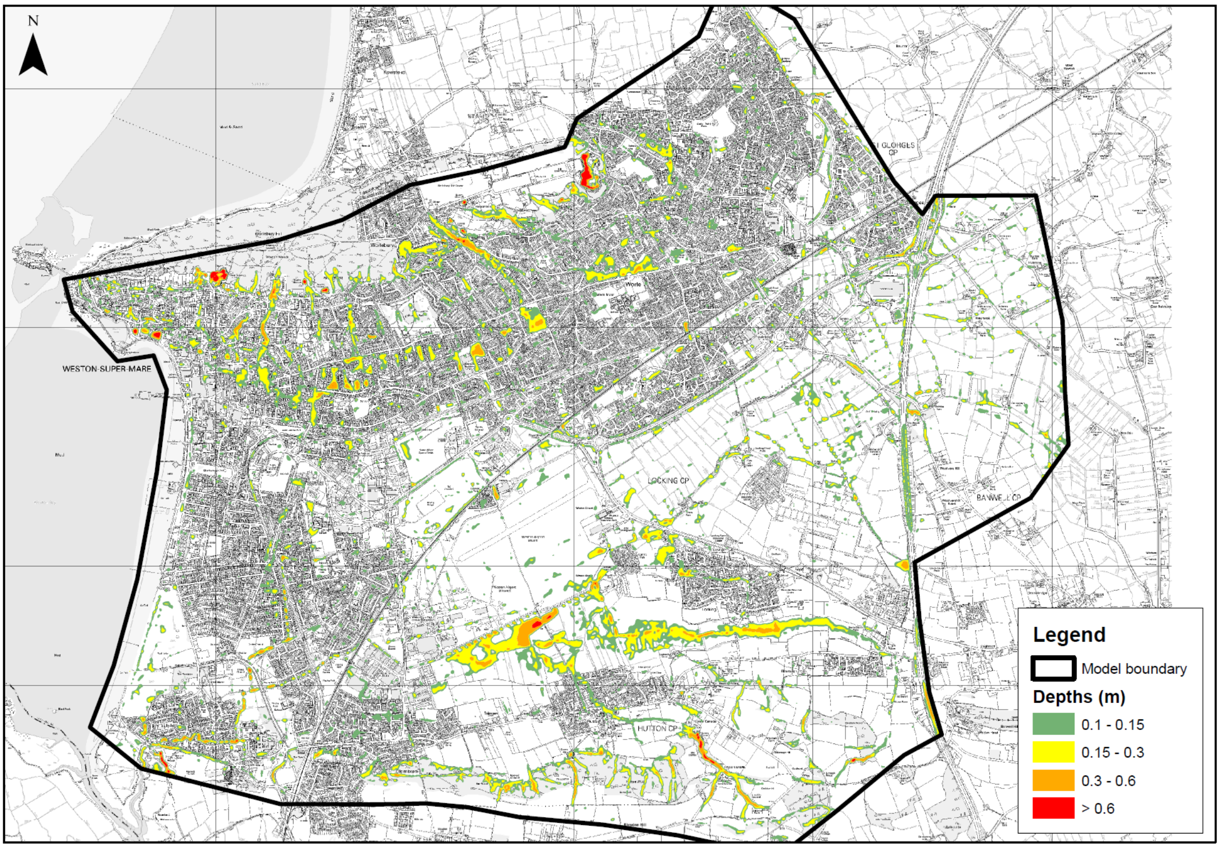

Weston-super-Mare
Surface Water Management Plan

North Somerset Council

June 2014

Final Report

9W0329

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HASKONING UK LTD.
COASTAL & RIVERS

Stratus House
Emperor Way
Exeter, Devon EX1 3QS
United Kingdom

+44 (0)1392 447999	Telephone
	Fax
info@exeter.royalhaskoning.com	E-mail
www.royalhaskoning.com	Internet

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Drafted by	Rachel Bird / Tom Ashby/ Nicola Wilson
Checked by	Martha Gaches
Date/initials check	09/07/2014 Martha Gaches
Approved by	Martin Whiting
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SUMMARY

As a result of the Flood and Water Management Act (2010), Local Authorities are required to undertake a leadership role for local flood risk management. This includes the flood risk from surface water, in particular the development and coordination of Surface Water Management Plans (SWMPs).

A partnership was established to enable the requirements of the Act to be fulfilled. This includes representatives from North Somerset Council Planning and Drainage departments, the Environment Agency, North Somerset Internal Drainage Board (IDB) and Wessex Water. North Somerset Council took the lead with the partnership and commissioned Royal HaskoningDHV in June 2010 to produce the Weston-super-Mare SWMP with guidance from the partnership. Secondary stakeholders were also identified and consulted as required.

This SWMP covers both the heavily urbanized Town Centre area and Weston Development Area, as shown in Figure 1.2. Large quantities ofdata already existed based on previous work, particularly the Level 2 Strategic Flood Risk Assessment (SFRA) completed in 2010 and the Environment Agency Surface Water Maps. These data were reviewed and used to help decide on the appropriate level of risk assessment for the area, based on the nature of existing problems and levels of risk. An intermediate assessment was deemed most suitable, identifying key problem areas using broad-scale hydraulic modelling and site assessments to guide the development of flood mitigation options and policies and to identify where future detailed assessment may be required.

A 2-dimensional TUFLOW hydraulic model was developed, incorporating the drainage system as an absorption rate. The Depth-Duration-Frequency function within the Flood Estimation Handbook (FEH) CD-ROM version 3 was then utilised to determine representative rainfall depths for Weston-super-Mare for various return period rainfall events.

For each return period event three scenarios were considered as part of the modelling process:

- Drainage system operating as designed
- Tide-locked scenario due to the low level of the outfall
- Saturated ground i.e. an intense storm following a period of continuous rainfall

The drainage system operating as designed is the main focus of this study. The other scenarios have been considered to ensure that the worst case is also taken into account.

The results from the modelling were mapped to show any flooding greater than 100mm in depth for each return period, as shown in Appendix C. The number of properties at risk, as well as critical / vulnerable assets, were highlighted for each event. This showed that across the study area there could be up to approximately 180 properties at risk from a 1 in 100 year design rainfall event assuming the drainage system is operating as designed. This would rise to over 900 properties if the whole area is saturated. In addition there could be approximately 29 to 49 critical / vulnerable assets at risk for the current drainage and saturated scenarios respectively. Note that these estimates are

based on an assumed threshold level of 300mm above adjacent ground level and includes a large number of flats.

Based on the number of properties at risk, an estimate was made of the potential damage that could be caused from a severe surface water flood event across the study area. This showed that the present value damage based on a 100 year scheme is approximately £14.5 million, suggesting that a scheme could be viable.

Following extensive reviews of the model results and the assessment of the number of properties affected by surface water flooding, with the exception of one or two locations, most of the flooding is limited to one or two properties per area. It is therefore unrealistic to identify specific key areas of flooding. Rather than identifying key flood risk areas we have therefore divided the study area into policy units, based on a number of criteria. These criteria include location, topography, land use, density of properties and drainage network. This has produced the following areas, as shown on Figure 4.2:

Policy Unit 1. Worlebury/Milton/Worle
Policy Unit 2. Uphill/Oldmixon/Hutton
Policy Unit 3. Central and West/South Worle
Policy Unit 4. Weston Villages/Locking

The majority of the properties and critical / vulnerable assets fall within Policy Unit 1 (Worlebury/Milton/Worle). Based on the area split above, appropriate policies for managing surface water flooding within each unit have been determined as shown in Table 4.3. These look at both the current situation i.e. policies that can be implemented straight away, and into the future should flooding become more of an issue. The policies considered as part of this assessment were ‘No Active Intervention’, ‘Maintain’, ‘Enhance’ and ‘Construct’. Options within each policy have then been recommended where possible and then an Action Plan has been developed to help prioritise and implement the policies.

CONTENTS

1 INTRODUCTION

1.1 Context

The Surface Water Management Plan (SWMP) Technical Guidance published by DEFRA (2010) describes surface water flooding as:

- Surface water run-off as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity, thus causing flooding (known as pluvial flooding);
- Flooding from groundwater where groundwater is defined as all water which is below the surface of the ground and in direct contact with the ground of subsoil;
- Sewer flooding; flooding which occurs when the capacity of underground systems is exceeded due to heavy rainfall, resulting in flooding inside and outside of buildings. Note that the normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters as a result of weather or tidal conditions;
- Flooding from open-channel and culverted watercourses which receive most of their flow from inside the urban area and perform an urban drainage function;
- Overland flows from the urban/rural fringe entering the built-up area, and;
- Overland flows resulting from groundwater sources.

As a result of the Flood and Water Management Act (2010), Local Authorities are required to undertake a leadership role for local flood risk management. This includes the flood risk from surface water, as outlined above and therefore includes the development and coordination of Surface Water Management Plans (SWMPs).

The Pitt Review referred to SWMPs as a **'tool to manage surface water flood risk on a local basis'**. SWMPs will assist Local Authorities in understanding the mechanisms of surface water flooding in their area, identifying areas at risk and potential options for mitigation. SWMPs should be evidence and risk based, take climate change into account and complement existing flood risk management policy. They should establish a long-term action plan to manage surface water in consultation with key local stakeholders and partners, such as county, unitary and district councils, the Environment Agency, IDB and water and sewerage companies
The framework for undertaking a SWMP is illustrated through the diagram shown in Figure 1.1. This demonstrates the four principal stages of a SWMP: Preparation; Risk Assessment; Options; and Implementation and Review. The DEFRA Guidance sets out a number of steps that should be followed under each stage. The process is largely sequential and can be followed by starting at 12 o'clock and progressing clockwise.

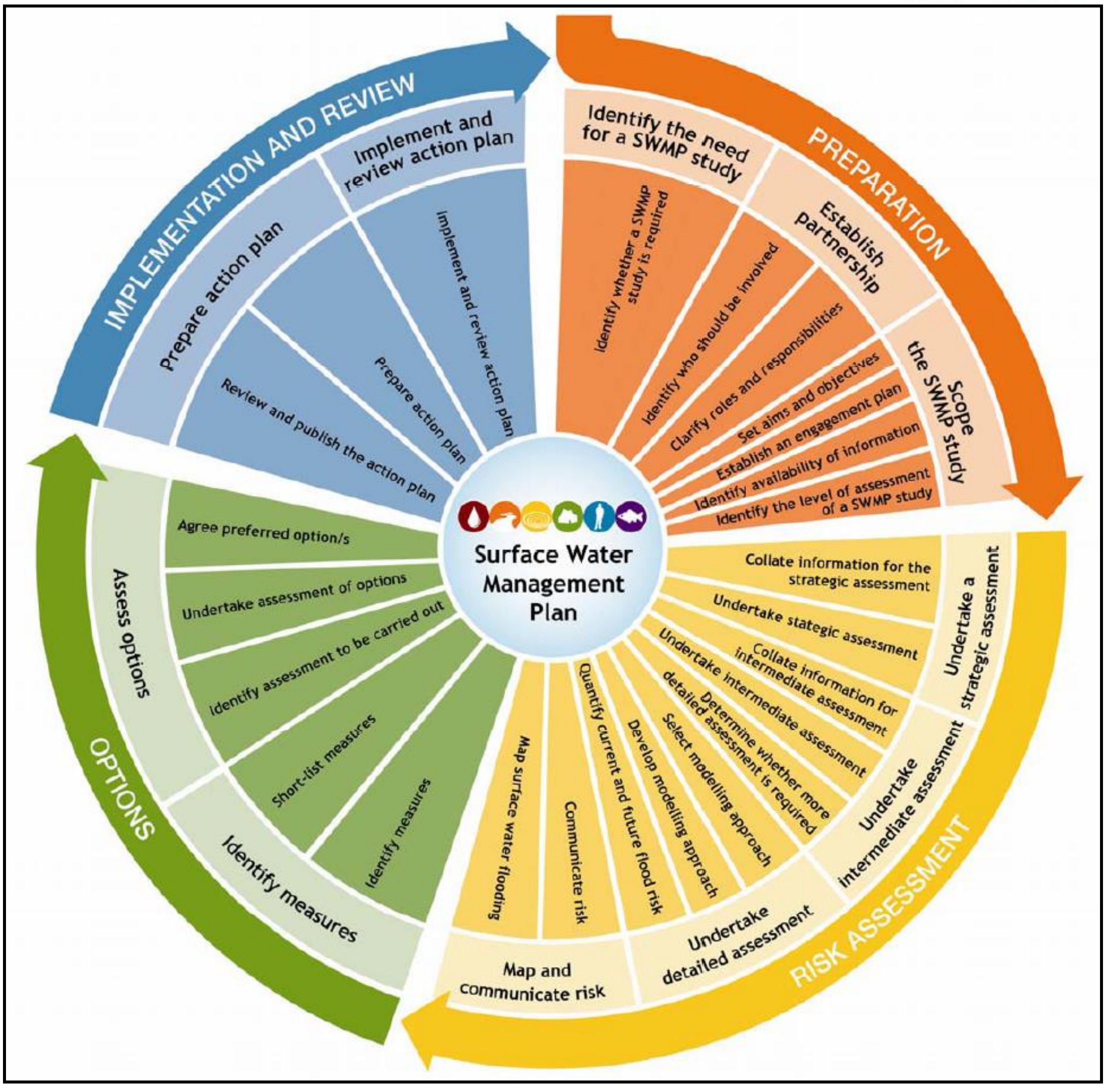

Figure 1.1 – Framework for undertaking a SWMP

Sections 2 to 5 of this report focus on each of the four segments shown above; Preparation, Risk Assessment, Options and Implementation and Review.

1.2 Study Area and Project Background

The study area covers the whole of the Weston-super-Mare urban area. It extends from Birnbeck Head and Worlebury Hill to the north to Uphill south of Weston-super-Mare, and from the coast to approximately 1km east of the M5 motorway (see Figure 1.2). The topography of the study area is shown in Figure 1.3.

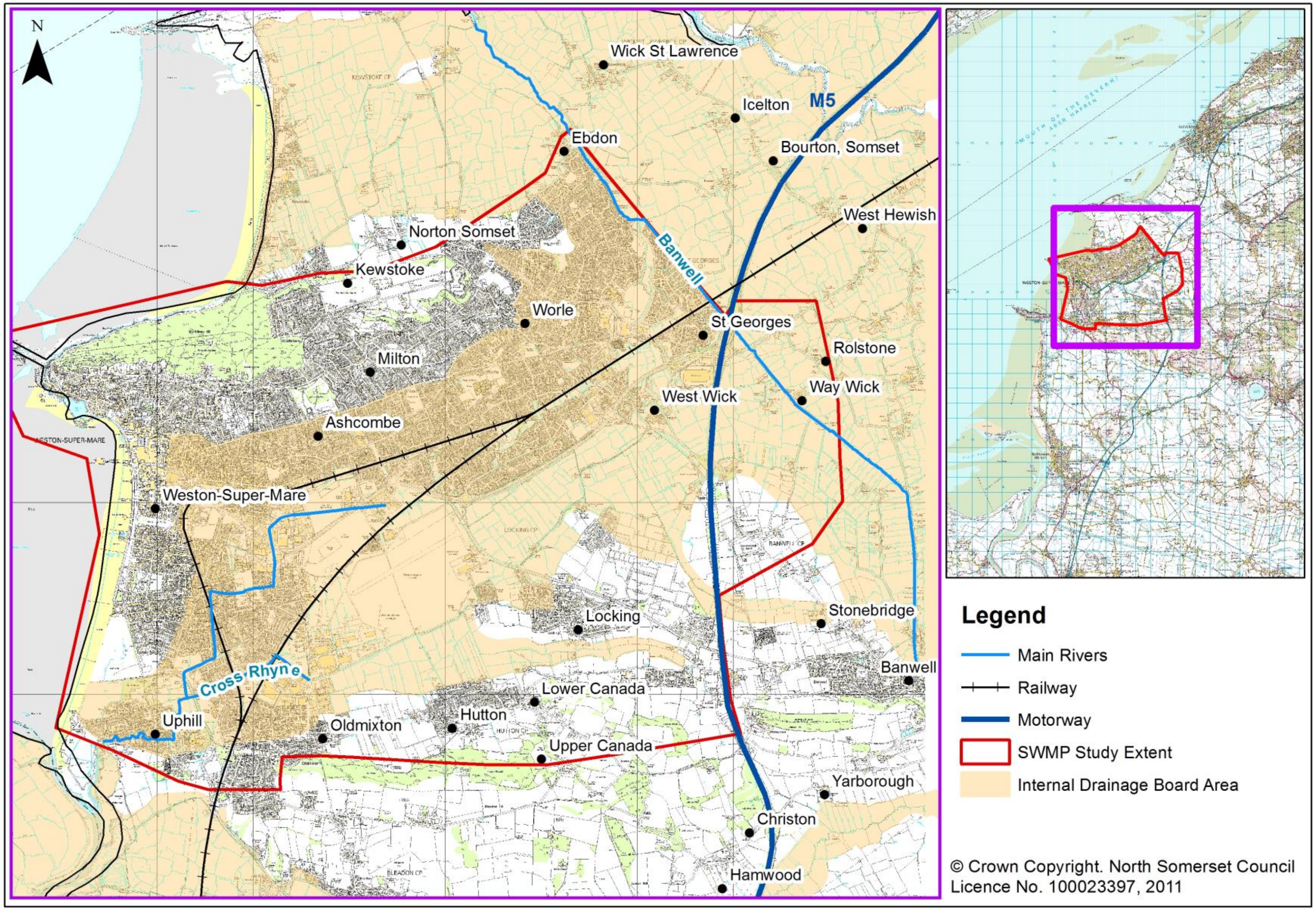

Figure 1.2 – Location plan

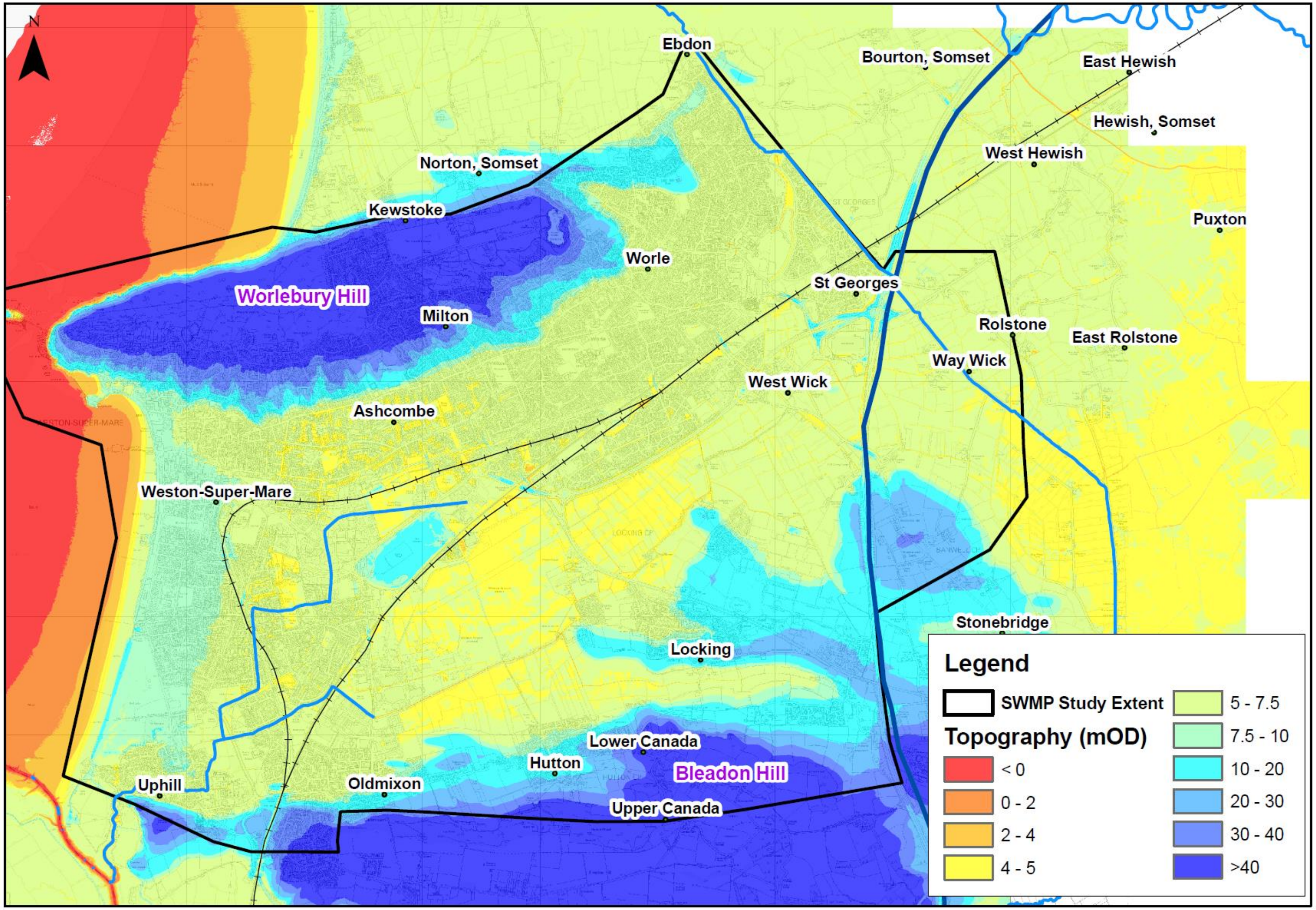

Figure 1.3 - Topography

Weston Bay is west facing with a wide inter-tidal mud area and sandy foreshore. The coastline is largely developed, fronted by residential, commercial, recreational and tourist interests.

