Bath and North East Somerset Flood Risk Management Strategy Report

Final Report
June 2010

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1. Executive Summary

Recommendations

1.1 The Flood Risk Management Strategy has concluded that there is no strategic solution reducing peak flow through Bath which is either technically or economically viable. As such the Strategy proposes the provision of compensatory storage upstream combined with on-site flood defences. New development must provide storage to offset the volume of water that would be displaced in a flood event by the defences on-site. In order to meet this requirement, a maximum flood storage area of 345,000m^3 volume would be required as this is equivalent to the total combined volume of the footprint of the identified development sites. Provision of compensatory storage off-site is more cost-effective than providing it on-site and allows for greater flexibility in master planning sites.

1.2 Given the limited impact of flooding on development sites proposed in Keynsham, Midsomer Norton and Radstock there is not a business case for off-site storage in these areas. The Strategy recommends that these sites proceed on a site-by-site basis.

Development and Policy Context

1.3 Major development is needed on brownfield regeneration sites across Bath & North East Somerset over the short, medium and long term to ensure that the regeneration ambitions of the district are met. Furthermore, over the next twenty years the national growth agenda will result in a step-change in employment and housing development which will require development on greenfield sites to meet demand. Brownfield sites are being prioritised for development within the district.

1.4 The move towards the preparation of a Local Development Framework has enabled Bath & North East Somerset Council to take a delivery led approach to spatial planning. The Core Strategy will be supplemented by Regeneration Delivery Plans for each of the district's urban centres. These Regeneration Delivery Plans are aimed at enabling delivery of development on brownfield sites to ensure that the regeneration outcomes of the district are met. This will be achieved by focusing on improving viability and the Council's role as facilitator to unlock site development constraints.

1.5 The Flood Risk Management Strategy has been commissioned by Bath & North East Somerset Council to identify where strategic and site based flood risk management measures can be implemented to make sites at risk of flooding developable without increasing the flood risk elsewhere. The Strategy links a series of proposed development sites to on- and off- site solutions and by considering all potential development sites together, the Council should ensure that individual sites are not left undevelopable because of flood risk.

1.6 The study is informed by the requirements of PPS25, RPG10 and the draft Regional Spatial Strategy for the South West, the SFRAs undertaken for B&NES, the Bristol Avon Catchment Flood Management Plan, the Bath Flood Defence Scheme Addendum to Option Identification Appraisal, the Adopted Local Plan and the Core Strategy Spatial Options.

1.7 PPS25 requires LPAs to undertake Strategic Flood Risk Assessments (SFRA) to inform the preparation of their Local Development Framework. RPG10 Policy F1 and the draft RSS set out the main priorities for flood risk management including defending existing properties, taking a sequential approach to new development and the benefits of opportunities to reduce the risk of flooding and create new wildlife areas.

1.8 SFRA Level 1 for B&NES identified that Bath, Keynsham and Midsomer/Radstock are the main 'critical areas' at risk of flooding predominantly from river sources. The SFRA Level 2 took these

findings further and recommended a 'Scoping Report' for flood risk management should be undertaken to identify potential options for managing flood risk in key areas and to provide an outline assessment of these options.

1.9 The Flood Risk Management Strategy Scoping Report for B&NES identified options for the 'critical area', which included raising and formalising existing flood defences at Bath, and raising defences or ground raising at Keynsham and Midsomer Norton / Radstock. This study builds on the findings of the Scoping Report and uses more up-to-date modelling, as appropriate, to provide detailed site by site recommendations.

1.10 The Bristol Avon Catchment Flood Management Plan identified that it is vital that existing flood defences be improved in Bath. It recognised the need for an overarching strategy to be developed for the future protection of Bath and hence this study will investigate the feasibility of an overarching strategic option or strategy of multiple options/actions.

1.11 The Bath Flood Defence Scheme Addendum to Option Identification Appraisal provided a detailed description of flood risk mechanisms and the existing standard of protection for Bath. It identified flood defence works for each of the twelve flood cells in the study to provide a standard of protection of 1 in 100 years.

1.12 Bath & North East Somerset Local Plan Policy NE14 states that the Council will not permit development where it is subject to flooding, causes net loss in flood storage capacity, where run-off from the development increases risk of flooding, if the development prevents the maintenance of the channels of watercourses or the existing drainage systems on the site are adversely affected. The Core Strategy Spatial Options for Bath & North East Somerset prioritises the management of flood risk through its supporting evidence base of Flood Risk Assessments (1 & 2) and the forthcoming Flood Risk Management Strategy.

High-level Options Appraisal

1.13 The policy and development targets summarised in the previous section required that a flood risk management strategy be produced to ensure the successful delivery of the regeneration requirements of the district.

1.14 A series of flood management options were identified for each site by inspecting the site, determining its proximity to the river or other potential flood routes (using available topographic data) and identifying its current and potential function.

1.15 These options were then assessed using an appraisal matrix specially designed for this study to reflect the PPS25 sequential tests and standard Flood and Coastal Defence Project Appraisal Guidance. These key factors assessed were: urban sustainability, economic development, social benefit, flood defence standards of protection; and cost of construction compared with value of damages avoided. The standard of protection was estimated using standard industry procedures.

1.16 New options to reduce flooding were identified for inclusion in the appraisal process, and options identified in the Scoping Study were reassessed. All options identified were either taken through to high-level appraisal, or discarded altogether on a cursory assessment, where there was an obvious failure to meet assessment criteria. Similarly, any obvious failure to meet the client requirements for development also warranted exclusion.

1.17 Three categories of option were identified for assessment:

- **Strategic Options** – a single scheme that benefits the whole study area. These include flood storage, bypass tunnel, raised defences, channel improvements, etc;
- **Sub-Strategic Options** – a combination of two or more developments functioning as a single flood defence installation protecting an area larger than the development sites immediately involved. By definition, such a strategy represents a combination of strategic option and site specific option; and

- **Site Specific Options** – works required to an individual development site to ensure that it can maintain the minimum standard of protection required. Site specific options included amongst others: raised hard defences, SUDS, wetland/flood detention creation, channel widening, or combinations of all three.

1.18 The option identification process was developed by a team of engineers, planners and environmental advisors in consultation with Bath & North East Somerset Council. The options to be included in the high level appraisal matrix were identified during a number of informal, internal meetings to ensure that they were fully in line with the development criteria and to develop capital cost estimates.

1.19 This allowed refinement of the list of options or the designs of particular options to improve them, based upon cost, buildability, practicality, potential complexity of ownership and/or funding issues, feasibility of construction, or whether there was an obviously poor assessment score under any of the criteria headings. Such an example was the option to over-dredge the river channel through Bath, which would be expensive (and costly to maintain) for a relatively small improvement in Standard of Protection.

1.20 A high-level appraisal was then undertaken of the identified options. The PPS25 Exceptions Test provides a very clear rationale for the appraisal methodology to incorporate a selection of key LDF Core Strategy Sustainability Appraisal (SA) objectives, and the first two of the three PPS25 exception test criteria, into the appraisal. Criteria are also included relating to the Regeneration Delivery Plan and the effect upon the townscape or landscape, which is protected by the World Heritage Site designation and other designations.

Viability and deliverability tests were also devised, with the weighting of sustainability to viability and deliverability of 50:50. The tests examine the two key drivers for viability:

- Will the FRM option be wholly funded by developers and/or gap funding (yes/no)?
- Would the physical configuration, land ownership, delivery vehicle and the timing of construction of the FRM option match that of the development(s) to which it relates?

1.21 The viability assessment compares the costs of flood risk options for each site within the context of overall development viability. The following stages were included within the assessment:

- Step 1 – Development capacity and potential assessment to establish the future scale and mix of development for each site.
- Step 2 – Completion of overall viability model to establish the likely order of magnitude scheme costs, revenues, return and an estimate of normal infrastructure costs prior to consideration of site costs. Assumptions regarding revenues are stated.
- Step 3 – Derivation of site flood risk infrastructure costs for strategic options. Where a strategic option has potential to mitigate fully the flood risk relating to a site a share of the total cost of strategic infrastructure is apportioned between sites. Three parallel apportionment mechanisms are used to determine the percentage of cost of flood risk management infrastructure that should be borne by each site.
- Step 4 – Comparison of flood risk management costs with scheme costs. Two parallel indicators are used to compare the costs of flood risk management with scheme costs.
- Step 5 – Consideration of the effect on overall scheme viability, based on stated threshold values of the cost of flood risk management infrastructure.

1.22 Deliverability is assessed against the following conditions:

- Suitability and use – Is the FRMS Option suitable considering the proposed use and likely layout and configuration of development in connection with FRMS options and other requirements e.g. safe egress?

- Delivery Vehicle - Does an appropriate delivery vehicle exist or have the potential to be established to implement the option?
- Need for land assembly and requirement for acquisition or compulsory purchase of non Council owned land. This assessment is based on the likely extent of land required.
- Timing and phasing – The fit between FRMS infrastructure delivery and development trajectory is assessed.

1.23 Consequently a number of strategic options, including the bypass channel and channel widening options, are found to exceed the viability parameters for many sites and do not satisfy the deliverability criteria, These options have at this stage been provisionally identified as not being viable.

Workshop

1.24 A well-attended workshop was held to present the findings of the high-level options appraisal. At the workshops views were elicited from stakeholders including Wessex Water, the Environment Agency and various Council departments on preferred options, constraints and alternative sites to consider. This culminated in the identification of five potential strategic options to be studied in more detail. Sequential testing was undertaken along with assessments of sustainability and of the general benefits to the built environment. Testing endorsed the removal of the channel widening and bypass tunnels which are rejected in the high-level appraisal.

Detailed Appraisal

1.25 The next task undertaken was a detailed economic assessment of the capital and maintenance costs of each option, compared with the value of flood damages avoided for the protected development sites for a range of severities of flood events and return periods in accordance with the Department for Environment, Food and Rural Affairs (Flood and Coastal Defence Project Appraisal Guidance, FCDPAG) guidelines. This was done by revising existing numerical flood models to include more detail on construction typologies and costs.

1.26 This appraisal concludes that the only technically feasible comprehensive strategic solution may be the raising of defences along the river channel throughout the city of Bath, with compensatory storage downstream. However, this would cost more than three times the economic value of damages avoided, making it unviable by industry guidelines. The only favoured option which is fully feasible in terms of the appraisal criteria is a sub-strategic option, namely, the installation of flood defence measures at the individual development sites.

1.27 However, a number of sites present issues of development viability that are exacerbated by the additional marginal cost of the identified flood risk infrastructure, which may impact on viability and site delivery in the absence of supporting scheme funding, especially since SUDS are generally required in any case in line with national and local policy.

1.28 The only strategic solution open to Bath & North East Somerset is to provide a compensatory storage area or areas upstream of the centre of Bath. Whilst it has been demonstrated that such areas could not protect the development sites in Bath against a flood event of any size, their provision would offset the volume of water that would theoretically be displaced by the combined developed footprints of the development sites. This approach would ensure that any development strategy implemented in Bath would meet the requirements of PPS25. In order to meet this requirement, a maximum flood storage area of 345,000m^3 volume would be required as this is equivalent to the total combined volume of the developed footprint of the development sites.

1.29 The construction of a single upstream storage site rather than a series of smaller compensatory storage areas has several viability and deliverability advantages:

- Many of the sites do not have sufficient room to provide an on-site storage area of similar extent to the developed footprint so the required total storage would not be achieved;
- A phased delivery of the total storage volume required may need to be adopted over a period of several years to mirror the construction programme of the individual development sites;
- The cost of building several small storage areas (particularly where access and working area is limited) would cost disproportionately more than a single large area lying outside the city boundary and the latter can also be forward-funded with the costs distributed amongst the various developments it seeks to serve.

1.30 Historically, it has been established that the Lower Bristol Road becomes impassable during times of flood. Analysis of modelling results indicates that this road benefits from a standard of protection of up to 1 in 20 years, or less. Although there are options enabling dry access to development sites on the Lower Bristol Road such as links to Midland Bridge or pedestrian routes across the river, the delivery of upstream compensatory storage provides an opportunity to consider improving the standard of protection on this road.

Development Principles and Guidance

1.31 This study has identified a strategic compensatory option for Bath, whilst the detailed site investigation and appraisal work facilitates the preparation of site-specific design options for flood defences and SUDS. These design options will assist developers in setting out the Council's expectations for the delivery and design of their sites in line with Development Plan policy and published regeneration objectives.

Implementation and Delivery Strategy

1.32 The recommended strategy for delivering on-site flood defence and SUDS infrastructure is as follows:

- The Council will seek guidance from the Environment Agency on whether a proposed development on a flood plain will require flood defences or a sustainable urban drainage scheme.
- Where measures are necessary, in accordance with PPS25 the Council will require developers to fund the full cost of flood defence and SUDS infrastructure needed as the direct consequence of a proposed development, whether to protect the development itself or mitigate the likely consequential impacts of the development on other properties. In addition it will be expected that a commuted maintenance sum sufficient to fund maintenance for 30 years is provided (for all flood defences and for any SUDS to be adopted by the council), to fund an appropriate proportion of the costs of flood defences needed partly to protect the proposed development and partly to protect other land or existing properties where there is no consequential impact of the proposed development on that land or existing properties.

1.33 It is recommended that off-site upstream storage forms part of the flood risk management approach for Bath. The upstream storage scheme could be part funded by the Regional Infrastructure Fund with the Environment Agency input through the regular bidding process. The Council will also be a key partner as land owner especially as several of the sites which the scheme would benefit are Council owned.

1.34 It is recommended that the scheme is forward funded within the first five years of the Core Strategy in order that it can begin meeting the needs of sites coming forward for development. It is also recommended that the costs of the scheme should be apportioned on the basis of the volume of water storage which a strategic scheme would provide in compensation for specific sites. A formula for developer contributions has been prepared for this purpose.

1.35 We have also made recommendations for monitoring, development management/control, and ensuring flexibility, again in line with PPS12. The responsibilities of the various actors in the planning process have been identified in relation to the strategy's recommendations.

Introduction

The Appointment

2.1 Atkins was commissioned in Spring 2009 to prepare a Flood Risk Management Strategy for Bath and North East Somerset Council.

2.2 There has been a significant amount of work previously done highlighting where flooding is a risk to both development sites and existing buildings including Level 1 Strategic Flood Risk Assessments for the whole district, Level 2 Assessments for Bath, Keynsham, Midsomer Norton and Radstock and the recently published Flood Risk Management Scoping Report.

2.3 This study builds on the Scoping Report and contributes to the Infrastructure Delivery Plan for Bath & North East Somerset. It should inform the allocation of strategic sites and site development briefs, providing an approach to managing flood risk in the four main settlements within the district, namely, Bath, Keynsham, Midsomer Norton and Radstock.

2.4 The brief was to identify and assess a range of strategic flood risk management options. Through individual site based appraisals flood risk management opportunities were to be identified, particularly strategic options which involve flood risk management contributions from individual sites operating in combination. Opportunities for the implementation of SUDS measures were to be identified. This would be accompanied by advice on implementation costs, and the identification of opportunities to open up the river for amenity benefits in combination with flood management measures. A copy of the brief can be found in Appendix A.

2.5 The strategy is an implementation document which will sit alongside the Council's Local Development Framework. It provides guidance and advice on flood risk management and sustainable urban drainage systems (SUDS) which will assist in implementing the Core Strategy and in development management.

Structure of the Report

2.6 This report is structured as follows:

- Section 2 provides an outline of the key policy drivers informing the strategy
- Section 3 provides a summary of the FRMS Options Appraisal.
- Section 4 sets out the flood risk management concept and site specific options map.
- Section 5 provides the flood risk management guidelines and SUDS guidance.
- Section 6 sets out the delivery and implementation strategy.

2.7 There are thirteen technical appendices.

3. Policy Context

3.1 This Section provides the strategic policy context which has influenced the development of the Flood Risk Management Strategy for Bath and North East Somerset. The implications of these policies for the study are summarised at the end of the Section.

National and Regional Policy Context

PPS25: Development and Flooding Risk (2001)

3.2 PPS25 sets out the Government's guidance to ensure that flood risk is taken into consideration at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk. Where new development is necessary in such areas PPS25 seeks to ensure that development is safe, does not increase the flood risk elsewhere and where possible reduces flood risk overall.

