SURFACE WATER MANAGEMENT PLAN

Final Report

Sefton Metropolition Borough Council
August 2011

Revision Schedule

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RELATED DOCUMENTS

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Executive Summary

The Metropolitan Borough of Sefton has suffered severe surface water flooding a number of times over the last 20 years with significant events occurring in the summer of 2010, as well as earlier in 2008, 2004, 2001 amongst others.

In addition to this parts of the area are influenced by shallow groundwater, there is a fluvial flood risk that is managed by pumping but which is sensitive to climate change, and there are influences on flood risk by high sea levels and the presence of railway lines and the Leeds and Liverpool Canal.

These issues have been addressed to some degree within the Alt Crossens and Mersey Estuary Catchment Flood Management Plans and within the Knowsley and Sefton Strategic Flood Risk Assessment, however, the understanding of the extent, mechanisms and consequences of surface water flooding, as well as the interactions between local sources of flooding (surface water, sewer, groundwater, ordinary watercourses and canals) with main river and tidal flooding remained relatively limited.

In order to address the gaps in understanding of these local flood sources, Sefton Metropolitan Borough Council (Sefton MBC), in partnership with United Utilities the Environment Agency and Capita Symonds, has developed a Surface Water Management Plan (SWMP) for the whole of the borough, but which focuses on key urban areas in which the risks are more acute and which have a greater vulnerability to flooding. The cost of developing the SWMP has been borne by funding of £100,000 from Defra with an additional £20,000 contributed by Sefton MBC.

As well as improving the understanding of local flooding sources, the SWMP will provide a tool for spatial planners to incorporate consideration of surface water flooding into the development of planning policy and into their development control procedures. Civil Contingencies, Highways and Facilities Management departments within the Council will also be able to use the information provided to review emergency response plans and to assist in the planning and delivery of adaptation measures for the effects of climate change on flood risk. The Council will also be able to use the information generated to assist and support its Partners and other stakeholders to increase the resilience of critical infrastructure to flood risk.

The SWMP has completed Phase 1 – Preparation and also Phase 2- Risk Assessment, up to the Intermediate Risk Assessment stage. Phase 3 – Options, has been partially completed with potential measures identified across all Critical Drainage Areas within the borough, and a Draft Action Plan has also been developed as part of Phase 4 – Implementation and Review.

A Strategic Risk Assessment was completed that reviewed flood risk and vulnerability information to prioritise those areas for further consideration at the Intermediate Risk Assessment Phase. The Strategic Assessment applied a risk-based approach to identify that the urban and intensively developed areas of the borough should be the focus of further analysis. The Intermediate Risk Assessment then undertook hydraulic modelling of both sewer flooding and surface water flooding for storm events with a 1 in 5 chance (20%), 1 in 30 chance (3.3%) and 1 in 100 chance (1%) of occurring in any given year. Climate change impacts on the 1 in 100 chance (1%) event were also considered by increasing rainfall intensity by 30%.

The results of the modelling exercises, along with information on other sources of flooding, have been reviewed in order to develop potential measures that could be implemented by Sefton MBC, its flood risk management partners and other stakeholders. Measures cover the implementation of actions required of Sefton MBC, as LLFA, under the Flood and Water Management Act 2010 and the Flood Risk Regulations 2009, continued development of the partnership developed with the EA and UU as part of the SWMP, including data sharing, and work to address assumptions and uncertainties in the data used to assess local flood risk within the SWMP.

Measures also include recommendations for the development of Planning and Development Control Policy within Sefton and across local boundaries where necessary, a review of emergency responses both within the council and within the communities that might be affected, as well as the provision of support to those local communities to understand and prepare for flooding. There are also recommendations for short, medium and long term flood risk management interventions that cover potential 'quick wins' to mitigate flooding and schemes that may require applications for alternative funding and long-term partnership working to develop cost-effective solutions. All measures are outlined in an Action Plan.

Finally, this report is the outcome of a joint project and should not be taken to represent the official policy of the partner organisations. The recommendations and action plan should not be taken as a commitment to carry out construction works or to expend resources on any other measures.

No reliance should be placed at this time on the information contained within this report prior to consultation with the partner organisations.

Glossary

Term	Definition
Aquifer	Water bearing rock, sand or gravel capable of yielding significant quantities of water
Asset Management Plan (AMP)	In the context of water services, a plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service
AStSWF	Areas Susceptible to Surface Water Flooding – The first generation broad scale national mapping of surface water flooding prepared for the Environment Agency
Catchment Flood Management Plan (CFMP)	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk
CDA	Critical Drainage Area
CFMP	Catchment Flood Management Plan
CIRIA	Construction Industry Research and Information Association
Civil Contingencies Act 2004	This Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums must put into place emergency plans for a range of circumstances including flooding
CLG	Government Department for Communities and Local Government
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions
Critical Drainage Area (CDA)	Areas of significant flood risk, characterised by the amount of surface runoff that drains into the area, the topography and hydraulic conditions of the pathway (e.g. sewer, river system), and the receptors (people, properties and infrastructure) that may be affected
Culvert	A buried or underground channel or pipe that carries a watercourse below the level of the ground
Defra	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model – three dimensional digital representation of unfiltered topography surface of an area
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 10 years
DTM	Digital Terrain Model – three-dimensional digital representation of a bare earth surface (i.e. with buildings, trees removed)
EA	Environment Agency – Who's play a central role in delivering the environmental priorities of central government and the Welsh Assembly Government through functions and roles
Indicative Flood Risk Areas	Areas determined by the Environment Agency as potentially having a significant level of flood risk, based on guidance published by Defra and WAG and the use of certain national datasets. These indicative areas are intended to provide a starting point for the determination of Flood Risk Areas by LLFAs
FMfSW	Flood Map for Surface Water – second generation mapping prepared for the Environment Agency on the risk of surface water flooding
Flood defence	Infrastructure used to protect an area against floods. For example, floodwalls and embankments; they are designed to a specific standard of protection (design standard)
Flood Risk Area	An area determined as having a significant risk of flooding in accordance with guidance published by Defra and WAG
Flood Risk Regulations (FRR)	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management
Flood and Water Management Act	An Act of Parliament passed into law in 2010 which forms part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, a major recommendation of which is to clarify the legislative framework for managing surface

Term	Definition
	water flood risk in England
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a river or stream
FRR	Flood Risk Regulations
IDB	Internal Drainage Board – Internal Drainage Boards (IDBs) are independent bodies responsible for land drainage in areas of special drainage
IUD	Integrated Urban Drainage
LDF	Local Development Framework
Lead Local Flood Authority	Local Authority responsible for taking the lead on local flood risk management
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
Local Flood Risk Zone	Local Flood Risk Zones are defined as discrete areas of flooding that do not exceed the national criteria for a Flood Risk Area but which still affect houses, businesses or infrastructure. A LFRZ is defined as the actual spatial extent of predicted flooding in a single location
Local Resilience Forum	A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner
LPA	Local Planning Authority
LRF	Local Resilience Forum
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers
NRD	National Receptor Dataset – a collection of risk receptors produced by the Environment Agency
Ordinary Watercourse	All watercourses that are not designated Main River, and which are the responsibility of Local Authorities or, where they exist, IDBs
Partner	A person or organisation with responsibility for the decision or actions that need to be taken
PFRA	Preliminary Flood Risk Assessment
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England
Pluvial Flooding	Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow
PPS25	Planning and Policy Statement 25: Development and Flood Risk
PA	Policy Area
Policy Area	One of more Critical Drainage Areas linked together to provide a planning policy tool for the end users. Primarily defined on a hydrological basis, but can also accommodate geological concerns where these significantly influence the implementation of SuDS
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood
Risk Management Authority (RMA)	As defined by the Floods and Water Management Act
RMA	Risk Management Authority
RBMP	River Basin Management Plan
Riparian Owner	A person who owns land on the bank of a natural watercourse or body of water
River Basin District (RBD)	A River Basin or Basins used for both strategic planning and reporting to the European Commission for the Water Framework Directive. There are eleven RBDs in

Term	Definition
	England and Wales.
River Basin Management Plan (RBMP)	River Basin Management Plans are plans for protecting and improving the water environment within a region and have been developed in consultation with organisations and individuals. They contain the main issues for the water environment and the actions we all need to take to deal with them.
Sewer Flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment
SIRS	Sewer Incident Recording System – A database held and managed by United Utilities that records flooding incidents from their sewer network.
Sefton MBC	Sefton Metropolitan District Council
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
Strategic Flood Risk Assessment (SFRA)	A Strategic Flood Risk Assessment provides the essential information on flood risk, taking climate change into account, that allows the local planning authority to understand the flood risk across its area so that the Sequential Test can be properly applied.
SuDS	Sustainable Drainage Systems
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Surface Water	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
SWMP	Surface Water Management Plan
Urban Creep	Urban Creep is the loss of permeable surfaces within urban areas creating increased runoff that can contribute to flooding and other problems.
UU	United Utilities Ltd
WaSC	Water and Sewerage Company
WIRS	Water Incident Recording System – A database held and managed by United utilities that records flooding incidents from their sewer network.

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1 Introduction

1.1 What is a Surface Water Management Plan?

1.1.1 A Surface Water Management Plan (SWMP) is the document that outlines the preferred surface water management strategy in a given location. In this context, surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.

1.1.2 This SWMP study has been undertaken in consultation with key local partners who are responsible for surface water management and drainage in the Sefton area, particularly United Utilities and the Environment Agency. The Partners have worked together to understand the causes and effects of surface water flooding and will agree the most cost effective way of managing surface water flood risk for the long term.

1.1.3 This document also establishes a long-term action plan to manage surface water and it will influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

1.2 Background

1.2.1 In 2004 the UK Government published its strategy for flood and coastal erosion risk management, Making Space for Water (MSfW)[1]. This document set out its approach to ensure that flood risk management in the future was delivered in a more effective, holistic, joined-up, and integrated manner.

1.2.2 It was recognised in MSfW that the focus of flood risk management had primarily been on fluvial and tidal sources and that flooding from surface water was poorly understood, particularly in urban areas where there is a complex interaction of drainage systems, a general sensitivity to the effects of climate change and difficulty in identifying responsibility for dealing with flood issues. This is compounded by these areas being a focus of growth and development.

1.2.3 As part of the MSfW programme, Defra commissioned 15 pilot studies to investigate aspects of integrated urban drainage. The Integrated Urban Drainage (IUD) pilot projects were distributed across England and examined partnership development, data sharing issues, modelling approaches and options to mitigate surface water flooding. Some also considered how in large areas of new development a more strategic approach to implementing surface water drainage infrastructure was beneficial. The 'IUD Pilots' were highly informative in helping to identify good practice approaches and contributed to the development of Defra's technical guidance on undertaking a surface water management plan[2].

1.2.4 In the summer of 2007, heavy rainfall resulted in extensive surface water flooding in parts of the UK such as Gloucestershire, Sheffield and Hull, causing considerable damage and disruption. The subsequent review into the causes, consequences and response to the event, known as the Pitt Review, examined the flooding and made a range of recommendations for future flood management, including the use of Surface Water Management Plans (SWMPs), coordinated by Local Authorities, to be the basis of managing all local flood risk. Most of the Pitt Review

[1] Defra (2004) Making Space for Water – developing a new Government strategy for flood and coastal erosion risk management in England
[2] Defra (2010) Surface Water Management Plan Technical Guidance

recommendations have recently been enacted through the Flood and Water Management Act 2010 (FWMA).

1.2.5 The Regional Leaders Board for the North West of England, 4NW, consulted councils in the region on flood risk issues, including surface water flooding, as part of developing its Regional Flood Risk Appraisal[3] (RFRA). The response indicated that two thirds of the councils had experienced surface water flooding associated with drainage systems and that the information held, where available, provided a reasonable indication of where past flooding had taken place but that it gave no indication to where future flooding might occur. It was also unclear what level of coordination existed between the number of organisations that held data on flooding such that a clear picture of flood risk might not be available.

1.2.6 Knowsley and Sefton Metropolitan Borough Council's Strategic Flood Risk Assessment (June 2009)[4] identified that the sewerage infrastructure of the urban parts of the Borough of Sefton is largely based on Victorian sewers and there is a risk of localised flooding associated with the existing public sewerage system. It also identified that the drainage system may be under capacity and/or subject to blockages resulting in localised flooding of roads and property.

1.2.7 DEFRA has since recognized the importance of addressing surface water flooding in Sefton and funded the Council to produce this Surface Water Management Plan for the Borough. This will be a major step in assisting the Borough to meet its requirements, as set out in the Flood Risk Regulations (FRR) and the FWMA. Another key aspect of the Act is to ensure that boroughs work in partnership with other Local Risk Authorities. The SWMP has assisted this process by creating a partnership to deliver the SWMP.

1.2.8 Records of surface water flooding across the borough of Sefton have been collated from the SWMP partners and reviewed to identify a full history of surface water flooding within Sefton. In total, 13 events, including the Leeds and Liverpool Canal failure in 1994, have been identified as having significant local consequences, that is to say that at least 8 properties and approximately 20 people have been impacted by those events. Further information is provided in Section 1.6.

1.2.9 The most recent of these events was in July 2010 when a total of 77 surface water flooding incidents affected properties in Aintree, Birkdale, Bootle, Brighton-le-Sands, Crosby, Formby, Litherland, Maghull, Melling, Netherton, Seaforth, Sefton, Southport, Thornton and Waterloo. Although no specific return period is available for the event, the July 2010 Hydrological Summary for the United Kingdom[5] indicates that despite water stress in many areas because of below average rainfall in the first 6 months of the year, the rainfall recorded in the north west in July was more than double the 1971-2000 average. The month was noted as the wettest month of the year and the sixth wettest July since 1914.

1.2.10 It is clear from the July 2010 event alone, not to mention those in October 2009 (9 reports of flooding), January 2008 (98 reports of flooding), July 2007 (75 reports of flooding), August and November 2004 (10 and 55 reports of flooding respectively) and April 2001 (59 reports of flooding), that surface water flooding is a frequent event with significant consequences across the borough.

1.3 Objectives

1.3.1 The agreed objectives of the SWMP are:

[3] 4NW (2008) North West Regional Spatial Strategy: Regional Flood Risk Appraisal
[4] Atkins (2009) Knowsley Council and Sefton Council Strategic Flood Risk Assessment
[5] CEH (2010) July 2010 Hydrological Summary for the United Kingdom

1. To determine and map current and potential surface water flood risk areas across the Sefton MBC area, irrespective of source.
2. To determine the consequences of surface water flooding on people, property, infrastructure and the environment, now and in the future.
3. To identify an effective, affordable and achievable strategy with sustainable and cost-beneficial measures to mitigate surface water flood risk, which achieve multiple benefits where possible, and which make the most of opportunities for economic, social and environmental enhancement.
4. To improve co-operation and co-ordination for better working relationships between Key Partners to the Surface Water Management Plan (SWMP) comprising Sefton Council, the Environment Agency, United Utilities and other stakeholders influencing surface water management, including establishment of a standing liaison requirement for subsequent delivery of the SWMP measures and any review of the SWMP.
5. To assess potential flood risk management measures to Critical and Vulnerable Infrastructure within Sefton.
6. To inform and advise spatial planning so that new development is directed away from areas at greatest risk of actual and potential surface water and other flooding so that appropriate surface water mitigation measures are promoted.
7. To assess the likely impact of potential flood risk management measures including their contribution to eco-hydrological benefit (i.e. WFD compliance) and to specific locations identified for potential development and thereby seek to inform future spatial planning policy and site guidance briefs.
8. To contribute to meeting the requirements of the Flood Risk Management Regulations, 2009 and the Flood and Water Management Act, 2010, and inform emergency planning decisions.
9. To develop an Action Plan for the delivery of SWMP measures showing how partners and stakeholders will work together to finance and implement the preferred measures.
10. To periodically review the appropriateness of SWMP datasets and modelling, the delivery of the Action Plan, the means of implementation and to monitor the effectiveness of the enacted SWMP measures, and to update the SWMP where resources allow.
11. To develop and implement an effective communications strategy involving all Partners that engages the affected communities and all stakeholders and helps their understanding of surface water flooding issues in Sefton.

1.4 Study Area

Location

1.4.2 The study area for this SWMP is defined by the administrative boundary of Sefton Metropolitan Borough Council, presented in Figure 1-1, overleaf.

1.4.3 The administrative boundary of Sefton covers an area of 155 square kilometres. Within this there is a diverse mixture of industrial, commercial and urban development coupled with rural green belt divides as well as 36 kilometres of coastline and extensive areas of sand dunes and coastal salt marsh. Sefton has a major port and extensive commuter travel into Liverpool from the key urban areas of Southport, Formby, Crosby, Litherland, Maghull and Bootle.

Figure 1-1: Sefton SWMP study area

1.4.4 Sefton is bordered to the east by Knowsley Borough Council and West Lancashire County Council, to the west by the Irish Sea and to the south by Liverpool.

General topography

1.4.5 Topography of the Sefton is typically flat and low lying, however, this generalisation hides a complexity that heavily influences the surface water drainage patterns of the study area.

1.4.6 High ground in the form of a low lying ridge up to an elevation of 20m AOD runs along the coast from the western edge of Formby to the southern edge of Southport. To the south and east of the borough there is high ground up to 35m AOD, upon which Lydiate, parts of Maghull, Litherland and part of Bootle are situated.

1.4.7 Low lying ground is typically located along the eastern boundary of Sefton, from west of Maghull northwards to the tip of Southport at Fiddler's Ferry. Splitting the higher areas of Maghull and Litherland is the River Alt, which runs north westwards between these two settlements, then along the boundary of Sefton until it turns south westwards, south east of Formby, to discharge to the sea north of Hightown.

1.4.8 The coastal ridge between Formby and Southport results in most watercourses within this area flowing inland away from the coast. Those north of Ainsdale typically drain eastwards to the boundary of Sefton MBC and then turn northwards, flowing via Fine Jane's Brook, Boundary Brook and Three Pools Waterway towards Crossens, where it discharges to the sea via Crossens pumping station at Banks. Those watercourses south of Ainsdale generally discharge southwards via Downholland Brook to the River Alt, which discharges into the sea via Altmouth pumping station.

1.4.9 Crosby, western parts of Litherland and Bootle generally lie on ground that slopes in a west and south westward direction towards the coastline and docks. Crosby and Litherland are split by the path of Rimrose Brook and also by the Leeds and Liverpool Canal, which zigzags across Sefton from north of Lydiate, passing through Maghull, Waddicar, Aintree, Litherland and Bootle on its way southwards to Liverpool City centre.

1.4.10 Figure 1-2, at the end of Section 1.4, presents the available topographical data for Sefton.

General land use

1.4.11 The northern half of Sefton, from Formby to Southport, is quite narrow and has a mix of urban areas, Formby, Ainsdale and Southport, bordered by coastal dunes to the west and arable and grazing fields to the east. The area immediately south and east of Formby is typically rural, dominated by arable fields until the edge of the urban areas of Crosby, Litherland and Maghull. There is a small pocket of woodland between Ince Blundell and Crosby, however, this is not extensive. Lydiate in the north east is also bordered by arable fields.

Significant infrastructure

1.4.12 Significant infrastructure within Sefton includes the following key transport routes:

- M57, M58
- A59, A5036 (T), A565, A5203; and
- Merseyrail Northern Line: Liverpool to Southport has stations at Bootle Oriel Road, Bootle New Strand, Seaforth and Litherland, Waterloo, Blundellsands and Crosby, Hall Road Station, Hightown, Formby, Freshfield, Ainsdale, Hillside, Birkdale, Southport. Merseyrail

Northern Line: Liverpool to Ormskirk has stations at Aintree, Old Roan Station and Maghull on the way to Ormskirk; and

- Manchester to Southport Line and Meols Cop Station.

1.4.13 Other infrastructure includes:

- Southport and Formby District General Hospital and Ashworth Hospital;
- 56 GPs Surgeries and 13 Health Centres;
- 8 Police Stations, 4 Fire Stations and 5 Ambulance Stations;
- 106 Schools, 39 Pre-schools, 46 Nurseries and 19 Children's Centres and
- 86 Residential Homes and 47 Nursing Homes

1.4.14 There are also the following environmental designations:

- Ribble and Alt Estuaries Ramsar Site and SPA;
- Proposed Mersey Narrows & North Wirral Foreshore Ramsar site and potential SPA;
- Sefton Coast SAC and SSSI;
- Ribble Estuary SSSI;
- Hesketh Golf Links SSSI;
- Mersey Narrows SSSI;
- Five historical parks and gardens;
- 25 conservation areas;
- 15 Scheduled Ancient Monuments (SAMs); and
- 560 Listed Buildings;

1.4.15 In addition, there are 41 Local Wildlife Sites or Sites of Geological or Geomorphological Interest.

Significant future development plans

1.4.16 The location of significant new development is set out in the Sefton Unitary Development Plan (2006). Sites still to be developed include:

- Land at Town Land, Kew, in Southport;
- Sites in Southport Town Centre and Seafront:;
- Land at Dunningsbridge Road and Bridle Road in Netherton;
- The Hawthorne Road corridor in Bootle:

1.4.17 Further locations for significant development will be set out in the Core Strategy and other development plan documents. These will in any case include sites within the urban area, especially in the settlements of Bootle and Southport. The Core Strategy Options are currently being considered. Two of the three options could also include development in the Green Belt, at locations on the edge of the settlements of Southport, Formby, Hightown, Crosby, Maghull, Aintree and Melling (Waddicar), however, it will be approximately 2012/13 before the Preferred Option is decided. At the moment it is certain only that development will take place within the existing urban area.

Interactions with neighbouring Boroughs / District Councils

1.4.18 The nature of the catchments of the River Alt and the drains that discharge at Crossens means that there are potential interactions with adjacent boroughs that could influence surface water flooding.

1.4.19 Areas of Sefton, particularly those north of Formby, drain to the watercourses that run along the eastern boundary of Sefton, which it shares with West Lancashire. Although the boundary is sparsely developed on the West Lancashire side, the floodplain is relatively extensive and therefore actions taken within Sefton could influence surface water related flooding in this area.

1.4.20 The River Alt has its source in Knowsley and drains a catchment that includes areas of Liverpool, Sefton, West Lancashire and a small part of St. Helens District. Flood levels within the River Alt are known to influence flooding in places like Formby and so actions taken to manage flood risk, either within the Alt or within its catchment, could therefore influence flooding for better or worse in some parts of Sefton.

1.4.21 In addition, the Leeds and Liverpool Canal enters Sefton from West Lancashire to the north east of Lydiate District before passing out of Sefton in Bootle into Liverpool City Centre. The canal has previously breached in Maghull in 1994. It should be noted that between Stanley Lock (Liverpool) and Dean Locks and Appley Locks (north west of Wigan) there are no locks to limit the available volume of floodwater in the event of a similar breach.

1.5 Flooding Interactions

1.5.1 There are a number of different sources of flooding within the borough, including fluvial and tidal flooding, flooding from the land, flooding from sewers and groundwater and flooding from artificial sources such as canals and reservoirs.

Fluvial Flooding

1.5.2 Fluvial flooding occurs when the amount of water exceeds the flow capacity of the river channel. Most rivers have a natural floodplain into which the water spills in times of flood. Flooding can also be caused by blockage of structures by debris within a watercourse.

1.5.3 Parts of Sefton are very low lying and the two primary catchments, the Alt and Crossens, are unusual in that they are predominantly pumped to the sea, though the Alt does have some capacity for natural gravity drainage. Both catchments have extensive floodplains, particularly the River Alt to the south east of Formby and in the Maghull area but also the Crossens sub-catchment to the north east of Southport, in the Crossens area.

1.5.4 Flooding from fluvial sources could be directly impacted by failure of the Altmouth and Crossens Pumping Stations or could simply be caused by the flow in the watercourses being higher than the capacity of the pumps or the channels leading to them.

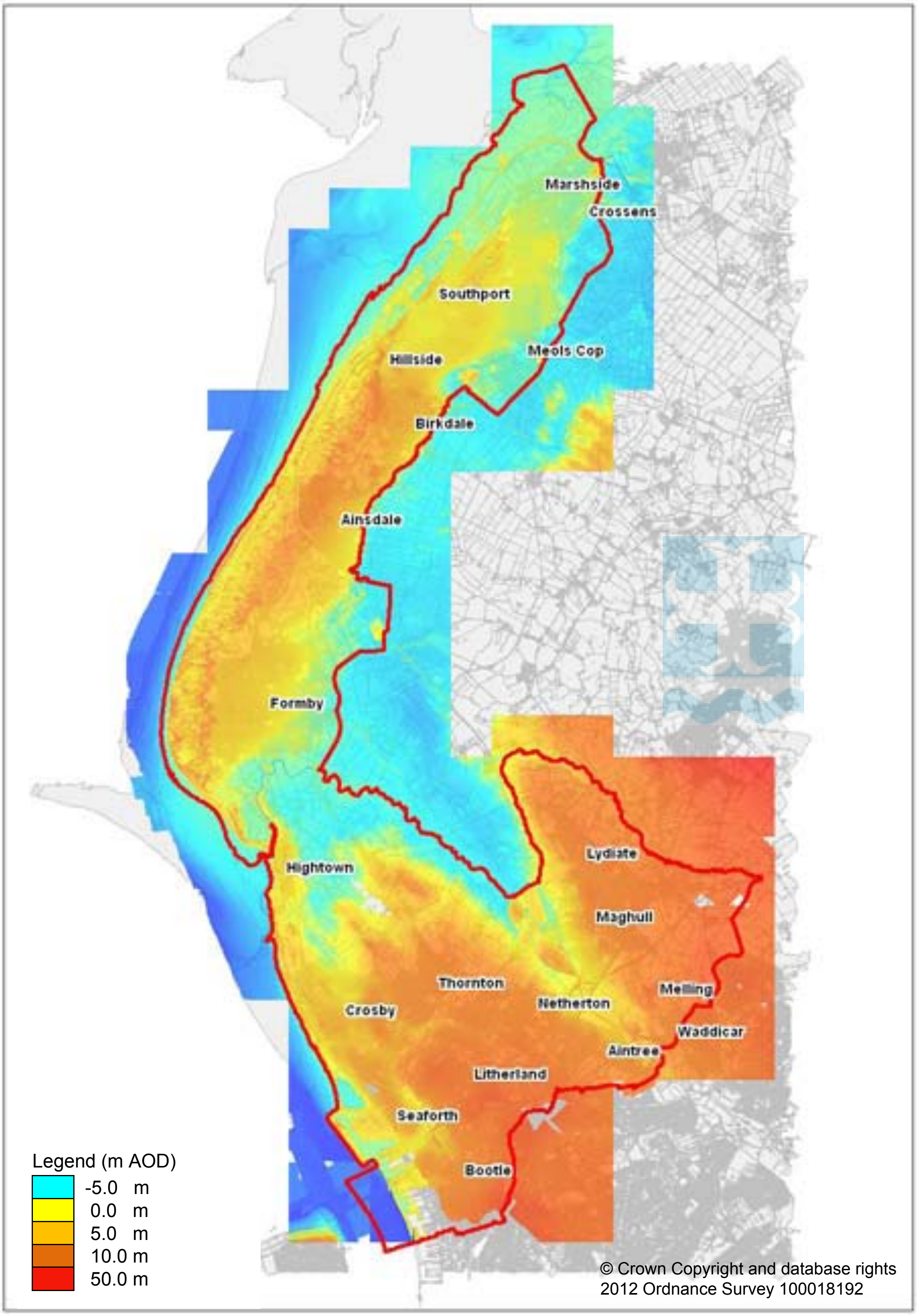

Figure 1-2: Sefton topography (based on available LiDAR coverage)

1.5.5 Fluvial flooding or channel full conditions can prevent the free discharge of smaller watercourses and can prevent the free discharge of surface water sewers, which can result in flooding further upstream in areas not directly affected by flooding in rivers and ordinary watercourses. This mechanism is known to occur within Sefton, particularly within Formby where levels in Ordinary Watercourses such as Dobb's Gutter are effected by high levels in Downholland Brook and the Alt.

Tidal Flooding

1.5.6 Tidal flooding occurs when a high astronomical tide and storm (tidal surge) exceeds the level of coastal land or coastal flood defences. Tidal flooding can also be caused by 'tide locking' of rivers or estuaries where high water levels prevent a river from discharging into the sea causing 'backing up' and resulting in tidal/fluvial flooding. Tide locking can also occur within surface water drainage systems that discharge directly to the sea.

1.5.7 Sefton has an extensive coastline, however, for the most part the ground levels are sufficiently high along the coast to limit the tidal floodplain. The exception is in the north of the borough, where, above Birkdale, land levels dip and the extent of tidal flooding increases inland to impact coastal marsh as well as properties in the Marshside and Crossens area.

1.5.8 The predominantly pumped nature of the catchments means that tide locking is not a significant issue, though there are times when the gravity drainage that is available at Altmouth pumping station is prevented at which times the pumps are brought into use. The phrase 'tide locking' is often used to describe when high water levels in fluvial rivers prevents the free discharge of smaller tributaries and outfalls. As mentioned under Fluvial Flooding, above, this is known to occur within Sefton.

Flooding from land

1.5.9 Flooding from land can be caused by rainfall being unable to infiltrate into the natural ground, often because the ground is saturated during the wetter winter months. In drier months, it is often high intensity storms with short durations that overwhelm the capacity of the ground or the capacity of the drainage system and gullies, which might themselves be full under such conditions.

1.5.10 When this happens it can result in (temporary) localised ponding and flooding. The natural topography and location of buildings/structures can influence the direction and depth of water flowing off impermeable and permeable surfaces. The cause of this surface water flooding can also include blockage and overflows of the drainage system and failure of sluice outfalls and pump systems.

Flooding from sewers

1.5.11 Flooding can also result when sewers, typically combined foul and surface water, are overwhelmed and surcharge water into the nearby environment.

1.5.12 Many of the sewers within Sefton's are Victorian in age and they were not designed to cope with the level of impermeable ground, e.g. due to paving over gardens etc., that drains to them. In places, there are sections in which the frequency of flooding would be expected to be between once every two years and once every 10 years.

1.5.13 Flooding from sewers can also be caused by blockage and failure of pumping systems and, as indicated above, it can also be influenced by river and tide levels.

Flooding from groundwater

1.5.14 Groundwater flooding occurs when water levels in the ground rise above surface elevations. It is most likely to occur in low-lying areas underlain by permeable rocks but can also occur where shallow soils overly an impermeable or slowly impermeable layer of strata, for example clay. In such circumstances, wet periods of weather can saturate the shallow soils causing a temporary or perched groundwater table to rise to the surface. Groundwater flooding can also be caused by rising groundwater levels following the cessation of groundwater pumping, particularly in mining areas.

1.5.15 The Alt Crossens CFMP[6] indicates that there are parts of the borough in which groundwater emergence may have been influenced by the cessation of pumping from former mines. The lower Alt catchment is identified as one of the areas at risk. This conclusion is supported by the Lower Mersey and North Merseyside Groundwater Resources Study[7], which indicates that there is a significant proportion of base flow in the River Alt that comes from the Permo-Triassic Sandstone.

1.5.16 The consequences of rising groundwater may not necessarily impact the location at which it emerges. The consequence is likely to be an increased probability and duration of flooding in those areas affected by flowing and ponding water in general, as identified in the AStSWF maps.

Artificial sources of flooding include reservoirs, canals and lakes

1.5.17 There are no large reservoirs within the Sefton area, however, the River Alt does provide a pathway for potential flooding from large reservoirs located in the east of Knowsley (White Man's Dam) and within St. Helens (No.3 and No.4 Reservoir). The Environment Agency's Reservoir Inundation Maps[8] indicate that the extent of flooding would reach Maghull.

1.5.18 There are a number of lakes within Sefton, the largest of which is Marine Lake in Southport. These typically act as a receptor for surface water runoff locally and do not pose a flood risk.

1.5.19 The Leeds and Liverpool Canal weaves its way across Sefton. It enters Sefton north east of Lydiate and passes through Aintree, Netherton, Litherland and Seaforth before passing into Liverpool City Centre from Bootle. The canal is lies above ground on one side or another along parts of its length and in a number of locations crosses existing watercourses, which are culverted. The canal has previously breached in Maghull in 1994, when the roof of a culvert containing Maghull Brook ruptured beneath the canal, which then led to the progressive collapse of the culvert and the canal to burst its banks, causing the flooding of 200 to 300 properties in Maghull.

1.6 Records of Past Floods

1.6.1 A list of historical flood events from surface water, sewer, canal or groundwater sources that had locally significant consequences is presented in Table 1-1, overleaf.

1.6.2 To assist LLFAs in determining Flood Risk Areas during the development of PFRAs, the Environment Agency produced indicative Flood Risk Areas based on an assessment of 1km grid squares. A square was classified as being a 'place where flood risk is an issue' if more than 200 people or 20 businesses or 1 critical service are flooded to a depth of greater than 0.3m during a 1 in 200 year storm event (using the FMfSW dataset).

[6] Environment Agency (2008) Alt Crossens Catchment Flood Management Plan – Final Plan
[7] ESI (2009) Lower Mersey and North Merseyside Groundwater Resources Study: Final Report
[8] www.environment-agency.gov.uk

1.6.3 The criteria for determining the local significance of consequences when proposing new or expanding Flood Risk Areas was left to each LLFA, though it was recommended that some measure of equivalent risk was applied. The Merseyside group of authorities have determined that flood events that resulted in impacts to 20 people should be considered as having had locally significant harmful consequences. The threshold of 20 people was chosen as it is an order of magnitude less than was required to identify a $1km^2$ grid cell as being a 'place where flood risk is an issue' in the national assessment of indicative Flood Risk Areas that was undertaken by the Environment Agency.

1.6.4 Guidance presented in *Selecting and reviewing Flood Risk Areas for local sources of flooding*[9] indicates that there are on average 2.34 people per property. Consequently, any flood event that results in 8 or more properties impacted is equivalent to 20 people and therefore considered to be locally significant.

1.6.5 The list presented in Table 1-1 was developed from a full list of flood events that is presented in Appendix A.1 of Sefton MBC's PFRA. The criteria for inclusion in the full list requires that a flood event is caused by local sources (i.e. not main river or the sea) and that it affected two or more properties.

Table 1-1: Past flood events from local sources with significant local consequences.

Date	Main source of flooding	Description	Data Source
19/07/2010 to 22/07/2010	Surface Water	A total of 77 surface water flooding incidents affected properties in Aintree, Birkdale, Bootle, Brighton-le-Sands, Crosby, Formby, Litherland, Maghull, Melling, Netherton, Seaforth, Sefton, Southport, Thornton and Waterloo. Impacts in Maghull were locally significant in isolation.	SMBC
06/10/2009 to 08/10/2009	Surface Water	9 records of flooding in Maghull and Southport	UU (WIRS)
21/01/2008	Surface water / ordinary watercourse	An intense storm system produced surface water flooding across Sefton. There were 98 records of flooding in Ainsdale, Aintree, Blundellsands, Bootle, Crosby, Crossens, Formby, Lunt, Lydiate, Maghull, Melling, Netherton, Southport and Thornton. Impacts in Formby, Maghull and Southport were locally significant in isolation.	SMBC
20/07/2007 to 22/07/2007	Surface water	Flooding incidents reported across Sefton (75 in total). Some internal flooding of properties. Incidents concentrated in Crosby, Sefton & Maghull	SMBC
30/11/2004	Surface Water	55 records of flooding in Ainsdale, Aintree, Birkdale, Bootle, Formby, Litherland, Maghull, Melling, Seaforth and Southport. Impacts in Maghull and Southport were locally significant in isolation.	SMBC
01/08/2004	Surface Water	10 residential properties were recorded having suffered internal and external flooding in Southport.	SMBC
30/04/2001	Surface water / ordinary watercourse	Records of 5 properties flooding are held by Sefton MBC, though it is understood that nearer 25 properties were impacted.	SMBC
12/04/2001	Surface Water	59 residential properties were recorded having suffered internal and external flooding at Claremont Avenue area in Maghull and 10 residential properties were recorded having suffered internal and external flooding at Hawksworth Drive area in Formby.	SMBC

[9] Defra (2010) Selecting and reviewing Flood Risk Areas for local sources of flooding: Guidance to Lead Local Flood Authorities – Flood Risk Regulations 2009

Date	Main source of flooding	Description	Data Source
24/11/1996 to 25/11/1996	Surface Water	11 records of flooding in Litherland, Maghull and Southport	UU (SIRS)
01/10/1994	Canal	The Leeds and Liverpool Canal broke through into the Maghull Brook culvert at the point at which the culvert passes beneath the canal. Inundation of the canal water into the culvert led to the progressive failure of the culvert and resulted in the canal bursting its bank. Over 200 properties are understood to have flooded	SMBC
31/07/1994 to 03/08/1994	Surface Water	8 records of flooding in Southport and Waterloo	UU (SIRS)
24/01/1994 to 27/01/1994	Surface Water	9 records of flooding in Bootle, Crosby, Formby, Litherland and Waterloo	UU (SIRS)
13/12/1993 to 15/12/1993	Surface Water	8 records of flooding in Aintree, Formby, Lydiate, Maghull and Southport	UU (SIRS)

1.6.6 Past flooding can often be from an unknown source, because records are insufficient to identify where the water came from, or it can be a result of interactions between different sources some of which may not have been identified.

1.6.7 There are gaps within the data available from Sefton MBC, however, from the records available there is no direct evidence that past floods in Sefton from local sources have been a result of interactions between local flooding sources and flooding from the sea, though it should be acknowledged that because significant areas of Sefton are pumped it is highly likely that levels in main rivers have been affected to some degree by the sea level at the time, which may have consequently impacted local sources of flooding.

1.6.8 There is some evidence that past floods, particularly in Formby, have been related to high water levels within Main Rivers, particularly the River Alt and its tributaries, and there is some evidence that past floods have related to ordinary watercourses, for example Dobb's Gutter in Formby.

1.6.9 There is little direct evidence that any of the local flooding sources are related to groundwater, though this is likely to be due to a lack of information rather than a lack of connection between the two, as groundwater is known to influence baseflows in the River Alt and groundwater monitoring networks suggest groundwater at shallow depths (<1m) in parts Formby[10]. Therefore it is likely to be an influence. Groundwater is also understood to have an influence in flooding on Maghull.

1.6.10 A breach of the Leeds and Liverpool Canal in October 1994 resulted in significant inundation of properties in Maghull. The canal breach resulted in the collapse of the culvert through which the Maghull Brook passed, however, it is not clear whether the brook then contributed to this flooding or whether the inundation was due entirely to the water within the canal.

1.7 Linkages with Other Plans

1.7.1 The increased focus on flood risk over recent years is an important element of adaptation to climate change. The clarification of the role of Sefton Metropolitan Borough Council as Lead

[10] IMCORE Project (2010) Sefton Coast – Hydrological Monitoring Progress Report October 2010

Local Flood Authorities (LLFA) is welcomed. The creation of a number of new documents can at times be confusing and the Sefton SWMP links into all of them in the following way:

Regional Flood Risk Appraisal (RFRA)

1.7.2 This was produced by 4NW in 2008 and gives a regional overview of flooding from all sources. Given the Governments intention to revoke Regional Spatial Strategies (RSS) at an early date, which the RFRA supported as an evidence base, it is unlikely that the RFRA will be updated. Any update is likely to reflect the additional information on local sources of flood risk (surface water, groundwater and ordinary watercourses) from this SWMP, which may also generate new policies that would be incorporated into the next generation of regional spatial planning documents (if any).

Alt Crossens Catchment Flood Management Plan (CFMP)

1.7.3 The Alt Crossens Catchment Flood Management Plan was published in 2008 by the Environment Agency and sets out policies for the sustainable management of flood risk across the Alt and Crossens sub-catchments over the long-term (50 to 100 years) taking climate change into account. More detailed flood risk management strategies for individual rivers or sections of river may sit under these.

1.7.4 The Plan emphasises the role of the pumping stations and defences as an important asset for the management of flood risk to people and the rural economy. The effects of climate change are particularly acute because of the pumped nature of the catchments.

1.7.5 This Plan will be periodically reviewed, approximately five years from when it was published, to ensure that it continues to reflect any changes in the catchments. There are links to the SWMP where there are known interactions between surface water and fluvial flooding.

Mersey Estuary Catchment Flood Management Plan (CFMP)

1.7.6 The Mersey Estuary Catchment Flood Management Plan[11] was published in 2008 by the Environment Agency and sets out policies for the sustainable management of flood risk across the whole of the Mersey Estuary over the long-term (50 to 100 years) taking climate change into account. More detailed flood risk management strategies for individual rivers or sections of river may sit under these.

1.7.7 The Plan emphasises the need to maintain existing levels of protection within the Liverpool area whilst responding to the pressures of urban development, land use change and climate change.

