

Hull City Council Flood Investigation Report

December 2013 City Centre Tidal Surge Flood Event



04 February 2014
HCCFWMAS190002

Revision Schedule

Hull City Council Flood Investigation Report

4th February 2014
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Rev	Date	Details
01	09/01/14	Working Draft
02	22/01/14	Draft inc partner comments
03	04/02/14	Final for scrutiny

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Executive Summary

The 5th December tidal surge was at a level not experienced for at least 60 years; a storm surge moved around the UK coastline affecting coastal locations before moving down the East coast and into the Humber Estuary causing flooding in East Yorkshire. The highest ever tide was recorded at the Hull Barrier which provides a 1 in 200 year standard of protection.

The surge coincided with high spring tides, resulting in record water levels along our coast and tidal rivers, causing flooding to more than 400 properties in the East Riding (north bank of the Humber) and in Hull. There was also significant flooding on the south bank of the Humber.

A formal investigation under Section 19 of the Flood and Water Management Act was considered appropriate. The collection of data following the event has been completed and analysis of that data is being carried out by Kingston upon Hull City Council as the Lead Local Flood Authority (LLFA). This report details the findings of the investigations, the co-operation of partners was received and welcomed throughout.

Hull City Council and the Environment Agency are the main operating authorities involved in a tidal flooding event in the city. The collected data has been reported in the investigation, and pending further analysis, a range of immediate and longer term work programmes to improve the City's resilience to flood risk from tidal inundation will be delivered.

The forecasting and warning for the tidal surge was very complex with a positive surge of 1.9m adding to an already high astronomic tidal level. The surge was difficult to predict resulting in flood warnings and severe flood warnings being issued in the city with very little lead time to allow effective emergency planning arrangements to be commenced. Further work is being done by the Environment Agency to fully examine improvements that can be made to improve lead times before the issuing of warnings.

The tidal flood defences in the city, managed by the Environment Agency, protected 19,000 properties from significant flooding and the role of the Hull Tidal Surge Barrier was recognised and rightly celebrated by many in the city. The barrier was, however, within 40cm of being overwhelmed by the tidal levels and other defences in Victoria Dock Village and St Andrews Quay were similarly at their design limits and only narrowly avoided overtopping. Further work has already been carried out by the Environment Agency to fully understand the improvements that can be made to ensure the city's defences remain resilient to future flood risks: as part of the Humber Flood Risk Management Strategy, published in 2008.

Significant ingress of flood waters occurred into the English Street area and flows spread into the city centre and as far as Hessle Road to the west, flood damage to 115 businesses and 149 residential properties has been recorded. Tidal levels in Hull peaked at 5.8mAOD (as recorded at the Hull Tidal Surge

Barrier). The lowest levels of defence in the city are adjacent to Albert Dock at Riverside Quay with levels of 5.04mAOD and, at the height of the tidal flood event, sea water entered into the dock and, once this was quickly filled, it flowed onwards into the city. As part of the Humber Flood Risk Management Strategy the Environment Agency are currently appraising a range of flood defence improvements for the Humber frontage in the city and works to improve the standard of protection at more vulnerable points such as the Riverside Quay will be a key priority. A clear recommendation is made in the report to ensure the Agency investigate all options to accelerate this project, supported by others working in partnership, as appropriate.

The tidal surge peak arrived at Hull approximately 30 minutes (19:15hrs) before the expected peak of the astronomical tide (19:47hrs). As the surge reached its peak, sea water started to flow into Albert Dock over the flood defences at Riverside Quay as well as through the lock gates to the dock. A Reverse Head Restraint System (RHRS), owned by the Environment Agency, can be deployed by Associated British Ports in advance of high tidal levels to ensure the lock gates remain closed. An informal agreement had been reached between the EA and ABP for the operation of the RHRS but some details had not been established at the time of the flood event on the 5th December. Both authorities were working on the arrangements at the time of the event and this has subsequently been adopted by both parties.

It had not been possible to deploy the gate's vertical bolt locking system, which are part of the RHRS, into the floor of the lock. It has been shown that the majority of flooding was caused by the sheer quantity of water flowing over Riverside Quay and through the dock.

A recommendation is made for the Environment Agency and ABP to fully investigate this issue, although it is understood that this is now substantially complete. Even if the Albert Dock RHRS had been in place, the flood extent would have been equally significant. It can be concluded that the dock gate RHRS does play a significant role in lower order tidal surge events and that its reliable operation is a key part of the flood defences.

Once the tidal peak had been reached and the Humber retreated the resulting flood waters were quickly drawn down by Yorkshire Waters sewerage infrastructure and discharged at Salt End Treatment Works. This was possible due to the limited amount of rainfall already in the system.

The data and findings from all partners will further inform the findings of this investigation and updates will be made available at a later date.

1. Introduction

1.1 LLFA Investigation

HCC as the LLFA has a responsibility to record and report flood incidents as detailed within Section 19 of the FWMA:

Section 19

(1) On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate:

- (a) which risk management authorities have relevant flood risk management functions, and
- (b) whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in response to the flood.

(2) Where an authority carries out an investigation under subsection (1) it must:

- (a) publish the results of its investigation, and
- (b) notify any relevant risk management authorities.

It was deemed necessary to complete an investigation into the flood incident on 5th December 2013 as more than 250 properties, commercial centres and many roads were reported as flooded.

This report provides the details of the conditions leading to the flooding, the impacts of the flooding, and the roles and responsibilities of all operating authorities in the area. Recommendations and conclusions are given, and further investigations from relevant authorities will be required to deliver these. Partners are already progressing a range of data gathering exercises in this regard.

