O & H Properties Ltd. Marlborough Developments Ltd. and Barratt Strategic

GREATHADDON

Flood Risk Assessment / Water Management Strategy

Project Ref: 15188

Doc Ref: 15188/400/01 Rev F

April 2012

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Document Control Sheet

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For and on behalf of Peter Brett Associates LLP

Revision	Date	Description	Prepared	Reviewed	Approved
C	December 2010	Updated to reflect the EA's additional requirements	Madelaine Davies Stuart Harwood	Graham Thompson	Ron Henry
D	January 2011	Minor textual amendments	Paul James	Stuart Harwood	Ron Henry
E	April 2011	Minor textual amendments	Stuart Harwood	-	Ron Henry
F	April 2012	Surface water drianage strategy updated for employment area	Paul James		Ron Henry

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1 Executive Summary

a. This PPS25 compliant Flood Risk Assessment has been prepared in support of an application for planning permission relating to proposals for development of an urban extension on approximately 391 hectares of land at Great Haddon, located to the south of Peterborough, Cambridgeshire immediately south west of the Hampton development area. It is currently proposed that the development will comprise of up to 5350 dwellings and approximately 65ha of employment land as well as community and health buildings, educational facilities, neighbourhood and district centres, leisure facilities, sports and recreational facilities, site for gypsy and traveller pitches; a range of strategic open spaces including new landscaping, woodland and allotments; cemetery provision and supporting infrastructure.

b. The proposed sites currently comprise a mix of arable agricultural land and pockets of mature woodland and are bisected west to east by the Stanground Lode, categorised as Main River and under the control of the Environment Agency.

c. A tributary watercourse (hereafter referred to as The Northern Tributary) joins the Stanground Lode approximately 720m beyond the western boundary of the site (the A1(M)). The Stanground Lode runs along the southern fringe of Orton Pit Special Area of Conservation (SAC) and Haddon Lake, both created through clay extraction for the brick making industry. Hydraulic connectivity with the latter is afforded by a 600mm diameter pipe.

d. Long Pond, another former clay pit, is located in the north-eastern corner of the sites and is linked to the Stanground Lode via a 300mm diameter pipe.

e. Further former clay pits, known as Beeby's Lakes, are located a short distance beyond the eastern boundary of the sites (the A15 London Road).

f. Crown Lakes, two further clay pits, are located outside of the site to the east and north-east of Beeby's Lakes. Crown Lakes accept flow from a field drainage ditchcourse and discharge by gravity to the Stanground Lode.

g. Other areas of note within the sites include Jones' Covert, part of the Orton Pit SAC/SSSI, and Chamber's Dole, The Belt and Two Pond Coppice, both of which are designated as County Wildlife Sites (Although it should be noted that Chambers Dole, The Belt and Two Pond Coppice are not contained within the planning application boundary). Madam White's Covert, located adjacent to the confluence of the Stanground Lode and the Northern Tributary, does not benefit from any statutory or non-statutory designation.

h. The Environment Agency's Flood Zone map indicates that the floodplain associated with the Stanground Lode and its Northern Tributary is confined to a relatively narrow corridor with a localised increase in the extent of floodplain at the confluence of the two branches. The Flood Zone map suggests that both Orton Pit SAC and Haddon Lake would be inundated during the 1 in 100 year flood. However, the Flood Zone map is not considered sufficiently robust to inform development planning and design matters.

i. The Environment Agency was consulted towards the latter part of 2007 and again towards the latter part of 2008 to agree the issues to be addressed from a flood risk perspective, the scope of technical work required and design principles that should be applied.

j. The Agency advised that a hydraulic model should be used to establish the extents of the 1 in 20 year, 1 in 100 year, 1 in 100 year plus climate change, 1,000 year and the 1,000 year plus climate change floodplain outlines.

k. The Agency also advised that the development proposals should be supported by a surface water drainage strategy and that this strategy should seek to utilise the former clay pits for surface water balancing, wherever feasible.

l. The Environment Agency provided a copy of an ISIS hydraulic model of the Stanground Lode, taken from the Agency's Nene Catchment Strategic Model. Model schematisation was revised and updated to reflect:

(i) local/site-specific features/flooding mechanisms and

(ii) the nature of the Hampton development surface water drainage strategy (the Hampton development being located immediately to the north and east of the sites).

m. Catchment inflows were estimated using the procedures set out in the Flood Estimation Handbook.

n. The modelling analysis shows that the majority of the sites lie outside the 1 in 100 year floodplain of the Stanground Lode. On this basis and within the context of PPS25, Annex D, Table D.1, some limited areas of the river corridor immediately adjacent to the watercourse are shown to lie within Flood Zone 3a – High Probability. The modelling analysis of the 1,000yr event shows that the vast majority of the sites are classified as Flood Zone 1 – Low Probability. The proposal therefore satisfies the requirements of the Sequential Test as development will be located in an area at the lowest probability of flooding.

o. Development will give rise to a large increase in impermeable area within the catchment of the Stanground Lode, thereby increasing the rate and volume of surface water run-off. A scheme for the disposal of surface water run-off has therefore been devised to regulate outflows to the Stanground Lode and demonstrate a commitment to reduced downstream flood risk.

p. The strategy adopts similar design principles to those previously approved by the Environment Agency in respect of the adjacent Hampton Development and includes a series of balancing ponds that serve individual development sub-catchments and discharge to either the Stanground Lode or The Northern Tributary.

q. It is currently proposed that balancing ponds discharging to the Lode upstream of the confluence with the Northern Tributary will be designed based upon a limiting outflow equivalent to the greenfield rate of run-off.

r. Balancing ponds outfalling to the Northern Tributary will discharge surface water at a rate that exceeds the greenfield rate of run-off. To compensate for elevated rates of outflow from these balancing ponds, it is proposed that floodwater will be diverted into a new conveyance channel located immediately to the south of the Lode. Floodwater diversion will be achieved by constructing a side spill/weir in the right bank of the Lode approximately 430m downstream of the Lode and Northern Tributary confluence.

s. The conveyance channel will also receive unattenuated surface water flows arising from the development located to the south.

t. Flows entering the conveyance channel will be routed east, beneath the A15 (London Road), towards Beeby's Lakes.

u. Floodwater stored in Beeby's Lakes will ultimately be pumped into the watercourse located south of the Lakes and routed under the East Coast Mainline Railway to Crown Lakes, from where it will be discharged into the Stanground Lode in accordance with the criteria previously agreed with the Environment Agency in respect of the Hampton development.

v. The hydraulic model used for the purposes of defining floodplain outlines was re-configured to represent the form of the proposed surface water drainage strategy and comprised an assessment of the “as existing/baseline” condition and the “design” condition (i.e. including details of the proposed drainage strategy).

w. In accordance with the Agency’s requirements, the modelling analysis tested the strategy for the 1 in 20 year and 1 in 100 year plus climate change scenarios and considered both a short duration storm scenario (critical duration for the developed sub-catchments) and long duration storm scenario (critical duration for the contributing rural catchment).

x. The performance of the strategy has been assessed through comparison of flow and stage hydrographs for the “as existing/baseline” and “design” scenarios at a number of locations through the river system.

y. The modelling analysis has shown that peak flood flows in the Stanground Lode downstream of the weir link to the conveyance channel are reduced when compared to the “existing/prior to development” flow regime. In addition, the strategy reduces the frequency of floodwater spill to Orton Pit SAC and safeguards the SAC from floodwater inundation to the 1 in 100 year plus climate change design standard.

z. On account of the above, the surface water drainage strategy and use of Beeby’s Lakes is considered to offer a strategic benefit to both the Orton Pit SAC and areas downstream.

aa. In addition to the strategic solution outlined above, it is proposed that the development will incorporate a range of Sustainable Drainage Systems (SuDS) in order to:

- Reduce peak flows
- Reduce surface water volumes entering watercourses
- Improve water quality by removing pollutants associated with diffuse pollutant sources
- Reduce potable water demand through rainwater harvesting
- Improve amenity through the provision of open space and wildlife habitat
- Replicate natural drainage patterns/processes
- Capture and convey overland flood flows

bb. It is currently proposed that surface water drainage infrastructure and SuDS components will be brought forward for adoption by the Water Authority or Peterborough City Council. Beeby’s Lakes will be brought forward for adoption by Peterborough City Council in accordance with principles previously established in respect of the adjacent Hampton development.

cc. The assessment acknowledges the nature of residual risk and identifies issues to be considered as design work progresses.

2 Introduction

a. Peter Brett Associates has been engaged by O & H Properties Ltd, Marlborough Developments Ltd and Barratt Strategic (the Great Haddon Consortium), to undertake a Flood Risk Assessment (FRA) in line with the guidance in Planning Policy Statement 25 (PPS25) and following consultation with the Environment Agency to support the development of an urban extension at Great Haddon, Peterborough. A location plan for the Great Haddon scheme is contained within Appendix A.

b. The Great Haddon Development is located approximately three miles south-west of Peterborough, Cambridgeshire, and forms the southernmost part of the 'Peterborough Southern Expansion' area.

c. The outline planning application for Great Haddon will seek permission for the following:

Development of an urban extension comprising up to 5350 residential dwellings; 65 hectares of employment land (B1, B2, B8 and a site for a household recycling centre); a district centre (with up to 9,200 square metres (99,031 sq. ft) retail floor space) and two neighbourhood centres (with up to 2300 square metres (24,758 sq. ft) retail floor space) comprising district/ neighbourhood retail (A1-A5), community and health (C3, D1), leisure (D2), residential (C3) and commercial (B1) uses. Provision for education facilities (sites for three primary and one secondary schools); sports and recreational facilities; site for gypsy and traveller pitches, a range of strategic open spaces including new landscaping, woodland and allotments; cemetery provision. Associated highway infrastructure (including pedestrian, bridleway and cycle routes), public transport infrastructure and car parking for all uses. Utilities and renewable energy infrastructure, foul and surface water drainage networks (including SuDS and lakes).

All in accordance with the Development Framework Plan reference: PST021-DFP-01L. This is contained within Appendix C for reference.

d. Peter Brett Associates, Consulting Engineers are specialists in, amongst other areas, hydrology, flood defence and river engineering. Peter Brett Associates are one of the Environment Agency's National Framework Consultants for Flood Risk Mapping.

e. Government policy in respect of development and flood risk is set out within the Department for Communities and Local Government (DCLG) Planning Policy Statement 25 (PPS25) 'Development and Flood Risk' which was issued on 7th December 2006.

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

g. The Local Planning Authority (LPA), Peterborough City Council, will make the final decision with regard to any planning application. PPS25, paragraph 26, confirms that 'Following the coming into force, on 1st October 2006, of the amendment to Article 10 of The Town and Country Planning (General Development Procedure) Order 1995 (the "GDPO"), LPA's are required to consult the Environment Agency on all applications for development in flood risk areas (except minor development), including those in areas with critical drainage problems and for any development on land exceeding one hectare outside flood risk areas.'

h. This report summarises:-

- The planning policy context and legislative framework that should be taken into account when planning a development from a flood risk perspective.
- The nature of the existing flood risk constraint associated with watercourses and waterbodies within and adjacent to the sites.
- The likely nature of the impact of development proposals on flood risk and details of proposed mitigation measures.
- The scope of technical work undertaken to date and further technical work required to enable a detailed appraisal of flood risk constraints to inform both development masterplanning and the preparation of a PPS25 compliant Flood Risk Assessment.

3 Proposed Development Sites

3.1 Sites Location and Plan

a. The sites comprise the tract of land to the southwest of Peterborough extending between Orton Southgate and the new Hampton Township to the northwest and north respectively, the villages of Stilton to the south and Yaxley to the east. The proposed sites are bounded by the A1 Motorway to the west and the A1139 (Fletton Parkway) to the north with the A15 (London Road) forming part of the southern and eastern boundary of the sites.

b. The National Grid Reference of the site centre is approximately 516500 292500 and its general location and extent is shown on Drawing 15188/400/01, Site Location Plan contained within Appendix A.

3.1.1 Description

a. Currently the sites comprise a mix of arable agricultural land and occasional pockets of mature woodland. The largest block of woodland, surrounding "The Belt", to the north of the Stanground Lode and outside of Client Land Ownership, (NGR: 515500, 293300) has been designated as a Site of Special Scientific Interest.

3.1.2 Topography

a. The topography of the sites is generally relatively flat, sloping gently downhill towards Stanground Lode. Topographic survey of the sites is presented in Drawings 15188/400/02, 03 and 04, which are contained within Appendix B for reference. These drawings show two distinct high points to the north-west and south of the sites (21mAOD and 34mAOD respectively). Elevations decrease eastwards to a level of 16mAOD near the former clay pits.

