The changing nature of flood risk: Portsmouth Hampshire

Vicary, David

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The Changing nature of flood risk: Portsmouth, Hampshire

Abstract

The nature of flood risk is affected by numerous factors both natural and anthropogenic, these factors are constantly changing and so with it the nature of flood risk throughout the UK. The City of Portsmouth was recently identified as one of the most vulnerable urban areas to storm surge risk and has a recent history of urban flood events. This report assess how the ‘risk’ of flooding is set to change in the future, this has been conducted within the framework that risk consists of two elements; the hazard and vulnerability towards it. A combination of desktop research, analysis of observational and collection of primary data allowed for confident assertions to be made. Observational data pertaining to both sea surface and rainfall data in Portsmouth was analysed to identify changes in the flood hazards and determine trends and make future predictions in order to make risk reduction recommendations. The report also analyses the awareness and attitudes of flood risk of a sample group of Portsmouth residents. It was discovered that the risk of both flood hazards is on the increase and the awareness of these hazards is low. The information collected has allowed for several key recommendations to be made to reduce and manage the risk effectively.
Acknowledgements

This report would have not been possible if it was not for the assistance of many people. In particular I would like to thank my supervisor and tutor David Whiting for his constant help and support throughout, the members of the regional resilience unit at the Government office for the South East where I gained valuable skills related to the field of disaster risk management and numerous life skills that I will carry with me into any future career. A special thank you goes to Ted Vary for giving me this opportunity. I would also like to thanks Lisa Giles from the Environment Agency and the staff at Proudman Oceanographic Laboratory for their assistance in providing me with crucial data and the residents of Portsmouth who also spared their time to complete the questionnaire. Finally I would like to thank my friends and family who have supported me throughout my degree.
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<tr>
<td>ABI</td>
<td>Association of British Insurers</td>
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<tr>
<td>DCLG</td>
<td>Department for communities and local government</td>
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<td>DEFRA</td>
<td>Department for Environment Food and Rural Affairs</td>
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<td>DTI</td>
<td>Department of Trade &amp; Industry</td>
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<td>EA</td>
<td>Environment Agency</td>
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<td>GCM</td>
<td>Global Climate Model</td>
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<td>GIA</td>
<td>Glacial isostatic adjustment</td>
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<td>GIS</td>
<td>Geographical Information Systems</td>
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<td>IPCC</td>
<td>International Panel on Climate Change</td>
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<td>NAO</td>
<td>North Atlantic Oscillation</td>
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<td>NOAA</td>
<td>National Oceanographic &amp; Atmospheric Administration</td>
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<td>POL</td>
<td>Proudman Oceanographic Libratory</td>
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<td>PPS</td>
<td>Planning Policy Statement</td>
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<td>RFDC</td>
<td>Regional Flood Defence Committee</td>
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<td>RMS</td>
<td>Risk Management Solutions</td>
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<td>SE</td>
<td>South East</td>
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<td>SUDS</td>
<td>Sustainable Urban Drainage Systems</td>
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<td>TORRO</td>
<td>Tornado and Storm Research Organisation</td>
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<td></td>
<td>United Nations International Strategy for Disaster</td>
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<tr>
<td>UNISDR</td>
<td>Reduction</td>
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<tr>
<td>USD</td>
<td>United States Dollar</td>
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Introduction

Background

Flood Risk in the UK threatens over 10% of the UK’s housing stock and since 1952 has led to losses of USD $6,979,230,000 (CRED, 2007). There is an ever increasing demand for affordable housing, which is leading to poor land use management and increase pressure being placed on the urban environment. Floods are increasing in frequency and loss potentials increasing as more assets are placed knowingly or not at risk. It is neither practical nor economically feasible to eliminate flood risk in the UK, therefore the risks have to be managed as efficiently as current external constraints allow.

This is further compounded by the high probability of the risk increasing in the near future due to increasing pressures from a changing climate. Climate change and its possible impacts to the UK and globally are receiving unprecedented media coverage. Our changing climate is being linked with increasingly devastating hydro-metological events around the world, from Hurricane activity, flooding and extreme temperature.

Several major UK cities were identified in 2006 as being exposed to storm surge risk, these cities are; Cardiff, Hull, Portsmouth, London and the Thames Gateway region (Press Association, 2006). As well as the threat from coastal inundation, urban flood risk is also changing in nature, becoming more frequent with increasing losses.

The risk posed to coastal urban areas from the aforementioned hazards has the potential to create an economic, social and environmental disaster. The city of Portsmouth, the UK’s only island city and second most densely populated urban area next to London is vulnerable to both urban flooding and storm surges hazards and will
be used as the focus of this report, to investigate how the nature of risk will change in the future and how detrimental change can be mitigated or adapted to.

**Project Aims**

The aim of this research project is to assess the flood risk in Portsmouth, and investigate how it is likely to change in the medium to long term (50-100 years). This research should then lead on to say which flood type poses the greatest risk, and allow for risk reduction recommendations to be made.

**Objectives**

- Identify the flood hazards in Portsmouth
- Identify the main factors pertaining to vulnerability
- Assess how both hazards and vulnerability will change in the medium – long term
- Critically evaluate public awareness of flood risk
- Recommend how flood risk can be reduced now and in the future

**Project Framework**

To maintain continuity and a sense of structure throughout the report, ‘risk’ will be treated as separate elements; the hazards and vulnerability to them. This relationship between Risk or disaster, Vulnerability and the Hazard can be expressed as:

\[ R = H \times V \]

Separating the research into the 2 key elements will allow for a holistic view of the current and future risks, and how in turn they can be reduced. The project will now go on to look at relevant literature pertaining to flood risk, then a methodology
explaining what data is needed and how this will be collated. The evidence will then be analysed leading to conclusions and recommendations for risk reduction.
Literature Review

Introduction

This section of the report will draw upon available literature to perform a systematic assessment of the flood risk in Portsmouth, by treating hazards and vulnerability as separate entities it will allow for a holistic view of the risk. The review will first introduce the city of Portsmouth and relative information such as location and demographics, this will continue to a brief explanation of the flood hazards and their impacts including case study evidence. The nature of flood risk in the UK and the core approaches to mitigation will be analysed very briefly as these are already well documented. Contemporary government policy pertaining directly or indirectly to flooding will be discussed and so will the insurances industries changing attitude toward flood risk. This will proceed to look at future factors that could increase flood risk on the south coast including research into climate and future development.

Portsmouth

The City of Portsmouth is located on the south coast of England in the county of Hampshire and is the UK’s only island city. The island is separated from the mainland to the north by a narrow creek, which is bridged by both road and rail. Portsmouth harbour lies to the west of the island and the large tidal bay of Langston harbour to the east. To the south are the Solent and the Isle of Wight.
The city of Portsmouth has a population of 186,701 and a population density of 46.9 persons per hectare, making the city the most densely populated unitary authority in England and the second most densely populated city outside of inner London. The population swells by 18,800 daily with a combination of commuters entering and leaving the city. Data obtained from (National Statistics, 2001). The main housing types on the island are terraced houses, with a total 2,404 highly vulnerable basement dwellings (National Statistics, 2003). Portsmouth is the 4th most deprived authority in the SE of England (Portsmouth City Council, 2006, p. 9), affluence is directly related to flood risk in terms of insurance cover and ability to recover. The city contains key infrastructure such as military and public ports, a main line rail connection and is the gateway to many different destinations from the UK.