1.7.8 This Plan will be periodically reviewed, approximately five years from when it was published, to ensure that it continues to reflect any changes in the catchment. There are links to the SWMP where there are known interactions between surface water, fluvial flooding and coastal flooding along the coastline between Bootle and Crosby.

Lower Alt with Crossens Flood Risk Management Strategy

1.7.9 The Lower Alt with Crossens Pumped Drainage Strategy – Other Sources strategy was provided as part of this study. The strategy has been developed from a study that utilises a detailed 1D/2D hydraulic model of the main river network to assess fluvial flood risk and the risk from other sources within the catchment.

1.7.10 The document identifies that flood risk within Formby is increased when water ponds behind the Altmouth Pumping Station. All four of the pumps at the pumping station are utilised when the

[11] Environment Agency (2008) Mersey Estuary Catchment Flood Management Plan

water levels and flows it must deal with exceed those of an event with a 1 in 5 chance (20%) of occurring in any given year. The pumps have a capacity equal to the flow expected from a 1 in 50 chance (2%) event. When flows reaching the pumping station rise above the combined capacity of the pumps then water levels will rise behind the pumping station and influence flood risk upstream.

1.7.11 The strategy recommends that the partnership between Sefton Council and the Agency (via the Strategy or SWMPs) is strengthened to examine how best to manage flood risk to Formby in an appropriate way, considering both short term and long term sustainable options. This joint working recommendation is extended to cover Southport, Maghull

Preliminary Flood Risk Assessment (PFRA)

1.7.12 These are required as part of the Flood Risk Regulations, which implement the requirements of the European Floods Directive. Sefton, as a LLFA, has produced a PFRA in conjunction with Liverpool City Council to give an overview of all local sources of flood risk. Although this SWMP fed into the PFRA where possible, the next update of the PFRA will benefit from an increased level of information relating to surface water from this SWMP. Sefton has a responsibility to review its PFRA every 6 years.

Surface Water Management Plans (SWMP)

1.7.13 The Sefton SWMP provides much improved probabilistic 2-dimensional modelling and data over what has been made available at a national scale by the Environment Agency. In particular, it provides data on lower return periods, climate change and provides information on velocity, depth and hazard to people.

1.7.14 The SWMP will also contain an Action Plan that has been developed in conjunction with both the borough and other relevant Risk Management Authorities. This data and actions and associated policy interventions will feed directly into the operational level of the borough across many departments, in particular into spatial and emergency planning policies and designations and into the management of local authority controlled land.

Strategic Flood Risk Assessments (SFRA)

1.7.15 Each local planning authority is required to produce a SFRA under Planning Policy Statement 25 (PPS25). The SFRA provides an important tool to guide planning policies and land use decisions. Current SFRAs have a strong emphasis on flooding from main rivers and the sea and are relatively weak in evaluating flooding from other local sources including surface water, groundwater and ordinary watercourses. The information from the Sefton SWMP will improve this understanding and should be used to update the SFRA. Sefton Council intends to update the SFRA in 2011/12 and this will feed into the choice of development sites in the Core Strategy and other DPDs.

Shoreline Management Plans (SMP)

1.7.16 Two sub-cells (11a and 11b) from the North West England and North Wales Shoreline Management Plan 2, including four Policy Statement areas, cover the Sefton coastline: the Mersey Estuary (11a 7), Seaforth to River Alt (11a 8), Formby Dunes (11a 9) and Ribble Estuary (11b 1).

1.7.17 A Shoreline Management Plan (SMP) provides a large-scale assessment of the risks associated with erosion and flooding at the coast. It presents policy options to manage these risks, which can impact people, development and historic and natural environments. SMPs are the equivalent of CFMPs within the hierarchy of strategy and plan documents that are used to plan the work to manage coastal risks. Although a non-statutory, high level policy document, regional and local planning authorities should consider SMP policies when developing their statutory land use development plans.

1.7.18 The four Policy Statement locations are each summarised in a short document that provides an overview of the long-term plan for the management of the coast and how that will be achieved. For each unit within the Policy Statement area there is information on the short-term (0-20years), medium-term (20-50 years) and long-term (50-100 years) policy and approach along with justification on social, environmental and economic grounds. Key assumptions are also highlighted.

1.7.19 The document highlights predicted implications of the policies being adopted on features such as property and population, land use, infrastructure and material assets, amenity and recreation, historic environment, landscape, character and visual amenity, earth heritage, soils and geology, water and biodiversity, flora and fauna. An action plan is detailed, similar to that in Appendix E of this document.

Development Plan Documents (DPDs) and Supplementary Planning Documents (SPDs)

1.7.20 DPDs, including the Core Strategy, Site Allocations DPD and any relevant Area Action Plans (AAPs) and SPDs, will need to reflect the results from the SWMP. They may need to include policies for the whole borough or for specific parts of boroughs, for example Critical Drainage Areas. The updated SFRA will assist with this. The Council will also examine surface water flood risk more closely when assessing the suitability of sites for development.

Green Infrastructure Study

1.7.21 North West, Liverpool City Region and local green infrastructure documents recognise the importance of green infrastructure to flood risk and surface water management. For example, the Green Space Strategy for Sefton (2008) sets out 5 aims for green space in Sefton, one of which is 'Making the most of the ways in which green space can help reduce the impacts of climate change'.

1.7.22 The draft Green Space Study for Sefton (2011) assesses the green infrastructure benefits of urban greenspaces, including their scope for flood risk management. Green Spaces in Flood Zone 3 or which have the highest risk of surface water flooding have high water and flood risk management benefits, and their development is generally precluded. The draft Green Space Study will feed into the choice of development sites in the Core Strategy and other DPDs.

Green Belt Study

1.7.23 The draft Green Belt Study (2011) for Sefton assesses the suitability of land within the Green Belt for development. Flood risk – principally from rivers or the sea- is one of the assessment criteria. The draft Green Belt Study will feed into the choice of development sites in the Core Strategy and other DPDs.

Local Flood Risk Management Strategies (LFRMS)

1.7.24 The Flood and Water Management Act 2010 (FWMA) requires each LLFA to produce a Local Flood Risk Management Strategy (LFRMS). Whilst the Sefton SWMP will not actually produce these, it will, in conjunction with the Sefton PFRA, the Knowsley and Sefton SFRA, the CFMPs covering the Alt Crossens and Mersey Estuary, provide the necessary evidence base to support the development of LFRMS. No new modelling is anticipated to produce these strategies, as the outputs of the SWMP should be sufficient.

1.7.25 The figure below illustrates how the CFMP, PFRA, SWMP and SFRA link to and underpin the development of a Local Flood Risk Management Strategy.

Figure 1-3: The Sefton SWMP in context with other plans

1.8 Existing Legislation

Flood and Water Management Act 2010 (FWMA)

1.8.2 The Flood and Water Management Act 2010 (FWMA)[12] presents a number of challenges for policy makers and the flood and coastal risk management authorities identified to co-ordinate and deliver local flood risk management (surface water, groundwater and flooding from ordinary water courses). 'Upper Tier' local authorities have been empowered to manage local flood risk through new responsibilities for flooding from surface and groundwater.

1.8.3 The FWMA reinforces the need to manage flooding holistically and in a sustainable manner. This has grown from the key principles within Making Space for Water (Defra, 2005) and was further reinforced by the summer 2007 floods and the Pitt Review (Cabinet Office, 2008). It implements several key recommendations of Sir Michael Pitt's Review of the summer 2007 floods, whilst also protecting water supplies to consumers and protecting community groups from excessive charges for surface water drainage.

Flood Risk Regulations 2009 (FRR)

1.8.4 The FWMA must also be considered in the context of the EU Floods Directive[13], which was transposed into law by the Flood Risk Regulations 2009[14] (the Regulations) on 10 December 2009. The Regulations requires three main types of assessment / plan:

1. Preliminary Flood Risk Assessments (maps and reports for Sea, Main River and Reservoirs flooding) to be completed by Lead Local Flood Authorities and the Environment Agency by the 22 December 2011. Flood Risk Areas, at potentially significant risk of flooding, will also be identified. Maps and management plans will be developed on the basis of these flood risk areas.

2. Flood Hazard Maps and Flood Risk Maps. The Environment Agency and Lead Local Flood Authorities are required to produce Hazard and Risk maps for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2013.

3. Flood Risk Management Plans. The Environment Agency and Lead Local Flood Authorities are required to produce Flood Risk Management Plans for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2015.

[12] Flood and Water Management Act (2010), available at: http://www.legislation.gov.uk/ukpga/2010/29/contents
[13] EU Floods Directive (2007/60/EC), available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:288:0027:0034:EN:PDF
[14] Flood Risk Regulations (2009), available at: http://www.legislation.gov.uk/uksi/2009/3042/contents/made

1.8.5 The figure, overleaf, illustrates how this SWMP fits into the delivery of local flood and coastal risk management, and where the responsibilities for this lie.

Water Framework Directive (2000/60/EC) (WFD)

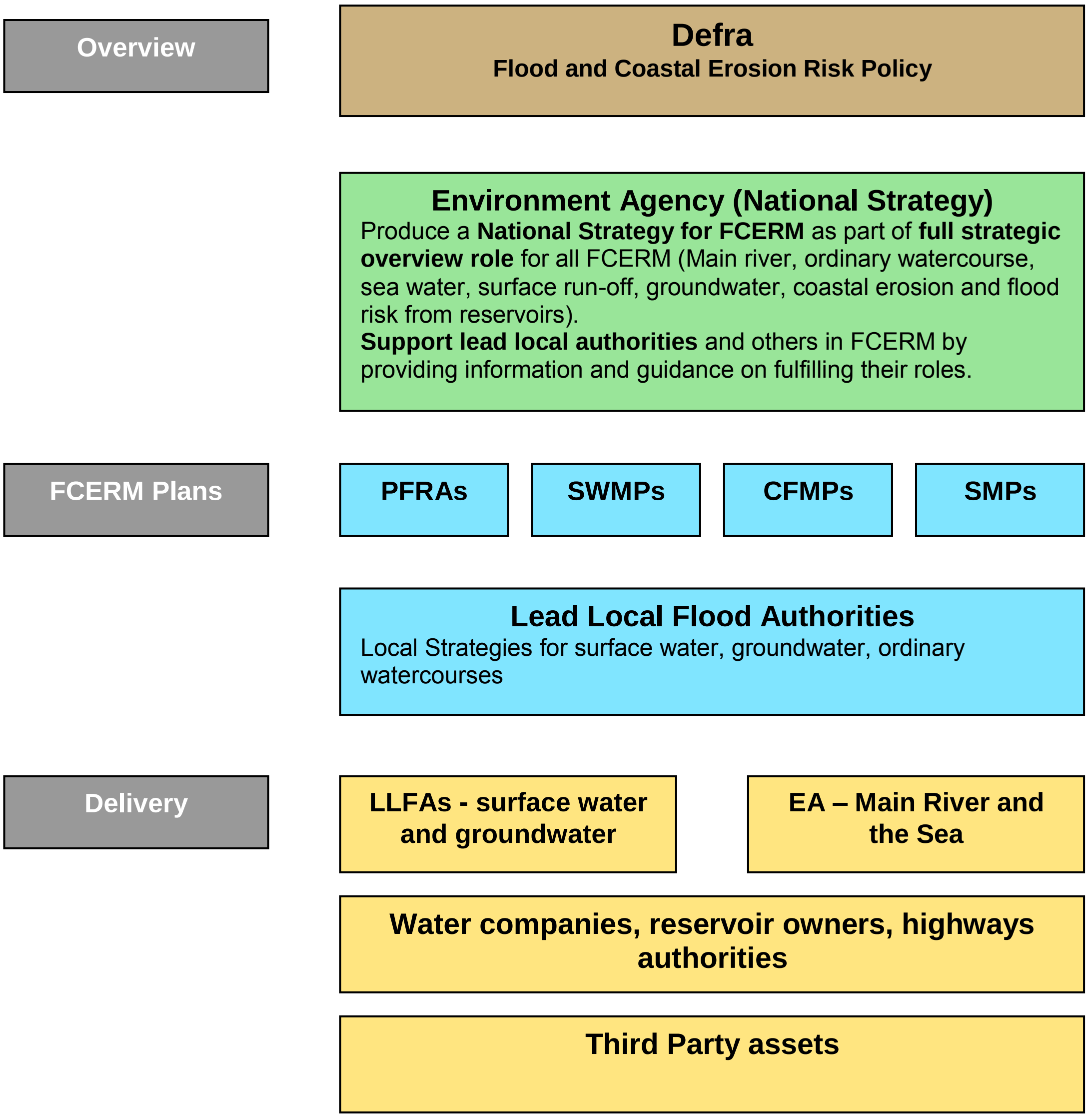

Figure 1-4: The Sefton SWMP in context with the delivery of local flood risk management

1.8.6 The Water Framework Directive[15] is a European Community Directive (2000/60/EC) of the European Parliament and Council designed to integrate the management of water bodies across Europe. It requires all inland and coastal waters to reach good status by 2015 through a catchment-based system of River Basin Management Plans that set out a programme of measures to improve the status of all natural water bodies.

1.8.7 As a result of its focus on urban drainage systems and the management of discharges and overflows, a SWMP can also contribute to the management of water quality. Solutions and actions may address both flood and pollution risk and can therefore have multiple benefits, contributing to a reduction in flood risk as well as fulfilling the improvements and compliance in

[15] EU Water Framework Directive (2000/60/EC), available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF

ecology, water quality and habitats that is required under the Water Framework Directive (WFD).

1.8.8 When preparing the action plan the SWMP must consider the impacts of solutions and actions on compliance with the WFD. Where an action or solution contributes to a deterioration of status under the WFD or a failure to achieve the water bodies objectives then Article 4.7 of the WFD can be used to justify the measure, but only if certain criteria are met.

Habitats Directive (92/43/EEC)

1.8.9 When completing the Action Plan or assessing solutions, the effect on Natura 2000 sites should be considered, and where it is possible that land use changes could significantly affect a Natura 2000 site an 'Appropriate Assessment' must be carried out in accordance with the Habitats Directive[16]. An Appropriate Assessment will aim to identify significant potential effects of land use plans against the Conservation objectives of Natura 2000 sites.

Strategic Assessment Directive (2001/42/EC)

1.8.10 The Strategic Assessment Directive sets out the actions required to assess the effects of certain plans and programmes on the environment. Local authorities should decide if a SWMP requires Strategic Environmental Assessment by making a 'screening decision'. Guidance is contained in section 2 of 'A Practical Guide to the Strategic Environmental Assessment Directive'[17].

1.8.11 Whether a SWMP will require SEA will depend on a number of factors including whether it applies over a wide area, its environmental effects and its statutory status

[16] EU Habitats Directive (92/43/EEC), available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1992L0043:20070101:EN:PDF
[17] ODPM (2005): http://www.communities.gov.uk/documents/planningandbuilding/pdf/practicalguidesea.pdf

2 Phase 1: Preparation

2.1 Partnership

2.1.1 Sefton SWMP has been developed through the participation of Key Partners, who will have responsibility for the decisions and actions that will be implemented through the plan.

2.1.2 Sefton Metropolitan Borough Council is the Lead Partner of the SWMP, in its role as Lead Local Flood Authority with responsibility for local flood risk management. Other key partners include Sefton Council's Planning team, the Environment Agency, United Utilities and Capita Symonds, as agent for Sefton Council.

2.1.3 Partnership arrangements for the SWMP are set out in Figure 2-1, below:

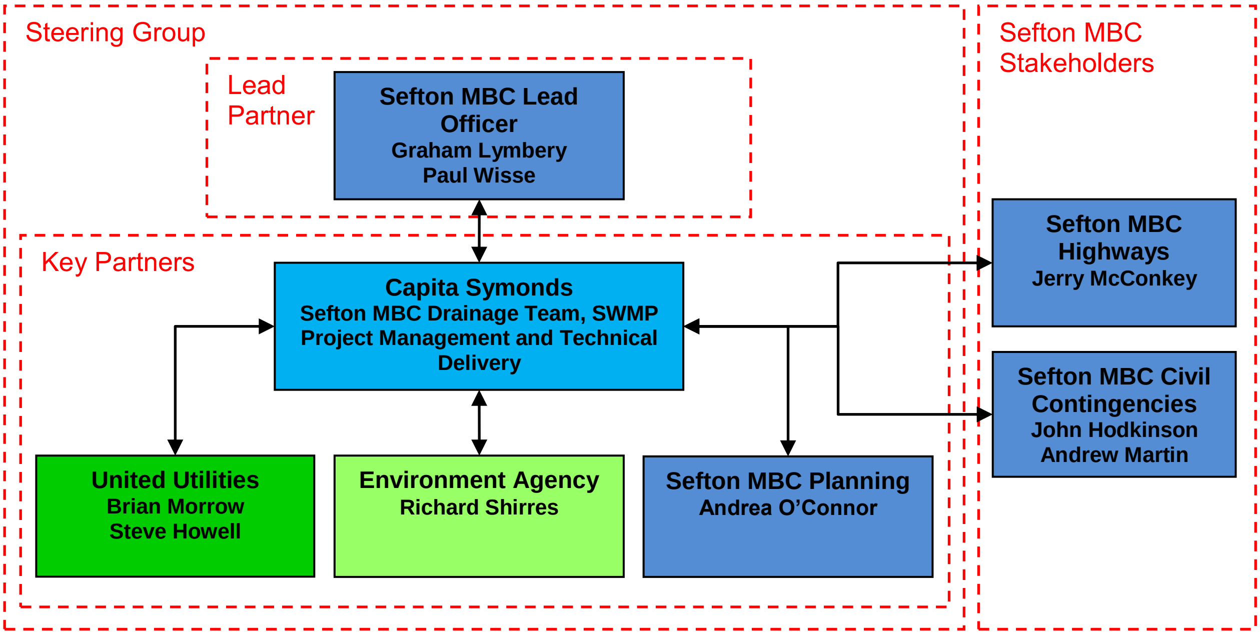

Figure 2-1: Partnership arrangements for the SWMP

2.1.4 Key partners have agreed roles and responsibilities and the following are considered to be amongst the most important for the successful delivery of the SWMP:

1. To actively participate as a Key Partner in the SWMP Study;
2. To ensure that the Strategic Objectives of the SWMP (See Section 1.3), as established by the Steering Group, are complied with where possible or practicable; and
3. To provide all data or other information which is relevant to the assessment process of the SWMP, and to provide such information as soon as is reasonably available and requested.

2.2 Data Collection

2.2.1 The collection and collation of strategic level data was undertaken as part of the SWMP Strategic Assessment. Data was collected from each of the following organisations:

- Sefton Metropolitan Borough Council – Planning, Civil Contingencies, Highways
- Environment Agency
- United Utilities
- 4NW (North West Regional Leaders Board)

2.2.2 The following summary table presents the datasets collected and used within the SWMP.

Table 2-1: Data collected

Source	Dataset	Description	Data Quality[18]
Sefton MBC	OS Mastermap	Detailed mapping of every fixed feature, equivalent to 1:1250 scale	1 – Best Possible
	Boundary data	Ward boundaries	1
	Historical flooding records	Records of flooding received by the Drainage team from all sources (2001 to 2010). Some records missing grid-references	2 – Data with known deficiencies.
		Records of the October 1994 Leeds & Liverpool Canal flood	2
	Asset GIS datasets	Highway drainage assets	2
		Formby ordinary watercourses	2
	Environmental Designations	Listed Buildings	1
		Ancient Monuments	1
		Parks & Gardens	1
		Conservation Areas	1
		Registered Parks	1
	Historical OS Mapping	Datasets from 1893-1894, 1908-1911, 1927-1928 and 1936-1939	2
	Survey of Dobb's Gutter	Surveyed November 2010	1
	Groundwater Emergence Map	GIS layers used within Knowsley and Sefton SFRA	3 – Gross Assumptions
	Culvert asset information	Information on some culverts and assets within the borough	2/3
	Report on Hard Sea Defences on the Sefton Coast (2007)	Report discussing the need for hard coastal defences on the Sefton Coast focussing on Crosby and Southport.	n/a
	Adapting to Climate Change Assessment of Risks for Sefton (2011)	A draft action plan aimed at identifying actions across many functions of the Council in response to the effects of climate change, including flood risk.	n/a
	UKCP09 predictions for the Formby-Southport area (2009)	Report examining the potential magnitude of climate change and sea conditions in the vicinity of Formby and Southport	3
	Knowsley and Sefton SFRA (2009)	Joint Strategic Flood Risk Assessment for Knowsley MBC and Sefton MBC	n/a
	Additional GIS datasets	Locations of key receptors within the Borough	1
		Location of Rest Centres	1
		Traffic Sensitive Routes GIS dataset	1
Environment	Alt Crossens	Report on flood risk management policy in the	n/a

[18] Data quality score based on Defra's Surface Water Management Plan Technical Guidance[2]. Score of 1 = Best Possible, no better available, Score of 2 = Data with known deficiencies, best replaced as soon as possible, Score of 3 = Gross Assumptions, not invented but based on experience or assumptions, Score of 4 = Heroic Assumptions, an educated guess.

Source	Dataset	Description	Data Quality[18]
Agency	Catchment Flood Management Plan	Alt Crossens catchments containing Southport, Formby, Maghull and parts of Aintree, Netherton, Thornton and Crosby	
	Mersey Estuary Catchment Flood Management Plan	Report on flood risk management policy covering Bootle and parts of Aintree, Netherton, Litherland, Seaforth and Crosby	n/a
Environment Agency (cont)	National Receptors Vulnerable to Flooding Database	Digital dataset providing point data classifying the use of property across the borough into one of 327 fields and one of 66 multi-coloured manual codes for assessing the consequences and damages from flooding	2
	LiDAR data	Light Detection and Ranging (LiDAR) topographical data for the borough collated and merged from two data sources: the Environment Agency, and Bluesky International Limited.	1
	GIS Datasets	AStSWF	2
		FMfSW	2
		AStGWF	3
		FZ Maps	2
		Flood Warning Areas	n/a
		Main Rivers	1
		Groundwater monitoring locations and level data	1
	Lower Mersey and North Merseyside Water Resources Study: Final Report Volume 1	Study into the Permo-Triassic Sandstone Aquifer within Merseyside and fluvial and groundwater flooding	n/a
United Utilities	Asset GIS Datasets	Data on the locations of: CSOs, Drainage Area Boundaries, Detention Tanks, Manholes, Pumping Stations, Rising Mains, Sewers and Wastewater Treatment Works	2
	Network Model Results	For all networks within Sefton	2
	Historical Flooding Records	Sewer Incident Reporting System (SIRS) (1992 to 2008) and Water Incident Reporting System (WIRS) (2008 to 2010) records of historical flooding associated with the sewer systems	2
	DG5 Register	Location/year information on properties currently within United Utilities DG5 register[19] (June 2009)	1
4NW	North West Regional Spatial Strategy Regional Flood Risk Appraisal (October 2008)	Regional flood risk appraisal covering the Sefton area	n/a
Bluesky Limited	LiDAR Data	Additional LiDAR datasets to fill in gaps within the datasets held by the Environment Agency	1
Infoterra	Photogrammetry data	5m DTM captured from their aerial imagery catalogue	2

[19] Register within the Director General of OFWAT's Report on Issue Number 5. This register, records the number of properties that have been affected by flooding either internally, or externally, and hence is a record of past events. It does not record properties that are considered to be at risk from external or internal flooding and therefore does not identify future flood risk. It also does not record properties that were effected by events in excess of the 1 in 30-year storm or properties affected by sources of flooding other than the sewer system

2.3 Data Review

2.3.1 All data collected through the SWMP has been reviewed to assess its quality (indicated in Table 2-1 above) and to assess its usefulness to the study.

2.3.2 Detailed comments on the quality of the data are presented in Appendix A, however, it is fair to say that the data available to this study is generally of good quality (Quality score of 1 to 2), in particular the mapping, topographical and GIS datasets available.

2.3.3 There are gaps in the available LiDAR datasets that have typically been filled with photogrammetry data sampled at the same resolution as the modelling undertaken for this study. It is understood that the EA has programmed in the collection of updated LiDAR data that includes this area, therefore it is anticipated that these gaps will be filled in for future revisions of the SWMP.

2.3.4 It is considered that there are limitations within the datasets concerning groundwater and climate change, which is primarily because of the large and typically strategic scale of modelling that may have been used to inform them and as such a data quality score of 3 has been applied.

2.3.5 Despite the good quality of some of the datasets, there are known gaps in the datasets recording historical flood events and there are known issues in the recording of property/land-use type within the National Receptors Database that particularly affect large properties spread out over a wide area (e.g. Schools) or which cover multiple sites in close proximity. This has resulted in some caution being applied in its use.

2.4 Asset Register

2.4.1 Section 21 of the FWMA 2010 sets a duty on Sefton MBC (LLFA) to maintain a register of structures or features, and a record of information about each of those structures or features, which, in the opinion of the authority, are likely to have a significant effect on flood risk in its area.

2.4.2 From the 6th of April 2011 all LLFAs have a duty to maintain a register. The legal characteristics of the register and record are outlined overleaf.

2.4.3 Defra has provided each LLFA with templates to demonstrate what information should be contained in the asset register. Although these templates are not intended as a working tool, they provide a good example of how an asset register might be structured and they have been included in Appendix B.

2.4.4 Populating the asset register is outside the scope of the SWMP project and is the responsibility of Sefton MBC. The expectation from Defra is that LLFAs will utilise a risk-based approach to populate the register and record with those structures or features considered the most significant first.

Table 2-2: Requirements of Register and Record of Assets likely to have a significant effect on flood risk

	Register	Record
a.	Must be made available for inspection at all reasonable times.	Up to the LLFA to decide if they wish to make it available for inspection
b.	Must contain a list of structures or features which in the opinion of the authority, are likely to have a significant effect on a local flood risk.	For each structure or feature listed on the register, the record must contain information about its ownership and state of repair.
c.	s.21 (2) of the Act allows for further regulations to be made about the content of the register and record. There is currently no plan to provide such regulations therefore their content should be decided on by the LLFA depending on what information will be useful to them.	
d.	There is no legal requirement to have a separate register and record although as indicated above, only the register needs to be made available for public inspection.	

2.4.5 In line with the example asset register presented in Appendix B, the following features should be considered as suitable for inclusion. Information on the location of many of these features is already available within the datasets collected as part of this SWMP and the only additional work required to develop it would be to ensure that all gaps were filled with the necessary information.

Table 2-3: Potential contents of the asset register and record

Linear Features	Point Features	Polygon Features
Open channel Culvert Sewer Drain, including highway drain Rising main Flood Defence Bank Flood Defence wall Railway embankment/cutting Canal	Manhole Inlet Trash Screen Outlet Pumping Stations Gully Inspection Chamber Junction Change of physical character or direction	Reservoir, including lakes & ponds Flood storage pond Swale Soakaway/Filter strip Permeable paved area

3 Phase 2: Risk Assessment

3.1 Strategic Risk Assessment

3.1.1 The aim of the Phase 2 Strategic Risk Assessment is to assess the broad locations that are vulnerable to surface water flooding and to identify a list of sites requiring further assessment at the Intermediate Stage.

3.1.2 The study area covers the entire borough of Sefton and whilst there was a reasonable understanding within the Drainage team of the distribution of past flooding events, there was a limited understanding of areas that may be vulnerable to surface water flooding in the future.

3.1.3 The principal method of undertaking the Strategic Assessment (SA) was through a multi-criteria analysis of datasets covering the entire borough that identify potential sources and pathways of flooding. The methodology used is summarised below. Further detail of the methodology is provided in Appendix C.

1. A 500m x 500m grid was used to analyse flood risk data and historical records in order to identifying what sources of flooding were present within each cell. Weightings were applied to each source of flooding within each cell to generate an aggregate flood score for each cell.
2. A 500m x 500m grid was used to analyse the potentially vulnerable receptors within each cell, applying a weighting to each in order to produce an aggregate infrastructure score.
3. A final stage of analysis used the results of the first two stages to identify and prioritise the areas for further consideration in an Intermediate Assessment.

3.1.4 The final output from a combination of the two methods above is presented in Figure C-3 to Figure C-4 in Appendix C.

3.1.5 In summary, the final output of the strategic risk assessment identifies those broad areas that are both more susceptible to surface water flooding and vulnerable to surface water flooding. The assessment identified 15 assessment zones in which the risk and consequences of surface water flooding indicate that further assessment is required.

3.1.6 These 15 zones cover six distinct areas:

1. The Southport area (Crossens, Southport Town Centre, Birkdale, Meols Cop and Hillside);
2. Ainsdale;
3. Formby;
4. Hightown;
5. Crosby, Bootle, Waterloo, Thornton, Litherland, Netherton and Aintree; and
6. Maghull.

3.2 Intermediate Risk Assessment

3.2.1 The aim of the Phase 2 Intermediate Assessment is to identify the sources and mechanisms of surface water flooding across the study area. This is achieved through an intermediate assessment of pluvial flooding, sewer flooding, groundwater flooding and flooding from ordinary watercourses along with the interactions with main rivers and the sea. The modelling outputs are mapped using GIS software.

3.2.2 In the light of extensive historical records of surface water flooding and the results from the over-arching national pluvial modelling suggesting that there are almost 100,000 properties at risk across the Borough[20,21], it is appropriate to adopt this level of assessment to further quantify the risks.

3.2.3 The purpose of this intermediate assessment is to further identify those parts of the borough that are likely to be at greater risk of surface water flooding and which may require a more detailed assessment. The methodology used for this SWMP is summarised in Sections 3.4 to 3.8 below. Further detail of the methodology is provided in Appendix C.

3.3 Risk Overview

3.3.1 Figures presenting an overview of the pluvial, groundwater and fluvial flood risk within the study area are provided in Appendix D.

3.3.2 Pluvial flood risk is based on the results of modelling from the Intermediate Risk Assessment, and the figures present those areas that may flood to a depth of 80mm[22] or more from an event with a 1 in 100 (1%) chance in any given year and from an event with a 1 in 100 (1%) chance in any given year plus a 30% increase in rainfall intensity to allow for the currently understood impacts of climate change.

3.3.3 Groundwater flood risk is based on the Groundwater Emergence Maps (GEM) developed by Jacobs as part of the Groundwater Flooding Scoping Study for Defra. These figures were previously presented in the Knowsley and Sefton MBC Strategic Flood Risk Assessment and they identify areas where, in exceptionally wet winters, groundwater could be at or close to the ground level. There is no probability associated with this information.

3.3.4 Fluvial flood risk is based on the Environment Agency's flood zone maps and in particular Flood Zone 3, which identifies the area at risk from fluvial flooding with a 1 in 100 (1%) chance of flooding in any given year. The flood extents do not take account of flood defences and do not show watercourses with catchment areas smaller than $3km^2$.

3.3.5 There may be interactions between the sources of flooding presented in the above and therefore figures are also presented in Appendix D that provide an overview of those areas in which pluvial and groundwater flooding may interact, in which pluvial and fluvial flooding may interact, in which fluvial and groundwater flooding may interact and in which all three sources of flooding may combine.

[20] This value was obtained using GIS software by counting the number of buildings contained within the area classified as Less Susceptible to Surface Water Flooding, i.e. may flood between depths of 0.1 and 0.3m, in the Environment Agency's AStSWF dataset.

[21] There are approximately 173,000 buildings identified in the OS Mastermap® topography layers covering the Sefton borough, though this includes smaller buildings such as sheds, garages etc. The National Receptors Database (NRD) indicates that there are in the region of 146,000 receptors, though this includes features such as parks and post boxes. A combination of the two indicates that there are approximately 144,000 buildings on the OS Mastermap® layer that are also within the NRD.

[22] The SWMP adopted 80mm as the minimum flood depth to represent on maps and figures as a conservative means of representing those areas that flood through the collection of rainfall, overland flow and sewer flooding. Adoption of a lower value would have identified those areas that receive rainfall and would not have allowed the differentiation of flooded areas from those that just get wet.

Accuracy and limitations of mapping

3.3.6 The mapping shown within this report is suitable to identify broad areas which are more likely to be vulnerable to surface water flooding. This allows Sefton MBC and its partners to undertake more detailed analysis in areas that are most vulnerable to surface water flooding.

3.3.7 In addition, the maps can also be used as an evidence base to support the spatial planning to ensure that surface water flooding is appropriately considered when allocating land for housing development. The map can be used to assist emergency planners in preparing their Multi-Agency response plans.

3.3.8 Please note that these maps only show the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall in urban areas) for defined areas. Due to the coarse nature of the source data used they are not detailed enough to account for precise addresses. Individual properties therefore may not always face the same chance of flooding as the areas that surround them.

3.3.9 There may also be particular occasions when flooding occurs and the observed pattern of flooding does not in reality match the predicted patterns shown on these maps. Capita Symonds has done all it can to ensure that the maps reflect all the data made available and has applied expert knowledge to create conclusions that are as reliable as possible. It is essential that anyone using these maps fully understands the complexity of the data utilised in production of the maps, is aware of the limitations and does not use the maps in isolation.

3.3.10 Capita Symonds, Sefton MBC or its partners will not be liable if the maps by their nature are not as accurate as might be desired or are misused or misunderstood despite our warnings. For this reason we are not able to promise that the maps will always be completely accurate or up to date.

3.4 Surface Water Flooding

3.4.1 Surface water flooding can be caused by rainfall being unable to infiltrate into the natural ground, often because the ground is saturated or because high intensity storms with short durations overwhelm the infiltration capacity of the ground or the capacity of the drainage system and gullies. When this happens it can result in (temporary) localised ponding and flooding. The cause of this surface water flooding can also include blockage and overflows of the drainage system and failure of sluice outfalls and pump systems.

3.4.2 The natural topography and location of buildings/structures influences the direction and depth of water flowing off impermeable and permeable surfaces and to a greater or lesser degree determines where it ponds, flows or discharges.

Methodology

3.4.3 The following briefly summarises the methodology followed to define surface water flooding from pluvial sources within the areas identified for Intermediate Risk Assessment. Further detail of the methodology is provided in Appendix C.

1. For more frequent events, WBM's TUFLOW software was used to dynamically route overland flood volumes obtained from the outputs of United Utilities sewer network models to provide an indication of potential flow path directions and areas where surface water will pond;
2. For less frequent events, the above was combined with a direct rainfall approach, whereby rainfall events of known probability were applied directly to the ground surface and routed

overland to provide an indication of potential flow path directions and areas where surface water will pond;

3. The outputs from this modelling were supported by field visits undertaken by Capita staff and members of the modelling team; and
4. The outputs were verified (where possible) against historic surface water flood records held by Sefton, the Environment Agency and United Utilities.

3.4.4 The modelled depth outputs from the above are presented in Figure 1-1-01 to Figure 1-4-09, the modelled velocity outputs are presented in Figure 2-1-01 to Figure 2-4-09 and the modelled hazard outputs are presented in Figure 3-1-01 to Figure 3-4-09, all of which are provided in Appendix D.

3.4.5 In summary, outputs have been produced for depth, velocity and hazard (based on guidance presented in Defra's *Flood Risk to People Methodology* (FD2321/TR1)[23]) for the following events:

1. Pluvial flooding with a 1 in 5 (20%) chance of occurring in any given year;
2. Pluvial flooding with a 1 in 30 (3.3%) chance of occurring in any given year;
3. Pluvial flooding with a 1 in 100 (1%) chance of occurring in any given year; and
4. Pluvial flooding with a 1 in 100 (1%) chance of occurring in any given year with a 30% increase in rainfall intensity to allow for the currently anticipated effects of climate change.

3.4.6 The key assumptions of the modelling undertaken are that:

1. United Utilities network model outputs are an appropriate method of representing consequences of pluvial flooding for more frequent events. The baseline assumption is that the capacity of the system can and does manage these rainfall events that flooding, where simulated, is a reflection of where flooding would typically be expected;
2. For more extreme events, it is appropriate for no allowance to be made for local variations in drainage, pumping or other works constructed for the purpose of flood risk management and that there is no allowance made for watercourses being at capacity.

Flooding Mechanisms

3.4.7 Those areas of Sefton that have been considered in the Phase 2 Intermediate Risk Assessment are predominantly urban.

3.4.8 As described in Section 1.4, most areas are relatively flat with little relief. Despite this, there can be areas in which the topography forms a shallow basin, such as in parts of Southport where development has taken place on land that was historically part of a large dune system (see Figure 1-3-02). In the south of the borough there is greater relief, which can result in more clearly defined flow paths, though in many places embankments and cuttings associated with railways and the Leeds and Liverpool Canal result in impediments to these flow paths, resulting in areas of ponding (see Figure 1-3-07).

3.4.9 Allowing for the above, modelling of the flooding expected from a storm with a 1 in 5 (20%) chance of occurring in any given year results in relatively limited impacts with isolated properties flooded along with minor roads and some traffic sensitive routes. In most areas the mechanism of flooding is therefore shallow flow from manholes and the collection of this flood water into

[23] Defra and Environment Agency Flood and Coastal R&D Programme (2006) Flood Risks to People – Phase 2, FD2321/TR1, Guidance Document

lower lying areas. This is particularly common between Southport and Formby, in Hightown and to the north of Crosby. Elsewhere, the greater relief in Bootle and Maghull results in areas where the ponding is more extensive, though the mechanisms remain the same (Figures 1-3-09 and 1-3-06 respectively).

3.4.10 As the severity of storm event increases to 1 in 30 (3.3%) in any given year, the volume and intensity of rainfall is such that the volume of flooding from manholes increases in addition to the number of manholes from which flooding occurs. The result of this is typically greater depths of flooding in those areas that flood during more frequent events, along with new areas of ponding in areas that previously did not.

3.4.11 Again, the mechanism between Southport and the north of Crosby is predominantly collection of water in low lying areas, whilst in Thornton, Bootle, Aintree, Netherton, Litherland, Maghull and Lydiate, the mechanism becomes increasingly one of ponding and flooding along what was historically a watercourse or a drain that fed a watercourse. Examples include areas around Water Lane in Thornton (Figure 1-2-08), which eventually discharges to Hunt's Brook, flooding in Princess Way in Seaforth along the path of Rimrose Brook, flooding along Menai Road and Province Road (all Figure 1-2-09), which follow the course of a southern tributary of Rimrose Brook, and Maghull Brook.

3.4.12 This trend continues as the severity of storm events increase and the chance of flooding decreases to 1 in 100 (1%) in any given year. Sewer flooding and rainfall collecting in depressions create extensive areas of ponded floodwater between Southport and north Crosby (Figures 1-3-01 to 1-3-05). These areas inevitably highlight underlying topographical features, particularly in Southport, however, in areas such as Formby it is a reflection of the flatness of the area coupled with the presence of the Formby Bypass to the east, which acts as a restriction to flow that causes flood water to collect and cause extensive flooding of property along its western edge.

3.4.13 In these extreme events, flooding is identified along pathways that would have fed Rimrose Brook, the River Alt, Whinny Brook and Maghull Brook. The extent of flooding along these pathways is significantly influenced by existing or historical infrastructure in these areas, such as railway lines, the canal and road layouts (Figures 1-3-06 to 1-3-09).

LLFA Responsibilities

3.4.14 Sefton MBC is responsible for the overall management of watercourses other than 'main rivers', which typically involves limiting the effect of flooding by ensuring that the surface water and land drainage systems within its control perform satisfactorily. Sefton MBC therefore has responsibility for water that cannot enter the surface water drainage system because the storm intensity exceeds the capacity of drainage ditches or gullies.

3.4.15 United Utilities is the flood risk management authority that has responsibility for the foul and surface water sewer system and is therefore responsible for water that has entered the sewer system and which then floods from the sewer system.

3.5 Ordinary Watercourse Flooding

3.5.1 All watercourses in England and Wales are either 'main rivers' or 'ordinary watercourses'. The Water Resources Act (1991) defines 'main rivers' as "a watercourse shown as such on a main river map", and are usually larger rivers or streams. The Floods and Water Management Act (2010) defines a watercourse that is not a main river as an ordinary watercourse – including ditches, dykes, rivers, streams and drains (but not public sewers).

3.5.2 Flooding from ordinary watercourses occurs when water levels rise higher than bank levels, causing floodwater to spill across adjacent land (floodplain). The main reasons for water levels rising in ordinary watercourses are:

- intense or prolonged rainfall causing runoff rates and flow to increase in watercourses, exceeding the capacity of the channel. This can be exacerbated by wet conditions leading up to an event and where there are significant contributions of groundwater;
- constrictions in the channel or blockage of structures causing flood water to backup; and
- high water levels preventing discharge at the outlet of the ordinary watercourse (often into a main river).

Methodology

3.5.3 Ordinary watercourses have not explicitly been modelled. As outlined in the following sections, the majority of ordinary watercourses within the urban areas of Sefton either form part of the piped drainage network, which is assessed using the methods described above in Section 3.4, and the remainder are field drains in low-lying, undeveloped areas that were screened out in the Strategic Assessment (Section 3.1).