3.1.3 Geology

a. The geology of the sites consists of Jurassic aged Oxford Clay, which is underlain by the relatively thin Kellaways Formation (the Kellaways Sand and Kellaways Clay), the thin Cornbrash Formation and the Great Oolite Group (Blisworth Clay Formation, Blisworth Limestone Formation and Rutland Formation).

b. The geological map shows the Jurassic aged Oxford Clay is partially overlain and masked by Quaternary aged Glacial and Alluvial deposits. These are principally shown on the south-eastern side of the development area where Glaciolacustrine Deposits are overlain by Boulder Clay and Glaciofluvial Deposits, Head deposits were found to widely cover the north of the sites. A tract of Alluvium follows the line along the full length of the Stanground Lode watercourse.

c. The regional dip of the natural strata is very shallow (less than 1 degree to the horizontal) to the south-east and often appears horizontal. No faults are inferred on the sites although faulting is shown to the south of the sites. The fault shown terminates close to the southern application boundary and trends north-west to south-east with upthrowing to the south-west bringing the Kellaways Formation and Cornbrash to the surface.

d. The Oxford Clay has historically been extracted in the area for brick making with several clay pits close to the sites to the north-east and south and adjacent to the east, to supply the London Brick Company brickworks to the North.

e. Groundwater monitoring in standpipes installed in boreholes on the southern side of the sites recorded groundwater levels standing between 0.34m below ground level and 3.4m below ground level in the boulder clay. The shallow groundwater level recorded is considered to represent perched groundwater trapped in pockets of chalk material within the Boulder Clay and is not indicative of a general groundwater level.

3.1.4 Watercourses and Water Bodies

a. The location of water bodies and watercourses on and adjacent to the sites are indicated on Drawing 15188/400/06, contained within Appendix A for reference.

b. The sites are bisected by the Stanground Lode, categorised as Main River and under the control of the Environment Agency. On the eastern boundary (NGR: 517600, 293600) the Stanground Lode drains a catchment of approximately 12.92 km^2. The Lode rises to the west in the hamlet of Morborne whilst an un-named tributary of the Lode (referred to as the Northern Tributary) rises in the vicinity of Haddon. These drain areas of 5.79 km^2 and 3.58 km^2 respectively with the confluence of the two watercourses located a short distance to the east of the A1 Motorway at NGR: 516100, 292650. The Stanground Lode flows north-eastwards, passing alongside the southern boundary of Haddon Lake. Downstream of the sites the Stanground Lode continues for approximately 4.5km in a north-easterly direction towards the Old Fletton suburb of Peterborough, eventually discharging to the River Nene (the catchment area to the confluence being 29.73 km^2).

c. A number of ditches, drains and ponds are located both within and on the fringes of the sites. These are illustrated in Drawings 15188/400/06 and 15188/400/09, contained within Appendix A for reference. Three balancing ponds, controlled by the Highways Authority, lie to the east of the A1(M) motorway along the western application boundary. To the north of the sites lie several ditchcourses that lead to the disused Orton clay pits. Haddon Lake lies just beyond the eastern application boundary.

d. Haddon Lake lies to the north-east of the sites and the Stanground Lode runs along its southern side. A 600mm diameter pipe connects the Haddon Lake and Lode and high ground along the footpath (the “Green Wheel”) located on the southern fringe of the lake defines the threshold at which floodwater would spill from the Stanground Lode to the Lake. Haddon Lake receives pumped inflows from Hampton Vale associated with the Hampton development to the north and the retained water level of the Lake is 9.3mAOD, set by the invert level of the connecting pipe.

e. A disused clay pit, Orton Pit, lies to the west of Haddon Lake and to the east of the northern fringe of the sites. Orton Pit was formed through a dragline technique and not re-profiled following its abandonment. Its current topography is dominated by steep parallel troughs which run the length of the pit. Following its abandonment, water has been retained in the base of the troughs creating numerous small waterbodies, combining to provide a large amount of marginal water habitat. This habitat has since been colonised by Great Crested Newts (GCN’s). Given the high level of legislative protection in the UK afforded to GCN’s and their habitat by virtue of the Conservation Regulations 2007,Orton Pit has been adopted by the European Commission as a Special Area of Conservation (SAC). The extent of the Orton Pit SAC and other protected ecological habitats on and adjacent to the sites are indicated in drawing 15188/400/08, contained within Appendix A for reference.

f. Beeby’s Lakes East and West are located to the east of the A15, London Road, outside of the Great Haddon sites, and fall within the Hampton Leys site. Beeby’s Lakes do not currently have a direct hydraulic link to the Stanground Lode. Beeby’s Lake East and West have an existing retained water level of 5.5mAOD and 6.0mAOD respectively. There is no existing hydraulic connectivity between the two lakes. In order to maintain the water levels, Beeby’s Lake West is pumped to Beeby’s Lake East, which in turn is pumped to the riparian ditchcourse located immediately to the south, on an ad-hoc basis.

g. A further disused clay pit, known locally as Long Pond, is located in the northeast corner of the sites, aligned parallel with the eastern boundary. Long Pond is fed by a number of field drainage ditches that drain a small catchment to the south. The water level in Long Pond is managed by an overflow weir/overflow channel and 300mm diameter pipe which discharges to the Stanground Lode. The weir/channel and thus the maximum retained water level of Long Pond is approximately 10.7mAOD. The normal water level is approximately 9.91mAOD.

h. Fletton Lake lies on the left bank of the Stanground Lode just downstream of the Fletton Parkway crossing. The Lake is connected to the watercourse by twin 380mm diameter pipes.

i. Crown Lakes lie to the north-east of the Hampton Site and to the south of the Stanground Lode. The lakes accept water from the existing riparian ditchcourse and discharge by gravity to the Stanground Lode through a ditch/channel.

3.1.5 Groundwater Vulnerability

a. The Environment Agency publish on their website (www.environment-agency.gov.uk) indicative Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. The Zones define areas where a range of human activities may damage/pollute groundwater. The maps show three main zones (inner, outer and total catchment) and a fourth zone of special interest.

b. A site's location within a SPZ will determine the level of restriction applied to a range of activities within the context of Agency policy. Restricted activities, as defined by "Policy and Practice for the Protection of Groundwater" (Environment Agency, 1992) are:

i) Groundwater abstraction;

ii) Physical disturbance of aquifers and groundwater flow;

iii) Waste disposal to land;

iv) Land Contamination;

v) Disposal of liquid effluent, sludges and slurries to land;

vi) Discharges to underground strata;

vii) Diffuse pollution of groundwater;

viii) Additional activities or developments which pose a threat to groundwater quality.

c. Examination of Agency mapping shows that the sites do not lie within a Source Protection Zone. This is illustrated in Figure 1, Appendix A.

3.2 Development Proposals

a. Great Haddon forms the southernmost part of the Peterborough Southern Expansion Area and comprises approximately 389 hectares of land inside the proposed development boundary. As illustrated in David Lock Associates Development Framework Plan, drawing number PST021-DFP-01L, and Summary Land Use Budget PST-DFP-01 (contained within Appendix C) the proposed Great Haddon Development will comprise the following:

- Up to 5350 residential dwellings (approximately 129ha, including District and Local Centres) at an average density of 40 dwellings per ha (ranging between 10dph in low density areas to 100dph in the district centres). The current Land Use Budget, contained within Appendix C, indicates that 5326 dwellings will be provided.

- Approximately 65ha of employment land, the quantum of which has yet to be defined in detail. Although initial allowance has been made to accommodate a recycling/ 'green' businesses park and strategic distribution, the remainder being incorporated in District and Neighbourhood Centres and Community Sites.

- A district centre and two neighbourhood centres comprising district/neighbourhood retail, community and health, leisure, residential and commercial uses and dwellings.
- Three Primary schools (total area approximately 6.6ha) and 1 Secondary school (approximately 8.9ha).
- Sports and recreational facilities.
- Site for gypsy and traveller pitches.
- Approximately 118ha of green areas which include Green Open Spaces, Playing Fields, Proposed and Existing Woodland, allotments and Planting Buffers.
- Associated highway infrastructure (including pedestrian, bridleway and cycle routes), public transport infrastructure and car parking for all uses.
- Utilities and renewable energy infrastructure.

3.3 Existing Flood Defences

a. The Environment Agency has confirmed that the Stanground Lode does not benefit from flood defences that would control the passage of floodwaters.

4 Planning Policy and Legislative Framework

a. Set out below is a summary of the national, regional and local policy, legislation and guidance relating to surface water drainage and fluvial flood risk that the Great Haddon Development will comply with as part of the proposals.

4.1 National Legislation, Policy and Guidance

4.1.1 National Planning Policy Framework (March 2012)

a. The Planning Policy Statement 25 (PPS25): *Development and Flood Risk* (March 2010) has recently been replaced by the National Planning Policy Framework (NPPF) and its accompanying Technical Guidance, published in March 2012. Currently, the Technical Guidance is a draft/interim document pending a wider review of guidance to support planning policy and retains the main aspects of PPS25.

b. NPPF seeks ensure that flood risk is taken into account at all stages of the planning process, to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at highest flood risk. NPPF retains a risk based approach to the planning process and requires that the Sequential Test is used to guide the decision making process.

c. The Technical Guidance defines three Flood Zones to be used as the basis for applying the Sequential Test and the Flood Risk Vulnerability Classification which defines the type of development that is considered appropriate within each Flood Zone. Taken together, the Flood Zones and Flood Risk Vulnerability Classification are used to provide a Flood Risk Vulnerability and Flood Zone “Compatibility” matrix.

d. The NPPF Flood Zones do not currently take account of climate change impacts. However, NPPF requires that the spatial planning process should consider such issues and contingency allowances are provided to enable the implications of climate change to be considered over the lifetime of the development.

4.1.2 Water Framework Directive (2000/60/EC)

a. The Water Framework Directive (WFD) is a wide-ranging piece of European legislation that establishes a new legal framework for the protection, improvement and sustainable use of surface waters, coastal waters and groundwater across Europe in order to:-

- Prevent deterioration and enhance status of aquatic ecosystems, including groundwater.
- Promote sustainable water use.
- Reduce pollution.
- Contribute to the mitigation of floods and droughts.

b. Water management has historically been co-ordinated according to administrative or political boundaries. The WFD promotes a new approach based upon management by river basin – the natural geographical and hydrological unit. River basin management plans include clear objectives in respect of water quality and pollution control and a detailed account of how objectives are to be met within a prescribed timeframe.

4.1.3 Water Resources Act, 1991

a. The Water Resources Act 1991 (WRA) came into effect in 1991 and replaced the corresponding sections of the Water Act 1989.

b. The WRA sets out the responsibilities of the Environment Agency in relation to water pollution, resource management, flood defence, fisheries, and in some areas, navigation. The WRA regulates discharges to controlled waters, namely rivers, estuaries, coastal waters, lakes and groundwater. Discharge to controlled waters is only permitted with the consent of the Environment Agency. Similarly, a licence is required to abstract from controlled waters.

4.1.4 Flood and Water Management Act (2010)

a. The Flood and Water Management Act takes forward some of the proposals from three previous strategy documents published by the UK Government - Future Water (2008), Making Space for Water (2008) and the UK Government's response to Sir Michael Pitt's Review of the summer 2007 floods.

b. In doing so, it gives the EA a strategic overview role for flood risk, and gives local authorities responsibility for preparing and putting in place strategies for managing flood risk from groundwater, surface water and ordinary watercourses in their areas.

c. The Act is being implemented in stages via secondary legislation (ministerial orders). At the time of writing, there had been seven orders- six composite orders for England and Wales, and one order for England only.

4.1.5 The Groundwater Regulations, 1998

a. The regulations transpose the requirements of the Groundwater Directive into UK legislation. The regulations place a duty on the Environment Agency to protect groundwater by prohibiting discharges of List I substances to groundwater and preventing pollution of groundwater resulting from the discharge of List II substances.

b. The regulations require that the direct or indirect discharge of List I or List II substances must be subject to prior investigation and authorisation and also allow notices to be served to control activities which may lead to discharges of List I or List II substances.

4.1.6 Interim Code of Practice for Sustainable Drainage Systems, 2004

a. This Code of Practice provides support for developers in promoting and implementing a sustainable approach to water management and in particular Sustainable Drainage Systems (SuDS), to ensure their long-term viability and to promote consistent use. The document sets out the key regulatory requirements that must be considered and adhered to before SuDS are installed and commissioned.

4.1.7 Sewers for Adoption 6th Edition

a. Sewers for Adoption is the standard in England and Wales for the design and construction of sewers to adoptable standards. It is a guide to assist developers in preparing their submission to a Sewerage Undertaker prior to entering an Adoption Agreement under Section 104 of the Water Industry Act 1991.

4.1.8 Eco-towns - Living a greener future, Department for Communities and Local Government April 2008

a. The code is a voluntary standard designed to improve all aspects of sustainability for all new homes.

b. Sustainability ratings are provided based on a review of the measures included within a home to increase its sustainability. To achieve the highest rating a home would need to demonstrate the following:

- sustainable urban drainage systems and new water treatment infrastructure resilient to climate change and providing biodiversity benefits through habitat enhancement;
- green roofs, permeable pavements, wetlands and ponds;
- household and rainwater harvesting, stormwater attenuation as well as developing other sustainable provision solutions for non potable water such as for watering gardens. As well as reducing the demands on waste water systems, this will support the wider objectives of increasing bio-diversity in the Eco-towns;
- a strong expectation for development to have all of their built-up parts (including housing, other public buildings and critical infrastructure) fully within Flood Zone 1(the lowest risk);
- No development in Flood Zone 3 (high risk) and Flood Zone 2 (medium risk) which should, as far as possible, be used for open spaces and informal recreational areas that could serve as multi-functional spaces e.g. be used for flood storage.

