Brighton & Hove City Council

Surface Water Management Plan

On behalf of

Brighton & Hove City Council

Project Ref: 23301/005 | Rev: E | Date: April 2014

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0	29.01.2013	Draft – Work in Progress	VH	DH	DH
A	08.07.2013	Draft – Phase 2 added	VH	DH	DH
B	20.11.2013	Draft – Phase 3 & 4 added	VH	DH	DH
C	03.01.2014	Draft for comment	VH	DH	DH
D	16.01.2014	Inclusion of BHCC comments	VH	DH	DH
E	04.04.2014	Inclusion of EA/ SW comments	VH	CB	DH

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1 Introduction

Peter Brett Associates LLP (PBA) has been commissioned by Brighton & Hove City Council (BHCC) to prepare a Surface Water Management Plan (SWMP) for Brighton & Hove.

In December 2009 BHCC became a Lead Local Flood Authority (LLFA) responsible for local Flood Risk Management for all sources of flooding with the exception of the sea, main rivers and reservoirs. Although LLFA's must also consider the interaction of local sources of flood risk with main rivers, the sea and reservoirs. The first phase of this process was completed in June 2010 and the information utilised to complete the Preliminary Flood Risk Assessment (PFRA) for Brighton and Hove.

In 2009, BHCC were granted £275,000 in funding by Defra to progress a SWMP for Brighton & Hove. PBA were commissioned to undertake Phase 1 of the SWMP.

Following a subsequent period of re-organisation within the council, PBA were asked to progress Phase 2 (Risk Assessment Stage) of the SWMP) in September 2012. PBA were then commissioned to complete the SWMP and undertake Phase 3 (Options) and Phase 4 (Action Plan).

The SWMP process is a non-statutory process advocated by Defra to facilitate integrated local Flood Risk Management and to assist the LLFA in meeting the requirements of the current legislation governing flood risk.

The following report provides an overview and review of all stages of the SWMP. A section is also included within the report on the legislative background to SWMP's to give some context to the requirements and the purpose of the report.

2 Legislative Background

The significant flooding witnessed across the UK in 1998 and 2000 could be considered the catalyst for increased awareness of flood risk as a material planning consideration. As a result of these and subsequent flood events the government released a series of flood risk management practice and policy documents over the past decade, including Making Space for Water in 2004 and Future Water in 2008.

In 2006, Planning Policy Guidance 25 (PPG25) – Development and Flood Risk was replaced by PPS25, which reinforced the earlier guidance, aimed at directing development to areas of lower flood risk, and first introduced the concept
of SWMPs for reducing flood risk.

Following the devastating floods of 2005 in central Europe the EU Flood Directive was published in 2007, which places key requirements for member states to identify and communicate flood risk, through preparation of PFRAs, Flood Risk and Hazard Maps and the introduction of Flood Risk Management Plans.

The UK witnessed some of its worst ever flooding the summer of 2007, which resulted in approximately £3 billion pounds worth of damage. Sir Michael Pitt's review published in 2008, concluded that the impact of the floods could have been reduced with greater local leadership of flood risk management and effective cooperation between responsible organisations.

The culmination of this work; into flood risk strategy and policy; the requirement for legislative change to comply with the EU; and the urgent need to act upon Pitt's recommendations, has been the Flood and Water Management Act (FWMA), which was published in April 2009 (draft) and received Royal Assent on 8th April 2010.

2.1 Making Space for Water (2004) and Future Water (2008)

Making Space for Water was released in 2004 setting out the Government's overall strategy for managing flood and coastal erosion. This document aimed to reduce the threat to people and property through a range of measures using a holistic and integrated approach, which delivers the environmental, social and economic benefits. Making Space for Water proposed that high risk urban areas should take a more integrated approach to drainage management across all types of flooding (fluvial, pluvial, sewer, groundwater flooding etc.). Integrated urban drainage was therefore proposed and supported through the consultation phase of the document. Defra proposed to pilot a number of different approaches to urban drainage management.

Future Water (2008) sets out a vision for sustainable water supplies and a protected water environment, making proposals for the use of SWMP's to coordinate the management of surface water drainage. The use of SWMP's as the intended vehicle for delivery of integrated urban drainage management was proposed following 15 pilot studies funded by Defra to explore the integrated approach within Making Space for Water.

Both Making Space for Water and Future Water set out a new overall strategy for managing flood risk with the aim of reducing the threat to people and property, whilst also providing a protected water environment, with proposals for coordinated management of surface water drainage.

2.2 Planning Policy

Planning Policy 25 (PPS25) - Development and Flood Risk Practice Guide (2006) (now superseded by the National Planning Policy Framework(NPPF)) states that the SWMP is a key stage in consideration of flood risk in the planning process as well as taking on a key role in managing surface water drainage as a coordinated approach.

2.3 The Pitt Review (2008)

Summer 2007 was one of the wettest summers since records began in 1910. Intense rainfall within short storm durations resulted in 55,000 properties flooding and damages exceeding £3billion. The Pitt Review, 2008, provided a review of the summer 2007 event and highlighted lessons learnt through a number of recommendations. The Pitt Review highlighted that consequences of flooding could have been reduced through more effective local co-ordination with all relevant parties and ensuring that Local Authorities take the lead on managing local flood risk (supported by relevant stakeholders).

One of the recommendations was that SWMP should be adopted particularly where surface water flood risk is seen as high.

Recommendation 18 of the Pitt Review states that:
"Local Surface Water Management Plans, as set out under PPS25 and coordinated by local authorities, should provide the basis for managing all local flood risk."

The Pitt Review continues by stating that:
"The Review is of the opinion that SWMPs should be used by local authorities to help manage all local flood risk and will be equally applicable to urban and rural areas" and "SWMPs will build on SFRAs and provide the vehicle for local organisations to develop a shared understanding of local flood risk, including setting out priorities for action, maintenance needs and links into local development frameworks and emergency plans".

2.4 Flood Risk Regulations (2009)

The Flood Risk Regulations 2009 (FRR) (statutory instrument No. 3042) came into force on the 10th December 2009 and transpose the EU Floods Directive (Directive 2007/60/EC) on assessment and management of floods into English Law. The EU Directive came from European Community Environmental Legislation written in response to cross border European flooding in 2000 and 2004.

To coordinate the local flood risk management strategy the FWMA (discussed in chapter 8) and FRR introduce the role of the LLFA. In this legislation, LLFA is defined as either the unitary authority for the area or the county council for the area if there is no unitary authority. New powers are conveyed to the LLFA to enable a range of duties to be performed, these are described in section 2.6.

As Brighton & Hove City Council is a unitary authority it is therefore a LLFA. The FRR places a duty upon LLFA to prepare the following deliverables:

- Preliminary Flood Risk Assessment Part 2 (Section 10) – by 22nd June 2011
- Flood hazard maps and flood risk maps Part 3 (Section 19) – by 22nd June 2013
- Flood risk management plans Part 4 (Section 26) – by 22nd June 2015

2.5 Flood and Water Management Act 2010

The culmination of the government's work on flood risk strategy and policy, combined with the requirement for legislative change to comply with the EU and the need to act upon the Pitt Report recommendations, has been the Flood and Water Management Act (FWMA), which was published in April 2009 (draft) and received Royal Assent on 8th April 2010.

The FWMA has the following primary aims:

- *Update water management legislation* – to accord with the latest government strategies and to comply with EU legislation.
- *Clarify roles and responsibilities* – the EA will maintain their national role of managing Main River fluvial and coastal flood risk, whilst taking a new strategic overview role of all flood risk issues. Local Authorities will become responsible for management of local flood risk from all other sources, including ordinary watercourses, surface water and groundwater.
- *Adaptation to Climate Change* – the Act includes proposals to encourage the uptake and implementation of Sustainable Drainage and protect essential water supplies. Local Authorities will also become responsible for approval and adoption of Sustainable Drainage Systems (SuDS) from new development.
- *Update Reservoir legislation* – the 'Large Reservoir' classification has been reduced from 25,000m^3 of stored water down to 10,000m^3. A risk based approach to safety is adopted and the role of the Reservoir Manager replaces the previous Undertaker role.

Under the Flood and Water Management Act, 2010 the principal new responsibilities of a LLFA are as follows:

- Section 9 – Requirement to develop, apply, maintain and monitor a Local Strategy for Flood Risk Management.
- Section 19 – Requirement to Investigate Floods, where appropriate, and to publish the findings.
- Section 21 – Duty to maintain a Register of Structures which affect flood risk.
- Section 30 – Power to Designate third party assets, which affect flooding.
- Section 31 – Requirement to consent works to ordinary watercourses under the Land Drainage Act 1991.
- Section 32 – Establish the role of the SuDS Approving Body (SAB) and the new approval process for surface water drainage systems. Implementation date to be determined following the Defra consultation on the new National Standards for SuDS.

3 Surface Water Management Plan Process

3.1 Background

The SWMP process was initially developed by Defra from the results of 15 studies into Integrated Urban Drainage Management undertaken in 2007 / 2008. The results of these initial studies were used to develop the SWMP Technical Guidance, which was published in February 2009 and updated in March 2010.

This guidance was, however, first used to undertake six SWMP pilot studies (started in December 2008) in some of the worst affected areas during the 2007 floods. The results of these first six pilots were incorporated into the March 2010 version of the guidance. The primary change in the guidance was the introduction of three levels of risk assessment within Phase 2 of the SWMP. The three levels of assessment identified (strategic, intermediate and detailed) allow local authorities to determine the most appropriate scale of assessment depending upon their current level of knowledge and the size and nature of catchment under consideration.

3.2 Aims and Principles

A SWMP is a structured process of four phases; preparation, risk assessment, options and implementation, which together provide a framework for identifying and understanding the nature of local flood risks and the available options for future mitigation and management.

The process of partnership working advocated by the guidance is designed to encourage the development of innovative solutions and practices involving all the required stakeholders.

A SWMP should not be considered as a one-off process, but should be used to establish a long-term plan for local flood risk management which can be used to influence and facilitate capital investment, maintenance regimes, land-use planning and setting policy, emergency planning and public engagement.

The SWMP process is also designed to help meet the requirements of the FRR and FWMA, whilst being flexible to meet local needs and requirements of individual LLFAs.

3.3 Process

The SWMP process is a partnership based approach to understand and resolve the complex causes of local surface water flooding, and to agree on the most cost effective way to manage and mitigate flood risk.

Led by the local authority the partnership will principally comprise representatives from the Environment Agency (EA) and the local Water and Sewerage Company (WaSC) – Southern Water (SW). By working in partnership, sharing information and data, all sources of local flood risk can be considered together and consolidated into a single (GIS) platform. The formation of the flood risk GIS database will also provide a tool to facilitate the on-going responsibility of local flood risk management.

The SWMP will consider not only surface water flood risk from sewers and drains, but also ordinary watercourses, groundwater, overland flow, springs and ditch networks. This will then allow a holistic analysis of local flood risk scenarios and identification of significant risk areas.

Further analysis and verification of significant risk areas will quantify the frequency, extent and consequence (including financial implications) of potential flood risks. This then allows a structured approach to be taken towards mitigation option appraisal and the most cost effective solutions can be prioritised for implementation. The output from the verification phase will also be used to communicate the identified risk to local stakeholders and the general public in the form of flood risk and flood hazard maps (FRR requirement for 22 December 2013).

In broad terms the SWMP process can be considered as having two primary functions; the first (described above) is to essentially address existing flood risk issues; and the second to assess the effects of new development and climate change, on flood risk.

While facilitating local flood risk management the first primary SWMP function will also allow the preparation of a PFRA (FRR requirement for 22 December 2011) for the authority area in the context of the EU Flood Directive requirement. The PFRA for local flood risk should include maps showing topography and land use, a description of past floods and their impact together with an assessment of the potential consequences of future flooding.

The second primary SWMP function can support the development planning process and facilitate a range of associated planning related functions. The SWMP will identify areas where flood risk exists and which can be developed with appropriate mitigation, whether that be using specific drainage techniques or by contributing to a community mitigation scheme. This information can directly inform and update Core Strategy Policies and facilitate assessment of proposal sites. The SWMP will also form part of the evidence base and provide a vehicle for implementation of the policies.

The whole SWMP process and its outputs will be a primary input to the Flood Risk Management Plan (FRMP) in the context of 'local' flood risk, which is also an EU Flood Directive requirement (FRR requirement for 22 December 2015).

In the current version of the Defra SWMP guidance there are four principal Phases (as shown in figure 3.1) to the SWMP process which together form an established risk based approach to investment in flood defence and drainage:

1. **Preparation**
    - Identify the need for a SWMP Study
    - Establish the partnership
    - Collect and collate the data
    - Scope the SWMP Study
2. **Risk Assessment**
    - Undertake Strategic Assessment and / or
    - Undertake Intermediate Assessment and / or
    - Undertake Detailed Assessment
    - Map and Communicate flood risk
3. **Options**
    - Identify mitigation measures
    - Assess Options
    - Cost benefit analysis
    - Drainage strategy for new development (if appropriate)

4. Implementation & Review

- Prepare an Action Plan
- Secure funding
- Implement actions and review

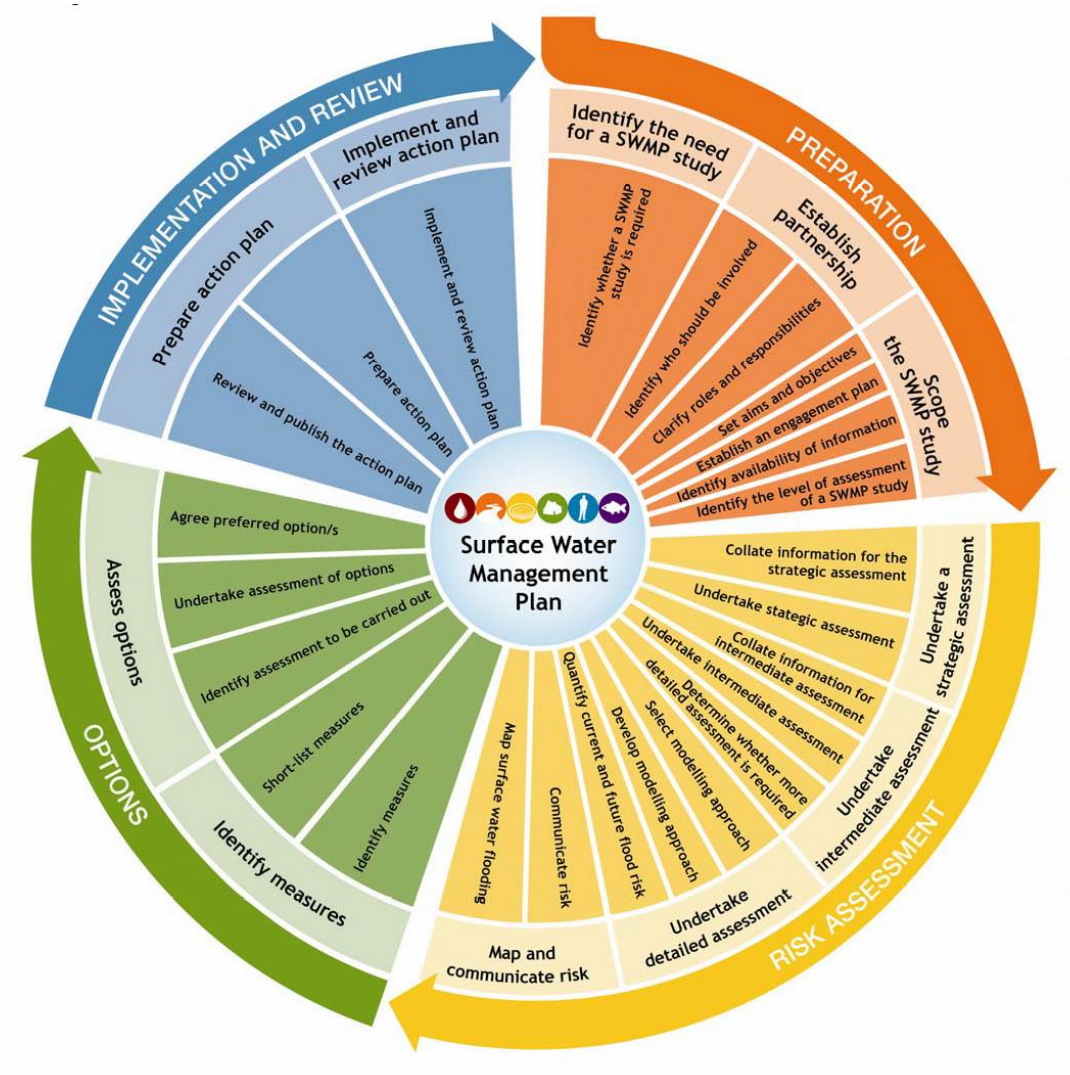


Figure 3.1 Extract from SWMP Surface Water Management Plan Technical Guidance (Defra, March 2010) – SWMP wheel diagram

4 Phase 1 - Preparation

Information from the Phase 1 (Data Collection) of the BHCC SWMP will be used to inform the Phase 2 Risk Assessment process.

4.1 Establish the Partnership

The SWMP is a partnership approach which aims to understand and resolve causes of local surface water flooding. A SWMP identifies flood risk, undertakes different levels of assessment, maps risk and identifies measures and options to mitigate risk.

As part of the Phase 1 SWMP process, a partnership was set up in 2010 led by BHCC to consider and identity local flood risk. The partnership comprised representatives from:

- Brighton & Hove City Council (BHCC)
- The Environment Agency (EA),
- Southern Water (SW),
- Peter Brett Associates LLP (PBA).

The partnership arrangement allowed the sharing of information and data to identify all sources of local flood risk, which was consolidated into a GIS database. The SWMP partnership was also used to discuss the requirements of the FRR and delivery programme for the PFRA.

4.2 Stakeholders

Other stakeholders outside the partnership were also contacted to obtain information and data. These included:

- East Sussex Fire and Rescue Service,
- Network Rail,
- Highways Agency
- South Downs National Parks Authority.

BHCC has not undertaken public consultation or communication as part of the SWMP Phase 1 Preparation stage. However, it is envisaged that community engagement will form part of the Phase 4 Implementation and Review stage potentially involving information and educational literature and/ or workshops. The aim of this will be to raise awareness of the issues and identify ways in which home owners can help to protect themselves.