The study area is characterised by a network of rhynes connecting to two significant watercourses, the River Banwell and the Uphill Great Rhyne Banwell, and Cross Rhyne are ‘Main River’ and under the control of the Environment Agency.

The Uphill Great Rhyne is approximately 4.5km in length and drains water from the area of Weston Airfield. Uphill Great Rhyne runs from Wyvern School through the residential areas of southern Weston-super-Mare and Uphill and discharges at Uphill Sluice. A 1.6km culvert feeds surface water into the head of Uphill Great Rhyne. Another major channel, Cross Rhyne, joins Uphill Great Rhyne upstream of Weston General Hospital. Cross Rhyne drains water from the Weston Airfield area. The channel outfalls into Uphill Pill, via Uphill Sluice, which was constructed in 2004. It is a tidal sluice which prevents tide water from entering Uphill Great Rhyne at high tide and allows the Rhyne to drain at low tide. There is a period of approximately 3 hours on each tide when the Uphill Great Rhyne is tide locked and cannot drain which will compound any surface water flooding issues in the area.

The River Banwell is a largely artificial channel 9km in length, located to the east of Weston-super-Mare. The river rises at a spring at Banwell Village, drains the surrounding agricultural land and discharges through New Bow Sluice, a tidal defence structure. The current sluice was constructed in 1990, replacing an earlier sluice of inadequate capacity and is 0.8km upstream of the confluence with the Severn Estuary. The gradient of the river channel is very shallow (approximately 1 in 3300 or 2.7m over 9km) and the flow in the river is consequently dominated by daily tide locking at the New Bow sluice. Ground water levels are reported to be very close to ground level in some of the developed areas. This causes problems with constructing local sustainable urban drainage attenuation measures and results in potential problems with water logging. In one area, due to development it has been necessary to pump surface water into the River Banwell and construct a number of small storage facilities to counteract the increased flood risk.

North Somerset Levels Internal Drainage Board (IDB) operates and maintains the rhyne system. This includes water control structures which are used to control water levels in the area. Typically, during the summer months, water in the River Banwell is held back or penned to provide water for irrigation, wet fencing and general amenity. During the winter months these various water level control structures are opened to allow the free discharge of flow and to reduce flooding risks. The IDB also operate control structures as part of local flood storage systems in the area of the Locking Castle development.

With the exception of Worlebury Hill to the north and Bleadon Hill to the south the topography of the study area is very flat. This is shown in Figure 1.3 and reflected by both the Environment Agency mapping and the modelling results from this study.

Based on the information provided to Lead Local Flood Authorities for the production of a Preliminary Flood Risk Assessment (PFRA), Weston-super-Mare is not classed as an Indicative Flood Risk Area in terms of surface water flooding. These Flood Risk Areas are made up of clusters of Places above the Flood Risk Thresholds that are adjacent to each other. Some areas of Weston-super-Mare are classified as Places above the Flood

Risk Threshold as they do exceed at least one of the thresholds set to identity flood risk places, i.e. the number of people at risk from surface water is greater than 200, or there is at least one critical service at risk, or the number of non-residential properties at risk is greater than 20. The Places that are above the Flood Risk Threshold include parts of Worlebury, the sea front and central Weston-super-Mare, Worle, Milton and the land between Hutton and Locking.

Flood defences in the study area are mostly tidal, comprising a newly constructed sea defence (2010) along the urban sea front at Weston-super-Mare and a sluice at Uphill. The River Banwell also has a small section of defended reach at St Georges. The rest of the watercourses in the study area are undefended for the most part with small culverted sections in urban reaches.

1.3 History of Flooding in Weston-super-Mare from all sources

Flooding is an issue with varying levels of severity across most of the study area. Significant and extensive flooding has occurred on a number of occasions due to a combination of high tides, high waves and strong onshore wind conditions. This flood risk has been significantly reduced following the completion of the 2010 sea defence scheme. In some locations flooding is made worse by tide locking as some areas are below the high tide level and cannot drain during high tide periods. Less severe but more frequent flooding in the town and the highway network is predominantly from locally overtopped defences (both tidal and fluvial), surface water run-off and the blockage of drains and culverts.

There is a history of fluvial and tidal flooding within the study area, as shown in Figure 1.4. The north of Weston-super-Mare has previously been affected by flooding which results from overtopping of the sea defence wall between Marine Lake and Grand Pier. Work to build a new sea defence scheme has recently been completed to address these tidal flooding issues. In addition, anecdotal reports indicate that in recent years minor flooding has also occurred in the low lying areas (such as the airfield and railway triangle, Banwell Moor and St Georges Village). Significant tidal flooding has also been recorded in the past at Uphill as a result of the failure of the previous Uphill tidal sluice.

Surface water flooding due to intense rainfall is known to be a problem, as shown by the Wessex Water DG5 database. This mainly flags up the sea front area, Milton Hill and the east of Uphill. Note that following the completion of the sea defence scheme, the drainage along the sea front has been improved.

The Environment Agency records flooding incidents in their Flood Reconnaissance Information System (FRIS) and the system highlights the source of flooding where possible. North Somerset Council and the IDB have collated information regarding flooding incidents, although less in known regarding the source of the flooding.

There is limited evidence of any groundwater flooding, although there are several springs in this area where the flooding could have been attributed to alternative sources e.g. surface water run-off or river flooding. In addition, the high groundwater table in this low lying area could contribute to the severity and impact of fluvial or surface water flood events by reducing the storage capacity of the ground.

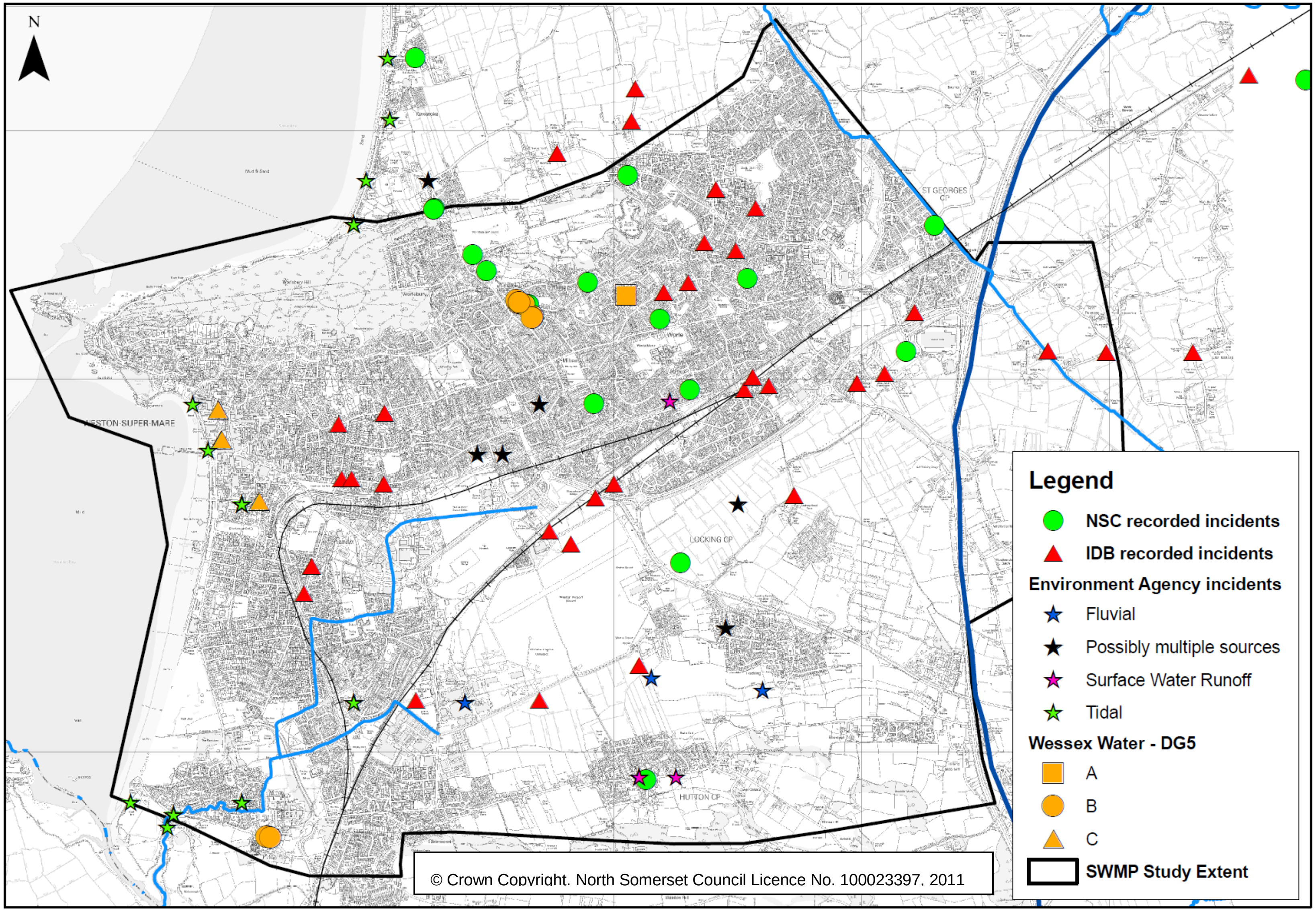

Figure 1.4 – Locations of historic flooding (up to 2010)

The Environment Agency has produced a number of groundwater vulnerability maps. These are split based on the superficial (drift) aquifers and bedrock aquifers. These maps show that there are no Principal superficial (drift) vulnerability zones but there are areas of vulnerability based on the bedrock. Worlebury area, south of Hutton and Banwell are all classed as Principal aquifers and therefore provide a high level of water storage, whilst the Locking area is a Secondary A aquifer which supports the local rather than strategic water supply. The remaining area is classed as Secondary B aquifer which has a low permeability and therefore limited water storage.

There are also a number of source protection zones within the study area. These zones are designed to help protect the drinking water supply by monitoring the risk of contamination from any activities that might cause pollution in the area. Banwell, to the east of the M5 is an inner protection zone, whilst Bleadon, Christon and Loxton area are covered by an outer zone.

There are a number of Environmental Designations within the study area as shown in Figure 1.5. The main concern for this study is the 106 listed buildings. The remaining designations are either related to the Severn Estuary, or some of the cliffs, parks, gardens and ancient woodland. It is unlikely that surface water flooding will cause significant damage to these designations, although prolonged ponding of water could harm the vegetation and wildlife in the area.

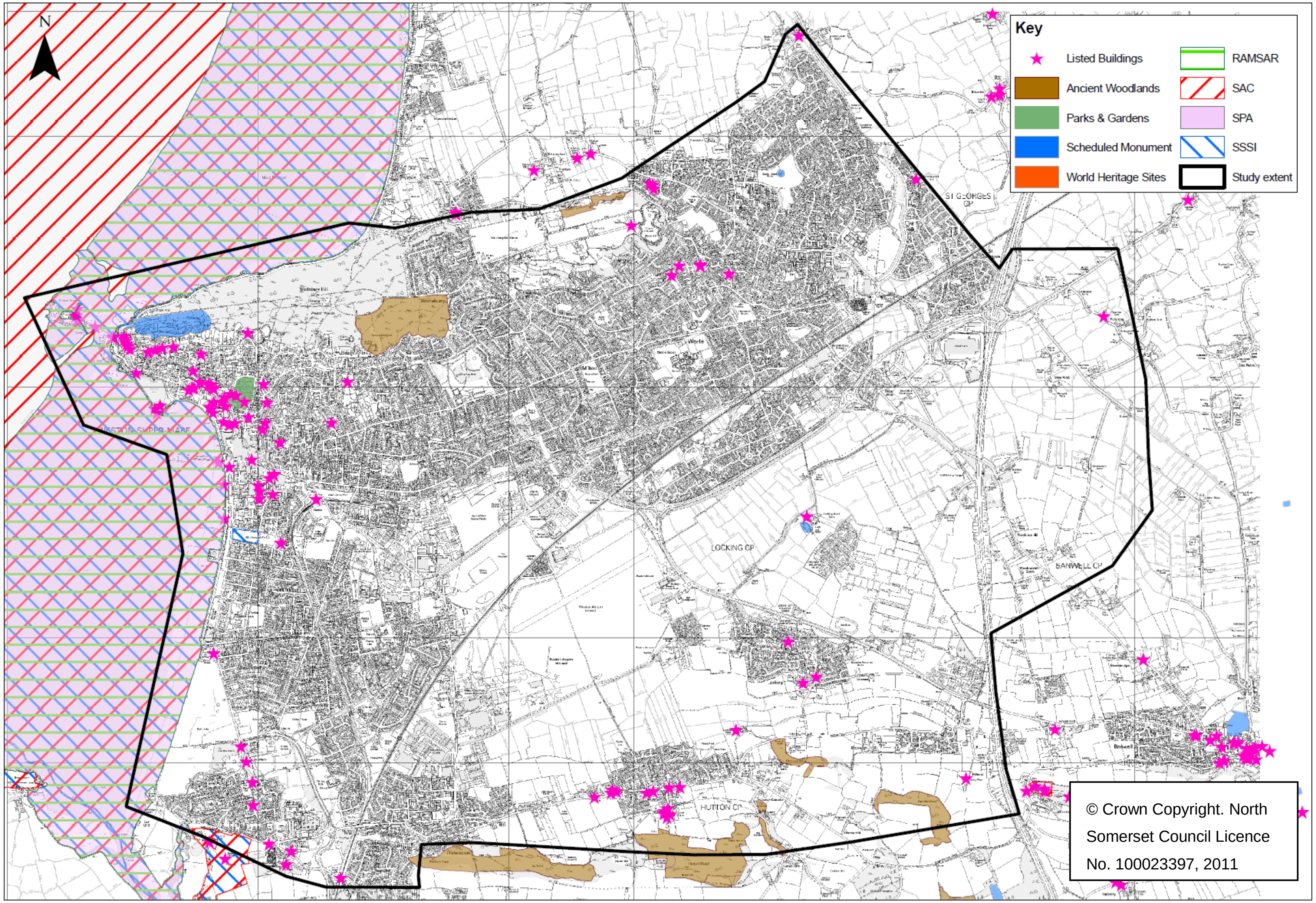

Figure 1.5 – Environmental designations

1.4 Current and previous projects

There have been a number of studies completed covering Weston-super-Mare in recent years.

Weston-super-Mare sea defence studies
There were numerous studies related to the new sea wall, which was constructed between 2008 and 2010, with completion in October 2010. The focus of these studies was the tidal flood risk to the town. These studies included hydraulic modelling, benefit assessment and a Project Appraisal Report.

Weston-super-Mare Flood Management Studies
There has also been a Flood Management Study for Weston-super-Mare, with a number of follow up reports due to changes in the planning requirements and expected housing numbers. The focus of these studies was the fluvial flood risk to the Weston Development Area and the impact of development on the surrounding area. Based on 1-dimensional hydraulic modelling these studies put forward a recommendation for a strategic approach in the area, focusing on the use of a “super pond” in the Uphill catchment, along with improvement works along the River Banwell. Amendments are currently being made to this plan due to recent planning applications and changes to housing allocations.

Strategic Flood Risk Assessments
A Level 1 Strategic Flood Risk Assessment (SFRA) was undertaken for the whole of the North Somerset Council area in 2008. This report provided an overview of the flood risk to the area and pulled together existing information regarding historic, current and future flood risk. A Level 2 SFRA was then undertaken in 2010 focusing on Weston-super-Mare and the surrounding area (including the Weston Development Area). This involved utilising existing information regarding the fluvial flood risk and extending the existing 2 dimensional hydraulic model to further look at the tidal flood risk both now and 100 years into the future. This Level 2 report also provided recommendations for planning across Weston-super-Mare.

Weston Villages Strategic Flood Storage Studies
There have been numerous studies into the potential to create strategic flood storage in the development area of Weston-super-Mare for both the Cross Rhyne and River Banwell. This has included detailed modelling studies to inform the design and construction of the storage ponds. These storage ponds are currently (summer 2014) under construction through a phased approach to align with the development of the area.

Detailed Flood Risk Studies
Detailed studies and modelling have been undertaken at Diamond Batch/Summer Lane to identify potential flood risk management schemes to manage flooding in these locations.

There have also been national projects to map the surface water flood risk across England. This is discussed in Section 3.2.

2 PREPARATION

Once the need for a SWMP has been identified, a partnership should be established, (if it does not already exist), and partners should identify how they will work together to deliver the SWMP. Project aims and objectives should be defined and the timing and mechanisms of stakeholder engagement established. An assessment should then be undertaken to identify the information required for the study, its availability and quality. Based on the defined objectives, current knowledge of surface water flooding, and the availability of information, partners should agree the level of assessment at which the SWMP study should start.

2.1 Partnership

The Weston-super-Mare SWMP involves the following partners / primary stakeholders:

- North Somerset Council (Planning and Drainage representatives)
- Environment Agency
- North Somerset Levels IDB
- Wessex Water

The following secondary stakeholders were also identified and have been consulted as required:

- North Somerset Council Corporate Communications, Education, Housing, Highways, Car parks
- Primary Care Trust – Hospitals, doctors surgeries etc
- Emergency Services & Weston-super-Mare Coastguard
- Weston-super-Mare Town Council
- Community groups
- Other utility companies e.g. Bristol Water / Gas / Electricity / Telecoms / Cable
- Network Rail
- Large and small businesses including Hotels
- Local Radio and TV
- Car parks (private owners)
- Camping and Caravan sites

North Somerset Council took the lead with the partnership and commissioned Royal HaskoningDHV in June 2010 to produce the SWMP with guidance from the partnership.

2.2 SWMP Objectives

At the start of the partnership terms of reference were created to specify the aims and objectives. This set out the purposes of the partnership, the principles and the roles and responsibilities. The main objectives of the partnership were:

- Create a project plan outlining key activities and milestones
- Agreed list of stakeholders

- Help to produce a SWMP that matches the agreed scope and outcomes
- Produce a Communication strategy
- Develop a costed programme of mitigation works based on the findings of the SWMP
- Commitment to a wider and longer term partnership in North Somerset

2.3 Collation of Information

The existing data collected as part of the Level 2 SFRA was reviewed and data gaps highlighted. A data request was then issued to the partners to try to fill these data gaps. Table 2.1 shows the datasets which were utilised as part of this study, along with details of the source of the data and the use:

Table 2.1 – Dataset used

Dataset	Source*	Use
EA Flood Zones	EA	To highlight the fluvial and tidal flood risk so that combined events can be considered.
EA Surface Water Maps	NSC	To flag up key areas at risk based on National mapping.
OS Mapping & Mastermap data	NSC	To provide background information and input to the model
Locations & details where available of historic flood incidents	EA, NSC, WW, IDB	Used to verify the model results (up to 2010)
LIDAR (Light Detection and Ranging)	EA	To provide details of the topography of the area for review and input into the hydraulic model
Flood defence information	EA, NSC	
Details of any current SUDS in place or plan	NSC / WW	We were provided with an idea of some of the proposed works at Milton Hill.
Gauge data	EA / WW	Used to verify rainfall quantity and intensity. This included the rainfall data reviewed by Wessex Water for the calibration of their Milton Hill model.
Locations of Environmental Designations	Website download	These were downloaded from magic.defra.gov.uk to provide information regarding any potential damage to environmental designations.
Schematics of sewer networks including information regarding known capacity limitations or planned improvements	WW	To determine the drainage capacity of the system
Geology data	BGS	This data was downloaded for the UK from the BGS website to give an indication of the underlying geology of the study area and therefore some context to the flood risk areas shown.
Ground water information	EA	Downloaded from EA website to provide an indication of the potential groundwater flood risk.
Borehole data	BGS	Sample borehole data viewed from BGS website to provide further details regarding the soil and permeability of the area.