4.2 Local Policy and Guidance

4.2.1 Peterborough Local Plan (First Replacement) Adopted 2005

a. The Local Plan includes the following policies in respect of Water and Drainage that are relevant in this instance:

- Policy U1 Water Supply, Sewage Disposal and Surface Water Drainage- Development which increases on or off-site demand on potable or foul water infrastructure will only be permitted if there is sufficient existing or potential for creation of new capacity for the development to be accommodated.
- Policy U2 Sustainable Surface Water Drainage- Development shall not increase downstream flood risk, have detrimental effects on the ecology of any watercourse or adversely impact on existing flood protection or drainage structures.
- Policy U4 Water Conservation- Developments must not be wasteful of potential water resources.
- Policy U5 Floodland and Washland- Development will not be permitted in; areas of unacceptable risk of flooding; which reduce floodplain; constrain floodflow paths; reduce flood storage volume or increases the number of people currently at risk from floodwater.
- Policy U6 Development at Risk of Flooding- Risk of flooding, including consideration for flood defence structures and mitigation measures, must be assessed for the whole lifetime of the development. Development should take account of potential alternative sites not affected by risk of flooding.
- Policy U8 Access to Watercourses- Development must provided sufficient access for the maintenance of watercourses and associated infrastructure.
- Policy U9 Pollution of Watercourses and Groundwater- Development will not be permitted in close proximity to potable groundwater recourses or vulnerable aquifers.

Sufficient measures must be provided as to prevent pollution of surface or ground waters.

b. The Local Plan also includes the following policies in respect of Landscape and the Natural Environment:

- Policy LNE13 Conservation of Ponds, Wetlands and Watercourses- Development must not unacceptably harm sites of ecological interest.

- Policy LNE14 Sites of International Nature Conservation Importance- Developments which may impact on designated sites of European nature conservation importance will be subject to the most rigorous of examinations. Developments which impact on designated sites of European nature conservation importance will only be permitted if there is an overriding public interest or is necessary for reasons of human health or public safety.

- Policy LNE15 Sites of National Nature Conservation Importance- Developments which impact on Sites of Specific Scientific Interest will be subject to special scrutiny. Developments which impact on SSSIs will not be permitted unless the reasons for development outweigh the conservational value. Where development is permitted PCC will attach conditions to ensure protection and/or enhancement to SSSIs.

4.2.2 Peterborough City Council Core Strategy Preferred Options

a. The Peterborough City Council Core Strategy is a strategic document, establishing certain principles that are core to the way that the area develops in the longer term. It will apply to the whole of the administrative area of Peterborough City Council. The Core Strategy will cover the period to 2021 (with provision for delivery of housing beyond that date). Because the Core Strategy is strategic in nature, it will not set out detailed policies and it does not identify individual parcels of land for development or protection or improvement. It will establish certain principles which will form part of a 'chain of conformity' for future development. The Core Strategy is, itself, required to be in general conformity with the regional spatial strategy for the East of England. The Core strategy Policies relevant to flood risk and water management are as follows:

- CS3 Urban Extension- minimise risk of flooding to the development site, taking climate change into account.

- CS20- National Policies will apply to Special Protection Areas, Special Areas of Conservation, Ramsar Site and Sites of Special Scientific Interest. Planning permission of developments which will have an adverse impact upon Local Nature reserves, County Wildlife Sites and/or Regionally Important Geological / Geomorphologic Sites will only be granted if there are demonstrable reasons for the proposed development which outweigh the need to safeguard the nature/ geological conservation value of the site.

- CS21 Flood risk- The granting or refusal of planning permission for developments will be informed by the results of the Peterborough City Council Strategic Flood Risk Assessment (detailed below), the requirements of PPS25 and the long term flood management goals of the Environment Agency. No development will be permitted in high risk flood zones. All developments should employ SuDS where feasible. And where appropriate development should help achieve the long-term flood management goals of the River Nene and River Welland Catchment Flood Management Plans.

4.2.3 Peterborough City Council Strategic Flood Risk Assessment (SFRA)

a. In December 2004 Peterborough City Council appointed Haskoning UK Ltd to undertake a Strategic Flood Risk Assessment (SFRA) of the District with the purpose of

(i) classifying all land into the three flood risk zones defined in PPG25 and
(ii) providing a reference and policy document to inform preparation of the Local Development Frameworks and advise private and commercial developers of their obligations under PPG25 (the policy guidance in force at that time).

b. The SFRA presents Flood Zone maps based upon data taken from the Environment Agency's Nene Catchment Strategic Model. However, the flood outlines are defined using Synthetic Aperture Radar (SAR) topographical data and the vertical accuracy is quoted as being +/- 0.5m. For this reason the report recommends that the flood risk maps require further consideration.

4.2.4 Huntingdonshire District Council- Local Plan

a. The Huntingdonshire Local Plan was adopted by the District Council in December 1995. Some of the policies have been superseded by the Huntingdonshire Local Plan Alteration (Adopted 2002). The Alteration contains some new policies, mostly concerned with the settlement strategy and housing. The District Council has also prepared a range of Supplementary and Interim Planning Guidance which builds upon the policies in the Local Plan (detailed below). The policies relating to water management and flood risk are as follows:

- CS 8- the District Council will require satisfactory arrangement for the availability of water supply , sewerage and the disposal facilities, surface water run-off facilities and provision for land drainage when considering planning applications for a development.

- CS9- the District Council will normally refuse development proposals that prejudice schemes for flood water management.

- En22- Wherever relevant, the determination of the applications for planning permission will take appropriate account of the interests of nature and wildlife conservation.

- En23- Development within, or which adversely affects a site of Special Scientific Interest, National Nature Reserve of Local Nature Reserve, or which has a significant adverse effect on the interests of wildlife in an area of special importance for nature conservation, will not be permitted.

4.2.5 Huntingdonshire District Council- Interim Planning Policy Statement

a. The Council has also produced an Interim Planning Policy Statement outlining the local policies it intends to apply when dealing with planning proposals. This includes a mixture of saved Development Plan policies, policies from the withdrawn Core Strategy and other local planning policy guidance. This Interim Planning Policy Statement was adopted by the Council on 18 April 2007.

- P2 Natural Resources- Minimising water consumption, and have no adverse impact on water resources and flood risk.

- P10 Flood Risk- developments should not be placed in areas at risk from flooding without suitable mitigating measures or increase flood risk in other locations. Developments should promote SuDS and be informed by and FRA.

- G4 Protected habitats and Species- Development should not harm sites of national or international importance for biodiversity or geology. Proposals which could damage County Wildlife Sites, Local Nature Reserves, Ancient woodland, important species, or Protected Roadside verges will not be permitted unless the need for development significantly outweighs the potential harm to conservation interests, in this instance appropriate mitigation measures and or compensatory work should be provided as part of the development

4.2.6 Huntingdon District Council- Submission Core Strategy

a. The Core Strategy sets the strategic spatial planning framework for how Huntingdonshire will develop up to 2026. It contains strategic policies to manage growth and guide new development in Huntingdonshire. The Core Strategy provides the local context for considering the long-term social, economic, environmental and resource impacts of development.

- CS9 Strategic Green Space Enhancement- within these areas actions will be taken to contribute, where possible, to flood protection.

4.2.7 River Nene Catchment Flood Management Plan (Summary of Draft Plan July 2006)

a. The River Nene CFMP outlines the Environment Agency's current understanding of flood risk in the catchment, assesses future flood risk and identifies flood risk management policies. As part of the CFMP, the River Nene catchment has been divided into 8 policy units. The Great Haddon site lies within the Main River Nene policy unit. Within this policy unit, the CFMP proposes the following policies:-

- Consider controlling the contributions to flood flow made by tributary catchments

- Implement local protection if necessary.

- Reduce flood risk where prominent, for example commercial/industrial areas of Northampton and Wellingborough.

- Consider the reinstatement of floodplain and develop floodplain storage, using opportunities, where presented, in planned sequence.

5 Flood Risk Assessment

5.1 Existing Information on Flood Risk

5.1.1 Tidal / Coastal

a. Flooding arising from tidal or coastal sources is not an issue at this location.

5.1.2 Groundwater

a. Flooding arising from groundwater sources is not known to be an issue at this location.

5.1.3 Surface Water

a. The sites are currently drained by a series of field ditches which discharge to the Stanground Lode, its Northern Tributary, Long Pond and the Orton Pit SAC.

5.1.4 Watercourses

a. The Environment Agency publishes floodplain maps on the internet (www.environment-agency.gov.uk). These maps show the possible extent of fluvial flooding for the 1 in 100-year flood (that which would have a 1% probability of being exceeded each year) or the possible extent of tidal flooding to a 1 in 200-year event. Also shown is the possible extent of flooding arising from a 1 in 1,000-year event (0.1% probability).

b. The Environment Agency's Flood Zone map is presented in Figure 2, Appendix A. This indicates that the floodplain associated with the Stanground Lode and its Northern Tributary is confined to a relatively narrow corridor with a localised increase in the extent of floodplain at the confluence of the two branches. However, the map suggests that both Orton Pit SAC and Haddon Lake would be inundated during the 1 in 100 year flood. Thus, the vast majority of the Great Haddon development area lies outside of the floodplain.

c. The Environment Agency advised that Flood Zone data is not considered sufficiently robust to inform development planning and design matters.

d. A hydraulic model of the Stanground Lode has therefore been developed to enable the extents of the 1 in 100 year floodplain to be assessed, to identify factors controlling local flood hydraulics and to inform development design and flood risk mitigation measures.

5.2 Hydraulic Assessment

a. The hydraulic modelling analysis consists of the following:

i) Development of a hydraulic model to facilitate an assessment of the existing or "baseline" condition and enable the extents of the 1 in 20 year, 1 in 100 year, 1 in 100 year plus climate change, 1 in 1,000 year and 1 in 1,000 year plus climate change floodplain outlines to be defined.

ii) Development of a hydraulic model representing the form of the proposed/"design" condition and representing the proposed configuration of the surface water drainage strategy.

b. The latter configuration has been used to identify development impacts and inform design of the surface water drainage strategy, to include the utilisation of Beeby's Lakes for flood flow attenuation. Beeby's Lakes East and West lie outside of the Great Haddon sites and will also be utilised as strategic attenuation facilities for the Hampton Leys development, promoted by O & H Hampton Ltd. The Hampton Leys development is located to the immediate north of Beeby's Lakes and also forms part of the Peterborough Southern Expansion, as indicated on drawing 15188/400/05 contained in Appendix A. It is anticipated that the Hampton Leys stormwater drainage strategy will be implemented ahead of the Great Haddon water management strategy, and will make due allowance for the potential surface water run-off flows generated by the Great Haddon Development.

c. Scenario (i) is summarised in the sections that follow. Details of the proposed surface water drainage strategy and modelling relating to (ii) above are summarised in Section 6.

5.2.1 Data Collection

a. The Environment Agency provided a copy of an ISIS hydraulic model of the Stanground Lode (taken from the Agency's Nene Catchment Strategic Model). The model includes 8.5km of the Stanground Lode extending from the A1(M) through to the confluence with the River Nene.

b. The schematisation of the Agency's model is shown in Figure 3, Appendix A with the ISIS schematic shown in Figure 4, Appendix A.

5.2.2 Survey Data

a. Topographical survey of the Great Haddon site, inside the current red line boundary, has been undertaken by Associated Surveying Consultants (ASC) as indicated in Survey Drawing number ASC.08.680, dated December 2008. Topographical survey of the A15 and Beeby's Lakes is taken from a survey for the Hampton Leys scheme also undertaken by ASC (Drawing number ASC.07.525, dated August 07). These topographical surveys form the base of the survey drawings contained within Appendix B.

5.2.3 Rainfall, Flow and Level Data

a. Previous studies utilised data from the Haddon Lake gauging station to calibrate a rainfall-run-off model for the Stanground Lode catchment. A subsequent review concluded that gauging station flow records were unreliable, although original findings in respect of catchment time-to-peak remained valid.

5.2.4 Assessment of "Baseline" Condition

a. The ISIS model provided by the Environment Agency has been taken forward as the basis for the assessment of the "baseline" condition (as agreed with the Environment Agency). However, model schematisation has been revised and updated to reflect:

(i) local/site-specific features/flooding mechanisms and

(ii) the nature of the Hampton development surface water drainage strategy.

b. Changes associated with the Hampton surface water drainage strategy are summarised below:

- Addition of pumped surface water inflow to Haddon Lake from Hampton Vale
- Addition of Pumphouse Lake pumped inflow
- Two inflows (4ain and 4bin) added to represent flows from the IKEA development
- Fletton Lake spills and pumped inflow to lake included

- Four bridges that are to be removed as part of the Hampton development between the A15 and the railway were removed from the model

c. Other modifications to the Agency's model are as follows:

- The Northern tributary has been included through the sites with cross-sections taken from the topographical survey discussed above
- Left overbank floodplain flow route included in the upper reach of the Stanground Lode branch (upstream of the confluence with the Northern Tributary)
- The floodplain component of cross-sections was modified at locations where flood flow conveyance is not considered possible (i.e.: lakes/pits)
- The spill over the crossing at ST7034 was revised based upon the sites topographical survey
- Spill units were added along the left bank of the Lode to reflect floodwater interaction with Haddon Lake and the SAC (spill geometry based upon topographical survey discussed above)
- Conduit link between Haddon Lake and the Lode added to model
- A NOTWEIR has been added to accommodate an abrupt change in bed level.

d. The revised ISIS schematic is shown in Figure 5, Appendix A.

e. Water level data taken from the Agency's Nene Catchment Strategic Model was used to provide a downstream boundary for the Stanground Lode model developed to inform this Flood Risk Assessment.

