CHAKTOMUK JUNCTION ENVIRONMENTAL, HYDROLOGICAL AND MORPHOLOGICAL STUDY

PURPOSE

ETP1 COURSE TOPIC COVERAGE:

- SUSTAINABLE DEVELOPMENT AND ENVIRONMENTAL AWARENESS
- INTEGRATED RESOURCE AND ENVIRONMENTAL MANAGEMENT (IREM) CONCEPTS AND BENEFITS
- ENVIRONMENTAL IMPACT ASSESSMENT (EIA)
- BARRIERS TO IREM
- IREM PRACTICAL TOOLS FOR IMPLEMENTATION
- ENVIRONMENTAL MODELING
- ENVIRONMENTAL MONITORING

This case study examines the implications of natural morphological changes occurring at the Chaktomuk junction on socio-economic, environmental resources and development activities in the Mekong River. Emphasis is given to a major scientific and engineering study which is being undertaken to better understand the hydrology and morphology of the junction. The potential serious adverse ecological impacts on flow in the Mekong River and fisheries of the Great Lake are highlighted in illustrating the importance of proper planning and implementation of development activities in the Mekong River Basin and in informing decision making.

ISSUES

Specific issues highlighted by this case study are:

1. Natural and human-induced morphological changes at the Chaktomuk junction are reaching a critical stage, posing many threats such as heavy bank erosion, sedimentation, disturbances to fish migration, and hydrological changes
2. Comprehensive study of the complex Mekong River ecosystem and the potential impacts of engineering works at the junction is necessary to develop appropriate and sustainable management responses to observed morphological changes
3. The need to understand how human activities along the river are exacerbating natural morphological change at the Chaktomuk junction as part of broader planning for sustainable development in the Mekong River Basin.

LEARNING OBJECTIVES

After completing this case study, participants will be able to:

- Define complexity and discuss why the Chaktomuk junction phenomenon is complex
- Describe the potential impact of morphological changes occurring at the Chaktomuk junction on two or more valued ecosystem components

- Identify links between morphological changes occurring at the Chaktomuk junction and upstream development activities
- Discuss how the scientific and engineering studies being undertaken will help guide management responses to the Chaktomuk phenomenon
- Provide an example of an unsustainable river bank development activity occurring in or around Phnom Penh; discuss how these activities could be done differently to make them more sustainable
- Evaluate the Chaktomuk project's scale and methodology in terms of providing needed information for identifying appropriate engineering, environmental management and planning responses

PROJECT SUMMARY

Introduction and Background

The Chaktomuk area – known in French as the Quatre Bras – is the junction between the upper and lower Mekong, the Bassac and the Tonle Sap rivers. The Chaktomuk is therefore the key to the flow distribution between the four river branches and to the morphological development of the branches. Any development at Chaktomuk has the potential to impact on the entire lower Mekong River including the delta area in Vietnam and Cambodia's Tonle Sap Great Lake.

The Great Lake has a unique water regime with water from the Mekong River starting to flow into the Tonle Sap River in late May or early June and subsequently reversing starting in November when stored water returns to the Mekong River (Figure 1). During the rising stage, the flow from the upper Mekong River divides into the lower Mekong, Bassac and Tonle Sap rivers. During the falling stage, when the Great Lake drains through the Tonle Sap River, the combined flow of the Tonle Sap and upper Mekong bifurcates into the lower Mekong and Bassac rivers. This complex and changing flow pattern gives rise to a dynamic erosion and deposition pattern at the Chaktomuk junction.

The Great Lake is the largest freshwater body in Southeast Asia. It is a unique and fragile area. Its fishery sustains a large human population and is of great importance to Cambodia as well as other Mekong River Basin riparian countries. The Lake receives water both directly from rainfall, from its own drainage basin (67,600 km^2) of about 38%, and from Mekong River of about 62%. The Lake has capacity to absorb about 20% of the Mekong River floodwater, so it also plays a significant role as natural flood regulator in the Basin. The Lake size varies from 250,000 - 300,000 ha with a volume of 1.3 billion m^3 and depth of 1-2 m in the dry season to 1 - 1.3 million ha with a volume of 72 billion m^3 and depth of 8-10 m in the wet season. The volume and timing of flow entering the Lake from the Mekong River via the Tonle Sap play a very important role for the fishery in the Lake. The reservoir effect of the Great Lake also plays an important role in regulating flows in the lower Mekong River and hence for saline intrusion in the Vietnamese part of the Mekong Delta.