3.3 PPS25 requires the adoption of a risk-based approach at all levels of planning. As part of this approach Local Planning Authorities (LPAs) should undertake Strategic Flood Risk Assessments (SFRA) to inform the preparation of their Local Development Framework. The SFRA will provide the information needed to apply the sequential approach. This sequential risk-based approach to determining the suitability of land for development in flood risk areas is a central focus of the policy statement. It aims to steer new development to areas at the lowest probability of flooding and its application at all levels of the planning process is required, particularly in relation to the identification of land for development.

3.4 Other Government guidance should be considered in conjunction with PPS25 including that set out in 'Making Space for Water' and the forthcoming Water Framework Directive guidance.

Regional Planning Guidance for the South West (RPG10)

3.5 Policy F1 of RPG10 relates to the management of flood risk taking into account climate change and the increasing risk of river flooding. Policy F1 indicates that the main settlements in the region will need to manage flood risk by defending existing properties and directing growth to areas where it can be accommodated with minimal or no risk of flooding. The main priorities for flood risk management are set out as follows:

- 'Defend existing properties and, where possible, locate new development in places with little or no risk of flooding;
- Protect flood plains and land liable to tidal or coastal flooding from development;
- Following a sequential approach to development in flood risk areas;
- Use development to reduce the risk of flooding through location, layout and design;
- Relocate existing development from areas of the coast at risk, which cannot be realistically defended;
- Identify areas of opportunity for managed realignment to reduce the risk of flooding and create new wildlife areas.'

Draft Regional Spatial Strategy for the South West (June 2006)

3.6 The Draft Regional Spatial Strategy for the South West sets out the strategic vision for the period 2006 to 2026 and will replace RPG10 once it has been adopted. The draft version was published in June 2006 and has been subject to further comments from the Secretary of State. Following a

Government announcement on 25th September 2009, a Sustainability Appraisal is to be carried out of its proposals before the RSS can move forward to adoption.

3.7 Policy F1 of the draft RSS relates to flood risk management and sets out the same priorities as Policy F1 in RPG10.

Local Policy Context

Bath & North East Somerset Council Adopted Local Plan (October 2007)

3.8 The Adopted Local Plan published in October 2007 sets out the vision for development of the district up to 2011.

3.9 Local Plan Policy NE14 relates to the management of flood risk and states that development will not be permitted where:

- It is subject to flooding, causes flooding elsewhere or where it would impede the flow of flood water unless the flood hazard can be mitigated;
- It causes net loss in the flood storage capacity;
- The run-off from the development would result in, or increase the risk of, flooding of watercourses, ditches land or property;
- It would prevent the maintenance of the channels of watercourses; it would result in watercourse channel instability; or
- The existing drainage systems on the site are adversely affected, or if the land drainage of the site, when developed, is inadequate.

Bath & North East Somerset Council Core Strategy, Spatial Options (October 2009)

3.10 The Core Strategy Options Document, published on 1 October 2009, has undergone a period of consultation which ended in January 2010.

3.11 The Strategy identifies flooding as a key issue for the district, especially taking into account the effects of climate change. The Core Strategy prioritises the management of flood risk and will be supported by a robust evidence base of Strategic Flood Risk Assessments (1 & 2) and this Flood Risk Management Strategy.

3.12 An interim Sequential and Exceptions Test for Strategic Sites was prepared as an information paper for the Core Strategy Spatial Options. Once the Flood Risk Management Strategy is completed and agreed by the Council, a final Sequential Test report will be prepared to inform the Core Strategy submission document.

Strategic Flood Risk Assessment of Bath and North East Somerset (SFRA Level 1) (April 2008)

3.13 In accordance with PPS25 requirements for Local Authorities to apply the sequential test at all stages of planning, Strategic Flood Risk Assessments at levels 1 and 2 have been produced. These assessments took into account various sources of flooding as well as climate change, which informed the probability of flooding in different areas. The SFRA Level 1 provides a high-level assessment of flood risk, which involved investigating all sources of flooding across Bath & North East Somerset when applying the sequential test.

3.14 The SFRA Level 1 identified that the dominant source of flooding is from rivers, including Lower Avon, River Chew, Cam Brook and Wellow Brook and, to a lesser but still significant extent, sewers and surface water. A number of potential regeneration and development areas are considered to be at risk of flooding either now or in the future as a result of climate change. The urban areas of Bath, Keynsham and Midsomer Norton and Radstock are identified as the main areas at risk of flooding from a variety of sources including rivers, sewers, surface water and artificial sources.

3.15 The SFRA 1 concluded that there is a requirement for a strategic response to flood risk within Bath and North East Somerset. This can be achieved through the identification and implementation of strategic solutions that offer a sustainable means of addressing long-term flood risk.

Strategic Flood Risk Assessment of Bath and North East Somerset (SFRA Level 2 for Keynsham: May 2009, Bath: July 2009 and Midsomer Norton/Radstock: July 2009)

3.16 The SFRA Level 2 report builds upon the technical information and methodology used in SFRA Level 1. SFRA Level 2 investigates flood hazard in potential development areas where it may be necessary to apply the exception test. The study notes the 'critical areas' at risk from flooding as Keynsham, Bath and Midsomer Norton/Radstock.

3.17 The study indicates that most of the existing sewer infrastructure in Keynsham, Bath, Midsomer Norton and Radstock is unlikely to have sufficient capacity to cope with additional run-off resulting from climate change and future developments.

3.18 The outcome of the SFRA level 2 is that the long term management of flood risk, from all sources of flooding, will require a multi-lateral, multi-agency approach. The report recommends that a 'Scoping Report' for flood risk management should be undertaken to identify potential options for managing flood risk in key areas and to provide an outline assessment of these options.

Bath & North East Somerset Council Flood Risk Management Strategy Scoping Report, Capita Symonds (May 2009)

3.19 The Scoping Study for the preparation of a Flood Risk Management (FRM) Strategy builds on previous work undertaken for the SFRA Level 1 and Level 2.

3.20 The Study outlines the preferred FRM options for the 'critical areas' as follows:

- Bath - raise and formalise existing flood defences along the River Avon, in combination with flood resilient design and a storage area downstream of the City to offset loss of floodplain capacity.
- Keynsham - ground raising or raised defences within proposed development sites, in combination with flood resilient design (for raised defences only) and a flood storage area to offset loss of floodplain capacity. There is an opportunity to incorporate the floodplain storage area downstream of Somerdale and/or the flood storage area identified downstream of Bath.
- Midsomer Norton / Radstock - raised defences or ground raising in individual development sites on the Wellow Brook in combination with floodplain storage to offset loss of floodplain capacity. One floodplain storage area upstream of the urban area on the Wellow Brook could offset the composite loss.

3.21 In identifying the potential FRM options and developing success criteria the report recommends that the FRM Strategy should focus on the 'critical areas' of Bath, Keynsham and Midsomer Norton/Radstock. It also recommends that further investigation should be undertaken in the combination of raised defences (with various standards of protection) alongside other approaches, such as flood warning and flood resilience.

Bristol Avon Catchment Flood Management Plan (December 2008), (CFMP)

3.22 The Bristol Avon CFMP provides a detailed scoping report for the purpose of progressing forward the FRM Strategy and suggests a number of strategic options to manage flood risk to existing properties in Bath. Following appraisal the preferred option (option 5) aims to 'take further action to reduce flood risk.'

3.23 The CFMP identified the following actions for Bath which relate to improvements to existing flood defences:

- Improvements to existing assets through development opportunities on those lengths of flood defence identified as below standard;
- Identify an overall strategy for the future protection of Bath and for its existing defences; and
- Increase awareness of risk and response to flood warnings, and discourage inappropriate development.

Bath Flood Defence Scheme Addendum to Option Identification Appraisal – Black and Veatch (July 2005 and August 2004)

3.24 Black and Veatch undertook an Option Identification Appraisal for Bath in 2004 and 2005. The study provided a detailed description of flood risk mechanisms and existing standard of protection for Bath. The appraisal assessed three options: the Option 1 'do nothing', Option 2 'do minimum' and Option 3 'increase the standard of protection to 1 in 100 year standard or 1 in 200 year standard'.

3.25 Option 3 was identified as the preferred option as it investigated flood defence works for each of the flood cells identified in the study. The study assessed each of the twelve flood cells to provide a standard of protection of 1 in 100 years. An exception to this is flood cell 12R located at Churchill Bridge / Southgate, which is assessed for a 1 in 200 year scheme standard, as the existing defences to this cell provides a standard of protection of approximately 1 in 100 years.

Key Points

3.26 It is clear from PPS25 that inappropriate development in flood risk areas should be avoided and development should not increase flood risk elsewhere. The SFRAs undertaken for B&NES identify levels of flood risk in the district and enable the Local Planning Authority to apply a sequential test to development.

3.27 The SFRA Level 1 for B&NES indicates that Bath, Keynsham and Midsomer/Radstock are identified as the main 'critical areas' at risk of flooding from sources including rivers, sewers, surface water, and artificial sources. The SFRA Level 2 for B&NES recommended that a 'Scoping Report' for flood risk management should be undertaken to identify potential options for managing flood risk in the key areas, and to provide an outline assessment of these optionsGiven that many of the sites at risk are earmarked for redevelopment for regeneration purposes it is appropriate that a delivery-led approach is taken by the local planning authority towards this exercise. Consequently this Flood Risk Management Strategy should examine the possibilities for both strategic and site-level management of flood risk in the context of the proposed types of development on each of these sites.

3.28 The sequential and exceptions approaches of PPS25 are likely to be a useful part of any methodology used to appraise and refine the options since they replicate the process that developers are required to follow.

3.29 The additional detailed guidance provided in the regional (RPG 10 and Draft Regional Spatial Strategy for the South West) and local planning policies (Bath and North East Somerset Council Adopted Local Plan and Core Strategy Spatial Options) also inform appraisal methodology.

Amongst other things, these policies require the identification of areas of opportunity for managed realignment to reduce the risk of flooding and create new wildlife areas.

3.30 The Bristol Avon Catchment Flood Management Plan indicates that flood defences need to be improved in Bath and an overarching strategy is required. The Bath Flood Defence Scheme Addendum to Option Identification Appraisal provides a detailed description of flood risk mechanisms and existing standard of protection for Bath. It identifies flood defence works for each of the twelve flood cells in the study to provide a standard of protection of 1 in 100 years. These various matters may be capable of being considered alongside the core aims of the Flood Risk Management Strategy, since they may benefit or constrain FRMS options in relation to sustainability, deliverability and viability.

3.31 There is also likely to be a need for improved flood defences in the study area. The Flood Risk Management Strategy Scoping Report for B&NES identifies options for the 'critical areas', which included raising and formalising existing flood defences at Bath, and raising defences or ground raising at Keynsham and Midsomer Norton / Radstock. The SFRA Level 2 also highlights the capacity limitations of the existing sewer infrastructure in the 'critical areas'.

Summary of FRMS Options Appraisal

4.1 In this section the FRMS options appraisal process is outlined and the findings are set out.

Flood Risk Management Strategy Study

4.2 A series of flood management options were identified for each site by inspecting the site layout, its proximity to the river or other potential flood routes (using available topographic data) and its current and potential function. These were then assessed by use of an appraisal matrix to reflect the PPS25 sequential tests and standard Flood and Coastal Defence Project Appraisal Guidance. The key factors assessed were: urban sustainability, economic development, social benefit, flood defence standards of protection and cost of construction compared with the value of damages avoided.

4.3 The work undertaken can be broadly divided into two main deliverables for the procurement of flood protection, representing both the technical viability of providing flood protection measures and the economic:

- Strategic Options – as a minimum, providing flood protection to all development sites through the implementation of a single over-arching scheme or through the co-ordinated development of a group of sites to operate as an integrated scheme;
- Site Specific Options – the provision of flood protection to each site on a stand alone basis.

Development Sites and Property Numbers in Settlement Areas

4.4 Plans showing the location of the proposed development sites, one each for the Bath, Midsomer Norton, Radstock and Keynsham can be found in Appendix L. Each plan depicts the current 1 in 100 year (Flood zone 3a) flood envelope with the number of properties and/or floor area likely to be affected by flooding for that event clearly labelled. Where a site is not believed to be at risk of flooding for this event then no property numbers or floor area are given. The number of properties affected by flooding or otherwise has been ascertained by inspection of plans.

Standards of Protection

4.5 The flood zone envelopes are fundamental to the prioritisation of the need for flood management and in the identification of the scope of new options identified for more detailed investigation. These are Environment Agency designations, determined through a relatively coarse flood modelling exercise undertaken on a national scale. They are as follows:

- **Flood Zone 1** – Low Probability: Area having a less than 1 in 1,000 annual probability of river or sea flooding in any year (<0.1%)
- **Flood Zone 2** - Medium Probability: Area having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.
- **Flood Zone 3** – High Probability: Area having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

Existing Standard of Protection SFRA and FRMS

4.6 The development sites reside in a range of flood zones. Table 4.1 identifies the standard of protection indicated by the Environment Agency's Strategic Flood Risk Assessment (SFRA) flood envelopes (Flood Zones 1, 2 & 3) and compares it with the Standard of Protection estimated from the numerical modelling work undertaken as part of this Flood Risk Management Strategy (FRMS) study. The right hand most column headed "SFRA Estimated Current Standard of Protection Flood Return Period" lists the existing standard of protection estimated by inspection of the SFRA plans. These plans provide a flood outline for a range of flood return periods most notably 1,000-year return period (i.e. 1 in 1,000 year) and 1 in 100-year. Consequently, only a relatively crude estimate can be made of an area's vulnerability to flooding, such that the FRMS headed column is the more reliable. However, numerical modelling data provided by Bath and North East Somerset Council enabled the theoretical flood levels around each development site boundary to be assessed to a higher level of detail than inspection of the SFRA flood envelopes would provide. As a result, many of the proposed development sites were identified to be not at risk of flooding, this was particularly the case in the North East Somerset towns. A definitive list of these sites is provided in Table 4.1 below.

Table 4.1 Standards of Protections for the development sites

Redevelopment Site		Bank	FRMS Estimated Current Standard of Protection Flood Return Period (years)	SFRA Estimated Current Standard of Protection Flood Return Period (years)
No	Description			
B1b	Cornmarket to Podium	Right	25	<100
B2a	Empire Undercroft	Right	25	<100
B3a	The Rec / Sports Centre	Left	<10	<100
B2c	Grand Parade	Right	25	<100
B3b	Cricket Ground	Left	<10	<100
B4a	Manvers Street	Right	50	<100
B5	Former Menzies Hotel	Left	50	<100
B6g	The Forum	Right	50	100
B6a	Avon Street car & coach park		50	50
B6b	City of Bath College		100	100
B6e	1-3 James St West		75	>100
B6f	4 James St West		75	<100
B6diii	Rosewell Court		100	100
B6di	Kingsmead House		100	100
B6ci	Green Park House Topland		100	100

B6cii	Green Park House Other		100	100
B9a	South Quay	Left	50	<100
B9b	RBP to Travis Perkin	Left	25	<100
B7	Green Park Station	Right	25	<100
B8	BWR East	Left	25	<100
B21	Albion / Hinton Garage	Right	100	<100
B16	BWR Phase one	Left	25	<100
B20	Onega Centre	Right	100	100
B19	Comfortable Place	Right	25	<100
B17i	BWR Phase Two	Left	100	<100
B17ii	BWR Phase Three School	Left	100	<100
B12	Bath Press	Left	100	100
B18	Westmark	Right	100	100
B13a	Lower Bristol Road A	Left	100	<100
B14	Locksbrook	Right	50	<100
B13b	Lower Bristol Road B	Left	100	100
B13c	Lower Bristol Road C	Left	100	100
B13d	Lower Bristol Road D	Left	20	<100
B13e	Lower Bristol Road E	Left	100	100
B15	The Maltings Industrial Estate	Right	100	100
B13f	Lower Bristol Road F	Right	100	<100
KM11	Broadmead Lane Waste Site	Left	<100	<100
RK9	Combend	Right	10	<100

Standard of Protection Provided by Existing Defences

4.7 As stated in the CFMP, the standard of protection provided by the defences in Bath has been quoted in the past as ranging from 1 in 150 years (0.7%) to a wider range of standards (in more recent studies). The Environment Agency's flood zone map places many more properties in the flood zone

but, this is based on a fairly crude means of assessment. The estimate of annual damages provided in the CFMP however, still assumes a 1 in 150 year standard of protection.

