Flood Depth 0.6 m - 1.5 m)
F3	-	Lowland (Flood Depth 1.5 m - 3.0 m)
F4	-	Very lowland (Flood Depth> 3.0 m)
Groyne	-	A bank protection structure jutting out from the river bank into the river
Gur	-	Sugar produced by evaporation from cane juice
Kharif	-	Monsoon Season
Khas land	-	Land which is the property of the government
Kutcha	-	Of Temporary Construction (eg bamboo thatch building; earth road)
L	-	Local variety - usually of rice
LCB	-	Local Competitive Bidding
Mike 11	-	Danish computer model used in flow analysis - see SWMC
Mouza	-	A revenue unit comprising a number of villages
NAM	-	Computer model which derives run-off and groundwater recharge from rainfall
O & M	-	Operation and Maintenance
P	-	Present (economic situation)
Paddy	-	Unhusked rice
Pucca	-	Of permanent construction (eg tarred road or concrete building)
Rabi	-	Dry Season
Revetment	-	River bank protection of hard material such as concrete blocks
River Training	-	Controlling the course of the river by placing structures along the banks
Semi-Pucca	-	Of semi-permanent construction (eg corrugated Iron building with brick floor (Flood depth> 0.3 m)
T Aman	-	Transplanted Aman
Thana	-	Small administrative unit
ToR	-	Terms of Reference
Union	-	Division of a thana or upazila
Upazila	-	Upgraded thana as defined by the Local Government Ordinance of 1982
Zila	-	A district comprising a number of upazilas

ANNEX 2 - ECONOMIC ASSESSMENT

1. INTRODUCTION

1.1 Background

Over a period of 15 to 20 years since its construction, the BRE provided effective relief from uncontrolled and sustained inundation resulting from high flood flows in the Brahmaputra River. This has facilitated a substantial increase in agricultural production, as well as enhancement in the general development in the protected areas, despite having an adverse impact on the fisheries sector.

In recent years, the continuous erosion of the right bank of the river has resulted in frequent breaches of the BRE, and consequently the level of security against damaging floods has significantly declined. Furthermore, river bank erosion has very considerable direct consequences with the loss of agricultural land and settlements displacing large numbers of people.

Breaches of the BRE are increasing in frequency as progressively greater lengths of the old BRE become within range of aggressive river bends. The present strategy of realigning the BRE at relatively short set back distances from the bankline has also led to a higher degree of breaching and frequent retirements of the BRE within a reach experiencing rapid erosion.

With the exception of Sirajganj (population around 100,000), the instability of the bankline has discouraged the development of urban centres along the Brahmaputra River. In contrast to most locations, Sirajganj, has remained in the same position for approximately 150 years. This apparent stability has proved to be a temporary phenomenon and since the 1960's bank protection measures have been necessary to stabilize the bankline. In the early 1980s, the situation deteriorated rapidly and urgent action (ie. construction of Ranigram Groyne) was required to avoid the loss of the town. These protection measures are now once again under threat.

The main objective of the Master Plan is to develop a strategy for the long term stabilization of the bankline over the entire length of the right bank of the Brahmaputra, south of the confluence with the Teesta. Priority Works have been identified and designed under BRTS, and these will provide bank protection measures at locations where there is an urgent need for immediate action, either to protect major urban centres (e.g Sirajganj) or to ensure the effective and sustained functioning of the BRE (eg. Sariakandi and Mathurapara). The Priority Works are intended to form the initial stage of the Master Plan and so are entirely consistent with the long term strategy for bank stabilization.

This report is primarily concerned with the economic implications of the bank protection and BRE realignment at several priority locations, but also addresses other aspects of the Master Plan such as an optimal strategy for BRE realignment and the overall economic costs and benefits of long term bank stabilization. Financing constraints to the implementation of the Master Plan are also considered.

1.2 Objectives of the Economic Assessment

The main objectives of this economic assessment are to:

- evaluate the economic consequences of river bank erosion in relation to land, property and infrastructural losses;

- evaluate the economic consequences of flooding from a breach in the BRE with regard to crop and livestock losses, property and infrastructural damage;

- estimate the economic capital and recurrent costs of river bank protection works and BRE realignment;

- determine the economic viability of each priority location, and rank projects on the basis of standard economic criteria.

- determine an optimal strategy for embankment realignment; and

- evaluate the economic costs and benefits of long term bank stabilization

1.3 Information Sources

The information required for the evaluation of the consequences of river bank erosion and flooding from a breach in the BRE has been collected from both primary and secondary sources.

With regard to the primary sources, a field survey was undertaken in November 1990 as part of the preliminary selection and ranking of priority locations. This survey was undertaken by the BRTS Team Leader, Economist and River Engineer in order to obtain a contemporaneous set of data of the consequences of river bank erosion and breaches in the BRE. In early November 1991, a further rapid rural appraisal was conducted with a view the assessing the current situation in relation to bank erosion and BRE retirement, as well as to update and supplement information gathered during the 1990 survey. The 1991 survey was undertaken by the BRTS Economist and Sociologists (N.B. one of the primary tasks of the survey was to undertake an assessment of the social implications of the river bank erosion). All six priority sites were visited, namely Fulchari, Sariakandi, Mathurapara, Kazipur, Sirajganj and Betil.

During the 1990 and 1991 field surveys, for the purpose of the economic appraisal, information was gathered at each location on the following topics:

- Risk and likelihood of a breach in the BRE;

- Existing alignment of the BRE and proposed retirement (if applicable);

- Numbers of people likely to be displaced by river bank erosion over the next five years;

- Numbers of people likely to be severely affected by flooding from a breach in the BRE;

- Areas of land (agricultural, market and urban) likely to be eroded over the next five years and their respective values;

- Agricultural production (both crop and livestock) likely to be lost due to flooding from a breach;

- Public and private properties (including houses, shops, schools, health centres etc) at risk from erosion and flooding;

- Public infrastructure, e.g. roads, railways, ferry ghats, at risk from erosion and flooding.

- Important location specific factors, such as the possibility of a partial change in the river course (e.g. at Sariakandi, where less than 1 km. now separates the Brahmaputra from the Bangali)

Information with regard to the possible consequences of river bank erosion and BRE breaches (e.g number of people displaced, agricultural losses, property and infrastructure at risk) was collected at each location through group interviews with a number of community leaders and local farmers. It was expected that there would be bias in the respondents estimates of the likely consequences of erosion and/or flooding, so the information gathered was carefully scrutinised and the distorted data were rejected. Throughout the screening of the information, considerable attention was given to the establishment of a data set which provided a realistic basis for comparing the relative merits of the alternative sites. The information collected for each of the six priority locations during the field surveys is given in Appendix A.

The information was compared with aerial photographs and the 1:50,000 cartographic maps to check for major inconsistencies, as well as to assist with the estimation of areas affected by breaches in the BRE and the exposure of important infrastructure to the passage of breach flows. A more accurate estimation of the rural population densities at each location was also attained through interpretation of the 1:20,000 scale aerial photographs, and BBS population data (updated from the 1981 Population Census).

Given the limited time available for primary data collection, particularly with regard to information required for a thorough assessment of the wider agricultural implications of flooding from breaches in the BRE, the economic appraisal was very dependant on secondary sources. The main sources of secondary data are given in Table 1.1.

Table 1.1 Main Sources of Secondary Data

Source	Information Available
NW Regional Study (FAP-2)	Cropping systems; irrigated areas; crop yields and input usage; labour and draft power requirements; livestock and fish production; input and output prices; crop and non-agricultural flood damage.
FCD/I Agricultural Study FAP-12(Rapid Rural Appraisal)	Similar data to FAP-2, but for specific locations within BRE project area, ie. Kazipur and Kamarjani.
Bangladesh Bureau of Statistics (BBS)	Farm structure; land use crop areas; crop yields, crop flood damage; livestock and fish production. Size and distribution of population (1981 census); Public welfare facilities; Rail and Road infrastructure.
BWDB Evaluation Study of BRE, 1986	Agro-economic data similar to FAP-2
BWDB	Crop and Non-Agricultural Flood Damage Capital and O & M Expenditure on major Civil Works
Local Government Engineering Bureau (LGEB)	Unit costs of public buildings and infrastructure
Master Planning Organisation (MPO)	Flood regimes and agricultural production systems, irrigated areas
Jahangirnagar University (Geography Department)	Study of the Socio-Economic Impact of Bank Erosion
Urban Development Directorate, Ministry of Works	Sirajganj Paurashava Master Plan
Ministry of Local Government	Municipal Budgets
Ministry of Finance	Macro-economic trends Government Expenditure Foreign Aid

Links were also established with other FAP studies, e.g. FAP-5 (S.E. Regional Study), FAP-14 (Flood Response), and FAP-23 (Flood Proofing).

26

1.4 FAP Guidelines for Project Assessment

The methodology applied in the economic analysis has been based on the principles and procedures outlined in the FAP Guidelines for Project Assessment (FPCO July 1991). The Guidelines are based on internationally accepted techniques for the economic appraisal of investment projects. In addition to establishing a standard methodology for economic assessment of FAP projects, the Guidelines also provided the conversion factors to adjust financial prices to economic prices, and these have been used in the analysis.

78

2. KEY CHARACTERISTICS OF PRIORITY LOCATIONS

The project ToR called for the selection of six locations for the implementation of works on a priority basis. The six locations - Fulchari, Sariakandi, Mathurapara, Kazipur, Sirajganj and Betil - were selected from a list of eleven sites of active bank erosion in 1990/91 with, in almost all cases, an imminent risk of a breach in the BRE or where a breach has already occurred. The selection of the six priority locations was primarily based on the degree of economic losses/damage and social dislocation, so the size of the settlements affected strongly influenced the final ranking. However, the nature, rate and persistence of bank erosion, together with the amount of capital investment required at the different locations were also important considerations.

In addition, there is a very real concern that the Brahmaputra may break through to the Bangali River (if bank protection works are not implemented at Sariakandi/Deluabari and Mathurapara), which would result in a large proportion of the BRE project area being affected by prolonged inundation. The subsequent restoration of the continuity of the BRE without interruption of local drainage would require an expensive and socially disruptive realignment of the Bangali River.

The key characteristics of the priority locations are summarized as follows:

(a) Sirajganj

Substantial township and administrative centre with a population of approximately 100,000. Important trading centre with agro-industrial complex (textile, oil, sugar and jute mills) and two ferry ghats (BR and BIWTA). There has already been very considerable capital investment in bank protection works, including both groynes and revetment. The township is at present protected from flooding by the BRE which is incorporated in the bank stabilization works.

In 1990/91 the focus of erosion moved to the reach immediately south of the town where it breached the BRE in 1991. The passenger ferry ghat is also located in this erosion area. Flooding due to the breach is mainly restricted to the peri-urban (shanty area inhabited by people displaced by river erosion) and agricultural areas south of the township. With embayments to the north and south, the town defences are very exposed and the focus of erosion is expected to move next to this reach.

If bank protection works are undermined, active erosion could destroy most of the town over a period of 10 years.

(b) Fulchari

Fulchari is mainly a trading and administrative centre with Upazila headquarters and a population of about 10,000, but it also has an important rail ferry ghat for both goods and passengers (on Eastern Bengal Railway linking Dinajpur and Rangpur District with Dhaka).

Action has already been taken to stabilize the bankline through both cross-bars and "porcupine" revetment, but this has only been partially successful. A significant proportion of the Upazila HQ and market centre of Fulchari has been lost and/or displaced in the past three years. The ferry ghats also have to be continually relocated during the period of active erosion. Fulchari is not protected by the BRE, but is located on relatively high land so flooding is not a serious problem. If not realigned, the BRE is likely to be breached to the north of Fulchari within the next one to two years. This would severely disrupt the railway marshalling area located just behind the BRE.

(c) Sariakandi

Sariakandi is trading and administrative centre with Upazila headquarters and a population of around 15,000. Bank protection works have been implemented in the past (both groynes and revetment) with limited success. Sariakandi market and Upazila HQ have some protection, but the focus of erosion has now migrated downstream where it has breached the BRE and severely devastated a large agricultural area (approximately 400 ha) at Deluabari. Sariakandi is currently protected by the BRE.

Although there is still a real risk of loss/damage from river erosion and flooding at Sariakandi, the more immediate concern is the serious consequences of the possible capture of part of the Bangali River by the Brahmaputra. This could leave Sariakandi isolated on an island, and subjected to both active erosion and severe flooding from both the Brahmaputra and the captured Bangali channel. Furthermore, the significant increase in flood flows down the Bangali would inundate a large proportion of the BRE protected area.

(d) Betil

Betil consists of two large villages/markets and an important weaving centre. There is a high population density (1,800 per sq.km) for a rural area, with an estimated total of 18,500 people under threat from imminent erosion. In the longer term, Belkuchi Upazila headquarter to the north will also be at risk.

No measures have yet been taken to mitigate bank erosion. Although active erosion appears to have subsided in 1991, there is still a very high risk of the BRE being breached in the very near future (at present the BRE is only 150 meters from the river bank). Flooding from a breach in the BRE will severely disrupt this weaving centre at substantial cost to the local inhabitants.

(e) Kazipur

In recent years there has been very active erosion which has resulted in almost the entire loss of the old Kazipur town and Upazila headquarters. The Upazila HQ has now been moved to a new site and the displaced population are mainly living on the BRE. Population in the new market area (including BRE) and Upazila HQ is estimated to be in the order of 8,500. The focus of active erosion migrated about 1 km downstream in 1991/92 but a health complex and a number of semi-pucca buildings remain under immediate threat.

Since the mid 1980s, the area has suffered from frequent breaches of the BRE. These breaches have resulted in severe crop damage, as well as social and economic dislocation. Retired embankments have also been recurrently built (with associated land acquisitions problems), but have subsequently been breached. The severely affected agricultural area has been subjected to a deposition of river sand, which is clearly seen on the satellite imagery and aerial photography.

A new retired embankment has been constructed, which is currently intact (located approximately 0.5 km from the river bank).

(f) Mathurapara

This is an area of very active bank erosion in recent years, which has resulted in the relocation of Mathurapara market and a number of villages. The BRE has also been frequently breached and during the 1991 monsoon the breach remained open. A direct channel connection with the Bangali River has now been created by flood flows. During 1991, there was a very high rate of erosion (about 300 metres over a length of 2 km) and very considerable displacement of people. The new Mathurapara market (population of around 3,000) is under immediate threat of erosion, as it is now located on the present bank line. The new market has already suffered from flooding from the breach which has destroyed or damaged a number of pucca and semi-pucca buildings and severely disrupted the population. Almost all the population are now living in Katcha houses or tin sheds and many have been displaced by recent river erosion.

It is highly likely that this location will remain an area of very active erosion in the immediate future with more dire social consequences. The most serious concern is the high probability that the Brahmaputra will break through to the Bangali if no mitigating action is taken, and the extremely severe consequences which could unfold.

3. ECONOMIC CONSEQUENCES OF RIVER BANK EROSION

On the basis of the information gathered during the field surveys and from secondary sources (see Chapter 1), the economic consequences of river bank erosion were derived.

The economic implications were estimated from a valuation of the land, property and infrastructure likely to be lost as a result of river bank erosion over a thirty year period (i.e. the economic life of a project as given in the FAP Guidelines).

3.1 Land

For the purpose of valuation, land was divided into five categories - protected (by the BRE) agricultural land, unprotected agricultural land, market land, land within Upazila HQs and urban land. Estimates of the areas likely to be eroded over the next five years for each of the six locations are presented in Table 3.1, and the total areas are summarized below in Table 3.2. Area estimates have been based on length of reach experiencing erosion and the expected rates of erosion. Expected erosion rates have been determined from an analysis of the frequency of different erosion rates at a given location over a period of 20 years (i.e 1973 to 1992), i.e a probabilistic approach has been applied.

Table 3.2 Area and Economic Value of Land Expected to be Eroded over the Next Five Years at Priority Locations

Priority Location	Length of Reach (Km)	Expected Erosion Rate (m/annum)	Total Area of Eroded Land Over the Next 5 Years (hectares)	Total Economic Value (`000 Tk)
Fulchari	12.5	60	375	86,900
Sariakandi	11	100	550	174,000
Mathurapara	11	100	550	74,375
Kazipur	17	75	640	128,500
Sirajganj	19	90	855	1,571,000
Betil	18	95	855	187,500

It is evident from the above table that there are significant differences between the various sites, which mainly reflect the expected rates of erosion but in the cases of Sirajganj and Sariakandi are a reflection of the urban development. The derivation of the nature and expected rate of erosion at the different sites is more fully discussed in Appendix C.

In order to determine the economic value of these land losses, the economic prices were applied as shown in Table 3.3

Table 3.3 Economic Prices of Land

Land Category	Economic Value: (`000 Tk/ha)
Agricultural Land (Unprotected)	125
Agricultural Land (Protected)	200
Market Land	500
Upazila HQ Land	1,000
Urban Land	3,000
Peri-Urban Land	900

The economic prices of agricultural land were determined on the basis of the present value (PV) of the economic net value of production over 50 years at a 12% discount rate. The prices of market and Upazila HQ land were derived from the current financial prices.

Urban and Peri-Urban land prices were based on the estimates given in the Sirajganj Master Plan (1991) prepared by the Urban Development Directorate of the Ministry of Works. The economic prices of non-agricultural land are assumed to equate with their financial values.

Given the differences in economic prices between the alternative locations, it is not surprising that there is even more disparity between the estimates of total land values, ranging from Tk 74.4 million in Mathurapara to Tk 1,571 million in Sirajganj. Clearly, at locations in which urban areas are at risk, there is a very significant increase in the overall value of losses.

3.2 Property and Infrastructure

In order to estimate the economic value of property likely to be lost or displaced over the next thirty years, public and private property were divided into three broad categories - pucca, semi-pucca and katcha. Estimates of the number of properties within each category for each location are given in Table 3.1. It is apparent from Table 3.1, that there is an obvious relationship between the number of properties and the number and size of settlements affected. The estimates were based on Upazila statistics and information collected from local government officials during the course of the field surveys, as well as interpretation of aerial photographs. For Sirajganj, some information was also provided in the Sirajganj Master Plan (1991), but regrettably no aerial photographs were available for the town.

The estimates are coarse and should be regarded as reasonable approximations for the purpose of economic valuation. Given the considerable uncertainty and speculation concerning a number of the key factors influencing the nature and rate of river bank erosion, a greater degree of accuracy in the estimates of the economic losses due to erosion is not justified. Greater accuracy would require a very marked increase in time allocated to primary data collection.

With respect to the valuation of these different categories of property, it should be noted that for semi-pucca and katcha buildings, the values are based on the costs of relocation coupled with the damage to the existing structure during dismantling, whereas pucca buildings have been priced at their full replacement cost (based on LGEB rates). The economic unit values of the property likely to be lost or displaced were derived from their current financial value adjusted by the standard conversion factor of 0.82. The economic and financial unit values are given in Table 3.4.

Table 3.4 Economic Prices of Property

Type of Property	Financial Unit value (`000 Tk)	Economic Unit Value (`000 Tk)
Public Building [1]		
-pucca	1,500	1,230
-Semi-pucca	250	205
Commercial/Industry		
-pucca	1,500	1,230
-semi pucca	250	205
Private Houses/Shops		
-pucca	300	246
-semi-pucca	15	12.3
-Katcha	5	4.1
Weaving Sheds	30	24.6

N.B. Unit values for semi-pucca and katcha buildings, including weaving sheds, are based on relocation costs.

An attempt was also made to estimate the value of the potential loss of public infrastructure, such as roads, bridges, culverts, railway embankments, at risk from erosion over the next 5 years. Estimate of the likely physical losses were made on the basis of aerial photographs, maps and inspection during the field trips.

1 School, health centres, clinics, government offices, P.O.s, godowns, covered markets, banks, mosques etc.

20

The economic unit values applied to the physical parameters were derived from the current financial unit value (based on LGEB rates) and adjusted by appropriate conversion factor (see Table 3.5). The costs of relocating the ferry ghats are based on the economic costs of employing a labour gang to regularly reshape the gangways and ramps to floating pontoons and jettys and to reconstruct a temporary bulkhead, during periods of active erosion. At Fulchari, the cost of land acquisition to resite the railway sidings is also included.

Table 3.5 Economic Prices of Infrastructure

Type of Infrastructure	Financial Unit	Unit Value (`000 Tk)	Conversion Factor	Economic Unit Value (`000 Tk)
Pucca Road	km	2,000	0.80	1,600
Katcha Road	km	400	0.76	304
Railway Embankment	km	3,000	0.76	2,280
Power and Telephone Lines (relocation cost)	No.	25	0.83	20.75
Ferryghat (relocation) costs/annum)	No.	240	0.76	182.4
Bridges/Culverts (road and railway)	No.	300	0.78	234

The total economic value of property and infrastructure likely to be lost to river erosion over a five year period at each priority location is presented in Table 3.6 and summarized in Table 3.7.

Table 3.7 Economic Value of Property and Infrastructure Expected to be Lost over the Next Five years at Priority Locations.

Priority Location	Property	Economic Value ('000 Tk) Infrastructure	Total
Fulchari	42,312	15,060	57,372
Sariakandi	69,003	16,708	85,711
Mathurapara	12,505	4,018	16,523
Kazipur	39,934	9,044	48,978
Sirajganj	322,055	54,880	376,935
Betil	56,375	15,328	71,703

4. ECONOMIC CONSEQUENCES OF FLOODING FROM A BREACH IN THE BRE

4.1 Impact on Agriculture and Fisheries

Estimates of the economic consequences of flooding from a breach in the BRE were also taken into account in the appraisal. The economic implications were derived from a valuation of:

- crop damage;
- livestock losses;
- impact on future agricultural and fisheries production; and
- property and infrastructural damage

4.1.1 Crop Damage

Crop damage due to flooding through a breach in the BRE can broadly be divided into two categories:

- areas severely affected in the immediate vicinity of the breaches, where crops are devastated by the volume and velocity of the flood water and sand deposition;

- areas partially affected by breaches, as a result of higher levels and longer periods of inundation.

(a) Severely Affected Areas

In the severely affected area within the close proximity of a breach, it has been assumed that a total loss of one years cropping will be experienced. In economic terms, this is reflected in the overall annual net agricultural benefits for the total area severely affected. In the locations where breaches have recently occurred, e.g. Kazipur, Mathurapara and Sonali bazar, farmers report a total loss of the monsoon rice crop following a breach. It is also very difficult to successfully cultivate a monsoon rice crop in subsequent years when the area is exposed to high velocity flood water and deep inundation.

Furthermore, a heavy deposition of fine sand occurs at the time of the breach which initially renders the land unsuitable for crop production in the following Rabi season. In subsequent years, farmers attempt to grow Boro rice or other Rabi crops, but productivity is low. Increasingly, these areas are being planted with sugarcane, which is able to withstand high levels of inundation although yields are reduced.

The scale of the areas severely affected by a breach in the BRE varies between locations and is related to the length of the breach. However, information based on the interpretation of aerial photographs, coupled with field visits to breach locations, indicates that a breach typically devastates an area extending to approximately 3.5 to 4 sq.km (400 ha). This estimate was used in the analysis at each priority location.

22

With regard to the valuation of the crop losses in the severely affected areas, the overall gross margin per hectare (in economic terms) that would be obtained from one year's crop production has been applied to the area affected. In subsequent years, it has been assumed that only sugar cane will be produced for a five year period, so the annual gross margin for sugar was used. [2]/ The cropping patterns within the two agricultural zones of the BRE project area, together with the derivation of the economic crop gross margins, are fully discussed in Appendix B.

The total area and net economic value of production lost due to flooding in severely affected areas at each priority location is given Tables 4.1 and 4.2 and summarized in Table 4.3

Table 4.3 Total Area and Net Economic Value of Crop Production Expected to be Lost in Severely Affected Areas

Priority Location	Severely Affected Agricultural Area (ha) [3]/	Reduction in Net Economic Value per Hectare: Initial Year (Tk/ha)	Reduction in Net Economic Value per Hectare: Future Years (Tk/ha)	Overall Reduction in Net Economic Value: Initial Year (`000 Tk)	Overall Reduction in Net Economic Value: Future Years (`000 Tk)
Fulchari	400	23,581	13,898	9,432	5,559
Sariakandi	320	24,140	14,457	7,725	4,626
Mathurapara	385	24,140	14,457	9,294	5,566
Kazipur	360	22,413	12,730	8,069	4,583
Sirajganj	100	21,559	11,876	2,156	1,187
Betil	345	21,559	11,876	7,438	4,097

(b) Partially Affected Areas

In the areas affected by higher level of inundation caused by breaches in the BRE, a more objective assessment of crop damage was undertaken. In this assessment, the timing, duration and depth of flooding was related to the stage of growth of the crop (taking into account the range of cropping patterns that are likely to be prevail within each zone - see Appendix B).

Time series data on the magnitude of change in the depth and duration of flooding resulting from various breach scenarios, at a given 10 day time interval, were generated by the Breach Simulation Model (see Annex 2 of the BRTS Second Interim Report). In spite of the limited

2 Sugar cane grown in severely affected areas is estimated to yield 20% less than average, and so a gross margin of Tk 9,638 per hectare per annum was applied.

3 Non-agricultural land (e.g. market, Upazila HQ and town land) severely affected has been excluded from the calculation of crop damage estimates.

26

time series data available (1986 to 1989), the results of the simulation model did permit the derivation of crop damage frequency curves, and thereby the calculation of expected annual crop losses at each priority location. The crop loss estimates obtained were regarded as a sufficiently accurate representation of a typical year for the purpose of the economic analysis.

On the basis of this information on the timing, duration and depth of flooding, it was possible to estimate the incremental areas affected (i.e. additional to normal flooding) for each breach location during the peak flood period in 1986, 1987, 1988 and 1989. This was derived from the cultivated areas which remained submerged, i.e. switched from F0 to the F1, F2 and F3 flood regimes [4]/ for a period is excess of 10 days. These areas are presented in Table 4.4. For example, in Fulchari an additional 8,630 hectares of F0 land remained inundated for a period in excess of 10 day during mid to late July 1989. The reduction in unit economic crop gross margins for each year were then applied to these incremental crop areas in order to derive the overall net economic value of production losses. Reductions in gross margin were estimated on the basis of the percentage loss of T. Aman (HYV), T. Aman (LIV) and sugar cane. (The main Kharif season cropping pattern of 50% T. Aman (HYV), 35% T. Aman (LIV) and 10% sugar cane was assumed).

Table 4.4 Incremental Areas Affected by Flooding From a Breach

Priority Location	Incremental Area Affected (ha)			
	1986	1987	1988	1989
Fulchari	145	29,563	35,787	8,630
Mathurapara/Sariakandi	373	49,344	59,835	41,891
Kazipur	280	17,692	19,659	12,946
Sirajganj	23	2,547	996	1,295
Betil	26	2,380	257	216

Estimates of the percentage crop loss resulting from different durations and depths of flooding at various stages of growth (from planting to harvesting) were made for each crop during the Kharif season. The estimates used in the analysis are shown in Table 4.2. For T. Aman damaged in July, it has been assumed that the affected area would be completely lost and then replanted in August, but would experience a 40 % yield reduction. August and September floods would, however, result in direct crop damage.

4 A full description of the various flood regimes used in the analysis is given in Appendix B.

28

Table 4.5 Crop Loss Factors

Crop	Month	Crop Loss Factor
T Aman	July	40 %
T Aman	August	60 %
T Aman	September	80 %
Suger Cane	July to September	20 %

N.B T. Aman - both HYV and LIV

Return periods were then assigned to each year based on the 10 day annual maximum flood flows in the Brahmaputra between 1956 and 1989. Frequency (probability of non-exceedence) estimates were than derived from these return periods for each year (1986 to 1989) and plotted against the overall net economic value of production losses. On the basis of these crop damage frequency curves, estimates of the expected annual average crop losses (calculated as the sum of the cost and frequency differentials) were determined for each priority location. The detailed calculations are given in Table 4.6, but for ease of reference the value of expected crop losses are summarized below in Table 4.7.

Table 4.7 Net Value of Production Expected to be Lost as a Result of Inundation from Breach in the BRE

Priority Location	Expected Net value of Production Lost ('000 Tk)
Fulchari	55,499
Sariakandi/Mathurapara	181,435
Kazipur	58,245
Sirajganj	5,909
Betil	2,121

N.B In the breach simulation model, the impact of breaches at Sariakandi and Mathurapara were regarded as identical, given their close proximity.

It is interesting to note that on the basis of published data on crop damage due to flooding from rivers and rainfall over a period of eighteen years, FAP-2 concluded that the crop damage in the N.W. Region is largely restricted to T Aus and T Aman rice crops and the average percentage damage to these crops is fairly similar, i.e. 2%-5%. Although Pabna District appears to be more vulnerable, with a crop damage factor of around 7 %, Bogra District is more typical with a loss of 3.5 %.

Similar crop damage factors were derived by the South East Regional Study (FAP-5). It should also be noted that these crop damage factors refers to 100 % damage of a portion of the cropped area, and not to yield reduction due to others factors (e.g. excessive rainfall, drought, and poor management practices).

4.1.2 Changes in Cropping Patterns as a Result of Regular Annual Flooding

In addition to the specific crop losses resulting from a breach in the BRE, the other main area of concern is the effect on future cropping systems and agricultural development within the BRE protected area. In the analysis, it has been assumed that if a breach remains open farmers would not just accept annual crop losses from repeated flooding, but would adjust their cropping patterns in response to the changes in flood regimes. This situation only arises at the Sariakandi/Mathurapara location. For the other locations, it has been assumed that a breach would be repaired under the present `ad hoc' system of embankment realignment.

Most of the agricultural benefits from flood control have primary resulted from an expansion of HYV T Aman during the Kharif season replacing either B Aman or a mixture of B Aus and B Aman. With continued exposure to flooding from a breach, this development will be reversed. The Rapid Rural Appraisal (RRA) of Kazipur, undertaken by FAP-12, found evidence for this change in cropping systems resulting from a frequent breaching of the BRE.

The Kazipur RRA concluded that:

"The BRE did successfully change the B Aus/Jute - B Aman - minor Rabi cropping pattern into a B Aus/Jute - T Aman pattern and then into irrigated HYV Boro - HYV T Aman over a large area. There has been a 50 % increase in T Aman production and about a 10 % increase is total monsoon rice production due to the project.

The embankment breaches since 1984 have again caused uncertain and serious flooding in 3 out of every 5 years, making T Aman production vulnerable to flood damage. Consequently both acreage and output of T Aman has declined due to flooding caused by breaches of the BRE".

In order to determine the likely changes to cropping patterns caused by flooding from a breach, typical cropping patterns were derived for each flood regime (i.e. F0, F1, F2, and F3) within both agricultural zones of the BRE protected area. The proportions of cultivated area falling within the various regimes for the base case, i.e no breaches, as generated by the breach simulation model were then applied to these "flood regime" cropping patterns to derive overall cropping patterns for each zone.

For the purpose of this analysis, it has been assumed that the timing, duration and depth of flooding that occurred during 1989 represent the average flooding condition that farmers expect. The proportion of cultivated area falling within the various flood depths during the first 10 days of August was taken as reflecting typical flood regimes. Future cropping scenarios, as a consequence of breaches, were then determined on the basis of changes to the cultivated areas within each flood regime. The anticipated changes in the proportions of cultivated area falling within each flood regime is presented in Table 4.8.

24

In addition to changes in flood regimes, future irrigation development also has a very significant impact on cropping systems, and this has also been taken into account in the analysis. Cropping patterns were therefore prepared for the present (P), Future with (FW) and Future without (FWO) project scenarios for the Sariakandi/Mathurapara location. A full discussion of the methodology used to derive these cropping patterns, together with Tables and Figures illustrating the various cropping patterns in the P, FW and FWO project scenarios are given in Appendix B.

After establishing the likely changes in cropping patterns resulting from breaches to the BRE, gross margins for a wide variety of crops were determined. These crops included B Aman, T Aman (LIV and HYV), Mixed B Aus and B Aman, Boro (Local and HYV), jute, wheat, oilseeds/pulses, potatoes, sugar cane, and vegetables. The assumptions, with regard to crop yields, input use and input/output prices, used to determine these crop gross margins are given in Appendix B.

On the basis of the likely changes in cropping systems and the crop gross margins, it was then possible to derive the incremental net agricultural benefits of preventing a breach through embankment retirement. Incremental net benefits (difference between the FW and FWO benefits streams) were determined over a 30 year period. These incremental net benefits were then carried forward into the overall project cost and benefit appraisal. For Sariakandi/ Mathurapara, the incremental net benefits are estimated to be in the order of Tk. 172 million per annum. The detailed calculation are provided in Appendix B. Table 12.

Table 4.8 Changes in the Proportion of Cultivated Area within Each Flood Regime at Sariakandi/Mathurapara

Flood Regime	% of Cultivated Area Within Each Flood Regime:- Without Breach	With Breach
F0	92.5 %	83.0 %
F1	1.7 %	6.8 %
F2	3.7 %	7.1 %
F3	2.1 %	3.1 %

4.1.3 Livestock

Discussion with farmers during the field surveys revealed that significant livestock losses were experienced in the areas severely affected by a breach in the BRE. No accurate statistics are available on livestock losses, and the approximate numbers of cattle, goats/sheep, and poultry can only be estimated. The valuation of these livestock losses were based on the current market prices converted to economic values by the standard conversion factor. The overall valuation of livestock losses at each priority location is given in Table 4.9.

Table 4.9 Economic Value of Livestock Losses as a Result of a Breach in the BRE

Priority Location	Value of Livestock Losses ('000 Tk)
Fulchari	1,070
Sariakandi	1,021
Mathurapara	1,070
Kazipur	1,046
Sirajganj	484
Betil	996

With regard to the impact on future livestock development within the BRE protected area, it has been assumed that breaches in the BRE would not have a significant effect.

In general, flood control projects have had an adverse impact on livestock feed resources through reducing fallow and grazing land, and by switching to short-strawed HYV of rice. (HYV straw also has much lower levels of digestibility and palatability than local varieties).

This has led to a deterioration in livestock health and productivity, as well as a marked decline in livestock numbers, particularly cattle which are reported to have decreased by 25 % to 40 % over the past ten years in certain parts of the BRE protected areas. Coupled with the increase in cropping intensity, this decline has created a noticeable shortage of draft power, especially for small and marginal farmers.

Flooding from a breach in the BRE is not likely to make a significant contribution to livestock feed resources, and so will have neither a negative nor positive impact on future livestock populations and productivity.

4.1.4 Fisheries

Capture fisheries has been identified as one of the sectors worse affected by flood control projects. The main negative effects of FCD/FCD1 schemes on fish production can be summarized as follows:

- construction of flood control embankments has reduced the area of perennial beels and floodplain available for fish spawning, nursery and feeding grounds, thereby reducing the overall fish production potential. This not only affects capture fisheries, but also pond culture fisheries which depend partly on the collection of fish fry from the wild;
- construction of regulators and cross dams prevents migration of fish to and from breeding grounds, has resulted in reduced stock of migratory species (principally higher value carp and prawns) and different species composition;

2X

- the reduced area of open water within the flood protected area has severely restricted subsistence fishing, with detrimental consequences on the income and nutrition of the poorest section of the community;

- reduced fish stocks and lower catch rates have endangered the livelihood of fisherman, many of whom have been forced to migrate from the protected areas in search of alternative employment;

- increased uses of chemical fertilizers and pesticides, associated with the adoption of HYVs has led to the pollution of natural water bodies and to higher fish mortality rates.

Quantification of any of these impacts is subject to a high degree of uncertainty, but it is now well accepted that flood control projects have very serious detrimental impacts on fish production and fishermen within the protected areas of a floodplain.

Capture fisheries appears to have suffered seriously in the past decade. Recent appraisals undertaken by FAP-12 in the BRE project area suggested that the annual fish production has decreased by about 35 % to 40 % in the Kamarjani area (as reported by fishermen and fish traders). Similarly, in the Kazipur area, fish production is estimated to have declined by up to 50 %.

Some improvements could be made to increase fish stocks in the floodplain; but, without natural replenishment, stocks will continue to decline.

To a limited extent, these negative consequences can be offset by:

- a reduction in the risk of losses of fish pond stocks due to flooding, which could encourage a more rapid development of fish farming;

- an improvement in the prospective returns from fish production in other water bodies, such as borrow pits.

FAP-12, in their appraisal of Kazipur, indicated that the construction of the BRE has resulted in some ponds being stocked with fry to compensate for the capture fisheries losses. However, in recent years, the frequent breaches in the Kazipur reach has completely negated this positive impact, and many ponds have reverted to a semi-derelict state. The only slight compensation is that water flowing through the breaches carry some young fish onto the flood plain which may facilitate fish breeding. In the analysis, it has been assumed that the negative consequences of the BRE have already been experienced and that capture fisheries production on the protected floodplain has now reached an equilibrium position. Consequently, in the FW project scenario (i.e. without breach) no further impact on capture fisheries in expected. However, a modest improvement in culture fisheries is envisaged as a result of flood protection vis-a-vis the FWO situation where the breach remains open, i.e. at the Sariakandi/Mathurapara only. In this situation, the estimation of the incremental fisheries benefit is based on a higher rate of growth in fish pond development, i.e.20 % in the FW situation compared with 10 % in the FWO situation over a 10 year period. In the present situation, it is estimated that there are approximately 630 ha of fish ponds in the BRE protected area providing a net return of Tk 27,475 per hectare (in economic terms). This economic gross margin is based on a yield of 1000 kg/ha @ at Tk 32.8 per km and a harvesting cost of Tk 5,325 (250 man-days x Tk. 21.3 per day). No yield improvement has been assumed in the FW or FWO situations.

In the FWO situation, the additional fish carried by flood waters through the breach are regarded as insignificant, and therefore not included in the appraisal.

With regard to river fishing (primarily artisanal), the situation is also one of decline with diminishing annual fish catches and reduced stocks.

4.2 Property and Infrastructural Damage

Damage to property (public and private) and infrastructure has also been divided into (a) areas severely affected in the immediate vicinity of the breach, devastated by the volume and velocity of the flood water, and (b) areas partially affected by the breach as a result of higher levels and longer periods of inundation.

(a) Severely Affected Areas

In the severely affected areas, the number of properties likely to be damaged or relocated as a consequence of a breach at each priority location are given in Table 4.1. These estimates are based on interpretation of aerial photography and information collected during the field surveys. With respect to the valuation of the different categories of property, the values of semi-pucca and Katcha buildings are based on the costs of relocation and the damage to the existing structure during dismantling. Whereas, damage to pucca buildings has been taken at 50 % of their full economic replacement value.

An attempt was also made to estimate the value of the damage to public infrastructure at risk from flooding. Estimates of the likely physical impact were made on the basis of aerial photographs, maps and inspection during the field trips. The valuation of this infrastructural damage was based on full economic replacement cost of the damaged length of road, railway embankment etc.

The total economic value of property and infrastructure likely to be severely damaged or relocated as a result of breach at each location is presented in Table 4.10.

Table 4.10 Economic Value of Property and Infrastructure Expected to be Damaged by Flooding in Severely Affected Areas

Priority Location	Economic Value of Property and Infrastructure Damaged by Flooding		('000 Tk)
	Property	Infrastructure	Total
Fulchari	6,929	7,030	13,959
Sariakandi	20,295	8,800	29,095
Mathurapara	7,175	2,222	9,397
Kazipur	13,243	6,194	19,437
Sirajganj	77,572	20,807	98,379
Betil	22,161	8,028	30,189

(b) Partially Affected Areas

Severe floods of the magnitude of those in 1987 and 1988 can cause extensive damage to property and infrastructure, as well as causing temporary dislocation of economic activity. However, in most years the effects of flooding on property and infrastructure are minimal. To quantify the likely extent of flood damage averted by flood control embankments, it is necessary to calculate the mean expected damage without protection by deriving a flood damage frequency curve.

Despite the difficulties in obtaining reliable time series data on non-agricultural flood damage (there is only a complete data set for 1986 to 1989), the N.W. Regional Study (FAP-2) have attempted to derive flood damage frequency curves. Annual return period were determined for the four years, 1986 to 1989, for selected stations in each district and a best fit line was estimated, relating damage to return period. This relationship was then used to generate the value of damage against different return periods.

On the basis of these damage frequency curves, the annual values of expected damage were derived for each district. Given the weaknesses in the data set, the marked inter-district differences derived by the analysis were regarded as unrealistic, so a regional average figure was derived. The regional average value of expected value was calculated at Tk 226 per hectare. A similar figure (Tk 276 per hectare) was derived by FAP-5 for the Noakhali Region.

In the present appraisal of priority locations, the NW Regional figure of Tk 226 per hectare was used. This was then converted to an economic value by applying the standard conversion factor of 0.82. This unit economic value was then multiplied by the area of land switching from the highland (i.e. F0 flood regime where most property is situated), to F1, F2 and F3 land for the breach scenarios at each priority location (as determined by the Breach Simulation Model) during the peak flood period in 1986, 1987, 1988 and 1989.

Estimates of the incremental areas affected by flooding from a breach are given in Table 4.4.

Frequency estimates (see Section 4.1.1) were then plotted against the overall economic value of damage. On the basis of these damage frequency curves, estimates of the expected annual average damage to property and infrastructure were determined for each priority location. The detailed calculations are given in Table 4.11 and a summary of the expected damage is presented in Table 4.12 below.

Table 4.12 Economic Value of Property and Infrastructure Damage Expected in Partially Affected Areas

Priority Location	Value of Property and Infrastructure Damage ('000 Tk)
Fulchari	1,170
Sariakandi/Mathurapara	4,263
Kazipur	1,359
Sirajganj	139
Betil	44

5. CAPITAL AND RECURRENT COSTS OF PRIORITY LOCATIONS

A major factor to consider in the appraisal of the various priority locations is the capital and recurrent costs of the bank protection works required to mitigate bank erosion and to safeguard the BRE, thereby avoiding the economic consequences previously discussed. Capital cost estimates for bank protection works and BRE repair (if necessary) have been prepared on the basis of detailed designs and analysis of current unit rates (April 1992).

For the purpose of this assessment, it has been assumed that within the timescale of the priority works programme, there will be a practical limitation on the distance that the BRE can be realigned; determined mainly by land acquisition and other social constraints. Consequently, if multiple breach/retirement cycles are to be avoided, some bank stabilization is required. A more comprehensive comparison of the alternative BRE realignment strategies is presented in Chapter 7.

5.1 Capital Investment

Estimates of the capital investment required at each priority location were derived from detailed designs (prepared by the BRTS team) and current unit rates.

Unit rates have been derived from first principles, based on the likely construction methods and current labour, material, machinery and transport costs. Prices of imported materials, such as geotextile, have been obtained from manufactures with additions for storage, transport, duties and taxes. Prices of local materials have been obtained from local suppliers or based on current BWDB contracts.

Duties and taxes on imported items have been included the unit rates, although it is expected that duties and taxes on contractor's equipment and imported materials (e.g geotextiles) will be met by GOB. The following rates of duties and taxes have been assumed.

Table 5.1 Duties and Taxes Included in Financial Capital Costs

Item	Duty	VAT (% of cif prices)	Other Taxes	Total
Cement	15%	15%	5%	35%
Geotextile	75%	15%	5%	95%
Steel	50%	15%	5%	70%

A breakdown of the financial capital cost, at various priority location is given in Table 5.2 and it can be seen that the costs of bank protection works have been sub-divided into land acquisition, earthworks, dredging, protection works, mooring and general facilities/temporary work.

A physical contingency of 5% has also been included in the total cost estimates.

Land acquisition costs for protection works have been based on an average land value of Tk. 125,000 per hectare (i.e for riverside land) and the estimated areas required for each location are given below:

Table 5.3 Land Acquisition for Priority Locations

Priority Location	Protection Works Area (ha)	Protection Works Value (Tk million)	BRE Realignment Area (ha)	BRE Realignment Value (Tk million)
Fulchari (Phase 1C)	18.5	2.3	75	15.0
Sariakandi/Mathurapara (Phase 1A)	16.8	2.1	115	23.0
Sariakandi/Mathurapara (Phase 1B,2)	12.5	1.6	121	24.2
Kazipur (Phase 1C)	8.5	1.1	88	17.6
Kazipur (Phase 2)	10.0	1.3	88	17.6
Sirajganj (Phase 1A)	6.0	3.6	--	--
Sirajganj (Phase 1B)	2.0	0.3	66	13.2
Betil (Phase 1C)	7.5	0.9	66	13.2
Betil (Phase 2)	10.0	11.3	--	--

It is evident from Table 5.2 that a very substantial capital investment is required for bank protection works; ranging from Tk 1006 million at Betil to Tk 2,326 million at Mathurapara/Sariakandi (in financial terms). There is also a substantial foreign component of around 45%.

To facilitate conversion to economic prices, all estimates were further disaggregrated into local and foreign costs; the local costs being further sub-divided into skilled labour, unskilled labour, materials (e.g cement, steel, brick aggregate, geotextile) plant/equipment transport and storage. The estimates of the proportion of local and foreign costs for each component are given in Table 5.4.

Economic capital costs were then determined by first deducting all duties and taxes on directly imported items and then applying a series of construction conversion factors to the local cost items. Foreign costs remained unchanged.

The conversion factors applied to local cost items are taken from the FPCO Guidelines for Project Assessment and listed in Table 5.5 below.

Table 5.5 Construction Conversion Factors

Item	Construction Conversion Factor
Unskilled Labour	0.71
Skilled Labour	0.82
Brick Aggregate	0.82
Machinery/Equipment	0.68
Transport	0.67

The detailed economic capital costs at each priority location are presented in Table 5.6 and summarized below in Table 5.7, along with the financial capital costs from Table 5.2. Economic costs typically equate to about 82 % of the overall financial valuation.

It should be noted that only a relatively modest capital investment is required for BRE realignment (approximately 5%, 10% of total capital costs) to ensure security from the serious social and economic consequences of a breach. The capital costs of the BRE realignment include the provision of a settlement berm.

Table 5.7 Financial and Economic Capital Costs at Priority Locations

Priority Location	Capital Cost (Tk Million)	
	Financial	Economic
Fulchari (Phase 1C)	1,307	1,022
Sariakandi/Mathurapara (Phase 1A)	1,441	1,142
Sariakandi/Mathurapara (Phase 1B,2)	1,306	1,027
Kazipur (Phase 1C)	764	597
Kazipur (Phase 2)	768	600
Sirajganj (Phase 1A)	1,848	1,494
Sirajganj (Phase 1B)	452	353
Betil (Phase 1C)	607	475
Betil (Phase 2)	534	417

In addition to the above capital expenditure, the costs of engineering design and supervision were also derived and added to the total capital costs at each priority location. Engineering design and supervision costs were estimated at 3% of total capital costs.

It should be noted that the above capital costs were derived on the basis of detailed estimates for the Priority Works contracts (Sirajganj and Sariakandi/Mathurapara) undertaken in October 1992. In March 1993 a review of these cost estimates was carried out which resulted in a 12½ percent increase in construction costs. On this basis, a similar increase in the capital costs for the works at all locations might be expected. In view, however, of the uncertainties involved and probable change in costs depending on method of construction, source of materials and economic climate, the costs in Table 5.7 have been retained as the basis of the economic analysis, with the potential increase in cost being provided for in the sensitivity analyses by a 10% increase in total costs and losses.

5.2 Operation and Maintenance Costs

Operation and maintenance costs of the bank protection and realigned embankment options were based on estimates of labour, materials and machinery/equipment required each year to ensure that the engineering works remain viable throughout the project lifetime (i.e. 30 years).

Estimates for embankment maintenance were derived from a review of on-going maintenance programmes, as well as an assessment of the specific requirements of the new designs. Reasonably reliable estimates were thereby obtained. Annual O & M costs were calculated to be in the order of 2.5 % of capital requirements.

With regard to the maintenance of bank protection works, it is important to realistically estimate the likely O & M cost required. Given the very substantial capital investment in high quality works, the annual maintenance requirements should be minimal.

To meet these requirements, it is estimated that annual O & M costs amounting to 1 % of the capital expenditure would be needed. In addition, a further 5 % would be required every five years for a more extensive repairs. The derivation of the recurrent cost estimate is described in detail in Annex 5 of the Master Plan Report.

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6. ECONOMIC APPRAISAL OF PRIORITY LOCATIONS

6.1 Methodology and Economic Criteria

The need for economic valuation of the project costs and benefits arises principally from the existence of distortions within an economy. These can lead to a divergence between market prices and real resource costs. Economic valuation attempts to correct these distortions by placing `real prices' on the physical quantities of project inputs and outputs. Considered purely from the point of view of efficient allocation of resources within an economy, the `correct' set of prices are those which reflect the next best alternative use, or `opportunity cost' of the resources used. For goods traded internationally, such prices are those obtainable for the product in world trade, since these prices represent the potential earnings from the output, if exported, or the potential costs in terms of foreign exchange, if imported.

Economic prices for non-traded goods are obtained by various adjustments to their monetary values. The most common adjustments are through the use of a shadow conversion factors and the removal of all transfer payments, such as duties and taxes. The conversion factors recommended in the FAP Guidelines for Project Assessment have been applied in the analysis.

Following completion of the economic valuation of the consequences of river bank erosion and flooding from breaches in the BRE, as well as the capital/recurrent costs of engineering works required to mitigate these consequences, the economic appraisal then adopted an incremental approach by contrasting the FWO and FW project situations over a 30 year planning horizon. Discounted cash flow techniques were then applied to the incremental net benefit streams in order to determine the economic viability of the various priority schemes. In accordance with FAP Guidelines, the following indicators of economic viability were derived;

- Net Present Value (NPV)
- Economic Internal Rate of Return (EIRR)
- Net Present Value Ratio (NPV Ratio) [5]/

Net present values have been calculated at a discount rate of 12 per cent corresponding to the opportunity cost of capital in Bangladesh. Sensitivity analyses were also undertaken for each priority location to assess the impact on the project's EIRR to changes in the cost and benefit streams.

Switching values (the proportionate change in costs and benefits required to achieve an EIRR of 12 %) were also estimated.

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5 The NPV ratio provides a measure of the relative efficiency in the utilization of public investment and recurrent expenditure for different projects. It is calculated by dividing the project's NPV in economic prices by the discounted public capital and operating cost stream in financial prices.

6.2 Phasing of the Consequences of Bank Erosion and Breaches in the BRE

In the FWO situation, the economic consequences of river bank erosion have been assessed over a 30 year time period. The phasing of these consequences has been based on the expected rates and extent of erosion at each priority site. The distribution of property and infrastructural losses has taken into consideration their location in relation to the present bankline, and therefore the likelihood of loss in any one year.

The estimated location of the bankline in 30 years time at each priority location is illustrated in Appendix C, Figures 2 to 6. These figures clearly indicate the area expected to be eroded both with and without the bank protection works.

The economic consequences of flooding as a result of a breach in the BRE at each priority location were phased according to the timing of the breach. The expected year of each breach (unless a breach is currently open) was determined for each location on the basis the nature and rate of erosion. The specific losses related to crop damage, livestock, property and infrastructure were assumed to be fully incurred at the time of the breach. Subsequent reductions in the net value of agricultural production are related to switches in cropping patterns as a consequence of changes in flooding regimes (see Chapter 4).

The avoidance of these economic losses in the FWO situation is therefore regarded as a benefit to the project, and consequently benefit streams were derived for each priority location. It should also be noted that in the derivation of the benefit streams, properly and infrastructure losses have been increased by 3% pe annum above the valuations outlined below. This was intended to reflect likely annual growth in the FWO situation, in accordance with FPCO guidelines.

The expected rates of erosion and their consequences, as well as the frequency and timing of breaches, at each priority location are summarized below:

(a) Fulchari

In the FWO project situation, it has been assumed that the present system of "ad hoc" embankment retirement would continue. 3 km of embankment would be constructed each year for a period between 3 and 4 years following a breach, at a cost of Tk 6.2 million per km. The retirements would take place in the dry season directly following a breach. An area of between 126 ha and 290 ha is expected to remain unprotected each year.

It is estimated that the overall gross margin per hectare would fall from Tk 23,581/ha to Tk 14,726/ha following exposure to flooding on the riverside of the BRE. This gross margin is based on a "riverside" cropping pattern in which the Kharif season cropping is predominantly broadcast Aus and Aman with a cropping intensity of 160% (in comparison with an average cropping intensity around 200% in the protected areas).

River bank erosion is expected to continue at a rate of 60 metre per annum over a 12.5 km reach. During the first five years a uniform annual loss of land, property and infrastructure is expected based on the valuations given in Table 3.6. This would include the loss of Fulchari Market.

Between years 6 and 30, the following losses are anticipated:-

Land:

	Area (ha)	Value (`000 Tk)
Agricultural land (protected)	1,125	225,000
Agricultural land (unprotected)	750	93,750
	1,875	318,750

Property:

Rural village property valued at Tk 22,736 per hectare with 75 hectares lost per annum. Therefore Tk. 1.705 million lost per annum.

Infrastructure:

Rural road infrastructure valued at Tk 7,305 per hectare with 75 hectares lost per annum. Therefore Tk. 0.548 million lost per annum. Ferry relocation costs, railway lines and bridges/culverts valued at a further Tk 1.691 million per annum.

The BRE is expected to be breached twice over a period of 5 years followed by four years of security; this cycle is repeated thereafter.

The land eroded in the FWO project situation appears as a disbenefit avoided in the economic cash flows, while the losses due to erosion in the FW project situation are taken as a cost. Losses due to erosion in the FW situation are estimated on the basis of the mean unit value of land, property and infrastructure lost in the FWO situation multiplied by the area likely to be eroded in the FW situation.

(b) Sariakandi/Mathurapara

In the FWO situation, it has been assumed that it would not be possible to retire the BRE without it being subjected to an immediate breach; as the Bangali River, in effect, acts a physical boundary to any retirement option. The BRE protected area will therefore be subjected to regular annual flooding from an open breach. In response to this, farmers would alter their cropping systems in relation to changes in flooding regimes. Consequently, this would result in a reduction in net agricultural benefits.

At Mathurapara, the BRE has been breached in the recent past, so it has been assumed that the reduction in the net benefits is currently being experienced, hence the inclusion of disbenefits in the FWO project stream from year 1 onwards. The impact of the severe damage to crops, livestock property and infrastructure has already taken place at Mathurapara, and so was excluded from the analyses.

At Sariakandi, it has been assumed that the protection works would be undermined and the BRE breached in Year 1 causing severe damage.

The river bank at Sariakandi/Mathurapara is expected to be eroded at a rate 100 metres per annum over a 16 km reach. At this rate of erosion, Sariakandi would be completely lost within 5 years, after which rural land, property and infrastructure would continue to be eroded.

In the FWO situation, it has been assumed that 6,600 ha of land would be eroded over 30 years.

During the first five years, a uniform annual loss of land, property and infrastructure is expected based on the valuations given in Table 3.6. This would included the loss of Sariakandi.

Between years 6 and 30, the following losses are anticipated:-

Land:

	Area (ha)	Value (`000 Tk)
Agricultural land (protected)	3,300	660,000
Agricultural land (unprotected)	2,200	275,000
	5,500	935,000

Property:

Rural village property valued at Tk 22,736 per hectare with 220 hectares lost per annum. Therefore Tk 5.002 million lost per annum.

Infrastructure:

Rural road infrastructure valued at Tk 7,305 per hectare with 220 hectares lost per annum. Therefore Tk 1.607 million lost per annum.

(c) Kazipur

In the FWO situation, it has been assume that the present system of "ad hoc" embankment retirement would continue. An area of between 360 ha and 540 ha is expected to remain unprotected each year with a reduction of Tk 7,687 per hectare (i.e. Tk 22,413/ha less Tk 14,726/ha) in net value.

River bank erosion is expected to continue at a rate of 75 metres per annum over a 17 km reach. During the first five years a uniform annual loss of land, property and infrastructure is expected based on the valuations given in Table 3.6. This would included the loss of Kazipur market.

Between years 6 and 30, the following losses are anticipated:

Land:

	Area (ha)	Value (`000 Tk)
Agricultural land (protected)	2,543	509,600
Agricultural land (unprotected)	637	79,625
	3,185	589,225

Property:

Rural village property valued at Tk 22,736 per hectare with 127.4 hectares lost per annum. Therefore Tk 2.9 million lost per annum.

Infrastructure:

Rural infrastructure valued at Tk 7,305 per hectare with 128 hectares lost per annum. Therefore Tk 0.935 million lost per annum.

The BRE is expected to be breached twice over a period of five years, followed by four years of security. This cycle is repeated thereafter.

(d) Sirajganj

In the FWO situation, it has been assumed that it would only be possible to retire the BRE to a position behind Sirajganj town. For the agricultural areas, the present `adhoc' system of realignment would continue. An area of between 150 ha and 600 ha is expected to remain unprotected each year, with a reduction in net value of Tk 6,833 per hectare.

River bank erosion is expected to continue at a rate of 90 metres per annum over a 19 km reach. At this rate of erosion Sirajganj town would be entirely lost over a period of 30 years, when the present bank protection measures are undermined. In addition rural land, property and infrastructure would also be eroded.

In the FWO situation, 5130 hectare of land are expected to be eroded over 30 years.

During the first five years, total loss of land property and infrastructure per annum is based on the valuation given in Table 3.6. It has been assumed that one third of the town land (i.e 500 hectare) would be eroded, of which 450 hectare would be urban and 50 hectare peri-urban. Since, the main commercial area would be affected in the initial period, it has been assumed that 50% of the property and infrastructure of Sirajganj town would be lost. The rate of loss is not anticipated to be uniform, but approximates to the following pattern: Year 1 - 15%, Year 2 - 20%, Year 3 - 25%, Year 4 - 25% and Year 5 - 15%.

Between year 6 and year 30, the following losses are also anticipated:-

Land:

82

	Area (ha)	Value (`000 Tk)
Agricultural land (protected)	3,275	655,000
Urban land	300	900,000
Peri-urban land	700	700,000
	4,275	2,225,000
	=====	=========

Property:

50% of the property value in Sirajganj town estimated at Tk 12,882 million per annum over 25 years; plus rural village property valued at Tk 22,736 per hectare. (i.e Tk 2.98 million per annum).

Infrastructure:

50% of the infrastructure value in Sirajganj town estimated at Tk 2.2 million per annum over 25 years; plus rural road infrastructure valued at Tk 7,305 per hectare (i.e. Tk 0.96 million per annum).