As with all major rivers in humid tropical regions in Asia, the Mekong River has a very high volume of sediment transport, principally suspended sediment (more than 90% of total solid transport) in its lower reaches. An understanding of the characteristics of these sediments and their transport mechanisms (entrainment, deposition, re-entrainment) in the complex Mekong-Tonle Sap-Great Lake system is of vital importance because these phenomena have direct impacts on the biological (particularly fish) environment of this system.

Local deforestation is generally given as the primary cause of the increased sedimentation rates. Whereas deforestation in the Basin upstream from Phnom Penh has increased the sediment concentration of the flood flows of this river, it has not yet been shown that deforestation within the direct catchment of the Great Lake has had a marked effect on sediment loadings into the Lake. Although the deforested zones are often only gently sloped, the impact of the system or magnitude of the erosive action of rainfall has not been established.

Since the Franco-Siamese Convention in 1926, the Mekong River from the sea to Phnom Penh port has been a very important maritime navigation course. Its maintenance has been essential. Regular dredging is necessary at three points in Cambodia for 5,000 dwt vessels to reach Phnom Penh. It is envisaged that the port of Phnom Penh should increase its maritime trade in the near future to accommodate the increased trade – the Japanese government donated US$26 million to upgrade the port in 1996.

Barrages and dams, especially mainstream dams, will have an influence on the flow of the Mekong River. Both hydropower dams and irrigation schemes will result in reduced flooding. However only large reservoirs or great numbers of medium-sized dams may will significantly affect the flood magnitude. This could have a governing and rather positive effect. However, on the contrary, irrigation dams, which divert water during the dry season, would worsen the natural flow conditions. Any flow intervention or flow diversion at the Mekong River, upstream of the Chaktomuk, should be evaluated carefully for possible impacts.

The Chaktomuk Phenomenon

The Chaktomuk area is morphologically active. The most striking morphological changes are an overall migration of the Mekong River towards the west, lengthening of the Chrui Chang War to the south and heavy bank erosion at Koh Norea. An analysis of river flow during different flow stages explains the main cause of the erosion at the Chaktomuk junction. The point Koh Norea is attacked during floods by currents coming from the upper Mekong River and subsequently diverted into the Bassac River. Again after the floods, the same bank is attacked by the reversed flow of the Tonle Sap River, which has a considerable velocity (1.0 to 1.5 m). There is no natural factor ensuring the stability of any part of the river banks which consist of easily eroded layers of fine sand and clay. The permanent erosion and downstream shifting of the Koh Norea point adds to the alteration in the river flow pattern. The flow of Mekong River flood and reverse flow from Great Lake is now diverting directly towards the vertical banks of Chbar Ampouv (Koh Norea).

Erosion is occurring at nearly 15 m per year and an unstable scour hole is threatening to approach the Monivong Bridge (Figures 2 and 3). The outlets to the Tonle Sap and Bassac rivers are in the process of silting up.

The consequences of deposition and erosion are being felt upstream and downstream in all drainages. The change in flow distribution to the Mekong and Bassac rivers affects the hydraulic regime of the junction between the two rivers further downstream in Vietnam at the Vam Nao pass and may indirectly, through the reservoir function of the Great Lake, affect salt water intrusion in the Delta. Historically, little notice was given to the downstream movement and its respective impacts. More recently, serious concerns have arisen over the negative ecological, hydraulic and socio-economical impacts of this phenomenon.