5.3 Hydrological Assessment

5.3.1 QMED Estimation

a. Catchment descriptors were derived at the gauging station (NGR 516800 293000) using the FEH CD-ROM. FEH descriptors are presented in Table 1 (Appendix D). The FEH catchment area was verified by reference to Ordnance Survey 1:25,000 scale maps of the area.

QMED was calculated using the standard FEH relationships

$$QMED_{rural} = 1.172 Area^{AE} \left(\frac{SAAR}{1000}\right)^{1.560} FARL^{2.642} \left(\frac{SPRHOST}{100}\right)^{1.211} 0.0198^{RESHOST}$$

Where AE denotes the area exponent and is given by:

$$AE = 1 - 0.015 \ln\left(\frac{AREA}{0.5}\right)$$

And RESHOST is a residual soils term obtained from HOST data defined by:

$$RESHOST = BFIHOST + 1.30\left(\frac{SPRHOST}{100}\right) - 0.987$$

QMED was calculated as = 1.960m^3/s.

b. The Flood Estimation Handbook sets out a procedure to adjust the QMED estimate derived from catchment descriptors. This method uses flow gauge data from analogue catchments identified by generating a pooling group in WinFAP. In this instance, a review of potential analogue sites indicated that an adjustment would reduce the QMED estimate by approximately 10%. In view of the uncertainties inherent within flood frequency estimation and in the interests of adopting a precautionary approach, an adjustment was not therefore applied.

c. Flood Frequency Curve

In order to derive flood flows for a range of return periods, a Flood Frequency Curve was generated for the study sites using WinFAP Version 2 and based upon the HiFlows dataset available in August 2008. The default pooling group is presented in Table 2, Appendix D. This pooling group was edited as follows:

- Stations 22801 and 32029 were removed on account of the short record lengths (7 years and 5 years respectively).
- Station 30014 – WinFAP indicates that the gauge becomes non-modular and flows are out of bank at AMAX 3. These potentially erroneous flows were excluded from the station record for the purposes of the analysis.
- Station 39017 – the station record states that the gauge is easily “drowned” due to a restriction immediately downstream, the gauging weir becomes non-modular before bankfull conditions are reached and bypassing of the gauge has been observed. The station was therefore removed from the pooling group.
- Station 31025 – the station record indicates that the gauge is modular to a flow threshold of approximately 17m^3/s. AMAX values (3 no.) above this threshold were therefore excluded from the station record for the purposes of the analysis.
- Station 33030 – the station is identified by WinFAP as not being suitable for pooling and was therefore removed from the pooling group.
- Station 37013 – the station was removed from the pooling group due to the influence of reservoirs/lakes.
- Station 35003 - the station is identified by WinFAP as not being suitable for pooling and was therefore removed from the pooling group.
- Station 24007 – FEH catchment descriptors indicate that the catchment soil wetness (PROPWET) is very different to that of the subject sites. The station was therefore removed from the pooling group.

d. The final pooling group, comprising 535 station years of flood data, is presented in Table 3, Appendix D.

e. A growth curve was produced for the study sites using generalised logistical fittings. The Flood Frequency Curve was derived by factoring the QMED value using the pooled growth curve fittings. The Growth Curve and Flood Frequency Curve are presented below:

Table 5.1 – Growth Factor and Flood Frequency Curve

Return Period (yrs)	Growth Factor	Flow (m^3/s)
QMED	1.000	1.960
10	1.827	3.582
20	2.157	4.227
50	2.615	5.125
100	2.986	5.853
200	3.384	6.634
500	3.956	7.755
1000	4.428	8.679

f. Derivation of Storm Hydrographs

i) The FEH catchment descriptors for the study sites were used to construct FEH boundary units in ISIS which generate a flow hydrograph based upon catchment characteristics and a profile of design rainfall.

ii) The critical design storm duration, D, was calculated using the standard FEH formula outlined in the FEH Volume 4. A critical storm duration of 11 hours was calculated.

In respect of the time to peak, Tp(0), previous studies of the Stanground Lode catchment calculated catchment time to peak using event data from the Haddon Lake gauging station. Following consultation with the Agency, and in the interests of consistency with previous work, it was agreed that this value (Tp = 6.4 hours) should be used as the basis of any further modelling undertaken to inform a Flood Risk Assessment.

iii) A design rainfall event of 1 in 140 years was used to derive inflow hydrographs for the 1 in 100 year flood return period. The design storm depth was distributed within the design storm duration using the 75% winter profile. The resulting flow hydrograph was scaled so that the peak matched that from the FEH statistical analysis (summarised above).

iv) The FEH inflow at the upstream extent of the model (in the vicinity of the A1(M)) was apportioned to the two branches of the Stanground Lode based upon areal weighting.

g. The catchment area of the Stanground Lode increases by approximately 19km^2 between the gauging station (NGR 516800 293000) and the confluence with the River Nene. Two additional FEH inflow boundaries were used to represent the inflow arising from (i) the catchment between the gauging station and Fletton Parkway at NGR 519850, 295950 (Residual 1) and (ii) Fletton Parkway and the confluence with the River Nene (Residual 2). Catchment descriptors for each of these FEH boundary units were derived by applying the area-weighting method (FEH Volume 5) to catchment descriptors at (i) the gauging station and Fletton Parkway and (ii) Fletton Parkway and the River Nene confluence (Ref Table 4, Appendix D).

h. FEH catchment areas were adjusted (reduced) based upon (i) the surface area of lakes within each catchment and (ii) the impermeable area associated with the Hampton development. The catchment area of catchment Residual 1 was reduced from 12.69km^2 to 11.22 km^2 and the catchment area of catchment Residual 2 was reduced from 6.17km^2 to 5.43km^2.

5.4 Results

a. Model results are presented on the CD enclosed in Appendix E and floodplain envelopes are presented in Figures 6 (1 in 20 year floodplain), 7 (1 in 100 year floodplain), 8 (1 in 100 year plus climate change floodplain) 9 (1 in 1,000 year) and 10 (1 in 1,000 year plus climate change), Appendix A. From these it can be seen that the 20 year flows are confined to the channel. Flooding associated with both the 1 in 100 year and 1 in 100 year plus climate change events is generally limited to a narrow corridor and only localised areas are affected, most notably in the vicinity of the confluence of the Stanground Lode and the Northern Tributary. The 1,000 year and 1,000 year plus climate change events affect a wider corridor most notably on the Northern Tributary and just downstream of the confluence of the tributary and the Stanground Lode.

5.5 Extent and Depth of Flooding

a. Hydraulic modelling has demonstrated that the vast majority of the sites lie outside the 1 in 100 year floodplain of the Stanground Lode. On the basis of the above and within the context of PPS25, Annex D, Table D.1, some limited areas of the river corridor immediately adjacent to the watercourse are shown to lie within Flood Zone 3a – High Probability. However, based upon an assessment of the 1,000 year floodplain extent, the vast majority of the sites are classified as Flood Zone 1 – Low Probability, as below:

Table 5.2 - Flood Zones

Zone 1 Low Probability	
Definition	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%).
Appropriate uses	All uses of land are appropriate in this zone
FRA requirements	For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a FRA. This need only be brief unless the factors above or other local considerations require particular attention. See Annex E for minimum requirements.
Policy aims	In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage techniques.
Zone 2 Medium Probability	
Definition	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.
Appropriate uses	The water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in Table D.2 are appropriate in this zone. Subject to the Sequential Test being applied, the highly vulnerable uses in Table D.2 are only appropriate in this zone if the Exception Test (see para. D.9.) is passed.
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 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.
Zone 3a High Probability	
Definition	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.
Appropriate uses	The water-compatible and less vulnerable uses of land in Table D.2 are appropriate in this zone. The highly vulnerable uses in Table D.2 should not be permitted in this zone. The more vulnerable and essential infrastructure uses in Table D.2 should only be permitted in this zone if the Exception Test (see para. D.9) is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain

	operational and safe for users in times of flood.
FRA requirements	All development proposals in this zone should be accompanied by a FRA. See Annex E for minimum requirements. PLANNING POLICY STATEMENT 25 | Annex D 24
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; ii. relocate existing development to land in zones with a lower probability of flooding; and iii. create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.
Zone 3b The Functional Floodplain	
Definition	This zone comprises land where water has to flow or be stored in times of flood. SFRAs should identify this Flood Zone (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, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes).
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 Test.
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 with a lower probability of flooding.

5.6 Sequential Test

a. PPS25 Annex D, Table D.2: Flood Risk Vulnerability Classification, indicates that the proposed development (residential and commercial use) would be categorised as "More Vulnerable". Within the context of PPS25 Annex D, Table D.3: Flood Risk Vulnerability and Flood Zone "Compatibility", “More Vulnerable” development within Flood Zone 1/2 is considered appropriate from a flood risk perspective.

5.7 Impact of Proposed Development

5.7.1 Fluvial

a. All built development (with the exception of watercourse crossings) will be located in Flood Zone 1, as shown on drawing PST021-DFP-01L, Appendix C (which includes the 1 in 1000 year floodplain outline). The proposals will not therefore impact upon flood storage or flood flow routing.

b. Development will include a number of new river crossings to facilitate vehicular and pedestrian access to the sites. These crossings will be designed in accordance with Environment Agency guidance and where such crossings consist of a culvert will accord with the following design criteria:

- Structures to have capacity to convey the 1 in 100 year plus climate change flow.
- Structure invert levels to be set 600mm below solid bed level and backfilled to bed level with inert material
- 500mm freeboard from 100 year plus climate change flood level to soffit
- Mammal ledges, if required, are to be included within design.

c. General arrangement details for each crossing will be provided following detailed design and as part of the Land Drainage Consent application for each crossing. Drawing 15188/400/05 shows the location of the crossings and Drawing 15188/50 Rev F details an indicative elevation of the Western Peripheral Road crossing (see Appendix A).

5.7.2 Surface Water

a. Development will give rise to a large increase in impermeable area within the catchment of the Stanground Lode. This in turn will result in an increase in surface water run-off to the watercourse. The development proposals include a surface water drainage strategy which will mitigate the impacts of increased surface water run-off. This is discussed in Section 6.1.

5.8 Mitigation Measures

5.8.1 Fluvial

a. As set out in 5.7.1 above, all built development (with the exception of watercourse crossings) will be located in Flood Zone 1. Where watercourse crossings encroach into the 1 in 100 year plus climate change floodplain, floodplain storage compensation will be provided in accordance with the Environment Agency's level for level and volume for volume criteria.

5.8.2 Surface Water

a. Measures to mitigate for the increase in surface water run-off following development are detailed in Section 6.

6 Surface Water Management Strategy

6.1 Introduction

a. The proposed development will give rise to an increase in the impermeable area of the site. This will result in an increase in the rate of surface water runoff to the adjacent watercourses/drains. A scheme for the control of surface water runoff has therefore been devised to regulate flows to the Stanground Lode and demonstrate a commitment to reducing downstream flood risk. In addition, the proposals will seek to facilitate habitat creation and will incorporate rainwater harvesting systems to assist with reducing potable water demand. This is discussed further in Section 7 of this report.

b. This section of the report sets out details of the proposed surface water management strategy for the Great Haddon development, together with an overview of its relationship to the strategy associated with the adjacent Hampton scheme.

c. The proposed strategy is illustrated on drawing 15188/400/05, contained within Appendix A.

6.2 Existing Surface Water Drainage Systems

a. The site is currently greenfield and is drained by an existing network of field drainage ditchcourses, or through overland flows, which discharge to the Stanground Lode, its Northern Tributary and the Orton Pit SAC. The locations and flow directions of the existing ditchcourses are indicated on drawing 15188/400/09, contained within Appendix A for reference. It is anticipated that the site will largely be re-profiled to provide development platforms, thus the majority of the existing ditchcourses will be filled and replaced by the formal drainage system described below. Ditchcourses to remain are indicated in drawing 15188/400/09. Measures will be included to ensure that no surface water run-off arising from the development will be able to enter existing ditchcourses which outfall to the Orton Pit SAC.