The BRE is expected to be breached in year 1 causing severe damage to the town. The town would then be to exposed to annual flooding from the breach, with an annual loss equivalent to 50 % of full breach damage, but at a declining rate as the town is eroded over a 30 year period. For the agricultural area, it has been assumed that breaches would occur in year 6 and 8, followed by a period of four years security; this cycle is repeated thereafter.

In the FW project situation, no erosion of Sirajganj town has been assumed, but 2,180 ha of agricultural land is estimated to be lost plus rural properties and infrastructure. This is partially offset by the reclamation of 25 hectares of town land, valued at peri-urban prices.

(e) Betil

In the FWO situation, it has been assumed that the present system of "ad hoc" embankment retirement would continue. An area of between 136 ha and 612 ha is expected to remain unprotected each year, with a reduction in net value of Tk 6,833 per hectare.

River bank erosion is expected to continue at a rate of 95 metres per annum over a 18 km reach. During the first five years, a uniform annual loss of land, property and infrastructure is expected based on the valuations given in Table 3.6. This would include two large weaving villages. Between years 6 and year 30, the following losses are anticipated:-

Land:

	Area (ha)	Value (`000Tk)
Agricultural land (protected)	3,705	741,000
Agricultural land (unprotected)	410	51,250
Weaving villages	60	60,000
Belkuchi Upazila HQ	100	50,000
	4,275	902,250

Property and Infrastructure:

A mix of weaving villages, rural property and infrastructure, plus Belkuchi Upazila is expected to be lost. In the absence of more accurate information, the annual values for property and infrastructure losses in the first five years have been assumed in subsequent years.

The BRE is expected to be breached twice over a period of 5 years, followed by 4 years of security; this cycle is repeated thereafter.

6.3 Phasing of Capital Expenditure

The phasing of the capital investment is shown in the project cash flows (Table 6.1).

The phasing of the works reflects the expected rate and timing of erosion at a given point along the present bankline to ensure the satisfactory stabilization of the reach. Typically, the priority works are divided into two phases with a 4 to 5 year interval between phases.

6.4 Economic Viability and Project Ranking

The EIRRS, NPVs and NPV ratios derived from the incremental net benefit stream for each priority location are given in Table 6.1, and summarized in Table 6.2 below. For comparison, and with reference to section 5.1, these indicators are also given [in square brackets] for a 10 percent increase in total costs and losses.

Table 6.2 Economic Viability of Priority Locations

Priority Location	EIRR (%)	NPV @ 12 % (Tk million)	NPV Ratio
Fulchari	-0.6 [-1.7]	-643 [-750]	-0.49 [-0.52]
Sariakandi } Mathurapara }	12.0 [9.8]	0 [-175]	0.00 [-0.07]
Kazipur	-1.5 [-1.9]	-562 [-672]	-0.42 [-0.46]
Sirajganj	23.2 [18.6]	532 [353]	0.24 [0.15]
Betil	5.3 [3.8]	-274 [-367]	-0.24 [-0.30]

86

It is evident from the above Table that there is a good economic justification for bank protection works in Sirajganj, Sariakandi and Mathurapara. These projects meet the economic viability threshold of 12 %. Sirajganj priority works are justified principally on the basis of protecting the large urban area, rather than avoiding agricultural losses as a consequence of erosion or flooding. The benefits of the Sariakandi and Mathurapara works are largely derived from the very adverse consequences of an open breach and the subsequent implications for crop production resulting from the flooding of a large proportion of the BRE protected area. It is also important to note that no allowance has been made for the possibility that the Brahmaputra may partially occupy the Bangali channel as a new anabranch. The consequences of this would be extremely serious, causing a rapid widening of the Bangali River and significant loss of agricultural land.

The continuity of the BRE could be re-established at Sariakandi/ Mathurapara if a 25 km length of the Bangali River was realigned. It is estimated that this would cost in the region of Tk. 2,000 million, in construction costs alone (i.e similar to the bank protection works for Sariakandi Phase 1A and Phase 1B), and require the acquisition of 850 hectares of good agricultural land. This would require the displacement of a large number of farming households and land acquisition would prove extremely difficult.

On purely economic grounds, there does not appear to be adequate justification for the implementation of bank protection works at Fulchari, Kazipur and Betil. The EIRRs fall short of the economic viability threshold, and the capital investment is unlikely to generate sufficient benefits to meet this target. This assessment is based entirely on economic criteria, but there are important social consequences that should also be taken into account when appraisal the various locations; these are outlined in Chapter 10. Although the economic viability of bank protection at these latter sites may be in doubt, there is clearly an immediate need, as well as good social and economic justification, to realign the BRE in the timely and planned manner during periods of active erosion, thereby avoiding the adverse consequences of a breach.

With regard to the ranking of priority works, the NPV ratio was considered the most appropriate criteria. On this basis, the following ranking was derived:

Table 6.3 Ranking of Priority Locations

Ranking	Priority Location	NPV Ratio
1	Sirajganj	0.24
2	Sariakandi } Mathurapara}	0.00
3	Betil	-0.24
4	Kazipur	-0.42
5	Fulchari	-0.49

It should, however, be noted that this ranking of priority sites is based on the situation prevailing in 1992 on the assumption that the engineering works for both bank protection and BRE realignment could be implemented immediately. Given the very dynamic and rapidly changing characteristics of river bank erosion along the Brahmaputra, it should not be assumed that the present situation will remain unchanged. The present ranking of priority sites should therefore not be regarded as definitive. Nevertheless, it is extremely likely the Sirajganj and Sariakandi/ Mathurapara will remain top priority for early implementation of bank protection works.

6.5 Sensitivity Analysis

Sensitivity tests were also undertaken for each priority location (Table 6.1). For Sirajganj and Sariakandi/Mathurapara, the results of this analysis highlights how sensitive the EIRRs are to the changes in the cost and benefit estimates used. However, for Kazipur, Fulchari and Betil, the EIRRs appears to be fairly insensitive to major changes in costs and benefits and these locations require a very substantial improvement in benefits to justify the capital investment.

The switching values for each priority location are given below: [6]/

	% increase/decrease in: Benefits	Costs
Fulchari	+152%	-60%
Sariakandi/Mathurapara	0%	0%
Kazipur	+105%	-51%
Sirajganj	-23%	+30%
Betil	+43%	-30%

The sensitivity analysis also indicated the assumptions made with regard to the timing and frequency of breaches can have a significant impact on the benefit stream. For example, it a breach remained open for two years the PV of benefits would increase by 30 %. Similarly, if three breaches in five years were assumed, PV of benefits rose by 16 %. The clearly demonstrates the importance of retiring the BRE in a timely and planned manner.

6 Switching value is the percentage change in costs and benefits required to obtain an EIRR of 12%.

7. ECONOMIC ASSESSMENT OF EMBANKMENT REALIGNMENT STRATEGIES

7.1 Alternative Realignment Strategies

A long term strategy for reducing bank erosion through river training would have an implementation period of the order of 30 years. Some continuing bank erosion would therefore occur during the implementation period. Until full control of bank erosion is achieved there will still be a need for a planned strategy for realigning the embankment to minimise the risk of breaching.

The objectives are to:

- maximise the degree and extent of flood alleviation provided by the BRE; whilst
- minimizing the risk of breaching of the BRE, and
- minimizing the social upheaval, disruption and loss of livelihood associated with the realignment of the BRE.

The level of flood alleviation provided by the BRE depends on its alignment; to be most effective it needs to be as close to the river as possible. The nearer the embankment is to the river, the higher the risk of breaching unless river training and bank protection works are also implemented, and the more frequent the need to realign the embankment. The risk of breaching can be reduced by realigning the embankment further away from the river. This would however expose the land between the embankment and the river to flooding. Thus in the absence of river training works there exists a tradeoff between embankment security, frequency of realignment and the area protected from flooding.

Under the present circumstances, due to massive social pressure, the embankment is typically only retired once a breach has occurred. Thus the damage which occurs to land and infrastructure behind the embankment as a consequence of a breach is not avoided. As explained in Chapter 4, the value of this damage is not insignificant.

In order to quantify the tradeoffs involved, a series of representative situations covering the full range of possible realignment strategies has been evaluated. These are summarized below and illustrated in Figure 7.1. In terms of embankment alignment they range from maintaining the current BWDB practice of realigning the BRE relatively close to the river, thereby minimizing the unprotected area, to various forms of planned realignment designed to significantly reduce the risk that breaches will occur and to minimise the frequency and cost of realignment.

The following three major possible approaches emerged from the initial evaluation:

1. Planned realignment of sections of the BRE whenever the distance between the bankline and the BRE reaches a predetermined minimum value, or trigger distance. This is Example 2 in Figure 7.1, Example 1 being a special case in which the trigger distance and set-back are minimized in response to social pressure. The set back distance of the new embankment should be selected so as to provide an optimal balance between security against breaching, frequency

of embankment reconstruction and the unprotected area. The present practice is an extreme case of this strategy in which the trigger distance tends towards zero.

2. Realignment of the BRE along entire reaches of the river to a set back distance likely to be almost safe from breaching for a period of about 30 years (Example 3 on Figure 7.1). The set-back distance in this case would vary between 2 and 5 km depending on location. The difference between this and the previous approach is that in this case the objective is to minimise the risk of breaching and avoid the major problems associated with multiple realignment.

3. Realignment of the BRE plus the construction (where the current BRE is breached or lost) of a low secondary embankment offering protection from floods with a return period of 1 in 10 years or less (Example 4 in Figure 7.1). This option can be conceptualized as a combination of Approach 2 and a modified version of Approach 1 (for the lower secondary embankment). It became apparent that this option was not viable in the case of the Jamuna river, firstly because the difference in water level between the 10 year and 100 year flood is small and secondly because the overtopping of the low embankment would result in rapid failure of the embankment and all the local disbenefits of a breach. Given the choice, farmers generally will opt for regular inundation that occurs relatively slowly in preference to alternating periods of freedom from flood and high risk of rapid rise in water level as breaches occur. This approach was therefore not pursued further.

7.2 Methodology for Selecting the most Appropriate Approach.

An optimal strategy for planned selective realignment of the BRE is one which maximizes the economic net benefit of realignment in order to provide an acceptable level of security against breaching by river bank erosion while minimizing the adverse impacts, including the area of land that is left exposed on the river side of the flood embankment.

Determining an optimal strategy therefore needs to take into account:

- direct costs such as land acquisition, embankment construction and maintenance;
- disbenefits such as loss of flood protection for areas exposed by embankment realignment;
- direct benefits such as flood protection and enhanced security against breaching of the embankment;
- indirect costs associated with the disruption and resettlement of affected people; and

- indirect benefits accruing from an enhanced level of confidence amongst those who receive an improved standard of flood protection or for whom the risk of damage from an embankment breach is reduced.

To assist in the decision making process, a spreadsheet was set up, based on tangible benefits and costs as described below. A qualitative evaluation of intangibles can then be combined with the net present values derived from the computation in order to make a final selection.

The key variables in this decision making process (see Figure 7.1 for definition sketches) are:

- the set-back distance (SB) between the old and new embankment alignment

- the trigger distance (TR), being the minimum distance between the embankment and the bankline that triggers the decision to realign.

The optimal strategy should minimise both SB and TR, thereby minimizing the cost of each retirement as well as the disbenefit from loss of flood protection, whilst achieving a given level of security against breaching. It would also seek to reduce to a feasible and acceptable level the frequency with which the embankment would need to be realigned.

7.2.1 Benefit and Cost Quantification.

<u>Flood Embankment Benefits</u>

Those benefiting from the BRE flood embankment fall into two categories: firstly, those farming the strip of land parallel to the river that would, in the absence of the embankment, be regularly inundated by out-of bank flow from the river; secondly those farming in the lower lying areas bordering the Karatoa-Bangali-Ichamati river system who have adjusted their farming system to suit the inundation pattern of this river system but who would be adversely affected by the additional depths and longer inundation durations associated with flows entering this system from the Jamuna.

Because of the complexity of the inundation pattern and the responses to it, both categories are difficult to quantify. The second category is marginally easier because the flood flows are confined to a topographically relatively well defined area and it has been possible to quantify the impact of flows from the Jamuna River entering this local drainage system, through the application of 1-D numerical modelling (see Chapter 4 of this Annex).

It has not been possible to define the first area in the same way because of the ill-defined boundaries and the importance of micro-topography, which is not discernible at the resolution of the mapping currently available. Rather than use arbitary values, the approach adopted has been to ignore the positive benefits derived from protecting this riverine area and to quantify only the loss of productivity and/or land value as the land passes from the protected class into the unprotected.

The Net Present Value of all alternatives is thus underestimated by the value of the benefits accruing from this first category of land.

8K

Benefits Relating to BRE Realignment

The benefit of realigning the embankment arises from the prevention of breaches and thereby, firstly, maintenance of the higher agricultural production levels enjoyed by those benefiting from the protection provided by the embankment and, secondly, prevention of the damage arising directly from a breach.

Benefits have thus been computed as a stream consisting of the uniform mean reduction in losses that would otherwise have occurred if the embankment were to be annually breached, minus an allowance for the remaining risk of a breach occurring. The latter includes allowance for the direct losses associated with an infrequent breach: land degradation, crop loss, property and rural infrastructure damage and livestock loss. These direct losses have not been included in the former on the grounds that they are in the main not of a frequently repetitive nature. For example: if a property is destroyed it is not normally reconstructed in a location where it will be destroyed again the following year by a similar flood event, if such a possibility can be seen to be a high risk.

In other words: the benefit of action is taken to be the prevention of annual breaching of the BRE, which could be expected to occur if no realignment were to take place. This analysis is conservative in that it does not take into consideration the additional benefit accruing from general regional development consequential upon the provision of security from severe flooding.

Disbenefits Relating to BRE Realignment

The disbenefits associated with embankment realignment are: firstly, the need to acquire land for the embankment itself and the borrow areas and, secondly, the downgrading of the value of land that changes in classification from protected to unprotected. The former is a major social as well as economic issue and has been described in detail in the respective technical Annex. Since these social considerations do not lend themselves to quantification, they have deliberately not been included in this analysis and will be treated as a separate, though closely linked, issue.

The disbenefit relating to the conversion of land from being protected to being unprotected has been treated in two ways: in terms of the reduction in the value of the land, which is the immediate financial impact perceived by the landowner, and also the reduction in annual production from the land. The latter results in lower disbenefit present values because the land is expected to be, in due course, eroded by the river.

Capital Costs Relating to Embankment Realignment

The cost of realigning the BRE has been estimated both on the basis of the standard BWDB cross-section and the proposed modified section, which includes provision for the temporary resettlement of families displaced by bank erosion. Costs are based on the work being carried out to full specification by LCB contracts under the supervision of the BWDB field officers. The length of the realigned embankment is generally between 1.2 and 1.5 times the straight length measured parallel to the river, due to its bow shape in plan. Since this sinuosity factor varies considerably from one location to another, depending on the pattern of earlier retirements, it has been taken as a constant factor of 1.35 for the purposes of this analysis.

Realignment will normally not take place over the full 10 km reach at one time: normally shorter sections will be realigned in response to the immediate threat. The length of the realigned section will depend on the shape of the erosion embayment in relation to the existing bankline and earlier patterns of BRE realignment. An attempt to take this into consideration would unnecessarily complicate the analysis and so the cost of realignment has been spread uniformally over the 30 year period of the analysis, the rationale being as follows. If it is accepted that the bankline on average over a period of time moves at a uniform rate over the full length of the reach being considered, a reasonable assumption based on observation over the behaviour of the river during the past 30 years), then, also on average, the embankment must be realigned over its full length at intervals equal to the setback distance divided by the mean erosion rate. The pattern of intermediate realignments will have only a relatively minor effect on the total length of reconstructed embankment that comprises the net movement; a large number of shorter realignments giving a somewhat larger total length of new embankment, some of which become redundant as subsequent realignments are implemented.

The average long-term cost of embankment realignment, assuming continuing bank erosion at the current level, will thus be inversely proportional to the set-back distance. If the set-back distance is doubled the frequency of realignment will be halved.

7.2.2 Quantification of Erosion and Breach Risk

The risk that erosion and the resulting bank-line retreat will breach the BRE can be assessed by considering the changing likelihood with time that an embankment located at a particular initial set-back distance will be breached.

Historic rates of bankline movement through erosion and accretion have been determined and probabilities assigned to the rates of erosion and accretion over a twenty year period (1973 to 1992). This analysis is described in detail in the BRTS Draft Final Report. It has been found that the shape of the cumulative distribution plot for both erosion and accretion rates are remarkably uniform over the length of the river, with only minor differences between the two main divisions; these being north and south of Sirajganj respectively. The average distribution that has been adopted for this analysis is shown in Figure 7.2 (this distribution has been computed for the reach between Sariakandi and Sirajganj); this particular example has a median erosion rate of around 150 m/y, which is typical for the river as whole. This median value relates to a length of the bankline where erosion is taking place and is not therefore the same as the mean bankline erosion rate for a reach taken over a longer period of time.

It is also known that higher than normal erosion rates, which are of primary concern in the context of this analysis, are linked to persistent patterns of erosion and accretion that are themselves linked to the development of braid channel bends. These zones of higher erosion are typically between 6 and 12 km long and are separated by zones of low erosion or accretion. For the purpose of this analysis a typical length of 10 km of river bank has been considered. As explained in the following section, the value adopted for this length does not have much impact on the selection of the optimal values for the setback and trigger distances.

10

The principal assumptions that are made are:

- the probability of the embankment's being breached in any one year is the same as the probability of exceedance of the annual erosion rate having a value equal to the distance separating the embankment from the river at the start of the monsoon season. Thus for the example shown in Figure 7.2, if the distance between embankment and river is 250 m there is, on average, a 20 percent probability of occurrence of an erosion rate of equal or greater than 250 m/y, which would then result in erosion and breaching of the embankment during the coming season.

- A decision can be taken to realign a length of embankment at the end of one monsoon season and the work can be completed before the onset of the subsequent monsoon season. This assumption has most impact on the selection of the trigger distance.

- Even after construction of the newly aligned section, the existing embankment will be retained intact until it is breached by bank erosion. If there is not an existing cross-flow control structure, a gated culvert will be provided in the existing embankment both to provide drainage of the area lying between the two embankments (a second gated culvert in the new section of embankment may also be necessary). When the old embankment is in imminent risk of being undermined by bank erosion, the area between the two embankments can be flooded in controlled manner so that when the breach does occur there is minimal direct impact.

- With low setback distances, there is a minor but finite risk that the realigned embankment may be breached in addition to the old embankment, if very rapid bank erosion develops; this has been provided for in the spreadsheet computation.

The first assumption is clearly a simplification of a very complex situation and does not take into consideration the fact that there is a pattern of duration of erosion rates; thus for example if erosion has been taking place at a rate of 250 m/y for two years in succession then there is a higher than 20 percent chance that it will continue at or near this rate for the coming year, but if it has been active for four years then there is a lower risk. In order to use this same analytical approach for a particular situation, it will, therefore, be necessary to modify the typical distribution curve to suit the specific circumstances.

7.3 Analysis of Realignment Strategies

Since the costs involved in river training works are an order of magnitude higher, per reach, than those of embankment realignment they tend to obscure the balance between other considerations; they have accordingly been omitted from this particular analysis and treated separately.

The analysis has been carried out for the river in the vicinity of Fulchari, Kazipur, Sirajganj and Betil. At Kazipur, for example, where realignment is most likely to be required in the near future, the following values have been used for this purpose:

72

(a) the damage resulting from a breach is constant per event over a given reach - this assumption is based on the results of the computed damage following embankment breaches. For example, a breach at Kazipur would result in damage to crops, livestock, property and infrastructure totalling Tk 86.8 million.

(b) The net value of production lost in areas exposed to flooding as a result of realignment is about Tk 7,700 per hectare or the drop in land value would be from Tk 200,000 to 125,000 per hectare.

(c) The construction cost of BRE realignment is Tk 4 million per kilometre.

(d) land, property and infrastructure lost through erosion is independent of the strategy adopted and is included in the spreadsheet computation for comparative purposes only.

A typical analysis (for Kazipur) is shown in Table 7.1, based on data presented in Table 7.2.

The results of the analysis for a range of setback and trigger distances are summarized in Tables 7.3 and 7.4 and plotted in Figures 7.3 and 7.4. Present Values have been computed for a discount rate of 12 percent. The graphs illustrate the tradeoff between avoiding breach damage through embankment realignment, the cost of multiple realignments and the reduction in productivity and land value over the area additionally exposed through realignment.

It can be seen that the risk of breach damage falls off rapidly as the set-back distance exceeds about three times the mean erosion rate. Thereafter the tradeoff is principally between the cost of realignment, which reduces asymptotically with set-back, and the reduced value of the land that has become unprotected, which increases linearly. The net present value peaks weakly at between eight and ten times the mean erosion rate but there is very little change beyond a ratio of about six. Other considerations, such as the social impacts, will clearly be more important in this range.

Since the value of breach damage is high in relation to all other benefits and costs, the relationship between trigger distance and risk of breaching becomes a significant factor for the lower set-back distances, simply because the embankment is exposed to attack for longer periods. A trigger value of the order of 1.5 times the mean erosion rate would appear to provide a reasonable level of confidence under the idealized conditions simulated in this model. In practice, this will have to be interpreted in relation to the recent history of erosion at the specific site.

Despite these provisos, the analysis demonstrates clearly that a policy of planned phased realignment using an optimized set-back distance is a viable and cost-effective strategy and that it is economically more attractive than a single stage larger scale full realignment of the embankment involving a set-back of the order of 2 to 5 km.

It should be again emphasized that in practice the establishment of the set back distance will be highly influenced by existing villages and other settlements, road and rail infrastructure as well as the irregular alignment of the existing BRE and the bankline. Consequently, while determining a hypothetical optimum set-back distance in economic terms provides a useful guide to decision makers, a more pragmatic approach to determining the alignment of the retired BRE will have to be followed at the local level.

8. ECONOMIC APPRAISAL OF THE MASTER PLAN

8.1 Scheduling of Bank Stabilization Works

On the basis of an analysis of river behaviour, and a forecast of the general long term pattern of bank erosion, it is considered that the stabilization of the right bank of the Brahmaputra can be successfully achieved through the construction of a series of "hard-points". These "hard-points" could be regarded as artificially providing solid areas of a bank, similar to more resistant rock formations in nature, which would place a limit on the lateral movement of the river bank. Measures to confine the river to one or more defined channels, i.e river training, are not considered technically appropriate or economically feasible at this time but may become viable as the region develops and data on the river's response to intervention becomes more plentiful.

It is envisaged that these proposed bank stabilization works would be implemented over a 30 year period, divided into three stages. It is anticipated that 27 hard-points would be constructed. The location of these hard-points is illustrated in Figure 8.1.

In determining the most appropriate implementation schedule the following factors have been taken into consideration:

- anticipated river behaviour and erosion rates over various reaches;
- economic consequences of river bank erosion and flooding from a breach in the BRE;
- social and environmental impact both with and without bank stabilization measures;
- capital and recurrent expenditure and sources of financing; and
- economic justification for individual schemes.

Stage 1

During the first stage of the Master Plan, it is anticipated that two phases of the Sirajganj protection works - Hard-points 1 and 8 (see Appendix C, Figure C5), and all the Sariakandi/Mathurapara protection works - Hard-points 2, 3, 4 and 5 (see Appendix C, Figure C3) would be completed. In addition, three further hard-points would be constructed; one upstream of Sariakandi (Hard-point 6) and two upstream of Sirajganj (Hard-points 9 and 10). These works would effectively stabilize the reaches immediately upstream of these two key locations. This first stage is expected to be implemented in two construction phases spanning over a period of 9 years, with a 3 year gap between phases (Table 8.1).

Stage 2

After allowing sufficient time (e.g 2 years) to determine the impact of Stage 1 works on river behaviour, as well as to monitor the changes in the nature and rate of bank erosion at various locations, the next stage of the Master Plan would be implemented. The final selection and scheduling of the priority sites for Stage 2 would of course, be undertaken following a thorough appraisal of the various technical, economic and social factors influencing the proposed capital investment at various locations. However, for the purpose of the present analysis, it has been assumed the bank stabilization works would include hard-points at:

Kazipur - 2 hard-points (11 and 12)
Betil - 2 hard-points (17 and 18)
Upstream of Kazipur - 2 hard-points (15 and 16)
Fulchari - 2 hard-points (13 and 14)
Upstream of Betil - 1 hard-point (19)
Downstream of Fulchari - 1 hard-point (17)

- node stabilization upstream of Kazipur (Hard-point 20)

- stabilization at Fulchari (Hard-points 21, 22, 23)

- two hard-points downstream of Betil (24 and 25)

- two hard-points upstream of Fulchari (26 and 27)

A uniform level of annual capital expenditure is assumed over a period of 20 years starting in year 11 (Table 8.1).

It should be noted that the selection of priority locations for implementation in the short term implies minor differences in sequence of construction from that indicated in Table 8.1. As required by the ToR, the selection of the priority locations was based on the assessment of the immediate erosion problems at the time (and therefore not necessarily representative of long term trends) and the ranking of these in terms of priority for urgent treatment. As the interrelationship between locations became clearer, the rationale arose for introducing additional hard-points (nos. 7, 10 and 15) in order to stabilize key reaches (as distinct from priority locations). The Master Plan sequence would therefore be preferred if a long term programme were to be embarked upon, whereas the "short term" works are suitable as isolated measures for early implementation in response to immediate needs at specific locations, within a relatively short time-frame, which are nonetheless consistent with the Master Plan.

8.2 BRE Realignment Schedule

During the implementation of the bank stabilization programme, long reaches of the right bank will remain unprotected from erosion. Consequently, in conjunction with the construction of bank protection works, it is imperative that a realignment of the BRE is implemented in a timely and planned manner to avoid the serious social and economic consequences of breaches.

As part of the protection works programme, new embankments will be constructed, if required, within the immediate vicinity of the hard-points A total of 120 km of embankment is expected to be built in this manner over the 30 year Master Plan period. These new embankments would, however, not cover the reaches remaining unprotected from erosion. Based on present distance between the bankline and the BRE, expected future erosion rates, and a setback distance of approximately 500 metres, it has been broadly estimated that an additional 100 km of embankment would need to be constructed over 30 years to ensure that the unprotected areas do not experience breaches. A planned realignment strategy should be followed for these exposed areas as indicated in Chapter 7.

In the economic analysis of the Master Plan, the length of BRE realignment required each year over a 30 year period has been calculated for both the future with and the future without bank stabilization scenarios. The net length of BRE realignment (ie difference between FW and FWO) was then valued at Tk 9.4 million per km (in economic terms) and added to the benefits of bank stabilization.

8.3 Financial and Economic Capital Costs

The estimation of financial and economic capital costs has been based on the levels of expenditure envisaged for the priority works (as outlined in Chapter 5). For hard points not considered as priority locations, typical costs associated with similar works have been assumed.

Over a 30 year period, the total financial cost is estimated at Tk 17,300 million (US$ 435 million) for the bank stabilization works, or Tk 19,400 million (US$ 487 million) based on the March 1993 review of cost estimates.

This capital expenditure would be disbursed according to the implementation schedule outlined in Section 8.1 at an average rate of Tk 575 million per annum. Significantly higher rates of expenditure are, however, expected during Stage 1, especially for the Phase 1A works at Sirajganj and Sariakandi/Mathurapara.

Economic capital costs were then derived using the methodology outlined in Chapter 5. Total capital expenditure, in economic terms is estimated to be Tk 13,900 million for the protection works. A detailed capital expenditure schedule is provided in Table 8.1.

The expenditure schedule based on the March 1993 review of cost estimates is given in Table 8.2; the corresponding mean annual expenditure would be Tk 650 million and the capital expenditure in economic terms is estimated to be Tk 15,600 million.

8.4 Operation and Maintenance Costs

Operation and maintenance costs for bank protection works were estimated to be in the order of 1% of capital costs per annum. In addition, a further 5% would be required every five years. Overall operation and maintenance expenditure gradually increases as more hard-points are constructed. In year 2, total O & M costs amount to Tk 33 million and rise to around an average of Tk 315 million (in financial terms) at the end of the programme.

8.5 Economic Benefits

Economic benefit streams for the Master Plan were largely derived from the estimation of the disbenefits avoided and cost saved from implementing bank protection works, as outlined for the various priority locations (see Chapter 6). For hard-points not considered as priority locations, benefits were assessed on the basis of the erosion of a typical rural areas with no major settlements or markets, but representative of a particular reach. With the exception of Sirajganj and Sariakandi/Mathurapara priority locations, the disbenefits avoided have been entirely restricted to the losses due to bank erosion and so have not included agricultural, property or infrastructural losses due to flooding. This has therefore avoided the possibility of double counting the loss due to the consequences of flooding.

The costs saved from the gradual reduction in the length of BRE requiring realignment each year have also been determined and included amongst the benefits to bank stabilization.

Economic benefit streams are presented in Table 8.3, and it can be seen that total benefits increase from Tk 380 million in year 6 to an average of Tk 745 million after year 30. Sirajganj and Sariakandi/Mathurapara priority locations generate the highest benefits and account for almost 50% of total benefits by year 30. During the first five years, the benefit stream is highly influenced by the loss of a substantial proportion of Sirajganj town.

These benefits have also been offset by bank erosion losses in the future with project situation which again have been derived from the estimates given for the priority works.

8.6 Economic Justification

An incremental net benefit stream for the Master Plan was derived over a 50 year period from the cost and benefits outlined above and detailed in Table 8.3.

The following EIRR, NPV and NPV ratio were calculated from the incremental net benefit stream. For comparison, and with reference to Section 5.1, these indicators are also given [in square brackets] for a 10 percent increase in total costs and losses.

EIRR	6.8%	[2.5%]
NPV (@ 12%)	- Tk 285 million	[-Tk 897 million]
NPV Ratio	- 0.06	[-0.13]

The above economic criteria indicate that the bank stabilization Master Plan does not meet the conventional economic viability threshold. It should, however, be noted that the application of high thresholds (eg. 12% EIRR), to determine economic viability, is not wholly appropriate for a major long term capital investment programme in public infrastructure, which generates considerable benefits not only for the present inhabitants on right bank of the Brahmaputra, but also for future generations. Taking into account the long term nature of the investment, the criteria should be based more on social time preference rather than opportunity cost of capital in order to establish economic justification.

In terms of social time preference criterion, which attempts to place greater weight on the direct net benefits to future generations, an EIRR of 6.8% would be regarded as reasonably adequate. On condition that the long term benefits (i.e 30 to 50 years) of the initial capital investment could be clearly demonstrated, without resort to any major additional capital expenditure, there would be a basis on which to provide an economic justification for the programme.

Furthermore, it is probable that capital and recurrent costs would decline, in real terms, as the programme progresses and local expertise is developed, and as the contractors' risks allowed for in the engineering cost estimates become more readily quantified. This has not been taken into account in the analysis, but would further strengthen the economic justification. It is also important to highlight the omission of the proposed Jamuna Bridge in the estimation of the economic benefits of the Master Plan. In the long term, without the bank stabilization programme, the future security of the bridge would be under threat. If this investment were included in the present analysis, the EIRR would be significantly enhanced.

Although the economic arguments in favour of the Master Plan may be the subject of debate, the social justification is firmly established. The social consequences of river bank erosion and flooding from a breach in the BRE are briefly outlined in Chapter 10, but discussed in more detail in Annex 1. It is also important to emphasize that there is clearly an immediate need, as well as good economic justification, to realign the BRE in a timely and planned manner at vulnerable locations.

Sensitivity tests were undertaken on the costs and benefits of the Master Plan, which indicated that the programme was fairly sensitive to changes in both the benefit and cost streams. The switching values indicated that an 8% increase in benefits or 7% decline in costs are required to increase the EIRR from 6.8% to 12%.

Finally, in the long term, there are only three realistic options available to the GOB namely:

(a) non-intervention, i.e allowing bank erosion to take its course, and accept the social and economic consequences, including the loss of Sirajganj and the BRE.

(b) progressively realign the BRE, through a combination of strategic and tactical retirements. This would require a major diversion of the Bangali River. Sirajganj town would also be lost.

(c) initiate bank stabilization at the most critical locations as the first stage of a long term strategy to stabilize the right bank of the river.

Option (a) is unacceptable as it would involve considerable loss of land, property and infrastructure and permanently displace large numbers of people as a result of bank erosion. Furthermore, substantial damage would be incurred as a consequence of flooding from numerous breaches in the BRE and the breakthrough to the Bangali River.

Option (b) would be more acceptable than option (a) as it would provide satisfactory level of security from flooding to people living in areas protected by the BRE. This option does not, however, address the problems of bank erosion and consequently accepts the loss of a major urban centre and other settlements. The future security of the proposed Jamuna Bridge would also be at risk.

Option (c) is therefore the only strategy which would provide a solution to the undesirable consequences of bank erosion. In the initial stages, bank protection works would mitigate the impact of bank erosion in locations where there is an urgent need for immediate action. In the long term a bank stabilization programme would provide an effective way of minimizing economic losses and social disruption for a large number of people living in the vicinity of the Brahmaputra right bank.

While there is clearly good social and economic justification for the Master Plan, the principal constraint to implementation would be the availability of finance for both capital and recurrent expenditure. This issue is discussed in Chapter 11.

9. INDIRECT ECONOMIC EFFECTS AND TRANSPORT CONSIDERATIONS

9.1 Indirect Economic Effects

The threat of river bank erosion and/or flooding from a breach in the BRE also has a negative effect on the level of productive investment and the effectiveness of past capital investment in both agricultural and industrial activities as well as services enterprises.

The immediate threat of river bank erosion is obviously an extremely strong disincentive to both private and public investment. This is illustrated in Fulchari, where no replacement or repair has been undertaken of the public buildings and roads in recent years. River bank erosion also marks an abrupt end to the benefits derived from previous investment; thereby severely curtailing their effectiveness.

With regard to flood hazard, it is well known that flooding can cause temporary economic dislocation through, inter alia, damaging roads and bridges, inundating houses, markets and factories because of the perceived risks of recurring inundation which could inhibit potential investors. The "French" study (Prefeasibility Study for Flood Control in Bangladesh, 1989) tentatively estimated that the annual indirect economic losses from floods to be in the order of 2 % of the annual growth of the non-agricultural sector. This estimate is based on:

- dislocation of communications for 2 to 6 weeks each year;
- transfer of investment funds to rehabilitation of damaged buildings and infrastructure at the expense of planned productive activities; and
- reduction in the useful life of capital stock and consequently it's productivity.

In addition to the costs of disruption, the levels of investment may also be generally lower.

With regard to the agricultural sector, the indirect effects of flooding would include:

- mitigating the long term benefits that can be attributed to past investment in land drainage and irrigation;
- reducing future investments in agricultural technology and consequently accepting lower levels of income,
- reducing the employment and income derived from the supply of farm inputs and the processing/marketing of farm produce, as well as other ancillary industries, thereby depressing the local economy.

By enhancing the current levels of public and private investment within the BRE protected areas, greater growth would be generated thereby increasing employment opportunities in both agriculture and rural industries. Increased public investment would also lead to an improvement in communications and transport which would further enhance incomes and employment opportunities. Similarly, greater government investment in schools and health centres would improve the quality of life of families living within the BRE project area.

The approach used in the economic analysis, in accordance with the FAP Guidelines, was not to quantify these secondary and multiplier effects. Any assumption made with regard to these effects would be wholly speculative and with little foundation as there is insufficient of data on which to make reliable estimates. Nevertheless, these secondary benefits could make an important contribution to the economic development of the BRE project area.

It should be noted that, in rural areas, these indirect economic effects are not wholly attributable to the capital investment in river bank protection, and so there is a danger of overstating these potential benefits. For example, agricultural production is likely to continue to be increased with an expansion in Rabi season cropping as a consequence of irrigation development (see Appendix B Chapter 2). However, for urban areas such as Sirajganj, river bank erosion and flooding have very considerable implications for the neighbouring population and other towns with trading links. A factor in the order of 1.25 to 1.30 could be applied to the direct benefits of the Sirajganj Town protection works to reflect these indirect economic losses.

9.2 Transport Considerations

9.2.1 River Navigation

The Bangladesh Inland Water Transport Authority (BIWTA) is responsible for classifying river routes and maintaining channel depths by dredging where necessary. Their statutory obligation is to ensure the navigability of the rivers, maintain ferry and launch ghats (except railway ghats) and river navigation marking.

At Sirajganj, the BIWTA operates and maintains a pontoon station for river cargo vessels, which is in regular and frequent use. Each year approximately 120 cargo vessels use the ghat. In addition, there are a large number of small vessels, of extremely shallow draft, capable of loads of up to 35 tons. These country boats moor at any convenient spot.

At Sirajganj, the majority of the larger country boats currently moor immediate to the south of the existing revetment, but a few use the bay downstream of Ranigram Groyne. At Sariakandi, there is a country boat landing either side of the Kalitola Groyne. This landing is extensively used, providing a direct link from the left bank to Sariakandi and Bogra markets. In Mathurapara, there is no defined landing. Char formation along the existing right bank provides a shallow, sheltered harbour for small fishing boats, and a few country boats. The banks are very high and steep at this point, and landings are generally made only by fishermen.

The possible impact of bank stabilization works on navigation relates mainly to the possible reduction of Least Available Depth (LAD) by deposition of sediments released in dredging works and the interference caused by the floating discharge lines. It may therefore be necessary for the contractor to undertake same channel development.

There is likely to be no disruption to the use of country boats, and there may even be an increase in traffic as a result of the project at certain locations e.g. Sariakandi/Mathurapara. Country boat steps are included in the standard hard-point design.

The impact of river bank erosion on ferry ghats has already be taken into account in the assessment of project benefits (Chapter 3), in which an allowance was made for the cost of relocating ghats at regular intervals during periods of active erosion. This is not regarded as a difficult operation, and disruption to services is kept to a minimum.

Overall, the impact on river navigation is therefore likely to be small either with or without the project.

9.2.2 Railway Transport

Bangladesh Railway operates two ferry ghats along the right bank of the Brahmaputra, one each at Sirajganj and Fulcharighat:

- Sirajganj is the right bank terminal on a spur of the Iswardi broad gauge line. Passengers and parcel goods are carried to connect with the left bank railway system terminating at Jagannathganj. At present, about two inter city trains use the ferry ghat each day, as well as some local trains. A broad estimate would suggest a daily ferry traffic of about 2,500 passengers (no coaches are shipped).

- Fulcharighat is the right bank terminal on a spur of the Parbatipur and Shantahar metre gauge line. Freight, passengers and parcel goods are carried to connect with the left bank railway system terminating at Bahadurabad ghat.

In both cases the ferry vessels have a loaded draft requirement of 1.5 m.

During the dry season, January to March, the service is sometimes discontinued for want of adequate depth of water.

River bank erosion does not create any major problems for the railway services, as ghats are relocated and railway track realigned as and when necessary; with little disruption to services. However, at Fulchari, after a period of between five and ten years, a marshalling area will be at risk and consequently will require relocation. At a later date, bank erosion may have progressed to a point where the main railway line is under threat, and realignment will inevitably create some disruption to the train services.

In general, there is not likely to be any major impact on railway services as a consequence of the implementation of bank protection works. In contrast, the construction of the Jamuna Bridge would effectively result in the termination of ferry services at Sirajganj, and considerably reduce the importance of Fulcharighat hastening its present decline. The Jamuna Bridge will clearly have an overriding impact on not only the ferry services across the Brahmaputra, but also the whole transport system of the North West Region. Any effects (either direct or indirect) on transportation as a consequences of river bank erosion or flooding are therefore insignificant in relation to the impact on communication resulting from the construction of the Jamuna Bridge.

9.2.3 Road Transport

The direct consequences of bank erosion on the road infrastructure have been taken into account in the assessment of benefits to the projects (Chapter 3). Similarly, the economic y2

consequences of flooding from a breach in the BRE have also included road infrastructure. However, the temporary dislocation and disruption to services caused by damage to roads and bridges has not be formally quantified in the analysis. These intangible benefits to improving flood protection should not be over looked and could be included to enhance the economic benefits of BRE realignment. Given the very strong economic case for a planned strategy to realign the BRE along reaches that will remain unprotected from river erosion, such increases in the benefit stream are unnecessary.

As with rail transport, the construction of the Jamuna Bridge will have a very major impact on the present and planned road transport services, as well as the future development of road infrastructure, throughout the North West Region. In comparison, the effects of bank protection work and BRE realignment are of little consequence.

32

10. SOCIAL CONSEQUENCES AND EMPLOYMENT IMPACT

10.1 Social Consequences

In the economic analysis of priority locations, the social consequences of river bank erosion and flooding from a breach to the BRE, have merely been reflected in terms of the number of people likely to be displaced over the next five years (see Table 10.1). A more thorough assessment of the social implications is presented in Annex 1. While population data are useful for comparative purposes, there is the danger of understating the dire consequences of river bank erosion and severe flooding for a very substantial number of poor families. The loss of land and livelihood, as well as physical, emotional and financial costs of displacement, which renders the vast majority of the displaced population destitute, cannot be adequately assessed in quantitative manner. It is also inappropriate to evaluate these social costs or to equate them with the economic consequences of river bank erosion and breaching.

There are, at present, no government programmes to resettle, rehabilitate or even assist these displaced families in finding alternative sources of income, consequently they remain destitute and depend almost entirely on hiring out their labour (mainly to local farmers). It is evident that a programme is urgently required to rehabilitate these displaced families in order to address this chronic problem immediately. It is therefore strongly recommended that a Master Plan for the Brahmaputra River Training and bank protection works, which accepts any displacement of population, should also include sufficient resources for the planned rehabilitation of these displaced people.

It should also be noted that there is often loss of life at the time of a breach; and although this has not been quantified in the analysis, it is clearly an important factor to take into account in the appraisal of proposed capital investment. In general, from both the social and economic viewpoints, it is imperative that the serious consequences of a breach in the BRE are avoided through a timely and planned realignment of the BRE (in the absence of bank protection works) during periods of active erosion.

Table 10.1 Population Expected to be Displaced by River Bank Erosion and Flooding over the Next Five Years

Priority Location	Number of People Displaced by Bank Erosion	Number of People Displaced by Flooding in Severely Affected Area
Fulchari	13,500	3,600
Sariakandi	20,200	8,700
Mathurapara	8,450	5,000
Kazipur	15,940	7,600
Sirajganj	46,000	31,000
Betil	18,500	8,800

10.2 EMPLOYMENT IMPACT

With regard to the employment impact, the primary aim of bank protection works is to avoid the loss of land and capital resources and consequently the flow of production and employment benefits which are generated by the use of these resources. In the FWO scenario, food grain production and agricultural employment benefits are expected to be lost either directly from bank erosion or as a consequence of flooding from a breach in the BRE.

In addition, there would also be considerable employment and production disbenefits resulting from the loss and/or damage to agro-industrial complexes in urban centres (such as Sirajganj).

The further loss of employment opportunities and sources of income for the population living in the vicinity of the Brahmaputra right bank will considerably aggravate the already very serious under-employment currently being experienced in the area. The large number of people that have been displaced by bank erosion in recent years now forms a very large pool of surplus labour with little or no prospect of securing permanent employment in the foreseeable future. In some locations, it is reported that certain levels of under-employment prevail even throughout the paddy harvest.

It is also important to note that construction of bank protection works and embankments will require a substantial labour force. This will help to alleviate, at least temporarily, the currently high levels of under-employment. The provision of direct employment for a large number of displacees with very limited sources of income could be regarded as one of the most important economic, as well as social, benefits of the priority works programme. For example, it is estimated that at Sirajganj, a total of 13,000 man-years will be required for the first phase of the town protection works. The estimated number of man-years of employment likely to be generated by the various priority works is given below:

Table 10.2 Employment Generated by Priority Works

Priority Location	Number of Man-years of Employment (`000)
Fulchari	10.2
Sariakandi/Mathurapara	24.9
Kazipur	13.6
Sirajganj	18.5
Betil	10.3

11. FINANCIAL CONSIDERATIONS

11.1 Financial Constraints to Implementation

The availability of financial resources is regarded as one of the major constraints to the implementation of a comprehensive bank stabilization programme, as envisaged in the Master Plan. Initial projects to protect key locations e.g. Sirajganj and Sariakandi/Mathurapara, are likely to received adequate support from major aid agencies, such as the World Bank. However, the funding required for future capital expenditure on additional bank stabilization measures, for which the economic justification is not so strong, has yet to be established. Given the magnitude of the funding requirements, GOB would clearly not be able to finance the programme from domestic resources.

In addition, concern has been expressed over the ability of GOB to finance recurrent expenditure both for the initial priority works and, in particular, for the whole bank stabilization programme.

11.2 Sources of Finance

The principal sources of finance for a major capital investment programme would include:

- multilateral funding agencies (e.g IDA, EDF and ADB) through loans, credits and grants;
- bilateral aid agencies (e.g KfW, ODA etc) through loans, grants and tied export credits;
- domestic sources, such as GOB, local banks and cost recovery from beneficiaries.

11.3 Cost Recovery

The main difficulty with a project of this nature is the almost complete lack of specific cash revenue that could be generated directly by the programme. Cost recovery from the beneficiaries of bank stabilization and flood protection investments is very problematic, and, in the past, this type of investment has commonly been regarded as the government's responsibility. The scale of the funding required for capital expenditure suggests that it would be unrealistic to expect beneficiaries to make a significant contribution. There is, however, an opportunity to establish the principle of O & M cost recovery for urban centres.

For the bank protection works at Sirajganj, the IDA (World Bank) have proposed that, as a condition of negotiation, a municipal cost recovery system be set up to finance a proportion of the expenditure required for maintenance of the protection works. The cost recovery arrangements would be based on a surcharge on municipal holding tax, following the reclassification of land within the municipal boundary which is presently assessed as agricultural. The principle of O & M cost recovery is already legally established for FCDI schemes, so it is not unreasonable to expect urban landowners, who significantly benefit from the protection works in term of land values alone, to make a significant contribution to their maintenance.

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Prior to implementation of the above cost recovery mechanism, a study would be undertaken to: (a) review municipal revenue from various taxes, licenses and fees; (b) assess the ability of different income groups to pay the tax increment; and (c) determine possible measures necessary to increase tax collection efficiency and to implement an advalorem tax structure.

Annual maintenance costs for Phase 1A of the Sirajganj protection works are expected to be in the order of Tk 36 million. Given that the present total municipal income from tax and fees in Sirajganj is approximately Tk 7 million per annum, there would have to be a very considerable widening of the tax base and substantial improvement in collection efficiency to enable the municipality to make more than a token contribution to the annual maintenance of the protection works. Realistically, even if a successful cost recovery mechanism were established, GOB would still be required to make a significant contribution to meeting O & M costs. It is interesting to note that approximately 65% of Sirajganj's current municipal income, required to meet local expenditure on public services, is obtained from GOB grants.

For rural areas and smaller settlements, the establishment of on O & M cost recovery mechanism is not considered feasible. The benefit of bank protection and flood control vary considerably from area to area, depending on proximity to the bankline and the BRE, general topography, and whether land is located on the riverside or landside of the BRE. Consequently, it would be effectively impossible to design an equitable system of direct cost recovery.

11.4 BWDB Current Budget

Without a major source of revenue from a cost recovery programme, GOB would therefore be required to meet a very large proportion of the O & M expenditure on bank protection works. In the initial five years of the bank stabilization programme, O & M costs are estimated to be in the order of Tk 60 million per annum, but rise to around Tk 315 million per annum at the end of Master Plan.

GOB ability to provide adequate funding for the maintenance of the protection works (and the BRE) is a major cause for concern and consequently a risk to the programme. Failure of GOB to provide an adequate and sustainable level of finance for O & M at an early stage of the programme could be regarded by international funding agencies as sufficient justification to discontinue support for future bank protection works, and so place the Master Plan in jeopardy.

Given that BWDB's present annual repair and maintenance budget (excluding Food For Work activities) is approximately Tk 110 million, maintenance of the bank protection works being considered under the Master Plan would immediately require an increase of Tk 60 million (ie. 55% increase) rising to Tk 315 million (i.e approaching a 300% increase) over a period of 30 years.

At present, BWDB repair and maintenance budget is supplemented by Food For Work programme activities, which provides wheat at an estimated value of around Tk 250 million per annum. This supplementary source of "revenue" could also made available for the maintenance of the BRE, which would help to reduce total cash requirements, but as a very high proportion of expenditure on bank protection works is required for materials, machinery and transport, it is unlikely to significantly offset the very substantial increases needed in

BWDB's budget. These funds would have to be made available by GOB in order to ensure that a regular maintenance programme is implemented.

11.5 Government Development Expenditure

GOB's scope for increasing public expenditure is limited by the shortages of domestic currency, as well as procedural and implementation problems, which also slows down effective absorption of foreign aid. Even with an improvement in the mobilisation of domestic resources (via, for example, the widening of the tax base and growth in tax revenue) there is still likely to be a need to reprioritorise the Annual Development Programme (ADP) to ensure that adequate funds are made available for O & M of major public assets; such as bank protection works.

The total ADP budget is approximately Tk 60,000 million, of which Tk 7,500 million (12.5%) is allocated to the development of water resources. External financing accounts for over 90% of the total ADP expenditure, of which project aid represents 60%. Generation of counterpart funds is significantly enhanced by commodity aid, which finances a further 30% of the ADP. It is hoped that, over the longer term, GOB is able to mobilise more domestic resource, so that its own contribution to financing the ADP can expand and so help to reduce its dependence on foreign aid.

With the limited availability of local resources, it is likely that new project aid commitments will adversely affect the implementation of ongoing programmes unless resources are reallocated to high priority projects and/or donors provide a larger proportion of total costs of a new project, including local costs, to minimise the demands on local currency resources. GOB could also place greater emphasis on mobilizing domestic resources to fund the ADP. Government revenue as a % of GDP is presently around 8% to 9% and there is urgent need to increase this proportion primarily through increased tax receipts.

At present, 65% of tax revenue is obtain through customs and excise duties and only 15% and 11% from income tax and sales tax respectively. There is clearly scope to increase the proportions of income tax and sales tax, but this is could only be implemented gradually and is unlikely to make any major impact on the availability of domestic resources in the short or medium term. Foreign aid, both project aid and commodity aid (to generate counterpart funds), will therefore be the main source of finance for both capital and recurrent expenditure in both the short and medium term.

11.6 Financing Capital and O & M Expenditure on Bank Stabilization

The main source of finance for capital expenditure on bank stabilization works will therefore have to be from project aid, in the form of either grants or soft loans from major international donors. To facilitate the flow of project aid, counterpart funds would also need to be made available by GOB in a timely manner.

With regard to capital costs, GOB should provide sufficient funds to BWDB in order the meet land acquisition and resettlement costs, as well as the construction of all sections of retired embankment. Project aid would be required for funding all other capital expenditure associated with the bank protection works including earthworks, dredging, revetment, and general facilities.

O & M costs would be mainly funded by GOB with a contribution from Sirajganj municipality. It is essential that GOB gives priority in the ADP to the bank stabilization measures to ensure that regular repair and maintenance is undertaken. The establishment by BWDB of a river bank protection works maintenance unit, comprising highly trained personnel responsible for the management of all O & M activities (including use of specialist plant and equipment) will greatly assist in enhancing BWDB's capability in the construction and maintenance of bank stabilization works. It successful, this unit will not only ensure continued donor support for the long term programme, but may also provide justification for an increased rate of implementation.

The Master Plan envisages a gradual implementation of river bank protection works over a period of 30 years, with an average rate of disbursement of approximately Tk 600 million per annum. This rate of implementation is designed to ensure that adequate financing of both capital and recurrent expenditure is maintained throughout the programme. However, with the anticipated enhancement in BWDB's capacity to construct and maintain the bank protection works and the willingness of GOB to provide additional counterpart finance, it is possible that aid donors will be able to assist with a more rapid implementation of the programme.

TABLES

TABLE 3.1. ECONOMIC CONSEQUENCES OF RIVER BANK EROSION OVER NEXT FIVE YEARS

	Unit	FULCHARI	SARIAKANDI	MATHURAPURA	KAZIPUR	SIRAJGANJ	BETIL
a) LAND LOSSES							
Agricultural Land - Unprotected	Ha.	268	0	535	420	0	0
- Protected	Ha.	67	470	0	180	355	800
Market Land	Ha.	0	0	15	0	0	55
Upazila HQ Land	Ha.	40	80	0	40	0	0
Urban Land	Ha.	0	0	0	0	450	0
Peri-Urban Land	Ha.	0	0	0	0	50	0
Sub-Total		375	550	550	640	855	855
b) PROPERTY LOSSES/DISPLACEMENT							
Public Buildings - Pucca	No.	15	20	0	10	75	10
- Semi-Pucca	No.	10	15	5	10	25	10
Commercial/Industry - Pucca	No.					50	
- Semi-Pucca	No.					25	
Weaving Sheds	No.	0	0	0	0	0	500
Private Houses/Shops - Pucca	No.	25	60	0	15	250	20
- Semi-Pucca	No.	765	1620	700	1335	6750	1800
- Katcha	No.	1525	1620	700	1335	3300	650
Sub-Total		2340	3335	1405	2705	10475	2990
c) INFRASTUCTURAL LOSSES/DISPLACEMENT							
Roads - Pucca	Km.	3	6	0	3	25	6
- Katcha	Km.	10	15	10	9	15	12
- Bridges/Culverts	No.	6	10	4	6	25	8
Railways - Embankment	Km.	1.5	0	0	0	0.5	0
- Bridges/Culverts	No.	2	0	0	0	2	0
Ferry Ghat (relocation)	No.	2				2	
Power/Telephone Lines	Km.	5	10	2	5	50	10

TABLE 3.6. ECONOMIC VALUATION OF THE CONSEQUENCES OF EROSION OVER NEXT FIVE YEARS ('000 Tk)

	FULCHARI	SARIAKANDI	MATHURAPURA	KAZIPUR	SIRAJGANJ	BETIL
a) LAND LOSSES						
Agricultural Land - Unprotected	33500	0	66875	52500	0	0
- Protected	13400	94000	0	36000	71000	160000
Market Land	0	0	7500	0	0	27500
Upazila HQ Land	40000	80000	0	40000	0	0
Urban Land	0	0	0	0	1350000	0
Peri-Urban Land	0	0	0	0	150000	0
Sub-Total	86900	174000	74375	128500	1571000	187500
b) PROPERTY LOSSES/DISPLACEMENT						
Public Buildings - Pucca	18450	24600	0	12300	92250	12300
- Semi-Pucca	2050	3075	1025	2050	5125	2050
Commercial/Industry - Pucca	0	0	0	0	61500	0
- Semi-Pucca	0	0	0	0	5125	0
Weaving Sheds	0	0	0	0	0	12300
Private Houses/Shops - Pucca	6150	14760	0	3690	61500	4920
- Semi-Pucca	9410	19926	8610	16421	83025	22140
- Katcha	6253	6642	2870	5474	13530	2665
Sub-Total	42312	69003	12505	39934	322055	56375
c) INFRASTUCTURAL LOSSES/DISPLACEMENT						
Roads - Pucca	4800	9600	0	4800	40000	9600
- Katcha	3040	4560	3040	2736	4560	3648
- Bridges/Culverts	1404	2340	936	1404	5850	1872
Railways - Embankment	3420	0	0	0	1140	0
- Bridges/Culverts	468	0	0	0	468	0
Ferry Ghat (relocation)	1824	0	0	0	1824	0
Power/Telephone Lines	104	208	42	104	1038	208
Sub-Total	15060	16708	4018	9044	54880	15328
TOTAL	144272	259711	90898	177478	1947935	259203

TABLE 4.1. ECONOMIC CONSEQUENCES OF FLOODING FROM BREACH AT PRIORITY LOCATIONS

	Unit	FULCHARI	SARIAKANDI	MATHURAPURA	KAZIPUR	SIRAJGANJ	BETIL
a) CROP DAMAGE							
Incremental Crop Loss :							
- Severely Affected Areas	Ha.	400	320	385	360	100	345
- Partially Affected Areas	Ha.	8630		41891	12946	1295	216
		9030	320	42276	13306	1395	561
b) LIVESTOCK LOSSES							
Cattle Losses	No.	250	230	250	240	100	220
Goat/Sheep Losses	No.	450	450	450	450	200	450
Poultry Losses	No.	3500	3500	3500	3500	3000	3500
c) SEVERE PROPERTY DAMAGE/DISPLACEMENT							
Public Buildings - Pucca	No.	2	8	0	3	30	3
- Semi-Pucca	No.	6	8	2	3	10	6
Commercial/Industry - Pucca	No.					20	
- Semi-Pucca	No.					10	
Weaving Sheds	No.		0	0	0	0	300
Private Houses/Shops - Pucca	No.	3	15	0	3	100	6
- Semi-Pucca	No.	200	725	400	635	2700	775
- Katcha	No.	400	725	450	635	1320	350
Sub-Total		611	1481	852	1279	4190	1440
e) SEVERE INFRASTUCTURAL DAMAGE/DISPLACEMENT							
Roads - Pucca	Km.	2	3		2	10	3
- Katcha	Km.	5	7	5	6	6	6
- Bridges/Culverts	No.	4	8	3	5	10	6
Railways - Embankment	Km.	0.5				0.2	
- Bridges/Culverts	No.	1				0.8	
Sub-Total							
f) PARTIAL PROPERTY/INFRASTUCTURAL DAMAGE							
- Incremental Areas Partially Affected	Ha.	8630	41891	41891	12946	1295	216

1/ Sariakandi/Mathurapara are regarded as one location with respect to incremental crop losses on partially affected areas.

