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CREST LEVEL ASSESSMENT OF
COASTAL STRUCTURES BY
FULL-SCALE MONITORING,
NEURAL NETWORK PREDICTION
AND HAZARD ANALYSIS
ON PERMISSIBLE WAVE OVERTOPPING

CLASH

EVK3-CT-2001-00058

R E P O R T

D33 : Report on full scale measurements Samphire Hoe

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Samphire Hoe Field Measurements

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Summary

CLASH Workpackage 3.3

Samphire Hoe Field Measurements

Report TR 133
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Under CLASH ("Crest level assessment of coastal structures by full scale monitoring, neural network prediction and hazard analysis on permissible wave overtopping"), HR Wallingford were committed to a programme of full scale measurements of wave overtopping at Samphire Hoe, Kent, England. This report describes the work carried out during the design of the overtopping equipment for the field measurements, the methodology, and reports on the first winter's field measurements.

This report is a revision of an earlier report TR 133 Rev 0.1, that specifically described the results from the first winter's field measurements.

Contents

1. Introduction

The processes of wave overtopping of seawalls are not yet understood fully, particularly those that may cause risks to people close behind seawalls. There remain important gaps in knowledge, despite significant improvements in recent years. To help reduce uncertainties in the prediction of coastal flooding, HR Wallingford (HRW) have been commissioned to develop improved prediction methods for use by coastal engineers. This research is supported by the EC under the CLASH project led by University of Gent (contract EVK3-2001-0058), and by Defra / EA under project No FD2412. CLASH is an extensive study by twelve partners at universities and research institutes across Europe, under the EC 5th Framework programme.

Under CLASH ("Crest level assessment of coastal structures by full scale monitoring, neural network prediction and hazard analysis on permissible wave overtopping"), HR Wallingford were committed to a programme of full scale measurements of wave overtopping at the seawall protecting the Samphire Hoe reclamation, Kent, England. This report describes the work carried out during the design of the overtopping equipment for the field measurements, the methodology, and reports on the first winter's field measurements.

1.1 BACKGROUND

The results of the CLASH project are intended to benefit citizens in low lying and populated coastal regions, who depend critically on the performance of coastal structures for defence against storm surges, wave attack, flooding and, erosion. Continuing sea level rise and climate change emphasis the need for reliable and robust predictions of overtopping hazards as higher storm surges and more severe storms may lead to flooding. The CLASH project will produce generally applicable prediction methods on the required crest height of most coastal structure types, based on permissible wave overtopping and hazard analysis.

A particular motivation for this research was the suggestion by earlier research in another EC project, OPTICREST, that there might be unexpected scale effects in some hydraulic modelling in which small-scale tests might under-predict overtopping at full scale. While these suggestions were not subsequently supported by large scale tests on vertical and battered seawalls by the VOWS team in the large flume at Barcelona, see Pearson et al (2002), it is clear that this uncertainty could have substantial impacts.

HRW has a long standing relationship with the management of the Samphire Hoe site, and has designed and implemented over six years overtopping hazard warning systems using tailored input data from the national meteorological centre, see Gouldby *et al.* (1999). These systems have used forecasts of wind speed and direction with predicted tide and surge levels, to predict potential occurrences of hazards from wave overtopping. This system does not use direct calculations of overtopping discharges, but has been steadily refined over 5 years of operation, using hourly observations of hazard from overtopping, categorised as low, medium or severe, recorded by on-site personnel who are responsible for the safety of the public.

1.2 REPORT OUTLINE

Following this introductory section, Chapter 2 discusses the Samphire Hoe site, and specifically refers to certain aspects of the project that affect the way overtopping is monitored there. In Chapter 3 the design and operation of the field measurement equipment is discussed, and the processing of the collected data is described in Chapter 4. Chapter 5 reports on the storms that were captured during the 2003 winter season and presents the data in raw format. Finally in Chapter 6 a very brief review of the measured data from the winter of 2003 compares the results to the prediction method of Besley (1999).

2. Overtopping Measurements at Samphire Hoe

2.1 INTRODUCTION

Samphire Hoe is located in the Southeast corner of England (Figure 1) immediately to the west of Dover and is an area of reclaimed land, comprising 4.9M m^3 of chalk marl excavated from the channel tunnel. The area of approximately 300,000m^2 is enclosed by a vertical Seawall with a crest level at +8.22mODN and a toe level at –2.42mODN (Figure 2). Samphire Hoe has been landscaped and is used by the public as a recreational area (Figure 3). The site is owned by Eurotunnel, and is run on their behalf by the White Cliffs Countryside Project (WCCP). Eurotunnel are represented by David Johnson, their Projects and Estates Manager, and WCCP are represented by Paul Holt who manages the site. Eurotunnel and WCCP agreed to allow HR Wallingford to conduct full scale measurements at Samphire Hoe, subject to conditions on access, risk assessment and liability.

Samphire Hoe is exposed to waves from the southwest and southeast. The seawall is subject to overtopping by spray (often termed white water overtopping) on approximately 30 days per year as a result of waves breaking over the rubble toe berm and impacting on the seawall face. Whole wave overtopping (usually termed "green water overtopping") is also observed regularly.

There were a range of issues that affected the way that the equipment could be deployed, and the measurements that could be made. Many of these have been described by Pullen & Allsop (2002) and Boone *et al.* (2002). Where these are relevant to the present discussion they will be mentioned again here, but for additional details refer to the earlier reports. A description of the equipment in terms of how it was described in the contractual Description of Work, and how this differed to the equipment that was passed by Eurotunnel and WCCP for deployment at Samphire Hoe is given in Appendix A.

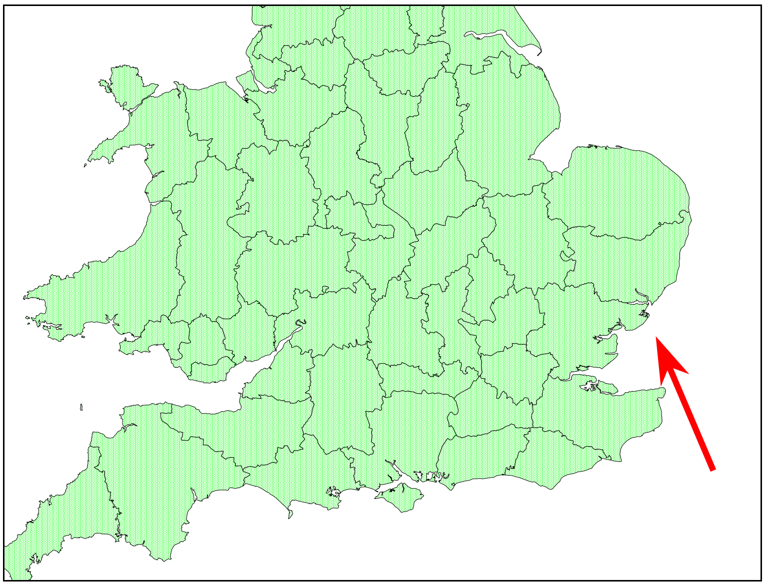

Figure 1: Location of Samphire Hoe in Southeast England

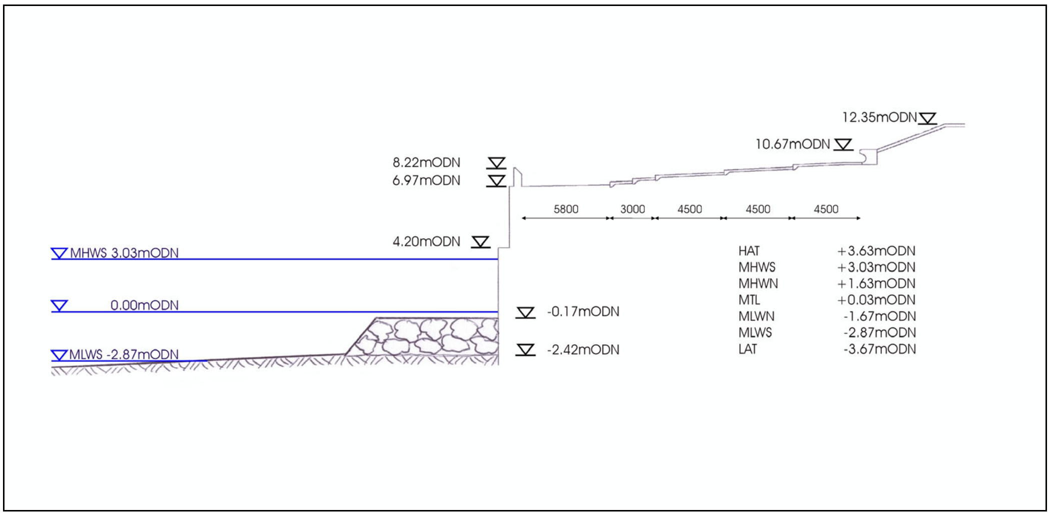

Figure 2: Section of the Samphire Hoe Seawall

Figure 3: Aerial view of Samphire Hoe with the study area in the foreground and Dover harbour in the background

2.2 STUDY AREA

The area adjacent to the corner of the western return wall and the western splay wall, at the southwest corner of the seawall as shown in Figure 4, was identified as the most suitable location for deploying the measuring equipment during discussions between HRW, Eurotunnel and the WCCP. The monitoring equipment was placed approximately 40m along the western splay wall from the adjacent corner. From this location it was possible to communicate with the data logging equipment (described below) and the support vehicle via a radio modem. The support vehicle was located near to the access road that runs along the base of the cliffs.

From the cross section though the seawall shown in Figure 2, it can be seen that there is a wide concrete promenade behind the parapet wall. The monitoring equipment was deployed across this promenade. The equipment was demountable and was cleared from the study area at the conclusion of each visit. Flush fitting mounting points for the main overtopping tanks were established on the seawall during a visit to the site in September 2002, which has allowed the equipment to be attached securely during each visit.

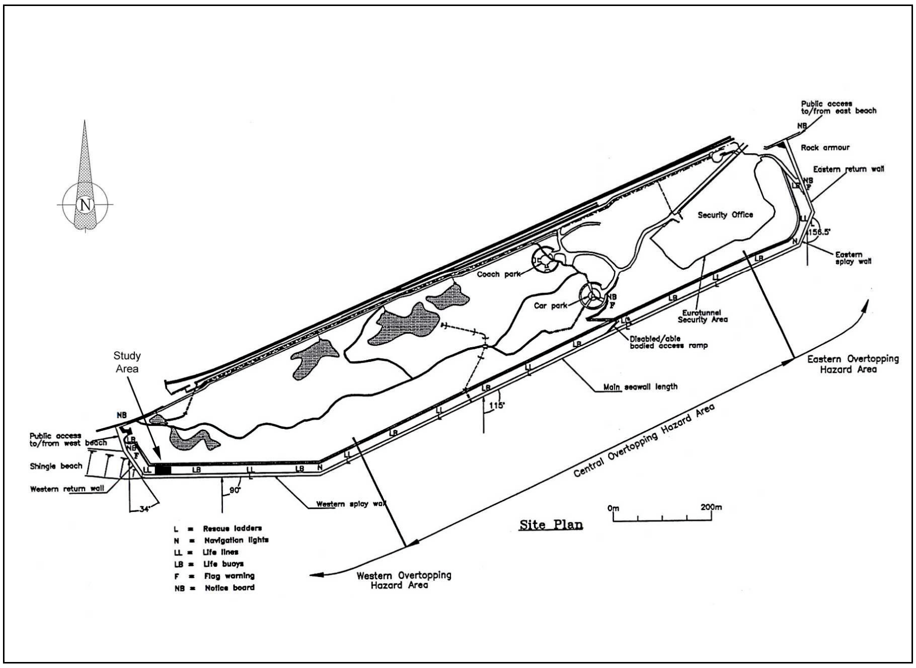

Figure 4: Plan of Samphire Hoe showing the location of the study area

2.3 HEALTH & SAFETY

Two specific issues required attention under the general heading of Health and Safety. Firstly, the general public have access to the seawall during times when overtopping hazards are not expected, and were free to access the study area whilst the monitoring equipment was being installed. Secondly, there may be some risk to the scientists themselves during the installation, operation and removal phases. The methods of installation and the operation of all the tasks during periods of field measurement were carefully described to prevent danger to the public and to the HR Wallingford scientists. A method statement describing procedures for all the major phases of each field trip is included in Appendix B, and the Health and Safety Risk Assessment is included in Appendix C.

2.4 FIELD MEASUREMENT GENERAL PROCEDURES

Each visit to Samphire Hoe to collect data was based on a standard timetable, which itself was based on the assumption that there would be 24~48hrs warning that suitable storm conditions would cause wave overtopping to occur. The timetable was also based on the fact that a first indication that a suitable storm was be likely to occur would allow approximately 48 hours notice. The following timetable outlines the general sequence of events that took place for the field measurement trips.

Day 1
Step 1: Assess probability of overtopping for Day 3 from weather forecasts, tide levels, predicted wave condition and wave direction, and predicted surge levels.
Step 2: Consult HRW and WCCP, with latest data from HRW hazard warning system, determine whether go / no go.
Step 3: Final preparations for early departure on Day 2.

Day 2
Step 1: Forecasts and latest overtopping predictions checked, load support vehicle. Eurotunnel and WCCP advised of our arrival time.
Step 2: The equipment and operatives were transferred to Samphire Hoe.
Step 3: At Samphire Hoe, equipment installed during a safe period.

Day 3
Step 1: Forecast and overtopping predictions checked with staff in Wallingford, final preparations.
Step 2: Conduct field measurements.
Step 3a: Secure site for field measurements on Day 4.
or Step 3b: Secure site for dismantling on Day 4.
or Step 3c: Dismantle equipment and return to Wallingford.

The timetable described above was broken down into individual operations which are now described in more detail. Some of these procedures are also covered in the General Methodology and Health & Safety Risk Assessment in Appendices B & C, respectively.

The assessment of the occurrence of overtopping began with a close examination of the weather forecast during the preceding week, and the likely occurrence of measurable overtopping. With increased numbers of the public at Samphire Hoe during the weekend, it was originally agreed that field measurements would generally avoid these periods. Following the two successful field trips conducted during the winter of 2003, both Eurotunnel and the WCCP agreed to allow field trips to take place during weekends if the conditions are favourable for overtopping.

Decisions to deploy were based on the weather forecast, predicted tide and surge levels, the time of the high tide(s), the wave overtopping hazard warning system developed by HRW and consultation with the WCCP. Guidelines on hazards being developed as part of Workpackage 6 were used to compare predictions of overtopping discharges and the hazards.

Identification of a suitable period during the day was required to install the equipment safely. Based on departure and journey times to Samphire Hoe, this would usually be when no overtopping was predicted, or when and if the sea level was below the level of the top of the berm for a considerable time during low tide; a condition that would not necessarily be possible during neap tides. Once at Samphire Hoe the deployment of the field measurement equipment would depend on a final assessment of the potential for overtopping hazards and the safety of the HRW scientists. Following that, and during the predetermined safe period, the van was taken to the field measurement site for the deployment of the equipment.

The deployed equipment included:

- Three overtopping tanks bolted to the promenade
- Portable logging equipment and control box
- Video and still cameras and stand
- Additional batteries and data logging equipment as back-up

Once installed the operation of the equipment was checked. During wave overtopping the scientists observed the measurements from the relative safety of the corner of the seawall adjacent to the measurement site, erected the video camera on a tripod, took photographs and wind readings and monitored the condition of the equipment. Direct note taking was complicated by the inclement conditions that were generally encountered.

During the winter and spring of 2003 the overtopping equipment was deployed at Samphire Hoe on two occasions. In general there were very few storms during this season that caused overtopping at Samphire Hoe. The first visit was during March where one storm was monitored on the 10^{th}, and the second visit was during May when storms were monitored on the 1^{st} & 2^{nd}. A range of conditions were encountered during these visits, and overtopping varied from light spray to high discharges from waves impacting violently on the seawall. These storms are covered in detail in Chapter 4.

3. Field Monitoring Equipment

The main pieces of field monitoring equipment will be described in this chapter. In particular, discussion will focus on the detailed design and calibration of certain aspects of the equipment, and as such will serve as a permanent record. One of the principal briefs for the design was that the equipment must be handled easily, constructed quickly and efficiently and, must occupy a minimum space during transport to and from the site. A description of the equipment in terms of how it was described in the contractual Description of Work, and how this differed to the equipment that was passed by Eurotunnel and WCCP for deployment at Samphire Hoe is given in Appendix A.

3.1 DESIGN OF THE OVERTOPPING COLLECTION TANKS

Overtopping water was captured in volumetric tanks placed across the promenade of the seawall. Three tanks were placed progressively farther back from the seawall parapet to identify the spatial effects of overtopping, as shown in Figure 5. By assessing the volumes captured in each tank, it was possible to estimate the volumes of overtopping water that landed between the tanks. Whilst it would have been desirable to have increased the number of tanks, there were practical limitations of the number that could be transported and installed on each occasion, and allowance had to be made for wheelchair and emergency vehicle access through the site.

One of the most important aspects of the design of the overtopping tanks was the rate at which overtopping water would discharge out of the tank. Two principal criteria were required:

- Overtopping tanks should never overfill, allowing all the overtopping water to be captured
- Discharge holes should not be so large that an accurate determination of the instantaneous water level could not be recorded

In order to design these criteria it was necessary to estimate the overtopping discharge and distribution of the overtopping in advance. Once the anticipated discharge and distribution had been established it was possible to determine the size and the number of discharge holes in each tank and then calibrate the tanks. Each of the different aspects of the tank design will be covered in the following sections.

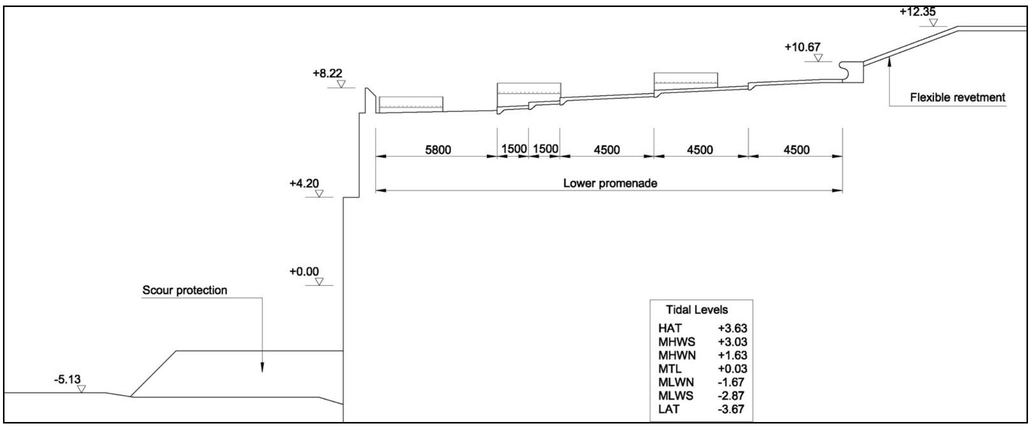

Figure 5: Generic section through the seawall showing the position of the overtopping tanks

3.1.1 Tank Capacity

The method used for determining the volumes of water entering the tanks were based on instantaneous measurements of water depth before and after each overtopping event. It was only necessary for the tank to be able to hold a limited amount of overtopping water for a short period to determine the water level accurately. Thereafter, the water drained from the tank through discharge holes that are described in detail below. The outside dimension and the internal shape of the tanks were determined from practical considerations. The overall size and weight were determined from a consideration of the available transport, a minimum clear width on the bottom level of the promenade to allow access to emergency vehicles, and minimising the weight to ensure safe and comfortable handling. The general dimensions and configuration of the tanks is shown in Figure 6. The tanks are open at the top to allow the overtopping discharges to be captured, and are divided into two compartments to increase the spatial resolution. The bottom section of each compartment is V shaped (90º), which allowed smaller overtopping volumes to be recorded more accurately when the tanks were empty.