The geography and location of the city is one of the main reasons for its vulnerability to flooding, the area I low lying with two thirds of the island below high tide level. This makes the area very sensitive to changes in relative sea level. On the coastal fringes of Portsmouth large areas of the land has been reclaimed from the sea. The waste water collected from the city by current drainage infrastructure has to be pumped away as it cannot escape via gravity flow.
The current flood risk to property from coastal inundation stands at 24,257, with 14,715 properties in high risk areas (1 in 200), and the remainder at medium risk (1 in 1000). (Portsmouth City Council, 2006, p. 10) See appendix 9.3 for indicative flood risk map. There is currently no data pertaining to the number of properties at risk from urban flooding, although southern and eastern regions are more vulnerable due to local elevation.

Flood Protection

To prevent flooding in Portsmouth from coastal inundation there are a series of sea walls and raised banks, with newly installed flood gates protecting the most vulnerable areas. To protect from urban flooding, a network of pumping stations remove water from the urbanised areas and release it into the sea. There is currently no redundancy built into either of these defences at present.

Hazards

A definition of Flood can be drawn from the Munich Reinsurance company who define flood as;

‘a temporary covering of land by water as a result of surface waters (still or flowing) escaping from their normal confines or as a result of heavy precipitation’ (Munich Re, 1997, p. 4)

As well as the above definition which encompasses many different flood types, storm surge and urban flooding have their own specific causes and characteristics which will now be detailed.
Storm Surge

A Storm Surge is defined as; ‘A temporary increase in sea level, above the level of the astronomical tide, caused by low atmospheric pressure and strong winds’ (Hulme M, 2002, p. 72). They are commonly associated with large tropical depressions such as hurricanes, but can result from less intense storms such as those that occur in UK. The low air pressure associated with the storm allows the sea level to rise and then the ‘storm – force onshore winds pile-up the water against a coast over hours, particularly at high tide vast quantities of water are amassed along the coastline’ (Swiss Re, 1998, p. 11). The bathymetry of the coastline, low lying topography and wave action can exacerbate the final surge height which can over top defences and flood low lying coastal areas. Dr Muir Wood of RMS (Risk Management Solutions) compared the randomness of such a tide coinciding with a severe storm surge with lemons lining up on a fruit machine. "The question is, is the second wheel going to come up with a lemon or not? If it does, you can have a catastrophic flood” (Press Association, 2006). Although the probability of each element coinciding with the other is relatively low, possible changes could be increasing the odds.

Urban Flooding

Floods in urban areas are ‘set off by high-intensity local precipitation that may continue for several hours’ (Swiss Re, 1998, p. 13) and or ‘typically in conjunction with thunder – storms’ (Munich Re, 2005, p. 10). In heavily urbanised areas the rain is not absorbed into the ground and runs off along the surface and into the drainage system, this often overloads the drainage infrastructure and waste water systems capacity. In turn causing them to back up and flood streets and homes with a mix of raw sewage and rainwater, with basement accommodation being particularly vulnerable.
Case Studies

Storm Surge

The most notable storm surge event in Europe struck the east coast of England and the southwest coast of the Netherlands on the 31 January 1953. The surge ‘caused the worst natural disaster in northern Europe over the past two centuries’ (RMS, 2003, p. 2). The storm surge was generated by an intense and fast moving low pressure weather system combined with a high tide. As the coasts of both east England and the Netherlands funnel together and the sea became shallow the surge was amplified and forced on to the coastal area.

![Figure 2- Scene from the 1953 Floods (RMS)](image)

The damage sustained along the east coast of England attributed to the surge and the waves lead to ‘1,200 flood defence breaches, 647 square kilometres of land flooded, 307 people died and 24,000 homes damaged, of which 500 were totally destroyed by floodwater’ (RMS, 2003, p. 4). The financial loss of materials only (excluding cost of business disruption and relocation) of the surge is estimated to be the ‘equivalent to around £1 billion in 2003’ (RMS, 2003, p. 5).

If the same event was to happen at present the potential loss is now far greater, models suggest that insured property losses that would occur today with the same extent of flooding as in 1953 would be £5.5 billion’ (RMS, 2003, p. 9). This highlights the fact that the increase in the assets now in coastal flood risk areas has risen since exponentially.

As mentioned previous, it has been suggested that Portsmouth among other coastal is at risk from ‘Katrina style flooding’ (Press Association, 2006). Hurricane Katrina generated a storm surge as high as 10m in some places along more than 150km of
coast and the sea water penetrated between 200m and 1,000m inland and caused USD$150bn worth of economic losses, with some of the loss being attributed to the surge. Although the coastal cities of the UK are highly unlikely to experience hurricane generated surges, an increase in storm intensity and increased development in coastal areas could hold the potential to generated larger and more destructive surges.

![Figure 3- Extensive storm surge damage to building in Biloxi (RMS 2005)](image)

**Urban Flooding**

There have been a numerous number of urban flooding events in urban areas throughout the UK. Portsmouth alone recently experienced two loss events, one in 2000 and to a lesser degree in 2006. These two events will now be discussed in more detail;

**2000 Floods**

This event was triggered by heavy persistent rainfall over Portsmouth, the total rainfall for the storms duration was 58.4mm which fell in 4 hours 30 minutes (Southern Water, 2007). This is the highest figure recorded by the EA since records began in the area in 1986 the previous record was 40mm in 24 hours in December 1993, to place this figure into perspective the average September rainfall for the area is 65mm. This event had a calculated return period of a one-in-a-108 year event (Southern Water, 2007)

The capacity of Portsmouth drainage infrastructure was overwhelmed due to the large volumes of runoff during the period of intense rainfall, the results led to the
failure and subsequent flooding of Southern Waters primary waste water pumping station. The failure at this site exacerbated the flooding and caused both water and sewage to flood 750 homes, numerous businesses schools and other properties (Owen, 2000, pp. 4-5)

![Figure 4 - Scenes from the 2000 Portsmouth Floods (Southern Water 2007)](image)

2006 Floods

The most recent incident of urban flooding in Portsmouth occurred on Wednesday September the 13th 2006. A storm that only lasted for 10 minutes swept across the area depositing 25mm of rainfall. The results of such a large volume of rainfall on such a localized area and in a small time overwhelmed the drainage capacity once again and resulted in numerous areas of localised flooding. 9 schools and numerous businesses were forced to close for several days. Transport infrastructure in the area was affected with 12” of water covering major roads, and major signal failures due to a flooded junction box on the railway line (Donovan, 2006, p. 3).
Flood Risk

Flood events globally are the primary source of natural catastrophes accounting for 32% of all events between 1990 and 2005. (United Nations, 2006) The frequency of flood disasters globally is on the increase. Figure 5 clearly shows increases in the number of flood events recorded per year between 1970 and 2005, indicating floods are one the most rapidly increasing forms of natural hazard.

![Figure 5 Number of Disasters attributed to floods 1975 - 2001 (UNISDR, 2005)](image)

Although an evident increase of flood events is apparent, the true increase may be less because the detailing and reporting of natural disaster events has increased markedly over the past two decades.

Flood Risk & the UK

Flooding is one of the greatest natural risks to property and assets in the UK; there are 2 million + homes at risk from flooding, which is a total of 10% of all homes in the UK (ABI, 2006). Nearly ½ million properties face a 1 in 75 chance of flooding (1.3% per annum) and 12,000 properties have a 10% probability of annual sewer flooding. (ABI, 2006)

The future risk is set to increase, potentially climate change will increase winter rainfall, the frequency of heavy rainfall, and sea level and storm surge heights. Without change in government policy or spending the number of properties at risk is estimated to increase by 1.5 million (ABI, 2006)
The Cost of UK flood risk

The annual costs of flood damage and mitigation in the UK are presented below using data adapted from the foresight report on flooding; there are a total 2,045,000 properties at risk from flooding in the UK as of 2004 (DTI, 2004, p. 10) and according to the EA ‘property, land and assets worth over £237bn is in danger of ending up under water’ (Osbourne H., 2006)

As can be seen the cost of flooding and the mitigation of flood risk in the UK is substantial, with £1.4billion and £800million respectively. What is interesting is that a much larger amount of money is spent on flood protection against intra – urban flood risk relative to annual damage. This can probably be justified due to the large economic loss potential in urban areas.

