Environment Agency

Bucklebury Flood Alleviation Scheme

Flood Risk Assessment

Revision A

Project Ref: 20627/005

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July 2010

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Environment Agency

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Revision	Date	Description	Prepared	Reviewed	Approved
-	30/07/2010	Issue to accompany planning application submitted to EA	A. Bamford	A. Hensler	S. Capel-Davies
A	14/09/2010	Updated Section 5.5: Flood Storage and Flow Routes			

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Contents

Tables

Figures

Appendices

Executive Summary

This Flood Risk Assessment has been prepared by Peter Brett Associates LLP (PBA), in liaison with the Environment Agency (EA), to support a planning application for the proposed works associated with the Bucklebury Flood Alleviation Scheme (FAS) in the village of Bucklebury, West Berkshire.

Following an extensive period of data collection and analysis, model construction, options testing and stakeholder consultation, PBA, on behalf of the EA, has been able to identify a programme of works to protect property and infrastructure in Bucklebury from fluvial flooding for events up to the 1 in 100 year flood event (including a suitable allowance for climate change), without detrimentally affecting other settlements within the catchment. The proposed flood alleviation scheme does not afford protection from flooding from groundwater or surface water flooding. The programme of works includes the following phases:

- Bucklebury Village Defences – A series of works to protect the village from direct flooding; and
- Downstream Works – Works to ensure that the downstream community of Stanford Dingley is not adversely affected by the Bucklebury defences.

The report has been prepared in accordance with the guidance set out in Planning Policy Statement 25 (PPS25) Development and Flood Risk, Annex E and summarises the methodology and results of the assessment.

In considering the proposals the following key principles have been applied:-

- Vulnerability to flooding from all sources;
- Protection of residents and property within Bucklebury; and
- No increased flood risk to third parties as a result of the proposed works.

1 Introduction

Peter Brett Associates LLP (PBA), Consulting Engineers have been appointed by the Environment Agency (EA) to undertake a Flood Risk Assessment (FRA) to support the planning application for the proposed works associated with the Bucklebury Flood Alleviation Scheme (FAS) in and around the village of Bucklebury, West Berkshire.

This FRA has been undertaken based on the following guidance:

- Planning Policy Statement 25 (PPS25) 'Development and Flood Risk', originally issued by the Department for Communities and Local Government on 7th December 2006 and updated in March 2010[1];
- The accompanying 'PPS25: Development and Flood Risk: Practice Guide' was issued in June 2008 and updated in December 2009; and
- Flood Risk Standing Advice (FRSA) for England – PPS25 National Version 2.0, issued by the Environment Agency in February 2009.

This FRA examines the potential impact of the proposed works on the flood risk within the study area.

The primary driver for the scheme is to protect property and infrastructure in Bucklebury from fluvial flooding, following flooding of a number of properties in July 2007. The scheme has been designed with a standard of protection (SoP) of 1 in 100 year flood event (including a suitable allowance for climate change) in agreement with the Environment Agency and residents.

The key objective of the scheme is to provide economically and technically sound fluvial flood defences which provide an adequate level of flood protection for properties at risk in Bucklebury, with minimal adverse environmental effects and no detriment to flood risk for other settlements. It is worth noting that this scheme is to provide protection to the existing dwellings and not to facilitate any new development.

Hydrodynamic modelling has been undertaken by PBA, to establish the baseline and proposed option scenarios. A copy of the Bucklebury FAS Modelling Report is included in Appendix 4 of this document.

The proposed scheme incorporates the following elements (see Section 5 for full details):

- A grassed embankment (Playing Field Bund & Marlston Road Bund) to the west of Bucklebury on the right bank of the River Pang, between the proposed in-channel control structure (see below) and existing high ground;
- An in-channel structure to restrict flow in the River Pang through Bucklebury;
- A 5 metre wide bypass channel which lies to the north of the River Pang and incorporates a bund on its southern side (Bypass Channel Bund) to prevent water flowing back into the village;
- Localised raising of ground levels along the right bank of the River Pang, downstream of the in-channel control structure, to prevent water spilling out in the village during a flood event;

[1] PPS25 builds on the previous guidance contained in the Planning Policy Guidance Note 25 (PPG25) 'Development and Flood Risk' which was issued on July 17, 2001, itself based on the DoE Circular 30/92 (MAFF Circular FD 1/92).

- A wall and raised ground, connecting North Village defences to high ground by bridge over the River Pang near Riverside Cottages; and

- A grassed embankment (Downstream Bund) east of Bucklebury, which follows the alignment of an existing agricultural field boundary, to ensure there is no detrimental impact to the community of Stanford Dingley as a result of the Bucklebury works.

PPS 25 requires that the Flood Risk Assessment be prepared by a suitably qualified competent person. PBA are specialists in, amongst other areas, hydrology, flood defence and river engineering.

West Berkshire Council (WBC) as the Planning Authority will make the final decision with regard to any planning application. Statutory Instrument 2006 No. 2375: The Town and Country Planning (General Development Procedure) (Amendment) (No. 2) (England) Order 2006, on 1st October 2006, made the EA a statutory consultee for planning applications where flood risk is a key issue.

The EA has been consulted on the preparation and contents of this FRA and is aware of the resulting implications.

2 Site Description and Location

2.1 Site Location and Plan

Bucklebury is an historical rural village on the River Pang situated approximately 8km north-east of Newbury in West Berkshire, at approximate National Grid Reference SU 55190 70988. Figure 1 in Appendix 1 shows the location of Bucklebury village and the River Pang.

There are a total of 26 houses in Bucklebury village, of which five are listed buildings and a further six are pre-1800. The village is within the North Wessex Downs AONB and is surrounded by arable and improved grassland fields with occasional woodland patches. There is a large pig farm to the north and west.

2.2 Topographic Survey

Numerous sources of topographic data have been used throughout the lifespan of the project. In the first instance the reader is referred to Appendix 2 (Section 5.1) of the Bucklebury FAS Modelling Report (PBA, 2010) for details about the topographic data used to build the hydrodynamic model.

In addition to this, a topographic survey was commissioned specifically for the proposed works. This was undertaken by Glanville Consultants in April 2010 in accordance with the EA's National Standard Contract and Specification for Surveying Services. A copy of this survey (T10508) is included in Appendix 2.

2.3 Existing Defences / Previous Works

The River Pang runs throughout the study area. No formal flood defence structures exist along the banks of the River Pang throughout the study area.