Chaktomuk Project: Information Needs and Management Objectives

What will happen if proactive measures are not taken to address the morphological changes occurring at the Chaktomuk junction? A spectacular example occurred in 1964 when the Monivong Bridge over the Bassac River collapsed, which drew public attention to morphological changes in the river. This bridge collapse prompted investigation of the fluvial process of the river. More recently, the urgent need for comprehensive environmental, hydrological and morphological study in the Chaktomuk area has been recognized in order to prevent further degradation and to identify remediation measures. Critical information needs, which have been identified include:

- Excavation of the Chrui Chang Var point bar, to a depth covering more than 10 flooding sequences, indicated a sedimentation rate of 20 to 50 cm per year. Deposition on the Chrui Chang Var point bar is the result of a complex fluvial relationship between the Great Lake and the upper Mekong River. A detailed geomorphological study would allow investigators to correlate the sedimentary structures observed in the excavation of the point bar to the various hydrographic processes responsible for this morphological evolution.
- The hydrological and hydraulic feasibility of an artificial regulation in the Chaktomuk will require substantial water balance data for the system in different conditions (normal year, dry year, wet year). It is therefore important to create a central database and to analyze all relevant information. This will allow investigators to advise responsible management agencies, contributing to better coordination and synchronization of their activities, avoiding duplication of efforts, and guiding implementation of future development projects.
- Because environmental information is not extensive in Cambodia, environmental impact assessments have often been general in nature or highly speculative. To make EIA worthwhile, gathering extensive environmental baseline information is essential. Limited resource management data for agriculture, capture fisheries, aquaculture, water quality and hydrology are available at present in support of environmental managers and decision makers.
- Any management and development plan for the Great Lake and the Tonle Sap River will be greatly dependant not only on the water quantity and water quality

of its tributaries but even more on the water quantity and the water quality of the Mekong River at the Chaktomuk junction. For this reason, it is of the utmost importance to coordinate municipal, national and regional development strategies and to closely cooperate with the Mekong River Commission (MRC) Basin Development Plan and Water Utilization Program to ensure that development strategies are consistent or least compatible.

- An important aspect to consider in studying the Chaktomuk junction is the strong correlation between flood flows in the Mekong River and the volume of entering the Tonle Sap River and the Great Lake. Regulation of the Mekong River floods would lead to a reduction in water supply to the Lake water. This would happen even if the regulation did not reduce the annual flow but only caused redistribution throughout the year, such as an increase of flow during dry periods and a reduction of flood peaks. Of equal importance is the assessment of low-flow levels – a reduction of the low flow would expedite the start of the drainage of the Lake.

The present phase of the Chaktomuk junction study is supported by the Japanese Government, executed by MRC in association with the Danish Hydraulics Institute (DHI) and HEACON BV, and implemented by the Cambodia National Mekong Committee (CNMC). Phase 1 of the study is from April 2000 to July 2001. The main emphasis in the present phase is on data collection and mathematical modeling. Phase 2 will be involve a feasibility study on the stabilization of the Chaktomuk junction and will focus more on environmental and socioeconomic issues, cost-benefit analysis and on the design aspects of river stabilization measures. The ultimate objective of the study is to identify measures that will minimize the risk of any further degradation of the Chaktomuk junction and potentially reverse recent undesirable trends in the hydraulic regime. It is obviously vital that these measures do not changes the flow in the Tonle Sap and adversely affect the flow distribution between the lower Mekong and Bassac rivers.

The objectives of the present phase of the Chaktomuk project are:

"To improve the hydrological, hydraulic, ecological, morphological and geomorphological knowledge, based on the available previous information and on the new data collected during the planned survey activities. Preparation of a framework for additional data field survey activities necessary to study the complex phenomena of the Chaktomuk area, ...

To analyze the historical evolution of the hydraulic regime and river morphology in the project area and to examine, determine and redefine the causes and the problems related to the downstream movement of the Chaktomuk and the disequalibrium of the morphological stability. To forecast the channel behavior, sediment transport capacity, hydrodynamics and morphodynamic variations, including analysis of risks. In addition training in modelling aptitude .... To formulate a preliminary proposal for a set of protective, regulating and development works ..."

