



UNIVERSITI PUTRA MALAYSIA

***ONE-DIMENSIONAL NUMERICAL MODELLING OF BEACH PROFILES
IN RESPONSE TO A SAND NOURISHMENT SCHEME***

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By

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ABSTRACT

The background of this study focuses on the study area of Teluk Cempedak Beach located in Kuantan, Pahang. Teluk Cempedak Beach is one of the main tourist attractions in the Pahang state. However, the beach has a history of erosion resulted in the narrowing of the beach area, which has affected adversely on the recreational and tourist activities in this area. To control the erosion problem, the Department of Irrigation and Drainage (DID) has decided to implement beach nourishment scheme as the soft engineering solution. From May to July 2004, the beach has been nourished with 178,000 m³ of sand. Beach profile survey data from July 2004 (nourished profiles) until October 2004 (post nourished profiles) is taken for this study. This study aims at investigating the performance of process based model of XBeach in predicting beach profiles in response to a sand nourishment scheme. XBeach is used as a tool to investigate the performance of the model in evaluating cross-shore profiles under real wave conditions. The modelled cross-shore profiles are compared with the measured profiles. The results indicated that the optimum values of tuning parameter for *facua*, *wetslp* and Chezy coefficient for erosive profiles are 0.1, 0.1 and 45 respectively. Meanwhile, for accretive profiles, the optimum value for tuning parameter, *facua*, is 0.0. Both profiles predicted the best modelled profiles under the input of initial water level of Mean Sea Level (MSL). The final Brier Skill Score (BSS) for CH 400, CH 500, CH 600, CH 700, CH 800, CH 900, CH 1000 and CH 1100 are -0.79, -1.19, 0.19, 0.57, 0.34, 0.71, 0.62, and 0.66 respectively. It is found that the performance of XBeach models showed promising results for erosive profiles but the other way around for accretive profiles. This is due to the limitations that are present in this study such as longshore transport and tidal process effect are neglected. XBEACH has been

validated extensively for erosive conditions but its use for modelling accretion, especially for sandy beaches, is limited. Investigating the modelled profile evolution produces a finding that higher waves tend to erode bed profile faster than lower waves.



ABSTRAK

Latar belakang kajian ini memfokuskan di tempat kajian iaitu terletak di Pantai Teluk Cempedak, Kuantan, Pahang. Pantai Teluk Cempedak ialah salah satu tarikan utama di negeri Pahang. Bagaimanapun, pantai tersebut mempunyai sejarah hakisan yang menyebabkan berlaku penyempitan pada kelebaran pantai dan aktiviti rekreasi dan pelancongan di kawasan ini telah terjejas. Bagi mengawal masalah hakisan ini, Jabatan Pengairan dan Saliran (JPS) telah mengambil keputusan untuk melaksanakan penambahan pasir di pantai tersebut. Daripada Mei sehingga Julai 2004, pantai tersebut telah ditambah pasir sebanyak 178,000 m³. Data ukur profil pantai daripada Julai 2004 sehingga Oktober 2004 diambil untuk kajian ini. Kajian ini bermatlamat untuk mengkaji prestasi model berasaskan proses iaitu XBeach dalam meramal- tindak balas profil pantai kepada skim penambahan pasir pantai. XBeach digunakan sebagai alat untuk mengkaji prestasi model dalam menilai profil arah tegak lurus pantai dalam keadaan ombak sebenar. Model profil arah tegak lurus pantai - dibandingkan dengan profil pantai yang telah diukur. Keputusan menunjukkan nilai optimum bagi parameter penentukuran untuk pekali *facua*, *wetslp* dan *Chezy* - untuk profil penghakisan masing-masing ialah 0.1, 0.1 dan 45. Manakala, untuk profil penumpukan, nilai pekali optimum bagi parameter penentukuran, *facua*, ialah 0.0. Kedua-dua profil meramalkan model terbaik bagi input paras air awal sebagai paras laut purata. *Brier Skill Score* (BSS) terakhir untuk CH 400, CH 500, CH 600, CH 700, CH 800, CH 900, CH 1000 dan CH 1100 masing-masing ialah -0.79, -1.19, 0.19, 0.57, 0.34, 0.71, 0.62, dan 0.66. Kajian ini mendapati prestasi model XBeach menunjukkan hasil yang memberangsangkan bagi profil penghakisan tetapi sebaliknya untuk profil penumpukan. Hal ini kerana had yang terdapat dalam kajian ini seperti kesan proses

pergerakan sedimen dalam arah sejajar pantai dan pasang surut diabaikan. XBeach telah disahkan secara mendalam untuk keadaan penghakisan tetapi penggunaan pemodelan untuk keadaan penumpukan terutamanya bagi pantai berpasir adalah terhad. Kajian model evolusi profil menghasilkan dapatan bahawa ombak yang tinggi cenderung untuk menghakis profil tanah lebih cepat daripada ombak yang rendah.



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CHAPTER 1

INTRODUCTION

Nearshore zone plays a very important part in this study. The boundary of this zone is from the low tide line, which marks the transition to the beach zone to the offshore boundary, which is the point where sediment transport is no longer significantly affected by the waves. Transportation of sediment both cross-shore and longshore happen in this zone. According to Nam (2010), nearshore zone is an active zone due to the external forces incoming such as the wind, tide, waves, and currents. Resulting to that, the bed material in this area is almost consistently in motion. Increasing or decreasing in the transport rate can cause accretion or erosion of sediment, affecting the beach profiles. Such changes in transport rate may happen naturally in the nearshore zone, for example, when the wave and/or wind conditions varies. Currents induced by waves and wind may change, resulting in changing sediment transport rates and evolution of the beach profiles. However, gradients in the transport rate can also be induced by man-made structures and activities such as beach nourishment. Beach nourishment is a process where a large amount of sand is used to fill the beach thus make it wider than the current state of the beach in order to compensate the sand that has lost due to erosion. Therefore, understanding the beach morphological evolution in this zone is necessary and important for protecting against erosion.

In order to understand the beach morphological evolution, numerical models have proven to be useful tools. Numerous software such as XBeach, Deft3D, SBeach, and SWAN have been developed in order to model various type of coasts and under various hydrodynamic conditions. The first advantage of numerical models is that they are often less expensive than physical models. Numerical models can easily simulate the beach morphology evolution under various scenarios of wave and current conditions that are difficult to carry out in the laboratory because of the high costs and time required. Furthermore, advanced and robust algorithms, as well as the capabilities of computers, are being developed and enhanced very quickly, enabling the improvement of numerical models for efficiently predicting the beach morphology evolution.

This chapter presents the general background of numerical models in simulating the beach profiles morphological evolution. From the issues stated, research objectives and research questions are generated accordingly. Besides that, the limitations and significance of the study were identified based on the available resources and current technologies. The thesis framework for the study has been laid out to give the viewers a brief outlook of what can be expected from the study.

1.1. Background

The background of this study is focuses on the study area which is Teluk Cempedak Beach located in Kuantan, Pahang. More details about the study area will be discussed in Chapter 3. Teluk Cempedak Beach is one of the main tourist attractions in the Pahang state. There are many public recreation activities, eateries as well as accommodation area located at the beach. However, the beach has a history of erosion

resulted in the narrowing of the beach area, which has affected adversely on the recreational and tourist activities in this area. The average retreat rate is estimated to 0.8 m/year. In order to overcome the erosion problem, the Department of Irrigation and Drainage (DID) has decided to use beach nourishment scheme as the soft engineering solution. From May to July 2004, the beach has been nourished with 178,000 m³ of sand. Beach profile survey data from July 2004 (nourished profiles) until October 2004 (post nourished profiles) is taken for this study.

A one-dimensional process based model of XBeach is used as a tool to investigate the performance of the model in evaluating cross-shore profiles under real wave conditions. The modelled cross-shore profiles are compared with the measured profiles.

1.2. Problem Statement

Kulkarni (2013) stated in his study that it is crucial to comprehend the processes which are dynamic in the coastal area to investigate the erosion effects. He also mentions that numerical modelling, a very useful tool for engineers, can help forecast the coastal erosion for a given set of environmental conditions but it is hard to forecast the true hydrodynamic and sediment transport patterns correctly at a location, as these processes comprise many complex interactions which are hard to model in their entirety. Numerical models make some assumptions for calculating these interactions and inaccuracies emerging from such assumptions are decreased by calibrating and validating the results with data collected from the site (Kulkarni, 2013).

Coastal processes are complicated and each site has its own unique hydrodynamic and morphodynamic conditions which make numerical modelling

computation cannot be standardized or be represented by straightforward formulae (Dabees, 2000). Given the complexity of coastal processes, which cannot be fully represented by deterministic formulae, and the high uncertainty in wave and sediment transport data (Kamphuis, 1999), numerous runs are required for sensitivity analysis and model calibration and verification which prohibit the practical application of such sophisticated models. One-dimensional coastal morphology models have demonstrated practical capability in predicting long-term shoreline change. However, most of one-dimensional models suffer from various constraints that limit their wide applicability. Research have been done by other researchers on numerical modelling of coastal erosion, beach evolution and others that are discussed in Chapter 2 but none on beach response due to sand nourishment scheme.

Therefore, this study is conducted to understand the beach response due to sand nourishment scheme and to apply one-dimensional model as well as calibrating it to ensure the practicability of the model.

1.3. Research Objectives and Questions

The main purpose of this study is to investigate the performance of process based model using XBeach in predicting beach profiles in response to a sand nourishment scheme. In conjunction of achieving the main purpose of this study, research objectives and research questions are formulated as shown below.

Research objectives are:

1. To develop one-dimensional cross-shore beach profiles model based on sand nourishment scheme at Teluk Cempedak Beach, Kuantan, Pahang.
2. To calibrate the model and determine the tuning parameters.

3. To investigate the capability of XBeach model using Brier Skill Score (BSS) by comparing the modelled profiles with the measured profiles.
4. To study the evolution process of nourished profiles under real wave condition.

Research questions are:

1. Are the modelled profiles able to represent the measured profiles? If not, what are the tuning parameters?
2. What are the evolution trends shown by the nourished profiles under real wave conditions?
3. What does the statistical error index indicate?
4. Is the one-dimensional process based model of XBeach capable to simulate the evolution of nourished profiles?

1.4. Scope of Work and Limitations

This study is focused on developing one-dimensional model of beach profiles using a process based model XBeach. The real wave information such as wave height, wave period and wave direction are obtained from a wave prediction model developed by National Oceanic and Atmospheric Administration (NOAA). For the calibration and sensitivity analysis, only a few parameters is applied, for example, short wave friction, breaking wave parameters, and wave skewness and asymmetry.

There are a few limitations of the study. First, only one-dimensional models are developed for this study. Second, longshore transport is not taken into account. Third, wind and tidal effect are neglected. Fourth, this model is site specific. Applying this to other site may need to do further parameterisation in order for the model to fit

the site applied. Fifth, stationary wave will be used instead of instationary wave. Sixth, high morphological acceleration factor (morfac) is used to decrease computational time. Lastly, uniform distribution of sediment properties, which is size of material of which 50%, is finer (D_{50}).

1.5. Significance of Study

In order to gain a deeper understanding of the sediment transport processes for a certain stretch of coastline, numerical modelling is an effective way in running various scenarios (Stuart et al., 2009). The use of the numerical model provided insight on daily evolution of the beach profiles selected for the study (Dan et al., 2015)

There has been no research done on one-dimensional modelling of bed profiles due to sand nourishment. Due to that, this thesis will serve as a tool for other researchers or coastal engineers to study the evolution of beach profiles in response to beach nourishment using open source software. Numerical modelling has been widely used in conjunction with availability of high performance computers and rapidly growing technology. Compared to physical modelling such as using lab, numerical modelling requires less time and cost. Although the conventional way is needed in order to verify or validate the model, researchers have to opt for numerical modelling for complex models such as two-dimensional and three-dimensional models.

1.6. Thesis Framework

The thesis contains five chapters and the summary of each chapter is given as follows:

Chapter 1 gives a general introduction of the overall study including the brief idea on the research concept. Research objectives and questions are developed to achieve the best outcomes of the research.

Chapter 2 provides literatures regarding beach nourishment scheme, morphological processes and the application of XBeach on previous studies.

Chapter 3 describes the as well as the overall procedure of the study starting from data collection until the production of the desired output using XBeach. The study area, Xbeach procedures and model input are introduced in this chapter.

Chapter 4 presents the results from one-dimensional beach profiles developed from XBeach. The results consist of model calibration, model performance and model profiles evolution. The indications of the results are thoroughly explained in this chapter.

Chapter 5 summarizes the overall works presented in the research. The general findings and analysis of the research is concluded. Each research answer is addressed in response to each research questions. Recommendations for engineering coastal solutions are provided for future research improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter covers the studies related to beach nourishment scheme and a study on the beach response due to sand nourishment in Teluk Cempedak. It also covers the morphological process that is related to this study. Furthermore, this chapter also discussed previous studies on XBeach, the tuning parameters used on the models and one-dimensional modelling of XBeach. Other than that, statistical error index that is used in this study is also discussed.

2.2 Beach Nourishment Scheme

Beach nourishment, also called artificial nourishment, replenishment, beach fill, and restoration, consists of the placement of large quantities of good quality sand within the near-shore system usually to address a continuing deficit of sand, manifested by shoreline recession (Dean, 2002).

Such nourishment can be used to create, to maintain a recreational beach, or to build out the shore in order to improve the capacity of the beach to protect coastal properties from wave attack (Komar, 1998).

Reeve et al. (2015), stated in their book that it is required finding a suitable source of material that is compatible with, but not necessarily identical to the material on the beach to be nourished. According to them, it is often the most satisfactory means of protecting a shoreline as it provided the necessary additional stock of material that allows a beach to respond naturally to various levels of wave attack. With beach nourishment, less interference with the natural processes at beach and the widened beach will have positive effects on the recreational activities and the environment (Reeve et al., 2015). Beach that has been nourished usually need to be re-nourished after 3-5 years depending on the severity of the erosion rate.

2.2.1. Beach Response due to Sand Nourishment at Teluk Cempedak

Ab Razak et al. (2013) did a study on the beach response due to beach nourishment on Teluk Cempedak. The investigation of the study focuses on the distribution pattern of sand volume changes, distribution pattern of beach level changes, the development of beach width, and application of the parabolic bay model to determine the stability of Cempedak Bay beach. Only the distribution pattern of sand volume changes is discussed in this literature review.

In the findings, it is found that three months after nourishment (August 2004 to October 2004), 37,000 m³ of sand in the system was lost. Only 10,000 m³ of sand was lost over the next monitoring period (November 2004 to July 2007). The substantial amount of sand that was lost three months after nourishment was due to stabilizing effects.

The zone of the beach was divided into three parts; north reach, middle reach and south reach. The period from July 2004 to October 2004 is referred to south-west

monsoon period. It is found that during this period, the north reach gains sand and the south reach loses sand. Table 2.1 describes the distribution pattern of sand towards the north and south profiles. It can be concluded that during south-west monsoon, the north reach attribute accretive cross-shore profiles meanwhile the middle and south reach attribute erosive cross-shore profiles.

Table 2.1: Net sand volume at three different reaches

Season	Period	North reach (m ³)	Middle reach (m ³)	South reach (m ³)
Southwest monsoon	July 2004 – October 2004	74	-223	-220

2.3 Morphological Processes

2.3.1. Sediment Transport

There are many processes, which may drive sediment transport process, i.e. wind, wave, tide or a combination amongst them. The transport occurs in the surf zone of sandy beaches normally dominated by the mechanism of wave breaking and transport in two directions that is to say cross-shore and along coastline.

The sediments could be divided into three based on their modes of transport as follow:

- i. **Bed load;** that is defined as the part of total load, which remain stays in the bottom of the area, and is transported by roll, slide or jump along the bed.

- ii. Suspended load; that is defined as the part of total load, which is moving because of the effect of fluid turbulence. If there is no fluid turbulence, they normally settle in the bottom.
- iii. Wash load; which is composed from very fine particles. Therefore, the wash load normally remains in the water body.

2.3.2. Cross-shore Transport

The beach profile may change because of natural condition. There is a cycle of beach profile change as explained by Kamphuis (2000) in Figure 2.1. The first one is the storm profile, or sometimes called the winter profile because it is often formed during the winter. The storm profile occurs when high and steep waves erode material from beach face to the deeper area and form bars near where the waves break. These bars are generated by the breaking wave and consecutively they cause the waves to break. In contrary, the second one is called the calm profile or “summer” profile which occurs when smaller and not so steep waves slowly move the material of bars back onshore, re-form a berm and make the beach profile steeper. The beach is classified being in a dynamic equilibrium condition if the beach profile does not change in the cross-shore direction.

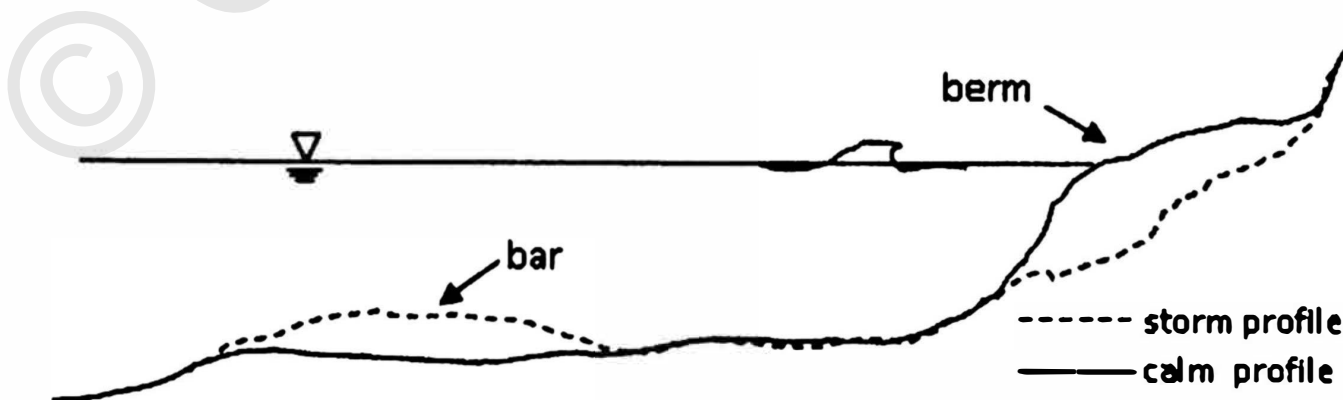


Figure 2.1: Change of Beach Profile (Source: Kamphuis, 2000)

Flows occurrence onshore direction in surf zone is induced by two mechanisms i.e. wave drift, which is defined as the mean velocity of a fluid particle, averaged over a wave period, and surface roller which is defined as a mass of water in front of the wave. The horizontal velocity of water particles in the surface roller is equal to the wave celerity c . To compensate the flow onshore direction, there is a return flow offshore direction near the bottom, which is called undertow (see Figure 2.2). Undertow reaches its maximum magnitude near the seabed. Further, the sand bar is formed because of undertow.

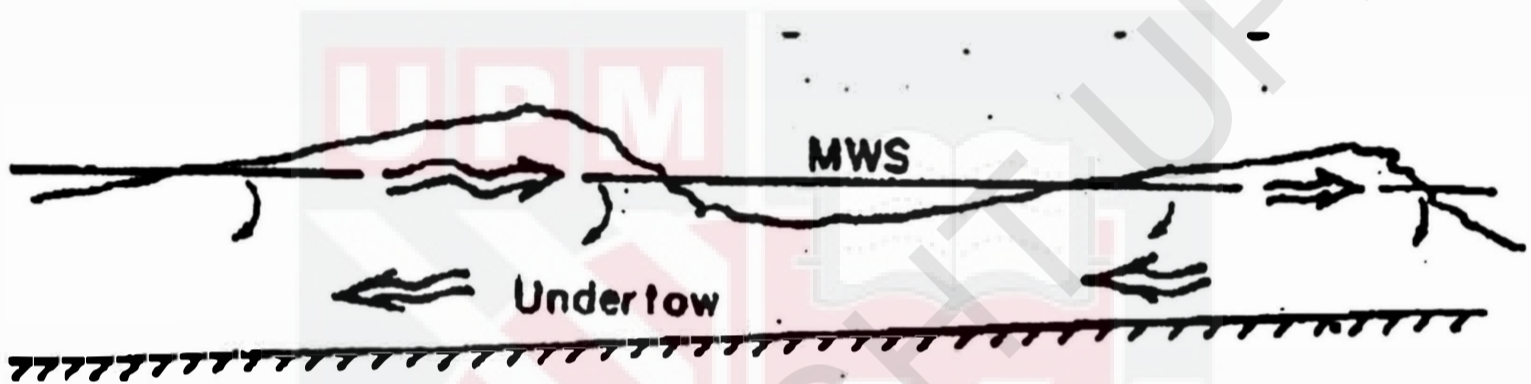


Figure 2.2: Sketch of undertow (Source: Svendsen, 2006)

2.4 Process Based Morphological Modelling

2.4.1. XBeach

XBeach is an open-source numerical model which is originally developed to simulate hydrodynamic and morphodynamic processes and impacts on sandy coasts with a domain size of kilometers and on the time scale of storms. Since then, the model has been applied to other types of coasts and purposes.

The model includes the hydrodynamic processes of short wave transformation (refraction, shoaling and breaking), long wave (infragravity wave) transformation (generation, propagation and dissipation), wave-induced setup and unsteady currents,

as well as overwash and inundation. The morphodynamic processes include bed load and suspended sediment transport, dune face avalanching, bed update and breaching. Effects of vegetation and of hard structures have been included. The model has been validated with a series of analytical, laboratory and field test cases using a standard set of parameter settings.

XBeach has two modes: a hydrostatic and a non-hydrostatic mode. In the hydrostatic mode, the short wave amplitude variation is solved separately from the long waves, currents and morphological change. This saves considerable computational time, with the expense that the phase of the short waves is not simulated. A more complete model is the non-hydrostatic model which solves all processes including short wave motions, but with more computational demand.

Examples of application of XBeach to other types and coasts are further discussed by including previous studies done by other researchers. First, a study done by Ab Razak et al. (2013). It is a study of shoreline evolution near an idealized groyne and the impact of sand bypassing on the accretion at the updrift coast by comparing analytical solution and XBeach numerical modelling. The results of this study showed promising results from XBeach. The XBeach model has been applied with a few parameters to help the model produce expected results. The sediment transport parameter which is onshore transport, *facua* with the value of 0.2 was set in XBeach. Avalanching module is activated to account for slumping of sandy material near the waterline which is *wetslp* and *dryslp* with the value of 0.1 for both parameters. High morphological acceleration factor, *morfac*, was used to save computational time and was found that the effect of *morfac* values is insignificant to the model.

Bolle et al. (2010) did a study on application and validation of XBeach for three different field sites. First, in Ostend, Belgium, one-dimensional and two-dimensional models were produced to improve the beach erosion predictions during storm events. Along with the main objective, one of the specific objectives is to test and develop reliable methods for numerical modelling of storm-induced morphological changes of a sandy coastal protection system, which in this study; the protection system is sea dikes.

The default settings were applied to the model except for *facua*, which is used for calibration parameter. The authors did not state the value of *facua* that produced the best model. The one dimensional XBeach models were compared with Durosta models. It was found that the performance of XBeach models is in general at least as good as Durosta for the beach erosion calculations during storm events.

The two-dimensional model applied the same hydrodynamic conditions and settings as the one-dimensional models. It is found that 2D models can improve the beach erosion predictions for Ostend.

Second, in Ada, Ghana, a new coastal protection scheme is designed to protect against long period waves. This site was still undergoing site survey during the study.

Lastly, In Elmina, Ghana, an XBeach model was constructed to get more insight into all wave driven sedimentation processes near Elmina harbour. Only two-dimensional model was produced for this site. The models produced for this study are able to give the authors insight into the complex mechanism and identify the most important one.

A paper by Pender and Karunarathna (2013) presents a methodology for modelling medium term (annual to decadal) cross-shore beach profile change and

erosion. XBeach is used to calibrate modelling storm-induced erosion and post-storm recovery in Narrabeen Beach, Sydney, Australia. The storm induced erosion model and post storm model used a different approach of calibration parameters.

For storm erosion modelling, three parameters that influence model simulations are Chézy coefficient, C ; permeability coefficient, k ; and wet cell gradient prior to avalanching, $wetslp$. The values of these parameters were varied in order to predict the most similar profile with the measured post-storm profiles. The final values for C , k and $wetslp$ are 45, 0.0031 m/s and 0.15 respectively. The result for modelling storm erosion has been proved to be effectively calibrated.

For post-storm recovery modelling, wave skewness ($facSk$) and wave asymmetry ($facAs$) were used to calibrate the models. These parameters determine the magnitude and direction of net sediment transport. The final values for $facSk$ and $facAs$ were 0.5 and 0.8 respectively. The result of this modelling proved to be encouraging.

2.4.2. One-dimensional numerical modelling of XBeach

This section discussed on the studies done on 1D numerical modelling of XBeach. First study is from Ruiz de Alegria-Arzaburu et al. (2011). The study is about the application of XBeach to model storm response on a macrotidal gravel beach. Macrotidal is applied to coastal areas where the tidal range is in excess of 4 m. Tidal currents dominate the processes active in macrotidal areas. In this study, XBeach numerical model has been used to simulate storm-induced morphological response on a macrotidal gravel barrier located in southwest UK. Using well-established parameterisation to define all relevant hydrodynamic, groundwater and sediment processes, the model was applied in 1D mode to simulate observed storm induced

beach profile responses. Investigations showed that the morphological response of the beach was best modelled using a total drag coefficient, C_D , of 0.007, and a hydraulic conductivity, K , of 0.05ms^{-1} . The model has been found unable of reproducing the formation of a berm, thus, beach recovery conditions cannot be modelled. This is mainly attributed to the fact that XBeach models long waves rather than individual waves, and thus it cannot simulate individual swash events that contribute to onshore sediment transport and berm accretion. However, the model is shown to provide good estimates of post-storm gravel beach/barrier profiles, and to define the threshold for overwash occurrence. Both attributes have utility in a range of practical coastal engineering and management applications.

Another research is from Van Dongeren et al. (2013). This study is about investigating low-frequency (infragravity) wave dynamics on a fringing coral reef using the numerical model, XBeach. The skill of the model was evaluated in one- and two-dimensions based on its predictions of short waves (0.04–0.2 Hz), infragravity waves (0.004–0.04 Hz) and water level measurements (tidal and wave setup) obtained during a 2009 field study at Ningaloo Reef in Western Australia. The model calibration was sensitive to friction coefficients for short waves and current/infragravity bed friction. The main purpose of 1D simulation was to identify the sensitivity of the model to the friction parameters f_w and c_f , as well as to identify the optimum values required to reproduce the key hydrodynamic processes (short waves, IG waves, and mean water levels) across the reef. XBeach was found to predict the range of important hydrodynamic processes across a complex reef-lagoon system with relatively good accuracy in both the 1D and 2DH modes for different sets of bottom friction parameter values. In both modes, the same optimum value for the short wave friction coefficient f_w was found. However, the current/IG friction coefficient c_f was reduced by

approximately 50% in the 2DH case to most accurately predict both the IG wave transformation across the reef and the mean water level (setup) variations. The strict shore-normal forcing in the 1D model resulted in larger IG wave generation and required higher wave bottom friction coefficients c_f to reproduce the field observations. Also, due to these higher friction coefficients, wave setup was significantly over predicted in 1D model.

2.4.3. Statistical Index Error using Brier Skill Score

The Brier Skill Score (BSS) calculates the performance of the performance relative to a baseline prediction. The BSS calculates the mean square difference between the prediction and observation with the mean square difference between baseline prediction and observation.

$$BSS = \frac{\frac{1}{N} \sum_{i=1}^N (z_{b,c} - z_{b,m})^2}{\frac{1}{N} \sum_{i=1}^N (z_{b,0} - z_{b,m})^2} \quad (2.1)$$

where $z_{b,c}$ is the computed bottom, $z_{b,m}$ is the measured bottom and $z_{b,0}$ is the initial bottom (variables taken at each cross-shore coordinate i).

Perfect agreement gives a Brier score of one, whereas modelling the baseline condition gives a score of zero. If the model prediction is further away from the final measured condition than the baseline prediction, the skill score is negative. Van Rijn et al. (2003) proposed a classification for the Brier Skill Score as shown in Table 2.2.

The BSS is very suitable for the prediction of bed evolution. The baseline prediction for morphodynamic modelling will usually be that the initial bed remains unaltered. In other words, the initial bathymetry is used as the baseline prediction for

the final bathymetry. A limitation of the BSS is that it cannot account for the migration direction of a bar; it just evaluates whether the computed bed level (at time t) is closer to the measured bed level (at time t) than the initial bed level. If the computed bar migration is in the wrong direction, but relatively small; this may result in a higher BSS compared to the situation with bar migration in the right direction, but much too large. The BSS will even be negative, if the bed profile in the latter situation is further away from the measured profile than the initial profile. The limitation shown here is that position and amplitude errors are included in the BSS. Distinguishing position errors from amplitude errors requires a visual inspection of measured and modelled profiles.

Table 2.2: Brier Skill Score quantification (Van Rijn et al., 2003)

Qualifications	Brier Skill Score
Excellent	1.0 – 0.8
Good	0.8 – 0.6
Reasonable/fair	0.6 – 0.3
Poor	0.3 – 0.0
Bad	< 0.0

CHAPTER 3

METHODOLOGY

3.1. Introduction

This chapter describes the study area and data collection that are used in developing 1D numerical modelling of XBeach. XBeach procedures are also briefly discussed and the model inputs are determined in this chapter. The model tuning parameters are also briefly described.

3.2. Study Area

The study area is located at Teluk Cempedak on the East Coast of Peninsular Malaysia near the town of Kuantan (see Figure 3.1). Teluk Cempedak is situated in a pocket bay adjacent to Hyatt- and Sheraton Hotel and has a total length of 1400 metres. Teluk Cempedak beach is considered one of the main tourist attractions in Pahang, where at the northern part of the beach is where the public recreational areas situated, while Hyatt and Sheraton hotels are situated in the southern part. The beach is located between the headlands of Tanjung Pelindung Tengah and Tanjung Tembeling, with Sungai Cempedak draining into the northern end of the bay. This river drains Bukit Pelindung and discharges some sediment and moderately polluted water from

developed areas within its catchment. The bay has been developed for public recreation as well as for local and international tourism activities.



Figure 3.1: The location of study area at Teluk Cempedak Beach, Kuantan (The aerial image is taken from Google Maps)

3.3. Data Collection

Data collection is the most important part of this study. Data made available in this study comprise the following: -

- (i) Profile survey data provided by DID (2007).
- (ii) Consist of nourished profiles and post-nourished profiles data.

The data is represented in 14 cross-shore profiles with the

interval of 100m longshore and 10m cross-shore. The surveys consist of 14 chainage (CH) lines from CH 100 to CH 1400. Only CH 400 until CH 1300 (see Figure 3.2) are involved in beach nourishment scheme. For the purpose of this study, only CH400 until CH 1100 will be analysed. CH 1200 and CH 1300 are neglected because those chainages are in the rocky area.

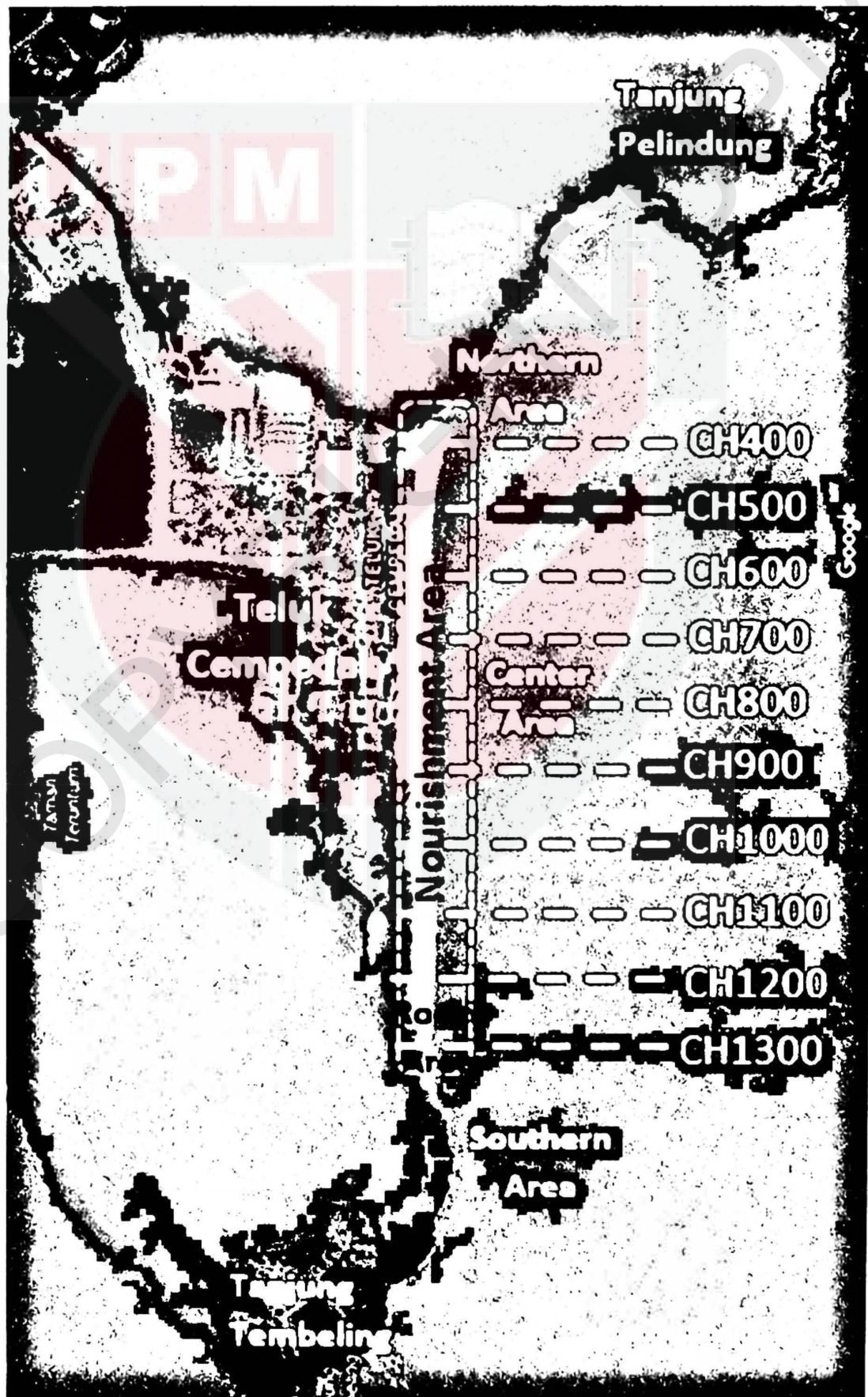


Figure 3.2: Transect profiles of nourishment area (The aerial image is taken form Google Maps)

(iii) Wave data.

Wave height, wave period and wave direction from the period of 4 months (July 2004 until October 2004) are obtained from the wave prediction model developed by NOAA.

(iv) Bed sediment data.

Design sediment size of D_{50} provided by DID (2007).

3.4. XBeach Procedures

XBeach model set-up involves three steps (See Figure 3.2). First is pre-processing. Followed by processing. Final is the post-processing.

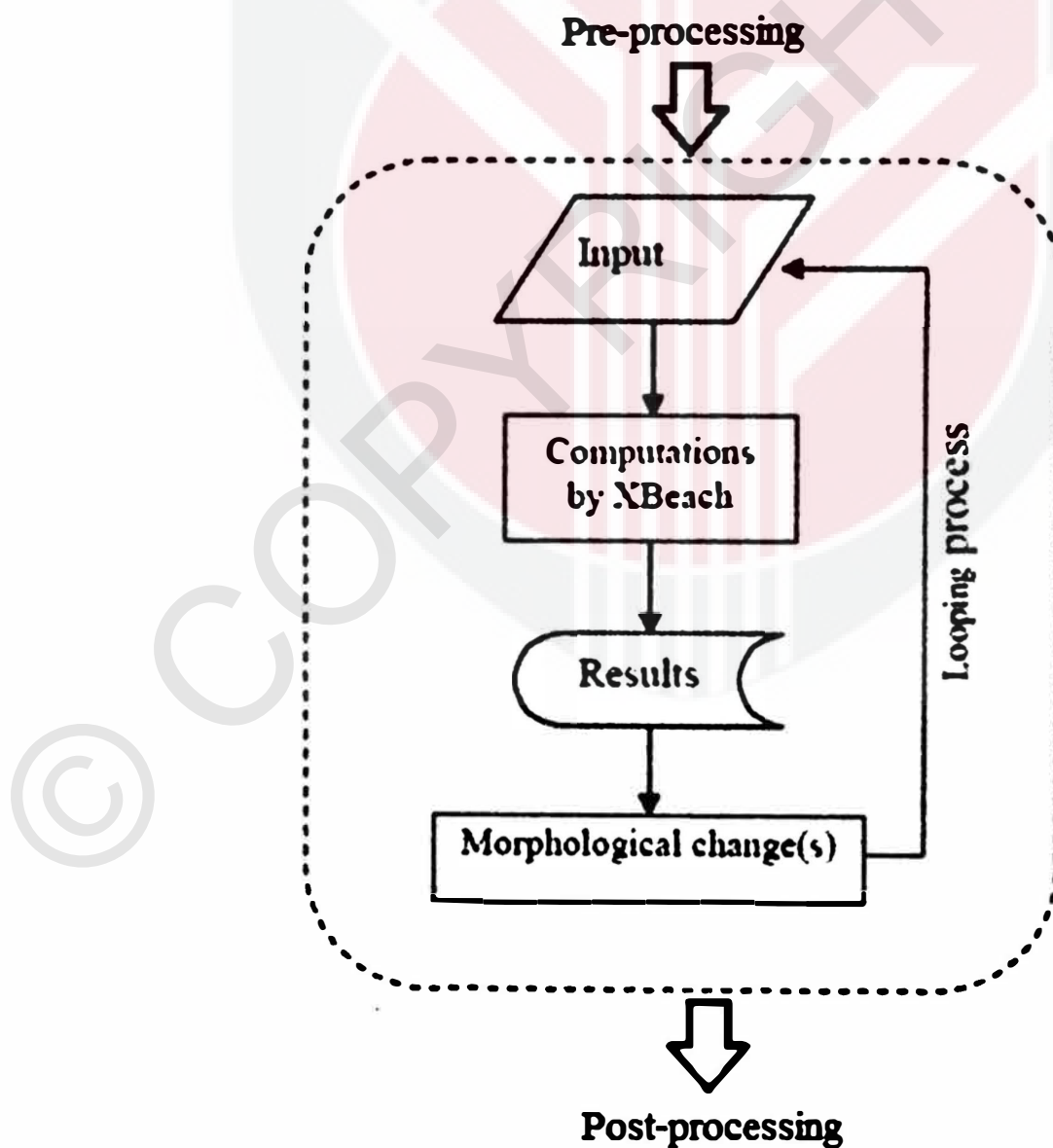


Figure 3.3: Three steps process of XBeach (Source: Modified from Risandi, 2011)

For pre-processing, the raw data used for this study is organized in a certain format so that XBeach can read the data. The data can be organized using Excel, Matlab or other softwares.