Following a flooding incident in January 1993, the National Rivers Authority (NRA) undertook some channel maintenance work in Bucklebury. This apparently consisted of the removal of channel and bankside vegetation, reinstatement of a ditch to the north of the riverside properties north of the River Pang, and some small scale manual dredging. This appeared to prevent a repeat of the flooding when a similar event occurred in April 1993. This work also appears to have inadvertently raised the right bank crest levels, removing a section of floodplain upstream of the village (PBA, 2001).

2.4 Geology

The British Geological Society map for the area indicates that the study area lies over two different bedrock types. The majority of the study area lies over white chalk, while the southern portion of the study area lies over part of the Lambeth group, formerly known as the Woolwich and Reading Beds, a combination of clay, silt, sand and gravel. Figure 2 in Appendix 1 shows the geological map of the study area.

2.5 EA Groundwater Map

The Environment Agency's online groundwater source protection zone maps indicate the risk of contamination to groundwater sources such as wells, boreholes and springs used for public water drinking supply.

The map indicates that the entire study area is within a source catchment protection zone, defined as *"the area around a source within which all groundwater recharge is presumed to be discharged at the source. In confined aquifers, the source catchment may be displaced some distance from the source. For heavily exploited aquifers, the final Source Catchment Protection Zone can be defined as the*

whole aquifer recharge area where the ratio of groundwater abstraction to aquifer recharge (average recharge multiplied by outcrop area) is >0.75." (see Figure 2.1)

Figure 2.1: EA Groundwater Source Protection Zone Map

2.6 Planning Policy Context

2.6.1 National Policy Context

National policy regarding flood risk is contained within Planning Policy Statement 25 (PPS25) 'Development and Flood Risk', issued by Communities and Local Government on 7th December 2006 and updated in March 2010.

The accompanying 'PPS25 Practice Guide' was issued in June 2008 and was updated in December 2009; whilst the EA's latest revision of their Flood Risk Standing Advice (FRSA) (version 2.1) was released in January 2009.

The updated PPS25 Practice Guide (paragraph 2.20) states that "*LDDs should deliver national and regional policy, while also taking account of specific local issues and concerns. The Core Strategy LDD should reflect the local planning authority's (LPA's) strategic planning policies and approach to flood risk. Site allocations should reflect the application of the Sequential Test, as well as guidance on how flood risk issues should be addressed at sites allocated within flood risk areas. Flood risk should be factored into LDDs in the detailed allocation of land use types across their area.*"

2.6.2 The South East Plan

The proposed scheme is compliant with the now-revoked South East Plan[2], including policies NRM2 (Water Quality) and NRM4 (Sustainable Flood Risk Management).

[2] See press release: http://www.communities.gov.uk/news/planningandbuilding/1632278

2.6.3 Local Planning Policy

Any future development would need to accord with the local planning policies with regard to flood risk and drainage, set out in the West Berkshire Council Local Development Framework – Proposed Submission Core Strategy, which will be submitted to the Secretary of State later this year, as detailed below[3]:

Policy CS17: Flooding

The sequential approach in accordance with PPS25 will be strictly applied across the District, with the preference for new development to be located within the Environment Agency's Flood Zone 1. Development within areas of flood risk from any source of flooding, including Critical Drainage Areas and areas with a history of groundwater flooding, will only be accepted if it is demonstrated that it is appropriate at that location and that there are no suitable and available alternative sites at a lower flood risk.

When development has to be located in flood risk areas it should be safe and not increase flood risk elsewhere including downstream, reducing the risk where possible and taking into account climate change. Development will only be permitted if it can be demonstrated that:

- It would not have an impact on the capacity of an area to store floodwater;
- It would not have a detrimental impact on the flow of flood water, 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;
- Surface water will be managed in a sustainable manner through the implementation of Sustainable Drainage Methods (SuDS) and to provide attenuation to Greenfield run-off rates and volumes, for all new development and re-development;
- Provision is made for the long term maintenance and management of any flood protection and or mitigation measures;
- Through the sequential test and exception test (where required), it is demonstrated that the benefits of the development to the community outweigh the risk of flooding;
- Dry escape should be provided above the 1 in 100 year flood level with an allowance for climate change for "More Vulnerable" development and "Highly Vulnerable" development. All other development uses should be 'safe' but preferably 'dry'.

Proposed development will require a Flood Risk Assessment for:

- Sites of 1 ha or more in Flood Zone 1;
- Sites in Flood Zone 2 or 3;
- Critical Drainage Areas;
- Areas with historic records of groundwater flooding;
- Areas near ponds or the Kennet and Avon Canal, that may overtop;
- Sites where access would be affected during a flood; and
- Sites with known sewage flooding.

2.6.4 West Berkshire SFRA

PPS25 confirms that Regional Planning Bodies (RPBs) or Local Planning Authorities (LPAs) should prepare Strategic Flood Risk Assessments (SFRAs) in consultation with the EA. The SFRA will then

[3] This is subject to change pending the Secretary of States review

be used to refine information on areas that may flood, taking into account other sources of flooding and the impacts of climate change, in addition to the information on the EA Flood Zone Map.

The West Berkshire SFRA was released as a final version in May 2008. The primary objective of the 'level 1' SFRA *"is to inform the revision of flooding policies, including the allocation of land for future development, with the emerging Local Development Framework (LDF). The SFRA also has a broader purpose and, in providing a robust depiction of flood risk across West Berkshire it can:*

- *Inform the developed of the policy that will underpin decision making within West Berkshire, particularly within areas that are affected by (and/or may adversely impact upon) flooding;*
- *Assist the development control process by providing a more informed response to development proposals affected by flooding, influencing the design of future development within West Berkshire;*
- *Help to identify and implement strategic solutions to flood risk, providing the basis for possible future flood attenuation works;*
- *Support and inform West Berkshire Council's emergency planning response to flooding."*

The information within the SFRA of relevance to the site is detailed in Section 3.2.

3 Assessment of Flood Risk

The degree of detail appropriate to any FRA is dependant upon the scale and potential impact of the proposed development (PPS25 Annex E, E3). In this case the FRA is to support a planning application for a FAS, classed as flood control infrastructure.

3.1 Existing Flood Risk

The Pang catchment and Bucklebury village is at risk of flooding from a number of sources; fluvial, from the River Pang, surface water and groundwater.

3.1.1 Fluvial

The proposed flood alleviation scheme will alleviate fluvial flood risk, and therefore this report focuses on this mechanism.

A number of properties within the village of Bucklebury lie in the fluvial floodplain of the River Pang, which flows from west to east through the settlement. Some flooding has been experienced historically, as detailed in Section 3.4, including some internal flooding of properties. Most noticeably, significant flooding occurred in July 2007, which led to the development of this flood alleviation scheme. The scheme is designed to reduce the risk of fluvial flooding to properties within the village, but does not impact on flood risk from other sources.