* EA = Environment Agency, NSC = North Somerset Council, WW = Wessex Water, IDB = Internal Drainage Board

3 RISK ASSESSMENT

The Preparation phase of the SWMP will help to identify the level of risk assessment required for the study:

- A strategic assessment can be carried out to identify areas more vulnerable to surface water flooding which require further study;
- An intermediate assessment, if required, highlights 'hotspots' of surface water flood risk within the study area and identifies quick win mitigation measures. Scoping of requirements for a detailed assessment can also form part of the intermediate assessment;
- A detailed assessment may be required to fully understand the flood risk and test potential mitigation measures.

Outputs from the intermediate and detailed assessments should be mapped and communicated to all partners and stakeholders identified in Section 2 in addition to the public.

3.1 Understand Risk

The preparation phase of the SWMP included the collation of information and discussions with the partners and primary stakeholders (listed in Section 2) during monthly stakeholder meetings. During this process of review and discussion, the appropriate level of risk assessment for the area was decided on, based on the nature of existing problems and levels of risk. On the basis of this, the approach for the study was devised along the lines of an intermediate assessment, identifying key problem areas using broad-scale hydraulic modelling and site assessments to guide the development of flood mitigation options and policies and to identify where future detailed assessment may be required. Following this stakeholder meetings were then held when necessary to discuss the outputs and findings of the study.

Wessex Water have undertaken a detailed assessment of surface water flooding for one of the main 'hotspots' within the study area (Milton Hill). This work includes a detailed hydraulic model of the drainage network combined with the overland DTM. For specific queries regarding Milton Hill we suggest that use of the outputs from the Wessex Water assessment should be considered as this is much more detailed and tailored to the specific area.

3.2 Environment Agency Surface Water Flooding Map

The Environment Agency has produced two sets of maps showing the surface water flood risk across England. The first generation maps, published in 2008, show the Areas Susceptible to Surface Water Flooding (AStSWF) and the second generation show the Flood Map for Surface Water (FMfSW). Since this study was undertaken, an updated FMfSW (uFMfSW) has been produced in November 2013 considered a significant improvement on the previous surface water flood maps in method and representation of flood risk. A technical note was produced (appendix D) comparing the representation of risk for the modelling produced as part of this SWMP with the uFMfSW. At the time of writing and for the purposes of this study, the uFMfSW has not been incorporated into this plan.

The FMfSW is the newer and therefore primary source of nationally derived information. The AStSWF map provides further supporting information, but ultimately it is the Lead Local Flood Authorities who decide which information to use, the nationally derived information, or local knowledge, historic records or models. Logically the LLFA know their area better than others and therefore are best placed to interpret the suitability of the maps for their area. Neither map is intended to be definitive, but provides information to support local flood risk management in the absence of any better information. When referred to together these are known as the Environment Agency surface water flood maps.

The maps have been developed at a national level to provide information to Government and Local Resilience Forums (LRF). This national scale means that the maps should be used with caution at a local level and should not be relied upon as the sole evidence for determining planning applications. The maps do not show the susceptibility of individual properties to surface water flooding.

Both sets of maps show a surface water flood event that results from rainfall-generated overland flow before the run-off enters any watercourse or sewer. Two types of events were considered; high intensity rainfall (typically >30mm/hr) resulting in overland flow and ponding in depressions in the topography, and lower intensity rainfall or melting snow where the ground has a low permeability e.g. due to being saturated, frozen or developed. Note that surface water flooding does not include sewer surcharge in isolation.

The AStSWF maps are split into three bandings, indicating ‘Less’ to ‘More’ susceptible to surface water flooding. Based on the Environment Agency Guidance note issued in 2009, the ‘More’ susceptible areas have “a natural vulnerability to flood first, flood deepest and/or flood for relatively frequent, less extreme events (when compared to the other bands)”.

These maps have been produced using a simplified method that ignores urban sewerage and drainage systems, ignores buildings, and uses a single rainfall event – therefore it only provides a general indication of areas which may be more likely to suffer from surface water flooding. Generally the single event chosen is from a high intensity storm, as this is thought to be the worst case scenario.

For the production of the FMfSW the following improvements were made compared to the AStSWF:

- better ground and surface data in many areas – using 'local' data rather than a ‘national’ average
- sewer flow now represented – using a single 'national' figure
- infiltration now represented – using 'national' figures
- storm duration more representative – using a single 'national' figure
- buildings now included – using 'local' data
- two storm likelihoods now mapped – 1 in 30 year and 1 in 200 year
- different roughness figures for urban and rural now included – using 'national' figures

Note that ‘local’ data does not mean it’s the most detailed data available, just that it varies at a local scale rather than using one or two national figures / estimates.

Even though a number of national assumptions (e.g. for sewer flow) had to be made to build a national model, first principles (e.g. some drainage is more realistic than none, some infiltration is more realistic than none) tell us that the FMfSW provides a better representation of surface water flood risk than the AStSWF map. Most significantly, the cruder assumptions inherent in AStSWF map mean they are generally too conservative (i.e. total area of land at risk shown was too large).

The Environment Agency has published guidance to support the release of the Environment Agency Surface Water Flood Maps. This guidance provides information regarding the production of the maps, the assumptions made and the limitations. It also provides guidance on how the maps should be used.

Based on the outputs of the FMfSW a number of classifications have been made.

These are:

- Places above flood risk thresholds – 1km grid square where at least one of the following flood risk indicators is above the thresholds given below:
    - Number of people at risk > 200
    - Critical services at risk > 1
    - Number of non-residential properties at risk > 20
- Clusters of AStSFW and FMfSW – formed from all 3km squares that contain 5 or more Places above the Flood Risk Thresholds that are touching
- England Indicative Flood Risk Areas – made up of clusters that contain more than 30,000 people

Within the study area for this SWMP there are seven 1km squares classified as places above the flood risk thresholds, six of which are in the northern part of the study area and the seventh is in the Locking / Hutton area.

Weston-super-Mare falls within a cluster of AStSFW, ranked 35th, based on the number of people at risk, but it does not fall within a cluster of FMfSW. It is therefore not classed as one of the ten Indicative Flood Risk Areas within England.

The Environment Agency has also highlighted the number of Listed Buildings at Risk from Surface Water Flooding across England. Again, there are none highlighted in the Weston-super-Mare area.

The AStSFW maps for Weston-super-Mare, Figure 3.2, show that large parts of the study are classed as susceptible to surface water, particularly in the Weston Development area between Hutton and Locking. Generally the FMfSW shows a much reduced picture of flood risk to the area. The 1 in 30 year FMfSW (Figure 3.3) shows that there are only small pockets of water at a depth of more than 0.1m across the study area, with the Weston Development Area between Locking and Hutton showing as the main risk area. Parts of Milton and Milton Road are also picked up as having deep water i.e. greater than 0.3m. The 1 in 200 year FMfSW (Figure 3.4) shows deep flooding in the fields between the Locking and Hutton area as well as flooding down Milton Hill and all around Milton Road. Areas of Ashcombe, Worle and Weston-super-Mare town centre are all affected by both shallow and deep flooding.

These maps provide an indication of the potential “at risk” locations within Weston-super-Mare but do not provide sufficient detail to allow decisions to be made regarding potential mitigation measures. They also do not take into account local knowledge and therefore it was decided that modelling specifically for this SWMP was required.

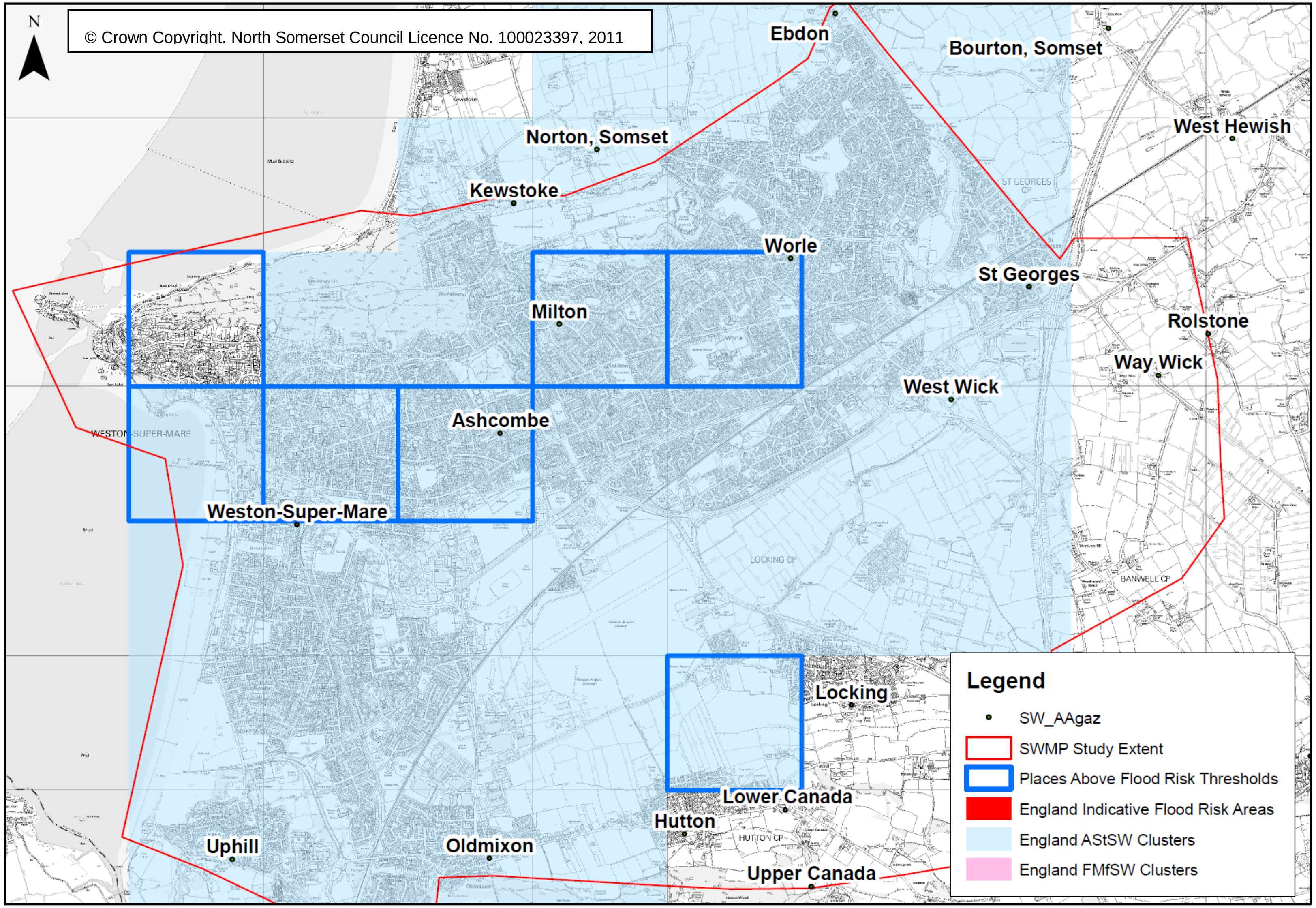

Figure 3.1 – Classifications based on FMfSW

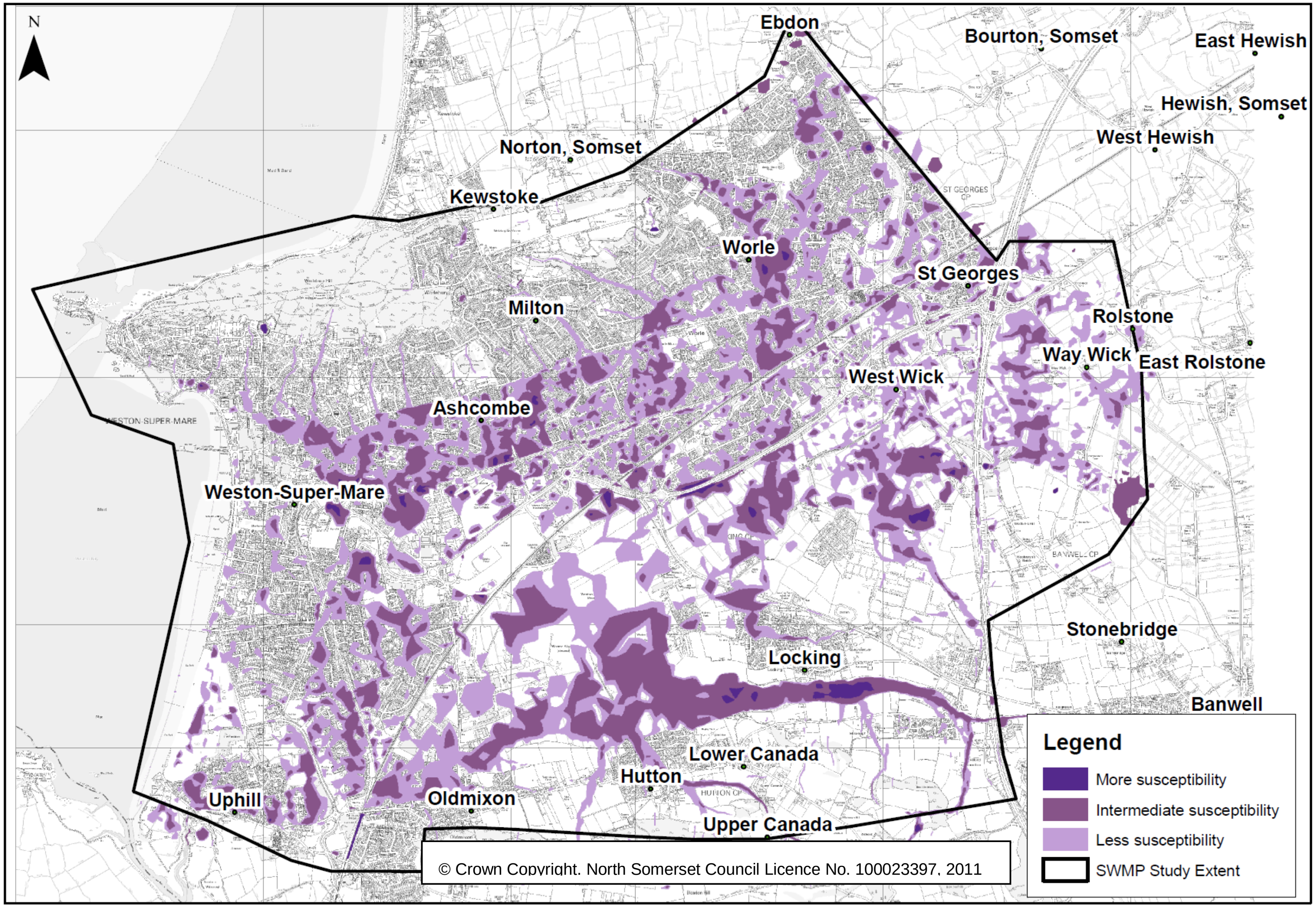

Figure 3.2 – AStSWF map

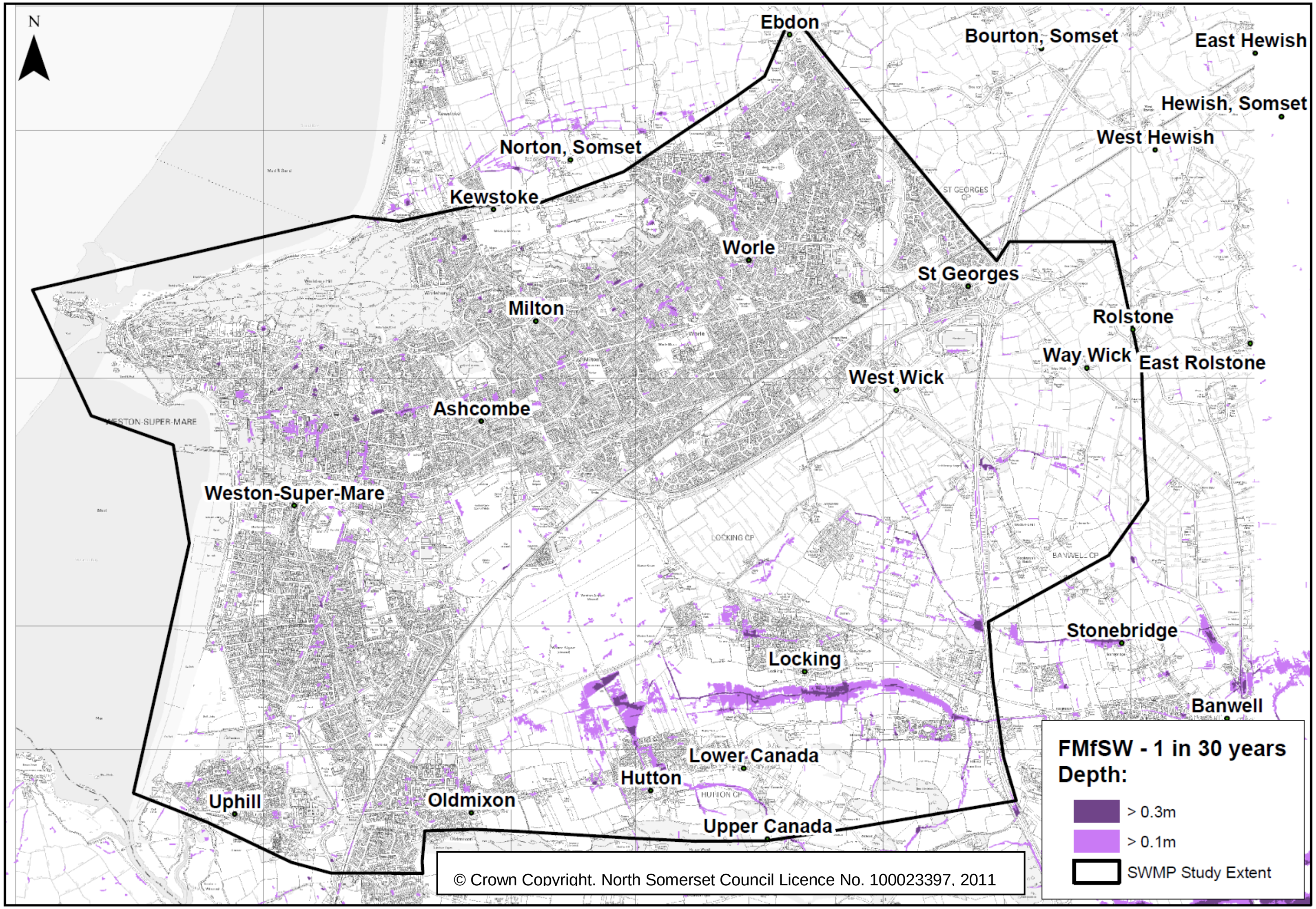

Figure 3.3 – 1 in 30 year FMfSW

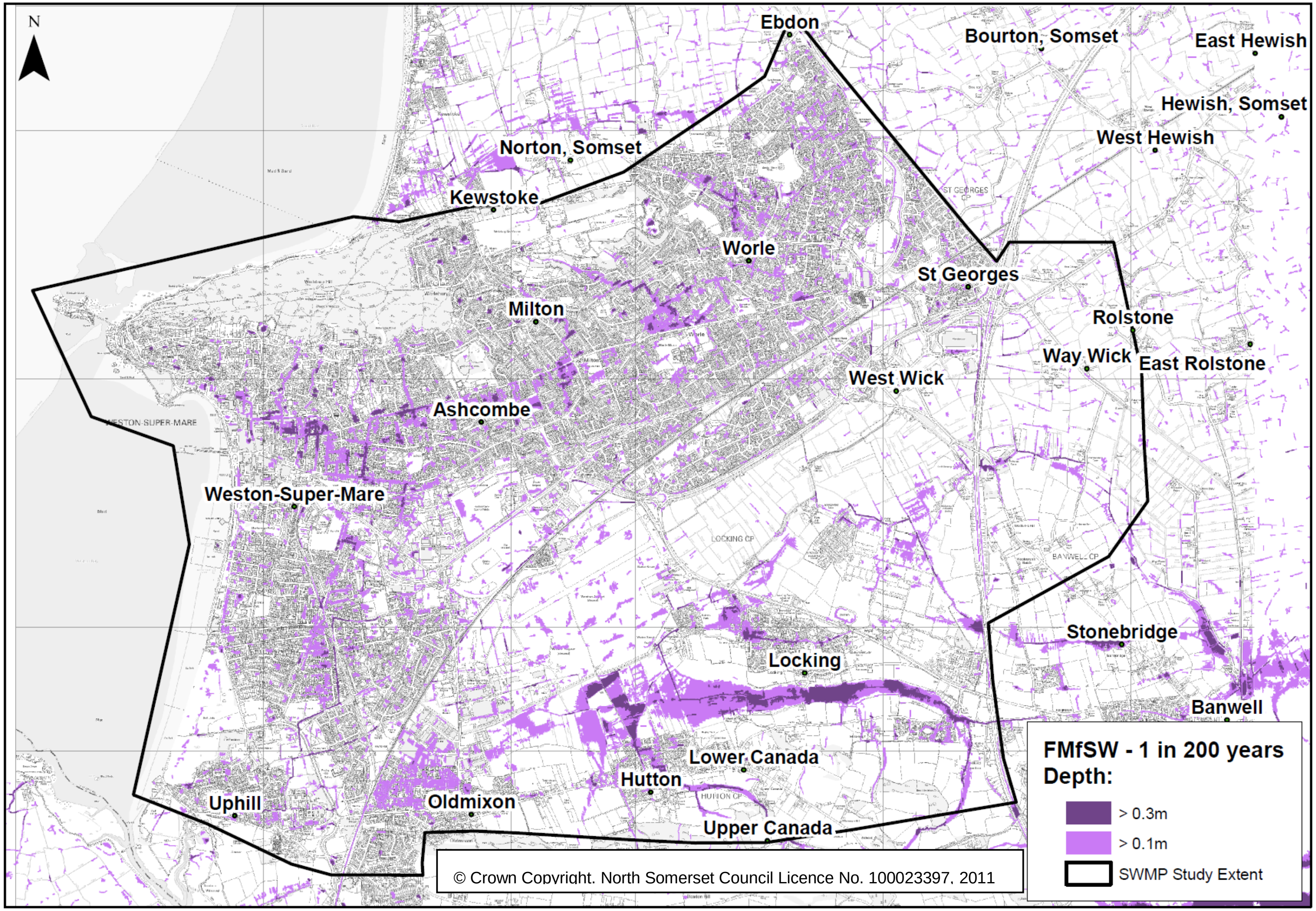

Figure 3.4 – 1 in 200 year FMfSW

3.3 Geology & Soils

The study area is predominantly made up of Triassic mudstone, siltstone and sandstone as shown in Figure 3.5. The hills to the north and the fields to the south of Hutton are made up of Dinantian limestone with subordinate sandstone and argillaceus rocks. There are then small sections of Lias mudstone, siltstone, limestone and sandstone in the Ebdon area and around the M5 south of Banwell. In addition, the superficial geology map (Figure 3.6) shows that most of the study area is covered by alluvium, made up of clay, silt and sand. This has been confirmed by a review of sample BGS boreholes that show predominantly clay across the study area.