4.8 The outcome of the numerical modelling analysis undertaken as part of the FRMS determined the following:

- Bath has a basic standard of protection (SoP) of 1 in 25 years (2% AEP) with many properties benefiting from 1 in 50 years SoP and above and to the exception of;
- The “Rec” & Sports Centre (B3a) and the Cricket Ground (B3b) which are protected to a standard of less than 1 in 10 years (10%AEP);
- Lower Bristol Road is assessed to have a 1 in 20 year standard of protection at most although in reality any restrictions to flow (such as an accumulation of debris downstream of Victoria Bridge / current Homebase site (B8) could reduce this to less than 1 in 10 years (10% AEP);
- Several properties shown to be in flood zones 2 and 3 would not be affected at all leaving SUDS installations as the only recommended flood management option.

4.9 In the other settlements, the standard of service is more consistent;

- Keynsham currently benefits from a SoP of around 1 in 50 with the exception of the old Cadbury factory site, which is only around 1 in 10 years (although some defences were constructed by the original owners);
- Radstock currently benefits from a high SoP apart from sites in and around RK9 and the A362 road bridge, which is no better than 1 in 10. Furthermore, one of the culverts beneath this road has collapsed, creating a blockage which promotes and exacerbates early flooding; and,
- Midsomer Norton currently benefits from a SoP of at least 1 in 75 years with the possible exception of the Welton area and the area just upstream of “The Island” [residential street (name)] and St Chad’s Avenue which may be prone to blockage at nearby culvert entrances.

4.10 The objective of this study is to identify how development sites within flood risk zones can be made more viable and deliverable through strategic or site-specific mitigation and compensation whilst seeking amenity value for users. The existing standards of protection across the study areas were found to vary greatly and comprise stretches of river corridor that enjoy a high standard of protection interspersed with areas with a very poor standards of protection. Since the highly protected sites would not be likely to contribute towards a city-wide flood defence scheme a more site-specific approach may be more viable.

4.11 The variations in existing flood defence standards of protection indicate that any flood defence construction works would be limited to a series of specific geographical areas. By implication, the value of any economic benefits to be achieved through their construction would similarly be limited to these neighbourhoods. Consequently, this suggests that the more viable strategies would address the development sites on an individual basis.

Option Identification and Appraisal Methodology

4.12 The approach adopted for the option identification and appraisal for flood risk management measures for Bath & North East Somerset comprised seven separate tasks:

- Task 1 – Review Existing Data and Reports;
- Task 2 – Identification and Review of Strategic Options;
- Task 3 – Workshop to Identify Short-list of Options;
- Tasks 4A and 4B – Assessment and Costing of the Short-list of Options;

- Task 5 – Preparation of Summary Consultation Report;
- Task 6 – Workshop to Confirm Preferred Options; and,
- Task 7 – Production of Final Deliverables; Options Appraisal Report, Guidelines for Site Specific Flood Risk Management Measures, A high level "Design Vision" for the study area.

Task 1 – Review of Existing Data

4.13 Review of the documents provided by Bath & North East Somerset Council enabled the Consultant to establish the client's development requirements for the city of Bath and those of the surrounding areas. These documents were:

- Bristol Avon Catchment Flood Management Plan (Environment Agency);
- Draft Regional Spatial Strategy;
- Strategic Flood Risk Assessment Level 2 Flood Maps for Bath, Keynsham, Radstock & Midsomer Norton;
- Level 1 Strategic Flood Risk Assessment Technical Report, Appendix maps and Executive Summary and Guidance documents;
- Level 2 Strategic Flood Risk Assessment Technical Report and Appendix maps for Bath, Keynsham, Radstock & Midsomer Norton;
- ISIS numerical river models of Bath and the River Wellow (Midsomer Norton & Radstock) and the Bristol-Bath TuFlow model covering Keynsham;
- Business Growth and Employment Land Study;
- Bath Public Realm and Movement Strategy;
- Plans of the development sites;
- FRMS Scoping Study;
- Retail Strategy;
- Sustainability Appraisal Scoping Report;
- Strategic Housing Marketing Assessment;
- List of Key Stakeholders and Significant Planning Applications;
- SHLAA Sites;
- Rapid Transit and Public Transport Routes;
- Biodiversity Action Plan for Bath Area;
- Aerial Photographs and LiDAR data;
- Bath Flood Defence Scheme Options Appraisal (Black & Veatch);
- River Avon Regeneration Pre-Feasibility Study (Royal Haskoning).

4.14 This data also made it possible to refine the method of assessment used in the outline appraisal matrix of the previous Scoping Study identifying a more intuitive approach for both the assessor and the reader.

4.15 On a more technical level, the results of previous flood study work (mostly relating to numerical flood models produced by other consultants) enabled the Consultant to identify the requirements for further flood defence scheme options for appraisal in Task 2.

Task 2 – Identification and Review of Strategic, Sub-Strategic & Site Specific Options

4.16 The following sections outline the approach adopted in the identification of the strategic options;

Initial Identification of Options

4.17 From the data review work undertaken in Task 1, new options to reduce flooding were identified for inclusion in the appraisal process, and options identified in the Scoping study were reassessed. All options identified were either taken forward to high-level appraisal, or discarded altogether on a cursory assessment, where there was an obvious failure to meet assessment criteria. Similarly, any obvious failure to meet the Council's requirements for development also warranted exclusion. All options discarded were recorded in the Proposed and Discounted Options Tables in Appendix B.

4.18 There were three categories of option identified for assessment:

- Strategic Options – a single scheme that benefits the whole study area. These include flood storage, bypass tunnel, raised defences, channel improvements, etc;
- Sub-Strategic Options – a combination of two or more developments functioning as a single flood defence installation protecting an area larger than the development sites immediately involved. By definition, such a strategy represents a combination of strategic option and site specific option;
- Site Specific Options – works required to an individual development site to ensure that it can maintain the minimum standard of protection required. Site specific options included amongst others: raised hard defences, SUDS, wetland/flood detention creation, channel widening, or combinations of all three.

4.19 The option identification process involved an initial brainstorming session. Options were then further developed in a subsequent desk based exercise. The options to be included in the high level appraisal matrix were identified during a number of informal, internal meetings to ensure that they were fully in line with the development criteria.

Development of Options in Line with Development Criteria

4.20 Some of the strategic flood storage options identified incorporate more than one area of land along the same river corridor; it was felt logical to combine these where a single development area is unable to provide the storage volume required. Other strategic options are examined wholly on their own merits. Similarly, certain strategic options, such as raised defences, would ultimately displace flood water to other urban areas further downstream, thus necessitating the inclusion of compensatory storage as part of that option. These were then assessed in more detail during Task 4.

4.21 At this juncture, the intention was to identify all the strategic options that were, to varying degrees, capable of being implemented by incorporating works at the individual development sites. Later stages of the appraisal investigated in more detail the high level options tabled, and any further solutions involving combinations with other options). Ultimately some conclusions as to whether one or more strategic options would be best for Bath & North East Somerset, or a combination of strategic and site-specific options, could not be reached until the end of Task 3 (the first Workshop) or during Task 4, where detailed modelling was undertaken to assess the Standard of Protection (SoP) afforded at each development site through testing of the strategic options.

4.22 The options tabled at the Task 3 workshop were too numerous to be considered for more detailed study and for the purposes of consultation had been presented in terms of their advantages and disadvantages, such as: loss of amenity value or poor levels of sustainability or excessive construction cost. This provided a natural opportunity in the appraisal process for the rejection of the less viable options, with the remainder being installed in the same numerical flood model used to

determine the river levels at the weak points in the existing line of flood defences. The findings of the of the Consultation work can be found in Appendix M.

4.23 The process used in designing the scope of the strategic flood defence options that would successfully support sustainable development of the named sites was undertaken as a brainstorming workshop guided by the development and flood defence constraints outlined in the reference material previously described. This process of sketching out the scheme designs was undertaken by The Consultant as part of the strategy assessment work. Appendix H contains several examples of these sketches which were produced for the larger sites and those representing the greatest opportunity for creating improved public amenity. These sketch drawings recorded the thought processes involved in defining the scope of a design that could maximise the amenity value of the immediate area, and provide a host of other benefits that could be achieved through a site's development. Such examples include:

- Avon Street Coach Park option proposed the construction of a pier in the channel and utilised river widening to compensate for potential loss of conveyance capacity. Being an elevated structure a raised riverside defence could be catered for without detrimental visual impact. This would also provide an opportunity for a water taxi service;
- Green Park Station option proposed the construction of an architecturally designed terraced channel to provide additional conveyance capacity for higher river flows and an increase in the length of riverside aspect (extending to James Street West, some way back from the main river). The grounds of the riverside area known as Green Park would also be re-profiled and re-landscaped to provide a small amount of compensatory storage public and a change to the style of the public amenity currently present;
- Locksbrook Island and existing riverside premises in the river corridor proposed an option involving the partial demolition of the ends of the island and their replacement with piers to improve flow conveyance capacity whilst maintaining the hard standing area and to provide a new jetty for freight handling and water taxi service. By providing a similar facility to the riverside of the current Sainsbury's and Travis Perkins sites (and the proposed Green Park and Avon Street developments) freight transport could be taken off the city's roads and a park and ride type water taxi service could be implemented;
- The upstream compensatory storage option proposed construction of a side-spill weir and ground re-profiling to enable controlled flooding of the area so that it could function as flood storage;
- The Riverside Park site in Keynsham proposed channel improvements and ground re-profiling to provide flood flow attenuation, thereby reducing the extent of flooding in the immediate vicinity;
- Keynsham Hams and Sydenham Mead, currently a functioning flood meadow either side of the Cadbury/Somerdale site was investigated for its potential to provide more controlled flood storage. This site is the downstream-most of all the areas studies and whilst of a beneficial size is not in proximity to an area that requires defending, other than the Somerdale site

4.24 The process used in designing the scope of the sub-strategic (site specific) flood defence options was limited to the geographic constraints of the site and works sufficient to meet the requirements outlined in the reference documents and general statutory guidance. The most immediate constraint under these circumstances is to protect the development footprint from flooding from a 1 in 100 year (1% AEP) event or greater without displacing floodwater downstream. The provision of environmental improvements or improvements in amenity were also sought out. On the larger sites, the design options investigated included the creation of small detention areas to offset the loss of flood footprint that would be presented by the new developments. If sufficient room were available, such a detention area would be investigated for its ability to provide some off-line storage for flood

waters from the River Avon as well. Alternatively, such storage areas could serve for the detention of surface water run-off as an improved SUDS opportunity.

Option Capital Cost Estimates

4.25 Past experience and the assessment criteria for the appraisal process required the development of indicative construction cost estimates for each option.

4.26 Whilst this was undertaken at a very high level, a standard approach to pricing was adopted for this work, whereby the key construction elements were quantified and an established construction unit-price rate applied. This can be illustrated using the following example of raising 6 kilometres of flood wall along the river corridor within the city of Bath.

4.27 The key construction element was 6,000 metres of reinforced concrete wall clad with limestone at a unit-price rate of approximately £2,500 per metre (plan length), equating to £15 million for an entire scheme. In addition to this, a further 5% was added in construction site overheads, along with further uplift figures for other key construction activities such as enabling works for working in the river channel. (Unit rates for various elements of construction were taken from industry standard databases ("Spons Pricing Database") and applied to quantities estimated from sketches drawn onto maps of the relevant areas.)

4.28 The large number of unknowns, with the potential to adversely affect accurate pricing at this early stage in the scheme's development presented a risk to reliable assessment. To compensate for this, an industry standard practice was adopted, that of applying a "weighting" figure to the construction cost estimate, as set out in the Flood and Coastal Defence Project Appraisal Guidance (FCDPAG). This figure can range between 40% and 60% and, less commonly, 80%.

4.29 The figure applied was established on a case by case assessment and covers: design costs, the expenditure required to obtain successful planning approval, legal costs and, if necessary, a Compulsory Purchase Order (CPO). Logically, a strategic, city wide flood defence option may involve a CPO, and a bypass tunnel (a traditionally cost heavy exercise involving many technical unknowns) a significant cost over-run and so an 80% optimism bias was applied in these cases. Conversely, a site specific option would assume planning and design costs to be part of the developer's normal expenditure and so an optimism bias of around only 20% was usually applied.

4.30 Overall assumptions made when pricing Strategic, Sub-Strategic and Site Specific options were as follows:

- **Strategic Options**: These were detailed to a sufficient scope and extent to ensure flood defence protection to the study areas in accordance with the data provided by the client (numerical flood models produced by others). Costs include planning and public consultation costs, detailed design, Compulsory Purchase Orders, surveys construction supervision and full construction costs (including for assumptions made on disposal of excavated material, contaminated or otherwise, purchase and installation of stone cladding to meet development control requirements for local area, amongst others). Cost of works would include enabling works (e.g. Large coffer dam across the riverside face of the site);
- **Sub-Strategic Options**: The scope and costs of works were developed so as to make advantage of benefits of scale when combining site specific options to work as a small scale strategic option, protecting discrete areas of Bath as opposed to just the development sites themselves.;
- **Site Specific Options**: These were normally assumed to protect the entire development site from flooding and not to assume that neighbouring properties/flood defence work by others could be relied upon to provide partial protection or protection to one or more sides of the property boundary. The sites were assumed to be developed anyway and that the flood defences identified as part of this study would merely be a construction element, rather than a construction project in their own right. Consequently, no design fees, fees incurred necessary to

obtain planning approval or legal or land purchase costs have been included in the works. The only cost included is that of purchase of materials for that works element, cost of excavation and fabrication and disposal (should it be deemed necessary for that particular site). Should additional 3rd party costs be considered a risk, and this is assessed on the merit of an individual site then these would be included (e.g. excavation of public highway to install SUDS solution (petrol interceptors etc) is likely to incur a large lump sum cost ("bounty") to be paid to the highways authority or local utilities provider). The cost of special enabling works is also included where considered likely to be required (e.g. coffer dams within the rivers). These unrelated items are both commonly found to run into the £100,000s.

Selection of Options for High Level Appraisal

4.31 The options then selected for assessment at the high level were streamed based upon cost, buildability, practicality, potential complexity of ownership and/or funding issues, feasibility of construction, or whether there was an obviously poor assessment criteria score under any of the criteria headings. Such an example was the option to over-dredge the river channel through Bath, which would not only be expensive for a relatively small improvement in Standard of Protection but would require very costly and frequent maintenance (>>£5M and would need doing every 2 years). This option was therefore discounted at an early stage; refer to the Proposed & Discounted Options table in Appendix B.

Presentation of Strategic and Site Specific Options

Flooding Risk Management Options Matrix

4.32 A flooding risk management matrix was created to enable the assessment of the strategic and site specific options to determine their effectiveness in relation to the development sites. Costs were calculated for all of the options to enable an appreciation of the financial requirements.

4.33 The strategic options were assessed on the existing standard of protection (SoP) for each development site using a 'traffic light' classification. For this high level appraisal stage the existing SoPs for each site were based on information reported in the Options Appraisal report by Black and Veatch (where the SoPs were determined at various locations along the River Avon in Bath), the Flood Zone maps and engineering judgement:

- GREEN – When the SoP was greater than 1 in 100 years, the strategic option was given a green light, confirming that additional site specific protection was not required in conjunction with this option.
- AMBER – When the SoP was between 1 in 50 to 1 in 100 years, the strategic option was given an amber light, confirming that additional site specific protection may be required in conjunction with this option.
- RED – When the SoP was less than 1 in 50 years, the strategic option was given a red light, confirming that additional site specific protection was likely required in conjunction with this option.

4.34 Strategic options were identified by first assessing each site individually to determine how the flood mechanism operated at each site and to assess its suitability for use as a flow retention measure (such as a storage lagoon, for example). This assessment included a review of the impacts of the Do Minimum (maintain existing regime) approach, to establish a baseline comparison. However, in order to reduce the complexity of the table, the potential flood management measures for which each site was assessed were categorised under seven headings:

- Flood storage Flood Storage;
- Bypass channel;
- Compensatory Storage;

- Glazed Flood Barrier;
- Channel Widening;
- Integrated Building Defences, SUDS, flood warning, flood walls & flood embankments;
- De-culverting and return to an open channel.