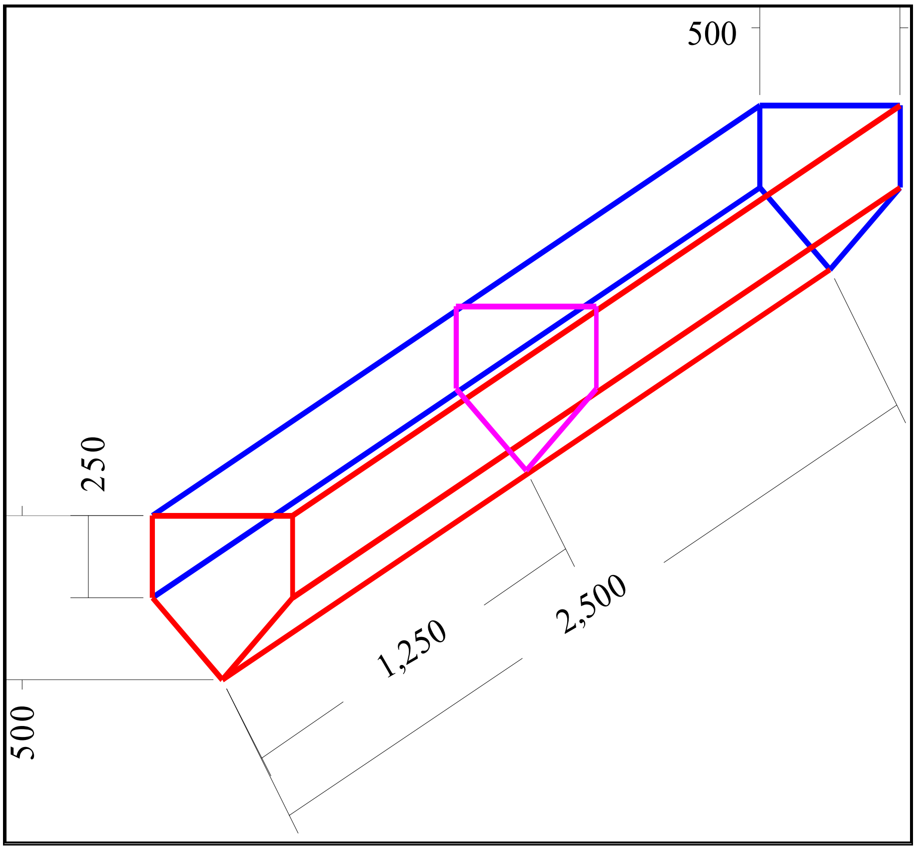

Figure 6: Dimensions and configuration of the overtopping tanks

3.1.2 Design Wave

The hazard warning system mentioned in Section 1.1 provided details of storms where overtopping had taken place, giving wave height, period and direction. Scatter plots of data collected at Samphire Hoe for wave heights and periods are shown in Figure 7 & Figure 8. These are for different storm events over the tidal range covering two winters from October 2000 to March 2002, and help to determine a design sea condition for the onset of wave overtopping. The data were fitted to an approximate normal distribution and the values with the highest probability of occurrence were used to establish a design wave condition, as shown in Figure 9 & Figure 10.

Overtopping discharge vary considerably with the water level in front of the structure, both the type of overtopping (pulsating or impacting) and the rate of discharge. Besley's (1999) method for a composite vertical wall was used to calculate maximum overtopping discharges and peak volumes for a range of water levels. These levels ranged from just above the level of the berm to High Atmospheric Tide (HAT, see Figure 5), and the most severe condition was used for the design of the tank discharge holes. With a design overtopping discharge rate and associated peak volume the next stage was to determine how this might be distributed across the promenade.

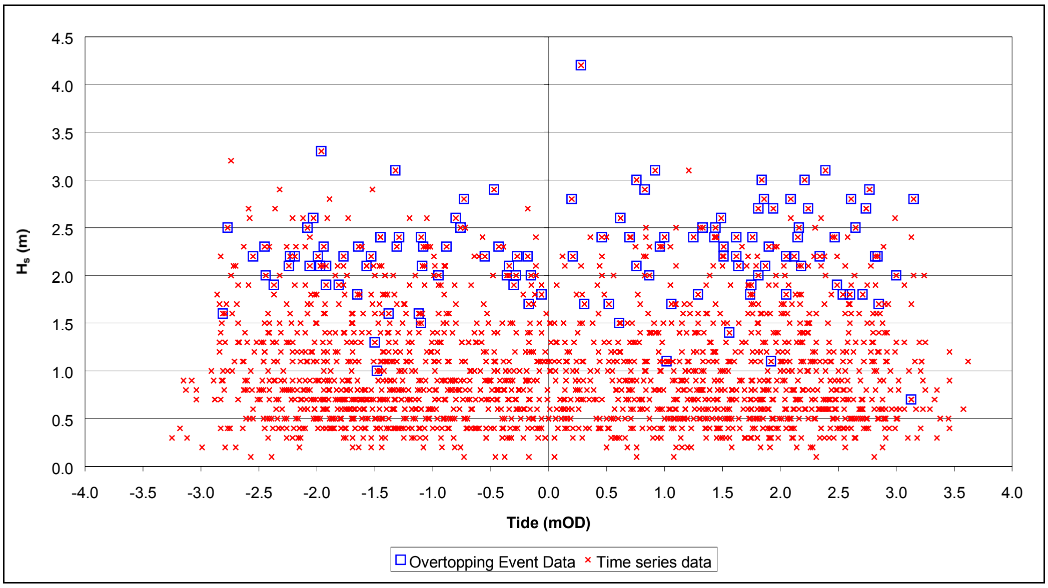

Figure 7: Recorded wave heights for overtopping events at Samphire Hoe

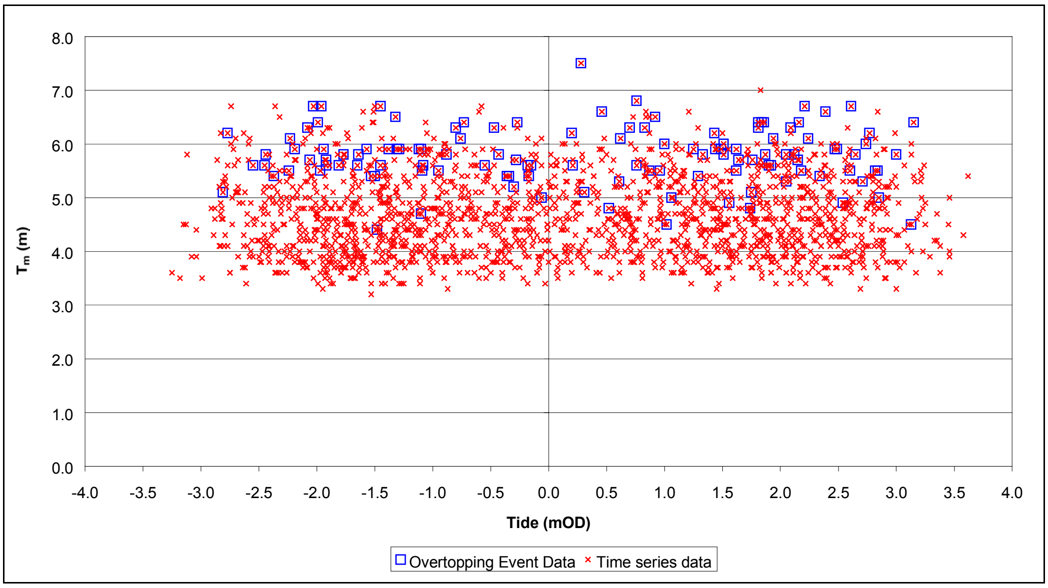

Figure 8: Recorded wave periods for overtopping events at Samphire Hoe

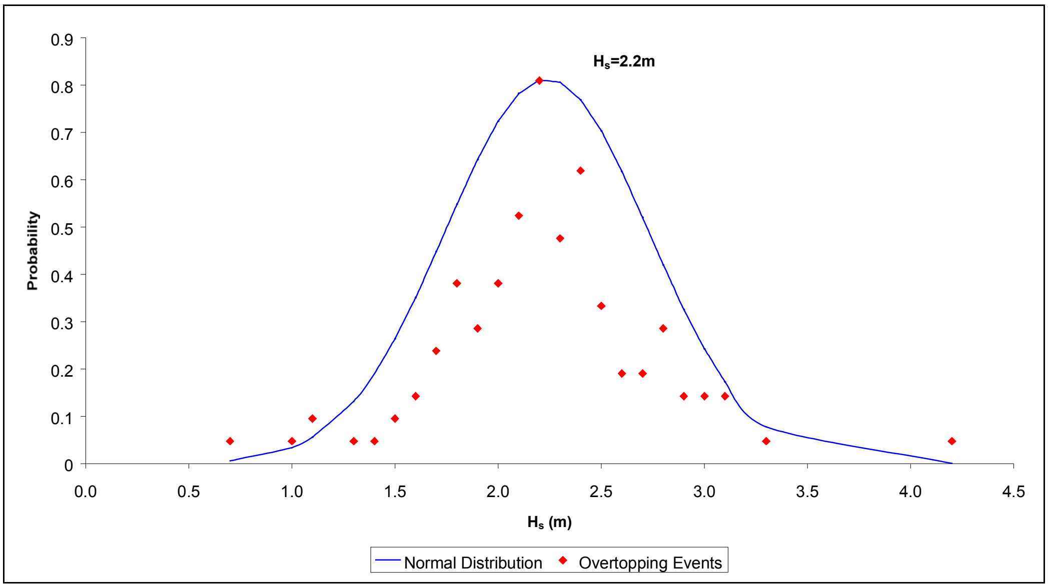

Figure 9: Normal distribution of wave heights for the design wave

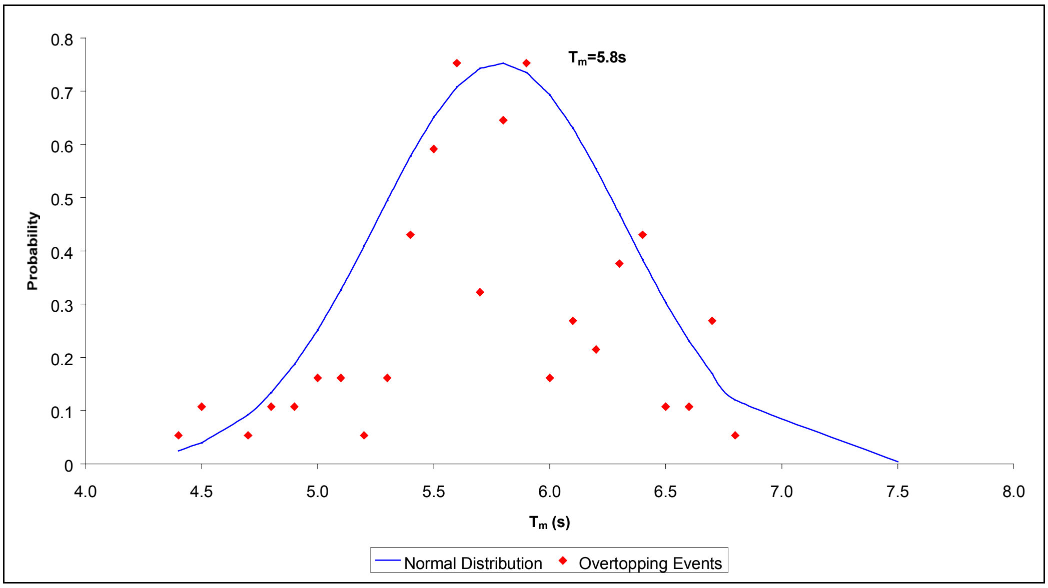

Figure 10: Normal distribution of wave periods for the design wave

3.1.3 Spatial Distribution of Overtopping

There is very little guidance currently available that describes how overtopping is distributed spatially, as most research has focussed on predicting mean overtopping rates for simple structures. Indeed the distribution of overtopping will depend on whether the wave is pulsating or impacting. Jensen & Sorensen (1979) presented some results for the distribution behind a rubble mound structure, and linear and exponential distributions had been anticipated from photographic and video images of waves overtopping vertical seawalls. To compare the possible distributions the maximum discharge rate was used for each of these possible methods, and the distributions back from the seawall crest are shown in Figure 11.

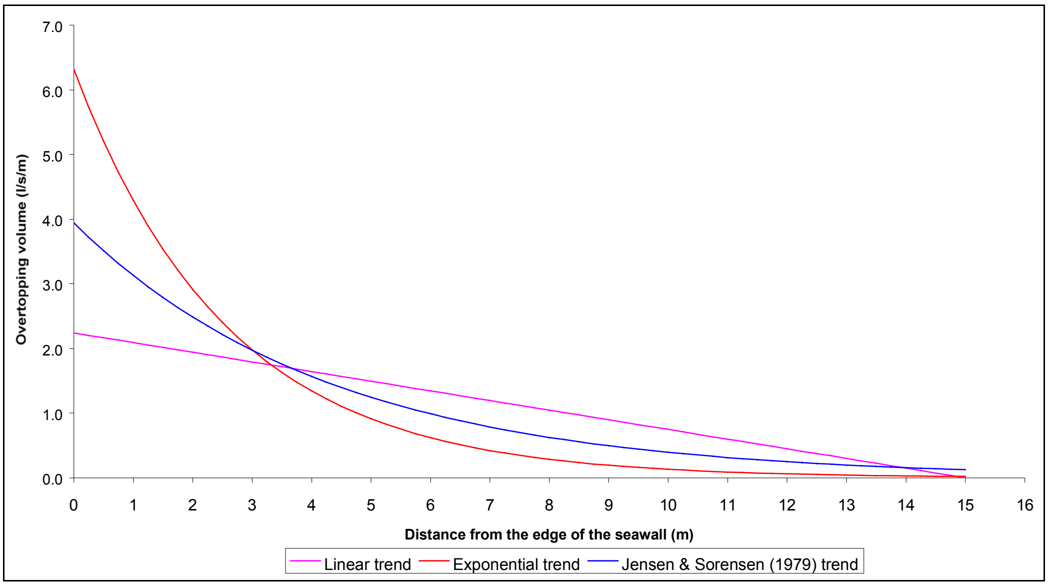

Figure 11: Different possible trends for the distribution of the overtopping

These assume that overtopping will reduce across the Samphire Hoe seawall promenade such that the total volume under each curve is the same. The case for the linear distribution is trivial. The exponential trend is described in Equation 1 and Jensen & Sorensen's method in Equation 2:

$$q(x) = q_0 e^{-x0.4} \tag{1}$$

$$q(x) = q_0 10^{-x0.1} \tag{2}$$

where q_0 is a normalised constant derived from the total volume and x is the distance along the promenade from the parapet wall at the front. In Equation 2 the coefficient *0.1* is that published by Jensen & Sorensen, and for the exponential curve the coefficient was adjusted to allow for a greater proportion of the discharge to fall in the area directly behind the parapet wall. It is clear, that from approximately 3.5m behind the parapet wall the general trend for the distribution, for practical purposes, is very similar.

3.1.4 Discharge from the Tanks

Assuming that overtopping discharges are distributed according to Jensen & Sorensen, then Figure 12 shows overtopping volumes in 0.25m sections across the promenade, where the red sections are those captured by the tanks and the blue those not captured. This distribution, in principal, provides a means of estimating the total volume of overtopping, but specifically gives volumes that may be used for the design of the discharge holes. A full description of the design of the discharge holes is given by Pullen & Melis (2003) and there is only the space here for a brief review.

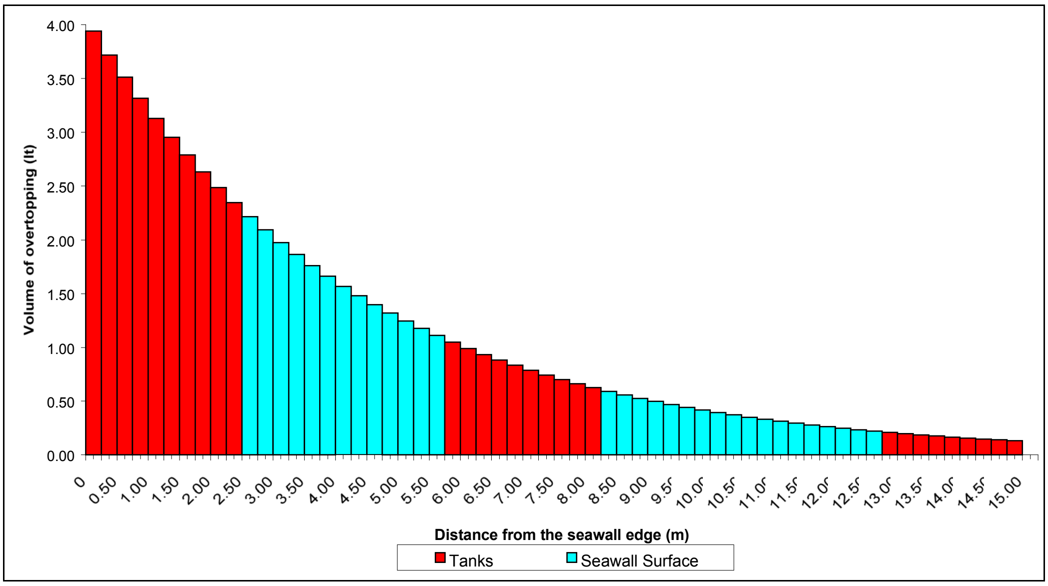

Figure 12: Jensen and Sorensen's distribution for overtopping across the promenade

From a simple application of Torricelli's theorem it is possible to relate the volume of water in the tanks and the size of the discharge orifice to the time taken (***T***) for the fluid to drain. This relationship, derived in full in Pullen & Melis (2003), is

$$T = \frac{2A}{C_d S\sqrt{2g}}\sqrt{Z} \qquad (3)$$

where ***A*** is the surface area of the fluid in the tank, ***Z*** is the head, ***S*** the surface area of the discharge orifice and $\boldsymbol{C_d}$ is the coefficient of discharge. $\boldsymbol{C_d}$ was determined experimentally for a discharge hole at an angle of 45° to the vertical punched into the same gauge steel as used for the tanks, and which is also described in Pullen & Melis (2003). The principal criterion that needed to be satisfied was that the rate of discharge out of the tank must exceed the specified mean overtopping discharge, and this was determined by assuming that the tank had previously been filled to levels given by a range of arbitrary times. That is, fill the tank for 20, 30, 40secs et cetera, and check that it would drain in less time.

A single hole diameter of 14.5mm (external hole punch diameter) was finally specified, and the number of holes was varied in each tank. Nine holes were placed in each section of the front tank, and this was based on the exponential distribution as shown in Figure 11. Four holes were place in the central tank and one in the rear tank at the top of the promenade, and this was determined by recognising that there was little variation in volume for the three general distributions shown in Figure 11. Given that each tank compartment had a maximum number of holes, it was then possible to close holes with rubber bungs according to the anticipated storm conditions. When low discharges were anticipated or encountered then all the holes were blocked on the central and rear tanks so that the individual wave-by-wave volumes could be determined more accurately.

3.1.5 Calibration of the Tanks

Each of the three tanks are divided into two compartments each with a nominal capacity of 240lt and a working capacity of approximately 205lt. At the bottom of each tank was placed a Druck PTX1830 pressure transducer with a range of 350mbar. Figure 13 shows a pressure transducer in place at the bottom of the second compartment in the forward tank directly behind the parapet wall. The discharge holes can also be seen, both with and without the rubber bungs. The output from the pressure transducers is measured in millivolts, and each of them was calibrated in the laboratory using a static water column. The calibration output from one of the pressure transducers is shown in Figure 14 and it can be seen that there is a perfect linear response of most of the range. The insert in Figure 14 shows that the response is logarithmic at the bottom of the range and for each transducer this was allowed for when the voltages were converted to head. The calibration coefficients are shown in Table 1, and it can be seen that there is very little variation among them.

Table 1: Druck pressure transducer calibration coefficients

Transducer	Linear Slope	Linear Intercept (millivolts)	Ln Slope	Ln Intercept (millivolts)
1725426	0.0939	-171	280	-2126
1727922	0.0937	-167	288	-2188
1727918	0.0935	-167	285	-2168
1727919	0.0937	-173	281	-2142
1727920	0.0938	-166	288	-2190
1725425	0.0938	-167	284	-2155
1727924	0.0939	-167	286	-2175

Once the pressure transducer had been calibrated they were tested in position in the tanks. With the transducer in place and all the holes stopped off with bungs, the tanks could be filled to a water level of approximately 425mm above the bottom of the V, the bungs were then released and the change in head recorded. The output trace with only one hole in the bottom of the tank is shown in Figure 15, where it can be seen that the overall variation in head is effectively linear. This linear behaviour of the drain down of the tanks was the same regardless of the number of holes that were open in the bottom of the tank, and allowed a convenient relationship between the number of holes and the drain time to be established, as shown in Figure 16. These relationships had major advantages for data processing, which will be described further in Chapter 4.