3.5.4 Formby is the primary area where flooding from ordinary watercourses is currently and has historically been an issue, particularly with respect to Dobb's Gutter. This flooding has typically been associated with high water levels in the main river (Downholland Brook and ultimately the River Alt) to which it discharges.

3.5.5 Detailed modelling work undertaken by Capita Symonds[24] since the completion of the Intermediate Risk Assessment, which utilises an integrated 1D/2D hydraulic model of the sewer system and ordinary watercourses built in ESTRY-TUFLOW, indicates that there are also capacity issues associated with the culverts on Dobb's Gutter through which the watercourse passes and also within the downstream piped sections between Watchyard Lane and Moss Side.

3.5.6 These capacity issues would result in relatively frequent flooding issues regardless of the water level in the receiving watercourses. This conclusion is supported by sewer network modelling undertaken by United Utilities, which was provided during the course of the SWMP.

3.5.7 As the watercourse is so heavily integrated within the sewer network within Formby, it was considered appropriate to also adopt the surface water modelling methodology described in Section 3.4 to assess flooding from Dobb's Gutter. A comparison of the simulated flood extents from the detailed 1D/2D hydraulic model and those generated by the surface water modelling indicates an almost identical flood extent, which confirms that the adoption of the surface water modelling results as being representative of ordinary watercourses within Formby is acceptable.

3.5.8 No allowance within the modelling was applied for the watercourse being at capacity, though with the benefit of the results obtained by the detailed modelling this approach would be recommended if the modelling were to be updated in the future.

Mechanisms

3.5.9 Sefton has an extensive network of field drains and ditches that are classed as ordinary watercourses. The majority of these are located outside of the urban area and have therefore not been explicitly modelled or assessed. Flooding within these ordinary watercourses is likely to be associated with the capacity of the watercourse being exceeded by the flow draining to it

[24] Capita Symonds (2011) Dobbs Gutter Flood Alleviation Scheme Project Appraisal Report (Draft)

or a result of discharge from the ordinary watercourse being restricted by raised levels within receiving main rivers, such as Farm Moss Pool, the River Alt and its tributaries, Fine Jane's Watercourse, Captains Watercourse, Marshside Drain and Crossens Marsh Drain.

3.5.10 Within those areas of Sefton that have been considered in the Phase 2 Intermediate Risk Assessment, i.e. the urban areas, the majority of ordinary watercourses now form part of the surface water sewer network. This is particularly the case in Maghull, where Maghull Brook has been subsumed almost entirely into the surface water sewer network, and in areas like Netherton and Thornton, where there are relics of Netherton Brook and Hunt's Brook within the sewer network that do not formally exist anymore. In all these cases the responsibility currently lies with Sefton MBC and riparian owners, as they are classed by United Utilities as private sewers and are in effect piped watercourses. This is also the case in Claremont Avenue and around Sefton Lane Industrial Estate.

3.5.11 Those historical ditches that once fed Rimrose Brook between Crosby, Litherland, Aintree and Bootle, now form part of the combined sewer system under United Utilities control and only remnants of Rimrose Brook remain, fed by small areas with surface water sewer networks and the undeveloped land that surrounds them. These would be the responsibility of the riparian owner, which may be Sefton MBC in some cases.

3.5.12 In Southport, the historical watercourse that was once a tributary of the Crossens Marsh Drain and which contains the Serpentine Lake, is now effectively part a surface water sewer system draining to Three Pools Waterway. This watercourse is again identified as a private sewer and therefore the responsibility of Sefton MBC and other riparian owners.

3.5.13 There are a number of similar watercourses within Formby. These watercourses, particularly Dobb's Gutter, form part of a complex system of drainage in which an extensive piped network of surface water and highway drainage managed by United Utilities drains to and is interconnected with piped watercourses and open ditches managed by Sefton MBC and riparian owners. Dobb's Gutter ultimately discharges to Moss Side, which is a main river.

3.5.14 The detailed modelling undertaken to date by Capita Symonds[24] indicates that, during an event with a 1 in 100 chance (1%) of occurring in any given year, many of the areas draining to the open sections of Dobb's Gutter peak at approximately the same time. In addition, when accounting for the combined discharge from the various sub-catchments, the total flow discharging to the watercourse exceeds the capacity of many of the culverts along the watercourse as well as the capacity of the piped network downstream. Flooding in the vicinity of the watercourse, in addition to flooding from the surrounding surface water sewer system, is therefore inevitable when an event of sufficient severity takes place.

3.5.15 Anecdotal evidence suggests that Dobb's Gutter is affected by high water levels in Moss Side, Downholland Brook and the River Alt, which it discharges into, and that this prevents the discharge of water from the watercourse. This has the same affect as an intense storm that exceeds the capacity of the system, there could be flooding locally directly from the watercourse or, as is more likely, there will be flooding from the surrounding surface water sewer system.

LLFA Responsibility

3.5.16 Sefton MBC has overall responsibility for the management of watercourses other than 'main rivers', which typically involves limiting the effect of flooding by ensuring that the surface water and land drainage systems within its control perform satisfactorily.

3.5.17 The actual maintenance and upkeep of ordinary watercourses and surface water features is the responsibility of the riparian owner, and Sefton MBC can enforce these actions through the use of its legal powers and responsibilities. Sefton is also a riparian owner in some locations (such as schools, playing fields, parks and allotments), and it therefore has responsibilities for the maintenance and upkeep of drainage in these locations.

3.5.18 In Formby, where both highway and property surface water drainage systems rely on a matrix of ditches, watercourses and piped watercourses for drainage, Sefton MBC maintain certain strategic sections of the land drainage system on a regular basis for the benefit of the public.

3.6 Groundwater Flooding

3.6.1 Groundwater flooding occurs when water levels in the ground rise above surface elevations. It is most likely to occur in low-lying areas underlain by permeable rocks but can also occur where shallow soils overly an impermeable or slowly impermeable layer of strata, for example clay. In such circumstances, wet periods of weather can saturate the shallow soils causing a temporary or perched groundwater table to rise to the surface. Groundwater flooding can also be caused by rising groundwater levels following the cessation of groundwater pumping, particularly in mining areas.

Methodology

3.6.2 The assessment of groundwater flood risk within the SWMP is based on the Groundwater Emergence Maps (GEM) developed by Jacobs as part of the Groundwater Flooding Scoping Study for Defra. These figures were previously presented in the Knowsley and Sefton MBC Strategic Flood Risk Assessment and they identify areas where, in exceptionally wet winters, groundwater could be at or close to the ground level. There is no probability associated with this information.

3.6.3 Information on rising groundwater has also been reviewed from within a report provided by the Environment Agency on local sandstone aquifers[7] and from within the Alt Crossens CFMP[6], both of which indicate that groundwater contributes a significant proportion to the base flow of the River Alt and that it is the low lying areas within the Alt catchment that are likely to experience the effects of rising groundwater.

3.6.4 The Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF) dataset has also been reviewed during this project, however, Defra's Groundwater Emergence Map has been preferred because guidance on the AStGWF dataset indicates that unless an area identified as 'susceptible to groundwater flooding' is also identified as 'at risk from surface water flooding', it is unlikely that this location would actually experience groundwater flooding to any appreciable depth, and therefore it is also unlikely that the consequences of such flooding would be significant.

3.6.5 Mapping of groundwater flood risk is presented in Figure 4-1-01 and Figure 4-1-02 in 0.

Mechanisms

3.6.6 The information available on groundwater flooding within Sefton indicates that the areas at risk from this source of flooding are likely to be affected by flooding from superficial deposits in which water levels in shallow deposits may rise to the surface or are at risk from rising groundwater from the underlying Permo-Triassic Sandstone aquifer. These latter areas are typically located within the low-lying areas within the catchment of the River Alt, though there are areas bordering the Leeds and Liverpool Canal in Crosby and Bootle and areas bordering the main rivers to the east of Southport.

3.6.7 It is unlikely that groundwater flooding would result in significant depths of water and the areas affected by flooding are likely to mirror those areas simulated to flood as a result of surface water flooding. Where groundwater is near to the surface, however, it is likely to influence other sources of flooding, such as surface water flooding and flooding from ordinary watercourses.

LLFA responsibility

3.6.8 Sefton MBCs new responsibilities under the Flood and Water Management Act (FWMA) 2010 will see the authority responsible for local flood risk management, which includes groundwater flooding.

3.6.9 There is very little that the Council can do to prevent rising of groundwater in response to the cessation of pumping activities or to prevent the saturation of shallow superficial deposits. It is unlikely that any groundwater emergence would actually result in groundwater flooding to any appreciable depth and, once it has emerged above ground, groundwater will follow the same overland pathways to the surface water drainage network as would runoff from any pluvial event.

3.6.10 On that basis, Sefton MBC will have a responsibility under the FWMA for investigating and recording details of flood events within their area. If groundwater is identified as the source or a contributory source of flooding then the authority can use it powers to undertake works or to enforce works by other riparian owners to ensure that the receiving surface water drainage system is working efficiently and effectively in maintaining local groundwater tables and in removing excess water.

3.7 Sewers

3.7.1 Sewer flooding can result when combined or surface water sewers are overwhelmed and surcharge water into the nearby environment. Flooding from sewers can also be caused by blockage and failure of pumping systems and it can also be influenced by river and tide levels.

Methodology

3.7.2 Flooding from combined and surface water sewers is explicitly incorporated within the assessment of surface water flooding discussed in Section 3.4. Modelling of the areas expected to flood from storms with a 1 in 5 chance (20%) and a 1 in 30 chance (3.3%) of occurring in any given year is based entirely on the outputs from United Utilities sewer network model results. Modelling of areas expected to flood with a 1 in 100 chance (1%) or less of occurring in any given year also includes outputs from United Utilities sewer network model results.

3.7.3 Use of United Utilities model results in the above effectively assesses the current risk from sewer flooding across the network, including those areas which may not yet have experienced flooding.

3.7.4 United Utilities has also provided its DG5 register[19]. This dataset was provided at the property level and whilst not presented within this SWMP it has been used as an additional dataset to identify areas that are currently at risk from sewer flooding and which have experienced flooding.

Mechanisms

3.7.5 The majority of Sefton is typically served by a combined sewer system. The exceptions being areas of Birkdale, Ainsdale, Formby, Maghull and parts of Aintree and Thornton which have a separate surface water sewer system. In total there are twenty drainage areas managed by

United Utilities, consisting of 59 pumping stations, 13 detention tanks, 41 combined sewer overflows (CSOs) and three wastewater treatment works (WwTWs).

3.7.6 Based on the available outputs of United Utilities' sewer models, the capacity of the sewer system is highly variable across the borough. Approximately 57% is at or above the flow anticipated from a storm with a 1 in 30 (3.3%) chance of occurring in any given year, indicating that 43% of the network would not provide the design capacity associated with a new build system, which is an understandable capacity issue affecting older sewerage systems[25]. Approximately 22% of the network has a capacity that is below the flow anticipated from a storm with a 1 in 5 (20%) chance of occurring in any given year.

LLFA Responsibilities

3.7.7 Sefton MBC has no responsibility for United Utilities combined or surface water sewer system, however, as the surface water sewer system feeds into ordinary watercourses and ditches Sefton MBC has a role to play through its responsibility for the overall management of watercourses other than 'main rivers', ditches and drainage channels, and which typically involves limiting the effect of flooding by ensuring that the surface water and land drainage systems within its control perform satisfactorily.

3.7.8 In Formby and some other areas, Sefton MBC cleanses certain strategic sections of open channel and piped watercourse and has responsibility for maintaining the free drainage of these areas. It is important for the efficient drainage of the wider surface water drainage network in Formby that this continues.

3.8 Other Influences

Main Rivers

3.8.2 The results of the surface water flooding modelling that is described in Section 3.4 have been compared to the Environment Agency's most up-to-date fluvial Flood Zone 3 extents on its website8 and in particular those areas of Flood Zone 3 that lie outside of areas benefiting from defences (ABDs). ABDs in relation to fluvial flooding define those areas that are normally protected from fluvial flooding with a 1 in 100 chance (1%) of occurring in any given year by the presence of flood defences.

3.8.3 A review identified that there are areas within the Phase 2 Intermediate Risk Assessment study area that are both at risk from both surface water flooding and which lie in areas that are not protected from fluvial flooding by defences. These are located in:

1. Arable fields and scrub land alongside Three Pools Waterway at Rye Hey (East of Southport);
2. Woodland, scrub and allotments at Gore Hey Covert (East of Southport);
3. A caravan park to the south east of Ainsdale on Plex Moss Lane;
4. Grazing land and a greenhouse/nursery south of Wham Dyke to the north east of Formby;
5. Grazing land between Formby Bypass and Downholland Brook by Formby Golf Centre;
6. Grazing land at Formby Moss;
7. Grazing land and storage areas by the Superstore south of Altcar Road;

[25] WRc (2006) Sewers for Adoption 6th Edition

8. Grazing land and allotments around Formby WwTW;
9. Storage areas and parking at property on Bridges lane/Sefton Lane; and
10. Arable land between the River Alt, Brooklea and Melling Brook to the east of the Merseyrail railway line to Ormskirk.

3.8.4 The areas that are impacted are typically arable or grazing land, within which the consequences of the combined risk would be limited. Key areas of concern for future flood risk management consideration include the caravan park to the south east of Ainsdale, because of the risk to people. There is a risk of pollution from the combined risks to the storage areas by the Formby Superstore and Bridges Lane/Sefton Lane, and at Formby WwTW, which should also be considered.

Tidal

3.8.5 The results of the surface water flooding modelling that is described in Section 3.4 have been compared to the Environment Agency's most up-to-date tidal Flood Zone 3 extents on their website8 and in particular those areas of Flood Zone 3 that lie outside of areas benefiting from defences (ABDs). ABDs in relation to tidal flooding define those areas that are normally protected from tidal flooding with a 1 in 200 chance (0.5%) of occurring in any given year by the presence of flood defences.

3.8.6 A review identified that there are no areas within the Phase 2 Intermediate Risk Assessment study area that are both at risk from both surface water flooding and which lie in areas that are not protected from tidal flooding by defences.

Canals

3.8.7 The Leeds and Liverpool Canal weaves its way through Sefton from Lydiate to Bootle, passing through Maghull, and passing by Aintree, Netherton and Litherland in the process.

3.8.8 The canal is known to have breached in October 1994. The roof of a culvert that passes beneath the embankment and through which the Maghull Brook is carried collapsed lead to a rapid loss of water from the canal and the progressive collapse of the stone culvert which then allowed the canal to burst its banks, flooding between 200 and 300 properties in Hickson Avenue and Greenbank in Maghull,

3.8.9 The canal generally follows the contour and there is therefore inevitably a side which lies above adjacent ground levels. The canal is raised on both sides where it enters Sefton MBC's administrative area and crosses Sudell Brook to the east of Lydiate and where it passes over Maghull Brook, Whinny Brook, Melling Brook, the River Alt, through parts of Aintree, in parts of Litherland and as it passes Seaforth.

3.8.10 There is inevitably a risk of flooding from this source and surface water flooding may play a contributory part by discharging to the canal in places where topography allows overland flow to enter the canal, which is shown to take place in Lydiate, Aintree, Netherton, Litherland, Seaforth and Bootle. The canal can then act as a pathway to channel surface water flood water from these areas into Seaforth, Bootle and potentially into Liverpool City Centre.

3.8.11 The canal embankment also plays a significant role in holding surface water flooding back in places. The surface water modelling results provide evidence that this could occur in Lydiate, Maghull, between the Ormskirk railway line and the M58, on Brooklea in Waddicar and Melling Watercourse, within Aintree Golf Course and Racecourse, and along its route through Netherton, Litherland, Seaforth and Bootle.

Maintenance and Operation of Systems

3.8.12 In addition to areas that are at fluvial flood risk and which do not benefit from defences, it was highlighted in Section 3.5 that there is considerable anecdotal evidence of ordinary watercourse flooding in Formby, particularly along Dobb's Gutter, which is affected by high water levels in Moss Side, Downholland Brook and the River Alt, which it discharges into, and that this prevents the discharge of water from the watercourse.

3.8.13 As discussed in Section 1.5, the River Alt is a pumped watercourse, though some natural gravity drainage is possible. The Alt Crossens CFMP indicates that the station has three separate means of discharging water from the Alt catchment:

1. Four storm pumps, each of 19.8m³/s capacity;
2. Four Dry Weather Flow (DWF) pumps, each of 1.1m³/s capacity; and
3. Gravity bypass flaps (area 3.3m²).

3.8.14 Major channel conveyance limitations are understood to mean that only two pumps can usefully operate at any one time, however, in general the risk of flooding in the catchment is limited to tributaries in Kirkby and Maghull and in areas around Formby (Acre lane Brook and Wham Dyke).

3.8.15 In Southport, the situation is more complex because drainage is highly integrated within the Crossens pumped catchment. The Alt Crossens CFMP indicates that the Three Pools channels provide drainage via pumping at Crossens Pumping Station for the higher areas of the Crossens sub-catchment. There are 9 pumps out of 16 catering for what is referred to as the 'higher system', of which the Three Pool channels form part.

3.8.16 The current operating regime of the Crossens catchment means that, when operating as intended, there is generally little risk from flooding though it is understood to be sensitive in a few locations to large flood events, including parts of Southport. There are three key elements, however, the failure of which could result in large scale flooding impacting Southport and surrounding areas. These are:

1. Pumping stations, particularly Crossens Pumping Station at Banks;
2. Existing coastal and tidal defences resulting in salt water ingress;
3. Embankment between Crossens Sluice and Banks Marsh Drain.

3.8.17 Given the sensitivities of these two pumped catchments, flooding from ordinary watercourses, ditches and within surface water sewers could therefore be directly impacted by failure of either of the Altmouth or Crossens Pumping Station.

3.9 Critical Drainage Areas

3.9.1 The Town and Country Planning (General Development Procedure) (Amendment) (No. 2) (England) Order 2006 introduces the concept of Critical Drainage areas as:

> *"an area within Flood Zone 1 which has critical drainage problems and which has been notified… [to]…the local planning authority by the Environment Agency"*

3.9.2 Within this SWMP, the definition of a CDA has been specifically defined as follows:

"a discrete geographical area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones (LFRZ) during sever weather thereby affecting people, property and local infrastructure."

3.9.3 In effect, therefore, land within a Critical Drainage Area either contributes to flooding within a LFRZ or acts as a pathway for the water that contributes to that flooding. At the outlet of the CDA, the land may be within a LFRZ and could therefore also be a receptor. Measures taken within a CDA to either increase infiltration or reduce surface water runoff would therefore contribute towards a reduction in flood risk within a LFRZ.

3.9.4 Local Flood Risk Zones are defined within the SWMP as:

"discrete areas of flooding that do not exceed the national criteria[26] for a Flood Risk Area but which still affect houses, business or infrastructure."

3.9.5 LFRZs have been defined as the actual extent of predicted flooding in a single location and, within the Sefton MBC SWMP, LFRZs have been determined directly from the surface water modelling outputs as those discrete areas of flooding that are greater than 80mm deep and which have a surface area greater than $5m^2$ [27]. LFRZs can represent both pathways and receptors of surface water flooding and facilitate the targeting of measures and options to manage flood risk by identifying significant pathways and therefore sources.

3.9.6 Related LFRZs can be grouped together within a Critical Drainage Areas or left in isolation and considered within a larger Policy Area (PA). A Policy Area could be defined to link together CDAs on a hydrological or geological basis and they may therefore cross borough boundaries. They should be primarily used as a planning policy tool for end users of the SWMP. PAs should be used to define general policy around issues that influence surface water runoff and flood risk, for example increasing impervious area or the use of SuDS. CDAs should be used for site-specific detailed planning and capital works schemes.

3.9.7 A summary table of each CDA, outlining location, size, receiving watercourses and flood risk influences is presented in Appendix C.

3.10 Summary of Risk

3.10.1 A large amount of information is available on different sources of flooding within the study area, consisting of new surface water modelling, sewer network capacity information and modelling, groundwater emergence mapping and fluvial/tidal flood risk extents. Assessment of this data indicates that in many areas the principal risk of flooding is from surface water flooding and sewer flooding. This conclusion is supported by the wealth of historical flood risk information collated by Sefton MBC and United Utilities.

3.10.2 The surface water and sewer flood risk can typically be defined in the following distinct classes:

1. In areas of low relief and few or no historical watercourses, such as parts of Southport and some areas of Crosby and Litherland, the flood risk comes primarily from ponding in wide topographical depressions that affect a large area.
2. In similar areas of low relief but in which there was once a historical watercourse or in which there remains a network of drainage, for example along the eastern edge of Southport,

[26] National criteria requires at least 200 people to be impacted for an event to meet thresholds for flooding to be considered an issue and at least 30,000 for the area to be identified as a Flood Risk Area.
[27] This is consistent with the Environment Agency's Strategic Flood Risk Mapping specification, which requires the removal of polygons that are less than $5m^2$.

Ainsdale and Formby, the flood risk will come from both ponding but also gradual flow in relatively wide floodplains.

3. In areas of greater relief, for example those areas draining to Rimrose Valley, areas of Netherton, Aintree and all of Maghull and Lydiate, the flooding mechanism is very clearly linked to historical or existing flow paths, with high velocity flow and narrower flood extents expected.
4. Finally, wide floodplains can be expected where flow path gradients reduce, which happens for example where flow paths approach the Alt, and also were flow paths are intercepted by features such as raised embankments associated with roads, railway lines and the Leeds and Liverpool Canal, which occurs in a number of locations in Maghull, Aintree, Netherton, Litherland and Bootle.

3.10.3 There are areas within Sefton that are at risk from fluvial and tidal flooding, however, for the large part these are managed by the presence of defences and the continued operation and maintenance of complex pumped drainage systems in both the Alt and Crossens Catchments.

3.10.4 There are a few areas where there is a risk from fluvial flooding that is not managed by defences and these areas can coincide with areas of surface water flooding, however, they tend to be located in areas of arable or grazing land and are therefore not significant influences. High water levels within the main drainage system controlled by pumping can, however, have a significant influence on areas that lie outside of the fluvial flood plain.

3.10.5 There are also areas within Sefton that are at risk from rising groundwater and also shallow groundwater reaching the surface. These tend to be associated with main rivers such as the River Alt, and Fine Jane's Brook and typically would not significantly contribute to surface water flooding with the exception of where Critical Drainage Areas interact with these watercourses, such as lower lying areas of Maghull, Aintree, Netherton and along the eastern edge of Ainsdale, Birkdale and Southport.

4 Phase 3: Options

4.1 Objectives

4.1.1 The Sefton SWMP has not involved detailed assessment of options across the borough and therefore options and preferred options cannot be presented in any detail.

4.1.2 The assessment and work to date has, however, identified a number of potential measures that should be investigated in the future with the aim of identifying a range of structural and non-structural measures for alleviating flood risk in critical drainage areas, which includes further assessment to eliminate those options that are not feasible or cost beneficial. The remaining options can then developed and tested against their relative effectiveness, benefits and costs and a prioritised list developed for future implementation.

4.1.3 The target level of flood protection should be set to 1 in 75 years to align solutions with the likely level of insurance cover available to the general public, however, this should take into account that new sewerage systems are typically designed for a 1 in 30 year event but that it is acceptable for open spaces to flood in more severe events.

4.1.4 Phase 3 delivers high-level identification of potential measures for each of the Critical Drainage Areas (CDAs) identified in Phase 2. The options assessment presented here follows that described in the Defra SWMP Guidance but are focussed on highlighting areas for further detailed analysis and immediate 'quick win' actions.

4.2 Measures

Borough-wide Measures

4.2.2 The following presents specific measures that could be applied generally across the borough to manage flooding. More information is presented in Appendix E.

Planning Policy

4.2.3 Existing planning policies with respect to surface water runoff and flood risk should be reviewed and expanded where possible. It should be the aim of any new planning policy to:

1. Ensure that developers consider the outputs of the SWMP when planning development and to demonstrate that development will remain safe and will not increase risk to others, particularly in Local Flood Risk Zones (LFRZs) where existing properties and sensitive receptors are already at risk from surface water flooding;
2. Encourage the reduction of surface water runoff rates and surface water runoff volumes below the existing rates and volumes across all new development and redevelopment, particularly within Critical Drainage Areas (CDAs) which identify those areas that contain and contribute to flooding in Local Flood Risk Zones (LFRZs) and which are therefore areas in which reductions in runoff rates or volumes from existing rates and volumes could contribute to a reduction in downstream flood risk;
3. Encourage the incorporation of Sustainable Drainage Systems, and in particular 'at source' SuDS measures in all new development and redevelopment, in order to improve water quality as well as reductions in runoff rate and volume. By also strongly supporting Requirement H3(3) in Part H of the Building Regulations (2000) Drainage and Waste

Disposal, the Council will encourage the use of infiltration and removal of surface water from sewers, which will contribute to a reduction in flood risk from this source;

4. Restrict some forms of permitted development through an Article 4 Direction, particularly within some CDAs, in order to restrict urban creep, which contributes to surface water flooding and pollution. This would apply to permitted development classes A.1, E.1 and F.1, all of which could potentially increase impervious areas; and

5. Integrate flood risk management needs clearly with green infrastructure plans and strategies.

4.2.4 Examples of how the above might be implemented are shown below. Also outlined is the area/location in which these policies should be implemented, the consequences of implementation, the evidence for implementation and the criteria to be applied:

1. New Greenfield development to restrict runoff to existing runoff rates and where possible volumes and to seek to maximise discharge to first soakaway, then watercourse and then sewer.

   Location: Borough-wide

   Consequences: None. Complies with current national planning policy and the principles of Sustainable Drainage Systems (SuDS).

   Evidence: Complies with current national planning policy and principles of Sustainable Drainage Systems (SuDS).

   Criteria: No increase in runoff rates from existing. No increase in volume discharged to watercourse or sewer for the 100-yr, 6-hour storm (refer to Section 4.5.5 SuDS Manual, CIRIA, 2007[28])

2. New Brownfield development must seek to reduce runoff by at least 50% from existing through discharge to soakaway. Where ground conditions are adequately shown not to facilitate a 50% reduction by discharge to soakaway then development must show that the maximum feasible discharge to soakaway is proposed and that a minimum reduction in total site runoff of 20% is provided.

   Location: Borough-wide

   Consequences: Minimum reduction in runoff rates of 20%, maximum reduction of 50%. Both may not be achievable through infiltration but above/below ground attenuation is achievable. Requires consideration surface water drainage at earliest possible stage and provision of sufficient space within development area.

   Evidence: As indicated in Section 3.7, approximately 43% of the sewer system has a capacity that is less than the current design standard and this is likely to increase with the currently understood effects of climate change. A reduction in runoff from Brownfield sites to below existing rates will reduce the flows entering the system and will contribute to a reduction in this flood risk.

   Criteria: 50% reduction in runoff rates from existing. No increase in volume discharged to watercourse or sewer for the 100-yr, 6-hour storm (refer to Section 4.5.5 SuDS Manual, CIRIA, 2007)

3. New Brownfield development greater than 0.5 hectare that lies within a Critical Drainage Areas must seek to reduce runoff to predevelopment Greenfield runoff rates through

[28] CIRIA (2007) The SuDS Manual. Report C697

discharge to first soakaway, then watercourse and lastly sewer. Where ground conditions are adequately shown not to facilitate this reduction by discharge to soakaway then development must show that the maximum feasible discharge to soakaway is proposed and that a minimum reduction in total site runoff of 20% is provided.

Location: All Critical Drainage Areas

Consequences: Reduction in runoff to pre-development Greenfield rates would restrict runoff to approximately 5l/s/ha, requiring attenuation for runoff generated above this rate of between approximately 387 and 442m^3 per hectare[29]. Infiltration may not be achievable but above/below ground attenuation is likely to be achievable on most sites. Requires consideration of surface water drainage at earliest possible stage and provision of sufficient space within development area. Likely to have significant beneficial consequences on sewer related flood risk.

Evidence: Approximately 2600 properties are currently at risk from sewer flooding in a 1 in 30 (3.3%) chance event within all CDAs across the borough (See Appendix C). As indicated in Section 3.7, approximately 43% of the sewer system has a capacity that is less than the current design standard and this is likely to increase with the currently understood effects of climate change. A reduction in runoff from Brownfield sites to below existing rates will reduce the flows entering the system and will contribute to a reduction in this flood risk.

Criteria: Reduction in runoff rates to pre-development Greenfield rates. No increase in volume discharged to watercourse or sewer for the 100-yr, 6-hour storm (refer to Section 4.5.5 SuDS Manual, CIRIA, 2007)

4. All new development across the borough to include at least one 'at source' SUDS measure. Where no ‘at source’ SUDS measure is proposed, provide evidence to show that such measures are not feasible as a result of existing ground conditions.

   Location: Borough-wide

   Consequences: Extends current national planning policy, which currently promotes SuDS, and consistent with current Sefton UDP. Would result in a net improvement in water quality and contribute to a reduction in surface water runoff from developments.

   Evidence: Extends current national planning policy, which currently promotes SuDS, and consistent with current Sefton UDP.

   Criteria: Incorporation of at least one source control SuDS measure, as identified within the SuDS Manual[28]

5. Permitted development rights for Classes A.1, E.1 and F.1 within Critical Drainage Areas are removed subject to the provision of sufficient information to show that surface water runoff is limited by the adoption of pervious surfaces and that runoff from these surfaces is retained within the curtilidge of the property[30].

   Location: All Critical Drainage Areas

   Consequences: As discussed in paragraph 4.2.13, the effect on urban creep in Sefton could be significant in terms of increased impermeable area, with

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[29] This estimate is based on 1ha of impermeable area, a volumetric runoff coefficient of between 0.74 and 0.84, a 100-yr,1-hour rainfall depth of 42.09mm and a 30% increase in rainfall intensity to allow for climate change.

[30] In October 2008 permitted development rights for front gardens were changed in order to try and reduce the impact that this type of development has on flooding and on pollution of watercourses.

consequences for runoff rate, runoff volume and water quality. Implementation would contribute towards slowing the rate of urban creep and reducing the impacts on flood risk. Appendix C presents a table indicating total predicted Urban Creep (m/year) for each Critical Drainage Area, which indicates that in some CDA's it could reach over 0.6ha per year.

Evidence: Refer to Allitt, M & Tewkesbury, A (2009) Investigations into Urban Creep at 5 Cities (http://www.ciwem.org/media/53157/Autumn2009_Paper_9.pdf) and G. B. Wright, S. Arthur, G. Bowles, N. Bastien & D. Unwin (2011) Urban creep in Scotland: stakeholder perceptions, quantification and cost implications of permeable solutions.

Criteria: Planning consent must be applied for with respect to development classes A.1, E.1 and F.1 and the proposed development must ensure that the areas are permeable (F.1 only) and that surface water is retained within the curtilidge of the property.

6. Development that includes enhancement of urban green spaces must show that consideration has been given to incorporating flood risk management measures that could contribute to a local and downstream reduction in flood risk.

   Location: Borough-wide

   Consequences: Opportunities for flood risk management measures, where they are shown to be capable of reducing flood risk elsewhere, are investigated and implemented where possible. Provides multiple benefits, potentially attracting multiple sources of funding and potentially contributing to habitat creation.

   Evidence: This SWMP indicates that there are many areas of current open green space that either act as a source or a pathway for surface water flooding within Sefton and opportunities to implement source control SuDS measures (See Appendix E). Sefton MBCs Green Space Study indicates that there are 32 existing urban green spaces that provide 'high benefits' with respect to flood risk management.

   Criteria: Evidence provided to show liaison with Sefton MBC over potential opportunities within the urban green space and, if so, evidence to show that potential has been investigated and is either wholly or in part incorporated or not being pursued because of constraints such as ground conditions, habitats etc.

7. Any redevelopment of urban green spaces, either in part or entirely, must show that consideration has been given to incorporating flood risk management measures that could contribute to a local and downstream reduction in flood risk.

   Location: Borough-wide

   Consequences: Opportunities for flood risk management measures, where they are shown to be capable of reducing flood risk elsewhere, are investigated and implemented where possible. Provides multiple benefits, potentially attracting multiple sources of funding and potentially contributing to habitat creation.

   Evidence: Sefton MBCs Green Space Study indicates that there are 32 existing urban green spaces that provide 'high benefits' with respect to flood risk management. This SWMP indicates that there are many areas of current open green space that either act as a source or a pathway for surface water flooding within Sefton and opportunities to implement source control SuDS measures (See Appendix E).

Criteria: Evidence provided to show liaison with Sefton MBC over potential opportunities within the urban green space and, if so, evidence to show that potential has been investigated and is either wholly or in part incorporated or not being pursued because of constraints such as ground conditions, habitats etc.

Community Resilience in CDAs and particularly LFRZs

4.2.5 The council should work with communities shown to be at risk from flooding to develop higher levels of community resilience and awareness. The council should focus on land owners and tenants whose property lies within a CDA and in particularly where that property lies within the more significant LFRZs that contain deep areas of ponding or that are part of or near to a significant flow path.

4.2.6 The aim should be to increase the awareness and understanding of the local sources of flooding and to promote the development of householder and business flood response plans. Advice should help identify where further information can be found on local sources of flooding, where support can be obtained for development of flood response plans, who to contact and what to do in the event of a flood.

Enhance emergency response procedures in CDAs

4.2.7 The information presented within the SWMP should be reviewed to identify if there are any CDAs in which there needs to be local modifications to Sefton MBCs response to flooding.

4.2.8 Beyond the initial response to a flood event, which may involve arranging for remedial work or voluntarily providing an emergency supply of sandbags (subject to availability), Sefton MBC has responsibility to investigate and record flood incidences. Sefton MBC currently has a priority list for investigating flooding with internal or imminent internal flooding of highest priority.

4.2.9 The LFRZs identified as part of the SWMP will assist Sefton MBC in understanding the potential sources of flooding when it is receiving reports of an incident, to understand the potential consequences of that flooding within the local and potentially wider area and what response may be required. It will also assist it to identify which relevant flood risk management partners may need to be notified.

Investigate the amount of 'urban creep' in Sefton

4.2.10 A recent study by Martin Allitt and Andrew Tewkesbury[31] investigated the problem of urban creep in five cities across the UK. Urban creep is the loss of permeable surfaces within urban areas, typically development like extensions, patios and paving of front gardens to create off-street parking, all of which were until recently forms of permitted development. The latter, paving of front gardens, has now become more restricted, however, the remainder continue to be forms of permitted development under certain conditions.

4.2.11 The five cities investigated were Leicester, Maidstone, Chester, Norwich and Newcastle-Upon-Tyne. Advanced analysis of land cover was undertaken from high resolution aerial imagery in order to identify those areas in which urban creep has taken place. The research took care to remove 'growth', such as new properties or the addition of paved areas associated with new properties as well as major highway improvement schemes. The remaining changes were considered to be urban creep.

[31] Allitt, M & Tewkesbury, A (2009) Investigations into Urban Creep at 5 Cities
http://www.ciwem.org/media/53157/Autumn2009_Paper_9.pdf

4.2.12 The study found differences in rate of urban creep between cities and also between property types. As might be expected, detached houses were shown to expand by more than twice the amount of semi-detached and three times as much as terraced housing. It was found that the average rates of urban creep were between 0.4 and 1.1 sq m/house/year depending on the city.

4.2.13 To put the rates defined by the 2009 study into perspective for Sefton, based on the number of properties and the different types of property within Sefton (identified from OS Mastermap and the National Receptors Database) and applying the weighted average urban creep values obtained from the 2009 study, the average annual increase in impermeable area as a result of urban creep amounts to 3.8ha.

4.2.14 A similar and more recent study focussed on urban creep in Scotland[32] suggests that solutions should be promoted through legislation, education and incentives. As indicated above, efforts have been made to contribute to a solution by changing permitted development rights for the paving of front gardens, however, it is strongly suggested that for the reasons outlined above Sefton MBC consider a similar approach to other classes of permitted development (e.g. classes A.1 and E.1 in addition to F.1) to minimise the contribution that urban creep has on surface water and sewer flooding in Sefton.

Critical Drainage Area specific measures

4.2.15 The following outlines recommendations for CDA specific measures that should be followed up and investigated at an appropriate time. More information is presented in Appendix E.

Cross-boundary policy in Waddicar, Aintree and Bootle

4.2.16 CDA 07 covers Waddicar and the catchment that drains to the Brooklea watercourse. The upper half of this catchment lies within the Metropolitan Borough of Knowsley. Consequently, implementation of planning policies outlined above will have limited impacts on the risk from surface water flooding here without application to those areas of Kirkby that lie within the CDA.

4.2.17 Sefton MBC's strategic planners should therefore work with their counterparts within Knowsley MBC to deliver integrated planning policy in this area.

4.2.18 Similar cross-boundary issues may exist within small parts of Aintree (CDA 09), and in Bootle (CDA 10). Sefton MBC's strategic planners should therefore work with their counterparts within the District of Liverpool to deliver integrated planning policy in these areas.

Detailed Study of the influence and effect of the Leeds and Liverpool Canal

4.2.19 The Leeds and Liverpool Canal is a potential source of flooding itself and an influence on the flood risk posed from surface water, sewer and groundwater flooding within Lydiate, Maghull, Waddicar, Aintree, Netherton, Litherland, Seaforth and Bootle. Two areas should be investigated further:

1. The consequences of failure of the canal should be investigated. Sefton MBC should assist British Waterways to identify locations at which to undertake analysis of the consequences of canal failure that could then be used to inform both the SWMP and the Knowsley and Sefton SFRA. The analysis should identify the extent, depth, velocity and hazards associated with future canal failure, which can then inform spatial planning as well as emergency planning.

[32] G. B. Wright, S. Arthur, G. Bowles, N. Bastien & D. Unwin. 2011. Urban creep in Scotland: stakeholder perceptions, quantification and cost implications of permeable solutions. *Water and Environment Journal,* Chartered Institute of Water and Environmental Management.

2. The effect that the canal has on surface water flooding during significant storm events with a 1 in 100 chance (1%) or less of occurring in any given year. Modelling undertaken during this SWMP has indicated that the canal receives flood water at various locations and that it can also provide a pathway for flood water to then impact on adjacent locations. Greater detail of the canal infrastructure, such as levels along towpaths, could improve the understanding of where overland flow could enter the canal, how fast, how far and in which direction it transfers this flood water and finally whether there is opportunity for this flood water to overtop the canal embankments and if so where this might take place.

4.2.20 A better understanding of the mechanisms of flooding associated with failure of the canal infrastructure within Sefton, as well as the interaction of the canal and overland flow, would assist British Waterways in understanding and managing flood risk from its assets. It would also improve the assessments made in the SWMP in many of the locations identified above and in particular CDA 01 to CDA 05 and CDA 07 to CDA 10. It may also assist with an understanding of cross-boundary issues, particularly with respect to the section of the canal that passes from Bootle into the District of Liverpool.

Detailed studies of the influence and effect of the railway

4.2.21 Sefton has active railway lines passing through the borough that link Liverpool to stations along the coast to Southport and from Sandhills via Maghull to Ormskirk. There is also an active link between the two that passes north of Orrell and a link from Southport to Wigan. In addition there are a number of routes of former railway lines through Bootle towards Fazakerley and from Southport and Meols Cop Station towards Preston that are now disused.

4.2.22 Modelling undertaken during this SWMP has indicated that the railway receives flood water at various locations and that it can also provide a pathway for flood water to then impact on adjacent locations. Greater detail of the railway infrastructure, and in particular drainage details that might affect the conveyance and storage within the railway could improve the understanding of where overland flow could enter the railway, how fast, how far and in which direction it transfers this flood water and finally whether there is opportunity for this flood water to impact adjacent areas and if so where this might take place.

4.2.23 It is recommended that Sefton MBC work with Merseyrail and Network Rail as stakeholders to obtain any additional information, detailed or otherwise, to provide a better understanding of the mechanisms of flooding associated with railway infrastructure, which will improve the assessments made in the SWMP in many of the locations and in particular CDA 02, CDA 04, CDA 05, CDA 08 to CDA 10, CDA 13, CDA 14, CDA 16 to CDA 18 and CDA 20 to CDA 22.

Appropriate Model Improvements

4.2.24 There are a number of locations within the surface water models where assumptions have been made or where data quality was poor. Examples include gaps in the LiDAR, the crest levels of embankments and the definition of structures for which no information was available.

4.2.25 Consequently, additional or higher quality data in these areas, for example survey data or observations made during site visits could improve the depiction of surface water and sewer flood risk within the SWMP. In some of these areas the Environment Agency may hold information, for example on Whinny Brook in CDA 04 and CDA 05, or on Melling Brook.

4.2.26 The Critical Drainage Areas that this affects include CDA 02, CDA 04, CDA 05, CDA 08, CDA 10 to CDA 14, CDA 17 and CDA 21.