4.35 The traffic light style of presentation for the General Options matrix provided a visual indication of how many development sites would directly benefit from flood defence measures implemented as part of any one of the strategic options.

4.36 Sustainable Drainage Systems (SUDS) have a variety of applications and as such the matrix shows the types of SUDS that could be used to achieve a site specific solution in accordance with PPS25 and CIRIA C697, refer to Matrix in Appendix B and Appendix K and relevant later sections for SUDS descriptions.

Spot Maps

4.37 Spot maps were created for this stage:

- Site Specific Spot Map – Bath.
- Site Specific Spot Map – Keynsham.
- Site Specific Spot Map – Midsomer Norton and Radstock.

4.38 The site specific maps highlight the different options that are available for each development site using a segmented spot (refer to Appendix C).

Option Appraisal Process

High Level Appraisal Matrix

4.39 Having considered the methodology suggested in the Scoping study we identified certain shortcomings were identified that could be rectified. These can be summarised as:

- Ensuring the appraisal is fully compliant with (derived from) the LDF Core Strategy Sustainability Appraisal;
- Ensuring it is directly related to the PPS25 exception test;
- Has a scoring/weighting that is consistent throughout (e.g. 1 = worst, 5 = best) against defined indicators for each of the evaluation criteria;
- Does not include “non-options” (e.g. ‘planning constraints’) or doubling up of criteria.

4.40 This transparent and workable matrix, based on a qualitative assessment using a hybrid Multi Criteria Appraisal (MCA) approach, was used in a similar form for both the high level and the second detailed phases. For the latter, the quality of the input data was finer, i.e. development capacity assumptions, physical areas, required volumes of storage (following modelling) and so forth.

4.41 The High Level Appraisal Matrix and a detailed summary of the criteria can be found in Appendix E.

Technical Assessment Criteria (Technical Feasibility and Benefit/Cost)

4.42 The technical assessment, which comprises the technical and benefits/cost feasibility, was applied to the strategic options and site specific options alike.

4.43 The Technical Feasibility test has been based on 3 sub-criteria, including,

- Flood Defence Standard of Service Anticipated;
- Residual Flood Risk - Properties Not Protected by Option (not used for high level appraisal);
- Risk of Flooding Merely being displaced (i.e., ‘Offsite impacts’).

4.44 The 'Residual Flood Risk' criteria are not reported in the High level appraisal matrix (i.e., recorded as a zero (0)), whilst the 'Flood Defence Standard of Service Anticipated' criteria are assessed by inspection of the proposed scheme option (e.g. a tunnel option is intended to be a 1% AEP plus 20% climate change scheme and so would be designed as such).

4.45 The impact to downstream conurbations / areas (or 'Risk of Flooding displaced') of each scheme option has been assessed against the following criteria:

- More detailed investigation required;
- Compensatory works required downstream;
- Defence works likely, but can be included in a scheme;
- Small scale mitigation required; and nothing is required further downstream.

4.46 The 'Benefit/Cost' test has also been revised to a more quantitative assessment from that recommended in the Scoping Study, in keeping with accepted industry-wide approach and more commonly used criteria. This makes for better transparency when peer reviews are undertaken. The Benefit/Cost test is based on two criteria:

- Average Annual Damages (£) (AADs) based on flood outlines (not used for high level appraisal);
- Likely Range of Construction Costs (£).

4.47 For site specific options, where the sub-options were similar in scope or price, the appraisal matrix recorded only one option in order to avoid any effective duplication of entries.

4.48 A definition of the range of scores applied under each assessment together with a description of the criteria used can be found in Appendix F.

Sustainability, Viability and Deliverability Assessment Criteria

4.49 The assessment of sustainability, viability and deliverability forms a central part of the appraisal. The criteria established enable an assessment to be made of how sites are likely to perform against the exceptions test set out in PPS25 and also allow a view to be formed on whether options are likely to prove viable in the context of overall development costs and whether they can be delivered.

4.50 The sequential test seeks to direct development to areas not subject to flood risk. However, certain uses consistent with the risk vulnerability classification may be accommodated if they satisfy the exceptions test (Annex D of PPS25) which requires that:

- It must be demonstrated that the development provides wider sustainability and community benefits that outweigh flood risk, informed by a SFRA where one has been prepared. If the DPD has reached the 'submission' stage – see Figure 4 of PPS12: Local Development Frameworks – the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal;
- The development should be on developable previously-developed land or, show that there are no reasonable such sites; and
- A FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

4.51 PPS25 provides a clear rationale for the appraisal methodology to incorporate:

- A selection of the LDF Core Strategy Sustainability Appraisal (SA) objectives, and
- The first two of the three PPS25 exception test criteria.

4.52 For the high-level appraisal, reasonable (if wide) assumptions and estimates are made, and then in the second, more detailed phase, the assumptions and estimates are refined and revisited using new data sources (e.g. flood modelling).

4.53 The SA objectives chosen are from the Core Strategy SA Report. Initially ten options were found to be appropriate (some SA objectives we felt overlapped in the context of flood risk management, and the full list was not manageable or necessary). The chosen objectives are:

- Improve accessibility to community facilities and local services (Objective 1);
- Meet identified need for sufficient and high quality and affordable housing (Objective 3);
- Promote stronger more vibrant and cohesive communities (Objective 4);
- Ensure communities have access to a wide range of employment opportunities, paid or unpaid (Objective 7);
- Ensure everyone has access to high quality and affordable public transport and promote cycling and Walking (Objective 10);
- Protect and enhance the district's cultural and historical assets (Objective 13);
- Encourage and protect habitats and biodiversity (taking account of climate change) (Objective 14);
- Encourage sustainable construction (Objective 16);
- Reduce vulnerability to, and manage, flood risk (taking account of climate change) (Objective 18); and
- Promote waste management in accordance with the waste hierarchy (Reduce, Reuse and Recycle) (Objective 20).

4.54 To this were added two further criteria:

- Does the option support the Regeneration Delivery Plan? and
- Does the option affect townscape or landscape?

4.55 The twelve criteria together represent the Sustainability criteria.

4.56 These are then weighted such that (a) they are equal to each other and (b) in total they equal the weighting attributed to the technical assessment. These weightings are shown in the top row of the appraisal matrix.

Viability and Deliverability Assessments

4.57 For the viability and deliverability assessments it was decided that, for transparency, this would follow the balancing of sustainability and technical feasibility, and would follow a sequential format with a yes/no output.

4.58 The tests examine the two key drivers for viability – will the FRM option be wholly funded by developers and/or gap funding (yes/no?); and if so, would the physical configuration, land ownership, delivery vehicle and the timing of construction of the FRM option match that of the development(s) to which it relates?

4.59 The viability assessment compares the costs of flood risk options for each site within the context of overall development viability. The following stages are included in the assessment.

- Step 1 – Development capacity and potential assessment to establish the future scale and mix of development for each site. This is based on a review of Regeneration Delivery Plans, area and site masterplans, outline planning applications, knowledge of emerging proposals and assumptions provided by the Council. Where this information is not available an assessment of capacity is based on the application of Development plan policies and guidance regarding

appropriate land uses and development densities. On the basis of the review it is concluded that site B13f is unlikely to have any significant development potential over the plan period and is not taken forward within the assessment.

- Step 2 – Completion of the overall viability model to establish the likely order of magnitude scheme costs, revenues, return and an estimate of normal infrastructure costs prior to consideration of site costs. Assumptions regarding revenues are based upon land registry sales data, on line property search and the West of England Housing Market Assessment. Costs are based upon BCIS Constructions costs for Q2 2009 for the South West region.
- Step 3 – Derivation of site flood risk infrastructure costs for strategic options. Where a strategic option has potential to mitigate fully the flood risk relating to a site a share of the total cost of strategic infrastructure is apportioned between sites. Three apportionment mechanisms are used to determine the % of flood risk management infrastructure should be borne by each site: total site area, total floorspace and projected revenue. It is found that the three indicators deliver similar results in terms of the shares realised. For sites where the strategic infrastructure option would not fully mitigate flood risk it is assumed that the total cost of mitigation would be the percentage contribution towards strategic option + 50% of cost of the on-site option.
- Step 4 – Comparison of flood risk management costs with scheme costs. Two indicators are used to compare the costs of flood risk management with scheme costs. These were flood infrastructure cost per sqm of development and flood risk management costs as a percentage of notional normal site infrastructure costs.
- Step 5 – Consideration of the effect on overall scheme viability. Based on those two indicators threshold values have been established to identify circumstances in which the cost of flood risk management infrastructure is likely to have an effect on scheme viability these are:
- Where cost exceeds £30/sqm or;
- Where overall flood risk management infrastructure exceeds ~20% of notional normal site infrastructure costs (Defined on an assumption that these costs are typically 8-10% of overall project costs).

4.60 On this basis strategic options which exceed these parameters for several sites are provisionally identified as not being viable. An assessment is then made of the potential for sites to attract external gap funding to enable redevelopment. Consideration has been given to whether sites may be able to attract gap funding for enabling infrastructure including flood risk management infrastructure. This may be possible if the option could enable beneficial use of vacant/derelict previously developed land. Sites are then identified as either viable or not viable.

4.61 An assessment is also made of the potential deliverability of Options. For the deliverability test to be satisfied all of the following conditions are to be satisfied:

- Suitability and use – Is the FRMS Option suitable considering the proposed use and likely layout and configuration of development in connection with FRMS options. In addition there is a need to consider whether the area is required to accommodate on-site FRM infrastructure, location of infrastructure or associated access and safety requirements would compromise the development potential of the site.
- Delivery Vehicle - Does an appropriate delivery vehicle exist or have the potential to be established to implement the option. Consideration is given to who would be responsible for delivering each option component (i.e. developer/landowner, EA, Local authority, Regeneration Partnership).
- Need for land assembly and requirement for acquisition or compulsory purchase of non Council owned land. This assessment is based on the likely extent of land required.

- Timing and phasing – The fit between FRMS infrastructure delivery and development trajectory. The assessment is based upon the extent and cost of forward provision of infrastructure required and whether the potential approach to infrastructure phasing is compatible with the development trajectory.

4.62 On the basis of the assessment, the bypass tunnel and channel widening options are evidently unviable. The other options have potential to be viable, although some sites are sensitive to the basis used for apportionment.

Identification of Short-listed Options

4.63 Once each option was assessed under each of the technical feasibility and sustainability criteria headings, the cumulative score was recorded in the far right hand column, weighted in order to provide a balance between the technical and the sustainability criteria score, and presented as a percentage of the maximum possible score. A threshold score was then established to ensure that appropriate options were short-listed for more detailed appraisal. This, together with the outcome from the Viability and Deliverability tests, determined the final short listed options and is presented in the High Level Appraisal Matrix (Strategic Options and Site Specific Options) in Appendix E.

4.64 Following the completion of the high level appraisal work (Tasks 1 and 2) and the workshop to develop the list of strategic flood defence options (Task 3), more detailed investigation was undertaken on these remaining options.

4.65 The majority of the strategic options investigated prove unviable at the detailed testing stage. The numerical flow model was modified to reflect the proposed design arrangements in order to establish technical viability and approximate construction costs were compared with the estimated financial return on completion of the development sites to establish financial viability. There are two main reasons that most of the strategic options proved unviable:

- The flows experienced in the River Avon are exceptionally large, so much so that the comparatively small areas available for the formation of flood storage areas or bypass channels would not contain, or convey a sufficient quantity of water, to achieve a beneficial impact on flood levels;
- The cost of the works required deliver the strategic options, in particular those involving works to the riverside, prove to be much higher than the financial returns that could be realised by the commercial premises located at those sites.

4.66 The above two points would not necessarily preclude these development options from proceeding to construction as other appraisal criteria such as those relating to urban regeneration and improvement in amenity could still provide an over-riding case.

4.67 The sub-strategic options were by definition, an intermediate stage between the strategic options and the site specific. On closer scrutiny, the same issues that prevented the strategic options from making the shortlist also apply to the sub-strategic. The strategic options are a set of flood defence works required at each development site to provide a viable flood defence scheme catering for the wider Bath area by working in combination. The logic for the sub-strategic schemes is that they involve the same site specific elements operating in combination as a modular scheme, albeit one that help defend a smaller area. The same issues of insufficient capacity to counter the high river flows were also found to apply. The constraints on the scheme's viability require that they attain a 1 in 100 year standard of protection as a minimum. Therefore, the sub-strategic option approach has proved unviable. Modelling does demonstrate that such an approach could help defend against lesser return periods but this is outside the remit of this flood risk management strategy.

Task 3 - Workshop to Identify Short List of Options

4.68 A workshop was convened at B&NES offices in the Guildhall on Tuesday 16 June 2009 to present the findings of the first stages of the appraisal. The appraisal work undertaken as part of Task 2

identified a short-list of viable options, reduced from a list of some 12 strategic options and 152 site specific (providing more than one option or option version for some sites) determined from technical appraisal, initial costing work and the high level appraisal. (See Appendix M.)

4.69 The site specific flood management proposals were not discussed on a site by site basis, as they were identified in accordance with the brief and guidance documents and their implementation is a matter for the planning process and presents no significant impact in CFMP terms.

4.70 The strategic options presented at the workshop are:

- Bath Option 1 - Upstream storage area south of the A4 at Claverton;
- Bath Option 2 - Bypass tunnel and pump station across centre of Bath;
- Bath Option 3 - Raised Defences along the entire river corridor;
- Bath Option 4 – Cumulative storage provided at each of the Bath development sites (a combination of channel widening and off-line detention areas);
- Bath Option 5 – Channel widening and deepening through Bath;
- Bath Option 6 – Lowering of Twerton Sluice;
- Bath Option 7 – Upstream storage;
- Midsomer Norton Option 8 – “Riverside” Upstream storage;
- Radstock Option 9 – River Wellow storage and council land to the north of Somervale Road;
- Radstock Option 10 – West Hill Gardens Flood Storage and Fox Hills Flood Storage;
- Midsomer Norton Option 11 – “Clandown” flood storage.

4.71 Options 3, 5 and 6 would require compensatory storage to be provided downstream of the city to prevent the excess of flood water not attenuated by these options from flooding downstream settlements.

4.72 The options were all presented to the workshop delegates in a series of slides and verbal presentations, outlining their individual benefits and disadvantages, determined from the assessment work already undertaken. This culminated in the identification of five potential strategic options to be studied in more detail; revising the existing numerical flood models to represent each of the options in turn to establish their effectiveness in flood management terms for a range of storm return periods and carrying out an economic assessment in accordance with the DEFRA (FCDPAG) guidelines. Sequential testing was similarly undertaken along with assessments for sustainability and general benefits to the built environment. The strategic options short listed for further investigation are set out in Table 4.2.

Table 4.2 Shortlist of Strategic Options

Option No.	Option	Description
1	Storage upstream of the A4	Provision of a flood storage area upstream of Bath to attenuate / detain flood water, protecting the entire city/development sites.
2	Storage upstream of the A4	Provision of a flood storage area upstream of Bath city centre to attenuate / detain peak flood flows, protecting development sites.
3	Raised Defences	Increase the height of river walls along river corridor through Bath to prevent

		overtopping by high river levels.
4	Cumulative storage in development areas	Provision of small flood storage areas at each development site to attenuate / detain peak flood flows, protecting development sites.
4a	Twerton Sluice adjustments	Lowering crest level of Twerton (situated downstream of Bath City centre) to reduce water levels in the channel to below overtopping of existing river walls along river corridor.
8	Midsomer Norton Option 8 – "Riverside" Upstream storage	Provision of upstream attenuation to reduce risk of flooding to properties currently at risk of a 1% AEP (1 in 100 year) event
9	Radstock Option 9 – River Wellow storage and council land to the north of Somervale Road	Provision of upstream attenuation to reduce risk of flooding to properties currently at risk of a 1% AEP (1 in 100 year) event. Repair to existing road culvert is also required.
10	Radstock Option 10 – West Hill Gardens Flood Storage and Fox Hills Flood Storage	Provision of upstream attenuation to reduce risk of flooding to properties currently at risk of a 1% AEP (1 in 100 year) event. Repair to existing road culvert is also required.
11	Midsomer Norton Option 11 – "Clandown" flood storage	Provision of upstream attenuation to reduce risk of flooding to properties currently at risk of a 1% AEP (1 in 100 year) event
All	Site Specific Options	The minimum flood defence requirement for each site was identified by inspection of the anticipated flood levels and their extent determined. This is the approach currently required as part of the Planning Process.