Flooding & Insurance

Private Insurance is a key mitigation method for the majority of businesses and residents in the UK with an average flood policy penetration of 95% (Crichton, 2005). Insurance allows the risk to be spread across policy holders, and can reduce the financial impact of a flood event.

Following the autumn 2000 floods in which 10,000 properties were flooded with a cost of £1.3bn (Environment Agency, 2001). There has been large scale and investment into flood risk management, to ensure insurance cover could still be provided. The insurance industry is now far more aware of flood risk, and has influence over the government on flood risk management issues.

The advancement in GIS (Geographic Information Systems) and understanding of flood risk is leading to more accurate pricing. The inevitable pricing
change is a benefit to the industry in terms of covering risk at more accurate prices and policy holders who will save money, but there will also be those who are detrimentally affected. Insurance penetration is lower in the less affluent members of society, but ironically these groups are on the whole more vulnerable to flooding due to the location of housing. With insurance premiums rising in higher risk areas, future penetration in these areas will fall further and with it personal financial mitigation.

A relatively new concept is that of the ‘flood resilient home’ of which the insurance industry is actively encouraging. This includes measures such as installing electricity points at a higher level, replacing MDF kitchen units with steel ones and laying ceramic floor tiles to replace carpets. This can be a very cost – effective way of reducing losses in high risk areas and will allow for continued flood insurance cover.
**Government & Flood Risk**

**Planning Policy Statement 25 (PPS25)**

Due to the increased demand for housing in the UK and specifically in government growth areas, there is the need to control limit development in flood risk areas. PPS25 aims are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding. This is an intuitive piece of planning policy that uses foresight combined with a process of risk identification, management and reduction to significantly reduce flood risk for the future if adhered too.

Land use planning in terms of flood risk has been very poor in Portsmouth; large areas of the island have been reclaimed for the sea or marsh land and then developed on, and it is in these areas the risk is the highest and there are further plans to develop. New policy such as PPS25 should prevent this from happening in the future.

**Home information pack**

As of June 2007 law will require all homes on the market to have ‘home information packs’ containing important information such as energy efficiency. The knowledge of whether or not a property is at risk to buyers is an important issue, although ‘at present flood and stability searches can be included in packs but this is not compulsory’ (DCLG, 2007, p. 23). Here soon to be in a place is a tool in which every new home buyer would be informed of the properties flood risk, this is a flood risk reduction opportunity that is being neglected.
Population and the South East Plan

One of the main contributions to a future increase in vulnerability is the future increase in population and the pressure that places current infrastructure and land use. In March 2006 the UK government published the ‘South East Plan’ which is a framework for the region up until 2026. One of the core aims of the plan is to increase the housing supply by 28,900 per year (South East England Regional Assembly, 2006); by 2026 south Hampshire will take its share of 80,000. According to figures published in the report Portsmouth will have to accommodate 14,700 homes and the Havant area will need to accommodate a further 6,301 homes (South East Regional Assembly, 2006, p. 77). Andy Watson, Southern Water’s Director of Operations has aired his concerns saying “With the present infrastructure, we do not support the plan for 14,000 new homes’ (Southern Water, 2007). This view is echoed by many, but at present has not been taken into consideration by policy makers. This increase in housing stock will increase the demand on an already stressed drainage and waste systems in the Portsmouth area, reducing its capacity to prevent urban flooding. The location of the new developments is yet to be revealed, but there are very few areas of land to develop on that are at a low risk of flooding, the implementation of PPS25 will be tested when it comes to finding suitable locations.

As well as the increase in housing in the near future, there are also large scale investments and redevelopment plans for many areas of the city, with costs predicted to go in to the £100’s of millions of public money and much more private investment, this investment is centred around the redevelopment and expansion of the main shopping areas and regenerating run down areas of the city. These changes will increase the potential economic loss, one area of redevelopment experiencing flooding in both 2000 and 2006.

Environmental Risk

As well as the obvious loss potential in the urban areas of the city, the local environment is at risk. Namely the Langston harbour area, which is a site of special scientific interest, with wetlands of international importance and a special area of conversation containing rare plants and animals.
During the 2000 and 2006 flood events, southern water pumped the mix of storm water and raw sewage into the harbour. This caused damage to the local ecosystem and presents health risks to those who use the area for recreational purposes. These 2 events are not isolated; in 2006 there were 19 controlled discharges (Pykett, 2007) into the harbour.

**Flood Risk & Climate**

There is no doubt that our climate is changing, the 2006-2007 winter season in the northern hemisphere being the warmest on record according to the National Oceanographic & Atmospheric Administration (NOAA) with the past 5 years in the UK 2002 – 2006 (Met Office, 2007) being the warmest since records began and 2007 set to be the warmest year on record. In terms of the nature of flood risk and climate change in Portsmouth, factors such as sea level, rainfall and storms are crucial and are all influenced by our climate.

**Sea Surface**

**Sea Level**

Sea level is a crucial factor in determining the risk from storm surges. There are two main factors that govern sea level rise; these are thermal expansion of the oceans and ice melt from glaciers, ice caps and the Greenland and Antarctic ice sheets.

The latest publication of IPCC (Intergovernmental Panel on Climate Change) 4th report details the latest data pertaining to global average sea level rise, the evidence suggests that ‘global average sea level rose at an average rate of 1.8mm per year over 1961 to 2003’ (IPCC, 2007, p. 7) and between 1993 and 2003 the rate increased to 3.1mm (IPCC, 2007). If this observed acceleration in sea level continues according to research conducted by Church and White in 2006 sea level in 2100 will be 310mm ± 30mm by 2100. (Church & White, 2006)

**Extreme Surges**

Extreme surges are another main component of a storm surges, much research has been conducted in this area since the 1953 floods specifically pertaining to the impacts of a changing climate. The UK Climate Impacts Programme (UKCIP) used computer models to simulate change in extreme surges for 3 emission level scenarios,
low, medium and high. The results for the change over a 50 year period on the central south coast area are 0.3m 0.5m and 0.9m respectively. (Hulme M, 2002, p. 76).

Although other studies suggest that ‘the pattern of increase in storm surge height is currently very uncertain and confidence is the prediction of extreme water levels is low’ (Lowe J., 2006).

This uncertainty can be related back to the future emissions of greenhouse gases, uncertainty in science, and possible natural climate variability.

Storminess

Storms are one of the key elements required to produce a storm surge, ‘global climatic change provoked by warming is predicted to increase the number and intensity of storms’ (Wisner, Blaikie, Cannon, & Davis, 2004, p. 86). The North Atlantic Ocean is the source of winter cyclonic depressions for the UK and Western Europe. A study of western European countries and storm activity, identified the UK is likely to see the most dramatic increase. Global Climate Models (GCM) simulated storm activity for several different scenarios; the results indicate that there will be a 25% increase in winter storm frequency and a 6% increase in intensity by 2100 (Lowe & Gregory, 2005, p. 1319).

Rainfall

As mentioned earlier, the main cause of urban flooding in Portsmouth are isolated convectional thunder storms which lead to intense precipitation over a localised area. Due to the localised nature of these events it is difficult to predict changes on a local scale, although there is evidence from a study by Osbourne that a greater proportion of precipitation is falling in larger events than in previous decades throughout the UK. Osbourne observed the ‘changes in the relative number and intensity of the convective and large scale precipitation events’ (Osbourne T., 2000, p. 362). Although this research does not directly link the observed changes with changes in climate, the evidence suggest that intense convective rainfall events now account for a much higher proportion of total rainfall in the UK than in previous decades. Research by (Haylock & Goodess, 2004) observed increases in heavy precipitation during the winter over Europe; this increase was linked to observed changes in the North Atlantic Oscillation (NAO), although no direct link could be established with a changing climate.
As well as the change in the frequency of intense rainfall, the distribution of annual rainfall is also set to change with the IPCC predicating an increase in winter rainfall and decrease in summer rainfall totals. Although the scale of change will vary over the UK with the SE expecting less total rainfall while northern parts of the country predicted a higher total.