BHCC has historically carried out limited community liaison and engagement prior to and following major flood events. BHCC were contacted during the extreme rainfall event in winter 2000/2001 to assist with emergency situations. This included advising residents on preventive measures and cleaning up after the event. During the winter flooding of 2000/2001 several members of the highways department were posted to affected areas to speak with the public and co-ordinate road closures.

4.3 Aims and Objectives

In order to structure and guide the SWMP process a number of objectives and aims were agreed by the partnership. These were as follows:

- Collate and map all the existing data relating to surface water flood risk in the local authority area including flood defence and drainage infrastructure (but excluding foul sewers).
- Review of EA national datasets with local knowledge and SWMP database.
- Establish areas where flood risk is currently a problem or where there could be risks in the future as a result of development and/or climate change.
- Identify ownership of drainage features and assets.
- Determine an approach to evaluate these problems and to devise potential solutions if practicable.
- Assess, plan and improve current and future drainage asset maintenance regimes using flood risk information.
- Development of future planning strategies and policies to facilitate flood risk mitigation and management.

4.4 Data Collection and Review

The following section summarises the data sources which were collected during Phase 1 of the SWMP. As the SWMP Phase 1 and PFRA were being produced simultaneously, one GIS database was produced and developed as SWMP information became available and EA data released to coincide with the requirements of the PFRA.

Brighton & Hove City Council (BHCC)

Internal departments at BHCC were able to provide the following data:

- CityClean – Locations of known soakaways
- Education – Location schools and anecdotal flooding information.
- Estates – Location of all BHCC Estate Land
- Highways – Flooding photos, anecdotal information on historic flood events, 'Flood Defence Assessment of Downland Flooding' (Binnie Black & Veatch, 2001) (report commissioned following the winter flooding in 2000/2001), Brighton Flood Defence Structures Condition Survey and Maintenance Brief (2007) and Bevendean Flood Alleviation Structures maintenance manual (BHCC, 2006).
- Parks – Details of a complaint concerning flooding at a specific location within the city.

Peter Brett Associates LLP (PBA)

PBA prepared the BHCC Strategic Flood Risk Assessment (SFRA) on behalf of BHCC in 2008. This document was used to identify any other forms of flooding that had not been provided by other stakeholders. The underlying database to the SFRA was acquired which included groundwater flooding, highway flooding, sewer flooding, flood history as well as proposed development locations.

Southern Water (SW)

All Southern Water asset records for combined and surface water sewers were provided for use in the SWMP and PFRA, subject to completion of a data sharing protocol. In addition, the Sewer Incident Record Form (SIRF) for the City was provided indicating areas of historic sewer flooding.

Environment Agency (EA)

- LiDAR data –Light Detection And Ranging data, which provides detailed elevation data to map terrain. However, the dataset for Brighton and Hove was incomplete and only areas of LiDAR in proximity to the coastline were provided.

The following data was release by the EA in accordance with PFRA requirements via their Geostore website and was included within the GIS database:

- Maps of Areas Susceptible to Groundwater Flooding (AStGWF).
- Maps of Areas Susceptible to Surface Water Flooding (AStSWF).
- Detailed River Network – shows fully attributed river centrelines.
- Flood Map - identifies EA fluvial and coastal flood zones.
- Flood Map for Surface Water (FMfSW) 1 in 30 yr chance of flooding in any year.
- Flood map for Surface Water (FMfSW) 1 in 200 yr chance of flooding in any year.
- Historic Flood Map- shows the combined extents of flooding from rivers and groundwater.
- Historic Landfill – shows sites where there is no PPC permit or waste management licence currently in force.
- National Receptor Database (NRD) – details receptors which are impacted by flood risk, this includes information on agriculture, buildings, environment, heritage, land use, miscellaneous, transport and utilities.

Further information was provided by the EA to assist the preparation of the PFRA. This includes Environmental sites, parks and world heritage sites.

Network Rail (NR)

PBA requested all Network Rail track drainage records in the Brighton and Hove study area. This was not provided by Network Rail and has been re-requested as part of the SWMP Phase 2.

East Sussex Fire and Rescue Service (ESFRS)

PBA requested all Fire Brigade records for flooding within the last ten years. The ESFRS provided flooding events for the Brighton and Hove area which was subsequently sorted for clear surface water flooding events only.

Highways Agency (HA)

The Highways Agency (HA) required a Memo of Understanding to be signed by BHCC to release data. Once this was completed they provided flood related data on the location of all HA assets as part of their Highways Agency Drainage Data Management System (HADDMS). This is used within the

Agency and by the Agency's supply chain as their central repository for drainage data and associated information.

4.5 Data Quality

The SWMP guidance emphasises the importance of understanding uncertainty or weakness in the data. The SWMP guidance provides the following information on data quality.

Data Quality Score	Description	Explanations	Example
1	Best possible	No better available; not possible to improve in the near future	High resolution LiDAR, River/sewer flow data, rain gauge data
2	Data with known deficiencies	Best replaced as soon as new data are available	Typical sewer or river model that is a few years old
3	Gross assumptions	Not invented but based on experience and judgement	Location, extent and depth of much surface water flooding. Operation of un-modelled highway drainage. 'Future risk' inputs e.g. rainfall, Population.
4	Heroic assumptions	An educated guess	Ground roughness for 2d models

Table 4.1 Recording the quality of data (SWMP Technical Guidance, March 2010)

The data described in Section 4.4 of this report has limited application. As discussed, the BHCC data is based on anecdotal accounts of flooding events, and whilst a wide range of locations have been included, details are not available on extents, depth or durations of flooding.

Network Rail has been unable to provide any of the requested drainage information. Network Rail land was a key source of flooding at Patcham during the 2000/2001 flood event. As a result there was disruption for approximately 5 days on the London to Brighton rail line. Groundwater was reported to have built up behind the railway embankment to the north of the A27, as a result of emerging springs. The railway line at this location was flooded and it is thought that the head of water forced through the embankment and emerged in a soakaway in the petrol station at the Patcham roundabout (refer to 'Flood Defence Assessment for Downland Flooding', Binnie Black & Veatch (2001) and section 5.2.3). An alternative theory is that because groundwater levels were high due to repeatedly long duration storms, the large quantities of water emerging from the soakaway could be attributed purely to groundwater flooding. However, as Network Rail data has not been received there is limited information concerning this area.

The ESFRS data was sorted to include only events that were clearly identified as surface water flooding issues. As such there is a number of additional surface water flooding records which could potentially be included in the database, however due to reporting limitations a conservative rationale has been applied to the use of this data.

HA data was provided in the form of their Drainage Data Management System (HADDMS), which was introduced in 2006. 'The Highways Agency Drainage and Flood Data Description', Highways Agency (2010), states that this system currently contains approximately 55% of the data on the type and location of HA drainage assets. The sources of this data vary from digitised drawings (not yet validated by field survey), as-built drawings, design drawings for a drainage scheme that was not actually built and recent field surveys. Hence the quality and reliability of the data provided is varied.

There are clear gaps in the database, which have been identified within Brighton and Hove. This includes an attenuation tank located underneath the Patcham roundabout and a number of soakaway located in Wilde Park. Both of these assets are known to be the responsibility of the HA yet are not contained within the HADDMS.

In accordance with the above table, a data quality score has been applied to all the data in the SWMP GIS database collated from BHCC and stakeholders. The data score is summarised by the data provider and detailed in table 3.3 below.

Source of data	Data Quality Score	Description
Brighton and Hove City Council	3	Gross assumptions
Southern Water	2	Data with known deficiencies
Environment Agency	1	Best possible
East Sussex Fire and Rescue Service	3	Gross assumptions
Highway Agency	3	Gross assumptions

Table 4.2 Data quality of BHCC SWMP/PFRA database

4.5.1 Database Collation and Mapping

The majority of information received was either provided in GIS format or CAD format. The different systems were converted to shape files and imported into Esri ARC GIS software. Within this software the files are stored in a geo-referenced database which can then be used to draw out data when required for different drawings or the output exported for use in PDF's or Geo PDF's.

Any hard copy information received has been either redrawn into AutoCad and the process above followed or data was manually entered into the database.

The Strategic Level Overview Plan (Drawing Number 23301/005/001 in Appendix A) has been produced to illustrate the work carried out in Phase 1. This shows the BHCC extents and depicts all the surface water flood risk information for the area. This will be used as the basis of the Risk Assessment stage of the SWMP (Phase 2).

5 Phase 2 – Risk Assessment

5.1 Aims

Phase 2 of the SWMP is the Risk Assessment stage and utilises the initial data collected within the Phase 1 preparation stage.

Phase 2 commences with identification of the appropriate level of risk assessment required. The level of existing information known together with the land use and consequence to flooding within the assessment area, are all used to determine the appropriate level of risk assessment required. There are three basic levels being Strategic Assessment, Intermediate Assessment and Detailed Assessment.

Based upon the level and quality of existing information it was decided that the Strategic Assessment would be the starting point for the SWMP Phase 2 Risk Assessment. Through the three stages of risk assessment the local significant flood risk areas (hotspot areas) within Brighton and Hove will be identified.

5.2 Strategic Assessment

5.2.1 Areas of Significant Flood Risk

Drawing number 23301/002/SK001 shows the areas of historical flood risk which were collated from anecdotal evidence from BHCC in order to form a historical flood record. Due to the low data quality scores attributed to much of the information collected, only data corroborated by a BHCC officer with extensive knowledge of the authority area was taken to form the historical flood records. These historical records were deemed to show that there was a consequence to the flooding (which is a requirement in the PFRA guidance).

Whilst other records of flooding are available, such as data from the ESFRS and SFRA, there is no information on the consequence or indicators to assess the consequences and so for the purposes of the PFRA they were considered not to have significant consequences and were not included.

Therefore, for the PFRA Annex 1 (Records of Past Floods and their significant consequences) 42 recorded historical flood records were submitted (refer Appendix A). As a result of this, the hotspot assessment concentrates on these areas.

A number of these historical events may have been addressed, for example, flood risk in Bevendean has been reduced by a re-design of the cascades on arable land upstream of the residential area. Therefore, the 42 anecdotal historical records have been reviewed as part of the Phase 2 SWMP so that the local flood risk areas (hotspots) are identified on the basis of relevant historical events as well as future flood risk.

5.2.2 Methodology for defining flood risk areas

1) Review of Preliminary Flood Risk Assessment (PFRA) 'Records of Past Flood and their significant consequences' – 42 anecdotal historical records

Flooding information collated from BHCC which was deemed to have 'significant consequences' was assessed from the PFRA Annex 1 (Records of Past Floods and their significant consequences) spreadsheet as discussed in section 5.2.1. Incidents which only affected the highway were deemed to be 'Low Risk' and those which flooded properties were classified as 'High Risk'. Where it was known subsequent works have been implemented these areas were identified as being 'resolved' - this is discussed in more detail below. A summary of this review can be found in Appendix A of this report.

2) Review of records of flooding instances in the 'Brighton and Hove Council Flood Defence Assessment for Downland Flooding' Report by Binnie Black & Veatch (BB&V)

In May 2001 a review of the Brighton and Hove Flood Defence structures was carried out. The summary of this was detailed in the BB&V Report. As part of this report a number recommendations were put forward and some were subsequently implemented. Therefore, it is considered that a number of the flood events shown in the historic flooding events table may have been resolved and hence their priority decreases. As part of the SWMP Phase 2 a review was carried out of each flood defence area / historic flooding area, and an assessment of any works was made. If the flood defence structure offers a 1 in 75 to 1 in 100 year level of protection or higher the area was considered to no longer be at significant risk of flooding having been satisfactorily mitigated to the desired standard. However, if residual risk is still considered high and the level of protection is not within the SWMP defined criteria stated above then the flood risk area will remain on the flood risk area list. This information was used to identify whether the flood risk for that area had been sufficiently resolved as part of the review of the PFRA anecdotal historical records discussed above.

From the 7 locations discussed in the BB&V Report, 6 locations were deemed to be unresolved and are detailed below:

- **Bevendean**

The 'significant consequences' historical events schedule includes five historical events occurring in the Bevendean Area on separate occasions between September 2000 and February 2001. The BB&V Report shows that the area has a long history of flooding since the area was constructed in the late 1940/ early 1950. Bodiam Close, located to the east of the Bevendean residential area, used to be the location of a dew pond until dwellings were constructed over it and shortly after this 5 dams were constructed in the upstream valley to restrict runoff flowing into the Close and further downstream into Bevendean.

The events in Bevendean in 2000/2001 were predominately as a result of prolonged and heavy rain falling on the 2km² downland area upstream of these retention ponds. Furthermore, the problem was exacerbated by farming regimes in the area resulting in a large silt load being carried and distributed in the flood.

Since the flooding in Bevendean, the retention ponds (cascades) have been re-configured and now only 3 ponds exist. Soakaways have been installed in the base of each pond to improve infiltration and ditches have been re-aligned. This was one of the options proposed in the report and would provide protection up to the 1 in 20 year event. It is assumed that the re-modelling of the cascades was in line with this report and therefore for the purposes of the SWMP it is assumed that 1 in 20 year protection is accurate for this location. It is not clear whether the proposed land use changes have been implemented, which if implemented would increase the level of protection to the 1 in 50 year level. Therefore, in line with the criteria stated above, alleviation measures are deemed insufficient to remove the site from the flood risk area list.

- **London Road, Patcham**

The BB&V Report states that flooding occurred in the Patcham area between the 7th and 19th November 2000. Reported flooding instances in the area have occurred since 1958. Flooding in the area resulted in severe flooding of the railway line and the A23 to the south of the A27 with 15 properties being flooded (plus additional basement flooding). In addition to surface water flooding, raw sewage flooding occurred as sewers become surcharged by surface water.

Flooding in 2000 was caused by springs breaking out from the railway cutting to the north of Patcham adjacent to the A23. Water appeared to the south of the A23 from soakaways located in the forecourt of the petrol station at the roundabout and springs located on the southern side of the railway. Water flooded across Mill Road, playing fields and onto the A23 and the Old London Road.

A number of alleviation options were proposed in the report such as reducing runoff from the upstream catchment, providing temporary storage (A27 embankment or playing field adjacent to the A23), constructing flood retaining bunds, increasing the drainage system capacity or improving the response to flooding incidents. It is thought that none of the physical measures have been implemented however the report does state that the EA were planning to install water level recording equipment at Ladies Mile Road by the end of 2001 which would improve response time to incidents. A request has been made to the EA to establish whether this has been carried out. For Phase 2 of the SWMP it is therefore assumed that the flooding has not been resolved at this location.

- **Mile Oak**

The Flood Defence Assessment for Downland Flooding states that flooding occurred on at least 2 occasions between October and December 2000. Flooding in the Mile Oak area took place when surface water runoff from the farm to the north of the A27 ran down Mile Oak Road and ponded at the junction with Nursery Close. Water subsequently flooded gardens and two properties.

In addition, groundwater levels rose causing flooding to the basement of the Mile Oak Inn and springs emerged in gardens causing flooding to gardens and roads.

A number of alleviation options were proposed in the report including reducing runoff from the farmland upstream, drawing down the water table (considered unviable), providing a bund/ embankment, constructing soakaways/ emergency pumping or groundwater monitoring for improved response to flooding. For Phase 2 of the SWMP it is therefore assumed that the flooding has not been resolved at this location.

- **Westdene**

The Flood Defence Assessment report refers to multiple flooding instances occurring in Millcroft, Westdene during the winter of 2000/2001. Flooding occurred when a small pond overflowed after heavy rainfall and entered gardens (flooding of properties did not occur). The presence of the permanent pond only dates to 1999 and this links with the flooding that occurred. In this time the pond was lined and therefore water does not infiltrate into the ground as it would have previously. A bund was built to protect the houses, however water seeped through the bund and flooding still occurred.

A number of alleviation options were proposed in the report such as reducing the overflow from the pond, temporary storage by constructing an impermeable barrier or constructing a soakaway. The report considers that none of the mitigation measures proposed can be justified on economic grounds because of the low cost of damage the flooding caused at this location. However it does suggest that for political reasons a soakaway would be the cheapest solution to implement. For Phase 2 of the SWMP it is therefore assumed that the flooding has not been resolved at this location.

- **Ovingdean**

The Flood Defence Assessment for Downland Flooding states that flooding occurred 4 times during the winter of 2000/2001 and flooded a property (Kett's Ridge on Ovingdean Road) on two of those occasions. Surface water runoff from the field behind the property is deemed to have caused the flooding when an embankment behind the houses breached.

A number of alleviation options were proposed including changing the land use, setting aside land to create barrier strips to reduce runoff velocities or constructing a flood barrier. The report considers that none of the mitigation measures proposed could be just justified on economic ground because of the low cost of damage the flooding caused at this location. However, for political reasons the report does suggest implementing a change of land use or a new flood embankment. For Phase 2 of the SWMP it is therefore assumed that the flooding has not been resolved at this location.

- **Lewes Road**

Flooding on Lewis Road covered in the Flood Defence Assessment for Downland Flooding report concentrates on the three most severe flooding locations located at Wild Park, Moulsecoomb and at the junction with The Avenue. Flooding took place on the highway in November 2000 for a duration of 2 weeks causing partial road closures and traffic disruptions (no properties were reported as flooded). The area flooded previously in 1958 when groundwater levels were high. It is thought that flooding in 2000 was also as a result of rising groundwater levels resulting in springs.

A number of alleviation options were proposed including drawing down the water table (considered unviable), providing temporary storage (Wild Park), constructing a new storm drain or improving monitoring and flood warning.

The report considers that none of the mitigation measures proposed can be just justified on economic ground because of the low cost of damage the flooding caused at this location. Therefore it is assumed that not measures have been implemented. For Phase 2 of the SWMP it is therefore assumed that the flooding has not been resolved at this location.