For processing, a text file called "params.txt" contains information about the grid and bathymetry, wave input, flow input and morphological input of the model which is needed to run XBeach. The other files required to be able to run XBeach are depth file, the x- and y- grid, the time series of water level and times series of the incident wave. All of those files must be located in one directory in such a way as to be able to be read during computation. The executable file "XBeach.exe" to run the model is obtained by compiling all of the XBeach source code written in Fortran 90. XBeach will compute the bed morphological change based on the given input using the equations provided and update the morphological change each time step based on the previous computation(s). The processes are looped back as simply illustrated in Figure 3.2 above.

For post-processing, The XBeach output files are a binary file type and are formatted in *.nc file extension. This typical file is readable using Matlab tools such as Quickplot developed by OpenEarth environment. OpenEarth is an open source system which is developed to provide, to compile and to share data, models as well as tools for analysing coastal environment. OpenEarth is fully supported by experts from Deltares, the Hydraulics Engineering and Environmental Fluid Mechanics division of TU Delft, Arcadis-Alkyon and UNESCO-IHE. The OpenEarth uses standard netCDF with CF convention for data storage and the data can easily be with the provided tools in Matlab, Phyton and Fortran.

3.5. Model Input

3.5.1. Wave Data

The wave data taken from wave prediction model by NOAA is from the period of 4 months, which is from 1/7/2014 until 31/10/2017. The interval of each data is 3 hours. Figure 3.4 shows the wave rose pattern for the study period of Teluk Cempedak Bay. Waves predominantly come from the southeast direction and the rest of the waves come from northeast direction with the significant wave height ranging from 0.2 to 2 m and wave mean period from two to 10 seconds. For this wave data, 33 percent of waves are in a range of 0.2 to 0.4 m followed by 30 percent that have wave heights of 0.4 to 0.6 m. No wave heights that exceed 2 m but only 0.7 percent of the heights are in the range of 1.8m to 2 m. Due to the southwest monsoon that occurs during this period, the wave height and wave period are relatively low.

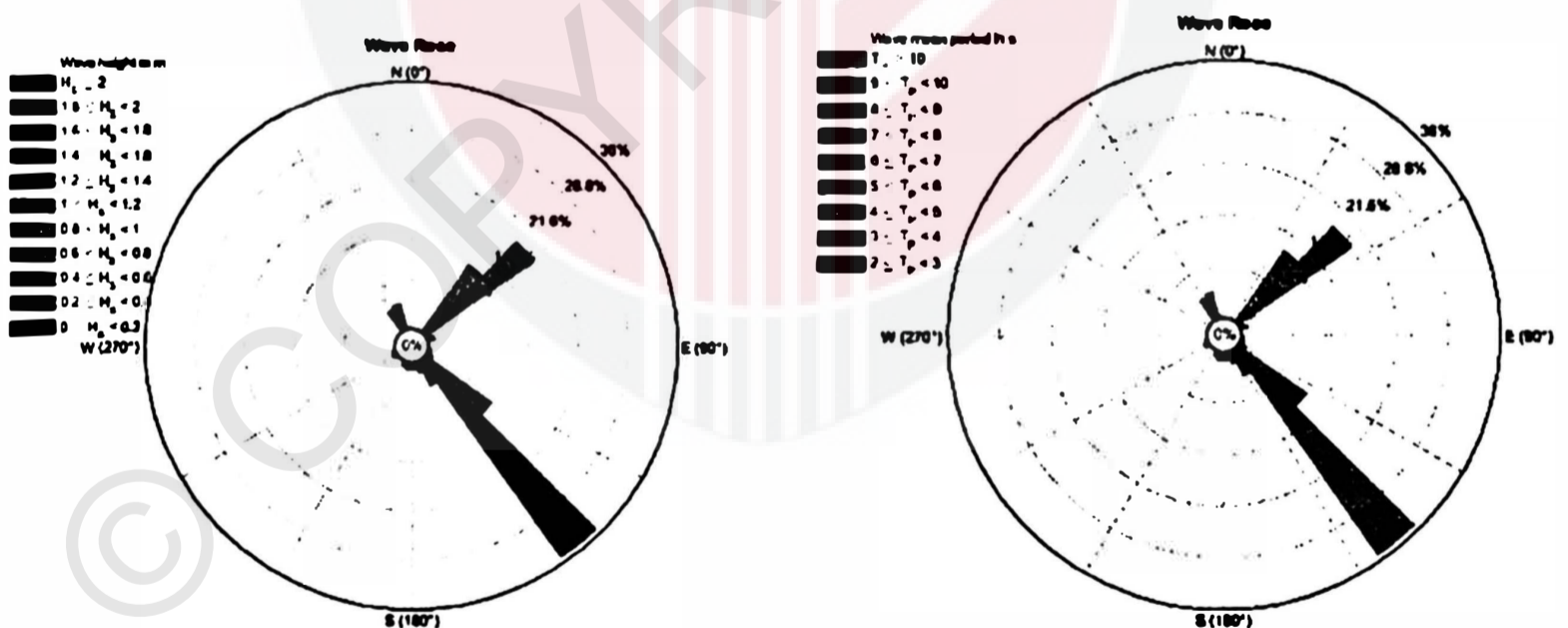


Figure 3.4: Wave rose pattern for Teluk Cempedak for the period from July 2004 to October 2004

Only wave height and wave period data were taken for model input. The direction of the wave is always be 270° because in one-dimensional model merely wave direction that is perpendicular to the shore is applied.

3.5.2. Bed Sediment Data

Table 3.1 shows the design size sand for the beach nourishment. Size of D_{50} is used for the whole nourishment area. Upper beach face and lower beach face have different size but the average value of those sizes are taken to be applied to the overall area of cross-shore profile since the model considers only uniform size of D_{50} .

Table 3.1: Plan view of location for design size sand of D_{50} . Mean sea level (MSL) is 0.05 m LSD

Profile	Upper beach face (Above MSL)	Lower beach face (Below MSL)	Average (Model)
CH 400	0.820 mm	0.280 mm	0.550 mm
CH 500	0.820 mm	0.280 mm	0.550 mm
CH 600	1.000 mm	0.330 mm	0.665 mm
CH 700	1.000 mm	0.330 mm	0.665 mm
CH 800	1.000 mm	0.330 mm	0.665 mm
CH 900	1.000 mm	0.330 mm	0.665 mm
CH 1000	1.000 mm	0.330 mm	0.665 mm
CH 1100	1.000 mm	0.330 mm	0.665 mm

*LSD refers to land survey datum

3.5.3. Grid and Bathymetry

A rectangular grid mesh (see Figure 3.5) were used with a uniform grid size of $dx=10$ m and $dy=0$. The cross-shore distance of the model, L_x , is 1250 m. There is no longshore distance, L_y , because 1D model does not consider longshore transport. That makes number of grids in x-direction, N_x , equals to 125 and number of grids in y-direction, N_y , equals to zero.

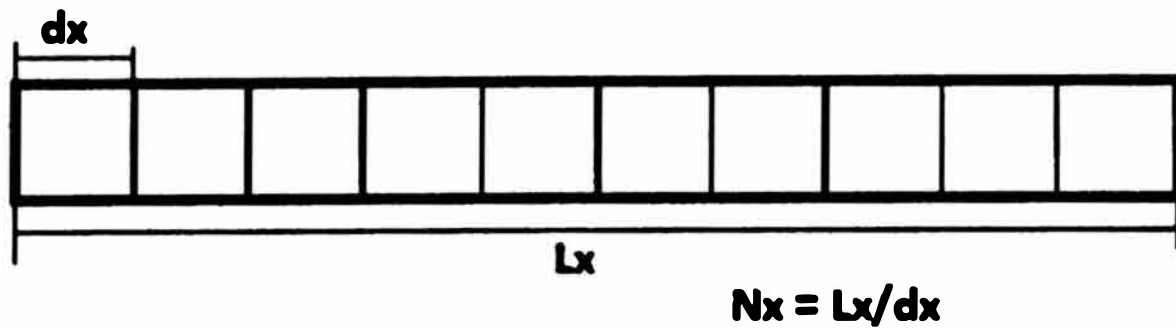


Figure 3.5: Grid details used by the model

A bathymetry survey data of July 2004 is used as an initial bathymetry for the calibration of wave models as well as for the morphological model. Figure 3.6 (a) and (b) show the cross-section profiles of nourished profiles (July 2004) and post-nourished profiles (October 2004) of CH 400 until CH 1100 that will be used for this study. The initial bathymetry of this model is July 2004 profile while the October 2004 profile is used to compare with the modelled profile.

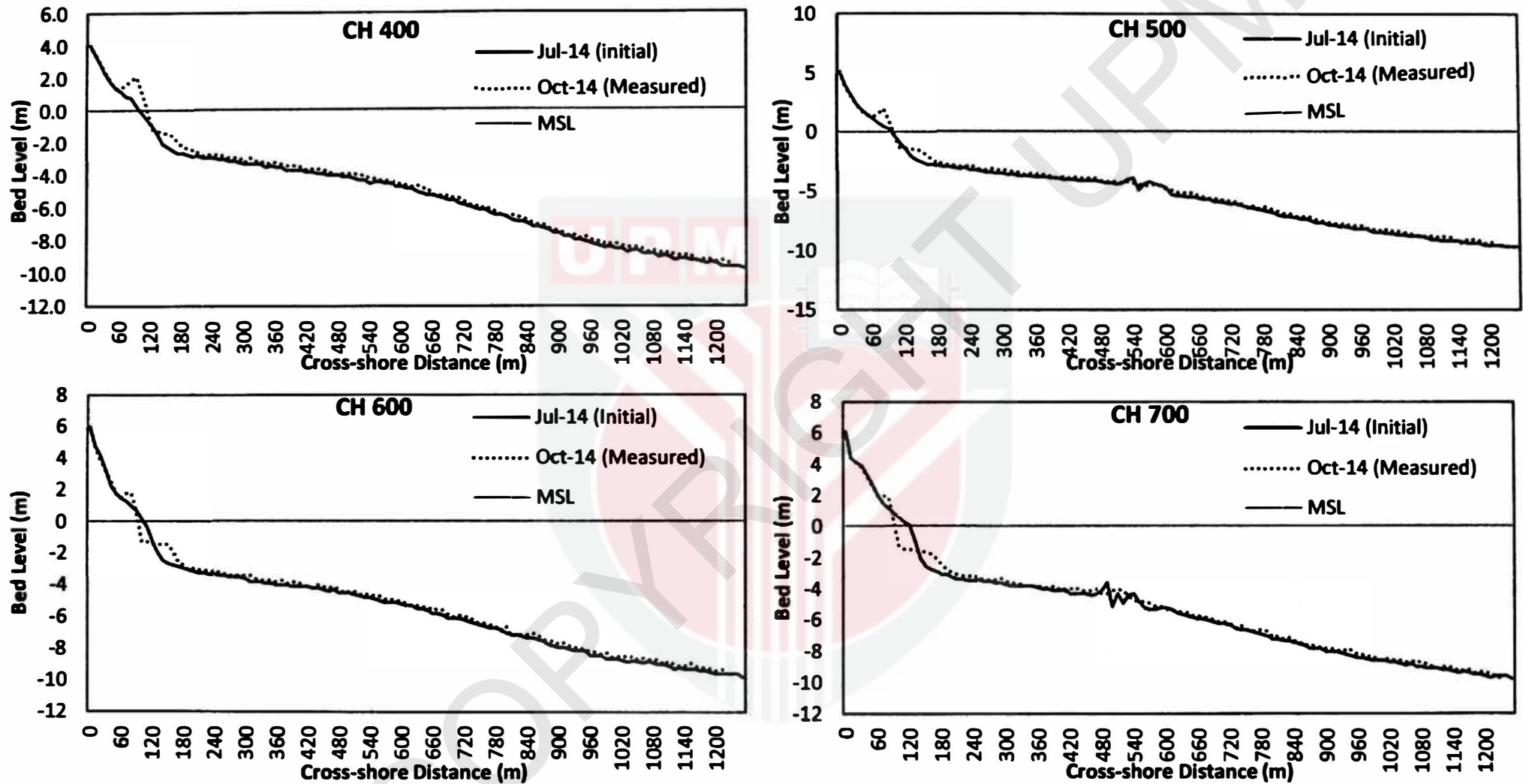


Figure 3.5 (a): Cross-section profiles at the nourished profile and post-nourished profile from CH 400 until CH 700. MSL refers to mean sea level (+0.05 LSD) in m

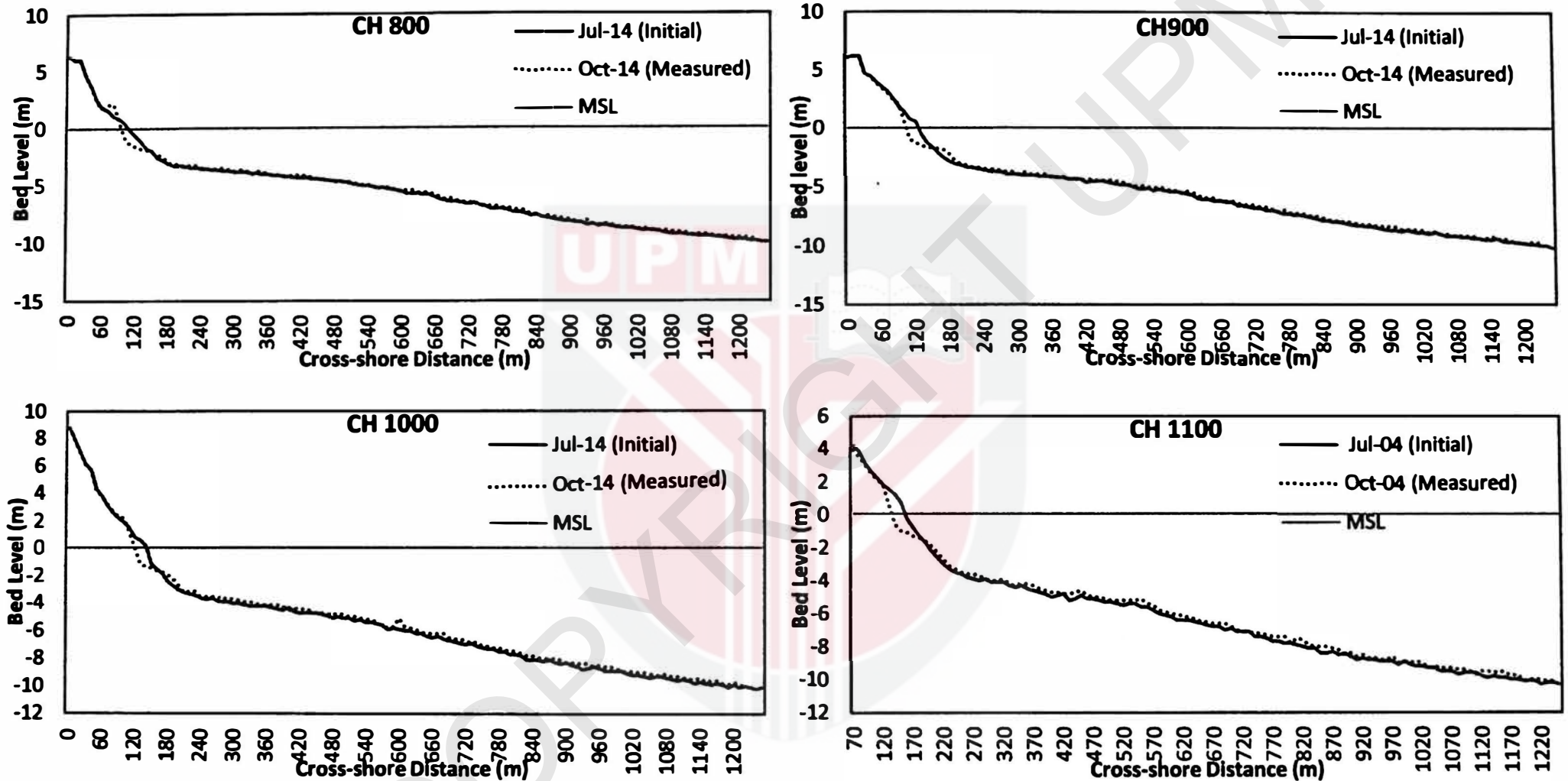


Figure 3.5 (b): Cross-section profiles at the nourished profile and post-nourished profile from CH 800 until CH 1100. MSL refers to mean sea level (+0.05 LSD) in m

3.5.4. Model Tuning Parameters

In order for the model to come out with expected outcomes, the model must undergo calibration process. As discussed in section 2.2.1, the cross-shore profiles of the beach are divided into two categories, erosive profiles and accretive profiles. Erosive profiles are CH 600 to CH 1100. Accretive profiles are CH 400 and CH 500.

These two profiles require different method of calibration. Based on the previous studies, the parameters chosen to be calibrated are the onshore transport due to changing the wave skewness and asymmetry factor (*facua*), the maximum gradient of wet cells before avalanching (*wetslp*), Chézy coefficient (*C*), and changing the initial water level to Mean Sea Level (MSL), Mean High Water Level (MHWL) and Mean Low Water Level (MLWL). The values of MSL, MHWL and MLWL are 0.05m, 0.95m and -0.95m respectively.

According to Deltares (2015), XBeach considers the wave energy of short waves as averaged over their length, and hence does not simulate the wave shape. A discretization of the wave skewness and asymmetry was introduced by Van Thiel de Vries (2009), to affect the sediment advection velocity. In this equation u_a is calculated as function of wave skewness (S_k), wave asymmetry parameter (A_s), root-mean square velocity u_{rms} and two calibration factor f_{Sk} and f_{As} (keyword: *facSk* & *facAs*), see equation (3.1). To set both values one can use the keyword: *facua*.

$$u_a = (f_{Sk}S_k - f_{As}A_s)u_{rms} \quad (3.1)$$

To account for the slumping of sandy material from the dune face to the foreshore during storm-induced dune erosion avalanching is introduced to update the bed evolution. Avalanching is introduced via the use of a critical bed slope for both the dry and wet area (keyword: *wetslp* and *dryslp*). It is considered that inundated areas

are much more prone to slumping and therefore two separate critical slopes for dry and wet points are used. When this critical slope is exceeded, material is exchanged between the adjacent cells to the amount needed to bring the slope back to the critical slope (see Equation 3.2).

$$\left| \frac{\partial z_b}{\partial x} \right| > m_{cr} \quad (3.2)$$

The bed friction associated with mean currents and long waves is included via the formulation of the bed shear stress. The dimensionless friction coefficient (c_f) can be calculated from the Chézy (C) value with equation (3.3). A typical Chézy value is in the order of 55 m^{1/2}/s.

$$c_f = \sqrt{\frac{g}{C^2}} \quad (3.3)$$

Table 3.2 shows the calibration model parameters for erosive profiles. Each profile will have a total number of 28 runs for calibration. Therefore, a total number of 168 runs were performed for erosive profiles.

Table 3.2: Calibration model parameters for erosive profiles

<i>Model parameters</i>	<i>Values</i>
<i>facua</i>	0.0: 0.1 : 0.2: 0.3: 0.4: 0.5: 0.6: 0.7: 0.8: 0.9: 1.0
<i>wetslp</i>	0.1 : 0.2: 0.3: 0.4: 0.5: 0.6: 0.7: 0.8: 0.9: 1.0
<i>Chézy coefficient</i>	40 : 45: 50: 55
<i>Intial water level</i>	MSL : MHWL: MLWL

*bolded items are the constant values used when calibrating other parameters

For accretive profiles, the tuning parameters used are *facua* and initial water level only. Table 3.3 shows the calibration model parameters for accretive profiles. Each profile will run for 14 times. That eventually makes the total number of 28 runs for accretive profiles.

Table 3.3: Calibration model parameters for accretive profiles

<i>Model parameters</i>	<i>Values</i>
<i>facua</i>	0.0: 0.1: 0.2: 0.3: 0.4: 0.5: 0.6: 0.7: 0.8: 0.9: 1.0
<i>Initial water level</i>	MSL: MHWL: MLWL

*bolded items are the constant values used when calibrating other parameters

Based on the parameters and the values determined for tuning, model calibration is conducted. These varying values of the parameters are expected to reveal the effect on the model cross-shore profile predictions. Figure 3.6 (a) and (b) shows the flowchart for model calibration in determining the optimum value for each parameter.

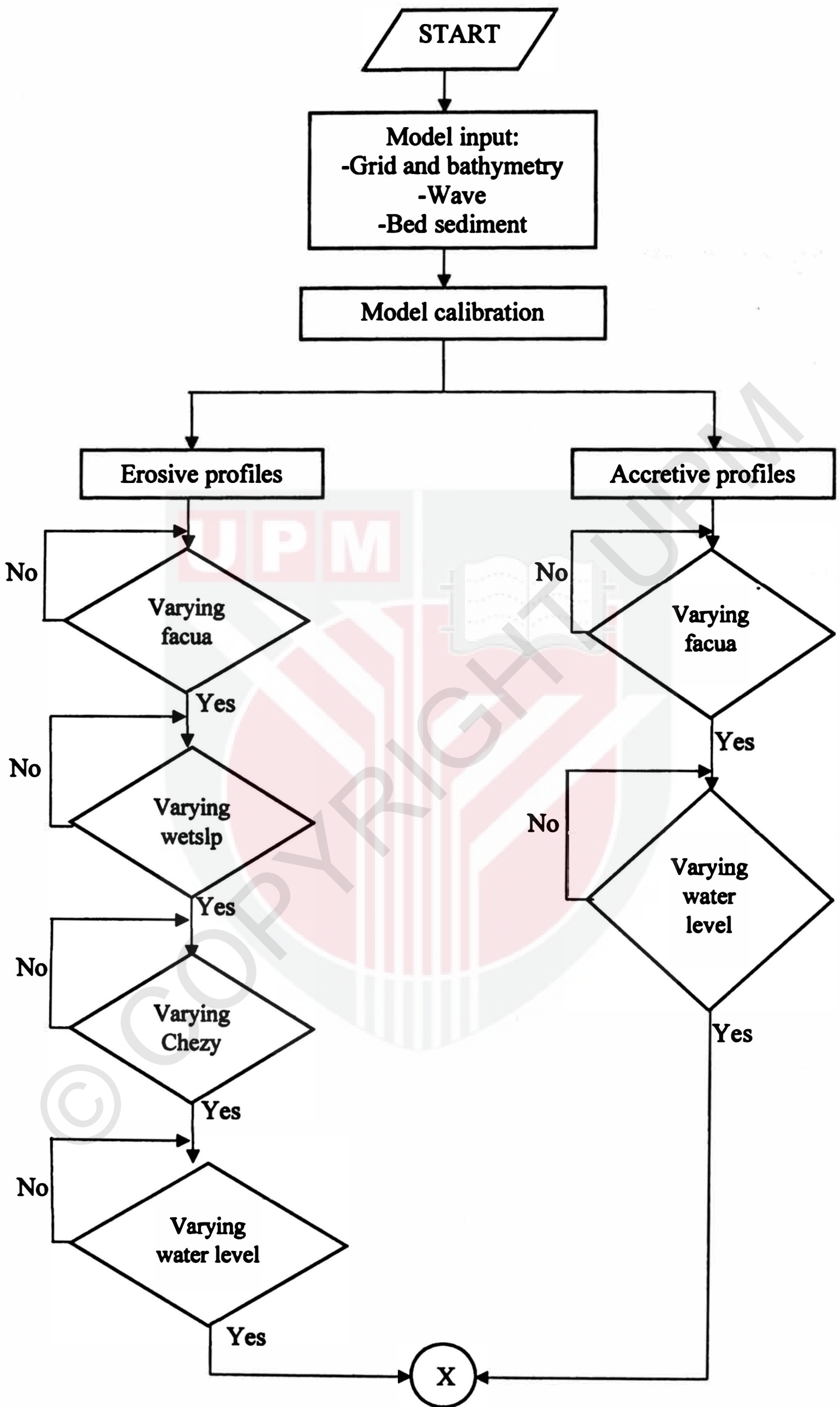


Figure 3.6 (a): Flowchart for model calibration (cont'd)

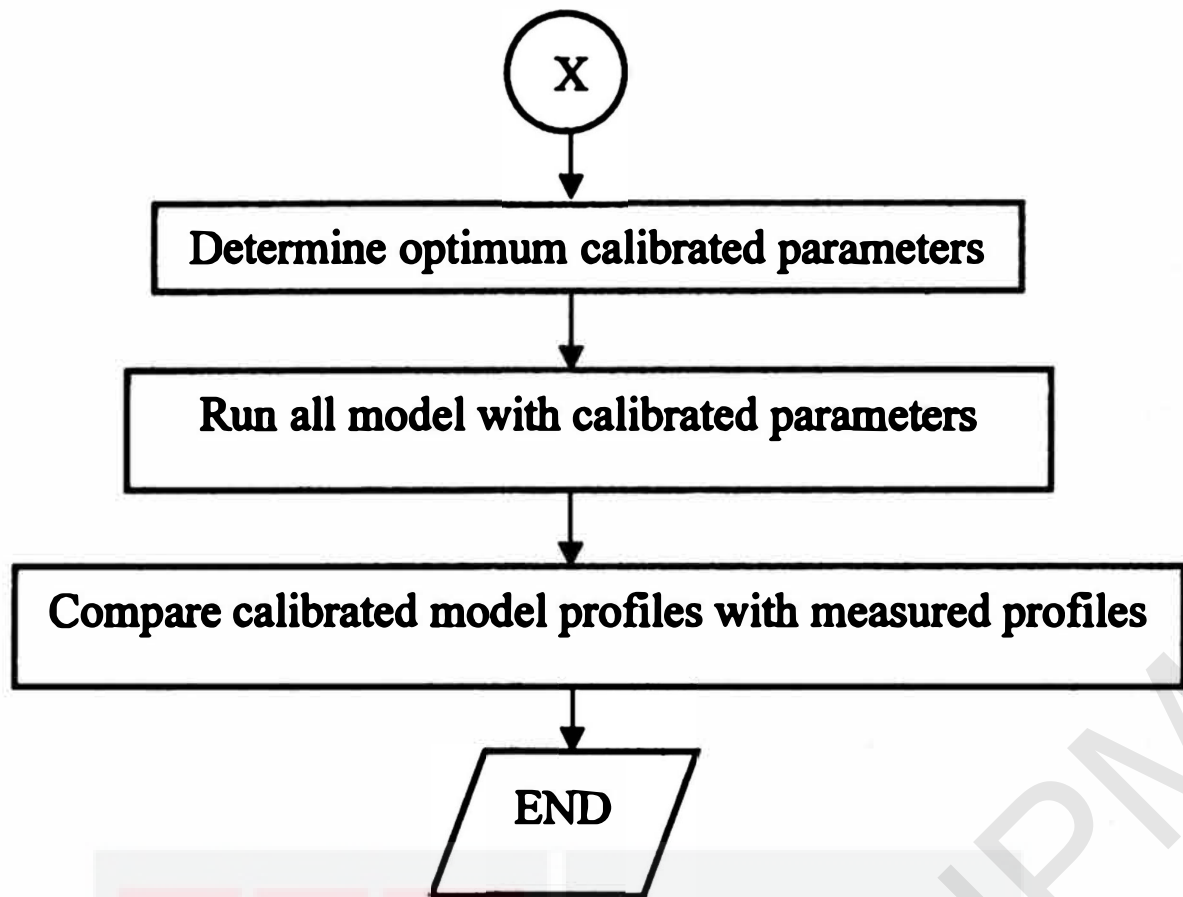


Figure 3.6 (b): Flowchart for model calibration

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter covers the results and discussions of the 1D models developed by XBeach. The results covered are the model calibration, model performances and modelled profiles evolution. Model calibration discussed on the effects of each tuning parameters used. Model performances discussed based on the rating given by the statistical index error. Modelled profiles evolution discussed on the evolution of the beach profiles under real wave condition.

4.2 Model Calibration

The tuning parameters discussed in section 3.54 is used for both erosive and accretive profiles. A high value of morphological acceleration factor, morfac, was used for the models. The value used is 100 since lower values (5, 10, 50) were also tested but no significant difference on the modelled profiles. Therefore, a higher value of morfac was used to save computational time. One simulation took about 15 minutes to complete simulation.

The calibrating parameters were chosen based on the highest value of BSS they produced. On top of that, visual inspection is also needed to make sure the models outcome turn out to what were expected.

The results of the modelled profiles focused only until cross-shore distance of 400 m. This is because beyond that, none of the models showed any changes of the bed profile. This could be due to not enough wave stirring at the offshore zone caused by the limitations of 1D models.

4.2.1. Erosive Profiles

It has been determined that erosive profiles in this study are from CH600 until CH1100. The indication of erosive profiles is shown in Figure 4.1. From the figure it can be seen that the measured profile shows erosion-deposition pattern where erosion occurs on the upper beach face and deposition occurs on the lower beach face.

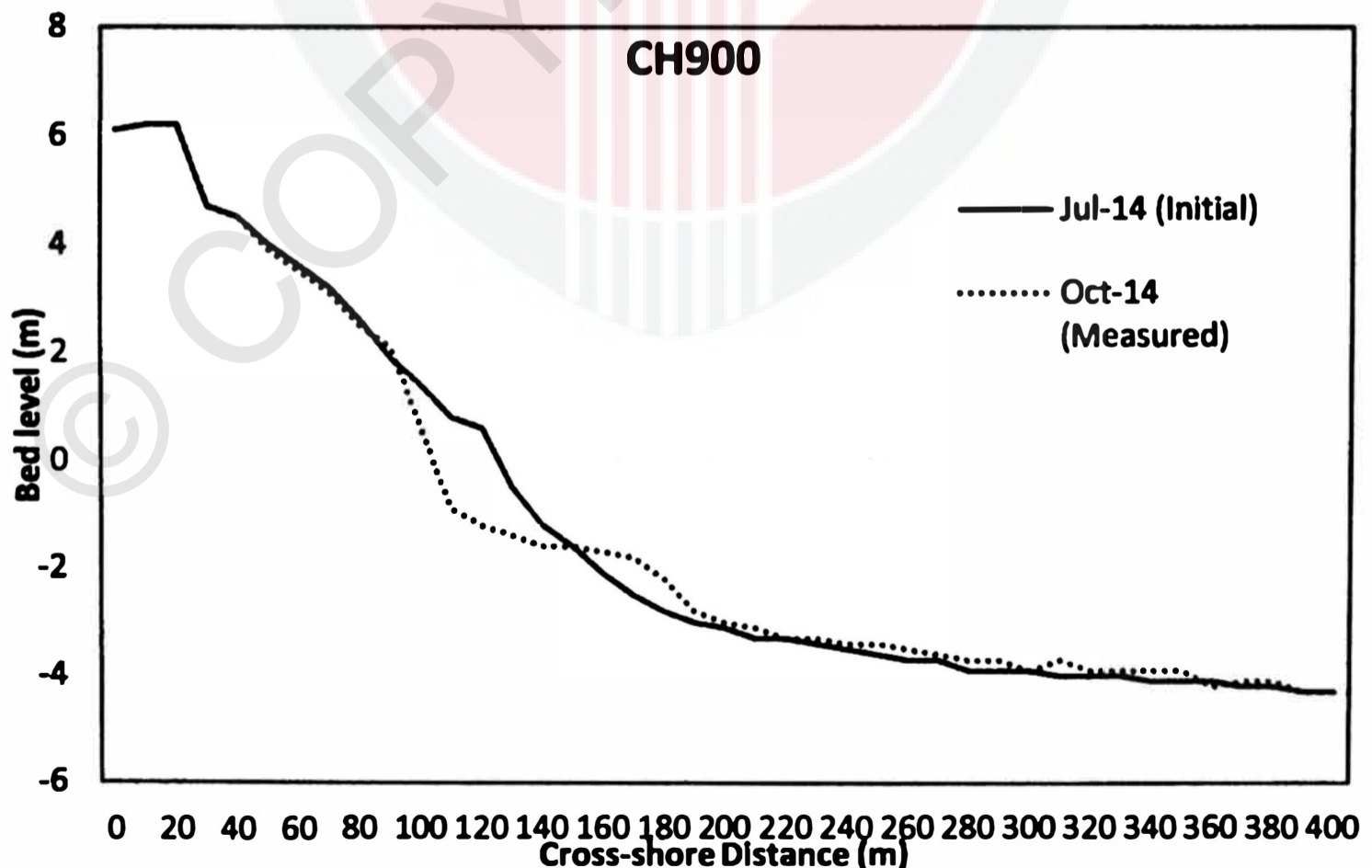


Figure 4.1: Example of erosive profile

4.2.1.1. Effect of facua

Table 4.1 shows the values of BSS based on the varying values of facua. It can be seen that most of the chainage have the highest BSS when facua is 0.2. Higher value of facua produces lower value of BSS.

Figure 4.2 (a), (b) and (c) show the effect of facua on the modelled profiles. It can be seen that higher value of facua shows a change in onshore transport direction. Values of facua 0.5 onwards shows the change in direction of erosion deposition. The modelled profiles of facua with the value 0.2 shows the most similar pattern to the measured profiles.

Table 4.1: Model skills performance (facua on erosive profiles)

<i>Parameter</i>	<i>BSS</i>					
	CH600	CH700	CH800	CH900	CH1000	CH1100
<i>0</i>	-0.44	0.60	-0.40	0.58	0.05	0.57
<i>0.1</i>	0.21	0.55	0.31	0.73	0.58	0.65
<i>0.2</i>	0.34	0.21	0.16	0.27	0.31	0.23
<i>0.3</i>	0.00	0.01	-0.02	0.12	0.06	0.06
<i>0.4</i>	-0.06	-0.04	-0.20	0.02	-0.08	-0.06
<i>0.5</i>	-0.12	-0.09	-0.31	-0.39	-0.20	-0.15
<i>0.6</i>	-0.17	-0.13	-0.40	-0.14	-0.27	-0.20
<i>0.7</i>	-0.21	-0.16	-0.46	-0.18	-0.32	-0.24
<i>0.8</i>	-0.26	-0.19	-0.53	-0.22	-0.36	-0.27
<i>0.9</i>	-0.30	-0.21	-0.57	-0.25	-0.37	-0.31
<i>1</i>	-0.32	-0.22	-0.61	-0.29	-0.40	-0.36

*bolded values are the highest BSS for that particular chainage

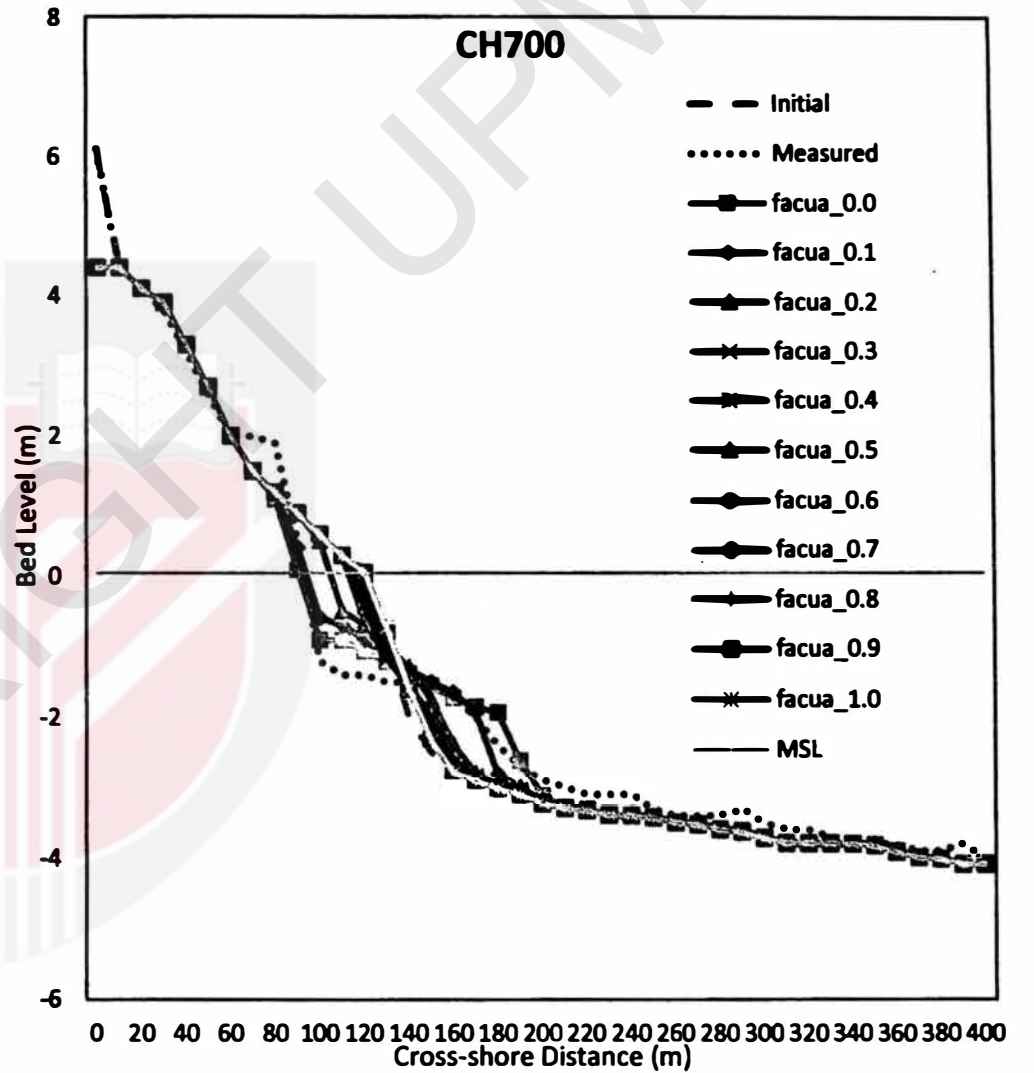
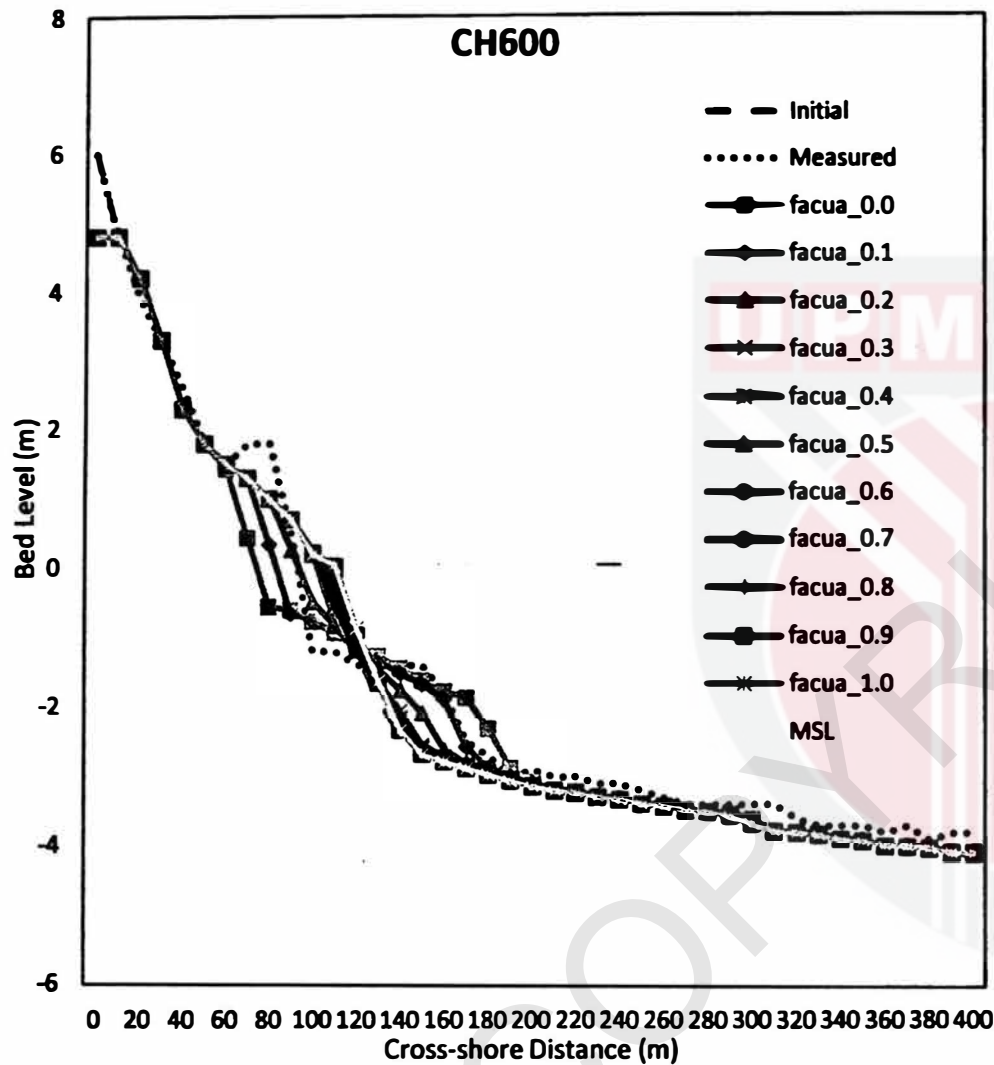