3.1.2 Surface Water (Pluvial)

Surface water flooding has occurred previously – for example in July 2007 when water flowed into the village from the roads to south, and fields to the north, causing flooding to some properties and exacerbating flooding in other areas. Several flood mechanisms were identified relating to the 2007 flood event, including blockages in surface water ditches and culverts. It is understood schemes are being progressed in parallel to this by WBC to address the surface water flood risk (see floodalleviation.co.uk).

Whilst the scheme is not designed to address surface water flooding, the construction of the by-pass channel will have some beneficial impacts. Firstly, the works will direct surface water from the fields to the north of the village towards the River Pang downstream of Bucklebury. Secondly, the water levels in the River Pang through Bucklebury will be reduced by the works and therefore the river will more readily accept surface water. There will be no adverse impact on surface water flooding as a result of the scheme.

3.1.3 Groundwater

There is a history of groundwater flooding in the Pang catchment, however it has been previously observed that Bucklebury is not as prone to groundwater flooding as other communities in the catchment. A section of the River Pang in the vicinity of Riverside Cottage appears to be brick lined and may be perched, anecdotal evidence suggests there may be other sections that are also lined, and part of the river may once have formed part of a mill channel. It is considered that the risk of groundwater flooding is relatively low as flows pass through the aquifer below the village and emerge 1-2km downstream towards Stanford Dingley.

Groundwater records were sourced from the EA, with the potential of providing additional information to assess the rarity of the July 2007 event. Levels for three observation bore holes were provided; Marlston Farm (NGR: SU 5338 7191), Bucklebury (NGR: SU 5561 7106) and Briff Lane (NGR: SU 5464 6990).

A large groundwater event occurred in the 2000 water year, which also coincided with peak flows at two of the three observation bore holes (Marlston Farm and Briff Lane), however the residents of Bucklebury have no recollection of any flooding occurring in the village as a result.

A groundwater analysis was undertaken during the completion of the Bucklebury FAS modelling work (Full details are provided in Section 3.3 of the Bucklebury FAS Modelling Report [PBA, 2010]), to assess if there was any correlation between the Bucklebury groundwater levels and daily mean flow. This analysis was not taken any further for use in the estimation of return period peak flows in Bucklebury, as whilst the records showed there was an increasing trend for higher daily mean flows coinciding with higher groundwater levels, the scatter was deemed too large make any useful relationship.

Whilst the scheme is not designed to address groundwater flooding, there will be no detrimental impact on the risk of groundwater flooding as a result of the scheme.

3.2 EA Flood Zone

The initial phase in identifying whether a site is potentially at risk of flooding is to consult the EA's Flood Zone maps, available on the EA's website. However, these are (often) based on coarse scale modelling and provide only an initial indication of the flood risk to a site.

The Flood Zones divide the floodplain into four categories of flood probability, and do not take flood defences into account. PPS25 defines the Flood Zones as:

- **Zone 1: 'Low Probability'** - This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).

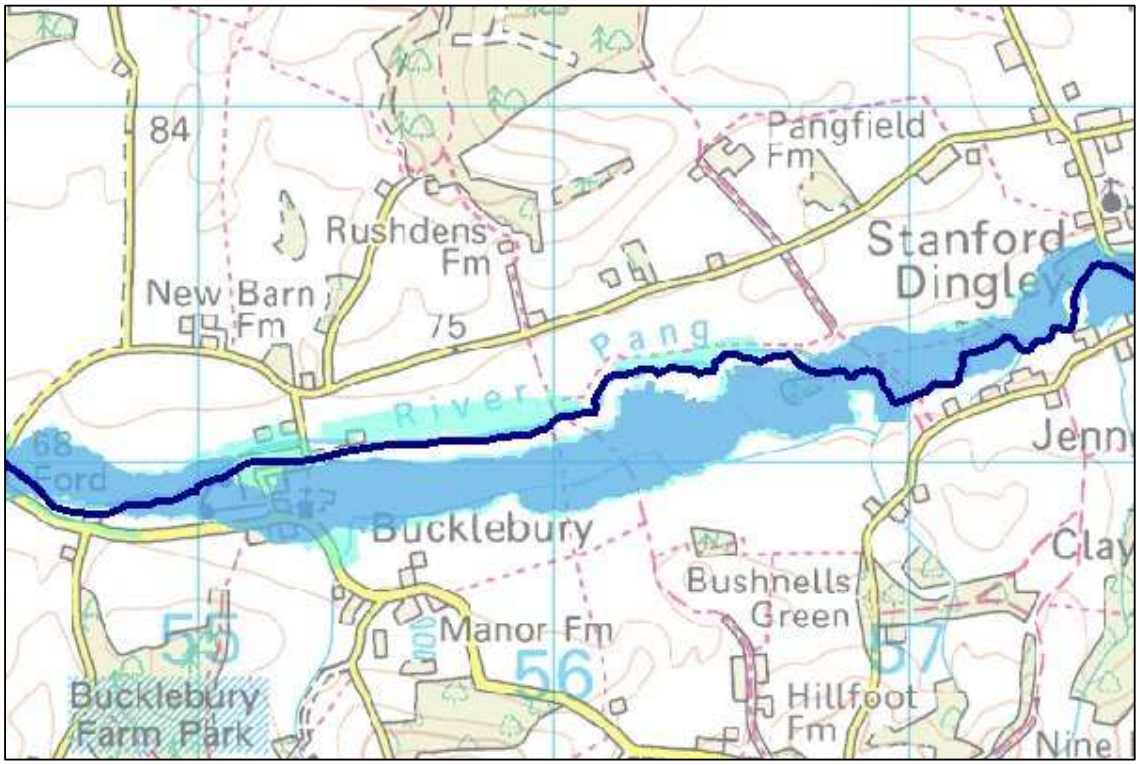
- **Zone 2: 'Medium Probability'** - This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.

- **Zone 3a: 'High Probability' -** This zone comprises land assessed as 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.

- **Zone 3b 'The Functional Floodplain' -** This zone comprises land where water has to flow or be stored in times of flood (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.

The EA's online flood map, an extract of which is reproduced in Figure 3.1, indicates that Bucklebury falls entirely within Flood Zones 2 and 3.

Figure 3.1: EA Flood Zone Map



PPS25 Annex D Table D.1 defines Flood Zone 3b as:

Zone 3b The Functional Floodplain

Definition

This zone comprises land where water has to flow or be stored in times of flood
Local planning authorities should identify in their SFRAs areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designated to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.

Appropriate uses
Only the water-compatible uses and the essential infrastructure listed in Table D.2 that has to be there should be permitted in this zone. It should be designed and constructed to:
- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows; and
- not increase flood risk elsewhere.