96

TABLE 4.2. ECONOMIC VALUATION OF THE CONSEQUENCES OF FLOODING AT PRIORITY LOCATION ('000 Tk)

	FULCHARI	SARIAKANDI	MATHURAPURA	KAZIPUR	SIRAJGANJ	BETIL
a) CROP DAMAGE						
Incremental Crop Loss :						
- Severely Affected Areas	9432	7725	9294	8069	2156	7438
- Partially Affected Areas	55499		181435	58245	5909	2122
	64931	7725	190729	66314	8065	9560
b) LIVESTOCK LOSSES						
Cattle Losses	615	566	615	590	246	541
Goat/Sheep Losses	369	369	369	369	164	369
Poultry Losses	86	86	86	86	74	86
	1070	1021	1070	1046	484	996
c) SEVERE PROPERTY DAMAGE/DISPLACEMENT						
Public Buildings - Pucca	1230	4920	0	1845	18450	1845
- Semi-Pucca	1230	1640	410	615	2050	1230
Commercial/Industry - Pucca	0	0	0	0	4100	0
- Semi-Pucca	0	0	0	0	2050	0
Weaving Sheds	0	0	0	0	0	7380
Private Houses/Shops - Pucca	369	1845	0	369	12300	738
- Semi-Pucca	2460	8918	4920	7811	33210	9533
- Katcha	1640	2973	1845	2604	5412	1435
Sub-Total	6929	20295	7175	13243	77572	22161
e) SEVERE INFRASTUCTURAL DAMAGE/DISPLACEMENT						
Roads - Pucca	3200	4800	0	3200	16000	4800
- Katcha	1520	2128	1520	1824	1824	1824
- Bridges/Culverts	936	1872	702	1170	2340	1404
Railways - Embankment	1140	0	0	0	456	0
- Bridges/Culverts	234	0	0	0	187	0
Sub-Total	7030	8800	2222	6194	20807	8028
f) PARTIAL PROPERTY/INFRASTUCTURAL DAMAGE						
- Incremental Areas Partially Affected	1170	4263	4263	1359	139	44
	81131	42104	205459	88155	107067	40789

Table 4.6. Calculation of Expected Value of Crop Loss as a Result of Inundation from a Breach in the BRE.

Year	Estimated Incremental Area Affected (Ha)	Net Value of Crop Loss (Tk./ha)	Estimated Overall Net Value Crop Loss(Tk.Mill)	Return Period (Years)	Frequency (probability of non-exceedence)	Loss and Frequency Differential (Tk.Million)	Cumulative Differential (Tk.Million)
a) FULCHARI							
1986	145	7121.05	1.03	1.00	0.00	0.00	0.00
1989	8630	7121.05	61.45	6.59	0.85	26.50	26.50
1987	29563	10411.25	307.79	10.30	0.90	10.09	36.59
1988	35787	13701.45	490.33	20.12	0.95	18.91	55.50
b) MATHURAPARA							
1986	373	7121.05	2.66	1.00	0.00	0.00	0.00
1989	41891	7121.05	298.31	6.59	0.85	127.65	127.65
1987	49344	10411.25	513.73	10.30	0.90	22.19	149.84
1988	59835	13701.45	819.83	20.12	0.95	31.60	181.43
c) KAZIPUR							
1986	280	7121.05	1.99	1.00	0.00	0.00	0.00
1989	12946	7121.05	92.19	6.59	0.85	39.95	39.95
1987	17692	10411.25	184.20	10.30	0.90	7.55	47.50
1988	19659	13701.45	269.36	20.12	0.95	10.75	58.24
d) SIRAJGANG							
1986	23	7121.05	0.16	1.00	0.00	0.00	0.000
1989	1295	7121.05	9.22	6.59	0.85	3.98	3.981
1987	2547	10411.25	26.52	10.30	0.90	0.98	4.957
1988	996	13701.45	13.65	20.12	0.95	0.95	5.909
e) BETIL							
1986	26	7121.05	0.19	1.00	0.00	0.00	0.000
1989	216	7121.05	1.54	6.59	0.85	0.73	0.731
1987	2380	10411.25	24.78	10.30	0.90	0.72	1.450
1988	257	13701.45	3.52	20.12	0.95	0.67	2.121

Table 4.11. Calculation of Expected Value of Property and Infrastructure Damage as a Result of Inundation from a Breach in the BRE.

Year	Estimated Incremental Area Affected (Ha)	Value of Property & Infra. Damage (Tk./ha)	Estimated Overall Value of Damage (Tk.Mill)	Return Period (Years)	Frequency (probability of non-exceedence)	Damage and Frequency Differential (Tk.Million)	Cumulative Differential (Tk.Million)
a) FULCHARI							
1986	145	185.32	0.03	1.00	0.00	0.00	0.00
1989	8630	185.32	1.60	6.59	0.85	0.69	0.69
1987	29563	185.32	5.48	10.30	0.90	0.19	0.88
1988	35787	185.32	6.63	20.12	0.95	0.29	1.17
b) MATHURAPARA							
1986	373	185.32	0.07	1.00	0.00	0.00	0.00
1989	41891	185.32	7.76	6.59	0.85	3.32	3.32
1987	49344	185.32	9.14	10.30	0.90	0.46	3.78
1988	59835	185.32	11.09	20.12	0.95	0.48	4.26
c) KAZIPUR							
1986	280	185.32	0.05	1.00	0.00	0.00	0.00
1989	12946	185.32	2.40	6.59	0.85	1.04	1.04
1987	17692	185.32	3.28	10.30	0.90	0.16	1.19
1988	19659	185.32	3.64	20.12	0.95	0.16	1.36
d) SIRAJGANG							
1986	23	185.32	0.00	1.00	0.00	0.00	0.00
1989	1295	185.32	0.24	6.59	0.85	0.10	0.10
1987	2547	185.32	0.47	10.30	0.90	0.02	0.12
1988	996	185.32	0.18	20.12	0.95	0.02	0.14
e) BETIL							
1986	26	185.32	0.00	1.00	0.00	0.00	0.00
1989	216	185.32	0.04	6.59	0.85	0.02	0.02
1987	2380	185.32	0.44	10.30	0.90	0.01	0.03
1988	257	185.32	0.05	20.12	0.95	0.01	0.04

TABLE 5.2. FINANCIAL CAPITAL COSTS OF BANK PROTECTION AND BRE REALIGNMENT ('000 Tk.) 1/ (Sheet 1 of 4)

	FULCHARI (Phase 1C)			SARIAKANDI/ MATHURAPARA (Phase 1A)			SARIAKANDI/ MATHURAPARA (Phase 1B,2)			KAZIPUR (Phase 1C)			KAZIPUR (Phase 2)		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
BRE REALIGNMENT															
i) LAND ACQUISITION 2/	15125	0	15125	23100	0	23100	24200	0	24200	17600	0	17600	17600	0	17600
ii) EARTHWORKS:															
Labour - Skilled	13910	0	13910	27828	0	27828	29153	0	29153	17234	0	17234	17234	0	17234
- Unskilled	37496	0	37496	75012	0	75012	78584	0	•78584	46454	0	46454	46454	0	46454
Machinery/Equipment	4553	3035	7588	9108	6072	15179	9541	6361	15902	5640	3760	9400	5640	3760	9400
Sub-Total	55959	3035	58994	111948	6072	118020	117279	6361	123640	69328	3760	73088	69328	3760	73088
TOTAL BRE REALIGNMENT COSTS	71084	3035	74119	135048	6072	141120	141479	6361	147840	86928	3760	90688	86928	3760	90688
BANK PROTECTION WORKS															
i) LAND ACQUISITION 3/	2313	0	2313	2094	0	2094	1563	0	1563	1063	0	1063	1250	0	1250
ii) EARTHWORKS:															
Labour - Skilled	4935	0	4935	15160	0	15160	7371	0	7371	2861	0	2861	3036	0	3036
- Unskilled	13303	0	13303	40865	0	40865	19868	0	19868	7711	0	7711	8184	0	8184
Machinery/Equipment	1615	1077	2692	4962	3308	8269	2412	1608	4020	936	624	1560	994	662	1656
Sub-Total	19853	1077	20930	60986	3308	64294	29651	1608	31259	11508	624	12132	12214	662	12876
iii) DREDGING/RECLAMATION:															
Labour - Skilled	2790	1196	3986	5177	2219	7396	5254	2252	7505	1527	655	2182	1527	655	2182
- Unskilled	3355	0	3355	6224	0	6224	6316	0	6316	1836	0	1836	1836	0	1836
Machinery/Equipment	21979	32969	54948	40779	61169	101948	41384	62076	103459	12031	18046	30077	12031	18046	30077
Transport	1150	1150	2300	2133	2133	4266	2165	2165	4330	629	629	1259	629	629	1259
Storage	1955	345	2300	3627	640	4266	3680	649	4330	1070	189	1259	1070	189	1259
Sub-Total	31229	35660	66888	57940	66161	124100	58799	67142	125940	17094	19519	36613	17094	19519	36613
iv) BANK PROTECTION WORKS:															
Labour - Skilled	14516	1613	16129	12485	1387	13872	12481	1387	13867	7976	886	8862	8009	890	8899
- Unskilled	66774	0	66774	57433	0	57433	57412	0	57412	36689	0	36689	36841	0	36841
Materials - Cement	56092	104170	160262	48245	89597	137842	48227	89564	137791	30819	57236	88055	30947	57474	88421
- Steel	167	167	333	143	143	286	143	143	286	91	91	183	92	92	184
- Brick Aggregate	254346	0	254346	218764	0	218764	218684	0	218684	139750	0	139750	140330	0	140330
- Geotextile	85826	57217	143044	73819	49213	123032	73792	49195	122987	47157	31438	78595	47353	31568	78921
Machinery/Equipment	50644	75965	126609	43559	65338	108897	43543	65314	108857	27826	41739	69565	27941	41912	69854
Transport	34772	34772	69545	29908	29908	59816	29897	29897	59794	19106	19106	38211	19185	19185	38370
Storage	1259	222	1482	1083	191	1274	1083	191	1274	692	122	814	695	123	818
Sub-Total	564396	274127	838523	485439	235778	721217	485261	235691	720953	310106	150619	460725	311393	151243	462636

TABLE 5.2. FINANCIAL CAPITAL COSTS OF BANK PROTECTION AND BRE REALIGNMENT ('000 Tk.) 1/ (Sheet 2 of 4)

	FULCHARI (Phase 1C)			SARIAKANDI/ MATHURAPARA (Phase 1A)			SARIAKANDI/ MATHURAPARA (Phase 1B,2)			KAZIPUR (Phase 1C)			KAZIPUR (Phase 2)		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
v) MOORING :															
Labour - Skilled	38	0	38	24	0	24	0	0	0	4	0	4	4	0	4
- Unskilled	158	0	158	81	0	81	0	0	0	12	0	12	12	0	12
Materials - Cement	49	92	141	26	47	73	0	0	0	4	7	11	4	7	11
- Steel	342	342	684	177	177	354	0	0	0	26	26	53	26	26	53
- Brick Aggregate	1057	0	1057	547	0	547	0	0	0	81	0	81	81	0	81
Machinery/Equipment	53	80	134	28	41	69	0	0	0	4	6	10	4	6	10
Pontoon	0	8875	8875	0	4591	4591	0	0	0	0	683	683	0	683	683
Transport	93	93	185	48	48	96	0	0	0	7	7	14	7	7	14
Sub-Total	1790	9481	11281	931	4905	5836	0	0	0	138	730	868	138	730	868
vi) GENERAL FACILITIES/TEMP.WORKS:															
Housing/Buildings	73723	18431	92153	100284	25071	125356	69055	17264	86319	40131	10033	50164	40340	10085	50425
Transport/Equipment	24190	24190	48380	32906	32906	65812	22659	22659	45318	13168	13168	26336	13237	13237	26473
Temporary Works	29489	7372	36861	40114	10028	50142	27622	6906	34528	16053	4013	20066	16136	4034	20170
Bond/Insurance	0	32254	32254	0	43874	43874	0	30212	30212	0	17557	17557	0	17649	17649
Surveys/Tests	10367	10367	20734	14102	14102	28205	9711	9711	19422	5643	5643	11287	5673	5673	11346
Sub-Total	137769	92614	230383	187407	125982	313389	129047	86751	215798	74996	50415	125411	75386	50677	126063
TOTAL BANK PROTECTION COSTS	757349	412958	1170318	794796	436133	1230930	704320	391192	1095512	414904	221906	636811	417474	222832	640307
TOTAL BASELINE COSTS	828433	415993	1244437	929844	442205	1372050	845799	397552	1243352	501832	225666	727499	504402	226592	730995
Physical Contingencies (@ 5%)	41422	20800	62222	46492	22110	68602	42290	19878	62168	25092	11283	36375	25220	11330	36550
TOTAL CAPITAL COSTS	869855	436793	1306659	976336	464315	1440652	888089	417430	1305520	526923	236950	763874	529622	237922	767544
TOTAL CAPITAL COSTS (Phase 1 and 2)	869855	436793	1306659				1864425	881745	2746172				1056546	474871	1531418

1/ Based costs expressed in April 1992 prices.

2/ Land acquisition costs for BRE realignment based on an average land value of Tk.200,000 per hectare.

3/ Land acquisition costs for bank protection works based on an average land value of Tk.125,000 per hectare, except for Sirajganj (Phase 1) where Tk.600,000 per hectare has been assumed.

78

TABLE 5.2. FINANCIAL CAPITAL COSTS OF BANK PROTECTION AND BRE REALIGNMENT ('000 Tk.) 1/ (Sheet 3 of 4)

	SIRAJGANJ (Phase 1A)			SIRAJGANJ (Phase 1B)			BETIL (Phase 1C)			BETIL (Phase 2)		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
BRE REALIGNMENT												
i) LAND ACQUISITION 2/	0	0	0	13200	0	13200	13200	0	13200	0	0	0
ii) EARTHWORKS:												
Labour - Skilled	0	0	0	14530	0	14530	15857	0	15857	0	0	0
- Unskilled	0	0	0	39165	0	39165	42742	0	42742	0	0	0
Machinery/Equipment	0	0	0	4755	3170	7925	5190	3460	8649	0	0	0
Sub-Total	0	0	0	58450	3170	61620	63788	3460	67248	0	0	0
TOTAL BRE REALIGNMENT COSTS	0	0	0	71650	3170	74820	76988	3460	80448	0	0	0
BANK PROTECTION WORKS												
i) LAND ACQUISITION 3/	3600	0	3600	250	0	250	938	0	938	1250	0	1250
ii) EARTHWORKS:												
Labour - Skilled	11659	0	11659	620	0	620	6049	0	6049	6581	0	6581
- Unskilled	31427	0	31427	1672	0	1672	16305	0	16305	17739	0	17739
Machinery/Equipment	3816	2544	6360	203	135	338	1980	1320	3299	2154	1436	3590
Sub-Total	46902	2544	49446	2496	135	2631	24333	1320	25653	26473	1436	27909
iii) DREDGING/RECLAMATION:												
Labour - Skilled	18564	7956	26521	1646	706	2352	1470	630	2100	1470	630	2100
- Unskilled	22318	0	22318	1979	0	1979	1767	0	1767	1767	0	1767
Machinery/Equipment	146229	219344	365573	12968	19453	32421	11577	17366	28943	11577	17366	28943
Transport	7650	7650	15299	678	678	1357	606	606	1211	606	606	1211
Storage	13004	2295	15299	1153	204	1357	1030	182	1211	1030	182	1211
Sub-Total	207766	237245	445010	18426	21040	39466	16449	18783	35233	16449	18783	35233
iv) BANK PROTECTION WORKS:												
Labour - Skilled	14379	1598	15977	4209	468	4676	5836	648	6485	5936	660	6596
- Unskilled	66144	0	66144	19360	0	19360	26847	0	26847	27308	0	27308
Materials - Cement	55562	103187	158749	16262	30202	46464	22552	41882	64434	22939	42602	65541
- Steel	165	165	330	48	48	97	67	67	134	68	68	136
- Brick Aggregate	251946	0	251946	73741	0	73741	102261	0	102261	104018	0	104018
- Geotextile	85016	56678	141694	24883	16589	41472	34507	23005	57512	35100	23400	58500
Machinery/Equipment	50166	75249	125414	14683	22024	36707	20362	30542	50904	20711	31067	51778
Transport	34444	34444	68888	10081	10081	20163	13980	13980	27961	14221	14221	28441
Storage	1248	220	1468	365	64	430	506	89	596	515	91	606
Sub-Total	559070	271540	830611	163633	79476	243109	226919	110214	337133	230817	112108	342925

7L

TABLE 5.2. FINANCIAL CAPITAL COSTS OF BANK PROTECTION AND BRE REALIGNMENT ('000 Tk.) 1/ (Sheet 4 of 4)

	SIRAJGANJ (Phase 1A)			SIRAJGANJ (Phase 1B)			BETIL (Phase 1C)			BETIL (Phase 2)		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
v) MOORING :												
Labour - Skilled	37	0	37	0	0	0	4	0	4	4	0	4
- Unskilled	122	0	122	0	0	0	13	0	13	13	0	13
Materials - Cement	38	71	110	0	0	0	4	7	11	4	7	11
- Steel	265	265	531	0	0	0	28	28	55	28	28	55
- Brick Aggregate	820	0	820	0	0	0	86	0	86	86	0	86
Machinery/Equipment	41	62	104	0	0	0	4	7	11	4	7	11
Pontoon	0	6887	6887	0	0	0	0	720	720	0	720	720
Transport	72	72	144	0	0	0	8	8	15	8	8	15
Sub-Total	1396	7358	8754	0	0	0	146	769	915	146	769	915
vi) GENERAL FACILITIES/TEMP.WORKS:												
Housing/Buildings	135194	33798	168992	22428	5607	28035	31371	7843	39214	32004	8001	40005
Transport/Equipment	44360	44360	88721	7359	7359	14718	10294	10294	20587	10501	10501	21003
Temporary Works	54077	13519	67597	8971	2243	11214	12548	3137	15685	12802	3200	16002
Bond/Insurance	0	59147	59147	0	9812	9812	0	13725	13725	0	14002	14002
Surveys/Tests	19012	19012	38023	3154	3154	6308	4412	4412	8823	4501	4501	9001
Sub-Total	252643	169837	422480	41912	28175	70087	58624	39410	98034	59807	40205	100012
TOTAL BANK PROTECTION COSTS	1071377	688523	1759901	226716	128827	355543	327409	170496	497906	334942	173301	508244
TOTAL BASELINE COSTS	1071377	688523	1759901	298366	131997	430363	404397	173956	578354	334942	173301	508244
Physical Contingencies (@ 5%)	53569	34426	87995	14918	6600	21518	20220	8698	28918	16747	8665	25412
TOTAL CAPITAL COSTS	1124946	722950	1847896	313284	138597	451881	424617	182654	607271	351690	181966	533656
TOTAL CAPITAL COSTS (Phase 1 and 2)				1438230	861546	2299777				776307	364620	1140927

1/ Based costs expressed in April 1992 prices.

2/ Land acquisition costs for BRE realignment based on an average land value of Tk.200,000 per hectare.

3/ Land acquisition costs for bank protection works based on an average land value of Tk.125,000 per hectare, except for Sirajganj (Phase 1) where Tk.600,000 per hectare has been assumed.

TABLE 5.4. PROPORTIONS OF LOCAL AND FOREIGN COSTS BY CAPITAL COMPONENT.

	% Local	% Foreign
i) LAND ACQUISITION	100%	0%
ii) EARTHWORKS:		
Labour - Skilled	100%	0%
- Unskilled	100%	0%
Machinery/Equipment	50%	40%
iii) DREDGING:		
Labour - Skilled	70%	30%
- Unskilled	100%	0%
Machinery/Equipment	40%	60%
Transport	50%	50%
Storage	85%	15%
iv) BANK PROTECTION WORKS:		
Labour - Skilled	90%	10%
- Unskilled	100%	0%
Materials - Cement	35%	65%
- Steel	50%	50%
- Bricks/Aggregate	100%	0%
- Geotextile	60%	40%
Machinery/Equipment	40%	60%
Transport	50%	50%
Storage	85%	15%
v) FERRY GHAT:		
Labour - Skilled	100%	0%
- Unskilled	100%	0%
Materials - Cement	35%	65%
- Steel	50%	50%
- Brick Aggregate	100%	0%
Machinery/Equipment	40%	60%
Pontoon	0%	100%
Transport	50%	50%
vi) GENERAL FACILITIES/TEMP.WORKS/MISC.:		
Housing/Buildings	80%	20%
Transport	50%	50%
Temporary Works	80%	20%
Bond/Insurance	0%	100%
Surveys/Tests	50%	50%
Miscellaneous 4/	65%	35%
vii) CONTRACTORS' PROFIT	0%	100%

TABLE 5.6. ECONOMIC CAPITAL COSTS OF BANK PROTECTION AND BRE REALIGNMENT ('000 Tk.)

(Sheet 1 of 2)

	FULCHARI (Phase 1C)	SARIAKANDI/ MATHURAPARA (Phase 1A)	SARIAKANDI/ MATHURAPARA (Phase 1B,2)	KAZIPUR (Phase 1C)	KAZIPUR (Phase 2)	SIRAJGANJ (Phase 1A)	SIRAJGANJ (Phase 1B)	BETIL (Phase 1C)	BETIL (Phase 2)
BRE REALIGNMENT									
i) LAND ACQUISITION 2/	15125	23100	24200	17600	17600	0	13200	13200	0
ii) EARTHWORKS:									
Labour - Skilled	11407	22819	23906	14132	14132	0	11914	13002	0
- Unskilled	26622	53259	55795	32982	32982	0	27807	30347	0
Machinery/Equipment	6131	12265	12849	7595	7595	0	6404	6989	0
Sub-Total	44160	88343	92550	54709	54709	0	46125	50338	0
TOTAL BRE REALIGNMENT COSTS	59285	111443	116750	72309	72309	0	59325	63538	0
BANK PROTECTION WORKS									
i) LAND ACQUISITION 3/	2313	2094	1563	1063	1250	3600	250	938	1250
ii) EARTHWORKS:									
Labour - Skilled	4047	12431	6044	2346	2490	9560	509	4960	5396
- Unskilled	9445	29014	14106	5475	5811	22313	1187	11576	12594
Machinery/Equipment	2175	6682	3248	1261	1338	5138	273	2666	2900
Sub-Total	15667	48127	23398	9081	9638	37012	1969	19202	20891
iii) DREDGING/RECLAMATION:									
Labour - Skilled	3484	6464	6560	1907	1907	23179	2056	1835	1835
- Unskilled	2382	4419	4484	1304	1304	15846	1405	1255	1255
Machinery/Equipment	47915	88898	90217	26227	26227	318780	28271	25239	25239
Transport	1920	3563	3615	1051	1051	12775	1133	1011	1011
Storage	1948	3614	3667	1066	1066	12958	1149	1026	1026
Sub-Total	57648	106957	108543	31555	31555	383538	34014	30366	30366
iv) BANK PROTECTION WORKS:									
Labour - Skilled	13516	11625	11621	7426	7457	13388	3919	5434	5527
- Unskilled	47410	40777	40762	26049	26157	46962	13745	19061	19389
Materials - Cement	117312	100900	100863	64457	64724	116205	34012	47166	47976
- Steel	194	167	167	107	107	192	56	78	79
- Brick Aggregate	208564	179386	179321	114595	115070	206596	60468	83854	85295
- Geotextile	68947	59302	59280	37883	38040	68296	19989	27721	28197
Machinery/Equipment	110403	94958	94923	60661	60912	109361	32009	44388	45151
Transport	58070	49946	49928	31906	32039	57522	16836	23347	23748
Storage	1255	1266	1079	690	692	1243	364	505	513
Sub-Total	625669	538327	537943	343773	345199	619766	181398	251554	255876

TABLE 5.6. ECONOMIC CAPITAL COSTS OF BANK PROTECTION AND BRE REALIGNMENT ('000 Tk.)

	FULCHARI (Phase 1C)	SARIAKANDI/ MATHURAPARA (Phase 1A)	SARIAKANDI/ MATHURAPARA (Phase 1B,2)	KAZIPUR (Phase 1C)	KAZIPUR (Phase 2)	SIRAJGANJ (Phase 1A)	SIRAJGANJ (Phase 1B)	BETIL (Phase 1C)	BETIL (Phase 2)
v) MOORING :									
Labour - Skilled	31	20	0	3	3	30	0	3	3
- Unskilled	112	58	0	9	9	87	0	9	9
Materials - Cement	103	53	0	8	8	80	0	8	8
- Steel	398	206	0	31	31	309	0	32	32
- Brick Aggregate	867	449	0	67	67	673	0	70	70
Machinery/Equipment	117	60	0	9	9	90	0	9	9
Pontoon	8875	4591	0	683	683	6887	0	720	720
Transport	155	80	0	12	12	120	0	13	13
Sub-Total	10657	5518	0	821	821	8276	0	865	865
vi) GENERAL FACILITIES/TEMP.WORKS:									
Housing/Buildings	78883	107304	73889	42941	43164	144657	23998	33567	34244
Transport/Equipment	40398	54953	37840	21991	22105	74082	12290	17190	17537
Temporary Works	31553	42922	29556	17176	17266	57863	9599	13427	13698
Bond/Insurance	32254	43874	30212	17557	17649	59147	9812	13725	14002
Surveys/Tests	18868	25667	17674	10271	10325	34601	5740	8029	8191
Sub-Total	201956	274720	189170	109936	110508	370350	61439	85938	87671
TOTAL BANK PROTECTION COSTS	913910	975742	860618	496228	498972	1422542	279070	388862	396919
TOTAL BASELINE COSTS	973195	1087185	977368	568538	571281	1422542	338395	452400	396919
Physical Contingencies (@ 5%)	48660	54359	48868	28427	28564	71127	16920	22620	19846
TOTAL CAPITAL COSTS	1021855	1141544	1026236	596965	599845	1493669	355315	475020	416765
TOTAL CAPITAL COSTS (Phase 1 and 2)	1021855		2167780		1196810		1848984		891785

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

(Sheet 1 of 15)

a) FULCHARIGHAT

				Breach		Breach					Breach		Breach			
	Loss of Fulcharighat						Loss of Rural Land and Property									
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FUTURE WITHOUT PROTECTION WORKS																
Bank Erosion Consequences : 1/																
- Land Losses		17380	17380	17380	17380	17380	12750	12750	12750	12750	12750	12750	12750	12750	12750	12750
- Property Losses		8462	8716	8978	9247	9525	1977	2036	2097	2160	2225	2291	2360	2431	2504	2579
- Infrastructural Losses		3012	3102	3195	3291	3390	1960	2019	2080	2142	2206	2273	2341	2411	2483	2558
BRE Breach Consequences :																
- Crop Damage 2/		0	0	64931	5559	64931	5559	5559	5559	5559	64931	5559	64931	5559	5559	5559
- Livestock Losses		0	0	1070	0	1070	0	0	0	0	1070	0	1070	0	0	0
- Severe Property Damage		0	0	7351	0	7799	0	0	0	0	9041	0	9591	0	0	0
- Severe Infrast. Damage		0	0	7458	0	7912	0	0	0	0	9173	0	9731	0	0	0
- Partial Infrast. Damage		0	0	1241	0	1317	0	0	0	0	1527	0	1620	0	0	0
Area Unprotected by BRE :																
- Reduced Agric. Production				1116	956	797	638	478	319	159	1275	2568	2568	2568	2568	2568
'Ad Hoc' Retirement :																
- Construction Costs Saved		0	0	18600	18600	18600	0	0	0	0	18600	18600	18600	18600	0	0
DISBENEFITS AVOIDED AND COSTS SAVED	0	28854	29199	131320	55034	132720	22883	22842	22804	22770	122797	44041	125562	44319	25864	26014
PROJECT CAPITAL COSTS																
i) Embankment Realignment	31125	31125														
ii) Bank Protection Works	479803	479803														
iii) Engineering/Supervision	15328	15328														
Sub-Total	526255	526255														
O & M COSTS																
i) Embankment Realignment		778	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556
ii) Bank Protection Works		4798	9596	9596	9596	47980	9596	9596	9596	9596	47980	9596	9596	9596	9596	47980
Sub-Total		5576	11152	11152	11152	49537	11152	11152	11152	11152	49537	11152	11152	11152	11152	49537
BANK EROSION LOSSES		8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361
TOTAL COSTS AND BANK EROSION LOSSES	526255	540192	19513	19513	19513	57897	19513	19513	19513	19513	57897	19513	19513	19513	19513	57897
INCREMENTAL NET BENEFITS	-526255	-511338	9686	111807	35521	74823	3370	3329	3291	3257	64900	24528	106049	24806	6351	-31884

NET PRESENT VALUE @ 12% : -643757 ECONOMIC INTERNAL RATE OF RETURN : -0.55%

NET PRESENT VALUE RATIO : -0.49

1/ Erosion Rate of 60 metres per year over 12.5 Km. reach.
2/ In addition to crop damage, includes reduced net value of agricultural production in subsequent years on land severely affected by breach.

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) : (Sheet 2 of 15)

a) FULCHARIGHAT

		Breach		Breach					Breach		Breach				
Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
FUTURE WITHOUT PROTECTION WORKS															
Bank Erosion Consequences : 1/															
- Land Losses	12750	12750	12750	12750	12750	12750	12750	12750	12750	12750	12750	12750	12750	12750	12750
- Property Losses	2656	2736	2818	2903	2990	3079	3172	3267	3365	3466	3570	3677	3787	3901	4018
- Infrastructural Losses	2635	2714	2795	2879	2965	3054	3146	3240	3337	3437	3541	3647	3756	3869	3985
BRE Breach Consequences :															
- Crop Damage 2/	5559	64931	5559	64931	5559	5559	5559	5559	64931	5559	64931	5559	5559	5559	5559
- Livestock Losses	0	1070	0	1070	0	0	0	0	1070	0	1070	0	0	0	0
- Severe Property Damage	0	11119	0	11796	0	0	0	0	13675	0	14508	0	0	0	0
- Severe Infrast. Damage	0	11281	0	11968	0	0	0	0	13874	0	14719	0	0	0	0
- Partial Infrast. Damage	0	1878	0	1992	0	0	0	0	2309	0	2450	0	0	0	0
Area Unprotected by BRE :															
- Reduced Agric. Production	2568	2568	2568	2568	2568	2568	2568	2568	2568	2568	2568	2568	2568	2568	2568
'Ad Hoc' Retirement :															
- Construction Costs Saved	0	18600	18600	18600	0	0	0	0	18600	18600	18600	18600	0	0	0
DISBENEFITS AVOIDED AND COSTS SAVED	26168	129646	45090	131457	26832	27011	27195	27384	136480	46380	138706	46801	28420	28647	28880
PROJECT CAPITAL COSTS															
i) Embankment Realignment															
ii) Bank Protection Works															
iii) Engineering/Supervision															
Sub-Total															
O & M COSTS															
i) Embankment Realignment	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556	1556
ii) Bank Protection Works	9596	9596	9596	9596	47980	9596	9596	9596	9596	47980	9596	9596	9596	9596	47980
Sub-Total	11152	11152	11152	11152	49537	11152	11152	11152	11152	49537	11152	11152	11152	11152	49537
BANK EROSION LOSSES	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361
TOTAL COSTS AND BANK EROSION LOSSES	19513	19513	19513	19513	57897	19513	19513	19513	19513	57897	19513	19513	19513	19513	57897
INCREMENTAL NET BENEFITS	6655	110133	25577	111944	-31065	7498	7682	7871	116967	-11517	119193	27288	8907	9134	-29017

78

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

Sensitivity Analysis - Fulchari	NPV @ 12%	EIRR	NPVR
Base Case	-643756.6	-0.6%	-0.49
Increase Incremental Benefits by 20%	-559103.6	1.6%	-0.43
Increase Incremental Benefits by 40%	-474450.3	3.5%	-0.36
Decrease Incremental Benefits by 20%	-728410.1	-3.3%	-0.56
Decrease Incremental Benefits by 40%	-813063.3	-7.5%	-0.62
Increase Total Costs and Losses by 10%	-750459.1	-1.7%	-0.52
Increase Total Costs and Losses by 20%	-857161.4	-2.8%	-0.55
Decrease Total Costs and Losses by 10%	-537054.5	0.7%	-0.46
Decrease Total Costs and Losses by 20%	-430352.2	2.1%	-0.41

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) : (Sheet 4 of 15)

b) SARIAKANDI/MATHURAPARA — Breach

	<-- Loss of Sariakandi						-->< Loss of Rural Land and Property									
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FUTURE WITHOUT BANK PROTECTION																
Erosion Consequences : 1/																
- Land Losses		49675	49675	49675	49675	49675	37400	37400	37400	37400	37400	37400	37400	37400	37400	37400
- Property Losses		16302	16791	17294	17813	18348	5799	5973	6152	6336	6526	6722	6924	7132	7346	7566
- Infrastructural Losses		4145	4270	4398	4530	4665	1863	1919	1976	2036	2097	2160	2224	2291	2360	2431
BRE Breach Consequences :																
- Crop Damage 2/		7725	4626	4626	4626	4626										
- Livestock Losses		1021														
- Severe Property Damage		20295														
- Severe Infrast. Damage		8800														
- Partial Infrast. Damage		4263	4391	4523	4658	4798	4942	5090	5243	5400	5562	5729	5901	6078	6260	6448
Reduction in Net Agric. Benefits	0	174555	174530	174506	174481	174457	174433	174408	174384	174359	174310	174310	174310	174310	174310	174310
Reduction in Net Fish Benefits	-0	137	273	410	547	683	820	957	1093	1230	1367	1367	1367	1367	1367	1367
DISBENEFITS AVOIDED	-0	286917	254556	255432	256330	257253	225256	225746	226248	226761	227262	227688	228126	228578	229043	229522
PROJECT CAPITAL COSTS																
i) Embankment Realignment	55722	55722				58375	58375									
ii) Bank Protection Works	512264	512264				451825	451825									
iii) Engineering/Supervision	15368	15368				13555	13555									
Sub-Total	583353	583353				523755	523755									
O & M COSTS																
i) Embankment Realignment		1393	2786	2786	2786	2786	4245	5705	5705	5705	5705	5705	5705	5705	5705	5705
ii) Bank Protection Works		5123	10245	10245	10245	20491	14764	19282	19282	19282	96409	19282	19282	19282	19282	96409
Sub-Total		6516	13031	13031	13031	23277	19009	24987	24987	24987	102114	24987	24987	24987	24987	102114
BANK EROSION LOSSES		11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948
TOTAL COSTS AND BANK EROSION LOSSES	583353	601817	24980	24980	24980	558980	554712	36935	36935	36935	114062	36935	36935	36935	36935	114062
INCREMENTAL NET BENEFITS	-583353	-314900	229576	230452	231351	-301727	-329456	188812	189313	189827	113200	190753	191192	191643	192108	115460

NET PRESENT VALUE @ 12% : 712 ECONOMIC INTERNAL RATE OF RETURN : 12.0%

NET PRESENT VALUE RATIO : 0.00

1/ Erosion Rate of 100 metres per year over 22 Km. reach.
2/ In addition to severe crop damage, includes reduced net value of agricultural production in subsequent years on land severely affected by breach.

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

b) SARIAKANDI/MATHURAPARA

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
FUTURE WITHOUT BANK PROTECTION															
Erosion Consequences : 1/															
- Land Losses	37400	37400	37400	37400	37400	37400	37400	37400	37400	37400	37400	37400	37400	37400	37400
- Property Losses	7793	8027	8268	8516	8771	9034	9305	9584	9872	10168	10473	10787	11111	11444	11788
- Infrastructural Losses	2504	2579	2656	2736	2818	2902	2989	3079	3172	3267	3365	3466	3570	3677	3787
BRE Breach Consequences :															
- Crop Damage 2/															
- Livestock Losses															
- Severe Property Damage															
- Severe Infrast. Damage															
- Partial Infrast. Damage	6642	6841	7046	7257	7475	7699	7930	8168	8413	8666	8926	9194	9469	9753	10046
Reduction in Net Agric. Benefits	174310	174310	174310	174310	174310	174310	174310	174310	174310	174310	174310	174310	174310	174310	174310
Reduction in Net Fish Benefits	1367	1367	1367	1367	1367	1367	1367	1367	1367	1367	1367	1367	1367	1367	1367
DISBENEFITS AVOIDED	230015	230523	231047	231586	232141	232713	233302	233909	234534	235177	235840	236523	237227	237951	238697
PROJECT CAPITAL COSTS															
i) Embankment Realignment															
ii) Bank Protection Works															
iii) Engineering/Supervision															
Sub-Total															
O & M COSTS															
i) Embankment Realignment	5705	5705	5705	5705	5705	5705	5705	5705	5705	5705	5705	5705	5705	5705	5705
ii) Bank Protection Works	19282	19282	19282	19282	96409	19282	19282	19282	19282	96409	19282	19282	19282	19282	96409
Sub-Total	24987	24987	24987	24987	102114	24987	24987	24987	24987	102114	24987	24987	24987	24987	102114
BANK EROSION LOSSES	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948
TOTAL COSTS AND BANK EROSION LOSSES	36935	36935	36935	36935	114062	36935	36935	36935	36935	114062	36935	36935	36935	36935	114062
INCREMENTAL NET BENEFITS	193080	193588	194112	194651	118079	195778	196367	196974	197599	121116	198906	199589	200292	201016	124636

Sensitivity Analysis - Sariakandi/Mathurapara	NPV @ 12%	EIRR	NPVR
Base Case	712	12.0%	0.00
Increase Incremental Benefits by 20%	353223	17.1%	0.16
Increase Incremental Benefits by 40%	705735	22.9%	0.33
Decrease Incremental Benefits by 20%	-351799	7.3%	-0.16
Decrease Incremental Benefits by 40%	-704311	2.6%	-0.33
Increase Total Costs and Losses by 10%	-175473	9.8%	-0.07
Increase Total Costs and Losses by 20%	-351657	8.1%	-0.14
Decrease Total Costs and Losses by 10%	176897	14.8%	0.09
Decrease Total Costs and Losses by 20%	353081	18.5%	0.21

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

c) KAZIPUR

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			Breach		Breach					Breach		Breach				
		<-----Loss of Kazipur Market				----><	-----Loss of Rural Land and Property									-----
FUTURE WITHOUT PROTECTION WORKS																
Bank Erosion Consequences :																
- Land Losses		25700	25700	25700	25700	25700	23569	23569	23569	23569	23569	23569	23569	23569	23569	23569
- Property Losses		7987	8226	8473	8727	8989	3374	3475	3579	3687	3797	3911	4028	4149	4274	4402
- Infrastructural Losses		1809	1863	1919	1977	2036	1084	1116	1150	1184	1220	1257	1294	1333	1373	1414
BRE Breach Consequences :																
- Crop Damage		0	66314	4583	66314	4583	4583	4583	4583	66314	4583	66314	4583	4583	4583	4583
- Livestock Losses		0	1046	0	1046	0	0	0	0	1046	0	1046	0	0	0	0
- Severe Property Damage		0	13640	0	14471	0	0	0	0	9089	0	9643	0	0	0	0
- Severe Infrast. Damage		0	6380	0	6768	0	0	0	0	2815	0	2986	0	0	0	0
- Partial Infrast. Damage		0	1400	0	1485	0	0	0	0	1722	0	1826	0	0	0	0
Area Unprotected by BRE :																
- Reduced Agric. Production				2767	2383	1999	1614	1230	846	461	2075	4151	4151	4151	4151	4151
"Ad Hoc" Retirement :																
- Construction Costs Saved		0	18600	18600	18600	0	0	0	0	18600	18600	18600	18600	0	0	0
DISBENEFITS AVOIDED AND COSTS SAVED	0	35498	143169	62042	147471	43306	34224	33973	33727	128487	53844	133303	56226	37785	37950	38119
PROJECT CAPITAL COSTS																
i) Embankment Realignment	75924					75924										
ii) Bank Protection Works	521039					523920										
iii) Engineering/Supervision	17909					17995										
Sub-Total	614872					617840										
O & M COSTS																
i) Embankment Realignment		1898	1898	1898	1898	1898	3796	3796	3796	3796	3796	3796	3796	3796	3796	3796
ii) Bank Protection Works		5210	5210	5210	5210	26052	10450	10450	10450	10450	52248	10450	10450	10450	10450	52248
Sub-Total		7109	7109	7109	7109	27950	14246	14246	14246	14246	56044	14246	14246	14246	14246	56044
BANK EROSION LOSSES		16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248
TOTAL COSTS AND BANK EROSION LOSSES	614872	23357	23357	23357	23357	662038	30494	30494	30494	30494	72293	30494	30494	30494	30494	72293
INCREMENTAL NET BENEFITS	-614872	12139	119812	38685	124114	-618732	3729	3479	3232	97992	-18448	102809	25731	7291	7455	-34174

NET PRESENT VALUE @ 12% : -562263 ECONOMIC INTERNAL RATE OF RETURN : -0.5%

NET PRESENT VALUE RATIO : -0.42

1/ Erosion Rate of 75 metres per year over 17 Km. reach.
2/ In addition to crop damage, includes reduced net value of agricultural production on land severely affected by breach.

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

c) KAZIPUR	Breach		Breach					Breach		Breach					Breach
Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
FUTURE WITHOUT PROTECTION WORKS															
Bank Erosion Consequences :															
- Land Losses	23569	23569	23569	23569	23569	23569	23569	23569	23569	23569	23569	23569	23569	23569	23569
- Property Losses	4534	4670	4810	4955	5103	5256	5414	5576	5744	5916	6093	6276	6465	6658	6858
- Infrastructural Losses	1457	1500	1545	1592	1640	1689	1739	1792	1845	1901	1958	2016	2077	2139	2203
BRE Breach Consequences :															
- Crop Damage	66314	4583	66314	4583	4583	4583	4583	66314	4583	66314	4583	4583	4583	4583	66314
- Livestock Losses	1046	0	1046	0	0	0	0	1046	0	1046	0	0	0	0	1046
- Severe Property Damage	11178	0	11859	0	0	0	0	13748	0	14585	0	0	0	0	16908
- Severe Infrast. Damage	3462	0	3673	0	0	0	0	4258	0	4517	0	0	0	0	5236
- Partial Infrast. Damage	2117	0	2246	0	0	0	0	2604	0	2763	0	0	0	0	3203
Area Unprotected by BRE :															
- Reduced Agric. Production	4151	4151	4151	4151	4151	4151	4151	4151	4151	4151	4151	4151	4151	4151	4151
'Ad Hoc' Retirement :															
- Construction Costs Saved	18600	18600	18600	0	0	0	0	18600	18600	18600	18600	0	0	0	0
DISBENEFITS AVOIDED AND COSTS SAVED	136428	57073	137814	38849	39045	39248	39456	141657	58492	143361	58954	40595	40844	41100	129489
PROJECT CAPITAL COSTS															
i) Embankment Realignment															
ii) Bank Protection Works															
iii) Engineering/Supervision															
Sub-Total															
O & M COSTS															
i) Embankment Realignment	3796	3796	3796	3796	3796	3796	3796	3796	3796	3796	3796	3796	3796	3796	3796
ii) Bank Protection Works	10450	10450	10450	10450	52248	10450	10450	10450	10450	52248	10450	10450	10450	10450	52248
Sub-Total	14246	14246	14246	14246	56044	14246	14246	14246	14246	56044	14246	14246	14246	14246	56044
BANK EROSION LOSSES	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248
TOTAL COSTS AND BANK EROSION LOSSES	30494	30494	30494	30494	72293	30494	30494	30494	30494	72293	30494	30494	30494	30494	72293
INCREMENTAL NET BENEFITS	105934	26579	107319	8355	-33247	8753	8962	111163	27997	71069	28460	10101	10350	10606	57196

20

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

Sensitivity Analysis - Kazipur	NPV @ 12%	EIRR	NPVR
Base Case	-562263	-0.5%	-0.42
Increase Incremental Benefits by 20%	-455542	2.2%	-0.34
Increase Incremental Benefits by 40%	-348820	4.6%	-0.26
Decrease Incremental Benefits by 20%	-668985	-3.8%	-0.50
Decrease Incremental Benefits by 40%	-775707	-9.2%	-0.58
Increase Total Costs and Losses by 10%	-671851	-1.9%	-0.46
Increase Total Costs and Losses by 20%	-781438	-3.2%	-0.49
Decrease Total Costs and Losses by 10%	-452676	1.0%	-0.38
Decrease Total Costs and Losses by 20%	-343089	2.8%	-0.32

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

d) SIRAJGANJ

		Breach					Breach		Breach					Breach		Breach
		(---------Loss of 1/3 Sirajganj Town------------)(					------------Loss of 2/3 of Sirajganj Town + Rural Land and Property---------------------------)									
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FUTURE WITHOUT PROTECTION WORKS																
Bank Erosion Consequences :																
- Land Losses		258150	344200	430250	430250	258150	90200	90200	90200	90200	90200	90200	90200	90200	90200	90200
- Property Losses		32206	66343	85417	87980	72495	15861	16336	16827	17331	17851	18387	18938	19507	20092	20695
- Infrastructural Losses		5488	11305	14556	14992	12354	3152	3247	3344	3445	3548	3654	3764	3877	3993	4113
BRE Breach Consequences :																
- Crop Damage		8065	1188	1188	1188	1188	8065	1188	8065	1188	1188	1188	1188	8065	1188	8065
- Livestock Losses		484	0	0	0	0	484	0	484	0	0	0	0	484	0	484
- Severe Property Damage		77572	38786	38531	38227	37869	37455	36983	36448	35848	35179	34438	33621	32723	31742	30672
- Severe Infrast. Damage		20807	10404	10335	10253	10157	10047	9920	9776	9615	9436	9237	9018	8777	8514	8227
- Partial Infrast. Damage		139	143	147	152	156	161	166	171	176	181	187	192	198	204	210
Area Unprotected by BRE :																
- Reduced Agric. Production			1025	854	683	512	2050	1879	1708	1537	4100	4100	4100	4100	4100	4100
Embankment Retirement :																
- Construction Costs Saved		93000	0	0	0	0	18600	18600	18600	0	0	0	0	18600	18600	18600
DISBENEFITS AVOIDED AND COSTS SAVED	0	495911	473544	581403	583825	392956	186375	178793	185873	159565	162283	161991	161621	187131	179233	185966
PROJECT CAPITAL COSTS																
i) Embankment Realignment						62291										
ii) Bank Protection Works	746835	746835				293024										
iii) Engineering/Supervision	22405	22405				10659										
Sub-Total	769240	769240				365975										
O & M COSTS																
i) Embankment Realignment		0	0	0	0	0	1557	1557	1557	1557	1557	1557	1557	1557	1557	1557
ii) Bank Protection Works		7468	14937	14937	14937	74683	17867	17867	17867	17867	89335	17867	17867	17867	17867	89335
Sub-Total		7468	14937	14937	14937	74683	19424	19424	19424	19424	90892	19424	19424	19424	19424	90892
BANK EROSION LOSSES		16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716
Less Reclaimed Peri-Urban Land			-22500													
TOTAL COSTS AND BANK EROSION LOSSES	769240	793424	9153	31653	31653	457375	36141	36141	36141	36141	107608	36141	36141	36141	36141	107608
INCREMENTAL NET BENEFITS	-769240	-297514	464391	549750	552171	-64418	150234	142653	149733	123425	54675	125850	125480	150991	143092	78358

NET PRESENT VALUE @ 12% : 531645 ECONOMIC INTERNAL RATE OF RETURN : 23.2%

NET PRESENT VALUE RATIO : 0.24

1/ Erosion Rate of 100 metres per year over 19 Km.
2/ In addition to crop damage, includes reduced net value of agricultural production in subsequent years on land severely affected by breach.

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

d) SIRAJGANJ

					Breach		Breach					Breach		Breach	
Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
FUTURE WITHOUT PROTECTION WORKS															
Bank Erosion Consequences :															
- Land Losses	90200	90200	90200	90200	90200	90200	90200	90200	90200	90200	90200	90200	90200	90200	90200
- Property Losses	21315	21955	22614	23292	23991	24710	25452	26215	27002	27812	28646	29506	30391	31302	32241
- Infrastructural Losses	4236	4363	4494	4629	4768	4911	5058	5210	5366	5527	5693	5864	6040	6221	6408
BRE Breach Consequences :															
- Crop Damage	1188	1188	1188	1188	8065	1188	8065	1188	1188	1188	1188	8065	1188	8065	1188
- Livestock Losses	0	0	0	0	484	0	484	0	0	0	0	484	0	484	0
- Severe Property Damage	29510	28250	26888	25419	23837	22138	20315	18363	16276	14046	11669	9136	6441	3575	532
- Severe Infrast. Damage	7915	7577	7212	6818	6394	5938	5449	4925	4366	3768	3130	2451	1728	959	143
- Partial Infrast. Damage	217	223	230	237	244	251	259	266	274	283	291	300	309	318	328
Area Unprotected by BRE :															
- Reduced Agric. Production	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100
Embankment Retirement :															
- Construction Costs Saved	0	0	0	0	18600	18600	18600	0	0	0	0	18600	18600	18600	0
DISBENEFITS AVOIDED AND COSTS SAVED	159281	158456	157525	156482	181282	172636	178582	151068	149371	147523	145517	169305	159595	164425	135739
PROJECT CAPITAL COSTS															
i) Embankment Realignment															
ii) Bank Protection Works															
iii) Engineering/Supervision															
Sub-Total															
O & M COSTS															
i) Embankment Realignment	1557	1557	1557	1557	1557	1557	1557	1557	1557	1557	1557	1557	1557	1557	1557
ii) Bank Protection Works	17867	17867	17867	17867	89335	17867	17867	17867	17867	89335	17867	17867	17867	17867	89335
Sub-Total	19424	19424	19424	19424	90892	19424	19424	19424	19424	90892	19424	19424	19424	19424	90892
BANK EROSION LOSSES	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716
Less Reclaimed Peri-Urban Land															
TOTAL COSTS AND BANK EROSION LOSSES	36141	36141	36141	36141	107608	36141	36141	36141	36141	107608	36141	36141	36141	36141	107608
INCREMENTAL NET BENEFITS	123140	122315	121384	120341	73674	136495	142441	114927	113231	39915	109376	133164	123455	128284	28131

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) : (Sheet 12 of 15)

Sensitivity Analysis - Sirajgang	NPV @ 12%	EIRR	NPVR
Base Case	531645	23.2%	0.24
Increase Incremental Benefits by 10%	763302	28.5%	0.35
Increase Incremental Benefits by 20%	994958	33.8%	0.46
Decrease Incremental Benefits by 10%	299989	18.2%	0.14
Decrease Incremental Benefits by 20%	68333	13.4%	0.03
Increase Total Costs and Losses by 10%	353154	18.6%	0.15
Increase Total Costs and Losses by 20%	174662	14.9%	0.07
Decrease Total Costs and Losses by 10%	710137	29.1%	0.36
Decrease Total Costs and Losses by 20%	888629	36.5%	0.51

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

e) BETIL

(----------Loss of Two Weaving Villages----------)(---------Loss of Belkuchi Upazila HQ, plus Rural Land and Property including Weaving Villages------

Year	0	1 Breach	2	3 Breach	4	5	6	7	8 Breach	9	10 Breach	11	12	13	14	15 Breach
FUTURE WITHOUT PROTECTION WORKS																
Bank Erosion Consequences : 1/																
- Land Losses		37500	37500	37500	37500	37500	36090	36090	36090	36090	36090	36090	36090	36090	36090	36090
- Property Losses		11275	11613	11962	12320	12690	13071	13463	13867	14283	14711	15153	15607	16075	16558	17054
- Infrastructural Losses		3066	3158	3252	3350	3450	3554	3660	3770	3883	4000	4120	4244	4371	4502	4637
BRE Breach Consequences :																
- Crop Damage 2/		9560	4097	9560	4097	4097	4097	4097	9560	4097	9560	4097	4097	4097	4097	9560
- Livestock Losses		996	0	996	0	0	0	0	996	0	996	0	0	0	0	996
- Severe Property Damage		22161	0	23511	0	0	0	0	27255	0	28915	0	0	0	0	33521
- Severe Infrast. Damage		8028	0	8517	0	0	0	0	9873	0	10475	0	0	0	0	12143
- Partial Infrast. Damage		44	0	47	0	0	0	0	54	0	57	0	0	0	0	67
Area Unprotected by BRE :																
- Reduced Agric. Production				929	1394	1859	2323	2323	2323	2323	2323	2323	2556	2788	3020	3253
'Ad Hoc' Retirement :																
- Construction Costs Saved		12400	12400	12400	12400	12400	12400	12400	12400	12400	12400	13640	14880	16120	17360	18600
DISBENEFITS AVOIDED AND COSTS SAVED	0	105030	68768	108673	71062	71996	71535	72034	116189	73077	119528	75423	77474	79541	81627	135920
PROJECT CAPITAL COSTS																
i) Embankment Realignment	66715															
ii) Bank Protection Works	408306					416765										
iii) Engineering/Supervision	14251					12503										
Sub-Total	489272					429268										
O & M COSTS																
i) Embankment Realignment		1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668
ii) Bank Protection Works		4083	4083	4083	4083	20415	8251	8251	8251	8251	41254	8251	8251	8251	8251	41254
Sub-Total		5751	5751	5751	5751	22083	9919	9919	9919	9919	42921	9919	9919	9919	9919	42921
BANK EROSION LOSSES		25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561
TOTAL COSTS AND BANK EROSION LOSSES	489272	31312	31312	31312	31312	476912	35480	35480	35480	35480	68483	35480	35480	35480	35480	68483
INCREMENTAL NET BENEFITS	-489272	73718	37456	77361	39749	-404916	36055	36554	80709	37597	51045	39943	41994	44062	46147	67437

NET PRESENT VALUE @ 12% : -274216 ECONOMIC INTERNAL RATE OF RETURN : 5.3%

NET PRESENT VALUE RATIO : -0.24

1/ Erosion Rate of 95 metres per year over 18 Km.
2/ In addition to crop damage, includes reduced net value of agricultural production on land severely affected by breach.

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

el BETIL

		Breach					Breach		Breach					Breach	
Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
FUTURE WITHOUT PROTECTION WORKS															
Bank Erosion Consequences : 1/															
- Land Losses	36090	36090	36090	36090	36090	36090	36090	36090	36090	36090	36090	36090	36090	36090	36090
- Property Losses	17566	18093	18636	19195	19771	20364	20975	21604	22252	22920	23607	24316	25045	25796	26570
- Infrastructural Losses	4776	4919	5067	5219	5376	5537	5703	5874	6050	6232	6419	6611	6810	7014	7224
BRE Breach Consequences :															
- Crop Damage 2/	4097	9560	4097	4097	4097	4097	9560	4097	9560	4097	4097	4097	4097	9560	4097
- Livestock Losses	0	996	0	0	0	0	996	0	996	0	0	0	0	996	0
- Severe Property Damage	0	35562	0	0	0	0	41226	0	43737	0	0	0	0	50703	0
- Severe Infrast. Damage	0	12883	0	0	0	0	14934	0	15844	0	0	0	0	18367	0
- Partial Infrast. Damage	0	71	0	0	0	0	82	0	87	0	0	0	0	101	0
Area Unprotected by BRE :															
- Reduced Agric. Production	3485	3717	3949	4182	4182	4182	4182	4182	4182	4182	4182	4182	4182	4182	4182
'Ad Hoc' Retirement :															
- Construction Costs Saved	19840	21080	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320
DISBENEFITS AVOIDED AND COSTS SAVED	85854	142971	90160	91103	91835	92590	156068	94167	161118	95841	96715	97616	98544	175129	100484
PROJECT CAPITAL COSTS															
i) Embankment Realignment															
ii) Bank Protection Works															
iii) Engineering/Supervision															
Sub-Total															
O & M COSTS															
i) Embankment Realignment	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668	1668
ii) Bank Protection Works	8251	8251	8251	8251	41254	8251	8251	8251	8251	41254	8251	8251	8251	8251	41254
Sub-Total	9919	9919	9919	9919	42921	9919	9919	9919	9919	42921	9919	9919	9919	9919	42921
BANK EROSION LOSSES	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561
TOTAL COSTS AND BANK EROSION LOSSES	35480	35480	35480	35480	68483	35480	35480	35480	35480	68483	35480	35480	35480	35480	68483
INCREMENTAL NET BENEFITS	50374	107491	54680	55623	23353	57110	120588	58687	125638	27358	61235	62136	63064	139649	32001

24

Table 6.1. Economic Appraisal of Priority Locations ('000 Tk) :

Sensitivity Analysis - Betil	NPV @ 12%	EIRR	NPVR
Base Case	-274216	5.3%	-0.24
Increase Incremental Benefits by 20%	-144058	8.5%	-0.13
Increase Incremental Benefits by 40%	-13900	11.7%	-0.01
Decrease Incremental Benefits by 20%	-404375	1.8%	-0.36
Decrease Incremental Benefits by 40%	-534533	-2.9%	-0.47
Increase Total Costs and Losses by 10%	-366717	3.8%	-0.30
Increase Total Costs and Losses by 20%	-459218	2.4%	-0.34
Decrease Total Costs and Losses by 10%	-181716	7.1%	-0.18
Decrease Total Costs and Losses by 20%	-89215	9.3%	-0.10

TABLE 7.1 COMPARISON OF COSTS AND BENEFITS FOR DIFFERENT BRE SETBACK DISTANCES (KAZIPUR) - SHEET 1 OF 2

Reach Length 10,000 m

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Mean Erosion Rate		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Trigger Distance (Ratio)	3	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Setback Ratio	12	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Mean BRE Setback		300	200	100	1200	1100	1000	900	800	700	600	500	400	300	200	100	1200	1100	1000	900	800
Realigned BRE Setback		1500	1400	1300										1500	1400	1300					
Breach Probability 1		5	12	50	0	0	0	0	0	0	0	0	1	5	12	50	0	0	0	0	0
Breach Probability 2		0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	N/A	N/A
Net Probability		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Nominal Realignments (No)	2.50	1												1							
Mean Frequency	.08																				
Length Factor	1.41																				
Mean Construction Cost	Tk'000	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803
Erosion loss (ha)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Value (Tk '000)	Tk'000/ha	Tk '000																			
Unprotected land	125	12500																			
Rural village property	23	2274																			
Rural roads	7	731																			
Total loss	155	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505	15505
Area 100% exposed (ha)		300	200	100	1200	1100	1000	900	800	700	600	500	400	300	200	100	1200	1100	1000	900	800
Area possibly exposed (ha)		0	0	600	0	0	0	0	0	0	0	0	0	0	0	600	0	0	0	0	0
Newly Exposed (ha)		300	0	600	600	0	0	0	0	0	0	0	0	0	0	600	600	0	0	0	0
Average area exposed (ha)	724																				
lost land value (Tk'000)	75.00	22500	0	45000	45000	0	0	0	0	0	0	0	0	0	0	45000	45000	0	0	0	0
Reduced Productivity	7.68	2304	1536	5376	9216	8448	7680	6912	6144	5376	4608	3840	3072	2304	1536	5376	9216	8448	7680	6912	6144
Incremental																					
Probability of Breach %		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Breach loss	Tk'000																				
Land degradation	8064																				
Livestock	1050																				
Property	13240																				
Infrastructure	6190																				
Increased Inundation	58250																				
Probability weighted		0	0	0	0	0	0	0	0	0	0	0	868	0	0	0	0	0	0	0	0
Benefits from flood protection		58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250	58250

Trigger Ratio for Erosion Rate 100 and Setback Ratio 4.0

Present Value at	.12	1	1.5	2	2.5	3	4	5	8	9	10	11
Construction cost	54.80	136.42	136.42	136.42	136.42	136.42	136.42	136.42				
Reduced Land Value	100.27	67.70	63.10	60.00	55.53	53.13	47.43	42.35				
Breach damage	.28	18.49	10.70	7.42	3.71	1.45	1.29	1.16				
Total costs	155.08	204.12	199.52	196.42	191.95	189.55	183.85	178.77				
Benefit (loss of production prevented)	468.93	450.72	458.52	461.79	465.50	467.76	467.92	468.06				
NPV	313.86	246.60	259.00	265.37	273.55	278.22	284.07	289.29				
Reduced productivity	42.36	18.91	17.69	18.16	17.41	18.21	18.95	20.28				
Total Costs	97.16	155.33	154.11	154.59	153.83	154.63	155.37	156.70				
NPV	371.77	295.39	304.41	307.21	311.67	313.14	312.55	311.36				
Erosion loss	124.38	124.38	124.38	124.38	124.38	124.38	124.38	124.38				

27

TABLE 7.1 COMPARISON OF COSTS AND BENEFITS FOR DIFFERENT BRE SETBACK DISTANCES (KAZIPUR) - SHEET 2 OF 2

Reach Length

Year		21	22	23	24	25	26	27	28	29	30
Mean Erosion Rate		100	100	100	100	100	100	100	100	100	100
Trigger Distance (Ratio)	3	300	300	300	300	300	300	300	300	300	300
Setback Ratio	12	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Mean BRE Setback		700	600	500	400	300	200	100	1200	1100	1000
Realigned BRE Setback						1500	1400	1300			
Breach Probability 1		0	0	0	1	0	12	50	0	0	0
Breach Probability 2		N/A	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A
Net Probability		0	0	0	1	0	0	0	0	0	0
Nominal Realignments (No)	2.50					1					
Mean Frequency	.08										
Length Factor	1.41										
Mean Construction Cost	Tk'000	6803	6803	6803	6803	6803	6803	6803	6803	6803	6803
Erosion loss (ha)		100	100	100	100	100	100	100	100	100	0
Value (Tk '000)	Tk'000/ha										
Unprotected land	125										
Rural village property	23										
Rural roads	7										
Total loss	155	15505	15505	15505	15505	15505	15505	15505	15505	15505	0
Area 100% exposed (ha)		700	600	500	400	300	200	100	1200	1100	1000
Area possibly exposed (ha)		0	0	0	0	0	0	600	0	0	0
Newly Exposed (ha)		0	0	0	0	0	0	600	600	0	0
Average area exposed (ha)	ERROR										
lost land value (Tk'000)	75.00	0	0	0	0	0	0	45000	45000	0	0
Reduced Productivity	.00	5376	4608	3840	3072	2304	1536	5376	9216	8448	7680
Incremental											
Probability of Breach %		0	0	0	1	0	0	0	0	0	0
Breach loss	Tk'000										
Land degradation	0										
Livestock	0										
Property	0										
Infrastructure	0										
Increased Inundation	0										
Probability weighted		0	0	0	868	0	0	0	0	0	0
Benefits from flood											
protection		58250	58250	58250	58250	58250	58250	58250	58250	58250	58250

Present Value at	.12
Construction cost	38.44
Reduced Land Value	38.53
Breach damage	.55
Total costs	76.97
Benefit (loss of	
production prevented)	328.57
NPV	251.60
Reduced productivity	26.92
Total Costs	65.36
NPV	263.22
Erosion loss	82.61

Ratio of Setback to Mean Erosion

EXPLANATORY NOTES ON TABLE 7.1
(Refer also to Table 7.2)

Row 4: Reach Length is a variable whose value is to be decided by the user The implicit assumption is that only one stretch of active erosion will occur in this reach at any one time. Its value will lie somewhere between half the dominant anabranch wavelength, in more braided sections, or the full wavelength, in more stably meandering anabranches.