Figure 4.2 (a): Effect of facua on erosive modelled profiles (CH600 and CH700)

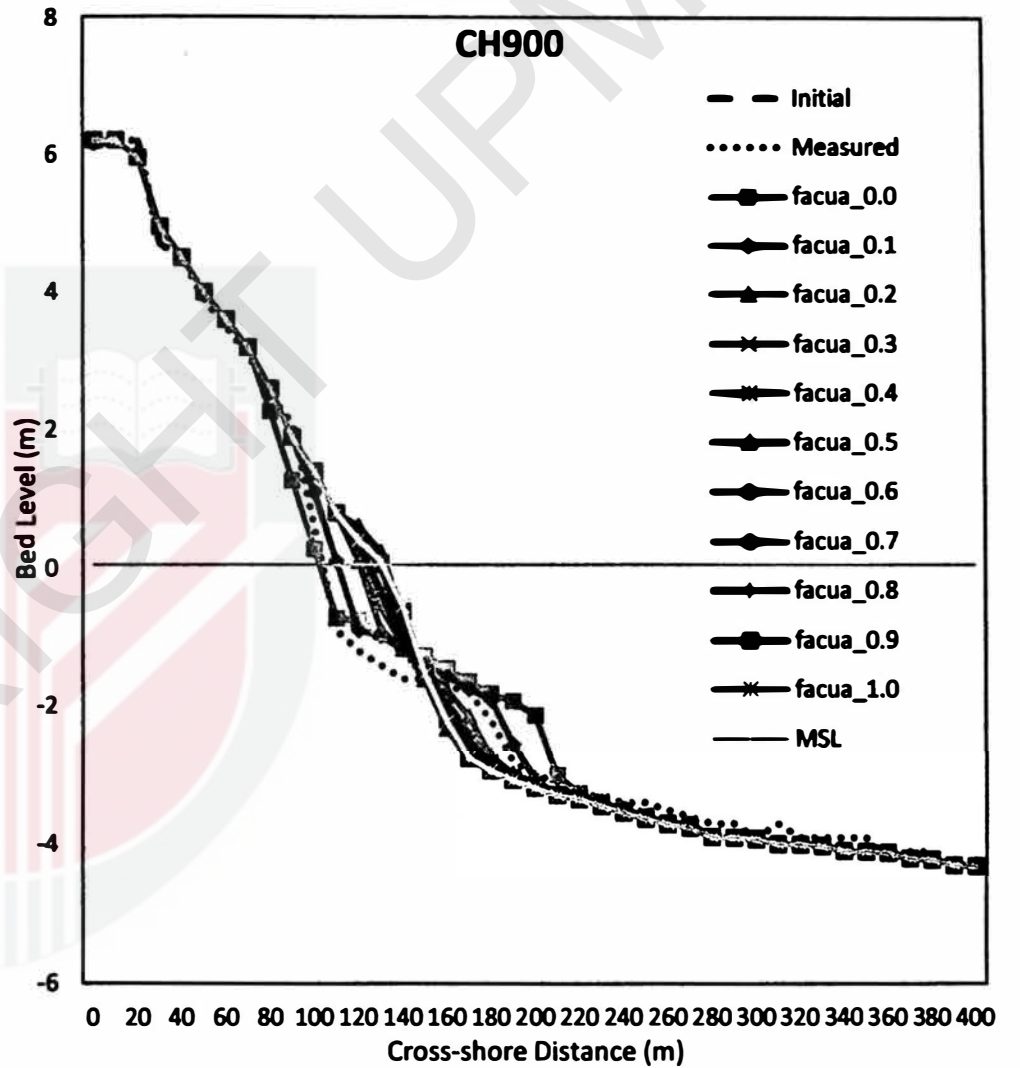
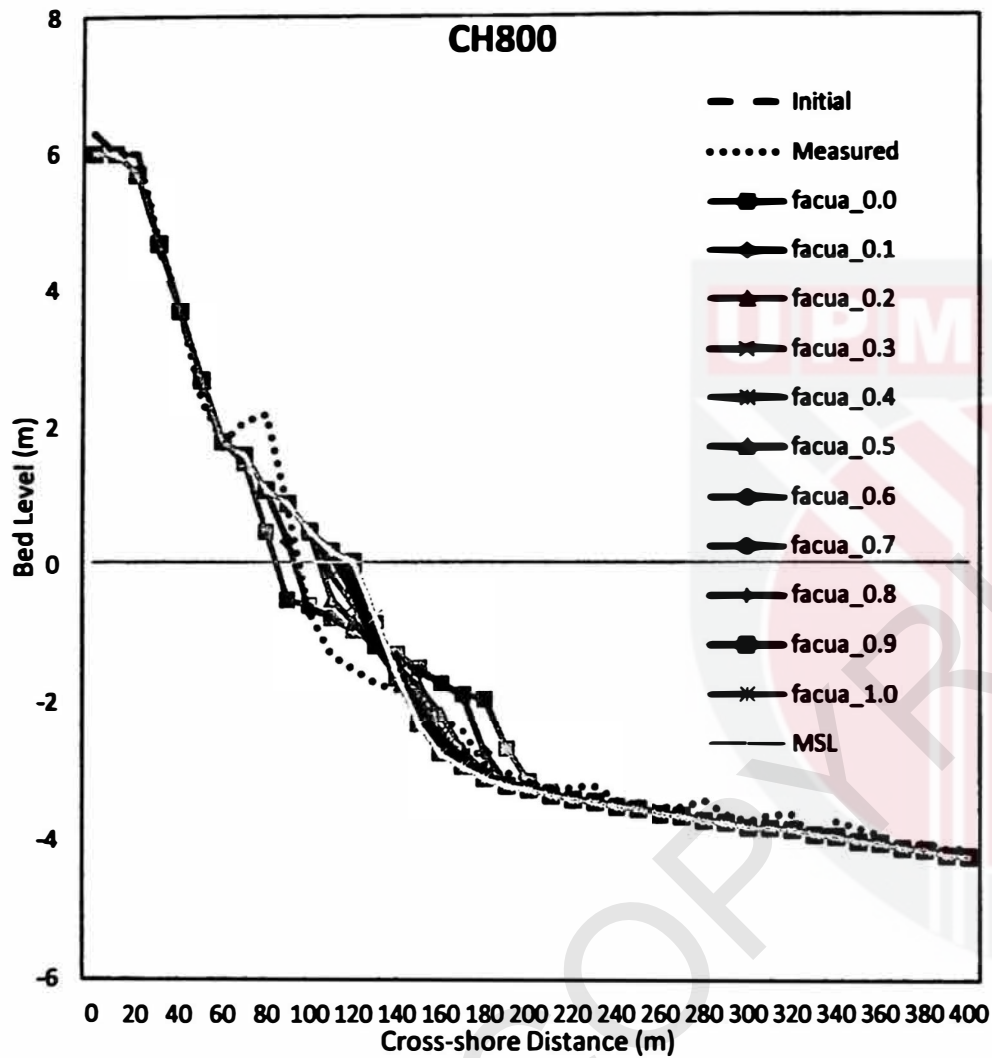


Figure 4.2 (b): Effect of facua on erosive modelled profiles (CH800 and CH900)

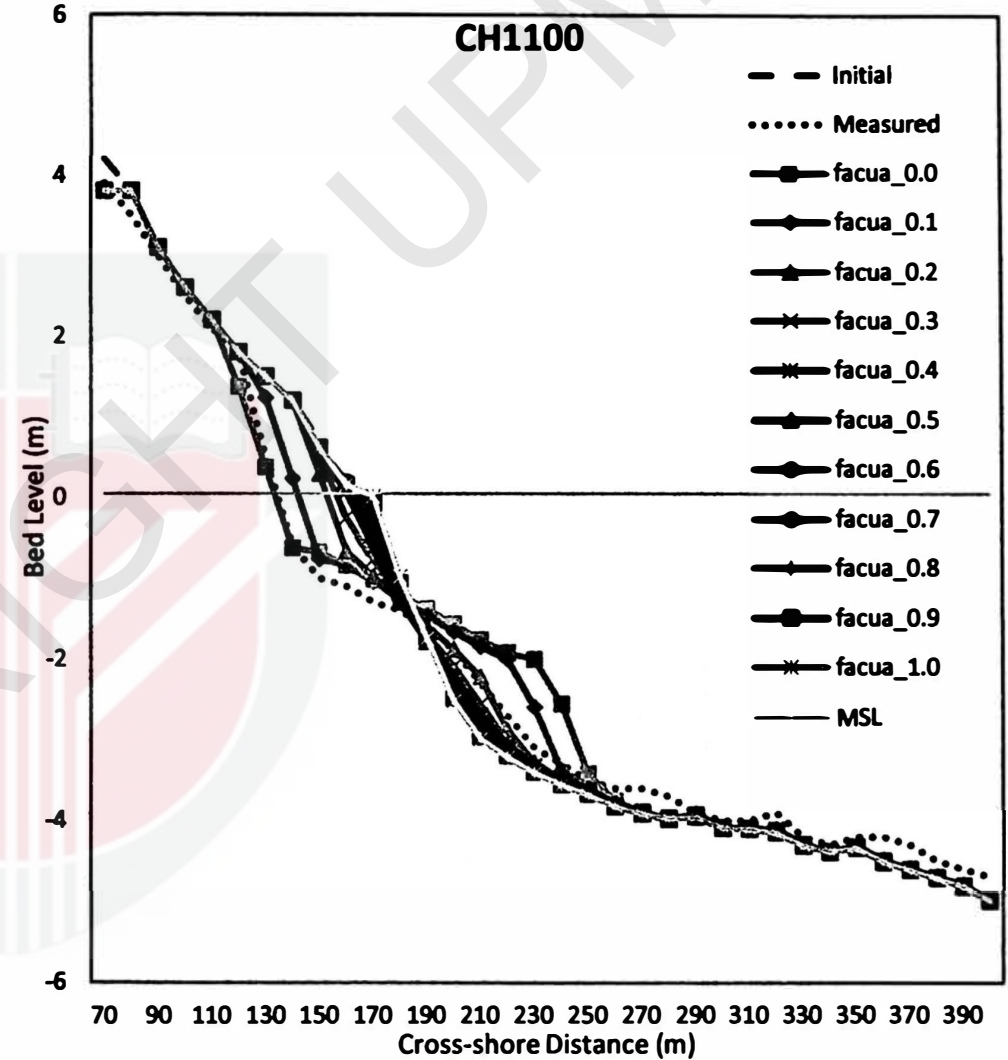
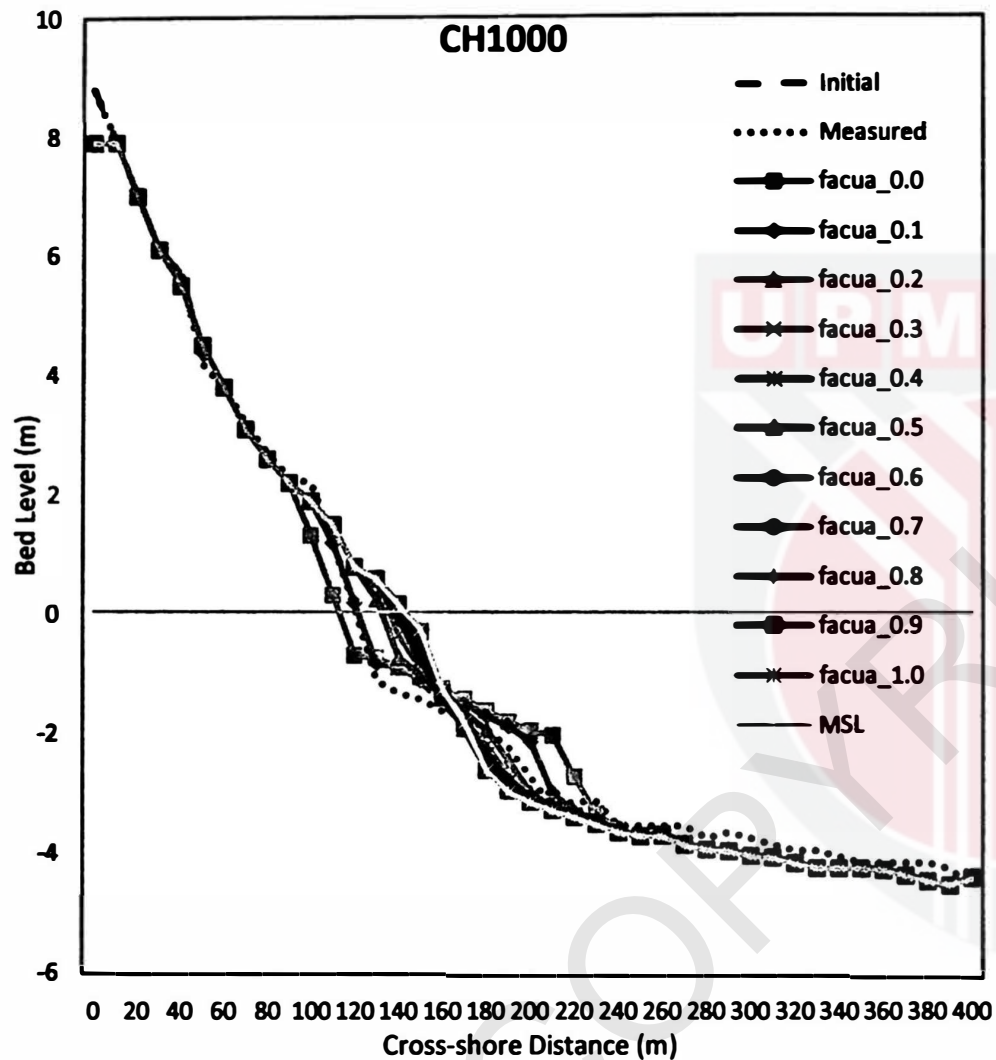


Figure 4.2 (c): Effect of facua on erosive modelled profiles (CH1000 and CH1100)

4.2.1.2. Effect of wetslp

From Table 4.2, it can be seen that wetslp value of 0.1 shows the highest BSS for all chainage. Increasing the value of wetslp shows a decreases on BSS and further increase in value shows no change on BSS.

From Figure 4.3 (a), (b) and (c), only wetslp value of 0.1 shows erosion on the upper beach face. Values of 0.2 and above shows similar patterns and no erosion on the upper beach. Wetslp 0.1 proves to be the optimum value.

Table 4.2: Model skills performance (wetslp on erosive profiles)

<i>Parameter</i>	<i>BSS</i>					
	CH600	CH700	CH800	CH900	CH1000	CH1100
<i>wetslp</i>						
<i>0.1</i>	0.21	0.55	0.31	0.73	0.58	0.65
<i>0.2</i>	0.17	0.14	0.31	0.23	-0.05	0.14
<i>0.3</i>	0.17	0.14	0.31	0.19	-0.07	0.11
<i>0.4</i>	0.17	0.14	0.31	0.19	-0.07	0.11
<i>0.5</i>	0.17	0.14	0.31	0.19	-0.07	0.11
<i>0.6</i>	0.17	0.14	0.31	0.19	-0.07	0.11
<i>0.7</i>	0.17	0.14	0.31	0.19	-0.07	0.11
<i>0.8</i>	0.17	0.14	0.31	0.19	-0.07	0.11
<i>0.9</i>	0.17	0.14	0.31	0.19	-0.07	0.11
<i>1</i>	0.17	0.14	0.31	0.19	-0.07	0.11

*bolded values are the highest BSS for that particular chainage

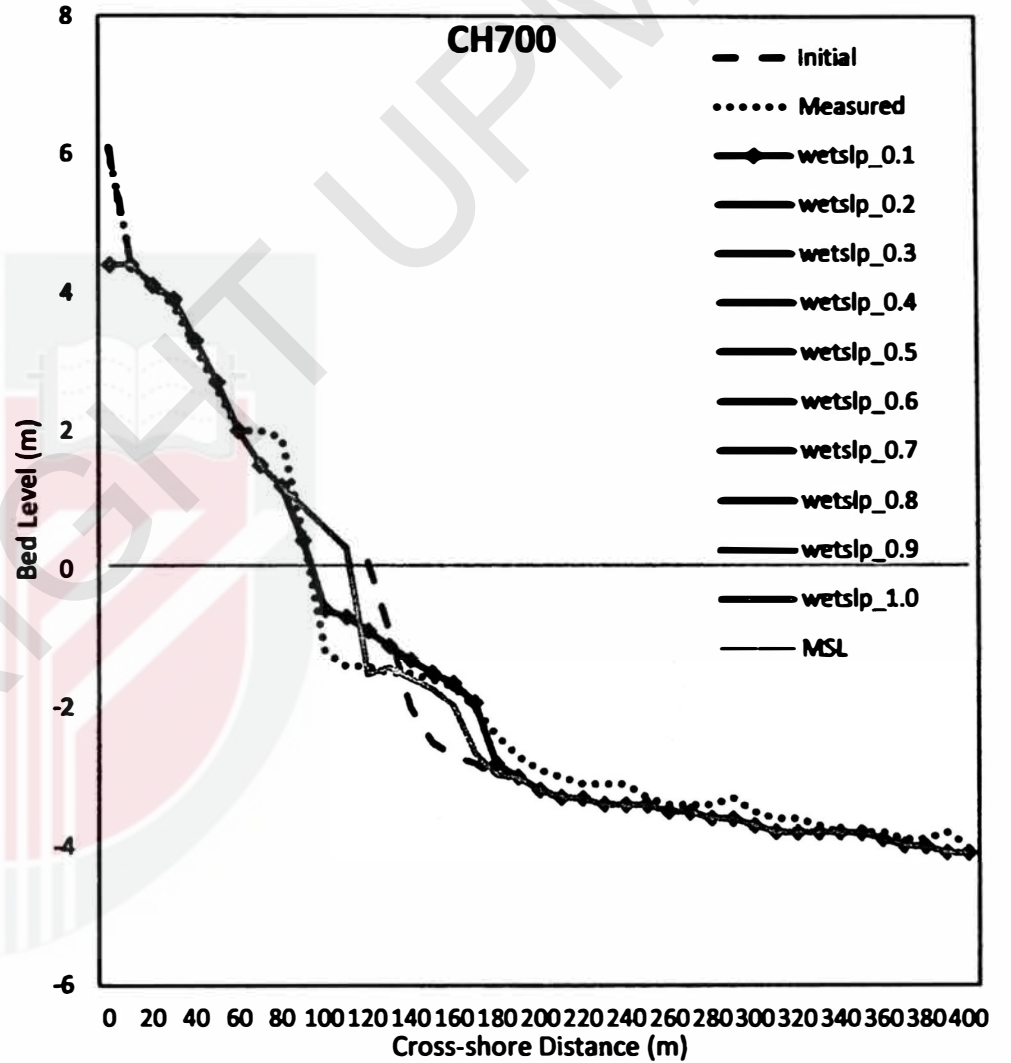
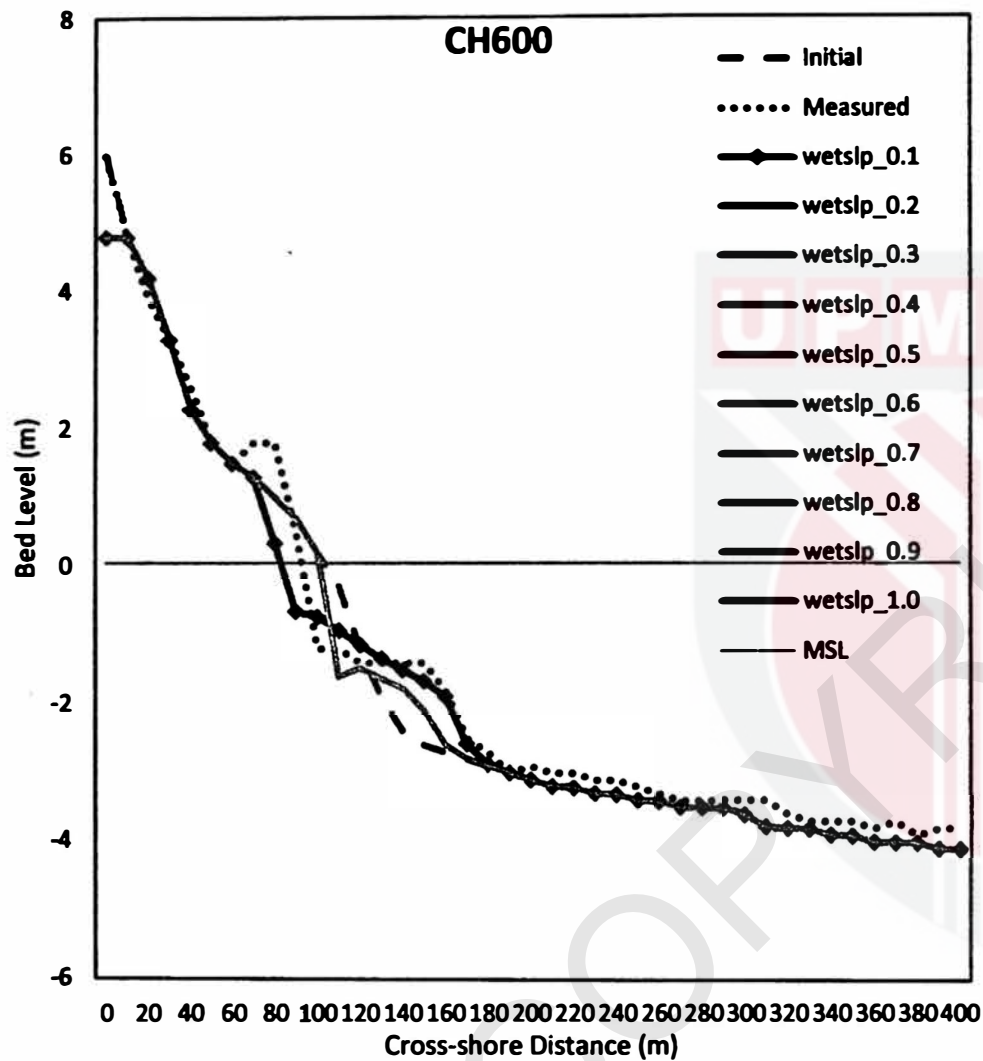


Figure 4.3 (a): Effect of wetslp on erosive-modelled profiles (CH600 and CH700)

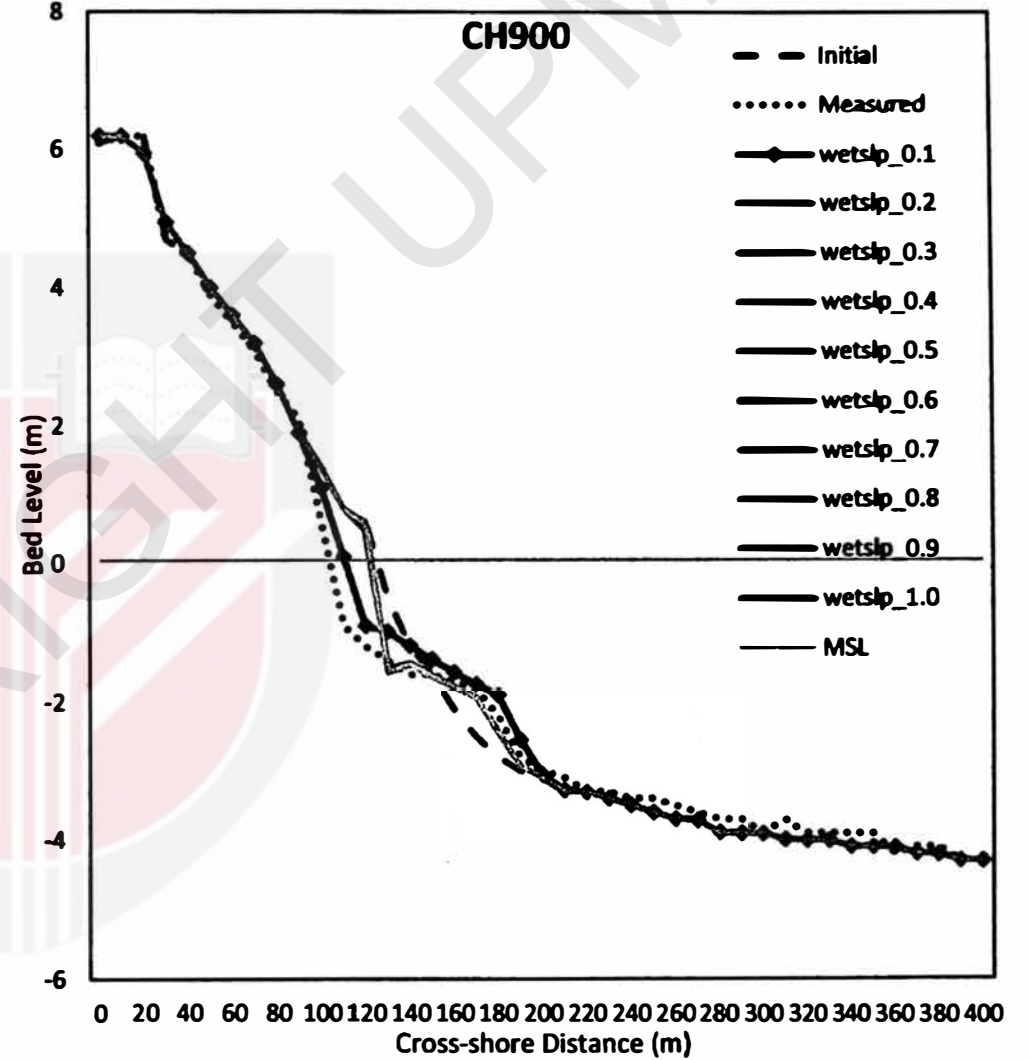
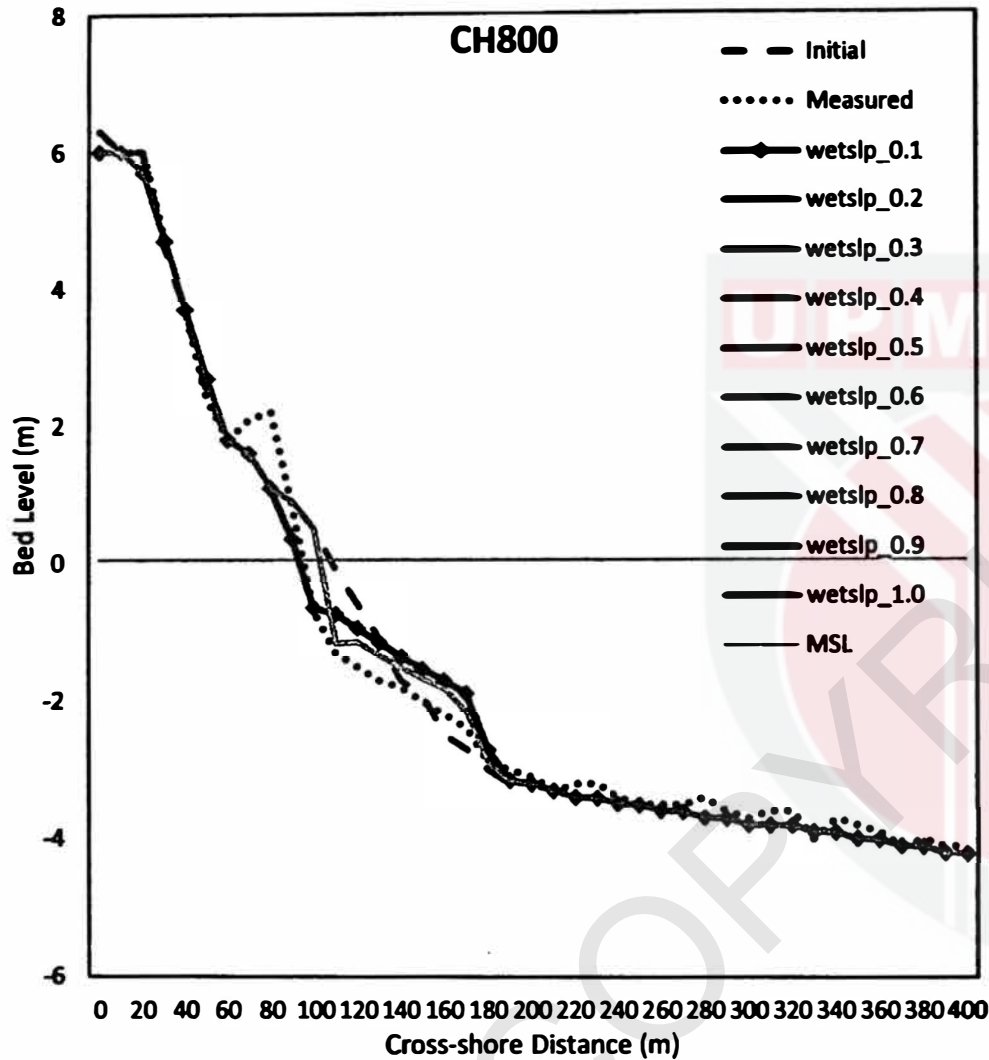


Figure 4.3 (b): Effect of wetslp on erosive-modelled profiles (CH800 and CH900)

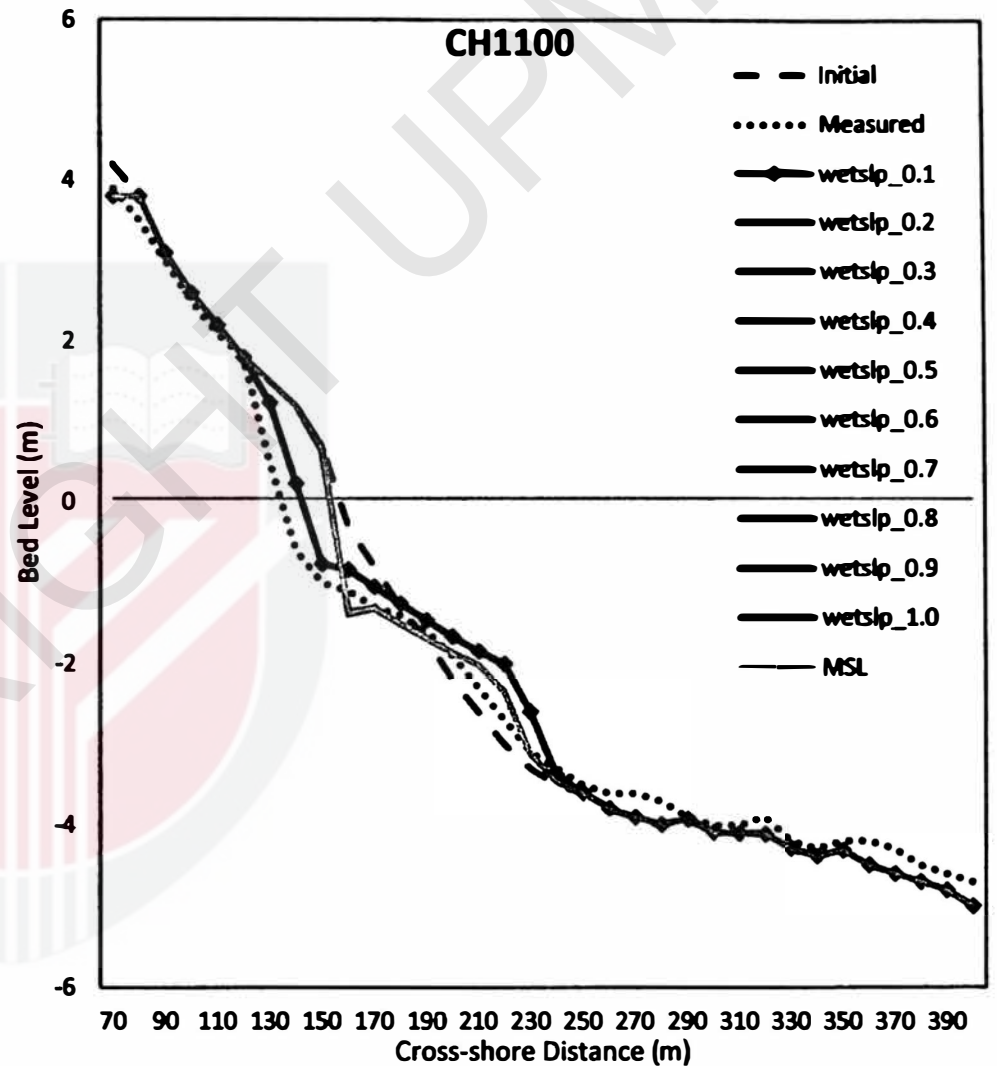
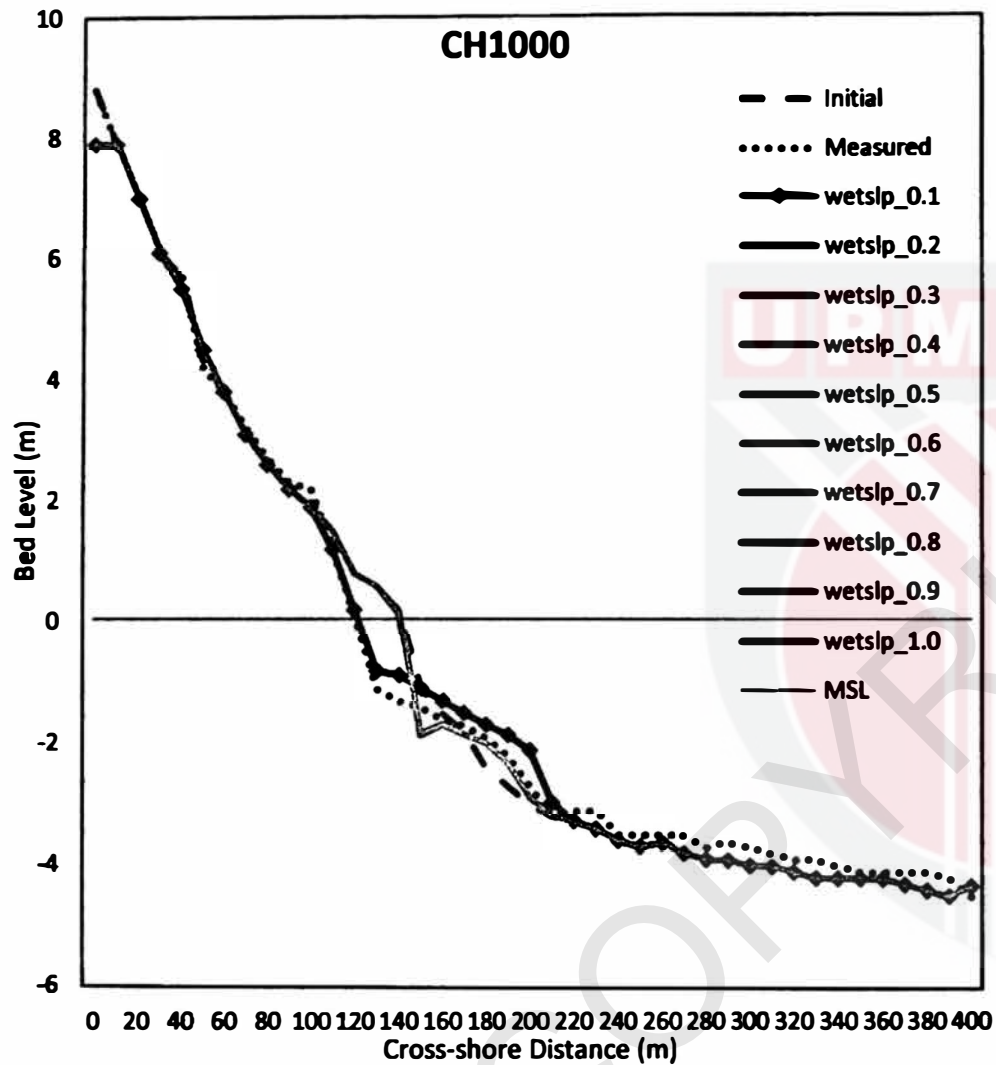


Figure 4.3 (c): Effect of wetslp on erosive-modelled profiles (CH1000 and CH1100)

4.2.1.3. Effect of Chezy coefficient

From Table 4.3, most of the models shows highest value of BSS when Chezy is 45. The values of BSS shows not much difference from each other as well as the modelled profiles shown in Figure 4.4 (a), (b) and (c). Therefore, the models shows not much sensitivity to the changing of Chezy coefficient values. However, selection of Chezy value of 45 is chosen since it shows an increase on the BSS values.