4.73 The discounted options were rejected on grounds of cost and practicality;

- Bypass Tunnel and Pumping Station would cost well in excess of £100 million, a sum which could not be realised by imposing a levy on developers. There was also a general reluctance amongst delegates to progress this further, although perhaps only one based on perception;
- Channel widening and deepening through Bath would cost at least the same (in excess of £100 million) if not more due to the ancillary costs of diverting utilities at each bridge, altering the alignment of structures or architectural importance and the compensation payments that would have to be paid to businesses that would suffer due to temporary closures of premises or customers unable navigate their way across Bath. Moreover, the large number of objections that could be anticipated in response to demolition and reconstruction of structures of archaeological and architectural importance would tie up the planning process for a long period, adding significantly to consultation costs.

4.74 A table of the options investigated, both discounted and taken forward can be found in Appendix H, complete with option descriptions.

Task 4 – Assessment and Costing of Short Listed Options

4.75 The next step in the study was to undertake a more detailed assessment of the strategic options, generating numerical models representing the form and function of each option and to assess the impact it has on flood levels once constructed. The modelling outputs enabled the economic value of benefits to be determined (assessed as damages avoided by the constructed works) which were then compared with the estimated whole life costs for each option (design and planning fees, compensation payments and construction and maintenance costs).

Numerical Modelling

4.76 Once the more viable strategic options were confirmed at the first options workshop, more detailed investigation was undertaken by the adaptation of the existing ISIS numerical model provided by B&NES. The key components of each option were installed in the model which was then analysed for a range of return periods, the key one being the 1 in 100 year storm event with an additional 20% of peak flow to represent future climate change. The results indicated the possible reduction in flood extent that might be achieved by each of the short listed options. Those failing to produce any effective reduction in flood depth were given no further consideration and were recorded as such in the appraisal matrix.

4.77 The modelling work identified only one option that was able to provide a comprehensive flood risk management scheme; the others proved to have a negligible impact on flood levels in the river at times of high flow:

- Bath Option 3 - Raised Defences along the entire river corridor would successfully prevent flooding for a 1% AEP event plus 20% allowance for climate change (CC);
- Bath Option 1 - Upstream storage area south of the A4 at Claverton only provides a negligible reduction in river levels along the length of the channel (approximately 30mm);
- Bath Option 4 – Cumulative storage provides at each of the Bath development sites (a combination of channel widening and off-line detention areas) provides a negligible reduction in river levels along the length of the channel (in some locations as little as 6mm to 30mm);
- Bath Option 6 – Lowering of Twerton Sluice provides a negligible reduction in river levels (of up to 88mm);
- Bath Option 7 – Upstream storage areas at provides a negligible reduction in river levels over the length of the channel (of up to 100mm in places).

4.78 The options identified for the North East Somerset towns prove to be unviable under economic assessment, in favour of site specific amelioration measures. Consequently, these options are not worth investigating any further, unless alternative drivers become apparent to over-ride the current business case. For completeness, the North East Somerset towns' options are as follows:

- Midsomer Norton Option 8 – "Riverside" Upstream storage is viable but would require more detailed modelling at design stage in order to establish the required size and shape;
- Radstock Option 9 – River Wellow storage and council land to the north of Somervale Road is viable but would require more detailed modelling at design stage in order to establish the required size and shape;
- Radstock Option 10 – West Hill Gardens Flood Storage and Fox Hills Flood Storage is viable but would require more detailed modelling at design stage in order to establish the required size and shape;
- Midsomer Norton Option 11 – "Clandown" flood storage is viable but would require more detailed modelling at design stage in order to establish the required size and shape.

Economic Assessment

4.79 The capital cost of each option has been determined by applying standard construction industry cost rates to the key dimensions required of each option (e.g. excavate 20,000m^3 of earth at £4/m^3 to form a flood storage area makes £80,000 plus overheads). Comparing this with the value of flood damages avoided (achieved by counting properties effectively removed from the flood plain and applying standard rates for flood damage) enables a comparison to be made between the cost of constructing a scheme and the savings to be achieved through the avoidance of damages. Those failing to provide a net benefit when comparing capital cost with the value of damages avoided are given no further consideration and are recorded as such in the appraisal matrix.

4.80 The cost of damages incurred for a range of flood events (from 1 in 10 to 1 in 100 year flood + 20%) averaged out over the 100 year appraisal period have been established for all the properties and commercial premises currently in the flood envelope, as well as for the development sites, assuming future completion of the development and full time occupation. In accordance with normal economic assessment practice, an allowance is also made for the impact of flooding on infrastructure as well. This process is undertaken using an industry standard spreadsheet package, the Flood and Coastal Defence Project Appraisal Guidance economics spreadsheet. Originally produced by the Department of the Environment Food and Rural Affairs this spreadsheet has links with a national database of properties (National Property Database) and unit cost damages database (The Multi Coloured Manual) and cross references flood levels generated by the numerical model used in this study with these databases. It is an effective means of assessing the value of flood damages affecting a given area.

4.81 A more detailed explanation of how the economic appraisal was carried out can be found in Appendix D. The results are summarised in Table 4.3 below.

Table 4.3 Present Value Assessment Summary

Option No.	Option Description	Present Value Damages (PVd)	Present Value Benefits (PVb)
0	Baseline Scenario	£30,266,920	£0
1	Storage upstream of the A4	£29,661,582	£605,338
2	Flood plain storage	£24,213,536	£6,053,384
3	Raised Defences	£0	£30,266,920
4	Cumulative storage in development areas	£23,910,867	£6,356,053
4a	Twerton Sluice adjustments	£29,056,244	£1,210,677

4.82 Table 4.3 should be read by comparing the two right hand columns.

- PVd - present value of damages still occurring for the range of flood events over the appraisal period. That is, the estimated damages that would still occur to those properties even with the proposed works in place;
- PVb – present value of damages avoided by virtue of the fact that the proposed works provide flood protection.

4.83 Table 4.3 shows that only option 3 provides wholesale protection (i.e. both existing and proposed properties) against flooding for the design flows. The remainder cannot legitimately be deemed to provide flood protection as, over a period of 100 years and several flood events of varying magnitude, they only provide minor flood mitigation by reducing the depth of flooding that occurs.

4.84 Given that the whole life cost of raised defences (option 3) is over £100 million, this is more than three times the economic value of damages prevented by the structure. Consequently, it cannot be deemed a viable flood management option under standard industry guidelines.

4.85 Economic assessment of the North East Somerset towns was undertaken by site survey. Each property is identified by inspecting its position in relation to the flood outline and boundaries to the flow of floodwater or weaknesses in existing defences can easily be identified. By inference, the small number of properties that makes this approach practical limits the benefits that would be realised were defence works to be undertaken.

4.86 The average value of benefits to be realised by protecting a property against flooding is £13,900 and represents the cumulative total of the value of damage incurred during each flood event that might occur during over a 100 year appraisal period, discounted back to today's figures (i.e. were £13,900 invested today, in 100 years time it would represent several £100,000's). This figure is multiplied by the total number of properties that lie in the 1% AEP + 20% CC flood zone at each site. The only development site found to be at risk is site RK9 Combend, which, from inspection, currently has some 10 properties located within its envelope. The only other site affected is the Broadmead Lane Waste Site, which would suffer no economic loss during a flood.

4.87 By comparing the economic value of damages with the cost of constructing the options the financial viability of the defence works has been established. A similar exercise was undertaken as part of the viability assessment work, but in terms of revenue that could be realised by developing the site.

Option Appraisal Matrix

4.88 In order to formally identify the viability of each option, the remaining options entered into the high level appraisal matrix have been updated using the results from the Task 4 activities. This also enabled the remaining columns of the table to be populated under the Technical Feasibility and Benefit/Cost headings, specifically: Residual Flood Risk [properties that remain unprotected post-scheme construction] and Indicative Number of Properties Protected [1%AEP + 20% CC design case], respectively.

4.89 The sustainability test and viability and deliverability test have also been reviewed and updated. Of the short listed options taken forward all of the options satisfy the viability and deliverability test.

4.90 The existing criteria scores such as, standard of flood defence protection anticipated, risk of flooding displaced to another conurbation and the likely range of construction costs has been updated with the results of the more detailed modelling and costing assessments. The outcome of the more detailed modelling work undertaken in Task 4 provides the figures for the number of properties protected and those that would remain unprotected during a flood event. This was achieved by plotting the depth of river water overtopping river banks during a flood event against topographical survey data for the surrounding area. In this way a good estimation of the likely route the flood water will take, along with its depth, can be made. Similarly, by knowing the depth of flood water in the river channel, the required height of flood defences can be determined, enabling the construction costs to be refined.

Results of the Study

4.91 As described in the preceding sections, the modelling work only identifies one technically feasible comprehensive strategic solution to flood risk management in the city of Bath and this has been discounted due to the high economic cost.

4.92 This is because the huge flows present in the channel for the design case (some 450m^3/s representing a 1 in 100 year event including a 20% allowance to reflect future increases due to climate change) require an extremely large flood detention area would be required to store the flow in excess of the channel's conveyance capacity, which would be larger than is actually available within the River Avon catchment. Indeed, across the range of return periods analysed the flows are

so large that the reduction in flood levels generated by the options modelled remains the same. This applies equally to the storage areas upstream of Bath, which achieve only a 1mm reduction in water level for a 1 in 25 year event, which is outside the sensitivity of the modelling software used.

Conclusions

4.93 The only technically feasible comprehensive strategic flood management solution would be the raising of defences along the river channel throughout the city of Bath, with compensatory storage downstream. However, this option would cost more than three times the economic value of the damages avoided, making it unviable by industry guidelines. The pumped tunnel solution was discounted at an early stage for similar reasons, despite an ongoing level of interest from other departments within B&NES. There is no strategic solution that will obviate the need for flood defences at any of the development sites.

4.94 The only favoured option which is fully feasible in terms of the appraisal criteria is the installation of flood defence measures at the individual development sites. However, a number of sites present issues of development viability that are exacerbated by the additional marginal cost of the identified flood risk infrastructure, which may impact on viability and site delivery in the absence of supporting scheme funding.

4.95 In light of changes in national policy relating to climate change and for reasons of sustainability and good practice SuDS installations should also be provided for all new developments. Appendix I (Site Specific Reports) identifies the range of flood risk management measures that should be implemented at each site, along with the size and/or defence heights required.

4.96 The construction of buildings and their associated flood protection measures in Bath would represent the displacement of around 250,000m^3 of flood water (representing the accumulated volume that would be displaced from each development site) from the floodplain, under the 1% AEP (1 in 100 year) +20% (climate change allowance) design case, adding to the risk of flooding to existing properties in settlements further downstream. Policy 5 requires B&NES to mitigate for loss of flood envelope due to future developments.

4.97 To this end, the only strategic solution open to B&NES is to provide a compensatory storage area or areas upstream of the centre of Bath. Whilst it has been demonstrated that such areas could not protect the development sites in Bath against a flood event of any size, the provision of such a storage area would offset the volume of water that would theoretically be displaced by the combined developed footprints of the development sites. This would ensure that any development strategy implemented in Bath would meet the requirements of PPS25. In order to meet this requirement, a maximum flood storage area of 345,000m^3 volume would be required as this is equivalent to the total combined volume of the developed footprint of the development sites.

4.98 The construction of a single upstream storage site, rather than a series of smaller compensatory storage areas as opposed to a larger upstream one, has several advantages;

- Many of the sites do not have sufficient land to provide an on-site storage area of similar extent to the developed footprint so the required total storage would not be achieved;
- Delivery of the total compensatory storage volume required to offset water displaced from the floodplain can be phased so that it mirrors the programme of development in Bath. This would maintain a sustainable rate of expenditure for forward funding and minimise the risk of full funding not being recouped if development sites do not come forward. When considering the provision of smaller storage areas on a site by site basis, it should be noted that the cost of building several small storage areas (particularly where access and size of working area is limited) would cost disproportionately more than a single large area, lying outside the city boundary and the latter can also be forward-funded with the costs distributed amongst the various developments it seeks to serve.

4.99 Some developments, however, could provide and benefit from some stand alone compensatory storage areas. For example, the use of Green Park as a detention area has been suggested. It could be modified to provide up to 20,000m^3 of storage with little re-profiling to existing ground levels. Due to its location and size it could comfortably provide compensatory storage for development site B9b on the opposite bank of the Avon; currently known as the 'RBP to Travis Perkins' site, this has an estimated flood footprint volume of 16,900m^3. However, as described above, there would have to be other over-riding considerations to justify such an approach. For example, given its location and current function, Green Park could be developed as a flood detention area in order to provide an improved amenity, parks facilities/entertainment, or habitat.

4.100 Spot Map 06 identifies some areas suitable for such an installation, although others may well be available following further investigation. This could be provided by re-profiling ground levels to provide around 300,000m^3 of flood storage, offsetting the 250,000m^3 of flood water that would no longer be contained in the development sites once constructed.

4.101 Other sites may also be available. For example, the Mill Lane Park and Ride site would not be able to provide enough storage to offset flood storage lost at the development sites but, if another site can be found so that, in combination, they can achieve the required volume this would also be a viable course of action open to B&NES. The storage areas proposed for Midsomer Norton and Radstock should be able to provide adequate mitigation against flood risk, however it is unlikely that these storage areas would improve the viability of site development on economic grounds alone.

4.102 Historically, it has been established that the Lower Bristol Road becomes impassable during times of flood. Analysis of modelling results indicates that this road benefits from a standard of protection of up to 1 in 20 years, or less. Continuous operation of this route during times of flooding would need to be assured in order to avoid the development sites along this stretch of road being cut-off, effectively making them undevelopable. Works would therefore need to be carried out to ensure that 24 hour access is provided; these could involve either the raising of a low level flood barrier (such as a low parapet running along each side with a road ramp at each end) or raised pedestrian access ways to bridge the flooded areas. Such a solution could utilise the Midland Bridge Road bridge as this already provides a direct route from the City centre and could further be extended by provision of an improved route along the left bank of the Avon, through the RBP and Travis Perkins sites. Whilst this solution will not provide vehicular access 365 days per year, normal access by staff can still be maintained. The only concern would be that access by the emergency services could not be maintained during times of flood, as would normal deliveries both presenting the risk of brief periods of reduced income should the premises have to close. There may be sufficient storage capacity upstream to offset any loss of flood storage due to protection works to Lower Bristol Road.

4.103 Clustering groups of development sites would not provide a viable solution because (as explained above) they are not large enough to provide sufficient protection and, if they were, the cost of such works would far outweigh the value of benefits avoided. The only advantage to be provided by adopting this approach is to encompass two or more adjacent sites with a single flood defence structure, thereby achieving a saving in construction costs through the economies of scale. For instance, constructing three development sites as a single larger one might enable a saving of 5% or more to be realised.

Recommendations

4.104 As no viable flood defence scheme can be proposed, the provision of upstream compensatory storage in advance of wider development in the flood plain should be brought forward for implementation as part of the future development strategy for Bath. This, and general on-site flood management infrastructure, will be expected to be developed before the development proposal is allowed to commence, including drainage infrastructure in support of the installation of SUDS features at each site.

4.105 The upstream compensatory storage site should be prepared for flood storage within the first five years of the Local Development Framework. This is the most appropriate site suitable for use as a compensatory storage area and would provide a good opportunity for wetland and habitat enhancement.

4.106 Other sites for use as storage areas can also be considered but they have to be able to provide a maximum of 345,000m^3 of storage (or at least match the combined future development footprint for which they are to compensate for) and be located upstream of those development areas (i.e. upstream of Bath).

4.107 Of those sites which would benefit from upstream storage there is no certainty that all of the sites identified would be developed over the development plan period. Therefore the costs of delivering any strategic flood management infrastructure should be linked with those sites which are expected to come forward over the plan period. Consequently, this should be addressed in any implementation strategy.