The permeability of mudstones varies significantly depending on the grain size, with coarser grains providing more permeability than fine grains. In Weston-super-Mare the permeability of the area is generally high. This is reflected by the Flood Estimation Handbook (FEH) catchment descriptors which show an SPRHOST of approximately 23% across the study area and a BFIHOST of 0.7.

A factor that also affects the permeability is the urbanisation of the area. The west and north of the study area are highly urbanised with limited green spaces in these areas and therefore permeability is significantly reduced here.

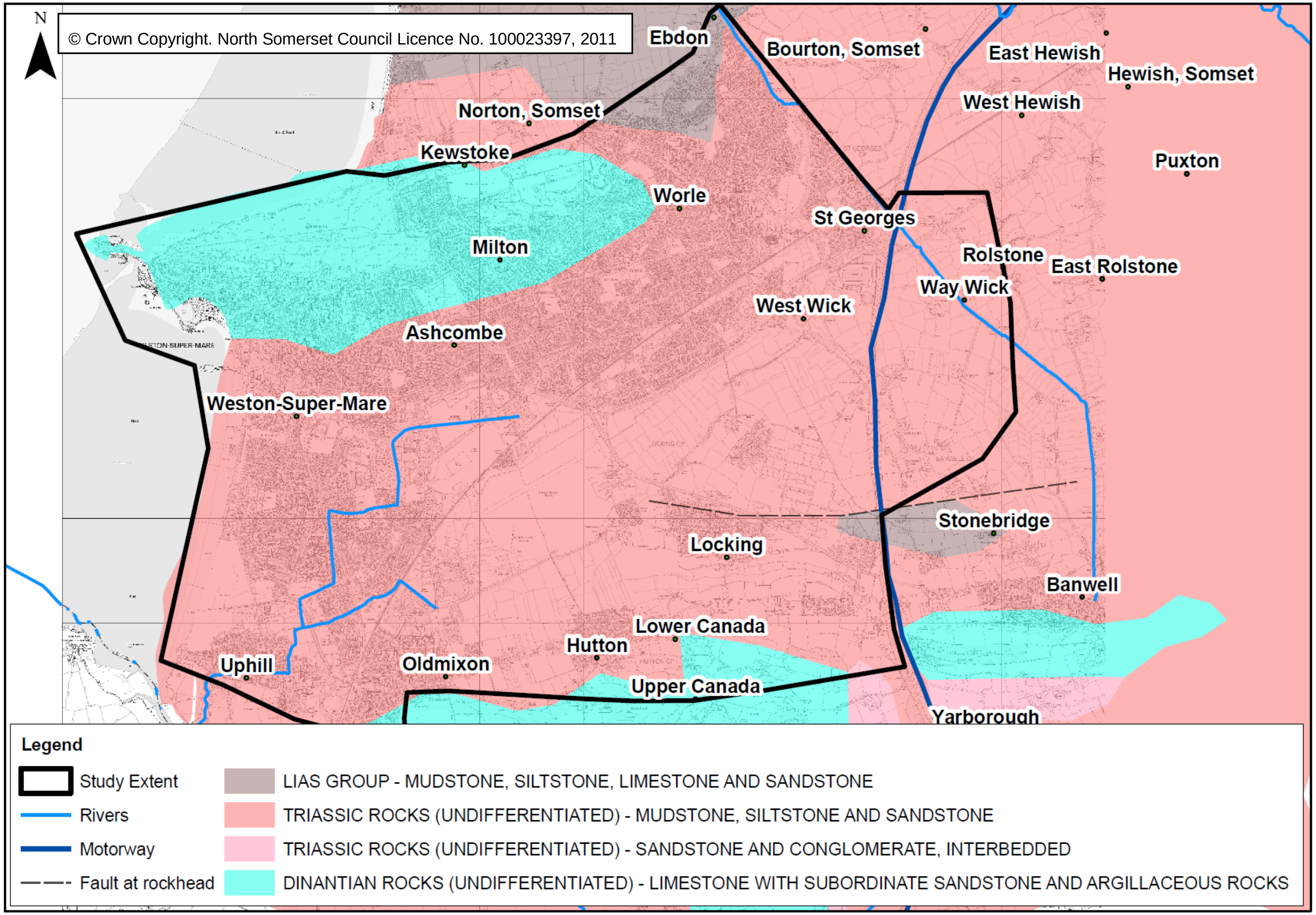

Figure 3.5 – 625k Bedrock Geology

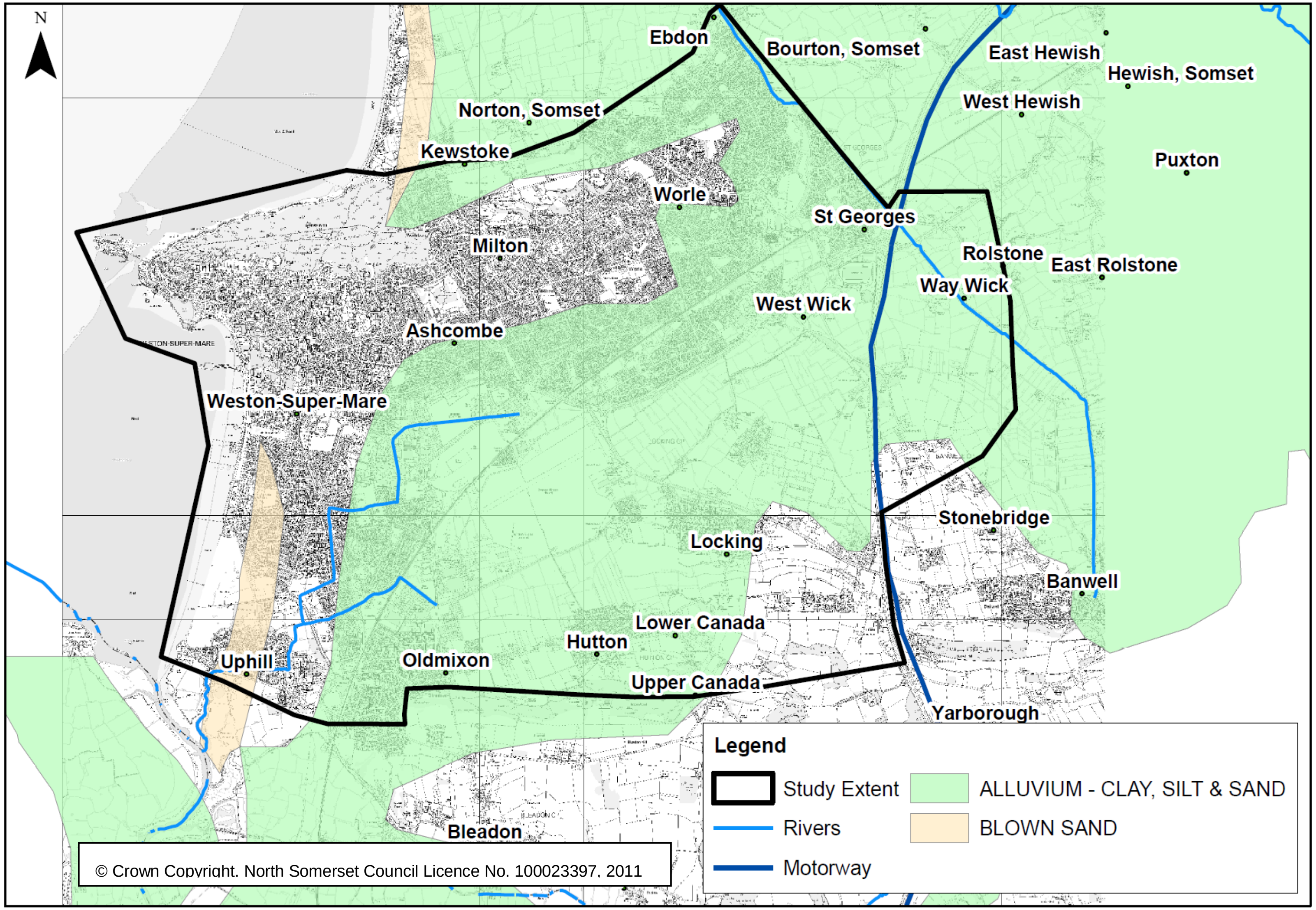

Figure 3.6 – 625k superficial

3.4 Hydrology & Hydrometry

Catchment descriptors covering the study area were obtained from the FEH CD-ROM version 3 to provide information regarding the nature of the soils, permeability and reaction to rainfall across the Weston-super-Mare area. The Depth-Duration-Frequency function within the FEH CD-ROM version 3 was then utilised to determine representative rainfall depths for Weston-super-Mare for various return period events, as shown in Table 3.1 below. Based on the nature of the study area and previous studies it was determined that short, intense rainfall events would produce the greatest flood risk and therefore it has been assumed that all of the rainfall fell in a 1 hour period. A 30% increase in the rainfall has been included for the climate change scenarios. This is the current recommended increase stated within National Planning Policy Framework Technical Guidance based on Defra guidance.

Table 3.1 – Rainfall depths for various return period rainfall events

Rainfall return period (years)	Rainfall depth (mm)
5	18.6
10	23.1
20	28.6
30	32.3
30 + climate change	42.0
50	37.6
100	46.2
100 + climate change	60.1

An areal factor has been included in this to account for point rainfall being applied across a large area.

As part of the work at Milton Hill undertaken by Wessex Water, rainfall data was collated and reviewed from the period of 2007 to 2010. Four rainfall events were analysed to help with the verification and calibration of their hydraulic model. This data was also reviewed as part of the SWMP.

The Environment Agency has two tipping bucket rainfall gauges close to Weston-super-Mare, at St Georges and Wick St Lawrence. St Georges data was obtained from March 2008 until the gauge closed in October 2009, whilst data for Wick St Lawrence was obtained from June 2008 to 2010. As Wick St Lawrence is intended as a replacement gauge for St Georges, it was selected to be used for the analysis.

Daily depth and time of tip data was used for historical rainfall analysis. The ten days with the greatest daily depth were selected and time of tip data for these days was then converted to millimetres per hour and graphed against time to establish the pattern of rainfall for that day.

From these ten events, four were selected for further analysis. These four were selected as having the convective style "peaky" rainfall which was known to be typical of the nature of the rainfall which has previously caused flooding at Milton Hill and is generally a problem across Weston-super-Mare. The four dates selected were:

- 1st September 2008

- 3rd September 2008
- 6th June 2009
- 29th July 2009

Radar data was extracted for these dates which gave 5 minute average intensities. The radar data was validated by comparing radar measurements at the Wick St Lawrence site which is 4.2 km north-east of Milton Hill.

A return period analysis was undertaken at Wick St Lawrence for each of the four events for the rain gauge and radar data. The results of this analysis are presented in Table 3.2.

Table 3.2 - Analysis of radar and rain gauge data for historical rainfall

Storm date	Estimated return period (years)		Comment
	Rain gauge	Radar	
01/09/08	1 to 0.5	0.5 to 0.33	Good rain gauge to radar correlation
03/09/08	0.17	1	Poor rain gauge to radar correlation
06/06/09	2	30+	Large radar shadowing effect from 6th - 7th. Possible thunder clouds therefore higher uncertainty in the radar data and associated return period
29/07/09	1	1	Possible radar data missing 29th 23:00 to 30th 00:30. Very questionable radar data beyond 09:05 on 30th. SE of radar squares is slipping into shadow on 29th.

3.5 Hydraulic Modelling Methodology

More detail than that provided by the Environment Agency's two surface water mapping exercises was needed regarding the locations and depths of surface water flood risk to Weston-super-Mare. Information regarding the whole study area was required and therefore it was decided that a broad-scale 2-dimensional model was the most appropriate approach with an allowance for the drainage system. The Environment Agency approved TUFLOW numerical modelling package was chosen for this study, in line with previous modelling undertaken as part of the SFRA.

The basic setup for the TUFLOW model was relatively simple with a grid size of 10 metres chosen to provide a compromise between accuracy of the representation of the terrain and model run times. The model domain includes the entire study area and has been adjusted to include those points from which rainfall would flow into the study area based on the topography.

A model time step of 2 seconds has been used. The recommendation is that the time step value should be approximately a half to a quarter of the grid size, therefore based on a 10 metre grid, approximately 5 seconds would be the recommended value for this study. Two seconds falls slightly lower than the TUFLOW recommended time step but is acceptable as it allows the model to cope better with the shallow depths and fast flows that are experienced in some areas of the model. The simulations were then run for 16 hours to allow time for water to drain away where possible.

The double precision version of TUFLOW has been used to run the model as recommended. This assists in reducing mass errors due to floating point imprecision.

The terrain used for the model is the most up-to-date Digital Terrain Model (DTM) data in the form of LiDAR data (Light Detection And Ranging) available at the time of modelling. Where multiple flights have been flown over the same area the newer data has been used. The LiDAR used was therefore flown between 2007 and 2010, combined to produce a 2m grid. For previous studies topographic survey had been undertaken. Spot checks have therefore been made of the LIDAR against some of this topographic survey data.

Roughness values have been applied to the 2D model surface based on land use categories defined and delineated by OS Mastermap data. Values of roughness for each material have also been assumed to vary with depth of water. Table 3.3 below provides details of the roughness values used; where the default Manning's n value is used when the depth is outside of the two specified ranges. The initial and continuing loss values represent infiltration into the ground. These values were determined based on a literary review and internet search, along with a series of sensitivity tests. The continuing loss is generally higher than the initial loss to represent the fact that during the event there is likely to be water sitting on the surface and therefore more water can be infiltrated, whereas when the rainfall first starts the assumption is that the ground is dry.

Table 3.3 – Roughness details

Material	Standard Manning's n	Depth range (mm)	Manning's n	Depth range (mm)	Manning's n	Initial loss (mm/hr)	Continuing loss (mm/hr)
Grassland	0.050	0 – 20	0.1	20 – 50	0.05	10	20
Roads	0.020	0 – 20	0.05	20 – 50	0.020	0	0
Buildings	0.3	0 – 20	1	20 – 50	0.3	0	0
Rough Ground	0.12	0 – 30	0.2	30 – 100	0.12	10	20
Trees	0.12	0 – 30	0.2	30 – 100	0.12	20	20
Inland water	0.045	0 – 20	0.06	20 – 100	0.045	0	0

The rainfall hyetograph has been applied across the entire catchment using a 2D RF boundary in TUFLOW, which converts the hyetograph into a hydrograph and applies the value at each cell.

As rain falls onto permeable areas of the catchment (anywhere other than roads, buildings and other man-made, impermeable hard surfaces) a proportion of it is absorbed by the ground. This was taken into account in the modelling to avoid over-estimation of the amount of surface water flooding that occurs.

The method used in this study has looked at FEH catchment descriptors to determine the Standard Percentage Run-off (SPR) value for a representative part of the catchment and used this to make an assumption as to the amount of rainfall that will be absorbed into the ground. The value obtained for the SPR is 25% which means that 75% of rainfall is absorbed into the ground. To model this, the inflow hyetograph with a multiplication factor of -0.75 has been applied (using 2D RF boundary) to those polygons taken from the Mastermap that represent the permeable areas.

To allow an assessment of the drainage in the study area, a GIS layer with the sewer network was provided by Wessex Water. This dataset showed the locations of all sewer pipes within the study area (numbering approximately 26,500). As is expected with large dataset of this nature, the data that accompanied all of these pipes was not complete with many lacking diameter and invert data, having poor connectivity or the line orientation being incorrect (i.e. DS to US rather than US to DS). These factors when considered with the large number of pipes would make a full model of the drainage system too time consuming and costly for a study of this nature. For the purpose of the SWMP study this type of modelling was outside the scope of the project and not appropriate for the level of investigation.

Based on previous research work an assessment was made of the drainage rate for the area. The rate was then calculated in mm per hour for the impermeable drained area (i.e. road network) and applied using a 2D RF boundary. Drainage was assumed to only apply to the impermeable area. It was assumed that on any permeable area the water soaked into the ground rather than entering the drainage system. The 2D RF boundary was therefore applied across the area classified as roads in the Master Map data.

Three scenarios were considered as part of the modelling process:

- Drainage system operating as designed
- Tide-locked scenario
- Saturated ground i.e. an intense storm following a period of continuous rainfall

The drainage system operating as designed is the main focus of this study. The other scenarios have been considered to ensure that the worst case is also taken into account. The outfall of the drainage system is relatively low and below Mean High Water Spring (MHWS). It has been assumed that the drainage system cannot discharge for the entirety of the tidal event. It is therefore recognised that tide locking is of particular importance when investigating surface water flooding at Weston-super-Mare. In order to model the impact of tide locking the GIS data showing the sewer pipes (amended to include diameters where possible) was used to determine the total capacity of the drainage system.

Calculations were performed based on this capacity, the rainfall rate and drainage rate to determine, for a storm of specified duration and probability, the time it takes for the volume in the sewers to be exceeded. Once this time had been reached the drainage in the model is stopped to allow all subsequent rainfall to flow over the surface.

For the saturated scenario it was assumed that there had been a large amount of rainfall before the event resulting in both the drainage network and the permeable ground being at capacity. This means that no additional water can enter the drainage system or be absorbed into the ground. This is the worst case scenario.

3.6 Model Verification and Calibration

There was limited calibration data available, particularly for large order events. The calibration process therefore focused on the 1 in 5 year scenario, as it generally reflects the known historic flooding across the area. The 1 in 5 year scenario was compared to a recent flood event and local knowledge with changes being made to the coefficients in the modelling to try to calibrate the model to the observed events.

The local knowledge was primarily from the steering group and project team. The model results were presented and discussed at a steering group meeting. Comments from all parties were then collated and reviewed against the modelling outputs as part of the verification process.

Due to the limited information available for calibration and verification of the modelling results, sensitivity testing was also carried out on some of the main assumptions of the modelling process.

- Drainage coefficient

The drainage coefficient was tested for the 1 in 5 year and 100 year scenarios both with and without tide locking. The standard value was 23.8mm/hr. This was first adjusted by ±20% i.e. 19.0 and 28.5mm/hr and there was negligible difference in the results.

- Depth varying Manning's n for permeable areas e.g. grass, rough ground etc.

Confidence is high in the base Mannings n values for the various different materials. The sensitivity testing has therefore focused on the initial loss and the continuing loss for the permeable materials. The initial loss was increased from 10mm/hr to 20mm/hr for grass and rough ground and from 20mm/hr to 25mm/hr for trees, whilst the continuing loss was increased from 20mm/hr to 25mm/hr and 30mm/hr for all of the permeable areas. For all tests undertaken there were not significant changes to the depths of flooding across the study area.

- Length of model run

Generally the models have been simulated for 16 hours. To ensure that this allowed for the areas of ponding to be clearly identified the model was also run for 48 hours. This highlighted that 16 hours was sufficient to give the required level of detail.