Essential infrastructure in this zone should pass the Exception Text

FRA requirements
All development proposals in this zone should be accompanied by a FRA. See Annex E for minimum requirements.

Policy aims
In this zone, developers and local authorities should seek opportunities to:
i. reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage techniques; and
ii. relocate existing development to land in zones with a lower probability of flooding.

3.3 SFRA Information

As noted in Section 2.5.4, West Berkshire Council's SFRA was released as a 'final version' in May 2008. Within the SFRA, the flood risk in West Berkshire, from all sources, is discussed in separate sections. Information that is relevant to the study area is listed below:

Fluvial (River) Flood Risk

63. "Within West Berkshire, the principal watercourses that pose a potential risk of fluvial flooding to properties include the River Kennet, the River Lambourn, the River Pang and the River Thames."

75. "The flood modelling on the upper River Pang is not detailed like it is for the other West Berkshire watercourses and it can be seen that the Flood Zones do not accurately follow the river. Therefore, accurate conclusions are difficult to draw in this case. It can be seen that the high risk Flood Zones are largely confined to the river corridor."

77. "The lower reaches of the River Pang, towards its confluence with the Thames, are where the greatest amounts of flooding are predicted. However, like many other parts of West Berkshire, the areas of flood risk are outside the urban area and only cover green space and rural land."

Groundwater Flooding

93. "Many of the reports of groundwater flooding in West Berkshire have arisen from communities in the Berkshire Downs. The permeable beds of cretaceous chalk within the Downs are aquifers and are capable storing and transporting groundwater flow. In such areas not only can normally dry areas of land flood due to locally high water tables, but intermittent streams called 'bournes' (or 'winterbournes') can be reactivated, causing flooding in locations remote from the perennial head of the stream. Flooding from both of these groundwater sources were experienced in 2000/2001 when sustained periods of heavy rainfall were experienced."

94. "Groundwater flooding is normally difficult to predict and challenging to mitigate. However, following the 2000/2001 event a groundwater monitoring network was set up by the Environment Agency to predict groundwater flooding from chalk aquifers. When groundwater levels in the boreholes reach a given height, warnings are triggered, which are issued to authorities and other external parties. The Environment Agency can use these levels to calculate how many days it will take before the known flood level is reached."

Geology

103. "The bedrock geology of West Berkshire is characterised predominantly by chalk to the north and west of the District, and clay to the south (i.e. south east of Thatcham). This geology will heavily influence both the susceptibility of areas to groundwater flooding, and the functionality of Sustainable Drainage techniques."

3.4 Historic Flooding Information

Flooding has occurred a number of times in recent years, including January 1993, Autumn 2000, July 2007 and February 2009:

1993 event

In December 1992 and on both the 10th and 13th January 1993, a total of 15-20 houses were affected by flooding, although only 2-3 suffered ground floor flooding. The other properties were affected by flooding to cellars (The Old Vicarage), garages, conservatories, driveways and gardens (PBA, 2001).

This flooding was caused by insufficient channel capacity through the village leading to excess flood flows overtopping both banks downstream of the Shallow Ford into the fields, and flooding of properties north of the river from this direction, while south of the river flood flows crossed the playing field and flooded properties adjacent to this area and across the road.

The return period of this event was estimated to be very low, possibly as low as the Mean Annual Flood and certainly less than 10 years (NRA, 1994).

2000 event

In October and November 2000 the river overtopped the left bank and flooded the village, although accounts given by Bob Keatley (the EA Inspector at the time) and local residents suggest no properties were flooded, except for two basements (although this was attributed to groundwater) and the garden of Riverside Cottages.

2007 event

A significant flood event occurred during July 2007 and 26 properties were flooded. The flooding occurred after a significant rainfall event fell over the Pang catchment (approximate return period of 140 years at West Isley and Yattendon [See Section 3.2.4 of the Bucklebury FAS Modelling Report (PBA, 2010)], which was already saturated. Flooding experienced in the village was from both fluvial and surface water mechanisms.

On the 19th/20th July 2007 water from the River Pang overtopped both its banks and flowed overland to the village, inundating properties north and south of the river. The peak of the flood was observed on the afternoon of the 20th July. Water was observed to flow into the village via surface water runoff from the roads to the south of the village and at a number of points along the River Pang.

During the summer months the main channel of the Pang had become heavily vegetated causing flows to be restricted and upstream water levels to rise. Clearance of some of the channel blockages during the flood event by local residents was observed to reduce the water levels within the village.

3.5 Hydrodynamic Modelling

Detailed hydrodynamic modelling for the scheme was undertaken by PBA in 2008/9. This modelling work was approved by the EA on the 20th January 2010 (see Appendix 3 of the Bucklebury FAS Modelling Report [PBA, 2010]).

3.5.1 Hydrological Modelling

Full details of the hydrological assessment undertaken for the scheme are provided in Section 3 and Appendix 1 of the Bucklebury FAS Modelling Report (PBA, 2010). A summary of the hydrological analysis from the above report is provided below:

A summary of the design peak flows are provided in Table 3.1:

Table 3.1: Summary of return period peak flows at Bucklebury gauge

Return Period	Peak Flow (m^3/s)
2	1.0
5	1.9
10	2.8
20	3.8
25	4.2
50	5.8
100	7.8
200	10.5
1,000	20.8

PBA's design hydrology has been derived assuming that the July 2007 event has a return period of 200 years. This hydrological analysis was approved by the EA on the 20th January 2010.

3.5.2 Hydraulic Modelling

A detailed baseline hydraulic model for the scheme was constructed by PBA for the EA's Project Appraisal Report (PAR stage / Feasibility Report) using the ISIS modelling software. Full details about the model construction, testing, and changes are provided in Section 4 and Appendix 2 of the Bucklebury FAS Modelling Report (PBA, 2010).

A detailed preferred option hydraulic model for the scheme was also constructed. Full details about the changes made in this model are described in Section 5.5 of the Bucklebury FAS modelling report (PBA, 2010). The model has been used to optimise the design of the scheme to ensure the primary technical objective is met, without adversely impacting any receptors, either upstream or downstream, of the study area. The proposed works required for the preferred option model are described in Section 5 of this report.