1.2 Site Location

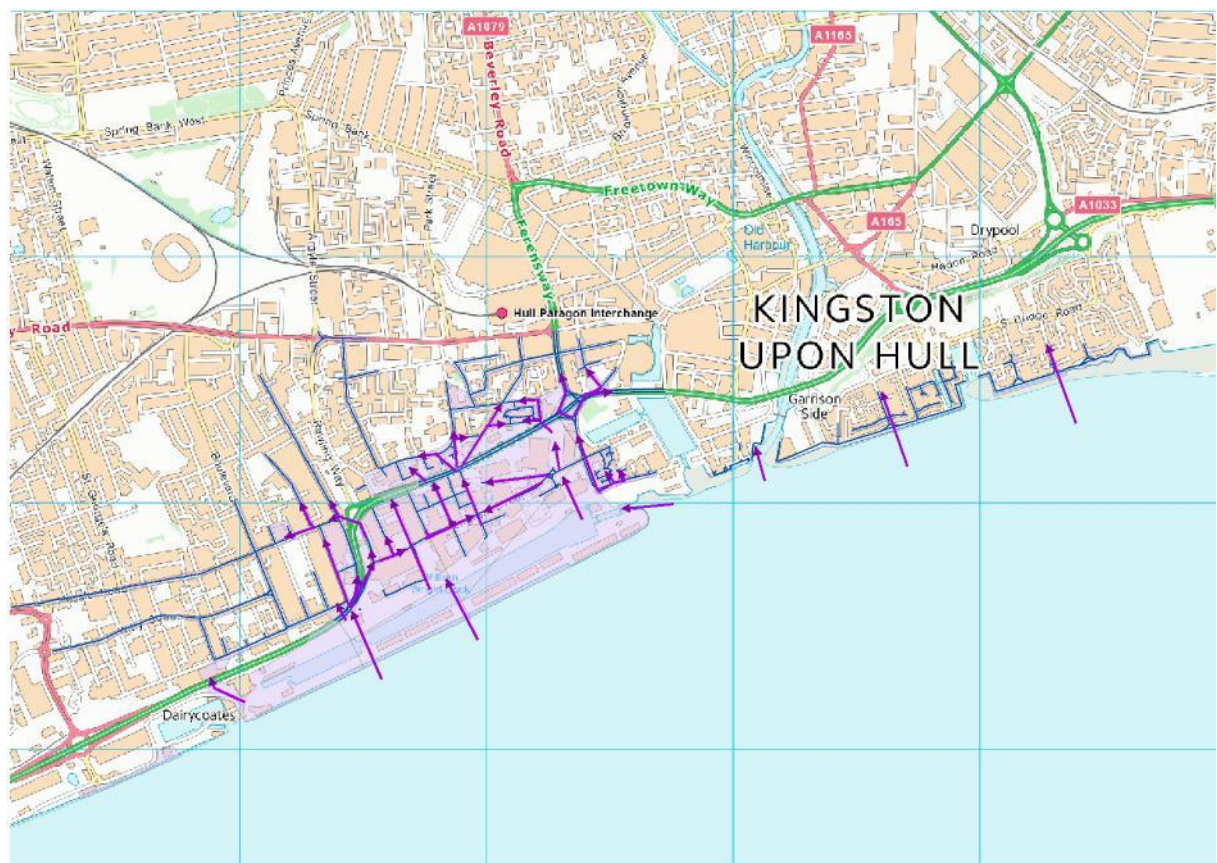
The tidal surge on the 5th December 2013 led to increased levels in the River Humber and an increased risk to the city's southern boundary and surrounding communities. Overtopping and road flooding occurred to the St Andrews Quay retail park in the west and the Victoria Dock Village residential area to the east. The focus of flooding was the area from the west bank of the river Hull through to the St Andrews Quay site and into the city centre with a northerly extreme of Anlaby Road.

Table 1 below shows where properties were flooded. Council officers have recorded all individual properties and businesses that have been affected and support is being given wherever required. Property numbers include residential and commercial - where no property numbers are recorded, road flooding occurred.

Location	Post Code	No. of Properties / Commercial Properties Flooded
Victoria Dock	HU9 1	
Wellington Street West / Anchorage Area	HU1 2	43
Walker Street and housing to south	HU3 2	56
Area bounded by Anlaby Road, Walker St, A63 & Ferensway	HU1 2 & HU3 2	50
Nelson St	HU1 1	1
Albert & William Wright Docks	HU3 4	4
Alfred Street	HU3 2	4
Anlaby Road	HU1 2	1
Daltry Street / Madeley Street	HU3 2	4
English Close	HU3 2	1
English Street	HU3 2	24
Goulton Street	HU3 4	2
Hessle Road	HU3 2 & HU3 3	5
Kingston Retail Park	HU1 2	13
Myton Street & Osbourne Street	HU1 2	5
Ropery Street	HU3 2	3
St Andrews Quay	HU3 4	2
St James Street	HU3 2	6
Strickland Street	HU3 4	9
Tadman Street	HU3 2	4
Wassand Street	HU3 4	3
Waverley Street	HU1 2	2
West Dock Street	HU3 4	22
Total		264

Table 1 – Flooded locations 5th December 2013

Figure 1 overleaf shows the areas of flooded properties shaded pink, flooded roads in blue and the flood flow routes are indicated by the purple arrows.



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**Figure 1 – Indicative map of flooded locations and flow routes
5th December 2013.**

1.3 Local Drainage System

The Hull drainage system is a complex interaction of rivers, streams, ditches, dykes and sewers. Many streams and ditches flow into the city from the surrounding East Riding of Yorkshire Council area. These flow through the city in a mixture of Main Rivers, permissively managed by the Environment Agency (EA), and through open drains and streams (Ordinary Watercourses permissively managed by local authorities, or often the responsibility of riparian landowners). Much of the system is culverted below ground.