Climate Variability

A large number of recent hydro-metrological events get labelled as an affect of ‘climate change’, variability in the climate also needs to be taken into consideration as a causational factor to elements such as rainfall and storms. Climate variations can occur annually or take place over a much longer time scale. The El Niño southern oscillation is an example of a well known variability, weather in the UK can be associated with the NAO as previously mentioned, observed changes in rainfall, temperature and storminess coincide with the decadal variation the NAO (Marshall, 2001). Solar activity also directly affects the UK climate; research has showed ‘over the last century the number of sunspots rose at the same time that the Earth's climate became steadily warmer’ (Whitehouse, 2004). If a direct link can be established between external variations, then anthropogenic forcing of the climate may be having a very minimal impact on the changes that are occurring.

Subsidence

Another more localised factor relating to sea level on the south coast of England is coastal subsidence due to glacial isostatic adjustment (GIA) or otherwise referred to as glacial rebound. This is a geological response to the retreat of the ice that covered large areas of Northern Europe during the last ice age. The large reduction in pressure on the land surface is causing it to slowly rise, in a counter movement or ‘tilt’ the south east of the UK is sinking. The impact of this is a relative increase in sea level in comparison to the land. A report into the affects of GIA on the UK by (Peltier B, 2002) indicates that the south east region of England is subsiding by 0.5mm per year. According to Munich reinsurance ‘storm surge catastrophes in the past decades would have been far less severe without the secular downward movement of the southern North Sea basin.’ (Munich Re, 1997, p. 26) Storm surge
risk in the future, for Portsmouth and other areas in the South East such as London is set to increase marginally due to this factor alone.

**Summary**

The city of Portsmouth is located in a naturally vulnerable area to flooding, but also contains a large population with key infrastructure and therefore large loss potential and it is clear that the area needs to be protected. Development, reclamation and poor land use planning has increased this further, with more planned development set for the future increasing loss potential. The two hazard types and associating impacts both have the potential to affect the city, and literature indicates the probability could be increasing.

The literature clearly indicates that climate in conjunction with other natural processes have the potential to increase flood risk, in terms of the effects on a specific location such as Portsmouth this still remains unclear, in terms of sea surface and changing rainfall patterns. Current UK policy and future developments are encouraging in terms of the reduction of flood risk overall, but opportunities to increase flood awareness are being missed. The future direction of the insurance industry and the influence it has on decision makers is also a positive, the only drawback being the potential low penetration rate of flood cover in high risk areas.

Through the desktop research it is clear that a more specific understanding of the changing risk is needed in Portsmouth, including the current awareness and opinions of those at risk.
Methodology

Related Theory

Vulnerability & Hazards
As mentioned previously to retain a sense of continuity through the project the methodology being adopted (R = H x V) is in order to indentify the risk each element needs to be assessed individually in relation to the location, which in this case is Portsmouth. The two hazards identified are tidal storm surges and intense precipitation, with vulnerability arising from numerous sourced discussed throughout the report.

Horizon Scanning
The nature of this project is to investigate the flood risk and how its nature is set to change in the future, this research follows a method of thinking known as ‘Horizon Scanning’, defined as;
“The systematic examination of potential threats, opportunities and likely future developments which are at the margins of current thinking and planning. Horizon scanning may explore novel and unexpected issues, as well as persistent problems or trends’ (DEFRA, 2006)
Horizon scanning is used by varying disciplines, from technology development, strategic government planning, risk management and insurance. Anticipating probable future changes in flood risks, will allow for informative recommendations concerning effective planning and preparedness.

Secondary Data

Desktop Research
A desktop research method was used to review current literature and publications in section 2. The research covered explanations of the hazard and case studies of their impact, identification of the main factors relating to vulnerability now and in the future. This method identified gaps and inadequacies in the current information available pertaining to flood risk in Portsmouth.
Observational Data

Secondary data was obtained in the form of raw sea surface and rainfall data for Portsmouth, this was then analysed to fill in the gaps identified through the researched literature in terms of specific data relating to Portsmouth instead of generic UK wide results presented in the reports researched. These results will support primary data and recommendations later on in the report.

Primary Data

Flood Risk Awareness

Public questionnaires were essential to the research, as an element of vulnerability is the awareness to a hazard. The data collected provides a representative sample of the public awareness and attitudes to varying elements of flood risk. This was achieved via an online questionnaire with 14 carefully selected questions.

Interviews

To gain an understanding of the risks and the challenges faced by those whose responsibility it is to manage them, and to be able to reflect this throughout the report interviews were conducted with;

- Dr Mike Bateman - Chairman Southern Regional Flood Defence Committee
- Tony Sharman – Ex Operations Manager, Southern Water Eastney Pumping Station
- No name – 4Delivery engineering consultant

Conclusions & Recommendations

The conclusions and recommendations found in section 7 & 8 of this report respectively are the culmination of the research conducted and are the logical ending point of any report. The conclusions will sum up the findings of this report relating back to the aims and objectives in section 1. The recommendations will be based upon the findings of the research and analysis carried out to allow for key recommendations in reducing flood risk spanning the short to long term.
Justification of Primary Research Method

As mentioned above the primary research method adopted was an online based questionnaire. The method adopted is not as well proven or as conventional as other data collection methods, but it has many positive aspects over more favoured methods. Naturally, the main drawback is that people without access to the internet are unable to access the questionnaire. Although internet penetration in the UK is now 62.3% (Miniwatts Marketing Group, 2007) which in turn means on average over half of those who receive leaflets could technically respond. The positive attributes of a paper based questionnaire are present such as the standardisation or questions and the ability to use a large sample in short periods of time. There are attributes that only a web based survey can offer, the cost benefit in comparison to other methods is sizeable in comparison to a postal questionnaire, aesthetically the questionnaire looks professional, the ability to export the data into a spreadsheet programme instantly for analysis is more efficient and the return period on getting results is relatively short. Therefore an online primary data collection method was adopted.

Data Collection

Both primary and secondary data was obtained from various sources. Rainfall data for Portsmouth was obtained from the EA Hydrological department for the southeast of England. The sea surface data for Portsmouth was obtained from the National tidal and sea level facility, which is hosted by the Proudman Oceanographic Laboratory (POL) website. As part of an assessment of flood risk, flood awareness of the population at risk is a fundamental factor. Therefore primary data was obtained from Portsmouth residents by means of an online questionnaire. Views and opinions of those involved with flood risk in Portsmouth were gained during personal interviews.