Table 4.3: Model skills performance (Chezy coefficient on erosive profiles)

<i>Parameter</i>	<i>BSS</i>					
	CH600	CH700	CH800	CH900	CH1000	CH1100
<i>40</i>	0.21	0.55	0.31	0.73	0.58	0.65
<i>45</i>	0.19	0.57	0.34	0.71	0.62	0.66
<i>55</i>	0.19	0.57	0.34	0.71	0.62	0.66
<i>60</i>	0.19	0.57	0.34	0.71	0.62	0.66

*bolded values are the highest BSS for that particular chainage

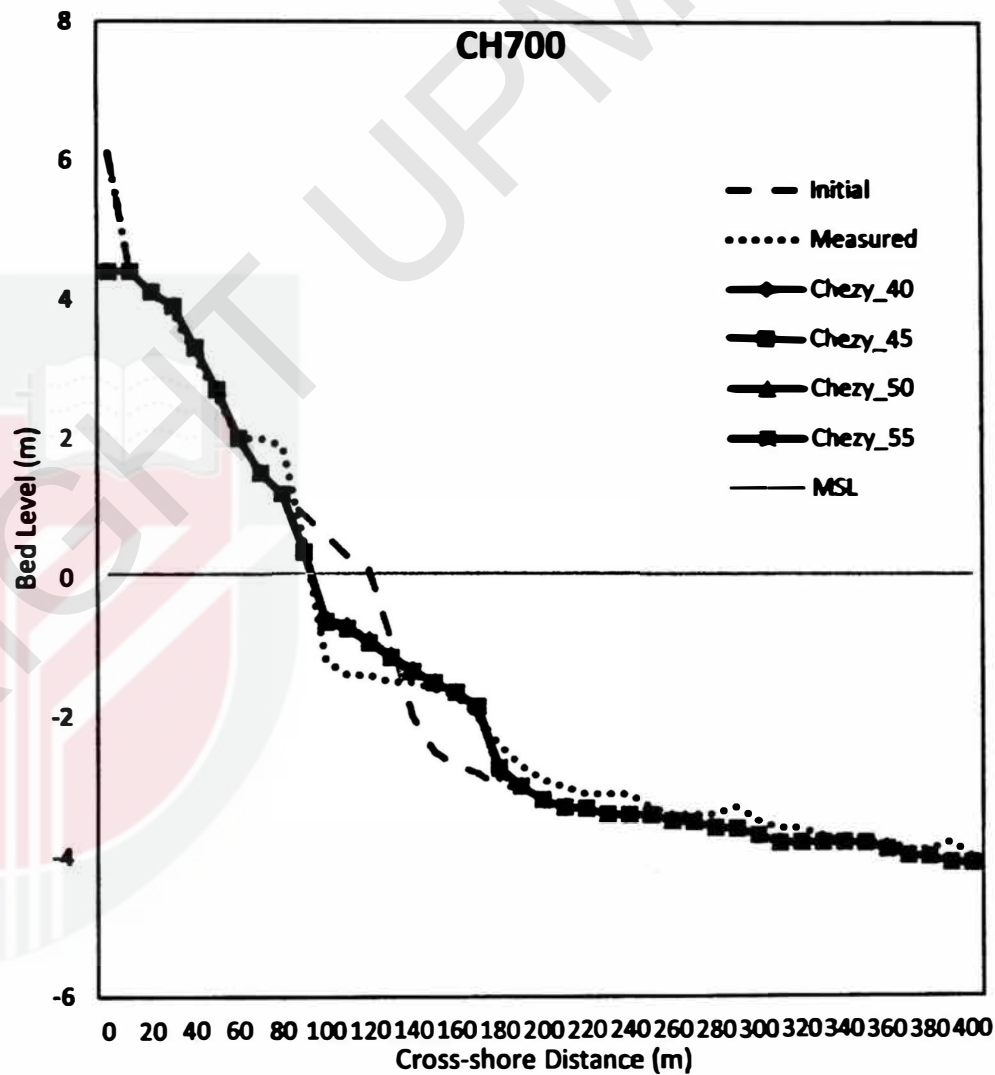
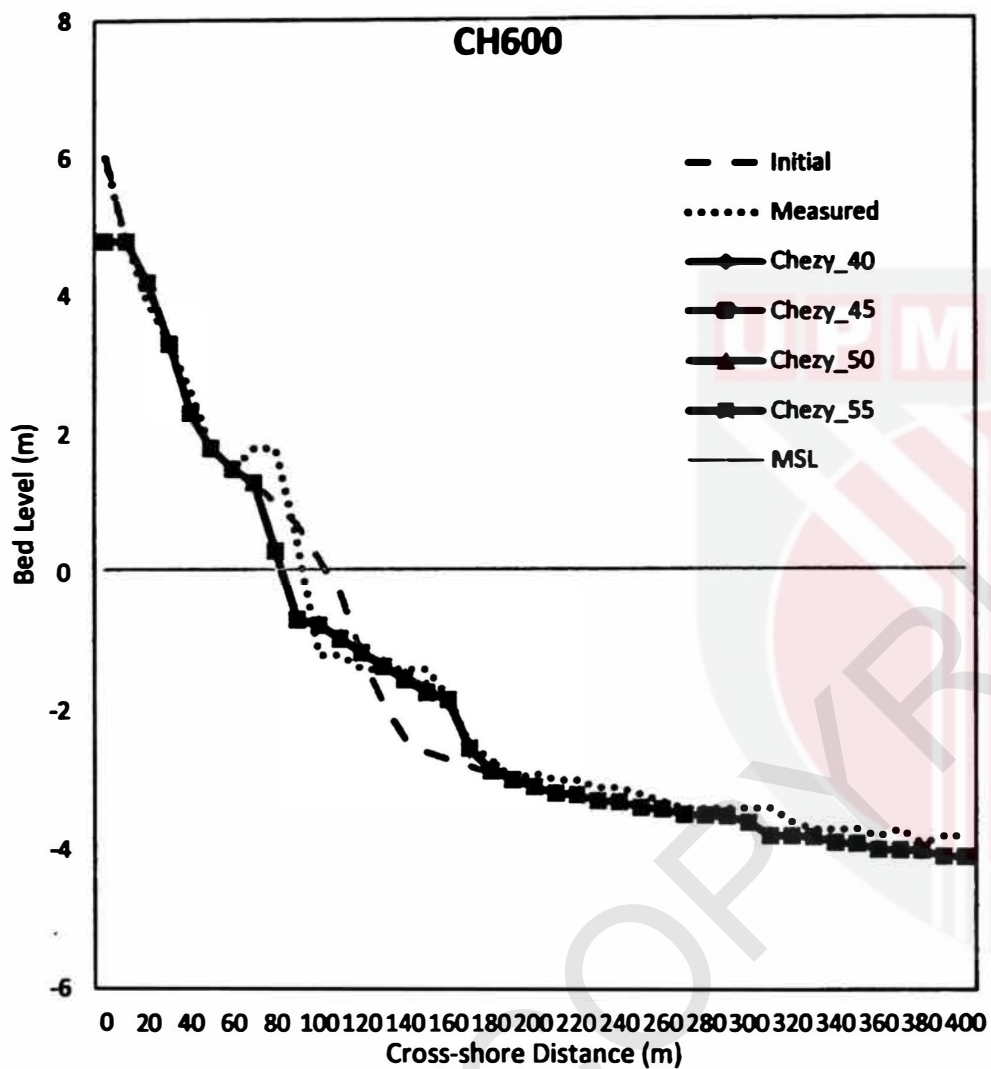


Figure 4.4 (a): Effect of Chezy coefficient on erosive-modelled profiles (CH600 and CH700)

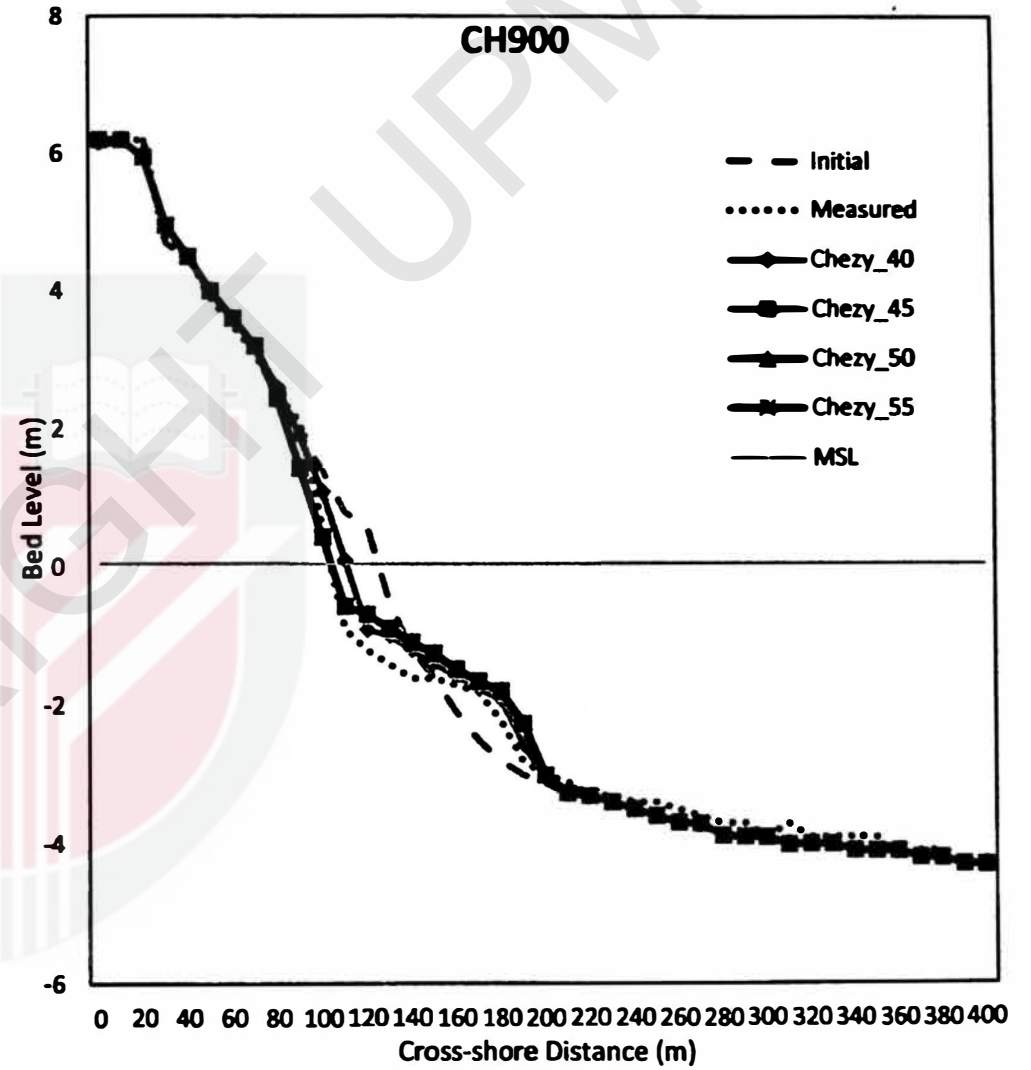
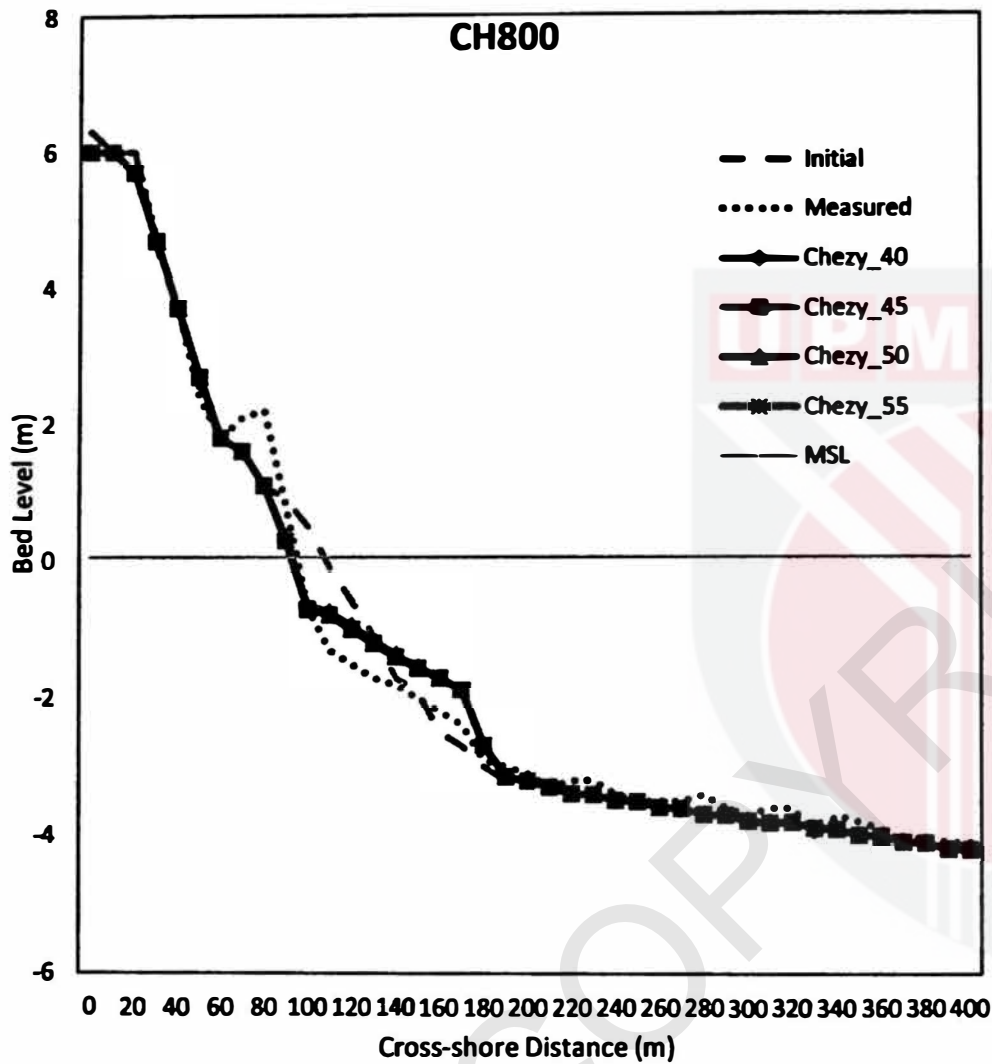


Figure 4.4 (b): Effect of Chezy coefficient on erosive-modelled profiles (CH800 and CH900)

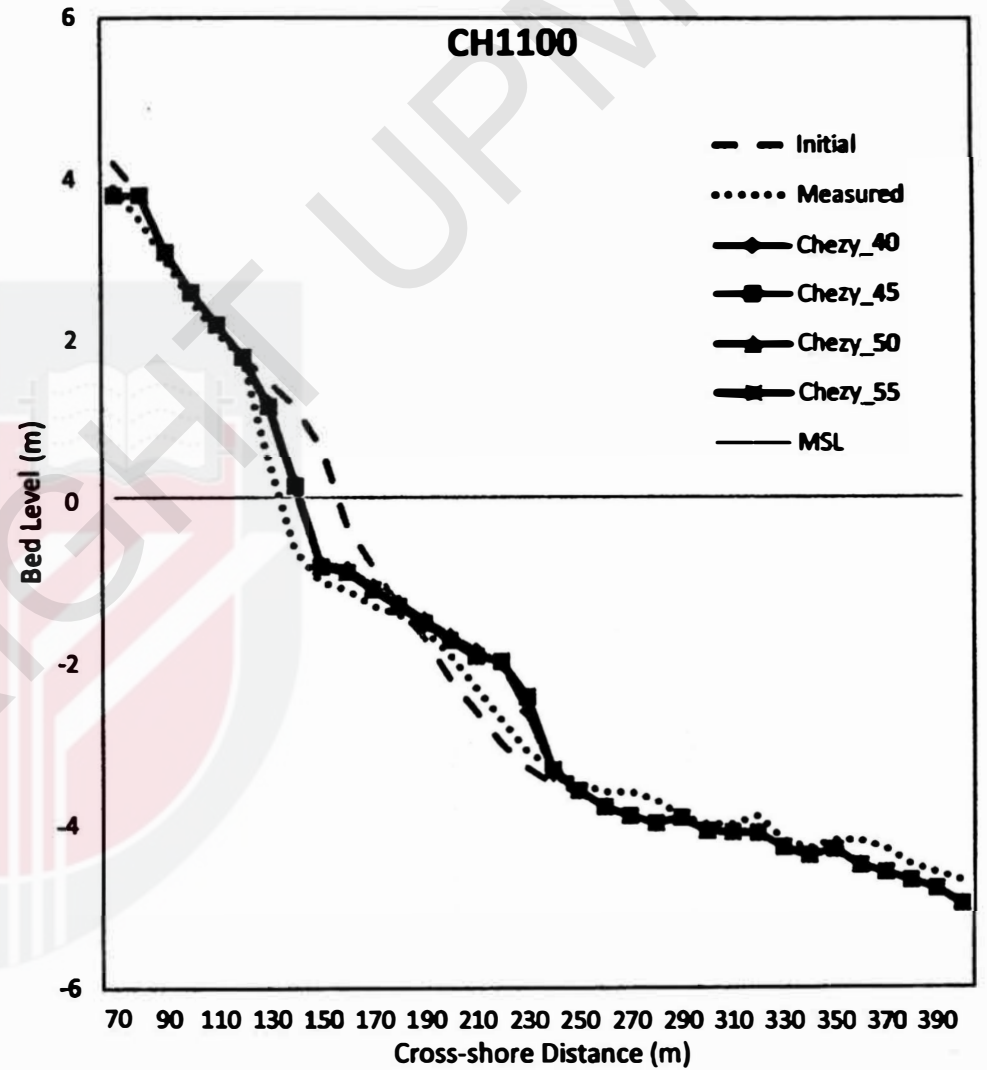
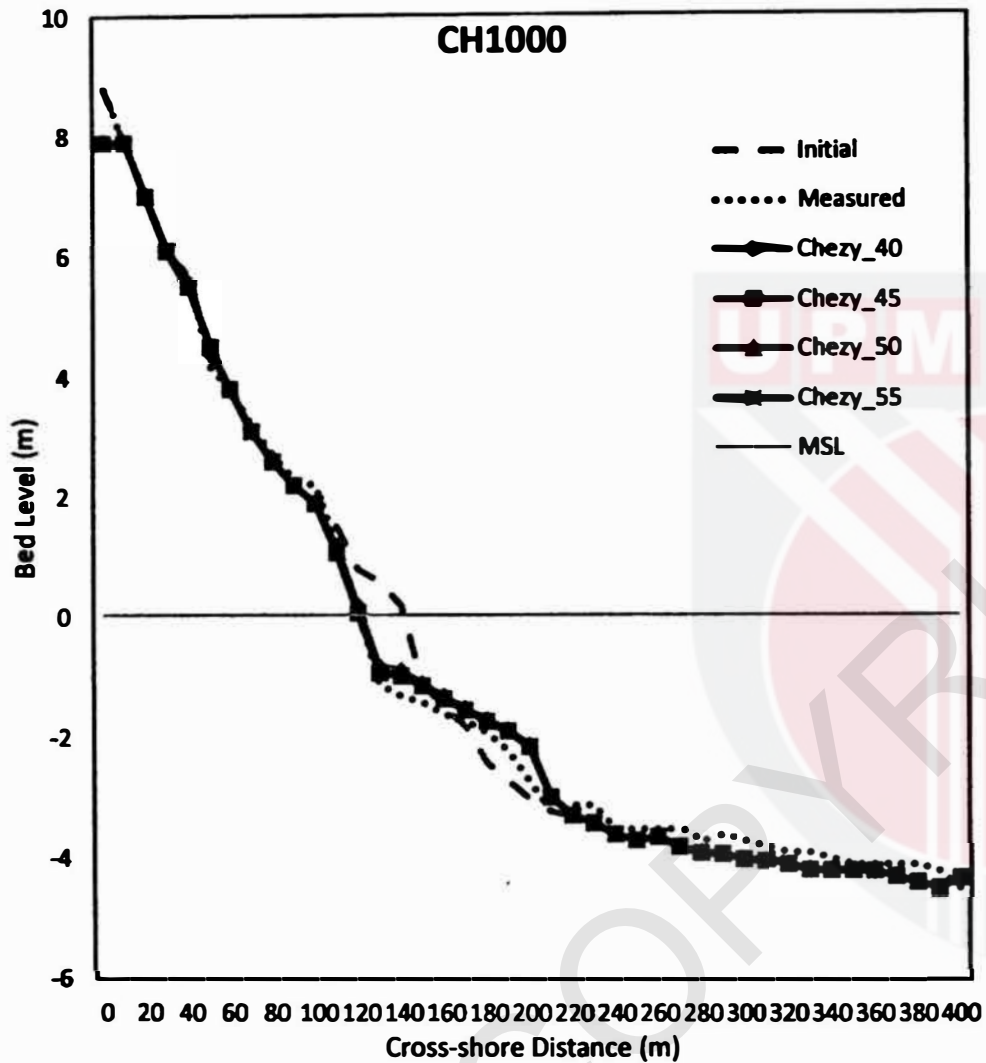


Figure 4.4 (c): Effect of Chezy coefficient on erosive-modelled profiles (CH1000 and CH1100)

4.2.1.4. Effect of initial water level

From Table 4.4, MSL shows the highest BSS on all chainage. Applying MHWL and MLWL on the model decreases the BSS value. The effect of changing the initial water level can be seen from Figure 4.5 (a), (b) and (c). The models show a shift in the erosion and deposition pattern in upward or downward direction. Obviously, MHWL affect the models erosion and deposition pattern to be shift upward and MLWL vice versa. This proves that MSL is the optimum initial water level for the models.

Table 4.4: Model skills performance (initial water level on erosive profiles)

<i>Parameter</i>	<i>BSS</i>					
	CH600	CH700	CH800	CH900	CH1000	CH1100
<i>MSL (0.05m)</i>	0.21	0.55	0.31	0.73	0.58	0.65
<i>MHWL (0.95m)</i>	-0.33	0.07	-0.83	0.25	-0.13	0.40
<i>MLWL (-0.95m)</i>	0.13	0.14	0.09	0.25	0.25	0.16

*bolded values are the highest BSS for that particular chainage

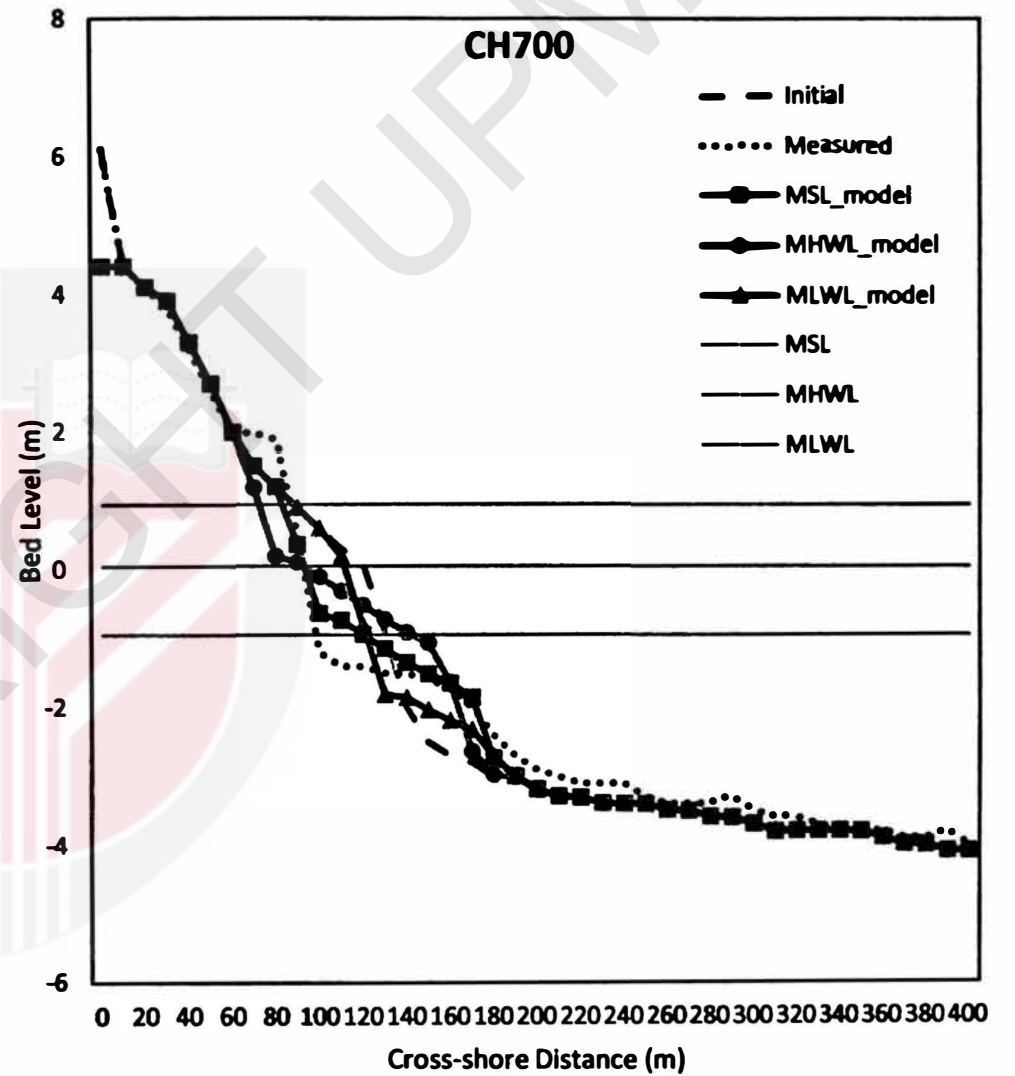
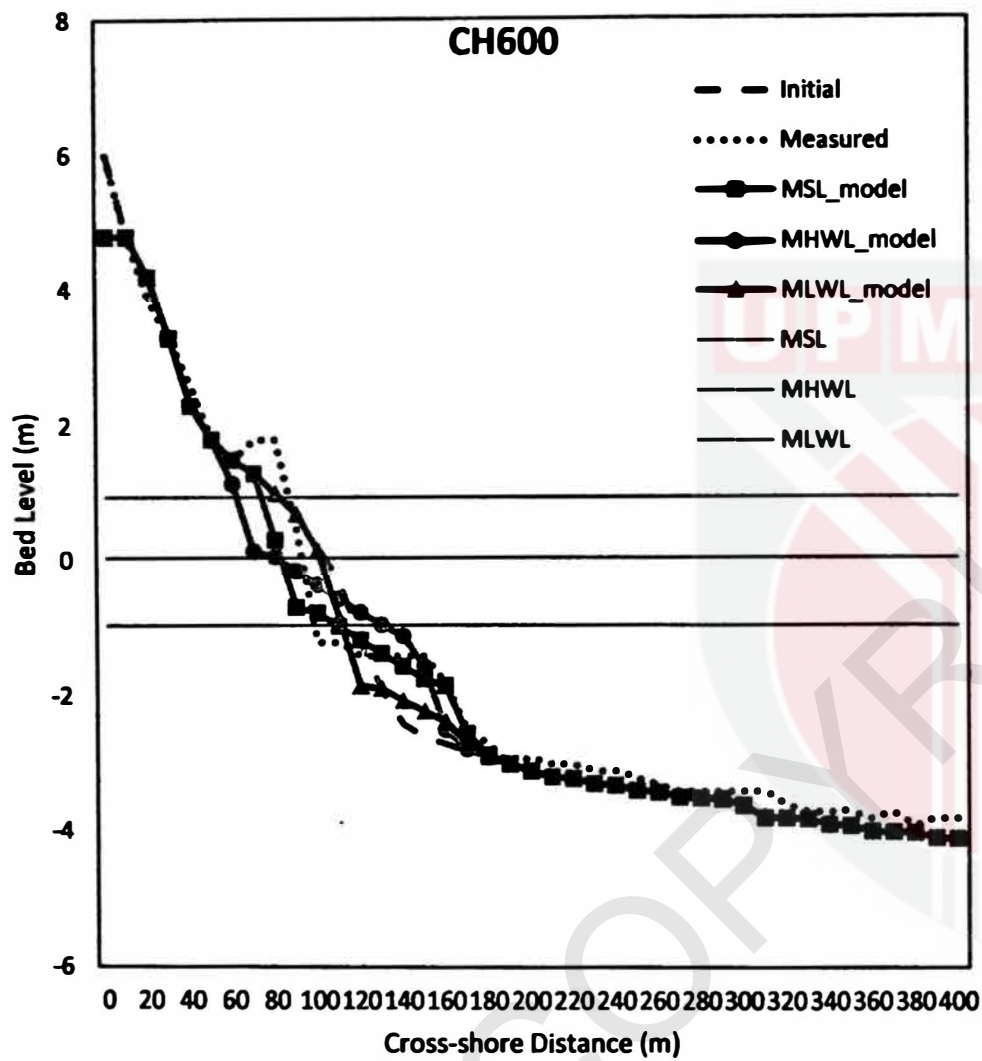


Figure 4.5 (a): Effect of initial water level on erosive-modelled profiles (CH600 and CH700)

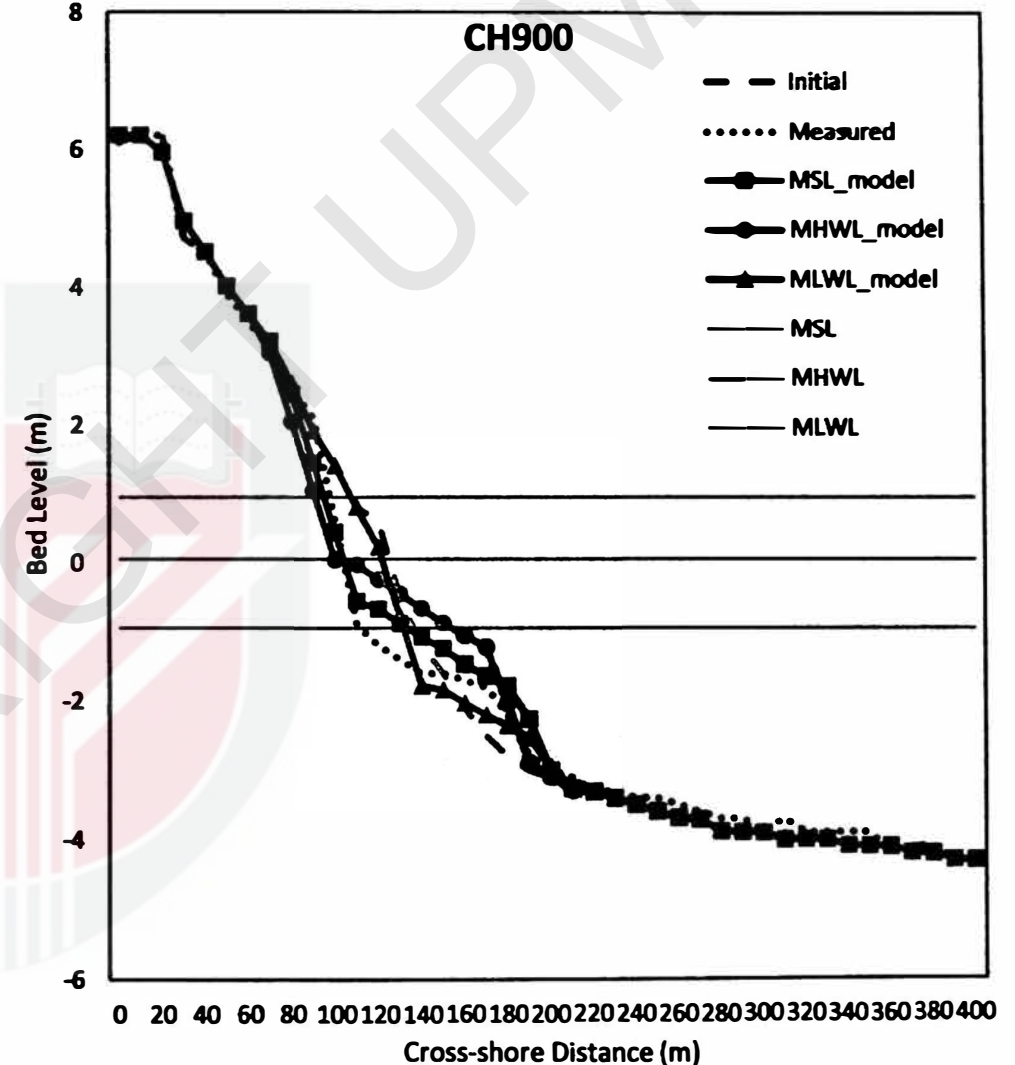
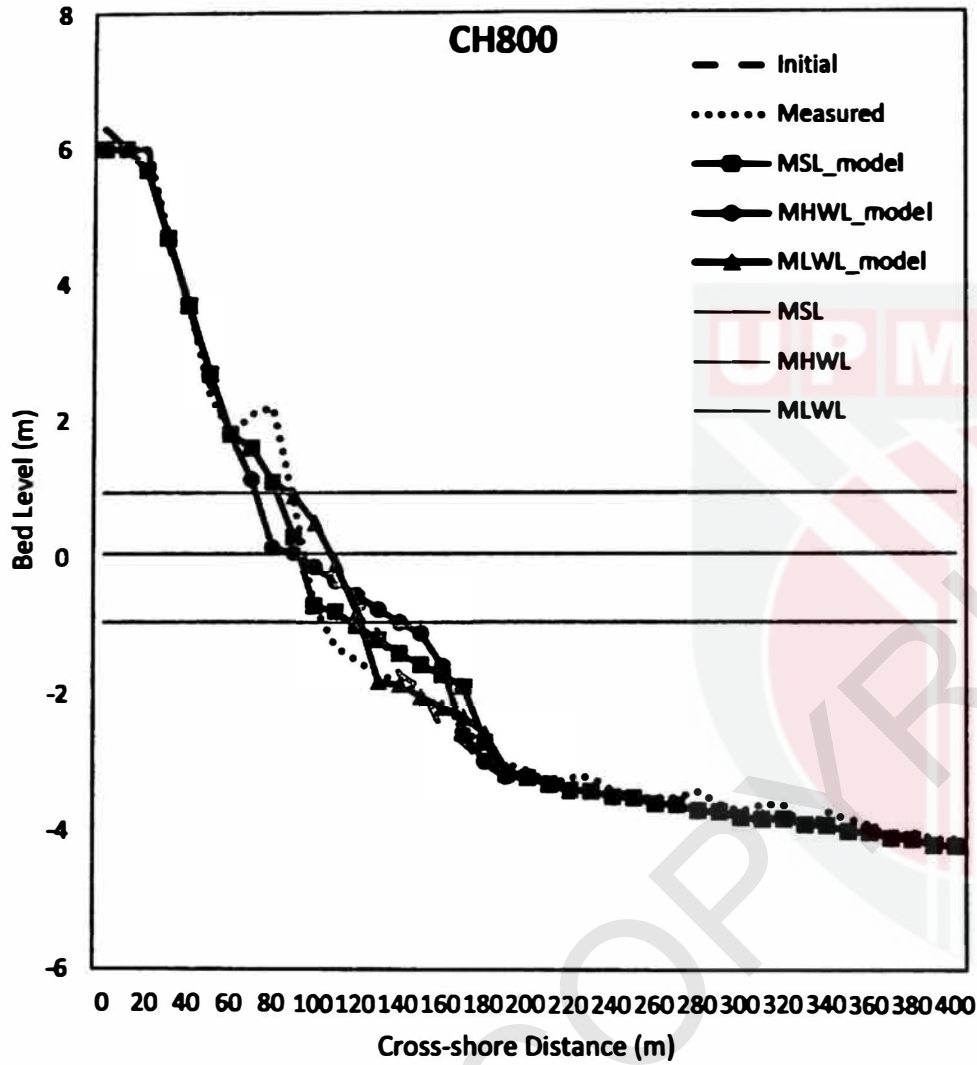


Figure 4.5 (b): Effect of initial water level on erosive-modelled profiles (CH800 and CH900)

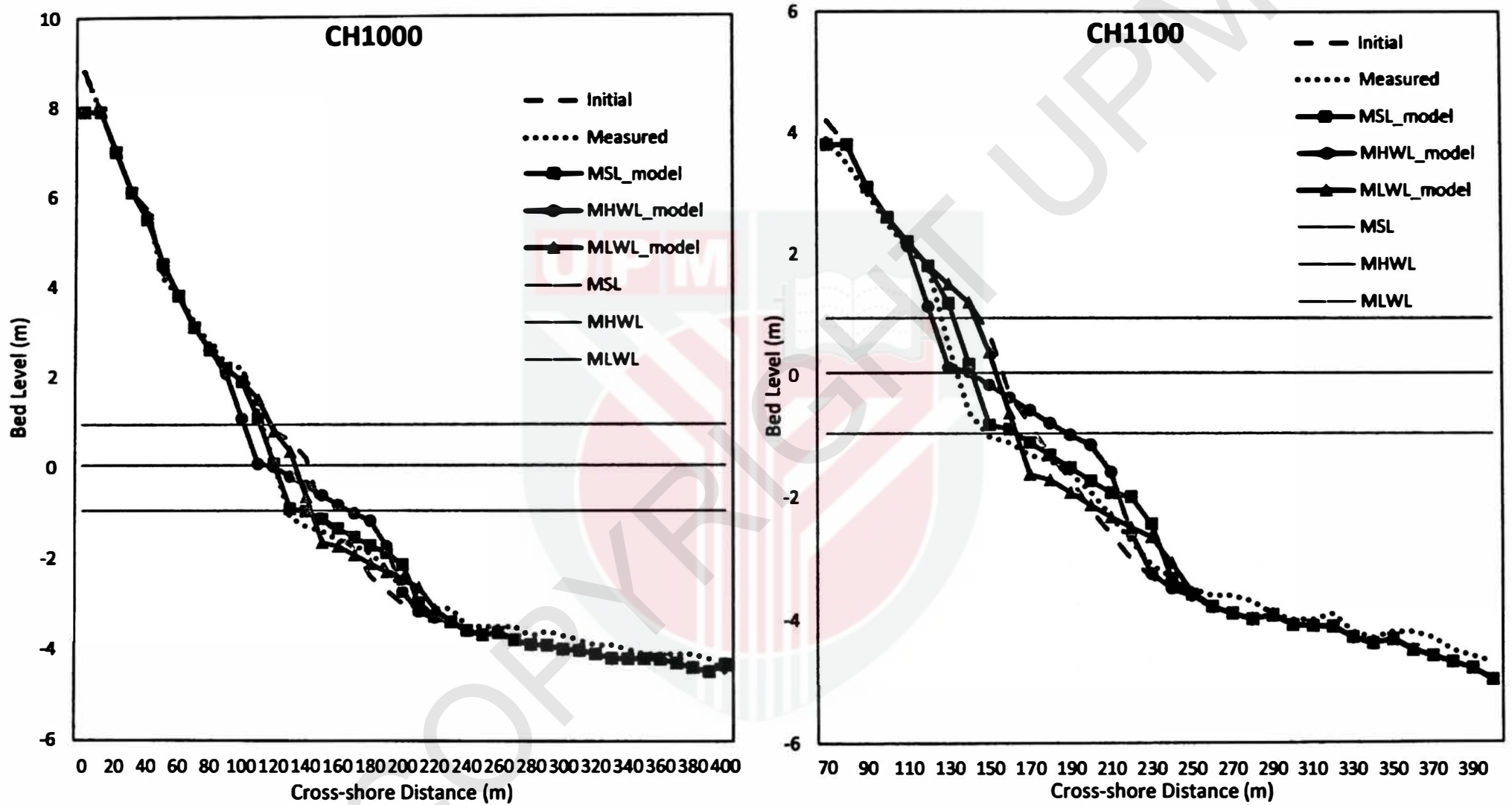


Figure 4.5 (c): Effect of initial water level on erosive-modelled profiles (CH1000 and CH1100)

4.2.1.5. Conclusion

After model calibration has completed, the values for calibrated is determined by choosing the best BSS produced by the models as well as by visual inspections which comparison between the modelled and measured profiles are made. The optimum values chosen for these calibrated parameters are shown in Table 4.5. These values are used in determining the model performances and modelled profiles evolution later on.

Table 4.5: Values of calibrated parameters (erosive profiles)

<i>Parameters</i>	<i>Value</i>
<i>facua</i>	0.1
<i>wetslp</i>	0.1
<i>Chezy coefficient</i>	45
<i>Initial water level</i>	MSL

4.2.2. Accretive Profiles

It has been determined that accretive profiles in this study are from CH400 until CH500. The indication of accretive profiles is shown in Figure 4.6. From the figure it can be seen that the measured profile shows deposition pattern where accretion occurs on the upper beach face as well as on the lower beach face.