The vast majority of the system is also classed as part of the sewerage system for the city as it passes flows derived from surface water drainage onto the hard surfaces across the city. The sewerage system is pumped in times of flood through a combination of pumping stations to the treatment works in the east of the city at Salt End. The pumping stations at West and East Hull are key to this operation. The Bransholme area of the city is served by a separate surface water drainage system which discharges flows into a storage lagoon before outfalling to the River Hull. Yorkshire Water is responsible for the city's sewerage system.

The 5th December 2013 flood event was solely associated with a tidal flood source from the River Humber. The River Humber is heavily managed to prevent tidal ingress throughout its length, and although the standards of protection are variable around the estuary, there would be as much as 115,000 hectares of land at risk of tidal inundation on both banks of the river without active management.

400,000 properties are at risk of tidal flooding around the estuary with more than 100,000 in the city of Hull alone. The City's Humber frontage is protected by a range of raised flood defence features including flood walls, wharfages and defence levels incorporated into the public realm, and the Hull Tidal Surge Barrier.

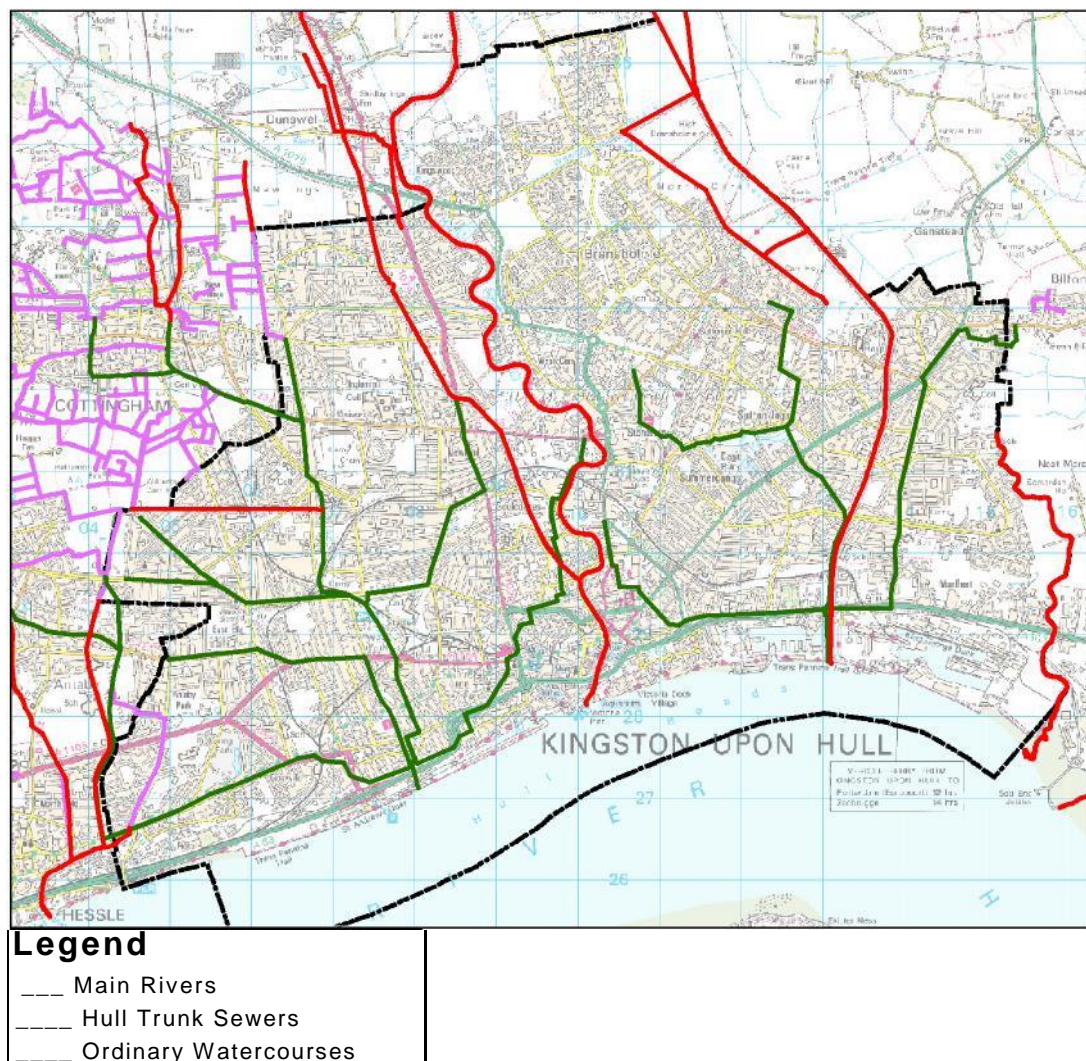


Figure 2 Hull Drainage Systems

2. Drainage History

2.1 Previous Tidal Flood Incidents

- 1953 – combination of wind, high tide and low pressure caused a storm surge in the North Sea. The flood and waves overwhelmed sea defences and caused extensive flooding. In England 307 people were killed along the East Coast.
- 1969 - areas adjacent to the River Hull and Holderness Drain were affected due to a tidal surge, widespread flooding of 855 houses occurred as the tidal levels rose in the city's watercourses.
- 1990 – previously biggest recorded water level at the Hull Tidal Surge Barrier 5.18mAOD