Figure 13: Forward tank showing Druck pressure transducer in place

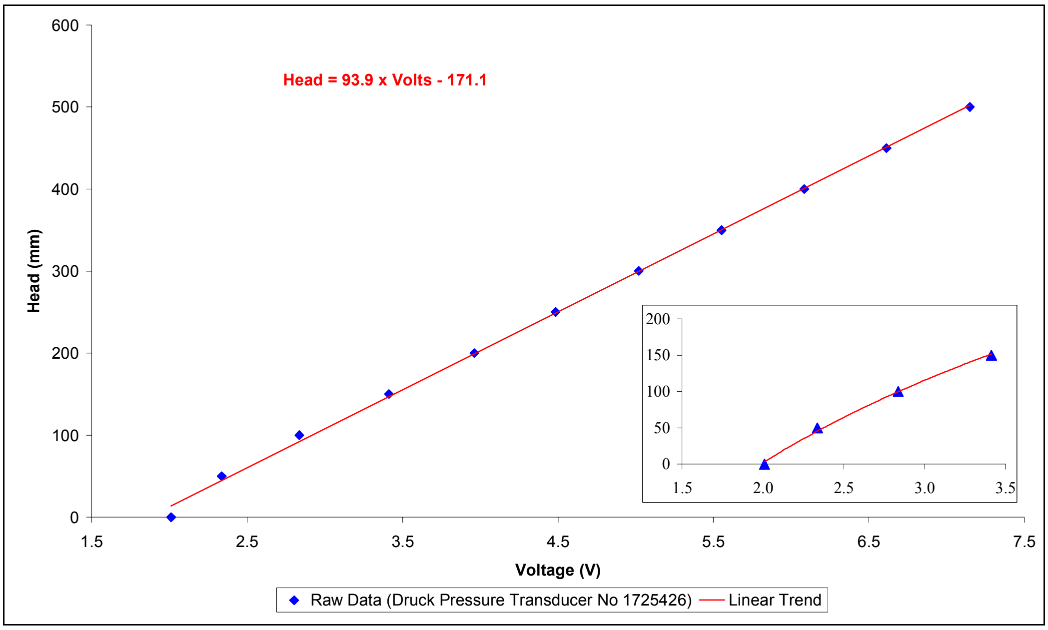

Figure 14: Druck pressure transducer calibration (in Volts)

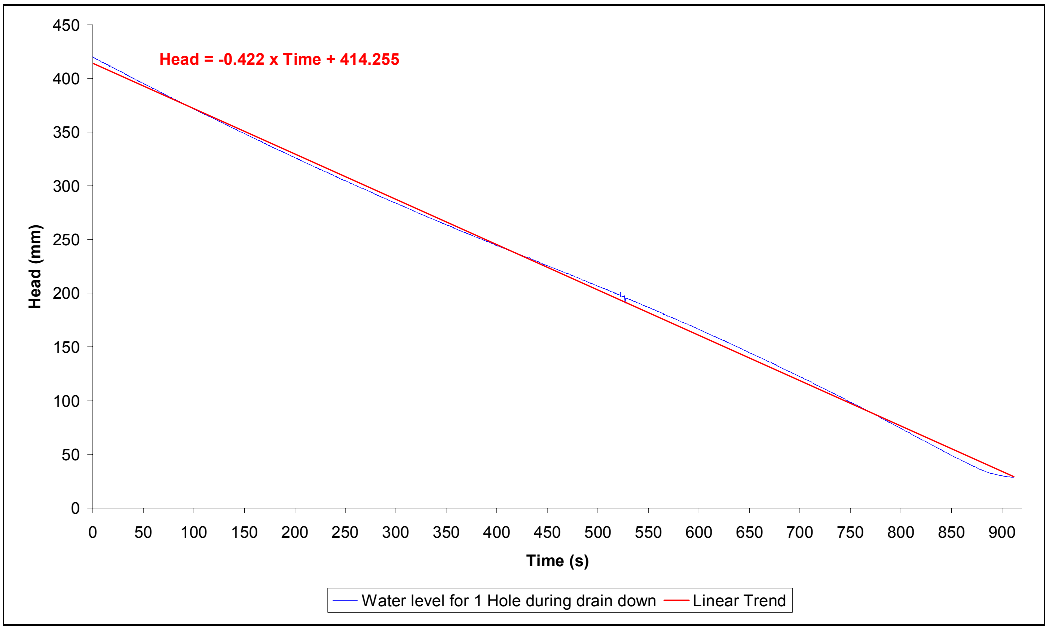

Figure 15: Recorded head during drain down of the tank

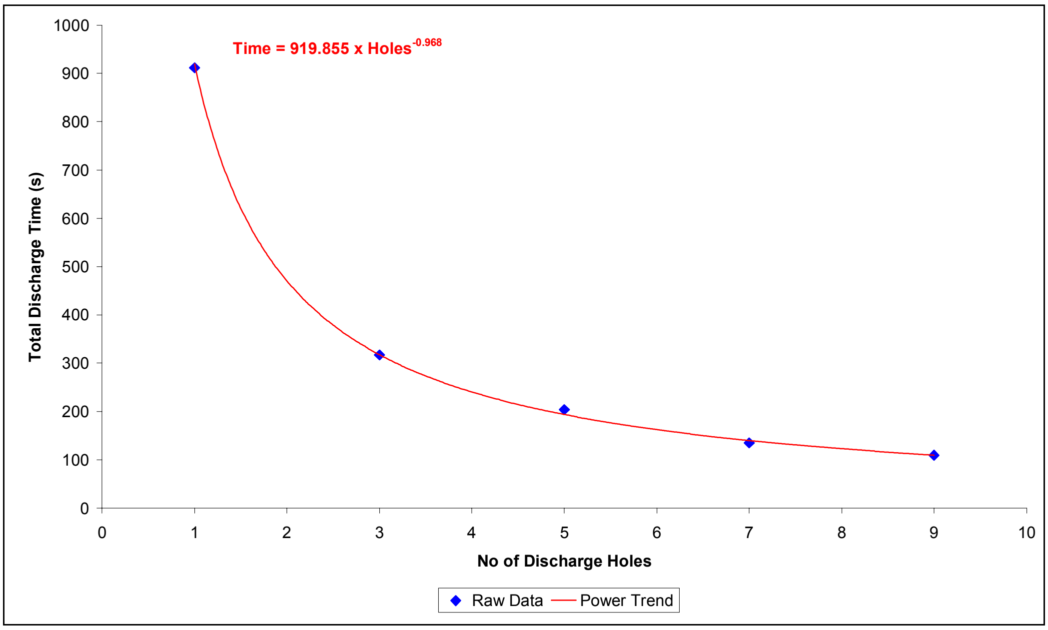

Figure 16: Relationship between the number discharge holes and drain time

3.2 OPERATION OF THE OVERTOPPING TANKS

The three tanks are shown in position in Figure 17. For the record, and with reference to Figure 5, the absolute position of the tanks with reference to the leeward side of the parapet wall are given in Table 2 in mm. As described above there was a Druck pressure transducer in each of the compartments of the three tanks, making a total of 6 in total plus one spare. Shown at the top of the dividing panel in the right hand corner of compartment 2 in Figure 13 can be seen an overtopping detector, of which there were 6, one in each compartment. Essentially, there were two recording devices per compartment, plus the spare transducer, making a total of 13 channels to be logged. This is now described.

Table 2: The position of the tanks across the promenade (in mm)

Tank	Front End	Dividing Section	Rear End
Forward	100	1,375	2,650
Central	5,900	7,175	8,450
Rear	13,350	16,625	15,900

Figure 17: The three tanks in position at Samphire Hoe

3.2.1 The Data Logging System

The data collected during field measurements were recorded on a dataTaker DT800 standalone logger, shown in Figure 18. This is a 'state-of-the-art' robust and highly versatile recording devise, specifically designed to be deployed in the field and left unattended for long periods. It also has the advantage that it does not require the long and bulky cabling requirement of the original measurement system outlined in Pullen & Allsop (2002), providing the field team with more time to install and check the main measurement equipment. This was especially useful as there is only a limited time in which the equipment can be installed safely, and it prevented potentially hazardous working practises from being employed. It avoids the cabling by being able to communicate via its RS232 port and a radio modem link with the laptop computer in the support vehicle. The dataTaker is battery-powered and accepts analogue and digital signals and stores these values in a local non-volatile 64Mb Compact Flash memory card, capable of storing up to 36hrs of data on all channels at a sampling rate of 4Hz. The batteries, when fully charged, supply the dataTaker, overtopping detectors and the pressure transducers with approximately 39amps in total. The system draws virtually no current when in standby mode, and approximately 1amp/hour when in full operation. The dataTaker, batteries and radio modem are housed in the control box, which is securely attached to the parapet wall next to the forward tank as shown in Figure 19.

All the cables from the pressure transducers and the overtopping detectors are routed back to the control box where they enter via waterproof seals. The control box itself is rated as remaining watertight during severe storm conditions (IP55), and, if necessary, it is possible to successfully operate the whole system without opening the box whilst it is secured to the parapet wall. Logging is started by uploading an acquisition 'sequence' and a 'run' command. Once these commands have been issued all incoming data is logged and streamed to the RS232 port. This allows the operators to view and store real-time data on the laptop, safe in the knowledge that if the radio link fails the data is still being recorded. The data can be downloaded to a computer by using the RS232 port or via USB following removal from the dataTaker. When conditions allow, spare batteries and an additional memory card are available. A general schematic of the entire system is shown in Figure 20.

The wave overtopping detectors are formed from two metal probes placed a few millimetres apart. These are coupled with a resistor chain such that when water is present between the probes the voltage changes across a digital input on the logger. The pressure transducers provide a current output related to the depth of water in which they are immersed, and this is converted to a voltage using a shunt resistor situated at the analogue inputs on the logger. The calibration of this voltage signal was described above. With the system fitted with 6 water presence detectors and seven pressure transducers, data rates up to around 4Hz are achievable. Reducing the number of data channels in use allows the data rate to be increased.

Figure 18: The dataTaker DT800 logger

Figure 19: The control box to the right of the forward tank

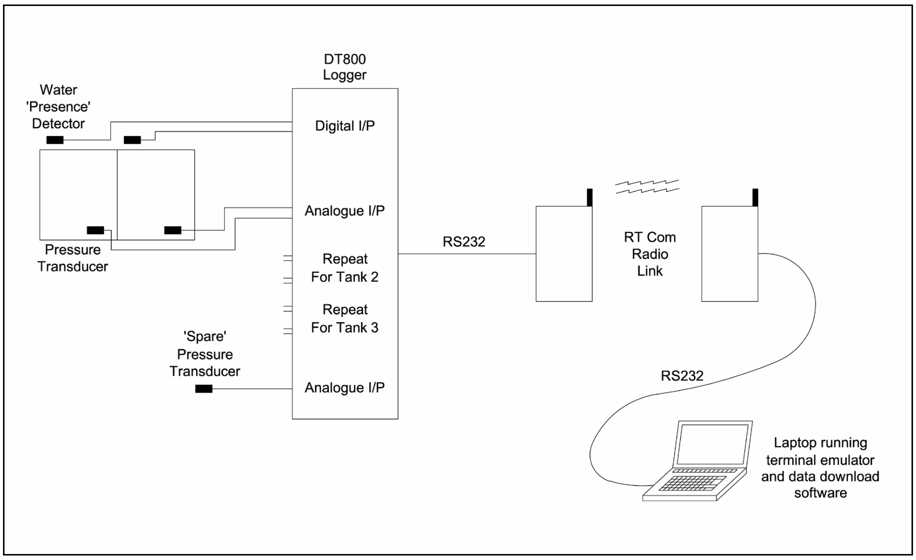

Figure 20: Schematic of the data logging system deployed at Samphire Hoe

4. Data Processing

The basic format of the raw data has been alluded to in the previous chapter, and is essentially comprised of a series of voltage readings and a timestamp giving date, hour, minute, second & fraction of a second readings at 4Hz intervals. These recorded data need to be converted into overtopping volumes, and the various processes involved are now described.

The first phase of the data processing converts the voltage readings into the head of water in the tanks. Typical converted data for Tanks 1 & 2 in Figure 21 shows that there is a lot of noise in the signals but individual overtopping events are clearly identifiable. In designing the system it was assumed that the digital overtopping detectors would be switched on each time a wave arrived in the tank, and that this could be used to examine the change in the pressure transducer signals to work out the change in head. In practise, however, the behaviour of the detectors was to prove inadequate for analysing the data. As an alternative, the data were examined for sudden changes or spikes that would indicate that an overtopping event had occurred. Having identified an event the signal would be examine to determine the instantaneous head in the tank. An example of this approach can be seen in Figure 22, where it is apparent that some of the overtopping events have been missed and that calculations of instantaneous head will be inaccurate. Several attempts were made to improve the algorithms for determining events and head levels, but none proved to be satisfactory.

A bespoke software application was developed that allowed each event to be examined manually, and overtopping was recorded by clicking directly on a graphical representation of the data and converting the mouse coordinates into the overtopping events. This method is labour intensive, but it was considered to be the most accurate available, and smaller overtopping events were identified that might have been missed had the process been fully automated. The manual analysis of the same set of data presented in Figure 22 is shown in Figure 23 which is clearly a significant improvement.

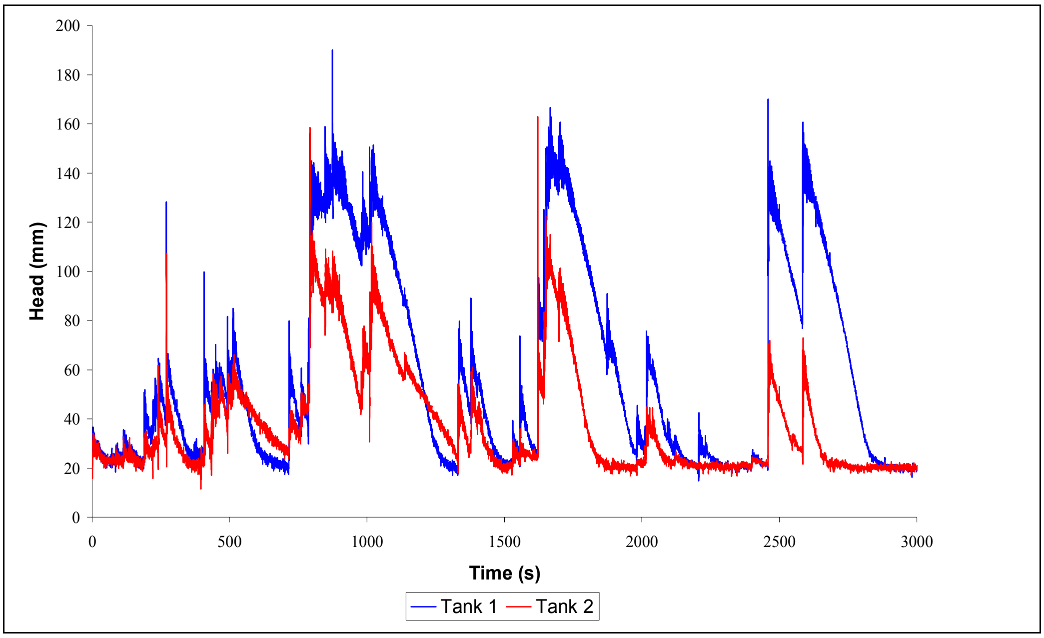

Figure 21: Raw and simultaneous overtopping in tanks 1 & 2

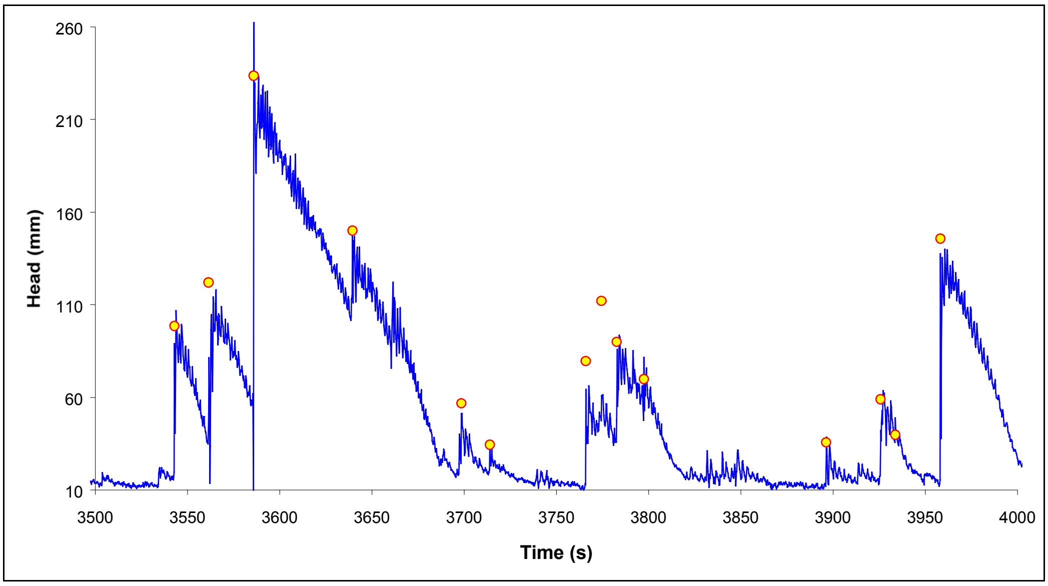

Figure 22: Automatic processing of individual overtopping events

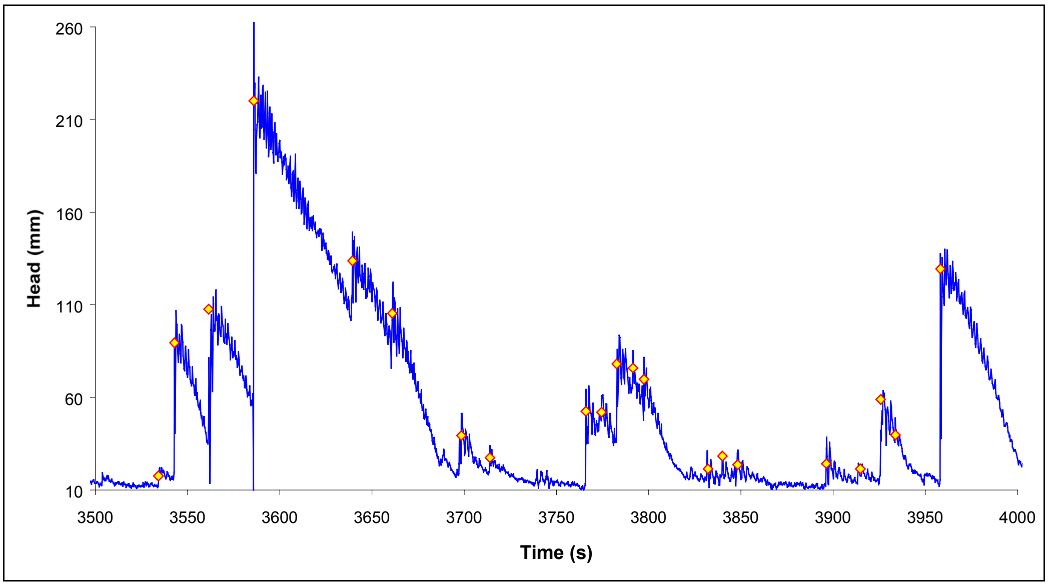

Figure 23: Improved manual processing of individual overtopping events

Once the signal from each of the six tanks had been processed, the individual recorded heads were converted into volumes. For each event that occurred there were a total of five possible alternatives for converting a head into a volume and four of these are shown in Figure 24. Cases ***a*** & ***b*** are the simplest and are calculated directly from the head because it is known that the tanks had been emptied previously. A knowledge of whether or not the tank is empty is determined from a knowledge of when the previous event took place, what the head was and how much overtopping water would have drained from the tank (refer to Sections 3.1.4 & 3.1.5). Cases ***c*** & ***d*** show examples of how the data were assessed depending on the previous water level ($\boldsymbol{Z_0}$), and the fifth case is similar to case ***c*** excepting that the new head does not come above the top of the ***V*** section.

Having established the volumes the next step was to group the data together into single events. To do this it was assumed that overtopping events distributed across the promenade would fall into the tank directly behind the parapet wall before arriving in the other tanks; from the observations made during field trips this is universally the case. Given that overtopping had occurred in tank 1, each tank was then checked for overtopping during the next 3 seconds - a conservative estimate of flight times across the promenade – and individual overtopping events were grouped together depending on how many tanks received the discharge. In this way tables were built up showing when overtopping was captured in 1, 2, 3, 4, 5 or all 6 tanks, and each of these cases were then dealt with individually to determine the volumes of overtopping that had not fallen across the tank locations.