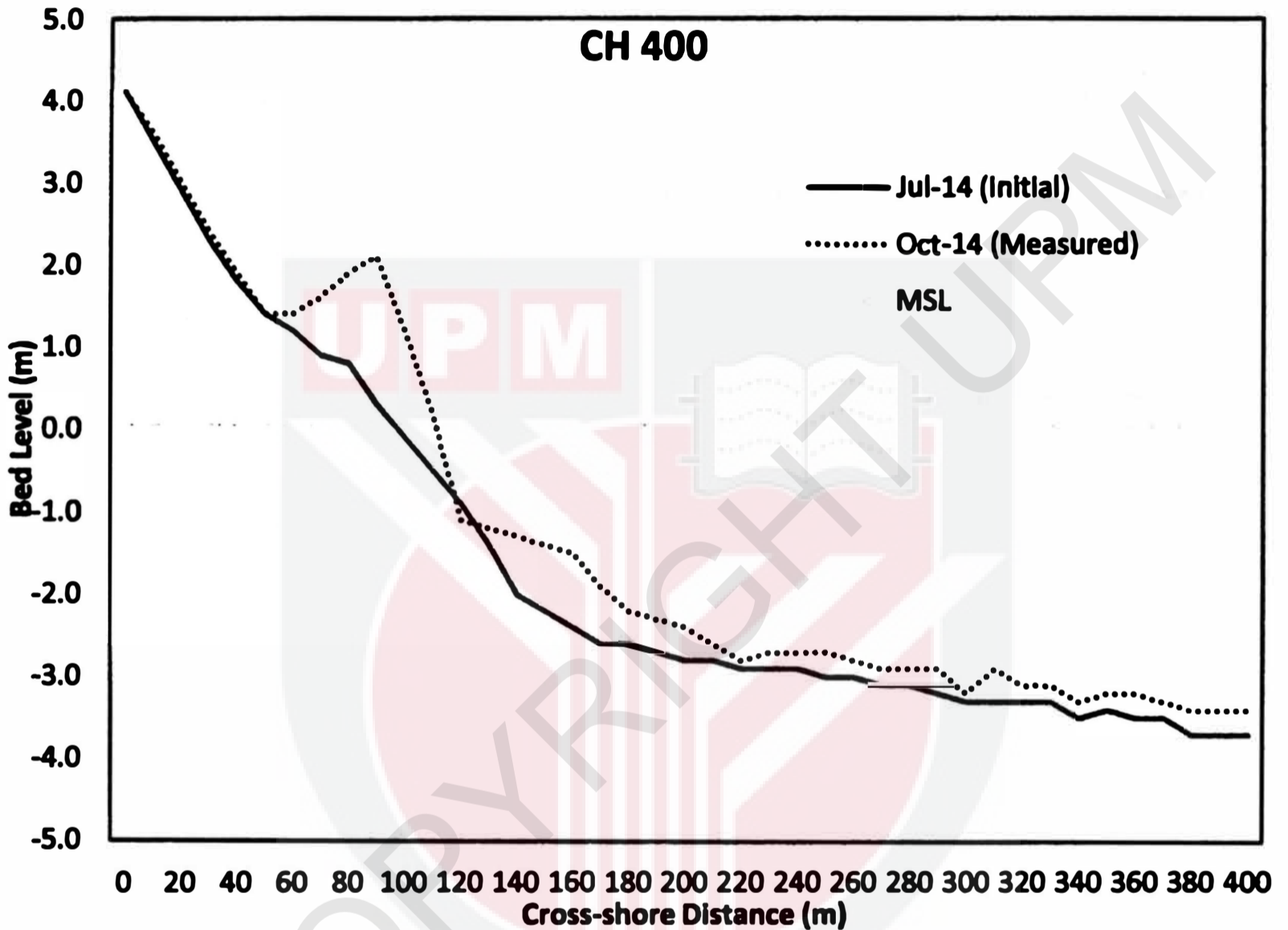


Figure 4.6: Example of accretive profile

4.2.2.1. Effect of facua

Table 4.6 shows that the highest value of BSS for CH400 and CH 500 when facua is 0.2 and 0.4 respectively. The visual inspections on Figure 4.7 shows that modelled profiles shows the most similarities to the measured profiles is when facua is 0.0. Although there is an overestimation on the erosion at the upper beach profile, the model is able to predict the deposition at the lower beach face almost accurately.

Table 4.6: Model skills performance (facua on accretive profiles)

<i>Parameter</i>	<i>BSS</i>	
	CH400	CH500
<i>facua</i>		
0	-0.79	-1.19
0.1	-0.44	-0.46
0.2	-0.06	-0.09
0.3	0.00	-0.12
0.4	0.03	-0.16
0.5	0.03	-0.22
0.6	0.02	-0.26
0.7	0.02	-0.31
0.8	-0.01	-0.34
0.9	-0.02	-0.38
1	-0.05	-0.41

*bolded values are the highest BSS for that particular chainage

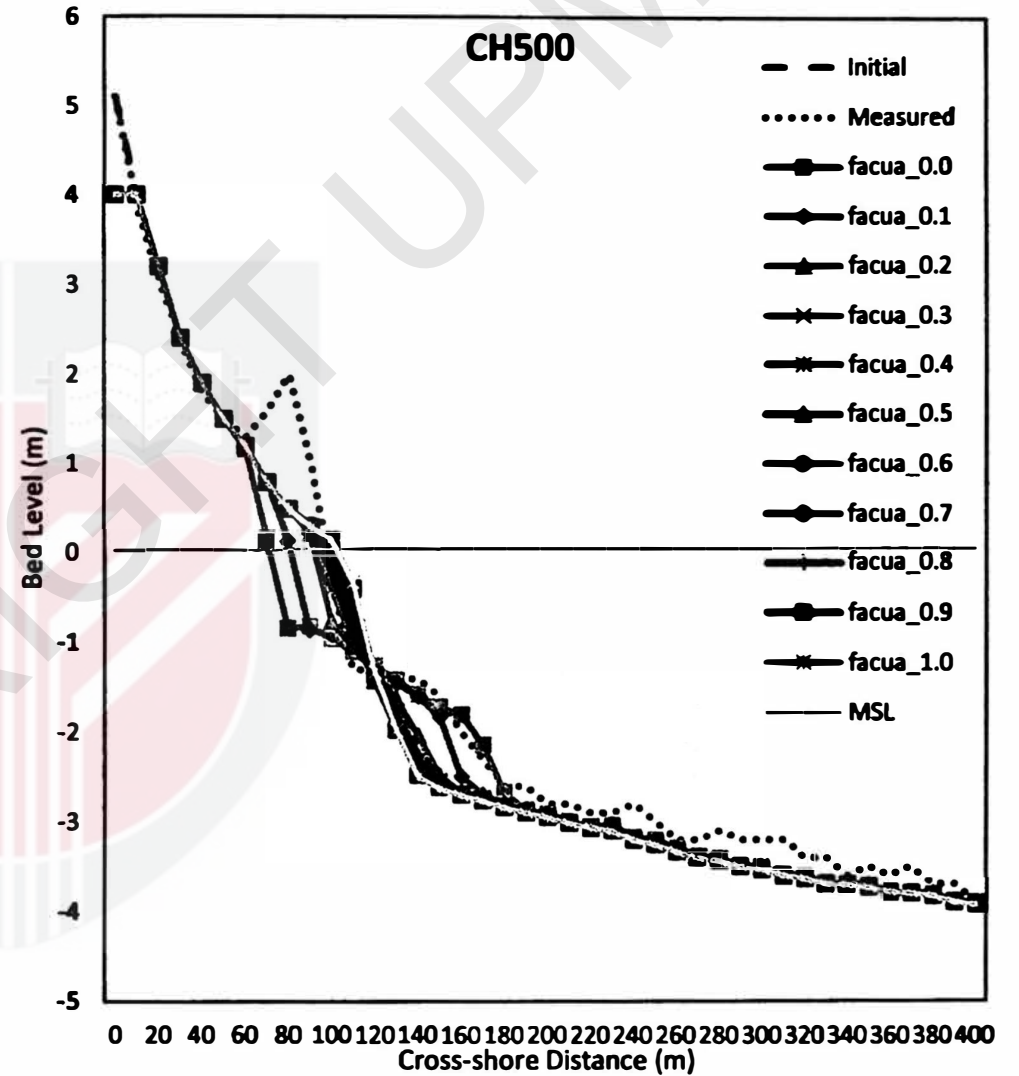
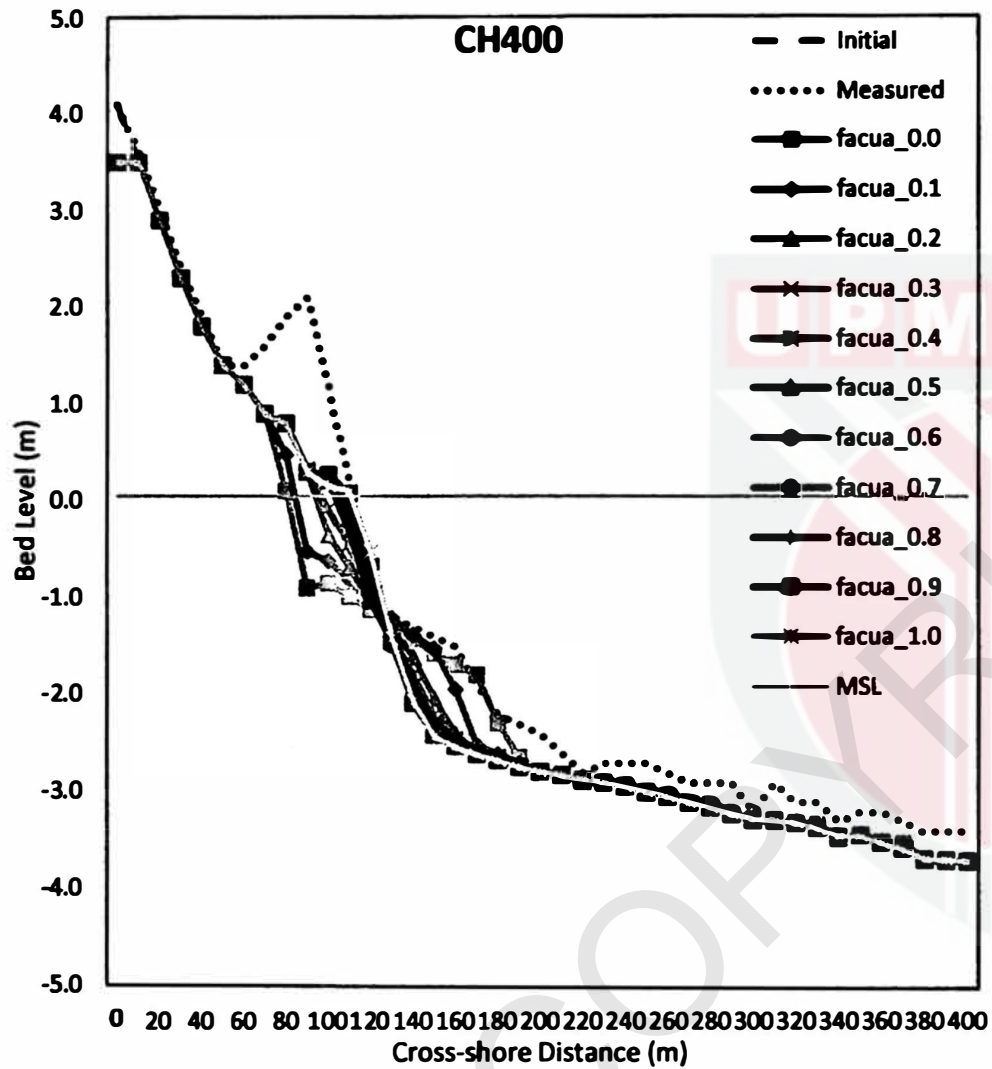


Figure 4.7: Effect of facua on accretive-modelled profiles

4.2.2.2. Effect of initial water level

From Table 4.7, the highest value of BSS for CH 400 is when water level of MHWL is applied meanwhile for CH 500 is when MSL is applied. The effect of initial water level on the modelled profiles (see Figure 4.8) is the same as erosive profiles. By visual inspection, MSL gives the most similarities with measured profiles compared to other water levels.

Table 4.7: Model skills performance (initial water level on accretive profiles)

<i>Parameter</i>	<i>BSS</i>	
	CH400	CH500
<i>Water level</i>		
<i>MSL (0.05m)</i>	-0.79	-1.19
<i>MHWL (0.95m)</i>	-0.68	-4.16
<i>MLWL (-0.95m)</i>	-0.19	-3.15

*bolded values are the highest BSS for that particular chainage

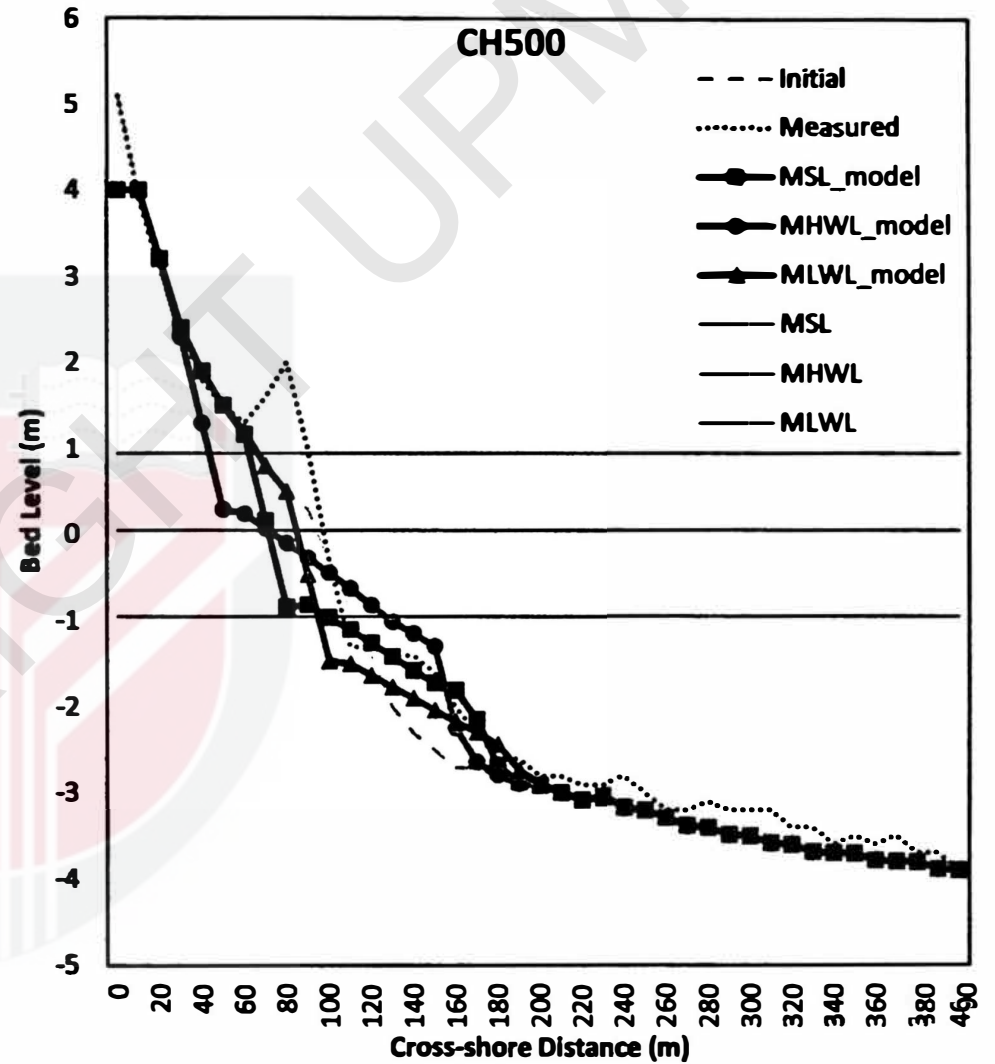
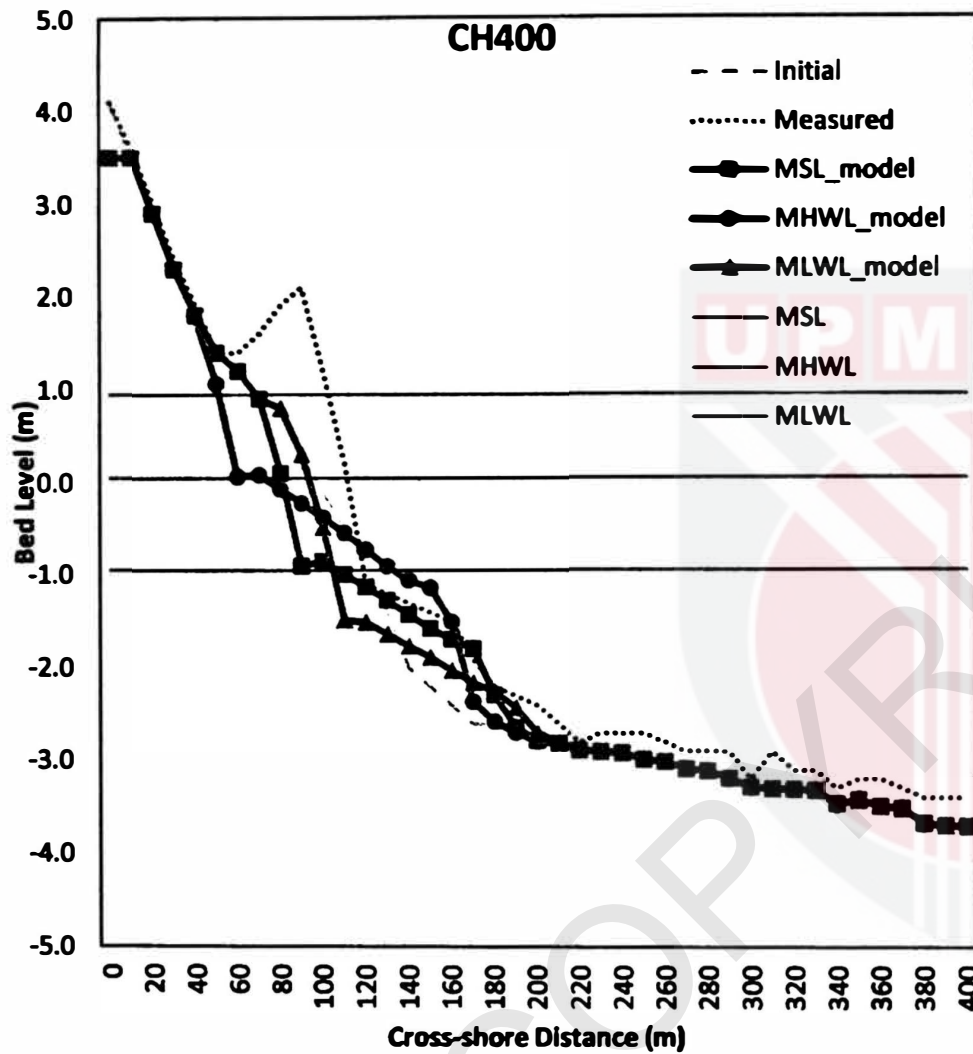


Figure 4.8: Effect of initial water level on accretive-modelled profiles

4.2.2.3. Conclusion

After model calibration has completed, the values for calibrated is determined by choosing the best BSS produced by the models as well as by visual inspections which comparison between the modelled and measured profiles are made. The optimum values chosen for these calibrated parameters are shown in Table 4.5. These values are used in determining the model performances and modelled profiles evolution later on. The optimum values chosen for these calibrated parameters are shown in Table 4.8.

Table 4.8: Values of calibrated parameters (accretive profiles)

<i>Parameter</i>	<i>Value</i>
<i>facua</i>	0.0
<i>Initial water level</i>	MSL

4.3 Model Performances

In order to investigate the model performance, the modelled profiles are compared with the measured profiles. Table 4.9 shows the final BSS value with the calibrated parameters. The comparison will be divided into four based on the indication of BSS.

Table 4.9: BSS values for calibrated parameters

<i>Profiles</i>	<i>BSS</i>	<i>Qualifications</i>
<i>CH 400</i>	-0.79	Bad
<i>CH 500</i>	-1.19	Bad
<i>CH 600</i>	0.19	Poor
<i>CH 700</i>	0.57	Fair
<i>CH 800</i>	0.34	Fair
<i>CH 900</i>	0.71	Good
<i>CH 1000</i>	0.62	Good
<i>CH 1100</i>	0.66	Good

4.3.1. Good representation of model results

CH 900, CH 1000 and CH 1100 are considered as good models since their BSS are in the category of good.

From Figure 4.9, it can be seen that the models is able to predict the pattern similar to measured profiles. These profiles are erosive profiles. Since during southwest monsoon, the south reach goes through erosion more than the north reach. These profiles are located near the south profiles inferring that the more erosive the profiles, the better the model predict the erosion.

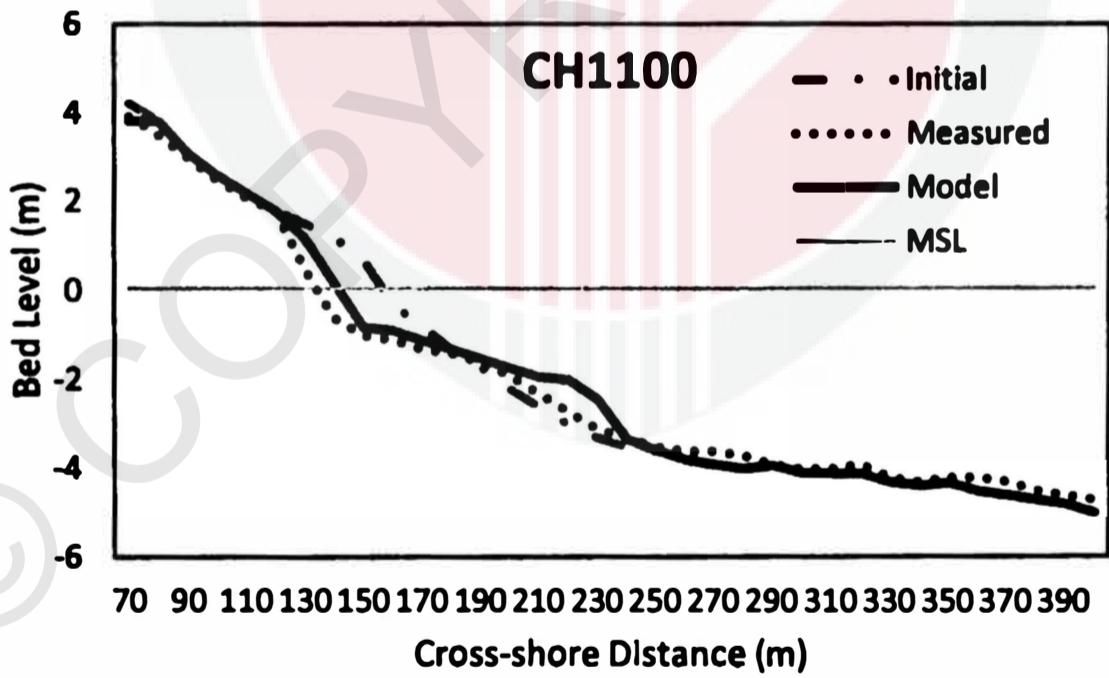
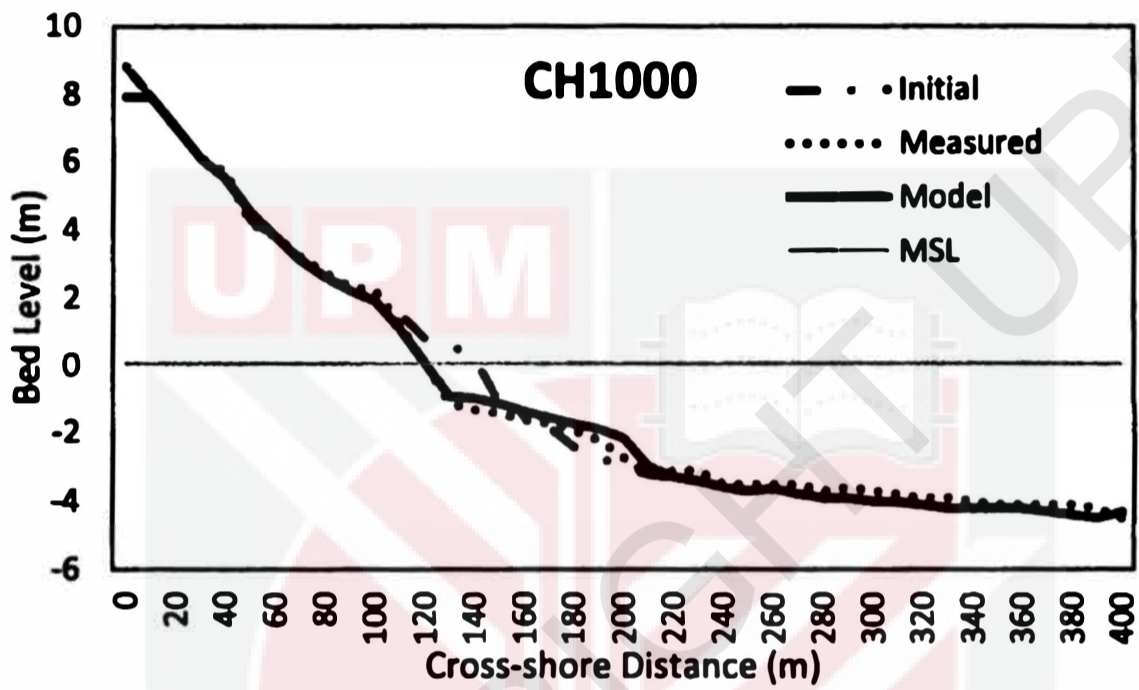
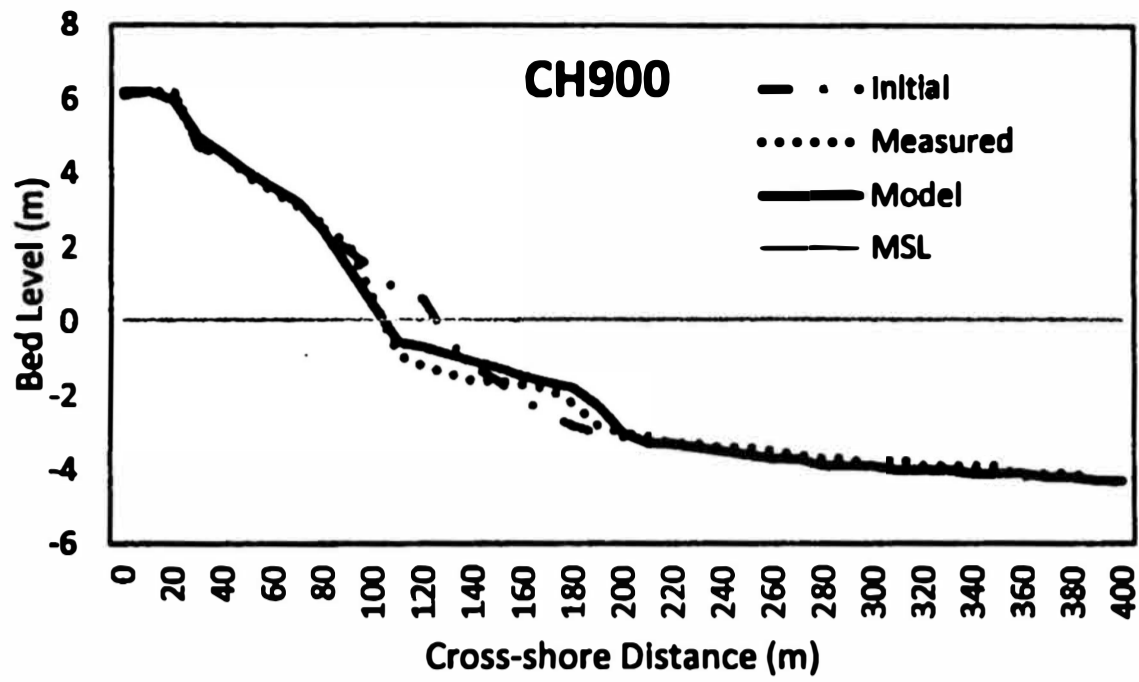


Figure 4.9: Good representation of model results

4.3.2. Fair representation of model results

CH 700 and CH800 is profiles that scored in the fair category. From Figure 4.10, it can be seen that the model from CH 700 is able to predict the deposition at the lower part of the lower beach face but underestimate the erosion the higher part of the lower beach face. Meanwhile in CH 800, there is an overestimation of deposition at the lower beach face.

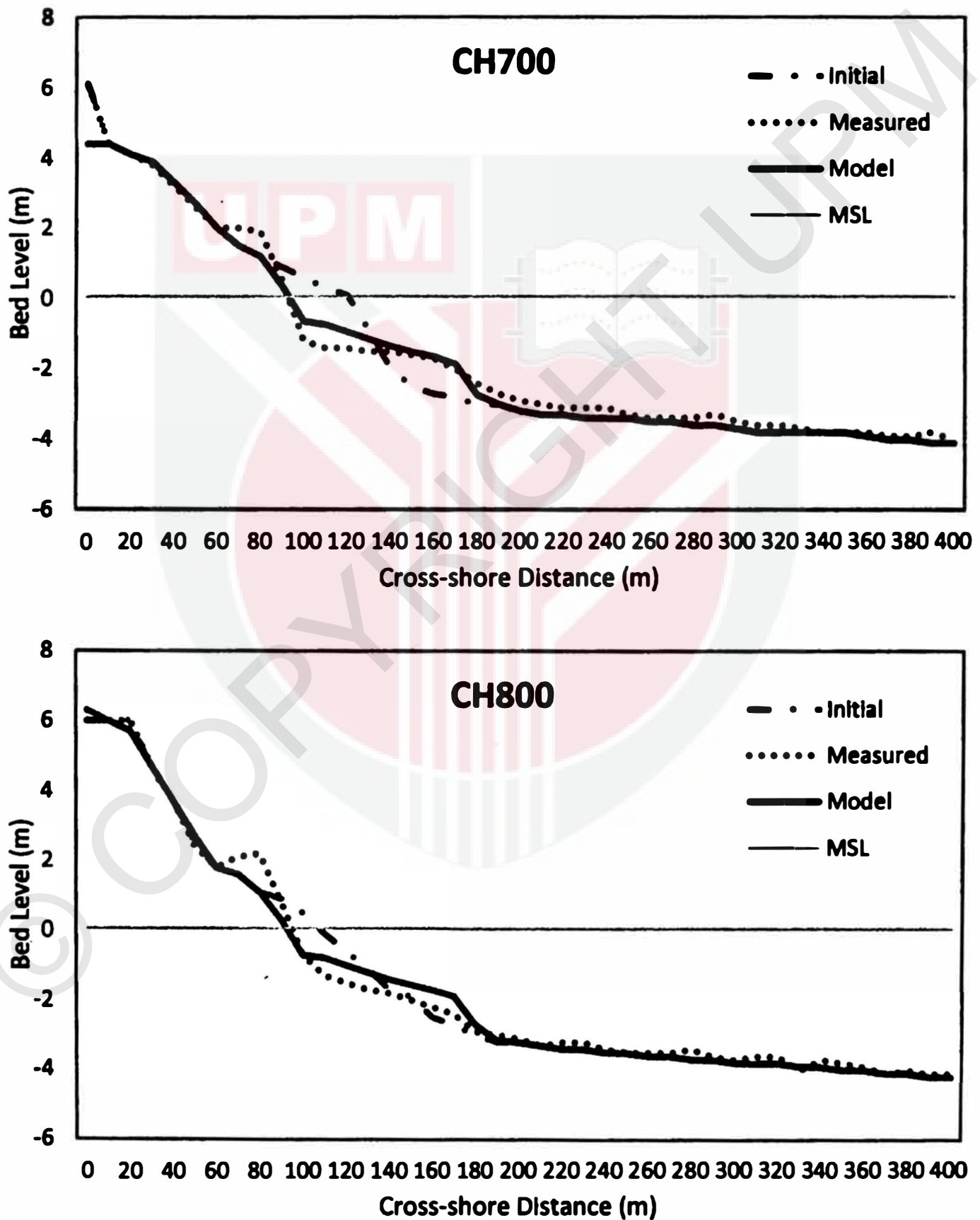


Figure 4.10: Fair representation of model results

4.3.3. Poor representation of model results

CH 600 is the only profile that scored in poor category. CH600 is considered as erosive profiles but the location of this CH is near the north reach which most of the accretion happens on the north reach during southwest monsoon. From Figure 4.11, it can be seen that the model has overestimated the erosion on the upper beach face.

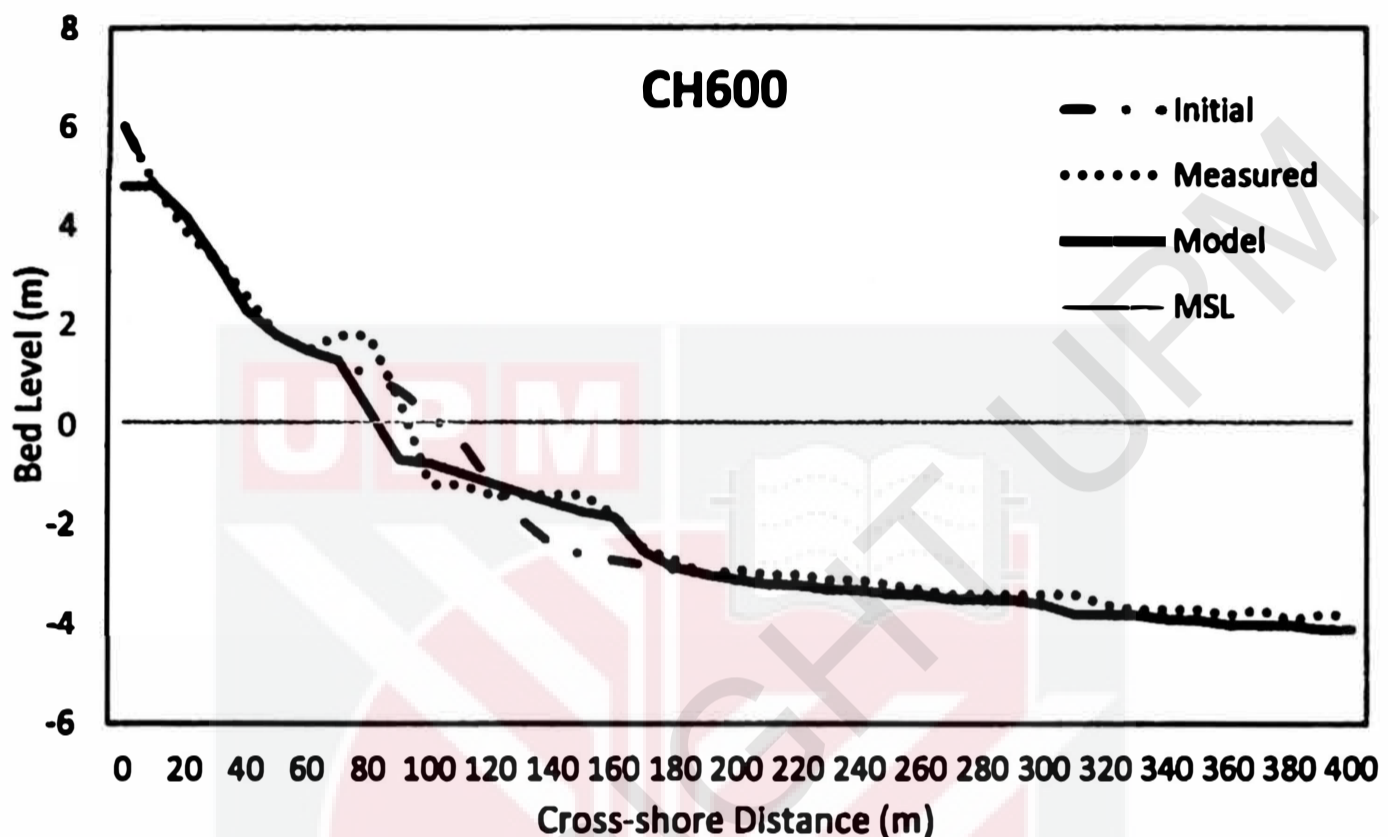


Figure 4.11: Poor representation of model results

4.3.4. Bad representation of model results

CH 400 and CH 500 is categorized as bad models because the models were not capable to predict the deposition on the upper beach face of both models (see Figure 4,12). There profiles are accretive profiles. The north reach gains sand from the south, which makes the deposition from longshore transport. It is beyond the model capability to predict the deposition at the upper beach face because 1D model neglects longshore transport.