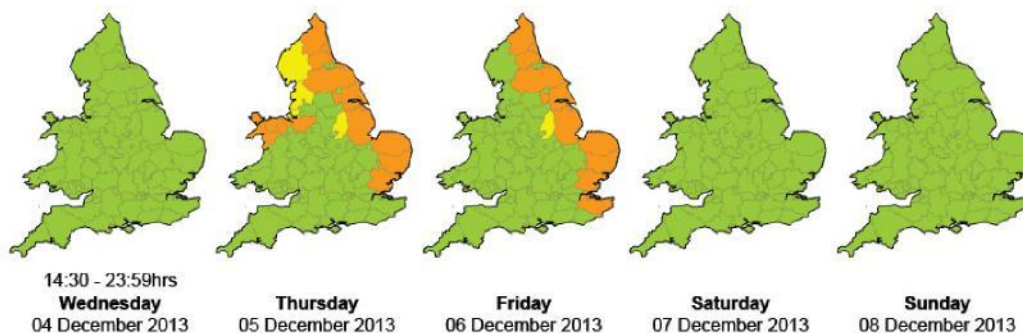
2.2 5th December 2013

Environment Agency advance weather forecasts predicted high tides and surge as early as 2nd December 2013 and this information was shared with key Local Resilience Forum partners. Based on more certain forecasts, the initial Flood Alert was issued at 17:58 on the 4th December and Flood Guidance Statements updated to show an 'amber' risk of flooding on the north bank of the estuary. This remained in force in all statements through the morning and afternoon of the 5th December. The risk was updated to a 'red' risk on the north bank in the 21:30 statement on the 5th December.

A selection of extracts from representative Flood Guidance Statements is reproduced below:

Flood Guidance Statement 14:30hrs Wednesday 04 December 2013

Our assessment of daily flood risk for England and Wales, working with flood forecasting teams in the Environment Agency and Natural Resources Wales, is below.

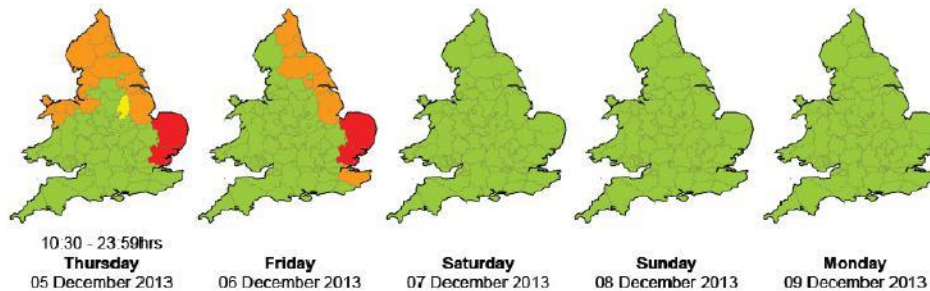


Update since 0730 issue. MEDIUM flood risk now extended to include much of the east coast of England and also the North Wales coastline. Significant coastal flooding possible.

There is medium likelihood of significant coastal impacts along much of the east coast of England during Thursday and Friday. On Thursday only, there is also a medium likelihood of significant flooding along the North Wales coastline bringing a MEDIUM overall flood risk.

Flood Guidance Statement 10:30hrs Thursday 05 December 2013

Our assessment of daily flood risk for England and Wales, working with flood forecasting teams in the Environment Agency and Natural Resources Wales, is below.

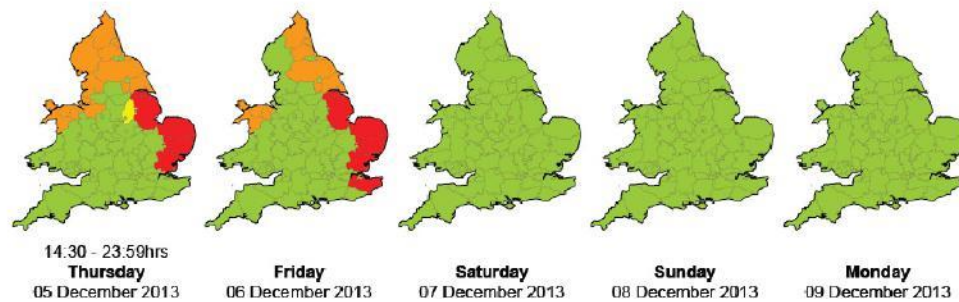


Update: The coastal flood risk in Norfolk, Suffolk and Essex is now HIGH (RED) due to the height of the forecast surge later today and into tomorrow.

There is also a medium likelihood of significant coastal flooding impacts along much of the rest of the east coast of England today and all of the east coast tomorrow. Today only, there is also a medium likelihood of significant coastal flooding impacts along the North Wales coastline and all of the north-west England coastline.

Flood Guidance Statement 14:30hrs Thursday 05 December 2013

Our assessment of daily flood risk for England and Wales, working with flood forecasting teams in the Environment Agency and Natural Resources Wales, is below.

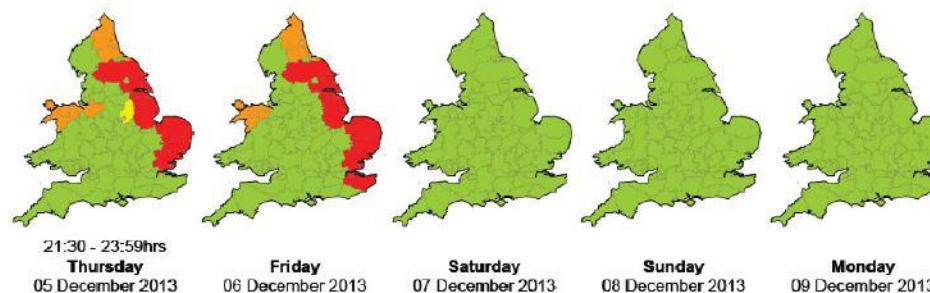


Update: The coastal flood risk is now HIGH (RED) for Lincolnshire, East Anglia and Essex coast later today and into tomorrow and for Kent tomorrow. MEDIUM flood risk has also been extended into Friday for the north coast of Wales.

There is also a medium likelihood of significant coastal flooding impacts along much of the rest of the east coast of England today and tomorrow. Today only, there is also a medium likelihood of significant coastal flooding impacts along all of the north-west England coastline.