- Terrain smoothing

Initial model runs showed significant areas of ponding and large flood depths even at low return periods. Investigation into this showed that it was caused by unexpectedly 'bumpy' terrain, particularly in the steeper, hilly areas to the North and South. This is partly due to the filtering undertaken during the Environment Agency processing of the Light Detection and Ranging (LiDAR). Different methods and levels of terrain smoothing were investigated to allow realistic flow paths and depths to occur.

3.7 Model confidence

Although new input and boundary data have been used, the modelling undertaken for this study can be seen as a further development on the Environment Agency FMfSW, by incorporating the local drainage network and looking at the study area at a higher level of accuracy. Local knowledge has also been utilised throughout the model build and verification of the model outputs.

Models of this nature, which cover a large area and feature significant areas of complex, shallow and steep flow can result in less certainty through those areas. We have endeavoured to improve the stability and accuracy of these models, for example by using depth-varying roughness values, double precision calculations and by adjusting the criteria by which model cells are considered to be wet or dry. Using a small timestep has also aided in reducing errors in model results. In steeper areas, filtering of the DTM can be less accurate which can impact on model result accuracy. The filtering process is used to remove buildings and vegetation from the surface and in areas with significantly varying and heavily vegetated or developed terrain ground levels can become unrealistic or problematic when used to build a model. This is countered by smoothing the terrain, and by verifying that flow paths are as they should be but it is important to note that in these areas confidence in model results is lower.

With broadscale, direct-rainfall modelling of this type it is difficult to calibrate the model, as the sort of catchment-wide rainfall that has been modelled is an idealised condition and as such, is unlikely to occur in one event across the entire catchment. Other issues with modelling of this type are that the more extreme events, which result in significant flooding, may not have occurred in the key areas of risk. Also lower levels of flooding caused by more frequent events can often go unreported or unrecorded.

While every effort has been made to reduce anomalies in the model results, in some locations flood depths from lower return period events appear greater than those from higher order events. Input conditions and model setup have been reviewed and confidence is high that they are correct, and the general trend of flooded area and depth is appropriate for increasing return periods. However, due to these small uncertainties in the modelling, anomalies still occur in the more sensitive areas of the model. It should be noted that these areas are limited in size and number and that given the scope and scale of this study they are not an issue, and do not have an impact on the overall worth of the modelling.

We have identified the areas of lower confidence in Appendix B.

With the uncertainties discussed above in mind, it has been important to review and verify the model results as far as possible, particularly using local knowledge, where available. Based on these reviews, we have confidence that the model results are indicative of the scale and nature of flooding for the return periods and conditions that are modelled and are appropriate for a study of this nature. However, for the design of significant schemes, such as flood storage or drainage improvements it is recommended that more detailed small scale modelling of the drainage network in the area of interest be undertaken. This was beyond the scope of this catchment wide study.

It is important to view all models as a tool, and that judgement and experience are required when reviewing the results to ensure that they are used appropriately and practically.

3.8 Map Flood Risk

The model results have been mapped and processed to ensure any anomalous results are removed i.e. artificial ponding spots due to the modelling process. The depths have then been split into 4 intervals of interest and the results are shown in Appendix C and an example shown in Figure 3.7:

- 100mm – 150mm (green)
- 150mm – 300mm (yellow)
- 300mm – 600mm (orange)
- Greater than 600mm (red)

For this modelling, rainfall has been applied across the entire model and therefore every cell shows as having some depth of flooding. To pick up the actual surface water flow and ponding we have therefore only focused on depths greater than 100mm, anything below this value will be unlikely to cause any flooding problems.

The maximum of 600mm has been chosen to represent deep flooding. This is consistent with other SWMPs across the country.

A review of the model results was carried out by members of the project team to identify the areas showing greatest flooding. This review was followed up by a comprehensive site visit to determine whether the extent of flooding, seen in the modelling results, was likely in each of the areas. Of particular interest were the areas in which a large number of properties were affected, those which covered a large area, featured large depths, were similar for each of the return periods modelled or appeared otherwise anomalous. The model outputs have been amended in a few areas in line with the findings from the site visit. Notable among the areas of amendment is Naunton Way (and surroundings) where a large cliff is present. Due to the workings of Tuflow, the very steep slope in this area has caused the gradient to be reduced and increased the plan area which has caused focussing of run-off into the lower elevations at the foot of the cliff. This has caused flood depths to be overestimated in this area. Similar behaviour has been observed around the quarries present within the study area, where fewer properties are affected, and along railway and road cuttings. These flooded areas are of lower importance as they are located away from properties. In some instances there are artificial deep spots created at the model boundary (shown on the flood map figures). These have been reviewed and manually edited from the results.

Table 3.4 shows the number of properties at risk from each scenario, split into commercial and residential properties. It is standard practice to assume that properties have a threshold of approximately 300mm above ground level. Therefore, only properties with a depth of flooding greater than this threshold are included within the property count.

The property count is based on the Local Land and Property Gazeteer (LLPG) data supplied by North Somerset Council. This dataset shows that there are a large number of flats within the study area (~10,000) but does not provide details regarding which are at ground level and which are at a higher level. All flats have therefore been included in the property count but this will exaggerate the number of properties where damage could occur and therefore the number of flats has also been highlighted in brackets.

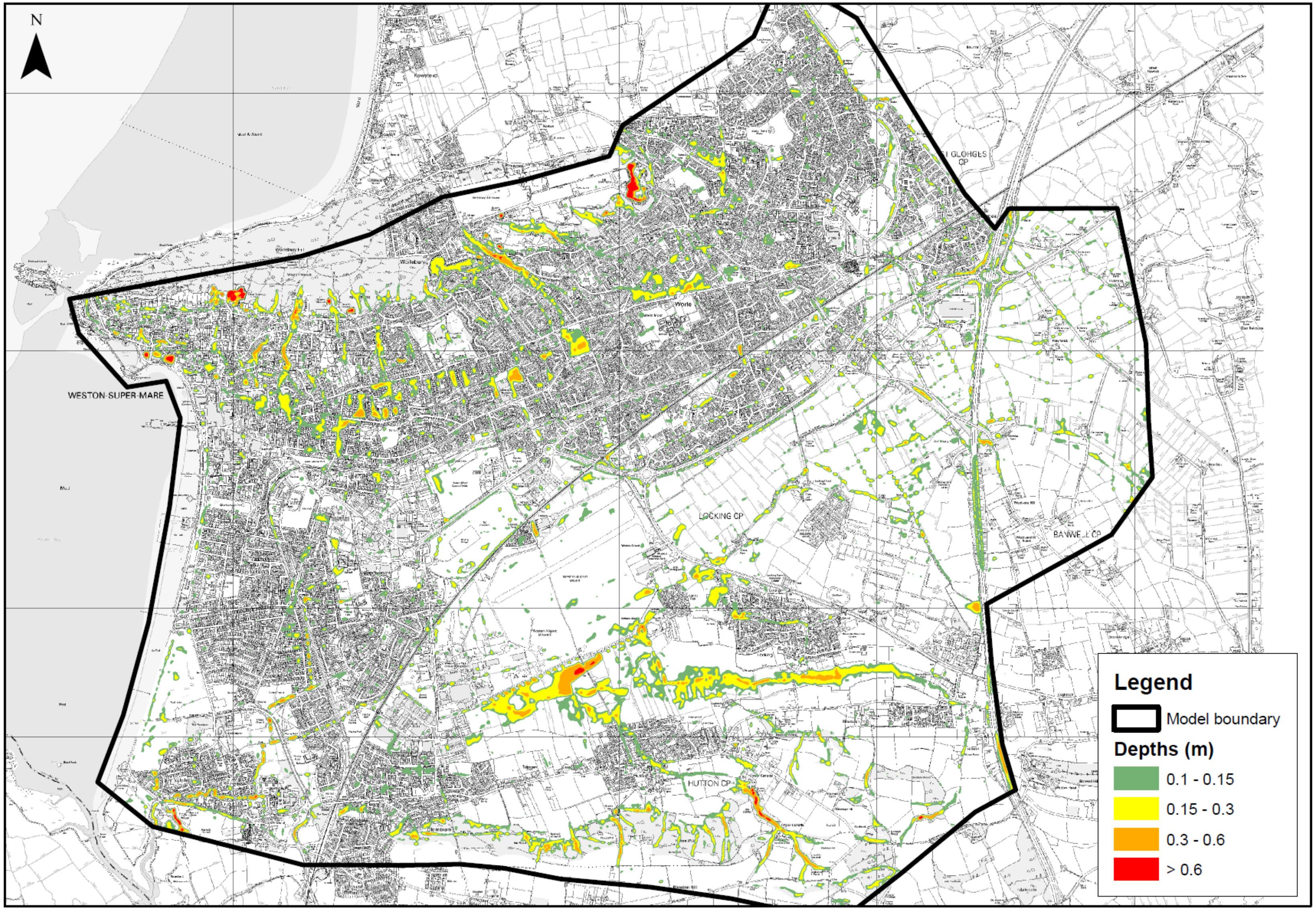

Figure 3.7 – 1 in 100 year depths with the current drainage operating as designed

During the property count the locations of flooding have been reviewed and some areas discounted as modelling anomalies. These areas can be seen in Appendix D.

Table 3.4 – Number of residential and commercial properties at risk. The number of flats (inc. homes with multiple occupancy (HMO)) is also shown.

Return Period (years)	Number of residential properties at risk						Number of commercial properties at risk		
	As designed		Tide-locked		Saturated		As designed	Tide-locked	Saturated
	Total	Flats	Total	Flats	Total	Flats			
5	55	44	61	38	127	61	14	15	16
10	61	40	77	48	275	159	3	3	42
20	78	56	97	69	340	167	4	5	57
30	86	64	177	142	488	189	4	5	68
50	140	109	270	225	575	219	19	19	83
100	179	123	291	212	951	304	27	28	122
30 + climate change	159	137	273	213	741	249	23	22	98
100 + climate change	385	204	709	486	1762	556	39	49	208

Table 3.5 shows the number of critical / vulnerable assets and listed buildings (all Grade II) at risk for each scenario. Table 3.6 provides a summary of the key locations at risk for each scenario modelled. Note that a threshold level of 100mm was considered during the count exercise. The main focus should be the drainage system, as designed. The saturated and tide-lock scenarios are there to show worst case scenarios. Other environmental designations could also be flooded but due to the nature of the designation e.g. park or woodland, the damage/impact is not expected to be significant or long term. They have therefore not been considered further as part of this assessment.

Table 3.5 – Numbers of critical / vulnerable assets and listed buildings at risk (greater than 100mm depth)

Return Period (years)	Number of Critical / vulnerable assets			Number of Listed Buildings		
	As designed	Tide-locked	Saturated	As designed	Tide-locked	Saturated
5	7	8	26	6	6	9
10	8	10	29	5	6	9
20	11	12	34	11	9	9
30	15	13	35	6	11	12
50	20	21	39	8	13	13
100	29	32	49	10	17	14
30 + climate change	22	24	43	10	16	14
100 + climate change	35	42	53	15	32	15

Care needs to be taken when viewing the model results. For each modelled scenario the maximum water levels in each cell have been plotted. As the water is moving the maximums in the nearby cells may occur at different times and therefore what shows as an area of ponding may just be the same water moving along a series of cells. The animations for each scenario have therefore also been reviewed when assessing the areas at risk.

Some of the main listed buildings at risk from surface water flooding are Shrubbery Lodge, Bristol Road Baptist Church and The Brow at Hutton. The critical / vulnerable assets at risk from a 1 in 100 year rainfall event with the drainage operating as expected are:

- 18 care / residential homes
  - Frenchay Mews Residential Home (2 buildings)
  - Old Ash House Residential Home
  - Tramore Nursing Home
  - Parkview Nursing Home
  - Alana Home for the Elderly
  - Rodney House Rest Home
  - Woodside House Residential Home
  - Ashlea Residential Retirement Home
  - Pine Lodge Resdiential Home
  - Oriel House Residential Home
  - Rest Home, Victoria Quadrant
  - Ambleside Nursing Home
  - Woodleigh Manor Care Home
  - Park House Residential Home
  - Tudor Rose Nursing Home
  - Ventura Residential Home
  - Uphill Court Nursing Residence
  - Nutwell Farm Residential Home
- 3 churches
  - Church Road Methodist Church
  - Our Lady of Lourdes RC Church
  - Church of the Nazarene
- 2 council buildings
  - Trading Standards Department, North Somerset Council (2 buildings)
- 2 medical buildings
  - Stafford Place Doctors Surgery
  - Weston-super-Mare general hospital, staff residences
- 3 schools
  - St Martins Junior School
  - Mendip Green First School
  - Castle Batch Primary School

Table 3.6– Summary of at risk locations

Return Period (yrs)	As designed	Tide-locked	Saturated
5	Minimal locations of flooding across the study area. Main risk locations in the hills to the North and locations around Hutton. Flooding around Milton Hill and Spring Valley matches with observed data. No flooding shown in Town Centre area.	Not much change. Some flooding starting in the centre of the study area but generally the same as without tide locking.	Pockets of flooding across the whole study area. Generally between 100 and 300mm. Area around Locking and Hutton (airfield site) shows up as a large area at risk. Only very small pockets of flood risk in the Town Centre area.
10	No significant change from 5 year scenario. Some more ponding in the centre of the study area.	No significant change from 5 year scenario.	No significant change from 5 year scenario. Just slightly increased extents.
20	No significant change. Small number of additional areas affected.	No significant change. Small number of additional areas affected.	No significant change. Small number of additional areas affected.
30	Areas of ponding starting to show up south of Milton Road. Generally up to 300mm deep. Ponding developing in the fields south of Cross Rhyne.	Slight increase in the number of areas affected but not a major change to the risk.	Widespread flooding. Depths generally between 100mm and 600mm with some areas of deep flooding (between Locking and Hutton). Town Centre showing areas of up to 300mm deep.
50	Flooding starts to be more wide spread across the study area although still generally in isolated pockets. Depths increasing slowly. Generally flooding between 100mm and 300mm deep.	Slight increase in the number of areas affected but not a major change to the risk.	Slight increase on the 30 year scenario with extents and depths of flooding increasing.
100	Depths of flooding increasing. More areas with depths of between 300mm and 600mm. Large areas of the land between Locking and Hutton affected. Town Centre still has only very small pockets of risk i.e. isolated low spots. Areas of deep flooding shown on Milton Hill.	Areas of the town centre starting to be affected although the depths are still low i.e. less than 300mm.	Majority of the area at risk with most at risk areas showing depths of greater than 150mm. Areas of deep flooding increased.
30+climate change	Small pockets of flood risk across the study area. Similar to the 50 year scenario.	No significant change. Slight increase in the number of areas showing as flooding.	Large areas affected. Pockets of deep flooding developing. Significant ponding south of Milton Road.
100+climate change	Flooding throughout the study area. Significant areas of ponding south of Milton Road and large area of deep flooding on Milton Hill.	Increased depths across the study area.	Flooding generally between 150 and 600mm with an increasing number of areas and size of areas showing deep flooding i.e. greater than 600mm.

3.9 Calculating Damage to Property

The damage to properties due to a flood event has been considered at both a local scale and a study area scale. This gives an indication of the total potential economic damage to Weston-super-Mare, along with information that can be used to determine the cost benefit ratio in localised hot spots. As part of this assessment, a tool has been developed that can be applied across the study area to quickly determine the potential damage values in localised hot spots or areas. For this study we have used the tool for the whole study area and five key flood risk locations as an example.

The damage to property has been undertaken based on a Weighted Annual Average Damage data from the MCM Handbook 2010. This has been split into residential and commercial damages. The commercial properties have then been split further into the main five bulk classes (Table 3.7) and the mean floor areas applied as stated in the MCM 2010. These areas are from the Department for Communities and Local Government (CLG) from 2008.

Table 3.7 – Bulk classes and associated mean floor space

Bulk Class	Mean Floor Space (m^2)
Retail	194
Office	290
Factory	798
Warehouse	772
All bulk	418

The majority of commercial properties fall within the all bulk class.

There are a large number of flats within the study area (approximately 10,500 flats & 140 Houses in Multiple Occupation (HMO)) which need to be considered carefully as part of the damage assessment as these properties could over exaggerate the cost of the actual damage. Only the flats on the ground floor will actually experience damage but due to the data provided it is not clear at this stage which flats are on the ground floor and so at risk, and which are on upper floors and therefore not at risk.

Some of these flats are known to be apartment blocks and therefore the majority of those flats will be on upper floors and so not at risk of flood damage. Other flats are converted terrace houses, therefore two, or more, flats will be registered at one property but only the ground floor flat and any basement will be at risk of flood damage. The data was not provided regarding which flats were upper floor and which were ground floor, and it is beyond the scope of this broad-scale assessment to look at each flat individually. Instead, it is known that Weston-super-Mare is similar to Weymouth in terms of property type, i.e. some apartment blocks and some converted terrace houses. From a recent study at Weymouth it was shown that 36% of the flats in the town were located on the ground floor. This seems to be a sensible percentage considering 50% of flats in converted terraces will be ground floor and generally in both Weymouth and Weston-super-Mare the apartment blocks are only three or four stories high. It was therefore assumed that this percentage could also apply to Weston-super-Mare.

The damages have therefore been calculated for three scenarios to provide a range of estimates:

- Total count of properties excluding all flats – this provides the lower limit for the damage value and is likely to be an underestimation
- Total count of properties including all flats – this provides the upper limit for the damage value but is likely to be an overestimation
- Total count of properties including 36% of flats – this provides the most likely damage value

For localised hot spot areas a more detailed assessment of the flats can be undertaken at a later date and therefore the actual number of flats at risk included in the property count.

The following assumptions have been made when undertaking the damage calculations:

- LLPG data has been used to obtain the property locations and descriptions i.e. BLPU classifications. The BLPU classifications were converted to MCM types based on the guidance in the *LLPG and SNN data entry conventions and best practice for the NLPG v2.0,* which was supplied along with the LLPG data. No amendments were made to this dataset.
- Any property listed as purely commercial (C), unclassified or mixed has been allocated a MCM classification of all bulk. A more detailed investigation would determine if these need to be included or not and if so an appropriate classification.
- Some elements listed in the LLPG dataset were excluded from the damage assessment. This included public conveniences, bus shelters, car parks, railway assets, marinas, utilities, land and allocated parking spaces.
- Residential and commercial Weighted Annual Average Damage (WAAD) values have been taken from the MCM Handbook 2010 Table 4.4 page 26 and Table 5.1b page 34 respectively. It has been assumed that the commercial properties do not have basements.
- The values in the WAAD Tables 4.4and 5.1b assume a specified standard of protection and no flood warning. Only discrete return period events have been modelled for this assessment and therefore it has been assumed that the standard of protection is the event one lower than the first event to cause flooding at a specific property. For example, properties that flood during a 5 year event are assumed to have a 2 year standard of protection, whilst properties that first flood during a 50 year event are assumed to have a 30 year standard of protection.
- A threshold level of 300mm has been assumed for all properties. In addition, the area of 'ponding' needed to be greater than 1m^2 for the property to be included.

The resulting damage values for the whole study area are shown in Table 3.8. The three scenarios regarding the flats are presented to highlight the significance of the flats in terms of the damage assessment. To give an indication of the present value of that damage three scheme lives have been considered.

Table 3.8 – Summary of damage calculation results (figures rounded to the nearest £1,000)

Property type	WAAD	PVd (10yr scheme)	PVd (50yr scheme)	PVd (100yr scheme)
Residential (including flats)	£561,000	£4,937,000	£14,507,000	£17,099,000
Residential (excluding flats)	£148,000	£1,302,000	£3,827,000	£4,511,000
Residential (inc. 36% of flats)	£297,000	£2,611,000	£7,673,000	£9,044,000
Commercial	£180,000	£1,581,000	£4,646,000	£5,476,000

Property type	**WAAD**	**PVd (10yr scheme)**	**PVd (50yr scheme)**	**PVd (100yr scheme)**
Total (including flats)	£741,000	£6,518,000	£19,152,000	£22,575,000
Total (excluding flats)	£328,000	£2,883,000	£8,472,000	£9,987,000
Total (including 36% flats)	£477,000	£4,192,000	£12,318,000	£14,520,000

4 OPTIONS

> The guidance states that in this phase a range of options should be identified, through stakeholder engagement, seeking to alleviate flood risk in the study area due to surface water. Options identified should go through a short-listing process to eliminate those that are unfeasible. The remaining options should be developed and tested by considering their relative effectiveness, benefits and costs. The most appropriate measures should then be agreed and taken forward to the implementation phase.

4.1 Identification

The initial approach to developing options to reduce surface water flooding was to identify the sites at risk from flooding using modelling as described in Section 3. For each of these sites we looked at the following details:

- Where was the flooding?
- Where was the water coming from?
- What route did it take to get there?