Maintenance – Watercourses, drains, ditches, trash screens

4.2.27 Sefton MBC currently undertakes maintenance on a number of ordinary watercourses and, in some locations, main rivers, to ensure that they function effectively. This typically takes place in Formby, which is particularly sensitive to the effects that vegetation and siltation have.

4.2.28 There are, however, ordinary watercourses elsewhere within the borough, many of which discharge into the surface water sewer network in places such as Lydiate, Maghull, Ainsdale, Birkdale and Southport in which maintenance should be considered, if it is not already.

4.2.29 Similarly, these locations may benefit from the installation of a trash screen to prevent the build up of debris that could enter the sewer system and cause blockages and which might also result in flood water backing up within the watercourse, resulting in flooding.

4.2.30 The Critical Drainage Areas that this affects include CDA 01 and CDA 02, CDA 04 and CDA 05, CDA 16 to CDA 18 and CDA 20 to CDA 21.

Enforcement – maintenance and removal of blockages/restrictions

4.2.31 In a number of locations there are ordinary watercourses and ditches that lie within developed areas and which can sometimes form the boundary between the gardens of two properties. In such locations it is the responsibility of the riparian owner to ensure that there is no impediment to the proper flow of the watercourse.

4.2.32 In any such areas, if the watercourse, ditch or drain has become blocked, filled in or the capacity of the watercourse reduced through inappropriately sized culverts, Sefton MBC should use its powers of enforcement under Section 25 of the Land Drainage Act 1991 if there are local flood risk issues.

4.2.33 There are ordinary watercourses, ditches and drains in situations like this in the Claremont Avenue area (CDA 03), between Glenholm Road and Whinny Brook (CDA 04), on College Avenue and between Park Road and Hoggs Hill Lane in Formby on Formby (CDA 16) and in Norburn Crescent, by Sunningdale Gardens and on Piercefield Road in Formby (CDA 17).

Resilience and Resistance Measures

4.2.34 Table 4-1, below, indicates the proportion of each CDA that is impacted during two key events. All of the existing properties within these areas, which amount to approximately 2,600 in the 1 in 30 (3.3%) chance event and 40,100 in the 1 in 100 (1%) chance event would potentially benefit from the retro fitting of resilience or resistance measures and all new development would potentially benefit from the incorporation of such measures where development is proposed in areas shown to be at risk.

Table 4-1: Proportion of CDA impacted under two key scenarios.

Critical Drainage Area	Percentage of CDA impacted in Q30 event	Percentage of CDA impacted in Q100 event
1	0.3	20.4
2	1.1	20.3
3	0.9	27.7
4	0.4	24.2
5	0.1	21.5
6	2.3	26.1
7	0.3	23.4
8	0.1	23.9

Critical Drainage Area	Percentage of CDA impacted in Q30 event	Percentage of CDA impacted in Q100 event
9	0.2	26.9
10	0.6	18.9
11	1.5	29.2
12	1.5	27.9
13	0.1	33.1
14	1.2	27.5
15	4.6	27.3
16	-	24.6
17	1.7	27.8
18	1.8	31.0
19	2.0	30.3
20	0.3	23.8
21	0.6	29.6
22	2.0	31.7

4.2.35 Given the nature of the flooding mechanisms in much of the Sefton area, there are many areas that would benefit from the installation of measures that increase the resilience of a property to flooding, i.e. they quicken the time of recovery and reduce the damage done in the event of a flood and therefore reduce the cost of the consequences of flooding.

4.2.36 Examples of flood resilience measures might include waterproof plaster on the walls, solid concrete floors rather than wooden floors and electricity circuits raised above the flood level.

4.2.37 Similarly, measures can be installed that increase the resistance of a property to flooding. Resistance measures prevent or reduce the likelihood of ingress of flood water and can include measures such as air brick covers, flood gates for doorways and windows and no-return valves for drainage pipes.

4.2.38 Most buildings that are impacted by flooding to a depth of greater than 100mm may benefit from resistance measures and these are likely to be effective when depths are relatively shallow and potentially up to up to approximately 0.6m[33]. Above this, and inevitably in some cases below this value, flood water is more than likely to ingress through somewhere and flood resilience measures become more appropriate.

4.2.39 Appendix E summarises the locations in which areas may benefit from flood resilience and/or resistance measures and GIS layers identifying areas in which flood depths are a) lower than 0.3m, b) between 0.3m and 0.6m and c) above 0.6m have been provided electronically to Sefton MBC for both the 1 in 30 (3.3%) chance and 1 in 100 (1%) chance flood events.

Engineering Measures – Capacity, Storage, Diversions, Flow Paths

4.2.40 Finally, there are a number of engineering measures, such as increasing the capacity of sewer systems, creation of storage for the attenuation of surface water runoff, diversion of flow paths into areas with fewer consequences of flooding and also the creation of new flow paths that may contribute to a reduction in flood risk in some critical drainage areas.

Flow paths

4.2.41 Modelling undertaken during this SWMP has indicated that there are a large number of areas in which flow or ponding takes place within the road. Although these areas may also be

[33] Communities and Local Government (2007) *Improving the Flood Performance of New Buildings: Flood resilient construction*

associated with wider areas of flooding that impacts many properties, in many places they create extensive linear LFRZs that generally may have isolated properties along the length of the road that appear to be at a marginal flood risk.

4.2.42 An exercise should be undertaken to review such flow paths in key CDAs and in known hotspots to determine whether these properties are at flood risk and if so whether it would be feasible to protect them through simple means, such as raising a dropped curb or raising the level of the pavement in places.

Storage/Attenuation

4.2.43 There are also a number of locations where it would appear to be feasible to investigate the potential for providing attenuation within the upper reaches of a catchment in order to restrict flows into a surface water sewer or to minimise the potential for overland flow. Locations identified as having the potential for storing surface water during times of flood are presented in Appendix E.

4.2.44 Any areas investigated further for storage and attenuation of surface water runoff should consider any opportunities for habitat creation in accordance with the North Merseyside Biodiversity Action Plan.

Diversions

4.2.45 In addition to the storage identified above, it may be feasible to create a diversion channel that collects and/or diverts flood water from its current pathway into areas in which the consequences of flooding are lower.

4.2.46 A specific example is Tithebarne Lane in Melling (CDA 06), where currently surface water runoff collects and flows north eastwards to pond at the junction with School Lane, flooding 10 properties. Analysis of topographical data locally indicates that a diversion could be created to direct runoff eastwards into fields and then into a watercourse that drains southwards towards Brooklea (See Figure E-1, p113).

4.2.47 Another examples includes the connection of the outlet of Dobb's Gutter in Formby, which currently drains through a low capacity (relative to the flows that it receives) piped network to Moss Side and then into Downholland Brook. It may be possible, to create a relief pipe from Watchyard Lane along Mitten Lane to connect to the upper reach of Bull Cop. The open section of Bull Cop starts to the east of Formby Bypass, however, the natural drainage catchment would include the areas to the north of Mitten Lane up to Miss Side and historically there was an open channel as far west as 48 Smithy Green (See Figure E-2, p114).

Relief pathways

4.2.48 There are places in which there is shown to be ponding to significant depths, amongst which there are two locations alongside Rimrose Valley at which there may be potential to create a pathway through the obstruction, thereby reducing the flood risk to people.

4.2.49 The first of these locations is near Nazeby Avenue, in which high topographical levels appear to prevent overland flow from reaching Rimrose Valley, which results in flooding to 29 properties. The second is across the valley in Ford on Ford Lane, where approximately 31 properties could be affected by the Leeds and Liverpool Canal cutting off a flow path (See Figure E-3, p114).

4.2.50 In Nazeby Avenue an existing surface water sewer may prevent the full extent of flooding simulated from being achieved, however, improvement to its capacity could reduce the risk further.

4.2.51 In Ford, an existing combined sewer runs beneath the Canal, however, increasing the capacity of the sewer could increase flood risk elsewhere and/or result in an increase in pollution in the event of a flood. Consequently, other option for removing ponded surface water from this area may need to be explored.

New Flood Defences

4.2.52 Finally, extensive flooding is identified, both in this SWMP and the Environment Agency's Flood Zone maps, in the vicinity of Eight Acre Lane, which runs alongside Wham Dyke.

4.2.53 Flooding here is caused primarily by surface water runoff entering Wham Dyke and the capacity of the culverts beneath the Formby Bypass being lower than the flow required. Flooding extends southwards, inundating many areas in the Hawksworth Drive area, across Southport Road and along Mount House Close towards Moss Side (See Figure E-4, p116)

4.2.54 The source of flooding in this location is primarily from the rural catchment to the north west, however, there are surface water sewers from the northern edge of Formby that also drain here. The watercourses are main rivers and therefore the responsibility of the Environment Agency.

4.2.55 Land use and development control policy can be used to ensure the issue does not increase, as can maintenance of Acre Lane Brook, Eight Acre Lane and Wham Dyke, as well as the culverts beneath Formby Bypass, to ensure that they work effectively. However, there may be an argument for the installation of flood defences along Sixteen Acre Lane and Eight Acre Lane between Deansgate Lane North and the Formby Bypass, to provide protection against ingress of flood water to these properties.

4.2.56 Consideration would need to be given to ensuring that surface water drainage from these areas was not unduly restricted, perhaps by provision of an emergency pumping station, however, in the region of 220 properties could be afforded protection if an option proves workable and cost-effective.

5 Phase 4: Implementation and Review

5.1 Action Plan/Recommendations

5.1.1 A Draft Action Plan is presented in Appendix E. This Draft Action Plan outlines recommendations and actions that should be implemented to ensure that Sefton MBC meet the requirements placed upon them by the FWMA and FRR and which could be implemented in order to reduce the chance and consequences of flooding, to improve the emergency response to flooding and to improve the integration of flood risk management activities across the borough.

5.1.2 Recommendations and actions identified in the plan relate to the following:

1. **Flood and Water Management Act / Flood Risk Regulations** - Duties and actions as required by the FRR and FWMA[34];
2. **Policy Action** - Spatial planning or development control recommendations;
3. **Communication / Partnerships** - Actions to communicate risk internally or externally to LLFA or create / improve flood risk related partnerships;
4. **Financial / Resourcing** - Actions to secure funding internally / externally to support works or additional resources to deliver actions;
5. **Investigation / Feasibility / Design** - Further investigation / feasibility study / design of mitigation; and
6. **Flooding Mitigation Action** - Maintenance or capital works undertaken to mitigate flood risk.

5.1.3 The Draft Action Plan identifies whether an action is borough wide or where it relates to specific CDAs. If an action is more site specific, this is also identified.

5.1.4 The lead organisation responsible for delivery of the action is identified, as are those organisations in a position to provide primary support or who should be considered to be stakeholders.

5.2 Implementation Programme

5.2.1 No firm implementation programme is presented for actions other than those in which the driver is compliance with EU timescales, and in particular those within the EU Floods Directive[13], via implementation of the Flood Risk Regulations. The following therefore is identified in the Draft Action Plan and they are to be repeated every 6 years:

1. Preparation of flood hazard and flood risk maps – 22nd December 2013
2. Preparation of local flood risk management plans – 22nd December 2015
3. First review and update of the Preliminary Flood Risk Appraisal (PFRA) – 22nd December 2017
4. First Review of flood hazard and flood risk maps – 22nd December 2019

[34] Refer to Appendix A of the LGG 'Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management' (February 2011) for minimum requirements

5. First Review of local flood risk management plans – 22nd December 2021

5.2.2 Timescales for the implementation of other actions and recommendations are dependent upon the outcome of further investigation and the availability of funding. Key partners should review these recommendations to identify where they could reasonably implement these actions in their entirety or part.

5.3 Review Timeframe and Responsibilities

5.3.1 Suggested timescales for review of progress on actions is presented within the Draft Action Plan, and it is anticipated that this could be undertaken through the regular Making Space for Water Group meetings held in Sefton and which currently involves all of the key flood risk management partners.

5.3.2 It is the responsibility of Sefton MBC, as LLFA, to review the actions presented within the Action Plan and to seek feedback from the lead organisation responsible for each action on progress made since the last meeting, anticipated progress to the next meeting, key issues encountered and any new actions that have arisen as a result.

5.4 Ongoing Monitoring

5.4.1 The partnership arrangements established as part of the SWMP process (e.g. Sefton MBC (Drainage, Highways, Spatial Planning and Civil Contingencies), EA and United Utilities working in collaboration) should continue beyond the completion of the SWMP in order to discuss and action the implementation of the proposed actions, review opportunities for operational efficiency and to review any legislative changes.

5.4.2 The SWMP Action Plan should be reviewed and updated once every six years as a minimum, but there may be circumstances which might trigger a review and/or an update of the action plan in the interim, for example:

1. Occurrence of a surface water flood event;
2. Additional data or modelling becoming available, which may alter the understanding of risk within the study area;
3. Outcome of investment decisions by partners is different to the preferred option, which may require a revision to the action plan; and
4. Additional (major) development or other changes in the catchment that may affect the surface water flood risk.

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www.environment-agency.gov.uk

Appendix A. Data Review

The following presents details of the review undertaken of each of the data sources obtained as part of this SWMP.

Table A-1 to Table A-4 detail the data provided by Sefton MBC, the Environment Agency, United Utilities and other sources as appropriate. A description is provided and comment is made as to the use of the data, its quality and any particularly useful attributes to the SWMP. Only relevant attributes are presented.

Data quality has been given a score based on Defra's Surface Water Management Plan Technical Guidance[2]. A Score of 1 represents the best possible data and might include for example detailed mapping data or digital topographical data.

A Score of 2 indicates data that has known deficiencies. It is best replaced or updated as soon as possible and includes most records of flooding from all sources and also most asset data, which have known omissions.

A Score of 3 represents data that is at best a gross assumption. It is not invented but has been based on experience or assumptions. This might include how to represent the results of climate modelling on design event rainfall or the precise extents of flooding recorded in historical events.

Finally, a Score of 4 represents a heroic assumption or an educated guess. Model parameters such as roughness for 2D models fall into this category, as would the size of structures based on aerial photography.

Table A-1: Data provided by Sefton MBC

Dataset	Description	Comment	Perceived Data Quality
OS Mastermap	Detailed mapping of every fixed feature, equivalent to 1:1250 scale (2009)	High quality, accurate and relatively recent mapping for the whole borough	1
Boundary data	Ward boundaries	Not used within study	1
Historical flooding records	Records of flooding received by the Drainage team from all sources (2001 to 2010).	Some records missing grid-references and some missing property level information. Occasionally just a street name. Description is often limited but sometimes contains source.	2/3
	Records of the October 1994 Leeds & Liverpool Canal flood	Records from various sources, including photographs of the breach and works to repair. Flood extent is estimated.	2/3
Asset GIS datasets	Highway drainage assets	Identifies highway drains and gully locations within the whole of Sefton	2
	Formby ordinary watercourses	Dataset only covers Formby and only identifies those ordinary watercourses that are maintained by Sefton MBC	2
Environmental Designations	Listed Buildings	Presumed up-to-date and accurate.	1
	Ancient Monuments		1
	Parks & Gardens		1
	Conservation Areas		1
	Registered Parks		1

Dataset	Description	Comment	Perceived Data Quality
Historical OS Mapping	Datasets from 1850, 1893-1894, 1908-1911, 1927-1928 and 1936-1939	Georeferenced (though in places slightly out) and covers most if not all of Sefton. Very useful for identifying the alignment of historical watercourses.	2
Survey of Dobb's Gutter	Surveyed November 2010	Detailed survey in 2D and 3D AutoCAD format of Dobb's Gutter from Freshfield Road to Watchyard Lane.	1
Groundwater Emergence Map	GIS layers used within Knowsley and Sefton SFRA	Groundwater Emergence Maps (GEMs) developed on behalf of Defra by Jacobs. GEMs show those areas in which, in exceptionally wet winters, groundwater levels may be at or near to the ground surface. It is not known to what degree the GEMs covering Sefton have been calibrated.	3
Culvert asset information	Information on culverts and assets within the borough	Information was provided by Sefton MBC with additional information on culvert diameter, invert levels or on general arrangement of assets for 10 locations within the wider borough. Information remains unknown for a further 19 locations, which remain an opportunity to improve the representation of surface water flooding in the SWMP models	2/3
Report on Hard Sea Defences on the Sefton Coast (2007)	Report discussing the need for hard coastal defences on the Sefton Coast focussing on Crosby and Southport.	Not the focus of the SWMP but useful background about the coastal defences and their state of repair in 2007.	n/a
Adapting to Climate Change Assessment of Risks for Sefton (2011)	A draft action plan aimed at identifying actions across many functions of the council in response to the effects of climate change, including flood risk.	Background information on the currently proposed methods for climate change adaptation within Sefton. Many aspects of the SWMP will be able to feed into the adaptation plan by providing a focus for prioritisation of actions to manage flood risk in relation to critical receptors and council funding.	n/a
UKCP09 predictions for the Formby-Southport area (2009)	Report examining the potential magnitude of climate change and sea conditions in the vicinity of Formby and Southport	Relevant information on the scaled-down predictions from the UKCP09 Terrestrial estimates and how they relate to the 25km x 25km grid nearest to Formby ad Southport. The document predicts • Winter precipitation increases of around 20% (may be between 8 and 60%) • Precipitation on the wettest day in winter up by around 15 to 20% for short (6-hour) storm events and unlikely to be more than 30% • Relative sea level very likely to be up between 38 and 45cm from 1990 levels (not including extra potential rises from polar ice sheet loss)	3
Knowsley and Sefton SFRA	Joint Strategic Flood Risk Assessment for	SFRA completed between 2008 and 2009 for the joint boroughs. Information on	n/a

Dataset	Description	Comment	Perceived Data Quality
(2009)	Knowsley MBC and Sefton MBC	surface water flooding is presented, though it is limited, and DG5 register information is based on post-code areas. The data collected and reviewed within the SWMP should be considered to have superseded the information presented here with respect to historical surface water flooding and surface water flood risk.	
Additional GIS datasets	Locations of key receptors within the Borough	Provision of GIS datasets covering Children's Centres, Dental Practices, Fire Stations, GP Practices, Health Centres, Hospitals, Nurseries, Nursing Homes, Police Stations, Preschool Playgroups, Residential Homes and Schools. Data was provided because of omissions or inaccuracies within the Environment Agency's National Receptors Vulnerable to Flooding Database	1
	Location of Rest Centres	Provided by Sefton MBC and reviewed, however, not used on advice of Sefton - *As part of the activation procedure we would contact the centre to request that it prepare to accept people, if at this point we were informed that it was flooded we'd simply select another of the 25 available centres. In light of this I would suggest not having a weighting (delete the column) for rest centres, as we have pre-identified 25 buildings for use a rest centre, but it is possible that we could adapt and use any building at our disposal i.e. any schools, youth centres and, as happened in the floods last year, church halls.*	1
	Traffic Sensitive Routes GIS dataset	GIS layer identifying roads that are sensitive to issues and which cause	1

Table A-2: Data provided by the Environment Agency

Dataset	Description	Comment	Perceived Data Quality
Alt Crossens Catchment Flood Management Plan	Report on flood risk management policy in the Alt Crossens catchments containing Southport, Formby, Maghull and parts of Aintree, Netherton, Thornton and Crosby	Useful background on the wider catchments that are affected with the majority of Sefton and how flood risks are currently managed within them. Also useful information on groundwater and the likely sensitivities to further development, land use change and climate change.	n/a
Mersey Estuary Catchment Flood Management Plan	Report on flood risk management policy covering Bootle and parts of Aintree, Netherton, Litherland, Seaforth and	Useful background on the wider catchments that are affected some of Sefton's coastline and how flood risks are currently managed within them. Also useful information on groundwater and the	n/a

Dataset	Description	Comment	Perceived Data Quality
	Crosby	likely sensitivities to further development, land use change and climate change.	
National Receptors Vulnerable to Flooding Database	Digital dataset providing point data classifying the use of property across the borough into one of 327 fields and one of 66 multi-coloured manual codes for assessing the consequences and damages from flooding	A good dataset providing point data of buildings that identifies the use of the building. Some inconsistency was noted between the buildings attributes within OS Mastermap and also issues noted with lather buildings or clusters of buildings that did not have attributes. Care required if just using NRD as means by which consequences/damages etc are estimated.	2
Topographical data	Light Detection and Ranging (LiDAR) topographical data for the borough collated and merged from two data sources	1m and 2m LiDAR available for much of Sefton, however, small gaps are noted in some areas and there was a significant gap in areas within the Alt catchment and near Maghull. Figure A-1 presents the DTM coverage used within the SWMP	1
GIS Datasets	AStSWF	National dataset	2
	FMfSW	National dataset – better fit with results of SWMP modelling than the AStSWF dataset	2
	AStGWF	Coarse scale (1km^2) identification of the proportion of areas that may be at risk from groundwater flooding. Dataset did not coincide with the GEM dataset and the GEM dataset was used in preference.	3
	FZ Maps	FZ2 and FZ3 maps were made available by Sefton MBC and United Utilities at the start of the project. Review of the EA's website (www.environment-agency.gov.uk) indicates that this dataset is no longer current and therefore mapping has omitted fluvial flood zones and reporting has used website as source of information	2
	Flood Warning Areas	Flood warning information on the Environment Agency's website has been used as the most up-to-date source of information. See www.environment-agency.gov.uk	n/a
	Main Rivers	A good dataset identifying the location and extent of main rivers within Sefton, parts of Knowsley and West Lancashire.	1
	Groundwater monitoring locations and level data	Groundwater monitoring locations and level data for 19 boreholes across Sefton. The data has been briefly reviewed but not used or analysed in detail as part of the assessment of extensively in relation to the risk of groundwater flooding.	1
Lower Mersey and	Study into the Permo-	Report discussed in detail the	n/a

Dataset	Description	Comment	Perceived Data Quality
North Merseyside Water Resources Study: Final Report Volume 1	Triassic Sandstone Aquifer within Merseyside and fluvial and groundwater flooding	hydrogeology of the underlying sandstone aquifer and comments on the nature of it rising as a result of cessation of pumping and its contribution to flow in the River Alt catchment.	

Table A-3: Data provided by United Utilities

Dataset	Description	Comment	Perceived Data Quality
Asset GIS Datasets	Data on the locations of: CSOs, Drainage Area Boundaries, Detention Tanks, Manholes, Pumping Stations, Rising Mains, Sewers and Wastewater Treatment Works	Generally good quality data identifying the location of assets. Sewer and Rising Main attributes include: • Feature Number: A unique asset ID • Feature Code: A short descriptive code • Length • Data Quality • Diameter (X and Y) • Shape • Start and End Depth • Start and End Invert Level • Material Type • Year Laid • Pipe Criticality • Function • Upstream and Downstream Manhole Reference Some of this data is missing, including the invert level, depth and diameter. CSO data includes attributes such as: • Reference • Name • Flow at first spill • Typical number of spills per year • Typical Spill duration (hrs) • Typical Spill Volume (m^3) Detention Tank attributes provide information on volume Manhole attributes provide a reference ID, location data and size/depth information Other data contains attributes identifying the asset and its location	2
Network Model Results	For all networks within Sefton	Link Data and Node Data are provided for the UU network models within Sefton. The models do not contain every pipe within the network and are therefore more strategic in	2

Dataset	Description	Comment	Perceived Data Quality
		nature. Information provided within the Link Data includes: • Asset Ref • Dry Weather Flow (DWF) peak flow • DWF peal velocity • Return Period Capacity of pipe • Peak 3 month flow and velocity • Peak 1 yr flow • Peak 2 yr flow • Peak 5 yr flow • Peak 10 yr flow • Peak 20 yr flow • Peak 30 yr flow • Pipe Full Capacity Information provided within the Node Data includes: • Node Ref • Max flood 1 yr • Max flood 2 yr • Max flood 5 yr • Max flood 10 yr • Max flood 20 yr • Max flood 30 yr • Max Top Water Level (TWL) 1 yr (m AOD) • Max TWL 2 yr • Max TWL 5 yr • Max TWL 10 yr • Max TWL 20 yr • Max TWL 30 yr • Ground Level (m AOD)	
Historical Flooding Records	Sewer Incident Reporting System (SIRS) (1992 to 2008) and Water Incident Reporting System (WIRS) (2008 to 2010) records of historical flooding associated with the sewer systems	Outputs from United Utilities incident recording systems. WIRS contains the following information: • Start Date • Main Cause • Additional Cause • Incident Responsibility • Asset Type • Asset Description • Asset Responsibility • Incident Id • AMS Id • Site Type Description • Property Name • Property Number • Dependent Street • Street • District	2

Dataset	Description	Comment	Perceived Data Quality
		• Town • Post Code; • Northing • Easting • Premise Occupied • Cellar Usage • Cellar Depth Of Flood • Cellar Extent Of Flood • Location Of Flooding SIRS data contains the same fields but in a different order	
DG5 Register	Location/year information on properties currently within United Utilities DG5 register[35] (June 2009)	United Utilities DG5 register was provided, giving the following attributes for the data within it: • Street • Location • Year	2

Table A-4: Obtained from other sources

Source	Dataset	Description	Comment	Perceived Quality
4NW	North West Regional Spatial Strategy Regional Flood Risk Appraisal (October 2008)	Regional flood risk appraisal covering the Sefton area	Report undertaken as an evidence base for the North West Regional Spatial Strategy. Covers all sources of flooding, though the focus is inevitably fluvial/tidal. The document does identify the extent to which surface water flooding is identified as an issue within the region.	n/a
Bluesky Limited	LiDAR Data	Additional LiDAR datasets to fill in gaps within the datasets held by the Environment Agency	Additional LiDAR (28.55 sq. km) at a 1m grid resolution to fill in gaps within the LiDAR data holdings provided by the Environment Agency. Figure A-1 presents the DTM coverage used in the SWMP	1
Infoterra	Photogrammetry data	5m DTM captured from their aerial imagery catalogue	Data used to fill in remaining gaps within LiDAR coverage. Vertical accuracy approximately similar to SAR data. Figure A-1 presents the DTM coverage used in the SWMP	2

[35] Register within the Director General of OFWAT's Report on Issue Number 5. This register, records the number of properties that have been affected by flooding either internally, or externally, and hence is a record of past events. It does not record properties that are considered to be at risk from external or internal flooding and therefore does not identify future flood risk. It also does not record properties that were effected by events in excess of the 1 in 30-year storm or properties affected by sources of flooding other than the sewer system

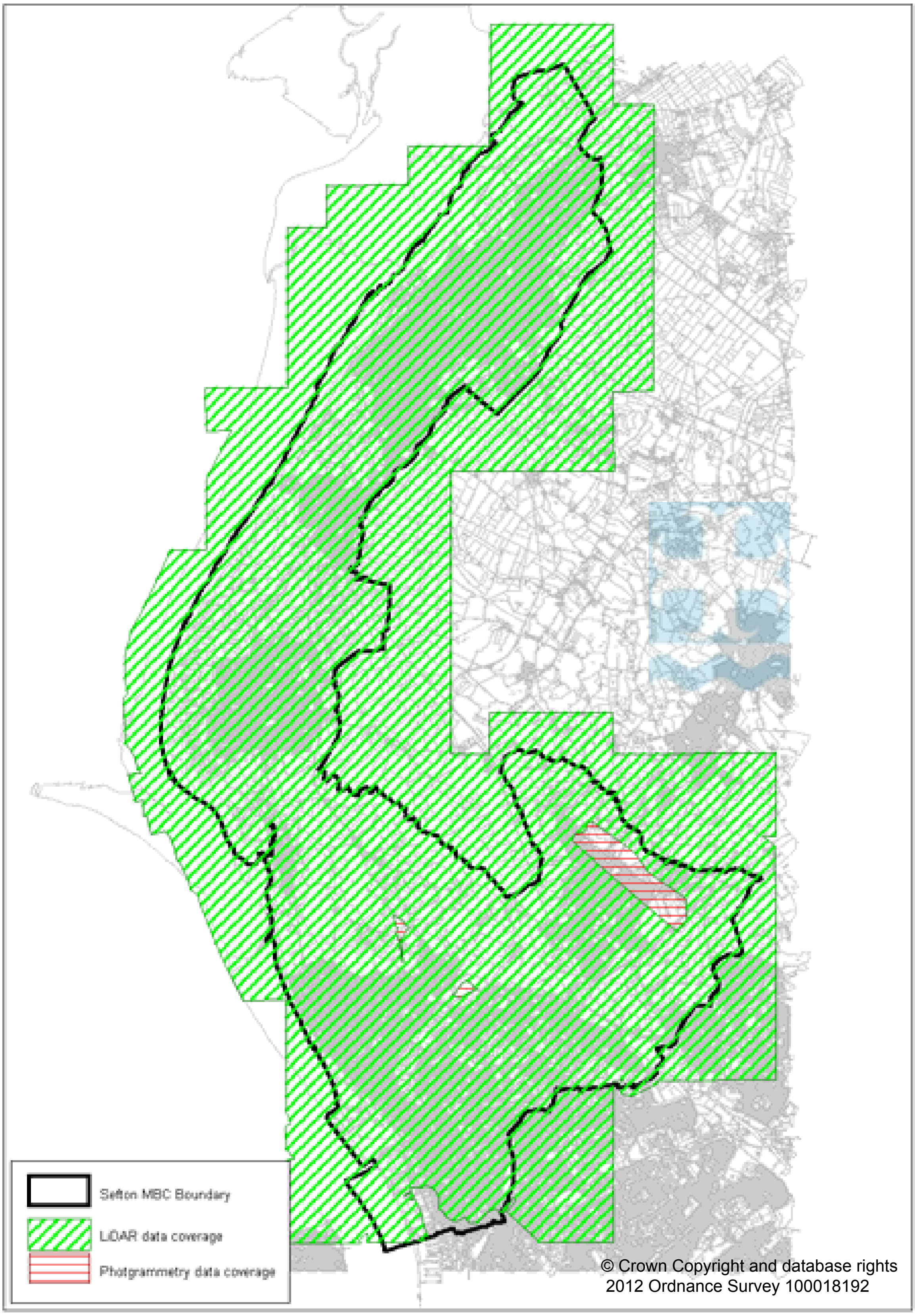

Figure A-1: DTM Coverage within the Sefton SWMP modelling

Appendix B. Asset Register Recommendation

Appendix C. Risk Assessment: Technical Details

Strategic Risk Assessment

The principal method of undertaking the Strategic Assessment (SA) was through a multi-criteria analysis of datasets covering the entire borough that identify potential sources and pathways of flooding. The methodology used is discussed below.

A 500m x 500m grid was used to analyse flood risk data and historical records in order to identifying what sources of flooding were present within each cell.

A 500m grid was considered an appropriate resolution at which to consider various sources of flood risk for the whole of Sefton, as the aim of the SA is to identify broad locations within Sefton that would then become the focus of further analysis. At the start of the SWMP process the available data on surface water flood risks was relatively scarce, therefore, a more detailed grid in the early stages of the study may have omitted important areas.

Using MapInfo GIS software, each 500m x 500m cell was interrogated to identify and count the sources of flooding within it. An attribute column was completed for each cell that identified, using 1 or 0, whether a source was present. Where the data related to the number of watercourses or the number of records of historical flooding within each cell then the count could be higher than 1.

Weightings were applied to each source of flooding within each cell and GIS was used to multiply the count for each source by its weighting. This was then summed to generate an aggregate flood score for each cell.

The flood risk data used in this stage is presented in Table C-1 whilst the weightings applied are presented in Table C-2.

Table C-1: Data used in the Strategic Assessment to represent source of flooding

Dataset	Description	Data Quality
Historical flooding records	Records of flooding received by the Drainage team from all sources (2001 to 2010). Some records missing grid-references	2
Groundwater Emergence Map	GIS layers used from the Knowsley and Sefton SFRA	2/3
GIS Datasets	AStSWF	2
	FZ Maps (FZ2 and FZ3)	2
	Main Rivers	1
Asset GIS Datasets	Manholes (specifically surface water sewer manholes)	2
Rolling Ball Analysis	Flow path analysis of the underlying DTM	2

Table C-2: Strategic Assessment multi-criteria analysis weightings

Dataset	Weighting
Areas Susceptible to Surface Water Flooding (AStSWF) – More Susceptible	2
Areas Susceptible to Surface Water Flooding (AStSWF) – Intermediate Susceptibility	1
Areas Susceptible to Surface Water Flooding (AStSWF) – Less Susceptible	1
Records of flooding incidents reported in the period 2001 – 2010	1.5
Flood Zone 2	0.25
Flood Zone 3	1.5
Groundwater Emergence Map	2
Watercourses	1.5
Surface Water Manholes	1
Outputs from "rolling ball" analysis	2.5

A second stage of the SA considered the infrastructure that could be affected by flooding within the borough. A similar process was undertaken, analysing the number of the different receptors within each cell and applying a weighting to each in order to produce an aggregate infrastructure score.

The weightings applied to receptors used the Flood Risk Vulnerability Classification that is presented in Table D.2 of Planning Policy Statement (PPS) 25 – *Development and Flood Risk*[36] as a guide. The infrastructure identified and the weightings adopted within the SA are presented in Table C-3.

Table C-3: Strategic Assessment infrastructure weightings

Infrastructure Type	Description	Weighting
Essential Infrastructure	Railway Freight Other Strategic Routes Waste Water Treatment Electricity Substation Southport General Hospital Hightown Access Rd	40
Highly Vulnerable	Police Fire Local Distributor Caravan/Travellers site Formby	30
More Vulnerable	Hospitals Schools Prisons Children's Nurseries Care Homes	20
Properties	Standard Residential Residential with Over 65's Residential with 5 or more people Industrial and Commercial	2 3 3 3

The output from the multi-criteria analysis, identifying those areas potentially at greater risk from flooding and those areas in which the infrastructure may be more vulnerable to flooding, are presented in …

[36] DCLG (2010) Planning Policy Statement 25: Development and Flood Risk

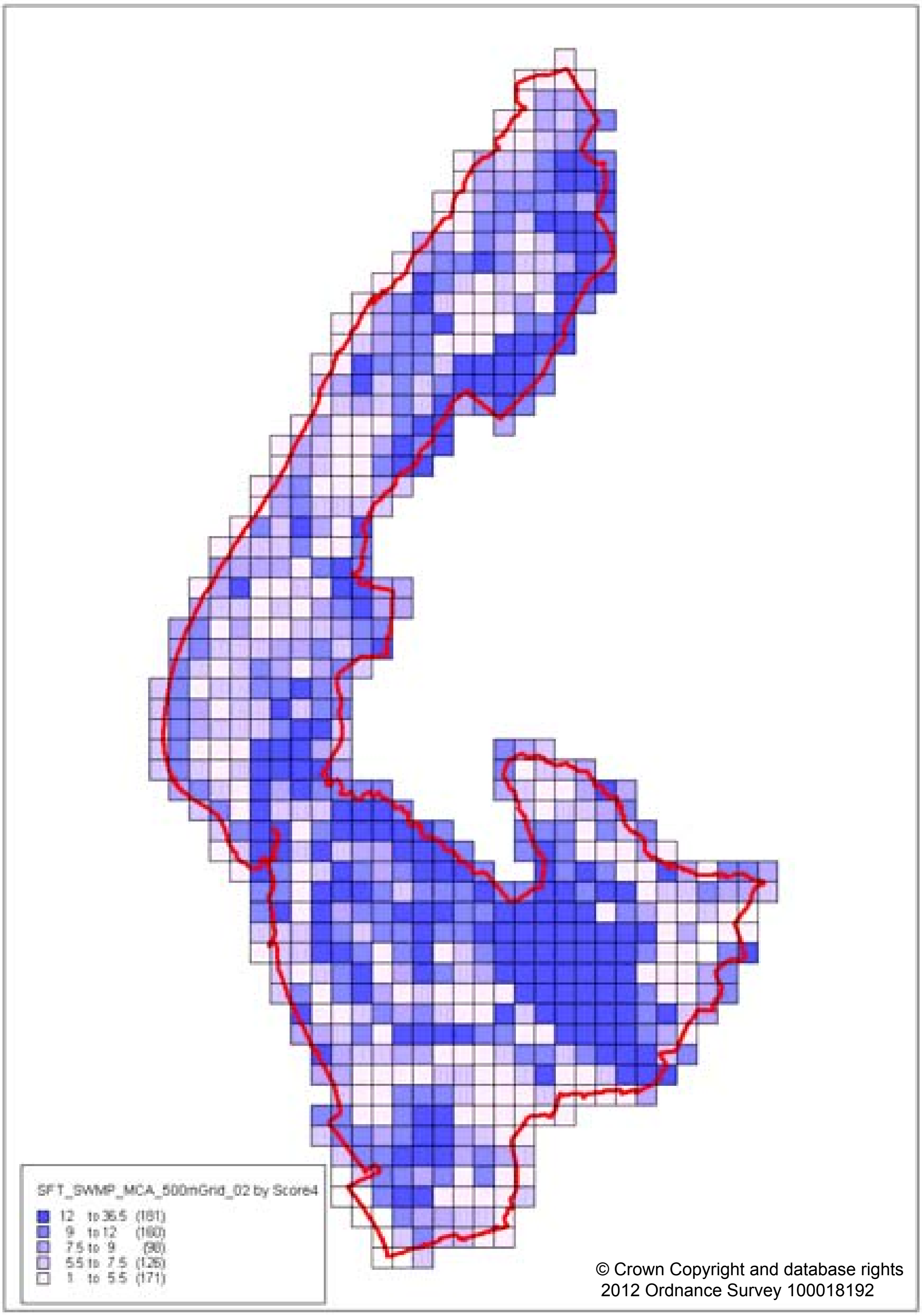

Figure C-1: Thematic map of the aggregate flood scores across the study area

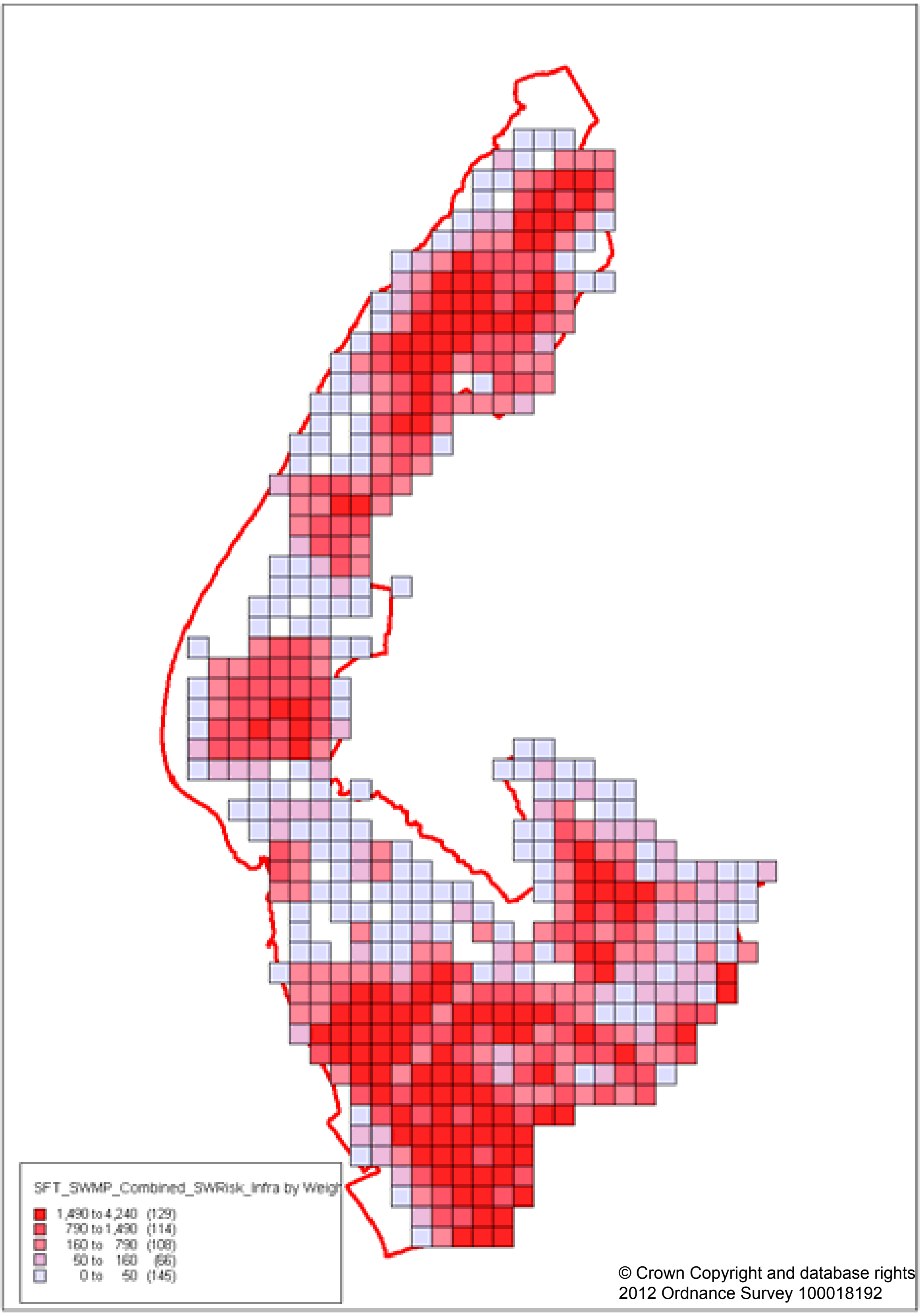

Figure C-2: Thematic map of the aggregate infrastructure scores across the study area

A final stage of the analysis used the results of the first two stages to identify and prioritise the areas for further consideration in a Phase 2 Intermediate Risk Assessment.