6.3 Strategy Overview

a. In accordance with design principles agreed following consultation with the Environment Agency in 2005, 2007 and 2008, a strategic approach to the management of surface water run-off has been adopted based upon the use of Beeby's Lakes. The proposed strategy is illustrated on drawing 15188/400/05, contained within Appendix A.

b. For the purposes of designing the surface water drainage strategy, the development site has been divided into a number of areas, or "sub-catchments", as shown on drawing 15188/400/05, Appendix A. A number of these sub-catchments will be served by surface water balancing ponds that will limit outflows of surface water to the Stanground Lode to the greenfield rate (2l/s/ha as previously agreed with the Environment Agency when developing the Hampton surface water drainage strategy). However, some sub-catchments will (i) discharge surface water flows at a rate in excess of the greenfield rate or (ii) outfall unattenuated surface water flows directly to the Stanground Lode. In addition, the Agency had previously advised that surface water flows arising from the development be drained directly to Beeby's Lakes wherever possible.

c. To mitigate the impacts of partially attenuated/unattenuated outflows to the Lode, and to provide a means of draining surface water directly to Beeby's Lakes, a flood flow conveyance channel will be provided. This channel will be connected to the Lode by means of a weir structure (fixed crest level, not adjustable) located along the southern bank and will outfall to Beeby's Lakes to the east. The weir and conveyance channel will serve to divert flood flows from the Lode to Beeby's Lakes. In addition, surface water flows arising from some sub-catchments located to the south will outfall directly to the conveyance channel (as opposed to the Lode) and will therefore be routed directly to Beeby's Lakes.

d. The route of the conveyance channel passes through the northern section of Long Pond, which will be backfilled to accommodate the channel. The channel will also be culverted beneath two ecological constraints, such that it will not impact upon the existing alignment of the 'important' and species rich hedgerows. It will also pass through a culvert beneath the A15 adjacent to the main Stanground Lode crossing.

e. The channel will be configured to include reed bed shelves to aid in maintaining the high water quality and to enable the creation of marginal water habitat.

f. The strategy will cater for surface water flows for up to and including the 1 in 100 year event plus an allowance for climate change and hydraulic modelling has been undertaken to inform the design of the surface water drainage strategy. This is discussed in Section 6.11.

6.4 Beeby's Lakes

a. Beeby's Lakes comprises two water bodies – Beeby's East and Beeby's West, which occupy areas of 15.36ha and 20.98ha respectively. Beeby's East and West have retained water levels of 5.5mAOD and 6.0mAOD respectively and, although there is an area of low ground between the two water bodies, there is currently no existing hydraulic connectivity between the two lakes.

b. There is currently no connection between the lakes and the Stanground Lode. Water levels are maintained by means of pumping from Beeby's West to Beeby's East which, in turn, is pumped to the ditchcourse located immediately to the south, on an ad-hoc basis.

c. In addition to receiving flows diverted from the Stanground Lode (as discussed in Section 6.3 above), Beeby's Lakes will also receive surface water flows arising from the Hampton Leys development, located immediately to the north of the lakes (ref dwg 15188/400/05). Full details are set out in the report titled "Hampton, Peterborough – Strategic Flood Study Phase 2, June 2002", this strategy having previously been approved by both the Environment Agency and Peterborough City Council and is contained in Appendix E. Surface water inflows arising from Hampton Leys and associated with the 1 in 100 year plus climate change event are shown on dwg 15188/400/05.

d. As part of the Hampton Leys surface water drainage strategy, it is proposed that Beeby's East and West will be hydraulically linked. It is currently anticipated that works associated with the Hampton Leys surface water drainage strategy will be implemented ahead of the Great Haddon scheme.

e. Following the implementation of works associated with the Hampton Leys surface water drainage strategy, the normal water level in Beeby's Lake West will be 6.0mAOD. As part of the Great Haddon scheme, the lake level will be drawn down by 0.5m to 5.5mAOD, (the same level as the existing normal water level in Beeby's Lake East). This additional storage volume will be provided so that water levels in Beeby's Lake West for higher order rainfall events will not impact upon the proposed playing fields to the north, which will be at a level of 6.5mAOD. The top water level in the 1 in 100 year event plus an allowance for climate change, following completion of both the Hampton Leys and Great Haddon schemes, is anticipated to be approximately 6.0mAOD, providing a freeboard of 0.5m to the proposed playing fields.

f. Hydraulic modelling has been undertaken to confirm the required storage capacity and anticipated top water levels for up to and including the 1 in 100 year rainfall event plus an allowance for climate change, this is summarised in Section 6.11.

6.5 Beeby's Lakes Operational Criteria

a. Surface water accumulating in Beeby's Lakes (East and West) will be discharged via a new pumping station to be constructed in the south-eastern part of Beebys East. The pumping station will discharge to the adjacent riparian watercourse which will convey the flows to Crown Lakes. These proposals are in accordance with the agreed option for the discharge of water from Beeby's Lakes as set out in the report titled "Hampton, Peterborough - Strategic Flood Study Phase 2, June 2002" that has been approved by the Environment Agency and Peterborough City Council.

b. In accordance with the aforementioned Strategic Flood Study, pumping from Beeby's Lakes will only take place when (i) water levels in the River Nene are below 3.80m AOD and (ii) water levels in the Stanground Lode have receded following a flood event.

c. The Crown Lakes currently discharge to the Stanground Lode via an existing ditch/channel and it is not proposed to alter the existing arrangements.

d. Thus, the receiving watercourse, Crown Lakes and their outfall will simply act as a conveyance route for the pumped discharge from Beeby's Lakes to Stanground Lode, the system proposed for Great Haddon being entirely compatible with the approved Hampton Strategy.

6.6 Design Parameters

a. This section of the report sets out the design parameters for the proposed surface water management and attenuation strategy for the Great Haddon development.

6.6.1 Adoptable Standards

a. It is envisaged that a sustainable surface water drainage strategy for the proposed development will be designed in accordance with Sewers for Adoption 6th edition.

b. The piped surface water drainage system will be designed utilising:

- FSR rainfall data (industry standard practice);
- a volumetric run-off coefficient (Cv) of 0.75 in accordance with industry standard practice
- MicroDrainage (WinDes) design software, such that the piped drainage network will have no above soffit surcharging in the 1 year rainfall event and no above ground flooding in the 30 year rainfall event

6.6.2 Impermeable Area

a. At this stage it has been assumed that the Great Haddon development will comprise an impermeable area of 193 hectares (as indicated on David Lock Associates Masterplan, drawing PST021-DFP-01L contained within Appendix C for reference). As the on plot development proposals are yet to be confirmed in detail, a robust estimate of potential impermeability for each development type has been taken at this stage, which will be confirmed or amended as development proposals are defined in detail. The impermeable area generated as a percentage of total development plot area is as follows:

- Higher Density Residential- 75%
- Medium Density Residential- 65%

- Primary Schools- 60%
- Secondary Schools- 60%
- Employment- 95%
- District Centre- 90%
- Neighbourhood Centre- 90%
- Community/ Civic Hub- 90%
- Primary Street Infrastructure- 100%

6.6.3 Flood Estimation Handbook (FEH)

a. The sizing of the attenuation ponds has been undertaken using catchment specific rainfall parameters derived from the Flood Estimation Handbook (FEH). The catchment parameter file is contained within Appendix D for reference.

6.6.4 Volumetric Run-off Coefficient for Design of Attenuation Ponds

a. A volumetric run-off coefficient (c_v) of 0.85 has been adopted in the sizing of the attenuation ponds.

6.6.5 Climate Change

a. In accordance with PPS25, the attenuation ponds have been sized to allow for an increase of up to 30% in rainfall intensity due to the effects of climate change.

6.6.6 Sizing of Attenuation Ponds

a. The proposed attenuation ponds shown on drawing 15188/400/05 contained in Appendix A have been sized to store the surface water run-off in a controlled manner, limiting to greenfield run-off rates where possible. However, the sizes of attenuation ponds are principally informed by space allocation in the masterplan.

b. The proposed attenuation ponds have been initially sized to accommodate rainfall events up to and including the 1 in 100 year event including climate change. The proposed attenuation ponds will be provided as both ‘wet’ and ‘dry’ ponds depending on location and viability for habitat creation and aesthetic appeal. ‘Wet’ ponds will generally have a retained water depth of 0.5m. All ponds will be provided with a 0.5m freeboard and storage depth will vary between 1m and 2m depending on local topography. All ponds will have side slopes provided at a minimum gradient of 1 in 3.

6.6.7 Storage Volumes Required

a. Using the parameters set out above, the Micro Drainage (WinDes) design software has been used to establish the storage volume required for the 1 in 100 year plus climate change rainfall event to attenuate surface water run-off to greenfield rates. Where it is not possible to attenuate to greenfield run-off rates, overflow controls have been provided to either cascade surface water run-off to another pond or to outfall to the Northern Tributary, Stanground Lode or the conveyance channel.

b. The degree of attenuation to greenfield run-off rates in up to and including the 1 in 100 year rainfall event including an allowance for climate change afforded to the development plots is as follows:

- Fully Attenuated: Catchments 1a-d, 4, 5 and 7
- Partially Attenuated: Catchment 2
- Unattenuated: Catchments 3 and 6a-d

Table 6.1: Catchment Surface Water Attenuation and Discharge Summary

Ref	Area	Impermeable area	Greenfield runoff rate	Attenuation	Volume of Attenuation	30min peak rate	11 hour peak rate	Outfall Location (ISIS Node)
1a,b, d and e*	75.66ha	71.99 ha	144 l/s	OS3 and OS5 (FA)	66,050m3	144 l/s	144 l/s	Through catchment 1c
1c	2.8ha	1.22 ha	2.4 l/s	3 (FA)	1,250m3	1.4 l/s	1.8 l/s	NTrib4D (Northern Trib)
2	13.3ha	8.85 ha	17.7 l/s	11 (PA)	1,650m3	5,732 l/s	796 l/s	NTrib2D (Northern Trib)
3	11.8ha	8.99 ha	18 l/s	-	-	5,502.9 l/s	811 l/s	NTrib2D (Northern Trib)
4	7.7ha	5.13 ha	10.3 l/s	9 (FA)	5,060m3	6.9 l/s	10.1 l/s	ST8501D (Stanground Lode)
5	10.3ha	5.61 ha	11.2 l/s	8 (FA)	5,450m3	8.6 l/s	11.1 l/s	ST7895D (Stanground Lode)
6a	108.6ha	71.11 ha	142.2 l/s	-	-	26,084 l/s	6,255 l/s	30516D (Conveyance Channel)
6b	11ha	7.98 ha	16 l/s	-	-	4,963 l/s	720 l/s	1862dd (Conveyance Channel)
6c	11.6ha	7.99 ha	16l/s	-	-	4,793 l/s	721 l/s	61517d (Conveyance Channel)
6d	9.1ha	6.06 ha	12.1 l/s	-	-	2,805 l/s	546 l/s	7688d (Conveyance Channel)
7	2.56ha	2.56 ha	5.1 l/s	4 (FA)	2,600m3	2.9 l/s	4 l/s	ST7314d (Stanground Lode)

FA = Fully attenuated to greenfield runoff rates
PA = Partial attenuation
* Indicates pumped outfall

c. It should be noted that the above information is based upon a “strategic” review of surface water runoff from the site, using robust assumptions. It is therefore anticipated that when the catchments are reviewed further at the detailed design stage, the discharge rates (for catchments discharging greater than the greenfield runoff rate) can be reduced further.

6.6.8 Overland Flows

a. For up to and including the 30 year rainfall event there will be no above ground surface water flooding associated with the new on-site surface water drainage network. However, in more extreme events where above ground flooding may occur, it is proposed that the levels of all hardstanding areas are designed such that they direct surface water run-off towards the proposed attenuation facilities or watercourse, where they will be intercepted and conveyed to Beeby’s Lakes.

b. It should be noted that proposals include a swale/ ditchcourse in the 'SAC Landscaping Buffer' to the east of the proposed employment area in order to intercept surface water run-off generated from the eastern side of the employment area, ensuring surface water run-off will be prevented from leaving the sites and impacting on the Orton Pit SSSI/ cSAC for rainfall events up to and including the 1 in 100 year rainfall event with a 30% allowance for Climate Change.

6.6.9 Pumping

a. A pumped solution will be implemented within part of the employment area. Surface water will be pumped to the main gravity network, ultimately discharging to the Northern Tributary of the Stanground Lode. This is necessary to safeguard the SAC (in accordance with the requirements of Natural England).

6.6.10 Central Open Space Watercourse

a. The watercourse contained within the Central Open Space will form a dual purpose of public open space and an interceptor / conveyance channel for surface water run-off.

b. The exact arrangement and alignment of the watercourse is yet to be defined in detail, however initial proposals are to provide short sections of channel defined by 0.5m weirs, with a retained water depth of approximately 0.5m. At this stage, it has been assumed that the Central Open Space Watercourse design will adopt the following parameters:

- FSR rainfall data
- a volumetric run-off coefficient (c_v) of 0.75

c. It is assumed that piped drainage systems may be used to drain parts of development parcels either side of the Central Open Space Watercourse and that plot levels will be provided to ensure that there would be no above ground flooding for the 1 in 30 year rainfall event. Given the close proximity of development to the Central Open Space Watercourse it is proposed that it be provided such that it is able to convey the run-off from the south and central areas of the Great Haddon development to the conveyance channel for rainfall events up to and including the 1 in 100 year event including an increase in rainfall intensity of 30% for climate change.

d. The Central Open Space Watercourse will also provide source control attenuation through delaying and reducing flood peaks (although the potential volumes have not been considered as part of the strategy based upon the use of Beeby's Lakes).