Secondary Data

Sea Surface

Sea Surface data is vital in assessing the flood risk from storm surges and high tides. Sea surface data for Portsmouth has been collected since 1991 by POL who established the UK tidal gauge network following the 1953 East coast floods, with the aim of providing warnings of possible flooding in coastal areas. The data is available
at request through the POL website after registering and stating the use of the data. The secondary data acquired from the Portsmouth tidal gauge located in Portsmouth harbour is the most accurate data available in terms of surge and sea level data. The data available was as follows:

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly Extremes</td>
<td>Maximum and Minimum values for sea surface height over all sampled data during the month</td>
</tr>
<tr>
<td>Monthly Extreme Surges</td>
<td>Largest difference between the height of the recorded tide above the predicted level</td>
</tr>
<tr>
<td>Monthly Means</td>
<td>recorded levels between high and low water levels for the month</td>
</tr>
</tbody>
</table>

Table 1 - Tidal Gauge Measurements

To identify the risk from surges, tidal level, extreme surges and monthly means are all relevant; the height tide data will indicate the possible maximum of the tide, extreme surge data will hold information pertaining to the frequency and height of the surges and the monthly mean data will indicate any changes in long term sea level. All the data has been quality checked, with errors arising from datum shifts and timing errors corrected. There have been periods when the gauging stations have been offline, 1998, 1999 and 2005 for two, three and one month respectively. This absence of data has very little affect because they analysis is based on long term trends, therefore these null values will be disregarded in the analysis of the sea surface data. Examples of the data in its raw format are below:

<table>
<thead>
<tr>
<th>Month (mm/yyyy)</th>
<th>Monthly Mean Value (metres)</th>
<th>No. of days used to calculate mean.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/02/1991</td>
<td>2.704</td>
<td>28</td>
</tr>
<tr>
<td>01/03/1991</td>
<td>2.774</td>
<td>31</td>
</tr>
<tr>
<td>01/04/1991</td>
<td>2.741</td>
<td>30</td>
</tr>
<tr>
<td>01/05/1991</td>
<td>2.653</td>
<td>31</td>
</tr>
<tr>
<td>01/06/1991</td>
<td>2.82</td>
<td>30</td>
</tr>
<tr>
<td>01/07/1991</td>
<td>2.798</td>
<td>31</td>
</tr>
<tr>
<td>01/08/1991</td>
<td>2.775</td>
<td>31</td>
</tr>
<tr>
<td>01/09/1991</td>
<td>2.866</td>
<td>30</td>
</tr>
<tr>
<td>01/10/1991</td>
<td>2.862</td>
<td>31</td>
</tr>
<tr>
<td>01/11/1991</td>
<td>2.889</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 2 - Monthly Mean Sea Level example data
Table 3- Extreme Surge Data Example

Precipitation

The rainfall data was acquired from the Environment agency’s hydrological office for the South East, the rainfall gauge is located at the Eastney Pumping station. The data received was highly detailed with 62,526 individual records in the form of ‘event rainfall data’ which measures every 0.2mm of rainfall recorded between 1/08/1986 – 01/03/2007. All the data has been quality checked by the EA, data for January 1988 is not available due to maintenance of the gauge, and the data for November 2007 has been discounted as it only recorded 0.2mm for one day. For the purposes of the research needed event rainfall is a much too detailed data set, therefore daily and monthly rainfall totals will be extrapolated from the data allowing a more appropriate data set sizes of 3,183 and 244 respectively. An example of the raw data for one day can be seen below.

Table 4- Rainfall Data Example
**Primary Data**

**Flood Risk Awareness**

Assessing flood risk awareness in Portsmouth involves a different approach than those applied to the collection and analysis of sea surface and rainfall data. There is currently no secondary data available where flood attitudes & awareness in Portsmouth can be accurately assessed. There are numerous ways to ascertain and collect data pertaining to the attitudes and awareness of a sample population.

There are many services based on the internet which offer questionnaire hosting, both free and charged. The free services did not offer the range, flexibility and aesthetic look that are required for this project. ‘SurvSoft’ was the service decided upon at a cost of $12 (£6) per month, the price was reduced further by sharing the service with a fellow student who had similar requirements.

Accessibility to the questionnaire is paramount, the initial web address for the survey was ‘http://www.survsoft.com/surv.php?s=34650&k=8546-0-927’. This web address was inadequate for the purposes of communicating the questionnaire to the target population. Therefore the web address ‘www.portsmouthfloodrisk.co.uk’ was purchased for £6. A much shorter, relevant address in a format familiar to all web users made the questionnaire more accessible. The total cost for the primary data collection was £9.

To create an awareness of the questionnaire among the target population small business card sized flyers (see figure 7) were handed out in the two main shopping areas (Southsea & Commercial Road) on a Saturday afternoon.

**Figure 7- Questionnaire Leaflet**
Questionnaire Design

A pilot study was conducted using 5 of my peers; this identified several minor issues such as grammatical errors and the need to reword some of the questions. Several technical issues were also highlighted; the open ended ‘how long have you lived in Portsmouth’ question was reformatted as results were being returned in both numerical and text format and at indiscriminate intervals. This was replaced with a single option such as 5 – 10 years. To make sure only Portsmouth residents took the questionnaire (as it was technically available to anyone with access to the internet) a postcode was required to complete the questionnaire in the form of a forced question, this therefore will increase the validity of the results.

The questions were designed to effectively gauge the awareness and attitudes of residents in Portsmouth regarding flood risk. Question 1 was used to primarily validate those taking the questionnaire, but also had applications in comparing results to specific locations. Question 2 concerning age groups, is designed so different groups can be linked with other questions. Questions 3 – 5 are designed to assess the attitudes towards flood risk, 6 - 9 will see if any measures have been taken to reduce risk. Questions 10 – 11 gauge respondents attitudes towards future risk, the final two questions deal with the financial side of flood risk protection and question 14 is an open ended question allowing for comments to be made.

As an added extra, once the respondent completes the survey, a ‘thank you’ message appears (see figure 8 ) after 5 seconds the user is the redirected to the EA flood map webpage to check the risk of coastal flooding to their property. An example questionnaire is located in Appendix 9.1.
Interviews

Two formal interviews were conducted and recordings of these interviews were made, one other interview was conducted but permission to record them was denied. The aim of the interviews is to gain an understanding of the flood risk from the perspective of those whose responsibility it is to manage it.

Dr Mike Bateman – Chairman Southern Regional Flood Defence Committee
Dr Mike Bateman, previously the pro – vice chancellor of the University of Portsmouth and now chairman of the southern flood defence committee. Regional Flood Defence Committee’s (RFDC) role’s are too; recommend the money which local authorities have to pay towards flood defence, prepare an annual programme of flood defence maintenance and to provide and operate flood warning systems. This position means that Dr Bateman is highly knowledgeable of flood risk on the south coast and its mitigation.

Tony Sharman – Ex Operations Manager, Southern Water Eastney Pumping Station
Tony Sharman a current employee of Southern Water, who previously was the operations manager at the main pumping station that protects Portsmouth from urban flooding and was present during the 2000 floods and failure of the station. The purpose of interviewing Mr Sharman was to gain a specific understanding of the drainage infrastructure and why it was vulnerable.

Unknown – 4Delivery engineering consultant
This interview was not planned, but occurred during a public consultation with Southern Water regarding the increased frequency of urban flood events. 4Delivery is a consortium comprised of utilities management, engineering and construction and water supply specialists. The individual interviewed did not want his name or interview recorded due to the sensitive nature of the issue.

Knowledge obtained through these interviews is integrated throughout this project in helping to build a more comprehensive picture of flood risk in Portsmouth but will not be discussed in detail. Although Southern Water during the interview were not willing to answer all the ‘key’ questions or divulge information such as storm pump usage data that would have aided with the process of this project.
Limitations of Data

Secondary Data

The main limiting factors that affect both sea surface and rainfall data is the relatively short time period that the data has been recorded in 15 and 21 years respectively. In terms of identifying long term trends with a high level of confidence the time scale may prove to be limiting. Although the same problem does face those in the field of climate change research and the changing nature of risk as accurate records have been around for a relatively small period of time. If changes are occurring as rapidly as literature suggests then the aforementioned time periods the data was collected should yield results in the data analysis process. The abnormalities in the data are discussed earlier on in this chapter. Due to the fact both data sets originate from Portsmouth itself, adds more validity to the results.