The initial design assumption for determining the size and distribution of the overtopping tanks had envisaged a uniform logarithmic distribution of overtopping across the promenade. This was a useful approach for the design, and it had been anticipated that some of the recorded data might behave similarly. That being the case, the individual volumes recorded in the tanks might have been used to construct a least squares logarithmic best fit to the data and then integrate the resulting expression to establish the total volume of water. However, in practice this approach was not always applicable or appropriate, and so a trapezoidal distribution of the individual volumes was assumed between the recorded data points at the positions given in Table 2 and the back of the promenade at 23,200mm. The trapezoidal distribution of a large discharge is shown in Figure 25, which is the general case for distribution across all 6 tanks. Different distributions were assumed depending on how many tanks received a discharge, but each assumed this basic approach. In effect, the missing water was calculated between tanks ***2*** & ***3***, ***4*** & ***5*** and from the end of ***6*** to the point at 23,200mm in front of the recurve as appropriate. When the last discharge was in tanks ***1***, ***3*** or ***5*** then the distribution would stop at that point. The total discharge is therefore the sum of the discharges in the tanks and the interpolated discharges between the tanks. A comparison of the difference between a trapezoidal and a logarithmic discharge is shown in Figure 26, and it is clear from this example that the trapezoidal distribution is a more realistic approximation.

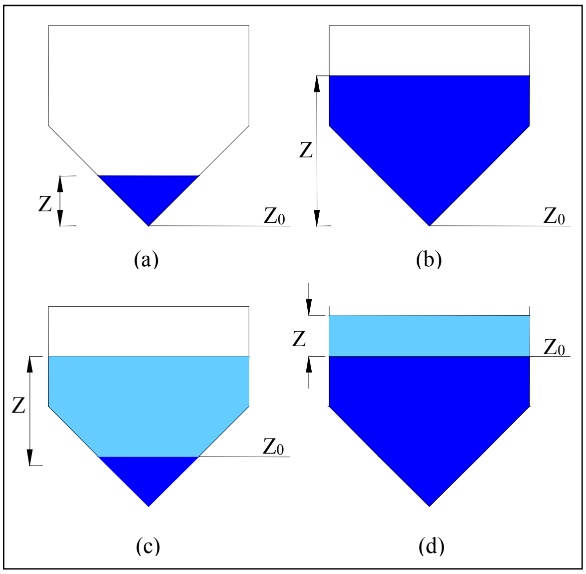

Figure 24: Generalised differences in head in the tanks between overtopping events

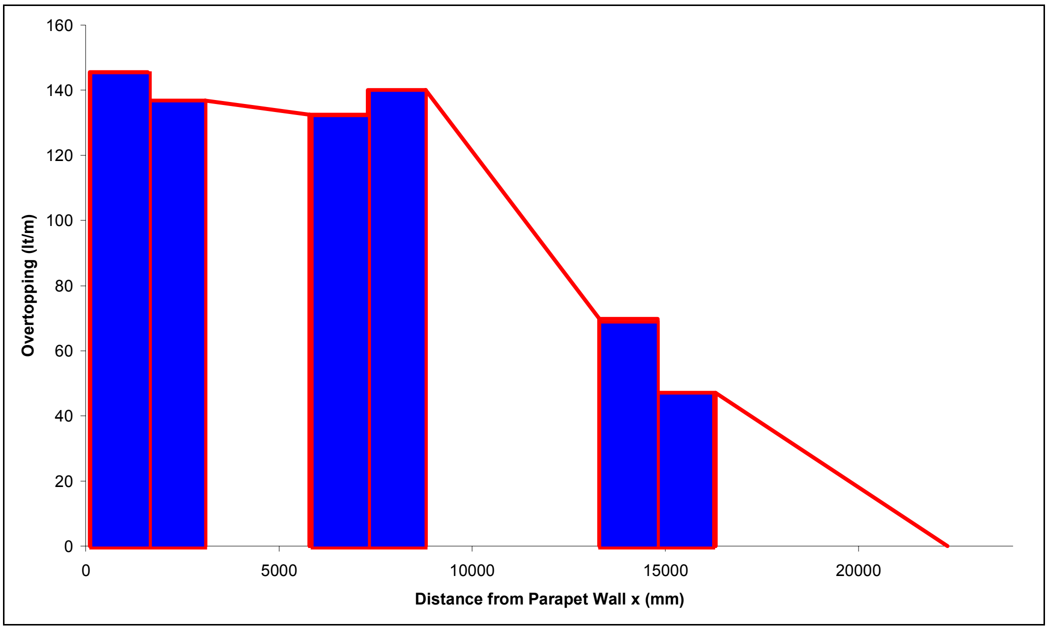

Figure 25: Trapezoidal distribution of overtopping across the promenade

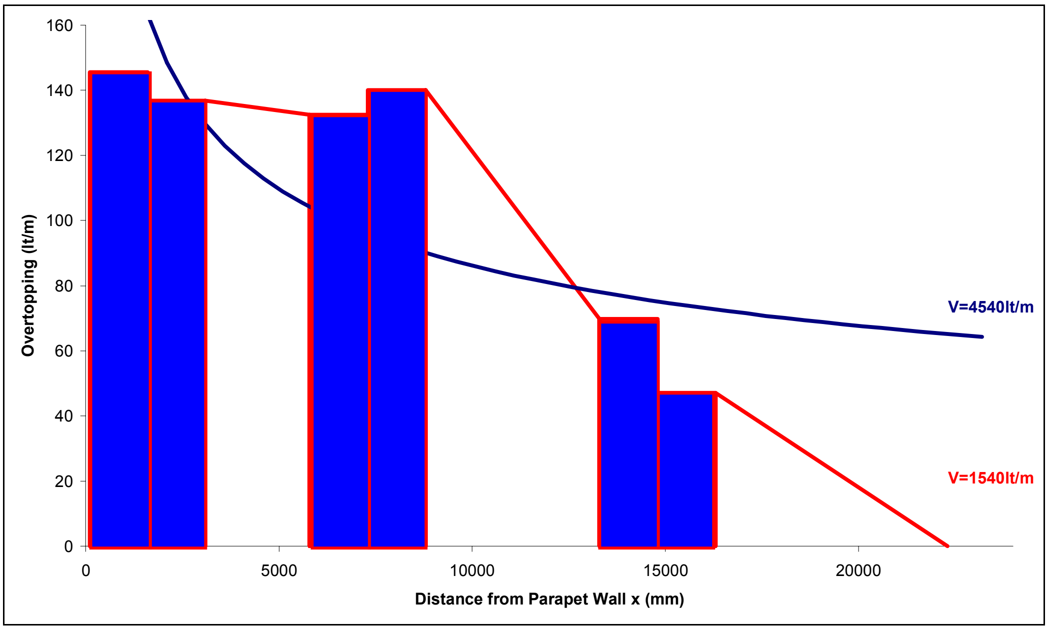

Figure 26: Comparison of the predicted volume for a trapezoidal and a logarithmic distribution of overtopping across the promenade

5. Field Measurements

5.1 WINTER STORMS 2003

The general criteria for suitable storms to occur at Samphire Hoe are a low pressure system travelling across the Atlantic with a steep pressure gradient arriving over the English channel. This will generally ensure that minimum wind speeds of 8~10m/s can be expected with wind directions between 150° and 240°, as reported by Gouldby & Alderson (2002) for example. These conditions will generally produce significant wave heights of 2m or more which is sufficient to cause overtopping at the monitoring site during the peak of the tidal cycle. The hazard warning system developed for Samphire Hoe by HRW and the Met Office gives a prediction of wave height and period, wind direction and surge levels up to 48hours before overtopping is likely to occur. These data are then entered into Besley's (1999) method for predicting overtopping on a composite vertical structure as a check before a final decision is made to visit the site. The extraction point for the predicted wave conditions is at 51.06N, 1.25E and the monitoring site is at 51.10N, 1.27E, a distance of approximately 4800m. The water depth at the extraction point is approximately 20m, which remains relatively constant until very close to the site where the bathymetry starts to slope at around 1:35. For the presentation of these results a simple shoaling coefficient (Goda) was applied to the wave heights.

During the winter and spring of 2003 there were two occasions on which these criteria were met, and it was feasible to take the monitoring equipment to Samphire Hoe to collect overtopping. The general behaviour of the weather for this storm season was such that there were very few opportunities to visit the site, but the visits did coincide with the most favourable conditions of the season. The first of these visits was during March where one storm was monitored on 10 March, and the second visit was during May when storms were monitored on 1 & 2 May. This chapter will describe these giving a brief description of the weather forecast and predicted overtopping rates, and present the processed data. For simplicity the three monitored storms will be referred to as Storms 01, 02 & 03, and will be dealt with in the following three sections.

5.1.1 Storm 01 (10 March 2003)

Overtopping Prediction

Figure 27 shows the predicted low pressure system over the British Isles for 10 March 2003. The legend to the right indicates that wind speeds in the range 15~20m/s were anticipated, and during the storm a maximum wind speed of 11m/s was recorded on a hand held anemometer. Figure 28 shows the predicted overtopping rates shown against the water level for this storm. The water level includes the surge level and the data are the latest available from the extraction point (the most reliable). From the figure it can be seen that a maximum overtopping discharge of approximately 0.3lt/m.s was predicted at 14:00.

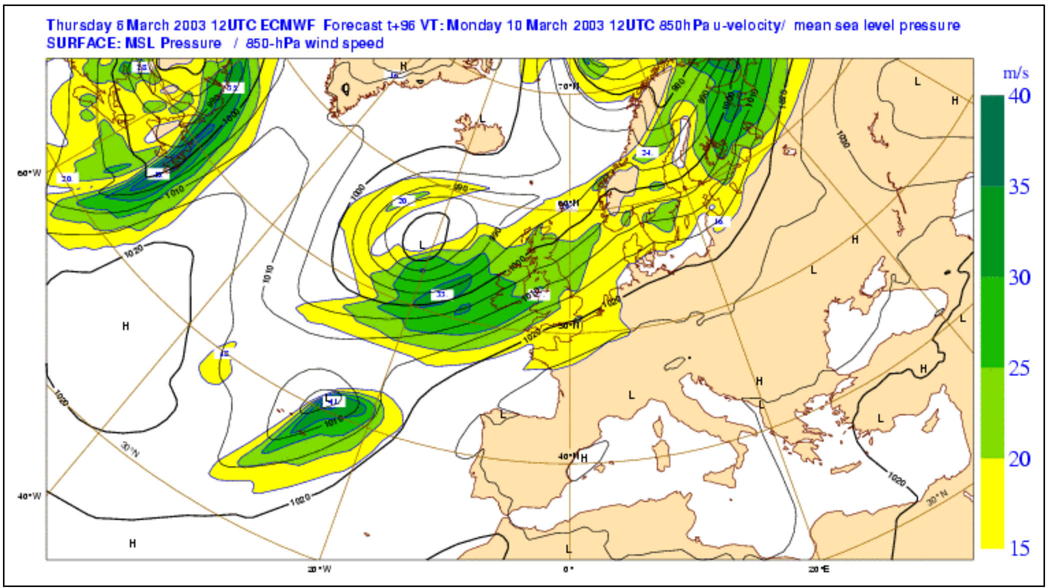

Figure 27: Forecast for 10 March storm (Courtesy of the European Centre for Medium-Range Weather Forecasts(ECMWF))

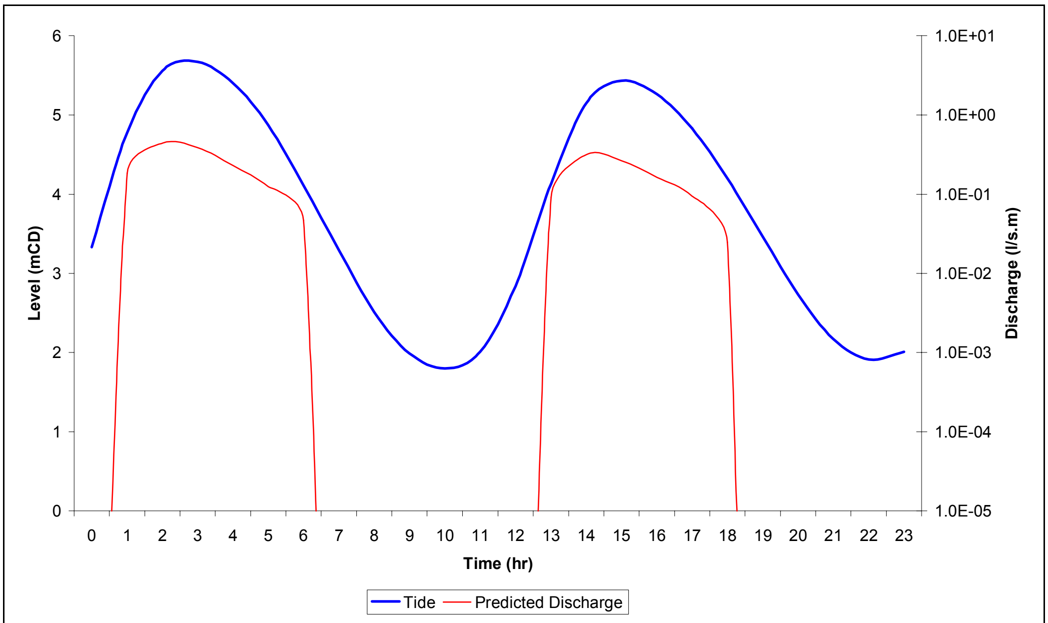

Figure 28: Overtopping prediction for 10 March storm

Results

During the storm overtopping water was seen to appear regularly over the top of the parapet wall, but this was in general sporadic and was spread along the length of the western splay wall. Overtopping was at the threshold level, and that would that did pass over the top of the parapet wall was blown widely across the promenade as a light spray. On one occasion the observers present were momentarily caught of guard by an overtopping wave, which was sufficient in volume to cause them to crouch protectively against the spray, but otherwise was fairly innocuous. A best guess was that this wave covered about 3~5m of the parapet wall as it came over and was dispersed over an area of not less than 100m^2 of the promenade. Containing somewhere between 25 and 50lt this represents a peak overtopping discharge of the order of say 5~10lt/m. Other than that no measurable quantities of overtopping water entered into the tanks. Mean overtopping discharges possibly peaked at around 0.05~0.10lt/s.m.

The principal result of this trip was the successful deployment and operation of all the equipment. This very successful exercise proved that the system was capable of working in the field, but also showed that it was possible to install the equipment and secure the site during the predicted safe working period. Moreover, valuable lessons were learned on improving the methods of installation that were to prove useful for subsequent trips.

5.1.2 Storm 02 (1 May 2003)

Overtopping Prediction

Figure 29 shows the predicted low pressure system over the British Isles for 1 May 2003. The legend to the right indicates that wind speeds in the range 15~20m/s were anticipated, and during the storm a maximum wind speed of 16m/s was recorded on a hand held anemometer. During the early stages of the storm the wind speeds were at gale force 5, and it was difficult to stand up straight at times. Figure 30 shows the predicted overtopping rates shown against the water level for this storm. From the figure it can be seen that a maximum overtopping discharge of approximately 1.4lt/m.s was predicted at 12:00.

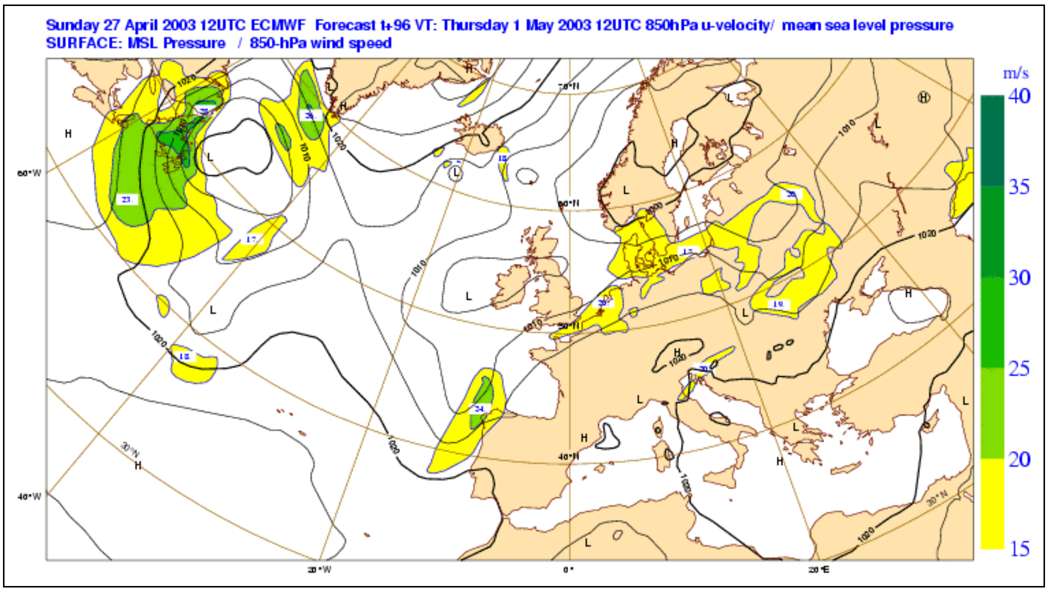

Figure 29: Forecast for 1 May storm (Courtesy of ECMWF)

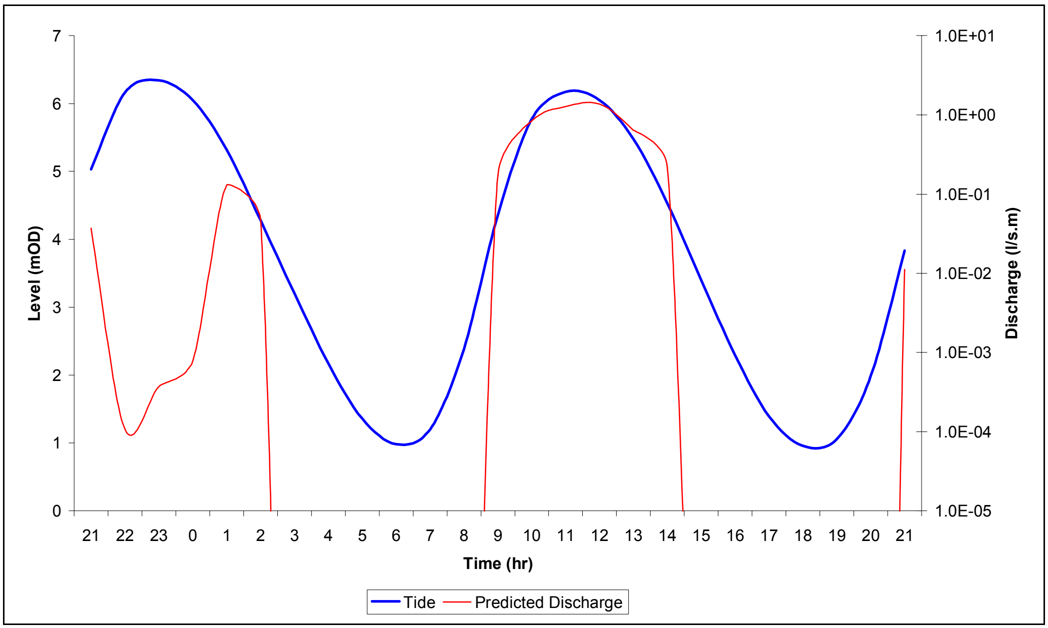

Figure 30: Overtopping prediction for 10 March storm

Results

Figure 31 shows a photograph of overtopping taken during the storm, and it is apparent from this that the overtopping water is arching over the parapet wall as it is caught by the wind. In particular it provides some insight in to how the results should be interpreted. The plume of water is just in front of the overtopping tanks and is quite narrow, being only 2~3m wide at this point. With the high wind speeds, the overtopping water, as expected, was blown over a wide area. The results that follow can therefore only be expected to represent a proportion of the overtopping discharge that might have been captured in the absence of wind.

In the figures that follow, to be described shortly, the raw results from the data processing are presented, and these are summarised partially in Table 3. This table shows the principal results of interest presented at half hourly intervals (1800s). To allow for changes in water level and changes in the wave conditions, it was assumed that a period of 1800s was a suitable time interval that might represent a change in the general conditions for assessing overtopping. Of particular interest, in Table 3, is the difference between the predicted mean discharge at 12:00 of 1.4lt/m.s as mentioned above, and the recorded discharge of 0.28lt/m.s; a difference of a factor of approximately 4. This might be expected from the evidence of the affect of the wind, and is consistent with visual and video observations made during the storm.

In Figure 32 to Figure 37 the individual overtopping events captured in tanks 1 to 6, respectively, are presented. The individual volumes are in lt/m and are shown against time on the abscissa, where time ***t=0s*** is taken as 09:59, the time when the data logger was started. In each figure is shown the water level to give an indication of how the overtopping was changing as this varied; note that the water level is scaled differently on each figure for presentational reasons.