6.7 Consideration of Further SuDS Measures

a. Section 6.3 above sets out proposals for the strategic management of surface water run-off. The Great Haddon development will aim to provide an exemplar strategy for managing surface water not only at a strategic level, but also at a local level.

b. As the plot by plot development proposals are confirmed in detail, the Great Haddon development will seek to incorporate further SuDS to reduce and delay surface water run-off flow peaks and mimic natural process where feasible. However ground investigations have identified that the ground conditions within the sites will preclude the use of Infiltration Source Control techniques. SuDS to be incorporated into the scheme in the future may take the form of any, or a combination, of the following:-

- Permeable pavements. Although the ground investigation has precluded the use of permeable pavements as an Infiltration Source Control, tanked systems at appropriate locations could provide storage, reduce surface water run-off peak flows and volumes.

- Filter drains. Can be provided to intercept flows, mimicking natural ground and filtering suspended fine particles.
- Swales. Provide source control by reducing flow speeds, reducing peak flows and potentially provide a storage volume.
- Rainwater Harvesting. Using either underground storage tanks to serve several properties or traditional water butts on individual down pipes. Rainwater harvesting will not be assumed to have an active role to play in mitigation against high order rainfall events by capturing and storing rooftop run-off as the systems are designed to contain water for day-to-day use all year. Once storage tanks are full, overflow will discharge to the surface water network unattenuated. As such rainwater harvesting systems may form a latent factor in run-off reduction. Rain water harvesting is discussed further in Section 7.1.
- Living Roofs, green roofs (and green walls), roof terraces and roof gardens. Green roofs provide some attenuation by reducing peak flows and volumes of surface water run-off. Living Roofs also have potential to help regulate the temperature of buildings and provide unique ecological habitat.

6.8 Water Quality and Pollution Control

a. The Great Haddon Development will aim to provide an exemplar strategy for managing the quality of surface water run-off arising from the increase in impermeable area generated by the development. Currently surface water run-off flows into the Stanground Lode and Northern Tributary. Several measures will be incorporated within the surface water drainage system to ensure that water quality, bio-diversity and ecology within the Stanground Lode corridor are maintained to the highest standards:

- Trapped Gullies are to be provided as standard across the sites.
- Vegetative systems proposed to mitigate against diffuse pollution.
- As development proposals are confirmed in detail and industrial uses are identified for the employment areas, site specific mitigation measures will be set up on a plot by plot basis as required based on the potential for surface water pollution.
- As indicated in Section 6.7 above the surface water management strategy will seek to maximise the use of grassed surface water conveyance channels/ swales and constructed wetlands to convey surface water run-off. Ponds, reed beds and grass channels / swales are effective at improving water quality by reducing pollutants associated with diffuse pollution sources and filtering suspended particles.
- Permeable pavements can improve the quality of surface water run-off and may be incorporated in lightly trafficked/ pedestrian hard standing areas. Permeable pavements limit potential pollution sources by reducing content of heavy metals and suspended fine particles. Biodegradation of hydrocarbons in permeable pavements can also reduce diffuse pollution.
- PBA has been undertaking surface water quality monitoring at Great Haddon and the surrounding area to ascertain baseline conditions for both Water Supply (Water Quality) Regulations 2000 (Water extracted for potable use) and Environmental Quality Standards (Water not extracted for potable use). Details of the assessment methodology, sampling locations and the existing surface water quality are set out in the Great Haddon Environmental Statement, Chapter 4- Ground Conditions, paragraph 4.72 onwards. In summary, the surface water quality of the existing water

bodies in and surrounding the proposed sites is understood to be high when compared against the requirements for both standards. Some high sulphate concentrations have been recorded, which is not unexpected given the underlying bedrock is the Oxford Clay which is rich in the naturally occurring sulphate bearing minerals selenite and epsomite. Additionally, slightly elevated chloride concentrations have been recorded. However, it is believed that these can be attributed to use of salt (sodium chloride) on the A1(M) in winter as a de-icier, which becomes dissolved in rainwater and enters watercourses, through the existing balancing ponds, which discharge to the Stanground Lode.

- The surface water quality monitoring regime will be maintained as part of the adoption and maintenance agreement for the Great Haddon development surface water management strategy to ensure the existing high water quality is maintained for the project life cycle.

6.9 Maintenance

a. In respect of adoption and maintenance, it is envisaged that the developer will maintain both the drainage sewers and the SuDS infrastructure until such time that the maintenance period has passed and sufficient sewer flows are recorded in order that sewers can be brought forward for adoption.

b. It is assumed that all sewers on the sites will be designed to adoptable standards (Sewers for Adoption) in order that the sewer infrastructure could be brought forward for adoption by the Statutory Undertaker, Anglian water.

c. There are several options for the adoption and maintenance of the SuDS infrastructure, (balancing ponds and swales; conveyance channel; and the proposed pumping station in the employment area):

- Current Legislation (Flood and Water Management Act) – Local Authority to adopt;
- Water Authority – Anglian Water adopt;
- Multi-Utility arrangement;
- Private Management Company.

d. The Environment Agency has agreed that a suitable maintenance regime can be secured by way of a Section 106 agreement (ref letter dated 8th October 2010). This matter can therefore be dealt with through an appropriate planning condition, as follows:

Suggested condition:
Development shall not begin until a detailed scheme for the provision, implementation, ownership and maintenance of the site's surface water drainage system, in accordance with the approved Flood Risk Assessment (dated December 2010, Reference 15188/400/01/Revision D), has been submitted to and approved in writing by the Local Planning Authority. This scheme shall include details of any overland flow routes. The scheme shall be implemented in accordance with the approved details and the applicant shall confirm in writing to the Local Planning Authority that this has taken place within one month of completion.

Reason
To prevent any increase in the risk of flooding as a result of the development.

Informative
This condition provides scope for the detailed design of the surface water drainage system to be altered at a later date to fit in with the wider strategy for Great Haddon, if necessary.

e. It has previously been agreed with Peterborough City Council (PCC) that, as part of the Hampton Leys development, Beeby's Lakes will be adopted and maintained by PCC.

6.10 Hydraulic Modelling to Inform Surface Water Drainage Strategy

a. As discussed above, development surface water flows will outfall

(i) directly to the Stanground Lode and its tributary and

(ii) to a new floodwater conveyance channel.

b. A new weir structure will provide a link between the Stanground Lode and the new conveyance channel, thereby facilitating the diversion of flood flows that will be routed via the conveyance channel to Beeby's Lakes. Hydraulic modelling has been undertaken to inform the design of the drainage strategy. This work is summarised below.

6.10.1 FEH Hydrology

a. Catchment hydrological boundary data is based upon the analysis set out in Section 5.3.

b. Development within the FEH catchments will reduce the area of greenfield and increase the extents of impermeable surfaces. Surface water flows arising from these impermeable areas are represented by the WinDes sewer network modelling (discussed below). The iSIS FEH catchment areas have therefore been reduced by the impermeable area represented in WinDes.

c. The catchment area to the gauging station (NGR 516800 293000) was reduced from 10.87km^2 to 9.07km^2 and the catchment area of catchment Residual 1 was reduced from 11.22km^2 to 11.08km^2. The catchment area of catchment Residual 2 was unchanged at 5.43km^2.

d. The modelling undertaken to inform the design of the surface water drainage strategy considers two scenarios:

- Hydrological inflows based upon the critical storm duration for the Stanground Lode catchment (11 hour storm duration)
- Hydrological inflows based upon the critical storm duration for the urbanised surface water drainage sub-catchments (30 minute storm duration).

e. The procedure for deriving inflow hydrographs for scenario (I) is summarised in Section 5.3 above. The same procedure was used for the range of return periods considered and short duration event hydrographs derived by reducing the boundary storm duration parameter to 30 minutes.

6.10.2 Surface Water Drainage Inflows

a. For each of the surface water drainage catchment areas shown on Drawing 15188/400/005 (Appendix A), a surface water sewer layout was developed within WinDes in accordance with Sewers for Adoption 6th Edition. A series of outflow hydrographs for each of the surface water drainage sub-catchments were produced for the 1 in 20 year and 1 in 100 year plus climate change flood return periods, for both the short and long storm durations. Peak flows for each surface water drainage sub-catchment are summarised in Table 6.2 below. The WinDes models including source control, storm files and simulations are included on the CD contained within Appendix E.

Table 6.2 - Peak Flows (m^3/s) for Each Surface Water Drainage Sub-Catchment

Return Period	Duration	1	2	3	4	5	6a	6b	6c	6d	7
20yr	Short	0.002	0.770	2.880	0.010	0.010	11.628	2.540	2.370	1.300	0.003
	Long	0.030	0.400	0.410	0.010	0.010	3.180	0.370	0.370	0.280	0.003
100yr incl climate change	Short	0.145	6.360	6.490	0.010	0.010	26.392	5.770	4.910	2.960	0.003
	Long	0.145	0.800	0.810	0.010	0.010	6.240	0.720	0.720	0.550	0.004

6.10.3 Hydraulic Model

a. The ISIS model used to represent the "Baseline" scenario was re-configured to represent the form of the proposed surface water drainage strategy (see Figure 11 Appendix A). The following alterations have been made to facilitate an appraisal of the "Design" scenario and to inform the design of the surface water drainage strategy:

- Addition of a side spill weir (5m wide at a level of 13.5mAOD) to route flows to the new conveyance channel, ultimately outfalling to Beeby's Lakes
- New reach included representing the form of the surface water conveyance channel, culverted under A15 (A15_USdd and A15_DS), outfalling to Beeby's Lake West (1.862 to A15_US)
- Surface water inflows arising from the proposed development added as lateral inflows (CATCH1 – CATCH7)
- Surface water inflows from the Hampton Leys development (HAMPTON1, 2, 3, 6, _LT42 and _LT18) to Beeby's Lakes
- Four road crossings added (HIGHWAY1 comprising a 6m wide by 1.2m high rectangular section culvert, HIGHWAY 2 comprising a 6m wide by 1.8m high rectangular section culvert, HIGHWAY 2A comprising a 1.2m wide by 0.7m high rectangular section culvert and HIGHWAY3 (representing the Western Peripheral Road) comprising an opening of approximately 25.5m wide with a soffit set at 18.1m).
- Two hedge crossings added (HEDGE 1 – HEDGE 2) within reach representing the new conveyance channel
- Channel improvement works on the Northern Tributary to accommodate surface water inflows (NTrib3 to NTrib1). Channel widened to a bed width of 6m, 1:2 side slopes to existing ground level.
- Reservoir Unit added to the model to represent Beeby's Lakes.

b. As set out in Section 6.5b above, pumping from Beeby's Lakes will only take place when (i) water levels in the River Nene are below 3.80m AOD and (ii) water levels in the Stanground Lode have receded following a flood event. Pumping will not therefore take place during flood conditions and on this basis a pumped discharge has not been included in the hydraulic model.

6.11 Results

a. As discussed in Section 5.2, the hydraulic modelling analysis consists of the following:

i Development of a hydraulic model to facilitate an assessment of the existing or "baseline" condition

ii Development of a hydraulic model representing the form of the proposed/"design" condition and representing the proposed configuration of the surface water drainage strategy.

b. Following consultation with the Environment Agency, it was agreed that the performance of the proposed surface water drainage strategy should be assessed through comparison of flow and stage hydrographs derived from (i) and (ii) above. The impacts of the proposed scheme have been assessed at the following locations:

- The Northern Tributary immediately upstream of the confluence with the Stanground Lode (Model node NTrib1);
- The Stanground Lode immediately upstream of the confluence with the Northern Tributary (Model node ST7613TribU);
- The Stanground Lode immediately upstream of the weir linking the Lode and the new conveyance channel (Model node ST7613);
- The Stanground Lode immediately downstream of the weir linking the Lode and the new conveyance channel (Model node ST7314);
- The Stanground Lode downstream of Fletton Lake in the vicinity of the confluence with the River Nene (Model node ST757)

c. Model results are discussed below and presented in Appendix E (model output hydrographs and tabulated data on CD). The locations of model nodes are shown on drawing 15188/400/05 contained within Appendix A.

6.11.1 1 in 100 Year Plus Climate Change Short Duration Scenario

a. Model hydrographs for the 1 in 100 year plus climate change short duration scenario ("baseline" vs "design" scenarios) are presented in Appendix E and a summary of the key trends is set out below:

- On the Northern Tributary immediately upstream of the confluence with the Stanground Lode (Model node NTrib1 – hydrograph 1) the model data shows a short duration inflow with a peak of approximately 8 m^3/s prior to the fluvial response. This inflow results from catchments 2 and 3 discharging to the watercourse largely unattenuated. The inflow has a duration of less than 1 hour which is consistent with the rapid response of the developed sub-catchment. The hydrograph resulting from the fluvial catchment response follows and the peak can be seen to be lower for the "design/proposed" scenario on account of the fact that the contributing greenfield catchment area has been reduced as discussed in Section 6.11.1 above.

- "Baseline" and "design/proposed" hydrographs on the Stanground Lode immediately upstream of the confluence with the Northern Tributary (Model node ST7613TribU – hydrograph 2) exhibit similar trends. However, surface water inflows to this reach are fully attenuated before being discharged to the Lode. In this instance, the profile of the early part of the "design" hydrograph is a function of backwatering from the confluence associated with surface water inflows to the Northern Tributary (note the negative flow shown during the early part of the "design" hydrograph).