3.5.3 Updates to Hydraulic Model since PAR stage

Minor amendments have been made to the model to support the detailed design stage of this project, between PAR approval and progression to planning application. This work has involved further optimisation of the scheme detail using most up-to-date data. Topographic survey undertaken for the proposed works in April 2010, as detailed in Section 2.2 and Appendix 2. The following changes were made to the model:

- Changes to both baseline and post-scheme models:
  - Spills from the right bank between cross sections 1.126-1.123 have been amended, based on the latest topographic survey;
  - The geometry of the spill floodplain section 8cinto9aus (based on LiDAR), between Res8c and Res9a has been reviewed against the latest topographic survey. This spill geometry has not been updated.
- Changes to both post-scheme models:
  - Spill 1.147_r from the Pang into the right bank floodplain has been reschematised by connecting to a cross section rather than a junction, to represent flow more appropriately;
  - Spill and bank heights on the right bank between 1.126 and 1.123 left as existing in the post scheme scenario. Based on the latest topographic survey, it has been found that it is not necessary raise or lower banks in this area, as previously proposed;

- The height of the bund between Res_6a and Res_6b has been set at 66.8mAOD, the proposed height;

- The height of the proposed bund on the right bank between sections 1.147 and 1.145 has been set at the 100yr plus climate change level with no freeboard, by amending the spill heights – set at 100yr plus climate change level with freeboard removed;

- Design spill from Res8c to 9a – freeboard removed from design so bund set 200mm lower at 63.6.

3.6 Existing Modelled Flood Levels

PBA have produced modelled flood levels for the study area from their latest baseline hydraulic model of Bucklebury. Flood levels for different flood events, at key areas within the study area, are provided in Table 3.2:

Table 3.2: PBA Baseline Modelled Flood Level Data at selected nodes through study area

Flood Event (Annual Probability)	Flood Level (m AOD)				
	Upstream of village close to Briff Lane (Node 1.151)	Upstream of Road Bridge in Village (Node 1.138)	Stanford Dingley (Node 1.101)	Playing field (Node Res 6b)	Right bank floodplain downstream of village (Node Res 9a)
1 in 100 (1%)	67.996	66.238	59.102	66.107	61.811
1 in 100 plus allowance for climate change	68.025	66.266	59.150	66.141	61.845

3.7 Vulnerability

PPS25 Table D.2 confirms the 'Flood Risk Vulnerability Classification' of a site, depending upon the proposed usage. This classification is subsequently applied to PPS25 Table D.3 to determine whether:

- The proposed development is suitable for the flood zone in which it is located; and

- Whether an Exception Test is required to be carried out for the proposed development.

In this case, the proposals will consist of the construction of flood control/defence infrastructure. Reference to Table D.2 confirms that 'flood control infrastructure' falls under the 'Water-compatible Development' classification and therefore is considered appropriate development within this location.

4 Impact of Climate Change

Climate change is expected to have a major influence on the potential for future flooding. Annex B of PPS25 confirms that *"there is an increasing body of scientific evidence that the global climate is changing as a result of human activity."*

Annex B, paragraph B9, continues to state that *"In making an assessment of the impacts of climate change on flooding from the land, rivers and sea as part of a flood risk assessment, the sensitivity ranges in Table B.2 may provide an appropriate precautionary response to the uncertainty about climate change impacts on rainfall intensities, river flow, wave height and wind speed."*

Table 4.1: PPS25 Table B.2 Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights.

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		

The potential for increased flood probability as the result of possible climate change has been addressed through the use of the climate change allowances in the consideration of the mitigation measures for the proposed works.

It should be noted that the 2009 UK Climate Projections (UKCP09) was published in July 2009 using the latest climate change assessment methodologies. This is referenced in the latest version of the PPS25 Practice Guide (para 3.97, 3.98), which states *"Pending further work being carried out by Defra and the Environment Agency on the differences between the UKCP09 and UKCIP02 projections, the Chief Planner's letter advised that whilst there is a range of projections in UKCP09 of future climate for any given variable, based on different emissions scenarios and probability levels, around the 50% probability point on the central emissions scenario the data are broadly similar to the UKCIP02 projections. As a result, there is a general expectation that the assumptions on changes in climate that LPAs have been working from remain reasonable……In line with the advice given in the Chief Planner's letter, the figures presented in Annex B of PPS25 should continue to be used until any revised guidance is issued."*

5 Detailed Flood Alleviation Scheme Proposals

Numerous alternatives were considered for the scheme including:

- Construction of a storage area immediately upstream of the village with no bypass channel;
- Construction of bypass channel with no additional storage;
- Increased maintenance / channel vegetation on the River Pang;
- Increased channel capacity through Bucklebury; and
- Increased flood warning within the village.

These were discounted as part of the progression from Pre-Feasibility (undertaken in 2001) as they did not achieve the primary technical objective (i.e. to protect Bucklebury up to a 100 year flood event with an allowance for climate change).

5.1 Proposed Works

The following description of the proposed works required for the preferred option model has been split into two parts:

I. The works required to protect Bucklebury directly **(Bucklebury Village Defences)**; and

II. The works to ensure that the downstream community of Stanford Dingley is not adversely affected **(Downstream Works)**.

A comprehensive summary of how the above proposed works have been modelled in the preferred option model is described in Section 5.5 of the Bucklebury FAS modelling report (PBA, 2010), a copy of which is included in Appendix 4 of this report.

5.2 Bucklebury Village Defences

The details of the proposed works are outlined below and annotated on Drawings 20627/005/001 to 20627/005/008, copies of which can be found in Appendix 3:

5.2.1 Marlston Road Bund & Playing Field Bund

A grassed earth embankment is proposed to the west of Bucklebury village to prevent flood water flowing through the village during a flood event. The embankment will begin on the southern boundary of the agricultural field, adjacent to the village playing field, and will follow the alignment of Marlston Road in an easterly direction for approximately 100m. It will then cross the field boundary into the playing field and continue along the western edge of the playing field, aligned in a south-north direction, for approximately 130m. The embankment crosses the field boundary into the garden of the private residence of Avalon and meets the in-channel control structure (see Section 5.2.2).

The Marlston Road Bund will be to a crest level of 67.1mAOD, equal to the modelled 1 in 1000 year flood level. The Playing Field Bund will be an average of 900mm high above the existing ground with a crest level of 66.8m AOD, equal to the modelled 1 in 100 year flood level with an allowance for climate change.

These embankments will include a standard flood defence marker kerb on the crest and erosion protection matting on the downstream slopes.

5.2.2 In-channel Structure

A permanent in-channel structure, located at the western end of the Avalon property, is proposed on the River Pang. The purpose of this structure is to create a 'pinch point' in the river, which will restrict flows through Bucklebury and ensure that the channel capacity through the village is not exceeded for the design event (1 in 100 years with an allowance for climate change).

The structure will not increase the bed level within the River Pang or impede the normal flow within the river. During a flood event, water will be encouraged to flow out of the left bank upstream of the control structure water into the bypass channel as well as the surrounding floodplain.