Importance of the Chaktomuk Project

It is anticipated that an improved understanding of the hydraulic, morphologic and environmental aspects of the Chaktomuk junction will enable engineers, environmental managers and planners, and decision makers to respond in an appropriate manner to the Chaktomuk phenomenon. Many observers have expressed concerns that poorly informed responses may have serious consequences. Issues of concern include:

Siltation and Reduction of Water Level in the Great Lake

The Chaktomuk junction has a direct ecological link with the Tonle Sap River and the Great Lake system, which produces 75% of Cambodia's freshwater fish for national consumption and export. Fisheries yield and aquaculture production are important contributors to the Cambodian economy as hard currency earners and form an important animal protein source to the Cambodian population.

Potential impacts to Cambodia's fisheries resources as a result of sediment transport to and from the Great Lake are a serious concern. Although siltation in the Great Lake and increased sediment loadings in the Tonle Sap River may result from excessive logging in the watershed and gem mining activities west of the Lake, sediment contributions from the Mekong River into the Great Lake are not yet fully understood and more study is required.

Siltation in the Great Lake could have a disastrous effect on the Lake's ecosystem. If no action is taken, the Lake could be reduced in volume considerably and its bottom shape might be transformed into a number of separate small lakes during the dry season and possible even swamp or farmland within a few decades. Increases in the Lake's temperature resulting from a decrease in water depth would seriously affect aquatic organisms and make the Lake's fisheries considerably less productive. Decreases in water depth would also impede movements of migratory fish in and out of the Lake.

Salt Water Intrusion in the Mekong Delta of Vietnam

The Great Lake functions as an important water reservoir and buffer to the Mekong and Bassac rivers. It therefore plays an important role in diminishing the effects of flooding and saline water infiltration in the Mekong Delta of Vietnam. If no measures are taken or if incorrect works are carried out at the Chaktomuk junction, increasing penetration of salt water into the Delta, which is already a problem, could potentially have catastrophic consequences for river and riparian ecological habitats.

Maritime Access Channel to the Port of Phnom Penh

Prior to 1974, regular maintenance dredging was undertaken to allow access of sea-going vessels to the port of Phnom Penh. These river works proved also to serve as a hydraulic regulating function for the Chaktomuk junction. When the works were stopped, siltation of the navigation channel in addition to other impacts resulted.

Rehabilitation of the Phnom Penh port was undertaken to diversify Cambodia's goods handling capability in support of the economy of the country and its foreign trade. Phnom Penh's port serves coastal and inter-island traffic within Southeast Asia and the Far East by small and medium size vessels. In contrast, the Sihanoukville port primarily serves long range intercontinental traffic. The benefits of having a maritime port at the center of the country's economic activities, using the huge navigation potential of the Mekong River, are considered to be extremely important- if only for the fact that a port monopoly situation in the country could be avoided. Rehabilitation of the Phnom Penh port allows access by vessels up to 4,000 DWT. Vessels moving in and out of the port require a minimum water depth of 5.50 m LLW – regular dredging will be necessary to maintain the access channel depth.

Threats to the Monivong Bridge and Road No. 1

National Road No. 1, which links Phnom Penh to Ho Chi Minh City, is an extremely important road in Cambodia since it opens Cambodia directly to the outside world. This road will soon be upgraded with assistance from the Asian Development Bank.

As mentioned previously, the Monivong Bridge of the National Road No. 1, where it crosses the Bassac River, was washed away in 1964 by a flood of the Mekong and Bassac rivers. The replacement bridge, which is at the same location, is once again under serious threat due to erosion on the left Bank of the Bassac River. A deep scour hole is approaching the right bank pier of the bridge which could result in the second collapse of bridge in 35 years at the same place and for the same reason. Although some experts feel the scouring position may have reached an equilibrium stage, they also indicate the situation could suddenly and dramatically change if the river morphology undergoes any variations. The consequences to the transport sector and the economy in the region would be devastating.