- Comparison of "baseline" and "design" hydrographs on the Stanground Lode immediately upstream (Model node ST7613 – hydrograph 3) and downstream (Model node ST7314 – hydrograph 4) of the weir linking the Lode to the new conveyance channel shows that the peak associated with the surface water inflow is reduced by approximately 50% as a result of floodwater being diverted. In addition, floodwater diversion facilitated by the weir link to the conveyance channel reduces the peak of the fluvial component by approximately 50%.

- Further downstream, in the vicinity of the confluence with the River Nene (Model node ST757 – hydrograph 5), the "baseline" hydrograph exhibits a "double" peak. This is a function of the urbanised nature of the catchment in the lower reach of the Lode which gives rise to a quicker flood response than the rural component of the Lode catchment. The profile of the early part of the "design" hydrograph differs very little from the "baseline" hydrograph. However, flows during the later stage of the "design" flow hydrograph are reduced by approximately 1.0 m^3/s as a result of floodwater diversion upstream to the conveyance channel.

- In respect of Beeby's Lakes, the modelling analysis indicates that the water level will increase by approximately 0.3m as a result of the stormwater inflow arising from both Hampton Leys and Great Haddon (stormwater from the latter being routed to the Lakes by the conveyance channel).

6.11.2 1 in 100 Year Plus Climate Change Long Duration Scenario

a. Model hydrographs for the 1 in 100 year plus climate change long duration scenario ("baseline" vs "design" scenarios) are presented in Appendix E and a summary of the key trends is set out below:

- On the Northern Tributary immediately upstream of the confluence with the Stanground Lode (Model node NTrib1 – hydrograph 6) the model data shows a "spike" on the rising limb of the flood hydrograph. This results from catchments 2 and 3 discharging to the watercourse largely unattenuated. The flow peak that follows shortly after this "spike" reflects the response of the rural catchment upstream. The hydrograph peak associated with the rural catchment response can be seen to be lower for the "design/proposed" scenario on account of the fact that the contributing greenfield catchment area has been reduced as discussed in Section 6.11.1 above.

- As noted above, surface water inflows to the Stanground Lode immediately upstream of the confluence with the Northern Tributary are fully attenuated. Floodwater levels during the rising limb phase of the flood hydrograph (Model node ST7613TribU – hydrograph 7) are marginally higher for the "design" scenario on account of the surface water inflows to the Northern Tributary and the associated "backwatering" from the confluence, as discussed above.

- Comparison of "baseline" and "design" hydrographs on the Stanground Lode immediately upstream (Model node ST7613 – hydrograph 8) and downstream (Model node ST7314 – hydrograph 9) of the weir linking the Lode to the new conveyance channel shows that floodwater diversion serves to mitigate the impact of unattenuated surface water inflows. In addition, the peak associated with the response of the upstream rural catchment is reduced by approximately 60%.

- Further downstream, in the vicinity of the confluence with the River Nene, comparison of "baseline" and "design" hydrographs (Model node ST757 – hydrograph 10) shows that the drainage strategy serves to reduce peak flows by over 1.5 m^3/s, such that peak floodwater levels are reduced by approximately 100mm.

- In respect of Beeby's Lakes, the modelling analysis indicates that the water level will increase by approximately 0.6m as a result of the stormwater inflow arising from both Hampton Leys and Great Haddon (stormwater from the latter being routed to the Lakes by the conveyance channel).

6.11.3 1 in 20 Year Scenario

a. The results of modelling analysis associated with the 1 in 20 year short and long duration storm scenarios are presented in Appendix E (model hydrographs 11 to 15 and 16 to 20 respectively). In respect of the short duration scenario, model hydrographs for the "baseline" and "design" scenarios exhibit similar trends to those discussed above in respect of the 1 in 100 year plus climate change event. Downstream of the weir linking the Lode to the new conveyance channel (Model node ST7314 – hydrograph 14), model output shows that the peak associated with the surface water inflow is reduced by approximately 25%. In addition, floodwater diversion facilitated by the weir link to the conveyance channel reduces the peak of the fluvial component by approximately 35%.

b. In respect of the long duration scenario, model hydrographs also exhibit similar trends to those discussed above in respect of the 1 in 100 year plus climate change event. Comparison of "baseline" and "design/proposed" hydrographs on the Stanground Lode immediately upstream (Model node ST7613 – hydrograph 18) and downstream (Model node ST7314 – hydrograph 19) of the weir linking the Lode to the new conveyance channel shows that floodwater diversion serves to mitigate the impact of unattenuated surface water inflows. In addition, the peak associated with the response of the upstream rural catchment is reduced by approximately 50%.

c. In respect of Beeby's Lakes, the modelling analysis indicates that the water level will increase by approximately 0.19m (short duration) and 0.37m (long duration) as a result of the stormwater inflow arising from both Hampton Leys and Great Haddon (stormwater from the latter being routed to the Lakes by the conveyance channel).

6.11.4 Floodwater Inundation of Orton Pit SAC

a. Both the Environment Agency and Natural England have highlighted the risk presented to Orton Pit SAC associated with floodwater inundation. These stakeholders advised that development proposals should include a surface water drainage/flood management strategy that controls/reduces the frequency of floodwater inundation, thereby safeguarding the ecological status of the SAC.

b. As noted above, the Agency's hydraulic model has been revised to include spill units that enable floodwater interaction between the Lode and Haddon Lake/Orton Pit SAC to be simulated. The analysis shows that floodwater currently spills over the left bank of the Stanground Lode and into both the Orton Pit SAC and Haddon Lake during a 1 in 100 year plus climate change event. However, following implementation of the drainage strategy based upon floodwater diversion to Beeby's Lakes, the modelling analysis shows that floodwater spill to both Haddon Lake and Orton Pit SAC does not occur during the 1 in 100 year plus climate change event.

6.11.5 Results Summary

a. The hydraulic modelling analysis may be summarised as follows:

- In respect of the short duration storm scenario, the proposed surface water drainage strategy gives rise to increased flood flows and levels in the vicinity of the confluence of the Stanground Lode and Northern Tributary. However, these impacts are "short-lived" (on account of the rapid flood response of urbanised catchments) and may be mitigated through localised improvement works, thereby safeguarding the proposed development. Although the surface water inflow is not fully attenuated/mitigated through floodwater diversion, the strategy serves to reduce peak flood levels downstream of the weir.

- In respect of the long duration storm scenario, surface water inflows coincide with the rising limb of the catchment flood response hydrograph and peak flood levels along the reaches upstream of the side weir are generally unaffected. Downstream of the weir linking the Lode and the conveyance channel, the fluvial flood peak is significantly reduced. Through attenuation of the flood flow arising from the wider natural catchment the strategy prevents floodwater spill from the Stanground Lode to the Orton Pit SAC during the 1 in 100 year plus climate change event. On this basis, the surface water drainage strategy and use of Beeby's Lakes is considered to offer a strategic benefit to both the Orton Pit SAC and areas downstream.

7 Reduction in Potable Water Demand

a. It is generally accepted that some form of reclaimed water system will be required in order to meet the requirements of the Code for Sustainable Homes (CfSH) levels 5 and 6 for reduction in potable water demand. It is currently envisaged that some of the development proposals at Great Haddon will include for provision of rainwater harvesting systems, the scope of which is yet to be defined in detail. Further measures, or the provision of grey water recycling systems where use of rainwater harvesting systems are not feasible, will be included as plot by plot development proposals are defined in detail. Assuming appropriate connection and plumbing facilities are incorporated into the design of dwellings, rainwater or recycled grey water will replace potable water in domestic uses where water quality is not critical (e.g. toilet flushing, garden watering, car washing and laundry). These uses can account for up to 40-60% of water consumption.

7.1 Code for Sustainable Homes Requirements

a. The Great Haddon development will be provided in line with the recommendations and requirements set out in Eco-Towns- Living a Greener Future and CfSH- Setting the standard for sustainability in new homes. Table 7.1 below sets out the proposed number of dwellings to be constructed per development phase and the CfSH levels that will be achieved.

Table 7.1- Great Haddon Potable Water Loading Comparison

Build out Phase	Private Homes	CfSH Code Level	Affordable Homes	CfSH Code Level
Up to end 2013	700	3	300	4
2013 to 2016	1050	4	450	4
2016 +	1980	6	846	6

Notes: Total 5326 dwellings based on Summary Land Use Budget

Total dwellings to be provided at CfSH Code level 3 (105 l/h/d)	700
Total dwellings to be provided at CfSH Code Level 4 (105 l/h/d)	1800
Total dwellings to be provided at CfSH Code Level 6 (80 l/d/d)	2826

Baseline peak potable water consumption demand (based on 200l/h/d)	124l/s
Great Haddon peak potable water consumption demand, allowing for CfSH water usage	60l/s

b. By adopting the proposed reduction in water use set out in CfSH it is anticipated that the Great Haddon Development will be able to achieve approximately 50% reduction in peak potable water demand.

7.2 Rainwater Harvesting Systems

a. Rain water harvesting will be promoted across the sites where necessary to comply with the requirements of CfSH, initially serving plots in the southwest. It is envisaged that rainwater harvesting systems will collect run-off from rooftops and potentially permeable pavement collectors. Rainwater run-off collected from paved areas would require initial treatment prior to entering the rainwater harvesting systems. Rainwater will then be held in below ground storage tanks and either be pumped or fall through gravity to dwellings.

b. In parts of the developments where rainwater harvesting systems are employed it is anticipated that systems will be provided on a block by block or neighbourhood basis, to serve no less than 100 dwellings, outfalling to a single point of storage/distribution. This is instead of the provision of individual systems on a dwelling by dwelling basis in order to provide the most efficient system possible. The exact arrangement will be subject to confirmation of on plot proposals. In the past, communal rainwater harvesting systems have resulted in arguments over maintenance liability under shared ownership. These issues could potentially be circumvented at Great Haddon as Anglian Water has indicated that they may be willing to consider adoption of rainwater harvesting systems which are installed within the development outside of any privately owned land. This will be confirmed following further consultation with Anglian Water and confirmation of rainwater harvesting proposals in detail. A centralised rainwater storage and pumping system may offer cost savings and reduce maintenance issues over the provision of individual systems in each dwelling. However, roof outlets, guttering and pipework should function as a part of the whole system, with access for routine maintenance and cleaning.

c. Rainwater collected will be filtered and stored for up to approximately 10-20 days, to be used in applications where potable water quality is not required (i.e. external taps and toilet flushing). It is not currently anticipated that rainwater will be treated to bring it to potable standards.

d. In the south of England rainwater harvesting systems generally require that dwellings have approximately 35m^2 roof plan area per head in order to provide a sufficient amount of water to deliver a viable solution. Calculation of the minimum requirement for catchment area will be reviewed once the proposals for blocks of dwellings are confirmed in detail. The provision for green infrastructure and permeable pavements will also need consideration. The minimum requirement for roof plan area may be an issue in high density housing, flats, or modern housing of three or more stories where residency may be high compared with potential catchment area. In cases where rainwater harvesting systems are not feasible consideration will be given to Grey Water recycling systems as an alternative.

e. The installation of rainwater harvesting systems in schools (or other public buildings) may also provide an additional benefit for the education authority. Water conservation now forms part of the National Curriculum. Rainwater Harvesting systems can be installed with monitoring units which indicate mains water and rainwater usage. These can be incorporated into lessons and provide a point of interaction between school children and resource recycling. This will help promote an environmentally friendly profile within the community.

7.3 Grey Water Recycling Systems

a. Grey water is defined as water that was previously supplied by a water undertaker as potable water, but has already been used in washbasins, baths or showers. Water from toilets, dish washing, clothes washing or other similar sources where water is likely to carry contaminants such as sewage, grease, food waste or detergents is generally not considered suitable for reclamation.

b. Grey water recycling systems could be implemented where rainwater harvesting systems are not feasible, in order to reduce demand on the potable water network.

c. It is anticipated that grey water recycling systems could potentially be employed on a similar basis to rainwater harvesting systems, being promoted on a block-by-block or neighbourhood basis in the most efficient method possible. Communal grey water recycling systems present the same issues with regards to shared ownership and maintenance liabilities. It should be noted that, to date, no discussions have been held with Anglian Water regarding the adoption of grey water recycling systems.

d. Grey water collected would be filtered and/or treated and stored for up to 3 days, to be utilised in applications where potable water quality is not required. It is not recommended that recycled grey water be used in as many applications as rainwater. Typical uses are toilet flushing and industrial processes (e.g. car washing).

e. As grey water is likely to carry additional contaminants the process of filtering and treating grey water can be more involved than that of rainwater harvesting systems. Any additional treatment processes may carry with them additional installation, operation and maintenance costs and maintenance liabilities, the extent of which are dependant upon the type of system proposed. Indeed, it may be possible to specify a type of system which requires very little human interaction in the treatment process and maintenance liabilities to be covered by the installer. Alternatively these duties could be undertaken by a management company set up as part of the Great Haddon development. The potential for this option will require review as on-plot proposals are confirmed in detail.