The structure will reduce the width of the channel from 3m to 1.45m, and will tie into the By-pass Channel Bund on the left bank (see Section 5.2.5), and the Playing Field Bund (see Section 5.2.1) on the right bank. Details of the proposed structure are shown on drawing 20627/005/007 included in Appendix 3.

The pinch point forming the In-channel structure will be constructed with reinforced concrete, with gabion baskets and mattresses forming the approach and downstream areas.

The construction of the in-channel control structure is considered to fall under Part 15A (b) of the GPDO and will be completed outside of the planning application by the EA.

5.2.3 Right Bank Raising at Avalon

Within the gardens of the 'Avalon' property, downstream of the In-channel Structure and Playing Field Bund, there will be raising of the ground level along the right bank of the River Pang to prevent flood water spilling out into village during a flood event. These works are shown in drawing 20627/005/008 in Appendix 3.

The proposals are to construct a low level grassed embankment from the Playing Field Bund/In-channel Structure, along an alignment close to the right bank of the river towards the boundary of 'The Smithy'.

The land will be raised to typically 200mm (variable) above existing ground levels with a maximum height of 400mm. This is to the 1 in 100 year flood level with allowance for climate change.

The raising of the right bank of the River Pang within the property of Avalon is considered to fall under Part 15A (b) of the GPDO and will be completed outside of the planning application by the EA.

5.2.4 By-pass Channel

A by-pass channel is proposed to the north of the village. The channel will link from the River Pang upstream of the In-channel Structure around the north of the village, crossing the road and rejoining the River Pang downstream of the old mill building. The purpose of the bypass channel is to convey flood water around the village during times of high flow. The bypass channel will be dry in normal conditions and it is expected to operate in flood events with a 20% annual probability (i.e. 1 in 5 year return period) or greater.

The width of the by-pass channel at bed level will be 5m. The reduction in ground levels is up to a maximum of 1400mm below existing ground levels. However, this depth varies throughout the length of the channel.

Where the bypass channel crosses the road, it is intended that the road will be lowered by approximately 0.5m and re-graded to facilitate flow during floods (i.e. to be a temporary ford). This would only become a ford when the bypass channel operates.

The lowering of the road will be completed by West Berkshire Council as part of their permitted work and therefore does form part of the planning application.

A low level berm will be constructed to the north of the by-pass channel and will extend from the River Pang to the existing paddock to the west of the road. This will be at the same height as the current left bank of the River Pang and will thereby minimise water entering the fields during low-order events. The berm will also minimise the direct runoff from the adjacent field and reduce pollutants entering the by-pass channel.

Details of the By-pass Channel are shown in Drawing 20627/005/002 in Appendix 3.

5.2.5 By-pass Channel Bund

The bund to the south (right bank) of the bypass channel, will be formed of a grassed embankment to prevent water from the by-pass channel spilling towards the River Pang and the village of Bucklebury. The embankment will be 400mm to 1m above existing ground levels with a crest level of 67.1mAOD. This crest level is equal to the modelled 1 in 1000 year flood level. Details are shown on drawing 20627/005/002 included in Appendix 3.

5.2.6 North Village Defences and Riverside Cottage

In the vicinity of Riverside Cottage the grassed embankment to the south of the by-pass channel will match the modelled 1 in 100 year flood level with allowance for climate change. This level is continued throughout this section of the scheme.

To the north of Riverside Cottage the embankment will tie in to a new wall which crosses the Riverside Cottage land tying in to the raised road verge to the east of the property. The road verge will be raised and tie in to the existing high ground approaching the bridge over the River Pang.

For details of this section of the works see Drawing 20629/005/006 in Appendix 3.

5.2.7 Other Modifications

Downstream of Bucklebury village, and upstream of the derelict mill, a low point adjacent to the track on the right bank of the River Pang will be raised using site won cohesive fill material. This will prevent water from flowing into the paddock of The Old Vicarage, and back into the village from the downstream side. The location of this existing low point is shown on Drawing 20629/005/002.

5.3 Downstream Works

The impacts on flood storage through changes to the floodplain and flood flows by the proposed works have been accommodated within the design of the downstream works features.

The details of the proposed modifications are outlined below and annotated on Drawing 20627/005/004, copies of which can be found in Appendix 3:

5.3.1 Discounted Downstream Bank Raising/Lowering

The downstream works originally proposed in Section 5.5.6 of the Bucklebury FAS Modelling Report (PBA, 2010) consisted of two elements: modifications to the right back of the River Pang, and construction of an embankment. The proposed modifications to the right bank of the Pang were reviewed, following the provision of the detailed topographic survey from Glanville Consultants in April 2010 (see Section 2.2), and the analysis showed that these works were no longer required for the scheme to meet its primary objective, and consequently they have been discounted. A copy of the analysis undertaken is included in Appendix 4.

5.3.2 Downstream Bund

An embankment is proposed to be constructed adjacent to the existing public right of way along an agricultural field boundary to the east of Bucklebury. The purpose of this embankment is to ensure that there is no increased flood risk in Stanford Dingley as a result of the Bucklebury defences.

The crest level of the proposed embankment is 63.6m AOD which is an average of 400mm above existing ground levels. This embankment is designed to be overtopped with the upstream water level 300mm above the crest of the embankment during the design flood event (1 in 100 year with allowance for climate change).

At the southern end of the embankment, at an existing bridge over a land drainage ditch, the height of the embankment will be reduced by 200mm. The bridge is of suitable construction and does not require any amendments as part of the Flood Alleviation Scheme. To the south of the bridge the existing ground levels will be raised to the same level of the bridge deck.

5.4 Impact of proposed works on modelled flood levels

The flood alleviation scheme has been designed to provide fluvial flood protection to the residents of Bucklebury without increasing flood risk to third parties, for example residents or communities upstream of downstream, in accordance with PPS25. The hydraulic model has been used as a tool to optimise the efficacy of the flood alleviation scheme whilst ensuring no detriment elsewhere.

Table 5.1 presents the post-scheme flood levels at selected nodes through the study area. Figures 6.1 and 6.2 in the Bucklebury FAS Modelling Report in Appendix 4 illustrate the 100yr flood extent under baseline and post-scheme scenarios.

Table 5.1: PBA Post Scheme Modelled Flood Level Data at selected nodes through study area

Flood Event (Annual Probability)	Flood Level (m AOD)				
	Upstream of village close to Briff Lane (Node 1.151)	Upstream of Road Bridge in Village (Node 1.138)	Stanford Dingley (Node 1.101)	Playing field (Node Res 6b)	Right bank floodplain downstream of village (Node Res 9a)
1 in 100 (1%)	67.996	65.937	59.101	65.406	61.776
1 in 100 plus allowance for climate change	68.025	66.009	59.148	65.427	61.813

When these post-scheme peak water levels levels are compared to the baseline flood levels, the change in flood risk can be found, as presented in Table 5.2. A negative difference represents a decrease in water level, and therefore flood risk, as a result of the works; i.e. a betterment as a result of the scheme.