Row 6: This has been carried out for a 30 year period

Row 8: The mean erosion rate is the net mean annual value for the reach including periods of both erosion and accretion: this has been derived from data for the period 1953 to 1992.

Row 9: The trigger distance is the minimum acceptable distance between the existing embankment and the river bank; this triggers the decision to realign the embankment; it is expressed as a proportion of the mean annual erosion rate (the ratio value is given in Col B)

Row 10: The retirement depth is the mean distance between the existing and the realigned embankments; it is expressed as a proportion of the mean annual erosion rate (the ratio value is given in Col B); it will noramlly remain constant for a reach

Row 11: The Mean BRE Setback is the mean value of the distance between the currently active BRE and the river bank. The value in Year 1 has been set at equal to the trigger distance; thereafter it reduces by the mean annual erosion rate until the setback is reduced to equal to or less than the mean annual erosion rate. At this point it is assumed that the embankment is breached and that the newly realigned embankment becomes the active embankment

Row 12: The Realigned BRE Setback is the distance between the newly realigned embankment and the river bank. When the mean setback reaches the trigger value, the new embankment is introduced at an initial setback equal to the current mean setback plus the Retirement Depth. The value decreases annually by the Mean Erosion Rate until the earlier embankment is "lost", at which time the realigned embankment converts to the current embankment in Row 11.

Row 13: This row shows the probability of the current BRE (Row 11) being breached. It is equal to the exceedance probability of the annual erosion rate equal to the current setback distance (i.e the probability of the existing setback distance being fully eroded within the coming year). The latter value is looked up in Row 67 and the corresponding value in Row 68 is found. The values in Row 67 are estimated from the values entered in Row 66, which relate to a median value of 150 m/y, derived from actual erosion data. The approximation made here is that the distribution about the median will be the same for varying median values; hence the values in Row 67 bear the same relationship to the median value as those in Row 66. The median in Row 67 is equal to the mean annual erosion rate.

Row 14: The same computation is carried out for the realigned embankment. Where there is no realigned embankment, the cell entry is N/A.

Row 15: The Net Probability is that relating to the realigned embankment if it exists, or otherwise to the current embankment. The assumption here is that if the current BRE breaches after the new embankment has been constructed the disbenefits will be relatively small and may be omitted from this analysis.

Row 16: The value in Col B is the number of years divided by the Retirement Depth Ratio. The rationale is that on average the time interval between realignments will be equal to the Retirement Depth divided by the Mean Erosion Rate. A digit 1 appearing in this Row indicates when the realignments would take place for this particular scenario.

Row 17: The value in Col B is the value in Row 16 divided by the number . of years. It is thus also the reciprocal of the Retirement Depth Ratio.

Row 18: The value in Col B provides allowance for the additional length of embankment that has to be constructed due to the sinuosity of a partial realignment. This value will increase as partial realignment lengths are reduced and as the Realignment Depth increases. For convenience, it may be set to be linearly proportional to the Retirement Depth Ratio.

Row 19; These values are the time averaged cost of embankment construction, equal to the cost of a single embankment over the full length of the reach multiplied by the frequency. Note that there is no specification of the length of each individual realignment, which may vary considerably depending on local conditions. The assumption is that the complete length of the embankment has to be be reconstructed on average at the frequency shown in Col B. Individual partial realignments will probably be more frequent than this. The use of an average annual cost avoids the unnecesary complication of the exact manner in which the realignment takes place. A factor provides allowance for the additional length of embankment required for each partial realignment.

Row 21: The erosion loss does not enter into the computation but is provided here for reference purposes. The erosion loss is equal to the mean annual rate multiplied by the reach length.

Row 22: The value in column B is taken from the Table in Rows 70 to 82.

Rows 23 to 25: The values in Col B are the unit values in Tk'000 taken from the Table in Rows 84 to 97

Row 26: The total loss per eroded hectare is given in Col B and the average annual loss for the reach in the following columns.

Row 28: The values in this row are the mean area in each year that is unprotected from riverine flooding, irrespective of whether a breach occurs. It is equal to the mean setback distance multiplied by the reach length.

Row 29: There is a risk that the area lying between the current and the realigned embankment will also be exposed as a consequence of a breach in the former. The area possibly exposed in this way has been computed by multiplying the area concerned by the risk of a breach occurring.

Row 30: The area newly exposed is that area which was previously protected but is now unprotected due to a realignment and breaching of the earlier embankment. In the eyes of the landowner, this area experiences a sudden one-off loss of value as a consequence of this transition (this is independent of the drop in land value linked to the increasing risk of loss through bank erosion).

Row 31: The average area exposed is simply the average value for the period of the analysis.

Row 33: The loss of land value is computed as being the area newly exposed multiplied by the difference in land value (Col B) shown in the Table (Rows 70 to 82)

Row 34: As an alternative means of placing a value on the loss, the reduced productivity is computed from the area exposed multiplied by the difference in gross margin (Col B) from the Table (Rows 85 to 96)

Row 37: As erosion continues the probability of a breach occurring increases. In any year the disbenefit is taken as the increment in this risk multiplied by the loss related to a breach.

Rows 38 to 43: These values are obtained from the Table (Rows 85 to 96) for the length of river under review.

Row 44: This row contains the value computed by multiplying the total loss a breach by the incremental risk of a breach occurring in that year.

Row 47: The total benefit from flood protection is taken as being equal in value to the mean loss of production in the protected area consequential upon flow occurring through a breach. This does not include the immediate losses experienced in the immediate vicinity of a breach nor the increased investment in agricultural and civil infrastructure arising from the increased security provided by the embankment. It is therefore conservative.

Row 50: The value in Col B is the discount rate for the NPV computation. The values in the other columns are the Setback Ratios for which the computation has been made.

Row 51: The Present Value of the construction cost is computed from the stream in Row 19.

Row 52: The Present Value of the drop in land value due to realignment of the embankment is derived from Row 33.

Row 53: The Present Value of the risk of breach damage is derived from Row 44

Row 55: The Present Value of the benefits arising from the prevention of increased inundation in the hinterland and consequential drop in production is derived from Row 47. The net benefit may also be expressed as the values in Row 53 subtracted from the values in this row.

Row 59: As as an alternative to Row 56 for expressing the disbenefit of embankment setback this row gives the Present Value of the reduced production resulting from the absence of protection from riverine flooding for the riparian lands.

Row 63: The value of land lost to erosion is shown for comparison.

TABLE 7.2 DATA TABLE

EROSION RATE DISTRIBUTION	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		0	50	60	70	80	90	100	150	175	200	225	250	275	300	325
SB		0	33	40	47	53	60	67	100	117	133	150	167	183	200	217
Prob		100	100	95	90	85	80	75	50	40	30	25	20	16	12	10

EROSION RATE DISTRIBUTION	Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		350	375	400	425	450	475	500	525	550	575	600	650	700	750	800
SB		233	250	267	283	300	317	333	350	367	383	400	433	467	500	533
Prob		8	7	6	5.5	5	4	3	2.5	2	1.5	1	.5	0	0	0

Land Values and productivity	Acquisition Price '000 Tk/ha	Economic Value '000 Tk/ha
Agricultural Land (unprotected)		125
Agricultural Land (protected)		200
Market Land		500
Upazila HQ Land		1,000
Urban Land		3,000
Peri-urban Land		900

Area affected by a Breach at	Severely Affected Area ha	Reduction in Net Economic Value Initial Year Tk/ha	Reduction in Net Economic Value Future Years Tk/ha	Severely Affected Area Value of Livestock loss '000 Tk	Severely Affected Area Value of Property loss '000 Tk	Severely Affected Area Value of Infrastructure loss '000 Tk	Increased Inundation Net Value of Production Lost '000 Tk	BRE Construction per km Earth-Works '000 Tk	BRE Construction per km Land Acquis '000 Tk	Agricultural Gross Margin Protected Tk/ha	Agricultural Gross Margin Exposed Tk/ha	Rural Village Property Tk/ha	Rural Road Infrastructure Tk/ha
Fulchari	400	23,580	13,900	1,070	6,930	7,030	55,500	3,650	1,730	23,580	14,730	22,740	7,310
Sariakandi	320	24,140	14,460	1,020	20,300	8,800	181,400	4,980	2,010	23,580	14,730	22,740	7,310
Mathurapara	385	24,140	14,460	1,070	1,180	2,220	181,400	5,210	2,060	23,580	14,730	22,740	7,310
Kazipur	360	22,400	12,730	1,050	13,240	6,190	58,250	4,000	1,790	22,410	14,730	22,740	7,310
Sirajganj	100	21,560	11,880	480	77,570	20,810	5,910	4,560	1,930	23,560	14,730	22,740	7,310
Betil	345	21,560	11,880	1,000	22,160	8,030	2,120	5,080	2,030	21,560	14,730	22,740	7,310

TABLE 7.3 COMPARISON OF NET PRESENT VALUES FOR DIFFERENT SETBACK RATIOS
(Values in Tk. million)

Trigger Setback Distance Ratio		FULCHARI				KAZIPUR				SIRAJGANJ				BETIL			
		NPV	Construction Cost	Red Ptivity	Benifit	NPV	Construction Cost	Red Ptivity	Benifit	NPV	Construction Cost	Red Ptivity	Benifit	NPV	Construction Cost	Red Ptivity	Benifit
2	1	-282.12	468.04	5.46	191.38	-316.76	503.71	4.73	191.68	-864.35	564.60	5.44	-294.30	-735.97	618.54	4.21	-113.22
2	2	158.20	240.52	14.26	412.97	160.99	258.85	12.37	432.21	-302.35	290.14	14.23	2.02	-329.16	317.86	11.00	-0.30
2	3	255.06	164.68	17.55	437.29	266.14	177.23	15.23	458.61	-181.63	198.66	17.51	34.54	-219.09	217.63	13.55	12.10
2	4	292.53	126.76	20.93	440.22	307.21	136.42	18.16	461.79	-135.34	152.91	20.88	38.46	-170.08	167.52	16.15	13.59
2	5	313.38	104.01	24.48	441.87	330.40	111.93	21.24	463.58	-109.23	125.47	24.43	40.66	-141.92	137.45	18.89	14.43
2	6	326.05	88.84	28.11	443.00	344.80	95.61	24.39	464.80	-93.05	107.17	28.05	42.17	-124.10	117.41	21.69	15.01
2	7	334.05	78.01	31.77	443.82	354.18	83.95	27.57	465.70	-82.52	94.10	31.70	43.27	-112.18	103.09	24.52	15.43
2	8	338.82	69.88	35.77	444.47	360.16	75.21	31.04	466.40	-75.84	84.30	35.69	44.14	-104.20	92.35	27.60	15.76
2	9	341.69	63.56	39.61	444.86	364.05	68.40	34.38	466.83	-71.53	76.67	39.52	44.66	-98.61	84.00	30.57	15.96
2	10	342.98	58.50	43.70	445.18	366.29	62.96	37.92	467.17	-69.08	70.58	43.60	45.09	-94.92	77.32	33.72	16.12
2	11	343.14	54.37	48.04	445.55	367.37	58.51	41.69	467.57	-67.93	65.59	47.93	45.58	-92.62	71.85	37.07	16.30
2	12	342.54	50.92	52.28	445.74	367.61	54.80	45.37	467.78	-67.75	61.43	52.16	45.84	-91.24	67.30	40.35	16.40
3	1	-255.38	468.04	7.23	219.89	-287.35	503.71	6.27	222.63	-827.99	564.60	7.21	-256.18	-722.81	618.54	5.58	-98.69
3	2	161.18	240.52	15.05	416.74	164.40	258.85	13.06	436.31	-298.09	290.14	15.01	7.06	-327.85	317.86	11.61	1.63
3	3	255.79	164.68	17.96	438.43	267.03	177.23	15.59	459.85	-180.52	198.66	17.92	36.07	-218.82	217.63	13.86	12.68
3	4	297.99	126.76	20.98	445.73	313.14	136.42	18.21	467.76	-128.03	152.91	20.93	45.82	-167.32	167.52	16.19	16.40
3	5	317.89	104.01	24.15	446.05	335.22	111.93	20.96	468.11	-103.31	125.47	24.09	46.25	-139.53	137.45	18.64	16.56
3	6	330.04	88.84	27.39	446.27	348.97	95.61	23.77	468.35	-87.95	107.17	27.33	46.54	-121.87	117.41	21.14	16.67
3	7	337.81	78.01	30.62	446.43	358.01	83.95	26.57	468.53	-77.89	94.10	30.55	46.76	-109.96	103.09	23.63	16.75
3	8	342.50	69.88	34.17	446.56	363.80	75.21	29.66	468.67	-71.47	84.30	34.10	46.93	-101.91	92.35	26.37	16.82
3	9	345.57	63.56	37.50	446.63	367.80	68.40	32.54	468.75	-67.06	76.67	37.42	47.03	-96.08	84.00	28.94	16.86
3	10	346.88	58.50	41.31	446.70	370.01	62.96	35.85	468.82	-64.67	70.58	41.21	47.12	-92.31	77.32	31.88	16.89
3	11	347.30	54.37	45.10	446.77	371.24	58.51	39.14	468.89	-63.38	65.59	45.00	47.21	-89.73	71.85	34.81	16.93
3	12	347.07	50.92	48.81	446.80	371.77	54.80	42.36	468.93	-62.87	61.43	48.70	47.26	-88.02	67.30	37.67	16.95

TABLE 7.3 COMPARISON OF NET PRESENT VALUES FOR DIFFERENT SETBACK RATIOS
(Values in Tk. million)

Trigger Distance	Setback Ratio	FULCHARI NPV	FULCHARI Construction Cost	FULCHARI Red L Value	FULCHARI Benifit	KAZIPUR NPV	KAZIPUR Construction Cost	KAZIPUR Red L Value	KAZIPUR Benifit	SIRAJGANJ NPV	SIRAJGANJ Construction Cost	SIRAJGANJ Red L Value	SIRAJGANJ Benifit	BETIL NPV	BETIL Construction Cost	BETIL Red L Value	BETIL Benifit
2	1	-282.12	468.04	58.78	191.38	-316.76	503.71	58.78	191.68	-864.35	564.60	58.78	-294.30	-735.97	618.54	58.78	-113.22
2	2	158.20	240.52	67.11	412.97	160.99	258.85	67.11	432.21	-302.35	290.14	67.11	2.02	-329.16	317.86	67.11	-0.30
2	3	255.06	164.68	70.33	437.29	266.14	177.23	70.33	458.61	-181.63	198.66	70.33	34.54	-219.09	217.63	70.33	12.10
2	4	292.53	126.76	73.39	440.22	307.21	136.42	73.39	461.79	-135.34	152.91	73.39	38.46	-170.08	167.52	73.39	13.59
2	5	313.38	104.01	76.62	441.87	330.40	111.93	76.62	463.58	-109.23	125.47	76.62	40.66	-141.92	137.45	76.62	14.43
2	6	326.05	88.84	79.91	443.00	344.80	95.61	79.91	464.80	-93.05	107.17	79.91	42.17	-124.10	117.41	79.91	15.01
2	7	334.05	78.01	83.57	443.82	354.18	83.95	83.57	465.70	-82.52	94.10	83.57	43.27	-112.18	103.09	83.57	15.43
2	8	338.82	69.88	87.31	444.47	360.16	75.21	87.31	466.40	-75.84	84.30	87.31	44.14	-104.20	92.35	87.31	15.76
2	9	341.69	63.56	91.70	444.86	364.05	68.40	91.70	466.83	-71.53	76.67	91.70	44.66	-98.61	84.00	91.70	15.96
2	10	342.98	58.50	94.06	445.18	366.29	62.96	94.06	467.17	-69.08	70.58	94.06	45.09	-94.92	77.32	94.06	16.12
2	11	343.14	54.37	98.68	445.55	367.37	58.51	98.68	467.57	-67.93	65.59	98.68	45.58	-92.62	71.85	98.68	16.30
2	12	342.54	50.92	103.20	445.74	367.61	54.80	103.20	467.78	-67.75	61.43	103.20	45.84	-91.24	67.30	103.20	16.40
3	1	-255.38	468.04	60.39	219.89	-287.35	503.71	60.39	222.63	-827.99	564.60	60.39	-256.18	-722.81	618.54	60.39	-98.69
3	2	161.18	240.52	67.83	416.74	164.40	258.85	67.83	436.31	-298.09	290.14	67.83	7.06	-327.85	317.86	67.83	1.63
3	3	255.79	164.68	70.59	438.43	267.03	177.23	70.59	459.85	-180.52	198.66	70.59	36.07	-218.82	217.63	70.59	12.68
3	4	297.99	126.76	73.21	445.73	313.14	136.42	73.21	467.76	-128.03	152.91	73.21	45.82	-167.32	167.52	73.21	16.40
3	5	317.89	104.01	76.54	446.05	335.22	111.93	76.54	468.11	-103.31	125.47	76.54	46.25	-139.53	137.45	76.54	16.56
3	6	330.04	88.84	79.48	446.27	348.97	95.61	79.48	468.35	-87.95	107.17	79.48	46.54	-121.87	117.41	79.48	16.67
3	7	337.81	78.01	81.96	446.43	358.01	83.95	81.96	468.53	-77.89	94.10	81.96	46.76	-109.96	103.09	81.96	16.75
3	8	342.50	69.88	86.09	446.56	363.80	75.21	86.09	468.67	-71.47	84.30	86.09	46.93	-101.91	92.35	86.09	16.82
3	9	345.57	63.56	89.00	446.63	367.80	68.40	89.00	468.75	-67.06	76.67	89.00	47.03	-96.08	84.00	89.00	16.86
3	10	346.88	58.50	92.12	446.70	370.01	62.96	92.12	468.82	-64.67	70.58	92.12	47.12	-92.31	77.32	92.12	16.89
3	11	347.30	54.37	96.24	446.77	371.24	58.51	96.24	468.89	-63.38	65.59	96.24	47.21	-89.73	71.85	96.24	16.93
3	12	347.07	50.92	100.27	446.80	371.77	54.80	100.27	468.93	-62.87	61.43	100.27	47.26	-88.02	67.30	100.27	16.95

202

TABLE 7.4 COMPARISON OF NET PRESENT VALUES FOR DIFFERENT TRIGGER DISTANCES
(Values in Tk. million)

Trigger Distance	Setback Ratio	FULCHARI NPV	FULCHARI Construction Cost	FULCHARI Red Ptivity	FULCHARI Benifit	KAZIPUR NPV	KAZIPUR Construction Cost	KAZIPUR Red Ptivity	KAZIPUR Benifit	SIRAJGANJ NPV	SIRAJGANJ Construction Cost	SIRAJGANJ Red Ptivity	SIRAJGANJ Benifit	BETIL NPV	BETIL Construction Cost	BETIL Red Ptivity	BETIL Benifit
1	6	318.34	88.84	29.77	436.96	336.80	95.61	25.84	458.24	-102.79	107.17	29.71	34.09	-128.46	117.41	22.98	11.93
2	6	326.05	88.84	28.11	443.00	344.80	95.61	24.39	464.80	-93.05	107.17	28.05	42.17	-124.10	117.41	21.69	15.01
3	6	330.04	88.84	27.39	446.27	348.97	95.61	23.77	468.35	-87.95	107.17	27.33	46.54	-121.87	117.41	21.14	16.67
4	6	330.71	88.84	27.51	447.06	349.73	95.61	23.87	469.21	-87.01	107.17	27.45	47.61	-121.56	117.41	21.23	17.08
5	6	329.84	88.84	28.38	447.06	348.97	95.61	24.63	469.21	-87.88	107.17	28.32	47.61	-122.24	117.41	21.90	17.08
6	6	328.30	88.84	29.92	447.06	347.64	95.61	25.97	469.21	-89.42	107.17	29.86	47.61	-123.43	117.41	23.09	17.08
7	6	326.08	88.84	32.14	447.06	345.71	95.61	27.89	469.21	-91.64	107.17	32.07	47.61	-125.14	117.41	24.81	17.08
8	6	323.25	88.84	34.97	447.06	343.26	95.61	30.35	469.21	-94.45	107.17	34.89	47.61	-127.32	117.41	26.99	17.08
9	6	319.97	88.84	38.25	447.06	340.41	95.61	33.20	469.21	-97.73	107.17	38.17	47.61	-129.85	117.41	29.52	17.08
10	6	316.27	88.84	41.95	447.06	337.20	95.61	36.41	469.21	-101.42	107.17	41.86	47.61	-132.71	117.41	32.38	17.08
11	6	312.20	88.84	46.02	447.06	333.67	95.61	39.93	469.21	-105.48	107.17	45.91	47.61	-135.85	117.41	35.51	17.08
12	6	307.81	88.84	50.41	447.06	329.86	95.61	43.75	469.21	-109.86	107.17	50.30	47.61	-139.24	117.41	38.90	17.08
1	10	336.65	58.50	47.23	442.39	360.19	62.96	40.99	464.14	-76.34	70.58	47.12	41.36	-99.07	77.32	36.45	14.70
2	10	342.98	58.50	43.70	445.18	366.29	62.96	37.92	467.17	-69.08	70.58	43.60	45.09	-94.92	77.32	33.72	16.12
3	10	346.88	58.50	41.31	446.70	370.01	62.96	35.85	468.82	-64.67	70.58	41.21	47.12	-92.31	77.32	31.88	16.89
4	10	348.62	58.50	39.94	447.06	371.59	62.96	34.66	469.21	-62.82	70.58	39.85	47.61	-91.06	77.32	30.82	17.08
5	10	349.08	58.50	39.48	447.06	371.99	62.96	34.26	469.21	-62.36	70.58	39.39	47.61	-90.71	77.32	30.47	17.08
6	10	348.73	58.50	39.83	447.06	371.69	62.96	34.56	469.21	-62.71	70.58	39.74	47.61	-90.98	77.32	30.74	17.08
7	10	347.65	58.50	40.91	447.06	370.75	62.96	35.50	469.21	-63.79	70.58	40.82	47.61	-91.81	77.32	31.57	17.08
8	10	345.92	58.50	42.64	447.06	369.25	62.96	37.00	469.21	-65.51	70.58	42.54	47.61	-93.15	77.32	32.90	17.08
9	10	343.62	58.50	44.94	447.06	367.25	62.96	39.00	469.21	-67.81	70.58	44.84	47.61	-94.93	77.32	34.68	17.08
10	10	340.79	58.50	47.77	447.06	364.80	62.96	41.45	469.21	-70.63	70.58	47.66	47.61	-97.10	77.32	36.86	17.08
11	10	337.38	58.50	51.18	447.06	361.84	62.96	44.41	469.21	-74.03	70.58	51.07	47.61	-99.74	77.32	39.50	17.08
12	10	333.43	58.50	55.13	447.06	358.41	62.96	47.84	469.21	-77.97	70.58	55.00	47.61	-102.78	77.32	42.54	17.08

TABLE 7.4 COMPARISON OF NET PRESENT VALUES FOR DIFFERENT TRIGGER DISTANCES (SHEET 2 OF 2)
(Values in Tk. million)

Trigger Distance	Setback Ratio	FULCHARI NPV	FULCHARI Construction Cost	FULCHARI Red L Value	FULCHARI Benifit	KAZIPUR NPV	KAZIPUR Construction Cost	KAZIPUR Red L Value	KAZIPUR Benifit	SIRAJGANJ NPV	SIRAJGANJ Construction Cost	SIRAJGANJ Red L Value	SIRAJGANJ Benifit	BETIL NPV	BETIL Construction Cost	BETIL Red L Value	BETIL Benifit
1	6	318.34	88.84	61.11	436.96	336.80	95.61	61.11	458.24	-102.79	107.17	61.11	34.09	-128.46	117.41	61.11	11.93
2	6	326.05	88.84	79.91	443.00	344.80	95.61	79.91	464.80	-93.05	107.17	79.91	42.17	-124.10	117.41	79.91	15.01
3	6	330.04	88.84	79.48	446.27	348.97	95.61	79.48	468.35	-87.95	107.17	79.48	46.54	-121.87	117.41	79.48	16.67
4	6	330.71	88.84	79.81	447.06	349.73	95.61	79.81	469.21	-87.01	107.17	79.81	47.61	-121.56	117.41	79.81	17.08
5	6	329.84	88.84	80.83	447.06	348.97	95.61	80.83	469.21	-87.88	107.17	80.83	47.61	-122.24	117.41	80.83	17.08
6	6	328.30	88.84	81.78	447.06	347.64	95.61	81.78	469.21	-89.42	107.17	81.78	47.61	-123.43	117.41	81.78	17.08
7	6	326.08	88.84	83.35	447.06	345.71	95.61	83.35	469.21	-91.64	107.17	83.35	47.61	-125.14	117.41	83.35	17.08
8	6	323.25	88.84	86.14	447.06	343.26	95.61	86.14	469.21	-94.45	107.17	86.14	47.61	-127.32	117.41	86.14	17.08
9	6	319.97	88.84	89.35	447.06	340.41	95.61	89.35	469.21	-97.73	107.17	89.35	47.61	-129.85	117.41	89.35	17.08
10	6	316.27	88.84	92.93	447.06	337.20	95.61	92.93	469.21	-101.42	107.17	92.93	47.61	-132.71	117.41	92.93	17.08
11	6	312.20	88.84	96.84	447.06	333.67	95.61	96.84	469.21	-105.48	107.17	96.84	47.61	-135.85	117.41	96.84	17.08
12	6	307.81	88.84	100.38	447.06	329.86	95.61	100.38	469.21	-109.86	107.17	100.38	47.61	-139.24	117.41	100.38	17.08
1	10	336.65	58.50	63.57	442.39	360.19	62.96	63.57	464.14	-76.34	70.58	63.57	41.36	-99.07	77.32	63.57	14.70
2	10	342.98	58.50	94.06	445.18	366.29	62.96	94.06	467.17	-69.08	70.58	94.06	45.09	-94.92	77.32	94.06	16.12
3	10	346.88	58.50	92.12	446.70	370.01	62.96	92.12	468.82	-64.67	70.58	92.12	47.12	-92.31	77.32	92.12	16.89
4	10	348.62	58.50	91.10	447.06	371.59	62.96	91.10	469.21	-62.82	70.58	91.10	47.61	-91.06	77.32	91.10	17.08
5	10	349.08	58.50	90.90	447.06	371.99	62.96	90.90	469.21	-62.36	70.58	90.90	47.61	-90.71	77.32	90.90	17.08
6	10	348.73	58.50	91.45	447.06	371.69	62.96	91.45	469.21	-62.71	70.58	91.45	47.61	-90.98	77.32	91.45	17.08
7	10	347.65	58.50	92.65	447.06	370.75	62.96	92.65	469.21	-63.79	70.58	92.65	47.61	-91.81	77.32	92.65	17.08
8	10	345.92	58.50	94.44	447.06	369.25	62.96	94.44	469.21	-65.51	70.58	94.44	47.61	-93.15	77.32	94.44	17.08
9	10	343.62	58.50	96.76	447.06	367.25	62.96	96.76	469.21	-67.81	70.58	96.76	47.61	-94.93	77.32	96.76	17.08
10	10	340.79	58.50	98.43	447.06	364.80	62.96	98.43	469.21	-70.63	70.58	98.43	47.61	-97.10	77.32	98.43	17.08
11	10	337.38	58.50	100.64	447.06	361.84	62.96	100.64	469.21	-74.03	70.58	100.64	47.61	-99.74	77.32	100.64	17.08
12	10	333.43	58.50	104.44	447.06	358.41	62.96	104.44	469.21	-77.97	70.58	104.44	47.61	-102.78	77.32	104.44	17.08

Table 8.1 Implementation Schedule for Bank Stabilization Works

Year	Location	Hard Point No	Financial Capital Cost (Tk million)
Stage 1(A)			
0/1	Sirajganj	1	1,848
0/1	Sariakandi/Mathurapara	2, 3 and 4	1,292
2			
3			
4			-------
		Sub-total	3,140
Stage 1(B)			
5	Sirajganj	8	373
5	Sariakandi/Mathurapara	5	575
6	Sariakandi/Mathurapara	6	575
7	U/S Sirajganj	9	600
8	U/S Sirajganj	10	600
9			-------
10		Sub-total	2,723
Stage 2			
11	Kazipur	11	669
12	D/S Fulchari	7	600
13	Fulchari	13	614
14	Fulchari	14	614
15	Kazipur	12	672
16	Betil	17	523
17	U/S Kazipur	15	600
18	Betil	18	534
19	U/S Kazipur	16	600
20	U/S Betil	19	600
21}	Fulchari	21	600
22}	Stabilization	22	600
23}		23	600
24	D/S Betil	24	600
25}	U/S Kazipur	20	1,200
26}	(Node Stabilization)		
27	D/S Betil	25	600
28	U/S Fulchari	26	600
29	U/S Fulchari	27	600

		Sub-total	11,426

		Total	17,289
			======

N.B U/S = Upstream

D/S = Downstream

Table 8.2 Implementation Schedule for Bank Stabilization Works based on March 1993 Review of Cost Estmates

Year Location	Hard Point No	Financial Capital Cost (Tk million)
Stage 1(A)		
0/1 Sirajganj	1	2,012
0/1 Sariakandi/Mathurapara	2, 3 and 4	1,513
2		
3		
4		-------
	Sub-total	3,525
Stage 1(B)		
5 Sirajganj	8	420
5 Sariakandi/Mathurapara	5	650
6 Sariakandi/Mathurapara	6	650
7 U/S Sirajganj	9	675
8 U/S Sirajganj	10	675
9		-------
10	Sub-total	3,070
Stage 2		
11 Kazipur	11	750
12 D/S Fulchari	7	675
13 Fulchari	13	690
14 Fulchari	14	690
15 Kazipur	12	755
16 Betil	17	590
17 U/S Kazipur	15	675
18 Betil	18	600
19 U/S Kazipur	16	675
20 U/S Betil	19	675
21} Fulchari	21	675
22} Stabilization	22	675
23}	23	675
24 D/S Betitl	24	675
25} U/S Kazipur	20	1,350
26} (Node Stabilization)		
27 D/S Betil	25	675
28 U/S Fulchari	26	675
29 U/S Fulchari	27	675

	Sub-total	12,850

	Total	19,445
		======

N.B U/S = Upstream

D/S = Downstream

Table 8.3. Economic Appraisal of Brahmaputra Right Bank Master Plan ('000 Tk) : (Sheet 1 of 5)

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FUTURE WITHOUT BANK STABILISATION																
Bank Erosion Consequences :																
- Sirajganj (Hard Points 1 & 8)	0	394223	471188	579214	581802	391100	157015	156961	156845	156664	156814	156516	156141	155684	155141	154507
- Sariak/Math.(Hard Points 2, 3 & 4) + Sariak/Math.(Hard Points 5 & 6)	-0	286917	254556	255432	256330	257253	225256	225746	226248	226761	227262	227688	228126	228578	229043	229522
- Hard Points 9 & 10								0	27333	27470	27608	27747	27887	28027	28160	28298
- Kazipur (Hard Points 11 & 12)												0	35496	35789	36092	36404
- Hard Point 7													0	8343	8403	8463
- Fulchari (Hard Points 13 & 14)														0	28854	29199
- Betil (Hard Points 17 & 18)																
- Hard Points 15 & 16																
- Hard Point 19																
- Hard Points 21, 22 & 23																
- Hard Point 20 (Node Stabilization)																
- Hard Points 24 & 25																
- Hard Points 26 & 27																
Sub-Total	-0	681140	725744	834646	838132	648353	382271	382707	410426	410896	411685	411951	447650	456422	485693	486393
BRE Realignment Costs Saved	0	141000	0	0	0	103400	0	47000	47000	0	0	197400	28200	103400	0	159800
DISBENEFITS AVOIDED AND COSTS SAVED	-0	822140	725744	834646	838132	751753	382271	429707	457426	410896	411685	609351	475850	559822	485693	646193
CAPITAL COSTS OF BANK STABILISATION :																
- Sirajganj (Hard Points 1 & 8)	769240	769240				301815										
- Sariak/Math.(Hard Points 2, 3 & 4)	527632	527632														
- Sariak/Math.(Hard Points 5 & 6)						488174	488174									
- Hard Points 9 & 10								475000	475000							
- Kazipur (Hard Points 11 & 12)												536670				536670
- Hard Point 7													475000			
- Fulchari (Hard Points 13 & 14)														494197	494197	
- Betil (Hard Points 17 & 18)																
- Hard Points 15 & 16																
- Hard Point 19																
- Hard Points 21, 22 & 23																
- Hard Point 20 (Node Stabilization)																
- Hard Points 24 & 25																
- Hard Points 26 & 27																
Sub-Total	1296872	1296872	0	0	0	789989	488174	475000	475000	0	0	536670	475000	494197	494197	536670

Table 8.3. Economic Appraisal of Brahmaputra Right Bank Master Plan ('000 Tk) :

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
FUTURE WITHOUT BANK STABILISATION															
Bank Erosion Consequences :															
- Sirajganj (Hard Points 1 & 8)	153777	152945	152008	150958	149789	148497	147074	145514	143809	141953	139938	137756	135399	132858	130125
- Sariak/Math.(Hard Points 2, 3 & 4) + Sariak/Math.(Hard Points 5 & 6)	230015	230523	231047	231586	232141	232713	233302	233909	234534	235177	235840	236523	237227	237951	238697
- Hard Points 9 & 10	28440	28586	28737	28892	29051	29216	29385	29560	29739	29925	30115	30312	30514	30722	30937
- Kazipur (Hard Points 11 & 12)	36725	28027	28160	28298	28440	28586	28737	28892	29051	29216	29385	29560	29739	29925	30115
- Hard Point 7	8526	8591	8657	8725	8796	8869	8943	9020	9100	9182	9266	9352	9442	9534	9629
- Fulchari (Hard Points 13 & 14)	29553	29918	30295	16687	16805	16927	17052	17181	17314	17451	17592	17737	17887	18041	18200
- Betil (Hard Points 17 & 18)	0	51841	52271	52714	53170	53640	52715	53213	53727	54256	54801	55363	55941	56536	57150
- Hard Points 15 & 16		0	27333	27470	27608	27747	27887	28027	28160	28298	28440	28586	28737	28892	29051
- Hard Point 19			0	25920	26135	26357	26585	26820	26357	26607	26864	27128	27401	27681	27970
- Hard Points 21, 22 & 23						0	16687	16805	16927	17052	17181	17314	17451	17592	17737
- Hard Point 20 (Node Stabilization)										0	27333	27470	27608	27747	27887
- Hard Points 24 & 25									0	16687	16805	16927	17052	17181	17314
- Hard Points 26 & 27													0	16687	16805
Sub-Total	487036	530431	558507	571250	571937	572552	588367	588941	588719	605804	633561	634028	634397	651347	651616
BRE Realignment Costs Saved	56400	103400	103400	112800	56400	253800	28200	159800	56400	216200	56400	216200	112800	169200	65800
DISBENEFITS AVOIDED AND COSTS SAVED	543436	633831	661907	684050	628337	826352	616567	748741	645119	822004	689961	850228	747197	820547	717416
CAPITAL COSTS OF BANK STABILISATION :															
- Sirajganj (Hard Points 1 & 8)															
- Sariak/Math.(Hard Points 2, 3 & 4)															
- Sariak/Math.(Hard Points 5 & 6)															
- Hard Points 9 & 10															
- Kazipur (Hard Points 11 & 12)															
- Hard Point 7															
- Fulchari (Hard Points 13 & 14)															
- Betil (Hard Points 17 & 18)	420555		429268												
- Hard Points 15 & 16		475000		475000											
- Hard Point 19					475000										
- Hard Points 21, 22 & 23						475000	475000	475000							
- Hard Point 20 (Node Stabilization)										475000	475000				
- Hard Points 24 & 25									475000			475000			
- Hard Points 26 & 27													475000	475000	
Sub-Total	420555	475000	429268	475000	475000	475000	475000	475000	475000	475000	475000	475000	475000	475000	0

222

Table 6.3. Economic Appraisal of Brahmaputra Right Bank Master Plan ('000 Tk) :

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
O & M COSTS OF BANK STABILISATION :																
- Sirajganj (Hard Points 1 & 8)		7692	15385	15385	15385	76924	18403	18403	18403	18403	92015	18403	18403	18403	18403	92015
- Sariak/Math.(Hard Points 2, 3 & 4)		5276	10553	10553	10553	52763	10553	10553	10553	10553	52763	10553	10553	10553	10553	52763
- Sariak/Math.(Hard Points 5 & 6)							4882	9763	9763	9763	48817	9763	9763	9763	9763	9763
- Hard Points 9 & 10									4750	9500	9500	9500	47500	9500	9500	9500
- Kazipur (Hard Points 11 & 12)													5367	5367	5367	5367
- Hard Point 7														4750	4750	4750
- Fulchari (Hard Points 13 & 14)															4942	9884
- Betil (Hard Points 17 & 18)																
- Hard Points 15 & 16																
- Hard Point 19																
- Hard Points 21, 22 & 23																
- Hard Point 20 (Node Stabilization)																
- Hard Points 24 & 25																
- Hard Points 26 & 27																
Sub-Total	0	12969	25937	25937	25937	129687	33837	38719	43469	48219	203095	48219	91586	58336	63278	184042
BANK EROSION LOSSES WITH STABILISATION :																
- Sirajganj (Hard Points 1 & 8)	0	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716
- Sariak/Math.(Hard Points 2, 3 & 4)	0	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948
+ Sariak/Math.(Hard Points 5 & 6)																
- Hard Points 9 & 10								0	16248	16248	16248	16248	16248	16248	16248	16248
- Kazipur (Hard Points 11 & 12)												0	16248	16248	16248	16248
- Hard Point 7													0	8361	8361	8361
- Fulchari (Hard Points 13 & 14)														0	8361	8361
- Betil (Hard Points 17 & 18)																
- Hard Points 15 & 16																
- Hard Point 19																
- Hard Points 21, 22 & 23																
- Hard Point 20 (Node Stabilization)																
- Hard Points 24 & 25																
- Hard Points 26 & 27																
Sub-Total	0	28665	28665	28665	28665	28665	28665	28665	44913	44913	44913	44913	61161	69522	77883	77883
TOTAL COSTS AND BANK EROSION LOSSES	1296872	1338505	54602	54602	54602	948341	550676	542384	563382	93132	248008	629802	627747	622055	635358	798595
INCREMENTAL NET BENEFITS	-1296872	-516365	671142	780044	783530	-196588	-168405	-112677	-105956	317764	163677	-20451	-151898	-62233	-149664	-152402

NET PRESENT VALUE @ 12% : -285403 ECONOMIC INTERNAL RATE OF RETURN : 6.8%

NET PRESENT VALUE RATIO : -0.06

Table 8.3. Economic Appraisal of Brahmaputra Right Bank Master Plan ('000 Tk) :

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
O & M COSTS OF BANK STABILISATION :															
- Sirajganj (Hard Points 1 & 8)	18403	18403	18403	18403	92015	18403	18403	18403	18403	92015	18403	18403	18403	18403	92015
- Sariak/Math.(Hard Points 2, 3 & 4)	10553	10553	10553	10553	52763	10553	10553	10553	10553	52763	10553	10553	10553	10553	52763
- Sariak/Math.(Hard Points 5 & 6)	9763	9763	9763	9763	48817	9763	9763	9763	9763	48817	9763	9763	9763	9763	48817
- Hard Points 9 & 10	9500	47500	9500	9500	9500	9500	47500	9500	9500	9500	9500	47500	9500	9500	9500
- Kazipur (Hard Points 11 & 12)	32200	10733	10733	10733	10733	53667	10733	10733	10733	10733	53667	10733	10733	10733	10733
- Hard Point 7	4750	23750	4750	4750	4750	4750	23750	4750	4750	4750	4750	23750	4750	4750	4750
- Fulchari (Hard Points 13 & 14)	9884	9884	49420	9884	9884	9884	9884	49420	9884	9884	9884	9884	49420	9884	9884
- Betil (Hard Points 17 & 18)		4206	4206	8498	8498	42491	8498	8498	8498	8498	42491	8498	8498	8498	8498
- Hard Points 15 & 16			4750	4750	9500	9500	47500	9500	9500	9500	9500	47500	9500	9500	9500
- Hard Point 19						4750	4750	4750	4750	23750	4750	4750	4750	4750	23750
- Hard Points 21, 22 & 23							4750	9500	14250	14250	71250	14250	14250	14250	14250
- Hard Point 20 (Node Stabilization)											4750	9500	9500	9500	47500
- Hard Points 24 & 25										4750	4750	4750	9500	47500	9500
- Hard Points 26 & 27														4750	9500
Sub-Total	95053	134792	122078	86835	246461	173261	196085	145370	110585	289211	254011	219835	169120	172335	350961
BANK EROSION LOSSES WITH STABILISATION :															
- Sirajganj (Hard Points 1 & 8)	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716	16716
- Sariak/Math.(Hard Points 2, 3 & 4)	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948	11948
+ Sariak/Math.(Hard Points 5 & 6)															
- Hard Points 9 & 10	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248
- Kazipur (Hard Points 11 & 12)	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248
- Hard Point 7	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361
- Fulchari (Hard Points 13 & 14)	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361	8361
- Betil (Hard Points 17 & 18)	0	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561	25561
- Hard Points 15 & 16		0	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248	16248
- Hard Point 19					0	12781	12781	12781	12781	12781	12781	12781	12781	12781	12781
- Hard Points 21, 22 & 23						0	8361	8361	8361	8361	8361	8361	8361	8361	8361
- Hard Point 20 (Node Stabilization)										0	8124	8124	8124	8124	8124
- Hard Points 24 & 25									0	8361	8361	8361	8361	8361	8361
- Hard Points 26 & 27												0	8361	8361	8361
Sub-Total	77883	103444	119692	119692	119692	132473	140834	140834	140834	149194	157319	157319	165679	165679	165679
TOTAL COSTS AND BANK EROSION LOSSES	593491	713236	671038	681527	841153	780734	811918	761204	726418	913405	886330	852153	809800	813014	516640
INCREMENTAL NET BENEFITS	-50055	-79405	-9131	2523	-212816	45618	-195352	-12463	-81299	-91402	-196369	-1925	-62603	7533	200776

Table 8.3. Economic Appraisal of Brahmaputra Right Bank Master Plan ('000 Tk) : (Sheet 5 of 5)

Sensitivity Analysis - Master Plan	EIRR	NPV @ 12%	NPVR
Base Case	6.8%	-285403	-0.06
Increase Incremental Benefits by 10%	14.0%	297591	0.02
Increase Incremental Benefits by 20%	21.7%	880586	0.10
Decrease Incremental Benefits by 10%	2.2%	-868398	-0.13
Decrease Incremental Benefits by 20%	-1.3%	-1451392	-0.21
Increase Total Costs and Losses by 10%	2.5%	-896938	-0.13
Increase Total Costs and Losses by 20%	-0.1%	-1508473	-0.18
Decrease Total Costs and Losses by 10%	14.9%	326132	0.03
Decrease Total Costs and Losses by 20%	25.1%	937666	0.13

FIGURES

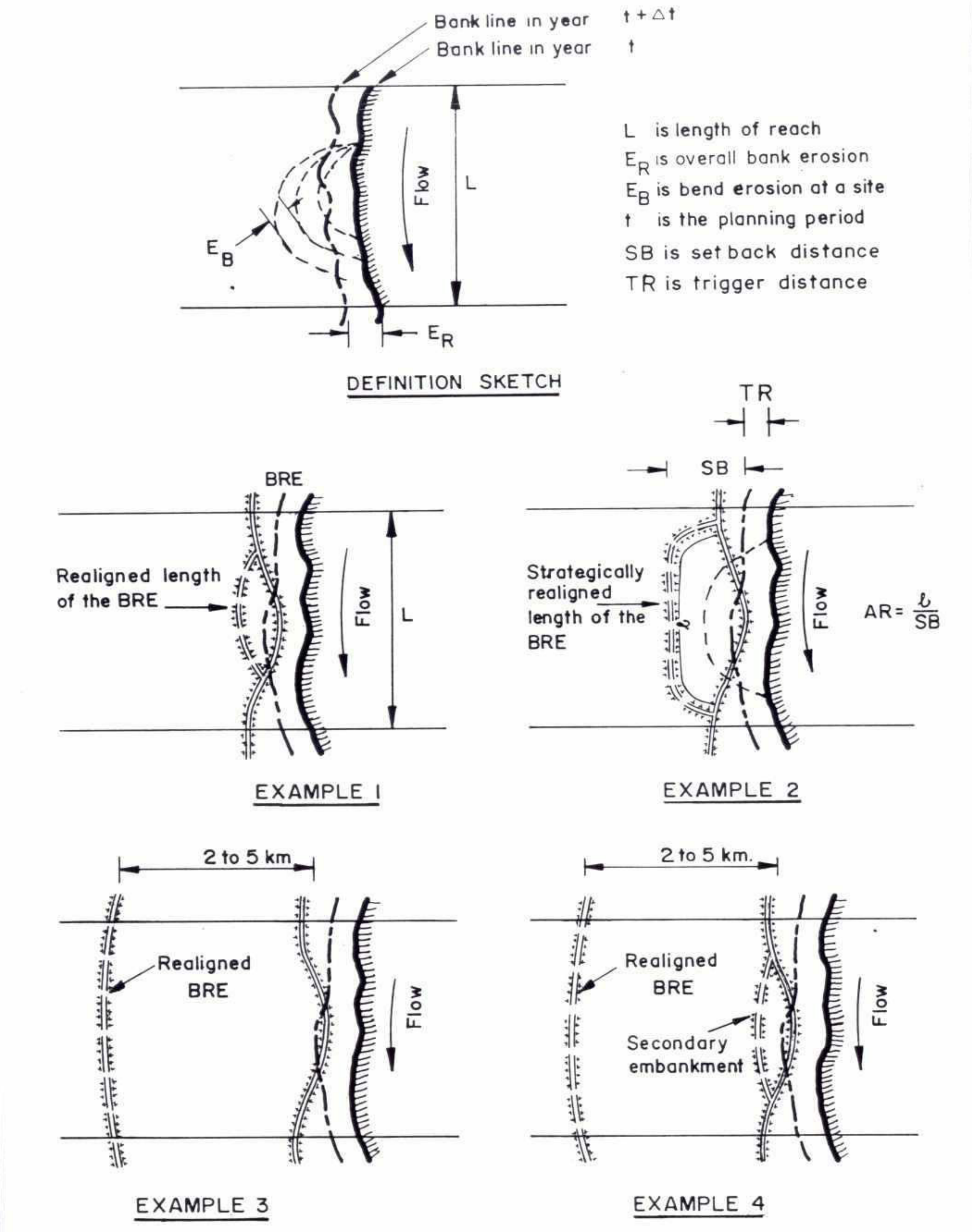
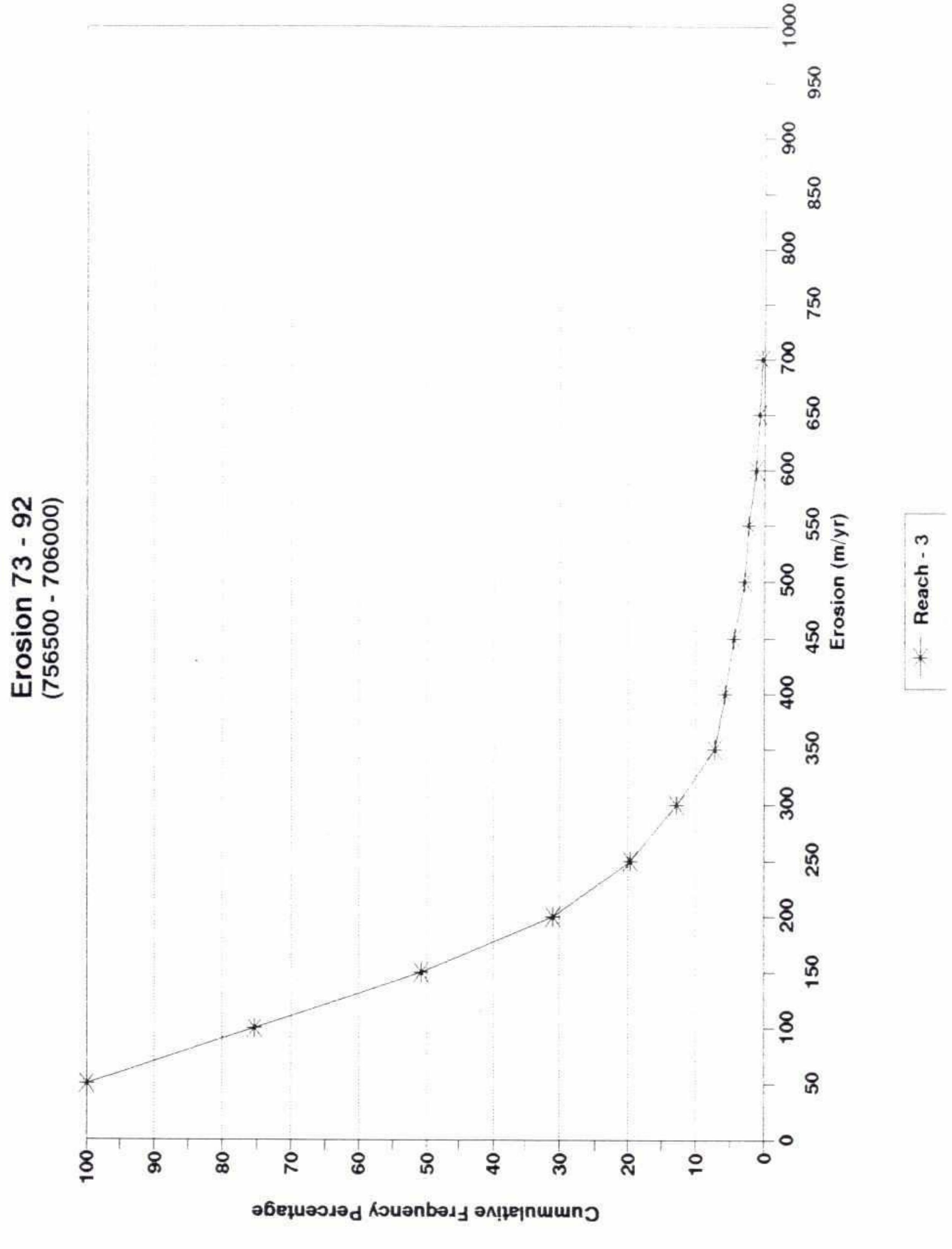
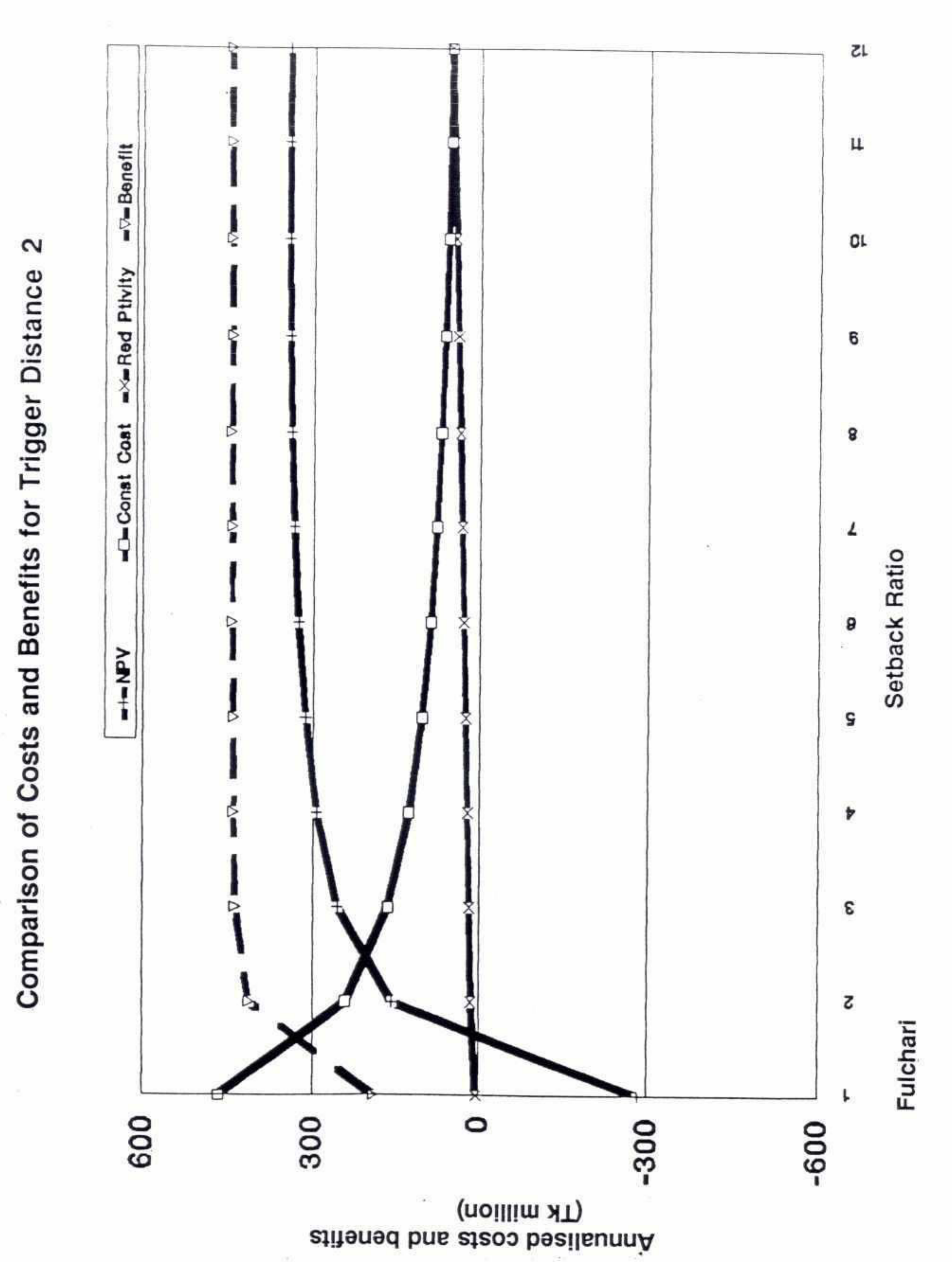