Flood Guidance Statement 21:30hrs Thursday 05 December 2013

Our assessment of daily flood risk for England and Wales, working with flood forecasting teams in the Environment Agency and Natural Resources Wales, is below.



2130 Update: The coastal flood risk is now HIGH (RED) for North Yorkshire and the East Riding of Yorkshire and continues to be HIGH (RED) for Lincolnshire, East Anglia and Essex coast this evening and into Friday and is also HIGH (RED) for Kent on Friday. A MEDIUM (AMBER) flood risk continues for the north coast of Wales for this evening and into Friday.

There is also a medium likelihood of significant coastal flooding impacts along the rest of the east coast of England today and tomorrow.

Through the day on the 5th December the EA forecasted high tides of 5.5m AOD - our defences are, on the whole, at 5.95m – and our defences were expected to be tested. Fortunately the wind direction was a favourable offshore wind and, for the North Humber shoreline through Hull, waves were not expected to be considerable.

Tactical and strategic level control rooms were established and manned from all partners and full emergency response procedures were followed. Strategic Co-ordination Group (SCG) convened at 10:00, 14:00 and 17:30 on the 5th December, the Hull City Council Incident Room was opened following the discussions at the 10am SCG meeting at which the developing incident was declared an emergency by the Chair of the SCG. As the events escalated the wind and wave direction changed therefore adding considerably to the surge. The increasing risk of overtopping, the likelihood of severe flood warnings and potential evacuation for the south bank of the Humber were identified and discussed from the earliest meeting of the SCG on the 5th. No major concerns were expressed with regard to the significance of the risks to the north bank until further information on increased surge level forecasts (400mm higher) was presented to the SCG at 17:30hrs.

The revised forecasts led to flood warnings being issued close to the expected surge peak:

Flood Warnings – North Bank east of Hull @ 18:09, North Bank west of Hull @ 18:15

Severe Flood Warnings – North Bank east of Hull @ 18:50, North Bank west of Hull @ 18:56

Investigations have shown that the flood warnings were issued almost at the same time as the onset of flooding into the city and CCTV records show deep, fast flowing flood waters in the English Street area at the time of the issue of the severe flood warnings.

Site investigations were initiated from the morning of the 6th December, officers from regeneration and area teams, assisted by EA officers, visited all flooded areas and collected flooded property impact data. Collation of data from event logs, social media, newspaper, CCTV and aerial photography has been undertaken and this has informed our understanding of the extent and mechanisms of flooding. A detailed topographic level survey has been commenced.

114 businesses and 149 residential properties are known to have flooded; there are likely to be others where the effects were minimal and have not been identified as flood damage, or the owner / occupier / operator of the premises does not want to highlight that they have suffered flood damage.

2.3 Drainage Assets



Victoria Dock, showing riverside defence wall at low tide (left) and evidence of over-topping (right).

Within the city the defences consist of a mixture of vertical sea walls and concrete revetments. Some of the defences have been raised by the construction of new wave return walls along the length of the crest of the existing structure. To the west, the defences abruptly change from sea walls to natural marshland. Along this length Clive Sullivan Way is on a raised embankment and effectively forms the defence. The defences are varied in age, with the original dock structures dating mainly from the late 19th Century and the early 20th. The area immediately to the west of the Hull Barrier consists of a mixture of different defences, part of the defence along this frontage is formed by the walls of various buildings and warehouses.

The Hull Tidal Surge Barrier has been in operation since 1980 to prevent high sea levels caused by surge tides overwhelming river defences. It is approximately 30 metres wide and takes roughly 30 minutes to open or close. The Barrier is closed when a predicted tidal level greater than 4.3 metres AOD is forecast. The Environment Agency recently spent £10M refurbishing the barrier to ensure its long term resilience and reliability.



Hull Tidal Surge Barrier in operation, 5th December 2013

Defence levels range in height along the Humber frontage and are, on the whole, of a scale to withstand an event with a chance of happening of 0.5% in any one year, which is the normal design level for tidal flood defences in England.

Victoria Dock Village:	5.95mAOD
St Andrews Quay:	6mAOD

The defences at Albert Dock range in height:

Albert Dock west:	6.04mAOD
Albert Dock central:	5.04mAOD
Albert Dock east:	5.6mAOD
Albert Dock Lock Gate:	5.8mAOD

The Albert Dock central section (Riverside Quay) of the flood defences was known to be a low point and was subject to a specific study to implement an improved scheme through the EA's Humber Frontages Flood Defence Project.

3. Possible Causes

There is a general consensus about how the flooding occurred. The risk of flooding was most prevalent at the Albert Dock central area where flood defences are the lowest level of 5.04mAOD. With only marginal overtopping and spray at St Andrews Quay and road flooding at Victoria Dock village it is accepted that the source of flood waters originated from the Albert Dock area.

Figure 1 shows the flooded areas, roads and flood flow routes, a detailed topographic survey is currently being undertaken to further detail all known flooded areas and flow routes.

Victoria Dock Village

Media reports of flooding understandably gave an impression of a significant flood risk for the residential area as flows onto the foreshore and over the defences made for some very dramatic footage. Defence levels at this point are set at 5.95m AoD, the formal defence forms the estuary frontage to the west of the development and the rear of the footpath to the east – hence the media footage showing this area being heavily inundated by waves breaking over the top of the defences. The resultant impacts were confined to flooded roads and some water in gardens.

Fruit Market / Pier

Flood levels in the Fruit Market area were contained by the defence walls. The council operated, Environment Agency managed flood gates were closed at 16:00. In addition the EA placed large sand bags behind a brick flood wall that adjoins the Dry Dock flood gate. Some minor seepage of an expansion joint and around the floodgate (Environment Agency) to the rear of the Dry Dock caused standing water to pond on Nelson Street and Humber Street but defences performed as expected. Victoria Pier sustained significant damage during the event.