Figure 31: Overtopping at the monitoring site during the storm

Table 3: Summary of the 1 May 2003 storm

Time Hr	H_s m	T_m s	Tide m	N_w	N_{ow}	V_{Max} lt/m	V_{Bar} lt/m	V_{Tot} lt/m	q lt/m.s
10:00	2.04	5.27	5.77	342	29	152	58	1689	0.94
10:30	2.10	5.28	6.04	341	14	129	35	487	0.27
11:00	2.15	5.28	6.17	341	6	245	127	761	0.42
11:30	2.17	5.41	6.15	333	10	178	52	520	0.29
12:00	2.18	5.54	6.05	325	8	241	62	498	0.28
12:30	2.08	5.42	5.83	332	9	53	21	193	0.11
13:00	1.98	5.29	5.48	340	4	32	22	89	0.05
13:30	1.84	5.41	5.01	333	8	40	17	138	0.08
14:00	1.70	5.53	4.53	325	11	50	23	254	0.14
14:30	1.59	5.53	3.97	325	16	69	19	298	0.17
15:00	1.47	5.53	3.40	325	4	21	15	62	0.03

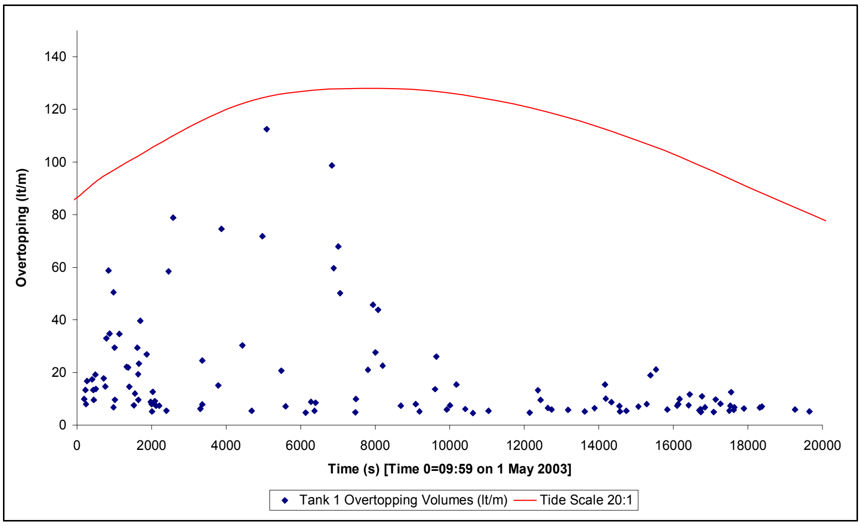

Figure 32: Overtopping discharges for Tank 1 for 1 May storm

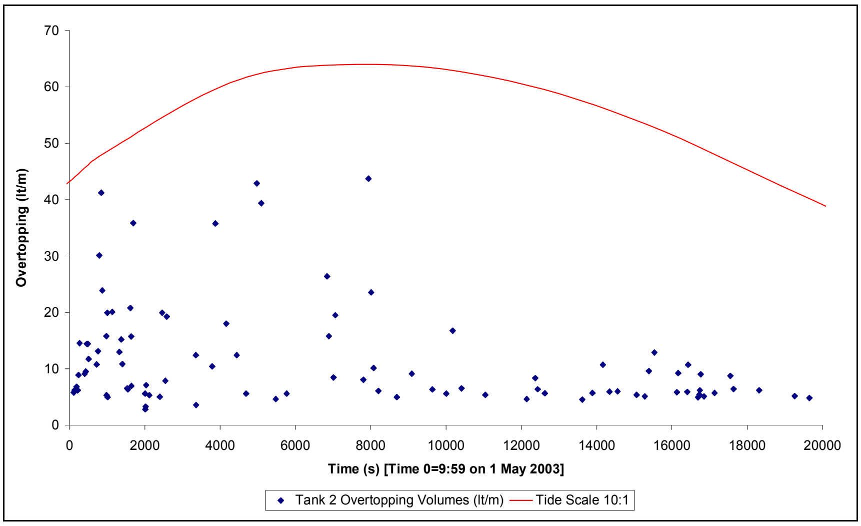

Figure 33: Overtopping discharges for Tank 2 for 1 May storm

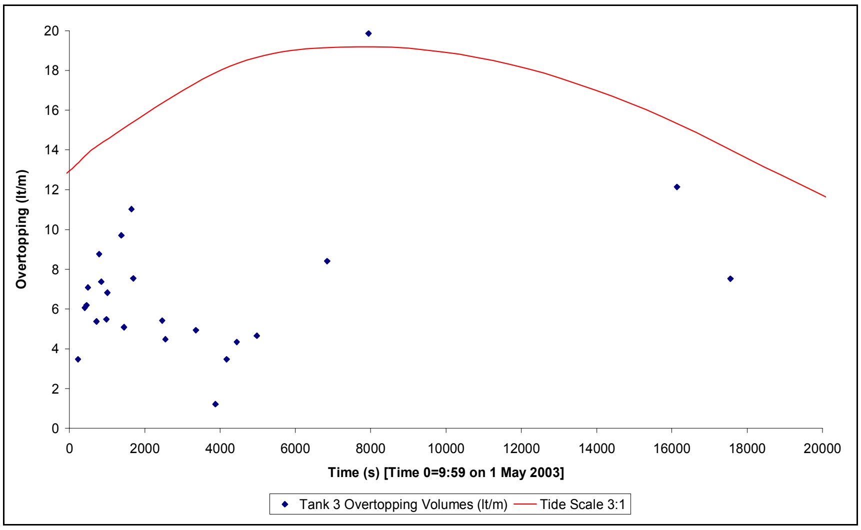

Figure 34: Overtopping discharges for Tank 3 for 1 May storm

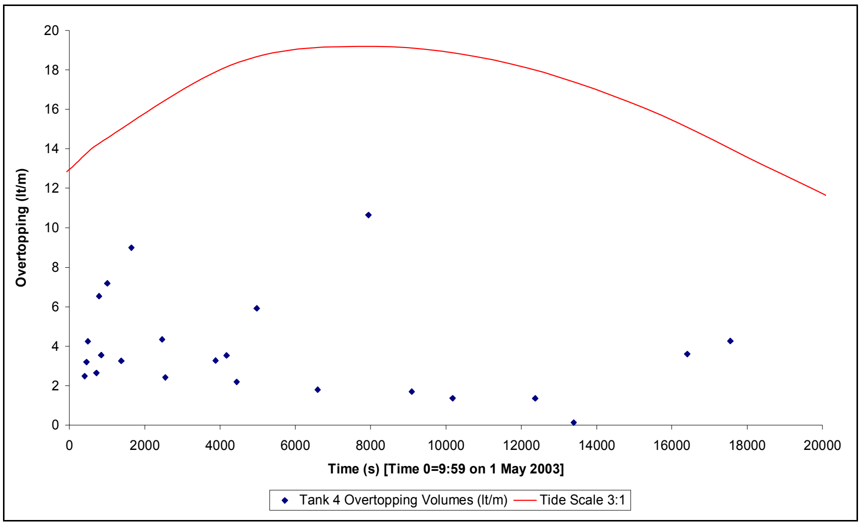

Figure 35: Overtopping discharges for Tank 4 for 1 May storm

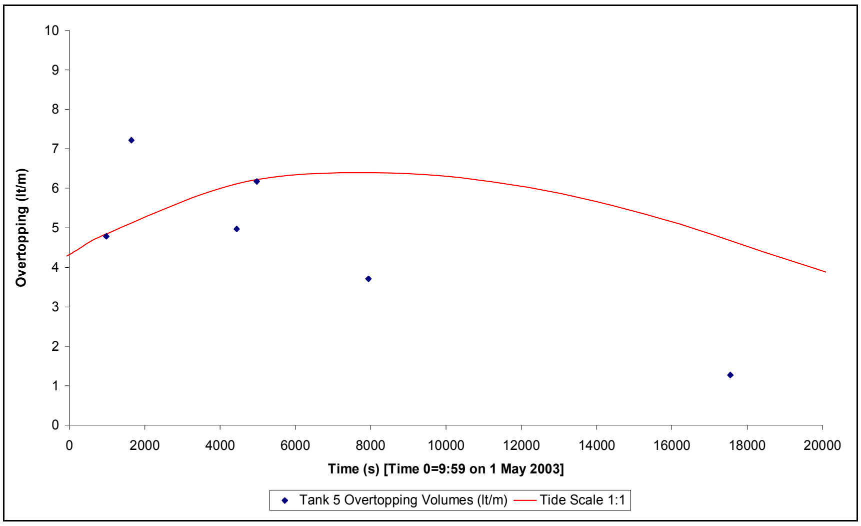

Figure 36: Overtopping discharges for Tank 5 for 1 May storm

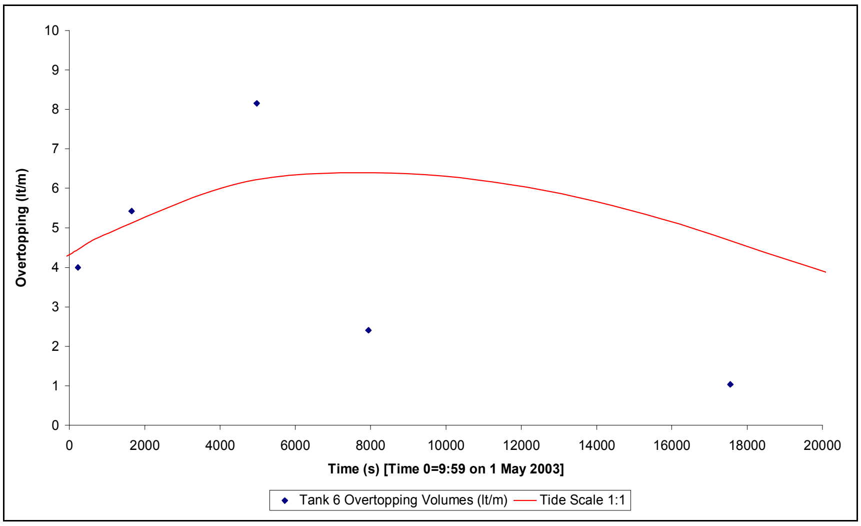

Figure 37: Overtopping discharges for Tank 6 for 1 May storm

5.1.3 Storm 03 (2 May 2003)

Overtopping Prediction

Figure 38 shows the predicted low pressure system over the British Isles prior to the storm of 1 May 2003. The legend to the right shows that wind speeds in the range 20~25m/s were expected, and during the early stages of the storm wind speeds were at storm force. Figure 39 shows the predicted overtopping rates shown against the water level for this storm. From the figure it can be seen that a maximum overtopping discharge of approximately 3.0lt/m.s was predicted at 23:30.

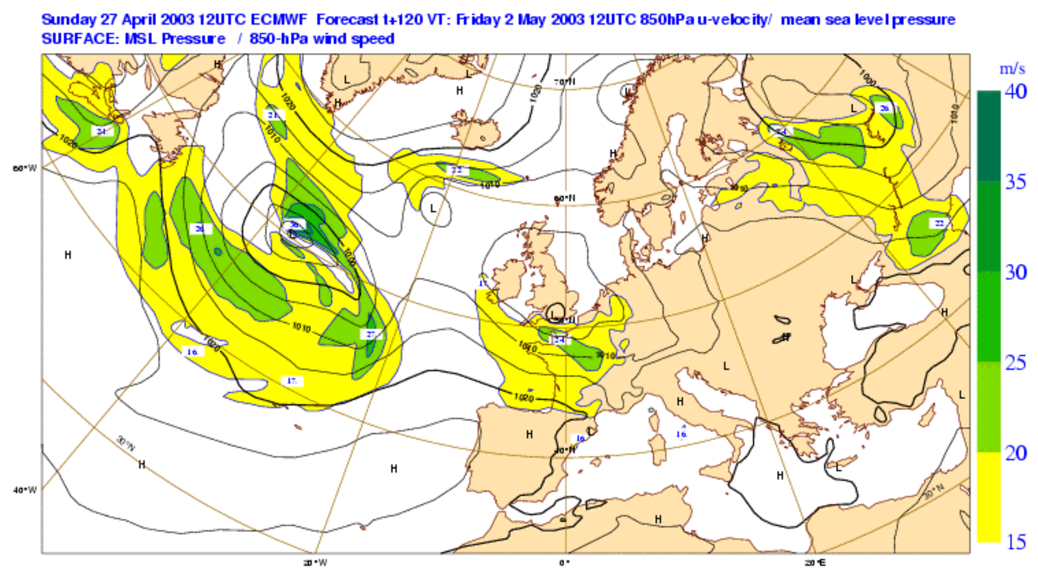

Figure 38: Forecast for 2 May storm (Courtesy of ECMWF)

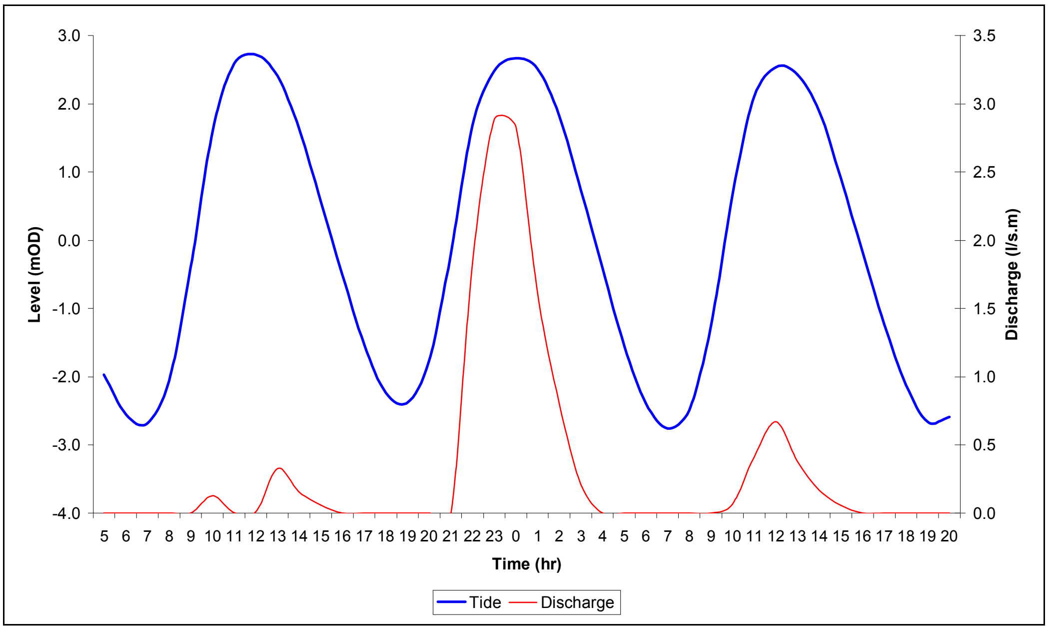

Figure 39: Overtopping prediction for 2 May storm

Results

The depth of water varies by several metres in front of the seawall along the whole length of Samphire Hoe, but the berm in front of the wall was placed to the same specification along the entire length. Being generally approximately 3.5m deep by 10m wide, the consequence of this is that the depth of water over the berm will also vary along the seawall, with different sections emerging as the water level changes. During the early evening of 2 May the berm was fully emerged at the monitoring site, but was submerged at the eastern end of the western splay wall (refer to Figure 4) when the storm arrived. At approximately 19:00 severe and violent overtopping started at this location.

High velocity winds were observed at this time (readings were not taken, but most likely storm force) and it took considerable effort to walk into the wind. Since overtopping was not expected to occur at the monitoring site until later that evening, the experimenters went to observe this overtopping. Dressed in waterproof safety clothing, they stationed themselves near to the point where overtopping was taking place. It was generally agreed that many of the observed overtopping events were in excess of 500lt/m and at times certainly considerably more. With the very high velocity winds that were present, the plumes of overtopping water were being blown over distances in excess of 100m. Considerable amounts of the discharges were falling directly behind the parapet wall, where instantaneous water depths of around 0.050m to 0.075m were observed on the bottom tier of the promenade. At a width of 5.8m, this represents volumes of between approximately 300lt/m and 500lt/m in this area. If it is assumed that this represents about half the water in each overtopping event, then the remaining half was being blown across areas of the order of 1000m^2. Clearly it was extremely hazardous in the area directly behind the parapet wall, but the peripheral area required further investigation.

The volumes of water landing across the promenade became less severe on each tier, with the least landing on the top tier in front of the recurve wall. It was decided that the only way to gain an improved scientific understanding of the potential hazards involved, was to go and stand directly in the path of the overtopping plume. It was agreed that standing on the top tier was equivalent to standing in a very heavy rain shower. Towards the lower tier, where it was still considered to be safe, the experience was similar to that which might be expected during a heavy hailstorm accompanied by a firm push on the back. Under these conditions there would be a high chance of being knocked over for any unprepared people.

Overtopping gradually moved along the western splay wall arriving at the monitoring site at 21:48. By the time that overtopping started at the monitoring site wind speeds had become insignificant and overtopping discharges were being directed vertically upwards and coming down in the area directly behind the parapet wall. Little or no overtopping discharge was being blown by the wind during the time that the storm was being observed visually. HRW staff left the site at approximately 23:00 when it become too dangerous to remain in the observation position. At this time the winds were still not affecting the overtopping discharges. The results of this storm are summarised in Table 4 below. Of particular interest is the close correlation between the predicted mean discharge of approximately 3.0lt/m.s at 23:30 and the recorded mean discharge of 3.24lt/m.s at 23:15.

In Figure 40 to Figure 45 the individual overtopping events captured in tanks 1 to 6, respectively, are presented. The individual volumes are in lt/m and are shown against time on the abscissa, where time ***t=0s*** is taken as 09:59, the time when the data logger was started. In each figure is shown the water level to give an indication of how the overtopping was changing as this varied; note that the water level is scaled differently on each figure for presentational reasons.

Table 4: Summary of the 2 May 2003 storm

Time Hr	H_s m	T_m s	Tide m	N_w	N_{ow}	V_{Max} lt/m	V_{Bar} lt/m	V_{Tot} lt/m	q lt/m.s
21:45	2.52	5.87	4.88	307	19	30	8	155	0.09
22:15	2.57	5.81	5.55	310	54	248	46	2490	1.38
22:45	2.57	5.82	5.95	309	61	556	97	5934	3.30
23:15	2.54	5.82	6.20	309	38	475	153	5830	3.24
23:45	2.50	5.83	6.29	309	24	801	136	3264	1.81
00:15	2.40	5.83	6.30	309	14	1075	147	2065	1.15
00:45	2.24	5.83	6.22	309	24	253	46	1092	0.61
01:15	2.10	5.95	6.01	302	17	730	181	3069	1.71
01:45	1.96	6.20	5.67	290	14	352	63	889	0.49
02:15	1.80	6.38	5.23	282	18	162	25	454	0.25
02:45	1.61	6.51	4.68	277	24	235	45	1076	0.60
03:15	1.46	6.39	4.16	282	30	35	11	344	0.19
03:45	1.33	6.02	3.69	299	10	19	11	111	0.06
04:15	1.27	5.84	3.26	308	2	3	3	6	0.00