4.108 The North East Somerset towns Keynsham, Midsomer Norton and Radstock have not demonstrated a viable business case for an off-site solution, leaving the provision of site specific flood defences as the only practical solution. Furthermore, detailed scrutiny of the flood modelling data shows that only the Combend site (RK9, Radstock) and the Keynsham Waste Site (KM11, Keynsham) are the only sites at significant risk of flooding.

4.109 With regard to the LDF Infrastructure Delivery Plan, the Council should adopt the Site Specific Reports provided in Appendix I as a live document to issue as guidance to prospective developers. As such, the Council would be able to modify and update it in accordance with any changes in the delivery plan or LDF. The SUDS installations proposed in the site specific reports are included in Appendix I.

4.110 Section 6 provides details of implementation and delivery of the strategy including the strategic up stream storage within Bath. Construction of any compensatory flood storage area or infrastructure protection works could be part funded by levying an additional charge on new development applications for the sites which benefit.

5. Flood Risk Management Concept

5.1 This section sets out the overall concept for managing flood risk in the District.

Objectives

5.2 A number of general objectives for the Strategy have been identified which go beyond simple flood risk management:

- To protect and, where possible, enhance biodiversity;
- To improve the quality of the landscape and visual amenity;
- To protect and enhance water quality and resources;
- To protect existing material assets;
- To protect and enhance cultural heritage features; and
- To improve recreational amenity.

5.3 In light of changes in national policy relating to climate change and for reasons of sustainability and good practice, SUDS installations should also be provided for all new developments. The installation of SUDS provides a number of opportunities to facilitate the objectives set out above. The development proposals should ensure that there is no net loss to existing biodiversity habitats as a result of development.

Bath

5.4 As there is no single, comprehensive strategic solution that will obviate the need for flood defences at any of the development sites in Bath. The most favourable option for managing flood risk in the city is the installation of on-site flood defence measures at each of the individual development sites combined with an off-site compensatory storage solution. Provision of off-site compensatory storage ensures maximum flexibility on-site in terms of site layout and design. Additionally, there are viability gains as water is stored on less valuable land and economies of scale are achieved through shared construction costs.

5.5 Forward funding of such construction works would be required but funds could be re-couped by imposing a levy on the developer. There are a number of ways in which this could be done and this Strategy recommends that the levy relates to the volume of water stored required by each site.

5.6 Because the construction of buildings and their associated flood protection measures within Bath would represent the displacement of around 250,000m^3 of flood water from the floodplain, the provision of a compensatory storage area upstream may be required to offset the flood water that would be displaced as a result of development on-site.

5.7 The sites which would benefit from the provision of compensatory storage at the upstream site can be seen on the plans in Appendix L.

North East Somerset

Given the results of the economic appraisals for Keynsham, Midsomer Norton and Radstock, the recommended flood risk management approach in these areas is a combination of integrated building defences at all sites, as well as a small number of on-site flood storage at particular locations. The options available for each site are summarised in the relevant Site Specific Report sheets in Appendix I.

6. Development Principles and Guidance

6.1 This section sets out the suitability for the various flood risk mitigation and SUDS options based on the constraints the individual sites presents particular types of sites in Bath and North East Somerset. The site specific reports in Appendix I identify the more appropriate types of measure and represents a record of the outcome of this suitability assessment work.

6.2 Other means of providing flood defences may also be applicable and it is recommended that developers give due regard to all relevant detailed technical guidance and consenting procedures.

Flood Risk Management Guidelines

6.3 In assessing the most suitable form of flood management for each site many factors were considered, particularly the physical site constraints:

- Is there sufficient room for the feature to be constructed without unduly impacting on the rest of the development?
- Does the position of the site allow successful functioning of a storage area?

6.4 The opportunities that each flood defence measure could afford to improve amenity, public access, biodiversity or general enhancement of the built environment are also considered. This section explains the process used in identifying the most appropriate flood risk management measure for each site and the most appropriate Sustainable Urban Drainage (SUDS) systems.

Flood Defence Measures and the Methodology used in their selection

6.5 This assessment is supplemented by further detail provided in a set of Site Specific Reports (Appendix I).

6.6 A numerical model was produced of the channel system through Bath, and the surrounding areas, in the case of Radstock, Midsomer Norton and Keynsham, which was run for a range of flow hydrographs, representing floods of various return events.

6.7 The modelling results provided the river level heights at times of flood and these were compared with survey data to identify existing flood defence levels, building threshold levels and those of the surrounding ground and roadways. This comparison makes it possible to determine which properties would be affected by flooding and to what degree. It is also possible to determine what flow routes the flood water would follow, establishing the position and extent of the flood protection works required at each site to protect neighbouring properties. The flood route mechanism also influences the choice of FRM measure proposed and the type of SUDS measure can also be determined from the outcome of this analysis. The following sections describe the flood defence measure by type detailing the process by which the most appropriate flood risk management measure has been identified.

Integrated Building Defences

6.8 Integrated Building Defences solely protect buildings within the developed site along with any associated key infrastructure or parking areas. They comprise a range of different structures, ranging from flood walls, earth embankments or the wholesale raising of ground levels on which the site is to be founded. All forms of these defences work by isolating the site from the flood water. Equally, this can lead to the site becoming cut off during a flood. Therefore, defence works often include raising the surface levels of service roads and the connecting public highway. Careful design can enable

integrated defences to be built into the landscape or incorporated into the building design to give them a more sympathetic, aesthetic appearance. In such instances, a low bund will be formed in the grounds of the development as a barrier to the path of floodwater, or sometimes taking the appearance of raised patio areas and pathways.

6.9 This type of defence is recommended where significant restrictions on the extent of the development site boundary were present.

6.10 In the absence of any viable strategic solution to flooding, the majority of defensive measures proposed come under the category of integrated building defence.

6.11 This approach to flood protection tends to be favoured by developers, due to the comparatively simple manner in which it can be applied, and the ease by which the necessary expenditure can be established and monitored. Its use in the Bath and North East Somerset Flood Risk Management Strategy is seen as a secondary recourse, with all efforts made to identify more imaginative approaches first.

6.12 The size and position of defences are determined by comparing the results of flood modelling against surveyed ground levels. This will determine the minimum height required of the flood defence, with its alignment selected to intercept flood routes. Once established, the integrated building defence should be placed in the original flood model to confirm its effectiveness.

Figure 6.1 – Raised Earth Embankment

Figure 6.2 – Raised Flood Wall

Figure 6.3 – Patio Based Feature

Flood Storage

6.13 Flood storage can only be applied to sites which cover a large area of land and lie adjacent to the watercourse, whether it is to be used as a playing field or car park. Some raised hard defences are required in order to contain water within the storage area; but this is often achieved by re-profiling the land to form earth bunds. Overspill weirs are also installed to ensure that the area fills in a steady manner and any water surplus to capacity is spilled back into the channel for effective flood management. Flood storage areas allow inundation of the developed site, but contain it within a carefully delineated area. This avoids the need to provide compensatory storage elsewhere, in mitigation of flood plain lost to the development. The advantages of this type of feature is that it can create a public amenity by improving its visual appearance through opening up the aspect of that area; the second advantage being that it can provide an opportunity for improved biodiversity in terms of habitat for birds, fish or plant life amongst others.

6.14 In cases where continued use of land is to be maintained during times of high flow, then a buried tank option can be considered at that location. This is particularly important with high profile playing fields, where ticket sales generate high revenues. Such an option would be appropriate for “The Rec”, Bath’s rugby ground.

6.15 Interrogation of the numerical river model can establish what proportion of excess flood flow will leave the river channel and cause inundation of the surrounding area. The duration of this period of excess flow can also be determined, as it is ultimately derived from the rainfall hydrographs also generated by this work. These two pieces of information can be used to determine the volume of flood flow that would need to be stored to prevent an area from flooding. It then remains to locate a site large enough to retain this excess flood water before it can reach the areas at risk of flooding.

6.16 Other important considerations are the elevation and length of side spill weirs, which would be installed in place of some sections of river bank, such that the flood detention area (FDA) will fill at the appropriate rate. If the FDA fills too quickly, it will have used up all its storage capacity before the worst of the floodwater comes through, allowing it to be conveyed to the areas at risk without any reduction in peak flow. By virtue of their function, FDAs need to be installed upstream of the area at risk of flooding.

6.17 The FDA then needs to be installed in the original flood model to ensure that it achieves the desired effect, or to determine whether further modifications are required.

Figure 6.4 – Flood Storage Area – Upstream Storage

Bypass Channel

6.18 Where a site lies next to a watercourse and is subject to flows crossing at times of high water levels, a bypass channel can be created to confine the flow of water to areas of low ground level, or confined between low walls. This effectively diverts the flow of water around a site and is only suitable for sites where the volume of flood water crossing the site is relatively small. A new watercourse can open up and improved the visual aspect of an area, create a new riverside footpath or cycleway (possibly contributing to a cycle network) and provide opportunities for water sports and fishing, and waterfront uses such as restaurants and moorings if navigable.

6.19 The need for a bypass channel has to be established by the determination of flood flow past an area prone to flooding. If it can be established that water flows across a site at a relatively shallow depth, then it is likely that this flow can be confined to an artificially constructed watercourse. This has the effect of increasing the conveyance capacity of the main channel; the same logic applies to establishing the viability of channel widening. Further criteria have to be assessed before such a feature can be established, however, these include verification that water levels downstream of the channel inlet are significantly lower than those at outlet, so that there is enough 'head' to push the diverted flow past the area at flood risk.

6.20 Once the layout and size of the bypass channel is established, it then has to be installed in the original flood model to check that it reduces flood levels in the manner intended.

Channel Widening

6.21 Where a site becomes inundated by high river levels, flooding can be avoided by effectively widening the channel through excavation of berms (steps) in the channel's bank. This reduces levels just enough to prevent them overtopping the riverside defences, thereby protecting property. It is prudent to combine this with some form of integrated building defence, especially where flooding from the River Avon is concerned as the flows experienced at times of flood are so great that channel widening has only a negligible mitigation effect. Consequently, this has only been proposed at certain sites downstream of Bath, where only a small reduction in river level is required to provide flood protection to a small number of individual sites. The constraint on this is one of available land, and whether its creation will reduce the area of land with the potential to be developed. It does, however, provide the opportunity to improve the riverside habitat.

6.22 The effectiveness of proposed channel widening as a flood management measure can be established by analysing numerical model results. If flood flows in a channel generate a small increase in water level when compared with the overall cross sectional area of the channel, then channel widening is generally a viable flood management solution. Again, confirmation is required by installing the modified channel width into the original model.

6.23 Widening is not always an effective solution if, for example, channel flow is fairly fast and flooding is caused by a downstream restriction creating higher water levels upstream then channel widening will have no effect; the restriction should be addressed in some other way (such as with a bypass channel, for example).

Compensatory Storage and Ground Re-profiling

6.24 Compensatory storage and ground re-profiling is not proposed as a means of protecting individual sites but as an opportunity to provide mitigatory storage in support of the development of a single site, or group of sites (depending on the area available). Several sites were considered for this, including Green Park. Proposed as part of a previous planning application for a design college, outside the scope of this study, this proposal would involve the remodelling of the ground contours within Green Park, to enable the site to be flooded in a managed way, at times of high river level. This inundation would only compensate for loss of flood plain by the development of the footprint within the "RBP to Travis Perkins" area, or of a similarly sized site slightly further downstream.

6.25 Larger sites have also been investigated for similar treatment for the potential to provide simultaneous storage for a number of development sites within Bath.

6.26 In certain circumstances it may not be possible to construct a compensatory storage for the following reasons;

- The area to be protected cannot generate sufficient benefits to offset the cost of flood alleviation or management works (this is often the case for developments not yet constructed); or,
- Construction of a flood management scheme is not technically viable.

6.27 When considering the viability of this approach for the purposes of flood mitigation both of the above concerns are potentially relevant. Flows in the River Avon at this location are so great that there is no upstream site large enough to accommodate a flood detention area of sufficient size. Also, the funding route for the technically viable scheme (raising flood defence works or a bypass tunnel) is not currently available to B&NES due to large costs involved when compared to the comparatively smaller value of flood damage that it would protect against. Normally, schemes of this size would have to be funded through application to Defra for Flood Defence Grant in Aid. However, the B&NES FRMS is a strategy based around the development of existing sites and not the protection of the city as a whole. This means that the only funding route currently available is by levying charges on developers and other Council budgets.Compensatory storage would only provide sufficient storage to compensate for loss of flood plain caused by development within the flood plain (mainly, flood zone 3). This flood management strategy is justified under the requirements of Policy 5 of the Avon Catchment Flood Management Plan. Such compensatory storage areas are a notional flood management provision and are sized in direct comparison with the volume of floodwater displaced from the flood plain by the development footprint, or accumulated displaced volume of several developed footprints, inconveniencing conurbations further downstream. Such developments would still need individual building defences to actually protect them from an incidence of flooding.

6.28 The advantage of forward funding a compensatory storage area for the cumulative development sites is that it reduces the constraints placed on the developer, allowing greater flexibility in the delivery programme. Once the storage area has been constructed, a developer is free to construct any shape or extent of development footprint they so wish (other planning constraints not withstanding). Furthermore, should only half the total number of development sites constructed in the short term, then a smaller compensatory storage area could be constructed, and extended once the future development programme can be established. The first phase of the storage works construction would be the more expensive as it requires the formation of the inlet structures and remodelling of riverside margins to ensure that existing habitats are preserved, or extended.

6.29 Appendix L provides a sketch of a possible compensatory storage area

Figure 6.5 – Compensatory Flood Storage – Rural Location

Glazed Flood Barrier

6.30 A glazed flood barrier (refer to figure 6.6) would be appropriate to just one site; the Empire Undercroft covered stone walkway. As this was a narrow corridor, subject to inundation (along with the small business premises for which it provided access to) it is sufficiently narrow to justify a single raised, parapet to act as a flood wall. Given its location, and the relatively low level of water it needed to protect against, a glazed flood wall would enable the undercroft to remain in use during times of flood and to retain the vista enjoyed by the pedestrians using it. Were it to protect a wider corridor, some form of mitigatory storage would have to be provided. The height of the glazed wall required at this location is some 2m, making it an impractical solution for more general applications outside of those areas requiring more aesthetic treatment (due to high cost).

Figure 6.6 – Glazed Flood Barrier

Preservation of Infrastructure

6.31 The preservation of infrastructure is a key consideration in the design of any flood management measure. When such measures are designed it is easy to overlook the need to protect public infrastructure and transport routes, without which habitation and use of a developed site would not be viable. Consequently, assessments of flood routing and extent must also establish whether transport routes would become jeopardized during a flood event. Similarly, important utilities such as power and foul sewerage must be protected, along with telecoms where, commercial premises are concerned.

6.32 The current a standard of protection of the Lower Bristol Road is estimated to be less than 1 in 20 years (5%AEP) and there have also been several recorded incidents of flooding in the past 50 years. This is a main communication route through the City, causing disruption at times of flood, and the main access to several of the proposed development sites. A lack of dry access to sites during a flood event renders those sites undevelopable. Dry access can be provided by either improving protection of the existing road or through alternative access routes such as elevated footways.

6.33 There are some development sites which would not be directly affected by flooding but which would be rendered undesirable for development due to loss of communication routes serving them, during times of flooding. This mainly applies to the Lower Bristol Road, which becomes inundated during times of high river level. Whilst these properties would remain unaffected by flooding, access, particularly vehicular access could be constrained or even denied at times of flood, potentially leading to loss of revenue for businesses during such periods Consequently, flood defence works would need to be undertaken to either ensure that the road and footpaths are isolated from flood water (such as raising kerb levels and road crest heights) or by installing pedestrian access bridges at key routes to the town centre or transport hubs (via the Midland Road Bridge, for example. One option could be to implement a water taxi service, extending a canal branch if necessary.

Sustainable Urban Drainage Solutions and Selection Methodology Used

6.34 Sustainable Urban Drainage has been proposed for all development sites for reasons of sustainability and good practice. Providing attenuation to stormwater run-off at every site will, at the very least, reduce the likelihood of the surface water drainage systems becoming surcharged and causing the flooding of roads and property by a secondary source (as opposed to river water going

out of banks being the primary cause). It will also delay stormwater run-off contributing to flows in the river during times of spate.