Illustration of Strategies for Embankment Retirement



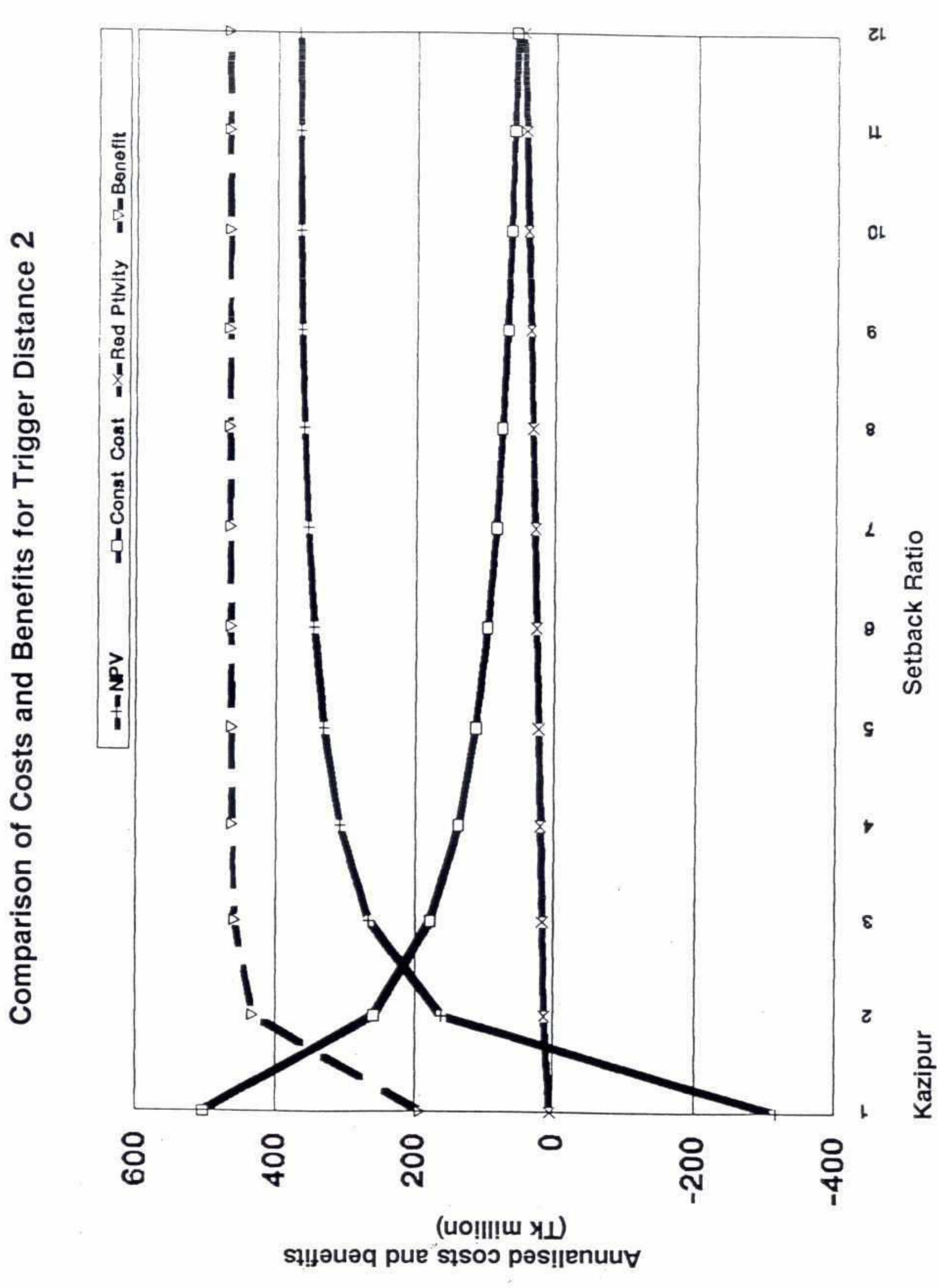
Cumulative Frequency Distribution of Erosion Rates

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.2



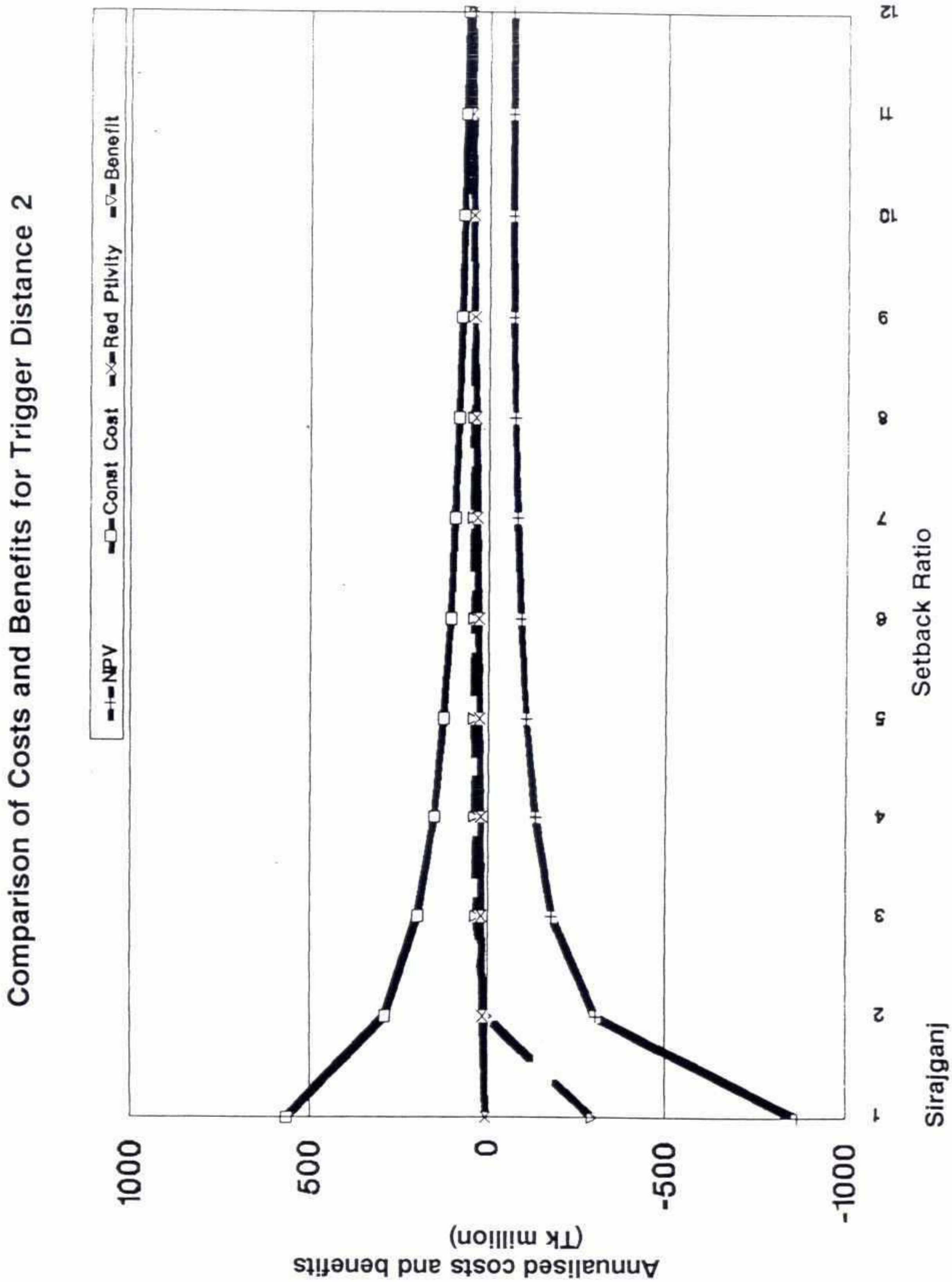
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3a



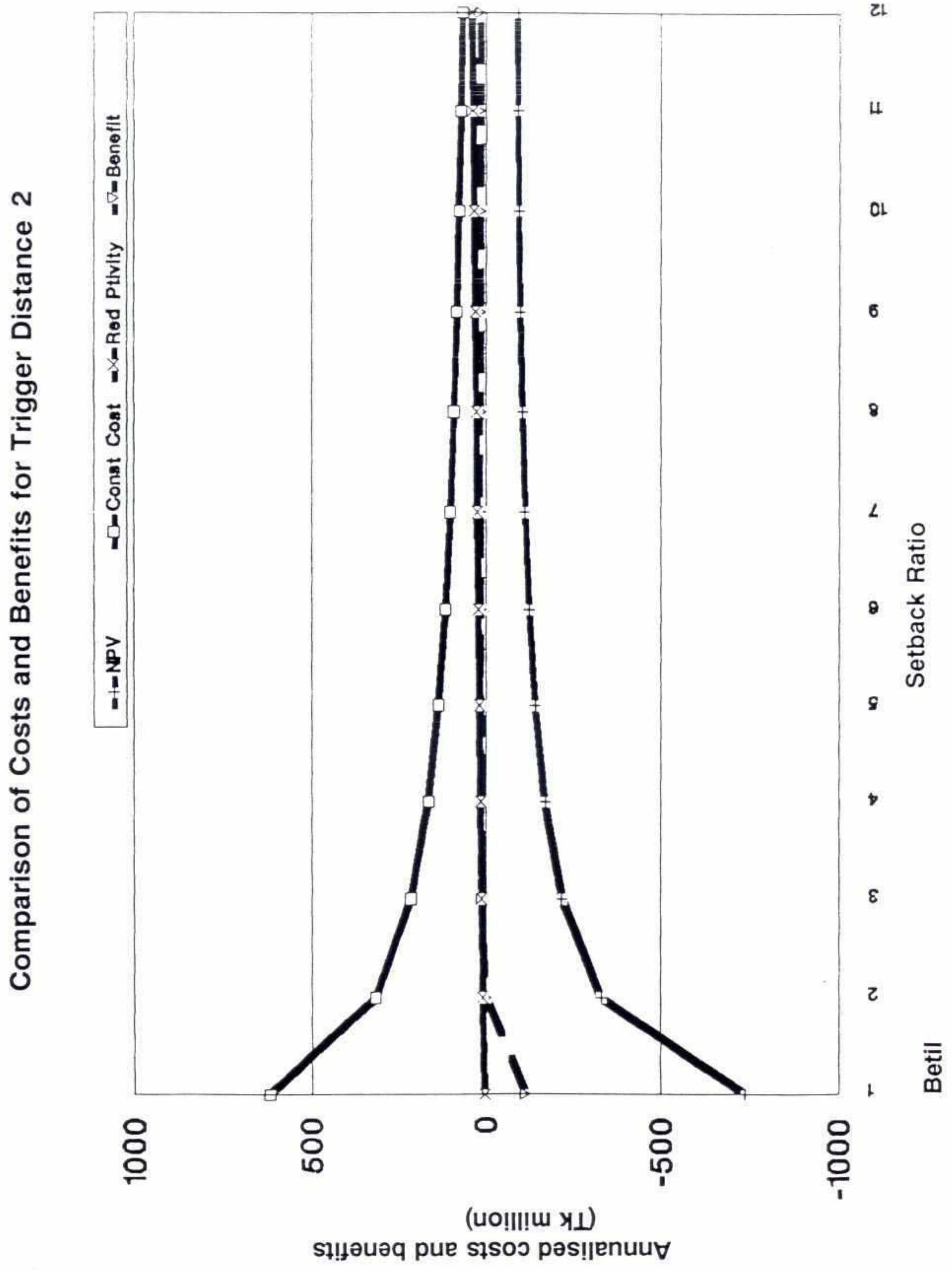
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3b



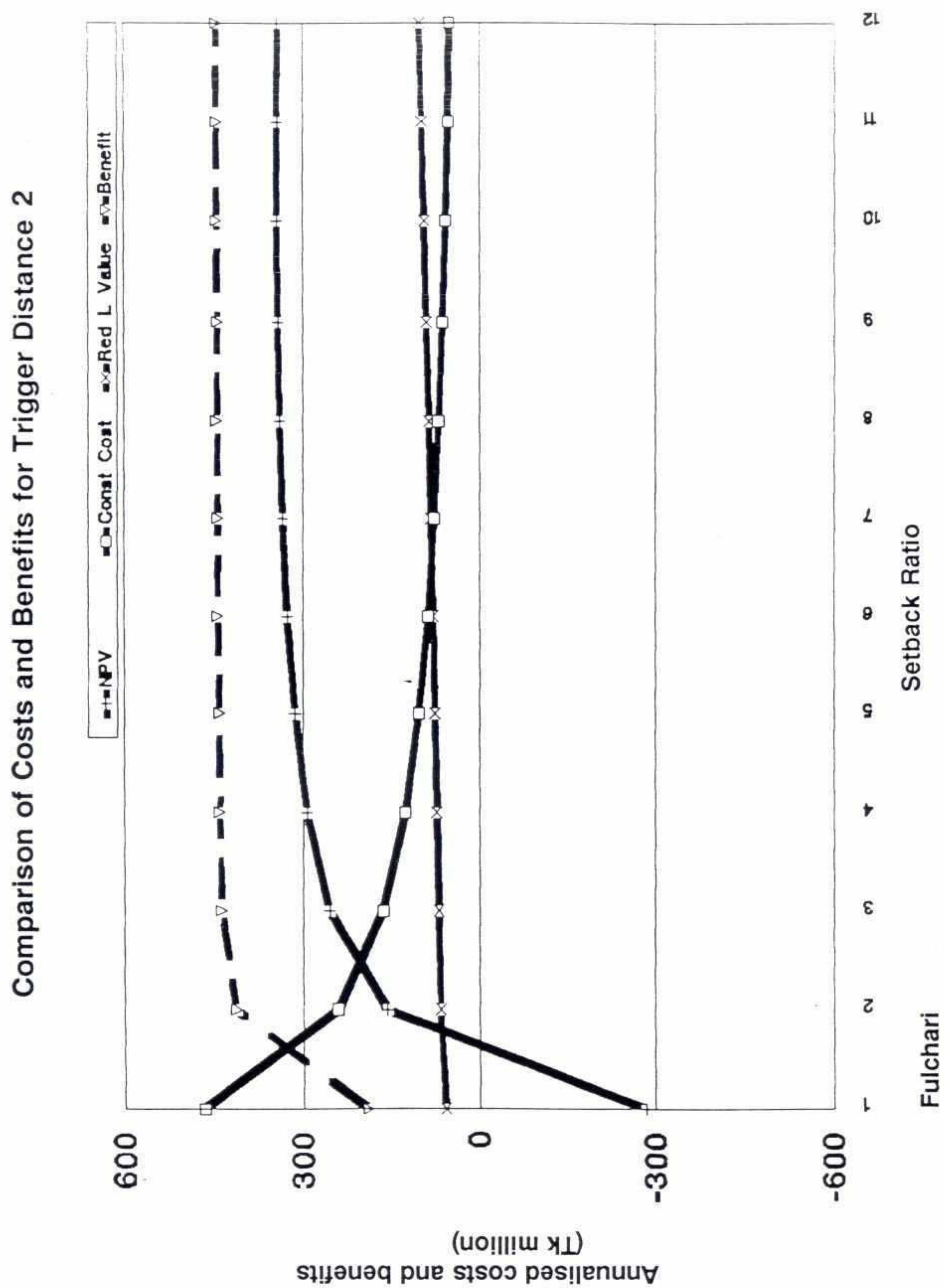
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3c



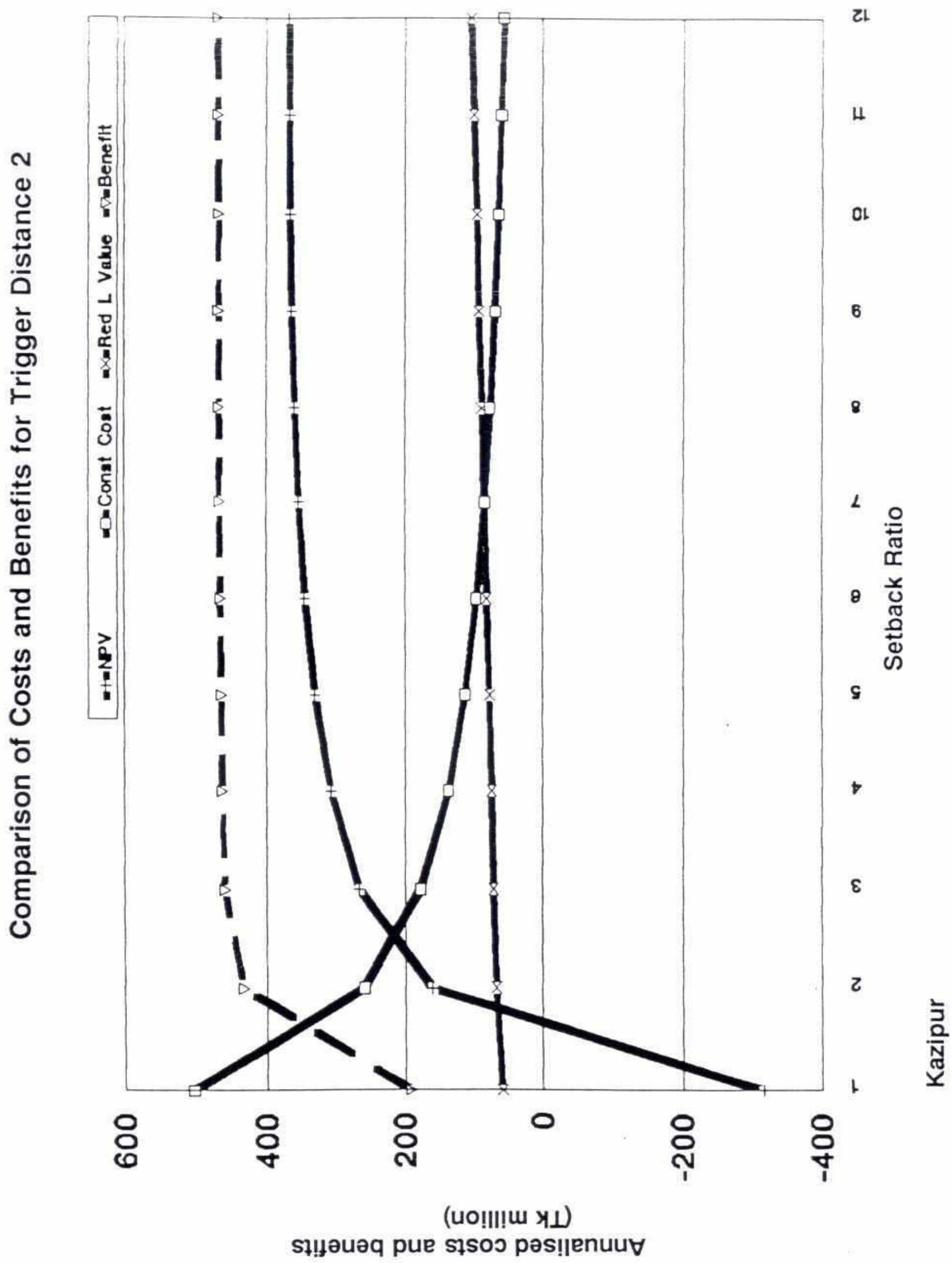
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3d



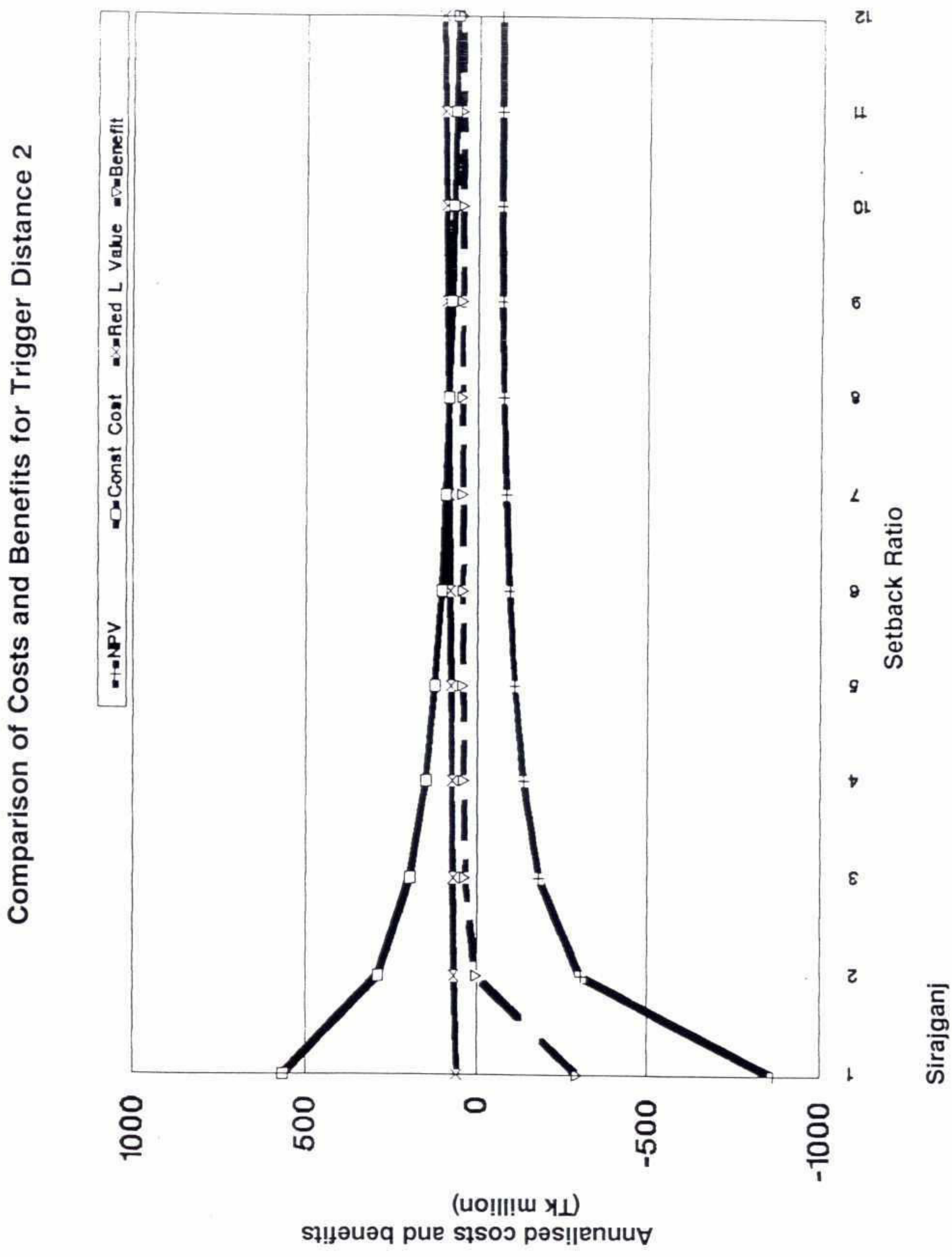
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3e



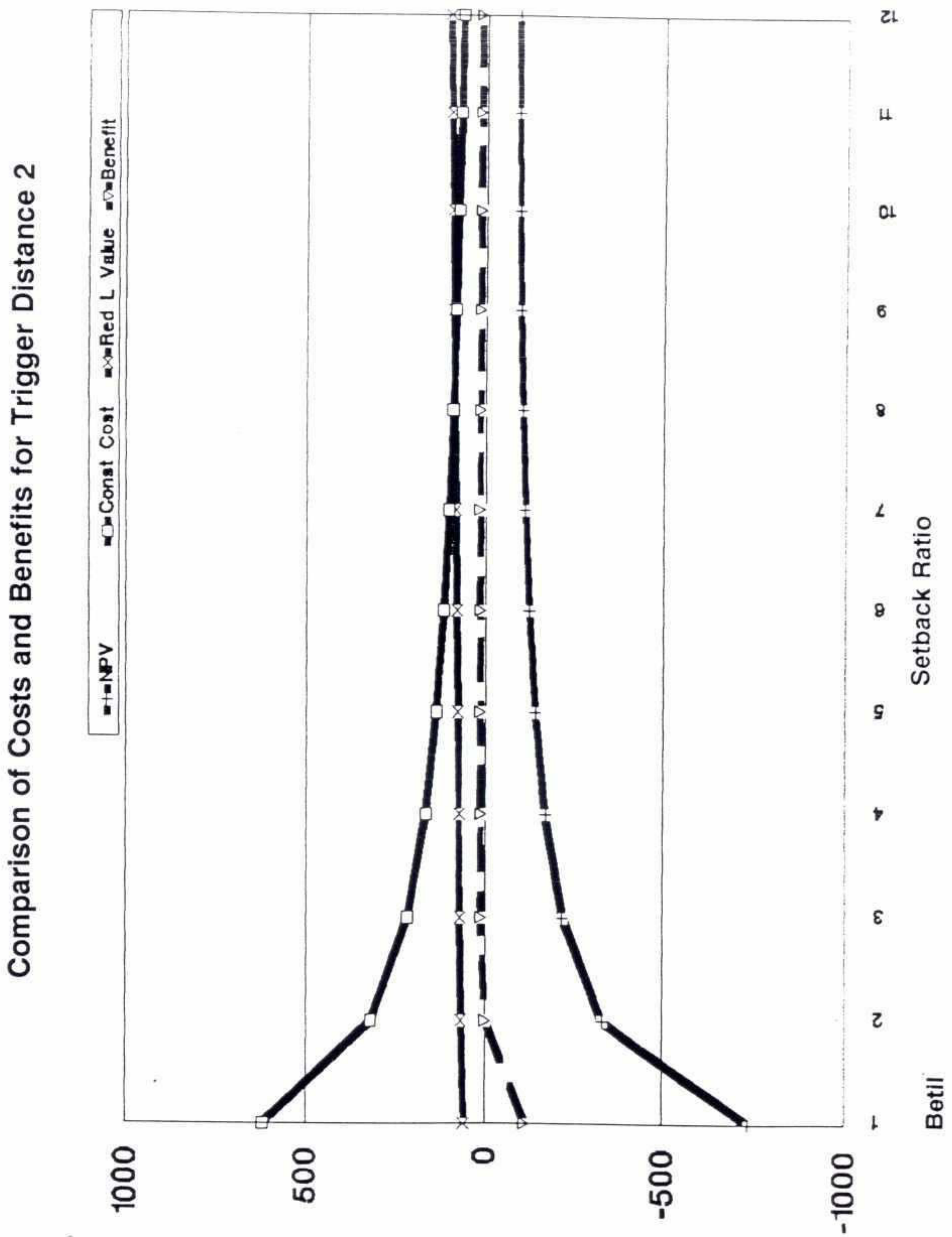
BRE Realignment: Variation of NPV with Setback Ratio

		Annex 2
Halcrow/DHI/EPC/DIG	*May 1993*	Figure 7.3f



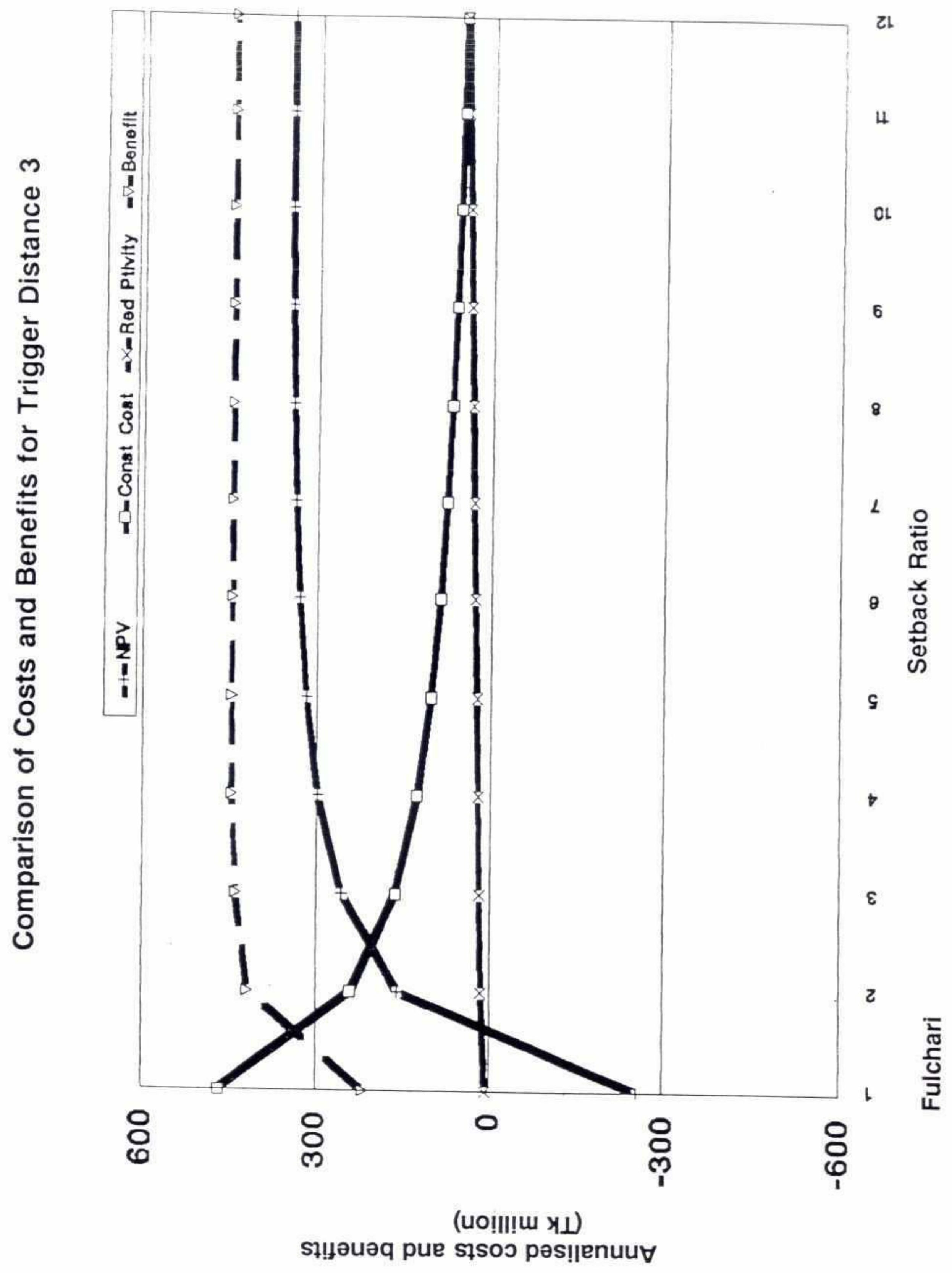
BRE Realignment: Variation of NPV with Setback Ratio

Halcrow/DHI/EPC/DIG *May 1993*	Annex 2
	Figure 7.3g



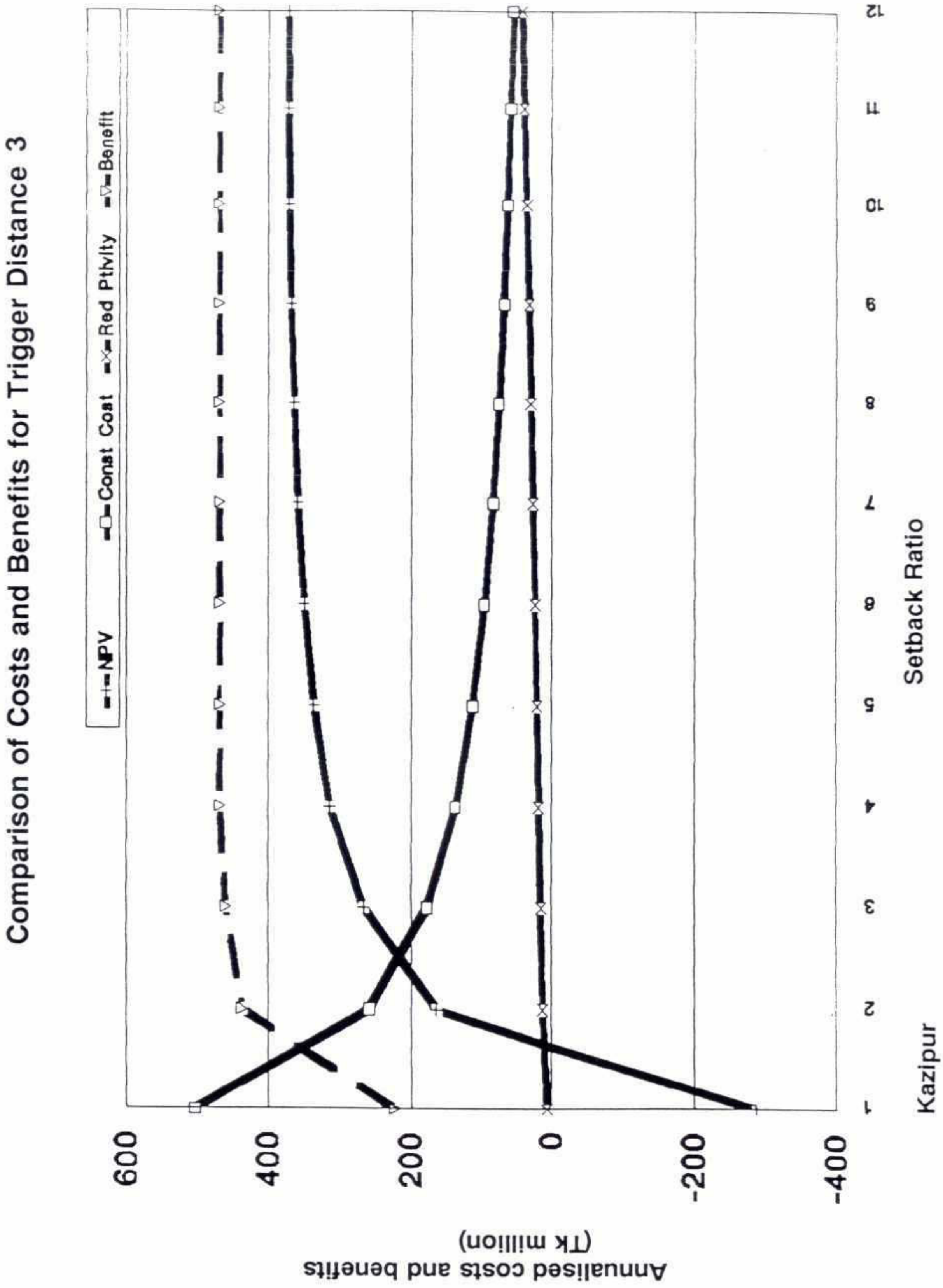
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3h



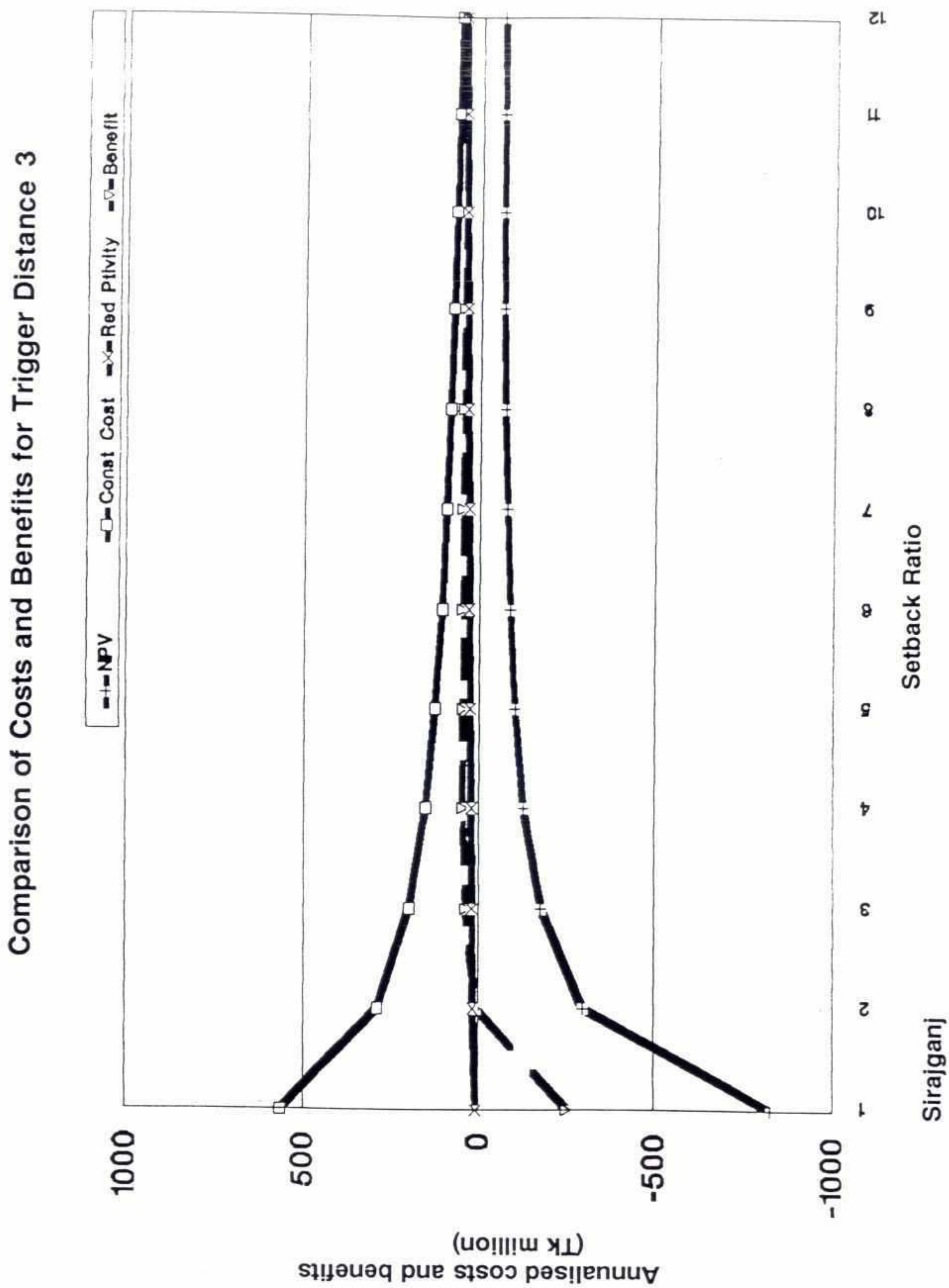
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3i

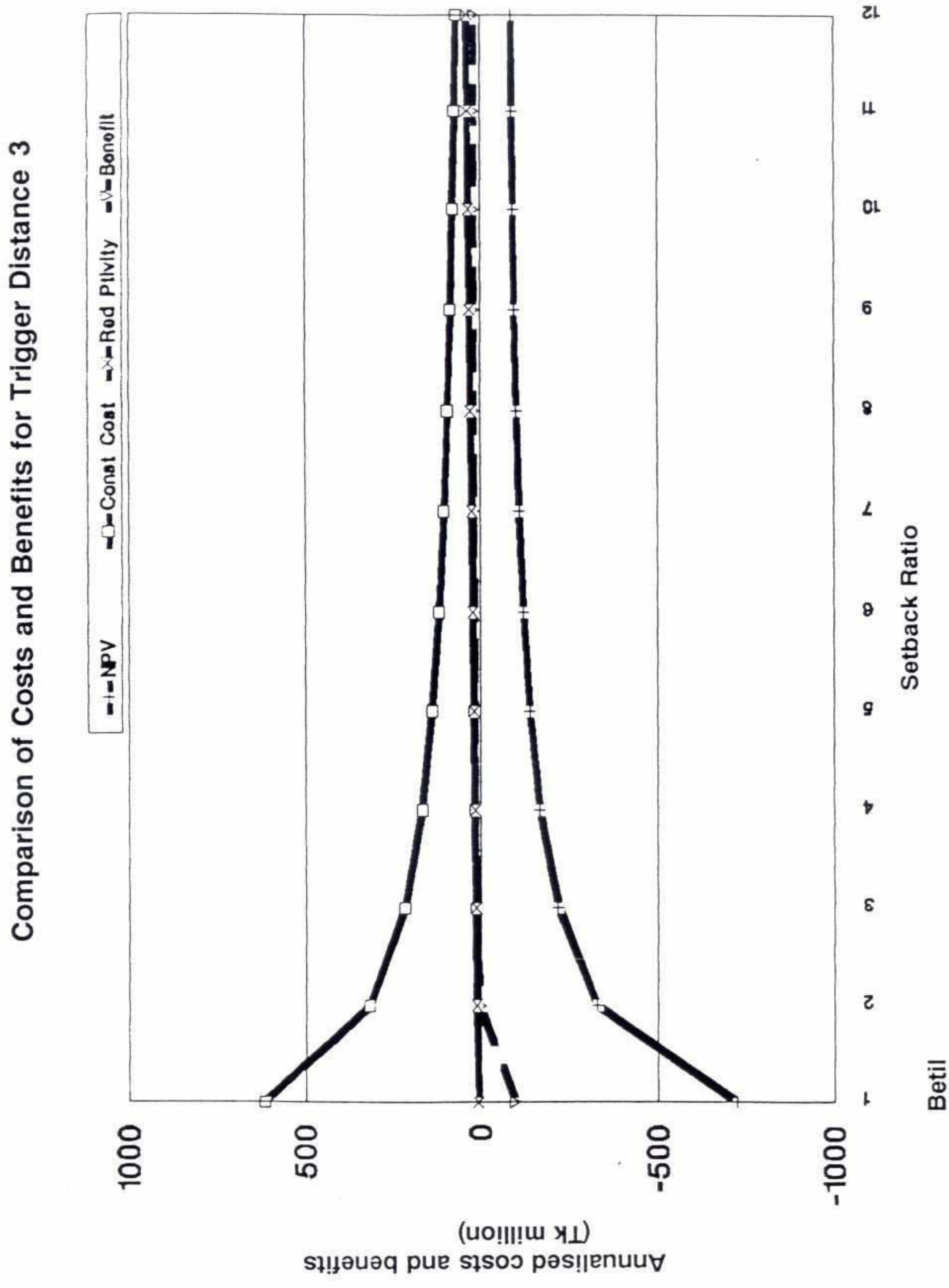


BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3j

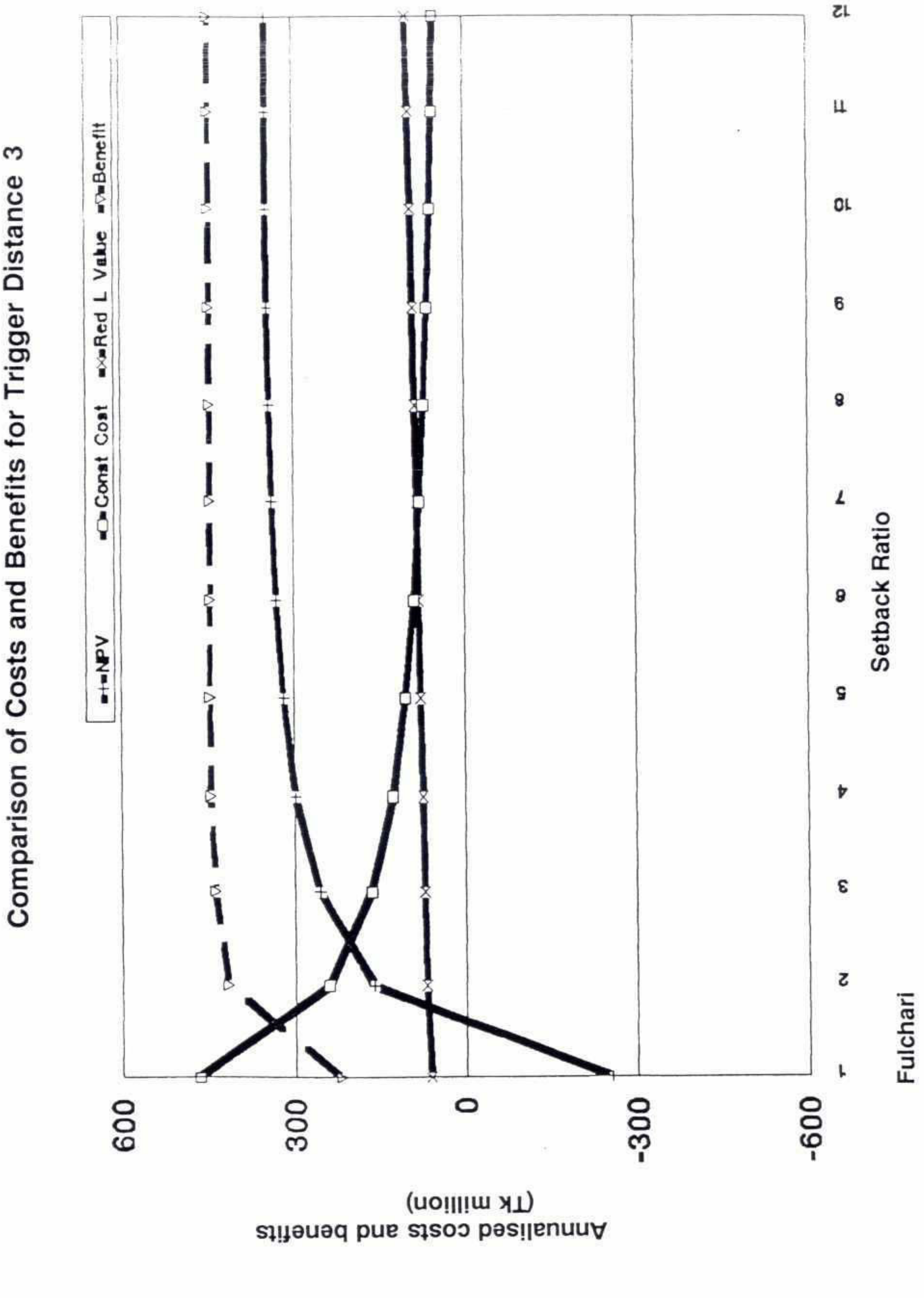


BRE Realignment: Variation of NPV with Setback Ratio



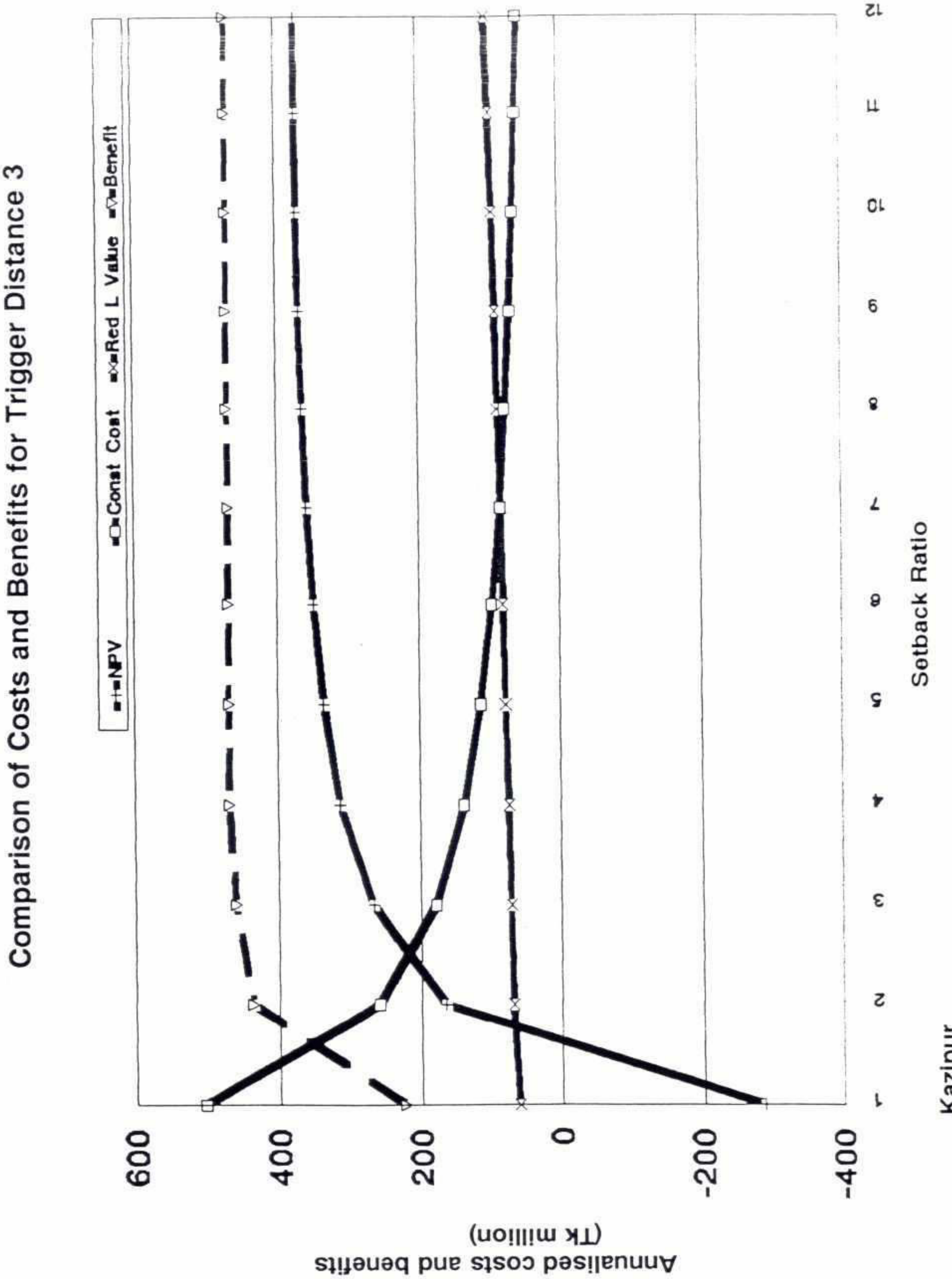
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.3l



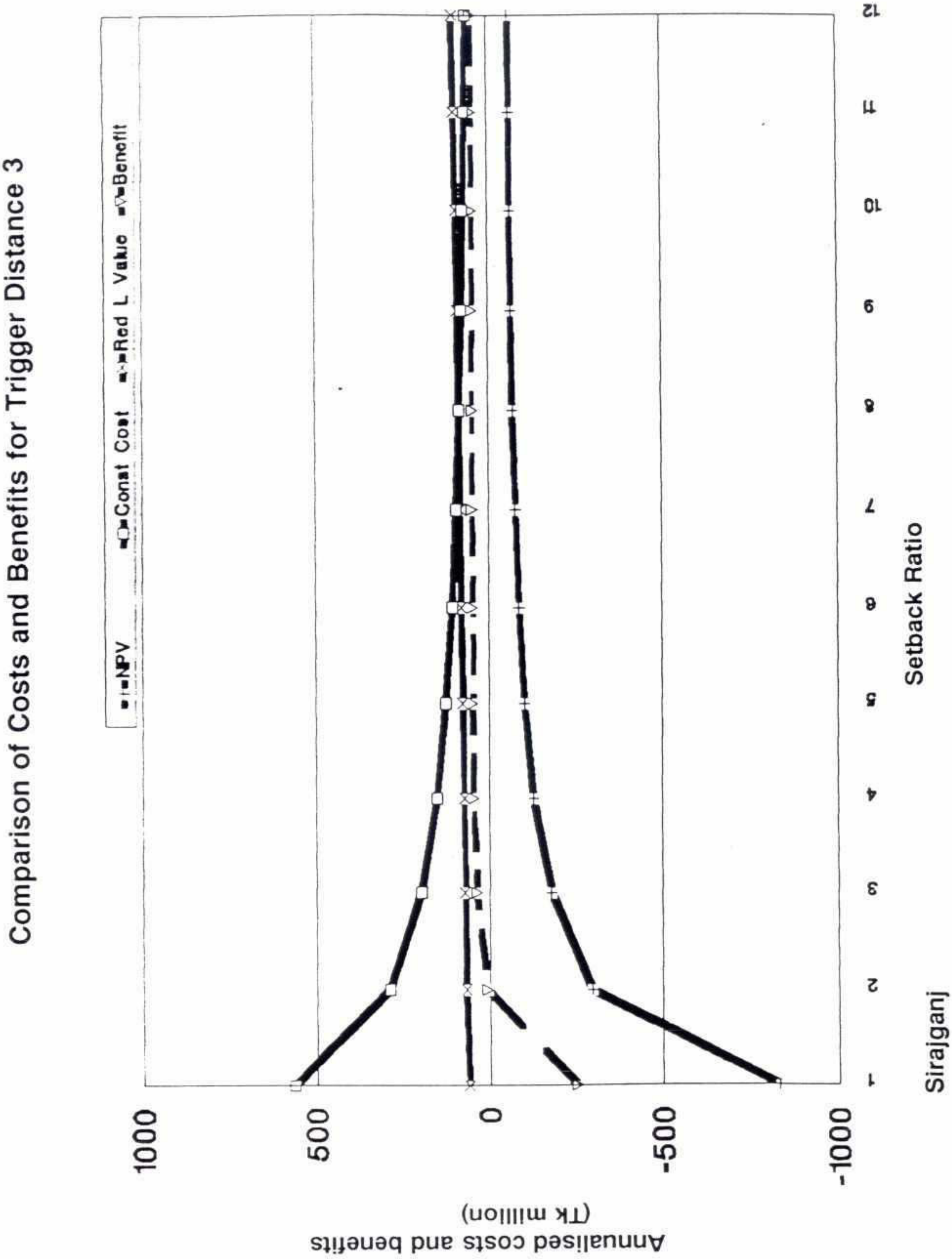
BRE Realignment: Variation of NPV with Setback Ratio

		Annex 2
Halcrow/DHI/EPC/DIG	*May 1993*	Figure 7.3m



BRE Realignment: Variation of NPV with Setback Ratio

		Annex 2
Halcrow/DHI/EPC/DIG	*May 1993*	Figure 7.3n



BRE Realignment: Variation of NPV with Setback Ratio

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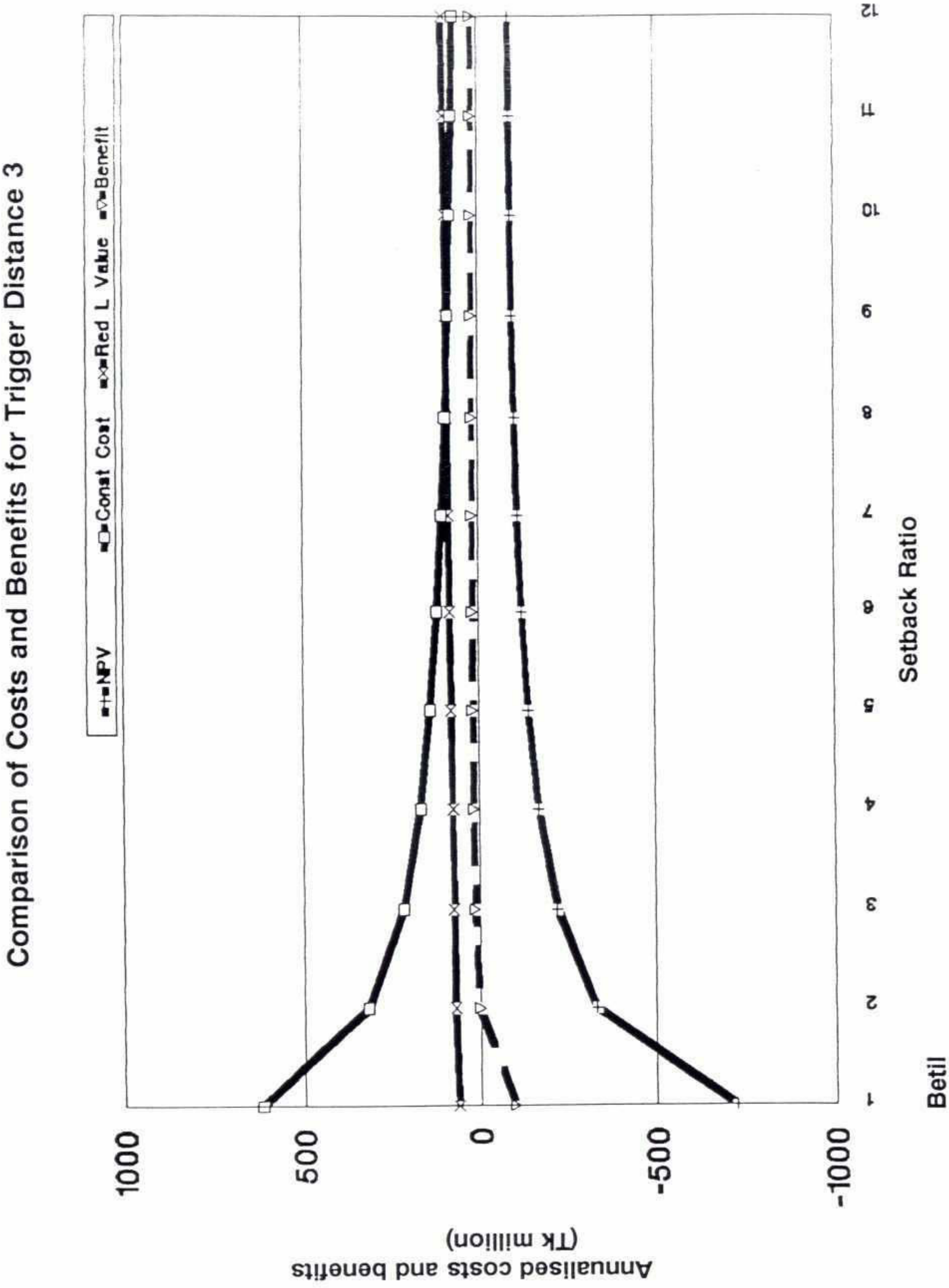
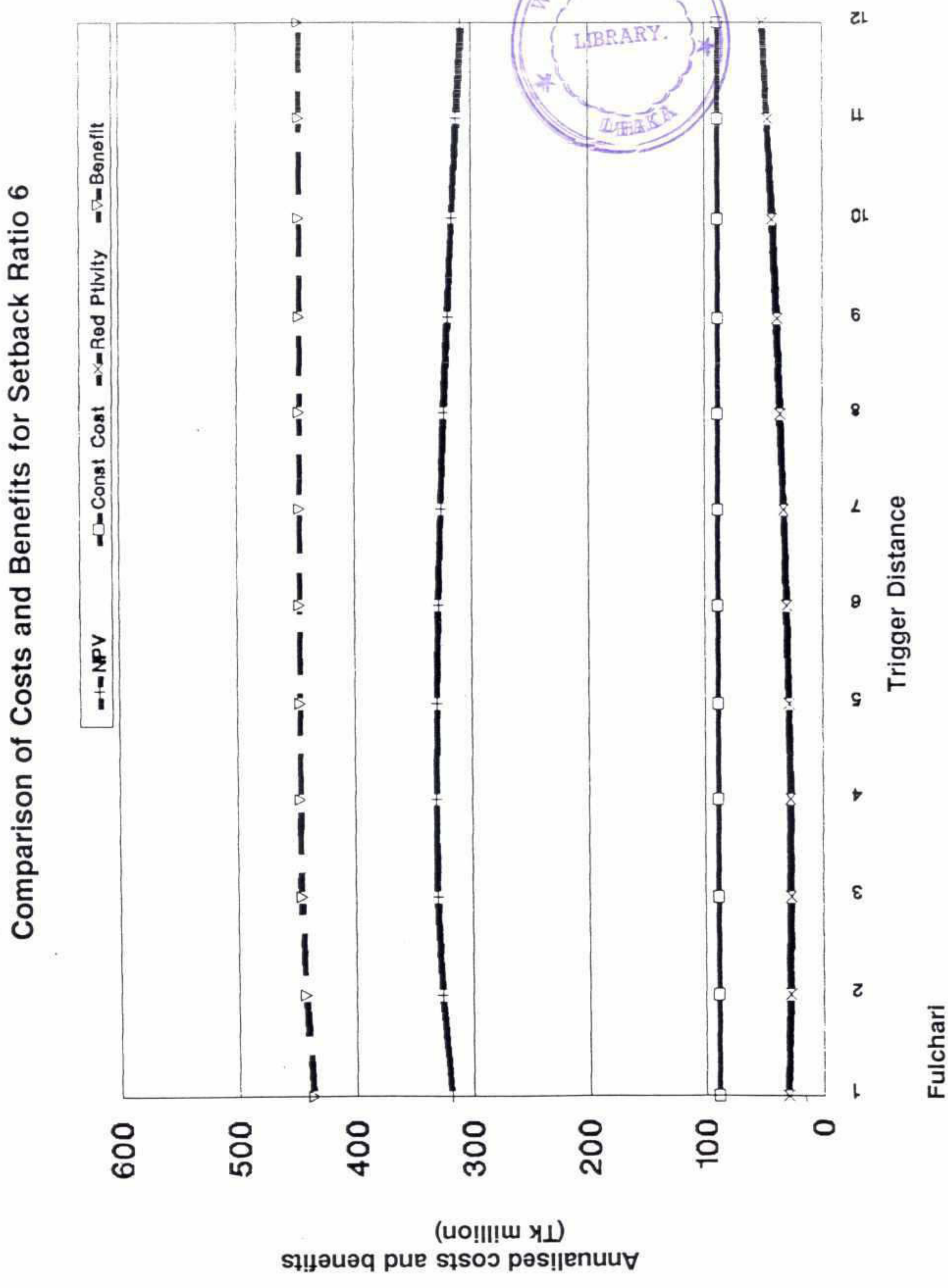
Halcrow/DHI/EPC/DIG	*May 1993*	Figure 7.3o