Instability and Erosion of the River Banks

Erosion of riverbanks is also jeopardizing buildings and people situated along the river. The modulated river channel and the shift in water flow, especially during the flood season, heavily attack the riverbanks of Southern Chbar Ampou peninsula (Koh Norea). The mass of Mekong River flood water is now diverted almost at right angles to the vertical slopes of the Chbar Ampou river banks washing away the unprotected soft sandy at a rate of 1 m to 1.5 m every year. Bank erosion is a serious concern to people living in the area who are losing their farm land and houses, especially along the east bank of the Bassac River. One pagoda located near the river bank collapsed into the river during the last flood season. Along the west bank of the river near the Monivong Bridge, heavy erosion is threatening buildings forcing the owners to start building their own bank protection.

Flood Drainage And Sewage Problems In Phnom Penh

Seasonal flooding in Phnom Penh is a concern to city residents. The existing storm water drainage and sewage system functions poorly and outlets to the Tonle Sap and Bassac rivers are silted up. Exacerbating this situation is unauthorized land reclamation and back-filling occurring in and around Phnom Penh which are thought to contribute to flooding in the city. To address these concerns, rehabilitation of the storm water and sewage outlets is necessary along with stricter planing guidelines for land reclamation along the river bank. Outputs from the Chaktomuk study will be useful in guiding urban development in Phnom Penh including upgrading of the drainage and sewer systems and in regulating potentially unsustainable land reclamation activities.

SITE VISIT METHODOLOGY

Course participants will complete a one day site visit in Phnom Penh during which they will have an opportunity to visit the Chaktomuk project office where they will be briefed by the project specialists on studies being undertaken at the Chaktomuk junction. The group will then visit selected locations accompanied by knowledgeable resource persons to observe first hand some of the problems which are being addressed by the project and development activities in and around Phnom Penh which may be contributing to the sedimentation occurring at the junction.

Participants will be organized into small groups for the site visit with each group being assigned a specific focus as summarized in the following table.

SUBJECT	FOCUS
Ecosystem	Prepare a conceptual model illustrating the complexity of the ecosystems at risk Detail how ecosystem components could be impacted by not taking any corrective action at the Chaktomuk junction Detail the potential impacts if inappropriate corrective actions are taken
Engineering	Provide an overview of the Chaktomuk project study objectives and methodology Outline what corrective actions are being considered at the Chaktomuk junction Summarize results of studies completed to date and explain how they are being used Assess the scope and content of the Chaktomuk project and detail additional studies which will be undertaken – Are all information gaps being addressed?
Management	Outline the roles and responsibilities of responsible government agencies and other involved organizations Summarize the management issues relating to the Chaktomuk project and development in and around Phnom Penh Identify existing resource use conflicts and appropriate planning and management responses

On completion of the site visit, small groups will be asked to present their findings to the class with emphasis on the practical lessons learned by course participants which reinforce IREM and EIA theory taught in the course.

TAKE HOME MESSAGES

Anticipated lessons learned by course participants in completing the case study and site visit might include:

1. The need to adopt a holistic perspective in striving to understand complexity. An integrated approach is necessary involving separate but linked studies of hydrology, environment, socio-economic and morphology in order to understand all aspects of a problem and to determine the most appropriate responses which avoid unintended and possibly irreversible consequences.
2. The use of adaptive management responses in dealing with complexity. In the absence of full information about potential serious environmental consequences of a proposed action, the best strategy is often to proceed in a cautious manner while observing how an ecosystem responds and then adjusting the actions being taken as appropriate. The other option of doing nothing until all information gaps have been addressed is generally not feasible given the possible undesirable consequences of not taking corrective actions in the short- to medium-term (e.g., collapse of the Monivong Bridge).
3. The importance of proper project scoping in assessing potential environmental impacts. Rather than completing a piece-meal assessment of individual development activities (e.g., dredging of shipping channel, land reclamation along the Phnom Penh riverbank), a better strategy is to broaden the scope of the assessment to include all activities in the same geographic area in determining how best to proceed.