The modelling highlighted many areas of potential flooding and it was important that these locations were visited in order to verify the model outputs. A site visit was conducted, visiting most of the sites identified. On site we assessed the likelihood that the modelled flooding could occur as well as looking at the areas around the flooding to determine if they were interconnected. During the site visit we noted:

- Existing defences
- Existing drainage
- Natural features providing protection

Using the information gathered during modelling and site verification initial options were developed through a series of workshops, following the site visit and using experience gained from previous projects and local knowledge.

Options were developed to manage the specific issues identified at each location. These options were then grouped together and streamlined with the aim of reducing the number of options. As the options are highly specific to each location, the options have been grouped into four policies. Each area at risk has then been assigned a policy for management of flood risk.

This process allows flexibility in the application of specific options whilst still addressing the primary problem as identified in this report. It will also allow for the policies to be used in future developments, should any further areas of flood risk be identified.

4.2 Option list

The short listed options and policies are described in summary below. The options were designed to either provide protection to the immediate vicinity, re-direct flow away from vulnerable areas, or to help attenuate the run-off.

Individual property protection

- Flood gates / walls – A permanent solution to protect properties, sometimes reliant on warning/implementation
- Road humps – Permanent road fixtures used to direct or slow water flow
- Threshold raising – Alterations to the entrance of a property to prevent water entering

Storage

- Swales - Use of roadside green space to provide attenuation areas
- Ponds and wetlands – Use of larger areas of green space to provide storage for larger volumes of water. All green spaces were highlighted based on the Mastermap classification to aid this assessment. See Figure 4.1.

Construction

- Road raising – Alterations to surface level of the road to reduce the depth of flooding or re direct water flow.
- Road lowering – Alterations to road surface level to channel water flow
- Increase drainage capacity – Increase in the capacity of road drainage by installing additional pipes and gullies
- Install additional outfall – Improvement of the drainage network by installation of a new outfall.

Small scale construction

- Improve drainage gullies (Access to network rather than capacity) – Replacement of existing gullies that have become blocked or damaged
- Increase number or size of gullies – Installation of additional or larger road gullies to convey more water into the drainage network.
- Surface flood routes – Allowing water to flow across some areas / roads to prevent flooding elsewhere.

SUDS (Sustainable Drainage Systems)

- Permeable paving – Replacement of existing hard paving with permeable alternatives, allowing water into the ground
- Green roofs – Use of green roofs to reduce run-off rates from structures
- Water butts – Encourage homeowners to use water butts to reduce water entering the drainage system during an event

General (applicable to all areas)

- Education
- Maintenance

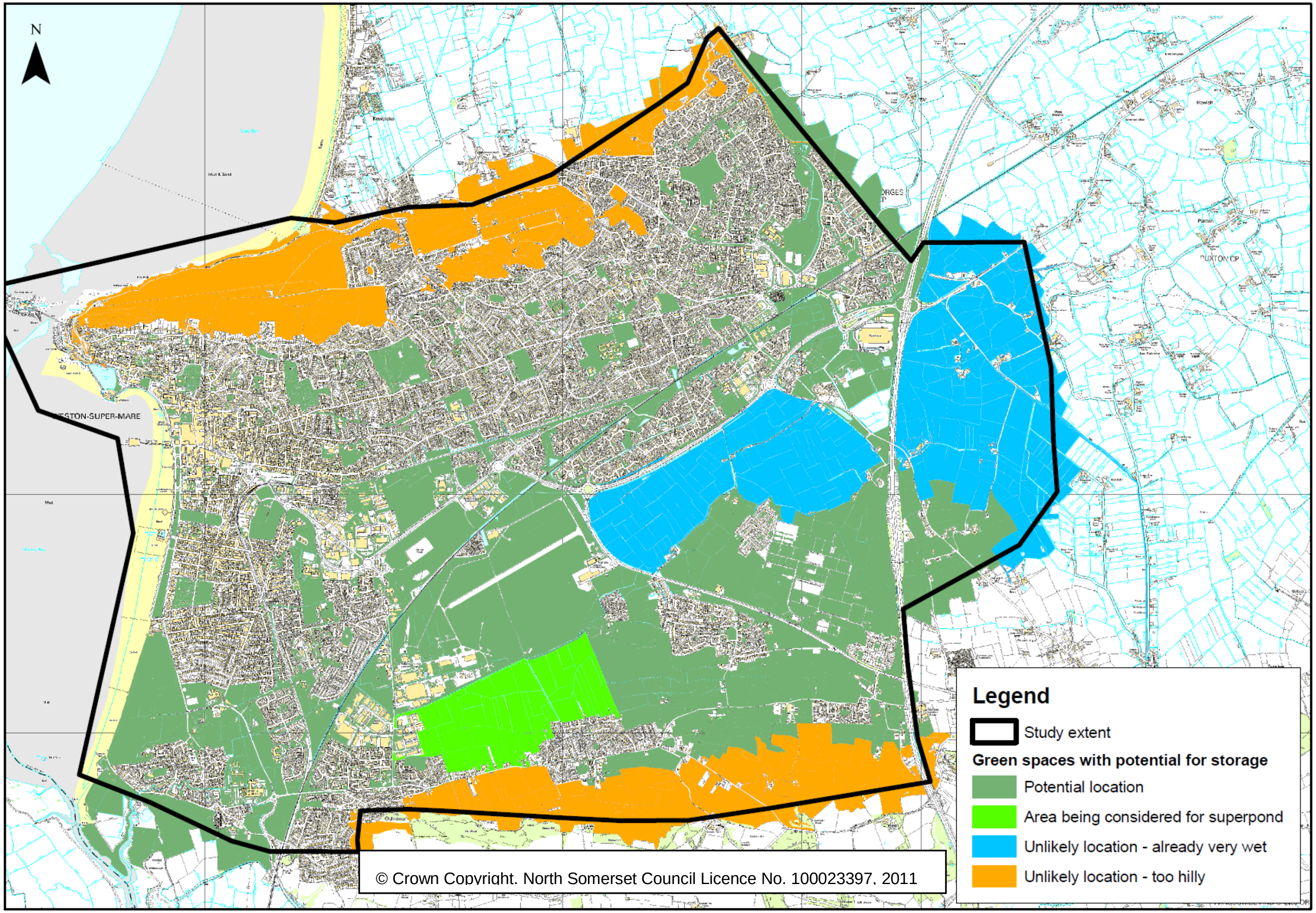

Figure 4.1 – Potential green open spaces within the study area that could be used for storage

4.3 Policies

The options list contains a large number of potential options making it complex to describe the exact location and scope of these within this report. It was therefore decided to group these options into policies. Each area identified as at risk was then given a policy. This means that all areas at risk are considered in a consistent manner and allows for flexibility in the application of specific options. It also makes it easier to compare different parts of the study area. The list of policies and options within each are shown below. This is in line with other broad-scale studies e.g. Catchment Flood Management Plans and Shoreline Management Plans.

There is a degree of cross over, where some options can be used in several policies. This is because options will be used in different ways and different combinations to achieve the required outcome.

No Active Intervention

This will be used to highlight areas where flooding does occur but there is no or little flood risk to properties or valuable assets and where attenuation or flow diversion would not benefit other areas. This is a standard option that is included within all option assessments to provide a baseline case.

Maintain Existing Scheme and Provide Education

This will be used in areas where small amounts of flooding occur that may affect access or property. In these areas the work/cost required to improve the scheme would be considerably larger than the benefit to the area. The option promotes the proper and regular maintenance of the existing scheme to allow it to function to full capacity. In addition to this education can be provided to local residents on causes of flooding and how they can help to mitigate the risk on a property by property basis. Examples of some of the potential solutions within this policy are:

- Education on residential SUDS
- Emptying water butts
- Threshold raising
- Gully maintenance/unblocking

Enhance Existing Scheme (inc. provision of temporary protection)

This option will be used where there is already a basic infrastructure in place which is currently not sufficient to prevent flooding but that with a small amount of construction work could be improved to provide a satisfactory standard of protection. For example where an existing drainage network has sufficient capacity available but there are insufficient gullies to convey the water into the system, the number or size of gullies could be increased. Other options are:

- Better use of existing flood storage
- Increase number of gullies
- Increase size of gullies
- Individual Property Protection (IPP) or modifications to property for flood resilience
- SUDS to public areas
- Raise awareness of risk for property owners to protect themselves
- Provision of water butts
- Surface water flood routes

Construct New Scheme
This policy will cover areas that are currently at risk of flooding and where the existing infrastructure is not sufficient. A new surface water scheme or extensive overhaul of the existing scheme is required and could be justified. Some of the options included within this policy include:

- Construct new ponds / wetlands
- Construct swales
- Road humps to direct or slow flow
- Permeable driveways
- Road profiling
- Road lowering
- Increase drainage capacity
- Install additional outfall

4.4 Option costs

Table provides an indication of the potential cost of the options identified in Sections 4.2 and 4.3. Note that due to the unknown sizes of defence required for each area, the cost per unit has been provided whether this is length, area or per item. This can then be applied to any area within the whole study area.

Table 4.1 – An indication of the potential cost of options (2011 base date)

Policy	Option	Approximate Cost (£)
Maintain	Gully maintenance / clearing	£100/hr
	Educational material	£5,000 based on 1,000 leaflets
	Threshold raising	£200 - £1,500 per property
Enhance	Flood proofing	Property specific
	Increase in number / size of gullies	£800 per gully (depending on size)
	Individual Property Protection (IPP)	£2,000 - £6,000 per property
	Provision of water butts (rainwater harvesting)	£35 per water butt (assuming bulk purchase)
	Alterations to surface flow routes	~£8,000 per 100m length
	Increase drainage capacity	£95 per metre (higher if services clash)
Construct	New outfall construction	£200,000 (outfall only, excludes upgrading drainage)
	Pond construction	£25 - £75 per square metre (depth dependent)
	Road re-profiling	£50 per square metre
	Permeable paving (public areas)	£75 - £100 per square metre
	Permeable driveway	£250 per square metre
	Road Humps	£1,000 per hump (assuming 4.5m in length, excluding traffic management)
	Storage beneath car parks	£100 - £200 per square metre based on excavation to 0.5m deep
	Swale construction	£50 - £100 per square metre

4.5 Policy areas

Following extensive reviews of the model results and the assessment of the number of properties affected by surface water flooding, with the exception of a small number of locations, most of the flooding is limited to one or two properties per area. It is therefore unrealistic to identify specific key areas of flooding, where larger new construction projects could be justified. In the limited cases where key areas can be identified (such as Milton Hill, see Section 4.6) this has been carried out and appropriate policies have been identified for these areas, along with recommendations for specific actions. Throughout the remaining study area property flooding is sporadic and as such, costs of flood mitigation measures would outweigh the benefits (with the possible exception of individual property protection).

Our revised approach to recommending policies and options for dealing with surface water flooding in Weston-super-Mare is to divide the study area into policy units based on a number of criteria including location, topography, land use, density of properties and drainage network. This has produced the following areas, as shown on Figure 4.2:

1. – Worlebury/Milton/Worle
2. – Uphill/Oldmixon/Hutton
3. – Central and West/South Worle
4. – Weston Villages/Locking

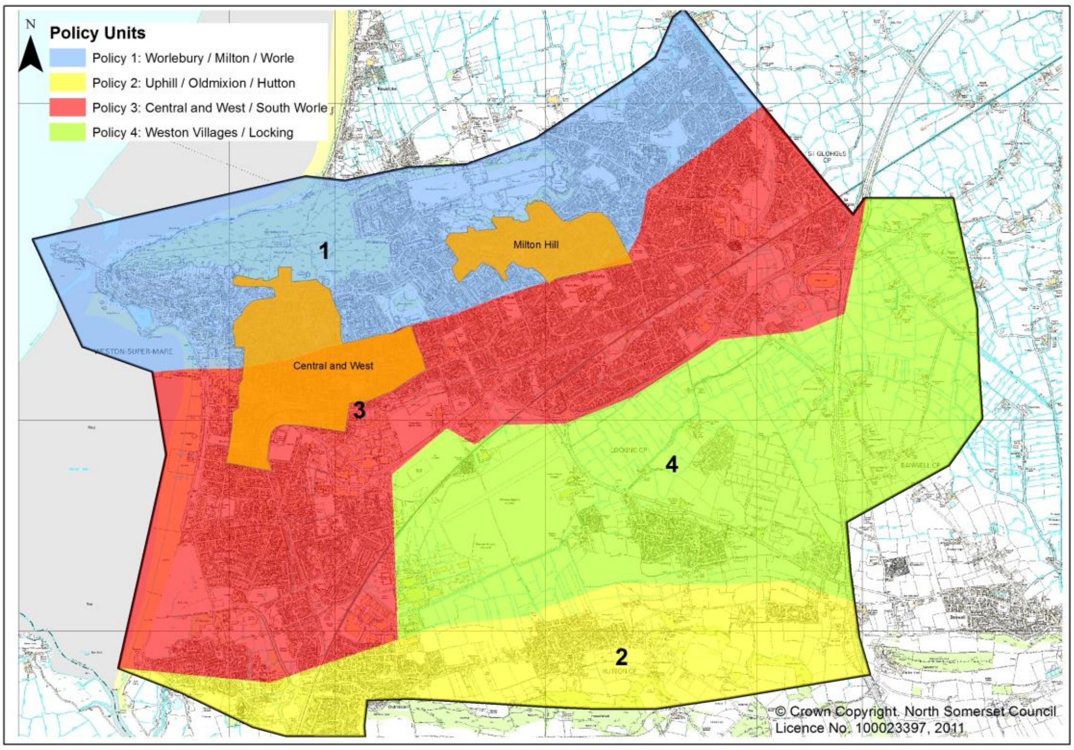

Figure 4.2 – Policy units

Table 4.2 below shows the number of properties and critical / vulnerable assets at risk from a 1 in 100 year event within each policy unit, based on the current drainage system operating as designed. This shows that the main area of focus is the hilly urban area to the north (Policy Area 1 – Worlebury/Milton/Worle). Note that this includes the Milton Hill area, which is discussed in more detail in Section 4.6.

Table 4.2 – Number of properties and critical / vulnerable assets at risk from a 1 in 100 year flood event

Policy ID		Policy Name	Properties	Critical / vulnerable assets
1		Worlebury/Milton/Worle	191	19
2		Uphill/Oldmixon/Hutton	9	2
3		Central and West/South Worle	4	8
4		Weston Villages/Locking	2	0

Appropriate policies for managing surface water flooding within each unit have been determined (Table 4.3) based on the current situation i.e. policies that can be implemented straight away, and looking into the future should flooding become more of an issue. Further details on specific areas within each policy unit are shown in Table 4.4, and for the case of Milton Hill are expanded upon further in Section 4.6. Note that where the policy of enhance or construct is chosen, regular maintenance should also be undertaken both now and following any works, particularly gully maintenance / clearing and the distribution of educational material to promote the consideration of surface water run-off. In addition, SUDS should be promoted for all new developments to mitigate against increased run-off and to ensure that there is no increase in the volume of water entering the drainage system post development. Some simple enhancements should be considered in all areas, e.g. the provision of water butts and the promotion of permeable paving for all new developments or retrofitting where possible.

Table 4.3 – General policies for each unit

ID	Policy Name	Current policy	Future policy
1	Worlebury/Milton/Worle	Construct with elements of enhancements	Construct with elements of enhancements
2	Uphill/Oldmixon/Hutton	Enhancements	Construct with elements of enhancements
3	Central and West/ South Worle	Construct with elements of enhancements	Construct with elements of enhancements
4	Weston Villages/Locking	Maintenance	Maintenance with links to strategic solution

Table 4.4 – Specific details within each unit

ID	Policy Unit	General policy	Specific elements	Approx. capital cost*	Locations
1	Worlebury/Worle/Milton	Construct	Pond construction	£50,000	Milton Hill / Upper Bristol Road junction
			Road re-profiling	£50,000	Milton Hill and Worlbury Road / Milton Road junction – divert water through golf course
			Swale construction	£20,000	e.g. near bottom end of Milton Hill, and along New Bristol Road, north of Worle
			Permeable paving (public areas)	£220,000	Mendip Green First School and area north of New Bristol Road in Worle.
			Permeable paving (private areas)	£2,500 per driveway	Encourage permeable driveway construction (both retrofitting and for all new developments)
			Storage below ground e.g. below existing car parks	£625,000	e.g. Upper Church Road area, in conjunction with permeable paving – this provides extra storage and relieves drainage in this area.
			Road humps	£20,000	Milton Hill, Upper Bristol Road
			Opportunities for sewer separation	TBC	Identify routes through Weston for the transfer of surface water drainage away from the foul system
		Elements of enhancements	Flood proofing and Individual Property Protection	£6,000 per property	Properties adjacent to Milton Hill and on known flood routes e.g. Spring Hill
			Raise awareness of risk	£500	Raise awareness of risk with property owners on known flood routes e.g. Spring Hill, to facilitate ability to protect themselves
2	Uphill/Oldmixon/Hutton	Enhancements	Increase in number / size of gullies	£5,000	Hutton – Moor Lane, Farm Road
			Raise awareness of risk	£500	Raise awareness of risk with property owners on known flood routes to facilitate ability to protect themselves
			Road alterations including road humps	£20,000	Hutton – Main Road / Church Lane junction
		Construct	Road re-profiling and road humps		Junction of Church Lane and Main Road in Hutton

ID	Policy Unit	General policy	Specific elements	Approx. capital cost*	Locations
3	Central and West/South Worle	Construct	Swale construction	£20,000	Green strip between Milton Road and Oakford Avenue / Lewisham Grove – connect roads either side by routing flood waters through narrow tracks between blocks of houses
			Road re-profiling	£30,000	Milton Avenue (leading to the Fire Station) – raise road to allow unhindered emergency vehicle access.
				£15,000	Oakford Avenue / Lewisham Grove, Chelswood Avenue – encourage the water into the gullies
				£25,000	New Bristol Road – re-profile and create flow routes to guide water away from Old Bristol Road and properties to existing drainage or potential storage area adjacent to Summer Lane North
3	Central and West/South Worle	Elements of enhancements	Increase in number / size of gullies	£10,000	Manor Road / Milton Road junction, Hill Road / Milton Road junction, Milton Avenue (leading to the Fire Station)
			Individual Property Protection	£6,000 per property	Properties that can not be protected through the construction process.
			Raise awareness of risk	£500	Raise awareness of risk with property owners on known flood routes to facilitate ability to protect themselves
			Transfer of Wessex water flows to Uphill storage	TBC	From areas to be identified and into the proposed strategic flood storage solution
4	Weston Villages/Locking	Maintenance	Gully maintenance	-	Standard maintenance of all drainage infrastructure. Ensure blockages are cleared, particularly prior to heavy rainfall.
			Educational material	£5,000	Encourage the promotion of educational material to ensure surface water considerations are at the forefront for local residents, employers and developers

* Capital costs are based on a 10 year scheme life (2011 base date). Cost estimate includes the design works etc as well as the actual build costs. Maintenance costs not included.

In Policy Unit 4 (Weston Villages/Locking) a strategic solution to both fluvial flood risk and the impact of development on surface water is being constructed by North Somerset Council, the Environment Agency and key developers. This will be in the form of a strategic flood storage and channel improvements. Any developments in this area should link to this strategic solution rather than implementing a site specific scheme.

4.6 Specific Areas

4.6.1 Milton Hill

Milton Hill is located in the suburb of Worle in Weston-super-Mare. The Milton Hill area has a history of flooding and 11 properties were flooded internally in 2007 and 5 in 2012. This matches Wessex Water modelling which indicate that 5 properties are at risk of internal flooding. The broad-scale modelling produced for this SWMP also highlighted this area as an “at risk” location with approximately 23 properties at risk from a 1 in 100 year event.

Wessex Water, along with North Somerset Council, have invested heavily in determining the flood risk to properties, assessing potential options and undertaking discussions with various stakeholders within this area. They have developed a detailed sewer network and overland flow model to assist with this assessment and reviewing of the potential options. The results of this model is discussed in more detail within the Technical Note in appendix D which shows correlation between sewer surcharging and anticipated routing of water with the SWMP modelled results in Milton Hill.

In 2012, Wessex Water undertook a flooding scheme in Coronation Road to upsize the foul sewer which alleviated flooding issues to Coronation Road.

In 2011, a 125m^3 storage tank was constructed in Milbury Gardens to alleviate flooding to 5 properties in Upper Bristol Road and Spring Hill. Further improvements are planned for this area of Milton Hill to provide further storage and alleviate flooding to the risk areas of Spring Hill and Spring Valley. This mitigation scheme involves the installation of one or two storage tanks to provide further storage of 600-800m^3, upgrading surface water sewers, installing cross-drains on the highway, modifying the road profile and upgrading road drainage.