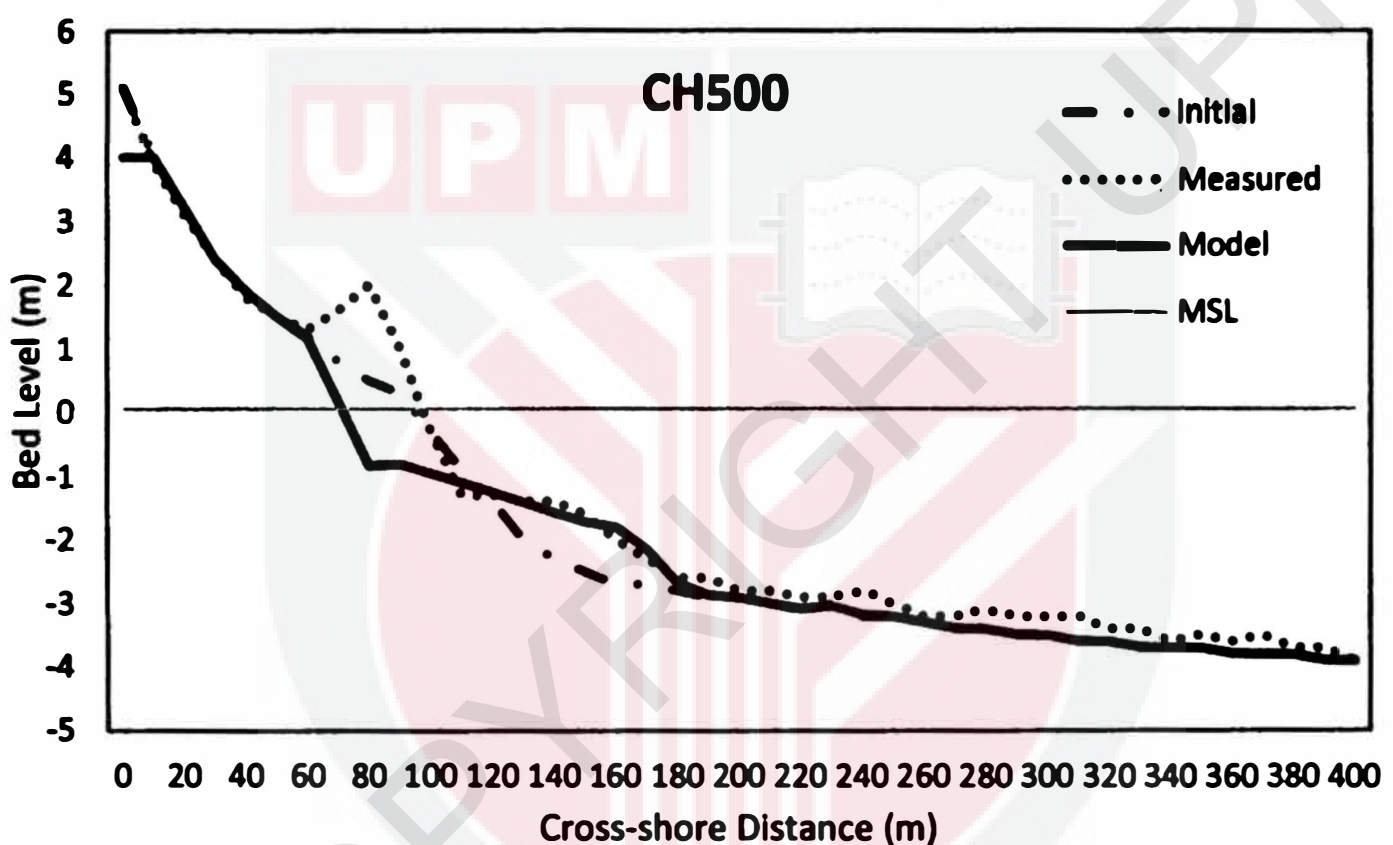
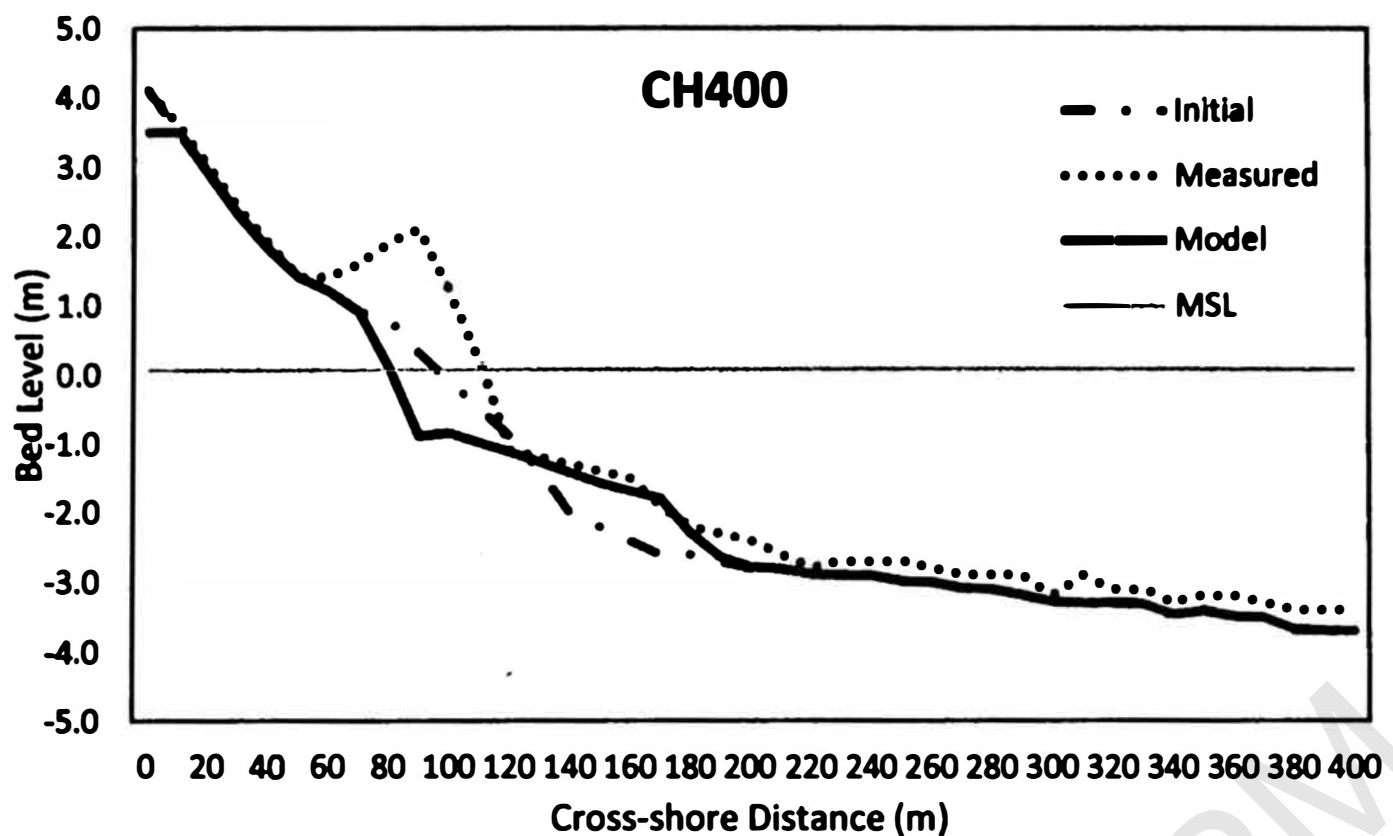


Figure 4.12: Bad representation model results

4.4 Modelled Profiles Evolution

Figure 4.14 (a) and (b) shows the modelled profile evolution at one-month interval. All the CHs show similar bed evolution. During the first three months, there were no major changes on the bed profile of the models. Then, during the fourth month, the model undergo a major change. This can be explained through the changing of seasonal monsoon during the fourth month. The period of northeast monsoon leads to the stronger on shore transport as proved in Figure 4.13. During the first three months

the wave height are less than 1.0 m. During the fourth month, the wave height starts to increase and are more than 1.0 m. This indicated that wave height less than 1.0 m does not give significant impact on the profile evolution. Meanwhile, wave height that are more than 1.0 m erodes profile faster due to the significant amount of energy dissipated on the beach.

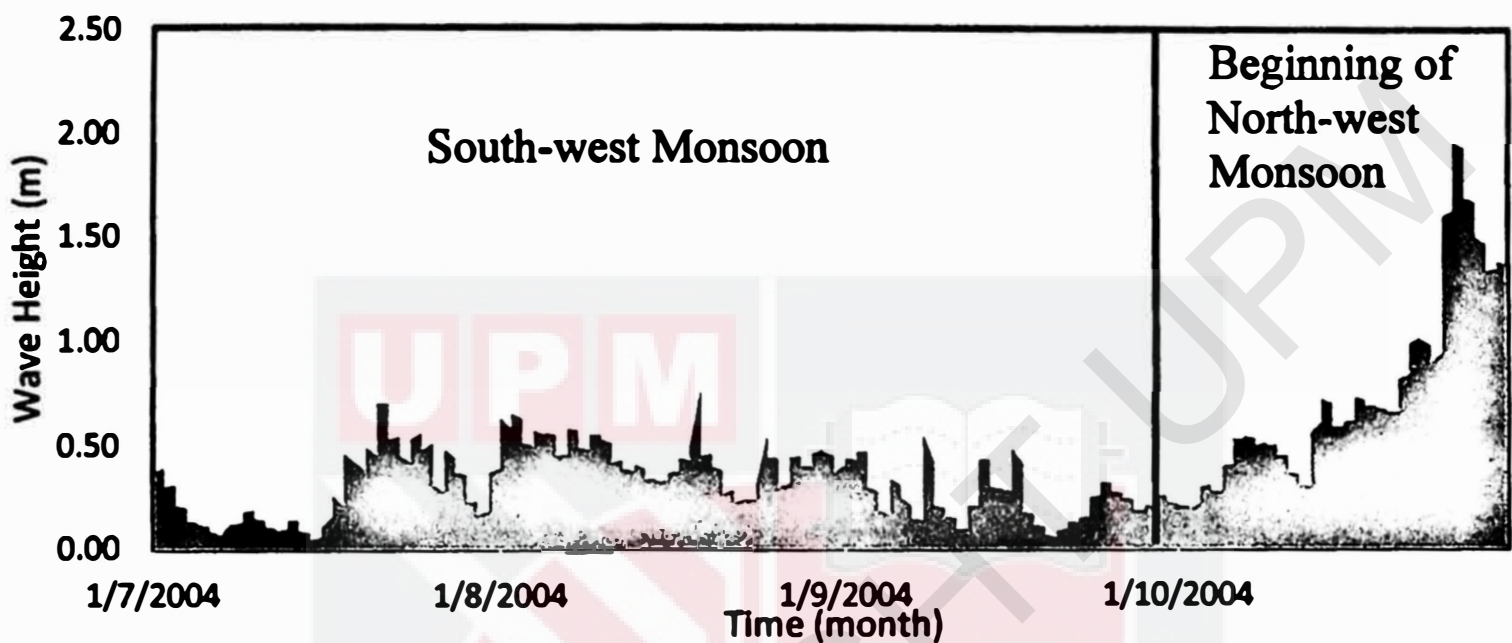


Figure 4.13: Wave height pattern along the period of July 2004 until October 2004

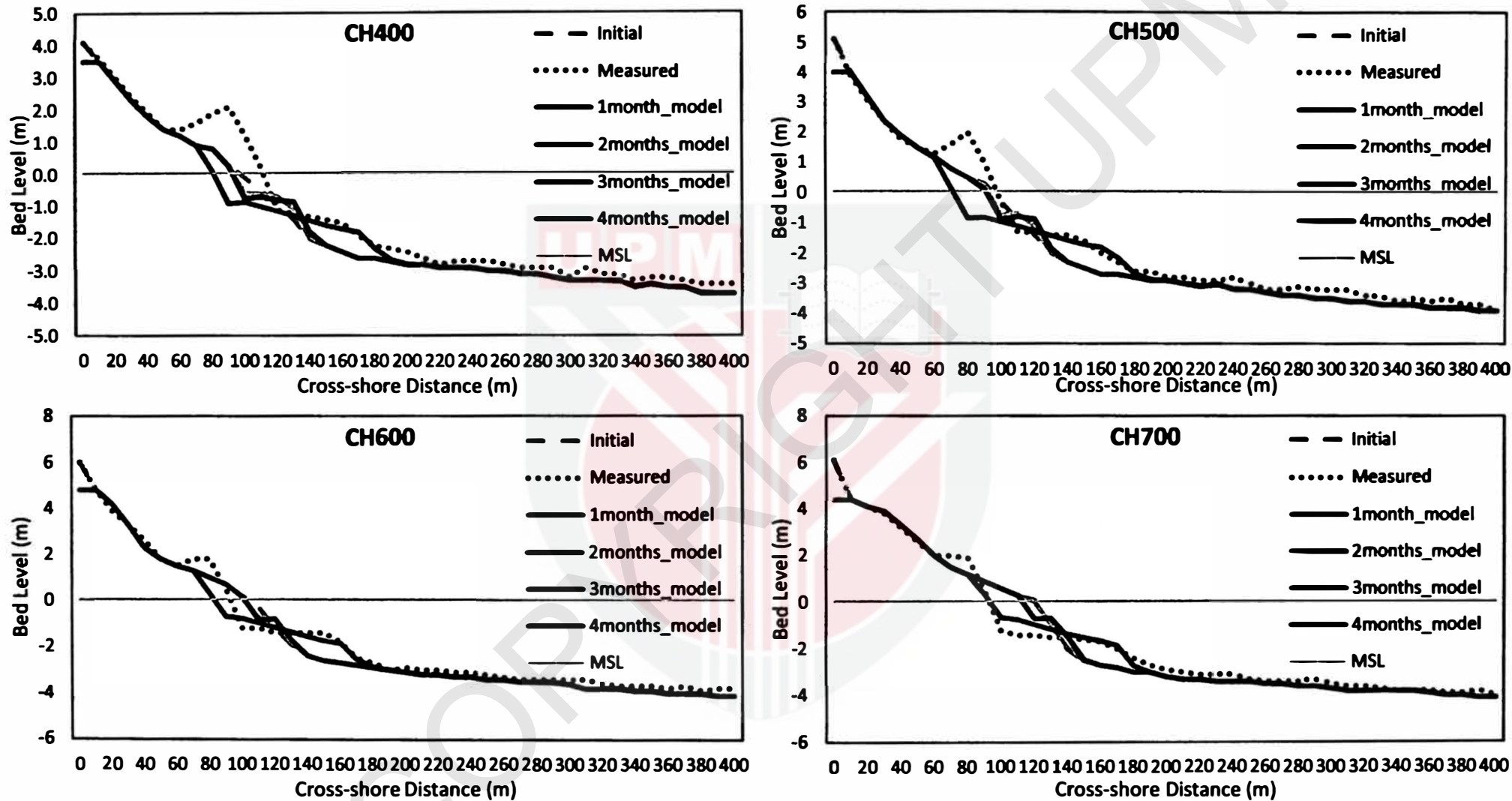


Figure 4.14 (a): Modelled profiles evolution at one-month interval (CH 400 until CH700)

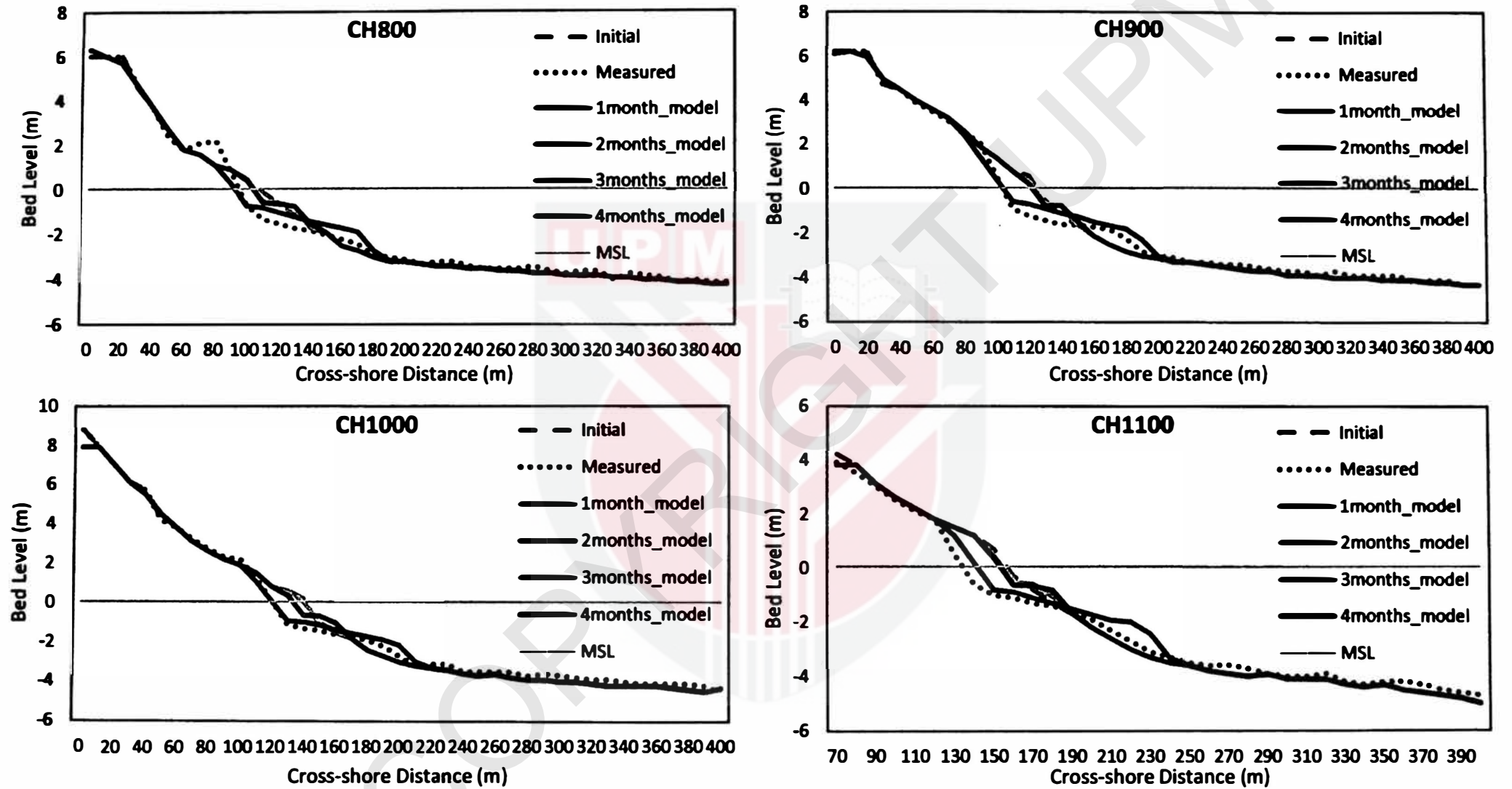


Figure 4.14 (b): Modelled profiles evolution at one-month interval (CH800 until CH 1100)

CHAPTER 5

CONCLUSIONS & RECOMMENDATIONS

5.1 Introduction

In this chapter, the findings are summarized in accordance of the study as described in Chapter 1, Section 1.3. In addition, the answers to the research questions, which are also stated in Section 1.3, are thoroughly addressed in reference to the findings in Chapter 4 of this study. Furthermore, recommendations are given for future research improvement purposes.

5.2 Conclusion

The performance of process-based model using XBEACH in predicting beach profiles in response to a sand nourishment scheme has proven to be promising for erosive profiles but the other way around for accretive profiles.

The models are calibrated using a few parameters to see the effect of the parameters on the model performance in order to determine the optimum value of each parameter. For erosive profiles, the calibrated parameters are $facua$, $wetslp$, Chezy and initial water level with the input value of 0.1, 0.1, 45 and MSL respectively. For accretive profiles, the calibrated parameters are $facua$ and initial water level with the input of 0.0 and MSL respectively.

The BSS of each profile is calculated to determine the capability of XBeach models. CH 900, CH1000 and CH 1100 are found to be good representatives of model results. CH 700 and CH 800 are categorized as fair representatives of model results. CH 600 is found to be poor representatives of model results. Lastly, CH 400 and CH500 are categorized as bad representatives of model results.

The evolution process of the models shown that major evolution occurs during the 4th month of the model simulation time due to the presence of higher wave height approaching the northeast monsoon.

5.3 Responses to Research Questions

1. Are the modelled profiles able to represent the measured profiles? If not, what are the tuning parameters?

Without the tuning parameters, the modelled profiles are not able to represent the measured profiles. As discussed in Chapter 3, Section 3.5.4, the tuning parameters that were used in this study are *facua*, *wetslp* and Chezy coefficient. Erosive profiles are tuned with *facua*, *wetslp* and Chezy coefficient. Meanwhile, accretive profiles are tuned with *facua*. These tuning parameters are then used for model calibration as shown in Chapter 4, Section 4.2. The results shown that the optimum values of tuning parameter for *facua*, *wetslp* and Chezy coefficient for erosive profiles are 0.1, 0.1 and 45 respectively. Meanwhile, for accretive profiles, the optimum value for tuning parameter, *facua*, is 0.0.

2. *What are the evolution trends shown by the nourished profiles under real wave conditions?*

The evolution trends shown that most of the changes of the bed profiles occur during the 4th month of the simulation time due to higher waves from the northeast monsoon. This was proved in Chapter 4, Section 4.4, shown that there were no major changes on the modelled profile during the first three months but on the fourth month, the modelled profile showed significant change. It can be concluded that wave height higher than 1.0 m erodes profile faster due to the significant amount of energy dissipated on the beach. On the other hand, wave height less than 1.0 m did not give significant impact on the profile evolution.

3. *What does the statistical error index indicate?*

The BSS indicates the performance score that the models obtained are categorized as excellent, good, fair, poor and bad. From Chapter 4, Section 4.3, the BSS values for for CH 400, CH 500, CH 600, CH 700, CH 800, CH 900, CH 1000 and CH 1100 are -0.79, -1.19, 0.19, 0.57, 0.34, 0.71, 0.62, and 0.66 respectively. From these values, CH 900, CH 1000 and CH 1100 are found to be good representation of model results. CH 700 and CH 800 found to be fair representation of model results. CH 600 is a poor representation of model results. Lastly, CH 400 and CH 500 are found to be bad representation of model results.

4. *Is the one-dimensional process based model of XBeach capable to simulate the evolution of nourished profiles?*

For erosive profiles, XBeach proved to be capable in simulating the evolution of nourished profiles. However, for accretive profiles, more modelling efforts are required to simulate the profiles so that it is comparable with the measured accretive profiles. As discussed in Chapter 4, Section 4.3, this is due to the limitation that present in this study such as longshore transport and tidal process effect are neglected. Although it is possible for accretive profiles to be accurately simulated, extensive studies and model calibration need to be done.

5.4 Recommendations

A few recommendations can be suggested in order to obtained better results for future study on this topic. First, more extensive calibration process could be done on the accretive models. This is because XBEACH has been validated extensively for erosive conditions but its use for modelling accretion, especially for sandy beaches, is limited.

Second, the wave data from field study could produce more accurate result than the wave data obtained from wave prediction model. This is because there were discrepancies in the data obtained from the wave prediction model.

Third, tidal and wind data could be included in this study as not all the sediment transport are from wave action alone. Considering tidal and wind might improve the accuracy of the results.

Fourth, instead of 1D model, 2D model could be used in this study as 2D include more important processes than 1D model. The use of 2D model enables a more

sophisticated method to incorporate near-shore hydrodynamics and morphodynamics due to alongshore variations in bathymetry, wave field or flow velocity.

Futhermore, using instationary wave instead of stationary wave to represent real wave characteritics. Stationary wave model efficiently solve wave-averaged equations but neglect infragravity waves. In order for a more realistic result to be produced, instationary wave can be used where the short wave variations on the wave group scale (short wave envelope) and the long waves associated with them are resolved.



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APPENDICES

APPENDIX A: PROFILE SURVEYS FROM THE COASTLINE OF PANTAI TELUK CEMPEDAK KUANTAN JULY 2004 AND OCTOBER 2004

CH 400

(All levels in m LSD)

Distance (m)	July 2004	October 2004
0	4.1	4.1
10	3.5	3.6
20	2.9	3
30	2.3	2.4
40	1.8	1.9
50	1.4	1.4
60	1.2	1.4
70	0.9	1.6
80	0.8	1.9
90	0.3	2.1
100	-0.1	1.2
110	-0.5	0.2
120	-0.9	-1.1
130	-1.4	-1.2
140	-2.0	-1.3
150	-2.2	-1.4
160	-2.4	-1.5
170	-2.6	-1.9
180	-2.6	-2.2
190	-2.7	-2.3
200	-2.8	-2.4
210	-2.8	-2.6
220	-2.9	-2.8
230	-2.9	-2.7
240	-2.9	-2.7
250	-3.0	-2.7
260	-3.0	-2.8
270	-3.1	-2.9
280	-3.1	-2.9
290	-3.2	-2.9
300	-3.3	-3.2
310	-3.3	-2.9
320	-3.3	-3.1
330	-3.3	-3.1
340	-3.5	-3.3

Distance (m)	July 2004	October 2004
350	-3.4	-3.2
360	-3.5	-3.2
370	-3.5	-3.3
380	-3.7	-3.4
390	-3.7	-3.4
400	-3.7	-3.4
410	-3.7	-3.5
420	-3.8	-3.7
430	-3.8	-3.6
440	-3.9	-3.6
450	-3.9	-3.7
460	-4.0	-3.7
470	-4.0	-4
480	-4.0	-3.9
490	-4.1	-3.9
500	-4.1	-3.9
510	-4.2	-3.9
520	-4.3	-4
530	-4.3	-4
540	-4.5	-4.2
550	-4.4	-4.2
560	-4.4	-4.3
570	-4.5	-4.3
580	-4.5	-4.4
590	-4.7	-4.4
600	-4.7	-4.6
610	-4.8	-4.6
620	-4.8	-4.7
630	-5.0	-4.6
640	-5.1	-4.8
650	-5.2	-4.8
660	-5.2	-5.2
670	-5.3	-5.2
680	-5.4	-5.3
690	-5.5	-5.2

700	-5.5	-5.4
710	-5.7	-5.4
720	-5.8	-5.6
730	-5.9	-5.8
740	-6.0	-5.8
750	-6.1	-6
760	-6.1	-5.9
770	-6.3	-6.1
780	-6.4	-6.2
790	-6.4	-6.4
800	-6.5	-6.5
810	-6.7	-6.4
820	-6.8	-6.5
830	-6.8	-6.6
840	-6.9	-6.7
850	-7.1	-6.9
860	-7.1	-7
870	-7.2	-7
880	-7.3	-7.2
890	-7.5	-7.3
900	-7.5	-7.4
910	-7.7	-7.5
920	-7.7	-7.7
930	-7.9	-7.6
940	-7.9	-7.8
950	-8.0	-7.7
960	-8.1	-7.9
970	-8.2	-8
980	-8.3	-8
990	-8.4	-8.2
1000	-8.4	-8.2
1010	-8.5	-8.2
1020	-8.5	-8.3
1030	-8.7	-8.4
1040	-8.6	-8.4
1050	-8.6	-8.4
1060	-8.8	-8.5
1070	-8.8	-8.7
1080	-8.8	-8.6
1090	-9.0	-8.7
1100	-8.9	-8.8
1110	-9.0	-8.7
1120	-9.2	-8.9
1130	-9.1	-8.9
1140	-9.1	-8.9

1150	-9.2	-8.9
1160	-9.2	-9.2
1170	-9.3	-9.2
1180	-9.4	-9.1
1190	-9.3	-9.2
1200	-9.4	-9.3
1210	-9.6	-9.2
1220	-9.6	-9.3
1230	-9.6	-9.5
1240	-9.6	
1250	-9.7	

Distance (m)	July 2004	October 2004
0	5.1	5.1
10	4	3.9
20	3.2	3.1
30	2.4	2.4
40	1.9	1.8
50	1.5	1.5
60	1.2	1.3
70	0.8	1.6
80	0.5	2
90	0.3	1
100	-0.3	-0.3
110	-0.9	-1.3
120	-1.4	-1.3
130	-2	-1.4
140	-2.3	-1.4
150	-2.5	-1.6
160	-2.7	-2
170	-2.7	-2.3
180	-2.8	-2.6
190	-2.9	-2.6
200	-2.9	-2.8
210	-3	-2.8
220	-3.1	-2.9
230	-3	-2.9
240	-3.2	-2.8
250	-3.2	-3
260	-3.3	-3.2
270	-3.4	-3.2
280	-3.4	-3.1
290	-3.5	-3.2
300	-3.5	-3.2
310	-3.6	-3.2
320	-3.6	-3.4
330	-3.7	-3.4
340	-3.7	-3.6
350	-3.7	-3.5
360	-3.8	-3.6
370	-3.8	-3.5
380	-3.8	-3.7
390	-3.9	-3.7

Distance (m)	July 2004	October 2004
400	-3.9	-3.9
410	-4	-3.8
420	-4	-3.9
430	-4	-3.8
440	-4.1	-3.9
450	-4.1	-3.9
460	-4.1	-3.9
470	-4.1	-3.9
480	-4.2	-4.1
490	-4.3	-4.2
500	-4.3	-4.2
510	-4.4	-4.2
520	-4.3	-4.3
530	-4	-4.2
540	-3.9	-4.3
550	-4.9	-4.4
560	-4.4	-4.5
570	-4.2	-4.5
580	-4.4	-4.4
590	-4.5	-4.5
600	-4.7	-4.8
610	-5.3	-4.9
620	-5.4	-5.1
630	-5.4	-5.1
640	-5.5	-5.2
650	-5.5	-5.1
660	-5.6	-5.4
670	-5.7	-5.5
680	-5.7	-5.6
690	-5.9	-5.6
700	-5.9	-5.8
710	-6	-5.7
720	-6.1	-5.9
730	-6.1	-5.9
740	-6.2	-6.1
750	-6.4	-6.3
760	-6.4	-6.2
770	-6.5	-6.5
780	-6.6	-6.3
790	-6.7	-6.4

800	-6.8	-6.6
810	-7	-6.7
820	-7.1	-6.9
830	-7.1	-6.9
840	-7.2	-7.1
850	-7.3	-7.1
860	-7.3	-7.1
870	-7.5	-7.2
880	-7.6	-7.4
890	-7.6	-7.5
900	-7.8	-7.6
910	-7.8	-7.7
920	-7.9	-7.7
930	-8	-7.8
940	-8.1	-7.9
950	-8.2	-7.9
960	-8.2	-7.9
970	-8.2	-8.1
980	-8.4	-8.3
990	-8.5	-8.2
1000	-8.5	-8.4
1010	-8.6	-8.2
1020	-8.6	-8.4
1030	-8.7	-8.4
1040	-8.7	-8.5
1050	-8.8	-8.6
1060	-8.8	-8.7
1070	-8.8	-8.8
1080	-8.9	-8.8
1090	-9.1	-8.8
1100	-9.1	-8.9
1110	-9.2	-8.8
1120	-9.2	-8.9
1130	-9.2	-8.9
1140	-9.2	-9.4
1150	-9.3	-9.3
1160	-9.4	-9
1170	-9.4	-9.1
1180	-9.4	-9.2
1190	-9.6	-9.4
1200	-9.6	-9.3
1210	-9.6	-9.4

1220	-9.6	
1230	-9.7	
1240	-9.7	
1250	-9.7	



Distance (m)	July 2004	October 2004
0	6	6
10	4.8	4.8
20	4.2	3.9
30	3.3	3.3
40	2.3	2.6
50	1.8	1.8
60	1.5	1.5
70	1.3	1.8
80	1	1.8
90	0.7	0.5
100	0.2	-1.2
110	-0.3	-1.2
120	-1.2	-1.4
130	-1.9	-1.4
140	-2.4	-1.4
150	-2.6	-1.4
160	-2.7	-1.8
170	-2.8	-2.5
180	-2.9	-2.7
190	-3	-3
200	-3.1	-2.9
210	-3.2	-3
220	-3.2	-3
230	-3.3	-3.1
240	-3.3	-3.1
250	-3.4	-3.2
260	-3.4	-3.3
270	-3.5	-3.4
280	-3.5	-3.4
290	-3.5	-3.4
300	-3.6	-3.4
310	-3.8	-3.4
320	-3.8	-3.6
330	-3.8	-3.7
340	-3.9	-3.7
350	-3.9	-3.7
360	-4	-3.8
370	-4	-3.7
380	-4	-3.9
390	-4.1	-3.8

Distance (m)	July 2004	October 2004
400	-4.1	-3.8
410	-4.1	-4
420	-4.1	-4.1
430	-4.2	-4.2
440	-4.2	-4
450	-4.3	-4.1
460	-4.4	-4.2
470	-4.3	-4.1
480	-4.5	-4.3
490	-4.5	-4.5
500	-4.5	-4.4
510	-4.6	-4.4
520	-4.7	-4.6
530	-4.8	-4.6
540	-4.8	-4.6
550	-4.9	-4.7
560	-5	-4.7
570	-5.1	-4.9
580	-5.1	-4.9
590	-5.1	-5
600	-5.2	-5
610	-5.3	-5.2
620	-5.3	-5.3
630	-5.5	-5.3
640	-5.5	-5.4
650	-5.6	-5.4
660	-5.8	-5.6
670	-5.8	-5.5
680	-5.9	-5.6
690	-6.1	-5.9
700	-6.1	-6
710	-6.1	-5.9
720	-6.2	-6
730	-6.3	-6
740	-6.4	-6.3
750	-6.5	-6.4
760	-6.6	-6.4
770	-6.7	-6.5
780	-6.7	-6.6
790	-6.8	-6.9

800	-7	-6.6
810	-7.1	-7.2
820	-7.1	-7.1
830	-7.2	-7.1
840	-7.3	-7.1
850	-7.3	-7
860	-7.4	-7.1
870	-7.5	-7.4
880	-7.7	-7.5
890	-7.8	-7.5
900	-7.9	-7.7
910	-7.9	-7.6
920	-8	-7.8
930	-8.1	-7.9
940	-8.1	-7.9
950	-8.1	-8.1
960	-8.4	-8.1
970	-8.4	-8.2
980	-8.4	-8.3
990	-8.6	-8.2
1000	-8.6	-8.5
1010	-8.6	-8.5
1020	-8.7	-8.4
1030	-8.8	-8.5
1040	-8.8	-8.5
1050	-8.8	-8.7
1060	-8.9	-8.6
1070	-8.8	-8.7
1080	-8.9	-8.7
1090	-9	-8.7
1100	-9	-9
1110	-9.1	-8.8
1120	-9.3	-9
1130	-9.2	-9.1
1140	-9.3	-9.1
1150	-9.3	-8.9
1160	-9.3	-9.1
1170	-9.4	-9.2
1180	-9.4	-9.2
1190	-9.5	-9.3
1200	-9.6	-9.4
1210	-9.6	-9.3

1220	-9.6	-9.4
1230	-9.6	
1240	-9.6	
1250	-9.8	

Distance (m)	July 2004	October 2004
0	6.1	6.1
10	4.4	4.4
20	4.1	4.1
30	3.9	3.8
40	3.3	3.2
50	2.7	2.6
60	2	2
70	1.5	2
80	1.2	1.9
90	0.9	0.5
100	0.6	-1.2
110	0.3	-1.4
120	0.1	-1.4
130	-0.9	-1.5
140	-2	-1.5
150	-2.5	-1.6
160	-2.7	-1.7
170	-2.8	-2
180	-3	-2.4
190	-3	-2.7
200	-3.2	-2.9
210	-3.3	-3
220	-3.3	-3.1
230	-3.4	-3.1
240	-3.4	-3.1
250	-3.4	-3.3
260	-3.5	-3.4
270	-3.5	-3.4
280	-3.6	-3.4
290	-3.6	-3.3
300	-3.7	-3.5
310	-3.8	-3.6
320	-3.8	-3.6
330	-3.8	-3.7
340	-3.8	-3.8
350	-3.8	-3.8
360	-3.9	-3.8
370	-4	-3.9
380	-4	-3.9
390	-4.1	-3.8

Distance (m)	July 2004	October 2004
400	-4.1	-4
410	-4	-4.1
420	-4.3	-4
430	-4.3	-3.9
440	-4.3	-4.1
450	-4.3	-4.1
460	-4.4	-4.1
470	-4.3	-4
480	-4.1	-4.3
490	-3.6	-4.3
500	-5.1	-4.1
510	-4.3	-4
520	-4.9	-4.1
530	-4.4	-4.4
540	-4.3	-4.7
550	-4.8	-4.8
560	-5.2	-4.8
570	-5.3	-4.9
580	-5.3	-5.1
590	-5.2	-5.1
600	-5.2	-5.3
610	-5.3	-5.3
620	-5.5	-5.4
630	-5.6	-5.5
640	-5.7	-5.5
650	-5.8	-5.7
660	-5.9	-5.7
670	-5.9	-5.8
680	-6	-5.8
690	-6.1	-6
700	-6.2	-6.1
710	-6.2	-6.1
720	-6.3	-6.2
730	-6.5	-6.5
740	-6.6	-6.3
750	-6.6	-6.6
760	-6.7	-6.7
770	-6.8	-6.6
780	-6.9	-6.6
790	-7	-6.7

800	-7.2	-7.1
810	-7.2	-7
820	-7.3	-7.2
830	-7.3	-7.1
840	-7.4	-7.3
850	-7.5	-7.4
860	-7.6	-7.6
870	-7.8	-7.5
880	-7.8	-7.7
890	-7.8	-7.7
900	-8	-7.8
910	-8	-7.8
920	-8	-7.9
930	-8.1	-8
940	-8.2	-7.8
950	-8.3	-8
960	-8.4	-8.2
970	-8.4	-8.2
980	-8.5	-8.3
990	-8.6	-8.4
1000	-8.6	-8.6
1010	-8.6	-8.5
1020	-8.7	-8.5
1030	-8.7	-8.6
1040	-8.8	-8.6
1050	-8.9	-8.7
1060	-8.8	-8.7
1070	-9	-8.6
1080	-9	-8.8
1090	-9.1	-8.8
1100	-9.1	-9
1110	-9.1	-9.1
1120	-9.2	-9
1130	-9.2	-9
1140	-9.3	-9.1
1150	-9.4	-9.3
1160	-9.3	-9.2
1170	-9.4	-9.2
1180	-9.5	-9.4
1190	-9.5	-9.3
1200	-9.6	-9.4
1210	-9.7	-9.4

1220	-9.6	-9.7
1230	-9.6	-9.7
1240	-9.6	
1250	-9.8	

Distance (m)	July 2004	October 2004
0	6.3	6.3
10	6	6
20	6	6
30	4.6	4.7
40	3.7	3.7
50	2.5	2.4
60	1.8	1.8
70	1.6	2.1
80	1.1	2.2
90	0.9	0.8
100	0.5	-0.7
110	-0.1	-1.3
120	-0.6	-1.5
130	-1.1	-1.7
140	-1.7	-1.8
150	-1.9	-2
160	-2.5	-2.2
170	-2.7	-2.4
180	-3	-2.9
190	-3.2	-3
200	-3.2	-3.1
210	-3.3	-3.3
220	-3.4	-3.2
230	-3.4	-3.2
240	-3.5	-3.4
250	-3.5	-3.5
260	-3.6	-3.5
270	-3.6	-3.5
280	-3.7	-3.4
290	-3.7	-3.6
300	-3.8	-3.7
310	-3.8	-3.6
320	-3.8	-3.6
330	-3.9	-4
340	-3.9	-3.7
350	-4	-3.8
360	-4	-3.9
370	-4.1	-4.1
380	-4.1	-4
390	-4.2	-4.1

Distance (m)	July 2004	October 2004
400	-4.2	-4.1
410	-4.3	-4.1
420	-4.3	-4
430	-4.3	-4.2
440	-4.4	-4.2
450	-4.4	-4.4
460	-4.5	-4.4
470	-4.5	-4.5
480	-4.6	-4.6
490	-4.6	-4.7
500	-4.7	-4.6
510	-4.8	-4.7
520	-4.9	-4.8
530	-5	-4.9
540	-5	-4.9
550	-5.1	-5.1
560	-5.2	-5.2
570	-5.2	-5
580	-5.3	-5.3
590	-5.4	-5.3
600	-5.5	-5.5
610	-5.7	-5.4
620	-5.7	-5.4
630	-5.7	-5.6
640	-5.8	-5.6
650	-5.8	-5.6
660	-6	-5.8
670	-6.2	-6
680	-6.3	-6.2
690	-6.4	-6.1
700	-6.4	-6.3
710	-6.5	-6.4
720	-6.6	-6.5
730	-6.5	-6.4
740	-6.7	-6.7
750	-6.8	-6.7
760	-7	-6.8
770	-7	-6.8
780	-7	-6.9
790	-7.1	-6.9

800	-7.3	-7
810	-7.3	-7.1
820	-7.4	-7.1
830	-7.6	-7.5
840	-7.5	-7.5
850	-7.7	-7.7
860	-7.8	-7.6
870	-7.9	-7.7
880	-8	-7.8
890	-8.1	-7.8
900	-8.1	-8
910	-8.2	-8.1
920	-8.2	-8.2
930	-8.4	-8
940	-8.3	-8.3
950	-8.5	-8.4
960	-8.4	-8.3
970	-8.5	-8.3
980	-8.6	-8.5
990	-8.7	-8.6
1000	-8.7	-8.6
1010	-8.7	-8.6
1020	-8.8	-8.8
1030	-8.9	-8.7
1040	-8.9	-8.8
1050	-8.9	-8.9
1060	-9	-8.9
1070	-9.1	-8.9
1080	-9.2	-9
1090	-9.2	-9
1100	-9.2	-9.1
1110	-9.3	-9.1
1120	-9.3	-9.3
1130	-9.4	-9.2
1140	-9.4	-9.2
1150	-9.4	-9.3
1160	-9.5	-9.4
1170	-9.5	-9.4
1180	-9.6	-9.4
1190	-9.7	-9.5
1200	-9.7	-9.5
1210	-9.7	-9.5

1220	-9.8	-9.6
1230	-9.8	-9.6
1240	-9.9	
1250	-9.9	

Distance (m)	July 2004	October 2004
0	6.1	6.1
10	6.2	6.2
20	6.2	6.2
30	4.7	4.7
40	4.5	4.5
50	4	3.9
60	3.6	3.5
70	3.2	3.1
80	2.6	2.5
90	1.9	2.1
100	1.4	0.6
110	0.8	-0.9
120	0.6	-1.2
130	-0.5	-1.4
140	-1.2	-1.6
150	-1.6	-1.6
160	-2.1	-1.7
170	-2.5	-1.8
180	-2.8	-2.2
190	-3	-2.8
200	-3.1	-3
210	-3.3	-3.1
220	-3.3	-3.3
230	-3.4	-3.3
240	-3.5	-3.4
250	-3.6	-3.4
260	-3.7	-3.5
270	-3.7	-3.6
280	-3.9	-3.7
290	-3.9	-3.7
300	-3.9	-3.9
310	-4	-3.7
320	-4	-3.9
330	-4	-3.9
340	-4.1	-3.9
350	-4.1	-3.9
360	-4.1	-4.2
370	-4.2	-4.1
380	-4.2	-4.1
390	-4.3	-4.3