6.35 Furthermore, many of the drainage features considered have the potential to improve biodiversity or amenity of the area. Predominantly, this would be achieved through the provision of ponds, swales and attenuation areas these would create an improved habitat on the site, mainly benefiting birdlife.

6.36 In order to determine a site's suitability for SUDS installations, and to identify the type of installation that would be most effective, the physical and historical data available for the site must first be assessed, including;

- Position within a flood zone;
- Type of site (i.e. brownfield or greenfield);
- Present or Intended use of site;
- Size of site;
- Gradient of ground surface;
- Presence of groundwater table;
- Site within a general or special permitted development zone;
- Permeability of ground and ground surface;
- Presence of watercourse within the site;
- Position of nearest public (surface water) sewer;
- Whether development is located on a landfill site.

6.37 All the above determine what manner of drainage system can be employed, not just to ensure successful functionality of the SUDS installation but to ensure that there is no seepage of contaminated material into the surface water sewer system, watercourses or groundwater table. The main types of SUDS installations that can be employed are outlined below.

Below Ground Storage

6.38 Below ground storage temporarily stores surface water run-off (for example from roofs, impermeable ground surfaces) in underground storage tanks, delaying discharge to the public water system, or watercourse until the storm peak has passed. Alternatively, the main secondary benefit could be the re-use of the stored water for irrigation during dry periods.

6.39 The main consideration for using such an installation is whether there is enough room on the site to incorporate a tank of adequate capacity. The finished tank will not take up any room on the surface but will be buried. There is a cost implication for the development of larger tanks and additional considerations such as ensuring flow does not back up into the tank from the discharge point causing flooding through an indirect route and a pollutant interceptor if there is risk of contamination (i.e. from parked cars).

Wetland Area

6.40 Wetland areas provide temporary storage of surface water run-off until such time as flows abate and provide improvements in biodiversity. Figure 6.7 illustrates a wetland area provided in a Bristol business park.

Figure 6.**7 –** Wetland Area

This type of installation is vulnerable to contamination by polluted surface water run-off. A large enough wetland area can also serve as a flood detention pond for incoming flood water. For such a feature to work, the profile of the surrounding ground levels needs to be suitable, although some re-grading of local ground levels can be undertaken. If the site is a brownfield site, or is located on land previously used for landfill, care is needed to ensure that water retained in the pond does not become contaminated, ultimately discharging polluted water into the nearest watercourse or sewer. Such a feature would operate most effectively if it were connected into the local watercourse system and should be sized according to the surface area of the site in order to be effective.

Infiltration SUDS - Soakaway

6.41 Soakaways collect surface water run-off allowing it to slowly permeate into the groundwater table. Suitability of the site should be assessed prior to selecting this type of feature. A soakaway would avoid the need to connect into the public sewerage system and thereby help reduce the risk of surface water drains becoming surcharged and inconveniencing site users or neighbouring properties. A soakaway cannot be installed on ground that is suspected of being contaminated as there is a risk of pollution, particularly of heavy metal toxins, being washed into the groundwater table. On a more practical level, soakaways are unable to operate where there are high groundwater levels as the water would not drain away. The site also has to be large enough to support the function of a soakaway, as these require a minimum radius of permeable, surrounding material to ensure that the collected water can seep away at a sufficiently high rate of flow, sized in relation to

the surface area of the site. A typical construction detail for a SUDS soakaway arrangement can be seen in figure 6.8 which demonstrates how run-off from permeable paving can be collected (in the gravel filters which can then be collected in a soakaway (unseen in this image), Other forms of soakaway include manhole chambers with permeable sides and bases where water collected from a surface water drainage network is allowed to seep into the surrounding soils in a controlled manner.

Figure 6.8 **– Infiltration SuDS (Permeable Paving and Filter Strip)**

Bio-retention Filter Bed

6.42 Bio-retention filter beds are a more natural form of soakaway and most commonly take the form of planted wetland (see figure 6.9, for an installation provided in an urban development scheme in Northamptonshire). As the water collected soaks into the surrounding ground the same issues apply to filter beds as do wetlands and soakaways, where run-off is directed into an above ground planting area, and water then percolates into the groundwater table.

Figure 6.9 – Bio-retention Filter Bed

6.43 One advantage of filter beds is that they can remove sediments from surface water run-off, effectively cleaning the water of coarse contaminated material. These installations may require cleaning out annually to remove accumulated contaminated material. No contaminated material can be present in the surrounding ground as water may percolate back up into the filter bed overwhelming it with contaminants rendering it ineffective and requiring frequent cleaning out by a specialist contractor. As with the wetland and soakaway, the feature has to be sized to accommodate the surface area of the development site and the ground has to be permeable with a low enough water table and of suitable ground profile to ensure the successful operation.

Filter Drain

6.44 Filter drains provide an alternative form of road gulley, collecting run-off in a trench lined with a membrane and filled to surrounding ground level with shingle. Water then either percolates into the underlying ground or continues along the drain to a purposely made connection with a watercourse or swale. This coarse filtering helps improve water quality and can halt the progress of pollutants in the case of an emergency spillage. In this instance the shingle would need to be disposed of as contaminated waste and replaced with a clean material. Figure 6.10 shows a discretely formed filter drain at the top of the slope to the swale in an urban development scheme in Northamptonshire. This provides an obstacle to pavement run-off flowing directly into a swale. This would be carried on through the surface water management system and then entering the swale, providing opportunity for interception were the possibility of contamination to flows a concern.

Figure 6.10 – Filter Drain

6.45 The selection of this feature depends on the site arrangement and on the permeability of the ground. If the ground is not permeable, a filter drain would need to discharge into a watercourse or a surface water sewer. Both of these require a mechanism to prevent flow backing up the drain at times of sewer surcharge or high river levels. Similarly, its successful operation requires low groundwater table and no buried contaminants. Filter drains also need to be sited at low points within the ground contours in order to successfully collect the water and provide the appropriate fall for flow to drain to a suitable discharge point. This feature can collect contaminants carried by surface water run-off, which is a consideration for car parking areas.

Swale

6.46 A swale is effectively a widened grass lined gulley, which both collects run-off and temporarily retains it, by virtue of its large cross section. Figure 6.11 shows an example of a swale used in an urban development scheme in Northamptonshire. This can only provide a brief period of attenuation and have to be sized such that it can provide a sufficiently large storage volume for the area served. Swales require ground of low permeability in order to hold water for the detention period. A high water table would cause them to permanently retain water, using up their potential storage capacity.

Figure 6.11 – Swale

6.47 A watercourse or surface water sewer needs to be fairly close to provide a discharge point and a mechanism should be provided to prevent flood water backing up from the discharge point and causing flooding. Again, this feature can be prone to the accumulation of pollutants carried in surface water run-off.

Above Ground Storage

6.48 Surface water drainage, such as culverts and pipes discharge into a purposely formed hollow in the ground (refer Figure 6.12 showing a business park development site in Swindon) providing medium term attenuation, particularly during times of high river level. Generally, the storage area has an outlet, typically served by a flap valve at outlet which will drain the pond once river levels drop. This will not only provide an enhanced habitat for smaller wildlife but will also provide a refuge during times of otherwise high flow in the river system.

Figure 6.12 – Above Ground Storage

6.49 Above ground storage is affected by the same constraints as a swale. The main issue being that such a feature requires a large area in order to ensure that its capacity is sufficient for the surface area of the site. The ground must have low permeability, too, although a lining could be installed to prevent the storage area from draining.

Porous Surfaces - Permeable Paving

6.50 Surfacing car parks with a permeable material and an underlying impermeable membrane will allow rainfall to be collected and diverted into any of the storage features outline above. Ideally, the collected water should pass through a petrol interceptor first, to collect hydrocarbons left behind by vehicles. Figure 6.13 shows the manner of construction typically adopted for the construction of permeable paving installations. In the example shown, the surface water gravitates through the formation layers of the paved surface where it is intercepted by a permeable membrane and collects in a manhole chamber to be taken to away to a suitable discharge point.

Figure 6.13 – Permeable Paving installation

6.51 As this feature works by infiltration, the same considerations should be given as with a filter bed or drain; whether the ground permeable enough, whether it contaminated (such as with ex-landfill sites or some brownfield sites); and whether the area of the development and its layout support use of permeable paving. A waterproof membrane can be installed so that water permeating through the permeable surface is collected and discharged into a nearby sewer or, with appropriate treatment, a watercourse.

Green Roofing

6.52 Green roofing relates to building roofs formed of a grassed fabric, or sometimes a seeded layer of topsoil (refer Figure 6.14). This delays run-off of rainwater into the gulley and downpipe system, and also feeds the grassed area, which provides thermal insulation to the building as a secondary benefit.

Figure 6.14 – Newly-planted Green Roof

6.53 This type of rainfall interception system is suitable for most locations where the only real consideration is whether the roof is positioned in the shade, hindering establishment of the grasses. As is reflected in the costing process, the unit area cost of installing a grassed roof increases as the area of roof increases. This is due to the weight of the roof increasing and requiring additional support or reinforcement. Similarly, the number of connection points with the gutter system would need to increase as the seepage rate of water in the grassed material is too slow to be accommodated by a normal bottom collector (such as a gutter) which would raise a risk of slumping of the saturated soil. Therefore, intermediate pick-up points for the drainage would be needed.

Conclusion

6.54 The appropriate SUDS solution for each site was identified using a pro-forma assessment technique, which considers; site area, slope, intended use, previous use (e.g. brownfield), groundwater conditions and permeability, proximity of a watercourse, surface water sewers and any landfill sites.

6.55 The type of Flood Risk Management and Sustainable Urban Drainage measures proposed for each sites can be found in Appendix H [site specific flood risk management and SUDS recommendations] and in Appendix I [site specific reports] and Appendix J [option cost breakdown which describes the options proposed, key quantities of construction works elements, construction cost rates and the final estimate of capital cost].

7. Implementation and Delivery Strategy

7.1 This section sets out the implementation and delivery strategy for the flood risk management strategy.

Background

7.2 The Revised PPS12 (June 2008) sets out Government guidance on Local Development Frameworks. The document is clear that core strategies '*should be supported by evidence of what physical, social and green infrastructure is needed to enable the amount of development proposed for the area, taking account of its type and distributions. This evidence should cover who will provide the infrastructure and when it will be provided. The Core Strategy should draw on and in parallel influence any strategies and investment plans of the local authority and other organisations.'*

7.3 The infrastructure planning process should identify, as far as possible:

- The infrastructure required to support development;
- Infrastructure needs and costs;
- Phasing of development;
- Funding sources and gaps in funding; and
- Responsibilities for delivery.

The PPS also states that Core Strategies must be effective;

- Deliverable;
- Flexible; and
- Able to be monitored.

7.4 The proposals set out in this flood risk management strategy both facilitate the deliverability of development proposals and must be deliverable themselves. This section of the report therefore considers the measures necessary to ensure that the flood risk management proposals are fully deliverable within the life of the Core Strategy.

Infrastructure Required to Support Development

7.5 The type of flood management infrastructure required to support individual developments is set out in Appendix I for all major development sites in the District. This Appendix also includes recommendations for Sustainable Urban Drainage Systems for each development site.

7.6 This study has provided an assessment of the flood risk management and SUDS infrastructure required to accompany development of those sites in the District which are at risk from flooding. A breakdown of the costs of the flood management infrastructure required to support development as provided in Appendix J.

7.7 The costs of infrastructure and the effect of these costs on overall development viability have been considered. In the absence of a flood risk management strategy the Environment Agency policy normally recommends that development proposals accommodate a volume of storage within the boundary of the site to avoid displacing flood risk to other neighbouring or downstream locations.

7.8 Within Bath the opportunity exists to provide some upstream compensatory storage in several locations. An analysis has been undertaken to compare the costs of mitigating flood risk on-site vs providing the flood storage component within a strategic upstream storage location.

7.9 It was found that of the sites requiring flood storage the upstream storage option is less costly than providing flood storage on-site in all cases. For around 55% of sites the inclusion of an off-site compensatory storage reduced costs significantly (by approximately 50%). This significant cost factor underpins the case for including an upstream storage component within the strategy.

Phasing of Development

7.10 Off-site flood management infrastructure must be in place before development sites progress the construction of on-site flood defences. The upstream compensatory storage site should be prepared for flood storage within the first five years of the Plan period.

7.11 Of those sites which would benefit from upstream storage there is no certainty that all of the sites identified would be developed over the development plan period. Therefore the costs of delivering any strategic flood management infrastructure should be linked with those sites which are expected to come forward over the plan period.

Delivery Mechanisms and Funding

7.12 The main delivery mechanisms for flood management infrastructure required to support development are:

- Site based flood risk assessments; and
- Planning obligations.

7.13 Both of these mechanisms are discussed in more detail below.

7.14 There needs to be reasonable certainty and confidence that there is a funding strategy in place to deliver the necessary flood defences to protect all new development. There are two key sources of funding:

- Funding from new development (developer contributions and planning conditions); and
- Public funding to support regeneration by facilitating infrastructure (Regional Infrastructure Fund, Regional Funding Allocation, HCA, EA).

Developer Contributions and Planning Conditions

7.15 PPS25 advises that, in certain circumstances, to meet the wider aims of sustainable development, it may be necessary to permit development that requires the provision of flood risk management, including defence and mitigation works. Such provision will generally be funded by the developer, and is only acceptable provided it is consistent with the relevant flood-risk management policies, passes the sequential and exception tests and does not have a significant adverse impact on flood flows or storage.

7.16 According to PPS25, where flood risk management works are required to mitigate the risk of flooding to a proposed development or increased risk at other locations, the Council and the developer should have regard to the following considerations regarding the contributions developers should make:

- Developers cannot normally call on public resources to provide defences and other measures for their proposed developments where they are not already programmed for the protection of existing development;
- Where previously programmed defences and other measures have already been provided at public expense to protect existing development, these may also provide opportunities for new development, provided this does not itself add to flood risk at other locations;
- For some previously developed land, public investment in land remediation and infrastructure may include an element of flood defence and mitigation investment as a means of bringing such land into beneficial use;

- Where the two preceding considerations do not apply but where other material considerations outweigh the risk of flooding, any necessary flood risk management, including defences or flood alleviation works required because of the development or which form a part of that development should normally be fully funded by the developer;
- Authorities may wish to consider entering into an agreement under Section 106 of the Town and Country Planning Act 1990 to ensure that the developer carries out the necessary works and that future maintenance commitments are met. They may also apply planning conditions which would require completion of the necessary works before the rest of the development can proceed;
- A dedicated commuted sum to fully fund whole life maintenance may be required to ensure the Local Authority can adopted the flood risk management measures;
- Where such works would provide a wider benefit, the funding provided by developers may be proportional to the benefits to them;
- After application of the above and all other relevant considerations the local planning authority, having taken advice from the Environment Agency and any other relevant operating authority, should negotiate an appropriate contribution from the developer. If agreement cannot be reached on the provision of that contribution or the provision of adequately sized and suitable on site mitigation, the application should be refused.

Regional Infrastructure Fund

7.17 The South West Regional Infrastructure Fund (RIF) is a rolling infrastructure fund operated at the regional level for which regional partners are held accountable. Its primary purpose is to facilitate the timely provision of regionally or sub-regionally significant infrastructure that supports the delivery of planned growth as set out in the Regional Spatial Strategy and/or the Regional Economic Strategy.

7.18 There is potential for the RIF to be used to help forward fund major infrastructure schemes, in situations where the anticipated public or private funding for the scheme will not be available in full at the time when the infrastructure is needed to support planned growth or development. The cost of the capital investment would then be recovered using a claw-back mechanism from pre-determined public and/or private funding streams as they become available.

7.19 The Regional Infrastructure Fund is a possible source of funding for the strategic flood storage required. The scheme meets the general, strategic, financial and process criteria set out in the 'Scheme Criteria and Operating Procedures' guidance. The Fund would pay for the development of the flood storage scheme and then require developer contributions from new development to recover the costs.