Primary

As well as the discussed benefits of the data collection method in section 3.5 there were some initially unseen limitations. Although there were 65 respondents who completed the questionnaire there are several questions with non-responses in which respondents did not answer the question. This could have been due to such factors as not fully understanding the question or simply missing it out by mistake. This does not have a major impact upon the final results as they are still representative.

The interviews that were carried out were not as productive as initially planned due to the sensitive nature of the issues covered. The interview with Southern Water was fruitless, in that all questions asked pertaining to urban flood risk and southern waters role in its managements were all avoided.

The aforementioned data, secondary in the form of literature review, sea surface and rainfall data combined with the primary data obtained from Portsmouth residents and those who were interviewed will allow for a comprehensive flood risk assessment.
**Data Analysis**

The data collected falls into two distinct categories, secondary and primary data. The secondary data collected is in the form of raw sea surface and rainfall data and is entirely numeric and therefore will be analysed via mathematical techniques and presented graphically and discussed. The primary data collected, which is concerned with the flood risk awareness and attitudes of Portsmouth residents was collected via online questionnaire and contains data which can be manipulated into numerical data and presented graphically which will allow for further analysis and discussion.

**Secondary Data**

**Sea Surface**

To ascertain whether the risk of tidal storm surges flooding areas of Portsmouth is increasing, sea surface data is crucial. Data collected been 1991 – 2006 regarding sea level and extreme surges will now be analysed.

*Sea Level*

![Graph showing mean sea level in Portsmouth Harbour 1991 - 2006](image)

Data pertaining to sea level was acquired from the gauging station in Portsmouth between January 1991 and November 2006. Using the mean monthly value for the months in between the dates just mentioned the data was placed into a spreadsheet programme to produce the line graph above; a trend line was then applied (see figure 9)
As is evident from a visual analysis, there has been a marked increase in the mean sea level in Portsmouth Harbour. The actual increase in mean level in the aforementioned period has been 80mm which over a 16 year period equates to a 5mm increase per annum. If the GIA rate of 0.5mm, as discussed in the literature review is taken into account then the actual sea level rise is occurring at 4.95mm per year.

Using another function of the spreadsheet programme the established trend line was extended allowing for a forecast to be made to a given point in the future (see figure 10). A 50 year forecast projects average sea level in 2057 to be 3.19m, which is an increase of 210mm. If we forecast 100 years from 1990 levels (2.8m) using the data above the predicted height is 3.3m, which is a change of 0.5m or 500mm. According to Church and Whites maximum value of change by 2090 will be 340mm. This suggest that sea level rise in Portsmouth is higher than the global predicted increase.

Figure 10 - Sea Level Rise 50 & 100 year forecast

Extreme Surges

As well as mean sea surface level, monthly extreme surge data was acquired for the same time scale. The same technique for creating the average sea surface level graph was applied below.
The above graph clearly shows an upward trend in extreme surge height in Portsmouth over the past 16 years the average height of a surge has increased from 42cm to 56cm which equates to a 9.3mm rise per year. There has been very little documented evidence to suggest the surge heights on average are increasing. Extrapolating this data to 2057 the average extreme surge height is 0.8m which falls just below the height predicted by the high emission climate model scenario analysed by Hume in section 2.11.1.2.

There is much evidence to support sea level rise globally; there was very little quantitative data to suggest extreme surge heights were also increasing. The data analysis above and evidence in the literature pertaining to increase storm intensity and frequency is evidence to prove that key the elements of a storm surge have increased and will for the foreseeable future continue to do so; therefore it can be said with confidence that the risk of a storm surge event in Portsmouth is on the increase.
Precipitation

Analysing rainfall records is aimed at identifying changes in intense rainfall events in Portsmouth, both daily and monthly rainfall are analysed.

Daily Rainfall

It was not possible due to limitations of the spreadsheet programme to analyse each individual rainfall event (62,526 events), therefore rainfall totals for each day were calculated and analysed to investigate any possible trends or patterns.

![Figure 12: Daily Rainfall Portsmouth 1986 - 2006](image)

A trend line was calculated and placed on the graph but there is no obvious positive or negative trend. The tallest spike in 2000 represents the 1 – 108 year return period rainfall the caused severe urban flooding in September 2000. However the rainfall event which caused local flooding in September 2006 does not stand out indicating that height daily rainfall totals are not directly related to flooding. Other spikes on the graph were investigated but no flood events such as those on the scale of 2000 and 2006 were identified. This suggests that an analysis of the intense rainfall events rather than the daily totals would yield more comprehensive results.

The seasons can be seen by peaks and troughs in the rainfall, and post 2000 the frequency of high amounts of rainfall per day appears to be in decline. An
interesting observation which is not immediately apparent is that of the 15 spikes (days) above +30mm per day 86.6% occurred between September and December as the chart below shows.

![Figure 13 - Graph to show days of rainfall <30mm per day](image)

Further investigation into these unexpected results identified the south coast to be vulnerable to convective storms during this period, due to the warm air over the sea meeting with cooler air as temperatures decrease during the autumn season. No direct record of convective storm activity was available, however tornado activity is. Tornados are a direct result of convectional storms and provide a good indication of vulnerable areas. Figure 13 shows all reported tornado activity in the UK up until 2005, as can be seen the central south coast including the Isle of Wight has experienced a large percentage of events and it can be suggested that this area is vulnerable to convective storms during later summer early autumn.

![Figure 14 – Spatial Distribution of UK tornados (Torro, 2006)](image)
Monthly Rainfall

During the literature review process, it became apparent that total rainfall was predicted to increase in the UK via a reduction in summer rainfall, but an increase in intense rainfall events and winter rainfall. This would go against apparent recent trends of reduced rainfall and the recently witnessed 4 year drought. Using the event rainfall data, monthly totals were compiled for the 20 year period.

![Average Monthly Rainfall Portsmouth 1986 – 2006](image)

**Figure 15 - Average Monthly Rainfall Portsmouth 1986 – 2006**

Primary Data

**Questionnaire**

The data was downloaded from the web based server. The results above clearly indicate that over the past two decades average monthly rainfall has increased by 5mm per decade or 0.5mm per year, these results concur with predictions Osbourne that overall rainfall is increasing in the UK.

into a spreadsheet programme. The results in a percentage and raw format can be found in appendix 9.2. 65 valid residents of Portsmouth responded to the questionnaire, 3 respondents were removed as the postcodes did not represent Portsmouth based location, with one respondent residing in Birmingham. 65 valid respondents is an adequate representative sample for the purposes of the research. The results for question 3 – 14 will now be presented and discussed

**Results**
3. Do you know if your property is at risk from flooding?

The results above displayed as a bar chart clearly indicate that the majority of the respondents (67%) are unaware of any potential flood risk, the results for those who are aware of the risk to their property where similar, 13% & 19% respectively. Using the postcode data of each individual respondent and the EA online flood map it was possible to compare those at risk with the responses. (Please note only based on flood map from storm surge). 60% of those who thought their properties are at risk are. Those respondents who said their properties were not at risk 25% fell within the projected flood risk area and those who were unsure 24% were at risk of an extreme surge. The results echo those of the EA who found that 41% (Environment Agency, 2005) of those potentially at risk were unaware of the fact.

4. To what extent do you agree with the statement ‘I am concerned about the flood risk in Portsmouth?’
The results from this question show that almost half (49%) of those surveyed agree or strongly agree that flood risk is of concern which is encouraging. From the results it could be suggested that the risk is being underestimated with 25% of residents who are not concerned about flood risk in the slightest with another quarter who are have no view point either way.

5. On a scale of 1 - 5 (1=being low risk 5=being high risk) how likely do you expect flooding resulting from a coastal storm surge and intense rainfall?