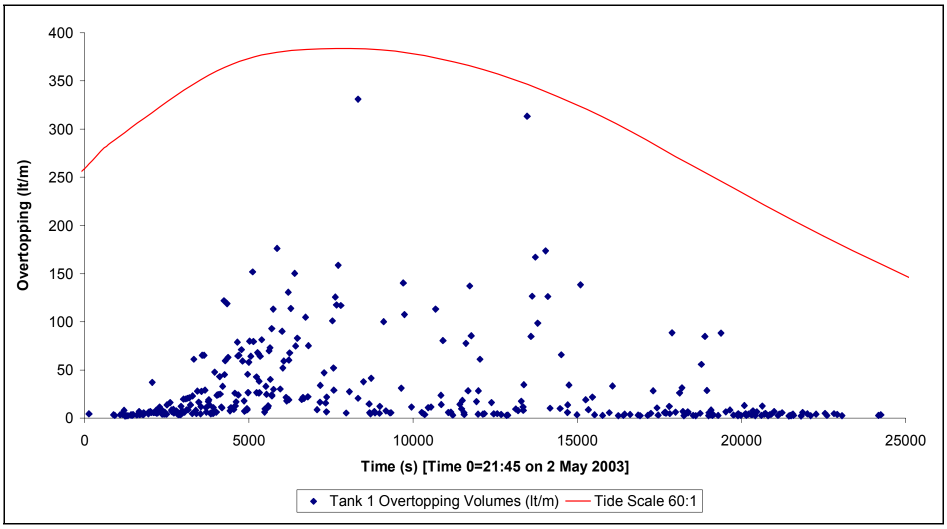

Figure 40: Overtopping discharges for Tank 1 for 2 May storm

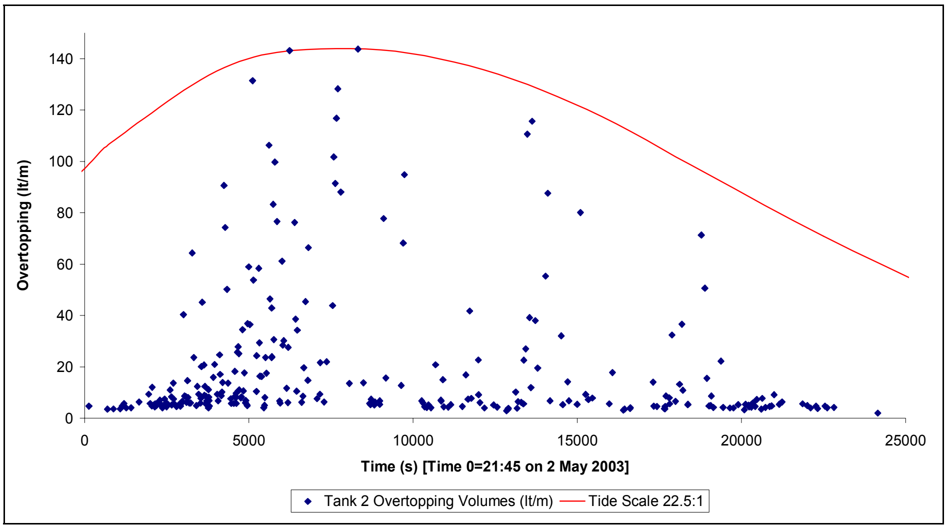

Figure 41: Overtopping discharges for Tank 2 for 2 May storm

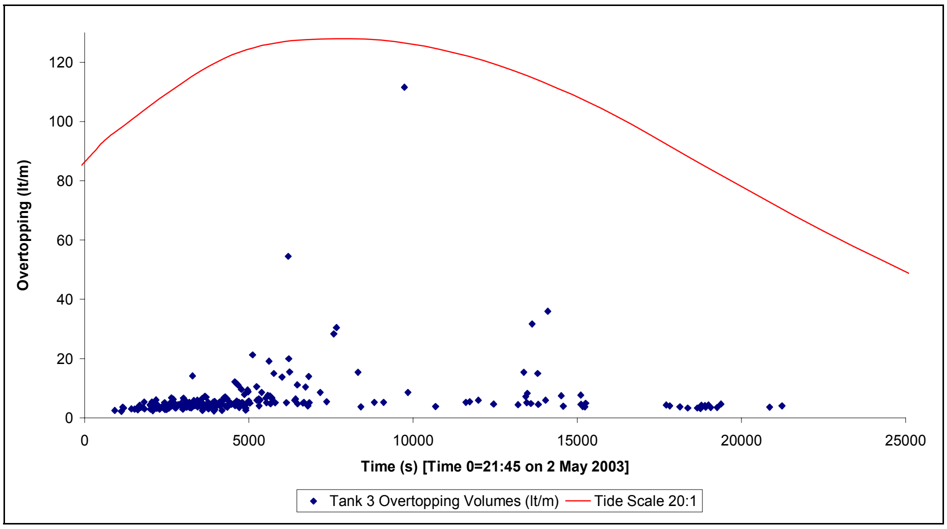

Figure 42: Overtopping discharges for Tank 3 for 2 May storm

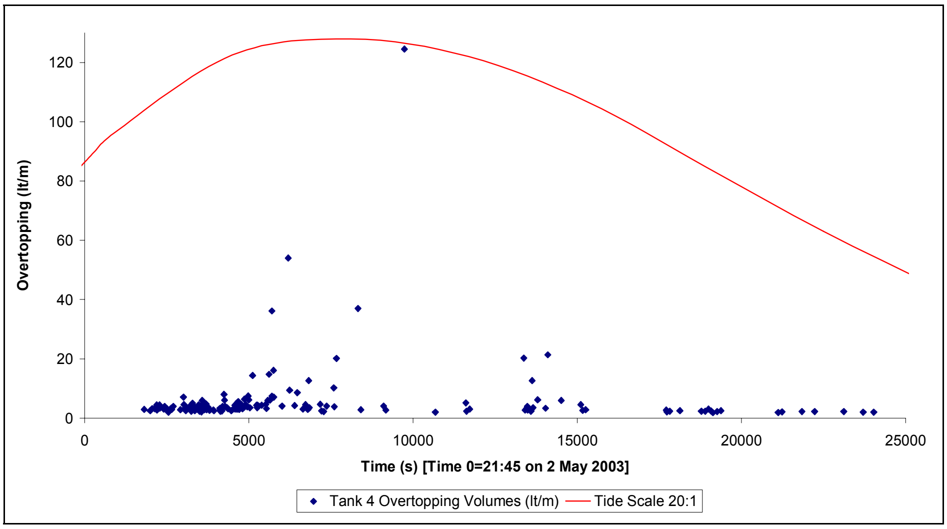

Figure 43: Overtopping discharges for Tank 4 for 2 May storm

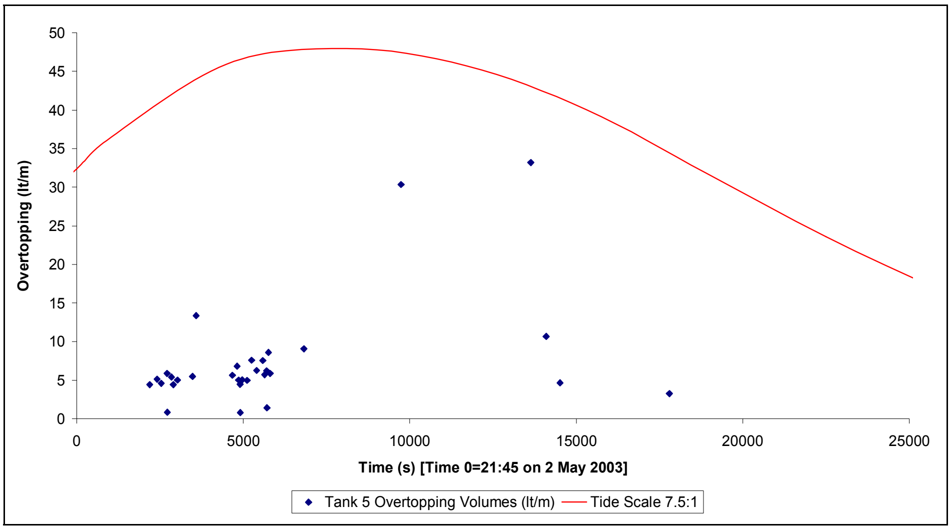

Figure 44: Overtopping discharges for Tank 5 for 2 May storm

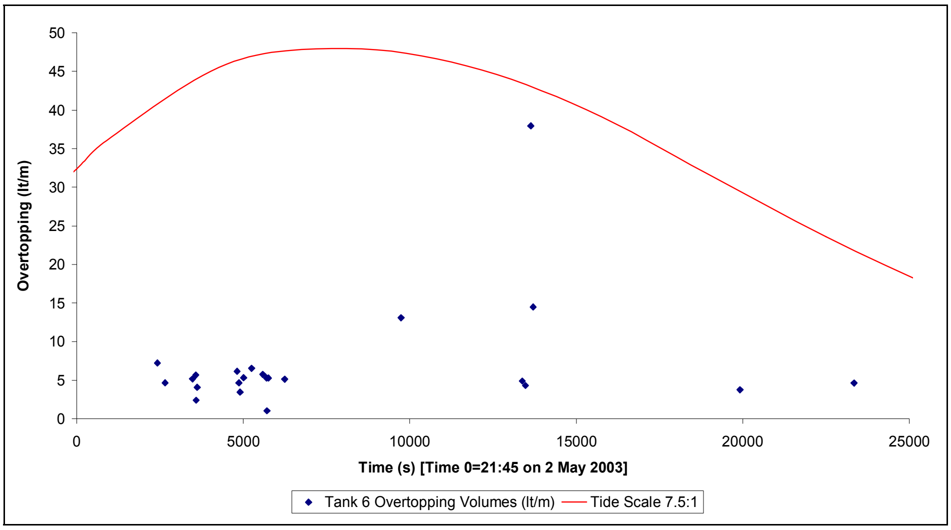

Figure 45: Overtopping discharges for Tank 6 for 2 May storm

5.2 WINTER 2003 / 2004

It must be emphasised that the deployment at Samphire Hoe was particularly difficult in the level of work needed to satisfy the owners. Permission to deploy had to be obtained from Eurotunnel before each deployment, and this includes an assessment of anticipated overtopping. HRW were only permitted to work on the seawall when overtopping $Q_{bar} < 1$ l/s.m, and installation operations are further limited to $Q_{bar} < 0.03$ l/s.m. This requires HRW to forecast storm conditions and to predict overtopping discharges. The window of deployment therefore falls between the lower limit given by that possible to be detected by the field measurement equipment and the upper limits given above. HRW had to track storms in for 5-10 days to make local preparations, to forecast overtopping, and discuss with Eurotunnel .

During the winter of 2003-2004, several storms were tracked and the field measurement team and equipment were readied for deployment. HRW had 4 possible opportunities in which late changes to the weather conditions (direction or timing) changed the predictions to no / low overtopping and these deployments were aborted, indeed one storm did so on the day of an intended departure. A number of smaller storms at Samphire Hoe were the result of rapidly developing low pressure systems that travel quickly up the English Channel. The limit of three days to prepare and deploy the equipment simply did not allow these storms to be captured. For only two other storms (including the 25/26 December) were HRW unable to find sufficient staff who were clear of other commitments. All reasonable and practicable steps were made to ensure that the equipment was deployed during the 2003 – 2004 winter storm season.

6. Discussion and Conclusions

6.1 MEAN DISCHARGE

This chapter describes the results of the analysis of the field measurements. The data, as summarised in Table 3 & Table 4, for Storms 02 & 03, respectively, and compared here to the empirical prediction method for composite vertical walls described by Besley (1999). Strictly speaking this technique is not wholly correct as the Samphire Hoe seawall is actually slightly battered, stepping back as it does in three distinct sections. Increased factors of 1.3 & 1.4 for walls battered to 10:1 & 5:1, respectively, are given by Bruce et al (2001), and it is probable that these could be applied to composite structures, too.

The results of Storm 02 are shown in Figure 46 and the results of Storm 03 are shown in Figure 47. The results of Storm 02 show that the general behaviour is in agreement with the predictions. The most significant observation that can be made is that the data are slightly below the prediction line but this is mainly due to the wind blowing the discharges away from the overtopping tanks, and so therefore the captured overtopping is below that predicted. However, for Storm 03 the wind had little or no affect on the overtopping plumes, and so they are in good agreement with the prediction.

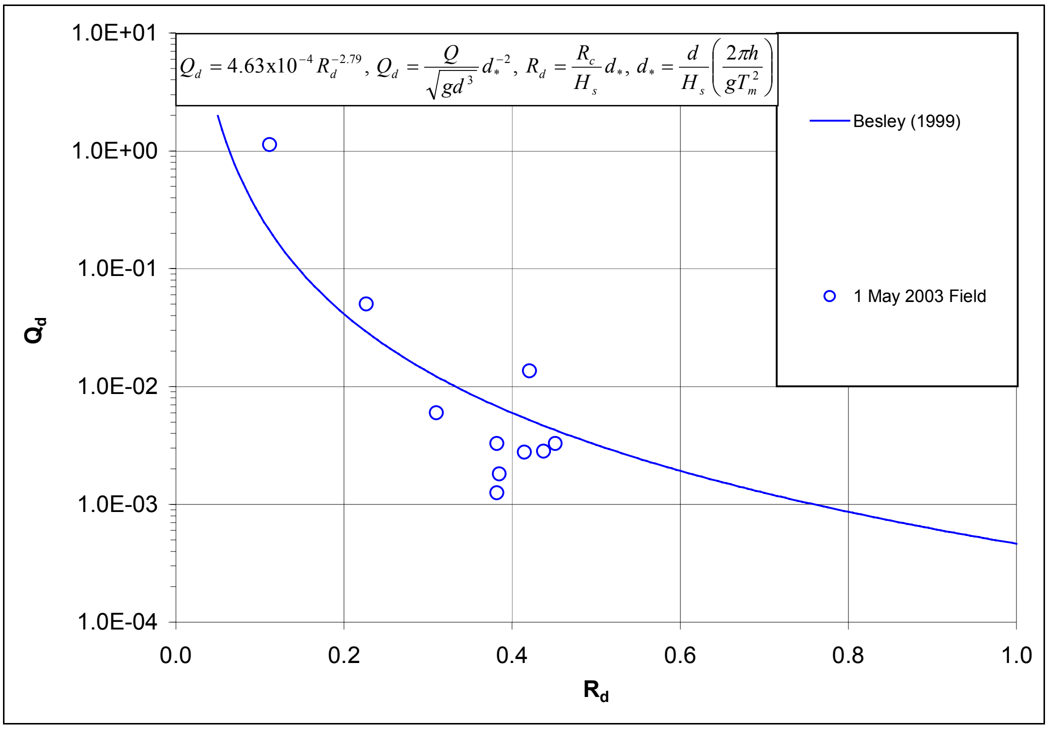

Figure 46: 1 May Field Measurements

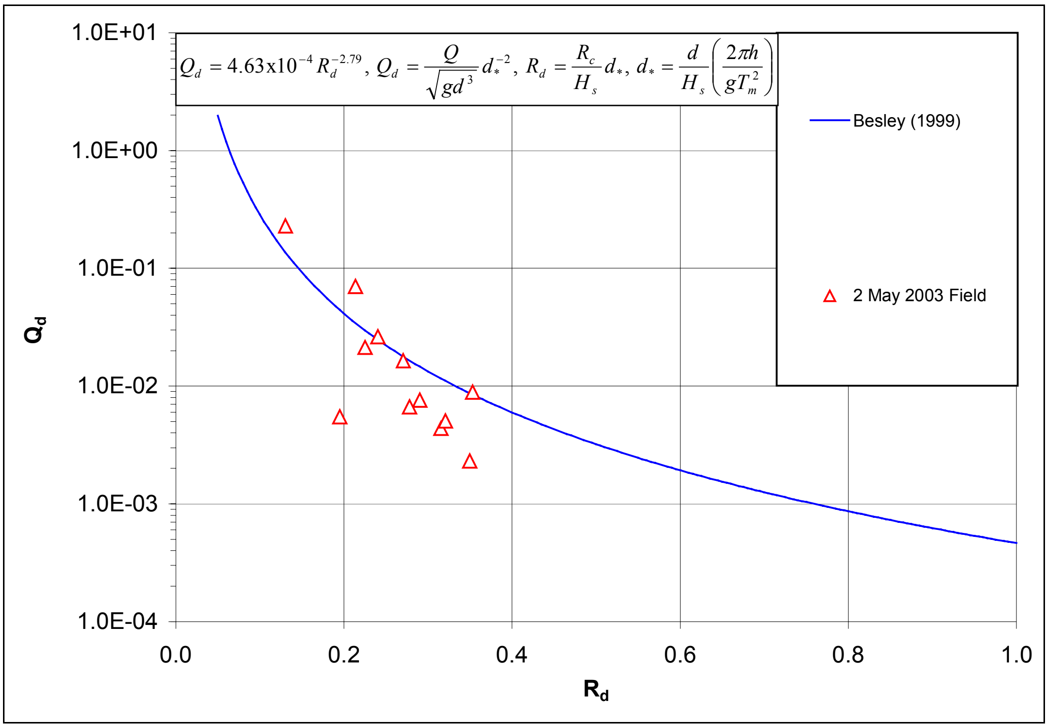

Figure 47: 2 May Field Measurements

6.2 SPATIAL DISTRIBUTION

The spatial distribution for each of the two storms are shown in Figure 48 and Figure 49, respectively. The methods for determining these distributions are discussed by Pullen *et al.* (2004), but here it should be noticed that the distributions are similar for both storms although for Storm 02 there were winds of 15m/s. Again this similarity is a consequence of the wind and has been discussed in detail by Pullen *et al.* (2004). They found that the percentage volume falling in the forward tanks was similar because discharges that would have entered the rear tanks were blown away by the wind. The general distributions therefore appear to be the same because discharges were mainly only captured in the forward tanks.

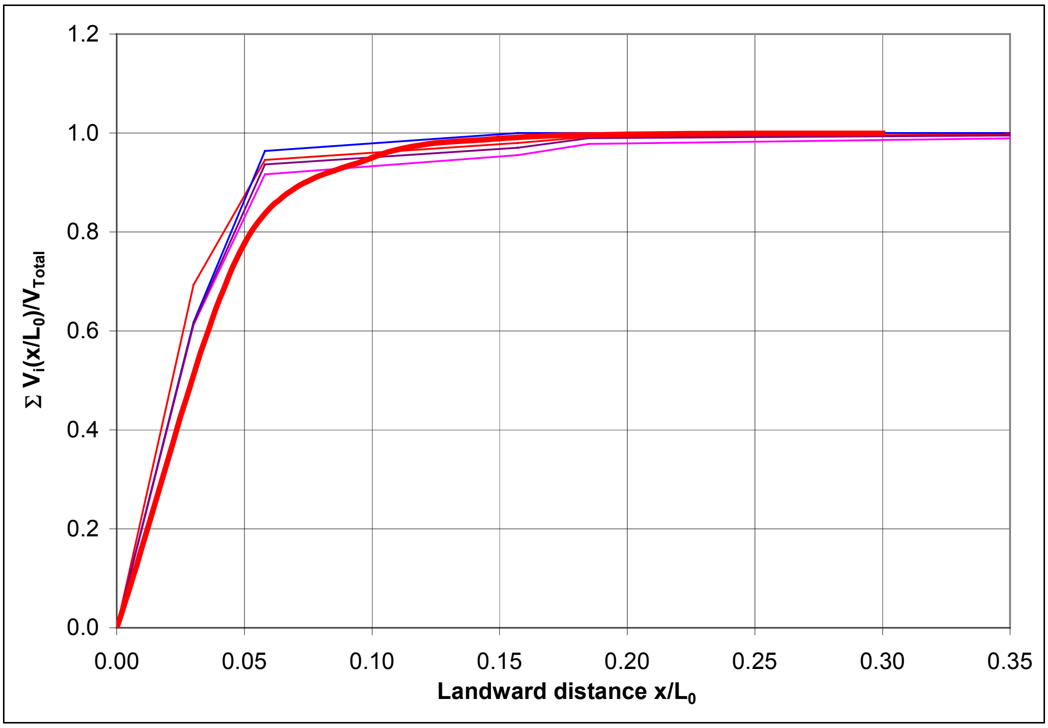

Figure 48: Spatial distribution 1 May 2003 field results

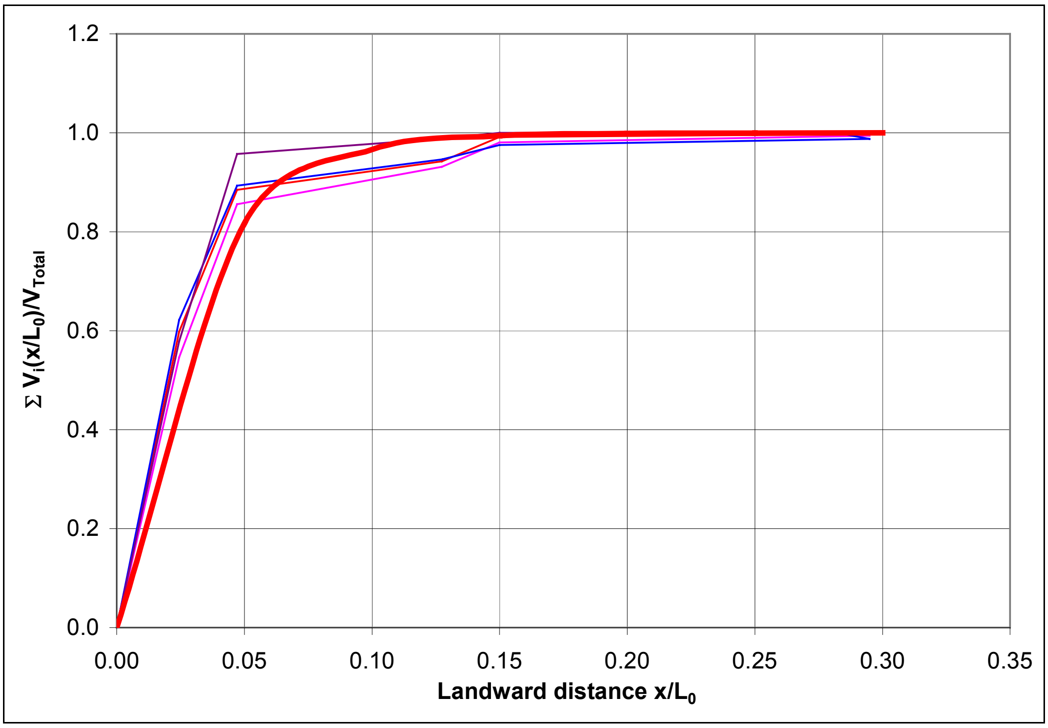

Figure 49: Spatial distribution 2 May 2003 field results

6.3 CONCLUDING REMARKS

Wave overtopping has been measured successfully at the Samphire Hoe field measurement site. The results are in agreement with the empirical prediction method for a composite vertical wall by Besley (1999).