Recommended approach

Funding of Upstream Storage

7.20 It is recommended that off-site upstream storage should form part of the flood risk management approach for Bath. The upstream storage scheme could be part funded by the Regional Infrastructure Fund with the Environment Agency input through the regular bidding process. The Council would also be a key partner as landowner especially as several of the sites which the scheme would benefit are Council owned.

7.21 It is recommended that the scheme should be forward funded as a priority infrastructure project for the city in order that it can begin meeting the needs of sites coming forward for development. It is recommended that the costs of the scheme are apportioned on the basis of the volume of water storage which a strategic scheme would provide in compensation for specific sites.

7.22 This should be implemented by applying the following formula which ensures that each site contributes an appropriate proportion of the £300,000 total cost of the scheme:

Financial contribution of each site = (volume required to protect each Development Site, cu.m.) x ((£300k / (combined total volume required for protection))

7.23 Based on the inclusion of all sites which would benefit from upstream compensatory storage the average cost is estimated to be in the region of £90per 100 cubic metres. These figures are based on the available flood modelling, current rates of inflation and reasonable estimates of construction costs and so should be revisited once the scale of Bath and North East Somerset Council's flood mitigation strategy is finalised and construction costs can be more accurately identified.

7.24 It is possible that not all sites identified may come forward for development. The design and phasing of the scheme should provide for sites where there is a prospect of development (i.e. sites within 5-10 year housing land supply or where known proposals exist in the case of commercial development). If it is found that a smaller scheme is required then the cost of such a scheme would be reduced.

7.25 Cost recovery could be realised through a standard charge on a £/cubic metres basis through a development tariff or planning obligation. This amount can then be disbursed back to the RIF/scheme funders. Further guidance on planning obligations is provided within the Council's Developer Contributions SPD.

On-site flood management infrastructure

7.26 Where the upstream compensatory storage solution is not applicable the Council should seek guidance from the Environment Agency on whether a proposed development on a flood plain will require flood defences or a sustainable urban drainage scheme. Where this is necessary, in accordance with PPS25, the Council will require developers:

- To fund the full cost of flood defences needed as the direct consequence of a proposed development, whether to protect the development itself or mitigate the likely consequential impacts of the development on other properties.
- To provide a commuted maintenance sum sufficient to fund maintenance for 30 years enabling the Local Authority to adopt the flood defence or Sustainable Urban Drainage System in perpetuity;
- To fund an appropriate proportion of the costs of flood defences needed partly to protect a proposed development and partly to protect other land or existing properties where there is no consequential impact of the proposed development on that land or existing properties;

Responsibilities for Delivery

7.27 The agencies with responsibility for delivering the flood management infrastructure identified in this study are:

- Bath and North East Somerset Council;
- The Environment Agency; and
- Developers and landowners.

Bath and North East Somerset Council

7.28 Bath and North East Somerset Council is the Local Planning Authority for the District and is therefore responsible for preparing local planning policies and for processing and making decisions on planning applications. In carrying out this work the Council is required to have regard to national planning policy set out in Planning Policy Guidance Notes and Planning Policy Statements. This includes PPS25, which requires Local Planning Authorities to take a risked based sequential approach to managing flood risk and development within the District. As a result, the Council is responsible for applying the sequential test and exception test to development proposals.

7.29 The Council is required to consult with the Environment Agency on certain development proposals located in Flood Risk Zones 2 and 3 and does so as a matter of course. The Council takes great

heed of the Environment Agency's specialist advice on flood risk matters and as part of consultations submits flood risk assessments to the Agency in order to ensure that they respond adequately to the flood risk posed. In most cases the Council will refuse planning applications where the Environment Agency is not satisfied that the Flood Risk Assessment or flood risk measures proposed within it are inadequate.

The Environment Agency

7.30 The Environment Agency manages flood risk through the implementation of flood management plans and physical measures such as flood defences. While the Environment Agency has powers to require appropriate maintenance of flood defences, they are under no statutory obligation to carry out such works, which generally remain the responsibility of the riparian landowner.

7.31 They work to reduce the probability of flooding from rivers and the sea through the management of land, river systems, and flood and coastal defences. The Agency also seeks to reduce the damage floods can do through effective land use planning, flood warning and emergency responses. Due to the potential impacts of climate change, the EA now plays a crucial role in ensuring that necessary adaptations to the expected changes in sea level, risk of flooding and water resource management are recognised and managed.

7.32 As a result the EA is a statutory consultee on certain planning applications within flood zones 2 and 3. The EA provides technical advice to Local Authorities when dealing with such applications and have the power to request the Secretary of State to call in decisions made by a Local Authority where it is contrary to their advice.

7.33 The EA also provides technical advice on flooding to developers and has prepared standing advice on the requirements of Flood Risk Assessments. Developers are advised to refer to both local planning guidance and the EA's standing advice before designing any development in Flood Risk Zones 2 and 3.

Landowners and Developers

7.34 With regard to flood risk management, PPS25 is clear in establishing the roles and responsibilities of land owners and developers. The primary responsibility for safeguarding land and property from flooding lies with the land owner and those proposing development are responsible for the following:

- Demonstrating that the proposal is consistent with PPS25 and the flood risk management policy in the Core Strategy;
- Providing a flood risk assessment that meets with the requirements of PPS25, the Environment Agency and this FRMS;
- Providing information to the Council that supports the application of the sequential test and the exception test;
- Designing the development so as to reduce the risk of flooding on the site and elsewhere, by incorporating sustainable drainage systems and where necessary flood resilience measures; and
- Identifying opportunities to reduce flood risk, enhance biodiversity and amenity, protect the historic environment and seek collective solutions to managing flood risk.

Flexibility

7.35 The PPS12 flexibility test states that a strategy is unlikely to be effective if it cannot deal with changing circumstances. Core Strategies should look over a long time frame therefore plans should be able to show how they will handle contingencies.

7.36 This flood risk management strategy considers all potential major development sites in the District and is innately flexible as to the actual sites which could be developed during the Plan period.

Furthermore, Appendix I provides a range of different flood management options for many sites, providing flexibility in the flood risk infrastructure that could be developed at each site.

7.37 Were compensatory storage to be provided by forward funding, for example, this would improve the attractiveness of the Bath sites to developers. Compensatory storage sites would have to be situated upstream of Bath to ensure that, at the very least, this strategy would withstand scrutiny. The excess floodwater displaced by future developments would need to be abstracted upstream of the development sites in order to prevent incremental increases in flood risk as flows continue downstream.

Monitoring

7.38 Effective monitoring and review is essential to reducing and managing flood risk and understanding the success of the implemented strategy. The Council could monitor:

- The number, and outcome, of applications subject to an FRA;
- The level of developer contributions associated with flood risk management being achieved;
- The time taken for decisions where a planning obligation associated with flood risk management has been agreed as part of the application;
- The delivery of flood defence infrastructure; and
- The effectiveness of flood defence infrastructure

7.39 It will also be necessary to monitor the implications of changing climate change forecasts and to assess whether these will require a review of the proposed flood defence strategy. The Environment Agency will be expected to undertake this role.

Development Management

7.40 The Council will apply a criteria based policy to development in areas of flood risk. Development will only be permitted if it can be demonstrated that:

- It would not have a significant impact on the capacity of an area to store floodwater;
- It would not impede the flow of surface water or obstruct the run-off of water due to high levels of groundwater;
- Measures required to manage any flood risk can be implemented;
- The management of surface water is done in a sustainable way;
- Provision is made for the long term maintenance and management of any flood protection and/or mitigation measures;
- The benefits of the proposal to the community outweigh the flood risk.

7.41 In areas of flood risk, Flood Risk Assessments will be required to be submitted to demonstrate how risk from all sources of flooding to the development itself and flood risk to others will be managed. The proposed development will be safe without increasing flood risk elsewhere and, where possible, will reduce flood risk overall.

7.42 Furthermore, all new development on sites assessed as part of this study will need to contain SUDS (see Appendix K), in line with Environment Agency standing advice.

Pre-Application discussions

7.43 Development in flood risk areas is often complex and requires a sensitive approach. Engaging in pre-application discussions at an early stage in the process is essential to avoid unnecessary costs and time delays at the planning application stage.

7.44 Proposers of development which may be affected by, or may add to flood risk should arrange pre-application discussions with the Council and the Environment Agency, and, where relevant, other bodies such as Internal Drainage Boards, sewerage undertakers, highways authorities and reservoir owners and operators. Such discussions should identify the likelihood and possible extent and nature of the flood risk, to assist in scoping the FRA and identify the information that will be required by the Council to reach a decision on the application when it is submitted. The Council will advise intending developers to undertake these steps where they appear necessary, but have not yet been addressed. Council planning officers can also advise on whether financial viability assessment should be submitted with the proposals for major developments.

7.45 Prior to submitting a planning application, the applicant should fully consider the impacts of the proposed development and any planning conditions or obligations to mitigate those impacts.

Preparing Planning Applications

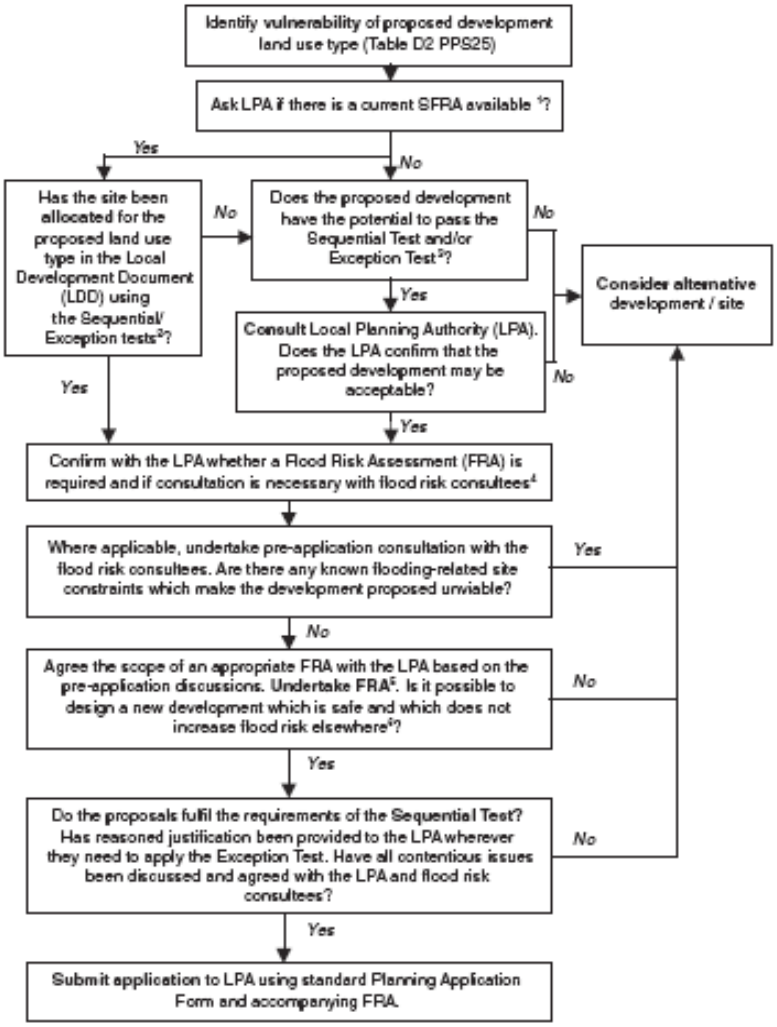
7.46 Planning applications for sites identified within this study and any other proposals for development located within areas at risk of flooding should be accompanied by a site level flood risk assessment. As part of the assessment the strategic and site level flood risk management options should be considered.

Risks to Successful Delivery

7.47 The risk to successful implementation of the recommendations in this flood risk management strategy is dependant on their timely delivery and the surety that they will be appropriately observed. The following outlines these risks in more detail and serves as a checklist for the Council's planning process:

- Construction of compensatory storage area does not take place. As a consequence sites would have to deal with compensatory storage on a site-by-site basis which would reduce site capacity and viability and in some cases may make sites undevelopable;
- Compensatory storage area is not functional before the construction of the development sites commences. Loss of income to the compensatory storage area, potentially increasing costs against the remaining development sites;
- Any sites proposed for the construction of a compensatory storage area should be carefully investigated in advance in case technical issues mean that particular site proves unviable. Detailed assessment may reveal further issues;
- The Developer does not construct the finished works in accordance with the advice of the Site Specific Reports. The planning process will require submission of drawings describing the finished works and this would be the means of managing this risk;
- Technical factors prevent phasing of compensatory storage area construction; cost of soil disposal/haulage combined with construction cost overheads make total construction cost greater than the levy figure which can reasonably be/already has been charged to the developers, changes in environmental/waste legislation lead to a prohibitive construction cost increase or works are no longer permitted.

Figure 7.1 – Taking Flood Risk into Account in the Preparation of Planning Applications



Flood Risk Assessments – General Principles

7.48 At planning application stage, it may be appropriate for a Flood Risk Assessment (FRA) to be submitted, demonstrating how flood risk from all sources of flooding to the development itself and flood risk to others will be managed now and taking climate change into account. Figure 6.1 shows the process of preparing FRA.

7.49 The purpose of FRA is to demonstrate whether any proposed development is likely to be affected by current or future flooding from any source in order to satisfy the Local Planning Authority that the development is safe and wherever possible reduces risk of flooding overall. The FRA should also demonstrate that the development will not increase the risk of flooding elsewhere.

7.50 Developers are advised to refer to further guidance in this FRMS on preparing Flood Risk Assessments, and to the Environment Agency's Flood Risk Standing Advice.

7.51 PPS 25 provides general guidance on FRAs and details the minimum requirements. Flood Risk Assessments should:

- Be proportionate to the risk and appropriate to the scale, nature and location of the development;
- Consider the risk of flooding arising from the development in addition to the risk of flooding to the development;
- Take the impacts of climate change into account;
- Be undertaken by competent people, as early as possible in the particular planning process, to avoid misplaced effort and raising landowner expectations where land is unsuitable for development;

- Consider both the potential adverse and beneficial effects of flood risk management infrastructure including raised defences, flow channels, flood storage areas and other artificial features together with the consequences of their failure;
- Consider the vulnerability of those that could occupy and use the development, taking account of the Sequential and Exception Tests and the vulnerability classification, including arrangements for safe access;
- Consider and quantify the different types of flooding (whether from natural and human sources and including joint and cumulative effects) and identify flood risk reduction measures, so that assessments are fit for the purpose of the decisions being made;
- Consider the effects of a range of flooding events including extreme events on people, property, the natural and historic environment and river and coastal processes;
- Include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular development or land use;
- Consider how the ability of water to soak into the ground may change with development, along with how the proposed layout of development may affect drainage systems; and
- Be supported by appropriate data and information, including historical information in previous events.

Site Specific Flood Risk Assessments

7.52 At the planning application stage, an appropriate FRA will be required to demonstrate how flood risk from all sources of flooding to the development itself and flood risk to others will be managed now and taking climate change into account. FRAs should be submitted with planning applications in areas of flood risk.

7.53 Planning applications for development proposals of 1 hectare or greater in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 should be accompanied by a FRA. This should identify and assess the risks of all forms of flooding to and from the development and demonstrate how these flood risks will be managed, taking climate change into account.

7.54 For major developments in Flood Zone 1, the FRA should identify opportunities to reduce the probability and consequences of flooding. A FRA will also be required where the proposed development or change of use to a more vulnerable class may be subject to other sources of flooding or where the Environment Agency, Internal Drainage Board and/or other bodies have indicated that there may be drainage problems.

7.55 The FRA should be prepared by the developer in consultation with the Council. The FRA should form part of an Environmental Statement when one is required by the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 as amended.

Appendix A
Study Brief

Appendix B
Proposed and Discounted Options Tables

Appendix C
Site Options Spot Maps

Appendix D
Economic Appraisal

Appendix E
High Level Options Appraisal

Appendix F
Appraisal Score Criteria

Appendix G
Traffic Light Matrix

Appendix H
Flood Risk Management Options Table

Appendix I
Site Specific Flood Risk Management and SUDS Recommendations

Appendix J
Option Cost Breakdown

Appendix K
SUDS Site Assessments and Indicative Costings

Appendix L
Development Site and Compensatory FDA Location Plans

Appendix M
Consultation Findings