5.2.3 Initial Hotspots

As part of the SWMP Phase 2 the PFRA past flooding records have been reviewed, as discussed above. The 42 PFRA Annex 1 (Records of Past Floods and their significant consequences) records of flooding have been highlighted as either ‘Resolved’, ‘Low Risk’ or ‘High Risk’. A summary of this can be found in Appendix A. This left 7 flood records as ‘High Risk’ and therefore these have been deemed to be the preliminary hotspots, which are shown on drawing 23301/005/002 in Appendix B. The 7 remaining flood records which are taken forward as hotspots are:

- Mile Oak
- Bevendean
- Patcham
- Carden Avenue/ Warmdene Road
- Moulsecoomb Primary School
- Ovingdean – Kett’s Ridge
- Blatchingham Mill School

5.2.4 Numerical Analysis of Flood Hot Spots

In order to rank the sites a statistical analysis of each location was carried out identifying the number and frequency of historical flooding events taking place, as well as the future flood risk. The flood risk data for each hotspot is shown in more detail on Drawings 23301/005/003-009.

The future flood risk was assessed by using the Flood Map for Surface Water (FMfSW) and the National Receptors database. The National Receptors database provides property points and classifications, which can be used to identify the number and type of property which lie within the FMfSW. The FMfSW was the locally agreed surface water information as defined in the Brighton and Hove City Preliminary Flood Risk Assessment (PBA, 2011). An assessment of the area within each preliminary hotspot was carried out (to exclude localised low points) and then property points which intersected the FMfSW were identified.

The FMfSW represents the 2nd generation mapping produced by the EA. The mapping shows where surface water runoff would be likely to pond from a 1 in 30 or 1 in 200 year rainfall event for a 1.1 hour storm duration for a 50% summer rainfall profile using a Digital Terrain Model (DTM). The FMfSW includes a reduction in rainfall to represent infiltration and also a reduction to represent the sewers. The mapping has two bandings; Surface Water Flooding (0.1m flood depth) and Deeper Surface Water Flooding (0.3m depth). Guidance on the FMfSW suggests that the deeper Surface Water Flooding (0.3m depth) is the depth at which property damages become significant and property flooding commences. Therefore, the FMfSW deeper flooding has been used for the numerical assessment as property flooding was the original criteria for selecting the hotspots (discussed in chapter 5.2.3)

The Numerical Assessment was tabulated in a spreadsheet with standard numerical weightings determined for each type of flooding incident. An average flood risk score was then generated based on the number and type of flooding events that took place within each catchment area. This included flooded properties, flooded schools, sewer flooding instances and future flood risk (FMfSW).

The numerical scores were then ranked to identify the highest risk sites within BHCC and hotspot sites were identified. A copy of the numerical assessment spreadsheet can be found in Appendix B. Table 5.1 below lists the sites in order, starting with the greatest level of risk.

Site Name	Hotspot Number	Flood Risk Score
Mile Oak	6	2340
Bevendean	3	895
Patcham	4	650
Carden Avenue/ Warmdene Road	5	640
Moulsecoomb Primary School	2	500
Ovingdean – Kett's Ridge	1	150
Blatchingham Mill School	7	100

Table 5.1: Strategic assessment hotspot sites

5.3 Intermediate Assessment

In order to verify the initial model findings of the strategic level assessment an intermediate level assessment comprising desktop studies of the six selected hotspots was carried out. The aim being to provide an engineering assessment of the likely causes of flooding, the potential consequences and identify possible solutions which could be developed, prior to embarking on any further detailed assessment, if considered appropriate.

The desk studies assessed geology, historic flooding, sewer records, historical maps and the catchment topography of each site, before a site visit was undertaken to verify the data. The studies conclude with an engineering opinion of the issues at each site.

Future Flood Risk was discussed in the BHCC PFRA (PFRA) (PBA, 2011). Within the PFRA Guidance future flood risk is defined as the potential flooding or potential flood risk and therefore is predominately defined by modelling. The FMfSW forms the second generation of surface water mapping which is the latest dataset. Notably, the FMfSW takes into consideration infiltration by reducing rainfall to 39% in rural areas and 70% in urban areas to replicate infiltration. In addition, the FMfSW also takes into account the presence of sewerage systems in urban areas and applies a reduction of 12mm/hr (Refer to 'What is the Flood Map for Surface Water' (EA, 2010)). A copy of this guidance can be found in Appendix C.

The PFRA considered that the SWMP database most accurately reflected the future flood risk from surface water. However, it was concluded that one of the EA national datasets, the FMfSW, would ultimately be nominated as the locally agreed surface water information and therefore the primary consideration of future flood risk.

Site visits were carried out on the 30th January and 14th February 2013 to confirm the information gathered on the hotspots. As part of the site visit at each hotspot an assessment of the topography, potential flood flow paths, existing structures or bunds, evidence of flooding and the presence of formal drainage was carried out.

5.3.1 Ovingdean – Kett's Ridge – Hotspot 1

Hotspot 1 is located to the east of Brighton in Ovingdean. The hotspot refers more specifically to one property called Kett's Ridge which is located on Ovingdean Road. The location of this hotspot in context of the Brighton and Hove City area is shown in figure 5.1 below.

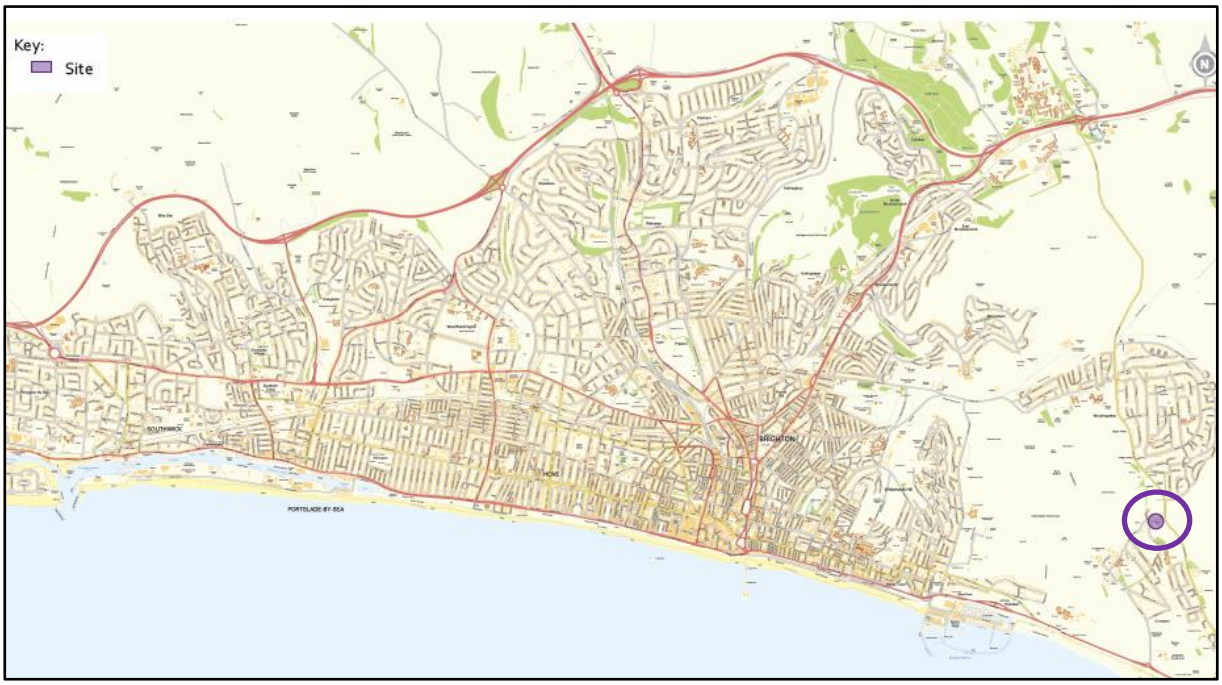


Figure 5.1 Hotspot 1

Drawing 23301/005/SK01 in Appendix D provides an overview of the hotspot and includes all information discussed in this chapter.

- **Historical Flood Risk**

Historical flooding at this location was identified in the BB&V Report and was discussed in section 5.2.2 of this report. The report states that there was a build-up of runoff from the arable fields at the embankment behind the property and flooding occurred when this embankment breached in the winter of 2000/2001.

The embankment forms part of the Bulstrode Farm Brighton Flood Defence Structures. BHCC have prepared the 'Bulstrode Farm Maintenance Brief' which describes the defences for this area. The defence adjacent to Kett's ridge is shown on the defence structures drawing as a ditch (the embankment is not marked).

- **Future Flood Risk**

The FMfSW does not indicate that there is any surface water flood risk to Kett's Ridge or any properties in the vicinity (i.e. in Ovingdean Close and Ovingdean Road).

- **Site Visit**

At the time of the site visit Kett's Ridge (the dwelling) was in the process of being renovated. The arable farmland to the west of Kett's Ridge has a relatively steep gradient falling towards Ovingdean Close. To the east of the field there is an embankment and ditch which form part of the Bulstrode Farm flood defence structures (as discussed above). The ditch and embankment were overgrown and did not appear to have been recently maintained (photographs 5.1 and 5.2).

Photograph 5.1: Looking north along embankment

Photograph 5.2: Embankment and ditch to the right

- **Drainage Features**

Topographically, the area falls from the west to the east. A ditch and adjacent embankment should prevent overland flows from the arable land to the east flowing into Ovingdean Close. Ovingdean Close is assumed to drain via soakaways as there is no Southern Water surface water or combined sewers located in the vicinity.

A review of the geological maps of the area indicated that the site and the adjacent farmland was underlain by Newhaven chalk formation ("chalk, white, soft with many marl seams and some nodular flints", BGS Geological maps).

- **Preliminary Engineering Opinion**

Based upon the information discussed above, runoff from the arable land should be prevented from entering residential properties by the ditch which runs along the boundary. This should also convey runoff away from this location based upon the site gradient. From the site visit it is apparent that regular maintenance is not taking place on this section of the Bulstrode Farm defences. Therefore it is recommended that an inspection regime is defined and regular maintenance is carried out by the nominated BHCC team. PBA have been unable to confirm when the embankment was constructed and therefore it is considered that the existing embankment may have been breached during the last historical flooding incident, as such it is recommended that a review of the defences in this location is carried out. Consideration should also be given to whether the ditch has an outfall or relies upon infiltration. If it is an infiltration ditch then the base of the ditch should be cleared of debris/silt and scarified to aid soakage.

5.3.2 Hotspot 2 - Moulsecoomb Primary School

Mouslecomb Primary School is located in Mouslecomb on the A270 (Lewes Road) adjacent to where the railway bridge crosses the A270. The location of this hotspot in context of the Brighton and Hove City Area is shown below in figure 5.2.

Figure 5.2: Hotspot 2

Drawing 23301/005/SK02 in Appendix E provides an overview of the hotspot and includes all information discussed in this chapter.

- **Historical Flood Risk**

The initial assessment of the hotspots highlighted the school as it had suffered internal flooding in the past. Reported flooding at the school took place in 2000 when the boiler room flooded from surface water runoff from the playing field. However, there had also been significant historical flooding of the adjacent Lewes Road itself which caused the road to be closed for approximately two weeks. As discussed in section 5.2.2 of this report and included in the BB&V report, flooding on the Lewes Road was reportedly due to high groundwater levels which resulted in springs emerging. Flooding was most severe opposite Wild Park, at the Railway Bridge at Moulsecoomb and at the junction with the Avenue (refer photographs 5.3 and 5.4 overleaf). The primary school is located near the Railway Bridge at Moulsecoomb. Based on the information above it is therefore considered that the two events are related and the larger catchment including the area of Lewes Road which flooded has been considered.

Photograph 5.3: Lewes Road Flooding (2000)

Photograph 5.4: Lewes Road Flooding (2000)

After discussions with the Highway Services team they reported that there was also highway flooding at the junction adjacent to the school in 2010/2011 but this did not result in flooding of the school. Subsequently the soakaway in this location was cleaned out and no further flooding has occurred.

- **Future Flood Risk**

The FMfSW shows that there is predicted surface water flood risk to Mouslecomb Primary school – this is shown as deep flooding of 0.3m depth, which would correlate with internal flooding at this location. Furthermore, surface water flooding is shown to occur along the length of Lewes Road and through Wild Park Recreation ground.

- **Site Visit**

The site visit encompassed two areas; the area outside the primary school and Lewes Road up to the entrance to Wild Park to the north of the railway line. The school grounds were not entered but were visible from the footway adjacent to the property.

From a visual inspection it appears that the footway adjacent to the school is at a slightly lower level than the road. Therefore, it was evident that if the road flooded then the footway would be also be flooded. Furthermore, an embankment has been constructed between the school playing field and the footway. Historically, the school flooded when the boiler room was flooded from the playing field and therefore it is assumed that the construction of this embankment was to restrict any highway flooding from flowing into the playing field (photographs 5.5, 5.6 and 5.7)

Photograph 5.5: Junction adjacent to railway towards school

Photograph 5.6: Looking north (school playing field and embankment to right

Photograph 5.7: Pavement adjacent to school

Wild Park lies to the west of Lewes Road and predominately comprises woodland and a sports ground. It is assumed that the sport ground area could channel overland runoff towards Lewes Road as the land falls this way and embankments appear to have been constructed around the perimeter. Furthermore there was ponding visible on both the footway adjacent to the park and also a small amount of ponding in the grassland adjacent to the road (photograph 5.8 and 5.8). This is also shown to be the case in the historical flooding event shown in photograph 5.4 above.

It is assumed that this flow could, in extreme events, exacerbate the flooding issue on Lewes Road.

Photograph 5.8: Ponding on footway adjacent to Wild Park

Photograph 5.9: Wild Park towards Lewes Road

- **Drainage Features**

From the site visit, it appeared that overland rural flows are exacerbating capacity of the local drainage systems during extreme rainfall events. There is no surface water sewer along Lewes Road, however few records of soakaway locations are available.

A review of the geological maps of the area indicated that the road lies in superficial deposits of head deposits (“variable deposits of sandy, silty clay, locally gravelly chalky and flinty in dry chalk valleys”) over Newhaven Chalk Formation (“chalk, white, soft with many marl seams and some nodular flints”, BGS Geological Maps). The school itself lies in New Pit chalk formation (“chalk, white, massively bedded, soft to firm with some flints in upper part”, BGS geological maps).

- **Preliminary Engineering Opinion**

Flooding at this location is likely to be the result of overland flows from runoff along Lewes Road and also from Wild Park. It is assumed that the drainage in the area is overwhelmed. Therefore we suggest solutions are considered to restrict flows into the area to allow the drainage system to work effectively. We propose to carry out a more detailed investigation and model the surface water drainage to assess potential attenuation schemes in Wild Park as part of Phase 3 of the SWMP. Local improvements to the footway adjacent to Moulsecoomb School could also be carried out to prevent runoff entering the school.

5.3.3 Hotspot 3 – Bevendean

Bevendean is a residential area located to the north east of the city. The location of this hotspot in context of the Brighton and Hove City Area is shown below in figure 5.3.

Figure 5.3 Hotspot 3

Drawing 23301/005/SK03 in Appendix F provides an overview of the hotspot and includes all information discussed in this chapter.

- **Historical Flood Risk**

Bevendean flooding was addressed in the BB&V report as discussed in section 5.2.2 of this report. Historically, downland runoff overwhelmed the cascades and soakaways resulting in flooding of properties in Bodiam Close, Bodiam Avenue, Heath Hill Avenue and Leybourne Parade. Flooding took place more than 4 times in the Bevendean area over of the winter of 2000/2001.

The Highway Services department stated that there have not been any recent flooding incidents in this area. They have however highlighted the lifetime of the soakaways in this location and have estimated that this will be between 10 – 20 years after which time they have suggested that the ground around them will be too silted up to manage runoff effectively and hence new measures to discharge runoff will need to be considered. Highway soakaways are assessed annually and are classed within their top 50 priority soakaways (maintenance as required).

- **Future Flood Risk**

The FMfSW shows that there is predicted surface water flood risk to the Bevendean area. This is shown as deep flooding of 0.3m depth along Bodiam Avenue and Bodiam Close. Furthermore shallow and deep flooding is shown through the houses on Heath Hill Avenue. This surface water mapping correlates with the flooding experienced at this location in 2000/2001. There is a large upstream catchment to this residential area which is highlighted by the FMfSW mapping.

- **Site Visit**

As discussed in section 5.2.2, the Bevendean area is protected from downland flooding by a series of cascades. As discussed previously, these form part of the Bodiam Close Flood Defence Structures. On the day of the site visit there was standing water in the top and bottom lagoon with the middle lagoon being empty. The soakaway in the bottom lagoon was not visible hence it was assumed it was submerged or covered in mud (photographs 5.10 and 5.11).

Photograph 5.10: Lower basin of Bevendean Cascades

Photograph 5.11: Bevendean Cascades

The site visit highlighted the relative levels of the road and dwellings throughout the hotspot. Noticeably, dwellings along Heath Hill Avenue between Taunton Road and Hornby Road are significantly lower than the adjacent road (refer photograph 5.14). This correlates with recorded flooding instances and also the FMfSW mapping discussed above.

Photograph 5.12: Property Level Protection to house in Bodiam Close

Photograph 5.13: Wall acting as flood defence structure

Photograph 5.14: Houses on Heath Hill Avenue

Photograph 5.15: Gradient from Bodiam Close up to Bodiam Avenue

- **Drainage Features**

Surface water drainage relies upon the large number of soakaways in the area. The cascades restrict overland flows from the downland area into the residential area and discharge runoff to ground via soakaways located in each basin, or overtop into the next basin for extreme events. There are no Southern Water surface water sewers, however there is a surface water sewer from the outfall of the final cascade basin into a soakaway in Bodiam Avenue.

A review of the geological maps of the area indicated that the valley upstream of Bevendean (cascades), following the FMfSW flood path, is superficial head deposits ("variable deposits of sandy, silty clay, locally gravelly chalky and flinty in dry chalk valleys", BGS geological maps) over Lewes Nodular Chalk formation. The surrounding area is Newhaven Chalk formation ("chalk, white, soft, with many marly seams and some nodular flints", BGS geological maps).

- **Preliminary Engineering Opinion**

Due to the large upstream rural catchment and dependence upon soakaways, overland flows will need to be managed. Potential options will focus on restricting any overflow flows, which may occur in extreme rainfall events, to the carriageways. Furthermore, regular inspections and maintenance on the cascades and soakaways (both highway and cascades) must be carried out.