Distance (m)	July 2004	October 2004
400	-4.3	-4.3
410	-4.3	-4.3
420	-4.6	-4.4
430	-4.5	-4.3
440	-4.5	-4.4
450	-4.5	-4.4
460	-4.6	-4.4
470	-4.7	-4.4
480	-4.8	-4.6
490	-4.8	-4.6
500	-4.9	-4.9
510	-5.1	-4.9
520	-5.2	-4.9
530	-5.1	-5
540	-5.3	-5.1
550	-5.2	-5
560	-5.3	-5.1
570	-5.4	-5.3
580	-5.4	-5.3
590	-5.5	-5.5
600	-5.6	-5.4
610	-5.7	-5.5
620	-6	-5.7
630	-6.1	-6
640	-6.1	-5.9
650	-6.2	-6
660	-6.2	-6.2
670	-6.3	-6.2
680	-6.3	-6.2
690	-6.6	-6.4
700	-6.6	-6.5
710	-6.7	-6.6
720	-6.8	-6.5
730	-6.8	-6.7
740	-7	-6.7
750	-7	-6.9
760	-7.1	-7.1
770	-7.3	-6.9
780	-7.3	-7.2
790	-7.4	-7.2

800	-7.4	-7.3
810	-7.5	-7.3
820	-7.6	-7.5
830	-7.7	-7.5
840	-7.9	-7.6
850	-7.9	-7.8
860	-8	-7.8
870	-8	-8
880	-8.1	-7.9
890	-8.2	-8
900	-8.3	-8.1
910	-8.3	-8.2
920	-8.4	-8.2
930	-8.4	-8.2
940	-8.5	-8.4
950	-8.6	-8.3
960	-8.7	-8.4
970	-8.7	-8.4
980	-8.8	-8.6
990	-8.7	-8.6
1000	-8.8	-8.6
1010	-8.9	-8.7
1020	-8.9	-8.7
1030	-9	-8.9
1040	-8.9	-8.8
1050	-9	-9
1060	-9.2	-9
1070	-9.2	-9.1
1080	-9.2	-9.2
1090	-9.3	-9.1
1100	-9.3	-9.2
1110	-9.4	-9.2
1120	-9.4	-9.4
1130	-9.5	-9.4
1140	-9.5	-9.2
1150	-9.4	-9.3
1160	-9.6	-9.5
1170	-9.7	-9.4
1180	-9.7	-9.7
1190	-9.8	-9.7
1200	-9.8	-9.8
1210	-9.9	-9.7

1220	-9.9	-9.7
1230	-10	-9.8
1240	-10	
1250	-10.2	

Distance (m)	July 2004	October 2004
0	8.8	8.8
10	7.9	7.9
20	7	7
30	6.1	6.1
40	5.7	5.7
50	4.3	4.2
60	3.8	3.8
70	3.1	3.2
80	2.6	2.7
90	2.2	2.3
100	1.9	2.2
110	1.5	1.2
120	0.8	0.1
130	0.6	-1.1
140	0.2	-1.3
150	-1.1	-1.4
160	-1.5	-1.6
170	-1.8	-1.7
180	-2.4	-1.9
190	-2.7	-2.2
200	-3	-2.7
210	-3.2	-3.2
220	-3.3	-3.1
230	-3.4	-3.1
240	-3.6	-3.5
250	-3.7	-3.5
260	-3.6	-3.5
270	-3.8	-3.5
280	-3.9	-3.7
290	-3.9	-3.6
300	-4	-3.7
310	-4	-3.8
320	-4.1	-3.9
330	-4.2	-3.9
340	-4.2	-4
350	-4.2	-4.1
360	-4.2	-4.1
370	-4.3	-4.1
380	-4.4	-4.1
390	-4.5	-4.2

Distance (m)	July 2004	October 2004
400	-4.3	-4.5
410	-4.6	-4.4
420	-4.7	-4.3
430	-4.7	-4.5
440	-4.7	-4.5
450	-4.7	-4.7
460	-4.8	-4.7
470	-4.9	-4.8
480	-5.1	-4.8
490	-5	-4.8
500	-5.1	-4.8
510	-5.1	-5
520	-5.3	-5
530	-5.2	-5.1
540	-5.4	-5.2
550	-5.4	-5.2
560	-5.5	-5.4
570	-5.6	-5.6
580	-5.9	-5.8
590	-5.8	-5.7
600	-5.9	-5.1
610	-6	-5.7
620	-6	-5.8
630	-6.2	-5.9
640	-6.2	-6.1
650	-6.4	-6.2
660	-6.5	-6.2
670	-6.4	-6.2
680	-6.6	-6.2
690	-6.7	-6.5
700	-6.8	-6.6
710	-6.9	-6.6
720	-7	-6.7
730	-6.9	-6.9
740	-7.1	-6.8
750	-7.2	-7.1
760	-7.3	-7.1
770	-7.3	-7.2
780	-7.5	-7.2
790	-7.5	-7.4

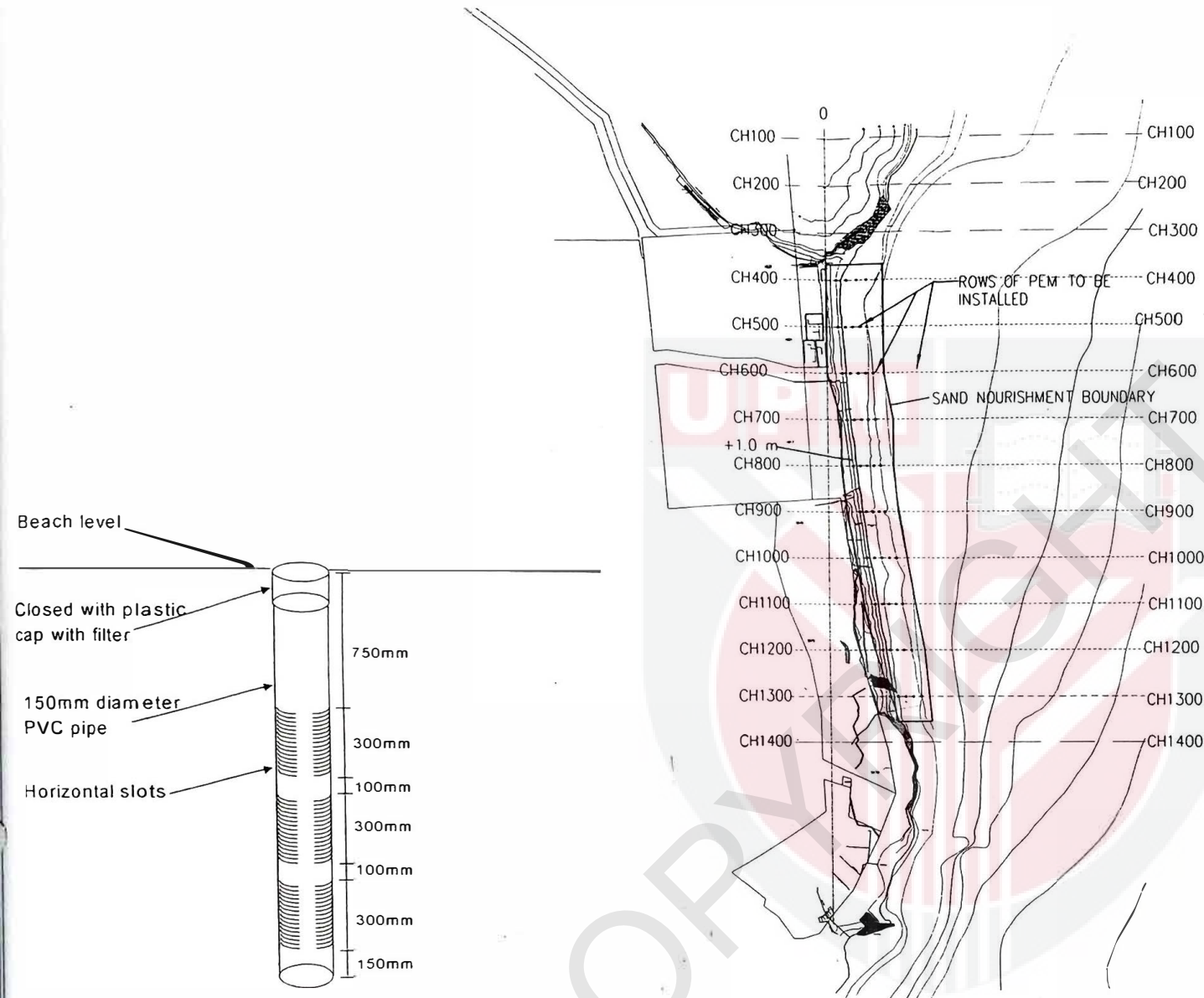
800	-7.7	-7.4
810	-7.7	-7.5
820	-7.8	-7.6
830	-8.1	-7.8
840	-8.1	-7.8
850	-8.1	-7.9
860	-8.2	-8
870	-8.1	-8
880	-8.3	-8
890	-8.4	-8.1
900	-8.3	-8.3
910	-8.5	-8.3
920	-8.6	-8.4
930	-8.8	-8.3
940	-8.7	-8.4
950	-8.6	-8.6
960	-8.7	-8.5
970	-8.9	-8.6
980	-8.9	-8.6
990	-8.9	-8.7
1000	-8.9	-8.9
1010	-9.1	-9
1020	-9.2	-8.9
1030	-9.2	-9
1040	-9.3	-9
1050	-9.4	-9.1
1060	-9.3	-9.2
1070	-9.3	-9.2
1080	-9.4	-9.1
1090	-9.5	-9.3
1100	-9.6	-9.3
1110	-9.5	-9.4
1120	-9.6	-9.5
1130	-9.8	-9.5
1140	-9.7	-9.4
1150	-9.8	-9.7
1160	-9.9	-9.6
1170	-9.8	-9.6
1180	-9.9	-9.8
1190	-10.1	-9.9
1200	-9.9	-9.7
1210	-10.1	-9.9

1220	-10	-10
1230	-10.1	
1240	-10.2	
1250	-10.1	

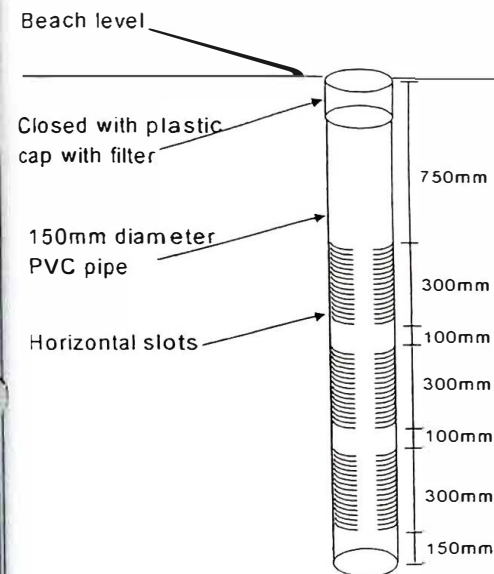
Distance (m)	July 2004	October 2004
70	4.2	3.9
80	3.8	3.5
90	3.1	3
100	2.6	2.5
110	2.2	2.1
120	1.8	1.8
130	1.5	0.5
140	1.2	-0.6
150	0.7	-1
160	-0.3	-1.1
170	-0.8	-1.3
180	-1.3	-1.4
190	-1.7	-1.6
200	-2.2	-1.9
210	-2.6	-2.3
220	-3	-2.7
230	-3.3	-3.1
240	-3.5	-3.3
250	-3.6	-3.5
260	-3.8	-3.6
270	-3.9	-3.6
280	-4	-3.7
290	-3.9	-3.9
300	-4.1	-4
310	-4.1	-4
320	-4.1	-3.9
330	-4.3	-4.2
340	-4.4	-4.3
350	-4.3	-4.2
360	-4.5	-4.2
370	-4.6	-4.3
380	-4.7	-4.5
390	-4.8	-4.6
400	-5	-4.7
410	-4.9	-4.7
420	-4.8	-4.8
430	-5.2	-4.8
440	-5.1	-4.7
450	-4.9	-4.6
460	-5.1	-4.9

Distance (m)	July 2004	October 2004
470	-5.1	-5
480	-5.2	-5
490	-5.3	-5.1
500	-5.3	-5.2
510	-5.4	-5.2
520	-5.5	-5.2
530	-5.4	-5.2
540	-5.4	-5.2
550	-5.6	-5.1
560	-5.6	-5.4
570	-5.8	-5.5
580	-6	-5.8
590	-6.1	-5.9
600	-6.2	-6
610	-6.4	-6.1
620	-6.4	-6.1
630	-6.4	-6.3
640	-6.5	-6.3
650	-6.6	-6.5
660	-6.7	-6.5
670	-6.8	-6.6
680	-6.8	-6.6
690	-7	-6.6
700	-6.9	-6.8
710	-7.1	-7
720	-7.1	-7.1
730	-7.1	-7.1
740	-7.4	-7.2
750	-7.4	-7.2
760	-7.5	-7.3
770	-7.7	-7.4
780	-7.7	-7.4
790	-7.8	-7.4
800	-7.8	-7.8
810	-7.9	-7.5
820	-8	-7.6
830	-8.1	-7.9
840	-8.1	-8
850	-8.4	-8
860	-8.4	-8

870	-8.3	-8.1
880	-8.5	-8.2
890	-8.4	-8.5
900	-8.6	-8.4
910	-8.8	-8.6
920	-8.7	-8.5
930	-8.8	-8.7
940	-8.8	-8.7
950	-8.9	-8.8
960	-8.9	-8.8
970	-8.9	-8.6
980	-9.1	-9
990	-8.9	-8.9
1000	-9.1	-9
1010	-9.2	-8.9
1020	-9.2	-9
1030	-9.3	-9.3
1040	-9.3	-9.2
1050	-9.5	-9.3
1060	-9.5	-9.3
1070	-9.5	-9.3
1080	-9.7	-9.4
1090	-9.6	-9.4
1100	-9.6	-9.5
1110	-9.6	-9.7
1120	-9.8	-9.5
1130	-9.9	-9.5
1140	-9.8	-9.6
1150	-9.9	-9.5
1160	-9.9	-9.6
1170	-10	-9.8
1180	-10	-9.7
1190	-10.1	-10.1
1200	-10.1	-10
1210	-10.1	-10
1220	-10.3	-10
1230	-10.2	-10.1
1240	-10.2	-10.1
1250	-10.3	

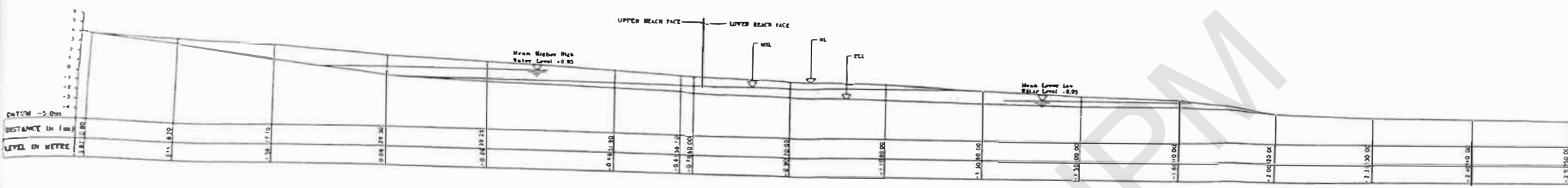


UPM

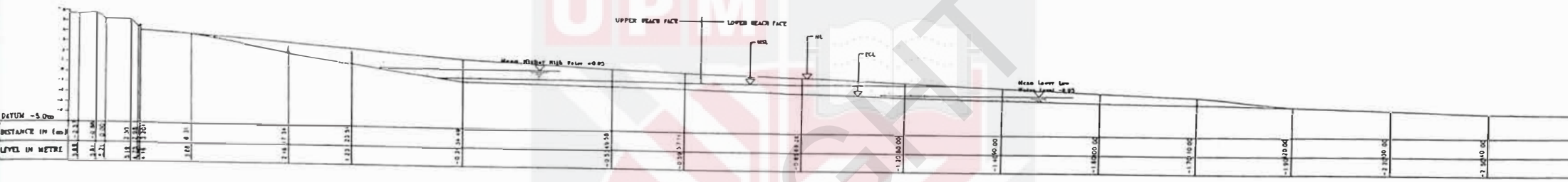


Pipe details

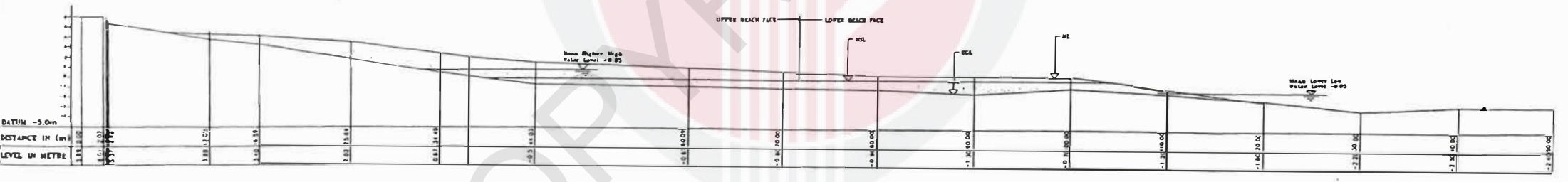
<p>NOTES :</p>	<p>PEMILIK:</p> <p>JABATAN PENGAIRAN DAN SALIRAN NEGERI PAHANG</p>	<p>PROJEK:</p> <p>PROJEK PERINTIS PEMULIHAN PANTAI PELANCONGAN DENGAN MENGGUNAKAN 'PRESSURE EQUALISATION MODULE' (PEM) DI TELUK CEPEDAK, KUANTAN PAHANG DARUL MAKMUR</p>	<p>COP & TANDA TANGAN JURUTERA :</p>	<p>JURUTERA PERLINDUNG :</p> <p>PERUNDING MUSTAFA NO.18, TINGKAT ATAS, JALAN SUBERMAN 7, BANDAR SERI SEMANTAN, 28000 TEMERLOH, PAHANG DARUL MAKMUR TEL: 09-2961285 FAX: 09-2961286</p>	<p>" I hereby certify that these works has been designed by me in accordance with sound engineering practices and that I take full responsibility of these design and proper performance of the same "</p>
					SKALA : 1 : 5000
					DIREKA : KDK
					DILUKIS : HAZRI
					DISEMAK : IR. MUSTAFA
					BIL. LUKISAN : REV.
					DRAW 3.06
					BL. Tarikh Pindaan Oleh



CH. 400



CH. 500



CH. 600

NOTES
 ECL = EXISTING GROUND LEVEL/SEA BED
 NL = NOURISHMENT LEVEL

NOTES

ALL DIMENSIONS FOR DISTANCES IN (M) ARE EXTRACTED FROM THE SIMPLY DRAWING OF ORIGINAL MEASUREMENT SERVICES SURVEY DATED NOV 2002/PP/03/248/01 TO 0/248. THE CONTRACTOR SHALL OBTAIN THESE ORIGINAL AND USE THESE VERTICAL REFERENCE TO COMPLETE THE SAND NOURISHMENT AND P.E.M. SYSTEM.

PEMILIK:

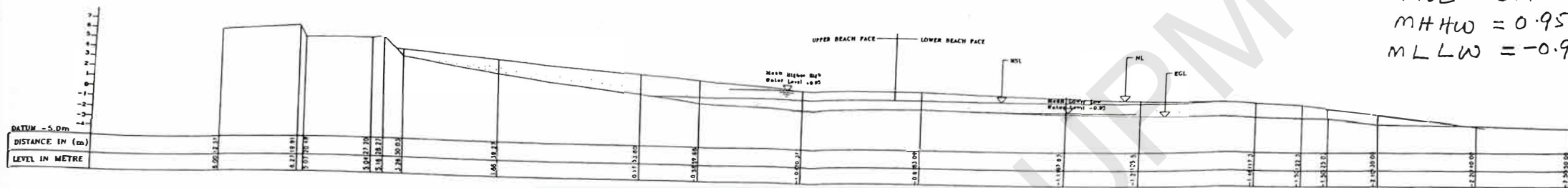
 JABATAN PENGAIRAN DAN SALIRAN
 NEGERI PAHANG

PROJEK:
 PROJEK PERINTIS PEMULIHAN PANTAI
 PELANCONGAN DENGAN MENGGUNAKAN
 "PRESSURE EQUALISATION MODULE"
 (PEM) DI TELUK CEPEDAK, KUANTAN,
 PAHANG DARUL MAKMUR

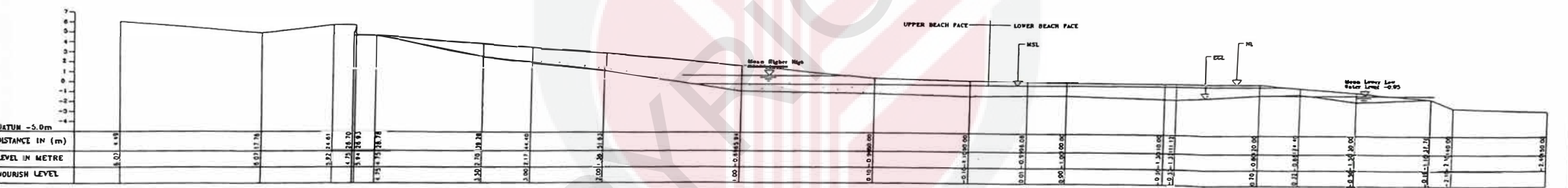
COP & TANDATANGAN JURUTERA:
 JURUTERA PERUNDING
PERUNDING MUSTAFA
 NO: 18, TINGKAT ATAS,
 JALAN SUDIRMAN 7,
 BANDAR SERI SEWANTAN,
 28000 TEMERLOH,
 PAHANG DARUL MAKMUR
 TEL: 09-2961285
 FAX: 09-2961286
 TAJUK: "SAND NOURISHMENT"
 PELAN KERATAN RENTAS DARI
 CH.4.00M, CH.5.00M & CH.6.00M

"I hereby certify that these works has been designed by me in accordance with sound engineering practice and that I take full responsibility of these design and proper performance of the same."	
SKALA	1 : 200
DIREKA	KOK
DILUKIS	HAZRI
DISEMAK	IR MUSTAFA
BIL. LUKISAN	REV
ORAW 3 02	

MSL = 0m
 MH HW = 0.95m
 MLLW = -0.95m



CH. 700




CH. 800

NOTES:
 EGL = EXISTING GROUND LEVEL/SEA BED
 ML = NOURISHMENT LEVEL

NOTES:
 ALL X - AXES FOR "DISTANCE IN (m)" ARE EXTRACTED FROM THE SURVEY DRAWING OF
 ADVISOR CONSULTING SERVICES (M) SDN BHD. (INC. NOS. 970327/MC/244/01) TO 7036.
 THE CONTRACTOR SHALL OBTAIN THESE DRAWING AND USE THEIR VERTICAL REFERENCE
 TO CONSTRUCT THE SAND NOURISHMENT AND P.E.M. SYSTEM

PEMILIK



JABATAN PENGAIRAN DAN SALIRAN
 NEGERI PAHANG

PROJEK
 PROJEK PERINTIS PEMULIHAN PANTAI
 PELANCONGAN DENGAN MENGGUNAKAN
 "PRESSURE EQUALISATION MODULE"
 (PEM) DI TELUK CEPEDAK, KUANTAN,
 PAHANG DARUL MAKMUR

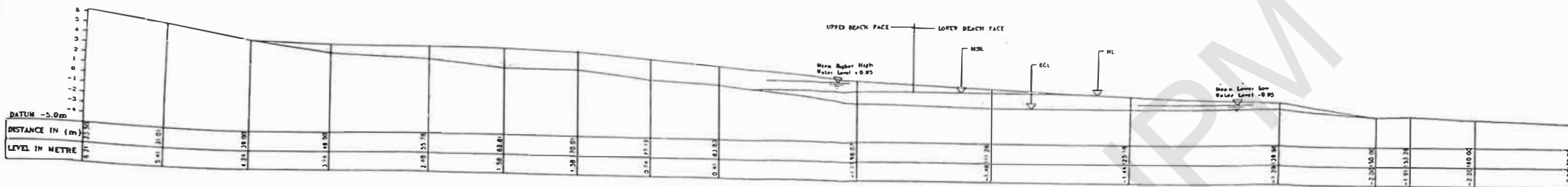
COP & TANDATANGAN JURUTERA

TAJUK "SAND NOURISHMENT"
 PELAN KERATAN RENTAS DARI
 CH 700M - CH 800M

JURUTERA PERUNDING
PERUNDING MUSTAFA
 NO. 18, TINGKAT ATAS,
 JALAN SUDIRMAN 7,
 BANDAR SERI SEMANTAN,
 28000 TEMERLOH,
 PAHANG DARUL MAKMUR
 TEL: 09-2961285
 FAX: 09-2961286

I hereby certify that these works has been designed by me in accordance with sound engineering practice and that I take full responsibility of these design and proper performance of the same

SKALA	1 : 200
DIREKA	KOK
DILUKIS	HAZRI
DISEMAK	IR MUSTAFA
BIL LUKISAN	REV
DRAW 3.03	



**APPENDIX B: WAVE HEIGHT, WAVE PERIOD AND WAVE DIRECTION
DATA FROM JULY UNTIL OCTOBER 2004 TAKEN FROM NOAA**

Date and Time	Wave Height (m)	Wave Period (s)	Wave Direction
1/7/2004 0:00	0.31	6.09	326.6
1/7/2004 3:00	0.29	6.15	327.18
1/7/2004 6:00	0.28	6.16	328.44
1/7/2004 9:00	0.28	6.19	329.39
1/7/2004 12:00	0.29	6.47	329.11
1/7/2004 15:00	0.32	6.69	330.93
1/7/2004 18:00	0.34	6.77	330.38
1/7/2004 21:00	0.37	6.83	329.96
2/7/2004 0:00	0.39	6.85	329.82
2/7/2004 3:00	0.4	6.84	329.86
2/7/2004 6:00	0.39	6.82	330.14
2/7/2004 9:00	0.37	6.76	330.77
2/7/2004 12:00	0.36	5.06	142.37
2/7/2004 15:00	0.34	5.05	140.43
2/7/2004 18:00	0.32	5.03	137.49
2/7/2004 21:00	0.3	4.99	134.02
3/7/2004 0:00	0.31	4.96	140.26
3/7/2004 3:00	0.3	4.93	137.74
3/7/2004 6:00	0.28	4.96	135.57
3/7/2004 9:00	0.27	4.91	134.29
3/7/2004 12:00	0.25	4.71	133.59
3/7/2004 15:00	0.24	4.51	140.21
3/7/2004 18:00	0.22	4.49	139.09
3/7/2004 21:00	0.21	4.49	138.04
4/7/2004 0:00	0.2	4.48	137.19
4/7/2004 3:00	0.19	4.42	136.84
4/7/2004 6:00	0.17	4.3	136.64
4/7/2004 9:00	0.16	3.72	146.01
4/7/2004 12:00	0.16	3.72	144.73
4/7/2004 15:00	0.15	3.68	143.85
4/7/2004 18:00	0.14	3.63	142.91
4/7/2004 21:00	0.14	3.58	141.86
5/7/2004 0:00	0.13	3.58	141.37
5/7/2004 3:00	0.13	3.61	141.2
5/7/2004 6:00	0.12	3.65	140.73
5/7/2004 9:00	0.11	3.67	140.71
5/7/2004 12:00	0.13	3.64	141.2
5/7/2004 15:00	0.14	3.59	141.52

5/7/2004 18:00	0.14	3.56	141.21
5/7/2004 21:00	0.12	3.59	140.9
6/7/2004 0:00	0.11	3.64	140.89
6/7/2004 3:00	0.1	3.71	141.13
6/7/2004 6:00	0.1	3.77	137.55
6/7/2004 9:00	0.09	3.81	137.9
6/7/2004 18:00	0.11	3.91	139.84
6/7/2004 21:00	0.09	3.95	140.8
7/7/2004 0:00	0.07	3.98	141.83
7/7/2004 6:00	0.08	5.23	141.03
7/7/2004 9:00	0.07	5.25	140.57
7/7/2004 15:00	0.08	5.28	139.3
7/7/2004 18:00	0.07	5.3	138.66
7/7/2004 21:00	0.07	5.32	138.06
8/7/2004 9:00	0.11	4.25	155.72
8/7/2004 12:00	0.13	4.25	156.39
8/7/2004 15:00	0.12	4.26	156.72
8/7/2004 18:00	0.12	4.25	156.6
8/7/2004 21:00	0.12	4.22	156.31
9/7/2004 0:00	0.13	4.18	155.41
9/7/2004 3:00	0.12	4.15	154.52
9/7/2004 6:00	0.11	4.13	153.53
9/7/2004 9:00	0.14	4.1	152.66
10/7/2004 3:00	0.19	3.29	144.31
10/7/2004 6:00	0.17	4.14	137.76
10/7/2004 9:00	0.16	4.18	140.8
10/7/2004 12:00	0.15	4.18	142.41
10/7/2004 15:00	0.17	4.18	142.85
10/7/2004 18:00	0.16	4.18	142.79
10/7/2004 21:00	0.15	4.18	142.35
11/7/2004 0:00	0.14	4.18	141.77
11/7/2004 3:00	0.13	4.2	141.3
11/7/2004 6:00	0.12	4.22	140.92
11/7/2004 9:00	0.12	4.23	140.77
11/7/2004 12:00	0.13	4.24	140.76
11/7/2004 15:00	0.12	4.25	140.62
11/7/2004 18:00	0.11	4.25	140.53
11/7/2004 21:00	0.11	4.24	140.31
12/7/2004 0:00	0.1	4.24	140.09
12/7/2004 3:00	0.09	4.25	139.77
12/7/2004 6:00	0.09	4.25	139.14
12/7/2004 9:00	0.08	4.25	138.07
12/7/2004 12:00	0.1	4.27	136.33
12/7/2004 15:00	0.1	4.32	132.59
12/7/2004 18:00	0.09	5.07	335.29

12/7/2004 21:00	0.09	5.08	335.11
13/7/2004 0:00	0.1	5.09	335.36
13/7/2004 3:00	0.1	5.1	335.71
13/7/2004 6:00	0.11	5.13	335.97
13/7/2004 9:00	0.11	5.16	336.08
13/7/2004 12:00	0.12	5.18	336.1
13/7/2004 15:00	0.13	5.19	335.98
13/7/2004 18:00	0.14	5.18	335.86
13/7/2004 21:00	0.14	5.14	335.86
14/7/2004 0:00	0.14	5.09	335.81
14/7/2004 3:00	0.14	5.02	335.79
14/7/2004 6:00	0.14	4.93	332.76
14/7/2004 9:00	0.13	4.83	332.81
14/7/2004 12:00	0.12	4.75	333
14/7/2004 15:00	0.11	4.68	333.36
14/7/2004 18:00	0.1	4.6	333.83
14/7/2004 21:00	0.09	4.51	334.2
15/7/2004 0:00	0.08	4.41	334.53
15/7/2004 3:00	0.08	4.35	334.75
15/7/2004 6:00	0.07	4.3	335.17
15/7/2004 9:00	0.06	4.26	335.52
15/7/2004 12:00	0.06	4.21	335.9
15/7/2004 15:00	0.05	4.17	336.55
15/7/2004 18:00	0.05	4.13	337.92
15/7/2004 21:00	0.05	4.11	341.48
16/7/2004 0:00	0.06	4.13	1.04
16/7/2004 3:00	0.05	4.15	110.79
16/7/2004 6:00	0.06	4.17	133.57
16/7/2004 9:00	0.11	3.21	152.86
16/7/2004 12:00	0.12	4.19	144.7
16/7/2004 15:00	0.14	4.19	145.45
16/7/2004 18:00	0.12	4.2	146.26
16/7/2004 21:00	0.11	4.21	148.06
17/7/2004 6:00	0.84	3.13	236.98
17/7/2004 9:00	0.72	3.56	236.56
17/7/2004 12:00	0.56	3.6	236.39
17/7/2004 15:00	0.43	3.63	236.06
17/7/2004 18:00	0.33	3.64	236.5
17/7/2004 21:00	0.26	4.17	242.94
18/7/2004 0:00	0.21	4.18	246.63
18/7/2004 3:00	0.17	4.19	251.32
18/7/2004 6:00	0.14	4.2	251.58
18/7/2004 9:00	0.16	4.2	234.75
18/7/2004 12:00	0.2	4.2	195.65
18/7/2004 21:00	0.46	3.08	165.05

19/7/2004 0:00	0.42	3.13	168.69
19/7/2004 3:00	0.41	2.98	180.91
19/7/2004 6:00	0.39	4.36	150.71
19/7/2004 9:00	0.41	4.5	150.78
19/7/2004 12:00	0.5	4.98	138.1
19/7/2004 15:00	0.55	2.78	183.43
19/7/2004 18:00	0.49	5	137.95
19/7/2004 21:00	0.42	5.01	137.81
20/7/2004 0:00	0.38	5.04	137.72
20/7/2004 3:00	0.37	5.06	137.8
20/7/2004 6:00	0.35	5.06	138.59
20/7/2004 9:00	0.34	5.04	139.69
20/7/2004 15:00	0.75	3.47	191.66
20/7/2004 18:00	0.59	3.62	193.81
20/7/2004 21:00	0.49	4.18	167.62
21/7/2004 0:00	0.45	4.31	164.47
21/7/2004 3:00	0.46	4.51	161.08
21/7/2004 6:00	0.47	4.95	153.03
21/7/2004 9:00	0.47	5.35	148.29
21/7/2004 12:00	0.48	5.51	143.26
21/7/2004 15:00	0.5	5.62	144.07
21/7/2004 18:00	0.51	5.68	144.69
21/7/2004 21:00	0.7	2.7	191.35
22/7/2004 0:00	0.7	3.48	178
22/7/2004 3:00	0.61	3.78	168.66
22/7/2004 6:00	0.54	5.53	144.22
22/7/2004 9:00	0.52	5.46	149.32
22/7/2004 12:00	0.53	5.41	148.84
22/7/2004 15:00	0.55	5.42	147.77
22/7/2004 18:00	0.54	5.45	146.39
22/7/2004 21:00	0.53	5.45	145.09
23/7/2004 0:00	0.54	5.42	143.89
23/7/2004 3:00	0.56	5.37	142.76
23/7/2004 6:00	0.61	2.96	167.5
23/7/2004 9:00	0.6	3.25	160.4
23/7/2004 12:00	0.58	3.25	163.79
23/7/2004 15:00	0.54	5.12	139.71
23/7/2004 18:00	0.49	5.12	139.58
23/7/2004 21:00	0.45	5.12	139.36
24/7/2004 0:00	0.42	5.12	139.08
24/7/2004 3:00	0.4	5.11	138.73
24/7/2004 6:00	0.36	5.1	138.42
24/7/2004 9:00	0.32	5.08	138.25
24/7/2004 12:00	0.38	5.02	138.39
24/7/2004 15:00	0.58	2.79	168.09

24/7/2004 18:00	0.52	3.42	157.9
24/7/2004 21:00	0.53	3.02	181.9
25/7/2004 0:00	0.56	3	193.03
25/7/2004 3:00	0.58	3.02	201.24
25/7/2004 6:00	0.49	3.24	187.88
25/7/2004 9:00	0.43	4.96	151.71
25/7/2004 12:00	0.49	2.95	184.67
25/7/2004 15:00	0.53	3.02	184.73
25/7/2004 18:00	0.5	4.88	154.97
25/7/2004 21:00	0.48	5.2	147.48
26/7/2004 0:00	0.51	5.37	146.41
26/7/2004 3:00	0.6	2.9	202.45
26/7/2004 6:00	0.56	3	202.27
26/7/2004 9:00	0.48	5.24	143.47
26/7/2004 12:00	0.45	5.2	142.71
26/7/2004 15:00	0.42	5.15	142.23
26/7/2004 18:00	0.35	5.1	141.79
26/7/2004 21:00	0.31	5.05	141.42
27/7/2004 0:00	0.28	5.03	140.84
27/7/2004 3:00	0.28	4.99	140.31
27/7/2004 6:00	0.29	5.02	139.8
27/7/2004 9:00	0.32	5.12	139.72
27/7/2004 12:00	0.36	5.26	139.67
27/7/2004 15:00	0.42	5.39	139.79
27/7/2004 18:00	0.49	5.36	139.62
27/7/2004 21:00	0.48	4.87	139.95
28/7/2004 0:00	0.44	4.74	137.92
28/7/2004 3:00	0.4	4.75	136.69
28/7/2004 6:00	0.36	4.76	135.83
28/7/2004 9:00	0.34	4.75	135.24
28/7/2004 12:00	0.37	4.7	134.88
28/7/2004 15:00	0.4	4.55	134.18
28/7/2004 18:00	0.38	4.57	133.58
28/7/2004 21:00	0.37	4.63	133.6
29/7/2004 0:00	0.36	4.69	134.19
29/7/2004 3:00	0.33	4.73	134.8
29/7/2004 6:00	0.3	4.74	135.54
29/7/2004 9:00	0.28	4.75	135.9
29/7/2004 12:00	0.27	4.76	136.06
29/7/2004 15:00	0.25	4.74	135.95
29/7/2004 18:00	0.25	4.73	135.72
29/7/2004 21:00	0.23	4.71	135.27
30/7/2004 0:00	0.23	4.69	135.06
30/7/2004 3:00	0.22	4.66	135.07
30/7/2004 6:00	0.21	4.62	134.83

30/7/2004 9:00	0.2	4.57	134.1
30/7/2004 12:00	0.19	4.47	136.01
30/7/2004 15:00	0.18	4.36	134.24
30/7/2004 18:00	0.17	4.32	132.09
30/7/2004 21:00	0.17	4.31	129.66
31/7/2004 0:00	0.19	4.35	127.1
31/7/2004 3:00	0.23	4.39	124.28
31/7/2004 6:00	0.25	6.1	332.32
31/7/2004 9:00	0.27	6.26	331.14
31/7/2004 12:00	0.32	6.42	330.01
31/7/2004 15:00	0.35	6.59	329.05
31/7/2004 18:00	0.36	6.64	331.59
31/7/2004 21:00	0.37	6.66	331.07
1/8/2004 0:00	0.39	6.63	330.63
1/8/2004 6:00	0.83	3.58	200.53
1/8/2004 9:00	0.69	4.2	185.88
1/8/2004 12:00	0.57	4.23	184.12
1/8/2004 15:00	0.5	4.27	180.42
1/8/2004 18:00	0.57	2.88	196.25
1/8/2004 21:00	0.63	3.25	193.99
2/8/2004 0:00	0.58	3.48	193.36
2/8/2004 3:00	0.51	4.53	149.36
2/8/2004 6:00	0.45	4.8	148.11
2/8/2004 9:00	0.41	4.9	147.15
2/8/2004 12:00	0.44	5.18	141.62
2/8/2004 15:00	0.52	5.48	137.16
2/8/2004 18:00	0.68	2.96	170.97
2/8/2004 21:00	0.65	3.28	169.19
3/8/2004 0:00	0.63	5.59	136.86
3/8/2004 3:00	0.61	5.57	136.34
3/8/2004 6:00	0.56	5.54	135.87
3/8/2004 9:00	0.52	5.51	135.47
3/8/2004 12:00	0.51	5.48	134.85
3/8/2004 15:00	0.53	5.32	138.04
3/8/2004 18:00	0.53	5.22	138.21
3/8/2004 21:00	0.51	5.25	138.43
4/8/2004 0:00	0.5	5.28	138.94
4/8/2004 3:00	0.5	5.26	139.71
4/8/2004 6:00	0.47	5.24	140.24
4/8/2004 9:00	0.47	5.21	139.94
4/8/2004 12:00	0.51	5.17	139.35
4/8/2004 15:00	0.59	2.93	153.32
4/8/2004 18:00	0.6	3.23	155.13
4/8/2004 21:00	0.57	5.04	141.89
5/8/2004 0:00	0.55	5.21	142.62