The Anchorage

43 properties are known to have flooded in the Wellington Street West area. Residents have confirmed that the flood water did not come overland but was due to surcharging sewerage infrastructure. Further evidence of surcharging gullies was experienced in the Humber Quays area but aside from accumulated silt and debris, no properties were threatened. It is considered that this was due to sewers being



Evidence of flooding at the Anchorage

overwhelmed locally due to tidal ingress from the Albert Dock area and the sudden influx of a huge volume of water from the estuary into the sewer.

English Street area

Significant flood waters originated from Albert Dock. In addition to this, the water level in the dock was seen to rise significantly through the latter part of the afternoon indicating a passage of tidal waters into the inner dock.

Flood flows passed into the full extent of the English Street, Jackson Street and Lister Street area with only a handful of commercial properties reporting minimal or no damage. Flows into



Wall destroyed by flood waters, English Street

the area came quickly and levels were as deep as 1.5m in places. Interviews and CCTV footage have confirmed issues of floating cars, floating heavy debris and pedestrians taking refuge for safety from the rapid flowing water.



Water mark, English Street

Significant clean up and recovery works are still ongoing throughout this area and associated damages and costs will be extreme. A longer term investigation is required to fully understand the business impact.

City Centre

Flood flows passed along Commercial Road, through the Kingston Retail Park and spread to either side of the Mytongate roundabout causing severe traffic disruption on the evening, and delays through into the 6th December due to the closure of the A63 – the A63 reopened at midday. The flow route can be seen across the Staples car park and into Myton Street and Anne Street, and flows also passed into the area from the central part of the English Street area via Porter Street.



Flooding at Kingston Retail Park

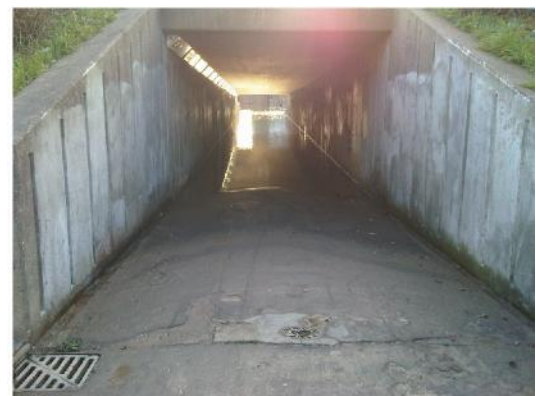
The easterly extent of flood flows in the city centre can be seen on Osborne Street in front of the old ambulance station and almost to the Anlaby Road / Anne Street / Carr lane junction. Osborne Street Police Station, the Ibis Hotel and the rear of Mecca Bingo were all inundated; the northern extent of flood flows on Ferensway was identified adjacent to the Mecca Bingo hall.

Flows passed along Osborne Street to the west and entered a wide range of lower lying properties throughout the Porter Street and Walker Street area to the south and west. In total 106 residential properties have so far been identified as being affected in this area. Many cars were flooded in the city centre area.

Strickland Street / Hesse Road

Flood water spread throughout the Smith & Nephew site and spread to the west under the Daltry Street flyover. Social media and CCTV footage showed flows crossing the A63 here and down the slip road, further compounding the issues around Smith & Nephew and Strickland Street; only a handful of properties on Madeley Street and Strickland Street were not affected. Flows spread to Hesse Road and the side streets of Coltman Street and Wellstead Street but this was the northern extent of the flood and depths were minimal. Even so, social media and other sources of footage show heavy spray and extensive standing water in this area.

The remaining commercial properties were flooded through flows passing onto the western extent of William Wright Dock and the area around the Lordline building. Flows passed through the pedestrian underpass flooding three commercial properties on West Dock Street / Goulton Street, water was reported to be coming out of the underpass in a 15 foot high spout as the force of water to the south of the A63 pushed flows through the underpass which acted as a siphon.



Underpass under the A63

St Andrews Quay

Overtopping of defences was observed along the frontage of St Andrews Quay but volumes were minimal and businesses report no issues. The road gullies in the area will have taken all flows.

Albert Dock

The defence levels by Albert Dock are known to be lower than other parts of the city and the Environment Agency are currently appraising the works required to ensure all defences along the Hull Humber frontage are renewed or replaced to provide a long term protection from flood risk and climatic change. Following approval later this year, prioritised delivery of all works will commence in five year programmes. The raising of the standard of protection on Albert Dock is a high priority to be in the first tranche of works. A temporary defence is also being considered to raise the height of the defence prior to the



Hull Humber frontage defences

permanent construction of raised defences.



Albert Dock RHRS

The lock gates at Albert Dock form an important part of the defence, and the Reverse Head Restraint System (RHRS) has been supplied by the Agency with the intention of ensuring that the lock gates remain closed during extreme tidal levels. ABP operate the lock gates and will in future be responsible for the operation of the RHRS. An attempt was made by ABP to deploy the RHRS on the 5th December but they were

unable to apply the vertical bolt locking system and, due to fears that the lock gates would be grossly distorted the RHRS was removed. As the closure mechanism at the base of the gates could not be deployed operatives feared that the gates would buckle and twist at the base of the gate with an increasing water pressure, thereby rendering them ineffective.

An informal agreement had been reached between the EA and ABP for the operation of the RHRS but some details had not been established at the time of the flood event on the 5th December.

Levels of 5.8mAOD have been recorded and this represents the highest level ever experienced at the tidal barrier and the highest tidal levels since 1953. Defence levels across the city withstood the tidal level well and very little damage to defences or other issues have been reported. The Environment Agency has surveyed all defences around the estuary following the event. The Hull Tidal Surge Barrier prevented significant flooding to 19,000 properties and more than £230M of direct damages were avoided because of this.