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FIGURES

Annex-1 The Flow Regime at the Chaktomuk Junction

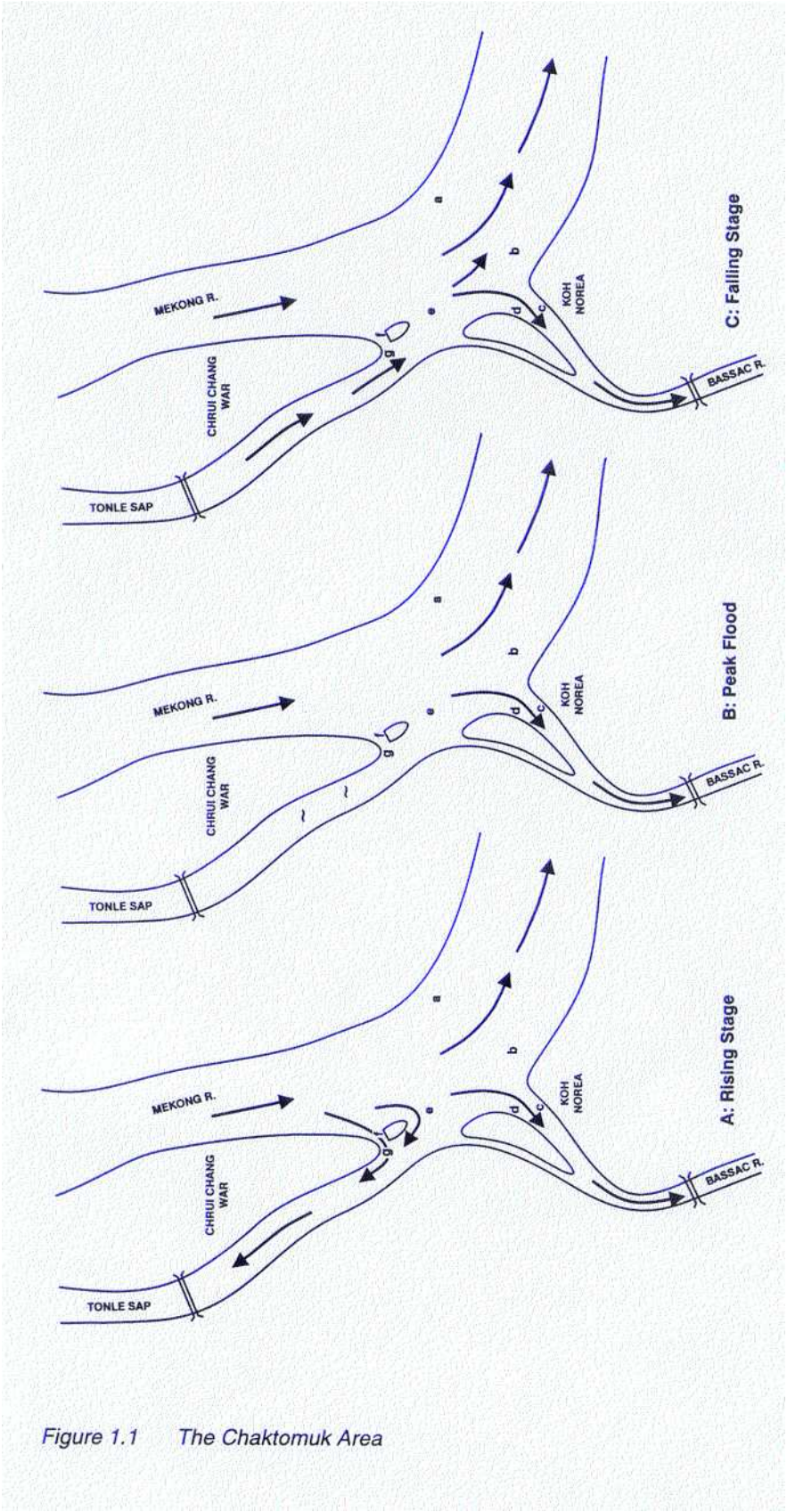
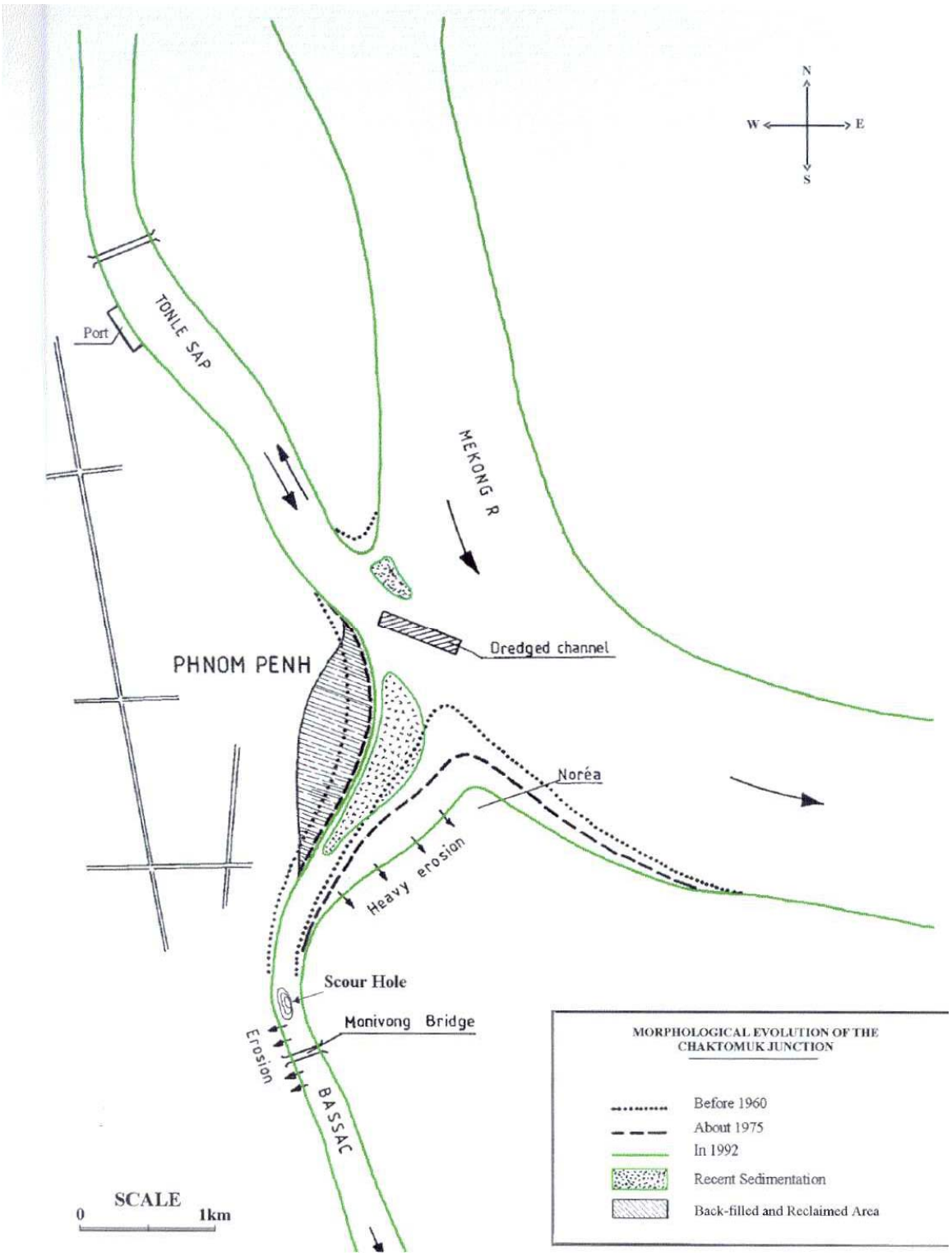