The proposed works are a combination of highway / footway works and attenuation, as described below.

- <u>Highway and Footway Works</u> - A large part of the overland surface water flow finds its way into Upper Bristol Road from Milton Hill. This new route for overland flow has come about because of highways improvements that were carried out some years ago. Anecdotal evidence suggests that there was no flooding before the road was realigned and overland highway flow came down Milton Hill and continued down Baytree Road.

  Part 1 of the proposal is to divert some of the water flowing down Milton Hill on to its original route. Some re-cambering of specific sections of the highway in Milton Hill / Upper Bristol Road and the creation of a channel in the footway at the bottom of the hill opposite the garage will direct water away from Upper Bristol Road and down Baytree Road; the original flow path.

- Attenuation Works - There is an area of green open space owned by the council behind the garage at the bottom of Milton Hill. The proposal is to create attenuation on this open space by landscaping the area to form one or two bunded, self-draining ponds.

  The proposal could also benefit the garage that regularly floods by the construction of a flow route through the garage car park and out of the rear wall which adjoins the green open space.

To review this option for Milton Hill in line with this SWMP, the 2-dimensional model built as part of this study was revised to produce a more localised model for Milton Hill. This had a refined grid size and more local details e.g. defined kerb and road heights. Changes were then made to the road camber to aid the re-direction of the flood water. The model showed that in theory the option could be achievable, although the detail of the cambering process would need thorough investigation.

Milton Hill is the only area looked at in specific detail as part of this study due to the known flood risk.

4.7 Sewer System

The majority of Weston-super-Mare is either drained by combined sewer system or where there is a separate foul and storm drainage this drains/links into the combined system. The majority of the system is pumped due to the topography of the area. The drainage system in Central and West area is a combined system and dependent on Black Rock Pumping Station as there is no gravity outfall. Wessex Water are seeking to achieve separation of storm flows to reduce the spill frequency at Black Rock combined system overflow (CSO).

Worle is a separately drained system but while foul water from the greater part drains west to Weston-super-Mare, storm water gravitates north east to the River Banwell and Wick St Lawrence STW with both systems dependent on pumping.

When Schedule 3 of the Flood and Water Management Act and the SuDS Approval Body (SAB) requirements are implemented, this will require surface water to be managed on site thereby reducing the connections of surface water into the sewer system and pressure on SPS. The policy option to retrofit SuDS will also seek to reduce the pressure on the pumped system.

4.8 Cost-Benefit Analysis

Due to the nature of surface water flooding, generally the areas at risk are extremely localised and fall in small pockets of land. It is therefore unusual that one big scheme can help across an entire area. Instead, localised works can be done to help solve a local problem. It is therefore not practical to determine the cost-benefit analysis for the whole study area, instead this needs to be focused on small pockets of flood risk.

To provide an indication of where the benefits may be sufficient for undertaking work, an assessment of the potential damage for each policy unit has been undertaken, as shown in Table 4.5. Using the information in Table 4.4 an approximate estimate of the capital costs within each policy unit has been calculated. The potential benefit is then shown as a range based on a scheme life of between 10 and 100 years. This range has been chosen because some elements like IPP should only be considered for a short term duration. Once flooding increases and more properties are at risk then construction options could become viable. A range of cost-benefit ratios are therefore provided in Table 4.5.

Table 4.5 – Summary of benefit for each unit

Unit ID	Policy Unit	Benefit* (£)	Potential solution	Approx. capital cost (£)	Cost-benefit ratio
1	Worlebury/Milton/Worle	4,000,000 – 14,000,000	Construct	£1,500,000**	2.7 – 9.3
2	Uphill/Oldmixon/Hutton	120,000 – 430,000	Enhance	£35,000	3.4 – 12.3
3	Central and West/South Worle	24,000 – 83,000	Construct	£100,000	0.2 – 0.8
4	Weston Villages/Locking	13,000 – 45,000	Maintain	£5,000	2.6 – 9.0

* Benefit shows range depending on an assumed scheme life time. Lower limit is based on 10 year scheme life and upper limit is based on 100 year scheme life. Benefit assumes that 36% of flats included. See Section 3.9.

** Note that this cost is the most uncertain due to the number of properties and wide spread nature of the flooding.

Table 4.5 shows that there is a good cost-benefit ratio in Policy Unit 1 (Worlebury/Milton/Worle) however care needs to be taken in particular when looking at this unit. The majority of properties at risk in Weston-super-Mare fall within this Policy Unit and therefore the benefits are very high, but the problems are still widespread across the study area. An assessment has been made of the potential options for the area, although not in detail, to ensure that all properties highlighted are protected as part of the options. The extent of protection would depend on the design of specific elements and may require local modelling work to confirm the number of properties that would benefit from each option element. Overall there is a need to carry out work in Policy Unit 1 (Worlebury/Milton/Worle) but a more detailed assessment of each option element should be undertaken to provide the benefit of each individual element. These should be developed in a strategic manner to ensure that the elements work together.

Policy Units 1, 2 and 4 show a good cost-benefit ratio and therefore reflect that work should be undertaken in these areas. Policy Unit 3 (Central and West/South Worle) shows that construction options may not be viable currently when considering the Policy Unit as a whole, however small distinct areas may still have a good cost-benefit ratio for individual construction schemes. In addition, further enhancements such as IPP should also be considered for this area.

One of the main reasons for the preferred policy to be 'Construct' for Policy Unit 3 (Central and West/South Worle) is due to the location of the Fire Station, which is classed as a Critical Asset. Safe access to and from the Fire Station is essential during a flood event and therefore there may be wider benefits for the whole of Weston-super-

Mare that can be associated with some of the construction work in this Policy Unit. This should be looked at in a detailed benefit assessment.

Each individual element of work will need to show it has a positive cost-benefit ratio and therefore just showing the policy unit does will not mean that each element will also. Further assessment work, including detailed design of options would be required to determine an accurate cost-benefit ratio for that particular area of flood risk.

The benefit of protecting one property and the potential costs of each option based on an assumed size has been reviewed. This helps to give an idea of how many properties need to be protected for each option to become viable.

Scheme costs for each option have been broadly developed by assuming a size of scheme or the number of units that would be required for a typical scheme for each option. This allows each option to be put into a cost band for analysis of the cost-benefit ratio to give an indication of the viability of each option on a 'per property protected' basis.

Tables 4.6 and 4.7 show the potential benefit (PVd) of protecting an individual property, for each return period of when the property first floods, for residential and commercial properties respectively. Various scheme lifetimes are included in the table to show how this has an impact. Table 4.8 then shows which options fall into each cost band. These bands are only a guide and will be heavily dependent on the size and location of each option.

Table 4.6 – Benefits for protecting individual residential properties

Return Period flooding starts	WAAD	PVd (10 yr scheme)	PVd (50yr scheme)	PVd (100yr scheme)
5 year	£4,900	£42,400	£124,700	£147,000
10 year	£3,200	£27,400	£80,500	£94,900
20 year	£1,600	£13,900	£40,900	£48,200
30 year	£1,000	£8,100	£23,900	£28,100
50 year	£600	£5,300	£15,600	£18,400
100 year	£350	£2,800	£8,200	£9,600

Table 4.7 – Benefits for protecting individual commercial properties

Return Period flooding starts	WAAD	PVd (10 yr scheme)	PVd (50yr scheme)	PVd (100yr scheme)
5 year	£10,300	£88,200	£259,300	£305,600
10 year	£7,900	£68,400	£201,000	£236,900
20 year	£4,700	£40,100	£117,800	£138,800
30 year	£3,200	£27,900	£82,100	£96,800
50 year	£2,300	£19,500	£57,300	£67,500
100 year	£1,200	£10,300	£30,300	£35,700

Table 4.8 – Option cost bands

Lost cost options* ~ < £10k	Medium cost options ~ £10k - £100k	High cost options ~ > £100k
• Threshold raising • Flood proofing • Increase in number / size of gullies • Individual Property Protection • Raise awareness of risk for property owners to protect themselves • Provision of water butts (rainwater harvesting)	• Alterations to surface flow routes • Increased drainage capacity • Pond construction • Road re-profiling • Swale construction • Permeable paving (private) • Road humps	• New outfall construction • Permeable paving (public areas) • Storage beneath car parks

* Some low cost options may not be suitable for very long scheme lives and therefore this needs to be considered when comparing to the potential benefits.

Comparison of benefits and scheme option costs indicate that the focus in the short-term should be on small-scale schemes e.g. individual property protection, for the protection of properties that flood on a regular basis e.g. approximately once every 5 years where the low cost options provide a good cost-benefit ratio. In the medium to long term other options should be considered as the number of properties experiencing more frequent flooding increases, particularly as the density of properties at risk increases. Then some of the options from the medium to high bands could become more viable.

4.9 New Development

Following the Flood and Water Management Act (2010) and the Technical Guidance to the National Planning Policy Framework (NPPF) (superseding PPS25) it is now a requirement that any new development should not increase the surface water run-off from the site, and where possible should improve on the existing situation. The imminent implementation of schedule 3 of the Flood and Water Management Act has been delayed but will require the creation of a SuDS Approval Body (SAB) and surface water from new development will need to be managed on site by sustainable drainage systems (SuDS). New developments should therefore not impact on others and in some cases help the situation.

For the Weston Development Area, strategic flood storage ponds are being developed to manage surface water run-off from developments within the Weston Villages and Parklands rather than a series of separate SuDS schemes. Both the surface water and fluvial flood risk is considered and offers a significant amount of betterment downstream.

The "super pond" will take the displaced flood water from a fluvial event due to the developments, along with the increased surface water run-off from the sites. A control structure will be installed at the downstream end to limit the volume and flow of water into the Uphill Great Rhyne and therefore reducing the flood risk to the properties in Uphill. The first stage of this project adjacent to the Cross Rhyne is under construction (summer 2014) with further storage on the River Banwell at design stage.

4.10 Funding

Under the new Flood Defence Grant in Aid funding system, launched by Defra/EA in May 2011, surface water flooding problems are eligible for full or partial funding (depending on a range of criteria).

Within this system is the ability to make applications for IPP grants (again, subject to eligibility criteria). It should be noted that commercial properties do not qualify for IPP grants and any homes built after 2009 will not be eligible for funding support under the new FDGiA rules. This is based on the idea that all new homes should be shown to be safe from flooding as part of their Flood Risk Assessments.

The benefits of reducing flood risk are high, both in financial terms (reduced losses, lower insurance premiums) and in social terms due to the avoidance of disruption. Any measures to reduce surface water flood risk will be of direct benefit to property owners and it is therefore appropriate to seek contributions as well as cooperation from individuals prior to implementing works. Obtaining external contributions to projects is a central theme in the revised funding arrangements, and contributions can help secure FDGiA.

5 IMPLEMENTATION AND REVIEW

The final phase involves preparing an implementation strategy (i.e. an action plan), that will deliver the agreed actions and monitor the implementation of these actions. This should include a coordinated delivery programme and a plan for monitoring the options once implemented in order to assess outcomes and benefits. The SWMP should then be reviewed and updated where required at regular appropriate intervals.

5.1 Action Plan

An action plan has been produced to assist in implementing the management measures identified in this report identifying lead partner, timescales and funding opportunities. This is included as an appendix (E) to maintain as a living document by the Flood Risk Partnership.

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Glossary of terms

Area of Outstanding Natural Beauty (AONB)

Areas of Outstanding Natural Beauty (AONB) were formally designated under the National Parks and Access to the Countryside Act of 1949 to protect areas of the countryside of high scenic quality that cannot be selected for National Park status due to their lack of opportunities for outdoor recreation (an essential objective of National Parks). Natural England is responsible for designating AONBs and advising Government and others on how they should be protected and managed. Further information on AONBs can be found at: http://www.aonb.org.uk

ArcMap

A Geographical Information System (GIS) computer Package produced by ESRI. Further information can be found at www.gis.com and also at www.esri.com.

Appropriate Assessment (AA)

Where there is likely to be a significant effect on a European site, an appropriate assessment must be carried out. An appropriate assessment determines whether a likely significant effect will occur as a result of a proposed plan, policy or project.

Bedrock Aquifers solid permeable formations e.g. sandstone, chalk and limestone.

Benefits

Those positive measurable and immeasurable changes that a plan will produce, including damages avoided.

Biodiversity Action Plan (BAP)

An agreed plan for a habitat or species, which forms part of the UK's commitment to biodiversity. For further information consult the BAP website: http://www.ukbap.org.uk

Birds Directive

European Community Directive (79/409/EEC) on the conservation of wild birds. Implemented in the UK as the Conservation (Natural Habitats, etc.) Regulations (1994). For further information consult Her Majesties Stationary Office website: http://www.hmso.gov.uk/si/si1994/Uksi_19942716_en_1.htm

Catchment

A surface water catchment is the total area that drains into a river. A groundwater catchment is the total area that contributes to the groundwater part of the river flow.

Catchment Abstraction Management Strategies (CAMS)

CAMS are strategies for managing water resources locally. They will make more information the allocation of water resources available and balance the needs of abstractors with those of the water environment by consulting with local interested parties.

Catchment Flood Management Plan (CFMP)

Catchment Flood Management Plans (CFMPs) are a large-scale strategic planning framework for managing flood risks to people and the developed and natural environment in a sustainable way.

Catchment Opportunities and Constraints

Main issues in the catchment, which are identified based on a combination of catchment characteristics (e.g. designated areas the need protecting or improving), Government policy/targets (e.g. Defra 'High Level Targets', 1999) and/or catchment initiatives (e.g. existing local authority strategies). Catchment policies/measures should aim to 'take account of constraints' and 'promote opportunities' through the CFMP appraisal framework (economic, environmental and technical). Designated sites have Water Level Management Plans (WLMPs) that set out water level management needs in certain parts of the catchment and some floodplain areas have nature conservation or heritage interest that benefit from more frequent flooding.

Catchment Sensitive Farming

Catchment Sensitive Farming is a pro-active approach to diffuse pollution. By reducing agricultural sources of diffuse pollution within river catchments, through land management practices, we can ensure that emissions to water are consistent with ecological requirements. Forty catchments across England, have been identified as priority areas for action, and will be targeted under a range of measures aimed at improving farm practices and reducing water pollution from agriculture. Advisers will work on a one to one basis with farmers, as well as leading a series of initiatives including workshops and farm demonstrations to encourage best practice.

Catchment Policies

The results of the CFMP, which are the stated policies for flood risk management within a defined flood risk area, based on the generic catchment policies.

Communication Plan

A plan that sets out the CFMP consultation programme and specific arrangements for internal (Environment Agency) and external consultation.

Consultation Group

A group of people who represent interested parties who we consult on the CFMP as agreed with the Project Board. The Consultation Group should be identified within the Communication Plan.

Countryside Character Areas

Countryside Character Areas are parts of England, which have a similar countryside character. There are 159 Character Areas in England on which strategies for both ecological and landscape issues can be based. Natural England extensively uses this framework to describe and shape objectives for planning and managing the countryside.

Countryside and Rights of Way Act (CRoW)

The Countryside and Rights of Way (CRoW) Act 2000 came into force on 30 January 2001. The Act applies in England and Wales and has five parts:

1. Access to the countryside;

2. Public rights of way and road traffic;
3. Nature conservation and wildlife protection;
4. Areas of outstanding natural beauty;
5. Miscellaneous and supplementary.

Part 3 is the most relevant in terms of catchment flood management as it gives biodiversity a statutory basis, revises SSSI notification procedures, greatly increases protection for SSSIs and strengthens the advisory role of EN / CCW, increases the scope of some wildlife offences and increases penalties. For further information refer to Her Majesty's Stationery office website:

http://www.hmso.gov.uk/acts/acts2000/20000037.htm

Critical Ordinary Watercourses (COWs)

Stretches of non-main watercourse that have been defined as critical in terms of flood risk management through consultation between us and Local Authorities.

Datasets A data set (or dataset) is a collection of data, usually presented in tabular form. Each column represents a particular variable. Each row corresponds to a given member of the data set in question.

Defra

Department for Environment, Food and Rural Affairs. The department of central Government responsible for flood management policy in England.

Depth-Duration-Frequency function Rainfall depth-duration-frequency (DDF) curves describe rainfall depth as a function of duration for given return periods and are important for the design of hydraulic structures.

Digital Elevation Model (DEM)

A digital elevation model is a representation of the topography of an area and gives the elevation of the upper surface whether it is the ground, vegetation or a building.

Digital Terrain Model (DTM)

A digital elevation model is a representation of the ground surface with buildings and vegetation removed. With airborne techniques automated filters have been developed which can detect buildings and remove them and fill the gap with interpolated data.

Department for Communities and Local Government (DCLG)

The department that is responsible for local communities and social issues.

Department for Transport, Local Government and the Regions (DTLR)

The former department of central Government responsible for policy on planning and other issues. Now replaced by the Office of the Deputy Prime Minister which has subsequently been replaced by the Department for Communities and Local Government (DCLG).

Drainage coefficient Measures how well a pavement will filtrate masses of water.

Environment Agency

Non-departmental public body responsible for implementing Government policy relating to the environment and flood risk management in England and Wales.

Environment Agency Vision

Our 'vision' for the environment and a sustainable future is: 'A healthy, rich and diverse environment in England and Wales, for present and future generations'. To achieve the targets that will make the 'vision' a reality we have identified nine key 'themes' or 'frameworks for change' which we will use to work for a more sustainable future.

1. A better quality of life: We will work with all sectors to improve the quality of the environment and the services it provides – for business, anglers, the boating community and other users of the waterways, farmers, planners and all sections of the community;

2. An improved environment for wildlife: We will make sure that our work and the work of those we authorise does not threaten important species and habitats;

3. Cleaner air for everyone;

4. Improved and protected inland and coastal waters: We will work to clean up polluted waters and to reduce the risk of further pollution;

5. Restored protected land with healthier soils;

6. A 'greener' business world;

7. Wiser sustainable use of natural resources;

8. Limiting and adapting to climate change;

9. Reducing flood risk: We will improve flood defences and information on flood risks.

For further information refer to our website: http://www.environment-agency.gov.uk

Environmentally Sensitive Areas (ESA)

ESA schemes were introduced by the Ministry of Agriculture, Fisheries and Food (MAFF; predecessor to Defra) in 1987 and are designated under the provisions of sections 18 and 19 of the 1986 Agriculture Act and Environmentally Sensitive Area (Stage II) Designation (Amendment)(No2) Order 2001. They are governed by Defra and offer incentives (on a 10 year agreement with a 5 year break clause) to encourage farmers to adopt agricultural practices which would protect and improve parts of the country of particularly high landscape, wildlife or historic value. Further details can be found on Defra's website: http://www.defra.gov.uk/erdp/schemes/esas/default.htm

Environmental Stewardship

Environmental Stewardship is a new agri-environment scheme, which provides funding to farmers and other land managers in England who deliver effective environmental management on their land. The scheme is intended to build on the recognised success of the Environmental Sensitive Areas scheme and the countryside Stewardship Scheme. Environmental stewardship has three elements:

1. Entry Level Stewardship (ELS): The aim is to encourage a large number of farmers across a wide area of farmland to deliver simple yet effective environmental management.

2. Organic Entry Level Stewardship (OELS): The aim is to encourage a large number of organic farmers across a wide area of farmland to deliver simple yet effective environmental management.

3. Higher Level Stewardship (HLS): The aim is to deliver significant environmental benefits in high priority situations and areas.

FEHCALC

Spreadsheet designed by John Packman from the Centre for Ecology and Hydrology, Wallingford to calculate peak flows, based on the rainfall-runoff methodology detailed in the Flood Estimation Handbook. Procedures are outlined within the MDSF guidelines.

Flood Defence

A structure (or system of structures) for reducing flooding from rivers or the sea. Flood Estimation Handbook (FEH) provides the current ways for estimating flood flows for the UK.

Floodplain

Any area of land over which water flows or would flow if there were no flood defences. It can also be a place where water is stored during flooding.

Flood Map

The Flood Map is our public map for floodplain information. It shows the Flood Zone extents, which ignore defences, the location of raised defences and the area benefiting from defences. Available on our website, it also provides information on the chance of general areas of land flooding.

Flood Estimation Handbook (FEH) The Flood Estimation Handbook and related software offer guidance on rainfall and river flood frequency estimation in the UK. Flood frequency estimates are required for the planning and assessment of flood defenses, and the design of other structures such as bridges, culverts, and reservoir spillways.

Flood Reconnaissance Information System (FRIS) Database held by the Environment Agency that provides historic flood incident information

Flood Risk

The level of flood risk is the frequency or likelihood of the flood events together with their consequences (such as loss, damage, harm, distress and disruption).

Flood Risk Management

Modifying the frequency or consequences of flooding to an appropriate level (equal to land use) and monitoring to make sure that flood risks remain at the proposed level. This should take account of other water level management requirements, and opportunities and constraints. It is not just about applying physical flood defence measures.