5.3.4 Hotspot 4 – Patcham

Patcham comprises the area from the A27 south along the London Road (A23) towards the City Centre. The location of this hotspot in context of the Brighton and Hove City Area is shown below in figure 5.4.

Figure 5.4: Hotspot 4

Drawing 23301/005/SK04 in Appendix G provides an overview of the hotspot and includes all information discussed in this chapter.

- **Historical Flood Risk**

Flooding in Patcham in 2000 was addressed in the BB&V report as discussed in section 5.2.2 of this report. After intense rainfall water emerged from springs in the railway located new Mill Road and also out of soakaways in the petrol station entrance (located on Mill Road). One hypothesis for this was the volume of water which was impounded to the north of the railway embankment and hence the head of water drove water through/under the railway embankment and created springs by the Petrol Station. Water then followed the topography of the land and flowed over Mill Road into Patcham Recreation Park (refer photographs 5.16 below), past Patcham Place (Youth Hostel) (photograph 5.17 and 5.18) and onto the London Road (A23).

Photograph 5.16: Water overflowing into Patcham Recreation Park (2000)

Photograph 5.17: Water from Recreation Park into Patcham Place (2000)

Photograph 5.18: Patcham Place (2000)

From this point the London Road goes up hill and therefore overland flow went down Old London Road causing flooding to properties and a number of basements (refer photos 19,20 and 21 below). The overland flow resulted in the Southern Water sewer being over capacity and as a result raw sewage emerged in Patcham and Preston Park (downstream of Old London Road).

Photograph 5.19: Junction London Road/ Old London Road (2000)

Photograph 5.20: Old London Road (2000)

Photograph 5.21: 94 Old London Road (2000)

BHCC Civil Contingencies manager informed PBA that flooding of basements has occurred in the last year (2012) due to rising groundwater levels, however flooding on the surface did not occur.

- **Future Flood Risk**

The FMfSW shows that there is predicted surface water flood risk to the Old London Road area. This is shown as deep flooding (>0.3m) along the majority of the road. A surface water flow path is shown from Mill Road over Patcham Recreation ground onto London Road and then into Old London Road. As discussed above this surface water flooding has occurred and hence the mapping is seen as an accurate representation of the flooding in this area.

- **Site Visit**

A site visit was carried out on the 14th February 2013 to confirm information received from various sources at both Phase 1 and the strategic assessment. In addition, this also provided an opportunity to identify and hypothesis potential reasons for the previous flood incidents and potential mitigation solutions.

The recreation ground is the existing flow path from the source of the springs to the location of historical flooding incidences (refer photograph 5.22 and 5.33)

Photograph 5.22: Towards the Recreation Ground from Mill Road

Photograph 5.23: Recreation Ground, London Road

Old London Road, as discussed above, had internal flooding of properties during the 2000 flooding event. The site visit confirm that the number of properties at risk was higher than expected as they were located lower than the road with a step down at the threshold of the property (refer photographs 5.26 and 5.27). There were also a number of basements along the road.

Photograph 5.24: Patcham Place, London Road

Photograph 5.25: A23 London Road junction with Old London Road

Photograph 5.26: Basement Properties at 94 Old London Road property)

Photograph 5.27: 54-57 Old London Road (steps down into

- **Drainage Features**

Historically, flooding in the area was attributed to springs breaking out by the railway and emerging from a soakaway located by the petrol station to the north of the hotspot. There are a number of Southern Water sewers which run south along the London Road.

The EA have advised that they now have an automated telemetry system providing 15 minute data and real time levels from a borehole located near Ladies Mile. There is a 3 stage alarm set on this borehole, which at Stage 1 informs BHCC of rising water levels, Stage 2 the EA decide whether to issue a Flood Alert and Stage 3 the EA decide whether to issue a Flood Warning.

BHCC are currently undertaking a Multi-Agency Flood Plan (MAFP) which covers the area. The aim of the MAFP is to put in place emergency plans, contingency plans and continuity plans in case of emergency. The MAFP will also require all the partners to set up teleconferencing and meetings to discuss the situation.

A review of the geological maps of the area indicated that the London Road follows a valley of superficial head deposits (“variable deposits of sandy, silty clay, locally gravelly chalky and flinty in dry chalk valleys”) over Seaford Chalk Formation (“chalk, pure, white soft to form with regular seams of nodular and several semi-tabular flints”, BGS geological maps) . The superficial deposits continue north indicating the valley running alongside the railway and following the alignments of the A23 and that of the historical flood flow path.

- **Preliminary Engineering Opinion**

Historical flooding in this area occurred as a result of the emergent springs to the north of the recreation ground. Overland flow from this then caused flooding downstream and sewers became overwhelmed. Therefore, it is proposed that the overland flows could be managed within the large recreation ground and discharged to the sewer or to ground following extreme rainfall events causing the emergent spring. Property level protection could also be used on thresholds.

5.3.5 Hotspot 5 – Carden Avenue/ Warmdene Road

Carden Avenue and Warmdene Road are located near Patcham in the north of the city. The location of this hotspot in context of the Brighton and Hove City Area is shown below in figure 5.5.

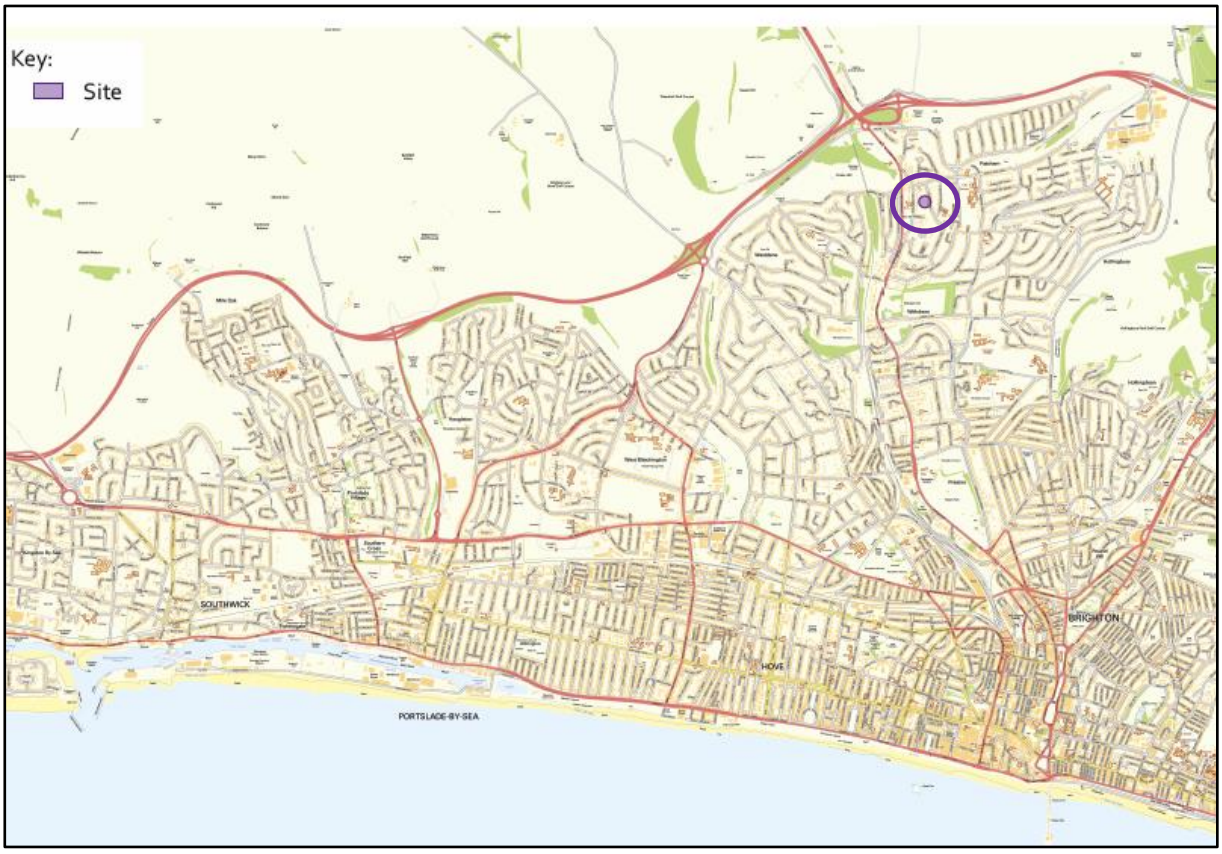


Figure 5.5: Hotspot 5

Drawing 23301/005/SK05 in Appendix H provides an overview of the hotspot and includes all information discussed in this chapter.

- **Historical Flood Risk**

Flooding in this area was recorded as part of Phase 1 data collection and was compiled through discussion with officers at BHCC. The Highway Services department have stated that the area flooded as soakaways need replacing and because the Southern Water sewer surcharges in heavy rainfall. This resulted in sewers being surcharged and flooding occurred at the bottom of Wilmington Parade.

Overland flow then occurs along Carden Avenue before the surface water flows to the low spot on Warmdene Road. Flooding has historically occurred at this low spot and Highway Services confirmed that Southern Water have installed an attenuation tank on Carden Avenue to increase the capacity of the Southern Water sewer. Refer to section 6.7.

- **Future Flood Risk**

The FMfSW shows that there is predicted surface water flood risk in Warmdene Road - this is shown as deep flooding of 0.3m depth in the properties at the low spot of the road (approximately Number 17). The mapping correlates with internal flooding at this location and discussions with the Highway Services team above.

- **Site Visit**

The site visit highlighted that there was a problem with flooding outside 17a Warmdene Road as at this location there are 4 gullies, 4 slot drains and flood gate (refer photographs 5.29 and 5.30 below). This is one of the properties identified as historically flooding along Warmdene Road. Ponding was also visible along Warmdene Way which is the surface water flood path identified by the FMfSW.

Photograph 5.29: Gullies and Slot drains outside 17a Warmdene Road

Photograph 5.30: Slot drains and flood gate

Photograph 5.31: Warmdene Way

- **Drainage Features**

There are a number of drainage features being used as property level protection outside 17a Warmdene Road. Southern Water records show that there are no surface water sewers along Warmdene Road and BHCC Highway Services have confirmed that the road relies upon soakaways to discharge surface water runoff.

A review of the geological maps of the area indicated that Warmdene Road has superficial head deposits (“variable deposits of sandy, silty clay, locally gravelly chalky and flinty in dry chalk valleys”,

BGS geological maps) in the area of flooding and following the flow path indicated on the FMfSW. The head deposits are underlaid with Seaford Chalk Formation ("chalk, pure, white soft to form with regular nodular and several semi-tabular flints"). Upstream of the catchment in the area to the south of Carden Avenue bedrock formation is Lewes nodular chalk formation ("chalk, off white, nodular with regular seams of large nodular flints).

- **Preliminary Engineering Opinion**

Warmdene Road lies in a localised depression and therefore overland flows will pond at this location unless managed at source. PBA propose to review the Southern Water sewer records and confirm the location and impact of the attenuation tank which has been installed on Carden Avenue. Furthermore a review of the soakaways in the area and their efficiency will also be carried out to establish a programme for replacement. Consideration will be given to the use of deep bore soakaways into the Seaford Chalk.

5.3.6 Hotspot 6 – Mile Oak

Mile Oak is located to the north west of the city to the south of the A27. The location of this hotspot in the context of the Brighton and Hove area is shown below in figure 5.6 below.

Figure 5.6: Hotspot 6

Drawing 23301/005/SK06 in Appendix H provides an overview of the hotspot and includes all information discussed in this chapter.

- **Historical Flood Risk**

Flooding occurred in the Mile Oak area in 2000 through two mechanisms; Groundwater flooding and overland downland flow from the downland area to the north of the A27. The flooding in 2000 resulted in flooding of residential properties and garages as well as flooding of gardens.

As discussed in the BB&V report detailed in section 5.2.2, springs emerged in the gardens of Mile Oak Road, Beechers Road, Heathfield Crescent, Heathfield Drive, Oakdene Crescent, Wickhurst Rise and

Valley Road with groundwater flooding persisting in these locations for 2 weeks. The BB&V report estimates that the upstream catchment to Mile Oak Road is 6.2km². Overland downland flow occurred in Mile Oak during heavy rainfall originating from Mile Oak Farm to the north of the A27. The overland flows were channelled under the A27 and along Mile Oak Road causing flooding to low lying dwellings (417 & 419 Mile Oak Road) and ponding at the junction of Mile Oak Road and Nursery Close. The BB&V report states that the majority of downland runoff is from Cockroost Hill which is located to the north east of the Mile Oak Farm. Runoff is channelled down the track on the western side of Cockroost Hill towards the farmyard where there are insufficient soakaways to cope with the runoff, thus runoff continues down Mile Oak Road into the residential area.

Mile Oak Farm does include some defence structures as part of Brighton Flood Defence Structures. These structures are located to the north of the farm and comprise of bunds. There are no structures located to intercept runoff from Cockroost Hill and runoff relies upon soakaways to manage overland flows.

The Highway Services department stated that soakaways in the area were repaired in April 2012 and there have been no reports about flooding following this.

- **Future Flood Risk**

The FMfSW shows that there is a significant extent of predicted deep (>0.3m) surface water flood risk to the Mile Oak area. Properties are shown to be at risk to the east of Mile Oak Road, which would correlate with internal flooding at this location.

- **Site Visit**

The land to the north of A27 is farmland/ farm buildings. The topography of the site falls to the local road which then passes underneath the A27 (as shown in photograph 5.33 and 5.34). Runoff is therefore channelled into the Mile Oak Farm area by the underpass. To the south of the A23 there are 3 super gullies on the eastern side of the road highlighting the quantity of runoff which is channelled along this section of road.

Photograph 5.32: Mile Oak Farm (Field adjacent to road)

Photograph 5.33: A27 Underpass (looking south)

Photograph 5.34: Super Gully by A27 Underpass (looking north)

Photo 5.35: Super Gully and saturated ground

The site visit highlighted a correlation between obviously lower properties and historically flooded properties, e.g. 417 and 419 Mile Oak Road shown in photogrpah 5.29.

Photo 5.36: Properties lower than road

Photo 5.37: Properties lower than road

- **Drainage Features**

The Mile Oak area relies upon soakaways to manage surface water runoff with a number of large super gullies discharging to a combined sewer in Mile Oak Road. The upstream catchment to the north of the A27 is over 6km², which is managed by a number of BHCC flood defence structures as discussed above.

A review of the geological maps of the area shows superficial head deposits (“variable deposits of sandy, silty clay, locally gravelly chalky and flinty in dry chalk valleys”) throughout the Mile Oak area. This correlates with the surface water flooding indicated on the FMfSW. This is underlain by Newhaven Chalk formation (“chalk, white, soft, with many marly seams and some nodular flints”, BGS geological maps).

- **Preliminary Engineering Opinion**

The Mile Oak area has suffered from flooding due to overland flows and emerging groundwater, therefore any mitigation measures will need to manage the overflow flows. Potential options include a detention basin located on the southern side of the rural catchment (to the north of the A27), local highway amendments, property level protection and review of the existing flood defence structures to confirm sufficient defences are included in this area.

Automated telemetry systems (similar to those located in Ladies Mile at Patcham) could also be considered to provide BHCC with a warning of rising water levels in the area.

5.3.7 Hotspot 7 – Blatchingham Mill School

Blatchingham Mill School is located to the north west of the city. The location of this hotspot in the context of the Brighton & Hove area is shown below in figure 5.7 below.

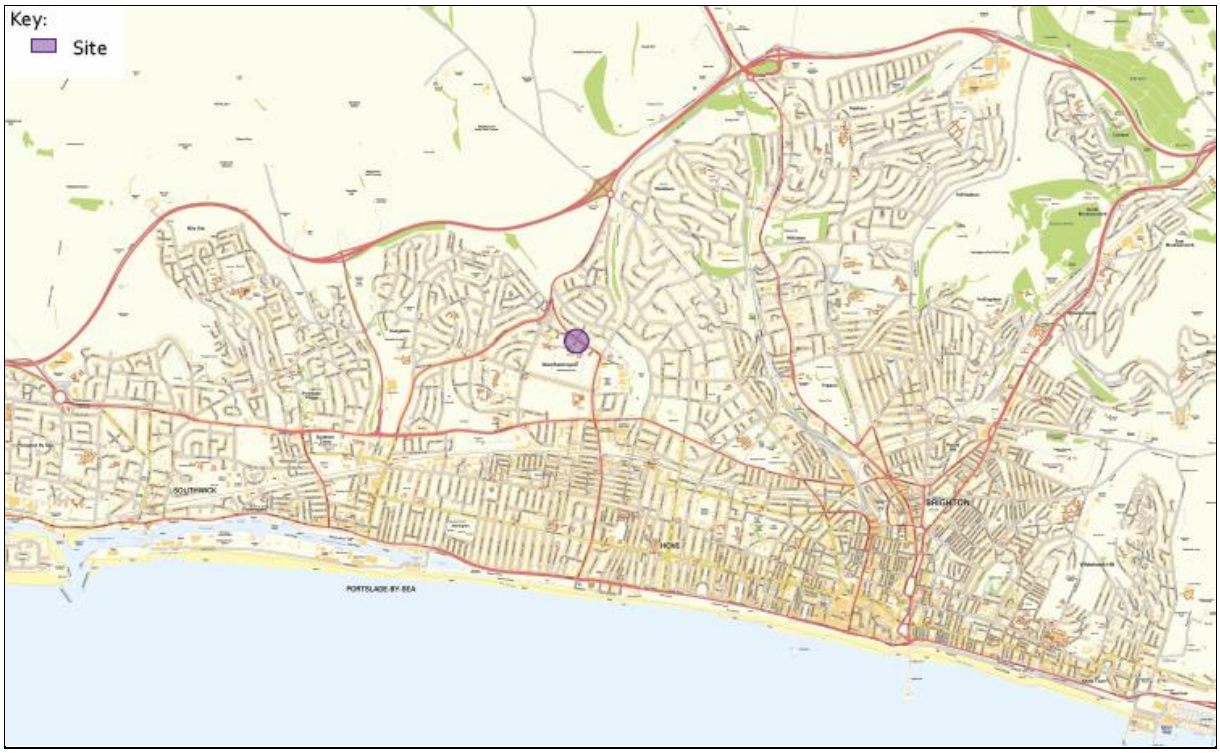


Figure 5.7: Hotspot 7

Drawing 23301/005/SK07 in Appendix J provides an overview of the hotspot and includes all information discussed in this chapter.