4. Roles and Responsibilities

4.1 Lead Local Flood Authority

Hull City Council is defined as a Lead Local Flood Authority in the FWMA, with the following main responsibilities: flooding from surface runoff, groundwater and ordinary watercourses, permissive powers to maintain ordinary watercourses, development of a Local Flood Risk Strategy, Asset Plans and Investigations.

The council received advance weather warnings for the 5th December 2013 event as detailed in section 2.2. Attendance at Strategic Co-ordination Group informed the need to open the Hull City Council control room at Civic 1 and all emergency response procedures were implemented as required.

Rest centres were set up and more than 50 residents were evacuated from care homes on Victoria Dock Village and Ferensway.

The investigation has found that there were some issues surrounding the availability of duty officers at short notice; this was compounded by the short lead time given by the Environment Agency issued warnings. Issues have been raised over the materials available in the Civic 1 incident room and communications between the incident room and the Strategic Command Group. A full debrief of all officers involved is required to identify issues and actions.

Key responsibilities are: managing flood risk from main rivers (including warning and informing), the sea and reservoirs including coastal erosion risk management, permissive powers to maintain Main Rivers, Strategic Overview over all forms of flooding and development of a National Flood Risk Strategy.

4.2 Environment Agency

The role of the Environment Agency in this event is well documented in all sections above, the city's defences defended vast parts of the city from tidal inundation and the work of the Environment Agency is key to the operation and management of these defences. It is essential that the River Hull Flood

Risk Management Strategy and Humber Hull Frontages flood defence appraisal works lead to improvements to the city's defences to ensure future flood risks and the impacts of climate change are appropriately managed.

It is also important that the review being carried out to update the Humber FRMS is completed by the EA and supported by the relevant LLFA's through formal acceptance by the end of 2014.

The investigation has highlighted issues in forecasting which, in turn, affects the timeliness of the issue of appropriate flood warnings and a full review of the warning and informing systems for Hull needs to be carried out by the EA.

4.3 Water and Sewage Company

Yorkshire Water Services are the water and sewage company covering Hull City Council and the surrounding catchment area, their key responsibilities include: managing the risks of flooding from water supply, surface and foul or combined sewer systems, working with developers and landowners to reduce the input of rainfall into sewers through the use of storage, source control and SuDS.

Yorkshire Water initiated pumping operations at Salt End and West Hull Pumping Station, with the sewerage system inundated by tidal waters in the English Street area, the actions of Yorkshire Water evacuated more than 350,000 tonnes of tidal flood water which aided a quick and effective recovery.

4.4 Port Authority

Associated British Ports has statutory powers as both a port and navigation authority. ABP operate sites around the Humber Estuary. The events of the 5th December 2013 unfolded around a number of port facilities in the Humber including the Albert Dock which is in their control.

As detailed in section 2.3, significant flooding would have been expected in this event due to the lower flood defence walls being overtopped and flood flows passing through the dock and into the city. Spare capacity in the dock can informally act as a 'reservoir' in such circumstances and in this regard the operation of the lock gates is imperative. In this instance the amount of water overwashing riverside areas of Albert Dock grossly exceeded any storage capacity that the dock basin could provide, and would not therefore have changed the outcome simply due to the volume of water vastly exceeding the 'reservoir' capacity within Albert Dock.

For lower order of magnitude events, than was experienced on the 5 December, the operation of the reverse head restraint system at Albert Dock would be important. The port authority have finalised agreements with the Environment Agency to ensure the lock gates can be safely deployed to provide their role as part of the formal flood defences on the Humber frontage, the company has also worked with the Agency to adopt a procedure that looks

to maximise opportunities to allow informal flood storage in the dock; this would only be effective in a scenario where the standard of protection of riverside sea walls was better than is currently the case and where a tidal surge was expected to overwash the top of the 'propped' lockgates. The company is working with the Environment Agency and the Council to develop short and long term improvements to the defences through ABP's estate.

The longer term improvement of the static riverside defence heights in this location by the Environment Agency will be key and the port authority is working closely with them in this regard. A temporary solution involving the use of 0.5 tonne sandbags is currently being investigated by the Environment Agency in advance of permanent solutions which are being considered.

4.5 Residents and businesses

Residents and businesses are encouraged to understand the flood risk in their local area and have a flood plan to steer their response in times of flooding. Actions such as placement of sandbags, moving valuable items to a safe place and semi / permanent measures such as installation of floodgates, airbrick covers etc further encouraged to reduce the consequences of flooding at a property level.

It is recommended that residents sign up to appropriate warnings for their area and keep contact details up to date and act upon all warnings appropriately. When flooding does occur residents are encouraged to document as much information as possible to aid the investigations of all operating authorities and to provide information to their loss adjusters and insurers.

Flood warning coverage in the area is known to be limited and where residents and businesses are signed up to warnings it is essential that the contact information provided is accurate and up to date, some issues have arose in this regard. Recommendations have been made for the Agency to review flood warning take up in the area and to carry out targeted activity to promote the flood warning service, this will be supported by Hull City Council.

4.6 Duty of Co-operation between Authorities

The Authorities in sections 4.1 to 4.4 above have a duty to co-operate with each other and this was fully demonstrated before and throughout the flood event. There is an increased need for partnership working to deliver the required solutions for improvement.

5. Recommendations

Significant flood waters on the 5th December 2013 as a result of the tidal surge have been found to have originated from the Albert Dock area. Given the severity of the event and the existing defence levels, overtopping of tidal waters into the dock was expected, the levels in the dock increased because of this and once the dock was filled flood waters passed into the city. Significant flooding would have been expected even without any consideration of how the lock gates were operated in the period leading up to the high tides, as the reverse head restraint system does play a part for lower order events. It remains important to ensure full operational and maintenance agreements are in place between the EA and ABP.