Flood Zones

We have produced flood zones in response to Planning Policy Guidance (PPG 25) and to provide planning authorities with quality assured flood risk data. The zones show the area at risk if there were no defences and are classified as follows:

Zone 1 - annual probability of flooding of less than 1000:1 (0.1 per cent);

Zone 2 - annual probability of flooding between 1000:1 (0.1 per cent) and 1:100 (1.0 per cent) for river flooding or 200:1 (0.5 per cent) for coastal flooding; and

Zone 3 - annual probability of flooding greater than or equal to 1:100 (1.0 per cent) for river flooding or greater than or equal to 200:1 (0.5 per cent) for coastal flooding.

Fluvial

Relating to a watercourse (river or stream).

Freshwater Fisheries Directive Designation

EC Directive 78/659/EEC on the Quality of Fresh Waters Needing Protection or Improvement in order to Support Fish Life ('The Freshwater Fish Directive') aims to protect and improve water quality and forms part of our water quality monitoring programme. Under the Directive, the UK Government was required to designate two categories of water: those suitable for salmonids (waters that have the potential to support fish of the family Salmonidae, mainly salmon and trout but also grayling) and those suitable for cyprinids (from the family Cyprinidae plus pike, perch and eel).

The Directive sets standards to protect freshwater fisheries, mainly relating to the quality of the water, and requires certain designated stretches of water to meet these standards so that fish can live or breed. For further information please consult our website:

http://www.environment-agency.gov.uk/

Geographical Information System (GIS)

A GIS is a computer-based system for capturing, storing, checking, integrating, manipulating, analysing and displaying data that are spatially referenced.

Geomorphology

The sediment erosion, deposition of transport processes that create the topography and shape of a river and its floodplain.

Groundwater

Water occurring below ground in natural formations (typically rocks, gravels and sands).

Highest Astronomic Tide (HAT)

The highest tide that can occur due solely to the arrangement of the moon, sun and planets.

Historic Flood Map

Shows the mapped extents of known historical flooding.

Hydrograph The scientific description and analysis of the physical conditions, boundaries, flow, and related characteristics of the earth's surface waters.

Hydrological Model

Estimates the flow in a river from a certain amount of rainfall falling into the catchment. Such models typically account for factors such as catchment area, topography, soils, geology and land use.

Hyetograph A hyetograph is a graphical representation of the distribution of rainfall over time.

Inception Report

Provides a detailed description of the work carried out during the CFMP Inception phase. This includes a summary of catchment data collection and preliminary understanding of the main issues to be considered for effective flood risk management during subsequent phases of the CFMP process.

Indicative Floodplain Maps (IFMs)

Maps showing our best estimate of the extent of the floodplain. These cover all main rivers and some ordinary watercourses. The floodplain is defined as the area having a 1 per cent per annum risk of fluvial, or a 0.5 per cent per annum risk of tidal inundation. Defended areas are also shown. These maps are sometimes referred to as Section 105 maps. These maps have been replaced by the flood zone map.

Indicative Standard of Protection

The range of level of protection to be considered for flood defences, based upon how the land being protected is used. They do not represent any entitlement to protection or minimum level to be achieved.

Interferometric Synthetic Aperture Radar (IFSAR)

Interferometric Synthetic Aperture Radar is a comparison of two or more radar images collected at slightly different geometries. This process extracts phase differences caused by changes in elevation relative to a reference point, producing Digital Terrain Elevation data. The technique is able to collect large areas of high-resolution data quickly and affordably no matter the conditions, night or day.

Internal Drainage Boards

Is a local public authority established in areas of special drainage need in England and Wales. They have permissive powers to manage water levels within their respective drainage districts. IDBs undertake works to reduce flood risk to people and property and manage water levels to meet local needs.

Land Use

Various designations of activities, developments, cropping types, etc for which land is used.

Land Management

Various forms of activities relating to agricultural, forestry, etc and other practices.

Local Development Documents (LDD)

These documents make up the Local Development Framework (LDF).

Local Resilience Forums (LRF) A Local Resilience Forum is a statutory body covering a police force area, designed to bring together category 1 and 2 responders for multi-agency co-operation and information sharing. Under the Civil Contingencies Act (2004) every part of the United Kingdom is required to establish a Local Resilience Forum.

LiDAR

Light Detection and Ranging (LIDAR) is an airborne mapping technique, which uses a laser to measure the distance between the aircraft and the ground.

Local Authority Development Plans

These statutory land development plans generally cover a 10-year period from when they are adopted. However, the local authorities currently review these plans every five years. A District Council and a Unitary Authority will produce a Local Plan and a County Council produce a Structure Plan. A Structure Plan guides the Local Plans of several District Councils.

Local Biodiversity Action Plan (LBAP)

A local agenda (produced by the local authority) with plans and targets to protect and improve biodiversity and achieve sustainable development. We are committed to Biodiversity Action Plans and work with central Government (Rio Earth Summit, 1992) to meet LBAP objectives.

Local Environment Agency Plan (LEAP)

An Environment Agency non-statutory plan based on the river basin (or sub-catchments or groups of smaller catchments) providing environmental baseline information and actions/objectives for that river basin (largely replaced the National Rivers Authority's Catchment Management Plans (CMPs)).

MAFF

The former Ministry of Agriculture, Fisheries and Food – all functions now incorporated within Defra.

Mean High Water Springs (MHWS)

The average of the spring tides which occur every two weeks.

Main River

Watercourses defined on a 'Main River Map' designated by Defra. The Environment Agency, have powers to carry out flood defence works, maintenance and operational activities for Main Rivers only. Responsibility for maintenance however rests with the land owner.

Modelling and Decision Support Framework (MDSF)

The Modelling and Decision Support Framework - a GIS based decision support tool developed specifically to help the CFMP process by automating parts of the analysis.

National Nature Reserve (NNR)

National Nature Reserves are designated under the National Parks and Access to the Countryside Act 1949 or the Wildlife and Countryside Act 1981 (as amended) mainly for nature conservation, but can also include sites with special geological of physiographic features. They were set up to protect the most important areas of wildlife habitat and geological formations in Britain, and as places for scientific research. All NNRs are "nationally important" and are best examples of a particular habitat/ecosystem. They are usually owned or leased by English Nature, or managed in accordance with a Nature Reserve Agreement with the landowner or occupier. At the end of March 2000 there were 200 NNRs in England covering 80,533 hectares. NNRs receive SSSI designation under The Countryside and Rights of Way Act 2000 and The Wildlife and Countryside Act 1981 (as amended). Further information about NNRs can be found on English Nature's website site:

http://www.englishnature.org.uk/special/nnr/nnr_search.asp

National Parks

The National Park Authority's duties and powers are derived from a number of Acts of Parliament and statements of Government policy, most recently the Environment Act 1995. The statutory purposes of National Parks are:

- to conserve and improve the natural beauty, wildlife and cultural heritage of the area;
- to promote opportunities for the public to understand and enjoy the area's special qualities.

In following these aims, it is also our job to try to cost effectively encourage the economic and social well being of the communities within the National Park. For further information please consult the National Park Authority's website at:

http://www.anpa.gov.uk/

National Flood and Coastal Defence Database

The DEFRA High Level Targets requires flood and coastal defence operating authorities to develop the National Flood and Coastal Defence Database (NFCDD). We are leading the development but working with local authorities and internal drainage boards to make sure the database is successfully implemented.

Natural Area Profiles and Landscape Character Areas (LCAs)

Natural Areas are parts of England that have specific wildlife and natural features. There are 120 Natural Areas in England and each has a unique identity due to the combination of wildlife, landforms, geology, land use and human impact. Further information about Natural Areas can be found on English Nature's Internet site:

http://www.englishnature.org.uk/science/natural/NA_search.asp

Landscape Character areas - The Countryside Character Initiative is a programme of information and advice on the character of the English countryside. It includes descriptions of the features and characteristics that make the landscape, and guidance documents on how to carry out Landscape Character Assessments. Further information about Landscape Character Areas can be found on the Natural England internet site:

http://www.naturalengland.org.uk/planning/landscape/default.htm

Non-main River

Non-main rivers are all watercourses not designated as Main River's (see above). The Local authority has powers to maintain these rivers but the land owner is responsible for maintaining them.

Ordnance Datum Newlyn

Ordnance Datum Newlyn (ODN) is a traditional vertical coordinate system, consisting of a tide gauge datum with initial point at Newlyn (Cornwall) and a Terrestrial Reference Frame observed by spirit levelling between 200 fundamental benchmarks across Britain. Each benchmark has an orthometric height only (not ellipsoid height or accurate horizontal position). This coordinate system is important because it is used to describe vertical positions of features on British maps (for example, spot heights and contours) in terms of height above mean sea level. The word Datum in the title refers, strictly speaking, to the tide gauge initial point only, not to the national levelled bench marks.

Other historic features

English Heritage (EH) is the national body responsible for identifying and protecting historic buildings by recommending the most important of them for “listing”. There are three grades of listed buildings depending on their relative importance:

- Grade I buildings are those of exceptional interest;
- Grade II* buildings are particularly important buildings of more than special interest; and
- Grade II buildings are of special interest, warranting every effort to preserve them.

Local authorities have the power to designate Conservation Areas in any area of “special architectural or historic interest”, whose character or appearance is worth protecting or improving. These qualities are judged against local and regional criteria, rather than national importance, as with listed buildings. In England, the main sources of information on recorded archaeological remains will be the Sites and Monuments Records (SMR) and the National Monuments Record (NMR). The SMR should contain information about all known archaeological remains. For further information refer to the English Heritage website: http://www.english-heritage.org.uk

The Pitt Review of 2007 These reviews identify the need for individual stakeholders to understand their infrastructure and responsibilities better, in a way that recognises:

- the impacts of climate change
- a need for greater coordination
- a need for stronger management and oversight.

Planning Policy Statement 25: Development and Flood Risk (PPS25)

One of a series of Planning Policy Statements issued by DCLG to advise local planning authorities and developers. While Planning Policy Statements are not statutory, planning authorities are obliged to consider them when preparing plans and determining planning applications. PPS25, issued in December 2006 (replacing PPG25 issued (2001), raises the profile of flood risk, which should be considered at all stages of the planning and development process and across the whole catchment. It emphasises the need to act in a precautionary way and to take account of climate change. It provides advice on future urban development in areas subject to flood risk, subjecting proposals to a sequential response (depends on the amount of risk) and promotes the concept of Sustainable Drainage Systems (SuDS) in new development or redevelopment. For further information please refer to the Department for Communities and Local Government website:

http://www.communities.gov.uk/index.asp?id=1504640

Pre-feasibility study

A pre-feasibility study is a preliminary study to determine if a feasibility study or project appraisal is needed.

Principal Aquifers:

These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

Problem areas:

Areas within the catchment at risk from flooding.

Probability of occurrence

The probability or chance of a flood event being met or exceeded in any one year.

Project Appraisal

The process of defining objectives, examining options and evaluating costs, benefits, risks, opportunities and uncertainties before making a decision.

Project team

The project team is responsible for producing the CFMP and is made up of Environment Agency staff helped by consultants.

Property

A property is defined here as one household, such that one building may house numerous properties. Property data has been taken from the National Property Dataset (NPD).

Radar data Radar is an acronym for "radio detection and ranging." A radar system usually operates in the ultra-high-frequency (UHF) or microwave part of the radio-frequency (RF) spectrum, and is used to detect the position and/or movement of objects.

Ramsar Site

The Ramsar Convention on Wetlands of International Importance, Especially as Waterfowl Habitat (1971) requires the UK Government to promote using wetlands wisely and to protect wetlands of international importance. This includes designating certain areas as Ramsar sites, where their importance for nature conservation (especially with respect to waterfowl) and environmental sustainability meet certain criteria.

Ramsar sites receive SSSI designation under The Countryside and Rights of Way (CRoW) Act 2000 and The Wildlife and Countryside Act 1981 (as amended). Further information can be located on the Ramsar convention on wetlands website: http://www.ramsar.org/

Regional Planning Guidance (RPG)

Planning Guidance issued for the South West by the Government Office for the South West Regional Assembly.

Regional Spatial Strategy (RSS)

This will replace the RPG. It sets out a regional framework that addresses the ‘spatial’ implications of broad issues like healthcare, education, crime, housing, investment, transport, the economy and environment.

Risk assessment

Considering the risks in a project, which leads to developing actions to control, reduce or accept the risks.

River Quality Objective (RQO)

Rivers and canals are monitored under the requirements of the Water Resources Act, 1991.

This legislation gave the Secretary of State for the Environment and for Wales the power to set Statutory Water Quality Objectives to meet specific water quality standards. To meet this we, as the nominated statutory body, have introduced the River Quality Objective (RQO) classification system.

Currently, RQOs are classified using a River Ecosystem (RE) Classification, which is based on a set of chemical water quality measures defined within the EC Freshwater Fish Directive (78/659/EEC). There are five river ecosystem classes, from RE1 to RE5. The RQO classification system provides an indication of the water quality conditions that we would like to see in all significant rivers but there are no legal requirements directly connected with it. Instead the RQO system provides an indication of the 'ideal' quality of waters and so shows their relative importance. For further information consult our website: http://www.environment-agency.gov.uk

Scenario

A possible future situation, which can influence either catchment flood processes or flood responses, and the success of flood risk management policies/measures. Scenarios will usually be made up of the following: urban development (both in the catchment and river corridor); change in land use and land management practice (including future environmental designations); or climate change.

Scheduled Monuments, Scheduled Ancient Monuments

To protect archaeological sites for future generations, the most valuable of them may be "scheduled". Scheduling gives nationally important sites and monuments are legal protection by placing them on a list, or 'schedule'. English Heritage identifies sites in England, which the Secretary of State for Culture, Media and Sport should place on the schedule. The current legislation, the Ancient Monuments and Archaeological Areas Act 1979, supports a system of Scheduled Monument Consent for any work affecting a designated monument. Further information can be found on English Heritage's website: http://www.english-heritage.org.uk

Section 105

Section of the Water Resources Act under which floodplain mapping is carried out. Level A was the initial Section 105 modelling, level B modelling has been carried out to look at main areas in more detail. For further detail refer to Her Majesty's Stationery office, now Office of Public Sector Information website:

http://www.hmso.gov.uk/acts/acts1991/Ukpga_19910057_en_12.htm

Shoreline Management Plan (SMP)

Non-statutory plans to provide sustainable coastal defence policies (to prevent erosion by the sea and flooding of low-lying coastal land) and to set objectives for managing the shoreline in the future. They are prepared by us or maritime local authorities, acting individually or as part of coastal defence groups.

Site of Special Scientific Interest (SSSI)

Sites of Special Scientific Interest (SSSIs) are notified under the Wildlife and Countryside Act 1981 (as amended) and the Countryside and Rights of Way (CRoW) Act 2000 for their flora, fauna, geological or physiographical features. Notification of a SSSI includes a list of work that may harm the special interest of the site. The Wildlife and Countryside Act 1981 (provisions relating to SSSIs) has been replaced by a new Section 28 in Schedule 9 of the CROW Act. The new Section 28 provides much better protection for SSSIs. All cSACs, SPAs and Ramsar sites are designated as SSSIs. For further information refer to English Nature's website: http://www.english-nature.com

Soil Moisture Deficit

Plants will extract water from the soil when there is not enough rain to match evaporation or transpiration, creating a soil moisture deficit. This deficit increases until there is more rain to refill the available water capacity.

Source protection zones We have defined Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. These zones show the risk of contamination from any activities that might cause pollution in the area

Special Area for Conservation (SAC)

SACs are internationally important sites for habitats and/or species, designated as required under the EC Habitats Directive. All SACs have now had their former candidate status confirmed.

SACs are protected for their internationally important habitat and non-bird species. They also receive SSSI designation under The Countryside and Rights of Way (CRoW) Act 2000; and The Wildlife and Countryside Act 1981 (as amended). For further details refer to the following The Joint Nature Conservation Committee website http://www.jncc.gov.uk

Special Protection Area (SPA), Proposed Special Protection Area (pSPA)

A site of international importance for birds, designated as required by the EC Birds Directive. A pSPA is a proposed site, but has the same status as a confirmed site. SPAs are designated for their international importance as breeding, feeding and roosting habitat for bird species. The Government must consider the conservation of SPAs in all its planning decisions.

SPAs receive SSSI designation under The Countryside and Rights of Way (CRoW) Act 2000 and The Wildlife and Countryside Act 1981 (as amended). For further details refer to the European Commission: website: http://europa.eu.int/

And The Joint Nature Conservation Committee website at:

http://www.jncc.gov.uk/ukspa/sites/spalistA-C.htm

Secondary Aquifers

These include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into two types:

- Secondary A - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers;

- Secondary B - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

Special Protection Zone - SPZ1 – Inner protection zone

Defined as the 50 day travel time from any point below the water table to the source. This zone has a minimum radius of 50 metres.

SPZ2 – Outer protection zone

Defined by a 400 day travel time from a point below the water table. The previous methodology gave an option to define SPZ2 as the minimum recharge area required to support 25 per cent of the protected yield. This option is no longer available in defining new SPZs and instead this zone has a minimum radius of 250 or 500 metres around the source, depending on the size of the abstraction.

Standard Percentage Run-off (SPR) The calculation of SPR is based on the analysis of flood event data; it is the percentage of rainfall that causes the short term increase in flow seen at the catchments outlet.

Steering Group

The Steering Group oversees the production of the CFMP and is made up of Environment Agency staff together with staff from other operating authorities or major interest groups.

Strategy plan

A long-term (usually 50 years or more) documented plan for river or coastal management, including all necessary work to meet defined flood and coastal defence objectives for the target area. A Strategy Plan is more detailed and usually covers a smaller area than a CFMP.

Strategic Environmental Assessment (SEA)

Applying Environmental Assessment to earlier, more strategic, tiers of decision-making policies, plans and programmes

Strategic Flood Risk Assessment (SFRA)

A broad scale assessment of flood risk carried out by a unitary authority or district council. These documents are drafted so that proposed developments can be quickly appraised to Planning policy Guidance.

Structure Plan

A statutory plan made up of part of the development Plan, prepared by County Councils or a combination of unitary authorities, containing strategic policies that cover main planning issues over a broad area and provide a framework for local planning, including Unitary Development Plans (UDPs).

Surface water flood management plans Recent government policy development has promoted the production of surface water management plans (SWMPs). This page looks how to use them and links to guidance from the Department for Environment, Food and Rural Affairs (Defra).

Surface water management plans (SWMPs) will be useful tool for:

- assessing the risk of surface water flooding
- identifying options to manage risk to acceptable level
- making the right investment decisions
- planning the delivery of actions to manage flood risk.

Superficial (drift) aquifers Permeable unconsolidated (loose) deposits. For example, sands and gravels.

Sustainability

A concept, which deals with man's effect, through development, on the environment. Sustainable development is 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundland, 1987). The degree to which flood risk management options avoid tying future generations into inflexible or expensive options for flood defence. This usually includes considering other defences and likely developments as well as processes within a catchment. It should also take account of, for example, the long-term demands for non-renewable materials.

Sustainable Drainage Systems (SuDS)

Management practices and control structures designed to drain surface water in a more sustainable way than some conventional techniques (may also be referred to as sustainable drainage techniques).

Telemetry

How a data signal is transferred to a remote control centre by the telephone network.

Tidal flood risk The risk of flooding due to the incoming or rising tide

Unitary Development Plan (UDP)

A statutory plan produced by unitary authorities, made up of part of the Development Plan and written in two parts: Part I – a written statement which contains the authority's general policies for their area; Part II – both a written statement and an ordnance plan, describing the policies in detail and illustrating them on a geographical basis. A UDP replaces Local Plans within unitary authorities.

Water Framework Directive (WFD)

European Community Directive (2000/60/EC) on integrated river basin management. The WFD sets out environmental objectives for water status based on: ecological and chemical measures; common monitoring and assessment strategies; arrangements for river basin administration and planning; and a programme of measures to meet the objectives. For further detail consult the European Commission website: http://europa.eu.int

Weighted Annual Average Damage data What this does is to weight damage potential by the probability of flooding of particular depths, taken from a range of project appraisals, resulting in their weighted average

Wildlife & Countryside Act

The Wildlife and Countryside Act 1981 (as amended) is the main mechanism for legally protecting wildlife in Great Britain. The Wildlife and Countryside Act is divided into four parts.

- Part I is concerned with the protection of wildlife;
- Part II relates to the countryside and national parks (and the designation of protected areas);
- Part III covers public rights of way;
- Part IV deals with miscellaneous provisions of the Act.

The designation of protected species is included in Schedules 1, 5 and 8 of the Act, which list protected birds, protected animals and protected plants, respectively.

APPENDICES