- **Historical Flood Risk**

Information received during Phase 1 of the SWMP stated that the drains and soakaways at the school were unable to manage runoff during extreme rainfall events, which caused internal flooding. Limited information is currently known regarding the historical flooding at Blatchington Mill School. The Highways Services were able to confirm that there were flooding issues in June 2011 however, there is some doubt as to whether the flooding was surface water flooding. Gullies at the school were cleaned out as a precaution and no issues have subsequently been reported to BHCC.

- **Future Flood Risk**

The FMfSW shows that there is predicted deep (>0.3m) surface water flood risk to Blatchington Mill School.

- **Site Visit**

Due to access restrictions the school grounds were not entered and as such no site information was able to be gathered.

- **Drainage Features**

From a review of the Southern Water records for the site there is no surface water connection to the school and therefore it is assumed that surface water runoff is discharged by private soakaways.

A review of the geological maps of the area indicated that part of the school lies upon Tarrant Chalk member – white with seam of large nodular and tabular flints and part of the site is on foundered strata with areas of collapsed Lambeth group sediments due to solution of underlying chalk. The Lambeth Group is Woolwich and Reading formation ("clay, silty with lignite beds and shell beds in in places. Basal glauconitic pebby sand", BGS geological maps).

- **Preliminary Engineering Opinion**

If the school's surface water drainage relies upon soakaways then the historical flooding at the school may have occurred through inappropriately designed, maintained or positioned soakaways becoming overwhelmed in extreme rainfall. However, due to the limited information available on the historical flooding issues and the future flood risk of the site it is proposed that a detailed assessment is carried out to gain more information on the historical flooding that has occurred at the site. This may involve contacting the school (via BHCC) to request more information on historical issues and confirm whether this was a surface water flooding issue.

5.4 Intermediate Level Assessment Summary

Table 5.1 below shows a summary of the potential causes of flooding at each hotspot and recommended actions for further investigation and assessment of mitigation measures.

Hotspot Name	Primary Causes of Flooding	Recommended Actions
1 – Ovingdean – Kett's Ridge	▪ Build-up of runoff from arable field ▪ Breach of embankment ▪ Lack of maintenance on ditch and embankment	▪ Regular inspections and maintenance to be carried out on ditch and embankment ▪ Review of flood defences design based on potential rural run-off and assessment of ditch conveyance or infiltration
2 – Mouslecoomb Primary School	▪ Overland rural flows exacerbating flooding ▪ Capacity issues for soakaways and sewers ▪ Soakaway maintenance reducing capacity	▪ Detailed review of Southern Water sewer records. ▪ Further investigation on knowledge of location of soakaways and their maintenance. ▪ Acquire LiDAR or procure third party DTM for the area. ▪ Modelling to assess potential mitigation solutions (Proposed detention basin in Wild Park). ▪ Minor footway improvements to restrict overland flow
3 – Bevendean	▪ Overland rural flows exacerbating flooding ▪ Lack of maintenance	▪ Highway amendments to replace speed ramps with speed cushions and install higher kerbs to allow flood flow path to

	of cascades including soakaways ▪ Houses intersect overflow flow routes	remain on highway. ▪ Regular inspections and maintenance of soakaways and adjacent ditches
4 – Patcham	▪ Rural flows from springs by railway exacerbating flooding downstream ▪ Capacity of sewers – system overwhelmed	▪ Earthworks to recreation area to retain overland flows. ▪ Localised highway amendments. ▪ Property level protection.
5 – Carden Avenue/ Warmdene Road	▪ Capacity of sewers – system overwhelmed ▪ Lack of maintenance of soakaways	▪ Detailed review of Southern Water sewer records. ▪ Discussion with Southern Water to confirm installation and level of protection of attenuation tank ▪ Further investigation on design and location of soakaways and their maintenance. ▪ Acquire LiDAR or procure third party DTM for the area. ▪ Highway amendments to restrict overland flows into Warmdene Road.
6 – Mile Oak	▪ Overland rural flows exacerbating flooding ▪ Capacity of sewers – system overwhelmed	▪ Modelling to assess potential mitigation solutions (Proposed detention basin). ▪ Highway amendments to restrict overland flows, e.g. Speed ramps, raised kerbs. ▪ Automated telemetry system for groundwater levels
7 – Blatchington Mill School	▪ Internal flooding issues	▪ Confirmation that historical flooding issue is surface water related and further investigation on the school drainage system.

Table 5.2 Summary of causes of flooding and actions

5.5 Detailed Assessment

Following completion of the Phase 2 Desk Studies the proposed options and next steps were agreed with BHCC. Provisional mitigation measures and concept solutions were developed which would provide obvious benefits in reducing flood risk and which were seemingly cost effective. Solutions that would require significant investment were discounted at this stage because it was deemed unlikely that sufficient funding could be obtained in the short term. It was considered that a further detailed risk assessment stage should not be undertaken and, if necessary, further information on the hotspots would be incorporated into Phase 3 (Options) for the SWMP.

5.5.1 Provisional Mitigation Solutions

- Hotspot 1 - Ovingdean – Kett's Ridge – Confirm the upstream rural catchment and verify the capacity of the existing ditch to manage overland flows.

- Hotspot 2 - Moulsecoomb Primary School – The opportunity exists to create a basin area within the recreation area adjacent to the Lewes Road and implement highway mitigation measures to manage overland flows on the surface.

- Hotspot 3 – Bevendean - Confine overland flow routes to the highway providing protection to the residential areas through highway improvements. Overland flows would be routed towards the playing field and new bunds constructed to restrict flows into Bevendean Primary School.

- Hotspot 4 – Patcham – Property level protection to be considered in Old London Road on properties with entrances lower than the road level or where basements are present. There is the opportunity to create a basin area within the recreation ground to restrict flows across Patcham Place and into Old London Road.

- Hotspot 5 - Carden Avenue/ Warmdene Road – The opportunity exists to restrict overland flows from Carden Avenue entering Warmdene Road by constructing a raised carriageway table crossing. There is the potential to create an overland flow path from the low spot in Warmdene Road to the school playing fields to the west.

- Hotspot 6 - Mile Oak – Restrict or divert flows from Cockroost Hill (at source) before overland flow reaches Mile Oak Farm. Create an attenuation area adjacent to Mile Oak Farm and divert overland flows from upstream of Mile Oak Farm into this area. Further management of overland flows along Mile Oak Road though introduction of speed ramps to reduce water bypassing super gullies.

- Hotspot 7 - Blatchingham Mill School – Regular maintenance of the existing drainage system.

6 Phase 3 – Options

Phase 3 of the SWMP process comprises the identification and assessment of options to remove, alleviate, or manage flood risk. This includes a cost benefit analysis of the proposed options to ensure the most cost effective and feasible options are selected for implementation and expenditure of public funds. Options which were deemed to be impractical, or where capital works were estimated to be very high, were excluded from further consideration to ensure that all the options assessed could be potentially implemented.

6.1 Modelling of existing catchments

As part of the Phase 3 options assessment, direct rainfall modelling was carried out on a number of the hotspots. Where this was considered a suitable technique and was undertaken for a hotspot, it is described in the following sections of this chapter. The modelling was carried out using TUFLOW, which is a modelling package used to simulate 1D or 2D flows incorporating complex overland flows as well as sewer networks.

EA LiDAR data (aerial 3D contours) was made accessible to BHCC through the Geostore website and was used to create 3D ground models or Digital Terrain Models (DTM). Where the extents of the natural catchments were outside the boundaries of this data the Flood Map for Surface Water DTM was used for additional areas. This methodology was also used for defining the natural catchment areas for each hotspot which are referenced in the following chapters. Further information on the modelling criteria can be found in Appendix L.

6.2 Cost Benefit Analysis

An economic analysis of the options was carried out, where possible, in order to identify and justify the costs and benefits of potential mitigation works compared to the existing 'do nothing' scenario.

In order to assess the options it was decided that the following monetised benefits and costs would be considered:

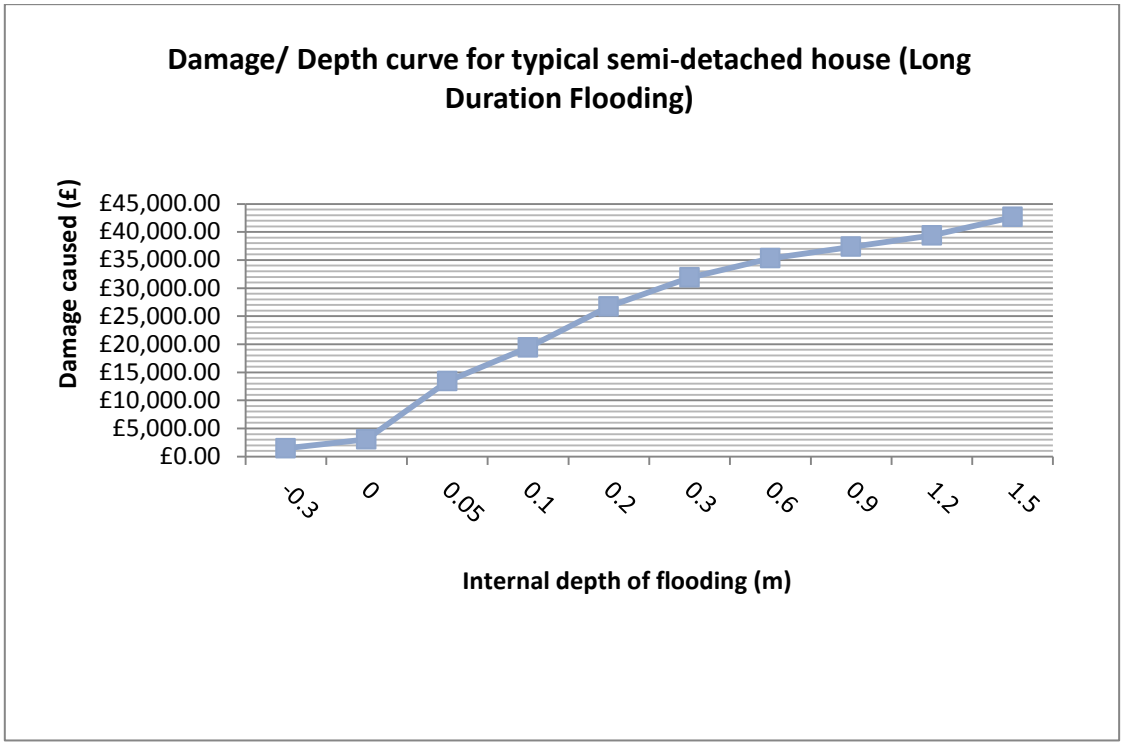
- Capital Costs (CAPEX) (costs associated with construction of the mitigation options).
- Reduction in damages to the property resulting from the mitigation.
- Reduction in damages to human health resulting from the mitigation.

Operational costs (OPEX) have not been considered as it was felt that the operational costs would not significantly increase over the existing scenario. In addition, non-monetised benefits and costs such as social and environmental impacts have not been included in the calculations.

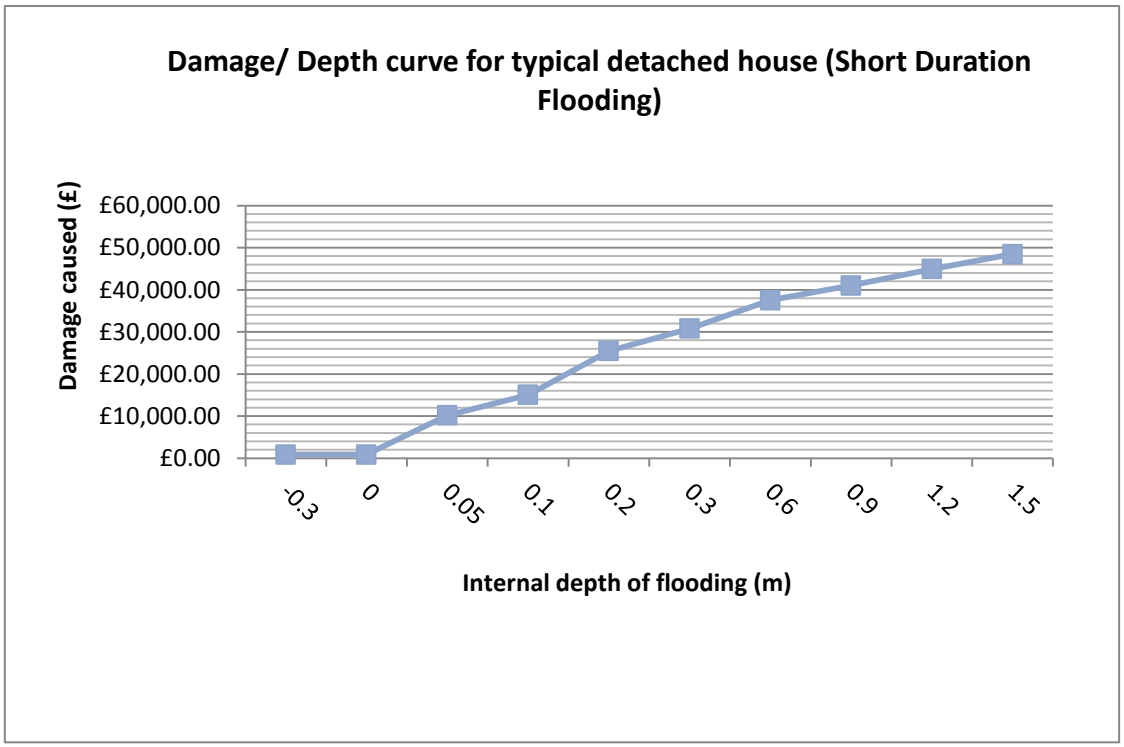
Damage caused to property by flooding has been estimated using 2010 data from 'The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques (Multi Coloured Manual)', Middlesex University. For the purposes of this study all properties were assumed to be the same building type within each study location, and general cost – damage data was used which does not specify the age of the property or social class of the area. These assessment assumptions allow different flow depths to be equated to a monetary value representing the property damage.

For the assessment of flood damages the most representative depth/damage curve from the following list was used based upon average property type with in the catchment and the critical storm duration:

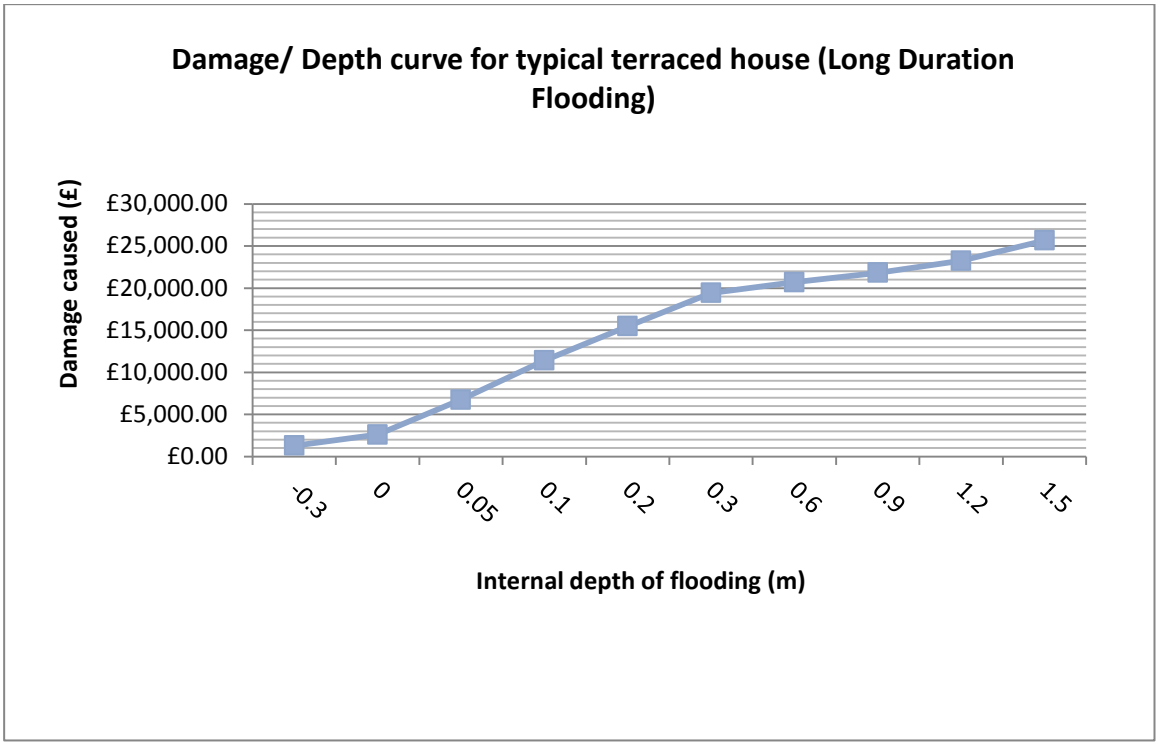
- Semi-detached properties with long duration flooding.
- Detached properties with short duration flooding.
- Terraced properties with long duration flooding.



Graph 6.1 Damage/ Depth curve for semi-detached dwelling



Graph 6.2 Damage/ Depth curve for detached dwelling



Graph 6.3 Damage/ Depth curve for terraced dwelling

Damages to property and health were annualised to produce an annual cost estimate and allow comparison of benefits for different return periods. Large storms will tend to cause the most damage but be the least likely to occur so the cost/benefit may be low, whereas small storms may have a low cost in terms of damages, but occur more frequently and therefore if mitigated the benefit – cost ratio could be high.

The Annual Average Damage (AAD) for property is the sum of the integrals between each pair of probability points for the property damage. In addition, the annualised damage to health has also been added to give the final AAD. The annualised damage to health is the integral between each pair of probability points for the number of properties flooded. The annual average benefit for each of the mitigation measures is the difference between the AAD for the existing 'do nothing' situation and the AAD of the mitigation option.