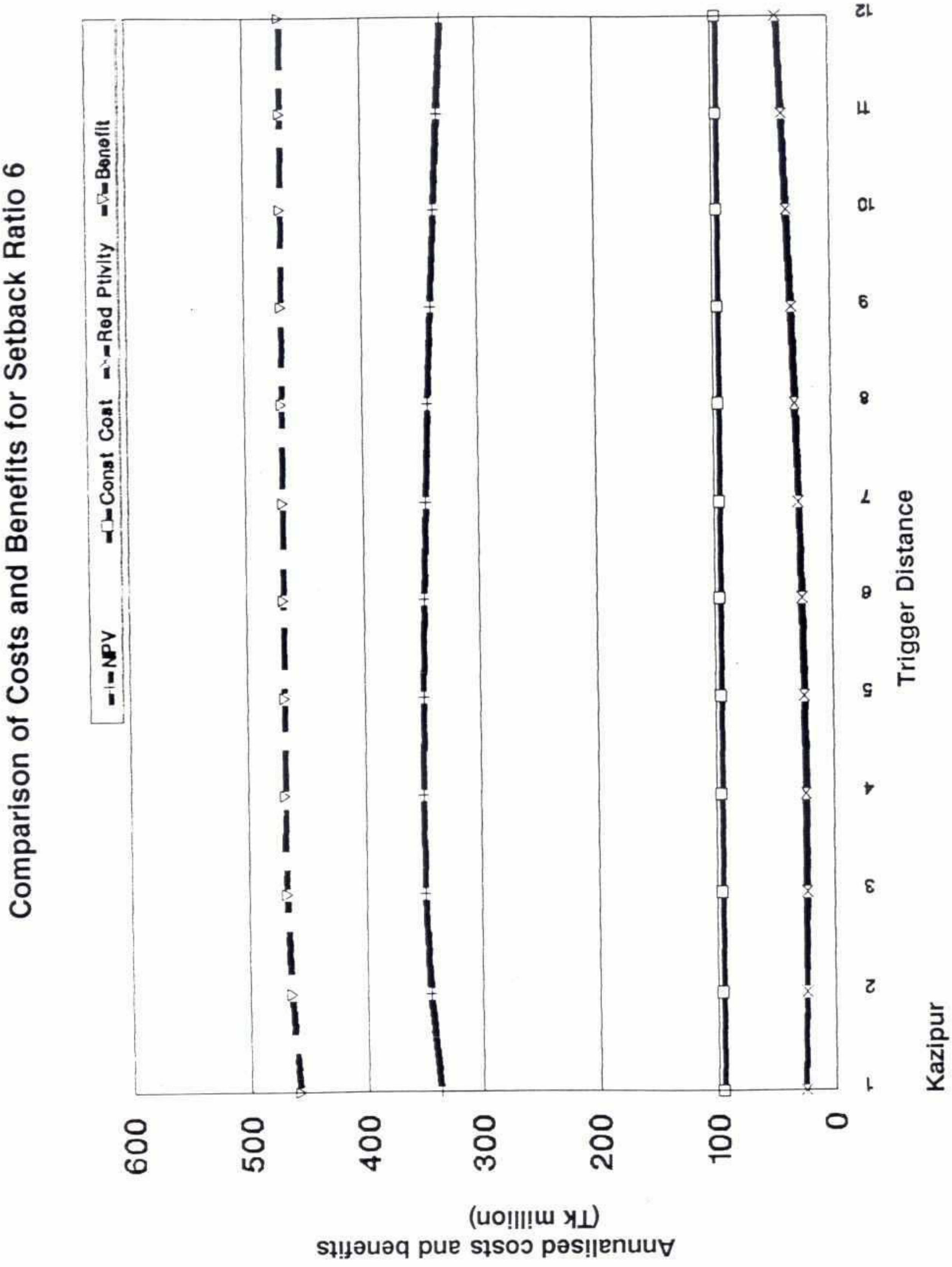
BRE Realignment: Variation of NPV with Setback Ratio

	Annex 2
Halcrow/DHI/EPC/DIG May 1993	Figure 7.3p



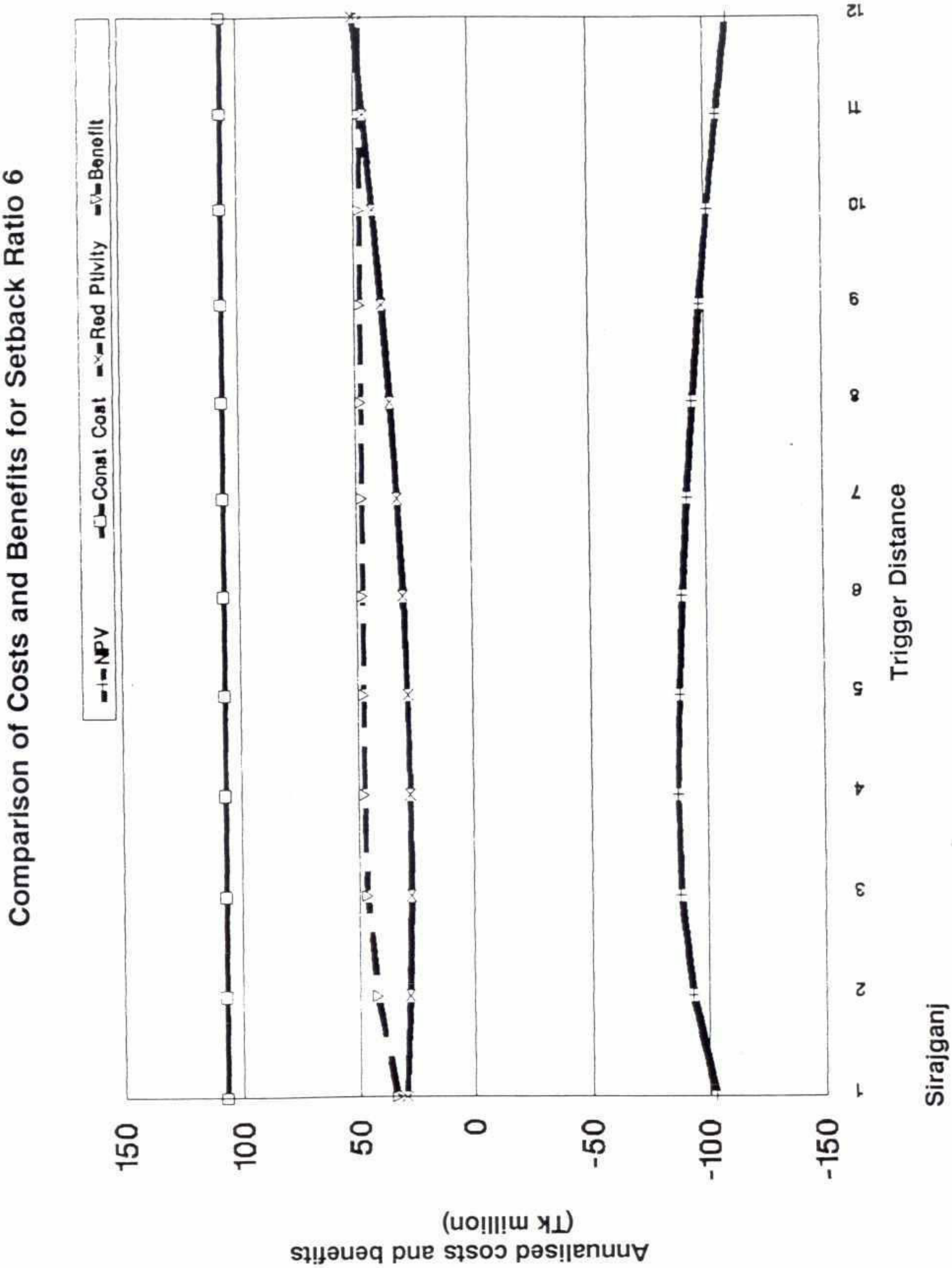
BRE Realignment: Variation of NPV with Trigger Distance

	Annex 2
Halcrow/DHI/EPC/DIG ***May 1993***	Figure 7.4a



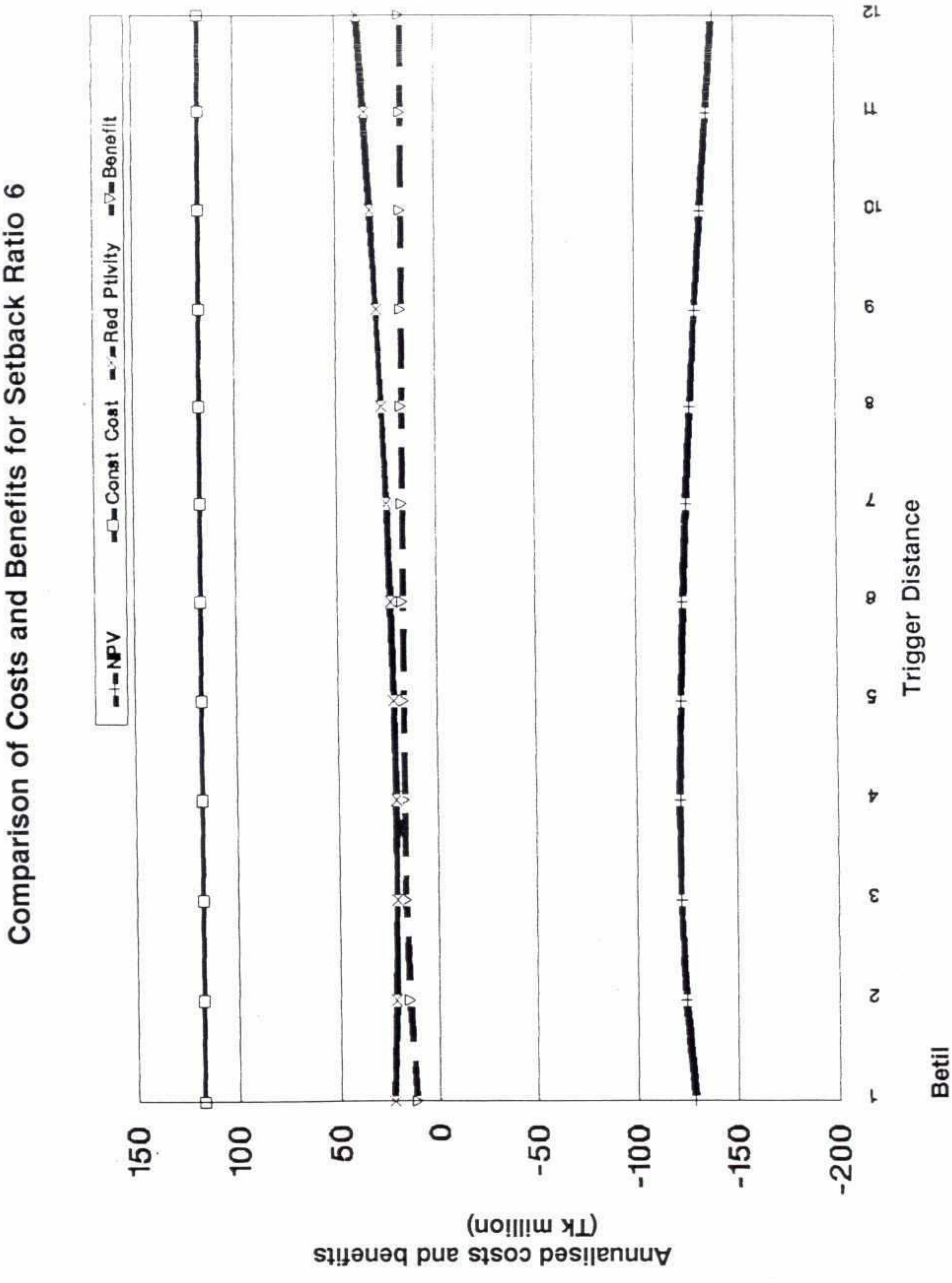
BRE Realignment: Variation of NPV with Trigger Distance

	Annex 2
Halcrow/DHI/EPC/DIG ***May 1993***	Figure 7.4b



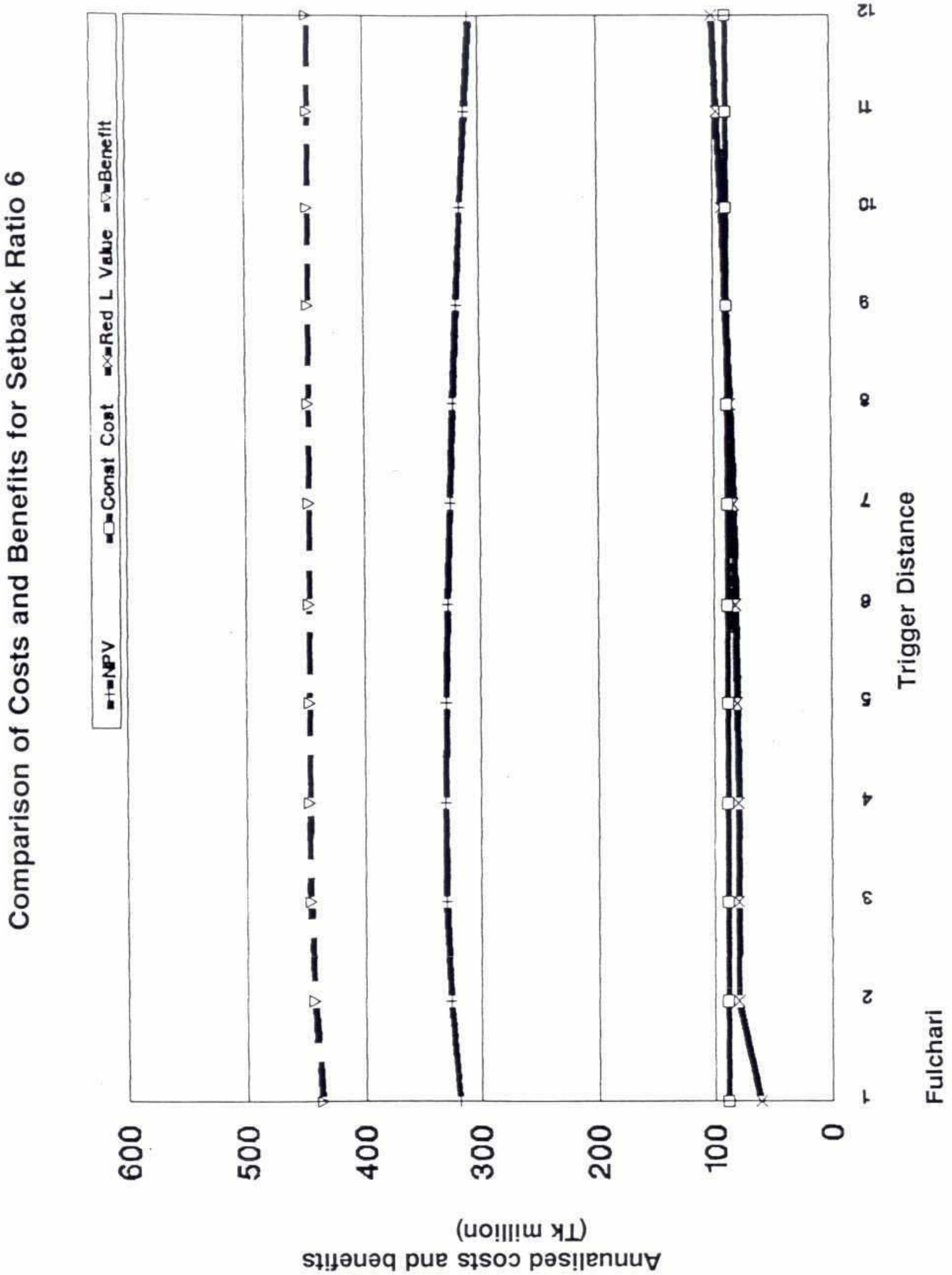
BRE Realignment: Variation of NPV with Trigger Distance

	Annex 2
Halcrow/DHI/EPC/DIG ***May 1993***	Figure 7.4c

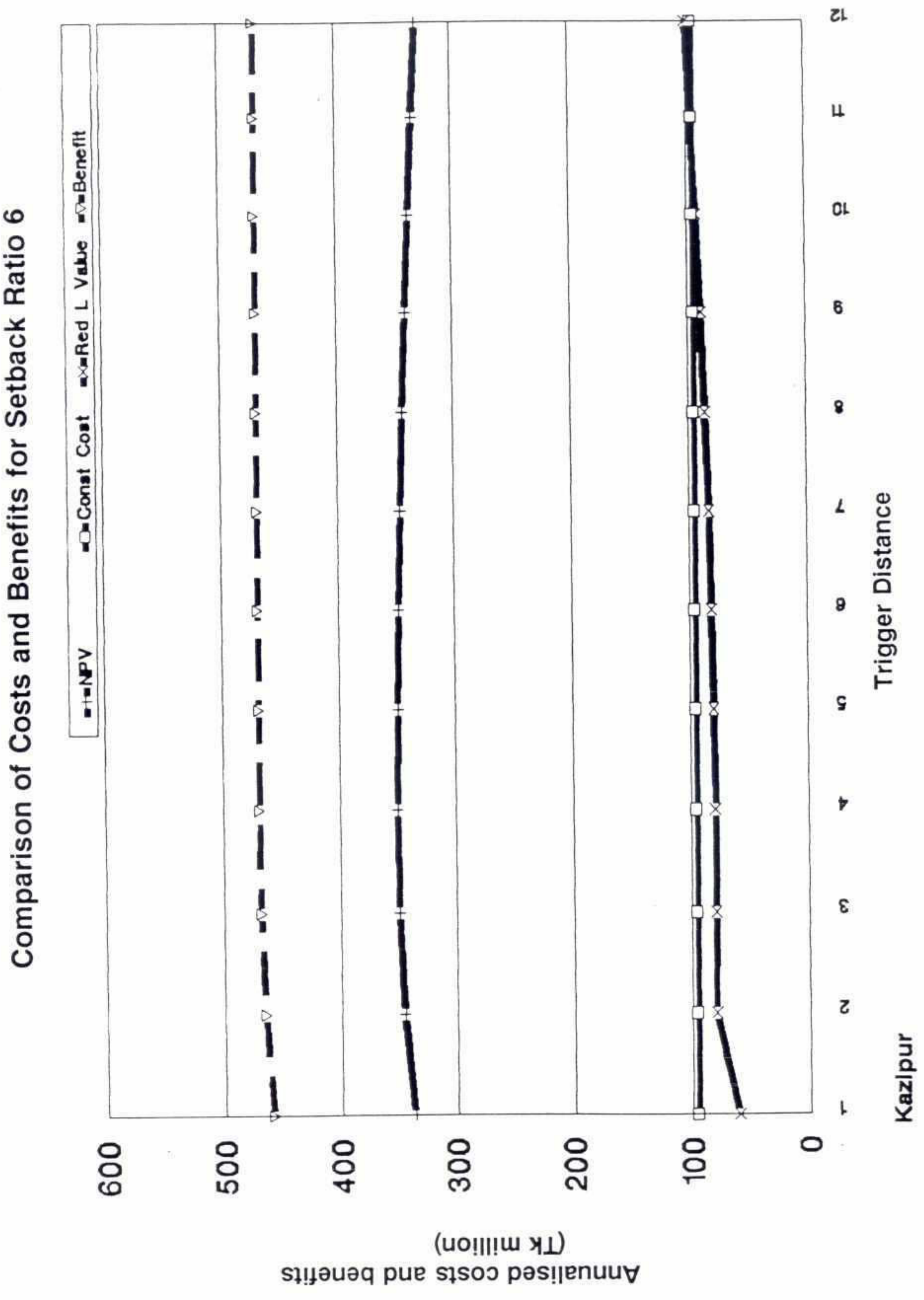


BRE Realignment: Variation of NPV with Trigger Distance

		Annex 2
Halcrow/DHI/EPC/DIG	***May 1993***	Figure 7.4d



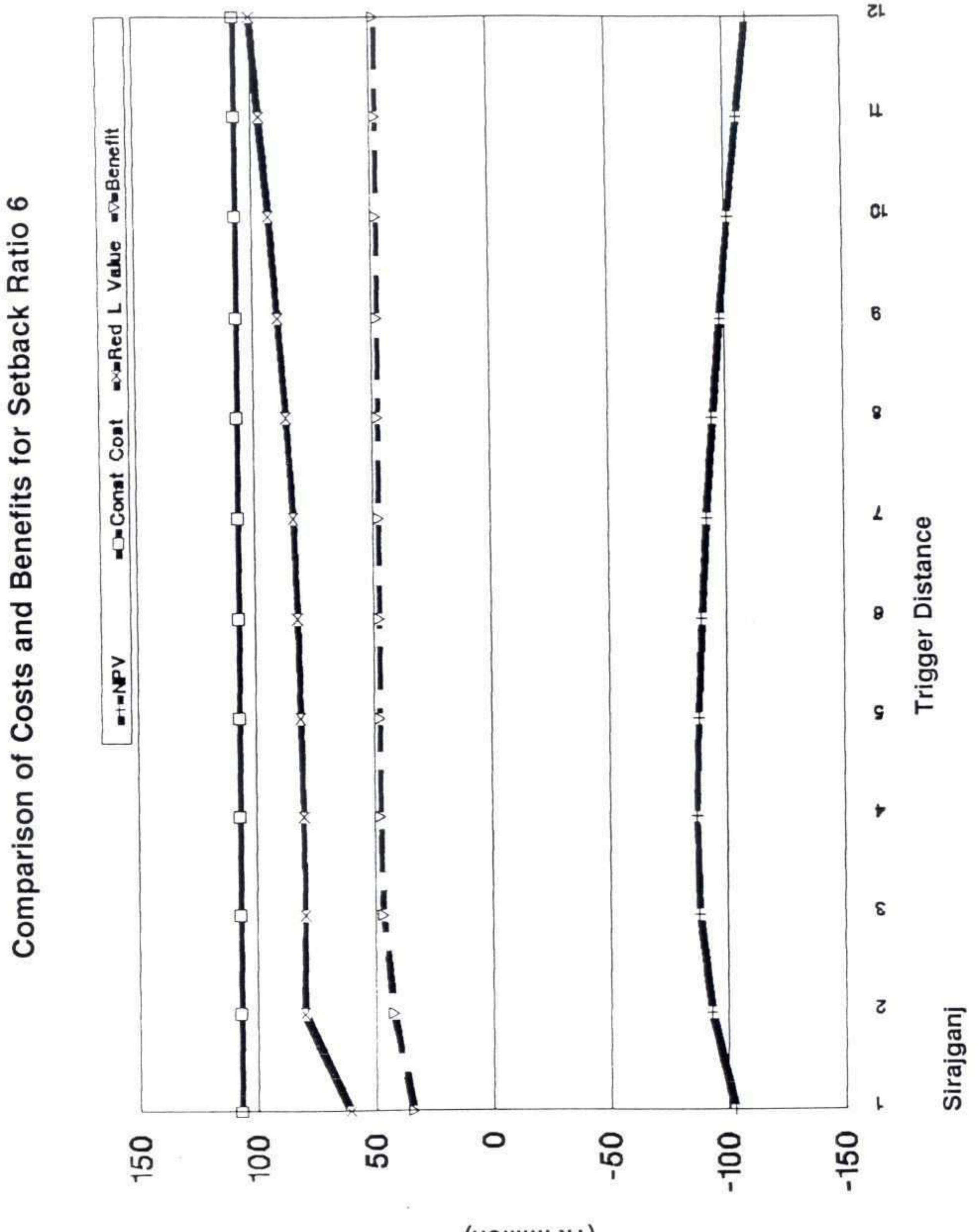
BRE Realignment: Variation of NPV with Trigger Distance



BRE Realignment: Variation of NPV with Trigger Distance

		Annex 2
Halcrow/DHI/EPC/DIG	*May 1993*	Figure 7.4f

280



BRE Realignment: Variation of NPV with Trigger Distance

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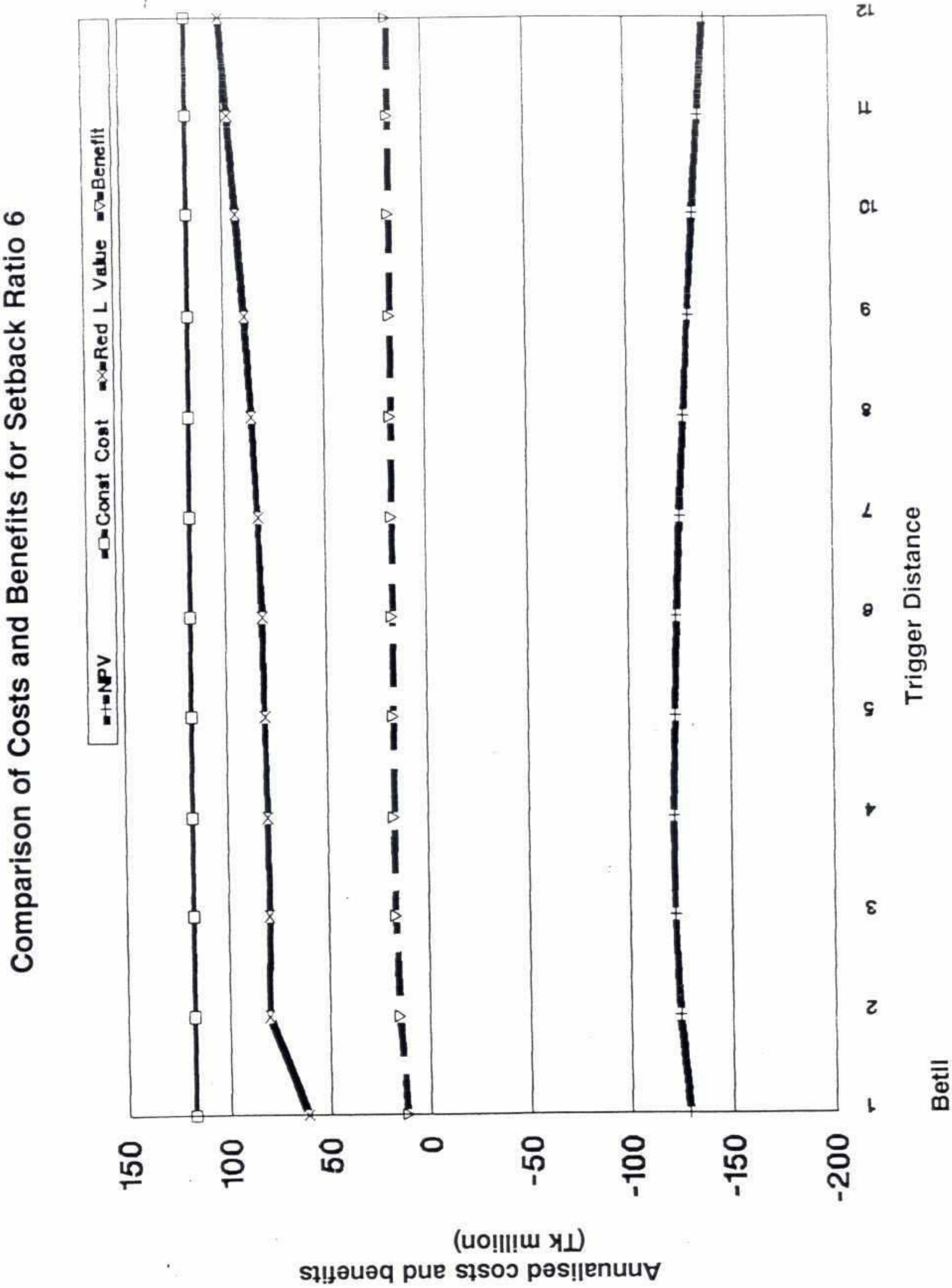
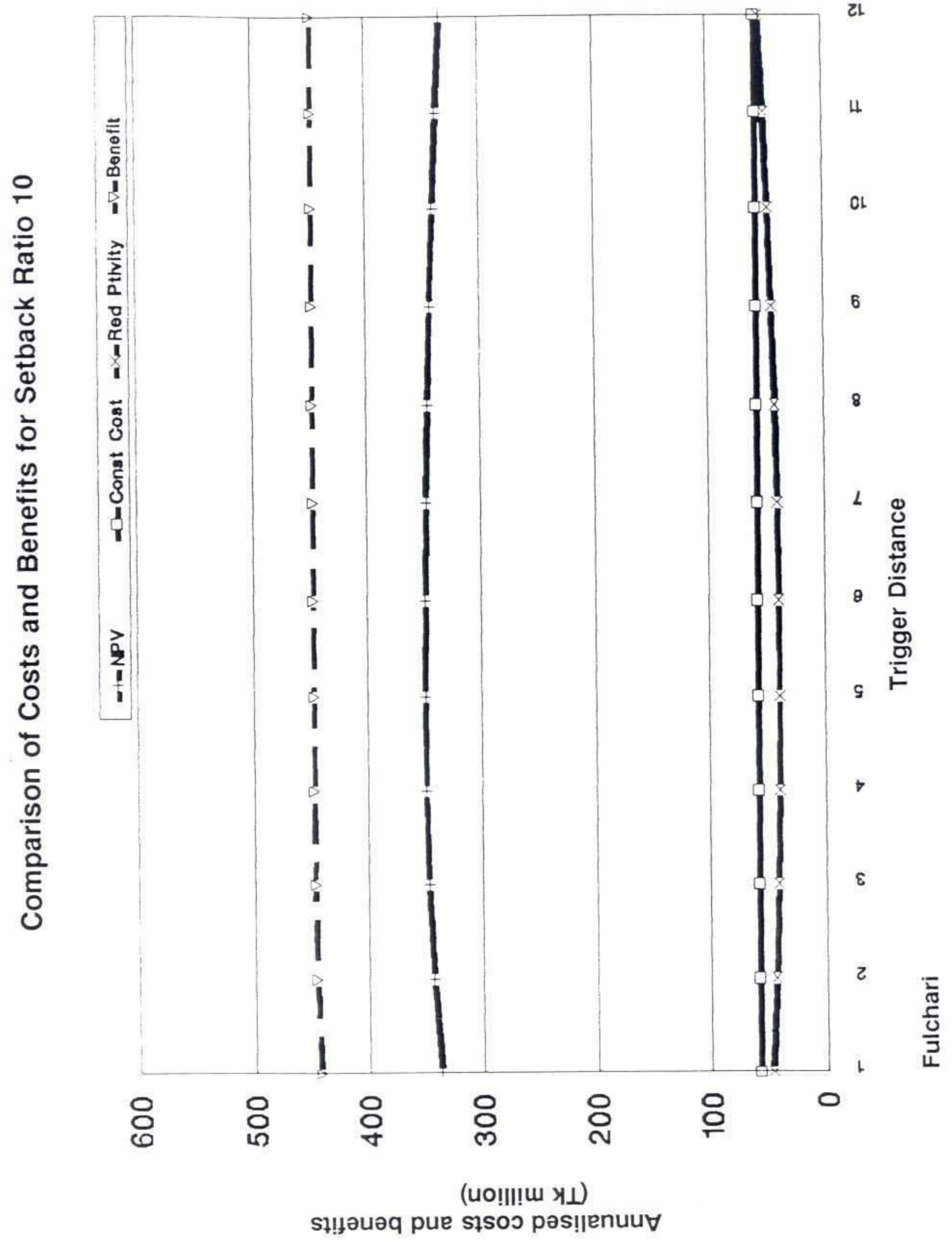
Halcrow/DHI/EPC/DIG	*May 1993*	Figure 7.4g



BRE Realignment: Variation of NPV with Trigger Distance

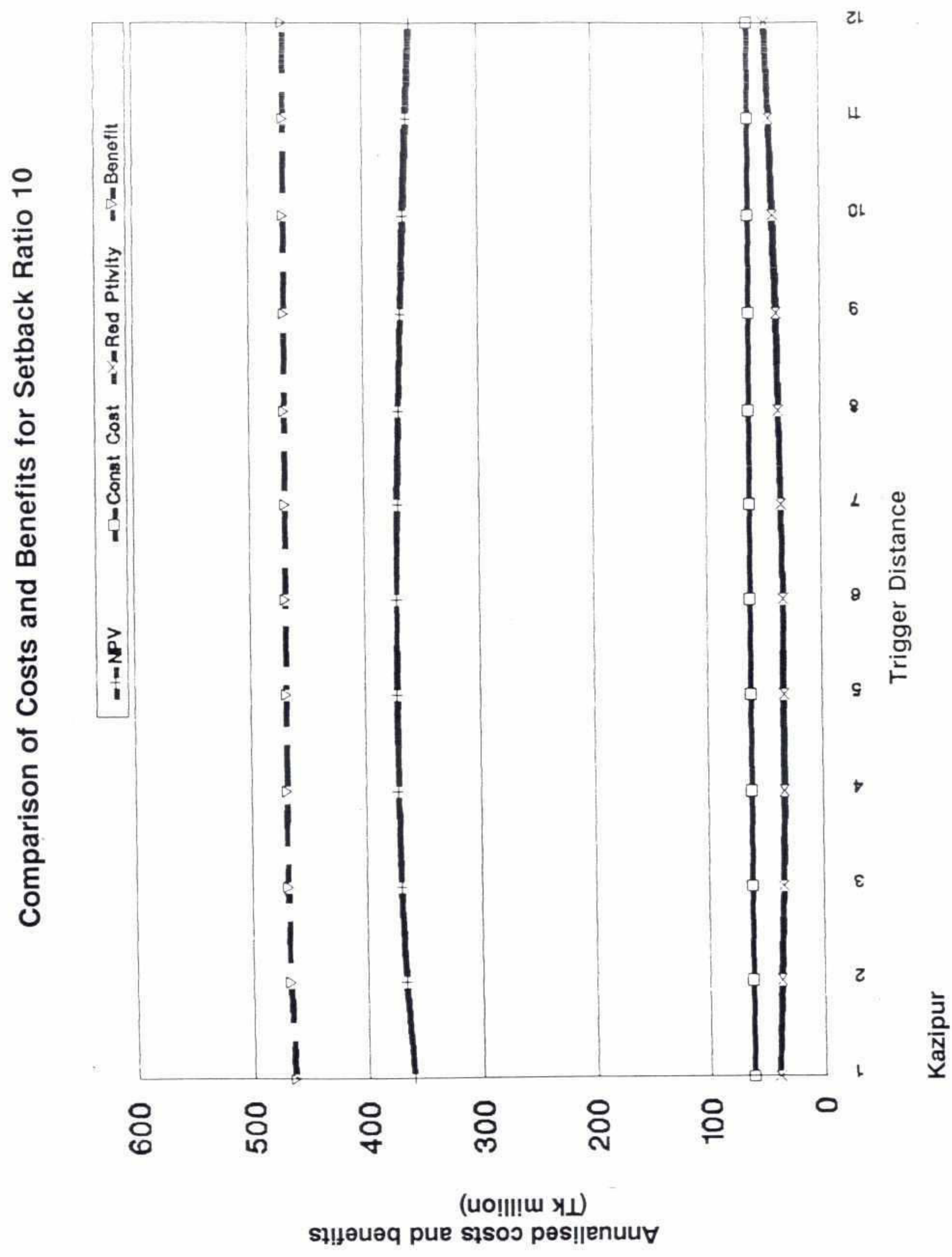
	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.4h



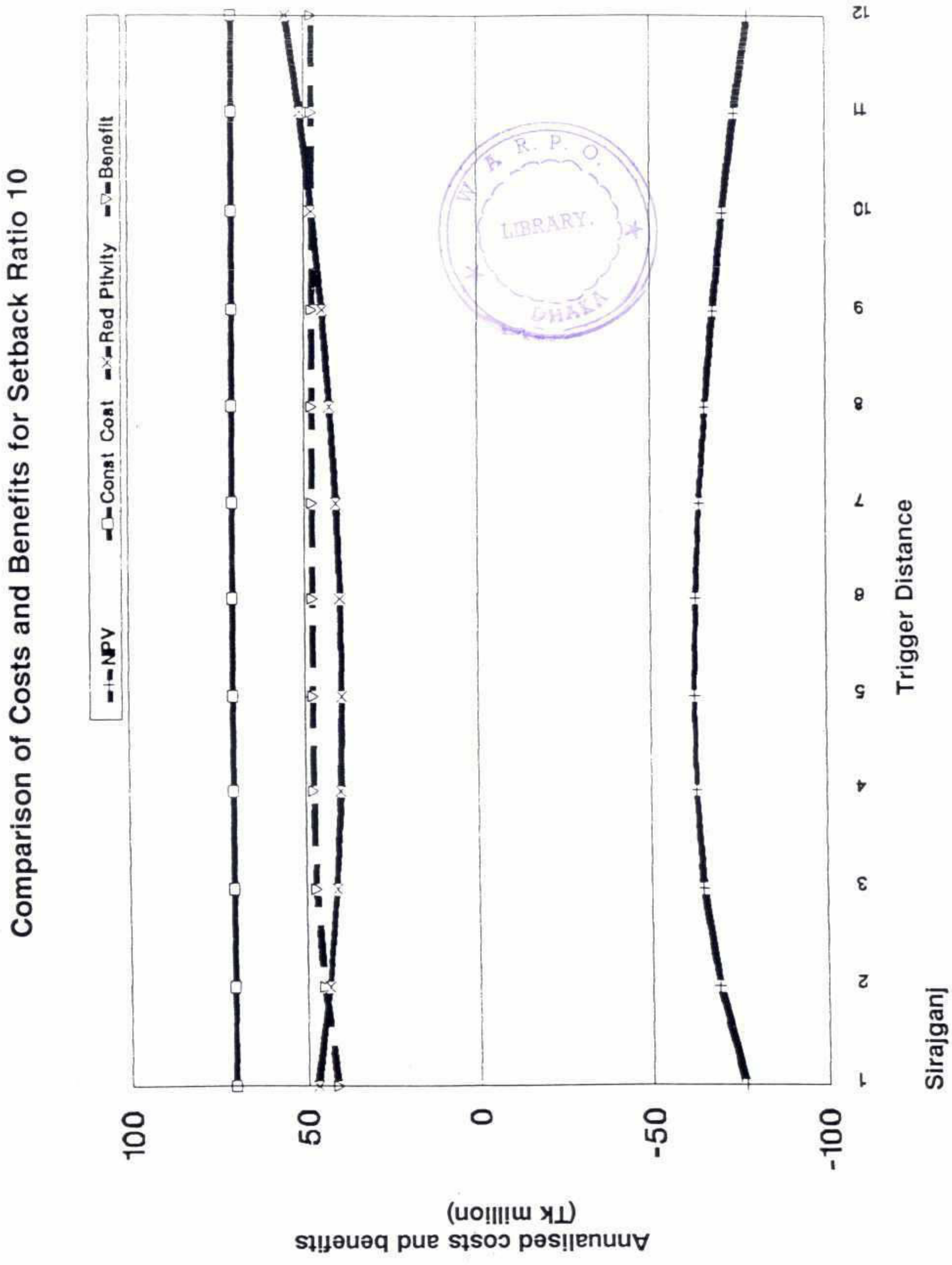
782

BRE Realignment: Variation of NPV with Trigger Distance

	Annex 2
Halcrow/DHI/EPC/DIG May 1993	Figure 7.4i

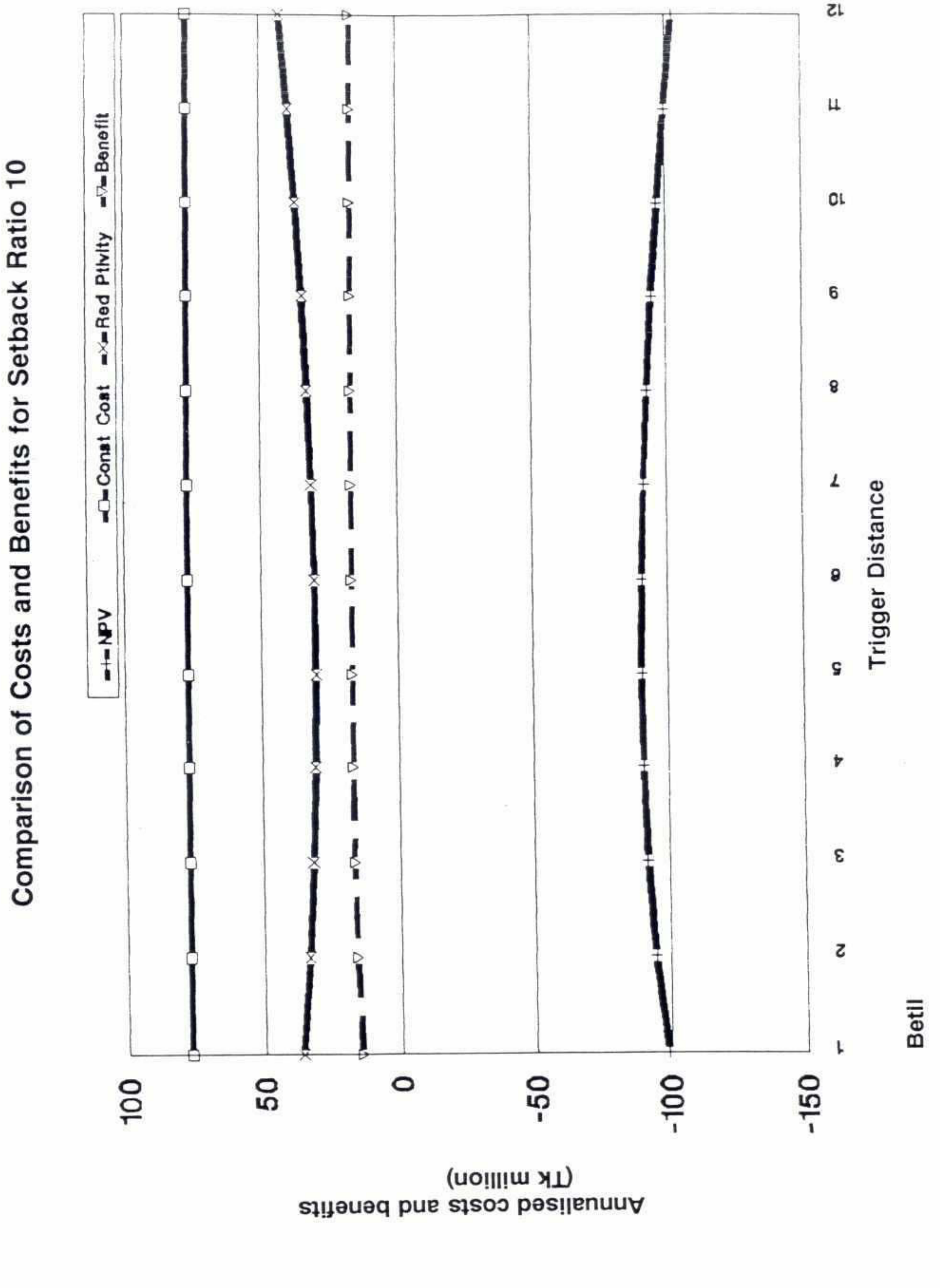


BRE Realignment: Variation of NPV with Trigger Distance



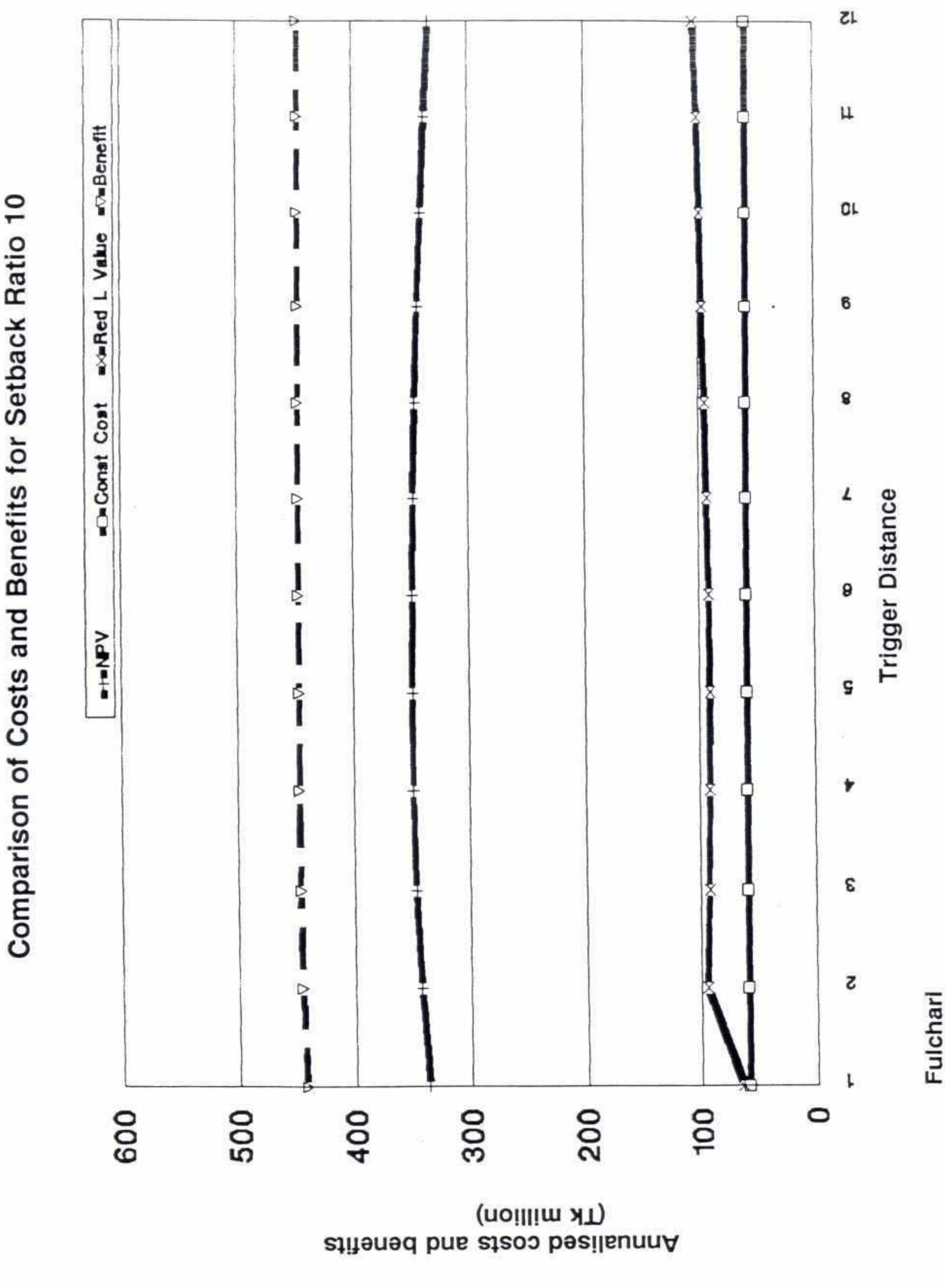
BRE Realignment: Variation of NPV with Trigger Distance

		Annex 2
Halcrow/DHI/EPC/DIG	*May 1993*	Figure 7.4k



BRE Realignment: Variation of NPV with Trigger Distance

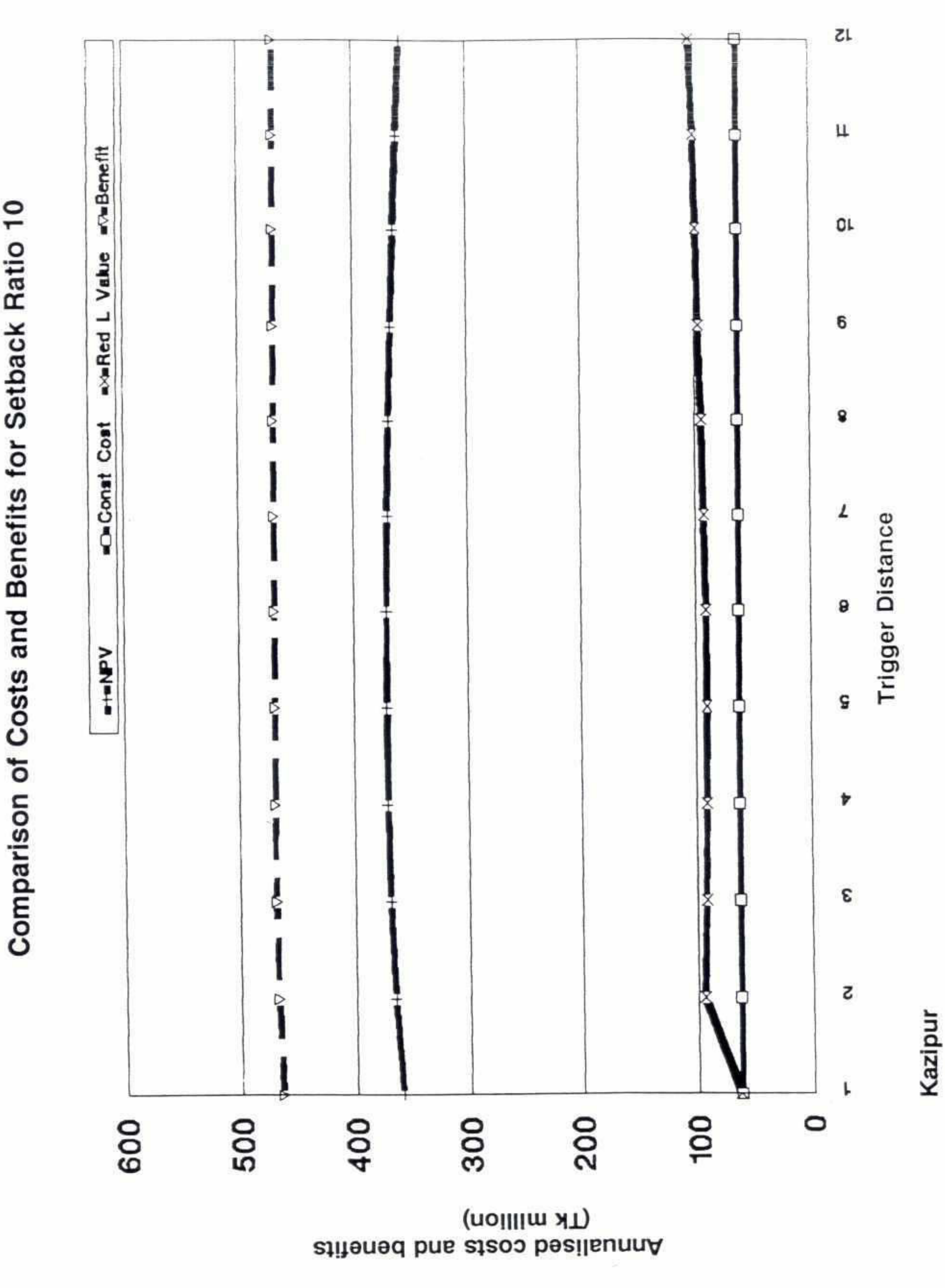
	Annex 2
Halcrow/DHI/EPC/DIG ***May 1993***	Figure 7.4l



283

BRE Realignment: Variation of NPV with Trigger Distance

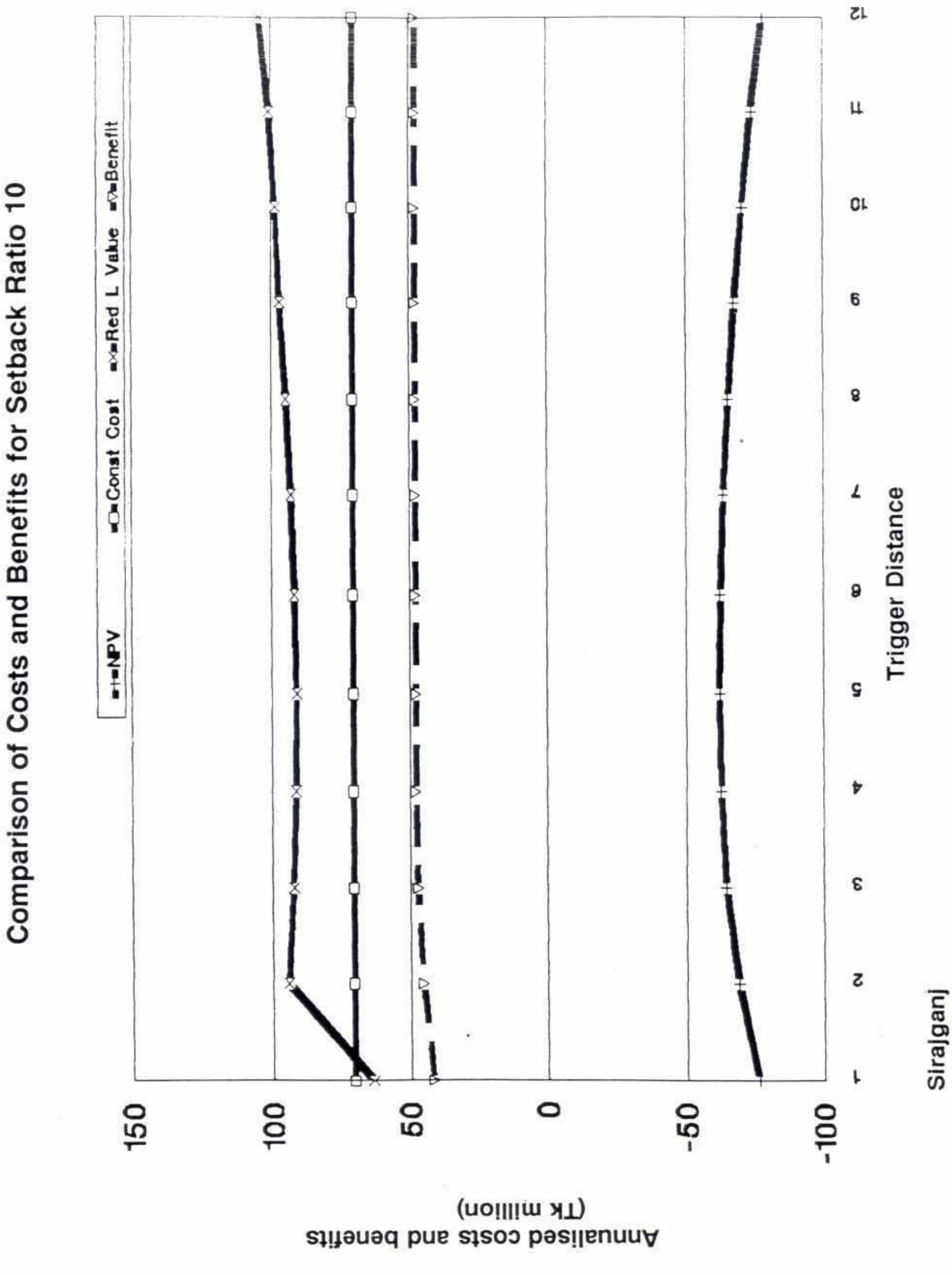
		Annex 2
Halcrow/DHI/EPC/DIG	*May 1993*	Figure 7.4m