The spatial distribution of the overtopping has been established, and this shows how the wind can affect the measurements and the distribution. Generally, the majority of the discharge will fall in the area directly behind the parapet wall and over a distance of approximately x/L_o.

7. Acknowledgements

This report has been prepared by Dr Tim Pullen of the Coastal Structures Group at HRW, who is the Project Engineer responsible for designing, building and operating the field measurements under the supervision of Prof. William Allsop. The cooperation of Eurotunnel and the White Cliffs Countryside Project is gratefully acknowledged. Dr. Stephen Richardson and John Alderson were present during the field measurements. Filippo Melis assisted in the design of the tanks, and Ian Payne & John Collins helped to devise the logging system. The design of these measurements also benefited from discussions with fieldwork colleagues within CLASH, particularly Tom Bruce, Jimmy Geeraerts, Dr John Pearson and Dr Peter Troch.

The support of the European Community Fifth Framework under Project Code EVK3-CT-2001-00058 and Defra / EA under Project Code FD2412, is also gratefully acknowledged.

8. References

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Appendices

Appendix A   Field Equipment

Samphire Hoe Field Equipment:
On the suitability of the various measurement devices as proposed in the description of work

Volumetric Tanks

Contract: *At Samphire Hoe, overtopping volumes will be captured by volumetric tanks formed by rapidly deployed fabric walls developed for emergency flood relief. A series of tanks progressively farther back from the seawall edge will identify spatial effects on the overtopping, important in identifying potential hazards.*

The original contract stated that the volumetric tanks would be "formed by rapidly deployed fabric walls developed for flood relief." During the detailed design of the volumetric tanks it was very soon realised that this approach was highly impractical, and would not work for the following reasons:

1) The design of the flood barriers requires that they be bolted to the ground in several places, more than was allowable at the Samphire Hoe site, and virtually impossible on the steeply sloping regions at the rear of the promenade.
2) There was no obvious method for determining either the total or individual overtopping volumes with reasonable accuracy.
3) Draining the tanks during storms would not be possible.
4) Leakage rates from the tanks during deployment would have been entirely random and would have varied on each deployment. No allowance for this would have been possible during the subsequent analysis.
5) Any wave with a sufficiently large individual overtopping volume would have caused the tanks to collapse during the impact.

Once it was realised that the flood relief barrier design was not possible, considerable additional resources were required to design, build, equip, calibrate and deploy improved volumetric tests. This improved design gave greater detail and accuracy to the results obtained, resulting in a far superior level of analysis for the storms than it had been possible to hope for during the original proposal. This was a significant improvement on the original concept, providing the project with far superior data than that described in the Description of Work (DoW).

Simple Overtopping Event Probes

Contract: *Overtopping events will be detected using simple overtopping event probes, adapted from those used routinely in the laboratory, and by a specialist "Overtopping, throw, velocity and trajectory detector" developed by UEDIN.*

These devices were deployed on the volumetric tanks to detect each individual overtopping event. The intention was that these data would assist in the analysis of the wave-by-wave overtopping volumes.

Unfortunately these devices did not operate according to their design. They had worked perfectly well in the laboratory when tested with seawater, but when deployed in the field they remained in the digital on position (1). All this data was effectively useless. As a result considerable resources had to be diverted to analyse the data to extract both the individual overtopping volumes and the distribution of the overtopping. In summary, this piece of equipment did not work, but the project did not lose this data because the additional work involved in the analysis provided the required information.

Overtopping Throw Velocity and Trajectory Detector

Contract: Overtopping events will be detected using simple overtopping event probes, adapted from those used routinely in the laboratory, and by a specialist "Overtopping, throw, velocity and trajectory detector" developed by UEDIN. This device has already been tested at large scale in large wave flume experiments (spring 2001). The overtopping throw / velocity detector identifies the position and velocity of the leading edge of the water plume as it passes landward over the seawall crest.

The original device developed by UEDIN was intended to be redesigned so that it could be deployed at Samphire Hoe. The prototype version of this was being tested at the time the details of the proposal were being finalised, and at that time it was anticipated that it would be suitable for the field measurements. Since that time a number of issues arose which complicated the possibility of its being used.

1) The software developed to analyse the path of the overtopping plume / jet across the devise was only able to establish a very coarse representation of the velocities and the trajectory of the jet. The VOWS team were never entirely satisfied with the operation of this device.
2) Scale model versions of the Overtopping Throw Velocity and Trajectory Detector (OTD) intended for use at Samphire Hoe performed badly when used for the 3d model tests for VOWS and SHADOW. Several modifications were tried, but detection at the probes was inconsistent and the overall quality of the collected data was poor.
3) Investigations into improving the effectiveness of the detectors did not result in a design that would guarantee their reliable performance when deployed in the field.
4) An OTD with a large array of individual detectors (64), as used in Barcelona, would have been needed to detect the full shape and direction of the overtopping plume / jet. This type of array would have been extremely difficult to install and secure in the field, and would have been highly hazardous to HRW staff and members of the public.
5) The storage capacity of the dataLogger used was 64MbStorage, and it was not possible to record sufficient quantities of quality data for the reason given in d) below: Assume distance between event probes is 0.25m
    a) Assume maximum velocity to record is 10 x max celerity (≈100m/s)
    b) Therefore sampling frequency is 100 / 0.25 = 400Hz
    c) Assume 200bytes/sample for 4Hrs = 1.1Gb storage required
6) There were numerous technical difficulties involved in attempting to set up the dataLogger to record both the overtopping and the any data that might come from the OTD. Since the principal objective was to record the overtopping volumes, the operation of the dataLogger was therefore biased towards achieving this successfully.

There were simply too many technical complications in attempting to deploy this equipment. It would have diverted significant resources, and there was only a small chance of recording any quality data.

Video Records of Overtopping

Contract: *These measurements will be supported / confirmed by video records of overtopping at the measurement tanks to give visual observations of overtopping events.*

Video records were made of all of the storms.

Spray Curtain

Contract: *Farther back from the seawall edge, an additional device (or devices) will be deployed to capture and measure spray. At the rear of the promenade deck, a spray curtain will be mounted on a robust tubular frame. The curtain itself may be formed by a mesh of small diameter holes (2mm has been found effective in Japan), or an array of hanging plastic strips (as used to close off open warehouse doors). Water captured by these devices will be collected and measured over each sample period.*

It states in Section 3.1 and 3.2 of the Workpackage 1 in the General Methodology Report final version CLA127/165 that all the equipment deployed at Samphire Hoe would need to be approved by Eurotunnel Developments Ltd (EDL) and the White Cliffs Countryside Project (WCCP). This point has been made on a number of occasions during presentations and in other documents, and it was always discussed as a prime requisite for the Samphire Hoe field measurements.

Once EDL and WCCP were aware of the detailed and proposed design of the Spray Curtain, they refused permission for it to be deployed at Samphire Hoe.

Appendix B Field Measurement Method Statement

Procedure	Method	Additional Notes
Installation of the overtopping equipment		
Accessing the site and parking the van	The HR staff will put on their personal protective equipment on arrival and then drive down the access road at the base of the cliffs and park at the measurement site. Parking and manoeuvring will be supervised.	This is also covered in the attached risk assessment.
Site survey and familiarisation for staff	Once the van has been parked the HR staff will observe their working environment and make themselves aware of the presence of members of the public and their free access to the site.	
Positioning of the information board	An information board outlining the work that is taking place, and including details of where additional information can be found, will be placed in a suitable position where it can be viewed by members of the public.	
Removal of the securing bolts from the anchor points	All of the relevant securing bolts will be removed from the anchor points and cleaned in preparation for receiving the tanks.	If for any reason the anchor points have been compromised and are not usable then deployment of the tanks will have to be abandoned.
Unloading the overtopping tanks from the van	The 6 (3 units divided into two halves) overtopping tanks will be removed from the van one at a time. Each tank will be moved into position and the support brackets will be attached.	
Fixing the tanks into position	The overtopping tanks will be secured into position by bolting to the anchor points. All tools and equipment used specifically for this operation will then be returned to the van.	
Fixing the support bracket to the parapet wall	The support bracket for the control box will be removed and attached to the parapet wall using heavy duty high tension security straps.	
Fixing the control box to the wall bracket	The control box is self contained and can be securely fastened to the four bolts on the support bracket.	
Attachment of the pressure transducers and overtopping detectors	Twelve pieces of low voltage / current electronic equipment are hardwired into the control box, and two pieces are required for each of the six tanks. Starting with tank 6 (the one farthest from the parapet wall) detector 6 and pressure transducer 6 will be uncoiled and attached to the tank. The same procedure will then be repeated for tanks 5 to 1.	

Procedure	Method	Additional Notes
Securing the cables.	Starting at tank 6 the cables will be secured to the tanks and the tank brackets at pre-prepared connecting points, and all the slack will be removed working back towards the control box. At the control box sufficient allowance has been made for coiling and securing the excess cable. Between tanks 5 & 4 and 3 & 2 the cables will be secured in cable protectors which will be clearly visible and marked with yellow hazard stripes.	
Wave and water level detector	In addition to the twelve pieces of electronic equipment for the tanks, a further pressure transducer will be lowered in front of the seawall (to the sea bed) so that the wave and water levels can be measured.	Details on the exact nature of the deployment of this equipment have yet to be finalised. To be discussed on arrival, before final decision to deploy is made.
Final inspection and securing site	When all the cables have been tidied and secured all tools and additional fixings can be returned to the van. The deployment of the equipment will have been completed and a final site inspection can be made	
After site is secured.	Depending on the time of day two different scenarios are imagined. If there is still sufficient daylight hours left, one member of the team will leave site with the van and check into our hotel. While the two remaining members man the site taking the opportunity to make notes / measurements / photographs of the equipment and site. Alternatively, the van will be removed to the designated parking area and the remaining daylight hours will be used as described above. In any event, the equipment / site will be monitored at all times during daylight hours while members of the public are likely to be around.	

Procedure	Method	Additional Notes
Data Collection		
Arrival on site	HR staff will arrive on site at daybreak so that the equipment is not left unattended during daylight hours. If members of the public are in the vicinity and the hazard warning flags are not flying, the a member of HR staff will attend the equipment.	
Accessing the site and parking the van	The HR staff will put on their personal protective equipment on arrival and then drive down the access road to the parking area and secure the site. Parking and manoeuvring will be supervised.	
Site survey and appraisal	Once the van has been parked the HR staff will make final adjustments / decisions based on the current weather and phase of the tidal cycle. If waves are not overtopping then the equipment will be inspected / adjusted prior to any anticipated event.	
Start of overtopping waves	The measurement equipment has been specifically designed to ensure that there is no need to approach the immediate measurement site during overtopping conditions. The equipment can be operated remotely from the van via radio telemetry, and will be turned on from the laptop in the van.	
Visual monitoring of overtopping	During overtopping the measurements will be observed from the top of the revetment above the recurve wall whilst it is safe to remain there, so that visual observations can be recorded. A video camera mounted on a tripod will be in constant operation at the observation point. Should an extreme storm occur, all members of the team will remain in the van.	
Inspection / maintenance of the equipment	The equipment has yet to be field tested, and it may be desirable to inspect and perform minor repairs or adjustment to the equipment. It is recognised that during the tidal cycle there are periods when overtopping will cease or be reduced to insignificant / zero volumes. The measurement team are able to predict the various overtopping phases of the tidal cycle using recently developed analysis techniques, and so it will be possible to identify periods when it is safe to approach the measuring equipment. The equipment will not be approached unless it is the judgement of all members of the team that overtopping has been reduced to insignificant (minor spray) / zero volumes.	

Procedure	Method	Additional Notes
After overtopping / end of daylight hours	Once the overtopping has subsided the equipment will be either dismantled if there is sufficient daylight left. Or the site will be manned until the end of the day before leaving site. If additional overtopping is expected the following day, then the team will return the following morning.	
Clear up, site inspection and securing the site.	Following the installation of all the bolt anchors the site will be inspected for debris and loose items and made safe and clean. All items that have note been previously placed back in the van will be cleared up. A final check will secure the site.	

Procedure	Method	Additional Notes
Removal of the overtopping equipment		
Site survey and familiarisation for staff	The van will be parked next to the parapet wall adjacent to the measurement site in preparation for the removal of the equipment. HR staff will make themselves aware of the presence of members of the public.	
Removal of pressure transducers and overtopping detectors	The pressure transducers and the overtopping detectors will be removed in the reverse order from the installation. That is, the wave and water level transducer will be removed and coiled up and then tank transducers 1 to 6 along with overtopping detectors 1 to 6.	
Removal of the overtopping tanks	Next the overtopping tanks will be unbolted from the seawall and the brackets removed. The tanks will then be loaded into the van along with the brackets.	
Replacement of security bolts	Following removal of the overtopping tanks the security bolts will be placed back into the anchors in the seawall promenade.	
Removal of the control box	The control box will be removed from the support bracket and placed in the van.	
Removal of the control box support bracket	The support bracket for the control box will be removed from the parapet wall and placed in to the van	
Securing the site	When the equipment has been loaded into the van the site will be checked for loose items and preparations will be made to leave the site	
Departure	Following securing the site the HR staff will guide the van off site and prepare to leave. Before exiting the HR staff will report to the security guards.	
NB: It is anticipated that some of the above procedures may happen concurrently, or will need to be revised as the work progresses.		

Appendix C   Health & Safety

CONTROL SHEET SAFETY MANAGEMENT 4:
RECORD OF COMPETENT PERSONS

Company name HR Wallingford

Name Dr Stephen Richardson | **Position** Scientist

Date appointed as competent person 17 February 2003

Areas of responsibility

All field measurement team members have collective responsibility and understand fully the requirements, limitations and potential hazards involved with these field measurements. Dr Stephen Richardson is professionally qualified with a relevant degree, and has specialist expert knowledge of violent wave overtopping.

Duties explained Yes

Skills and abilities required	**Yes**	**No**	**N/A**
Authority sufficient to carry out tasks?	☒	☐	☐
Principles of risk assessment and prevention understood?	☒	☐	☐
Knowledge of work activities sufficient?	☒	☐	☐
Technical knowledge sufficient?	☒	☐	☐
Communication skills adequate?	☒	☐	☐
Training skills adequate?	☐	☐	☒
Able to develop plans and strategies?	☐	☐	☒
Aware of own limitations?	☐	☐	☒

Training required

None

Date received

I am competent to carry out the work described in this document and my duties have been explained fully. I further declare that I have read, understood and will observe the procedures outlined in this document.

Signature | **Name** Dr Stephen Richardson

I believe that the person named above is competent to assist the employer in the duties listed above.

Signature | **Position** Project Engineer

CONTROL SHEET SAFETY MANAGEMENT 4:
RECORD OF COMPETENT PERSONS

Company name HR Wallingford			
Name John Alderson	**Position** Engineer		
Date appointed as competent person 17 February 2003			
Areas of responsibility All field measurement team members have collective responsibility and understand fully the requirements, limitations and potential hazards involved with these field measurements. John Alderson is professionally qualified with a relevant degree, and has specialist expert knowledge of violent wave overtopping.			**Duties explained** Yes
Skills and abilities required	**Yes**	**No**	**N/A**
Authority sufficient to carry out tasks?	☒	☐	☐
Principles of risk assessment and prevention understood?	☒	☐	☐
Knowledge of work activities sufficient?	☒	☐	☐
Technical knowledge sufficient?	☒	☐	☐
Communication skills adequate?	☒	☐	☐
Training skills adequate?	☐	☐	☒
Able to develop plans and strategies?	☐	☐	☒
Aware of own limitations?	☐	☐	☒
Training required None			**Date received**
I am competent to carry out the work described in this document and my duties have been explained fully. I further declare that I have read, understood and will observe the procedures outlined in this document.			
Signature	**Name** John Alderson		
I believe that the person named above is competent to assist the employer in the duties listed above.			
Signature	**Position** Project Engineer		

HAZARD IDENTIFICATION SHEET

Company name HR Wallingford			
Assessor Dr Tim Pullen		**Date** 17/02/03	**Ref nos**
Work activity Samphire Hoe wave overtopping data collection.		**Location** Samphire Hoe Seawall	
Persons affected HR Wallingford engineers and scientists directly involved with the operation at Samphire Hoe. Members of the public.			

Hazards present		**Comments**	**Assessment required**
Electrical	☐		
Work equipment	☒	Portable hand tools	No
Electrical maintenance	☐		
Equipment maintenance	☐		
Pressure systems	☐		
Harmful substances	☐		*
Noise / vibration	☐		*
Mechanical handling	☐		
Manual handling	☒	Lifting tanks from van and into position	Yes *
Storage of articles or substances	☐		
Working environment	☒	Near to sea and exposed to weather and public have access	Yes
Slips, trips and falls	☒	Carrying heavy objects over roughened surfaces	Yes
Workplace structure and layout	☐		
Access and egress	☒	Access road is unmetalled	Yes
Non-employees	☒	Public access to work area	Yes
Fire	☐		*
Violence	☒	Possible but unlikely	No
Systems of work	☒	1: Installation and removal of equipment 2: Data collection	Yes Yes
Construction work	☐		
Working at height	☐		

Display screen equipment ☐		*
Other hazards		
Refer to specific assessment control sheets for those marked *		

CONTROL SHEET MANUAL HANDLING AND ERGONOMICS 2:
MANUAL HANDLING OPERATIONS: PRELIMINARY ASSESSMENT

Company name HR Wallingford	
Assessor **Dr Tim Pullen** **Position** Project Engineer	Ref no
Operation Assessed: Moving and positioning overtopping tanks	**Date** 17/02/03
Assessment type **Single** X **Generic** ☐	

Preliminary assessment checklist	**Yes**	**No**
Are any of the lifting and lowering guideline figures exceeded? (adjust to take account of twisting and frequent lifting and lowering if applicable).	X	
Is the load difficult to grasp with both hands, eg due to its bulk or instability?		X
Is poor posture involved, eg stooping, leaning sideways, bending from the waist or hips?		X
Are there any adverse environmental conditions, eg too hot or cold, slippery floor, poor lighting, etc?	X	
Is the load carried further than 10 metres without rest?		X
Is the load held away from the body whilst being carried?		X
Are any of the pushing and pulling guideline figures exceeded?		X
Does any of the pushing or pulling occur with the hands above shoulder height or below knuckle height?		X
Are the guideline figures for handling whilst seated exceeded?		X
Is the load lifted from below the handler's lap or above shoulder height whilst seated?		X

Conclusion	**Yes**	**No**
Full assessment needed?	X	
Signature of assessor		

CONTROL SHEET MANUAL HANDLING AND ERGONOMICS 3:

MANUAL HANDLING OPERATIONS: FULL ASSESSMENT

Part A: Background Information

Company name HR Wallingford		
Assessor Dr Tim Pullen **Position** Project Engineer	**Date of assessment** 17/02/03	**Ref no**

Operation assessed Moving and positioning overtopping tanks.

Assessment type
- **Single** ☒
- **Generic** ☐

Location of operation
Samphire Hoe seawall

Names of individuals assessed
Dr Tim Pullen, John Alderson and Dr Stephen Richardson

Description of operation assessed
A large overtopping tank will need to be moved from the van into position. This should not involve moving over large distances as the van will be close to the mounting point. The tank is bulky but three people can handle it comfortably.