The level of damages per hotspot and hence the number of properties potentially affected is not expressly stated as the overland flow models are not calibrated and do not fully model the sub-terrainian sewer system. Therefore the level of potential flooding could be considered as high, however, the calculated damages are used to determine the relative benefit of implementing a mitigation scheme against the baseline.

- **Benefit Cost Ratio (BCR)**

As the benefits and costs for each option have been monetised, a benefit cost ratio was used in order to directly compare the options as well as evaluate the merit of each option. Both the Present Value (PV) of benefits and Benefit-Cost Ratio (BCR) have been calculated.

The PV of benefits is the total benefit over the lifetime of the option. The PV takes account of discounting, where a discount rate is applied to the future benefit of the options in order to compare future benefit to present day value. A rate of 3.5% for the first 30 years and 3% for the remaining 20 years has been used, in accordance with the Treasury Green Book.

The BCR is the PV of benefits divided by the PV of costs incurred for the option (i.e. any CAPEX or OPEX). Hence this method demonstrates the value of the option in terms of return per pound of cost. The cumulative net present value (NPV) is also calculated for every year of the scheme which equates to the PV of benefits minus the PV of costs. This provides a monetised net benefit over the lifetime of the scheme for the capital outlay.

Generally, if a BCR is greater than 1 then the project could be described as economically viable as the benefit from the scheme is greater than the cost for the scheme. It should be recognised that the schemes do not completely mitigate against flooding in all situations, but the benefit may be realised through reduced flooding depths and hence less damages.

6.3 Hotspot 1 – Ovingdean – Kett's Ridge

LiDAR information was provided to BHCC by the EA which covers the whole of the Brighton and Hove City area. Using this LiDAR data the natural catchment of the ditch upstream of Kett's Ridge could be defined. This is shown on Drawing 23301/012/010 in Appendix D. The ditch and embankment providing protection to Kett's Ridge drains a natural catchment of 1.07ha, however a further 2.16ha could also be considered as draining to this ditch due to the farmland track, which could act as a conduit for overland flow. Ovingdean Close in its entirety has a catchment of approximately 5.25ha.

There is uncertainty as to when the ditch and embankment (part of the Bulstrode Farm defences) were constructed. The Estates department confirmed that the Bulstrode Farm defences were in place before and after the flooding in 2000, however further correspondence suggests that dams and ditches were built following flooding of the new residential estate on Ovingdean Road as well as Kett's Ridge.

6.3.1 Mitigation Option

- **Option – New ditch and embankment**

An assessment of the rural runoff from the arable land to the west (Mount Pleasant) was carried out and is detailed in Appendix D. A variety of methods to calculate the rural runoff were considered, including ADAS 365, Institute of Hydrology Report Number 124 (IH 124) and Flood Estimation Handbook (FEH). Whilst FEH is generally considered appropriate for rural catchments the size of the site meant that this method was not appropriate (FEH catchment descriptors are not applicable to catchments smaller than 50ha). ADAS is no longer advised as suitable for greenfield runoff calculations on small catchments due to the limited and dated rainfall intensities used within the method. Therefore for the purposes of Hotspot 1 the IH 124 method was used (and factored down in accordance with the Interim Code of Practice for Sustainable Drainage (ICP SuDS)). An impermeable soil type was used in the calculation to replicate saturated ground. From this an assessment of the ditch capacity was calculated using Manning's Equation. This confirmed that the ditch needed to be a minimum of 1.8m² in cross sectional area (for the 1 in 100 year return period) adjacent to Kett's Ridge. The estimated cost to construct the embankment (assuming no ditch or embankment is currently present) would be approximately £40,000.

No as-built information is available on Bulstrode Farm defences and therefore the proposed action from Hotspot 1 is to undertake clearance of the existing ditch and topographical survey to confirm that the capacity of the ditch is sufficient to meet the rural runoff up to and including the 1 in 100 year storm return period.

6.3.1 Cost Benefit Analysis

An economic analysis was carried out in order to identify and justify the costs and benefits of the potential mitigation works compared to the 'do nothing' scenario.

Based upon the SWMP Living Draft guidance (Defra, 2009) it was decided to use a simpler approach to approximating annual damages from a single probability event. This was used instead of the method stated in section 6.2 to calculate the annualised damage. The living guidance document states that this approach was used on some of the early SWMP pilots but the approach is limited as it does not take into account the lower probability events. As such there is a risk that if this is compared against other options which take into account multiple return periods that the most effective solution will not be identified. However due to the limited information on flood depths for storm return period this method was considered more appropriate.

However, the following assumptions were made as part of the cost benefit analysis for Hotspot 1:

- All dwellings assumed to be detached.
- No assessment of damages to human health.
- Short duration flooding - flood duration is less than 12 hours.
- Kett's Ridge floods for the 1 in 100 year storm event and is assumed to not flood once the ditch has been excavated to the design standard described in option 1 above.

Based upon the assumptions stated above and the parameters set in section 6.2 the BCR is shown in table 6.1 below.

PV of costs	£ 39,301.00
PV of benefits	£ 7,368.88
Cumulative NPV	-£ 31,932.12
Benefit - cost ratio	**0.19**

Table 6.1 Hotspot 1 – Ovingdean Close – Ketts's Ridge BCR

The BCR is considered to be low (less than 1) and economically unviable. However the capital costs included for excavating a new ditch. Therefore it is recommended that the existing ditch and embankment are surveyed to confirm the size and maintenance carried out, then the capital cost of the ditch could be reduced thus increasing the BCR.

6.4 Hotspot 2 - Moulsecoomb Primary School

The natural catchment for Moulsecoomb Primary School was defined using LiDAR information and comprised an area of 500ha. This catchment is predominantly urban with an exception of a small area of Wild Park and therefore only partially affected by rural run-off. Run-off is channelled along highways through the catchment under the railway bridge towards the School. The natural catchment is shown on drawing 23301/012/011 in Appendix E.

The FMfSW highlights Moulsecoomb Primary School and also Lewes Road as at risk from surface water flooding. Lewes Road was discounted as a hotspot on its own because historically no internal flooding has occurred, but there were considerable road closures causing significant road traffic disruption during the flood event.

However, as part of Phase 3, there has been consideration of the whole of Lewes Road and not just the primary school.

Using the LiDAR data for the area and the catchment plan a surface water model was created to replicate the overland flows generated as detailed in section 6.1. The results of the surface water modelling are described in section 6.4.2 below.

6.4.1 Mitigation Option

- **Option 1 – Highway amendments and earthworks**

The FMfSW highlights that the Lewes Road is at risk of surface water flooding. In addition, there is an overland flow path from Moulsecoomb Wild Park (through the Sports Ground) onto Lewes Road. The proposed option is to restrict this overland flow and hence reduce flood risk on Lewes Road by creating an embankment and basin on the open space in Wild Park directly adjacent to Lewes Road.

Furthermore, the school will have a higher level of protection by introducing highway improvements including a raised wall at the back of the footway and raising the footway at the entrance to the school.

The estimated cost to construct option 1 would be approximately £400,000.

- **Option 2 – Groundwater monitoring**

As discussed in section 5.3.6 historically significant groundwater flooding occurred in the Mile Oak area during the winter of 2000. Springs emerged at multiple points along the Lewes Road and also within gardens as well as emerging from soakaways and road gullies. Therefore it is proposed that groundwater monitoring is considered and an automated telemetry system is installed similar to that at Ladies Mile in Patcham. Real-time groundwater levels could then be provided for the area and alarms set to warn of rising water levels in the area allowing time for emergency plans to be implemented.

6.4.2 Modelling

Surface water modelling was undertaken for the baseline scenario (existing) and proposed options for a range of storm return periods as detailed in section 6.1. The existing scenario is shown on drawings 23301/012/SK010-013 and the mitigation Option 1 is reflected on drawings 23301/012/SK014-017.

On review of the surface water flood maps, water is attenuated within the basin and for the 1 in 10 year there is a noticeable small area of flooding reduced by option 1 opposite Ringmer Road. There is no significant visual improvement as the storm return periods increase.

6.4.3 Cost Benefit Analysis

An economic analysis was carried out in order to identify and justify the costs and benefits of the potential mitigation works compared to the 'do nothing' scenario. The cost benefit analysis was undertaken in accordance with the methodology detailed in section 6.2 and considered a range of storm return periods in order to consider annualised damages and benefits. A copy of the summary from the cost estimate for capital costs of the scheme is included in Appendix E.

The following assumptions were made as part of the cost benefit analysis for Hotspot 2:

- All dwellings assumed to be semi- detached.
- Long duration flooding - flood duration is less than 12 hours.
- Whilst the options did not resolve flooding of houses the flood depths were reduced alleviating flooding and therefore the impacts (damages) were reduced. Based upon the assumptions stated above and the parameters set in section 6.2 the BCR is shown in table 6.1 below.

PV of costs	£ 394,589
PV of benefits	£ 8,563
Cumulative NPV	-£ 386,026
Benefit - cost ratio	**0.02**

- Table 6.2 Hotspot 2 – Moulsecoomb Primary School – BCR

The BCR is considered to be low (less than 1) and economically unviable. Whilst there are minor improvements over the existing scenario for the lower storm return periods, overall the scheme is seen to be economical unviable. This hotspot should be re-visited in future iterations of the SWMP or Local Strategy as and when more information is available to investigate whether the BCR can be improved. Therefore it is proposed that only groundwater monitoring should be taken forward to Phase 4 of the SWMP to provide a warning system so that property level protection could be used for houses at risk.

6.5 Hotspot 3 – Bevendean

Historically overland flows from Bevendean resulted in significant flooding downstream as discussed in chapter 5.3.3. The natural catchment area upstream of Bodiam Close comprises an area of approximately 180ha and overland flows have historically been managed by a series of three dams forming cascades with soakaway in the base of each basin.

The FMfSW and LiDAR information confirms that properties in Bodiam Close, Heath Hill Avenue, and Bodiam Avenue are at risk of surface water flooding.

Due to the size of the upstream catchment and the presence of existing source control features (cascades and soakaways), it was decided that any proposed mitigation options should seek to manage overland flows through the residential area, if the cascades were to be over whelmed.

Using the LiDAR data for the area and the catchment plan a surface water model was created to replicate the overland flows generated as detailed in section 6.1. A drawing of the model output can be found in Appendix F.

6.5.1 Mitigation Options

- **Option 1 – Highway Amendments**

To protect houses along Heath Hill Avenue, it is proposed to implement a number of highway improvements. This includes increasing the kerb height adjacent to the properties and increasing the height of the verge as well as vehicle crossovers. Raised tables will be installed at the junctions with Hornby Road, Leybourne Road, Taunton Road and the entrance to Partridge House Care Home to direct flows along Heath Hill Avenue. Furthermore, the existing speed ramps will be amended to avoid impedance of flows longitudinally along Heath Hill Avenue. The estimated cost of Option 1 is approximately £145,000

This option is shown on drawing 23301/012/003 in Appendix F.

- **Option 2 – Earthworks (including highway amendments)**

The FMfSW indicates that the primary school is flooded due to overland flows across the playing field from the east. The implementation of Option 1 would mean that a larger volume of water would be directed towards the playing fields. Therefore, Option 2 is to construct an embankment between the playing fields and Bevendean Primary School. The playing fields are lower than Heath Hill Avenue (to the north) and Taunton Road (to the south) therefore constructing an embankment north/south across the playing fields will provide protection to the school and restrict overland flows. The estimated cost of Option 2 is approximately £185,000

This option is shown on drawing 23301/012/003 in Appendix F.

6.5.2 Modelling

Surface water modelling was undertaken for the baseline scenario (existing) and proposed options for a range of storm return periods as detailed in section 6.1. The existing scenario is shown on drawings 23301/012/SK018-021 and the mitigation Option 1 is reflected on drawings 23301/012/SK022-029.

On review of the surface water flood mapping, Option 1 creates a visual improvement over the existing scenario for the 1 in 10 year storm return period at the junction of Leybourne Road and Heath Hill Avenue and Leybourne Road/ Taunton Road. However this does increase flooding of Bevendean Primary School. By the 1 in 30 year storm return period the flood depth in the school as well as flooding in properties along Heath Hill Avenue, has been decreased by Option 1 when compared to the existing scenario. This is repeated up to the 1 in 100 year storm return period.

Option 2 clearly retains runoff in the recreation ground for the 1 in 10 year storm return period, significantly reducing flooding of properties on Heath Hill Avenue and Leybourne Road/ Taunton Road. Flooding in Leybourne Road/ Taunton Road increases as the Return Period increases, as water effectively becomes trapped by the bund on the edge of the recreation ground and as water starts to overtop the raised kerbs along Heath Hill Avenue.

6.5.3 Cost Benefit Analysis

An economic analysis was carried out in order to identify and justify the costs and benefits of the potential mitigation works compared to the ‘do nothing’ scenario. The cost benefit analysis was undertaken in accordance with the methodology detailed in section 6.2 and considered a range of storm return periods in order to consider annualised damages and benefits. A copy of the summary from the cost estimate for capital costs of the scheme is included in Appendix F.

The following assumptions were made as part of the cost benefit analysis for Hotspot 3:

- All dwellings assumed to be semi- detached.
- Long duration flooding - flood duration is less than 12 hours.

Whilst the options did not resolve flooding of houses the flood depths were reduced alleviating flooding and therefore the impacts (damages) were reduced. Based upon the assumptions stated above and the parameters set in section 6.2 the BCR is shown in table 6.1 below.

PV of costs	£ 145,262
PV of benefits	£ 928,550
Cumulative NPV	£ 783,288
Benefit - cost ratio	**6.39**

Table 6.3 Hotspot 3 – Bevendean – Option 1 – BCR

PV of costs	£ 183,142
PV of benefits	£ 1,774,890
Cumulative NPV	£ 1,591,748
Benefit - cost ratio	**9.69**

Table 6.4 Hotspot 3 – Bevendean – Option 2 - BCR

Both options are economical viable with both schemes providing BRCs greater than 1. Option 2 provides the best benefit with a BCR of 9.7 versus 6.4 for option 1 with an additional £40,000 required for Option 2. Therefore it is suggested that Option 2 is implemented. As option 2 builds upon Option 1 implementation could be phased with the highway works being implemented as phase 1 and the earthworks as Phase 2 at a later date.

Flooding within this hotspot could be further exacerbated by poor maintenance of the existing flood defence structures which has not been reflected within the cost benefit analysis. Bodiam Close flood alleviation structures provides protection to Bevendean and more specifically Bodiam Close through 3 dams creating basins in the valley (cascades), each with a soakaway sited in the base. The Flood Defence Asset Inspections (PBA, 2013) highlighted this structure, as well as many of the other flood defence structures, to be in need of maintenance and recommendations were proposed to BHCC to rectify any issues. Should these recommendations not be implemented then the level of protection for Bevendean will decrease.

6.6 Hotspot 4 – Patcham

LiDAR information for Patcham shows that the natural catchment for the Old London Road is approximately 15.5km^2. The natural catchment to the north is divided by the A23 and A27 roads, but the majority of the study area is rural, with only a small area of urban and highway land being included. The natural catchment is shown on drawing 23301/012/013 in Appendix G.

The FMfSW highlights the connectivity of the larger rural catchment to the north of the A27 with Patcham as an underpass on Mill Road. Historically, significant flooding took place in Patcham (as described in Chapter 5.3.4), which was exacerbated by rising groundwater levels. As no records are available on the volume of groundwater which occurred during historical events, the surface water models which have been constructed do not include for groundwater flows. Therefore the models will not replicate the extent of groundwater flooding which occurred during the 2000/2001 flooding event.

A review of the Southern Water records for London Road was undertaken as part of Phase 3. This confirmed that there is a 1375mm diameter surface water sewer along the A23 which extends to Preston Park Railway Station where it joins a 450mm diameter combined sewer which continues down the A23 to the coastal storm water sewer tunnel. A throttle is formed in the network where these two

sewers join, limiting the flow to the downstream sewer. The BB&V report suggests that if this throttle was removed then the capacity of the sewer downstream from Preston Park would be exceeded in extreme storm events and result in the possibility that this would cause surface water flooding downstream and in the city centre. Therefore, upgrading the downstream 450mm diameter pipe was considered unfeasible due to capital costs, disruption to traffic and social impacts of upgrade works in a dense urban area. The BB&V report also suggests that a tunnel solution could be an option for installing a new surface water sewer from Patcham. However, these options have been discounted in the SWMP due to their scale and the practical approach of discounting solutions unlikely to be implemented by BHCC (as discussed in section 5.5).

Patcham groundwater levels are currently monitored by an automated telemetry system which was installed in March 2012 as discussed in section 5.3.4

During the winter of 2013/2014 Southern Water, BHCC Highways and East Sussex Fire and Rescue Service used temporary pipes and pumps on Old London Road to manage surcharged sewers (exacerbated by groundwater flooding) and discharge water to sewers in London Road. BHCC Highways installed a permanent pipe across the Old London Road to facilitate this emergency procedure in the future.

Using the LiDAR data for the area and the catchment plan a surface water model was created to replicate the overland flows generated as detailed in section 6.1. A drawing of the model output can be found in Appendix G.

6.6.1 Mitigation Options

- **Option 1 – Earthworks**

To reduce overland flows from Mill Road onto London Road, it is proposed to construct an embankment and basin to the south of the recreation ground. This will restrict overland flow into Old London Road. A spillway is included within the embankment to release runoff at a controlled rate back onto the London Road so that the sewer network can manage the controlled flow. Historically during the 2000/2001 event water by passed the super gulley in the A23 as it was unable to capture all the flow. As an emergency procedure during the same event, water was diverted into the sewers at Patcham causing the sewers downstream to surcharge, therefore emphasising the need for additional storage on the network or on the surface as opposed to installing further supergullies. The estimated cost to construct the embankment would be approximately £85,000.

This option is shown on drawing 23301/012/004 in Appendix G.

It should be noted that whilst the majority of the land in the area is part of the BHCC owned farm land part of the land just to the north of the A27 is owned by Southern Water. Therefore option 1 as shown on drawing 23301/012/004 would be subject to agreement with Southern Water.