Two methods were applied. The first method is a simple multiplication of the aggregate flood score from stage 1, which represents the likelihood of flooding within a cell, by the aggregate infrastructure score, which represents vulnerability and/or consequence. The resulting compound flood risk and vulnerability score is a risk-based score (probability x consequence) in which the higher the score the greater the risk and consequences of flooding. Ranking of the cells by this score provides an effective means of prioritisation.

The second method considers the areas most susceptible to flooding by ranking the aggregate flood score and selecting the top 400 cells only. These 400 cells were then ranked by their aggregate infrastructure score to produce a prioritised list of cells for review.

The compound flood risk and vulnerability score is presented in Figure C-3. The final areas adopted for consideration in the Intermediate Risk Assessment has been developed from a combination of the two methods above it is presented in Figure C-4.

In summary, the final output of the SA identifies those broad areas that are both more susceptible to surface water flooding and vulnerable to surface water flooding. The SA identified 15 assessment zones in which the risk and consequences of surface water flooding indicate that further assessment is required. These 15 zones cover six distinct areas:

1. The Southport area (Crossens, Southport Town Centre, Birkdale, Meols Cop and Hillside);
2. Ainsdale;
3. Formby;
4. Hightown;
5. Crosby, Bootle, Waterloo, Thornton, Litherland, Netherton and Aintree; and
6. Maghull.

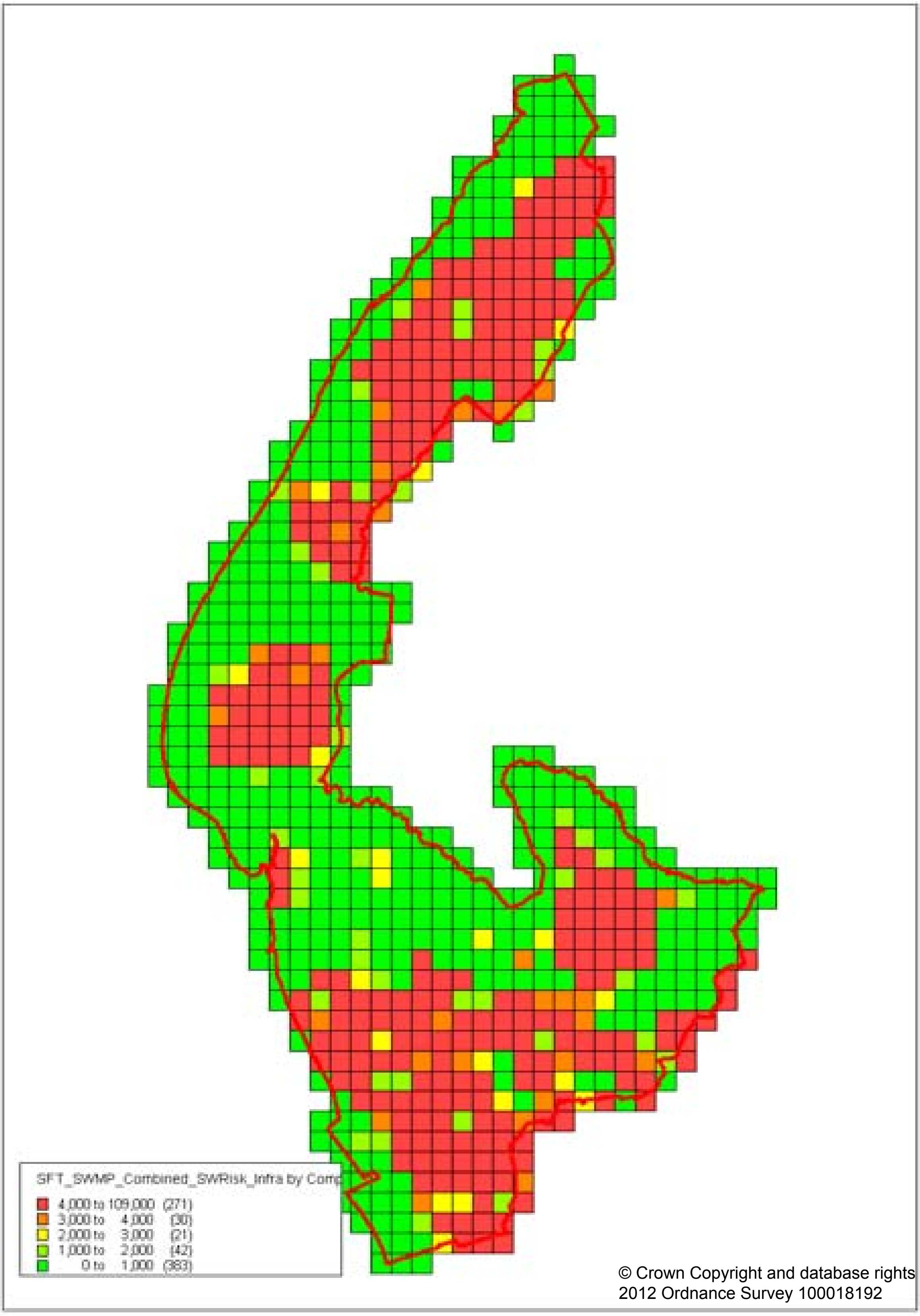

Figure C-3: Thematic map of the compound flood risk and vulnerability score across the study area

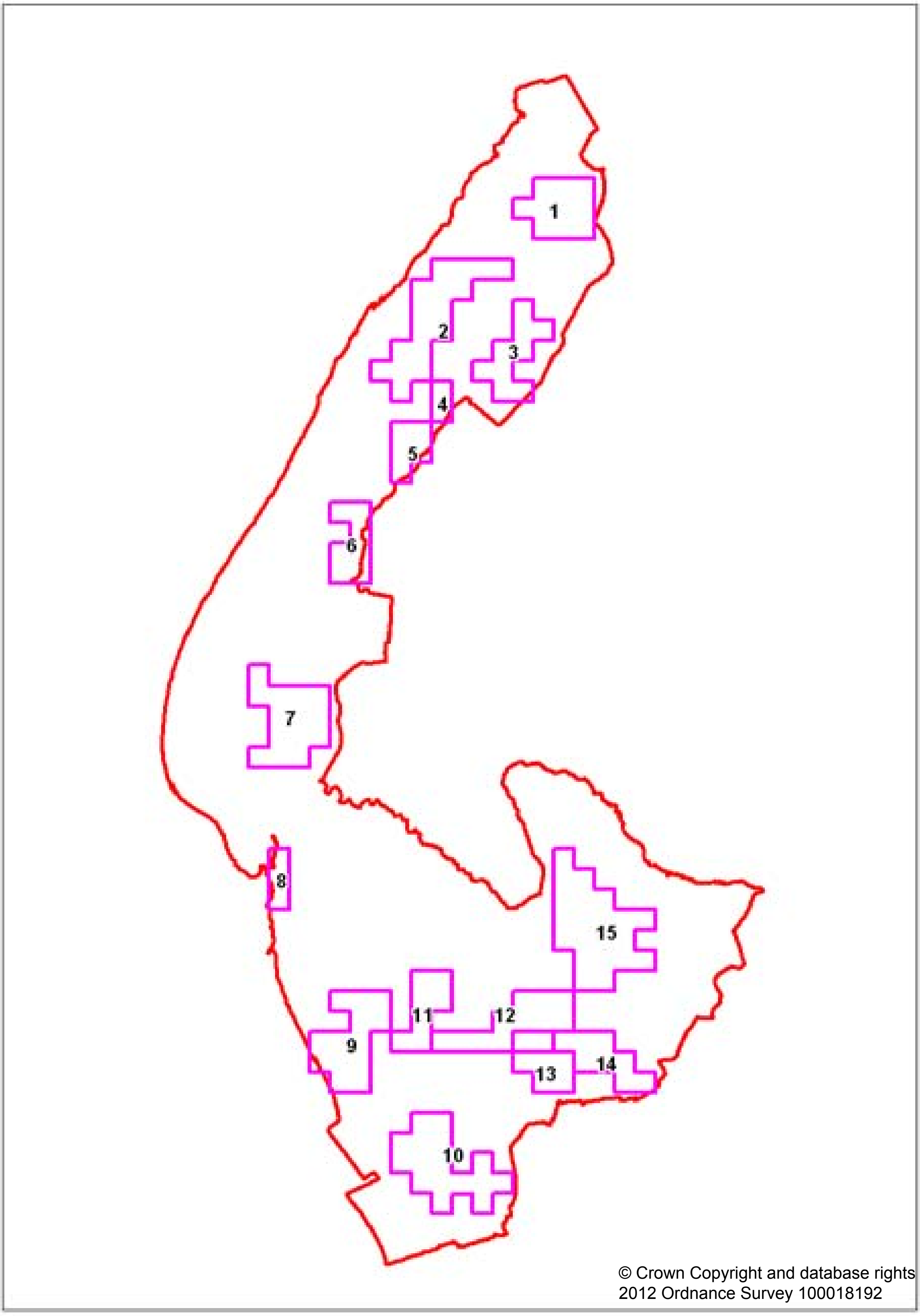

Figure C-4: Phase 2 Strategic Assessment – Zones for assessment in the Intermediate Assessment

Intermediate Risk Assessment

Phase 1: Preparation

In order to undertake more detailed analysis, the 15 zones identified in the Strategic Risk Assessment and in particular available data on the sources and mechanisms of flooding and the potential receptors within them was reviewed in detail. This enabled the extension of these 15 zones, first into catchments that included both the topographical and drainage network that fed these areas and then into model areas which also included down gradient receptors and the ultimate receiving watercourse.

Figure C-5, overleaf, presents the extents of the assessment zones, sub-catchments and the boundaries of the SWMP models developed during the Intermediate Risk Assessment. The data reviewed and used within the Intermediate Assessment is presented in Table C-4, below.

Table C-4: Data used in the Intermediate Assessment

Dataset	Description	Data Quality
OS Mastermap	Detailed mapping of every fixed feature, equivalent to 1:1250 scale	1
Historical flooding records	Records of flooding received by the Drainage team from all sources (2001 to 2010). Some records missing grid-references	2
	Records of the October 1994 Leeds & Liverpool Canal flood	2
Historical OS Mapping	Datasets from 1893-1894, 1908-1911, 1927-1928 and 1936-1939	2
Groundwater Emergence Map	GIS layers used within Knowsley and Sefton SFRA	3
Culvert asset information	Information on some culverts and assets within the borough	2
Additional GIS datasets	Locations of key receptors within the Borough	1
	Location of Rest Centres	1
	Traffic Sensitive Routes GIS dataset	1
National Receptors Vulnerable to Flooding Database	Digital dataset providing point data classifying the use of property across the borough into one of 327 fields and one of 66 multi-coloured manual codes for assessing the consequences and damages from flooding	2
LiDAR data	Light Detection and Ranging (LiDAR) topographical data for the borough collated and merged from two data sources	1
GIS Datasets	FZ Maps	2
	Main Rivers	1
	Groundwater monitoring locations and level data	1
Asset GIS Datasets	Data on the locations of: CSOs, Drainage Area Boundaries, Detention Tanks, Manholes, Pumping Stations, Rising Mains, Sewers and Wastewater Treatment Works	2
Network Model Results	For all networks within Sefton	2
Historical Flooding Records	Sewer Incident Reporting System (SIRS) (1992 to 2008) and Water Incident Reporting System (WIRS) (2008 to 2010) records of historical flooding associated with the sewer systems	2
DG5 Register	Location/year information on properties currently within United Utilities DG5 register (June 2009)	2
LiDAR Data	Additional LiDAR datasets to fill in gaps within the datasets held by the Environment Agency	1
Photogrammetry data	5m DTM captured from their aerial imagery catalogue	2

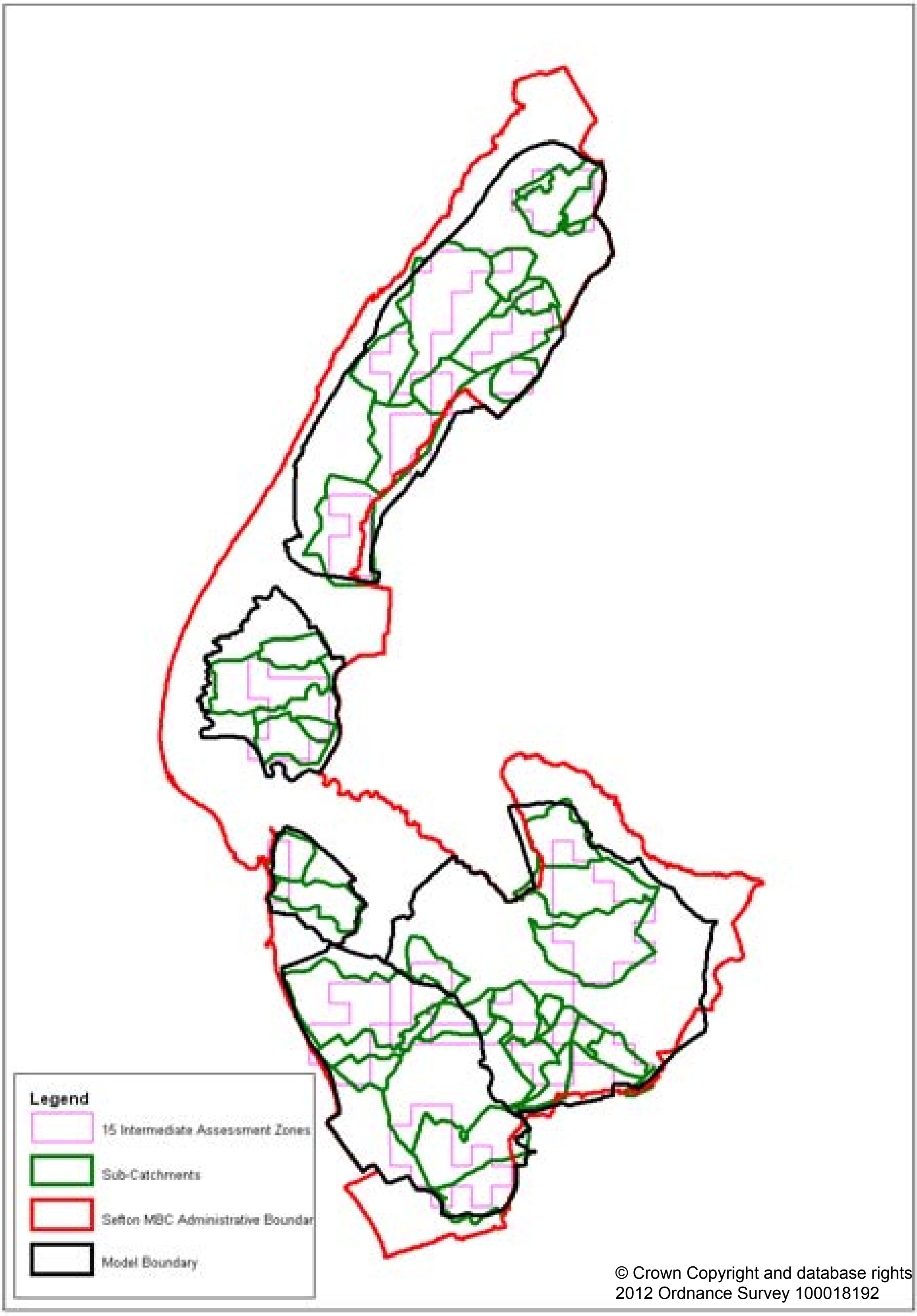

Figure C-5: Assessment zones, sub-catchments and model boundaries

Phase 2: Modelling

The Sefton SWMP modelling method was designed to analyse the impact of heavy rainfall events across the Borough by assessing flow paths, velocities and catchment response. In order to do this both routing of flood volumes and a direct rainfall approach were adopted.

Flood volumes from United Utilities' sewer network models was routed onto a digital terrain model at the location of the manholes for which the model outputs are recorded. In particular the Max_Flood_5_yr and Max_Flood_30_yr volumes from United Utilities Node_Data GIS layer was applied. The following key assumptions were made to generate the model input:

- Initial Loss – None
- Infiltration Loss – None
- Duration over which the flood volume discharges – 1.5 hours

The direct rainfall method incorporates conservative allowances for the drainage network and infiltration. The following key assumptions were made to generate the model input:

- Initial Loss – None
- Infiltration Loss – None
- Allowance for Drainage System – A constant value of 6.5mm/hr was applied
- No aerial reduction factor applied
- 'Summer' profile was used
- Storm duration – 1.1 hours

Rainfall inputs for a storm with a 1 in 100 chance (1%) of occurring in any given year were generated at a standard 10km grid square resolution across Sefton and then averaged to give an average rainfall depth of 46.3mm.

Total rainfall depths at each 10km grid centroid for all required return periods were extracted from the FEH CD-ROM (v3) Depth Duration Frequency (DDF) model. A comparison between the peak rainfall depths in adjacent 10km grid squares was completed to confirm the suitability of the 10km grid resolution for modelling purposes. The difference in total rainfall depths between the grid centroids was less than 5% which suggests that the data is suitable for use in the study.

A rainfall hyetograph was generated using an ISIS ReFH boundary unit. The effects of climate change on this event were incorporated by multiplying each node of the hyetograph by 30%.

Runoff coefficients for varying surfaces were not applied. The aim of the study was to present conservative results and to not overly complicate the modelling or allow too much subjectivity. It is, however, recommended that runoff coefficients be developed in the event that the modelling is refined for detailed assessments or for when the SWMP is updated.

Critical duration is a complex issue when modelling large areas for surface water flood risk. The critical duration can change rapidly even within a small area, due to the topography, land use, size of the upstream catchment and nature of the drainage systems. The ideal approach would be to model a wide range of durations. However, this is not always practical or economic when modelling large areas using 2D models that have long simulation times – such as within the Sefton study.

The Steering Group felt it appropriate to adopt a duration of 1.1 hours, which matches the duration adopted for the latest national surface water modelling product of the Environment Agency, the Flood Map for Surface Water (FMfSW).

As identified in Appendix A and presented in Figure A-1, the DTM used to create the models was a composite of two different sources of LiDAR data at resolutions of 1m and 2m respectively, with data gaps filled in using a 5m resolution DTM created from Photogrammetry data.

As a result of this, and also in response to small pockets of inconsistent elevations within the LiDAR, a number of DTM fixes were made where the data was patched by interpolating from surrounding points in the DTM.

In addition, flow paths to represent structures that are not represented within the DTM were also added. These were typically created by applying a z-patch or a z-line, which modified the underlying elevations of the dtm in the cells beneath so that it represents the invert level or crest level of the structure. The information used to apply these changes came either directly from data provided by Sefton MBC or it was estimated using aerial photography and measurements taken from LiDAR and OS Mastermap data. These patches and fixes are relatively limited but they represent an opportunity to improve the models in some locations. The locations of these fixes are presented in Figure C-6, overleaf.

Outputs

The modelling outputs, as can be seen in Appendix D, presented a significant number of areas where there is either ponding or a flow path for the more extreme events. In order to make some sense of these and to use the modelling outputs to assist in the definition of Local Flood Risk Zones (LFRZs), Critical Drainage Areas (CDAs) and Policy Areas (PAs), the depth results for the 1 in 100 chance (1%) event were converted from a depth grid into a contour that identified all areas in which the depth of flooding was greater than 80mm. This value was agreed by the Steering Group to represent a reasonable cut off that was typically lower than the entrance to most properties[37].

These flood extents, of which there were greater that 100,000, were filtered to identify those greater than 5m^2, which is consistent with the Environment Agency's Strategic Flood Risk Mapping specification. This process left approximately 73,000 areas identified as potential LFRZs. A further process of filtering was undertaken to select only those flood extents in which a building was inundated, either completely or partially, and where the building was classified within the National Receptors Database as either a home, a business or as infrastructure.

Combining those attributes of the OS Mastermap dataset that represented buildings with the NRD enabled only those buildings that were considered as vulnerable to be selected. This then enabled only those flood extents that intersected or contained entirely one or more of those buildings to be selected and recorded as a LFRZ. In total, there are 16,853 LFRZs identified across the study area that matched this criteria.

The created LFRZ dataset has been reviewed further and was used for further analysis to identify those LFRZs in which more than 8 properties were impacted, which is the local threshold for a significant local flood event, of which there are in the region of 265, and it has been used to identify those areas in which may benefit from flood resilience and resistance measures by identifying the maximum depth of flooding within each LFRZ.

Critical Drainage Areas (CDAs) have been defined by reviewing these key 265 LFRZs and identifying the catchment areas in which they lie and which drain to them. Where feasible, a number of key LFRZs have been considered together, either by virtue of the fact that they flow into each other or by the fact that they lie within the same catchment and drain to the same outlet.

In total 22 CDAs have been defined and these are presented in the following pages. These CDAs have been used to identify potential measures for inclusion in the Draft Action Plan and it is envisaged that they will form the basis of future planning policy and decisions.

[37] Part C of the Building Regulations – Site Preparation and Resistance to Contaminants and Moisture (DTLR, 2004) – contains guidance that elevates floor levels within buildings above the external ground.

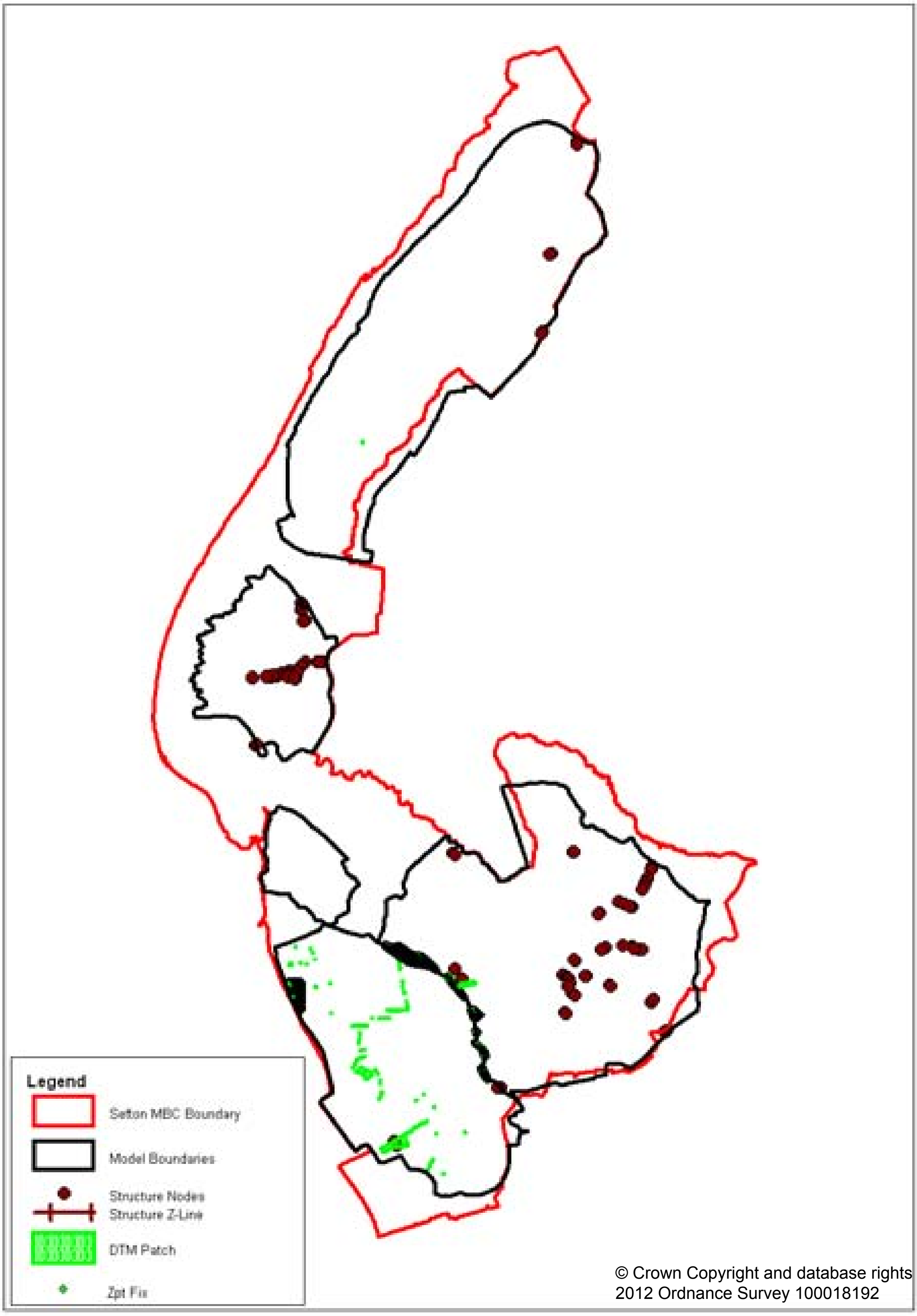

Figure C-6: DTM fixes for structures or inconsistencies within the Sefton SWMP models

Critical Drainage Areas

The following table presents a summary of Critical Drainage Areas (CDAs) that have been defined by this SWMP. A description of each CDA is presented in the following pages.

Table C-5: Summary of Critical Drainage Areas

Critical Drainage Area	Area (km^2	Catchment	Receiving Watercourse/ Water body	Influences
1	0.44	Alt	Rigby's Brook	SW, S, OW, C
2	2.39	Alt	Maghull Brook	SW, S, OW, C
3	1.19	Alt	Upland Drain	SW, S, OW, C, GW, FZ3
4	2.76	Alt	Whinny Brook	SW, S, OW, C, GW, FZ3
5	1.38	Alt	Melling Brook	SW, S, OW, C
6	0.04	Alt	Melling Brook	SW
7	0.53	Alt	Brooklea	SW, S, OW, C
8	1.60	Alt	River Alt, Moor Hey Tributary, Netherton Brook	SW, S, C, GW
9	1.98	Alt	Leeds and Liverpool Canal, Moor Hey Tributary, Netherton Brook	SW, S, C
10	15.18	Mersey Estuary	Rimrose Brook, Docks	SW, S, OW, C, GW
11	0.78	Alt	Hunts Brook	SW, S
12	0.60	Alt	Farmoss Pool	SW, S, OW
13	3.86	Alt	Farmoss Pool	SW, S, OW, GW
14	2.17	Mersey Estuary	Coast	SW, S
15	0.18	Alt	River Alt	SW
16	1.95	Alt	Hoggshill Lane	SW, S, OW, FZ3
17	8.13	Alt	Wham Dyke, Acre Lane Brook, Eight Acre Lane, Moss Side, Bull Cop, Boundary Brook, Downholland Brook	SW, S, OW, GW, FZ3
18	2.86	Alt	Sandy Brook	SW, S, OW, GW, FZ3
19	0.19	Ribble Estuary	Coast	SW, S
20	2.18	Crossens	Fine Jane's Brook	SW, S, OW, GW
21	12.39	Crossens	Fine Jane's Brook, Captains Watercourse, Three Pools Waterway, Crossens Marsh Drain, Marshside Drain	SW, S, OW, GW, FZ3
22	4.69	Ribble Estuary	Coast	SW, S, GW

Critical Drainage Area 01

Critical Drainage Area (CDA) 01 is located in Lydiate and it covers the catchment area that would naturally drain to Altcar Lane Brook via Rigby's Brook and an ordinary watercourse to the north.

The drainage network within the CDA consists of a separate surface water drainage system that discharges to Rigby's Brook and the ordinary watercourse to the north. A small section of ordinary watercourse to the north east discharges into the sewer network whilst a section of surface water sewer in the south of the CDA discharges southwards into CDA 02.

Sources of flooding include surface water and sewer flooding, which is indicated by the presence of DG5 properties within the CDA.

Local Flood Risk Zones (LFRZs) are shown in the north of the CDA following the natural pathway of an ordinary watercourse that is now predominantly part of the surface water sewer network. Ponding is seen upstream (east) of Sandy Lane and then in an area between Moss Lane and Weld Blundell Avenue. Ponding is also seen on the upside of the Leeds and Liverpool Canal in the Silverstone Grove/Pilling Lane area.

Deep flooding elsewhere in the CDA is also located on the upside of the Leeds and Liverpool Canal in the Silverstone Grove/Mallory Avenue area. This corresponds with records of flooding held by United Utilities in December 1993.

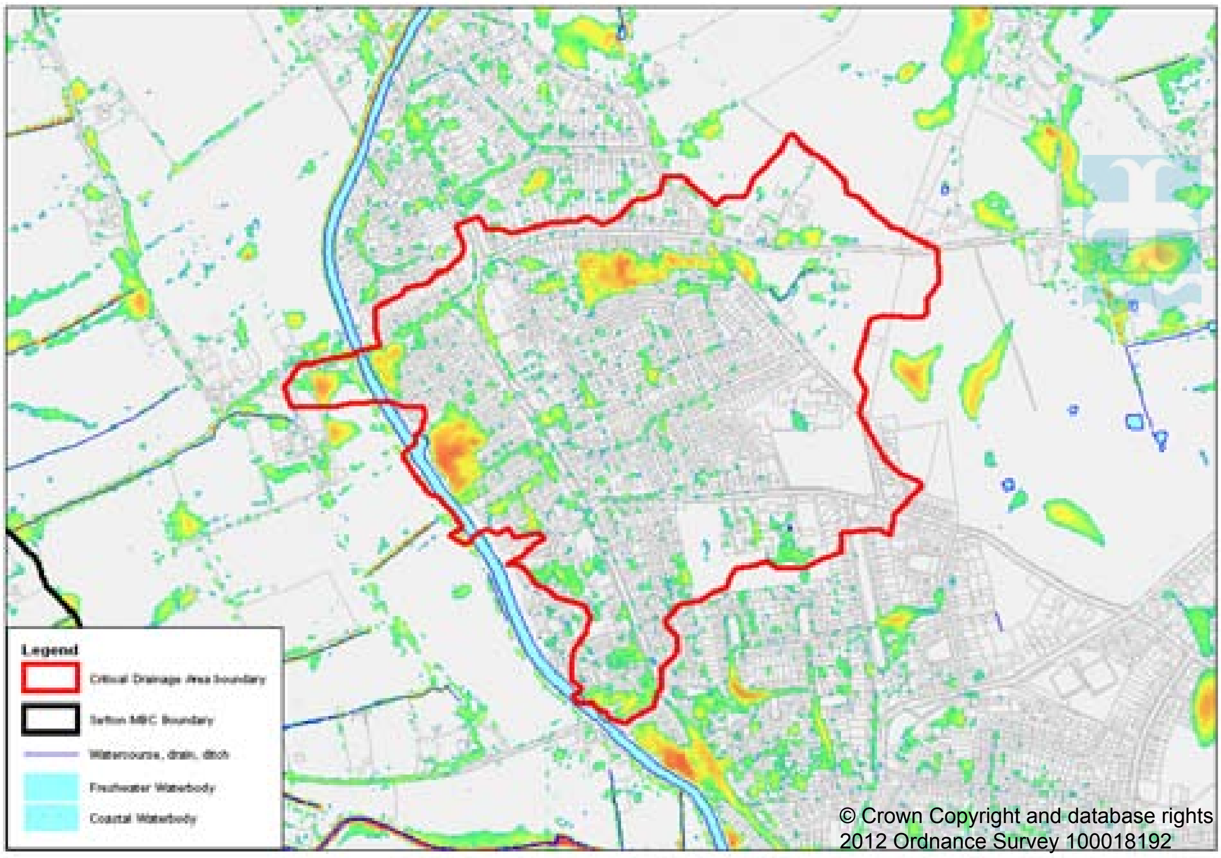

Figure C-7: Critical Drainage Area 01 – Lydiate: Rigby's Brook

Critical Drainage Area 02

CDA 02 is located in Maghull and it covers the catchment area upstream of the Leeds and Liverpool Canal that would have once naturally drained the Maghull Brook.

The drainage network within the CDA consists of a separate surface water drainage system that discharges to the main river sections of Maghull Brook. A small section of surface water sewer in CDA 01 to the north of the CDA discharges southwards into this CDA.

Sources of flooding include surface water and sewer flooding, which is indicated by the presence of DG5 properties within the CDA.

LFRZs are shown to the east of Kenyons Lane, which is where a tributary of Maghull Brook enters the surface water drainage system. Following this downstream, a second LFRZ is defined in the playing fields of Northway Primary School. To the west of Northway, LFRZs continue to follow the path of United Utilities surface water drainage system. An extensive LFRZ is defined between Oakhill Road and Wynstay Avenue, across Clent Avenue to an area of deep flooding centred on Hickson Avenue, which is located on the upstream side of the Leeds and Liverpool Canal and which was the worst hit area from the 1994 canal breach.

Elsewhere within the CDA, LFRZs are defined along other tributaries of Maghull Brook, covering properties between Mersey Avenue and Moss Lane, properties between Moss Lane and Kendal Drive and then along and around Ravenglass Avenue and across Northway to Dodd's Lane. There are also properties impacted along Tensing Road. Deep Flooding elsewhere in the CDA is also located on the upside of the Leeds and Liverpool Canal in the Highbanks area. Many of these LFRZ correspond with records of flooding held by Sefton MBC and United Utilities.

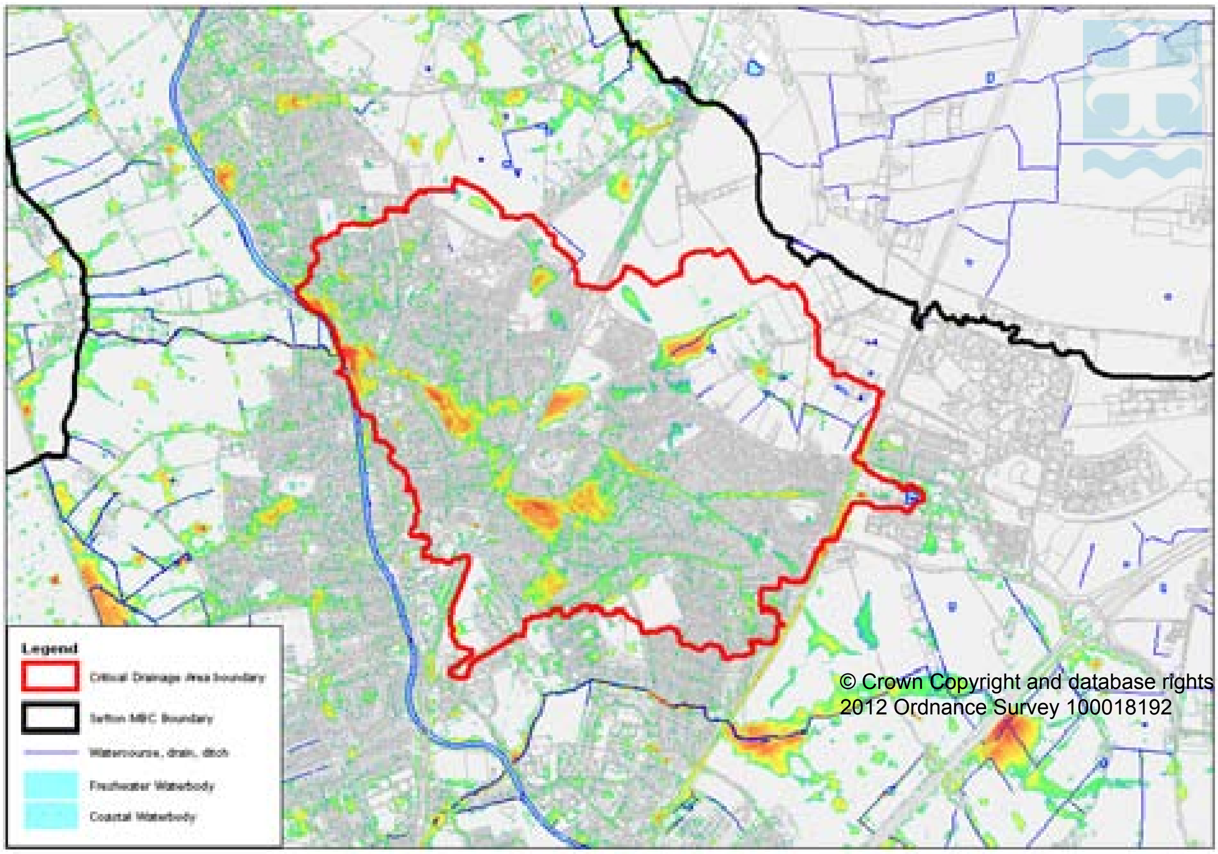

Figure C-8: Critical Drainage Area 02 – Maghull: Maghull Brook

Critical Drainage Area 03

CDA 03 is located in Maghull and it covers a number of small sub catchments that are generally downstream of the Leeds and Liverpool Canal that would have once naturally drained to the Upland Drain (a tributary of Maghull Brook), which lies immediately east of Dover's Brook.

The drainage network within the CDA consists of a series of three separate surface water drainage systems that discharge to ordinary watercourses that then discharge to the Upland Drain.

Sources of flooding include surface water and sewer flooding, which is indicated by the presence of DG5 properties within the CDA. Almost the entire CDA lies within an area at risk of groundwater emergence and the south western area, by Sefton Lane and Old Racecourse Road lies within fluvial Flood Zone 3 that is afforded protection by flood defences.

In the northern of the sub-catchments, a LFRZ is defined between The Round Meade, across West Meade, Airegate and The Thorns to Green Lane. A second LFRZ is identified from Manor House Close, running westwards across Green lane and down Hynchley Green to South Meade. These LFRZs have records of flooding from both United Utilities and Sefton MBC.

In the central sub-catchment, a LFRZ is defined on the eastern side of Liverpool Road South in an arc between that road and Buckingham Road.

In the southern sub-catchment, which includes Claremont Avenue, Rosslyn Road and Gainsborough Avenue, a series of LFRZs are defined within gardens all leading to an extensive LFRZ covering all of the Old Racecourse Road and many businesses and properties in the Sefton Lane Industrial Estate. There are many records of flooding in this area from both UU and Sefton MBC.

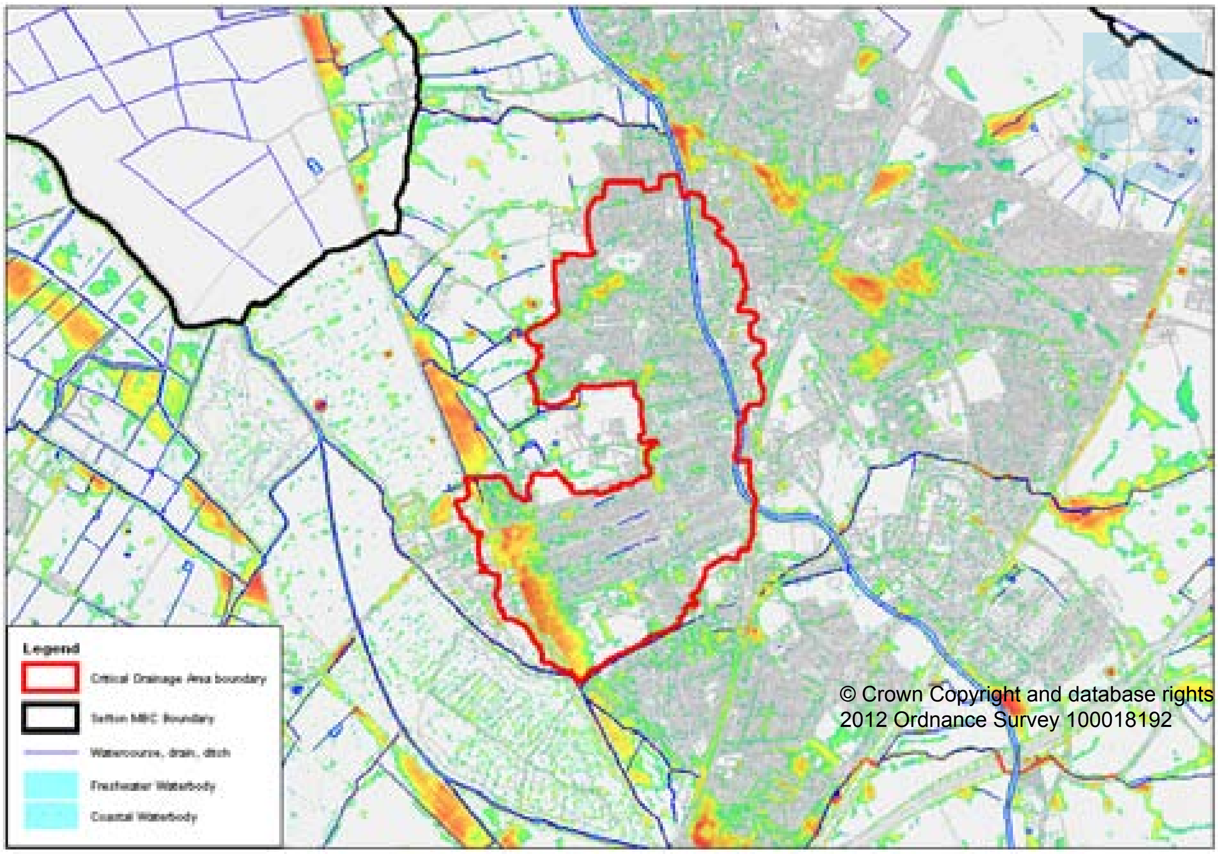

Figure C-9: Critical Drainage Area 03 – Maghull: Upland Drain

Critical Drainage Area 04

CDA 04 is located in Maghull and it covers the natural drainage catchment of Whinny Brook, which is a main river. Approximately 35% of the CDA is arable, whilst the remainder consists of the south eastern edge of Maghull. The CDA is truncated along the M58 in the east, as there is insufficient information about the capacity of the culvert beneath the motorway here to ascertain the influence of the small area to the east of the motorway that appears to drain beneath it into the watercourse. The topography in this area indicates that if the capacity of the culvert is minimal then flow would pass southwards towards Melling Brook.