5/8/2004 3:00	0.54	5.34	142.95
5/8/2004 6:00	0.48	5.42	143.1
5/8/2004 9:00	0.43	5.41	142.82
5/8/2004 12:00	0.45	5.42	142.27
5/8/2004 15:00	0.57	2.78	156.65
5/8/2004 18:00	0.57	5.21	143.98
5/8/2004 21:00	0.56	5.18	143.85
6/8/2004 0:00	0.55	5.23	143.61
6/8/2004 3:00	0.53	5.3	143.09
6/8/2004 6:00	0.48	5.33	142.42
6/8/2004 9:00	0.42	5.3	141.72
6/8/2004 12:00	0.4	5.25	140.79
6/8/2004 15:00	0.42	5.19	139.82
6/8/2004 18:00	0.43	5.07	139.41
6/8/2004 21:00	0.45	5.02	139.66
7/8/2004 0:00	0.46	5.24	140.62
7/8/2004 3:00	0.46	5.36	141.23
7/8/2004 6:00	0.44	5.44	141.58
7/8/2004 9:00	0.42	5.41	141.96
7/8/2004 12:00	0.47	5.38	141.93
7/8/2004 15:00	0.63	2.89	144.72
7/8/2004 18:00	0.6	3.38	148.6
7/8/2004 21:00	0.58	5.05	140.35
8/8/2004 0:00	0.57	5.09	140.49
8/8/2004 3:00	0.55	5.21	140.79
8/8/2004 6:00	0.52	5.41	140.55
8/8/2004 9:00	0.5	5.5	134.88
8/8/2004 12:00	0.52	5.52	134.38
8/8/2004 15:00	0.54	5.52	133.59
8/8/2004 18:00	0.52	5.5	132.72
8/8/2004 21:00	0.49	5.49	132.01
9/8/2004 0:00	0.48	5.49	131.75
9/8/2004 3:00	0.47	5.5	131.73
9/8/2004 6:00	0.46	5.5	131.9
9/8/2004 9:00	0.48	5.5	131.94
9/8/2004 12:00	0.57	5.48	131.88
9/8/2004 15:00	0.57	5.39	137.67
9/8/2004 18:00	0.55	5.32	138.79
9/8/2004 21:00	0.55	5.35	139.39
10/8/2004 0:00	0.55	5.38	140.06
10/8/2004 3:00	0.53	5.4	140.44
10/8/2004 6:00	0.5	5.44	140.01
10/8/2004 9:00	0.48	5.42	139.51
10/8/2004 12:00	0.52	5.39	138.82
10/8/2004 15:00	0.56	5.36	138.17

10/8/2004 18:00	0.54	5.28	138.22
10/8/2004 21:00	0.53	5.22	138.49
11/8/2004 0:00	0.51	5.22	139.07
11/8/2004 3:00	0.49	5.27	139.64
11/8/2004 6:00	0.46	5.33	139.62
11/8/2004 9:00	0.44	5.35	139.52
11/8/2004 12:00	0.47	5.33	139.17
11/8/2004 15:00	0.47	5.27	138.69
11/8/2004 18:00	0.44	5.21	138.15
11/8/2004 21:00	0.42	5.2	138.14
12/8/2004 0:00	0.43	5.26	138.6
12/8/2004 3:00	0.43	5.36	139.13
12/8/2004 6:00	0.42	5.43	139.48
12/8/2004 9:00	0.42	5.45	139.52
12/8/2004 12:00	0.43	5.44	139.16
12/8/2004 15:00	0.43	5.42	138.46
12/8/2004 18:00	0.41	5.39	137.48
12/8/2004 21:00	0.39	5.36	136.5
13/8/2004 0:00	0.38	5.34	135.65
13/8/2004 3:00	0.36	5.3	134.9
13/8/2004 6:00	0.34	5.27	134.43
13/8/2004 9:00	0.33	5.23	134.44
13/8/2004 12:00	0.35	5.2	134.83
13/8/2004 15:00	0.37	5.14	135.24
13/8/2004 18:00	0.4	5.03	136.24
13/8/2004 21:00	0.41	5.02	138
14/8/2004 0:00	0.39	5.11	139.37
14/8/2004 3:00	0.39	5.24	139.92
14/8/2004 6:00	0.39	5.34	139.85
14/8/2004 9:00	0.38	5.39	139.41
14/8/2004 12:00	0.37	5.41	138.69
14/8/2004 15:00	0.36	5.44	137.84
14/8/2004 18:00	0.35	5.46	128.85
14/8/2004 21:00	0.34	5.49	126.52
15/8/2004 0:00	0.34	5.53	124.05
15/8/2004 3:00	0.35	5.58	121.15
15/8/2004 6:00	0.35	5.61	120.39
15/8/2004 9:00	0.35	5.63	121.14
15/8/2004 12:00	0.35	5.62	123.69
15/8/2004 15:00	0.33	5.59	124.78
15/8/2004 18:00	0.33	5.55	125.26
15/8/2004 21:00	0.33	5.51	123.58
16/8/2004 0:00	0.33	5.49	119.86
16/8/2004 3:00	0.32	5.49	111.26
16/8/2004 6:00	0.32	5.49	98.59

16/8/2004 9:00	0.32	5.48	78.44
16/8/2004 12:00	0.34	5.44	125.77
16/8/2004 15:00	0.36	5.36	127.14
16/8/2004 18:00	0.37	5.18	130.04
16/8/2004 21:00	0.37	5.02	131.48
17/8/2004 0:00	0.38	4.96	140.73
17/8/2004 3:00	0.39	4.97	135.52
17/8/2004 6:00	0.38	5.01	137.44
17/8/2004 9:00	0.36	5.05	138.22
17/8/2004 12:00	0.36	5.06	137.84
17/8/2004 15:00	0.38	5.03	136.94
17/8/2004 18:00	0.42	4.91	143.46
17/8/2004 21:00	0.44	4.9	142.99
18/8/2004 0:00	0.43	5	135.31
18/8/2004 3:00	0.42	5.12	135.7
18/8/2004 6:00	0.4	5.21	135.99
18/8/2004 9:00	0.39	5.27	136.04
18/8/2004 12:00	0.4	5.33	135.9
18/8/2004 15:00	0.43	5.34	135.75
18/8/2004 18:00	0.47	5.27	135.46
18/8/2004 21:00	0.5	5.34	135.44
19/8/2004 0:00	0.77	2.96	185.94
19/8/2004 3:00	0.66	3.31	190.26
19/8/2004 6:00	0.59	5.46	132.85
19/8/2004 9:00	0.53	5.47	132.91
19/8/2004 12:00	0.49	5.5	132.46
19/8/2004 15:00	0.46	5.51	131.76
19/8/2004 18:00	0.45	5.52	131.38
19/8/2004 21:00	0.45	5.53	131.39
20/8/2004 0:00	0.46	5.53	131.85
20/8/2004 3:00	0.48	5.55	132.54
20/8/2004 6:00	0.47	5.58	133.16
20/8/2004 9:00	0.45	5.59	133.33
20/8/2004 12:00	0.45	5.59	133.36
20/8/2004 15:00	0.44	5.57	133.24
20/8/2004 18:00	0.42	5.53	133.14
20/8/2004 21:00	0.4	5.47	132.97
21/8/2004 0:00	0.38	5.35	134.68
21/8/2004 3:00	0.36	5.25	134.63
21/8/2004 6:00	0.34	5.22	134.73
21/8/2004 9:00	0.32	5.2	134.85
21/8/2004 12:00	0.3	5.19	134.96
21/8/2004 15:00	0.29	5.19	135
21/8/2004 18:00	0.27	5.18	134.99
21/8/2004 21:00	0.27	5.16	134.96

22/8/2004 0:00	0.29	5.1	134.87
22/8/2004 3:00	0.31	4.61	135.72
22/8/2004 6:00	0.3	4.5	138.9
22/8/2004 9:00	0.28	4.56	136.9
22/8/2004 12:00	0.27	4.6	137.09
22/8/2004 15:00	0.25	4.64	137.13
22/8/2004 18:00	0.24	4.67	137.08
22/8/2004 21:00	0.23	4.71	136.96
23/8/2004 0:00	0.24	4.78	136.96
23/8/2004 3:00	0.24	4.9	137.04
23/8/2004 6:00	0.25	5.03	135.86
23/8/2004 9:00	0.25	5.11	136.59
23/8/2004 12:00	0.27	5.17	137.16
23/8/2004 15:00	0.26	5.21	137.51
23/8/2004 18:00	0.25	5.25	137.67
23/8/2004 21:00	0.24	5.27	137.7
24/8/2004 0:00	0.24	5.28	137.66
24/8/2004 3:00	0.23	5.28	137.63
24/8/2004 6:00	0.23	5.27	137.55
24/8/2004 9:00	0.23	5.21	137.39
24/8/2004 12:00	0.25	5.1	137.18
24/8/2004 15:00	0.27	4.68	137.43
24/8/2004 18:00	0.28	4.44	142.15
24/8/2004 21:00	0.32	4.51	141.96
25/8/2004 3:00	0.66	3.26	201.05
25/8/2004 6:00	0.54	3.59	183.43
25/8/2004 9:00	0.45	4.15	160.61
25/8/2004 12:00	0.41	4.24	157.67
25/8/2004 15:00	0.43	4.41	154.39
25/8/2004 18:00	0.44	4.89	145.32
25/8/2004 21:00	0.44	5.06	140.28
26/8/2004 0:00	0.44	5.19	141.29
26/8/2004 3:00	0.42	5.29	141.97
26/8/2004 6:00	0.37	5.38	142.44
26/8/2004 9:00	0.34	5.43	142.72
26/8/2004 12:00	0.33	5.47	135.76
26/8/2004 15:00	0.31	5.48	135.53
26/8/2004 18:00	0.3	5.48	135.22
26/8/2004 21:00	0.3	5.48	134.93
27/8/2004 0:00	0.32	5.45	140.93
27/8/2004 3:00	0.39	5.29	141.07
27/8/2004 6:00	0.64	2.75	186.53
27/8/2004 9:00	0.52	3.26	180.29
27/8/2004 12:00	0.49	3.39	166.11
27/8/2004 15:00	0.47	5.02	139.01

27/8/2004 18:00	0.45	5.14	138.44
27/8/2004 21:00	0.44	5.27	137.84
28/8/2004 0:00	0.45	5.36	137.23
28/8/2004 3:00	0.45	5.48	132.38
28/8/2004 6:00	0.45	5.53	132.52
28/8/2004 9:00	0.44	5.57	132.76
28/8/2004 12:00	0.43	5.58	133.02
28/8/2004 15:00	0.42	5.58	133.21
28/8/2004 18:00	0.41	5.58	133.41
28/8/2004 21:00	0.4	5.59	133.56
29/8/2004 0:00	0.4	5.58	133.8
29/8/2004 3:00	0.43	5.57	134.17
29/8/2004 6:00	0.41	5.56	134.51
29/8/2004 9:00	0.39	5.57	134.59
29/8/2004 12:00	0.41	5.61	134.55
29/8/2004 15:00	0.44	5.6	134.5
29/8/2004 18:00	0.45	5.54	134.15
29/8/2004 21:00	0.46	5.5	133.79
30/8/2004 0:00	0.48	5.5	133.77
30/8/2004 3:00	0.5	5.57	133.99
30/8/2004 6:00	0.49	5.6	134.19
30/8/2004 9:00	0.47	5.62	134.24
30/8/2004 12:00	0.49	5.64	134.29
30/8/2004 15:00	0.53	5.66	134.36
30/8/2004 18:00	0.5	5.64	134.39
30/8/2004 21:00	0.47	5.57	134.31
31/8/2004 0:00	0.45	5.5	134.24
31/8/2004 3:00	0.43	5.32	135.15
31/8/2004 6:00	0.4	5.21	135.43
31/8/2004 9:00	0.36	5.15	135.52
31/8/2004 12:00	0.35	5.13	135.48
31/8/2004 15:00	0.34	5.11	135.41
31/8/2004 18:00	0.34	4.97	135.02
31/8/2004 21:00	0.37	4.5	141.19
1/9/2004 0:00	0.41	4.52	135.66
1/9/2004 3:00	0.44	4.63	136.91
1/9/2004 6:00	0.45	4.77	137.93
1/9/2004 9:00	0.44	4.86	138.02
1/9/2004 12:00	0.46	4.95	138.03
1/9/2004 15:00	0.46	4.98	133.79
1/9/2004 18:00	0.45	5.05	134.23
1/9/2004 21:00	0.44	5.1	134.44
2/9/2004 0:00	0.43	5.13	134.42
2/9/2004 3:00	0.43	5.13	134.39
2/9/2004 6:00	0.42	5.1	134.21

2/9/2004 9:00	0.42	5.05	133.89
2/9/2004 12:00	0.47	5.02	133.94
2/9/2004 15:00	0.49	5.01	134.46
2/9/2004 18:00	0.48	5.07	135.11
2/9/2004 21:00	0.47	5.11	135.48
3/9/2004 0:00	0.47	5.15	135.79
3/9/2004 3:00	0.47	5.17	135.96
3/9/2004 6:00	0.44	5.18	136.11
3/9/2004 9:00	0.41	5.18	136.17
3/9/2004 12:00	0.39	5.17	136.28
3/9/2004 15:00	0.35	5.17	136.35
3/9/2004 18:00	0.33	5.16	136.34
3/9/2004 21:00	0.3	5.15	136.29
4/9/2004 0:00	0.28	5.15	136.47
4/9/2004 3:00	0.27	5.16	136.86
4/9/2004 6:00	0.25	5.17	137.49
4/9/2004 9:00	0.24	5.18	138.23
4/9/2004 12:00	0.22	5.18	138.71
4/9/2004 15:00	0.21	5.17	138.98
4/9/2004 18:00	0.2	5.16	139.12
4/9/2004 21:00	0.19	5.15	139.14
5/9/2004 0:00	0.17	5.13	139.07
5/9/2004 3:00	0.16	5.11	138.91
5/9/2004 6:00	0.16	5.09	138.65
5/9/2004 9:00	0.19	5.05	138.28
5/9/2004 12:00	0.26	3.32	153.41
5/9/2004 15:00	0.38	3.2	152.67
5/9/2004 18:00	0.38	3.93	145.65
5/9/2004 21:00	0.34	4.1	144.2
6/9/2004 0:00	0.31	4.18	137.85
6/9/2004 3:00	0.28	4.22	136.74
6/9/2004 6:00	0.25	4.22	135.54
6/9/2004 9:00	0.24	4.21	134.32
6/9/2004 12:00	0.27	4.21	133.48
6/9/2004 15:00	0.33	4.16	133.13
6/9/2004 18:00	0.3	4.11	133.21
6/9/2004 21:00	0.25	4.12	133.2
7/9/2004 0:00	0.21	4.14	133.44
7/9/2004 3:00	0.19	4.15	133.82
7/9/2004 6:00	0.17	4.16	134.52
7/9/2004 9:00	0.17	4.17	135.25
7/9/2004 12:00	0.17	4.17	136.16
7/9/2004 15:00	0.17	4.17	137.08
7/9/2004 18:00	0.16	4.18	138.05
7/9/2004 21:00	0.15	4.19	138.97

8/9/2004 0:00	0.14	4.21	140.04
8/9/2004 3:00	0.14	4.24	140.98
8/9/2004 6:00	0.13	4.27	141.85
8/9/2004 9:00	0.19	4.29	142.54
8/9/2004 18:00	0.7	3.34	139.78
8/9/2004 21:00	0.54	3.61	138.37
9/9/2004 0:00	0.42	3.68	137.95
9/9/2004 3:00	0.34	4.12	131.97
9/9/2004 6:00	0.28	4.11	129.44
9/9/2004 9:00	0.26	4.09	130.08
9/9/2004 12:00	0.25	4.12	129.82
9/9/2004 15:00	0.24	4.16	131.93
9/9/2004 18:00	0.22	4.22	134.62
9/9/2004 21:00	0.21	4.29	136.98
10/9/2004 0:00	0.2	4.37	139.04
10/9/2004 3:00	0.19	4.46	140.52
10/9/2004 6:00	0.19	4.56	143.94
10/9/2004 9:00	0.2	4.62	144.16
10/9/2004 12:00	0.2	4.65	144.31
10/9/2004 15:00	0.18	4.67	144.39
10/9/2004 18:00	0.17	4.68	144.43
10/9/2004 21:00	0.16	4.67	144.47
11/9/2004 0:00	0.15	4.64	144.58
11/9/2004 3:00	0.14	4.6	144.68
11/9/2004 6:00	0.13	4.55	144.71
11/9/2004 9:00	0.12	4.49	144.47
11/9/2004 12:00	0.12	4.46	144.45
11/9/2004 15:00	0.11	4.43	144.43
11/9/2004 18:00	0.1	4.41	144.39
11/9/2004 21:00	0.1	4.39	144.31
12/9/2004 0:00	0.1	4.37	144.2
12/9/2004 3:00	0.09	4.34	144.03
12/9/2004 6:00	0.11	4.32	143.55
12/9/2004 9:00	0.13	4.29	141.8
12/9/2004 15:00	0.23	3.25	138.05
12/9/2004 18:00	0.22	3.5	137.3
12/9/2004 21:00	0.21	3.63	140.32
13/9/2004 0:00	0.21	3.69	143.2
13/9/2004 3:00	0.19	4.05	138.81
13/9/2004 6:00	0.19	4.14	135.48
13/9/2004 9:00	0.25	4.14	137.57
13/9/2004 12:00	0.43	4.11	142.22
13/9/2004 15:00	0.47	3.17	149.48
13/9/2004 18:00	0.44	4.57	142.44
13/9/2004 21:00	0.43	4.91	142

14/9/2004 0:00	0.43	5.14	141.21
14/9/2004 3:00	0.41	5.25	141.11
14/9/2004 6:00	0.39	5.32	140.83
14/9/2004 9:00	0.37	5.41	140.54
14/9/2004 12:00	0.36	5.53	140.75
14/9/2004 15:00	0.33	5.6	140.78
14/9/2004 18:00	0.32	5.65	140.82
14/9/2004 21:00	0.3	5.69	140.8
15/9/2004 0:00	0.29	5.71	140.75
15/9/2004 3:00	0.28	5.72	140.57
15/9/2004 6:00	0.27	5.72	139.68
15/9/2004 9:00	0.26	5.71	137.64
15/9/2004 12:00	0.28	5.71	133.89
15/9/2004 15:00	0.29	5.71	125.48
15/9/2004 18:00	0.29	5.71	103.24
15/9/2004 21:00	0.29	5.71	49.06
16/9/2004 0:00	0.28	5.7	14.35
16/9/2004 3:00	0.28	5.69	359.34
16/9/2004 6:00	0.26	5.67	352.71
16/9/2004 9:00	0.27	5.64	348.84
16/9/2004 12:00	0.36	5.6	346.74
16/9/2004 15:00	0.72	3.17	173.58
16/9/2004 18:00	0.57	3.59	167.37
16/9/2004 21:00	0.48	4.12	155.37
17/9/2004 0:00	0.41	4.17	153.89
17/9/2004 3:00	0.35	4.23	152.05
17/9/2004 6:00	0.3	4.3	150.6
17/9/2004 9:00	0.27	4.39	148.24
17/9/2004 12:00	0.24	5.15	340.37
17/9/2004 15:00	0.22	5.29	339.53
17/9/2004 18:00	0.2	5.31	338.96
17/9/2004 21:00	0.18	5.3	338.47
18/9/2004 0:00	0.17	5.27	338.38
18/9/2004 3:00	0.16	5.2	338.5
18/9/2004 6:00	0.15	5.13	339.26
18/9/2004 9:00	0.14	5.06	340.57
18/9/2004 12:00	0.14	4.98	343.91
18/9/2004 15:00	0.13	4.85	16.26
18/9/2004 18:00	0.12	4.75	87.94
18/9/2004 21:00	0.12	4.66	116.88
19/9/2004 0:00	0.11	4.58	127.53
19/9/2004 3:00	0.1	4.49	135.96
19/9/2004 6:00	0.09	4.43	137.27
19/9/2004 9:00	0.08	4.39	138.37
19/9/2004 12:00	0.1	4.34	139.46

19/9/2004 15:00	0.1	4.3	140.4
19/9/2004 18:00	0.08	4.26	141.26
19/9/2004 21:00	0.07	4.22	142
20/9/2004 0:00	0.06	4.18	142.79
20/9/2004 3:00	0.06	4.13	143.55
20/9/2004 6:00	0.06	4.09	148.04
20/9/2004 9:00	0.06	4.08	148.79
20/9/2004 12:00	0.07	7.51	48.72
20/9/2004 15:00	0.08	7.41	48.89
20/9/2004 18:00	0.08	7.3	49.05
20/9/2004 21:00	0.09	7.15	49.96
21/9/2004 0:00	0.1	7.04	50.36
21/9/2004 3:00	0.11	6.94	50.71
21/9/2004 6:00	0.12	6.84	51.1
21/9/2004 9:00	0.12	6.7	51.45
21/9/2004 12:00	0.13	6.39	58.66
21/9/2004 15:00	0.13	6	70.65
21/9/2004 18:00	0.13	5.84	69.33
21/9/2004 21:00	0.13	5.78	67.88
22/9/2004 0:00	0.13	5.72	67.46
22/9/2004 3:00	0.13	5.68	66.9
22/9/2004 6:00	0.13	5.64	66.41
22/9/2004 9:00	0.13	5.62	66.11
22/9/2004 12:00	0.13	5.58	66.07
22/9/2004 15:00	0.13	5.53	65.95
22/9/2004 18:00	0.14	4.36	72.34
22/9/2004 21:00	0.15	4.33	61.6
23/9/2004 0:00	0.16	4.32	56.57
23/9/2004 3:00	0.18	4.32	53.84
23/9/2004 6:00	0.19	4.33	52.44
23/9/2004 9:00	0.2	4.35	51.47
23/9/2004 12:00	0.21	4.39	50.76
23/9/2004 15:00	0.22	4.44	50.08
23/9/2004 18:00	0.24	4.5	49.61
23/9/2004 21:00	0.25	4.63	44.62
24/9/2004 0:00	0.26	4.74	44.57
24/9/2004 3:00	0.27	4.83	44.63
24/9/2004 6:00	0.29	4.94	44.93
24/9/2004 9:00	0.3	5.07	42.36
24/9/2004 12:00	0.31	5.16	43
24/9/2004 15:00	0.32	5.2	43.63
24/9/2004 18:00	0.32	5.22	44.4
24/9/2004 21:00	0.32	5.23	45.07
25/9/2004 0:00	0.32	5.22	45.79
25/9/2004 3:00	0.31	5.21	46.42

25/9/2004 6:00	0.3	5.2	47.18
25/9/2004 9:00	0.29	5.18	47.77
25/9/2004 12:00	0.29	5.15	48.46
25/9/2004 15:00	0.28	5.13	48.84
25/9/2004 18:00	0.28	5.1	49.21
25/9/2004 21:00	0.28	5.07	49.43
26/9/2004 0:00	0.27	5.04	49.44
26/9/2004 3:00	0.26	5.01	49.17
26/9/2004 6:00	0.26	4.97	48.76
26/9/2004 9:00	0.27	4.94	52.72
26/9/2004 12:00	0.26	4.92	52.36
26/9/2004 15:00	0.26	4.93	51.43
26/9/2004 18:00	0.25	4.94	50.59
26/9/2004 21:00	0.25	4.96	49.77
27/9/2004 0:00	0.24	4.98	46.29
27/9/2004 3:00	0.23	4.99	46.09
27/9/2004 6:00	0.23	4.98	46.15
27/9/2004 9:00	0.22	4.98	46.23
27/9/2004 12:00	0.22	4.95	49.62
27/9/2004 15:00	0.21	4.92	50.09
27/9/2004 18:00	0.2	4.89	50.85
27/9/2004 21:00	0.19	4.85	51.52
28/9/2004 0:00	0.19	4.82	52.49
28/9/2004 3:00	0.18	4.79	53.31
28/9/2004 6:00	0.18	4.76	54.78
28/9/2004 9:00	0.21	4.61	56.08
28/9/2004 12:00	0.22	4.39	108.06
28/9/2004 15:00	0.23	4.35	111.16
28/9/2004 18:00	0.22	4.35	108.95
28/9/2004 21:00	0.21	4.36	103.42
29/9/2004 0:00	0.21	4.38	95.98
29/9/2004 3:00	0.21	7.52	39.46
29/9/2004 6:00	0.21	7.43	39.55
29/9/2004 9:00	0.21	7.35	39.66
29/9/2004 12:00	0.23	7.26	38.28
29/9/2004 15:00	0.23	7.16	38.43
29/9/2004 18:00	0.23	7.08	38.54
29/9/2004 21:00	0.26	7.03	38.61
30/9/2004 0:00	0.26	6.99	38.69
30/9/2004 3:00	0.26	6.96	38.8
30/9/2004 6:00	0.25	6.94	38.92
30/9/2004 9:00	0.25	6.91	39.07
30/9/2004 12:00	0.27	6.89	39.23
30/9/2004 15:00	0.26	6.88	39.37
30/9/2004 18:00	0.24	6.85	39.49

30/9/2004 21:00	0.23	6.83	39.61
1/10/2004 0:00	0.22	6.78	39.74
1/10/2004 3:00	0.22	6.72	39.91
1/10/2004 6:00	0.22	6.63	40.09
1/10/2004 9:00	0.22	5.83	42.52
1/10/2004 12:00	0.22	5.77	42.17
1/10/2004 15:00	0.21	5.76	41.36
1/10/2004 18:00	0.21	5.74	39.79
1/10/2004 21:00	0.21	5.73	38.19
2/10/2004 0:00	0.21	5.73	37.38
2/10/2004 3:00	0.2	5.73	37.58
2/10/2004 6:00	0.19	5.73	38.54
2/10/2004 9:00	0.19	5.72	39
2/10/2004 12:00	0.18	5.68	39.07
2/10/2004 15:00	0.18	5.63	38.59
2/10/2004 18:00	0.19	5.56	37.99
2/10/2004 21:00	0.2	5.46	37.25
3/10/2004 0:00	0.22	5.11	23.36
3/10/2004 3:00	0.24	4.36	335.62
3/10/2004 6:00	0.25	4.34	333.24
3/10/2004 9:00	0.27	4.38	332.24
3/10/2004 12:00	0.28	4.44	332.67
3/10/2004 15:00	0.29	4.48	333.06
3/10/2004 18:00	0.29	4.48	331.63
3/10/2004 21:00	0.3	4.53	337.86
4/10/2004 0:00	0.31	4.61	336.01
4/10/2004 3:00	0.32	4.66	335.05
4/10/2004 6:00	0.3	4.68	334.9
4/10/2004 9:00	0.28	4.68	335.43
4/10/2004 12:00	0.27	4.66	336.23
4/10/2004 15:00	0.27	4.62	337.18
4/10/2004 18:00	0.26	4.56	338.68
4/10/2004 21:00	0.28	4.5	335.77
5/10/2004 0:00	0.28	4.47	336.86
5/10/2004 3:00	0.28	7.09	41.8
5/10/2004 6:00	0.29	7.13	41.86
5/10/2004 9:00	0.31	7.2	41.93
5/10/2004 12:00	0.33	7.35	42.37
5/10/2004 15:00	0.35	7.68	42.12
5/10/2004 18:00	0.37	8.38	41.49
5/10/2004 21:00	0.4	8.79	41.87
6/10/2004 0:00	0.41	8.94	44.5
6/10/2004 3:00	0.43	9.02	44.85
6/10/2004 6:00	0.45	9.06	45.04
6/10/2004 9:00	0.46	9.08	45.3

6/10/2004 12:00	0.48	9.09	45.5
6/10/2004 15:00	0.5	9.09	45.82
6/10/2004 18:00	0.52	9.08	46.08
6/10/2004 21:00	0.53	9.05	46.43
7/10/2004 0:00	0.53	9.01	46.7
7/10/2004 3:00	0.54	8.95	47
7/10/2004 6:00	0.55	8.88	47.18
7/10/2004 9:00	0.55	8.8	47.4
7/10/2004 12:00	0.55	8.61	45.53
7/10/2004 15:00	0.55	8.49	45.74
7/10/2004 18:00	0.55	8.4	45.92
7/10/2004 21:00	0.54	8.34	46.09
8/10/2004 0:00	0.53	8.29	46.2
8/10/2004 3:00	0.52	8.25	46.33
8/10/2004 6:00	0.51	8.21	46.41
8/10/2004 9:00	0.5	8.18	46.52
8/10/2004 12:00	0.5	8.15	46.6
8/10/2004 15:00	0.5	8.13	46.73
8/10/2004 18:00	0.5	8.11	46.8
8/10/2004 21:00	0.5	8.1	46.88
9/10/2004 0:00	0.51	8.09	46.92
9/10/2004 3:00	0.52	8.08	47.02
9/10/2004 6:00	0.52	8.05	47.14
9/10/2004 9:00	0.52	8.02	47.3
9/10/2004 12:00	0.52	7.97	46.14
9/10/2004 15:00	0.52	7.92	46.28
9/10/2004 18:00	0.51	7.87	46.39
9/10/2004 21:00	0.5	7.84	46.48
10/10/2004 0:00	0.5	7.82	46.53
10/10/2004 3:00	0.49	7.8	46.58
10/10/2004 6:00	0.49	7.77	46.61
10/10/2004 9:00	0.48	7.73	46.66
10/10/2004 12:00	0.48	7.69	46.71
10/10/2004 15:00	0.47	7.65	46.74
10/10/2004 18:00	0.46	7.61	46.74
10/10/2004 21:00	0.45	7.57	46.75
11/10/2004 0:00	0.45	7.53	46.78
11/10/2004 3:00	0.44	7.49	46.8
11/10/2004 6:00	0.43	7.44	46.79
11/10/2004 9:00	0.41	7.38	46.8
11/10/2004 12:00	0.4	7.31	46.79
11/10/2004 15:00	0.39	7.21	45.69
11/10/2004 18:00	0.38	7.11	45.61
11/10/2004 21:00	0.37	7.04	45.55
12/10/2004 0:00	0.36	6.99	45.51

12/10/2004 3:00	0.35	6.94	45.47
12/10/2004 6:00	0.34	6.9	45.48
12/10/2004 9:00	0.34	6.86	45.47
12/10/2004 12:00	0.33	6.82	45.46
12/10/2004 15:00	0.32	6.77	45.45
12/10/2004 18:00	0.31	6.7	45.41
12/10/2004 21:00	0.31	6.61	45.31
13/10/2004 0:00	0.3	6.49	44.61
13/10/2004 3:00	0.31	6.41	44.43
13/10/2004 6:00	0.33	6.35	44.24
13/10/2004 9:00	0.35	6.28	44.09
13/10/2004 12:00	0.4	6.22	43.94
13/10/2004 15:00	0.45	6.22	43.79
13/10/2004 18:00	0.51	6.32	43.73
13/10/2004 21:00	0.56	6.44	43.66
14/10/2004 0:00	0.61	6.58	43.69
14/10/2004 3:00	0.66	6.68	44.67
14/10/2004 6:00	0.7	6.76	44.49
14/10/2004 9:00	0.72	6.8	44.38
14/10/2004 12:00	0.75	6.83	44.23
14/10/2004 15:00	0.75	6.85	44.16
14/10/2004 18:00	0.74	6.86	44.25
14/10/2004 21:00	0.72	6.86	44.36
15/10/2004 0:00	0.7	6.86	44.47
15/10/2004 3:00	0.68	6.85	44.6
15/10/2004 6:00	0.65	6.83	44.76
15/10/2004 9:00	0.63	6.82	44.93
15/10/2004 12:00	0.62	6.79	45.12
15/10/2004 15:00	0.61	6.77	45.37
15/10/2004 18:00	0.6	6.75	45.66
15/10/2004 21:00	0.59	6.73	45.97
16/10/2004 0:00	0.59	6.71	46.24
16/10/2004 3:00	0.59	6.71	46.45
16/10/2004 6:00	0.59	6.71	46.59
16/10/2004 9:00	0.6	6.71	46.63
16/10/2004 12:00	0.6	6.71	46.61
16/10/2004 15:00	0.61	6.71	46.61
16/10/2004 18:00	0.61	6.71	46.59
16/10/2004 21:00	0.61	6.72	46.51
17/10/2004 0:00	0.62	6.73	46.4
17/10/2004 3:00	0.64	6.77	46.27
17/10/2004 6:00	0.66	6.85	46.15
17/10/2004 9:00	0.68	7.01	46.07
17/10/2004 12:00	0.7	8.14	47.45
17/10/2004 15:00	0.72	8.33	47.55

17/10/2004 18:00	0.72	8.5	47.71
17/10/2004 21:00	0.73	8.65	47.93
18/10/2004 0:00	0.72	8.75	48.13
18/10/2004 3:00	0.71	8.78	48.32
18/10/2004 6:00	0.7	8.75	48.45
18/10/2004 9:00	0.7	8.71	48.55
18/10/2004 12:00	0.69	8.66	48.62
18/10/2004 15:00	0.69	8.61	48.68
18/10/2004 18:00	0.69	8.55	48.7
18/10/2004 21:00	0.69	8.49	48.75
19/10/2004 0:00	0.69	8.41	48.81
19/10/2004 3:00	0.69	8.35	48.9
19/10/2004 6:00	0.7	8.28	48.99
19/10/2004 9:00	0.7	8.22	49.09
19/10/2004 12:00	0.7	8.15	49.12
19/10/2004 15:00	0.7	8.08	49.17
19/10/2004 18:00	0.69	8.01	49.16
19/10/2004 21:00	0.68	7.87	48.13
20/10/2004 0:00	0.67	7.78	48.11
20/10/2004 3:00	0.67	7.72	48.07
20/10/2004 6:00	0.66	7.68	48.01
20/10/2004 9:00	0.65	7.64	47.92
20/10/2004 12:00	0.65	7.62	47.78
20/10/2004 15:00	0.64	7.59	47.64
20/10/2004 18:00	0.65	7.58	47.46
20/10/2004 21:00	0.66	7.56	47.26
21/10/2004 0:00	0.66	7.55	47.04
21/10/2004 3:00	0.67	7.55	46.84
21/10/2004 6:00	0.68	7.54	46.63
21/10/2004 9:00	0.7	7.53	46.43
21/10/2004 12:00	0.73	4.63	48.07
21/10/2004 15:00	0.77	4.8	47.8
21/10/2004 18:00	0.79	4.99	43.39
21/10/2004 21:00	0.82	5.23	43.38
22/10/2004 0:00	0.84	5.43	43.36
22/10/2004 3:00	0.85	5.63	40.38
22/10/2004 6:00	0.87	5.79	40.6
22/10/2004 9:00	0.89	5.91	40.79
22/10/2004 12:00	0.92	6.02	38.85
22/10/2004 15:00	0.94	6.1	39.1
22/10/2004 18:00	0.96	6.12	39.35
22/10/2004 21:00	0.99	6.16	39.64
23/10/2004 0:00	1.02	6.22	40.07
23/10/2004 3:00	1.05	6.29	40.53
23/10/2004 6:00	1.08	6.35	41.1

23/10/2004 9:00	1.08	6.41	41.59
23/10/2004 12:00	1.07	6.45	42.08
23/10/2004 15:00	1.05	6.48	42.56
23/10/2004 18:00	1.03	6.5	43.04
23/10/2004 21:00	1.01	6.5	43.54
24/10/2004 0:00	0.98	6.48	43.98
24/10/2004 3:00	0.96	6.44	44.34
24/10/2004 6:00	0.94	6.39	44.59
24/10/2004 9:00	0.92	6.35	44.71
24/10/2004 12:00	0.91	6.3	44.67
24/10/2004 15:00	0.9	6.25	44.46
24/10/2004 18:00	0.9	6.22	44.08
24/10/2004 21:00	0.9	6.21	43.52
25/10/2004 0:00	0.95	6.23	42.95
25/10/2004 3:00	1.03	6.28	42.51
25/10/2004 6:00	1.12	6.32	42.59
25/10/2004 9:00	1.24	6.43	43.05
25/10/2004 12:00	1.37	6.75	41.98
25/10/2004 15:00	1.48	6.92	42.62
25/10/2004 18:00	1.55	7.05	43.29
25/10/2004 21:00	1.6	7.18	43.91
26/10/2004 0:00	1.63	7.34	43.03
26/10/2004 3:00	1.66	7.44	43.71
26/10/2004 6:00	1.71	7.51	44.38
26/10/2004 9:00	1.78	7.54	45.01
26/10/2004 12:00	1.88	7.55	45.62
26/10/2004 15:00	1.94	7.53	46.1
26/10/2004 18:00	1.97	7.54	46.43
26/10/2004 21:00	1.96	7.55	46.63
27/10/2004 0:00	1.93	7.56	46.74
27/10/2004 3:00	1.88	7.56	46.74
27/10/2004 6:00	1.82	7.56	46.65
27/10/2004 9:00	1.77	7.54	46.53
27/10/2004 12:00	1.74	7.53	46.41
27/10/2004 15:00	1.72	7.52	46.33
27/10/2004 18:00	1.71	7.51	46.32
27/10/2004 21:00	1.69	7.5	46.4
28/10/2004 0:00	1.67	7.48	46.6
28/10/2004 3:00	1.64	7.46	46.83
28/10/2004 6:00	1.6	7.41	47.04
28/10/2004 9:00	1.56	7.33	47.21
28/10/2004 12:00	1.54	7.21	48.7
28/10/2004 15:00	1.52	7.01	48.46
28/10/2004 18:00	1.51	6.91	47.97
28/10/2004 21:00	1.5	6.89	47.46

29/10/2004 0:00	1.47	6.91	47.05
29/10/2004 3:00	1.44	6.92	46.73
29/10/2004 6:00	1.41	6.93	46.59
29/10/2004 9:00	1.37	6.94	46.5
29/10/2004 12:00	1.34	6.94	46.43
29/10/2004 15:00	1.33	6.94	46.31
29/10/2004 18:00	1.33	6.95	46.06
29/10/2004 21:00	1.34	6.96	45.67
30/10/2004 0:00	1.35	6.99	45.29
30/10/2004 3:00	1.35	7.03	44.97
30/10/2004 6:00	1.36	7.07	44.7
30/10/2004 9:00	1.38	7.14	44.47
30/10/2004 12:00	1.39	7.27	43.64
30/10/2004 15:00	1.4	7.39	43.78
30/10/2004 18:00	1.39	7.48	43.98
30/10/2004 21:00	1.38	7.55	44.21
31/10/2004 0:00	1.37	7.59	44.48
31/10/2004 3:00	1.35	7.62	44.76
31/10/2004 6:00	1.32	7.63	44.98
31/10/2004 9:00	1.28	7.61	45.2
31/10/2004 12:00	1.24	7.58	45.47
31/10/2004 15:00	1.19	7.54	45.7
31/10/2004 18:00	1.14	7.5	45.92
31/10/2004 21:00	1.09	7.46	46.07