![Figure 18 - Hazard Perception](image)

The aim of this question was to see which flood risk was perceived as most likely to occur in Portsmouth, the radar graph below indicates a relatively even spread in terms of opinion with neither risk extending out much more than the other. The majority of results are centered around the neutral weighting of 3 which could be due to the lack of knowledge about each hazard. The risk from a storm surge is marginally the most expected cause of flooding.

The results were unexpected as it is said that ‘awareness of risk is conditioned by previous experience’ (Wisner, Blaikie, Cannon, & Davis, 2004) if this were true then intense rainfall which has resulted in 2 notable loss events within 6 years would be shown in the results. However risk from storm surges is more prevalent following the mass media coverage of Hurricane Katrina, in the same way awareness of tsunami hazards increased following the Indian Ocean event.
6. Have you taken any action to find out if your property is at risk from flooding?

![Figure 19 - Residents Action to investigate flood risk](image)

The above results clearly show that only a small percentage of those who were surveyed has taken any action to investigate if their property is at risk from flooding. For residents living on an island which has two potential devastating flood risks, the above results should be of concern to those who manage flood risk, and the insurers who cover risk. Similar results were expressed in question 7 ‘Have you taken any preventative measures at your property to protect from flooding?’ with only 7.2% of respondents taking action to increase their resilience to flooding.

Questions 8 & 9 ‘Are you aware that you can check the flood risk to your property on the Environment Agency Website’ & ‘Do you check for flood warnings during periods of extreme wet and stormy weather?’

![Figure 20 - Question 8 & 9](image)

As can be seen the results for both questions are very similar with under one third of respondents aware that they can check flood risk themselves. The results are mirrored in the number of respondents who are actually pro-active in checking flood warnings during periods of weather that are associated with flooding. The results are of
concern, for such a high risk area with 75% of respondents take no action to check for flood warnings.

10. Do you think that current flood defences will provide adequate protection for the next 50 Years?

The results above clearly indicate that the large majority of people do not believe that current flood defenses at present will provide adequate protection for the next 50 years. There are a slightly higher percentage of respondents (15%) who are aware that the protection from urban flooding at present is inadequate in comparison to coastal protection. This gives a more indicative result than that of question 5. There was an ‘I don’t know’ option for both elements of the question but not one single respondent selected this option, which would indicate that there a distinct awareness of the two hazard types.
11. To what extent do you agree that - 'Climate change is increasing the risk from flooding in Portsmouth'?

![Figure 22 - Climate change & Flood Risk](image)

Climate change and its current and future impacts have never been as prolific as they are now in the media. With the release of the latest IPCC 4\textsuperscript{th} report being presented as the top news stories and covering the front pages of newspapers in February 2007, and major political leaders making climate change policy central to the future of the country. It is therefore no surprise that 62\% of those sampled either agreeing or strongly agreeing that climate change is increasing the flood risk to Portsmouth, with only 6\% disagreeing with the statement.

12. Do you have insurance that covers your home contents and/or property from flood damage?

The UK flood insurance as discussed previously is based on private insurance, the penetration of which was unknown for Portsmouth. The results were unexpected in that only 24\% had said they were aware of having insurance policies that covered for flood damage. Flood insurance penetration in the UK is at 95\% (Crichton, 2005). Although further investigation shows that in the lower socio-economic groups the rate can be as low as 30\% (Crichton, 2005). Therefore it could be suggested that those surveyed are in very low – socio economic group, which in part is true as Portsmouth is not an affluent area. Both the answer ‘no’ and ‘don’t know’ accounted for 38\% respectively. The high percentage of those who are unsure could be due to the fact that the policy holder did not take the questionnaire or was in rented accommodation. Those who answered ‘no’ 28\% are at risk from coastal flooding alone using a post code analysis.
13. How should the cost of flood protection be spread?

As is clear the majority of respondents would agree with the more accurate pricing of flood risk insurance, this is no surprise as the majority of respondents will benefit from this. The second most favoured option is to spread the cost of flood protection across the whole country, such as national catastrophe pools that other countries have adopted. The question also had an ‘other’ option to leave open ended ideas for the spread of flood risk. There were several suggestions; one respondent commented that a combination of both the individual, central and local government should be implemented. The ‘sliding scale’ of cost is an efficient way of spreading the risk, except the most vulnerable have to pay the highest price but a large number are those who are not in a financial position to pay even higher premiums.

Question 14 - Further Comments
At the end of the questionnaire there was an open ended comments box, to allow the respondent to make any further suggestions and comments, there were a total of 6 respondents. A selection of these will now be discussed.

‘I would not know how or who to contact regarding Flood warnings, I have not seen any information from councils on this matter. A very interesting question form, which has now got me thinking about what I should do!’

The statement above is of concern, anyone living in an area at risk from flooding should be aware how to access flood warnings and information, although according to the EA only 7% of those at risk are aware of how to access warnings.
My property is over 200 years old, and as far as I’m aware, there has never been any flood damage in that period. I have lived in the same property for 23 years. During that time the oct.87 storms has been the worst time for us, which was mainly high wind damage.

This property is located on the edge of the flood risk area of storm surge flooding, and reinforces that awareness is based on experience, as the largest perceived risk is windstorm and not flood.

‘My basement is now permanently damp (past 10 years) with flooding happening as a result of combined high tide/intense rainfall-am probably about 5mm above the water table. Recent 3 floods apparently ’acts of God’- God seems to be acting out a lot in this area!’

This respondent is highly aware of the problems facing the area, due to the combined problem that rainfall and combined high tide brings. The risk to this property with a basement and its location places it at combined risk from both hazards, and has been flooded 3 times in 10 years. This respondent also appears to be aware that the probability of the events is increasing.

‘I think southern water have a duty to upgrade their pumping stations. As a direct result the sewer system cannot handle the runoff during heavy rain which has resulted in my property to flood’

The response above, highlights the major factor that the pumping stations, especially the Eastney site’s capacity to remove water from Portsmouth and other areas during increasing intensity of rainfall is not sufficient for present and future predicted scenarios.
Conclusion

Throughout the research it has clearly been identified that the city of Portsmouth is a vulnerable area in terms of flood risk and the nature of this risk was constantly shifting. This report analysed relevant literature, secondary observational data pertaining to sea surface and rainfall data in Portsmouth and allowed for forecasting techniques to be applied to base conclusions upon. Primary data was collected from Portsmouth residents which allowed a crucial element of risk to be investigated.

The research indicates that the two key elements of a storm surge, sea level and extreme surges are both increasing. The relative sea level in Portsmouth harbour including GIA subsidence is rising by 0.5mm a year and the average extreme surge height is increasing by 9.3mm per year. Future projections of 50 and 100 years forecast average sea level to be 3.19m and 3.4m respectively and the average extreme surge height to be 0.8m and 1.38m. Although the linear technique used to analyse the data cannot account for externalities such as natural variability or astronomical influences there are very pronounced increases over the 16 year period. This evidence combined with research reviewed in section 2 pertaining to increase storm intensity and frequency increase, it can therefore be suggested with a high level of confidence that these changes are set to continue and in turn will have a direct impact in terms of flood risk from storm surges. Referring back to Dr Muir Wood of RMS analogy of storm surge and a fruit machine in section 2.4.1, the odds of the lemons lining up on the fruit machine are increasing.

The changes in the intensity and frequency of intense precipitation are more uncertain at this point due to the limitations of the data analysis software used no discernable change could be indentified via a trend line analysis. There was no evident increase in increased daily rainfall amounts, although short intense rainfall events would have been diluted in assessing daily totals. This does not mean that there is not an increase, research by Osborne and IPCC findings indicate that the temporal distribution of rainfall is in fact changing with more intense rainfall events. The monthly rainfall graph reinforces the prediction that total rainfall is increasing, this can be used as an indication to suggest more rainfall is falling in intense events. An unexpected, although potentially valuable observation of the daily rainfall totals was the monthly distribution of the +30mm daily totals, 86.6% occurring between September and December.
There are several identified anthropogenic pressures resulting in increasing flood risk for both hazards. The new multi-million pound investments into the area in housing and other facilities such as regenerated shopping areas which have been identified to be at ‘risk’ will increase loss potential without any measures being taken to reduce the risk. The south east plan, which stipulates the construction of almost 15,000 in Portsmouth alone, will further reduce the areas capacity of current waste water infrastructure that has not been increased in line with previous urbanisation of the area.