The drainage network within the CDA consists of a separate surface water drainage system that discharges primarily to Whinny Brook as it passes through the area. The exceptions are a small area to the south of the Leeds and Liverpool Canal that discharges southwards into Melling Brook and areas in the south west of the catchment that discharges to Dover's Brook.

Sources of flooding include surface water and sewer flooding. Almost the entire CDA that lies to the west of the canal lies within an area at risk of groundwater emergence and areas bordering Dover's Brook and Melling Brook in the south western corner of the CDA are at risk from fluvial flooding.

The pathway of Whinny Brook forms a clear LFRZ that extends from the headwaters of the catchment down to where it meets Dover's Brook. Away from the watercourse there are LFRZs defined between Broadoak Road and Farmdale Drive, affecting properties between Station Road and the canal, affecting a large number of properties between Northway and Woodend Avenue, properties either side of Fouracres and The Crescent, and a significant number of properties between Melling Brook in the south and Hudson primary School off Moorhey Road.

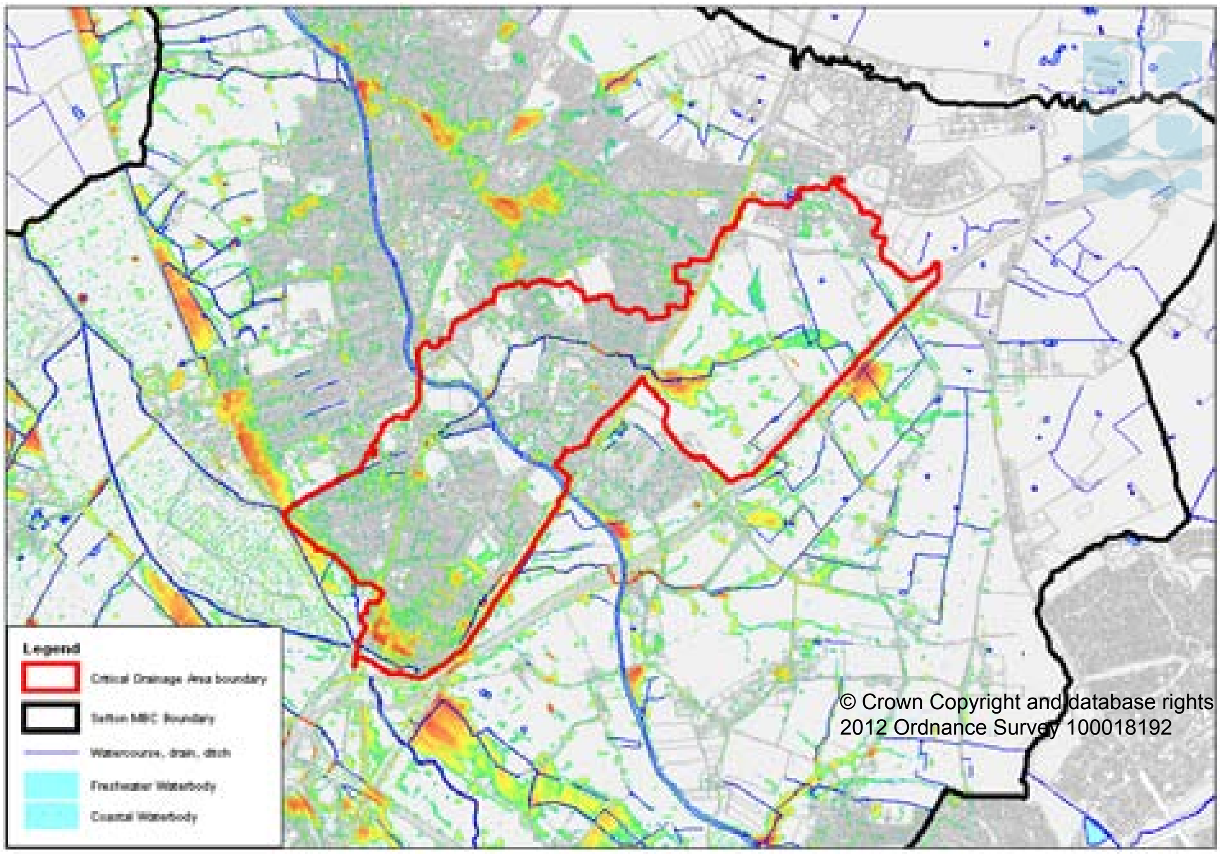

Figure C-10: Critical Drainage Area 04 – Maghull: Whinny Brook

Critical Drainage Area 05

CDA 05 is the predominantly rural catchment that drains via a network of ordinary watercourses, drains and ditches to Melling Brook, a main river to the south and east of Whinny Brook. As indicated above for CDA 04, there is probably some overlap with CDA 04 where land in the north could drain to either Whinny Brook, Melling Brook or both, depending upon the rate of flow and the capacity of culverts.

The drainage network within the CDA consists of a separate surface water drainage system that discharges primarily to Melling Brook.

Sources of flooding include surface water and sewer flooding. The CDA lies outside of the area at risk of groundwater emergence away from areas that have been defined as being at risk from fluvial flooding by the Environment Agency. It is highly likely however that there is a fluvial flood risk associated with Melling Brook but that it is not mapped by the Environment Agency by virtue of the catchment being smaller than 3km^2.

With the exception of flooding in arable fields in the headwaters, there is a key single LFRZ that is located between the Leeds and Liverpool Canal and Willow Hey. The deepest areas of this LFRA are in undeveloped areas. There are a number of historical records of flooding, from both United Utilities and Sefton MBC, that are located within and upstream of this LFRZ.

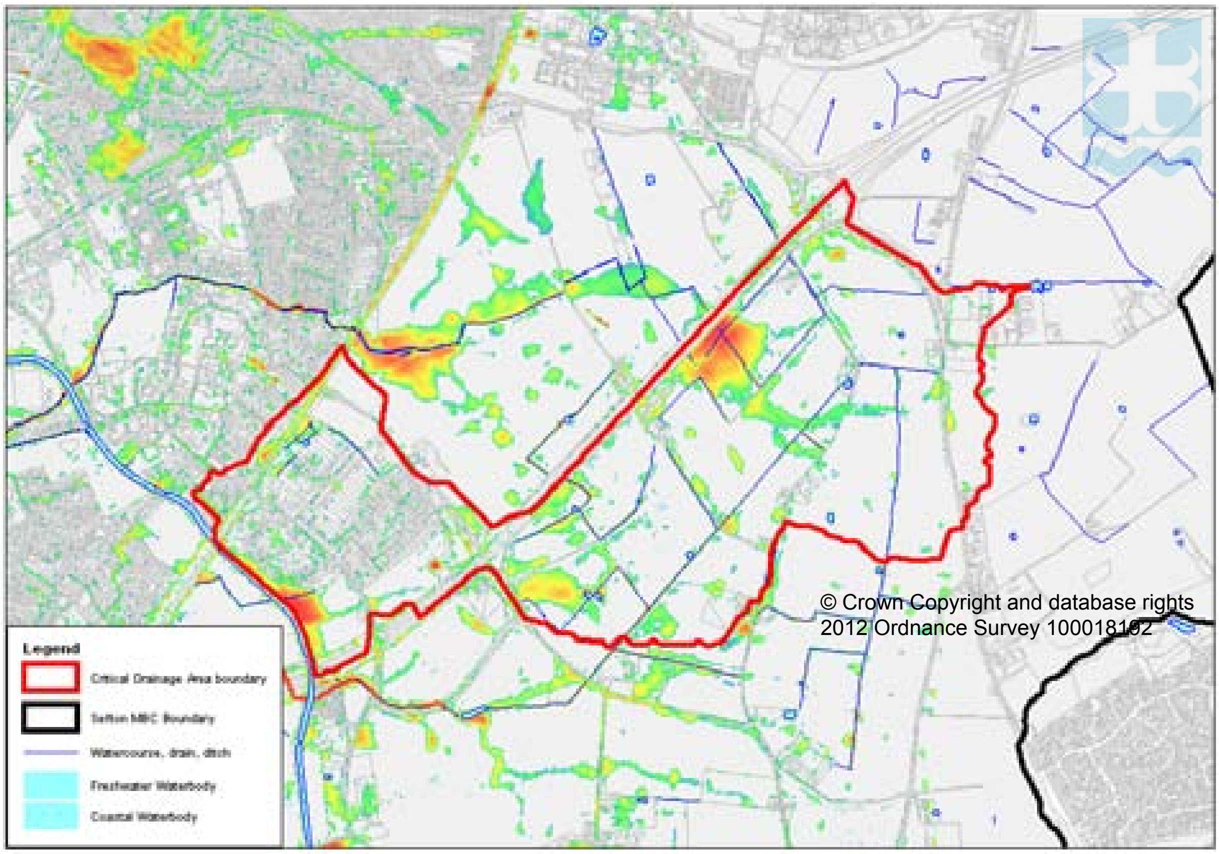

Figure C-11: Critical Drainage Area 05 – Maghull: Melling Brook

Critical Drainage Area 06

CDA 06 is a small catchment that covers the settlement of Melling to the south east of Maghull and which drains north westwards to eventually discharge to Melling Brook.

The drainage network within the CDA consists of a foul sewer only, indicating that there is no formal surface water drainage system.

Sources of flooding are limited to surface water flooding. The CDA contains records from both United Utilities and Sefton MBC of flooding in 1995 and 2010 respectively.

A single LFRZ is defined, containing the source, pathway and receptor of flooding in this village. Flow comes from a small rise in the south west and then flows northwestwards along Tithebarn Lane to pond and impact 7 properties at the junction of Tithebarn lane and School Lane.

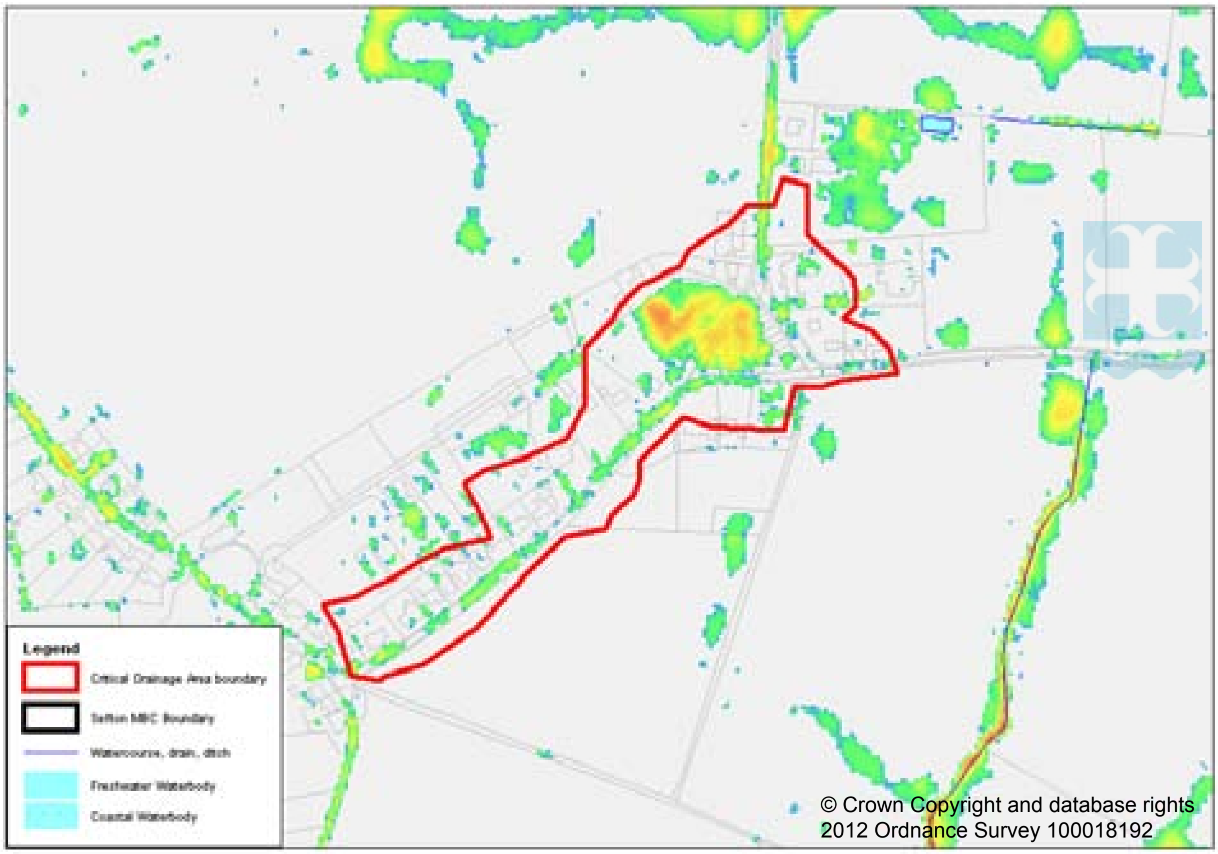

Figure C-12: Critical Drainage Area 06 – Melling: Melling Brook

Critical Drainage Area 07

CDA 07 is a small catchment that covers the settlement of Waddicar in the south east of Sefton. The catchment extends into Kirkby Park, in the borough of Knowsley.

The drainage network within the CDA consists of two separate surface water sewer systems that drain to Brooklea in the north and to an ordinary watercourse along the south eastern boundary that ultimately discharges to Melling Watercourse or directly to the River Alt

Sources of flooding include surface water and sewer flooding. The CDA contains records from both United Utilities and Sefton MBC of flooding between 1993 and 2010.

Numerous LFRZ are identified, including around the junction of Waddicar Lane and Liddell Avenue, across Station Road, Chestnut Walk, Baytree Grove, Dapple Heath Avenue and around Satinwood Crescent and Cypress Close. These seem to be both on natural flow paths, as these are also on the line of UU's sewer networks, but also relatively low lying, hence the extensive flood risk zones.

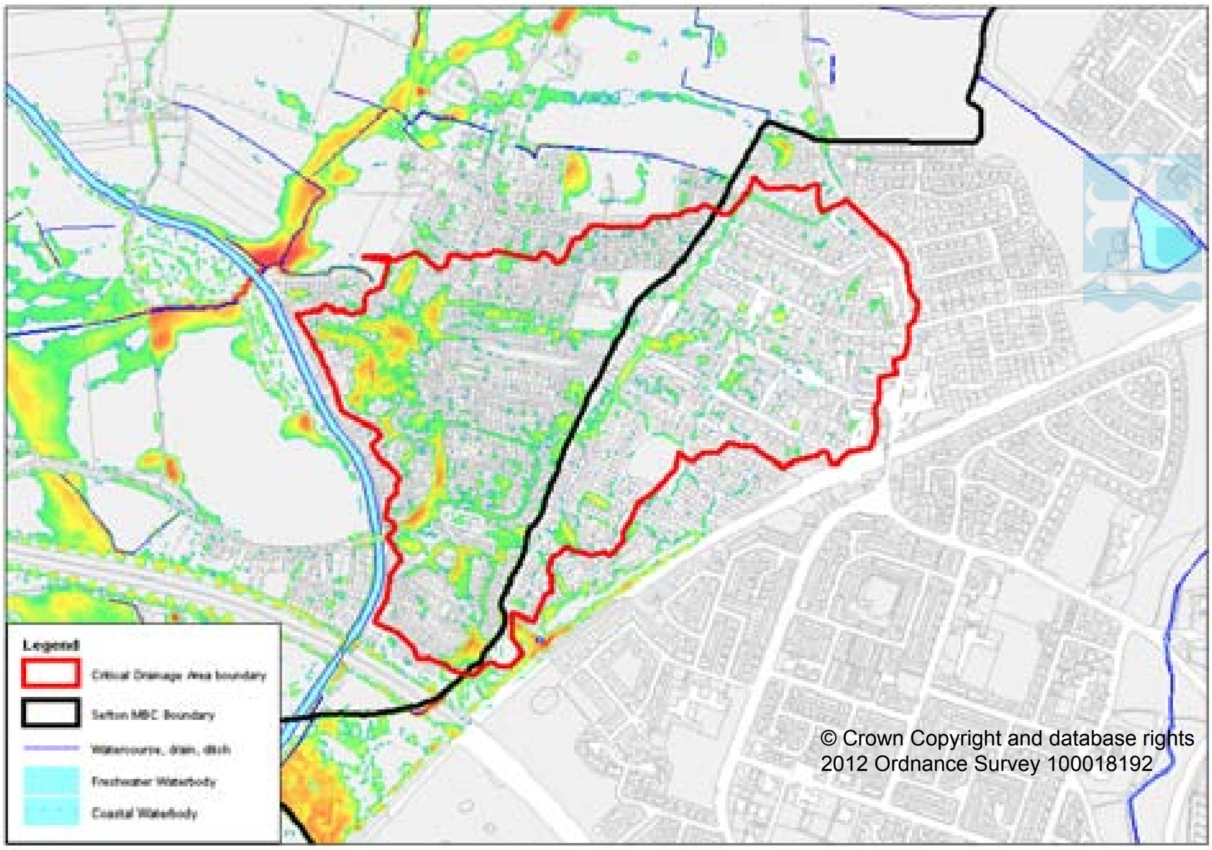

Figure C-13: Critical Drainage Area 07 – Waddicar: Brooklea

Critical Drainage Area 08

CDA 08 covers three distinct areas that all drain directly to the River Alt via surface water sewer systems. In the east is Aintree, extending between the Leeds and Liverpool Canal and the A5036, and in the north are two adjacent catchments on either side of Adrian's Lane.

The Aintree area either drains directly to the River Alt via one of 11 outfalls or it discharges via Moor Hey Tributary, which passes around the eastern side of the roundabout at the junction of the M57 and the A5036 to join the River Alt further west. The Netherton areas drain via two separate systems to Netherton Brook, which itself discharges into the River Alt.

The CDA does not include areas between the A59 in the east, the Leeds and Liverpool Canal in the north and north east and Bootle Golf Course or Netherton Industrial Estate in the south and west. Whilst these areas drain via surface water sewers to and through the areas within CDA 08, surface water flooding generated in these areas that did not re-enter the sewers would be intercepted by the canal and would not extensively contribute to surface water flooding within these areas. These areas are therefore covered in CDA 09.

Sources of flooding include surface water and sewer flooding and in Aintree, potentially groundwater flooding. The CDA contains records from both United Utilities and Sefton MBC of flooding between 1990 and 2008.

LFRZs in Aintree either lie on flow paths that typically follow the direction of streets in a north easterly direction towards the River Alt or they are areas of ponding along the northern boundary of the CDA.

Ponding is seen affecting properties around Taunton Drive. A LFRZ associated with a flow path and ponding is seen from Bull Bridge Lane to Windsor Park Road, impacting properties around Greenside Avenue, North Avenue, Altway, Sandhurst Drive, Oriel Drive and Martland Avenue in between.

A similar LFRZ exists between Aintree Parish Playing Field and Oriel Drive/Oreil Close with flooding of properties on Harrow Drive, Altway, Denstone Avenue, Tonbridge Drive and Haileybury Avenue. To the north west a LFRZ impacts properties between Mostyn Avenue, Stoneyhurst Avenue, Altway, Keble Drive and Oriel Drive.

Properties around Copy Lane are affected, including flats at Bechar's Court. Flooding extends from here along Ormskirk Road with little impact until it floods properties to the north of Dooley Drive and Deerbarn Drive. Finally a large number of properties are impacted in a LFRZ located around Cumberland Gate, between Copy Lane, Dunnings Bridge Road and the Leeds and Liverpool Canal.

A single LFRZ is seen in the smaller of the two Netherton areas, which primarily affects properties at the eastern end of Apollo Way. To the west in the second Netherton area, a flow path related LFRZ impacts area from and north of Lunar Drive, with flooding of properties within Parkway, Windsor Close and York Close until the Northern Perimeter Road.

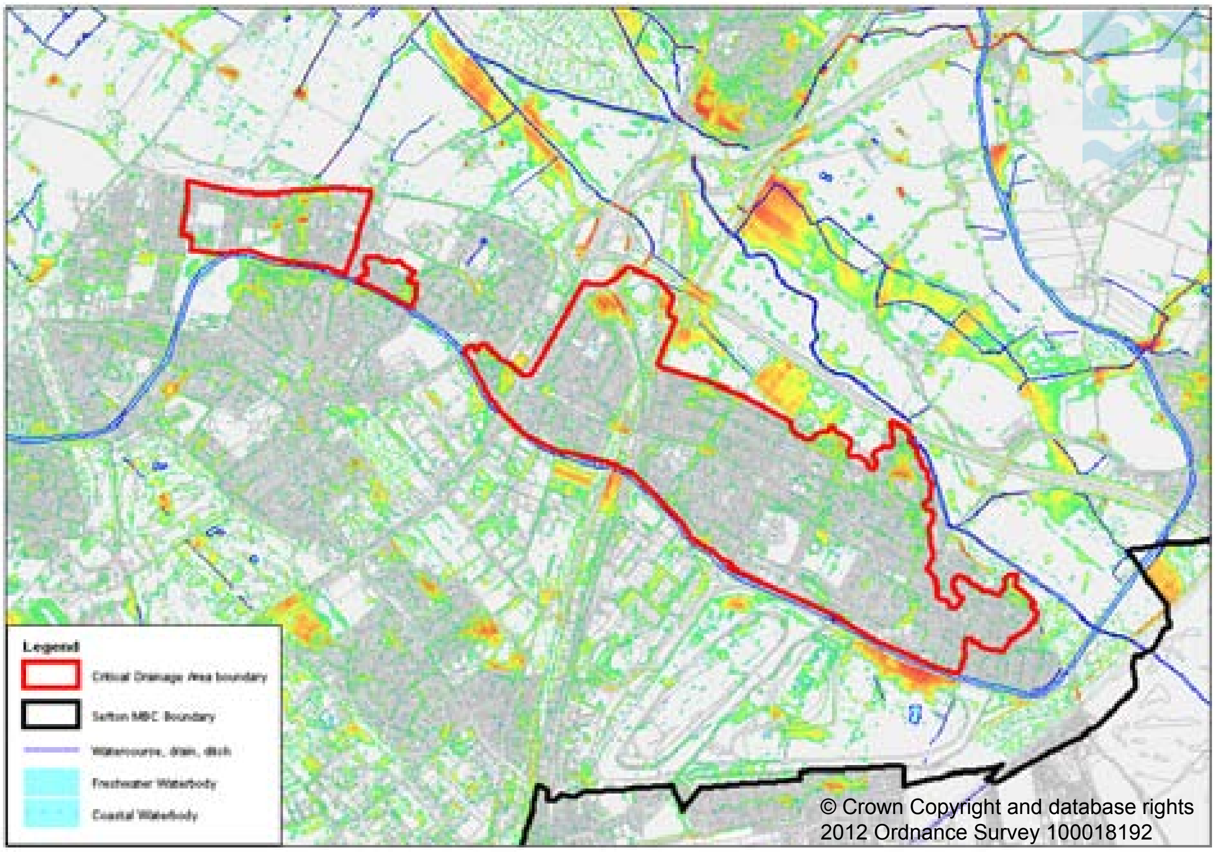

Figure C-14: Critical Drainage Area 08 – Aintree and Netherton: Netherton Brook, Moor Hey Tributary and the River Alt

Critical Drainage Area 09

CDA 09 covers two areas between the A59 in the east, the Leeds and Liverpool Canal in the north and north east and Bootle Golf Course or Netherton Industrial Estate in the south and west. The two areas are split by the A5036 and do not include Switch Island Leisure Park.

As indicated above, these areas generally drain via surface water sewers beneath the Leeds and Liverpool Canal and onto the areas discussed within CDA 08. The exceptions are the area around Netherton Moss Primary School and a small area to the west of the canal. Both are formerly drained by a combined system that takes flow to the west.

Sources of flooding include surface water and sewer flooding. The CDA contains records from both United Utilities and Sefton MBC of flooding between 1991 and 2010, with numerous records from events in February 2001 and July 2010.

Key LFRZs include properties flooded on Lingfield Close and between Parker Close and Hudswell Close. Extensive flooding of properties and a factory is seen to the north east of Marina Crescent and to the north west, ponding in Marlborough Avenue impacts properties on both sides of the road. To the north of these areas, extensive ponding and flooding in the area of Wakefield Industrial Estate is shown on the upstream side of the Leeds and Liverpool Canal.

In the Netherton area there are LFRZs containing is extensive flooding of properties along Howard Florey Avenue, St. Oswalds Way, Eden Vale, Westminster Avenue and Peterborough Drive. To the south, a LFRZ identifies impacts around The Marian Way and, to the west of the canal, flooding between Fleetwoods Lane and St. Augustine's Way results in a number of properties being impacted.

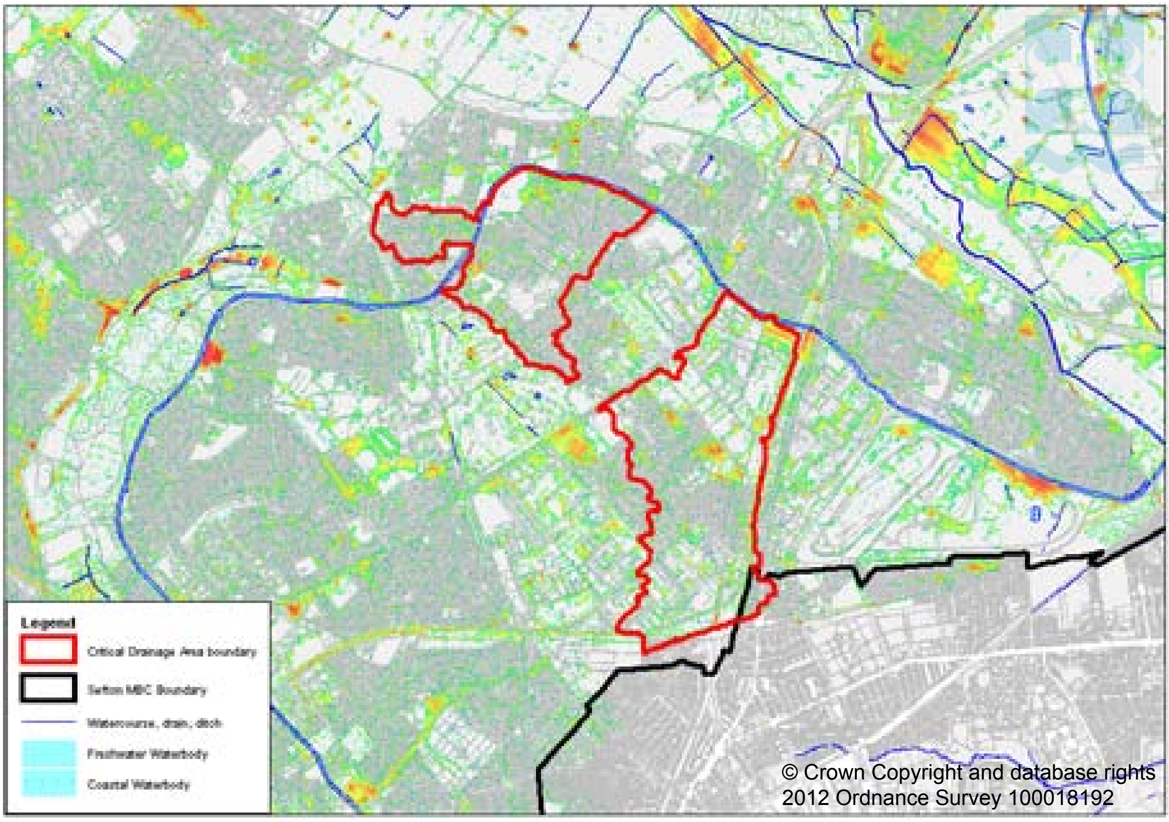

Figure C-15: Critical Drainage Area 09 – Aintree and Netherton: Leeds and Liverpool Canal

Critical Drainage Area 10

CDA 10 generally covers the majority of the natural catchment of Rimrose Brook and as a consequence it is the largest CDA within Sefton.

The area is almost entirely drained via combined foul and surface water sewers, which ultimately drain to Sandon WwTW at Liverpool Docks.

Sources of flooding include surface water and sewer flooding. In areas along Rimrose Valley into Seaforth and Bootle it also includes the risk of groundwater flooding. The CDA contains extensive records from Sefton MBC, particularly from flooding in July 2010 when Seaforth was particularly badly affected by surface water flooding. There are also Sefton MBC records from 2001 and 2004. Records from United Utilities are more scattered than those of Sefton and range between 1990 and 2008.

Within this CDA, there are a large number of smaller LFRZs associated with ponding of water in shallow depressions, however, the key LFRZs are associated with overland flow paths from historical watercourses and topographical features that would once have fed Rimrose Brook.

Starting in the east, properties are flooded in Chester Avenue to the east of Netherton Community Centre. To the west of here, properties are impacted at the eastern end of Moss Lane and in areas between Robinson Road and Kirkston Road North. At the end of this flow path, areas in Ford, around Lonsdale Mews, Oatfield Lane and Ford Lane are shown to flood.

To the north of this, along the path of the historical Rimrose Brook, a number of properties are impacted in Westmoreland Avenue and Cumberland Avenue To the north of the canal, and at the top of Rimrose Valley, the James Horrigan Court Elderly Persons Home is also affected.

Edgmoor Close is a LFRZ to the north of Rimrose Valley in which a number of properties are flooded. To the south of this, flooding extends in flow paths and areas of significant ponding from Moor Lane in the north, extending down and around The Northern Road, Moor Drive, the Byway, The Precincts, Rosedale Avenue, Seafield Avenue and Moorgate Avenue, through Belair Industrial Estate and along both The North Road South Parade/Nazeby Avenue and Kershaw Avenue/Endbutt Lane until it reaches Rimrose Valley.

Relatively minor ponding is seen on South Road in Waterloo, whilst extensive property flooding is seen along Ronald Close and Brook Vale, which run parallel to Rimrose Brook. To the east, flooding of the Merseyrail line to Waterloo Station is also shown.

As Rimrose Valley passes Waterloo Grammar playing fields and Rimrose Valley Country Park the flood extents increase significantly, though the main impacts are businesses to the south of here. Princess Way, Sandy Road and Seaforth Road are inundated and lie within a large LFRZ that covers both sides of the raised railway line at this location that extends down to Akenside Street on the east.

On the west of the railway, flooding extents further inundating property on Kelper Street and Lime Grove, including Our Lady of the Sea Catholic Primary School, property on Maple Close, and significant properties along Muspratt Road, Meadow Hey, Cookson Road, Bowles Street, Seaforth Road, Deepdale Avenue and Bulwer Street until Crosby Street South. The flooding crosses this into Shore Road and Regent Road and runs south eastwards parallel with the docks to Atlantic Terminal.

In addition to this significant flow path, there are LFRZs to the north east of the canal covering Sefton Road, Sefton Street and Field Lane, plus extensive areas along the southern edge of Church Road between the canal and Kirkstone Road South amongst which St. Phillips Church of England Controlled Primary School is impacted.

South of a now disused railway, extensive LFRZs are seen between the railway and Hawthorne Road right into Bootle Town Centre. Flooding is seen along a now hidden watercourse along Province Road, which extends north eastwards along Menai Road and Park Lane to Orrel Lane, with inundation of Springwell Park Community Primary School. There are also notable flow paths and ponding from Southport Road along Reeves Avenue to impact Vaux Crescent. Finally there is extensive flooding simulated at the junction of Marsh Lane with the Leeds and Liverpool Canal, with flooding to the Gas Depot and flooding continuing southwards on both the east and west sides of Hawthorne Road.

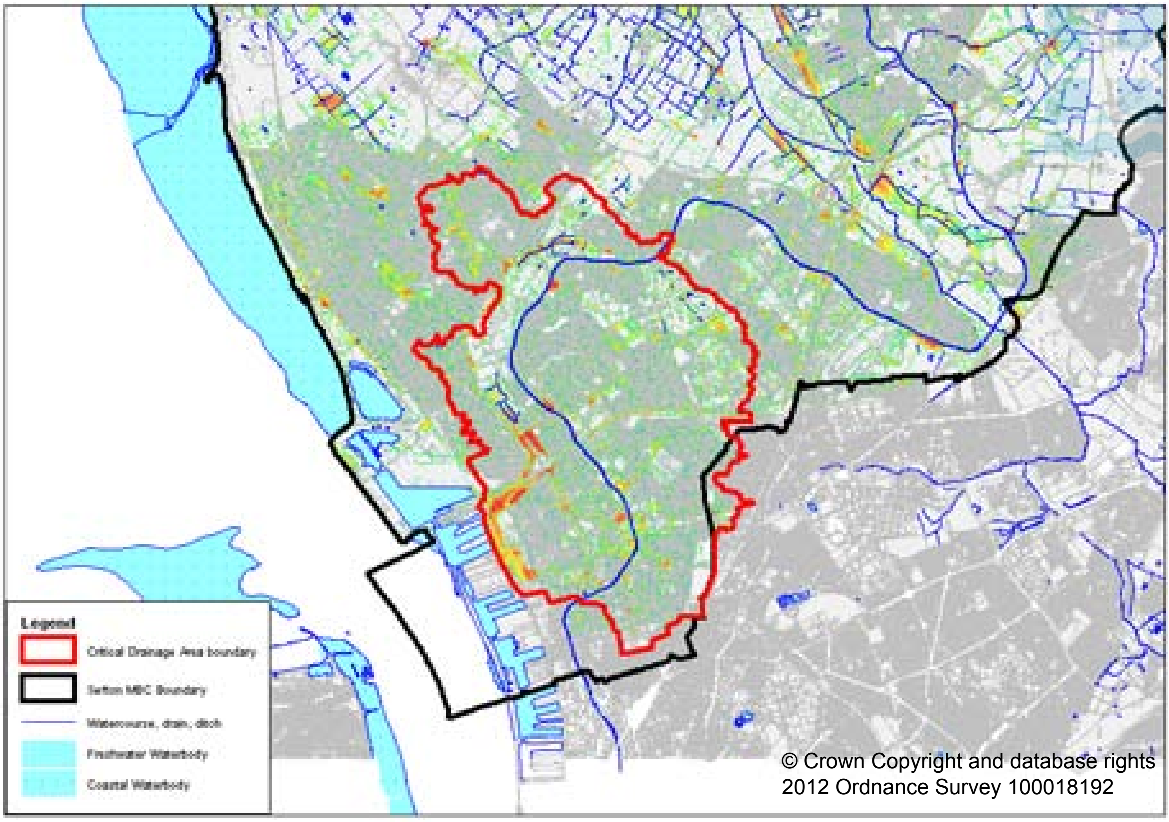

Figure C-16: Critical Drainage Area 10 – Bootle, Seaforth, Litherland and Great Crosby: Rimrose Brook

Critical Drainage Area 11

CDA 11 covers a catchment area in the headwaters of Hunts Brook that drains Thornton.

The upper third of the catchment is rural, and the majority of the remainder is drained via a surface water sewer into an ordinary watercourse that feeds Hunts Brook, however, in the middle of the CDA, some areas are drained by a combined sewer system discharging southwards.

Sources of flooding include surface water and sewer flooding. The CDA contains extensive records of flooding, particularly in Water Street and in isolated areas such as Stannyfield Drive and Runnel's Lane.

Within this CDA there are three principal LFRZs. These are located within Runnels Lane, where impacts to property are shown, and also along Stannyfield Drive, which appears to act as a flow path towards Water Street.

The main LFRZ, however, is along Halifax Crescent and across Water Street and Hartdale Road to Quarry Road. Significant numbers of properties are simulated to flood to significant and depths.

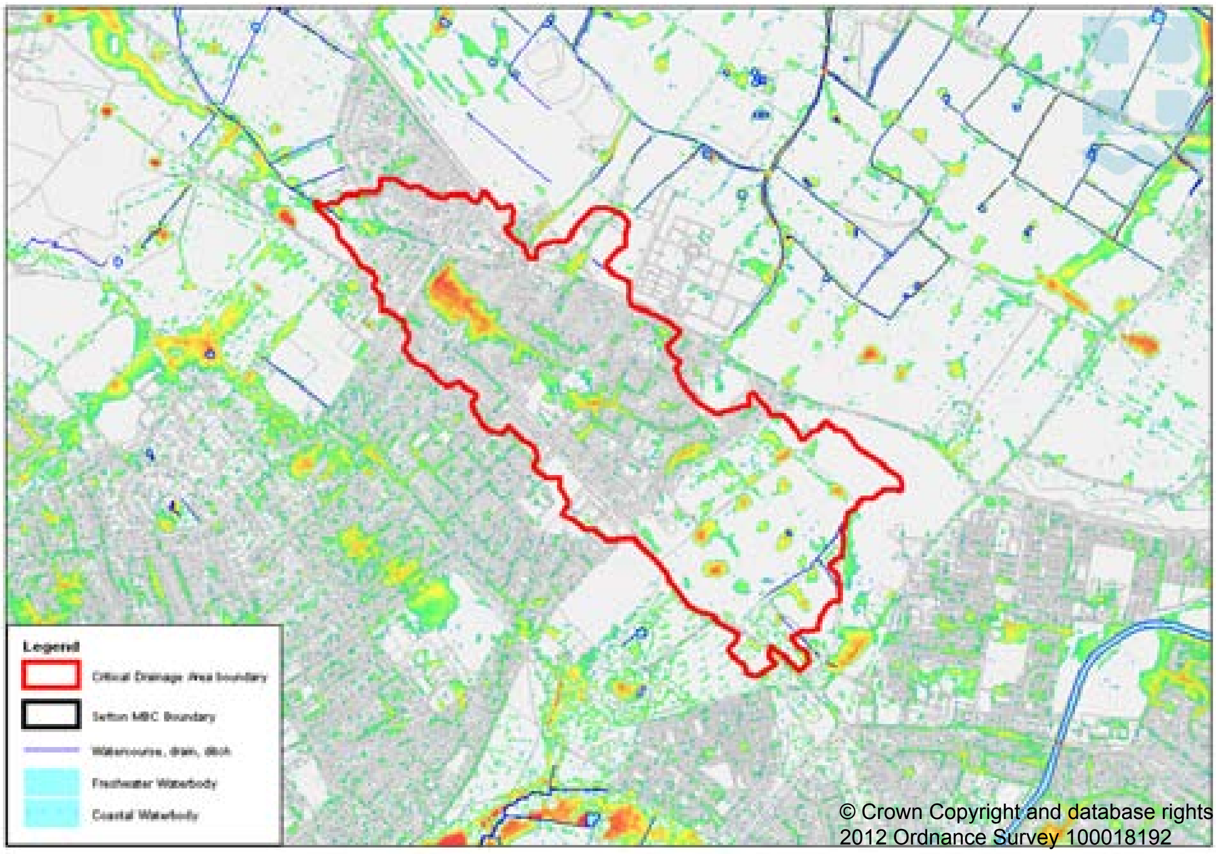

Figure C-17: Critical Drainage Area 11 – Thornton: Hunt's Brook

Critical Drainage Area 12

CDA 12 covers a catchment area that historically drained via ditches to Farmoss Pool.

The catchment is drained via a combined sewer system in a north westerly direction to the outlet of the catchment. At that point the combined sewer turns due south away from the natural flow direction to the south west.

Sources of flooding include surface water and sewer flooding. The CDA contains extensive records of flooding, particularly in 1994 but ranging between 1993 and 2010.