CONTROL SHEET MANUAL HANDLING AND ERGONOMICS 3: (continued)

Part B: Assessment Checklist

Risk factors		Yes	Comments
1. Task	Does the task involve:		
1.1	Holding the load at a distance from the trunk? approximate distance	☐	
1.2	Twisting the trunk? degree of twist	☐	
1.3	Poor posture, eg stooping, leaning sideways, bending from the waist or hips? describe	☒	See below.
1.4	Excessive lifting or lowering distances? length through which load lifted or lowered	☐	
1.5	Long carrying distances? distances load carried	☐	
1.6	Strenuous pushing or pulling of the load? details of starting or stopping forces, and continuous forces involved	☐	
1.7	A risk of sudden movement of load? nature of movement	☐	
1.8	Frequent or prolonged physical effort? frequency of operation or total duration of operation	☐	
1.9	Insufficient rest or recovery periods? current arrangements	☐	
1.10	Performance of the same task continuously throughout working day?	☐	
1.11	Handling whilst seated? weights involved	☐	
1.12	Use of clothing or ppe which prevents easy movement?	☐	

Risk factors		Yes	Comments
Load Is the load:			
2.1	Heavy? weight	☒	See below
2.2	Bulky, awkward or difficult to grasp? approximate dimensions	☒	See below
2.3	Unstable, or with contents likely to shift? nature of instability	☐	
2.4	Hazardous, eg sharp, hot, cold etc nature of identified hazard/s	☐	
2.5	Greasy, wet, slippery? describe origin of problem	☐	
2.6	Likely to obstruct the handler's vision?	☐	
2.7	Do any manufacturers instructions or special conditions apply (eg fragile)?	☐	
3. Working environment Are there:			
3.1	Space constraints preventing good posture? describe	☐	
3.2	Uneven, slippery or unstable floors? describe	☒	See below
3.3	Changes in the work level to be negotiated whilst handling the load? describe	☒	See below
3.4	Any obstacles or hazards to be negotiated? describe	☐	
3.5	Extremes of temperature, humidity, air movement? provide readings	☐	
3.6	Poor lighting conditions? provide readings	☐	
3.7	Any problems caused by other environmental conditions? describe problems	☐	

Risk factors		Yes	Comments
4. Individual capability Does the activity:			
4.1	Require above average strength or fitness? names of handlers not meeting these requirements	☐	
4.2	Put at risk those who may be pregnant or have a health problem? names of handlers at risk	☐	
4.3	Require training for its safe performance? names (or job titles) of handlers requiring training	☐	
4.4	Require any special training for its safe performance, eg how to assess the weight of an unmarked load? names (or job titles) of handlers requiring training	☐	

CONTROL SHEET MANUAL HANDLING AND ERGONOMICS 3 (continued)

Part C: Assessment Summary

Questions ticked 'yes'	Corrective action required?	Action needed (describe)	Date implemented	Signature
1.3	No	Part of the lifting and moving operation will require short movements as the tanks are positioned that may cause poor posture. This should only occur as the tank is removed from the van and should therefore not cause a significant problem.		
2.1	No	75kg. Three people handing the tank brings it within acceptable load limits.		
2.2	No	2500x500x500mm. See 1.3 above also. The tank is a large object which by virtue of its size and shape requires additional concentration during moving operations.		
3.2	No	Seawall concrete surface is not smooth and level. Additional concentration will be required during moving operations to compensate for the surface.		
3.3	No	Low level changes in work area need to be negotiated when tank is moved to new position.		
Risk rating score = 1x2x5=10				

CONTROL SHEET RISK 2:

WORKING ENVIRONMENT RISK ASSESSMENT

Company name HR Wallingford		
Assessor Dr Tim Pullen	**Date** 17/02/03	**Ref no**

Work activity assessed Working environment

Persons at risk HR Wallingford engineers and technicians. Members of the public.	**Persons especially at risk**
Hazards identified	**Problems identified**
Exposure to weather Exposure to sea Danger to public (see attached risk assessment)	The work area is some distance away from a telephone or any shelter other than the van. Minor injuries to HR staff are possible.

Current control measures
HR staff are aware of the nature of the work and are equipped with personal protective equipment. Three specialist engineers/scientists will be onsite who understand and can anticipate any potential dangers posed by the sea. The danger to the public is addressed in the attached risk assessment.

Hierarchy of control measures followed None. Safe systems of work need to be observed.

Specific legislative requirements applicable
Workplace (Health, Safety and Welfare) Regulations 1992

ASSESSMENT OF RISK

	Risk Rating Score			
Hazard	**Numbers**	**Severity**	**Likelihood**	**Risk rating**
Minor injuries	1	2	5	10
Falling over the parapet wall into the sea	1	10	0.5	5

Summary of risks
Risk is low. Safe systems of work need to be observed

Control measures required	**Completed**	**Date**
Minor injuries: A first aid kit will be available should it be required. Mobile phones will be available to call for help if required. Three members of HR staff will be present so that one can go for assistance if required. **Falling into the sea:** There is no requirement for HR staff to put themselves into a situation where this situation may occur.		
Health surveillance required None		
Review date This will be reviewed after the first field data collection exercise, and will be updated if required.		

CONTROL SHEET RISK 2:

SLIPS AND TRIPS RISK ASSESSMENT

Company name HR Wallingford				
Assessor Dr Tim Pullen			**Date** 17/02/03	**Ref no**
Work activity assessed Slips and trips				
Persons at risk HR Wallingford engineers and technicians.		**Persons especially at risk**		
Hazards identified		**Problems identified**		
Steps and roughened surfaces on seawall promenade				
Current control measures Move carefully and slowly over the stepped steps. Safety boots.				
Hierarchy of control measures followed				
Specific legislative requirements applicable Workplace (Health, Safety and Welfare) Regulations 1992				
ASSESSMENT OF RISK				
	Risk Rating Score			
Hazard	**Numbers**	**Severity**	**Likelihood**	**Risk rating**
Tripping while moving the overtopping tank over the steps	1	2	5	10
Summary of risks Risk is low. Safe systems of work need to be observed.				
Control measures required			**Completed**	**Date**
Move the tanks slowly, with agreed signals and with a prearranged method.				
Health surveillance required None				
Review date Following installation of the bolts, no difficulty was encountered during the moving of the tanks. An updated review will be required if winds are experienced during the data collection installation.				

CONTROL SHEET RISK 2:

ACCESS AND EGRESS RISK ASSESSMENT

Company name HR Wallingford		
Assessor Dr Tim Pullen	**Date** 17/02/03	**Ref no**
Work activity assessed Access and egress.		

Persons at risk HR Wallingford engineers / scientists. Members of the public.	**Persons especially at risk**
Hazards identified	**Problems identified**
Access road. Manoeuvring and parking on site	

Current control measures
Sensible and slow driving with consideration for the load in the van.

Hierarchy of control measures followed
None. Safe systems of work need to be observed.

Specific legislative requirements applicable
Workplace (Health, Safety and Welfare) Regulations 1992

ASSESSMENT OF RISK

	Risk Rating Score			
Hazard	**Numbers**	**Severity**	**Likelihood**	**Risk rating**
Driving on the rear access road	1	1	20	20
Manoeuvring the vehicle on site	1	1	20	20
Parking	1	1	20	20

Summary of risks
Risk is medium. Safe driving will need to be observed at all times to reduce the risk.

Control measures required	**Completed**	**Date**

Driving on rear access road: Restrict speed to a maximum of 5mph and with consideration for the fact that the road is steep in places and is unmetalled. **Manoeuvring the vehicle on site:** This will only be done with the assistance of HR staff outside of the vehicle and will be brought to a halt if members of the public are in close proximity. **Parking/Unloading:** This will only be done with the assistance of HR staff outside of the vehicle and will be brought to a halt if members of the public are in close proximity. The vehicle will be parked adjacent to the parapet wall with consideration for public access and will remain stationary unless this is unavoidable. The vehicle will be moved when the installation is complete. **Parking:** This will only be done with the assistance of HR staff outside of the vehicle and will be brought to a halt if members of the public are in close proximity. The vehicle will be parked in the parking bay adjacent to the access road and will remain stationary unless this is unavoidable.		
Health surveillance required None		
Review date These procedures will be reviewed and modified as required for subsequent field measurement trips.		

CONTROL SHEET RISK 2:

NON-EMPLOYEES RISK ASSESSMENT

Company name HR Wallingford		
Assessor Dr Tim Pullen	**Date** 17/02/03	**Ref no**

Work activity assessed Non Employees

Persons at risk Members of the public.	**Persons especially at risk**

Hazards identified	**Problems identified**
Injury to public	Members of the public approaching the work area Clear unobstructed access through and around the work area for members of the public

Current control measures
Be aware of members of the public and approach them and warn them of the potential hazards should they come near to the work area

Hierarchy of control measures followed
None. Safe methods of work need to be established

Specific legislative requirements applicable
Management of Health and Safety at Work Regulations 1999.

ASSESSMENT OF RISK

	Risk Rating Score			
Hazard	**Numbers**	**Severity**	**Likelihood**	**Risk rating**
Obstructions to public	2	1	10	20
Potential trip hazards and loose unattended items	2	2	10	40
Trailing cables	2	2	10	40
Enquiries by members of the public	2	1	20	40

Summary of risks
Risk is medium: There is potential risk to members of the public at all times during the work operation, and action is required to control the risk.

Control measures required	**Completed**	**Date**
Obstruction to public: The van will be kept close to the parapet wall with clear access around one side during installation. Equipment not in use or not required for data collection shall be kept in the		

<table>
<tr><td>van. The positioning of the equipment has been so arranged so as to allow clear access past and around for wheelchairs and emergency vehicles at all times. The overtopping tanks will be attended by a member of HR staff during daylight hours except during hazardous periods.

Potential trip hazards and loose unattended items: All loose non essential items will be placed in the van when they are not required.

Trailing cables: Cables will be sleeved inside cable protectors between the overtopping tanks and these will be clearly visible.

Enquiries by members of the public: It is anticipated that members of the public will approach HR staff regularly during the work. An information board outlining the project will be placed adjacent to the work area. HR staff will approach members of the public before they enter the work area and provide basic information when asked. HR staff will warn members of the public of the potential hazards involved by approaching the overtopping equipment and discourage then from approaching too closely.</td><td></td><td></td></tr>
<tr><td colspan="3">Health surveillance required
None</td></tr>
<tr><td colspan="3">Review date During the installation there were very few enquiries made by members of the public, and the general behaviour was a casual glance and an avoidance of the immediate working area. This will be reviewed after the first data collection exercise, and will be based on experienced gained during this phase of the work.</td></tr>
</table>

CONTROL SHEET RISK 2:

INSTALLATION AND REMOVAL RISK ASSESSMENT

Company name HR Wallingford		
Assessor Dr Tim Pullen	**Date** 17/02/03	**Ref no**
Work activity assessed Systems of Work: Installation and removal of equipment		

Persons at risk HR Wallingford Engineers / scientists. Members of the public.	**Persons especially at risk**
Hazards identified	**Problems identified**
Manual handling (see attached risk assessment) Slips and trips (see attached risk assessment) Danger to public (see attached risk assessment) Weather conditions affecting installation	Possible lack of time (daylight) for securing measurement site safely

Current control measures
Two members of the field measurement team have visited the site previously to install the anchor bolts. The experienced gained then will be utilised during the installation of the measurement equipment.

Hierarchy of control measures followed None. Safe methods of work need to be established.

Specific legislative requirements applicable
Workplace (Health, Safety and Welfare) Regulations 1992

Management of Health and Safety at Work Regulations 1999.

ASSESSMENT OF RISK

	Risk Rating Score			
Hazard	**Numbers**	**Severity**	**Likelihood**	**Risk rating**
Weather conditions affecting installation	1	1	5	5
Lack of time for securing measurement site	2	2	5	20

Summary of risks

<table>
<tr><td colspan="3">Some risk is low. Safe systems of work need to be observed.
Some risk is medium. Action required to control risk.</td></tr>
<tr><td>Control measures required</td><td>Completed</td><td>Date</td></tr>
<tr><td>Weather conditions affecting installation A sudden change in weather conditions may have to halt the installation of the equipment. The HR Wallingford staff will interpret all suitable forecasts before leaving for Samphire Hoe, and be in contact with support staff members at HR Wallingford whilst off the premises. A full review of the likely weather conditions will ascertain the likelihood of adverse conditions affecting the installation before this operation is started
Lack of time for securing measurement site It is recognised that the total time for installing the equipment will not be known until after the first full installation. It has been decided to limit the number of pieces of equipment on the first visit, and therefore the complexity of the operation, to a minimum. The procedures for installation are outlined in the Method Statement which is attached to this document, and are known to all members of the measurement team. Installation will only take place if it is anticipated that the work can be completed in the time available.</td><td></td><td></td></tr>
<tr><td colspan="3">Health surveillance required
None</td></tr>
<tr><td colspan="3">Review date This will be reviewed after the first data collection exercise, and will be based on experienced gained during this phase of the work.</td></tr>
</table>

CONTROL SHEET RISK 2:

DATA COLLECTION RISK ASSESSMENT

Company name HR Wallingford		
Assessor Dr Tim Pullen	**Date** 17/02/03	**Ref no**

Work activity assessed Systems of Work: Data Collection

Persons at risk	**Persons especially at risk**
HR Wallingford Engineers / scientists.	

Hazards identified	**Problems identified**
Exposure to severe overtopping waves	

Current control measures
All members of the field measurement team have specialist knowledge of wave overtopping, its cause and the conditions that affect overtopping. In particular, they able to determine the types of overtopping that might be expected from a brief appraisal of the conditions. They will be fully aware of when it is hazardous to approach the seawall.

Hierarchy of control measures followed None. Safe methods of work need to be established.

Specific legislative requirements applicable
Workplace (Health, Safety and Welfare) Regulations 1992

Management of Health and Safety at Work Regulations 1999.

ASSESSMENT OF RISK

Hazard	**Risk Rating Score**			
	Numbers	**Severity**	**Likelihood**	**Risk rating**
Exposure to severe overtopping waves	1	2	10	20

Summary of risks
Risk is medium. Action required to control risk.

Control measures required	**Completed**	**Date**
Exposure to severe overtopping waves Whilst it is recognised that members of the team are fully apprised of the working conditions, the nature of the work is clearly potentially hazardous. During overtopping the measurements will be observed from the top of the		

revetment above the recurve wall whilst it is safe to remain there, so that visual observations can be recorded. Should an extreme storm occur, all members of the team will remain in the van. The measurement equipment has been specifically designed to ensure that there is no need to approach the immediate measurement site during severe overtopping conditions. The equipment can monitor overtopping unattended continuously for periods of approximately 36hrs. The logged data will be monitored and downloaded from the safety of the van via radio telemetry. There is no particular necessity to approach the equipment from the time that it is installed until it is time to remove it. Nevertheless, the equipment has yet to be field tested, and it may be desirable to inspect and perform minor repairs or adjustment to the equipment. It is recognised that during the tidal cycle there are periods when overtopping will cease or be reduced to insignificant / zero volumes. The measurement team are able to predict the various overtopping phases of the tidal cycle using recently developed analysis techniques, and so it will be possible to identify periods when it is safe to approach the measuring equipment. The equipment will not be approached unless it is the judgement of all members of the team that overtopping has been reduced to insignificant (minor spray) / zero volumes. Since all members of the team understand the potential risks, then they will be aware of them at all times and so it is understood that this is also a control measure for the hazard.		
Health surveillance required None		
Review date This will be reviewed after the first data collection exercise, and will be based on experienced gained during this phase of the work.		

CONTROL SHEET PERSONAL PROTECTIVE EQUIPMENT 1:
PPE ASSESSMENT

Company name HR Wallingford			
Assessor: **Name** Dr Tim Pullen **Position** Project Engineer	**Date of Assessment** 17/02/03	**Reference No**	**Work Activity** Data collection at Samphire Hoe

Nature of hazard	**Part(s) of the body at risk**	**Characteristics required of PPE**	**Possible additional risks created by PPE**	**PPE chosen**	**Suitability requirements satisfied? ***
Exposure to weather	All	To keep personnel warm and dry	None identified	All weather jackets and trousers	Yes
Handling overtopping equipment	Hands and feet	Protect hands from cuts and feet from falling objects	None identified	Gloves and steel toe capped safety footwear	Yes
Wind blown flying debris	Head	Protect head	None identified	Safety helmet	Yes
Suitability requirements are: 1 effective in control of risk; 2 appropriate for conditions of use; 3 CE marked; 4 fit ok; 5 ergonomics ok; 6 compatibility ok; 7 additional risk adequately controlled; 8 employees consulted					
Comments					

CONTROL SHEET PERSONAL PROTECTIVE EQUIPMENT 4: PPE ISSUE RECORD

Company name			
Employee	**Type(s) of PPE issued**	**Date**	**Employee signature**
Dr Tim Pullen	High visibility all-weather jacket High visibility all-weather trousers Steel toe capped safety boots Leather gloves Safety helmet	30/04/03	
John Alderson	High visibility all-weather jacket High visibility all-weather trousers Steel toe capped safety boots Leather gloves Safety helmet	30/04/03	
Dr Stephen Richardson	High visibility all-weather jacket High visibility all-weather trousers Steel toe capped safety boots Leather gloves Safety helmet	30/04/03	

CONTROL SHEET SAFETY MANAGEMENT 5:
EMERGENCY PROCEDURE GUIDE

Company name HR Wallingford	
Emergency situation Injuries or severe weather conditions	
Signal for evacuation Since the team is small and will be in constant contact with each other the decision to evacuate will be clear and determined by any situation that presents itself.	
Evacuation procedure If all members of the team are able to enter the van unaided then all the equipment will be left and the team will retire and report to the security guards. In case of injury requiring special attention, one member of the team, if unable to alert the emergency services or the security guards, will evacuate and report the situation to the security guards. The remaining member of the team will attend the injured party.	
Emergency gathering points The van in the first instance, and then the security compound following that.	
Competent persons	**Specific responsibilities**
All members of the team are considered to be competent.	All members of the team will be responsible for their own safety and the collective safety of the team. Specific action / tasks will be determined by the nature of any situation.
Procedure for re-occupation of the workplace Following an evacuation due to extreme weather conditions, the team will return to the site when it is safe so that the equipment can be removed. In the event that a team member is unable to assist in the removal of the equipment, additional HR Wallingford staff are on standby to travel to Samphire Hoe to assist.	

Emergency equipment	**Telephone nos**	**Fax nos**
First aid kit Mobile telephones 1,000,000 candle light torch	Bev 01491 822206 Security guard No CONFIRM 999	

Person devising procedure Dr Tim Pullen	
Date devised 17/02/03	**Review date** Following initial visit.

APPENDIX B.1

Risk Rating Score

The overall risk rating score will provide an indication as to the level of risk associated with work activities and will help to decide whether the risk is 'acceptable'. It can also be used to prioritise actions to enable resources to be directed to control activities that pose the greatest risk. When assessing the severity of harm that could occur, the *likely* outcome of the accident should be considered. For example, a trailing cable across a walkway is likely to cause a minor injury although if the cable was at the top of stairs then the likely injury would be 'major'. Similarly, when assessing the likelihood of an accident occurring, the assessor should concentrate on what is likely, not what is possible. Existing control measures should be evaluated to identify whether they are sufficient to control the risk. If control measures have been stipulated for a work activity, it should be ascertained whether those measures are actually being implemented as planned. This will require both observation and questioning of employees. It is often found that insufficient training has been given or that procedures, although understood, are not being implemented due to a lack of management control. The assessor should also assess the impact of the severity of injury on first-aid requirements. As a general rule, if the risk rating score is 10 or less, it is unlikely that any further action will need to be taken apart from reviewing the assessment. If the cost of eliminating or significantly reducing the risk is small, however, consideration should be given to taking some action. All pertinent factors should have been considered before the risk is dismissed as trivial. If the number of people affected or the severity of injury is high and the only reason that the overall score is low is due to the effectiveness of the control measures that are in place, then action must be taken to ensure that those measures remain effective.

Risk is essentially a combination of three factors:
– the *numbers* of people that could be affected;
– the *severity* of likely injuries that persons could suffer;
– the *likelihood* of harm actually occurring.

The overall risk can be determined using the following formula:
Risk Rating = Numbers × Severity × Likelihood

The activities should be risk assessed as follows according to the criteria set out in below.

Risk rating score

Number of people affected		**Severity of injury**		**Likelihood of occurrence**	
1–5 persons	1	Negligible	1	Improbable	0.5
6–50 persons	2	Minor	2	Remote	1
50+ persons	3	Major	5	Possible	5
(or public/vulnerable persons affected)		Fatal	10	Likely	10
				Certain	20

Score: Action to be taken
Less than 10 Risk acceptable unless cost or effort to control the risk further is very low.

10–19 Risk is low. Action is required to reduce the risk, although low priority. Time, effort and cost should be proportional to the risk.

20–49 Risk is medium. Action required soon to control. Interim measures may be necessary in the short term.

50–99 Risk is high. Action required urgently to control risks. Interim measures required in the short term. Significant
effort, time etc, may have to be used to control the risk.

100+ Risk totally unacceptable, immediate action required before work activity can continue.

Risk assessment should be reviewed at regular intervals to ensure that risk is being properly controlled. Control measures may have to involve some considerable effort and time to control.

Notes:

Negligible injuries include bumps, small cuts, abrasions etc.
Minor injuries include those injuries that could result in time off work etc.
Major injuries include broken limbs, injuries to eyes, asphyxiation etc.

Improbable:	Probability close to zero.
Remote:	Unlikely
Possible:	Could occur sometime.
Likely:	Not surprised that it will happen.
Certain:	Most likely to happen. Not ‘if’ but ‘when’.