Table 5.2: PBA Post Scheme change in flood levels at selected nodes through study area (a negative difference represents a decrease in water level)

Flood Event (Annual Probability)	Difference (m)				
	Upstream of village close to Briff Lane (Node 1.151)	Upstream of Road Bridge in Village (Node 1.138)	Stanford Dingley (Node 1.101)	Playing field (Node Res 6b)	Right bank floodplain downstream of village (Node Res 9a)
1 in 100 (1%)	0	-0.301	-0.001	-0.701	-0.035
1 in 100 plus allowance for climate change	0	-0.257	-0.002	-0.714	-0.032

5.4.1 Impact in the village

As a result of the flood alleviation scheme, the right bank floodplain through Bucklebury will no longer be at risk of flooding up to the design flood event, and all the properties on the right bank of the River Pang in the village from downstream of the Playing Field bund to the mill structure and the properties located on the left bank between the River Pang and the bypass channel will be protected from flooding with a SoP of 1 in 100 year plus climate change.

5.4.2 Impact upstream

As shown in Table 5.2, there is no change in flood risk upstream of Bucklebury, with no detriment experienced at Briff Lane or further upstream, such as the shallow ford.

5.4.3 Impact downstream

There is no increase in flood risk in Stanford Dingley as a result of the Flood Alleviation Scheme, as shown in Table 5.2. The proposed works downstream of Bucklebury in the right bank floodplain have been designed to mitigate against any increase in flood risk resulting from the bypass channel and associated village defences. Indeed, there is a small reduction in flood risk in Stanford Dingley, as shown in Table 5.2 and in more detail in Section 5.5.7 of the Modelling Report in Appendix 4.

5.5 Flood Storage and Flow Routes

The construction of the bunds on the west side of Bucklebury will retain water upstream of the village. The volume of water retained to the level of the 1 in 100 year flood event with allowance for climate change is approximately 22,000m^3. The Downstream Bund between Bucklebury and Stanford Dingley will also retain water during a flood event and restrict the flow of flood water. This will ensure that Stanford Dingley is not adversely impacted as a result of the scheme.

The creation of the By-pass Channel effectively channels water through Bucklebury quicker, which without the proposed Downstream Bund would result in a slightly flashier hydrograph downstream leading to a small increase in flood risk in Stanford Dingley. The proposed downstream works are designed to encourage flood flows back into the floodplain downstream of Bucklebury, and restore the flood flow rates to similar to the existing, thereby mitigating against any detriment.

The hydraulic modelling of the study area has indicated that the proposed work will not have an adverse effect on other properties in the catchment. This was assessed by considering the sensitivities and tolerances in the model as detailed in Sections 4 and 5 in the Bucklebury FAS

Modelling Report [PBA 2010], Appendix 4. The approach was discussed and agreed with the EA and independently reviewed and accepted on behalf of the EA in January 2010.

During a design flood event (1 in 100 year with allowance for climate change), the flood flow routes through Bucklebury would be diverted to be only through the River Pang or the By-pass channel and floodplain to the north of the village.

5.6 The Sequential Test and Exception Test

The construction of the Bucklebury FAS is to provide the village of Bucklebury with defences against fluvial flooding. In order to provide the design level of defence it is necessary that works are carried out on land that is at high risk of flooding, these works could not be carried out elsewhere and operate as an effective flood defence. Therefore it is not necessary to consider a further Sequential Test to identify an alternative location for these works.

As the construction of flood control infrastructure such as this flood alleviation scheme is defined as "Water Compatible Development" within PPS 25, it is considered to be appropriate development in all flood zones and there is no requirement for the Exception Test to be carried out.

5.7 Lifetime of the Proposed Works

The complete FAS will be regularly inspected by the EA. Should there be any defects noted during these inspections then the EA will arrange for corrective measures to be undertaken. These defences will be maintained by the EA for their design life or as long as they are needed.

The proposed works have been designed to have a 100 year life.

6 Mitigation Measures

6.1 Construction Sequence

In order to prevent a temporary increase in flood risk during the works, the sequence of construction has been considered should a flood occur whilst the scheme is only partially complete.

Once constructed, the In-channel Structure will create a pinch point in the River Pang, causing more water to spill into the floodplain. Therefore the In-channel Structure will not restrict flow in the River Pang prior to the completion of the By-pass Channel.

The completed By-pass Channel will increase the conveyance of flood water to the downstream side of Bucklebury. The impact of this would be to increase the flood risk to Stanford Dingley. The construction of the Downstream Bund will restrict flows downstream of Bucklebury, ensuring that Stanford Dingley will not be adversely impacted by the scheme. Therefore the Downstream Bund will be completed prior to the By-pass channel becoming operational.

6.2 Reservoir Design Criteria

Some elements of the proposed works fall under the requirements of the Reservoirs Act as proposed to be modified by the Flood and Water Management Act 2010. These elements are shown on Drawing 20627/005/001 and are listed below:

- Marlston Road Bund,
- Playing Field Bund,
- By-pass Channel Bund
- In-channel Structure.

The design approach used for each of these structures is being independently reviewed and will be signed off by the EA appointed Reservoir Engineer.

The Environment Agency Operations and maintenance team have been consulted on the proposed works and the future maintenance requirements.

6.3 Downstream Bund

The Downstream Bund as described in Section 5.3.2 is designed to retain water between Bucklebury and Stanford Dingley. Without this bund the works would have an adverse impact in terms of flood risk downstream of the scheme. The inclusion of this bund ensures that there is no adverse impact on flood risk to Stanford Dingley or elsewhere downstream of the Bucklebury FAS.

6.4 Flood Warning and Evacuation Plan

It is recommended that a Flood Warning and Evacuation Plan (FWEP) is developed for residents of Bucklebury. The FWEP would detail how to prepare for a flood and what actions to take during a flood event. As part of the FWEP residents of Bucklebury would be advised to register with the EA's flood warning system through Floodline.

Monitoring of flood levels upstream of the bund is to be considered, such information could be used as part of a flood warning system for the village.

7 Residual Risk

7.1 Overtopping of defences

The Bucklebury Flood Alleviation Scheme is designed to defend Bucklebury from fluvial flooding up to a 1 in 100 year flood event with allowance for climate change. A flood event greater than the design flood event may occur. During such a flood the defences would be likely to be overtopped with flood water entering the village. The proposed defences would reduce the depth and extent of flooding experienced in the village during these flood events that are greater than the design event, but not prevent flooding from occurring.