Within this CDA there are many small LFRZs, however, the principal areas are an area of ponding to the south of the catchment between Cranfield Road, Moorfield Road and Rosemoor Drive.

Other key areas follow the path of the combined sewer from Edgemoor Drive and cover flooding between this road and Meribel Close and Beech Park.

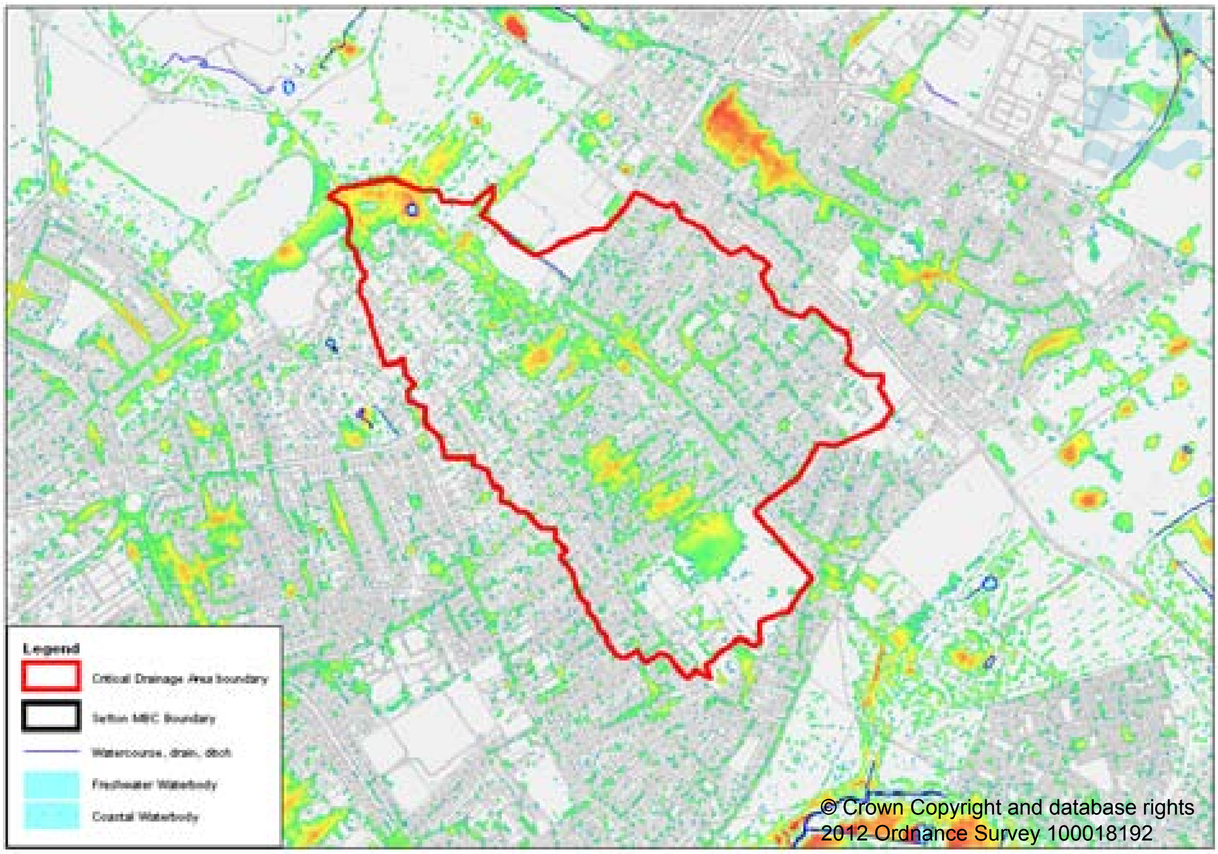

Figure C-18: Critical Drainage Area 12 – Thornton: Farmoss Pool

Critical Drainage Area 13

CDA 13 covers a catchment area that historically drained to Farmoss Pool. It is border to the east by the Merseyrail railway line and covers parts of Great Crosby and Waterloo. Historical watercourses existed to the north east of the CDA, which would have been fed historically by the flow from CDA 12.

The catchment is drained via a combined sewer system that ultimately drains to Sandon WwTW in North Liverpool Docks.

Sources of flooding include surface water and sewer flooding, and there are very small areas in which groundwater flooding is considered to be a risk. The CDA contains extensive records of flooding from 1993 onwards, with many recorded in July 2010. Within this CDA there are many small LFRZs, however, the principal LFRZs are associated with large areas of ponding.

The first of these areas is located to the west of College Road, between Rossett Park Football Club in the north and Crosby Road in the south. This are affects in the region of 394 properties. South east of this LFRZ, there are isolated areas impacting Parkfield Road, Molyneux Road and St. Johns Road.

North of this LFRZ, there are two areas of ponding. The first is between St. Michaels Road and Campion Tennis Club to the west of Dowhills Road. The second extends from Alexandra Park to St. Michaels Road, impacting properties in Cambridge Road, Cambridge Drive, Ince Avenue, Victoria Avenue, Cambridge Avenue and Victoria Road West.

In the north of the CDA, there are flow paths that follow the path of historical watercourses. These are located along De Villiers Avenue, Longfield Avenue, Woodend Avenue, Oaklands Avenue, St. Michaels Road, St. Andrews Drive, Hall Road East and Paddock Close.

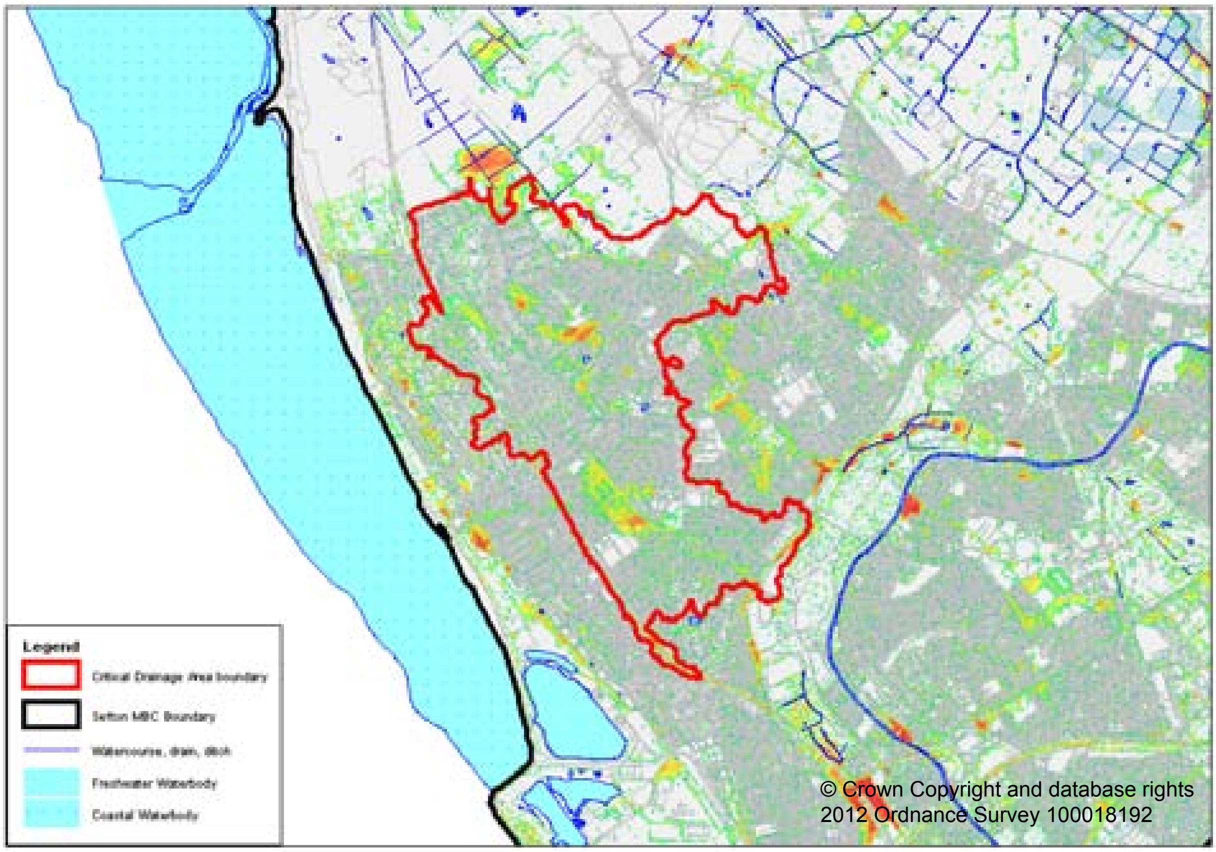

Figure C-19: Critical Drainage Area 13 – Crosby: Farmoss Pool

Critical Drainage Area 14

CDA 14 contains two sub-catchments that both naturally drain towards the coast and which are drained via a combined sewer system that ultimately discharges to Sandon WwTW in North Liverpool Docks.

Sources of flooding include surface water and sewer flooding. The CDA contains extensive records of flooding from 1993 onwards, with some recorded in 2009 and 2010. Within this CDA there are many small LFRZs associated with flow and ponding in roads, however, the principal LFRZ is associated with Warrenhouse Road, Sudbury Road, Endsleigh Road, Holden Road and Westward View. There is also flooding along Pinehurst Avenue.

In the small northern catchment there is a principal LFRZ covering Bronte Close, Channel Reach, Almacs Close and Seathwaite Close. A LFRZ covers areas along Warrenhouse Road, Endsleigh Road and Sudbury Road and there is flooding to Mason Street to the south.

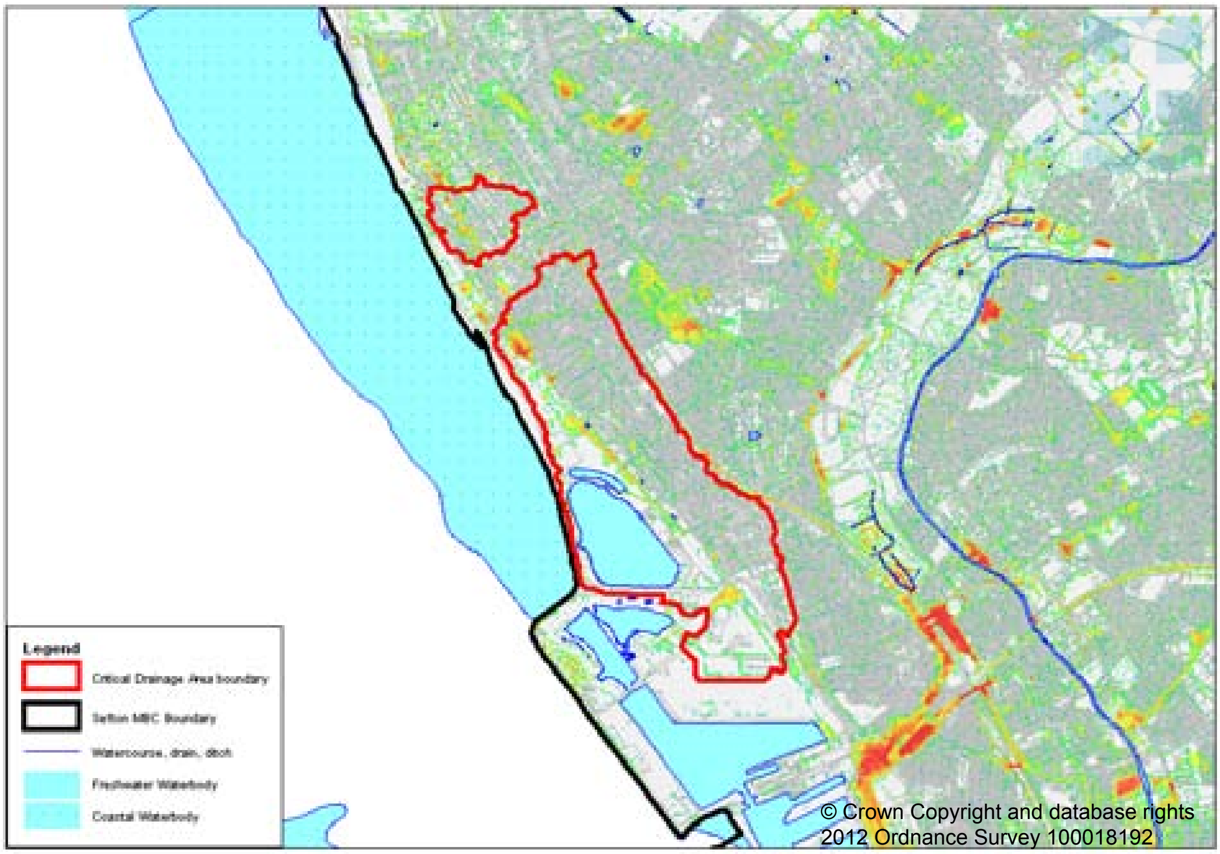

Figure C-20: Critical Drainage Area 14 – Crosby and Blundellsands: Coast

Critical Drainage Area 15

CDA 15 contains two sub-catchments that both naturally drain towards the River Alt and which are drained via a combined sewer systems that ultimately discharge to Sandon WwTW in North Liverpool Docks and two small surface water sewer system that drain to the River Alt.

Sources of flooding include surface water and sewer flooding. The CDA contains no records of flooding.

Within this CDA there are many small LFRZs associated with ponding in roads and shallow depressions, however, the principal LFRZs in this area are associated with low lying areas on either side of. There is also a low lying area affecting property and a police station to the west of.

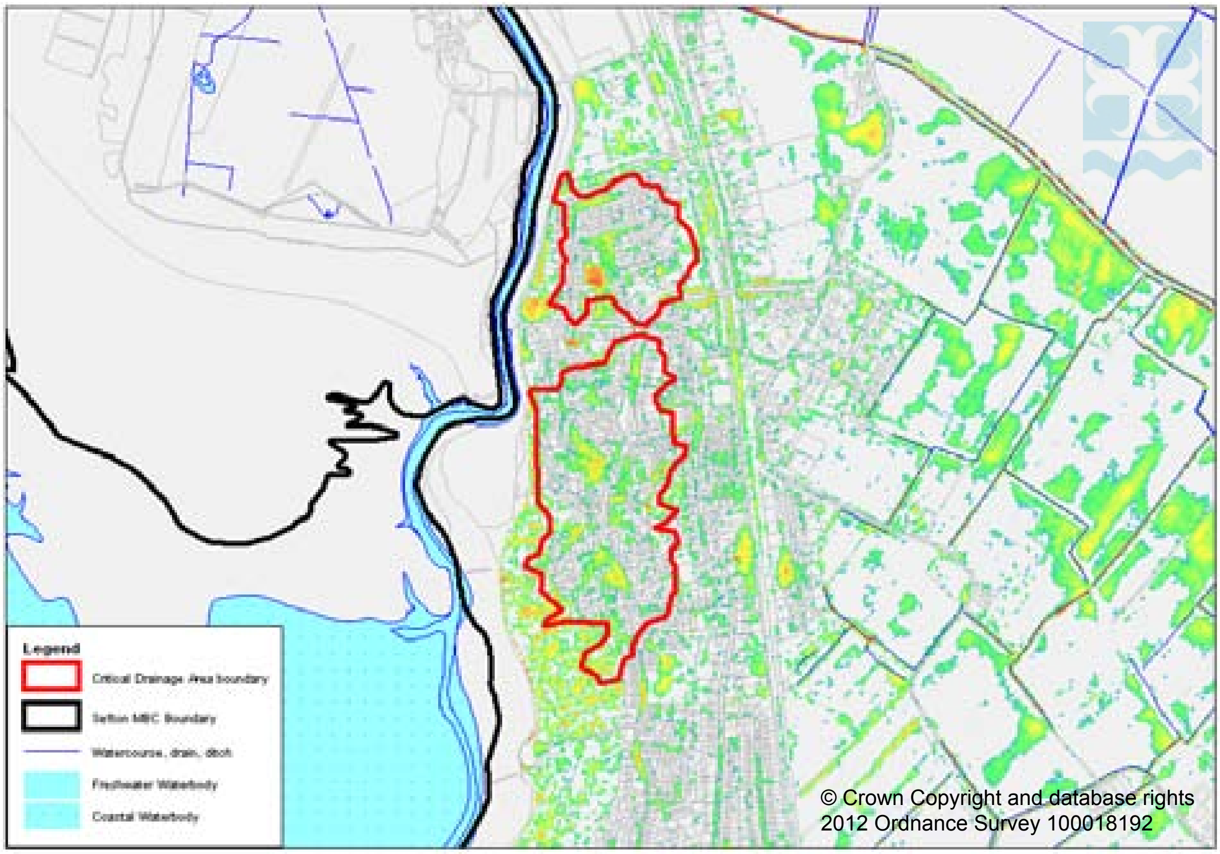

Figure C-21: Critical Drainage Area 15 – Hightown: Coast

Critical Drainage Area 16

CDA 16 covers the lower south and south west areas of Formby. It is drained by a surface water drainage system that is managed by United Utilities and which ultimately discharges to the Hoggshill Lane watercourse, which is a main river maintained by the Environment Agency to ensure effective drainage of the area.

Sources of flooding include surface water and sewer flooding and there are minor areas to the south around Formby WwTW that are affected by fluvial flooding. The CDA contains records of flooding from 2008 and 2010, mostly in the south eastern corner around Hoggshill Lane and Park Lane.

Within this CDA there are a number of LFRZs. In the north west there are LFRZs affecting properties along Larkhill Lane and Wicks Lane, at the junction of Harrington lane and Wicks Lane, between Greenloons Drive and Greenloons Walk, either side of St. Luke's Drive and Bushby's Park and between Kirklake Road and Queens Road.

Elsewhere, a LFRZ corresponds with the records of historical flooding in Park Road, Hoggshill Lane, Osborne Road and within the WwTW.

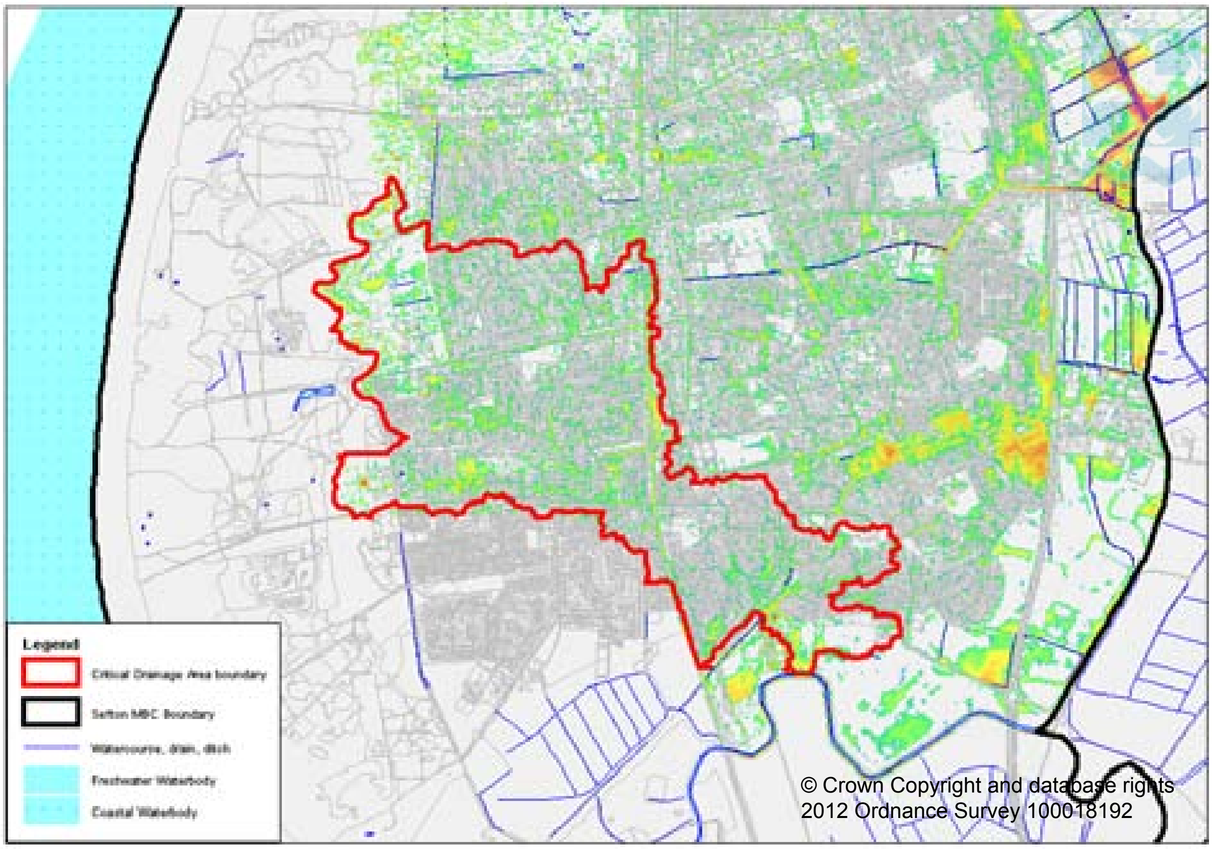

Figure C-22: Critical Drainage Area 16 – Formby: Hoggshill Lane

Critical Drainage Area 17

CDA 17 contains the remainder of Formby, extending from Little Altcar in the south east to Woodvale Airfield in the north and covering areas from Larkhill Lane to Wham Dyke and Downholland Brook.

The CDA is drained by surface water drainage systems managed by United Utilities that feed a number of ordinary watercourses, ditches and drains that in many cases then enter piped systems. These ordinary watercourses and the piped systems are maintained by Sefton MBC. These ultimately discharge to Wham Dyke and Downholland Brook via various smaller watercourses such a Moss Side, Acre Lane Brook, Eight Acre Lane, Bull Cop and Boundary Brook.

Sources of flooding include surface water and sewer flooding within the catchment and along the eastern boundary there are areas by Wham Dyke and to the east of Formby Bypass that experience fluvial flooding.. The CDA contains records of flooding from both United Utilities and Sefton MBC that extend from 1992 through to 2010, with many records in January 2008 when serious flooding took place in many locations such as Lonsdale Road and Hawksworth Drive.

Starting in the south of the CDA, there is an extensive LFRZ that affects numerous properties between Phillips Close/Tyrers Close and the Formby Bypass to the east. This affects properties along Phillips Lane, Norburn Crescent, Birkey Lane, Conifer Court, Liverpool Road, Lytles Close, Cross Close, The Nurseries, Harthorne Cresent, Ditchfield, Bolton Close, Easby Close, Whalley Drive and properties between Formby Lane, Altcar Road and Fountain Way. Properties to the north on are also affected.

To the north, properties bordering Dobb's Gutter are affected from Freshfield Road eastwards to Moss Lane, covering Hallsall Lane, Davenham Road, Church Road, Watchyard Lane and Freshfield Primary School. To the north of Moss Side, the LFRZ extends northwards alongside the Formby Bypass, affecting properties along Mount House Road, Longfield, Heather Close, Lingdales, Turnacre and Hawksworth Drive up to Eight Acre Lane.

Properties to the east of Formby Bypass are also affected, including those along Southport Old Road such as Golf View, Fernlea, Rose Farm, parts of Warren Farm, the Golf Centre in the Formby Moss area and further south properties within Formby Business Park.

Elsewhere within the CDA there are LFRZs that affect a number of properties in Wrigley's Lane and Wrigley's Close, at the junction of Derby Road and Freshfield Road and in St. Peter's Avenue. Areas around Abbots Way and Abbot Close also suffer from flooding.

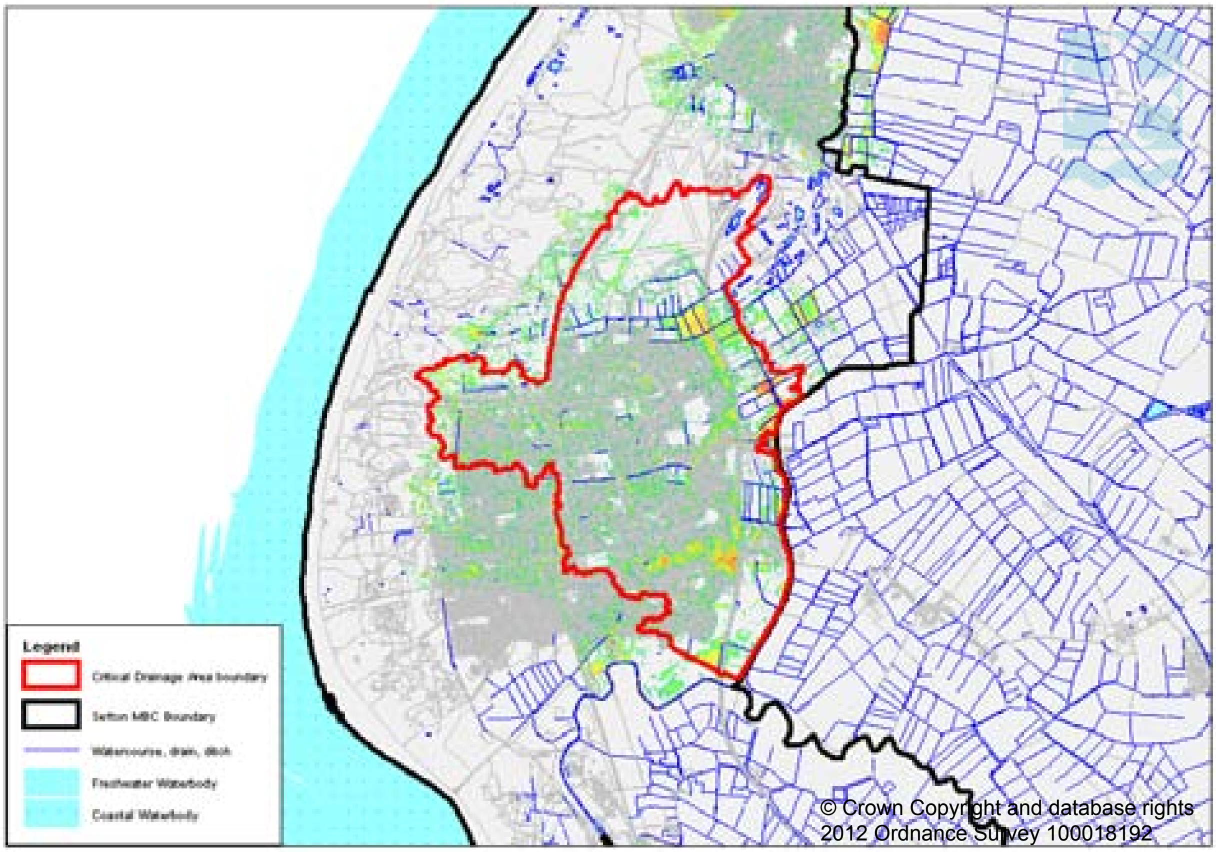

Figure C-23: Critical Drainage Area 17 – Formby: Wham Dyke and Downholland Brook

Critical Drainage Area 18

CDA 18 contains the majority of Ainsdale that drains to Sandy Brook in the east. The adjacent CDA 19 drains to the west.

The CDA is drained by surface water drainage systems managed by United Utilities that discharge to Sandy Brook via six outfalls.

Sources of flooding include surface water and sewer flooding, though there is some interaction with fluvial flooding in the vicinity of Plex Moss. The CDA contains limited records of flooding, which suggests that either the drainage system generally has adequate capacity or that it has not been subject to an event of sufficient severity within the period that records are available.

Within this CDA there are LFRZs defined in the south between Liverpool Road and Cornwall Way and between Rose Crescent and Sandy Brook. North of Meadow Lane, Kings Meadow Primary School and Early Years Education Centre is shown to be impacted. North west of here there are numerous LFRZs that affect property in the region of Gleneagles Drive, Windemere Crescent, Woodside Avenue and further north west still, a LFRZ that affects Westminster Drive and in particular Merefield School.

North of this there is extensive flooding shown alongside the Merseyrail line to Southport. Properties along Mossgiel Avenue, including Ainsdale Station, and along Station Road, Sandringham Road and Burnley Road. Areas along Halifax Road, Salford Road, Leamington Road, Liverpool Avenue and Ainsdale St. John's Church of England Primary School are also flooded.

It should be noted that there are areas within CDA18, particularly west of the railway line, in which the underlying drift geology is typically sand from sand dunes and in which groundwater levels are potentially up to around 2.5m below ground level. In such locations, infiltration could contribute towards a reduction in surface water flooding and the actual extent of any surface water flooding could therefore be less than modelled and presented in Appendix D.

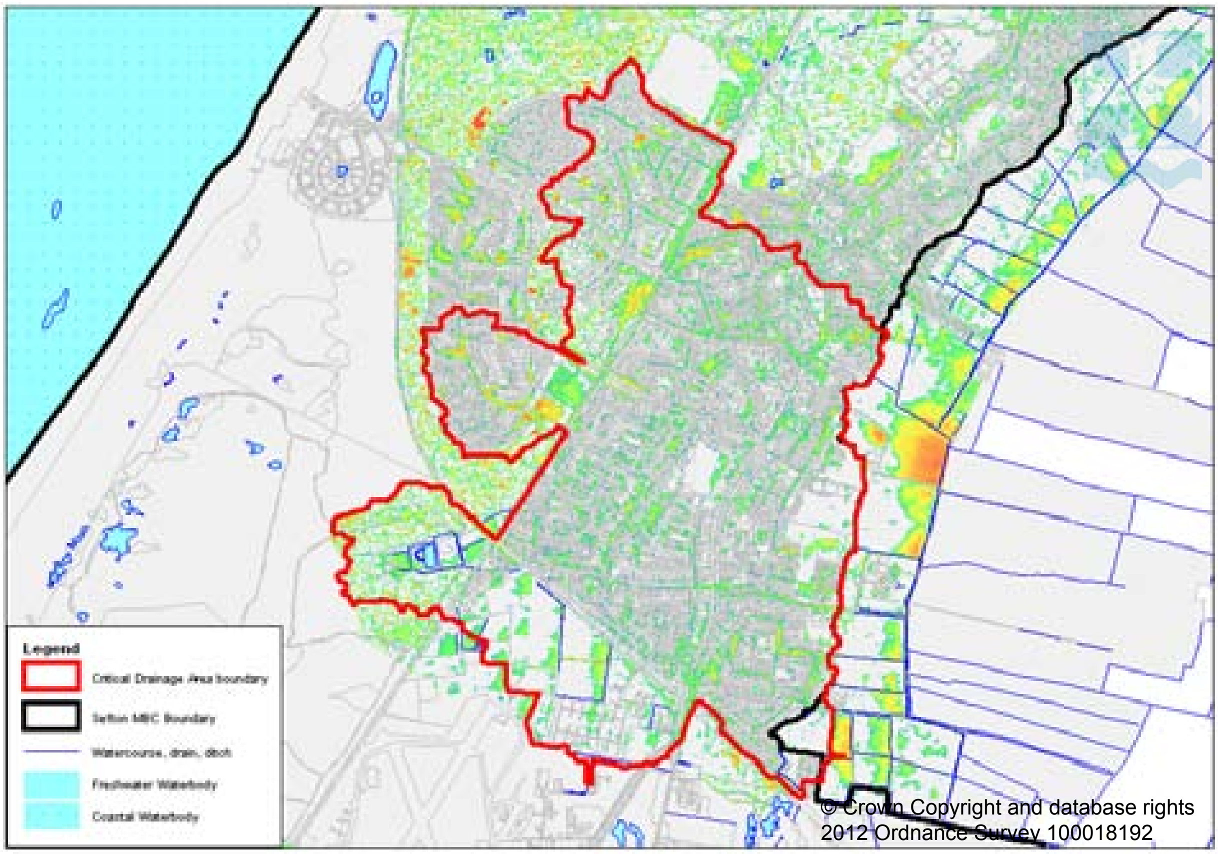

Figure C-24: Critical Drainage Area 18 – Ainsdale: Sandy Brook

Critical Drainage Area 19

CDA 19 contains those areas of Ainsdale that drain westwards. The CDA is drained by a surface water sewer network managed by United Utilities that ultimately discharges via Ainsdale Hills to the boating lake and from there to the coast.

Sources of flooding include surface water and sewer flooding. The CDA contains no historical records of flooding.

Within this CDA there are shown to be LFRZs that typically relate to ponding in and around depressions and roads, specifically those off Westminster Drive such as Grafton Drive, Daresbury Avenue, Arden Close, Bareford Close and Stratford Close. The pattern of flooding indicates that is likely that these depressions are a relic of the sand dunes that were historically here before development took place.

As within CDA18, the underlying drift geology in this area is typically sand from sand dunes and in which groundwater levels are potentially up to around 2.5m below ground level. In such locations, infiltration could contribute towards a reduction in surface water flooding and the actual extent of any surface water flooding could therefore be less than modelled and presented in Appendix D.

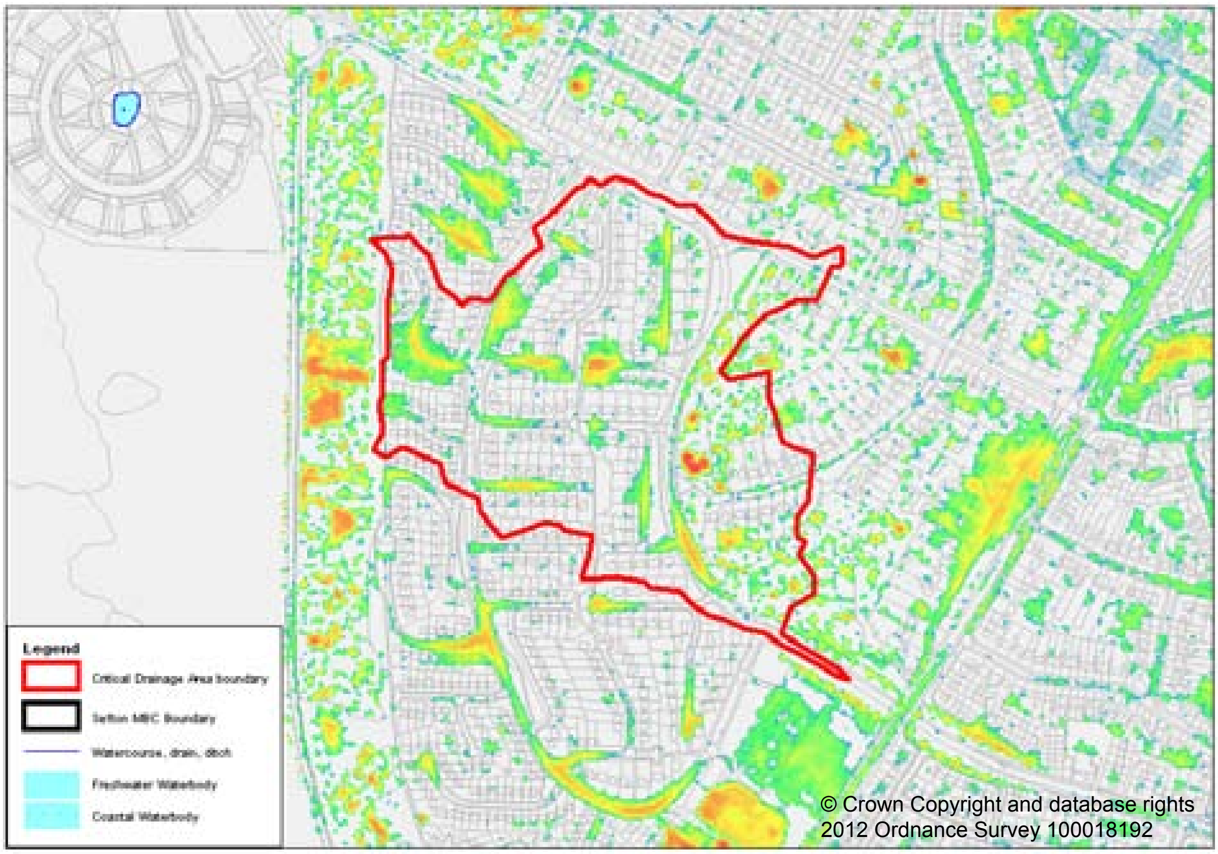

Figure C-25: Critical Drainage Area 19 – Ainsdale: Coast

Critical Drainage Area 20

CDA 20 contains the southern parts of Birkdale, including parts of Southport and Ainsdale Golf Course and Hillside Golf Course.

The CDA is drained by a mixture of combined sewer and surface water sewer networks. Surface water sewers drain the western edge of the area southwards to discharge to Sandy Brook. There is also a small surface water network in the east of the CDA draining directly to Sandy Brook. Sections of surface water drainage in the north discharge to Sandy Brook outside of the CDA. The combined sewer system here ultimately drains to the Southport (Bank End) WwTW.

Sources of flooding include surface water and sewer flooding and there are isolated small pockets where groundwater may emerge, mainly along Liverpool Road and by Sandy Brook. The CDA contains some records of flooding that mainly lie along the eastern boundary by Sandy Brook.

Within this CDA there are numerous small LFRZs that affect isolated properties, however the key LFRZs are located in Central Avenue and Ryder Crescent in the south, both of which coincide with records of flooding. There is a LFRZ affecting Halsall Road, Shaftesbury Road, Shaftesbury Avenue and Norfolk Road. Sandon Road, between Hillside Road and Cardigan Road is also within a LFRZ and, to the north, properties within Birkdale Trading Estate, between Clifford Road and Richmond Road/Bedford Drive are also within a LFRZ. Hillside Station is also affected by a LFRZ.

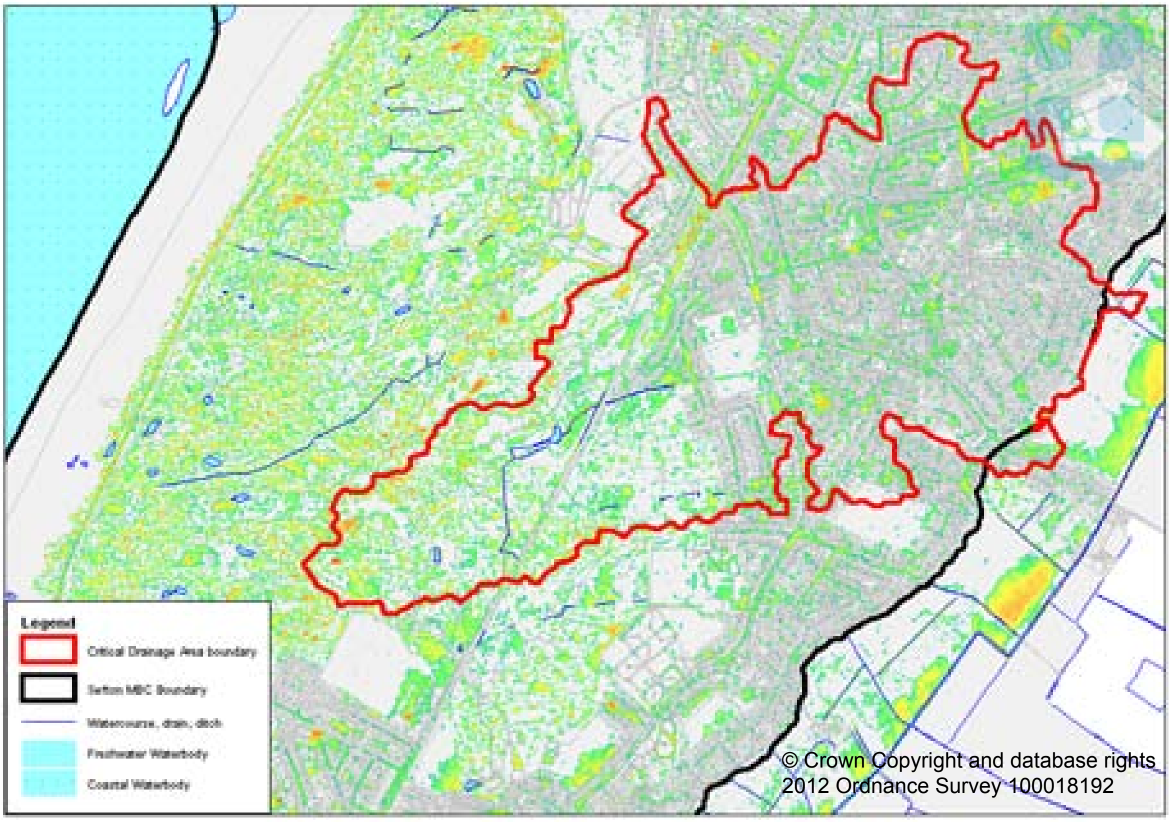

Figure C-26: Critical Drainage Area 20 – Birkdale: Sandy Brook

Critical Drainage Area 21

CDA 21 contains the areas around Bedford Park and the majority of Southport from Meols Cop northwards to Marshside, Churchtown and Crossens.