Another key element of flood risk is the awareness and attitude towards the hazard, primary research indicates that awareness of both flood risks is low. The lack of proactive action taken by those who live in a vulnerable area is of concern, even more of an issue is that almost 20% residents who do not know if they are at risk of flooding are. Although there does appear to be a good awareness among residents that current risks will increase in the medium to long term. It is clear that awareness of flood risk in Portsmouth needs to be increased in order to reduce this element of vulnerability.

In terms of which flood risk is the greatest at present and in the future, urban flood risk is the greatest currently as current capacity in inadequate to deal with the more intense rainfall events and therefore should be the focus of any investment. This does in no way mean storm surge risk should be disregarded, over the next 50 – 100 years the probability of this event through research conducted in this report will increase. Therefore pro-active measures to increase resilience from an individual household level upwards should start to be integrated.

It has to be taken into account the element of uncertainty that surrounds our climate and future predictions, although as our knowledge and understanding increases we can be more confident in future predictions.

In conclusion the risk of flooding, urban and storm surge is inexorably increasing in Portsmouth, and will continue to do so in the medium to long term if a pragmatic combination of mitigation and adaptive risk management is not adopted. The findings in this report could also be applied in some aspects to other coastal and urban areas.
**Recommendations & Future Development**

**Recommendations**

The research identified the main issues pertaining to the changing nature of flood risk in Portsmouth, and the conclusion summarised these findings. This final section of the report will make key recommendations that will allow for flood risk reduction from the short to long term.

As identified in the literature review, the home owner’s information pack is an opportunity to promote awareness of flood risk to every single residential property in the UK. Over the next 50 years a generation of new property buyers would have received the pack, and in turn potentially would be aware of possible flood risk. Therefore flood risk information should be compulsory in home information packs as of June 2007. Although this could reduce house prices, it will reduce risk via increased awareness and in turn reduced losses.

The seasonal vulnerability indentified to convective storms that produce intense localised rainfall can be used for better preparedness. Targeted maintenance of the waste water infrastructure, clearing of drains etc towards the end of the summer should reduce localised flooding. Currently there is no early warning system in place to alert of potential storms, the use of rainfall radar observations would allow pumping stations to be primed before a storm hit. The current capacity of the waste water infrastructure needs increasing, primarily the increase in the capacity of the pumping stations to remove the water from the joint drainage system.

A relatively new technology in terms of urban drainage construction is sustainable urban drainage systems (SUDS). These essentially reduce run off into drainage systems via varying methods such as porous road surfacing that allows for infiltration, or increasing the time between the rain falling and entering the drainage system. In such a highly urbanised area as Portsmouth this could be very successful and further research into their application and effects should be investigated.

Flood resilient measures should be integrated into high risk properties such as basement flats after a flood event or during any planned retrofitting. These measures can be highly cost-effective if a property was to be flooded. This should be incentivised with a reduction in premium costs or the refusal of insurance cover; flood
resilient measures have been proven to reduce the losses and recovery costs of flood events.

In terms of the South East plan, new development should be a last result, with refurbishment and flat conversions to be made priority. Any new developments should have the drainage infrastructure in place before development, and if built in high risk areas have a raised living space such as having a garage at the bottom of the property.

Latest Developments

During the later stages of this research project there have been recent developments in terms of both flood risks in Portsmouth. Southern Water recently announced a £20million plan to protect Portsmouth from future urban flooding. These include a new £10million pumping station at Eastney (still in consultation stage), the separation of rainwater and foul before it reaches the sewers, improved screening of storm water before it is released and other key changes to reduce urban flood risk. Very recently (April 2007) Portsmouth city council applied for £35million from the EA to improve coastal defences on the island to protect from storm surges.

These recent developments reinforce the research findings of this report, and the moves to reduce flood risk in Portsmouth are much needed. These latest measures are heavily grounded in mitigation, more attention needs to be placed upon adaptive measures such as those discussed in the recommendation section. A combination of both approaches will leave the least amount of residual flood risk in the future.

Future Research Opportunities

During the research it was clear that there are inadequacies in providing flood insurance cover for those who do not have the monetary ability to do so, but are at very high risk. Further research into possible solutions in providing flood insurance cover should be undertaken as this is a serious issue for many at risk properties throughout the UK. Also research into how to integrate flood resilient measures into high risk properties to reduce the impact of future flooding could also be investigated in future research projects.
Bibliography


Word Count - 12,946
Appendix

Sample Questionnaire

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**Portsmouth Flood Risk Questionnaire**

The University of Portsmouth is currently undertaking research into flood risk in the area, related to intense rainfall resulting in urban flooding and storm surges resulting in coastal flooding. Flood preparedness and awareness of local residents is crucial to build up a complete picture of the risk.

This questionnaire will take less than 2 minutes to complete and will greatly assist in understanding flood risk in Portsmouth.

* Indicates required questions.

---

1. Please enter your Postcode *

---

2. How many years have you lived in Portsmouth? (if more than 15 please state how many in 'other')

- [ ] 1-2
- [ ] 3-5
- [ ] 6-10
- [ ] 11-25
- [ ] Other ___________

---

3. Do you know if your property is at risk from flooding?

- [ ] Yes, the property is at risk
- [ ] No, the property is not at risk
- [ ] I do not know if the property is at risk from flooding

---

4. To what extent do you agree with the statement 'I am concerned about the flood risk in Portsmouth'

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
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5. On a scale of 1 - 5 (1 = low risk; 5 = high risk) how likely do you expect flooding resulting from a coastal storm surge and intense rainfall?

<table>
<thead>
<tr>
<th>Coastal Storm Surge</th>
<th>Intense Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

6. Have you taken any action to find out if your property is at risk from flooding?

- [ ] Yes
- [ ] No

---

7. Have you taken any preventative measures at your property to protect from flooding?

- [ ] Yes
- [ ] No

---

* **SurvSoft**
Portsmouth Flood Risk Questionnaire

8. Are you aware that you can check the flood risk to your property on the Environment Agency’s website?
   - Yes
   - No

9. Do you check for flood warnings during periods of extreme wet and or stormy weather?
   - Yes
   - No

10. Do you think that current flood defences will provide adequate protection for the next 50 years?
    
    | Yes | No | Don’t know |
    |-----|----|------------|
    | Storm Surge Flooding |   |            |
    | Urban Flooding |   |            |

11. To what extent do you agree that - “Climate change is increasing the risk from flooding in Portsmouth”

    | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
    |----------------|-------|---------|----------|-------------------|

12. Do you have insurance that covers your home contents and/or property from flood damage?

   - Yes
   - No
   - Don’t know

13. How should the cost of flood protection be spread?

   - Everyone should pay an equal amount in the UK
   - Over a postal code area (i.e. postcode)
   - A sliding scale (higher the risk to individual property, higher the cost)
   - Should not have to pay anything

   Other:
   

14. If you have any further comments or questions please write them below.

   

Finish
Appendix 9.2

Questionnaire Result’s Percentage Format
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<th>Question</th>
<th>Result Raw</th>
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<tr>
<td></td>
<td>No, the property is not at risk</td>
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<td>19.23%</td>
</tr>
<tr>
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<td>I do not know if the property is at risk from flooding</td>
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Storm Surge Flood Map