Figure 1.1 The Chaktomuk Area

Annex-3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E
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Port
TONLE SAP
MEKONG R
PHNOM PENH
Dredged channel
Noréa
Heavy erosion
Scour Hole
Monivong Bridge
Erosion
BASSAC
SCALE
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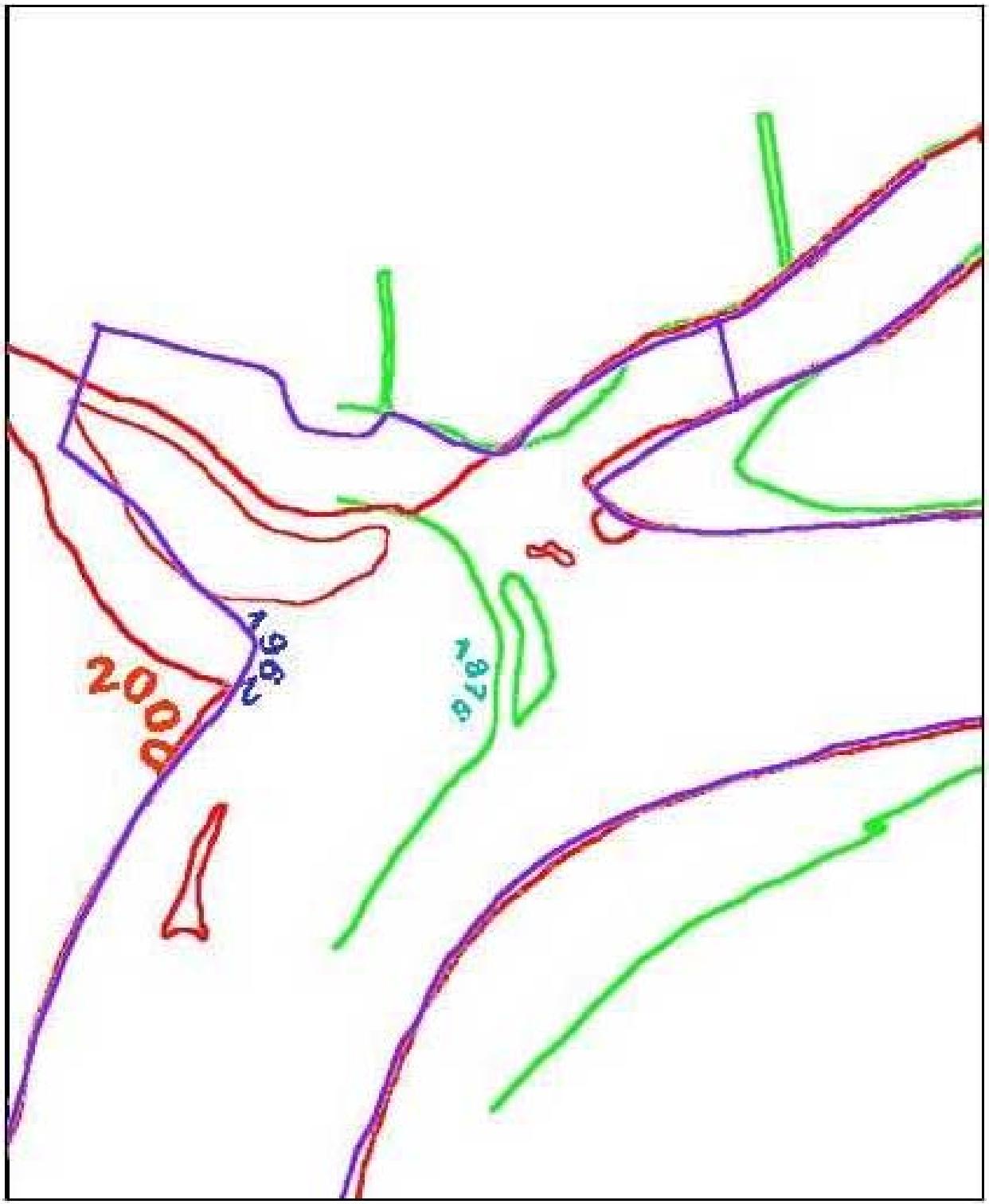
1km
MORPHOLOGICAL EVOLUTION OF THE CHAKTOMUK JUNCTION
Before 1960
About 1975
In 1992
Recent Sedimentation
Back-filled and Reclaimed Area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