The CDA is drained by a mixture of combined sewers and surface water drainage networks. Around Bedford Park a surface water drainage network takes runoff from parts of CDA 20 along with runoff from north of Bedford Park directly to Fine Jane's Brook. The north eastern side of this area is drained via combined sewer heading northwards to ultimately discharge to Southport (Bank End) WwTW.

In Meols Cop a surface water drainage network drains an area to the north west of King George V College directly into Fine Jane's Brook, and the remainder is drained via combined sewer northwards. There are areas drained by surface water sewer in Marshside and Crossens, however, the remainder of the area is typically drained via combined sewer towards Bank End WwTW.

Sources of flooding include surface water and sewer flooding. Groundwater flooding is identified as a risk along parts of Fine Jane's Brook in the east and within some of the dunes to the west of the Marshside area of Southport. Fluvial and tidal flooding is also noted in Marshside, Crossens though these areas are all defended. The CDA contains records of flooding distributed across the area dating between 1993 and 2009.

Within this CDA there are numerous small LFRZs that affect isolated properties, however there are also a large number of significant LFRZs that affect numerous properties. In the Bedford Park area such LFRZs are located along Bedford Road and between Clinning Road and Stamford Road. This area lies near to the path of a now non-existent watercourse so may be related to a flow path that once fed it. To the east of here, there is significant and extensive flooding of a Garden Centre off Bentham Way.

To the north west, properties along Cemetery Road/Portland Street lie within a LFRZ, properties either side of Scarisbrick New Road between Ash Street and Cumberland Road also fall within a LFRZ as do properties within the vicinity of Jane's Brook Road. North east of this, properties between Balfour Road, Forest Road and Dodworth Avenue are affected, as are properties in Haig Avenue and the junction of Hart Street and Norwood Road.

Further east still, properties and businesses along Butts Lane, Crowland Street and Wennington Road are affected. This LFRZ extends northwards to impact a large number of properties around Cobden Road, Canning Road, Milton Street, Newton Street, Bispham Road, Old Park Lane and Heysham Road, and then back westwards to impact Athole Grove, Wennington Road again, Fisher Drive and Hereford Road.

West of this large LFRZ, the area of ponding and inundation continues to be extensive, covering areas immediately to the east and west of Meols Cop Station and areas to the north and west of Norwood Primary School (which remains dry but surrounded by flood water) and Holy Family Catholic Primary School. Further west still there is a large LFRZ that includes Kensington Industrial Park, including Hall Street, Kensington Road and Zetland Street.

Moving northwards of High Park, LFRZs are noted along Roe Lane, Moss Lane and Mill Lane. A large LFRZ extends from Preston Road (north west of Holy Trinity Sports Ground), affecting Rawlinson Road, Hilbre Close, Hilbre Drive, Rawlinson Drive and extending eastwards to affect Montrose Drive, Kings Hey Drive, Beresford Drive, Beresford Gardens, Coudray Road and properties to the south of Cambridge Road.

North of Cambridge Road, a series of LFRZs affect Marshside and Churchtown. In the west, a small LFRZ includes most of the flats in Cambridge Gardens. To the north west, flooding in Churchhill Avenue and Emannuel Road combine on Radnor Road to extend down Longacre as far as Larkfield Lane. South of here in Bakers Lane, a LFRZ extends southwards down Marshside Road and then eastwards across Mallee Crescent towards Larkfield Primary School. From Marshside Road this LFRZ also extends eastwards along Balmoral Drive towards The Pool, which lies to the north of Serpentine Lake, which drains southwards to Three Pools Waterway.

East of Serpentine Lane there is a LFRZ that affects. A LFRZ also continues to extend north eastwards along Balmoral Drive, though few properties are affected here. It joins however, with a LFRZ within Lexton Drive and Rathmore Crescent to affect properties from North Road northwards across Asland Gardens, Roselea Drive, then spreading north westwards to The Pool which then goes northwards to Poolside Walk and The Causeway and westwards to Preston New Road and Merepark Drive.

An area to the south west of here, along Lytham Road, impacts a number of properties and there is a LFRZ that affects properties along Kingston Crescent. Along the coastal edge of Marshside, which is served by a surface water sewer, parts of the sewage works fall within a LFRZ, as do properties around Bodmin Avenue, Helston Close, Croyde Close, Dawlish Drive and further west, Preesall Close.

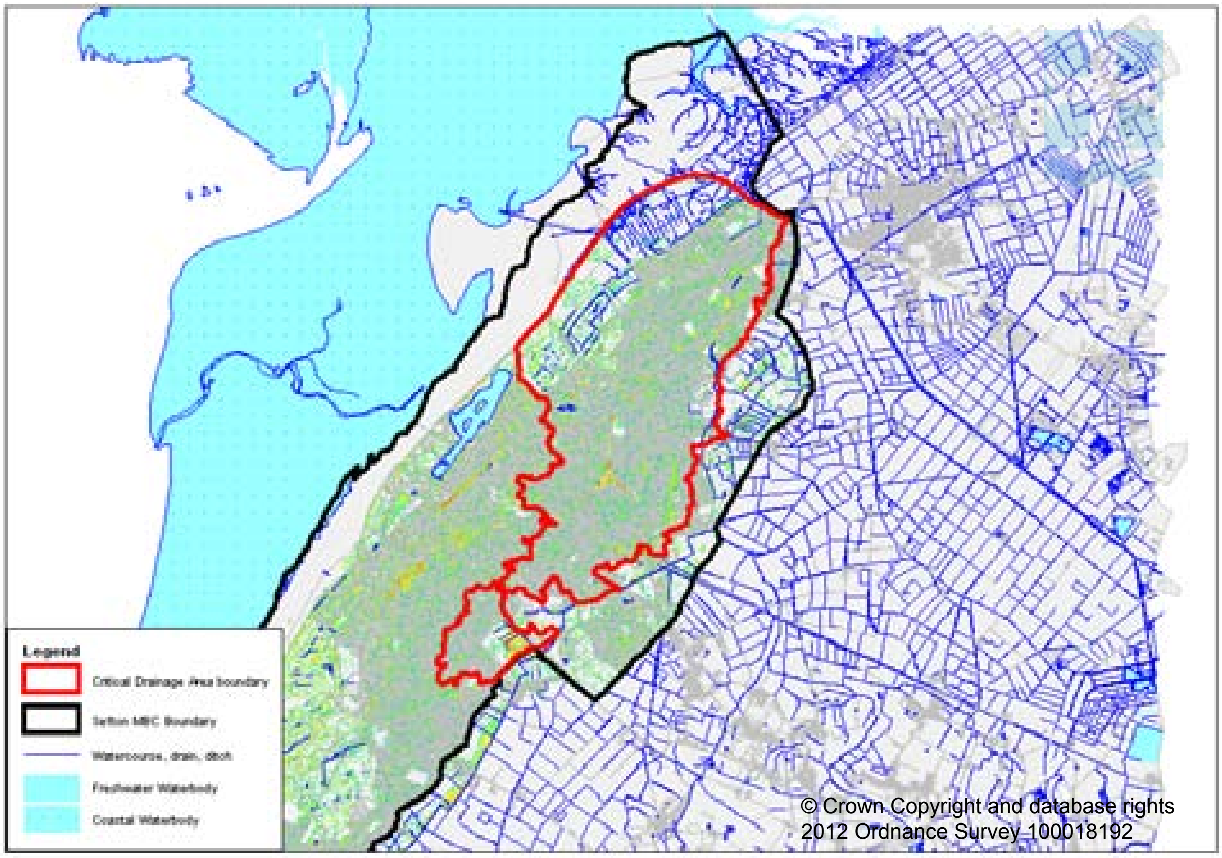

Figure C-27: Critical Drainage Area 21 – Southport: Three Pools

Critical Drainage Area 22

CDA 22 contains those areas of Southport that naturally drain towards the coast, incorporating Southport Town Centre from just south of Hesketh Park to Birkdale as far as Hillside Station.

The CDA is drained predominantly by a combines sewer system, however, small areas in the north contain a surface water sewer system and areas of Birkdale south of Birkdale Station, are served by a combination of combined and surface water sewers.

Sources of flooding include surface water and sewer flooding although there are also isolated pockets of areas at risk of groundwater flooding and areas around Marine Lake lie within an area at flood risk, though protected by defences. The CDA contains numerous records of flooding, though these tend to be located more in Southport than Birkdale.

Within this CDA, there are no historical watercourses and the LFRZs within this CDA therefore tend to define areas in which the topography is low lying and the mechanisms of flooding are ponding related. The pattern of LFRZs suggests that there is a control being exerted by relic topographical features of dune systems running parallel to the coast that no longer exist.

A LFRZ is identified along the length of the Merseyrail railway line to Southport, with flooding shown to impact Hillside Station and sections between Birkdale Station and Southport. East of the railway, in the vicinity of Trafalgar Road and Gainsborough Road, a LFRZ impacts a number of properties. This area extends northwards via Grosvenor Road to impact Waterloo Road and areas surrounding here.

From here in a north easterly direction there us an extensive series of LFRZs that include properties either side of Oxford Road, Weld Road and Saxon Road as far as Gloucester Road. A series of LFRZs continue to extend in a wide swathe north eastwards from Gloucester Road to include properties alongside Aughton Road, Upper Aughton Road, Lyons Road, Part Street, Talbot Street, Duke Street, Cross Street, Railway Street, Portland Street, Southbank Road to Tulketh Street near to Southport Station. Outlying LFRZs associated with this large area include small areas such as Ericson Drive, areas along Alma Road and Clarence Road, Liverpool Road by Abbey Gardens.

East of the railway station in Southport there is a LFRZ that includes properties alongside London Street, Hawesside Street, Vulcan Street and in areas around Arnside Terrace.

forms a significant LFRZ that affects business and property through the whole of South Town Centre. This extends to Union Street and Castle Street, areas around Seabank Road, Bath Street North and Gordon Street, Manchester Road and Court Road. The areas to the north, within an area defined by Leicester Street to the south west, The Promenade to the north west, Gordon Street to the south east and Park Road West to the north east, contains numerous areas showing ponding and impacts to property.

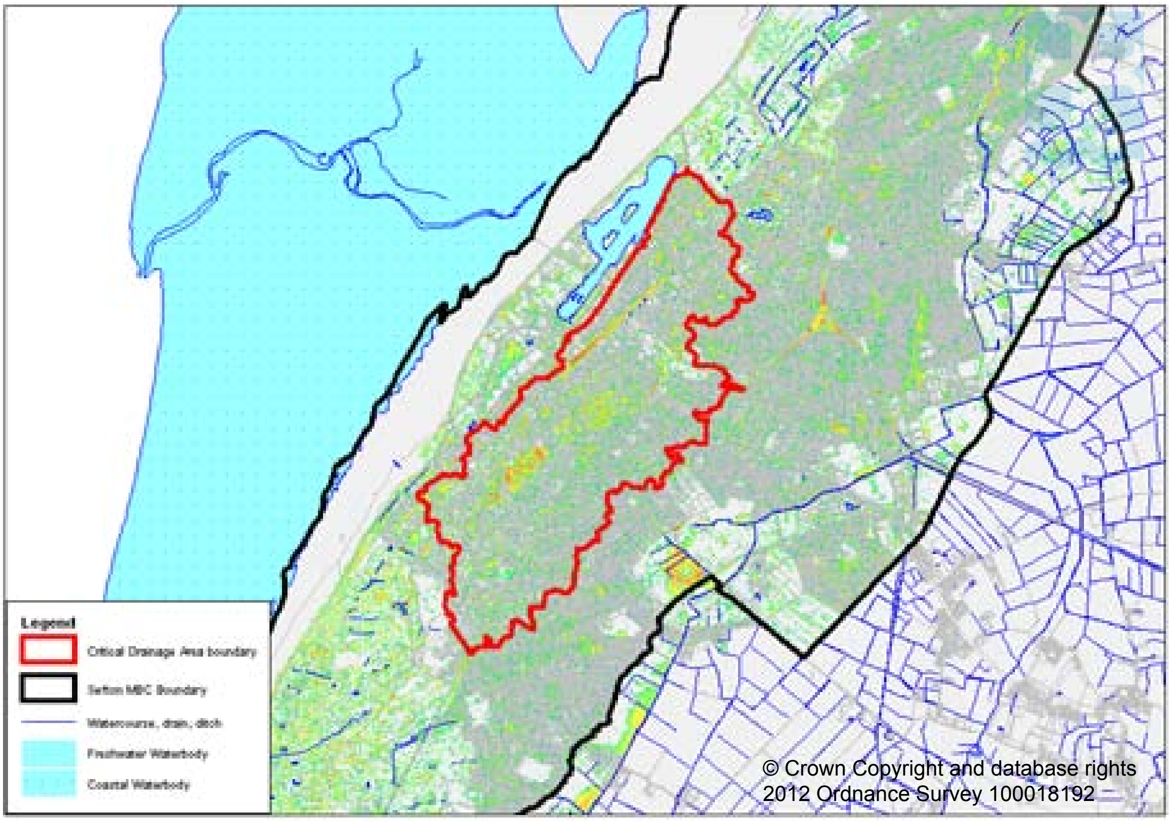

Figure C-28: Critical Drainage Area 22 – Southport: Coast

Critical Drainage Area Analysis

Statistical analysis has been undertaken on each critical drainage area to provide some justification for the measures and policies proposed within this SWMP. The following has been investigated and are presented in Table C-6, below:

- The number of homes, businesses and infrastructure (HBI) within each CDA;
- The type and number of homes within each CDA (detached, semi-detached and terraced);
- Estimated urban creep per year within each CDA;
- The number of HBI impacted during a Q100 event;
- The percentage of HBI impacted within each CDA during a Q100 event;
- The average number of HBI impacted per hectare per CDA during a Q100 event;
- The number of HBI impacted during a Q30 event;
- The percentage of HBI impacted within each CDA during a Q30 event;
- The average number of HBI impacted per hectare per CDA during a Q30 event.

Table C-6: Critical Drainage Area analysis

CDA	Area (ha)	No. of HBI	No. of Det.	No. of Semi.	No. of Terr.	Est. Urban Creep (m^2/yr)	Q100 HBI Imp.	Q100 % HBI Imp.	Q100 HBI Imp./ha	Q30 HBI Imp.	Q30 % HBI Imp.	Q30 HBI Imp./ha
1	44	843	201	486	91	365	256	30%	5.82	8	1%	0.18
2	239	4,719	250	2,743	1,138	1,452	1,130	24%	4.72	87	2%	0.36
3	119	2,161	330	1,089	459	762	724	34%	6.10	38	2%	0.32
4	276	3,037	395	1,429	805	1,002	780	26%	2.82	18	1%	0.07
5	138	321	85	147	45	133	82	26%	0.59	1	0%	0.01
6	4	46	18	12	9	21	22	48%	5.17	4	9%	0.94
7	53	719	207	265	182	298	232	32%	4.39	6	1%	0.11
8	160	3,743	102	2,202	990	1,099	863	23%	5.38	7	0%	0.04
9	198	3,486	98	1,090	1,659	769	839	24%	4.23	2	0%	0.01
10	1,518	32,886	634	9,213	14,353	6,397	10,670	32%	7.03	1,033	3%	0.68
11	78	1,147	139	526	306	365	249	22%	3.18	6	1%	0.08
12	60	1,151	107	656	313	392	308	27%	5.15	19	2%	0.32
13	386	8,449	789	3,333	2,253	2,292	2,785	33%	7.21	221	3%	0.57
14	217	4,156	153	1,032	1,110	702	1,164	28%	5.35	112	3%	0.52
15	18	296	161	90	23	168	143	48%	7.93	2	1%	0.11
16	195	2,743	1,133	1,209	171	1,405	936	34%	4.80	27	1%	0.14
17	813	6,962	2,213	2,827	685	2,983	2,351	34%	2.89	393	6%	0.48
18	286	3,797	1,447	1,654	208	1,836	977	26%	3.41	22	1%	0.08
19	19	196	188	8	0	154	56	29%	2.90	-	0%	-
20	218	2,785	321	1,943	191	1,045	657	24%	3.01	12	0%	0.05
21	1,239	19,445	2,730	10,620	1,720	6,601	5,980	31%	4.83	178	1%	0.14
22	469	12,779	1,393	2,223	1,067	2,152	5,450	43%	11.62	320	3%	0.68

The above table indicates that CDA 10 has the highest number of homes, businesses and infrastructure impacted during events with a 1in 100 (1%) and a 1 in 30 (3.3%) chance of occurring in any given year. This isn't surprising given the area of the CDA, and whilst not the worst in terms of the percentage of HBI impacted (32%, which is approximately average for all of the CDA's together) it is ranked 3rd in terms of HBI impacted per unit area. CDA 10 is also ranked 2nd with respect to total estimated urban creep per year, though when normalised by the area of the CDA, it is actually near the bottom of the CDA ranks because of the high proportion of Terraced housing.

By scoring each of the CDAs with a value of between 1 and 22 depending upon its rank in the last 6 columns of Table C-6 (grey fill), then the top three CDAs, i.e. those that have the highest number of properties impacted, the greatest percentage of properties impacted and the highest number of properties per unit area for both events, are CDA 22, CDA 10 and CDA13. If the predicted rate of urban creep, normalised by CDA area, is added then the ranking remains the same.

The rankings are presented below for reference. This should not be interpreted as a weighted scale of risk within each CDA, i.e. the risks implied by being rank number 1 does not imply that the risks are twice as great as those in rank number 2, as that is not the case. The rankings could, however, be used, along with the additional information presented within this SWMP, to guide application of recommended policy within these areas. This is principally because the scores are a reflection of the impact of both the 1 in 100 (1% chance event (pluvial and sewer flooding) and the 1 in 30 (3.3%) chance event (primarily sewer flooding) on homes, businesses and infrastructure.

Table C-7: Critical Drainage Area ranking scores

Rank	CDA	Sum of Scores (Columns 8 to 13, grey fill)	CDA	Sum of Scores (Columns 8 to 13, grey fill plus Urban Creep normalised by CDA area (ha)
1	22	120	22	127
2	10	118	10	124
3	13	111	13	124
4	17	98	3	106
5	14	96	17	102
6	3	90	16	101
7	21	87	14	98
8	6	85	21	98
9	16	82	6	95
10	2	78	2	92
11	1	70	1	91
12	12	70	15	91
13	15	69	12	87
14	18	58	18	73
15	7	55	7	67
16	8	46	8	64
17	4	45	4	48
18	20	37	20	46
19	9	33	11	40
20	11	32	19	40
21	19	20	9	38
22	5	18	5	19

Appendix D. Maps

Index of Maps Provided

Depth

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Sefton_SWMP_depth_5yrRP_Figure_1-1-4
Sefton_SWMP_depth_5yrRP_Figure_1-1-5
Sefton_SWMP_depth_5yrRP_Figure_1-1-6
Sefton_SWMP_depth_5yrRP_Figure_1-1-7
Sefton_SWMP_depth_5yrRP_Figure_1-1-8
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Sefton_SWMP_depth_30yrRP_Figure_1-2-6
Sefton_SWMP_depth_30yrRP_Figure_1-2-7
Sefton_SWMP_depth_30yrRP_Figure_1-2-8
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Sefton_SWMP_hazard_100CCyrRP_Figure_3-4-9

Groundwater
Sefton_SWMP_ groundwater_Figure_4-1-01
Sefton_SWMP_ groundwater_Figure_4-1-02

Appendix E. Draft Action Plan and Option Assessment Details

Draft Action Plan

A Draft Action Plan is presented in this Appendix, which outlines the following types of actions. Actions may be borough wide, relate to all Critical Drainage Areas or relate to specific locations.

Table E-1: Action type, definitions and explanations

Action Type Abbreviation	Definition	Explanation
FWMA / FRR	Flood and Water Management Act / Flood Risk Regulations	Duties and actions as required by the FRR and FWMA - Refer to Appendix A of the LGG 'Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management' (February 2011) for minimum requirements
Policy	Policy Action	Spatial planning or development control actions
C + M	Communication / Partnerships	Actions to communicate risk internally or externally to LLFA or create / improve flood risk related partnerships
F + R	Financial / Resourcing	Actions to secure funding internally / externally to support works or additional resources to deliver actions
I / F / D	Investigation / Feasibility / Design	Further investigation / feasibility study / Design of mitigation
FMA	Flooding Mitigation Action	Maintenance or capital works undertaken to mitigate flood risk

Potential Measures

<u>Flood Resistance and Resilience</u>

In addition to the measures presented in Section 4.2 and those outlined in the Draft Action Plan, the following table provides details of the areas that may benefit from the fitting of resilience and resistance measures. Appendix C identifies how the CDAs were defined and also how benefits from resilience and resistance measures were identified.

Table E-2: Areas that may benefit from resilience and resistance measures

Critical Drainage Area	Local Flood Risk Zone
01 – Lydiate	Between Moss Lane and Weld Blundell Avenue Silverstone Grove/Pilling Lane Silverstone Grove/Mallory Avenue
02 – Maghull	Between Oakhill Road and Wynstay Avenue, across Clent Avenue to Hickson Avenue Between Mersey Avenue and Moss Lane Between Moss Lane and Kendal Drive and then along and around Ravenglass Avenue and across Northway to Dodd's Lane. Tensing Road The Highbanks area
03 – Maghull	Between The Round Meade, across West Meade, Airegate and The Thorns to Green Lane

Critical Drainage Area	Local Flood Risk Zone
	From Manor House Close, running westwards across Green lane and down Hynchley Green to South Meade Between Liverpool Road South and Buckingham Road Old Racecourse Road and the Sefton Lane Industrial Estate
04 – Maghull	Adjacent to Whinny Brook to Dover Brook Between Broadoak Road and Farmdale Drive Between Station Road and the canal Between Northway and Woodend Avenue Either side of Fouracres and The Crescent Between Melling Brook in the south and Hudson primary School off Moorhey Road
05 - Maghull	Between the Leeds and Liverpool Canal and Willow Hey
06 – Melling	The junction of Tithebarn lane and School Lane
07 – Waddicar	From the junction of Waddicar Lane and Liddell Avenue, across Station Road, Chestnut Walk, Baytree Grove, Dapple Heath Avenue Satinwood Crescent and Cypress Close
08 – Aintree and Netherton	Taunton Drive From Bull Bridge Lane to Windsor Park Road, impacting properties around Greenside Avenue, North Avenue, Altway, Sandhurst Drive, Oriel Drive and Martland Avenue in between Between Aintree Parish Playing Field and Oriel Drive/Oreil Close with flooding of properties on Harrow Drive, Altway, Denstone Avenue, Tonbridge Drive and Haileybury Avenue Between Mostyn Avenue, Stoneyhurst Avenue, Altway, Keble Drive and Oriel Drive Copy Lane, including flats at Bechar's Court North of Dooley Drive and Deerbarn Drive Around Cumberland Gate, between Copy Lane, Dunnings Bridge Road and the Leeds and Liverpool Canal Eastern end of Apollo Way From and north of Lunar Drive, Parkway, Windsor Close and York Close until the Northern Perimeter Road
09 – Aintree and Netherton	Lingfield Close Between Parker Close and Hudswell Close Marina Crescent Marlborough Avenue Howard Florey Avenue, St. Oswalds Way, Eden Vale, Westminster Avenue and Peterborough Drive The Marian Way Between Fleetwoods Lane and St. Augustine's Way
10 – Bootle, Seaforth, Litherland and Great Crosby	Chester Avenue Eastern end of Moss Lane and in areas between Robinson Road and Kirkston Road North Areas in Ford, around Lonsdale Mews, Oatfield Lane and Ford Lane Westmoreland Avenue and Cumberland Avenue James Horrigan Court Elderly Persons Home Edgmoor Close From Moor Lane in the north, extending down and around The Northern Road, Moor Drive, the Byway, The Precincts, Rosedale Avenue, Seafield Avenue and Moorgate Avenue, through Belair Industrial Estate and along both The North Road South Parade/Nazeby Avenue and Kershaw Avenue/Endbutt Lane South Road in Waterloo Ronald Close and Brook Vale Princess Way, Sandy Road and Seaforth Road to Akenside Street Kelper Street and Lime Grove, Our Lady of the Sea Catholic Primary School, Maple Close, Muspratt Road, Meadow Hey, Cookson Road, Bowles Street, Seaforth Road, Deepdale Avenue and Bulwer Street until Crosby Street South

Critical Drainage Area	Local Flood Risk Zone
	Shore Road and Regent Road to Atlantic Terminal Sefton Road, Sefton Street and Field Lane Church Road between the canal and Kirkstone Road South including St. Phillips Church of England Controlled Primary School Between the railway and Hawthorne Road southwards into Bootle Town Centre Province Road, north eastwards along Menai Road and Park Lane to Orrel Lane, including Springwell Park Community Primary School From Southport Road along Reeves Avenue to impact Vaux Crescent Junction of Marsh Lane with the Leeds and Liverpool Canal
11 – Thornton	Newfield Close and Stannyfield Drive along Halifax Crescent, across Water Street and Hartdale Road to Quarry Road
12 – Thornton	Between Cranfield Road, Moorfield Road and Rosemoor Drive From Edgemoor Drive and cover flooding between this road and Meribel Close and Beech Park
13 – Crosby	West of College Road, between Rossett Park Football Club in the north and Crosby Road Parkfield Road, Molyneux Road and St. Johns Road Between St. Michaels Road and Campion Tennis Club to the west of Dowhills Road From Alexandra Park to St. Michaels Road, impacting properties in Cambridge Road, Cambridge Drive, Ince Avenue, Victoria Avenue, Cambridge Avenue and Victoria Road West Along De Villiers Avenue, Longfield Avenue, Woodend Avenue, Oaklands Avenue, St. Michaels Road, St. Andrews Drive, Hall Road East and Paddock Close
14 – Crosby and Blundellsands	Bronte Close, Channel Reach, Almacs Close and Seathwaite Close Warrenhouse Road, Sudbury Road, Endsleigh Road, Holden Road and Westward View Pinehurst Avenue Mason Street
15 – Hightown	Thornbeck Avenue St. Stephen's Road
16 – Formby	Larkhill Lane and Wicks Lane Junction of Harrington lane and Wicks Lane Between Greenloons Drive and Greenloons Walk St. Luke's Drive and Bushby's Park Between Kirklake Road and Queens Road Park Road, Hoggshill Lane, Osborne Road
17 – Formby	Phillips Close/Tyrers Close, Phillips Lane, Norburn Crescent, Birkey Lane, Conifer Court, Liverpool Road, Lytles Close, Cross Close, The Nurseries, Harthorne Cresent, Ditchfield, Bolton Close, Easby Close, Whalley Drive Formby Lane, Altcar Road and Fountain Way Burlington Avenue From Freshfield Road eastwards to Moss Lane, covering Hallsall Lane, Davenham Road, Church Road, Watchyard Lane and Freshfield Primary School Mount House Road, Longfield, Heather Close, Lingdales, Turnacre and Hawksworth Drive up to Eight Acre Lane Southport Old Road Wrigley's Lane and Wrigley's Close, Junction of Derby Road and Freshfield Road St. Peter's Avenue. Abbots Way and Abbot Close
18 – Ainsdale	Between Liverpool Road and Cornwall Way Between Rose Crescent and Sandy Brook Kings Meadow Primary School and Early Years Education Centre Gleneagles Drive, Windemere Crescent, Woodside Avenue Westminster Drive and Merefield School Mossgiel Avenue, including Ainsdale Station, and along Station Road, Sandringham

Critical Drainage Area	Local Flood Risk Zone
	Road and Burnley Road Halifax Road, Salford Road, Leamington Road, Liverpool Avenue and Ainsdale St. John's Church of England Primary School
19 – Ainsdale	Off Westminster Drive such as Grafton Drive, Daresbury Avenue, Arden Close, Bareford Close and Stratford Close
20 – Birkdale	Central Avenue and Ryder Cresent Halsall Road, Shaftesbury Road, Shaftesbury Avenue and Norfolk Road Sandon Road, between Hillside Road and Cardigan Road Within Birkdale Trading Estate, between Clifford Road and Richmond Road/Bedford Drive Hillside Station
21 – Southport	Bedford Road Between Clinning Road and Stamford Road Cemetery Road/Portland Street Scarisbrick New Road between Ash Street and Cumberland Road Jane's Brook Road Between Balfour Road, Forest Road and Dodworth Avenue Haig Avenue and the junction of Hart Street and Norwood Road Butts Lane, Crowland Street and Wennington Road Cobden Road, Canning Road, Milton Street, Newton Street, Bispham Road, Old Park Lane and Heysham Road Athole Grove, Wennington Road, Fisher Drive and Hereford Road Roe Lane, Moss Lane and Mill Lane From Preston Road (north west of Holy Trinity Sports Ground), affecting Rawlinson Road, Hilbre Close, Hilbre Drive, Rawlinson Drive and extending eastwards to affect Montrose Drive, Kings Hey Drive, Beresford Drive, Beresford Gardens, Coudray Road and properties to the south of Cambridge Road Cambridge Gardens Churchhill Avenue, Emannuel Road, Radnor Road , Longacre and Larkfield Lane Bakers Lane, Marshside Road, Mallee Crescent and Larkfield Primary School Balmoral Drive towards The Pool Merlewood Avenue Lexton Drive and Rathmore Crescent North Road, Asland Gardens, Roselea Drive, Poolside Walk, The Causeway, Preston New Road and Merepark Drive Lytham Road Kingston Crescent Bodmin Avenue, Helston Close, Croyde Close, Dawlish Drive and Preesall Close
22 – Southport	Trafalgar Road and Gainsborough Road Grosvenor Road to impact Waterloo Road Oxford Road, Weld Road and Saxon Road as far as Gloucester Road Aughton Road, Upper Aughton Road, Lyons Road, Part Street, Talbot Street, Duke Street, Cross Street, Railway Street, Portland Street, Southbank Road to Tulketh Street near to Southport Station Ericson Drive Alma Road and Clarence Road, Liverpool Road by Abbey Gardens London Street, Hawesside Street, Vulcan Street and in areas around Arnside Terrace Lord Street, Union Street and Castle Street, Seabank Road, Bath Street North and Gordon Street, Manchester Road and Court Road Area defined by Leicester Street to the south west, The Promenade to the north west, Gordon Street to the south east and Park Road West to the north east

Surface Water Storage/Attenuation

The following locations have been identified as potential surface water storage areas:

Table E-3: Potential attenuation areas within Sefton

Critical Drainage Area	Easting	Northing	Location
01	337200	404175	Ordinary Watercourse
02	338400	403235	Maghull Brook
	337960	403055	Maghull Brook
04	338620	401870	Whinny Brook
	339640	401890	Whinny Brook
	338450	401120	Whinny Brook
08	337800	398840	Aintree Parish Playing Fields
	335555	400035	Parkway
10	333615	399395	Rimrose Brook
	333130	397395	Rimrose Brook
	334390	398445	Moss Lane Playing Fields
	334540	398270	Moss Lane Playing Fields
	334330	397700	Church Lane
	334165	396120	Bootle North Recreation Ground
	335000	395600	Derby Park
11	333755	400650	Thornton County Primary School
12	333425	400075	Chesterfield High School
17	329640	406830	Phillips Lane Park
20	331880	413750	Hillside Golf Course
21	336825	419520	Pool Covert
	336730	419580	Recreation Ground

Potential diversion of flow

The following figure indicates the small catchment draining to Melling and identifies the potential direction of a diversion that may redirect some of the flow into the adjacent Brooklea catchment

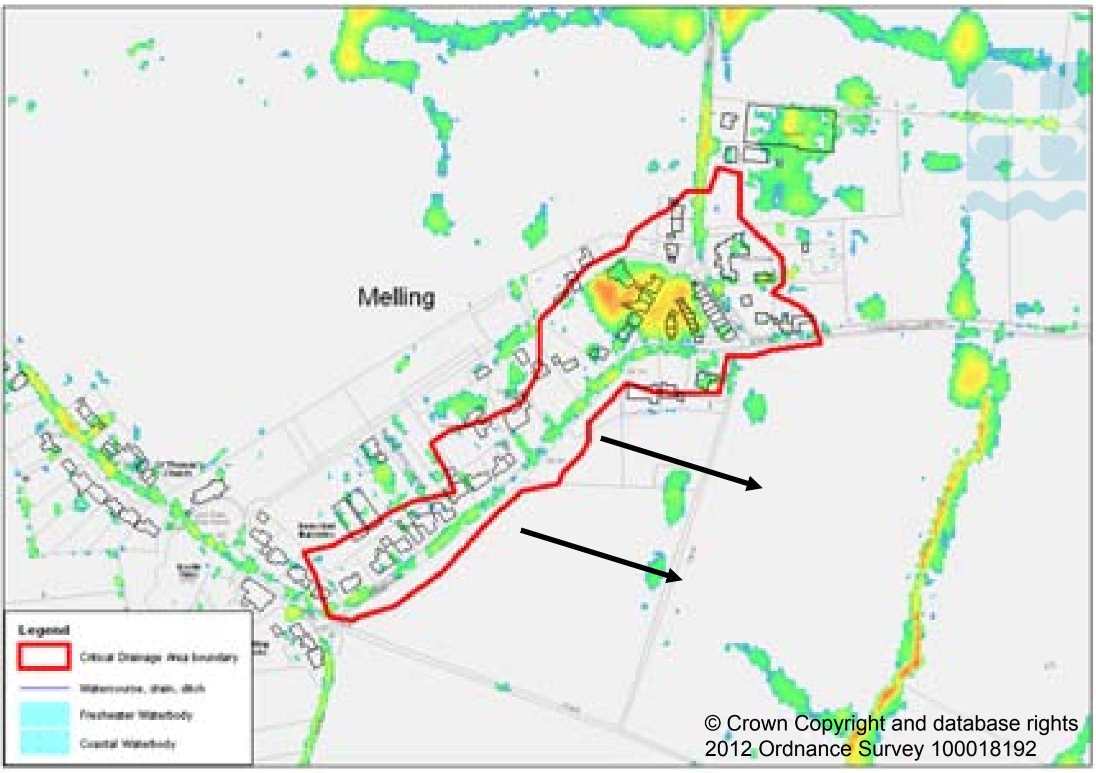

Figure E-1: Potential diversion to Brooklea at Melling

Potential relief culvert from Dobb's Gutter

The following figure indicates the potential direction of a relief culvert to take approximately 50% of the flow from the upper catchment into Bull Cop. It is understood that this option is under investigation as part of a study into Dobb's Gutter.

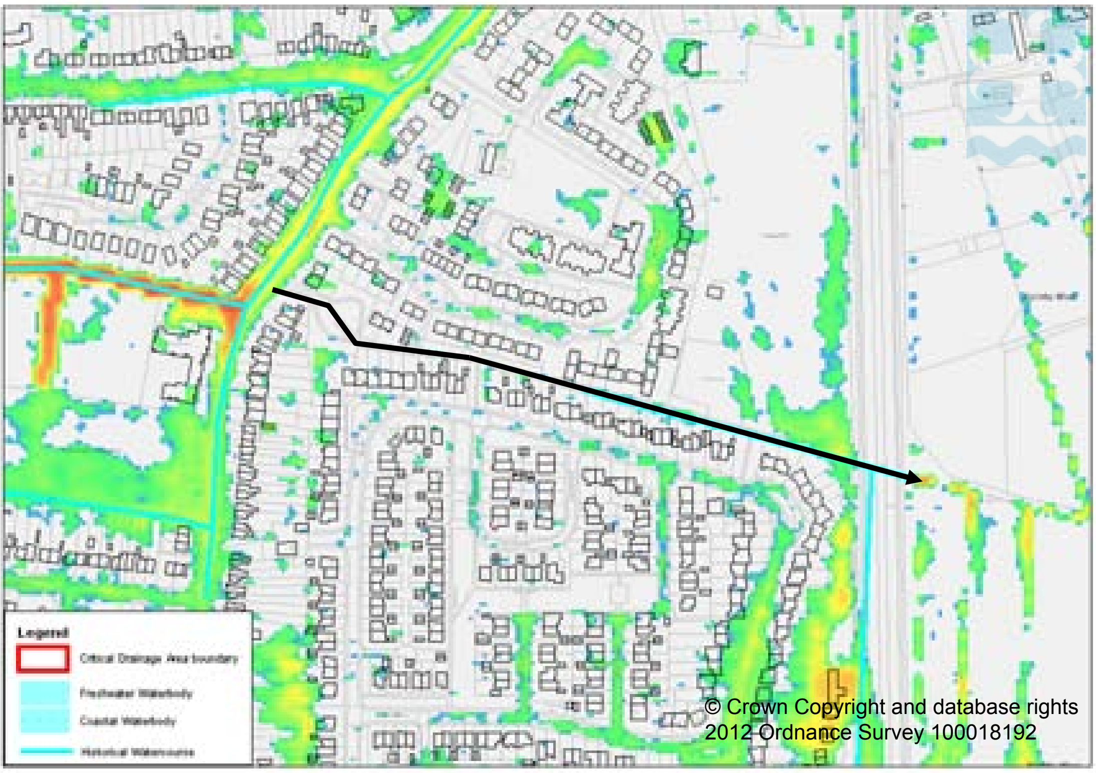

Figure E-2: Potential relief diversion from Dobb's Gutter to Bull Cop

Relief of deep ponding

The following figure indicates the location of deep ponding along the edge of Rimrose Country Park. To the west lies Nazeby Avenue and to the east lies Ford Lane. Both areas could be addressed by investigation of ways to direct floodwater past obstructions and into Rimrose Country Park.

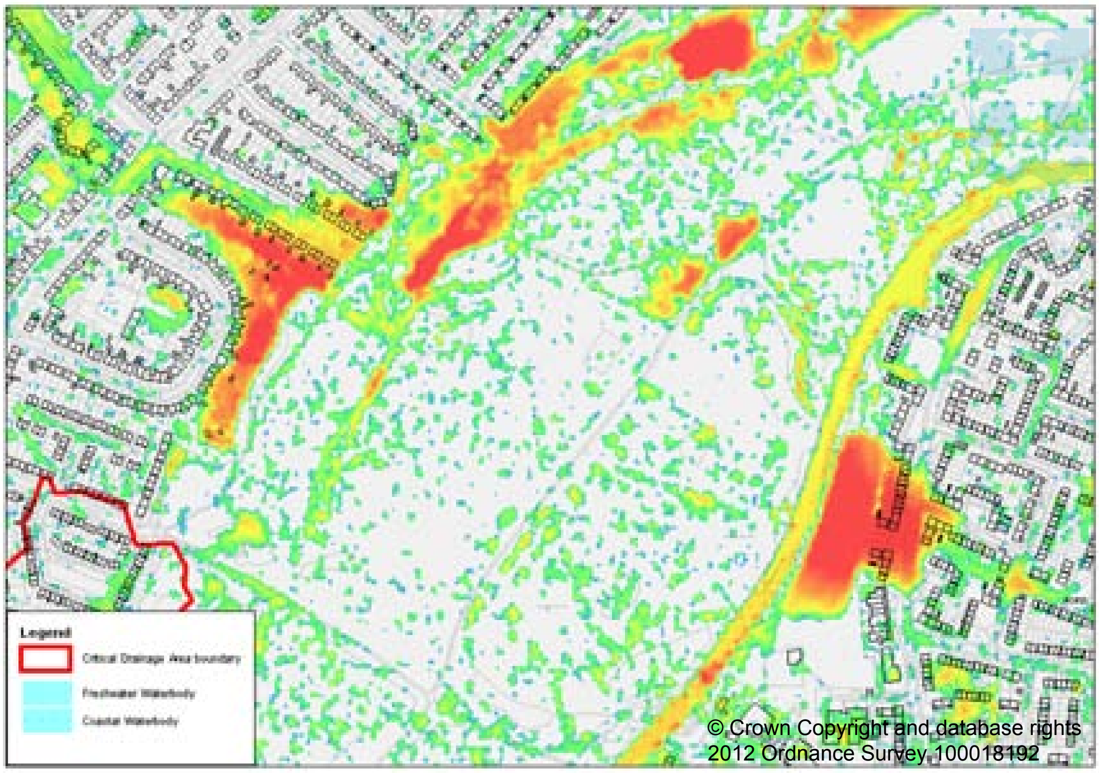

Figure E-3: Ponding in Nazeby Avenue and Ford Lane

Potential new flood defences

The following figure indicates the area inundated to the north of Hawksworth Drive, affecting the land between Acre Lane Brook/Eight Acre Lane and Wham Dyke. The flow paths to this area typically come from the north west, suggesting that surface water runoff from the rural area is the predominant source of flooding, complicated by the fact that Wham Dyke and Acre Lane Brook/Eight Acre Lane are main rivers and therefore the Environment Agency's responsibility.

A new defence along the southern edge of Acre Lane Brook/Eight Acre could relieve this source of flooding on the properties in this area, though care would be needed to ensure no impact on surface water runoff in this area, as some of it does discharge into the watercourse here.

Figure E-4: Flooding in Hawksworth Drive area from Wham Dyke, Acre Lane Brook and Eight Acre Lane