7.2 Seepage under bund

An assessment of potential seepage of water under the proposed bunds under the requirements of the Reservoirs Act (as mentioned in Section 6.2) has been undertaken. The foundation stratum for the bunds and bypass channel raised bank is River Terrace Deposits (overlying Chalk). Seepage beneath the embankment/bank through these permeable layers could be a potential concern. Preliminary analysis of seepage flows beneath the upstream embankment using flow net analysis has indicated that seepage rates are approximately 0.0001m^3/s/m assuming a sustained flood level at the crest of the embankment (equal to a 1 in 100 year flood event with allowance for climate change). This seepage rate is not considered significant in the context of water flow rates in the main channel or the wider drainage system during a flood event. It is envisaged that the pre-existing positive drainage on the downstream side of the bunds will allow any water emerging from beneath the bunds on the downstream side to drain down the valley.

The assessment is based on an assumed permeability value for the River Terrace Gravel. As a sensitivity check the permeability has been increased by an order of magnitude, therefore maximum seepage flow below the upstream embankment during the peak of the design flood event is 0.001m^3/s/m, which over the approximate 120m length of the Playing Field Bund amounts to 432m^3/hr. This is a very low flow in comparison with the 9.4m^3/s (approximately 33,700m^3/hr) for the peak flow in the River Pang during a 1 in 100 year flood event with allowance for climate change.

It is considered that these volumes of water due to seepage can be accommodated within the existing drainage systems on the downstream side of the bund.

7.3 Breach of defences

The Bunds around the west and north of Bucklebury have been designed to comply with the requirements of the Reservoirs Act including design to remain intact during a 1 in 10,000 year flood event when they will overtop. The design approach is being reviewed and final design will be signed off by a Reservoir Engineer. The defences will be regularly inspected and maintained by the Environment Agency. In the extremely unlikely event of a breach of the proposed defences there would be a significant impact on the village, an assessment of such a breach has been summarised below.

The closest property to the proposed bunds covered by the Reservoir Act has a threshold level approximately 700mm below the 1 in 100 year flood level with allowance for climate change, and is at a distance of approximately 25 metres downstream of the bund.

The nature of the impact on Bucklebury is partly dependant on the location of the breach. If the breach was of part of the Playing Field Bund the water would flow across the playing field before reaching any properties. This distance of approximately 100m from the Playing Field Bund to the nearest properties would reduce the rate at which water levels would rise at the properties, and reduce the velocity of the water from the breach when it reaches the properties. Alternatively if the breach was of the By-pass Channel Bund then water would flow either into the River Pang causing the

capacity of the channel to be exceeded, or into the gardens of properties that are on the north side of the village.

During a breach of the proposed bunds water levels around properties would be likely to rise by up to several hundred millimetres within a couple of minutes in the area downstream of the defences. This would be likely to cause flooding with little warning to properties within the village.

Following a breach of the defences the flood levels in Bucklebury would become similar to the current situation without the presence of the proposed flood defences and would not be expected to cause an increase in flood risk elsewhere.

As mentioned in Section 6.4, a FWEP is recommended to be prepared for the residents of Bucklebury. It is anticipated that through the EA's flood warning system the residents can be aware of when the flood defences are in operation, protecting Bucklebury from flooding.

7.4 Ford on road to north of village

As part of the construction of the By-pass Channel the road to the north of Bucklebury will be lowered by approximately 0.5m and as a result the road will be liable to flooding during flood events of 1 in 5 years or greater. To warn road users of this hazard introduced by the works it is proposed that appropriate road signage is erected.

Whilst the road may remain safe for motor vehicles to pass, up to a depth of a couple of hundred millimetres of water, it is considered that due to the flow of the water it would not be safe for pedestrians to cross the ford over the by-pass channel when it is in operation. Appropriate signage is to be provided to warn pedestrians of this hazard.

The proposed road level at the lowest point is approximately 65.5m AOD, this is 670mm below the modelled 1 in 100 year flood level with allowance for climate change.

The lowering of this section of road will increase the risk of flooding and therefore the road will become impassable during a flood event. As a benefit of the flood defences being constructed, access within the village will be at reduced risk of flooding, as will access away from the village towards the south.

7.5 Other Forms of Flooding

The proposed defences are designed to defend Bucklebury from fluvial flooding from the River Pang to a 1 in 100 year flood with allowance for climate change. Flooding from other sources such as surface water, ground water or drainage systems may also occur and this scheme is not designed to prevent flooding from these other sources.

8 Summary

This FRA has been produced in support of a planning application for flood control measures as part of the Bucklebury FAS:

- The proposed FAS is “water compatible development” and this therefore considered to be appropriate development in all flood zones in accordance with PPS25;
- The standard of defence provided by the scheme to Bucklebury is 1 in 100 years with allowance for climate change;
- The construction of the downstream bund ensures that there will be no adverse impact on the downstream community of Stanford Dingley as a result of these proposed works. There is no increase in flood risk to property upstream of the village.
- There is a residual risk of a breach in the proposed defences around Bucklebury which would cause water levels to rise at a rapid rate. However, the risk of a breach occuring is low as the defences will be regularly inspected and maintained by the EA.
- Access to and from the village by the road to the north will be impacted during times of flood. Access during these times will be using alternative routes to the south of the village. Appropriate warning signs for vehicles and pedestrians are to be provided at the ford.
- It is recommended that a FWEP is prepared and distributed to the residents of Bucklebury to provide additional information on flooding.

9 References

- National Rivers Authority, Hydrological Analysis for Bucklebury (River Pang) Feasibility Study, 1994
- Peter Brett Associates, Pre-feasibility Report Bucklebury Flood Alleviation Scheme, June 2001
- Peter Brett Associates, Bucklebury Flood Alleviation Scheme Modelling Report, February 2010

Appendix 1 – Location Plan(s)

- Figure 1 – 1:50,000 scale Site Location Plan
- Figure 2 – 1:25:000 scale extract of BGS Geological Map

Appendix 2 – Topographic Survey

- Glanville Consultants topographical survey (T10508) April 2010

Appendix 3 – PBA Drawings

- 20627/005/001 Local Plan Area
- 20627/005/002 Bypass Channel
- 20627/005/003 Embankment and Bank Raising
- 20627/005/004 Downstream Mitigation Works
- 20627/005/005 Stables Area
- 20627/005/006 Riverside Cottages Defences
- 20627/005/007 Control Structure
- 20627/005/008 Avalon

Appendix 4 – Modelling Reports

- Bucklebury FAS Modelling Report, PBA 2010
- Detailed Design Modelling Technical Note