- **Option 2 – Property Level Protection**

Property Level Protection (PLP) aims to reduce the impact of flooding to homes and businesses by installing specific property protection measures. The Environment Agency recommends a number of PLP measures to protect properties against flooding which can be installed in advance of rising flood waters. These measures include:

- Sandbags
- Automatic flood proof doors and windows or purpose built flood boards
- Air brick covers
- Fitting non return valves to drains and water inlet/outlet pipes
- Flood Barriers

The flood barriers can be installed for a number of different protection heights and can be installed on doorways, windows, across driveways. Examples of door barriers are shown in photograph 6.1.

Photograph 6.1 Examples of flood defence (source UK Flood Barriers)

A combination of air brick covers, non-return valves, window defences and door defences are proposed for properties along Old London Road. Due to the local topography, Old London Road is lower than London Road at the northern junction where these two roads meet. A number of properties also have floor levels lower than the adjacent footway or have basement rooms and therefore are at risk of flooding from overland flows or when sewers surcharge.

PLP was advocated in the recommendations of the Pitt Review (2008), *"The general provision of sandbags should be phased out in favour of better products such as kite-marked flood boards, air brick covers targeted at the vulnerable and other forms of temporary defence"*

Door defences have been estimated to cost approximately £650 per unit and airbrick covers approximately £50. The proposed extent of PLP for dwellings on the Old London Road is shown on drawing 23301/012/004. The estimated cost to implement property level protection would be approximately £35,000.

6.6.2 Modelling

Surface water modelling was undertaken for the baseline scenario (existing) and proposed options for a range of storm return periods as detailed in section 6.1. The existing scenario is shown on drawings 23301/012/SK30-33 and the mitigation Option 1 is reflected on drawings 23301/012/SK034-037. Option 2 (Property Level Protection) has not been modelled and the cost benefit analysis (discussed in more detail below) has been calculated based upon the products maximum design flood levels and the existing surface water modelling.

Throughout the surface water flood map for Option 1 the implications of the proposed embankment located on the recreation ground are evidence. Water is clearly retained on the recreation ground by the bund and the depth of flooding is reduced, most notably at the junction of London Road/ Old London Road. The extent of the flooding has also been reduced along Old London Road down to the junction of the Deneway and A23 London Road. During the 1 in 100 year storm return period the basin is overwhelmed and flooding in Old London Road returns to mimic the existing scenario. However, flooding to the southern end of Old London Road is not as deep nor is the extent of the deep flooding as large on the London Road.

6.6.3 Cost Benefit Analysis

The following assumptions were made as part of the cost benefit analysis for Hotspot 4:

- All dwellings assumed to be semi- detached.
- Long duration flooding - flood duration is less than 12 hours.

- **Option 1 - Earthworks**

An economic analysis was carried out in order to identify and justify the costs and benefits of option 1 compared to the 'do nothing' scenario. The cost benefit analysis was undertaken in accordance with the methodology detailed in section 6.2 and considered a range of storm return periods in order to consider annualised damages and benefits. A copy of the summary from the cost estimate for capital costs of the scheme is included in Appendix G.

Based upon the assumptions stated above and the parameters set in section 6.2 the BCR is shown in table 6.1 below.

PV of costs	£85,020
PV of benefits	£251,122
Cumulative NPV	£166,102
Benefit - cost ratio	**2.95**

Table 6.5 Hotspot 4 Patcham – Option 1 Earthworks- Property Level Protection BCR

- **Option 2 – Property Level Protection**

The BCR for Option 2 was calculated by identifying the cost of flooding occurring during the existing scenario for the varying storm return periods. The flood levels were then reviewed and an assessment as to whether the PLP removed internal flooding of these individual properties was then carried out. All internal flooding up to and including the 100 year storm return period could be removed using property level protection. The annualised damages and benefits were then calculated in accordance with section 6.2 of this report.

A copy of the summary from the cost estimate for the capital costs of the scheme is included in Appendix G. Based upon the assumptions stated above and the parameters set in section 6.2 the BCR is shown in table 6.1 below.

PV of costs	£36,169
PV of benefits	£510,057
Cumulative NPV	£473,888
Benefit - cost ratio	**14.1**

Table 6.6 Hotspot 4 Patcham – Option 2 Properly Level Protection BCR

Historically, the Patcham area has been prone to flooding from groundwater and this has not been replicated within the modelling. Groundwater flooding is difficult to quantify and this would result in flood depths being higher within Old London Road properties, therefore the PV benefits would be higher for the PLP, thus increasing the BCR.

- **Option 3 – Property Level Protection and Earthworks**

Option 3 combines options 1 and 2 and proposes to implement both the earthworks on Patcham Place as well as the Property Level Protection.

A copy of the summary from the cost estimate for the capital costs of the scheme is included in Appendix G. Based upon the assumptions stated above and the parameters set in section 6.2 the BCR is shown in table 6.1 below.

PV of costs	£109,505
PV of benefits	£897,215
Cumulative NPV	£787,710
Benefit - cost ratio	**8.19**

Table 6.6 Hotspot 4 Patcham – Option 3 Combined Properly Level Protection and Earthworks BCR

All of the options are economical viable with schemes providing BCRs greater than 1. Option 2 provides the best benefit with a BCR of 14.1 versus 2.95 and 8.19 for option 1 and 3 respectively. Therefore it is suggested that option 2 is implemented. Community engagement and consultation should be undertaken to gain full support for the PLP. Option 1 could be undertaken should public support not be received for the PLP scheme.

6.7 Hotspot 5 – Carden Avenue/ Warmdene Road

The LiDAR information for the area shows the natural catchment for the Warmdene Road to be 174ha. This catchment is predominantly urban and is therefore not affected by rural run-off. Run-off is channelled along highways through the catchment (when gullies are overwhelmed). The natural catchment is shown on drawing 23301/012/014.

The FMfSW highlights Warmdene Road as at risk of flooding from surface water, with overland flows from Warmdene Way and Carden Avenue.

The Highway Services team stated that residents at 19, 17, 17a and 15 have historically been prone to flooding with further properties on the opposite side of the road also flooding on some occasions. As discussed in Chapter 5.3.5, flooding was reportedly attributed to soakaways needing replacement and the Southern Water sewers being surcharged during extreme rainfall events. Flooding from sewers at the bottom of Wilmington Parade caused overland flows into Carden Avenue and then into Warmdene Road.

Southern Water's Sewer Incident Record Form (SIRF) states that there have been three instances of flooding in Carden Avenue and Warmdene Road. In 2009 flooding was recorded in Warmdene Road as foul flooding, it could however be attributed to ingress of excess surface water into the foul sewer network in the area. During this incident 6 properties were flooded internally and 3 properties' external space was flooded. Records state that flooding also occurred on Carden Avenue in 1995 (combined sewer but no recorded property flooding), in 2000 (foul flooding with external flooding of 3 houses) and 2009 (foul flooding with 4 internal properties flooding).

BHCC has suggested that Southern Water installed an attenuation tank in Carden Avenue a few years ago, which has managed run-off into the sewer network. Therefore it was considered that this attenuation would have resolved flooding along Carden Avenue and hence no mitigation options have been included for Carden Avenue. Southern Water has subsequently stated that this was a draft improvement scheme and they have been unable to confirm that the attenuation tank was installed. Therefore it is considered that the scheme was in fact put on hold for viability reasons. However, Southern Water are keen to implement a scheme and in partnership with BHCC the proposals could now be reviewed to see whether a collaborative approach could make a commercially viable scheme. The location and existence of the Carden Avenue attenuation tank will be investigated further by Southern Water and BHCC.

6.7.1 Mitigation Options

- **Option 1 – Raised table and Syphon Sewer**

To mitigate against overland flows from Carden Avenue and areas further upstream, it is proposed that a raised table is installed at the junction of Carden Avenue and Warmdene Road. This will ensure that any overland flows remain on Carden Avenue and are managed by entering into the sewer network or soakaways rather than overwhelming existing infrastructure and ponding at the low spot on Warmdene Road.

The FMfSW and LiDAR both highlight that Warmdene Road is located in a depression and therefore topographically it will prone to overland flows when drainage infrastructure is overwhelmed. In order to prevent soakaways being inundated with surface water runoff during extreme events it is proposed that a by-pass pipe is constructed from the low spot on Warmdene road into the playing fields at Patcham High School. This system will work as a syphon and no storage will be provided on the playing fields, as it is assumed the water will pond temporarily whilst infiltration occurs.

This option is shown on Drawing 23301/005/005 in Appendix H.

- **Option 2 - Review condition of existing soakaways in Warmdene Road and Carden Avenue**

The Highway Services team highlighted that the soakaways were old in this location and needed replacement or renovation. Therefore, Option 2 is to mitigate against flood risk in the area by investigating the current condition of all soakaways and develop an action plan for their replacement.

6.7.2 Cost Benefit Analysis

An economic analysis was carried out in order to identify and justify the costs and benefits of the potential mitigation works compared to the ‘do nothing’ scenario. Only Option 1 which included the raised table and sewer has been assessed as the condition and performance of existing soakaways is unknown and therefore assessing the benefit would be difficult to quantify.

However, in this case assumptions also had to be made as to the benefits that the proposed option would provide and it was decided that the mitigation would only offer benefit up to a 1 in 5 year storm return period. This is because it is difficult to model and hence quantify the benefits that this scheme would provide given the large upstream catchment size. A copy of the summary of the cost estimate for the capital works of the scheme is included in Appendix H.

Based upon the SWMP Living Draft guidance (Defra, 2009) it was decided to use a simpler approach to approximating annual damages from a single probability event. This was used instead of the method stated in section 6.2 to calculate the annualised damage. The living guidance document states that this approach was used on some of the early SWMP pilots, but the approach is limited as it does not take into account the lower probability events. As such there is a risk that if this is compared against other options which take into account multiple return periods the most effective solution will not be identified.

However, the following assumptions were made as part of the cost benefit analysis for Hotspot 5:

- All dwellings assumed to be semi-detached.
- No assessment of damages to human health.
- Long duration flooding - flood duration is more than 12 hours.
- Four properties assumed to flood to 0.3m on western side of Warmdene Road and three properties assumed to flood to 0.149 on the eastern side of Warmdene Road (these are arbitrary values and not based on evidence).

A copy of the summary from the cost estimate for the capital costs of the scheme is included in Appendix H. Based upon the assumptions stated above and the parameters set in section 6.2 the BCR is shown in table 6.1 below.

PV of costs	£ 54,062
PV of benefits	£ 910,060
Cumulative NPV	£ 855,997
Benefit - cost ratio	**16.8**

Table 6.7 Hotspot 5 Carden Avenue/ Warmdene BCR- Option 1

The option is economical viable with the schemes providing a BRC greater than 1. Following a partnership meeting BHCC stated that there was potentially already an existing sewer from a gully adjacent to 17a Warmdene Road into a soakaway in the playing fields. Therefore, it is proposed that a drainage investigation is carried out to confirm whether this is the case and whether any existing system could be modified to include the proposed syphon to the park. This would decrease the capital costs of the scheme and therefore potentially increase the BCR. A drainage survey would cost approximately £3000.

6.8 Hotspot 6 – Mile Oak

LiDAR information indicated that the upstream catchment from the Mile Oak underpass at the A27 is in the region of 648 ha (6.48km^2). The natural catchment is shown on drawing 23301/012/015 in Appendix I.

As discussed in chapter 5.3.6 there are a number of structures which form the Mile Oak Farm BHCC Flood Defence Structures. These date back to 1987 following severe surface water runoff in the area and are shown on the Mile Oak Catchment Plan (refer drawing 23301/012/015 in appendix I). These embankments manage the overland flows from the fields higher in the Mile Oak catchment and farming regimes have been set so that overland flow is not exacerbated. However, the BB&V reported that large volumes of runoff were still occurring from the track on the western side of Cockroost Hill and to a lesser extent on the track from Southwick Hill and Whitelot Bottom. These areas are indicated on drawing 23301/012/015 in Appendix I.

The options assessment for Mile Oak focuses on mitigation of the existing flood risk from overland flows from Mile Oak farmland. There are further potential mitigation measures in the form of highway works to the south of the A27 to divert overland flows into the sewer network. The BHCC Estates department have correspondence which states that the land to the south of the A27 and east of Mile Oak Road was specifically lowered to attenuate runoff from the highway.

Using the LiDAR data for the area and the catchment plan a surface water model was created to replicate the overland flows generated as detailed in section 6.1. A drawing of the model output can be found in Appendix I.

6.8.1 Mitigation Options

- **Option 1 – Earthworks and Highway amendments**

Mitigation options focus on managing overland flows from the large rural catchment. Initially run-off will be diverted off farm tracks by concrete speed humps. These farm tracks currently act as conduits for overland flow. Furthermore, embankments will be constructed at the bottom of Cockroost Hill and opposite Mile Oak Barn to protect Mile Oak Farm. Once any remaining overland flow reaches Mile Oak Farm it will be diverted into a basin adjacent to Mile Oak Road and attenuated. Speed ramps will also be used on Mile Oak Road (south of the underpass) to ensure run-off does not by-pass super gullies.

- **Option 2 – Groundwater monitoring**

As discussed in section 5.3.6 historically significant groundwater flooding occurred in the Mile Oak area during the 2000 flood event. Springs emerged in gardens throughout the Mile Oak Area. Therefore it is proposed that groundwater monitoring is considered and an automated telemetry system is installed similar to that at Ladies Mile in Patcham. Real-time groundwater levels could then be provided for the area and alarms set to warn of rising water levels in the area allowing for emergency plans to be implemented.

6.8.2 Modelling

Surface Water modelling was undertaken for the baseline scenario (existing) and proposed options for a range of storm return periods as detailed in section 6.1. On review of the surface water mapping produced for the existing scenario it was evident that the modelling did not reflect the historical flooding which had occurred from runoff from Cockroost Hill. Flooding has previously followed the valley base up past Mile Oak Barn. Therefore whilst the option of an additional bund at the base of Cockroost Hill is not quantified in the cost benefit analysis it is still considered a viable option to mitigate flood risk based upon knowledge of historical events in the area. Furthermore flooding in the area is exacerbated by groundwater flooding which cannot be quantified within the model.

6.8.3 Cost Benefit Analysis

An economic analysis was carried out in order to identify and justify the costs and benefits of the potential mitigation works compared to the 'do nothing' scenario. Only Option 1 which included the earthworks and highway amendments has been assessed as groundwater monitoring provides early warning as opposed to quantifiable benefit. A copy of the summary from the cost estimate for capital costs of the scheme is included in Appendix I.

The cost benefit analysis was undertaken in accordance with the methodology detailed in section 6.2 and considered a range of storm return periods in order to consider annualised damages and benefits.

The following assumptions were made as part of the cost benefit analysis for Hotspot 6:

- All dwellings assumed to be semi- detached.
- Long duration flooding - flood duration is less than 12 hours.

Whilst the options did not resolve flooding of houses the flood depths were reduced alleviating flooding and therefore the impacts (damages) were reduced. Based upon the assumptions stated above and the parameters set in section 6.2 the BCR is shown in table 6.1 below.

PV of costs	£ 221,056
PV of benefits	£ 134,767
Cumulative NPV	-£ 86,288
Benefit - cost ratio	**0.67**

Table 6.18 Hotspot 6 – Mile Oak BCR

It is anticipated that flooding is exacerbated by groundwater rising in Mile Oak Road. Therefore in reality costs would be increased and could reduce the BCR. The benefit cost ratio is considered to be low (less than 1) and economically unviable. Therefore from a purely financial point of view the scheme is economically unviable. There still may be some benefit in implementing the Cockroost Hill embankments given historical reports of overland flows from this area. Given that it is difficult to quantify both the existing damage and the proposed benefits in the catchment it is proposed that only groundwater monitoring is taken forward and other flood alleviation measures should be re-visited in future iterations of the SWMP/ Local Strategy. PLP could be considered a more cost effective option especially to mitigate against groundwater flooding. Groundwater monitoring would provide the alarm mechanism to allow PLP to be implemented.

6.9 Hotspot 7 – Blatchingham Mill School

Through discussions with the Education department at BHCC they were unable to identify specific information on surface water flooding issues at Blatchingham Mill School. The Highway Services department confirmed that there was last flooding at the school in June 2011. They reported that there were issues with the schools drainage system which was causing internal flooding. Clarification of the exact drainage issues was not provided, however following clearance of the rainwater gullies there has been no further complaints of surface water flooding. The FMfSW for the area (refer to drawing 23301/005/SK07 in Appendix J) shows that there is a low spot in the vicinity of the school grounds and therefore there is potential for future flooding. BHCC could consider the following options as a next step to investigate historical flooding issues at the site:

- Property Level protection (Approximately £5-10K)
- Drainage survey/ investigation (Approximately £3-5K)
- No further work (assume existing maintenance issue)

6.10 Summary of Cost Benefit Analysis

Table 6.19 below summarises the BCR for each of the options proposed within this chapter.

Hotspot Name	Option	Benefit Cost Ratio
1 – Ovingdean – Kett's Ridge	Option 1 – New ditch and embankment	0.19
2 – Mouslecoomb Primary School	Option 1 – Highway amendments	0.02
	Option 2 – Groundwater monitoring	Not assessed
3 – Bevendean	Option 1 – Highway amendment	6.39
	Options 2 – Earthworks and highway amendments	9.69
4 – Patcham	Option 1 – Earthworks	2.95
	Option 2 – Property Level Protection	14.1
	Option 3 – Earthworks and Property Level Protection	8.19
5 – Carden Avenue/ Warmdene Road	Option 1 – Raised table and Syphon Sewer	16.8
	Option 2 – Review existing soakaways	Not assessed
6 – Mile Oak	Option 1 – Earthworks and highway amendments	0.67
	Option 2 – Groundwater monitoring	Not assessed
7 – Blatchington Mill School	Options not assessed	

7 Phase 4 – Implementation and Review

The final phase of the SWMP is to collate the information and findings of the first three phases into an Action Plan for implementing the preferred options and / or for undertaking further work to more accurately define flood risk.

7.1 Action Plan

Seven hotspot sites were identified by the risk assessment stages and all of these are included within the first iteration of SWMP Action Plan to ensure their acknowledgement as risk areas.