BRE Realignment: Variation of NPV with Trigger Distance

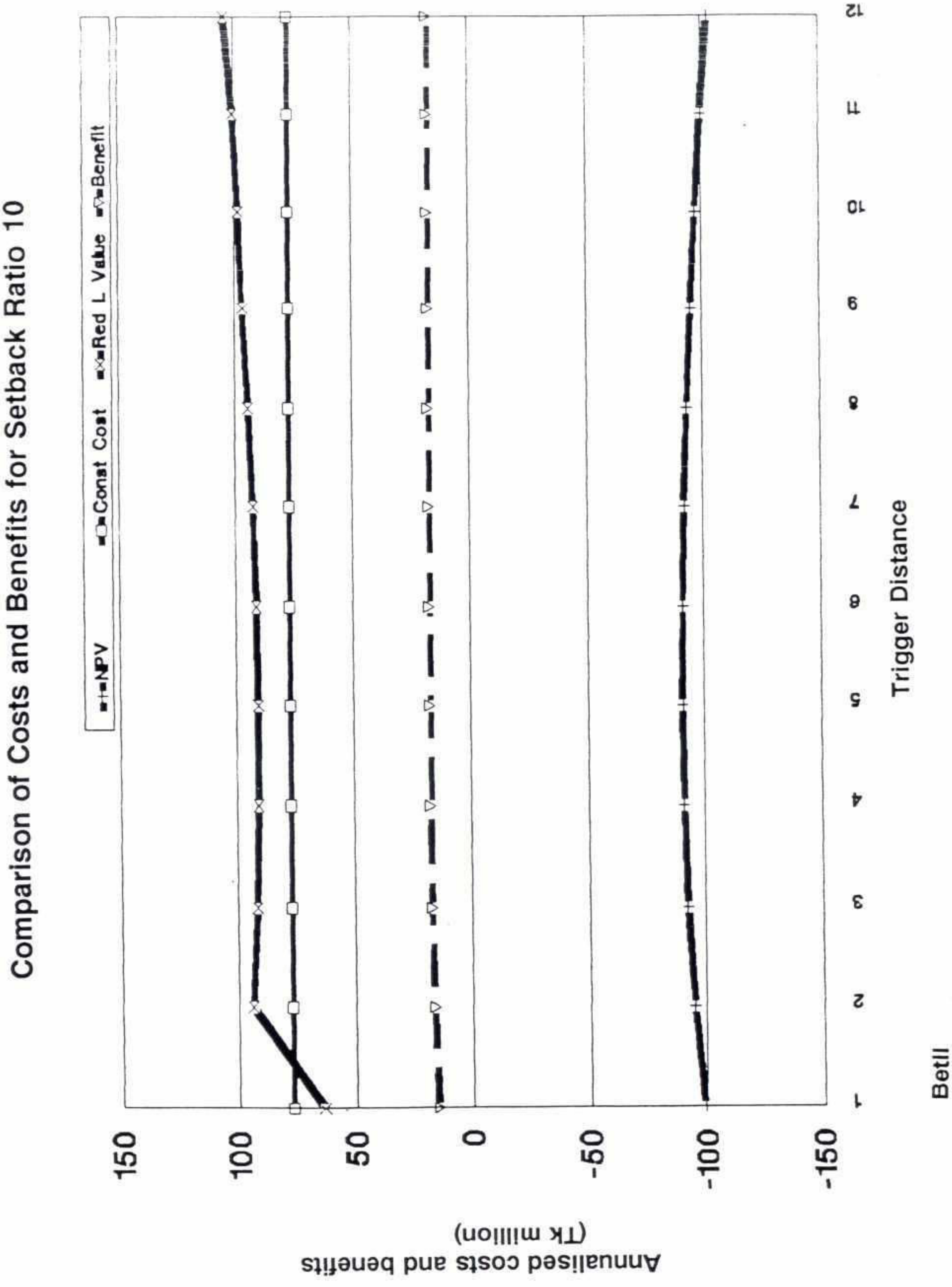
Halcrow/DHI/EPC/DIG	May 1993	Annex 2 Figure 7.4n

287



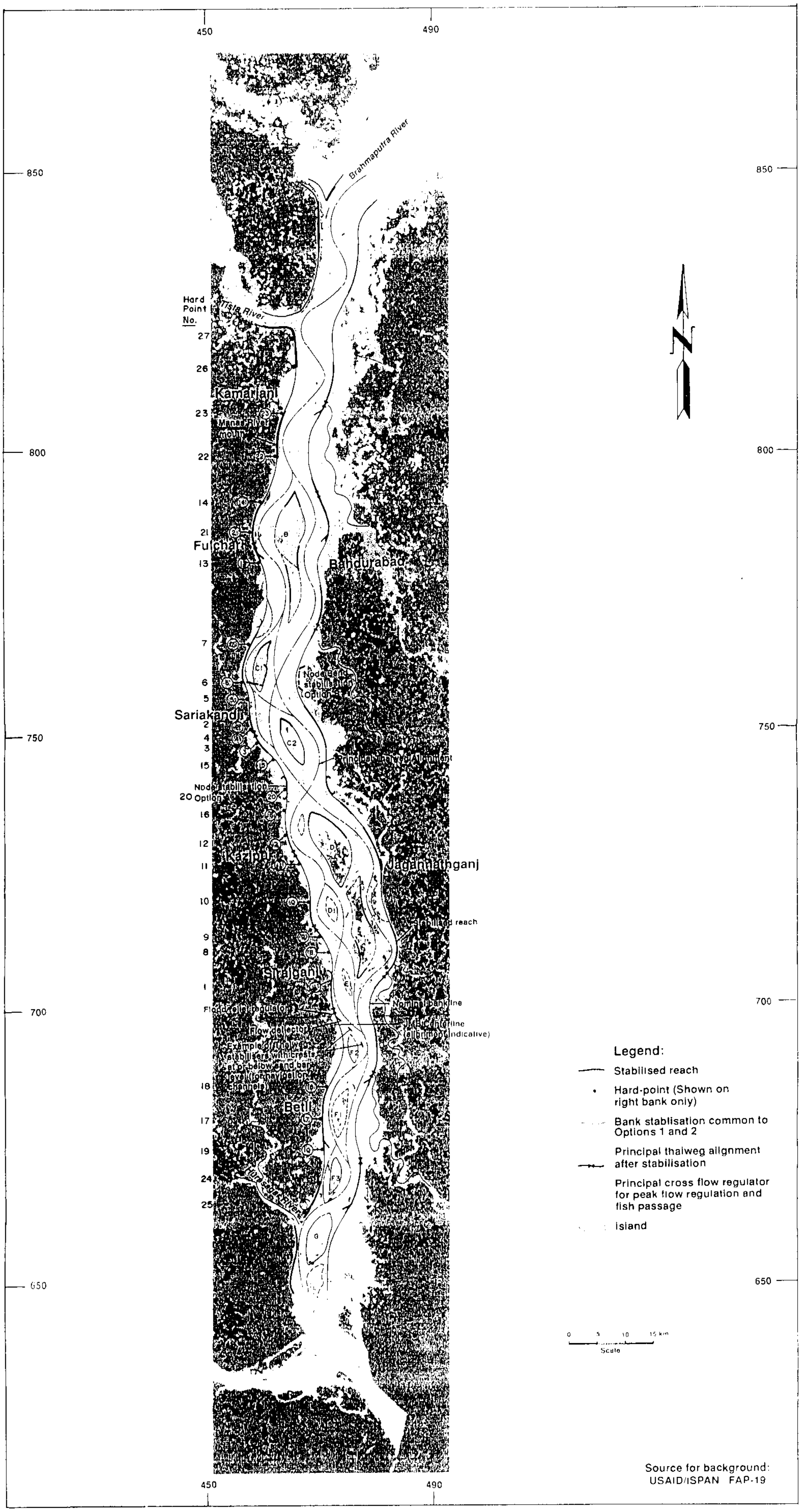
BRE Realignment: Variation of NPV with Trigger Distance

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.4o



BRE Realignment: Variation of NPV with Trigger Distance

	Annex 2
Halcrow/DHI/EPC/DIG *May 1993*	Figure 7.4p



Tentative Planform for Long Term River Training Option 1

Halcrow/DHI/EPC/DIG | Annex 2

May 1993 | Figure 8.1

APPENDICES

HALCROW

292

APPENDIX A

AGRO-SOCIO-ECONOMIC DATA FROM PRIORITY LOCATIONS

RIVER TRAINING STUDIES OF THE BRAHMAPUTRA RIVER

MASTER PLAN REPORT

ANNEX 2, APPENDIX A: AGRO-SOCIO-ECONOMIC DATA FROM PRIORITY LOCATIONS

CONTENTS

278

FULCHARI

(a) Past losses due to erosion:

Part of Fulchari Upazila HQ;

- 5 pucca public buildings (schools, market), 400 semi-pucca and katcha houses/shops had to be moved in 1989, 1990 and 1991;

- 80 hectares of agricultural land;

- 20 hectares of Upazila HQ land;

Passenger and goods railway ghat also frequently relocated

Displaced people mainly living on embankment or in Upazila HQ.

(b) Future consequences of erosion:

Fulchari Upazila HQ currently being eroded and consists of:

15 pucca public buildings (schools, Upazila HQ complex, health centre, telephone exchange, P.O., godowns, market)

10 semi-pucca public buildings (schools, godowns)

15 pucca private houses

500 semi-pucca private buildings (shops, houses)

1000 katcha buildings (shops/houses)

40 hectares of Upazila HQ land

335 hectares of rural land at risk over next 5 years, of which 70% is unprotected from flood.

Population seriously affected:

Fulchari Upazila HQ	10,000
Rural Area	3,500

	13,500

+ power lines, telephone lines, katcha roads, railway line, 2 girder bridges (rail, road) also at risk.

(c) Future consequences of flooding (if BRE breached):

Fulcharighat town already unprotected, but located on high ground. In normal flood there is no serious impact (only just submerged). In the 1988 flood, the town was 1.5 meters under water, but only damaged katcha buildings and tin sheds. Flood subsided after 15 days. Main problem was breakdown of services (e.g. electricity, telephone) and communications (roads and railway for one month).

BRE is likely to be breached within the next 2 to 3 years, at a point north of Fulchari town. If breach, population seriously affected - 3,600;

- rural land severely affected - 400 ha.

- BR railway sidings and associated buildings located just behind BRE and would be severely affected.

Main kharif crops - Aus/Aman (90%), jute (10%)
Main Rabi crops - Boro, pulses/mustard, wheat, vegetables
Perennial crops - sugar cane (10%)

N.B Substantial area unprotected at present. Visible difference in level of agricultural production between unprotected and protected areas. Also pockets of land in the unprotected area are inundated for two months during monsoon. Farmers therefore have to delay planting which has resulted in significant yield losses. This inundation is due to the BRE.

Boro is mainly irrigated by STW.

N.B Main access road to Fulchari eroded at 16 points in 1988 flood. Road has been recently neglected due to withdrawal of government funds for maintenance.

Ferryghat:-

(a) Passenger Rail Ferryghat

4 trains per day. Importance declining. Continual relocation of ghat during active erosion period. Eroded 1 km in 5 years. Passenger gangway can be reshaped by labourers within hours. No disruption to service.

(b) Goods Rail Ferryghat

2-3 trains per day. Dinajpur/Rangpur to Dhaka. Continual relocation. Loading ramp can be reshape within hours. No disruption to service. Agricultural produce to Dhaka. Consumer goods and construction materials on return.

SARIAKANDI

(a) Past losses due to erosion:

Only limited loss of agricultural land in recent years (1987-1991). Bank protection works in place.

(b) Future consequence of erosion:

Sariakandi Upazila HQ under threat if protection works undermined; town consists of:

20 pucca public buildings (schools, Upazila HQ, health centre, telephone exchange, P.O., godowns, markets, banks, police station)

15 semi-pucca buildings (schools, godowns),

50 pucca houses

1,250 semi-pucca buildings (shops, houses)

1,250 katcha buildings (shops, houses)

80 hectares town land

470 hectares of rural land over the next five years, of which all is currently protected by BRE.

Population displaced:

Sariakandi Upazila HQ	15,000
Rural Area	5,200

	20,200

+ power lines, telephone lines, roads, bridges and culverts also at risk.

(c) Future consequences of flooding (if BRE breached):

Sariakandi town currently protected, located just behind the BRE, but if BRE breached there is likely to be substantial damage to pucca and semi-pucca buildings in parts of the town close to the breach, as well as to katcha buildings that have not been moved.

Bridges/culverts, roads, power line etc also at risk.

Already breached south of Sariakandi at Deluabari (in 1991). Devastated area of approximately 400 ha, heavy sand deposit, not suitable for cropping for at least one to two years.

Previous cropping:

Main monsoon crops	- Aus/Aman (90%), Jute (10%)
Winter crops	- Boro, wheat, oilseed, vegetables.

Little sugar cane

High proportion of land irrigated; Boro irrigated by STW and DTW. Cropping intensity - 200% approx.

Population seriously affected by flood:

Upazila HQ	5,000
Rural Area	3,700

	8,700

N.B Danger of Brahmaputra capturing the Bangali. This would leave Sariakandi isolated on an island, and subjected to both active erosion and severe flooding from both the Brahmaputra and the captured Bangali channel.

MATHURAPARA

(a) Past losses due to erosion:

Mathurapara market and a number of villages over 5 years, plus breach in BRE. Market moved to new site (1 km from previous site). Most displaced people living on embankment or in new market. During 1991 there was very rapid erosion (0.5 km to 1 km), new market now under immediate threat.

(b) Future consequences of erosion:

Mathurapara Market now under immediate threat, and consists of:

5 semi-pucca public (schools, godowns)

250 semi-pucca shops/houses

250 katcha houses

15 hectares of market land

535 hectares of rural land over the next five years, of which all is unprotected from flood

Population displaced:

Market	3,000
Rural Area	5,450

	8,450

Minor road/bridges at risk, but no power lines, telephone lines, water supply etc.

(c) Consequences of flooding (BRE already breached)

Market already severely damaged by flood. A number of pucca and semi-pucca building have been destroyed or damaged and the population has been severely disrupted. Population is now living in katcha houses or tin sheds and many are displaces from recent erosion.

Agricultural land severely affected = 400 ha

Farmers unable to plant monsoon crops in severely affected area, because of damage by floods (from both high velocity and depth of inundation). Farmers responded to this loss by planting a high of proportion of area with Rabi crops. Sugar cane area also increases. Production of winter crops was also very limited in the Rabi season following the breach, because of sand deposition.

Previous cropping pattern is similar to Sariakandi, i.e. intensive irrigated agriculture. Consequently, there has ben a very substantial drop in crop production, particularly in the severely affected areas.

Population severely affected

Market	1,000
Rural Area	4,000
	5,000

N.B. Danger of Brahmaputra capturing Bangali.

370

KAZIPUR

(a) Past Losses due to erosion:

Kazipur Upazila HQ and 15 villages in recent years plus bridges/culverts, godowns, mosques and other buildings. Displaced population mainly living on embankment or within local area. BRE frequently retired and breached in 1984, 1987, 1988.

(b) Future consequence of erosion:

One large health complex and some semi-pucca buildings under immediate threat.

In future, new market and Upazila HQ could be under threat from erosion, consisting of:

- 10 Pucca buildings,
- 10 Semi-pucca buildings (schools, godowns),
- 10 Pucca private houses,
- 700 Semi-pucca shops/houses,
- 700 Katcha shops/houses,
- 40 ha Upazila HQ land,
- 600 ha rural land over next five years, of which 70% is unprotected.

Population displaced:

Market	8,500
Rural Area	7,440

	15,940

Minor roads/bridges at risk, as well as power/telephone lines.

(c) Consequences of flooding:

BRE retired in 1991, so no immediate threat of flooding. It breached in future:

Agricultural land severely affected	390 ha
Market land severely affected	10 ha

Farmers unable to plant monsoon crops in severely affected areas. Farmers respond by planting more Rabi crops, and growing sugar cane.

High proportion of sugar cane grown in vicinity (30%), especially in seriously affected areas. Other important crops in the vicinity are Aus/Aman, jute, Boro, what, pulses and oilseeds. High proportion of irrigated land.

People seriously affected

Market	2,800
Rural area	4,800

	7,600

BETIL

(a) Past losses due to erosion:

5 villages in recent years. 3 Semi-permanent markets. 6 schools and 8 other public buildings. Displaced population now living on the embankment or in the local "weaving villages".

(b) Future consequences of erosion:

2 large weaving villages at risk, 800 hectares of agricultural land and 50 hectares of village land over the next five years. 10 pucca public buildings and 10 semi-pucca public buildings.

Villages are predominately weaving villages each contain approximately 250 houses/factory compounds. Factory/houses buildings are typically constructed of corrugated iron walls and roof on a timber frame with a concrete/brick floor. These buildings and the installed machinery (handlooms, dyeing and spoiling machinery) can be moved to alternative sites.

The area is a traditional weaving centre renowned throughout the country. It also provides employment for a very large number of weavers both from the local area and migrant workers from other parts of Bangladesh.

Population displaced:

Weaving villages	8,500
Rural Areas	10,000

	18,500

Minor roads/bridges, power lines, telephone lines also at risk.

(c) Consequences of flooding (if breached)

Weaving villages within the immediate vicinity of the breach will be very badly damaged if not removed. There would also be severe dislocation to a large number of weaving sheds during the flooding period. This would not only significantly reduce production, but thousands of weavers would also be temporarily without employment and a source of income. This would clearly be very disruptive to this important weaving area.

Village land seriously affected 30 ha
Agricultural land seriously affected 370 ha
Main monsoon crops - Aus/Aman (40%), Jute (10%)
Winter crops - Boro pulses, wheat, mustard

Perennial crops - sugar cane (5%)
Some irrigation

Road, bridges/culverts, power lines etc. also at risk.

People seriously affected

Weaving village	5,100
Rural Area	3,700

	8,800

SIRAJGANJ

(a) Past losses due to erosion:

Substantial investment in protection works has reduced erosion losses around the town to a minimum. Erosion mainly to North and South of town.

(b) Future consequences of erosion:

Sirajganj town (population approx. 100,000) is at risk:

The town consists of approximately:

150 pucca public buildings (schools, government buildings, health centres, POs, police stations, telephone exchange, godowns, factories, banks)

50 semi-pucca public buildings (schools, godowns, factories, mosques)

100 pucca factory units

50 semi-pucca factory units

500 pucca private houses

13,500 semi-pucca shops/houses

6,600 katcha shops/houses

750 ha urban land

750 ha peri-urban land

It is estimated that one third of the town could be eroded over the next five years.

355 ha rural land, railway line, bridge/culverts, pucca roads, power lines, telephone lines all at risk over the next five year. Very major infrastructural losses will occur.

Population displaced

Urban area	100,000
Rural area	4,000

	104,000

Focus of erosion has now moved to a position south of the town where it has breached the BRE (in 1991). The passenger ferry is located at this erosion site. Flooding is mainly restricted to the peri-urban (shanty area inhabited by people displaced by river erosion) and agricultural areas south of the town.

(c) Future consequences of flooding:

Sirajganj town currently protected, located just behind the BRE. But if breached, there is likely to be sustaintial damage to pucca and semi-pucca building in parts of the town close to the breach, as well as to tin sheds/katcha buildings if not relocated.

The railway line is in very close proximity and bridges/culverts, roads, power lines, telephone lines also at risk.

Town land severely affected	300 ha
Agricultural land severely affected	100 ha
	---------
	400 ha

High proportion of sugar cane grown in this area 10 % to 15 % of cultivated land. Other important crops are Aman/Aus, Jute, Boro, Wheat, Pulses and Oilseeds.

Some irrigation

People seriously affected

Town	30,000
Rural Area	1,000

	31,000

N.B BR passenger ferry ghat and BIWTA ferry ghat.

APPENDIX B

METHODOLOGY FOR ESTIMATING AGRICULTURAL COSTS AND BENEFITS

239

RIVER TRAINING STUDIES OF THE BRAHMAPUTRA RIVER

MASTER PLAN REPORT

ANNEX 2, APPENDIX B: METHODOLOGY FOR ESTIMATING THE AGRICULTURAL COSTS AND BENEFITS

CONTENTS

TABLES

FIGURES

23 2

1. INTRODUCTION

Most of the agricultural benefits from flood control have resulted principally from an expansion of HYV T Aman areas during the Kharif season replacing either B Aman or a mixture of B Aus and B Aman. To a lesser extent, benefits can also be attributed to the protection of HYV Boro, but this is more speculative since Boro is usually harvested before flooding becomes a threat. Availability of irrigation is, by far, the most important determinant of HYV Boro production. However, as HYV Boro spreads to more marginal areas, flood protection increases in importance.

In the analysis the impact of flooding from breaches on the present and future agricultural development in the BRE protected area has been based on the following key parameters:

- cultivated areas within each flood regime in Present (P), Future With Project (FW), i.e. protected by BRE, and Future Without Project (FWO) - i.e. with breach in BRE.
- irrigated areas (P, FW and FWO)
- cropping patterns (P, FW and FWO)
- input use, yields and prices (P, FW and FWO)

The other main agricultural benefit from flood control is the reduction in crop damage. In the analysis, the incremental crop losses (i.e. in addition to the present damage) resulting directly from a breach in the BRE have been evaluated.

The methodology, assumptions and data sources used in the analysis are discussed in the following sections.

290

2. CROPPING SYSTEMS AND CROP PRODUCTIVITY

2.1 Flood Regime

Micro-elevations have a major influence on cropping systems and crop production in Bangladesh. For the purpose of assessing flood control options, the Master Plan Organisation (MPO) categorized the various micro-elevation into land types based primarily on flood depth, namely:

Land Type	Flood Depth
F0 (Highland)	> 0.3 m
F1 (Medium Highland)	0.3 - 0.9 m
F2 (Medium Lowland)	0.9 - 1.9 m
F3 (Lowland)	> 1.8 (Seasonal)
F4 (Very Lowland)	> 1.8 (for 9 months +)

This classification has in the past been useful, at the national planning level, as a basis for assessing the agricultural impact of FCD/FCDI projects. However, with the widespread adoption of High Yielding Varieties (HYVs) of rice, as well as Local Improved Varieties (LIVs), farmers are determining their cropping systems on, slightly different criteria. This criteria is based on the farmers' perception of the expected [1]/ timing, duration and depth of flooding and their guiding principles are as follows:

(a) Flood depths in excess of 0.3 m over a period of greater than 10 days during transplanting and growing period in the Kharif season severely limits the cultivation of short-statured HYV Aus and Aman rice. Areas with a flood depths of normally less than 0.3 m, i.e. F0 in the MPO classification, are suitable for HYV Aus and Aman rice production.

(b) Local and LIV transplanted Aus and Aman rice can only be grown where water levels do not rise above 0.6 m for a duration in excess of 10 days between transplanting and when the plant is fully grown and the panicle has emerged. This is the farmers' perception of F1 land, i.e between 0.3 m to 0.6m, which is suitable for the taller local (and LIV) transplanted Aus and Aman varieties of rice in the Kharif season. The MPO limit of 0.9 m is too high.

(c) Broadcast Aus and Aman rice (low yielding local varieties) are suitable for areas with a typical flood depth of between 0.6 m and 1.5 m (of 10 days + duration) during the Kharif season. This is regarded as F2 land.

1 Expectation of an average flood event over a five year return period.

292

(d) Lowland land, i.e with flood depths typically in excess of 1.5 m, is only suitable for broadcast Aman rice and/or deep water (floating) rice. The limit to this F3 category is perceived as 3.0 m.

(e) Deeply flooded areas (i.e. in excess of 3.0 m) has extremely limited cropping potential and is generally used for fisheries.

For the purpose of this analysis, the following classification has therefore been applied: - F0 (<0.3 m), F1 (0.3 - 0.6 m), F2 (0.6 - 1.5 m), F3 (1.5 - 3.0 m) and F4 (3.0 m+). This corresponds to the classification currently being used by BWDB for analysis of FCD/FCDI projects.

The normal practice in Bangladesh is to determine typical cropping patterns for each flood regime within the project area, and then estimate the proportion of the area lying within the various regimes. Future cropping scenarios are then derived on the basis of changes to areas within each flooding regime. The proportions of the present area lying within each flood regime are given in Table 1.

The estimation of the incremental changes to flood depths, duration and timing as a result of breaches in the BRE, and the consequent effect on flood regimes in the BRE protected area, have been undertaken with the aid of a hydrodynamic model. The methodology and assumptions used in this breach simulation model are discussed in Annex 2 of the BRTS 2nd Interim Report.

2.2 Irrigation Development

During the 1980s, there has been a very dramatic increase in Rabi season irrigation within the BRE protected area. The growth in the number of STW, Deep Tubewells (DTW) and Low Lift Pumps (LLPs) currently operating in Pabna and Bogra Districts is given in Table 2.

With the availability of irrigation, farmers will grow HYV Boro rice in preference to almost any other crop. The yield advantage (see Section 2.5), together with the significantly reduced risk from flood damage, explains this preference. In addition, HYV Boro rice is given the highest priority with regard to the distribution of irrigation water, often to the exclusion of all other Rabi crops. The rapid expansion of the irrigated area is therefore reflected in an exponential increase in HYV Boro rice production during the past decade (Table 3).

It is currently estimated that almost 60 % of the cultivated area of Bogra District and 30 % of the cultivated area of Pabna District now is planted with HYV Boro in the Rabi Season. In the analysis, the present situation has assumed these levels of irrigation development. In order to highlight the differences in both flood regimes and irrigation development, the BRE protected area was divided in two zones - Northern and Southern (Figure B1). Cropping patterns were then derived for each zone separately. The Northern Zone lies almost exclusively within Bogra District, while the Southern Zone largely corresponds with Sirajganj (ex Pabna) District.

In the FWO and FW project scenarios, it has been assumed that the proportions of irrigated area within each zone would continue to expand. The irrigated area in the Northern Zone is expected to expand to a maximum of 80% of the cultivated area within the next ten years, while the irrigated area in the Southern Zone is projected to increase to 50 %. It is understood that the availability of groundwater is not a major constraint to further tubewell development in the NW Region (FAP-2 are exploring this aspect). However, there are likely to be other social and institutional (and possibly economic) constraints which may restrict the full development of groundwater resources. It is also very unlikely that Boro rice would account for 100 % of Rabi cropping, as farmers will continue to allocate a certain proportion of land to oilseeds/pulses, potatoes and winter vegetables.

In the analysis, it is anticipated that there would be no marked difference in future irrigation development between the FW and FWO situations.

2.3 Cropping Patterns

Changes to flood regimes as a consequence of breaches in the BRE, coupled with irrigation development in the protected area, have significant implications for future cropping systems. In order to predict the effect of these changes, it was necessary to derive typical cropping patterns by flood regime and irrigation availability.

Eight different cropping patterns were prepared for the present situation, representating four flood regimes (F0, F1, F2 and F3) in each of the agricultural zones. (Flood regimes - F3 and F4 have been considered jointly).

The present cropping patterns have been derived with reference to a variety of secondary sources, including BBS crop area statistics, FAP-2 survey results, FAP-12 survey results (Kazipur and Kamarjani Rapid Rural Appraisals), MPO agricultural models and in consultation with agricultural extension officers familiar with the area. The present cropping patterns used in the analysis are given in Table 4, and illustrated in Figures B2 and B3.

The cropping patterns in the FW and FWO situations were derived on the basis of trends in irrigation development and, in particular, on the flood regimes expected to prevail following a breach (in FWO situation) and fully protected (in FW situation). The changes in the proportions of area lying within each flood regime were determined by the Breach Simulation Model. It should be noted that, if the effects of further irrigation development are excluded, only the overall cropping patterns for each zone (weighted by proportions of F0 to F3 land) are altered as a result of a breach; the separate cropping patterns for each flood regime remain unchanged. In the FW and FWO situations, cropping patterns are intended to reflect agronomically feasible systems (bearing in mind farmers' preferences) under specific flood conditions. The cropping patterns used in the analysis are dominated by rice production which reflects reality as well as farmers' preferences. The most significant benefit from flood control (i.e. without breach) is that it is possible to expand T Aman rice (HYV and LIV) as the expence of low yielding B Aman rice. Changes in the levels of flood control are not expected to have any significant impact on crop diversification, so the areas of minor Rabi crop, (such as oilseeds, pulses, potatoes and vegetables) remained in similar proportions.

Details of the cropping patterns used in the analysis for the FW and FWO project situations are given in Table 5 and 6 respectively.

296

2.4 **Crop Input Use**

Estimates of the present, FW and FWO project levels of input use have been made for the following crop:

Broadcast Aus	(B Aus)
Transported Aus	(T Aus) - LIV and HYV
Broadcast Aman	(B Aman)
Transplanted Aman	(T Aman) - LIV and HYV
Mixed B Aus and B Aman	
Local Boro	
HYV Boro	
Jute	
Wheat	
Oilseeds/Pulses	
Potatoes	
Sugar Cane	
Vegetables	

Data on crop input use (i.e. labour, draft power, seeds, fertilizer, pesticides, and organic manure) were collected from a variety of sources.

- MPO Technical Report No. 14 - Agricultural Production Systems;
- MOA Agro-Economic Research - Costs and Returns;
- FAP-12 survey results for Kazipur and Kamarjani RRAs;
- FAP-2 pre-feasibility studies.

The crop input assumptions applied in the analyses for P, FW and FWO situations were derived from a sythesis of the above sources, and are presented in Table 7.

2.5 **Crop Yields**

The levels of crop productivity used in the analyses are based on the sources listed above under Crop Input Use (2.4). While there is a reasonable consensus with regard to the estimates of present yield levels, there is some controversy with regard to appropriate yield levels in the FWO and FW project situations. In particular, MPO future yield levels appear to be significantly higher than other sources.

Previous appraisals of FCD/FCDI projects have commonly assumed the agricultural extension programme would accompany projects and therefore farmers would use recommended levels of inputs and consequently obtain higher yields.

298

In practice, while FCD projects have generally led to a significant change in cropping patterns (due to altered flood regimes), it appears that there is little consistent evidence to suggest that FCD projects have any impact on crop yields. Results currently available from FAP-12 are clearly indicating that FCD/FCDI projects have little or no direct effect on yield levels.

Nevertheless, in the current analysis, a more optimistic view has been taken. Modest increases in the yields of T Aus (LIV and HYV), T Aman (LIV and HYV) and Boro (HYV) were assumed to rise in both the FW and FWO situation over next ten years, as farm management practices improved. No difference in crop productivity has been assumed between the FW and FWO situations. For all other crops, no improvement on the present yield levels is anticipated.

Crop yields in the present, FW and FWO project situations used in the analysis are given in Table 8.

3. AGRICULTURAL COSTS AND BENEFITS

3.1 Financial and Economic Prices

The financial input and output prices used in the analysis were obtained from price data collected by FAP-2. With regard to crop prices, FAP-2 collected 1991 prices from the Directorate of Agricultural Marketing. There was a high degree of uniformity between the prices at the twenty survey locations in the N.W. Region, so average farm gate prices were determined and used in the FAP-2 pre-feasibility studies.

Labour wages rates, draft power hire charges and the prices of organic manure were collected by FAP-2 through field survey and reflect the average prices prevailing in 1991.

Fertilizer prices were collected by FAP-2 from the July 1991 Regional data gathered by IFDC. This data showed almost uniform price throughout the N.W. Region. Seed prices were gathered from the Directorate of Agricultural Marketing where available (mainly for paddy); for other seed prices a factor of 1.5 was applied to the respective crop output price.
The conversion of financial prices to economic prices followed the recommendations in the FAP Guidelines for Project Assessment. The conversion factors given in Annex 6 of the guidelines were used. The financial and economic prices for crops are presented in Table 9.

3.2 Costs of Minor Irrigation

The capital and operating costs of different types of irrigation were estimated from MPO data. Capital costs were annualized in order to determine average annual costs per hectare irrigated. Depreciation periods for LLP and STW were taken as five years for engines, seven years for pumps and ten years for wells (based on the estimates given in MPO Technical Report No. 13). For DTWs, engines have been depreciated over seven years, pumps over ten years and the well over 15 years. It was also assumed that only HYV Boro and HYV T Aman are irrigated, and that 80 % of the annual costs would be attributed to the Boro crop and 20 % to the Aman crop. The estimated costs of minor irrigation used in the analysis is given in Table 10.

3.3 Crop Budgets

The physical input and output quantities presented in Tables 7 and 8 were valued in terms of their respective economic prices (Table 9) in order to prepare a series of crop budgets for the P, FW and FWO Project situations, Economic crop gross margins were than determined, and a summary of the results of the crop budget analysis is given in Table 11. Crop budgets were prepared in economic terms, since the economic viability of the proposed project is of primary interest at this stage.

3.4 Incremental Agricultural Benefits

Net agricultural benefits in P, FW and FWO project situations were derived by multiplying the areas of each crop by their respective economic gross margins. The analysis was undertaken separately for the Northern and Southern zones and then aggregated. A summary of the net agricultural benefits in P, FW and FWO project situations at Mathurapara/Sariakandi priority location is presented in Table 12.

Incremental agricultural benefits are then derived from the difference between the net agricultural benefit streams between the FW and FWO project scenarios over a 30 year appraisal period. These net agricultural benefit streams were then carried forward into the overall project cost and benefit appraisal.

Table 1 Proportion of BRE Protected Area Within Each Flood Regime

Flood Regime	Southern Zone (% of Cultivated Area)	Northern Zone
F0	74.1 %	98.5 %
F1	6.7 %	0.1 %
F2	14.2 %	0.3 %
F3	5.0 %	1.1 %

N.B F4 is included under F3 and accounts for an insignificant proportion of cultivated area.

Source: Consultants' Estimate.

Table 2 Irrigation Development in Bogra and Pabna Districts

A) Shallow Tubewells

Area Irrigation by District from 1980-81 to 1986-87 (Area in Ha)

District	1980-81 Area Irrigated	1981-82 Area Irrigated	1982-83 Area Irrigated	1983-84 Area Irrigated
Bogra	18990	36635	37241	38704
Pabna	14060	24976	32864	24756

	1984-85	1985-86	1986-87
Bogra	32406	16215	37351
Pabna	24289	3231	32899

B) Deep Tubewells

District-wise Progress of DTW from 1980-81 to 1987-88 (Area in Ha)

District	1980-81 Area Irrigated	1981-82 Area Irrigated	1982-83 Area Irrigated	1983-84 Area Irrigated
Bogra	23109	27299	48672	41662
Pabna	5434	12051	32272	29419

	1984-85	1985-86	1986-87	1987-88
Bogra	43886	35574	37092	42117
Pabna	32975	24879	23636	271319

Table 2 (Continued) Irrigation Development in Bogra and Pabna Districts

C) Low Lift Pumps

Area Irrigated by District from 1980/81 to 1987/88 (Area in Ha).

District	1980-81 Area Irrigated	1981-82 Area Irrigated	1982-83 Area Irrigated	1983-84 Area Irrigated
Bogra	7494	6803	11099	9787
Pabna	8656	6560	12952	11640

	1984-85	1985-86	1986-87	1987-88
Bogra	19530	28499	30977	31968
Pabna	22581	20978	24165	24709

Source: BADC

Table 3 HYV Boro Paddy-Cultivated Area (ha) and Yields (mt/ha) between 1977-78 and 1989-90

A.	**Area (ha)**												
	1977-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90
Bogra	20012	21502	22387	23036	36387	44393	68409	75988	88075	93522	140457	156846	169854
Pabna	9957	8745	8846	10943	29814	36174	44294	47939	47484	51417	76306	86334	95802
B.	**Yield (mt/ha)**												
Bogra	4.01	4.26	4.29	4.54	4.48	4.36	4.22	4.43	4.59	3.99	4.01	4.1	3.75
Pabna	4.48	3.4	3.94	4.45	4.55	4.97	4.29	4.63	5.21	4.35	3.94	4.15	4.03

N.B. Total cultivated area in Bogra and Pabna

Districts is estimated at 297,000 ha. and 370,000 ha. respectively.

Source: Bangladesh Bureau of Statistics.

Table 4 - Present Cropping Patterns in the BRE Project Area

A) NORTHERN ZONE

Crop	% of Cultivated Area				
	F0	F1	F2	F3	Overall
B.Aus (L)	0	5	5	0	0
T.Aus (L/LIV)	10	10	0	0	10
T.Aus (HYV)	10	5	0	0	10
B.Aus/B.Aman	0	10	10	15	0
Jute	5	0	0	0	5
B.Aman (L)	0	0	20	15	0
T.Aman (L/LIV)	35	75	0	0	35
T.Aman (HYV)	50	0	0	0	49
Boro (L)	0	0	0	0	0
Boro (HYV)	60	60	60	60	60
Wheat	5	6	11	27	5
Oilseed/Pulses	6	8	8	0	6
Potatoes	6	8	8	0	6
Sugar Cane	10	5	0	0	10
Vegetables/Chillies	8	8	8	8	8
Cropping Intensity	205	200	130	125	204
% of Total Area	98.5	0.1	0.3	1.08	100

Table 4 - Present Cropping Patterns in the BRE Project Area

B) SOUTHERN ZONE

Crop	% of Cultivated Area				
	F0	F1	F2	F3	Overall
B.Aus (L)	15	10	10	0	13
T.Aus (L/LIV)	15	20	0	0	12
T.Aus (HYV)	20	10	0	0	15
B.Aus/B.Aman	0	15	25	30	6
Jute	5	5	0	0	4
B.Aman (L)	0	0	30	30	6
T.Aman (L/LIV)	35	75	0	0	31
T.Aman (HYV)	50	0	0	0	37
Boro (L)	0	0	0	0	0
Boro (HYV)	30	30	30	30	30
Wheat	24	30	20	32	24
Oilseed/Pulses	15	14	9	0	13
Potatoes	8	8	8	0	8
Sugar Cane	5	5	0	0	4
Vegetables/Chillies	8	8	8	8	8
Cropping Intensity	230	230	140	130	212
% of Total Area	74.05	6.73	14.15	5.07	100

Table 5 - FWO Cropping Patterns in the BRE Project Area.

A) NORTHERN ZONE

Crop	% of Cultivated Area				
	F0	F1	F2	F3	Overall
B.Aus (L)	0	0	0	0	0
T.Aus (L/LIV)	0	0	0	0	0
T.Aus (HYV)	10	5	0	0	9
B.Aus/B.Aman	0	10	10	10	1
Jute	0	0	0	0	0
B.Aman (L)	0	0	10	10	1
T.Aman (L/LIV)	35	75	0	0	35
T.Aman (HYV)	55	0	0	0	50
Boro (L)	0	0	0	0	0
Boro (HYV)	80	80	80	80	80
Wheat	0	0	0	7	0
Oilseed/Pulses	5	5	5	0	5
Potatoes	5	5	7	0	5
Sugar Cane	5	5	0	0	5
Vegetables/Chillies	5	5	8	8	5
Cropping Intensity	200	190	120	115	195
% of Total Area	90.34	4.64	3.19	1.83	100

Table 5 - FWO Cropping Patterns in the BRE Project Area.

B) SOUTHERN ZONE

Crop	% of Cultivated Area				
	F0	F1	F2	F3	Overall
B.Aus (L)	5	5	5	0	5
T.Aus (L/LIV)	10	10	0	0	7
T.Aus (HYV)	10	5	0	0	7
B.Aus/B.Aman	0	10	15	20	6
Jute	5	5	0	0	4
B.Aman (L)	0	0	25	20	6
T.Aman (L/LIV)	35	75	0	0	31
T.Aman (HYV)	50	0	0	0	30
Boro (L)	0	0	0	0	0
Boro (HYV)	50	50	50	50	50
Wheat	10	15	15	28	13
Pulse	10	10	10	0	9
Potatoes	8	8	8	0	7
Sugar Cane	5	5	0	0	4
Vegetables/Chillies	7	7	7	7	7
Cropping Intensity	205	205	135	125	186
% of Total Area	60.6	13.17	19.17	7.06	100

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Table 6 - FW Cropping Patterns in the BRE Project Area.

A) NORTHERN ZONE

Crop	% of Cultivated Area F0	F1	F2	F3	Overall
B.Aus (L)	0	0	0	0	0
T.Aus (L/LIV)	0	0	0	0	0
T.Aus (HYV)	10	5	0	0	10
B.Aus/B.Aman	0	10	10	10	0
Jute	0	0	0	0	0
B.Aman (L)	0	0	10	10	0
T.Aman (L/LIV)	35	75	0	0	35
T.Aman (HYV)	55	0	0	0	54
Boro (L)	0	0	0	0	0
Boro (HYV)	80	80	80	80	80
Wheat	0	0	0	7	0
Oilseed	5	5	5	0	5
Potatoes	5	5	7	0	5
Sugar Cane	5	5	0	0	5
Vegetables/Chillies	5	5	8	8	5
Cropping Intensity	200	190	120	115	199
% of Total Area	98.5	0.1	0.3	1.08	100

Table 6 - FW Cropping Patterns in the BRE Project Area.

B) SOUTHERN ZONE

Crop	% of Cultivated Area F0	F1	F2	F3	Overall
B.Aus (L)	5	5	5	0	5
T.Aus (L/LIV)	10	10	0	0	8
T.Aus (HYV)	10	5	0	0	8
B.Aus/B.Aman	0	10	15	20	4
Jute	5	5	0	0	4
B.Aman (L)	0	0	25	20	5
T.Aman (L/LIV)	35	75	0	0	31
T.Aman (HYV)	50	0	0	0	37
Boro (L)	0	0	0	0	0
Boro (HYV)	50	50	50	50	50
Wheat	10	15	15	28	12
Pulse	10	10	10	0	9
Potatoes	8	8	8	0	8
Sugar Cane	5	5	0	0	4
Vegetables/Chillies	7	7	7	7	7
Cropping Intensity	205	205	135	125	191
% of Total Area	74.05	6.73	14.15	5.07	100

Table 7a: Physical Input Quantities per Hectare under Present Conditions.

Crop	Labour (man days)			Draft Animals (pair days)			Seed (kgs)	Fertilizer (kgs)				Pesticide (kgs)	Irrign Charges (Taka)
	Own	Hired	Total	Own	Hired	Total	Total	Urea	TSP	MP	Cow Dung		
Broadcast Aus (L)	78	42	120	35	10	45	90	30	15	10	1500	0.0	0
Transplanted Aus (LIV)	105	53	158	35	10	45	30	75	40	10	0	0.3	0
Transplanted Aus (HYV)	119	60	179	35	10	45	30	125	60	20	0	0.5	825
Broadcast Aus/Aman (L)	81	44	125	35	10	45	100	30	15	10	0	0.0	0
Jute	140	70	210	35	10	45	10	30	30	10	0	0.0	0
Broadcast Aman (L)	67	33	100	35	10	45	90	0	0	0	1500	0.0	0
Transplanted Aman (LIV)	99	49	148	35	13	48	30	75	40	10	0	0.3	0
Transplanted Aman (HYV)	109	56	165	35	13	48	30	125	60	20	0	0.5	825
Boro (L)	67	33	100	35	10	45	30	50	20	10	0	0.0	0
Boro (HYV)	140	70	210	40	13	53	30	125	60	20	0	0.5	3300
Wheat	71	39	110	33	10	43	110	30	30	10	0	0.3	0
Oilseed/Pulses	39	11	50	30	5	35	20	30	30	10	0	0.3	0
Potato	158	42	200	45	5	50	1000	40	20	20	1500	0.8	825
Sugar Cane	189	61	250	45	5	50	5000	50	40	30	1500	0.8	0
Vegetables/Chillies	112	38	150	45	5	50	10	30	30	10	1500	0.3	825

284

Table 7b: Physical Input Quantities per Hectare under Future With and Without Project Conditions.

Crop	Labour (man days)			Draft Animals (pair days)			Draft Animals (kgs)	Seed		Fertilizer (kgs)			(kgs)	Pesticide Charges (Taka)	Irrign
	Own	Hired	Total	Own	Hired	Total	Total		Urea	TSP	MP	Cow Dung			
Broadcast Aus (L)		78	42	120	35	10	45	90		30	15	10	1500	0.0	0
Transplanted Aus (LIV)		112	56	168	36	11	47	30		100	50	20	0	0.3	0
Transplanted Aus (HYV)		126	63	189	36	11	47	30		150	75	30	0	0.5	825
Broadcast Aus/Aman (L)		81	44	125	35	10	45	100		30	15	10	0	0.0	0
Jute		140	70	210	35	10	45	10		30	30	10	0	0.0	0
Broadcast Aman (L)		67	33	100	35	10	45	90		0	0	0	1500	0.0	0
Transplanted Aman (LIV)		105	53	158	37	13	50	30		100	50	20	0	0.3	0
Transplanted Aman (HYV)		116	59	175	37	13	50	30		150	75	30	0	0.5	825
Boro (L)		67	33	100	35	10	45	30		50	20	10	0	0.0	0
Boro (HYV)		146	74	220	40	15	55	30		150	75	30	0	0.5	3300
Wheat		78	42	120	35	10	45	110		50	50	15	0	0.3	0
Oilseed/Pulses		39	11	50	30	5	35	20		30	30	10	0	0.3	0
Potato		158	42	200	45	5	50	1000		40	20	20	1500	0.8	825
Sugar Cane		189	61	250	45	5	50	5000		50	40	30	1500	0.8	0
Vegetables/Chillies		112	38	150	45	5	50	10		30	30	10	1500	0.3	825

Table 8: Yields per Hectare under Present, Future Without and Future With Project Conditions

Crop	Units	Present (P)	Future With and Without (FW & FWO)
Main Products:			
Broadcast Aus (L)	tonne/ha	1.25	1.25
Transplanted Aus (LIV)	"	2.25	2.50
Transplanted Aus (HYV)	"	3.50	3.75
Broadcast Aus/Aman (L)	"	1.50	1.50
Jute	"	1.50	1.50
Broadcast Aman (L)	"	1.20	1.50
Transplanted Aman (LIV)	"	2.25	2.50
Transplanted Aman (HYV)	"	3.50	3.75
Boro (L)	"	2.25	2.25
Boro (HYV)	"	4.00	4.25
Wheat	"	1.25	1.50
Oilseed/Pulses	"	0.85	0.85
Potato	"	6.50	6.50
Sugar Cane	"	42.00	42.00
Vegetables/Chillies	"	5.50	5.50
By Products:			
Broadcast Aus (L)	tonne/ha	1.88	1.88
Transplanted Aus (LIV)	"	2.93	3.25
Transplanted Aus (HYV)	"	3.50	3.75
Broadcast Aus/Aman (L)	"	1.95	1.95
Jute	"	3.00	3.00
Broadcast Aman (L)	"	1.44	1.80
Transplanted Aman (LIV)	"	2.25	2.50
Transplanted Aman (HYV)	"	3.15	3.38
Boro (L)	"	2.25	2.25
Boro (HYV)	"	3.20	3.40
Wheat	"	1.25	1.50
Oilseed/Pulses	"	0.85	0.85
Potato	"	0.00	0.00
Sugar Cane	"	0.00	0.00
Vegetables/Chillies	"	0.00	0.00

Notes:

The yields of major food crops (i.e. rice and wheat) under the FWO and FW conditions reflect better farming practices, improved varieties and greater availability of irrigation water from further tubewell development. The increase in yields from the Present to FWO and FW conditions is assumed to occur over a ten year period commencing in 1991.

Table 9a: Financial and Economic Farmgate Prices for Major Agricultural Inputs and Outputs. (Taka, 1991).

Commodities	Unit	Financial Prices	Conversion Factor	Economic Prices
FARM OUTPUTS:				
Main Products:				
Broadcast Aus (L)	kg	5.36	0.97	5.20
Transplanted Aus (LIV)	kg	5.36	0.97	5.20
Transplanted Aus (HYV)	kg	5.71	0.97	5.54
Broadcast Aus/Aman (L)	kg	5.71	0.97	5.54
Jute	kg	5.75	0.82	4.72
Broadcast Aman (L)	kg	6.04	0.97	5.86
Transplanted Aman (LIV)	kg	6.04	0.97	5.86
Transplanted Aman (HYV)	kg	6.06	0.97	5.88
Boro (L)	kg	5.89	0.97	5.71
Boro (HYV)	kg	5.93	0.97	5.75
Wheat	kg	6.66	0.98	6.53
Oilseed/Pulses	kg	11.00	0.92	10.12
Potato	kg	4.50	0.92	4.14
Sugar Cane	kg	0.70	0.92	0.64
Vegetables/Chillies	kg	4.50	0.92	4.14
By Products:				
Broadcast Aus (L)	tonne	700	0.82	574
Transplanted Aus (LIV)	tonne	750	0.82	615
Transplanted Aus (HYV)	tonne	750	0.82	615
Broadcast Aus/Aman (L)	tonne	700	0.82	574
Jute	tonne	1500	0.82	1230
Broadcast Aman (L)	tonne	750	0.82	615
Transplanted Aman (LIV)	tonne	800	0.82	656
Transplanted Aman (HYV)	tonne	800	0.82	656
Boro (L)	tonne	750	0.82	615
Boro (HYV)	tonne	750	0.82	615
Wheat	tonne	400	0.82	328
Oilseed/Pulses	tonne	500	0.82	410
Potato	tonne	0	0.82	0
Sugar Cane	tonne	0	0.82	0
Vegetables/Chillies	tonne	0	0.82	0

Table 9b: Financial and Economic Farmgate Prices for Major Agricultural Inputs and Outputs, (Taka, 1990) - Continued.

FARM INPUTS:				
Unskilled Labour	Man Day	30	0.71	21.30
Draft Power	Pair Day	30	0.82	24.60
Seeds:				
Broadcast Aus (L)	kg	11.00	0.97	10.67
Transplanted Aus (LIV)	kg	11.00	0.97	10.67
Transplanted Aus (HYV)	kg	10.50	0.97	10.19
Broadcast Aus/Aman (L)	kg	10.50	0.97	10.19
Jute	kg	25.00	0.82	20.50
Broadcast Aman (L)	kg	10.00	0.97	9.70
Transplanted Aman (LIV)	kg	10.00	0.97	9.70
Transplanted Aman (HYV)	kg	9.00	0.97	8.73
Boro (L)	kg	11.00	0.97	10.67
Boro (HYV)	kg	10.00	0.97	9.70
Wheat	kg	12.00	0.98	11.76
Oilseed/Pulses	kg	11.00	0.92	10.12
Potato	kg	12.50	0.92	11.50
Sugar Cane	kg	0.79	0.92	0.73
Vegetables/Chillies	kg	80.00	0.92	73.60
Chemical Fertilizer:				
Urea	kg Product	4.90	1.54	7.55
TSP	kg Product	5.55	1.09	6.05
MP	kg Product	4.44	1.43	6.35
Cow dung	kg Product	0.50	0.82	0.41
Pesticides:				
Average Cost of Pesticide	kg Product	500.00	0.91	455.00

Table 10 Costs of Minor Irrigation

Type	Command Area (ha)	Costs per Hectare (Taka/year)	
		Financial	Economic
Low lift pump	16	4051	2768
Shallow tubewell	5	5576	3992
Deepast STW	5	6162	4301
Deep tubewell	24	5895	4226

Source: Consultants' Estimate

Table 11a: Gross Margin per Crop per Hectare under Present Conditions, (Taka, 1991 ECONOMIC PRICES).

Crop	Gross Value of Production	Non-Family Inputs	All Inputs Including Family Resources	Gross Margin Excluding Family Resources	Gross Margin Including Family Resources
Broadcast Aus (L)	7575	3097	5619	4479	1956
Transplanted Aus (LIV)	13497	2680	5778	10817	7719
Transplanted Aus (HYV)	21538	3890	7286	17648	14252
Broadcast Aus/Aman (L)	9427	2582	5169	6845	4259
Jute	10763	2413	6256	8349	4506
Broadcast Aman (L)	7916	2437	4725	5479	3191
Transplanted Aman (LIV)	14658	2640	5609	12019	9049
Transplanted Aman (HYV)	22640	3835	7018	18805	15622
Boro (L)	14239	1831	4119	12408	10120
Boro (HYV)	24976	6963	10929	18014	14048
Wheat	8569	2955	5280	5613	3289
Oilseed/Pulses	8951	1145	2714	7806	6237
Potato	26910	14024	18496	12886	8414
Sugar Cane	27048	6822	11955	20226	15093
Vegetables/Chillies	22770	2869	6361	19901	16409

Table 11b: Gross Margin per Crop per Hectare under Future With and Without Project Conditions, (Taka, 1991 ECONOMIC PRICES).

Crop	Gross Value of Production	Non- Family Inputs	All Inputs Including Family Resources	Gross Margin Excluding Family Resources	Gross Margin Including Family Resources
Broadcast Aus (L)	7575	3097	5619	4479	1956
Transplanted Aus (LIV)	14997	3081	6353	11915	8644
Transplanted Aus (HYV)	23076	4322	7891	18755	15185
Broadcast Aus/Aman (L)	9427	2582	5169	6845	4259
Jute	10763	2413	6256	8349	4506
Broadcast Aman (L)	9895	2437	4725	7458	5170
Transplanted Aman (LIV)	16287	3038	6184	13249	10103
Transplanted Aman (HYV)	24257	4242	7623	20015	16634
Boro (L)	14239	1831	4119	12408	10120
Boro (HYV)	26537	7440	11534	19098	15004
Wheat	10282	3323	5845	6959	4437
Oilseed/Pulses	8951	1145	2714	7806	6237
Potato	26910	14024	18496	12886	8414
Sugar Cane	27048	6822	11955	20226	15093
Vegetables/Chillies	22770	2869	6361	19901	16409

Table 12: Net Agricultural Benefits - Present, FWO and FW Project Situations at Sariakandi/Mathurapura.

PRESENT SITUATION

Crop	% Cropped Area	Total Area(ha)	Net Benefit (Tk/ha)	Net Agric. Benefit ('000 Tk.)
B.Aus (L)	5	8545	1956	16717
T.Aus (LIV)	11	19937	7719	153902
T.Aus (HYV)	12	21888	14252	311941
B.Aus/Aman (L)	2	4160	4259	17717
Jute	5	8550	4506	38525
B.Aman	2	3987	5170	20612
T.Aman (LIV)	33	61676	9049	558100
T.Aman (HYV)	45	83322	15622	1301677
Boro (L)	0	0	10120	0
Boro (HYV)	50	91724	14048	1288524
Wheat	12	21929	3289	72125
Oilseed/Pulses	9	15770	6237	98360
Potato	7	12071	8414	101561
Sugar Cane	9	16888	15093	254887
Vegetables/Chillies	8	14813	16409	243067
Total	208	385259	136143	4477715

FWO PROJECT SITUATION

Crop	% Cropped Area	Total Area(ha)	Net Benefit (Tk/ha)	Net Agric. Benefit ('000 Tk.)
B.Aus (L)	2	3001	1956	5871
T.Aus (LIV)	3	4764	8644	41184
T.Aus (HYV)	8	15512	15185	235556
B.Aus/Aman (L)	3	4784	4259	20375
Jute	1	2382	4506	10734
B.Aman (L)	2	4612	5170	23847
T.Aman (LIV)	34	62400	10103	630415
T.Aman (HYV)	43	79482	16634	1322122
Boro (L)	0	0	10120	0
Boro (HYV)	70	128757	15004	1931842
Wheat	5	8478	4437	37615
Oilseed/Pulses	6	11921	6237	74352
Potato	6	10798	8414	90850
Sugar Cane	5	10065	15093	151917
Vegetables/Chillies	6	10731	16409	176092
Total	193	357688	142171	4752771

Table 12: Net Agricultural Benefits - Present, FWO and FW Project Situations at Sariakandi/Mathurapura.