Discussions between the Environment Agency and ABP to resolve the operation and deployment of the props were ongoing at the time of the 5th December 2013 flood event and it is understood that an agreement on operation has been reached. The reverse head restraint system was successfully completed in advance of the high tides of the 4th January 2014.

Concerns over the levels of residual tidal risk to the English Street area have been raised previously and discussions have been held over the last year to understand this issue. Modelling work had shown that even with tidal inundation into the dock the informal storage of flood waters in the dock meant that the wider English Street area would be defended against a tidal event in excess of 1 in 200 years.

An investigation is required to identify the issues observed in the Albert Dock area, the dock side would have overtopped in such a severe event and we need to understand the severity of the event to quantify this and the mitigation effect of the storage in Albert Dock. The EA have already substantially completed this investigation work and have concluded that the amount of water entering Albert Dock over low points in the riverside defences far exceeded that which entered the dock through the lock. Clearly levels built up in the dock in advance of the high tide by water entering the lock as RHRS could not be deployed, and via the low sections on the river wall adjacent to the dock. The operational agreement between ABP and the Environment Agency to safely close the gates and deploy the RHRS has been optimised to ensure that, where possible, the dock can act as a secondary storage feature when levels overtop the dock wall, although as mentioned above using the dock basin as a 'reservoir' would have had no effect on the events of 5 December.

The raising of defence heights along the Albert Dock wall is essential to give a long term solution to manage future significant tides, priority should be given to accelerating all programmes of work in this regard.

The information received in advance of the event by all partners did not highlight any major concerns with regard to the impending risks in the city despite significant issues already being forecasted on the south bank, the

warnings and severe flood warnings were issued as the onset of flooding ensued and no time was available for measured and considered deployment of emergency procedures and plans. Work is required to reassess the modelling and forecasting information and procedures governing flood warnings on the north bank.

Table 1 Recommendations

Operating Authority / Stakeholder	Recommended Actions
Environment Agency	Full review of the forecasting and warning activities undertaken during the event and improvements considered and implemented
Environment Agency	Review of all tidal flood modelling to identify that the ongoing Humber Flood Risk Management Strategy, Hull Humber Frontage appraisal works and the forecasting and warning programmes of the Agency are calibrated against the recorded flood levels of the 5 th December 2013 event
Environment Agency / Hull City Council	Full topographic survey of all flooded locations in cooperation with Hull City Council
Environment Agency / Hull City Council	Deliver a programme of promotional and communications activity to increase the sign up of flood warnings and to provide information and guidance to residents and businesses on flood resilience activities
Environment Agency / Associated British Ports	Full and final implementation of the operational procedures for the Albert Dock Lock Gates and consideration of the ways in which the agreements can be optimised to allow the dock to provide an informal flood storage role
Environment Agency	Humber Hull Frontages appraisal works, detailed design and delivery programmes to be reviewed and wherever possible to be accelerated. Defence improvements in the Albert Dock area to be given highest priority
Hull City Council	Review all activities in the incident room on the 5 th December and make recommendations to improve the issues identified – materials, rotas etc.
Hull City Council	Incorporate the findings of all Environment Agency model reviews into all flood risk planning and policy documents and procedures
Hull City Council	Review full impact of damages to the business community and share with partners including the Local Enterprise Partnership

6. Conclusion

The 5th December 2013 tidal surge event led to record tide levels in the city of Hull; existing flood defence infrastructure protected more than 19,000 properties. The complexity of the emerging tidal surge conditions proved difficult to forecast; accurate levels in the Estuary and flood warnings and severe flood warnings in the city were issued close to the onset of flooding.

The lowest defence levels in the city are located at the riverside quay of Albert Dock and significant flood waters overwhelmed the dock and passed onto the English Street area. Flood waters passed through to the city centre and Hessle Road to the West damaging more than 260 properties and businesses and causing significant travel disruption with large sections of the A63 being under tidal flood water. The financial impact to the business community in the flood event is still being quantified but direct and indirect damages will be considerable and some may find it difficult to recover.

More limited flood impacts were experienced in Victoria Dock Village and St Andrews Quay and defences here were close to being overwhelmed.

Key recommendations to review warning and informing procedures and to accelerate and deliver improved flood defence works at Albert Dock are made and all partners are working together to achieve these goals and all other recommendations.

Abbreviations / Acronyms

EA Environment Agency

HCC Hull City Council

FWMA Flood and Water Management Act 2010

LDA Land Drainage Act 1991

LLFA Lead Local Flood Authority

WRA Water Resources Act 1991

Useful Links and Contacts

Useful Contacts and Links

Environment Agency

General Enquiries 08708 506 506 (Mon-Fri, 8am - 6pm)
Incident Hotline 0800 80 70 60 (24hrs)

Lead Local Flood Authority Hull City Council

Water and Sewage Operator

Yorkshire Water Services
General Enquiries 0845 1 24 24 24

Highways Act 1980:

<http://www.legislation.gov.uk/ukpga/1980/66/contents>

Water Resources Act 1991:

<http://www.legislation.gov.uk/ukpga/1991/57/contents>

Land Drainage Act 1991:

<http://www.legislation.gov.uk/ukpga/1991/59/contents>

EA - 'Living on the Edge' a guide to the rights and responsibilities of riverside occupation:

<http://www.environment-agency.gov.uk/homeandleisure/floods/31626.aspx>

EA - River and Coastal Maintenance Programmes:

<http://www.environment-agency.gov.uk/homeandleisure/floods/109548.aspx>

EA - Prepare your Property for Flooding:

How to reduce flood damage

Flood protection products and services

<http://www.environment-agency.gov.uk/homeandleisure/floods/31644.aspx>