BHCC aspire to use the SWMP as an evidence base for securing Defra's Flood Defence Grant in Aid (FDGiA) funding. FDGIA funding provides funding for local authorities to implement flood risk management studies, strategies and projects. Local Authorities have to complete a Medium Term Plan form to request FDGiA funding which helps the EA to assess flood risk works nationally over the next five years. Local authorities submit details of work to add to the national list of proposals. Therefore, the hotspot sites will be reviewed, updated and reported to the EA so that future funding applications can be made. Local levy funding can also be awarded to a local authority through the Medium Term Plan. Local levy is raised by a levy on councils and used to support flood risk management strategies at a local level which do not have national significance to be awarded FDGiA funding.

Together with the Partnership, BHCC has assessed the highest flood risk areas within Brighton and Hove City and the Action Plan seeks to implement first and foremost schemes which are physically and financially achievable by the interested stakeholders.

The full BHCC SWMP Action Plan is written in a schedule format, contained in Appendix M, and includes a summary of the phase 1, 2 and 3 investigation, recommended actions and conclusions together with proposed timeframes for implementation and details of costs and funding, however, a summary of the initial Action Plan is detailed below.

Action Plan Summary

- ***Hotspot 1 – Ovingdean – Kett's Ridge*** *– Maintenance on existing ditch and topographical survey of ditch to confirm capacity is in accordance with requirements.*
- ***Hotspot 2 – Moulsecoomb Primary School*** *– Investigation for potential monitoring of groundwater levels and implementation of automated telemetry system.*
- ***Hotspot 3 – Bevendean*** *– Highway amendments along Heath Hill Avenue including raised kerbs and verges as well as raised table at junctions to restrict overland flows. Construction of embankments on playing fields.*
- **Hotspot 4 – Patcham** *–Public consultation on property level protection for dwellings on Old London Road.*
- ***Hotspot 5 – Carden Avenue/ Warmdene Road*** *– Drainage investigation into existing infrastructure. Raised table at the junction of Carden Avenue and Warmdene Road to restrict overland flows into Warmdene Road. Proposed sewer to act as a syphon to divert runoff from Warmdene Road into Patcham School playing fields. Review of condition of existing soakaways in the area.*
- ***Hotspot 6 – Mile Oak*** *– Construction of embankments at the bottom of Cockroost Hill. Investigation for potential monitoring of groundwater levels and implementation of automated telemetry system.*
- ***Hotspot 7 – Blatchingham Mill School*** *– Consideration by BHCC on further investigation work.*

Action Plan Priorities

In order to progress the action plan it is proposed that the following next steps are considered.

Hotspot	Next Steps	Priority
Hotspot 1 – Ovingdean	▪ Topographical survey of existing embankment and ditch.	Medium
Hotspot 2 – Moulsecoomb Primary School	▪ Consultation with EA to discuss groundwater monitoring scheme.	Medium
Hotspot 3 – Bevendean	▪ Prepare FDGiA funding request for Option 2 embankment and highway works.	High
Hotspot 4 – Patcham	▪ Prepare FDGiA funding request for embankment. ▪ Public Consultation to discuss implementation of property level protection.	Low High
Hotspot 5 – Carden Avenue/ Warmdene Road	▪ Consultation with Southern Water to investigate Carden Avenue Attenuation Scheme. ▪ Drainage investigation of existing infrastructure on Warmdene Avenue.	Medium High
Hotspot 6 – Mile Oak	▪ Consultation with EA to discuss groundwater monitoring scheme.	High
Hotspot 7 – Blatchingham Mill School	▪ BHCC decision on further investigation.	Low

7.2 Review and Monitoring

The implementation of any actions / mitigation schemes from the SWMP should be assessed in the context of the requirements for a Strategic Environmental Assessment (SEA). The need for a SEA will depend upon whether actions of the SWMP affect a wide area, its statutory status and the potential environmental effects.

It is recommended that the data included in the SWMP is reviewed on an annual basis and the GIS database is updated with new information and datasets of predicted flood risk and / or recorded flood instances that have occurred. The Action plan should be reviewed at same time against funding budgets and opportunities for the coming year to consider whether scheduled works can be implemented and / or whether new actions should be included into the plan. It is anticipated that this review and update process of the SWMP will be incorporated into the work on the upcoming Local Flood Risk Management Strategy ('Local Strategy'). The Local Strategy is required under Section 9 of the FWMA and requires the LLFA to 'develop, maintain and apply and monitor a strategy for local flood risk management in its area'.

However, as a minimum a review of the information should be undertaken on a six year cycle to align with the FRR on-going flood risk management cycle so that the SWMP can be used to inform the PFRA update. BHCC are currently discussing the potential of a collaborative approach to Flood Risk Management Plans (required by 22nd June 2015) with the EA.

Of the SWMP objectives set at the start of the process, and which are listed in section 4.3 of this report, BHCC can consider the majority to be achieved with the exception of the following two objectives that the finalised SWMP can now facilitate in the future:

- Assess, plan and improve current and future drainage asset maintenance regimes using flood risk information.
- Development of future planning strategies and policies to facilitate flood risk mitigation and management.

8 Lead Local Flood Authority Responsibilities

Under the FWMA 2010 the principal new responsibilities of a LLFA are as follows:

- Section 9 Requirement to develop, apply, maintain and monitor a **Local Strategy** for Flood Risk Management.
- Section 19 Requirement to **Investigate Floods**, where appropriate, and to publish the findings.
- Section 21 Duty to maintain a **Register of Structures** which affect flood risk.
- Section 30 Power to **Designate third party assets**, which affect flooding.
- Section 32 Establish the role of the **SuDS Approving Body** (SAB) and the new approval process for surface water drainage systems. Implementation date to be determined following the Defra consultation on the new National Standards for SuDS.
- Section 31 Requirement to consent works to ordinary watercourses under the Land Drainage Act 1991

Under the FRR, 2009 LLFAs also have the responsibilities outlined in Section 2.4 of this report. These include the production of a PFRA, which was completed in June 2011, as discussed in section 3.3 of this Report.

The EA produced indicative Flood Risk Areas (iFRA) which identified 10 significant flood risk areas within England, of which one covered the Brighton & Hove City area. The Brighton and Hove cluster encompassed an area spreading over 3 administrative areas (and 3 LLFA's); The City of Brighton and Hove, West Sussex County and East Sussex County. BHCC decided to amend the iFRA to suit their administrative boundary to the west and east, which was agreed with the EA. The BHCC indicative Flood Risk Area is shown on drawing 6.3 in Appendix K.

8.1 Section 9 – Local Strategy

This provision came into force from 1st October 2010 and local strategy should be developed within a reasonable timeframe. The Local Strategy should include the following elements:

a) the risk management authorities in the authority's area,
b) the flood risk management functions that may be exercised by those authorities,
c) the objectives for managing local flood risk,
d) the measures proposed to achieve those objectives,
e) how and when the measures are expected to be implemented,
f) the costs and benefits of those measures, and how they are to be paid for,
g) the assessment of local flood risk for the purpose of the strategy,
h) how and when the strategy is to be reviewed, and,
i) how the strategy contributes to the achievement of wider environmental objectives.

The LLFA must consult the other risk management authorities and the public about its Local Strategy and publish a summary. The local strategy must be consistent with the National Strategy produced by the EA for Flood and Coastal Erosion Risk Management (FCERM) for England.

8.2 Section 19 – Investigate Floods

Under Section 19 of the FWMA, a LLFA should investigate significant flood events and publish the results of its investigation.

8.3 Section 21 – Register of Structures Affecting Flood Risk

Under Section 21 of the FWMA a LLFA has to establish and maintain a register of structures which have an effect on flood risk and must keep a record of information about each structure (to include ownership, state of repair etc.).

BHCC has started a Register of Structures Affecting Flood Risk which is incorporated into the SWMP GIS database and will be maintained and updated.

8.4 Section 30 – Designate Third Party Assets

Under Section 30 of the FWMA (Schedule 1 Risk Management: Designation of Features), a LLFA has the power to designate structures and features that affects flood risk that are owned by a third party and are located on private land. Once a structure or feature has been designated as affecting flooding the owner must then obtain consent in order to alter, remove or replace it.

BHCC has not designated any third party assets as affecting flood risk at the time of compiling this report.

8.5 Section 32 – SuDS Approving Body (SAB)

Under Section 32 of the FWMA (Schedule 3 Sustainable drainage) almost all future construction and development works which have a drainage implication must be approved by the SAB. Applications will be either submitted to the approving body as free-standing applications or combined with an application for planning permission (either outline or full). The SuDS approval process is designed to be separate from the Council's current planning system, however, the two bodies will liaise and advise each other of their respective decisions.

The SAB must review and assess the applications in line with the new National Standards (NS) (not yet published) for sustainable drainage and either grant or refuse consent. A number of stakeholders will be consulted as part of the review process including the Water and Sewerage Company (WaSC) – Southern Water, the Environment Agency, relevant Highway Authority, British Waterways and (where appropriate) any Internal Drainage Boards.

The SAB will have a duty to adopt and maintain drainage systems upon request that have been approved and constructed in accordance with the NS, with the exception of single property systems and publicly maintained roads.

The introduction of the SAB is currently anticipated to commence in April 2014.

8.6 Schedule 2, Section 32 – Land Drainage Consent

Under Schedule 2 of the FWMA (Risk Management: Amendment of Other Acts) Section 32, the Land Drainage Act 1991 is amended so that from the 6th April 2012 LLFAs will be responsible for the consenting role for works affecting ordinary watercourses (previously an EA role). In addition, the FWMA also amends the Land Drainage Act to require that any new culvert must have consent.

9 Summary and Conclusion

9.1 Summary

BHCC was one of 77 local authorities considered most at risk from surface water flooding by Defra and were awarded funding to prepare a SWMP. In conjunction with Southern Water and the EA, BHCC has undertaken the SWMP process defined by Defra's Technical Guidance, which includes the following stages:

1. Preparation
   - *Identify the need for a SWMP Study*
   - *Establish the partnership*
   - *Scope the SWMP Study*
2. Risk Assessment
   - *Undertake Strategic Assessment*
   - *Undertake Intermediate Assessment*
   - *Map and Communicate flood risk*
3. Options
   - *Identify mitigation measures*
   - *Assess Options*
   - *Cost benefit analysis*
   - *Drainage strategy for new development (if appropriate)*
4. Implementation & Review
   - *Prepare an Action Plan*
   - *Secure funding*
   - *Implement actions and review*

This process has identified the local sources of flood risk, highlighted the areas at greatest risk within Brighton and Hove City and allowed potential mitigation measures to be developed.

In the first phase of the SWMP the collection and collation of flood risk data through the partnership has created a GIS database for the study. In the phase 2 Risk Assessment stage of the SWMP progressive levels of investigation, through the Strategic and Intermediate Assessments were used to define the 'hotspot' or locally significant areas of flood risk.

The seven hotspot areas identified with the highest flood risk are:

- Ovingdean – Kett's Ridge
- Moulescoomb Primary School
- Bevendean
- Patcham
- Carden Avenue/ Warmdene Road
- Mile Oak
- Blatchington Mill School

In Phase 3 of the SWMP various options for the mitigation of the identified flood risk were considered. At the majority of hotspots the options for mitigation seek to manage and attenuate overland flows on the surface when existing sewers are overwhelmed.

A number of the mitigation options developed were hydraulically modelled. This allowed a comparison of the flooding extent and depth for each option against the existing baseline situation. A cost benefit analysis was then carried out by assigning a cost to flow depths and damages in properties. This allowed BCR to be calculated for each option, highlighting which option would provide the most cost effective benefit to reduce flooding.

Phase 4 of the SWMP produced an Action Plan for the implementation of the proposed mitigation measures and recommendations for further work, which is summarised below.

- ***Hotspot 1 – Ovingdean – Kett's Ridge*** *– Maintenance on existing ditch and topographical survey of ditch to confirm capacity is in accordance with requirements.*

- ***Hotspot 2 – Moulsecoomb Primary School*** *– Investigation for potential monitoring of groundwater levels and implementation of automated telemetry system.*

- ***Hotspot 3 – Bevendean*** *– Highway amendments along Heath Hill Avenue including raised kerbs and verges as well as raised table at junctions to restrict overland flows. Construction of embankments on playing fields.*

- **Hotspot 4 – Patcham** *–Public consultation on property level protection for dwellings on Old London Road.*

- ***Hotspot 5 – Carden Avenue/ Warmdene Road*** *– Drainage investigation into existing infrastructure. Raised table at the junction of Carden Avenue and Warmdene Road to restrict overland flows into Warmdene Road*. Proposed sewer to act as a syphon to divert runoff from Warmdene Road into Patcham School playing fields. Review of condition of existing soakaways in the area.

- ***Hotspot 6 – Mile Oak*** *– Construction of embankments at the bottom of Cockroost Hill. Investigation for potential monitoring of groundwater levels and implementation of automated telemetry system.*

- ***Hotspot 7 – Blatchingham Mill School*** *– Consideration by BHCC on further investigation work.*

9.2 Conclusion

BHCC has established an effective partnership with EA and re-initiated the partnership with Southern Water, following personnel changes, which together has completed the first full cycle of the SWMP process.

In undertaking the SWMP BHCC have completed a thorough assessment of local flood risk and established a GIS database of available historic and currently predicted future flood risk data. This will provide a valuable evidence base for preparation of the 'Local Strategy' report and BHCC's other on-going local flood risk management responsibilities and functions under the FWMA and FRR.

Completion of the SWMP will now allow BHCC to bid for FDGiA funding through the Medium Term Plan to implement flood alleviation schemes identified directly through the process and included in the Phase 4 Action Plan. As such using the SWMP BHCC is able to pro-actively address and reduce flood risk in Brighton and Hove.

The objectives of the SWMP established at the outset for completion of the study and achievements at the culmination of the study have all been either achieved or can now be undertaken by the completion of the flood risk management resource the SWMP provides.

In order to derive best value from the SWMP continual review and implementation is an important consideration. Keeping the GIS database up to date and current will assist BHCC in completing its LLFA duties and responsibilities, in particular the database has facilitated the following requirements of the FWMA:

- Section 19 — Requirement to **Investigate Floods**, where appropriate, and to publish the findings.
- Section 21 — Duty to maintain a **Register of Structures** which affect flood risk
- Section 31 — Requirement to consent works to ordinary watercourses under the Land Drainage Act 1991

In addition the SWMP could be used to support future funding bids and be an evidence base for planning policy and the assessment of S106 (Town and Country Planning Act 1990) or Community Infrastructure Levy (CIL) contributions.

Following completion of the SWMP a further partnership meeting will be held to discuss and accept the SWMP. The SWMP Technical Guidance (Defra, March 2010) advises that the partnership should 'continue to work together to discuss implementation of the proposed actions, and to discuss progress of any further work or follow up actions which were identified in the preparation of the action plan'.

Appendix A

Phase 1 - Preparation:

- Drawing 233301/005/001 – Surface Water Management Plan: Strategic Level Overview
- Drawing 23301/002/SK001 – Historic Flood Events
- Review of Historical Flooding Instances
- PFRA Annex 1 – Records of past floods and their consequences

Appendix B

Strategic Level Assessment

- **Numerical Assessment:**
  - Drawing Number 23301/005/002: Preliminary Hotspots
  - Numerical Assessment spreadsheet

Appendix C

What is the Flood Map for Surface Water (EA, 2010)

Appendix D Hotspot 1: Ovingdean – Kett's Ridge

Phase 2 - Intermediate Level Assessment

- Drawing Number 23301/005/SK01: Hotspot 1: Ovingdean – Kett's Ridge

Phase 3 – Options

- Drawing 23301/012/010 – Catchment Plan
- Greenfield runoff calculation
- Cost Estimate – Summary sheet

Appendix E Hotspot 2: Moulsecoomb Primary School

Phase 2 - Intermediate Level Assessment

- Drawing Number 23301/005/ SK02: Hotspot 2: Moulsecoomb Primary School

Phase 3 - Options

- Drawing 23301/012/011 – Catchment Plan
- Drawing 23301/012/002 – Proposed Options
- Cost Estimate – Summary sheet
- Figure 23301/012/SK010-017 – Surface Water Flood Map
- Figure 23301/012/SK046 – Extent of Economic Analysis

Appendix F Hotspot 3: Bevendean

Phase 2 - Intermediate Level Assessment

- Drawing Number 23301/005/ SK03: Hotspot 3: Bevendean

Phase 3 – Options

- Drawing 23301/012/012 – Catchment Plan
- Drawing 23301/012/003 – Proposed Options
- Cost Estimate – Summary sheet
- Figure 23301/012/SK018-029 – Surface Water Flood Map
- Figure 23301/012/SK047 – Extent of Economic Analysis

Appendix G Hotspot 4: Patcham

Phase 2 - Intermediate Level Assessment

- Drawing Number 23301/005/ SK04: Hotspot 4: Patcham- Old London Road/ London Road

Phase 3 – Options

- Drawing 23301/012/013 – Catchment Plan
- Drawing 23301/012/004– Proposed Options
- Cost Estimate – Summary sheet
- Figure 23301/012/SK030-037
- Figure 23301/012/SK048 – Extent of Economic Analysis

Appendix H Hotspot 5 – Carden Avenue/ Warmdene Road

Phase 2 - Intermediate Level Assessment

- Drawing Number 23301/005/ SK05: Hotspot 5: Carden Avenue/ Warmdene Road

Phase 3 – Options

- Drawing 23301/012/014 – Catchment Plan
- Drawing 23301/012/005 – Proposed Options
- Cost Estimate – Summary sheet

Appendix I Hotspot 6: Mile Oak

Phase 2 - Intermediate Level Assessment

- Drawing Number 23301/005/ SK06: Hotspot 6: Mile Oak

Phase 3 – Options

- Drawing 23301/012/015 – Catchment Plan
- Drawing 23301/012/006 – Proposed Options
- Cost Estimate – Summary sheet
- Figure 23301/012/SK038-045 - Surface Water Flood Map
- Figure 23301/012/SK049 – Extent of Economic Analysis

Appendix J Hotspot 7: Blatchington Mill School

Phase 2 - Intermediate Level Assessment

- Drawing Number 23301/005/ SK07: Hotspot 7: Blatchington Mill School

Appendix K

Indicative Flood Risk Areas

Appendix L

Modeling Assumptions

INFORMATION TO FOLLOW

Appendix M

Phase 4 - Action Plan