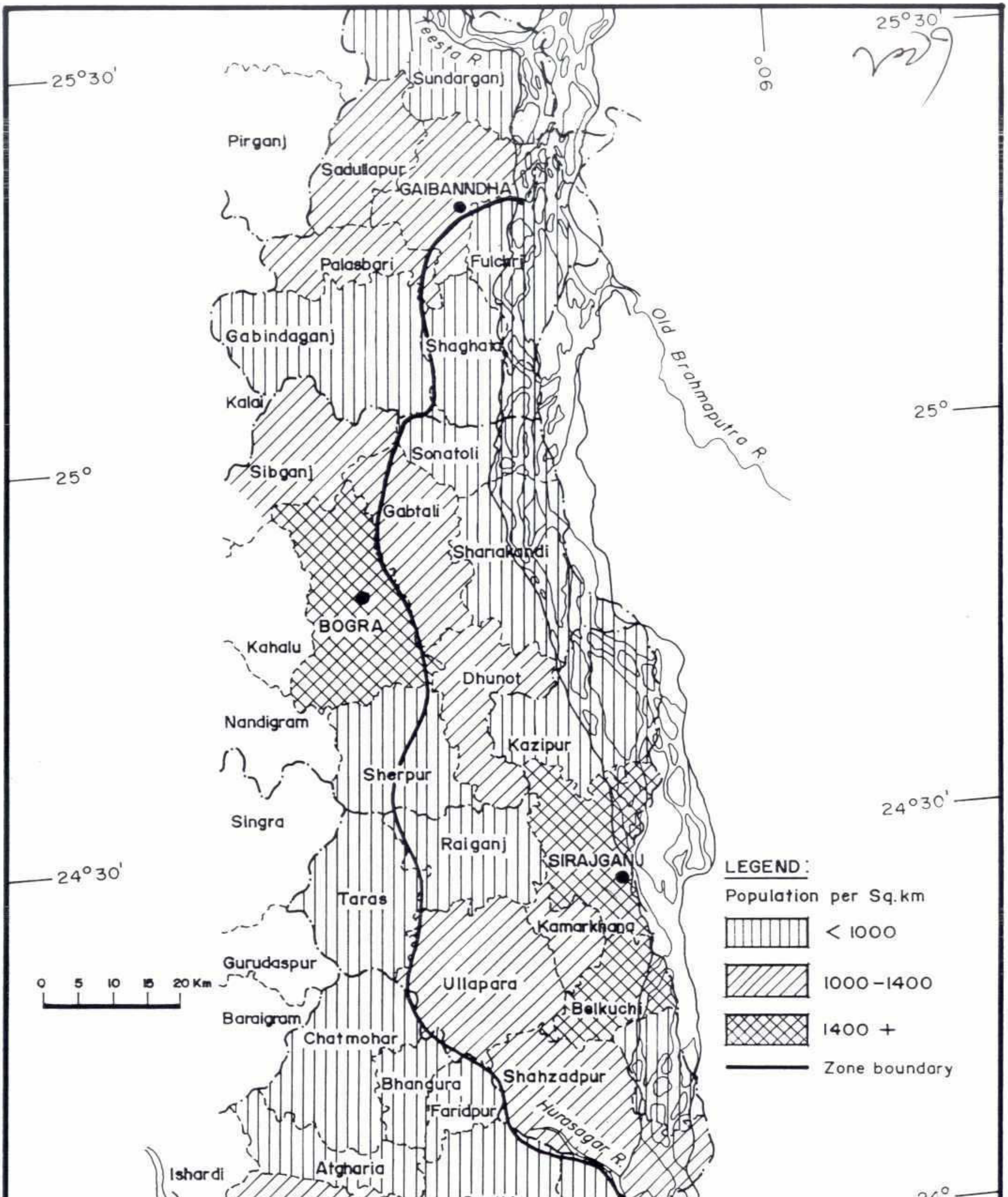
(Sheet 2 of 2)

FW PROJECT SITUATION

Crop	% Cropped Area	Total Area(ha)	Net Benefit (Tk/ha)	Net Agric. Benefit ('000 Tk.)
B.Aus (L)	2	3065	1956	5997
T.Aus (LIV)	3	5217	8644	45097
T.Aus (HYV)	9	16888	15185	256447
B.Aus/Aman (L)	1	2636	4259	11227
Jute	1	2609	4506	11754
B.Aman (L)	2	3103	5170	16046
T.Aman (LIV)	33	61676	10103	623098
T.Aman (HYV)	48	89263	16634	1484829
Boro (L)	0	0	10120	0
Boro (HYV)	70	128757	15004	1931842
Wheat	4	7813	4437	34665
Oilseed/Pulses	7	12095	6237	75435
Potato	6	10875	8414	91505
Sugar Cane	6	10947	15093	165219
Vegetables/Chillies	6	10599	16409	173919
Total	197	365543	142171	4927082

FWO PROJECT SITUATION (Year 1)

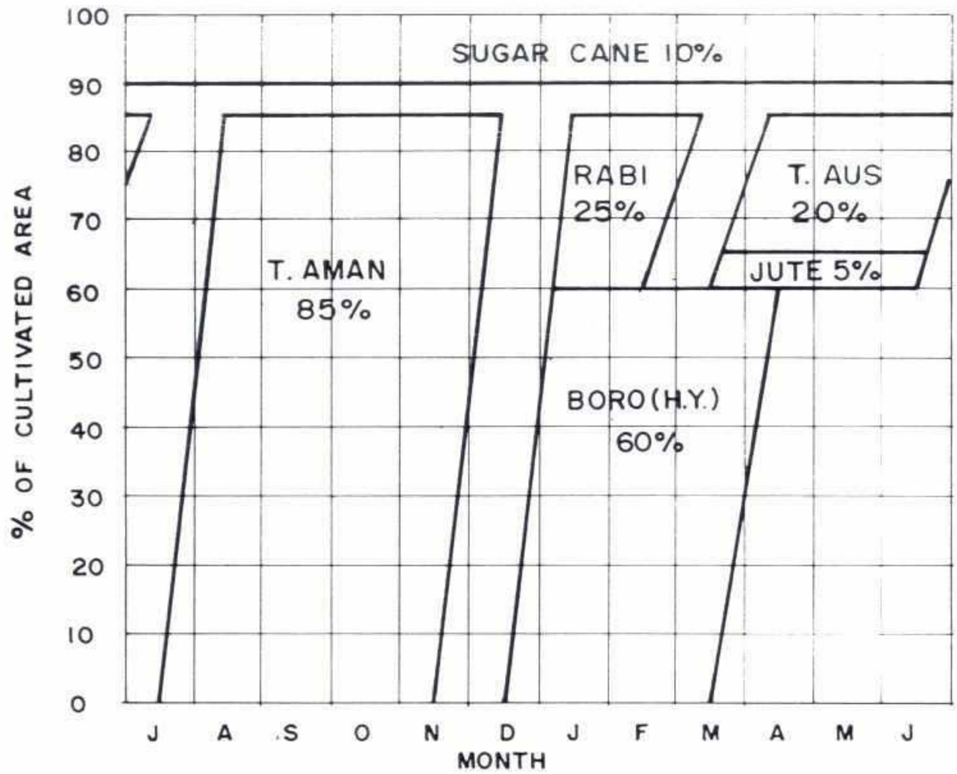
Crop	% Cropped Area	Total Area(ha)	Net Benefit (Tk/ha)	Net Agric. Benefit ('000 Tk.)
B.Aus (L)	5	8431	1956	16494
T.Aus (LIV)	10	19025	7719	146858
T.Aus (HYV)	11	19851	14252	282918
B.Aus/Aman (L)	4	7014	4259	29871
Jute	4	7829	4506	35278
B.Aman (L)	3	6182	5170	31964
T.Aman (LIV)	34	62400	9049	564654
T.Aman (HYV)	40	74035	15622	1156593
Boro (L)	0	0	10120	0
Boro (HYV)	50	91724	14048	1288524
Wheat	12	22681	3289	74598
Oilseed/Pulses	8	15467	6237	96467
Potato	7	12093	8414	101751
Sugar Cane	8	15512	15093	234124
Vegetables/Chillies	8	14813	16409	243067
Total	204	377057	136143	4303161



Agricultural Zones in the BRE Project Area

	Annex 2 Appendix B
Halcrow/DHI/EPC/DIG *May 1993*	Figure B1

F0



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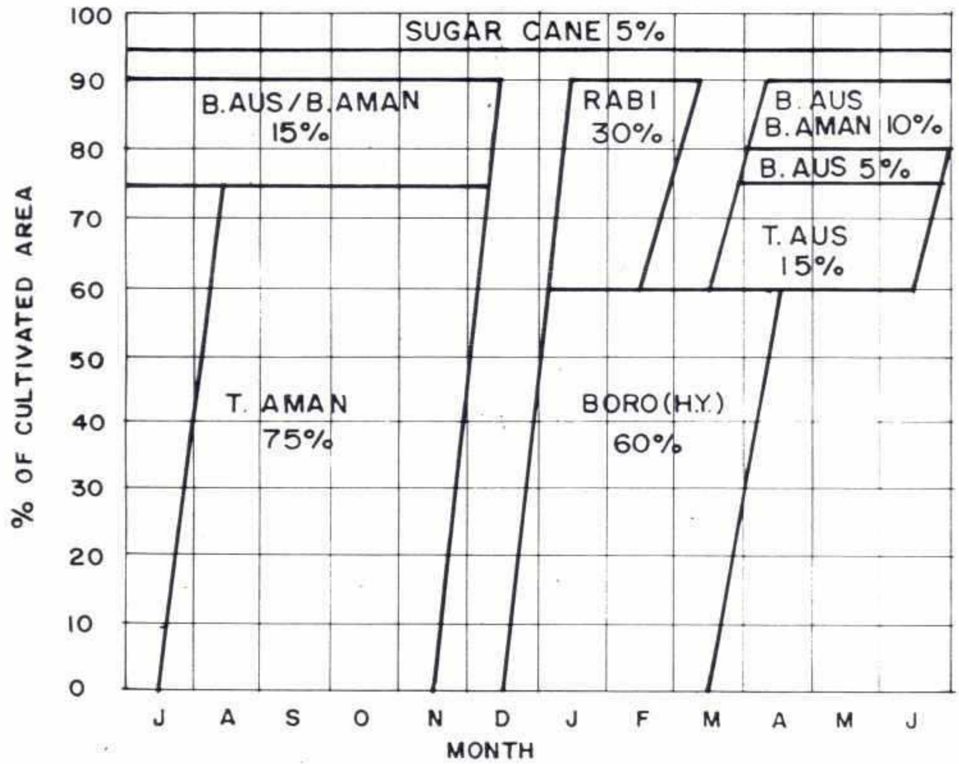


F0 = < 0.3 m Flood depth

F1 = 0.3m to 0.6m Flood depth

Crop Calendars for Northern Zone of BRE Project Area

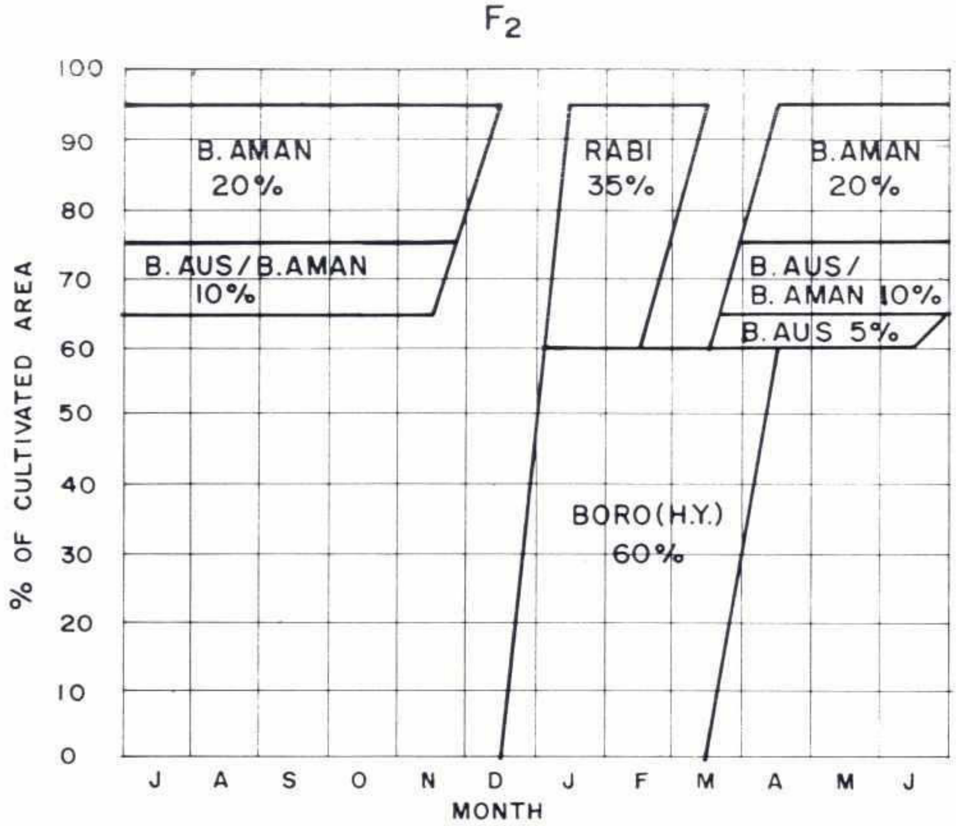
(Sheet 1 of 2)

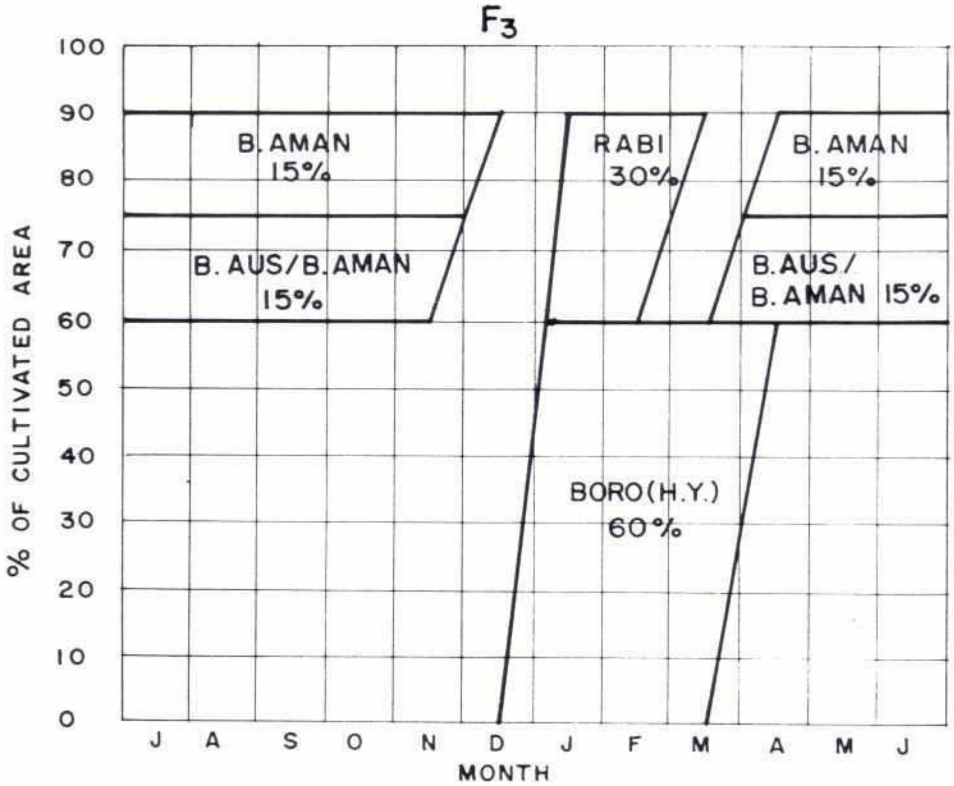
Halcrow/DHI/EPC/DIG

May 1993

Annex 2 Appendix B

Figure B2





F_2 = 0.6 m to 1.5 m Flood depth.

F_3 = > 1.5 m Flood depth.

Crop Calendars for Northern Zone of BRE Project Area

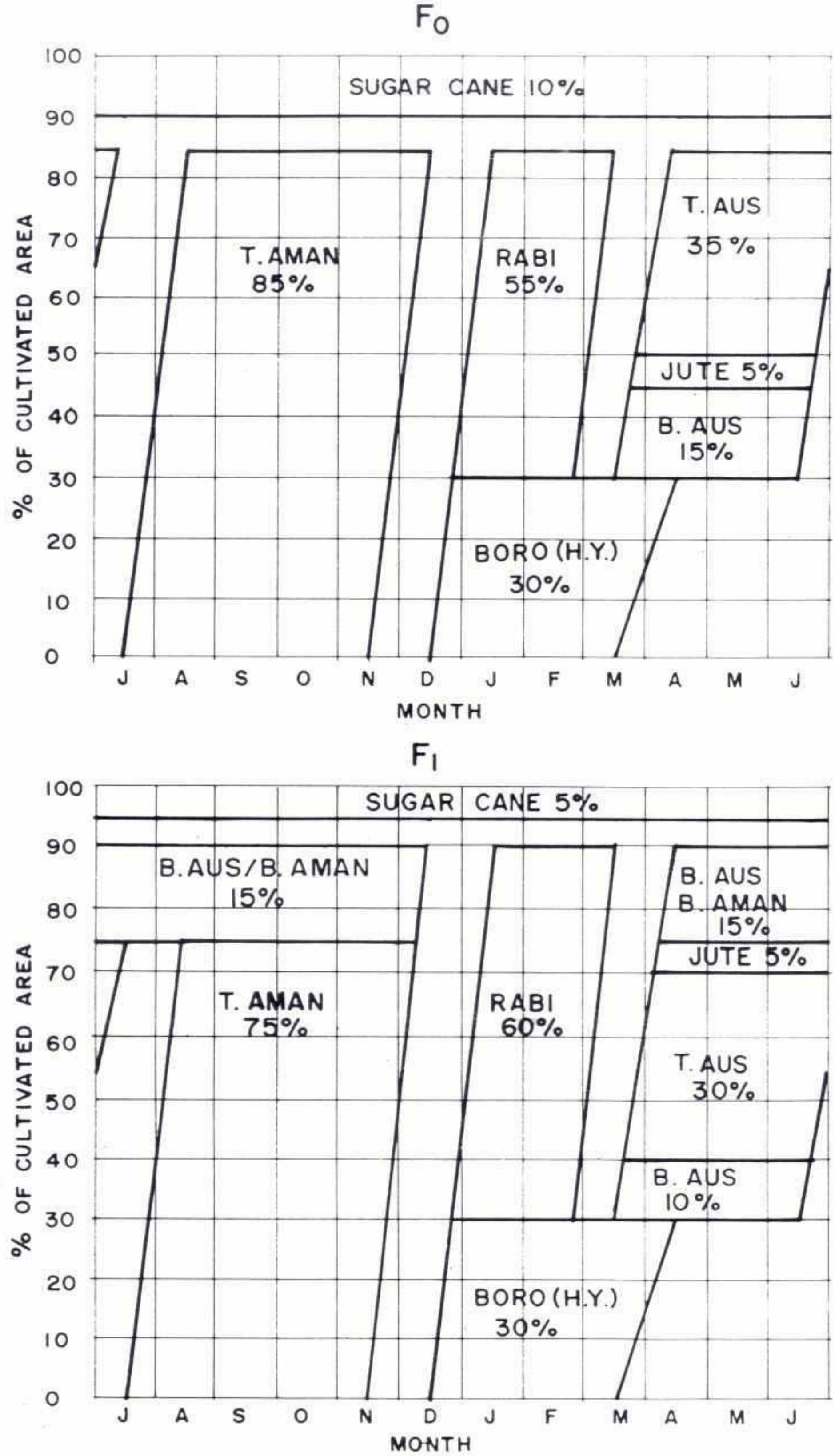
(Sheet 2 of 2)

Annex 2 Appendix B

Figure B2

Halcrow/DHI/EPC/DIG *May 1993*

200



F_0 = < 0.3m Flood depth

F_1 = 0.3m to 0.6m Flood depth.

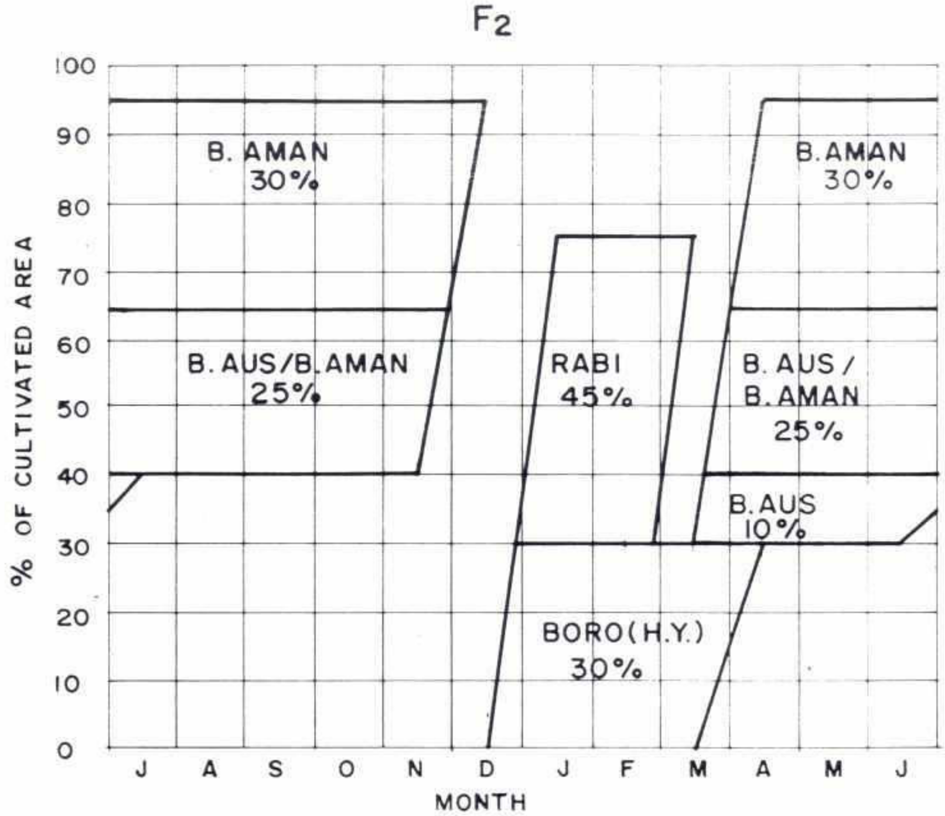
Crop Calendars for Southern Zone of BRE Project Area

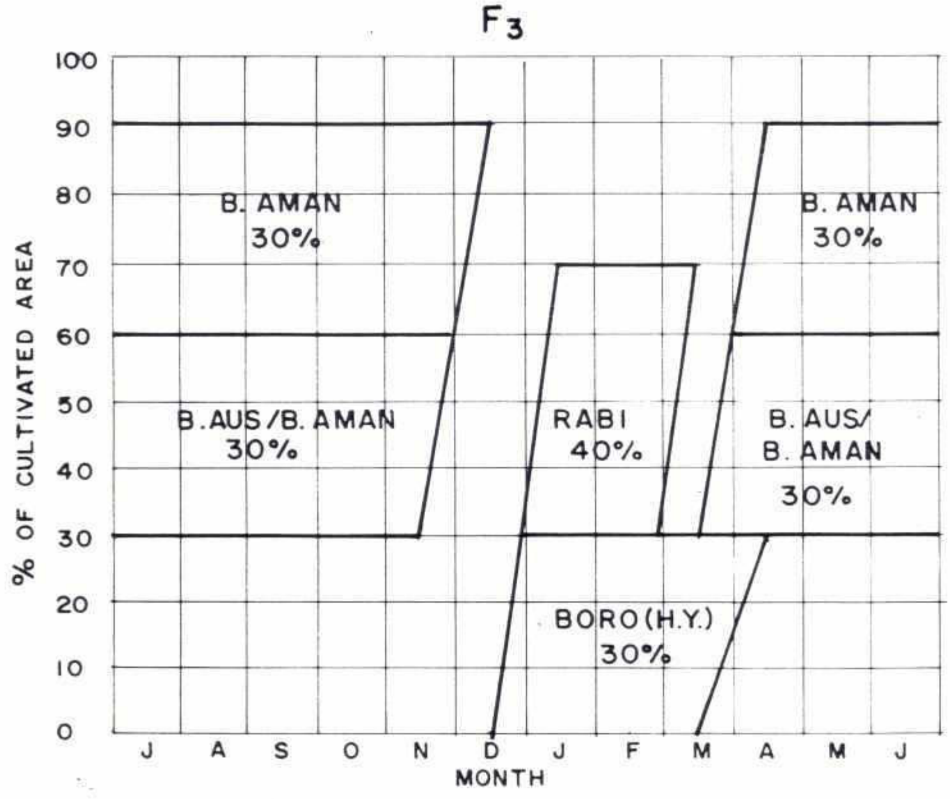
(Sheet 1 of 2)

Annex 2 Appendix B

Figure B3

Halcrow/DHI/EPC/DIG *May 1993*





F_2 = 0.6m to 1.5m Flood depth.

F_3 = >1.5m Flood depth.

Crop Calendars for Southern Zone of BRE Project Area

(Sheet 2 of 2)

Halcrow/DHI/EPC/DIG *May 1993*

Annex 2 Appendix B

Figure B3

APPENDIX C

A REVIEW OF PREDICTED RIVER BEHAVIOUR AT PRIORITY LOCATIONS

2 0 6

RIVER TRAINING STUDIES OF THE BRAHMAPUTRA RIVER

MASTER PLAN REPORT

ANNEX 2, APPENDIX C: A REVIEW OF PREDICTED RIVER BEHAVIOUR AT PRIORITY LOCATIONS

CONTENTS

A REVIEW OF PREDICTED RIVER BEHAVIOUR AT PRIORITY LOCATIONS

The following is a review of the morphological situation at the six priority locations as a consequence of the improved understanding of the behaviour of the river, and in particular its planform evolution, that has arisen as a result of the progress made during the course of the Study. The priority locations, and the present pattern of islands in the river, are shown in Figure C1.

1. FULCHARIGHAT

The Dec 1990 aerial photography shows that the small radius aggressive bend that had been active until 1989 had reached its peak and stalled. In its place a large radius long wavelength bend was developing, scaled on the large bend at Gabargaon on the left bank. From the limited SPOT coverage available it is possible to follow the evolution of the Gabargaon bend. Between March 1989 and November 1990 it had moved laterally almost 1,000 m, reached a radius to width ratio of about 6.0, and was showing all the signs of stalling. The final planform corresponds closely with the set of maximum large bend planforms that have been catalogued under the BRTS morphological studies. Superimposing this bend evolution onto the Fulcharighat 1989 bend leads to the inference that the latter could develop rapidly to the form shown on Figure C2 and soon after that it would most probably stall and a cutoff would develop.

In terms of the security of the BRE, it seems probable that it will be breached north of Fulchari but if the bend migrates downstream then the breach could occur in the vicinity of where the railway line crosses the BRE. In either case flooding of the permanent railway facilities west of the BRE would be severely affected.

From inspection of the anabranch pattern evolution over recent years it seems that there are two principal planforms that can develop, one based on the prevalent shorter wavelength thalweg meander and the other on the large bend form that is currently dominant. This is reinforced by the presence of the small metastable char just north of Fulcharighat which has all the attributes of a secondary level metastable char. The secondary chars further downstream are less well defined which may be due to the fact that they are still evolving but may also be because they tend to be subjugated by the change from short to long wavelength dominance.

After the large bend reaches its apogee and stalls the most likely development is that the resulting cut-off channel will re-establish the shorter waveform, the exact wavelength of which will depend on the annual sequence of flood magnitudes at the time but may be expected to fall within the range 15 to 17 km.

Taking a medium to long term view therefore, any bank stabilization measure should be such that it can accommodate these two waveforms. An embayment corresponding to the shorter wavelength is a strong persistent feature over recent years and also appears on older 1:50,000 maps. It would therefore seem to be an appropriate first stage stabilization target.

2. SARIAKANDI AND MATHURAPARA

Over the past 30 years the right bank of the Jamuna (Brahmaputra) has shifted westward by a net amount in the order 3 km over a considerable length and there is now only a thin sliver of land separating it from the Bangali River; in places this strip is less than 1 km wide. Erosion is continuing and during the last monsoon season the bankline retreated a further 300 m on average over a length of several kilometres, further reducing the separation. Since aggressive bends can result in annual rates of bank erosion in the range 500 to 1000 m, and occasionally more, it is reasonable to anticipate an imminent breakthrough, although it is not possible to predict the particular year in which it will occur. See Figure C3.

The meandering pattern of the Bangali means that the width of the separating band of land varies and therefore the most vulnerable stretches, in terms of the least amount of erosion required for a breakthrough, can be simply identified. However the pattern of the Jamuna bank erosion is of a complex stochastic nature and it is not necessarily most likely that the breakthrough will first occur at the narrowest point. The least width of separation at present is in fact to the north of Sariakandi on a stretch of the Jamuna river that has been relatively quiescent for a number of years and which at present shows no signs of becoming active again. Although by the nature of the river, this situation could change rapidly.

The object in this case is therefore to stabilize the bankline in the most cost-effective way that will minimise the risk of a breakthrough occurring. In order to achieve this it is necessary to look at the reach as a whole and not to be unduly influenced by the variation in the width of the separating strip or the pattern of erosion that happens to be taking place in any one year. At the same time the presence of significant townships such as Sariakandi cannot be ignored.

The fundamental assumption that has been made, based on the interpretation of planform dynamics, is that it is unlikely that severe erosion will occur simultaneously to the north and south of Sariakandi and that although the focus may switch, this will take place over several years so that an appropriate timely response can be initiated.

The second important assumption is that the depth of embayments that will form between hardened lengths of the river bank will not exceed the most severe depth of penetration observed in the case of very aggressive bends. This assumption is also consistent with the conclusion reached by the JMB detailed design studies which was based on both morphological interpretation and physical modelling. Because of the ever-changing bankline planform, the final positioning of the hard-points will have to be made close to the time of construction.

The remarkably consistent long term trend in bank line movement over this reach as a whole suggest strongly that the current quiescent conditions immediately to the north of Sariakandi may be expected to end within the coming five to ten years. This could well be replaced by a period of active erosion, possibly centred about 3 to 4 km north of Sariakandi. Such erosion would then threaten the flank of Kalitola Groyne and necessitate the construction of further bank stabilization works to prevent a possible breakthrough into the Bangali in this area. It is even possible that the changing focus of erosion will take place sooner and that the priority for stabilization will shift from Mathurapara to north of Sariakandi. Close monitoring of the situation is thus called for, and further measures north of Sariakandi will be required in the short term.

3. **KAZIPUR**

Kazipur lies opposite Island D (see Figure C1). It was the scene of unusually severe bank erosion between 1988 and 1990, associated with one of the shorter wavelength aggressive bends which reached a peak in 1990. The deep scour trench that was created moved about 1 km downstream during the 1991 monsoon season with reduced rate of erosion. This bend now appears almost to have completed its life cycle.

It has been noted that the cross-over between Islands D and E is poorly defined to the extent that in recent years the flow has only been from east to west and the two islands have tended to overlap and are now near to merging. If this trend continues, the two islands may coalesce to form one island of about 36 km length. This implies a major anabranch wavelength of about 72 km or around double that of the theoretical single thread wavelength for dominant discharge, the nearest equivalent of a single anabranch bend of this scale being the 33 km long reach to the east of the current extended Island B. From the time snapshots of the river available it may be inferred that such a bend is not a long term stable feature, in which case there are two principal modes of evolution:

(a) the island might become attached to left bank;

(b) the two anabranches might develop individually on either side of the island to form a multiple channel anastomosed system. The feature north of the Dudhkumar river, which has a major island length of about 36 km, may represent such an evolution.

In either case the right bank would come under increased attack, with the former probably creating the more aggressive condition. An average bank retreat rale of over 100 m/y over the reach could be expected with the upper part between Kazipur and Simla, where the current anabranch width is only about 3.5 km, experiencing more attack than the lower wider section.

Two hard-points at the locations shown in Figure C4 are proposed, to stabilize the reach in the vicinity of Kazipur itself.

For reference: the maximum widths of the "Dudhkumar" feature scaled off the 1765, 1830 and 1988 maps were 6, 12 and 15 km respectively, giving averaged widening rates of 92 and 19 m/y and a longterm average of 40 m/y.

4. **SIRAJGANJ**

At Sirajganj the erosion of the bankline since the 1950s has resulted in parts of the old established town now fronting directly onto the river bank. In other areas urban and peri-urban development has expanded up to the river bank. The existing bank protection works, consisting of concrete block armouring but without an effective underlying filter layer, extend over a length of about 1.5 km and when this was threatened with outflanking in the 1980s, Ranigram Groyne was constructed to the north of the town. The groyne has a sand core with concrete block armour but no filter layer. The total length provided with direct protection by these existing works is some 2.2 km.

It is very apparent from the 1992 bankline planform that this stabilized length of bankline forms a modest protrusion into the river. For reasons that are not clear, this is also the point on the river where the braiding intensity reduces markedly and linked to this is the fact that the main river channel tends to be more pronounced and somewhat less shifting than further upstream. In recent years the effect has been further enhanced by the gradual decline of the main left bank anabranch which has resulted in a larger proportion of the river flow passing down the right bank anabranch past Sirajganj.

The existing Sirajganj bank protection works are thus becoming increasingly exposed to steadily more severe attack by the river and since even normal monsoon season flow conditions result in local failures, due both to undermining and the large scale migration of the fine sandy material through the coarse matrix of armour layer. A larger than normal flow is likely to cause widespread failure that could not be contained with the existing facilities available to the concerned authorities. Rapid erosion of the bankline would follow and much of the town could be destroyed in a matter of 5 years.

The immediate object in this case is to stabilize the existing bankline in the vicinity of the Sirajganj urban area to a standard that will withstand at least a 1 in 100 year event (see Figure C5). Larger events would possibly cause significant damage requiring urgent attention but would not be expected to result in catastrophic failure.

There are strong social arguments for providing the upgraded standard of protection to the full length of bankline that is currently protected, although in purely economic terms the most downstream length perhaps ranks lower in importance.

To overcome the uncertainty over the reliability of the Ranigram Groyne, the revetment will be extended upstream to connect with the groyne and a new nose will be constructed.

From examination of LANDSAT imagery it can be seen that accretion in the large embayment upstream of Sirajganj started in about 1981 and by 1985 the embayment was almost completely filled in. This timescale for rapid accretion is consistent with the predictors. Since 1986 there has been no significant erosion but there was a short burst of intense erosion immediately downstream in 1988-90 and incipient erosion in the bay downstream of Ranigram Groyne in 1992. The fact that the latter came to nothing is most probably linked to the generally relatively quiescent conditions since 1990 as the river recovers from the 1988 scour and its immediate aftermath. This quiescence has been accentuated by the relatively low monsoon flows over the past two seasons. However, the likely scenario that islands D and E will merge, as descried in section 4.6.1 which follows, may well lead to the bank between Kazipur and Sirajganj coming under increasing attack.

A new hard-point at the site of the existing Sailabari Groyne (Figure C5) will have a significant role to play in preventing the formation of any aggressive shorter wavelength bend which would threaten the flank of Ranigram Groyne, and, consequently, Sirajganj town.

To stabilize this reach of the river and prevent any outflanking tendency, a hard-point further north is required. The additional hard-point proposed at Simla will have the further advantage of affording some protection to Simla/Sonali Bazar.

5. BETIL

It has long been recognised that the pattern of the river south of Sirajganj is significantly different to that to the north. The more detailed analysis of planform characteristics has merely emphasized this without throwing up any clear explanation for the reason behind it. The most significant parameter change is perhaps the water surface slope that shows a distinct flattening south of Sirajganj. This is accentuated by the superimposed backwater effect of the Ganges (see First Interim Report).

Compared to Sirajganj, where the net westward movement of the bankline has been limited to about 1 km since 1830, this lower section of the river has experienced major bankline movements and the right bank is now some 5 km further west than it was in 1914. All the indications are that the river will continue to move westward in this reach, both through widening of the anabranch and an overall drift, at an average rate of about 100 m/y.

Although there are signs that the river has strong tendencies to maintain a meandering planform, it has been unable to settle down to any regular meander pattern. This may be attributable to the speed with which the relatively short wavelength high sinuosity large bends evolve and die through cut-off development. These cut-offs then tend to evolve into braid bar islands but find difficulty in taking up a regular pattern of their own, perhaps because of the widely ranging flows that they carry.

The west anabranch flanking Island F is a case in point. It has no clearly defined evolution of secondary metastable chars and the thalweg planform displays a very irregular waveform. Its future is closely linked to the development of the "throat" section upstream, which only 30 years ago was an island reach and unless the JMB is constructed in the near future it may revert to that state. If that were to occur then instead of the unstable and unequal split of flows around Island F, there would be a rather more stable cross-over condition.

With the construction of the JMB, there is a high probability that a char group will develop a short distance downstream of the bridge where the mean velocity reduces, reinforced by the Ganges backwater effect. This is likely to have a major impact on the pattern of char development, which is largely unpredictable at this stage.

As a short-term measure for bank stabilization, there seems little option but to place a series of hard-points along the right bank in the anticipation that this will encourage the evolution of a more regular pattern. This lower reach is dominated by the larger waveform bend and there is a dearth of shorter wavelength bend information on which to base an alternative plan. In the absence of such natural tendencies it is reasonable to expect that the introduction of a regular spacing of hardpoints will in itself establish a pattern.

The first two hard-points to be constructed on this reach under the Master Plan will be those shown as Phase 1C works in Figure C6. The locations are planned to give a measure of protection to the town and the handloom industry, as well as to the retired BRE.

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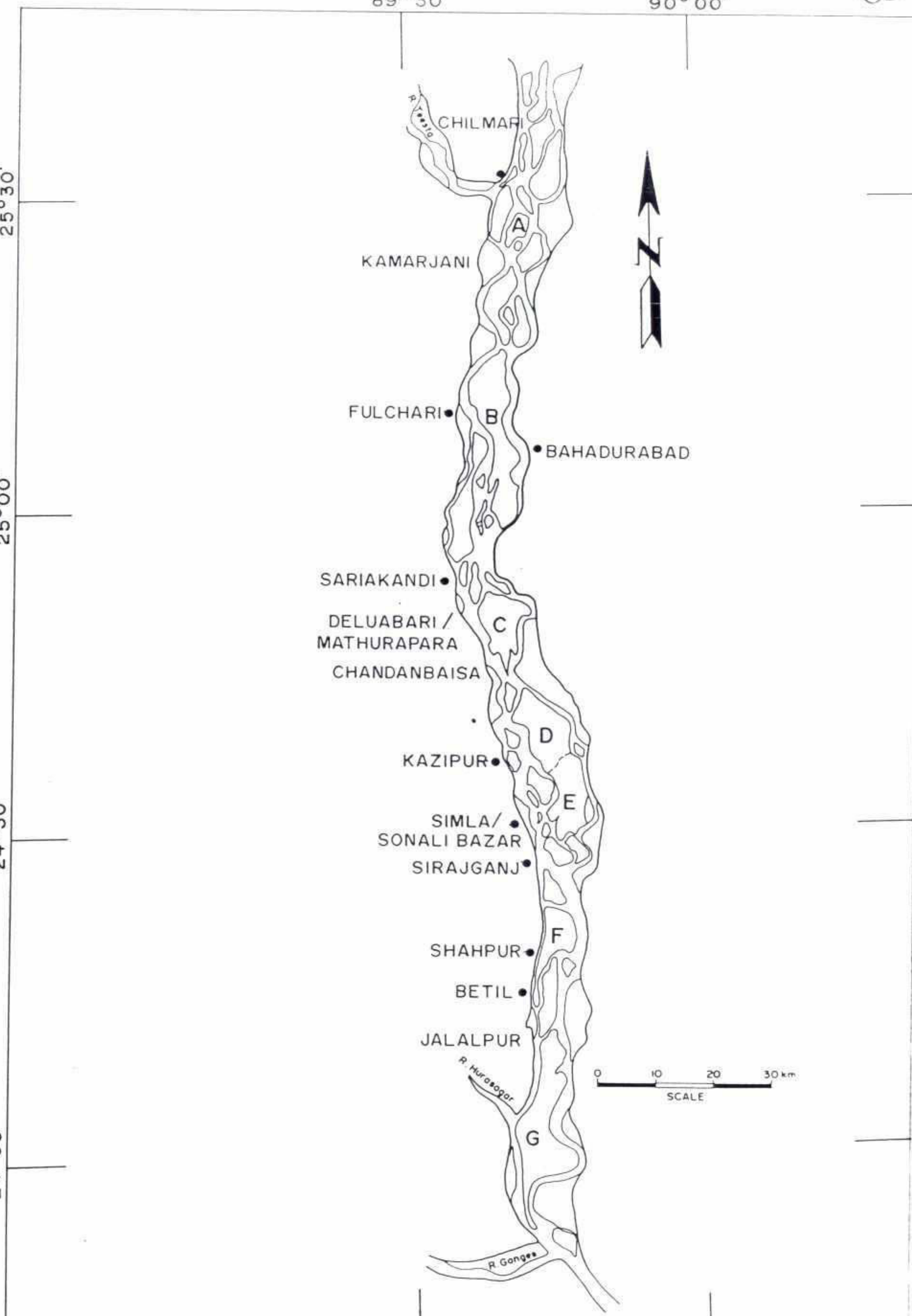

Present Island Pattern

Annex 2 Appendix C

Figure C1

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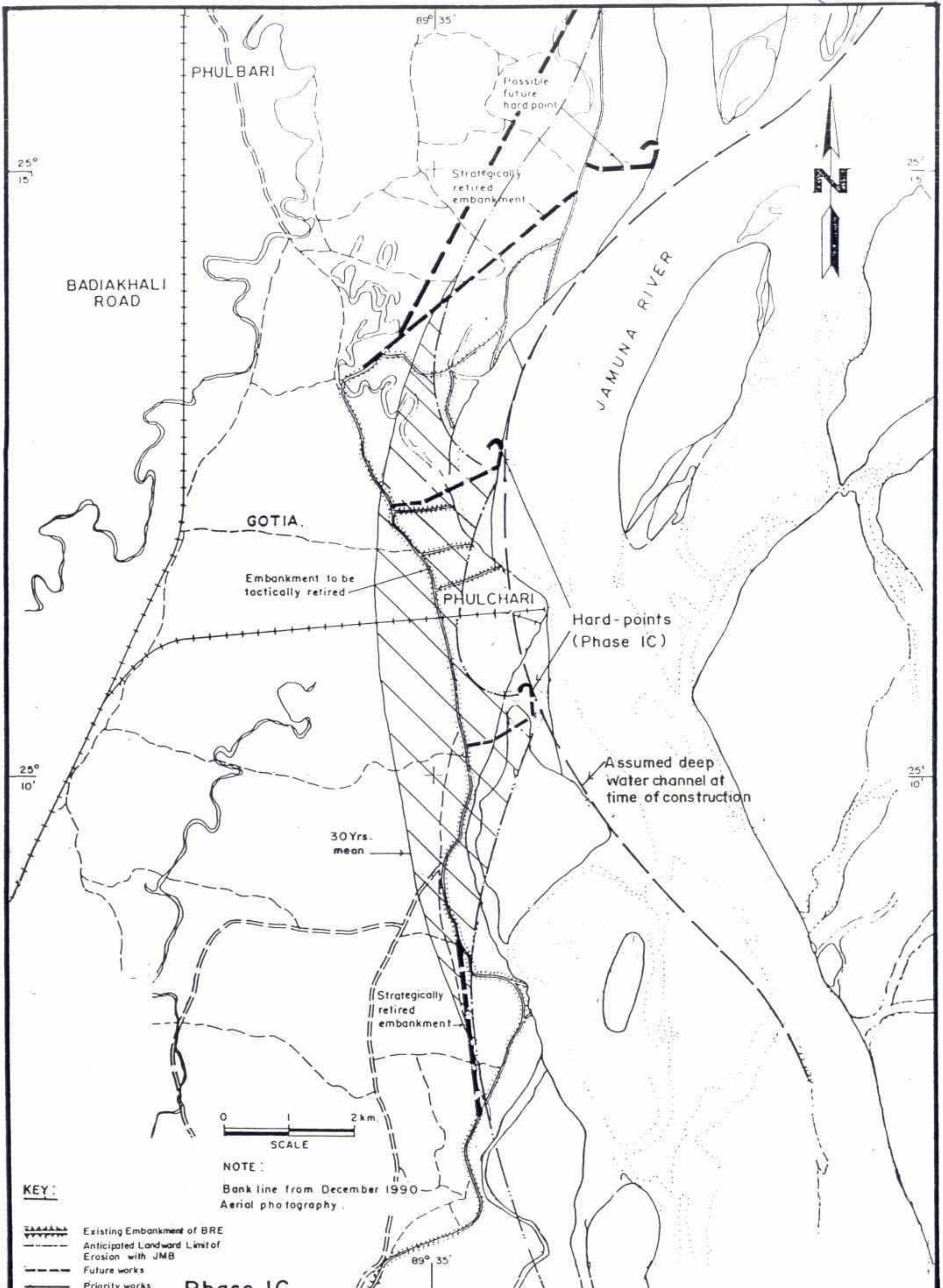
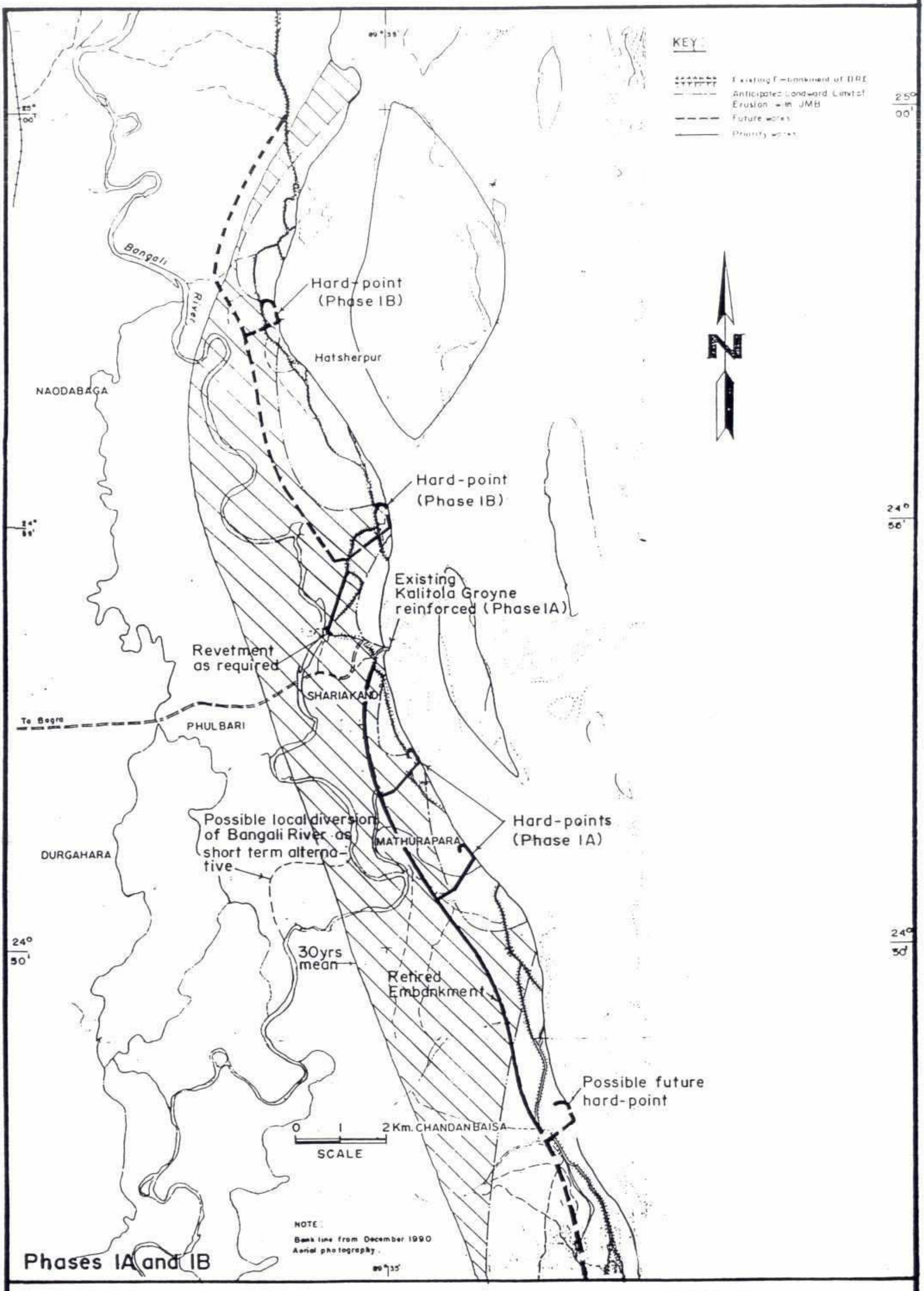
220



Priority and Future Works at Fulchari

	Annex 2 Appendix C
Halcrow/DHI/EPC/DIG *May 1993*	Figure C2



Priority and Future Works at Sariakandi and Mathurapara

Annex 2 Appendix C

Figure C3

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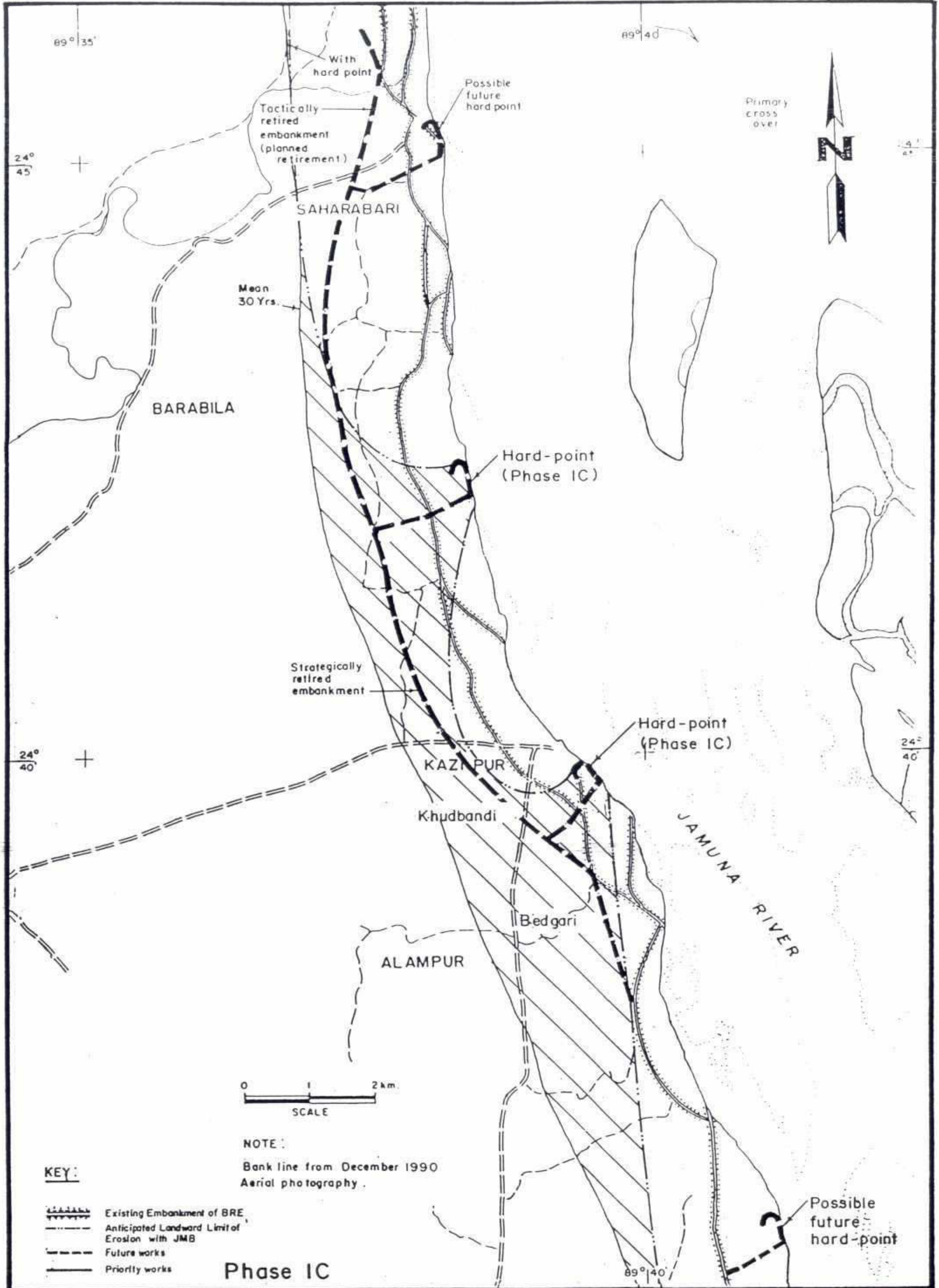

Priority and Future Works at Kazipur

Annex 2 Appendix C

Figure C4

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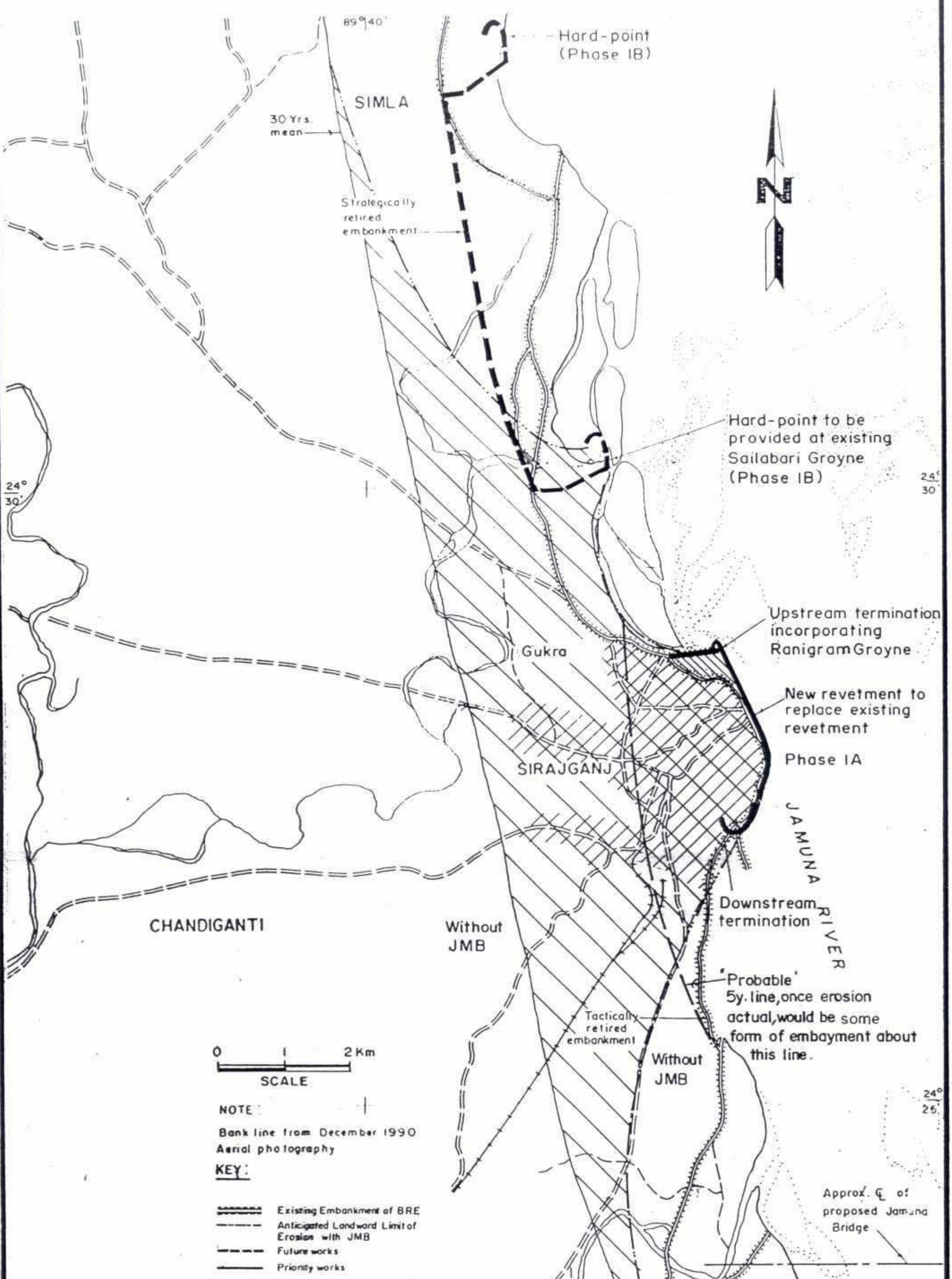
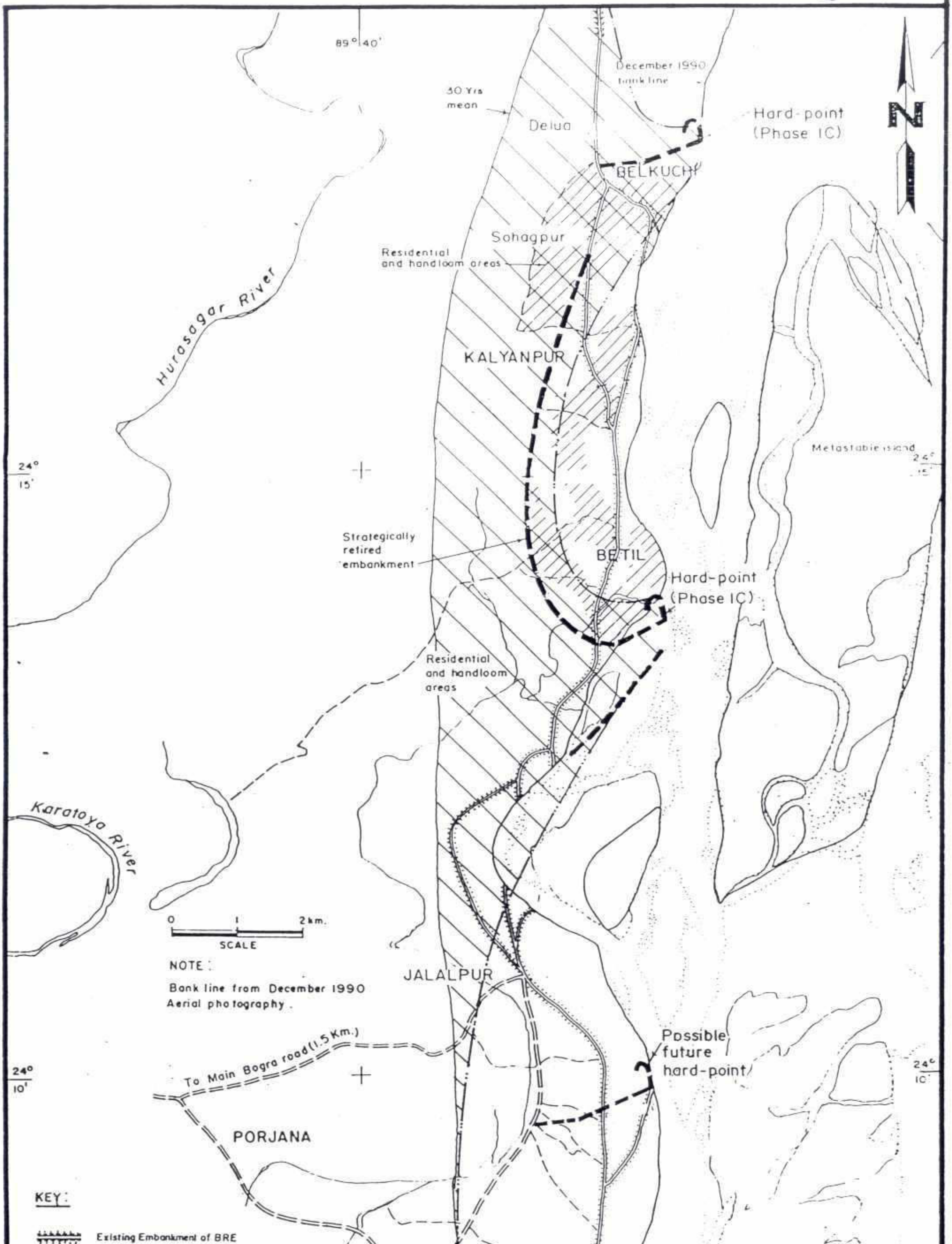
226



Priority and Future Works at Sirajganj

Annex 2 Appendix C

Halcrow/DHI/EPC/DIG *May 1993* Figure C5



Priority and Future Works at Betil

	Annex 2 Appendix C
Halcrow/DHI/EPC/DIG *May 1993*	Figure C6