7.4 Abstraction from Water Bodies

a. Although it is not confirmed at this stage the Great Haddon development may seek to utilise the extensive water assets adjacent to the sites (Haddon Lake and Beeby's Lakes) to supply potable water to the sites, thereby alleviating demand on the incumbent potable water network. The existing high quality of water in the water bodies surrounding the sites is such that the quality of abstracted water would be of near potable water quality, thus requiring minimum water treatment.

b. Should water abstraction from surrounding waterbodies be included within the development proposals, a potable water treatment works will be provided within the site, the location of which is subject to confirmation and dependent upon the proposed source waterbodies.

c. It should be noted that the full potable water supply to the sites will be supplied in line with statutory requirements by Anglian Water regardless of the potential for reduction in demand from the above measures.

7.5 Foul Water

7.5.1 Water Cycle Study

a. The city of Peterborough and the surrounding area is served by Flag Fen wastewater treatment works. Treated effluent is discharged to a channel known as the Counter Drain, which conveys flows to the Dog-in-a-Doublet pumping station where effluent is pumped to the tidal River Nene. The capacity of the wastewater treatment works will be increased to accommodate growth and any increased discharge from the works may lead to increased flood risk from the Counter Drain. The Addendum to Peterborough Water Cycle Study (July 2010), enclosed in Appendix A indicates that any increased risk can be mitigated through improvements to the Counter Drain and/or the Dog-in-a-Doublet pumping station.

b. The Addendum to Peterborough Water Cycle Study (July 2010) states that funding for any improvement works will be sought through Section 106 agreements.

c. The Addendum to Peterborough Water Cycle Study (July 2010) concludes that:

"…*the following Water Cycle Study partners (Peterborough City Council, Anglian Water, Environment Agency) are satisfied that any constraints to growth based on the wastewater network and treatment capacity can and are being overcome through partnership working and monitoring, to ensure that growth is delivered sustainably"*

d. In respect of individual developments, the Addendum to Peterborough Water Cycle Study (July 2010) indicates that "If appropriate, given the scale and the nature of the development, a condition/Section 106 obligation will be imposed upon the developer requiring the agreement of a drainage strategy including any appropriate/necessary off site works"

e. Matters related to foul water drainage can therefore be dealt with through appropriate planning conditions.

7.5.2 Reduction in Sewer Flows

a. Anglian Water assumes that generally 90% of potable water supply will be returned to the foul water sewer system. By incorporating measures to reduce the total volume of water required and recycling grey water which would ordinarily be discharged to foul sewers, the Great Haddon development will aim to reduce demands on foul water conveyance and treatment infrastructure. Full details of the Foul Sewer Design Solution can be found in the Utilities Section of the Great Haddon ES chapters.

8 Residual Risk

a. Hydraulic modelling has demonstrated that the extent of the1 in 100 year plus climate change floodplain of the Stanground Lode and the Northern Tributary is limited to localised areas within a very narrow corridor adjacent to the watercourses.

b. However, there remains some uncertainty associated with the design flood levels. It should also be noted that the nature of flood risk at this location may vary as a result of more extreme conditions/circumstances than those considered or changes in landform/changes to the upstream catchment. Consideration should therefore be given to the design of the development so that potential flood damage is minimised in the highly unlikely event of flooding.

c. As part of the development proposals, new crossings/culverts will be constructed. Whilst such features will be designed in accordance with the Environment Agency's requirements, structure blockage may impede flood flow conveyance, thereby increasing upstream flood water levels. Such issues will be considered as part of the detailed design process.

d. The residual risk associated with surcharging of the surface water drainage system cannot be quantified until the detailed drainage design for each phase of development has been finalised. Surcharging of the surface water drainage system may result in localised flooding of areas allocated for car-parking and communal/landscaped areas for events in excess of the 1 in 30 year storm. Development ground levels will be designed so as to route any above ground flows to the proposed surface water balancing/routing features and an assessment of 'exceedance' will be carried out for the development generally in accordance with the principles set out in CIRIA 635 (Designing for Exceedance in Urban Drainage – Good Practice, 2006) as part of the detailed design process.

e. Floor levels will be set based upon the detailed surface water drainage design information once available for each phase of development. Guidance from the Association of British Insurers (ABI) recommends that floor levels in new residential buildings are set above the 1 in 200 year plus climate change flood level. Floor levels should be agreed with funders and insurers.

f. The surface water balancing/attenuation infrastructure will be designed to cater for rainfall events up to and including the 1 in 100 year plus climate change event. In addition, balancing ponds will be provided with a freeboard of 0.5m. The conveyance channel will be designed with a freeboard of approximately 1-2m in the 1 in 100 year plus climate change event.

As noted in Section 6.5 above, pumping from Beeby's Lakes will only take place when (i) water levels in the River Nene are below 3.80m AOD and (ii) water levels in the Stanground Lode have receded following a flood event. In the interests of providing a robust solution, the detailed design process will consider the potential impact upon lake levels of significant storm events occurring shortly after the 1 in 100 year plus climate change event (often referred to as "follow-on" storms).

Appendix A

Scheme Drawings

Appendix A

Drawing 15188/400/01 – Site Location Plan

Drawing 15188/400/06 – Watercourses and Water Bodies Location Plan

Drawing 15188/400/05 – Preliminary Surface Water Strategy

Drawing 15188/400/10 – Proposed Attenuation/Conveyance Channel Context Plan

Drawing 15188/50 - Bridge Elevation

Drawing 15188/400/08 – Protected Ecological Habitat Location Plan

Drawing 15188/400/09- Existing Ditchcourse Location Plan

Figure 1 – Groundwater Source Protection Zones

Figure 2 – EA Floodplain Map

Figure 3 – EA Model Schematic (MapInfo plan)

Figure 4 – EA ISIS Model Schematic

Figure 5 – PBA (Revised from EA's) Baseline ISIS Schematic

Figure 6 – 1 in 20 year Floodplain Outline

Figure 7 – 1 in 100 year Floodplain Outline

Figure 8 – 1 in 100 year + cc Floodplain Outline

Figure 9 – 1 in 1,000 year Floodplain Outline

Figure 10 – 1 in 1,000 year + cc Floodplain Outline

Figure 11 – Proposed ISIS Schematic

Addendum to Peterborough Water Cycle Study – Detailed Strategy, July 2010

Figure 1- EA Groundwater Source Protection Zones

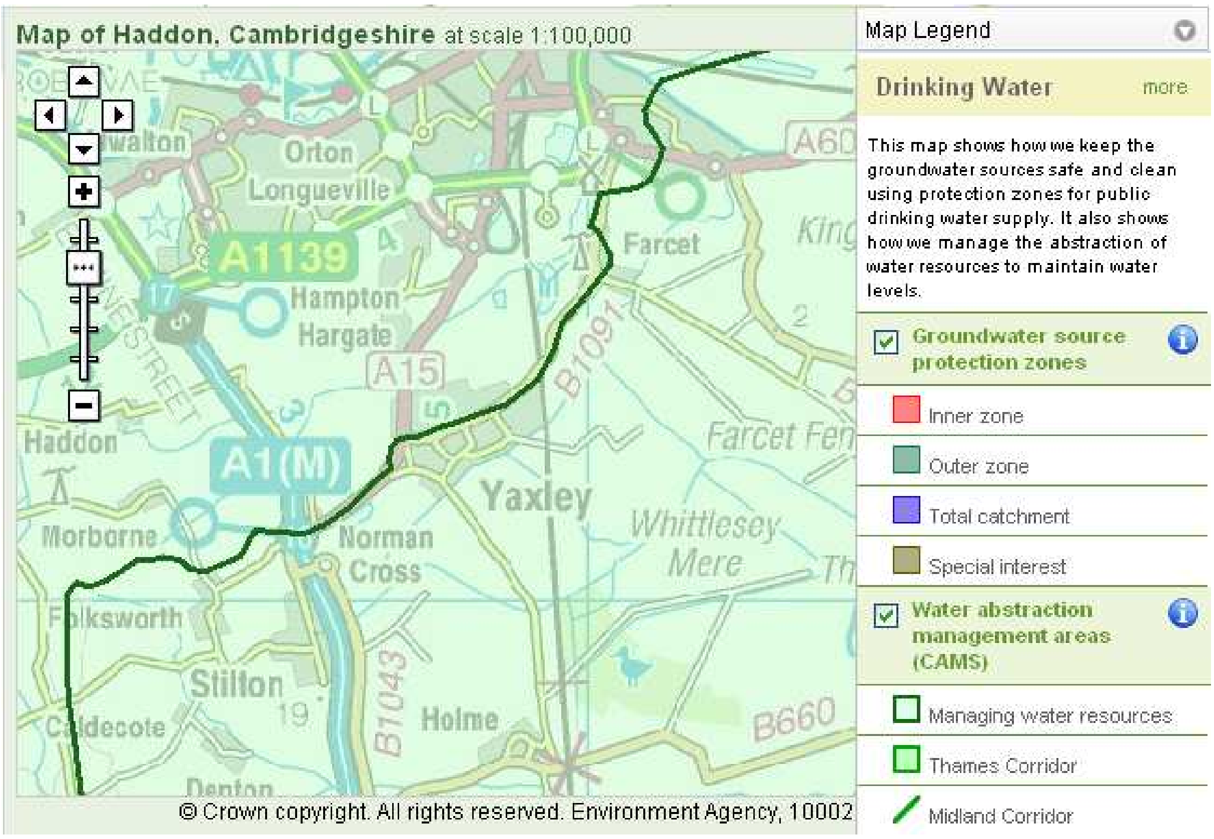
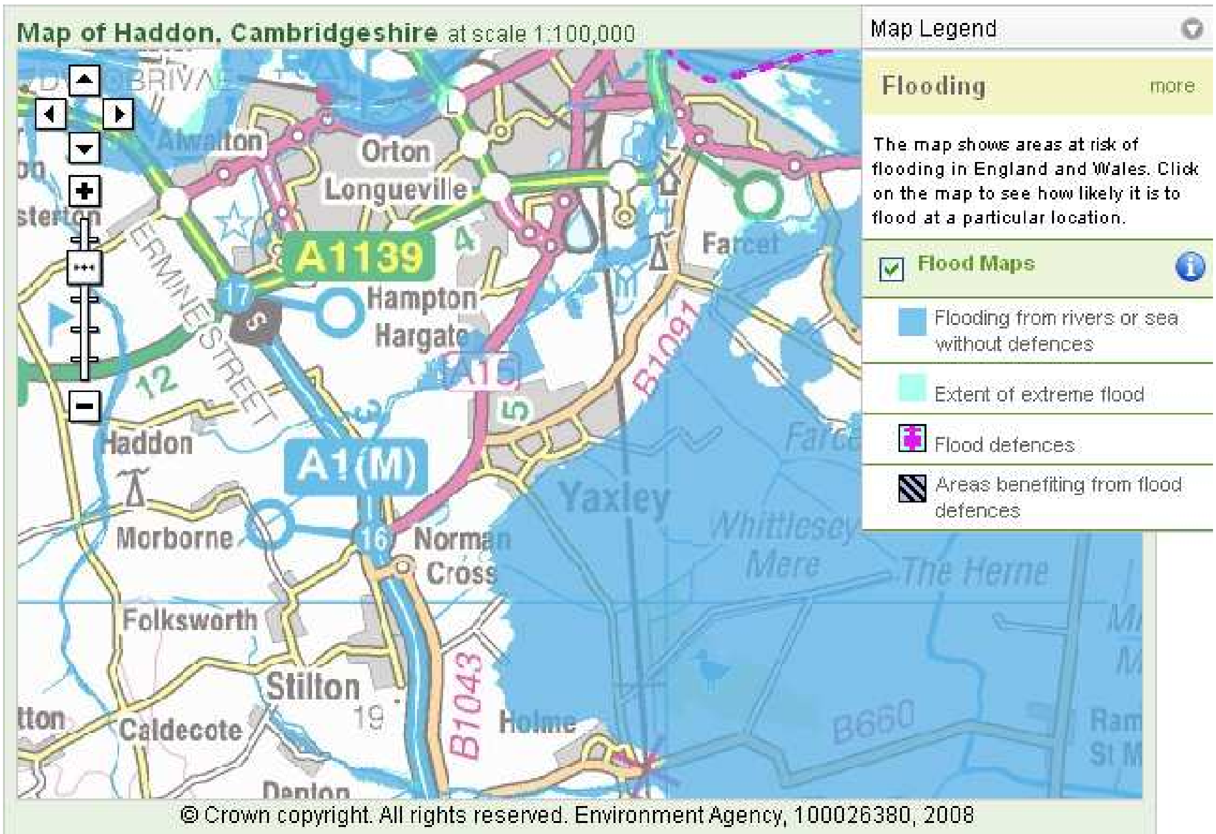


Figure 2- EA Flood Map



Appendix B

Topographic Survey

Appendix B

Drawings 15188/400/02 – 04 Topographical Survey

Appendix C

Development Framework Plan and Land Use Budget

Appendix C

David Lock Associates Masterplan, drawing PST021-DFP-01L

Summary Land Use Budget, PST-DFP-01

Appendix D

FEH Information

Appendix D:

Table 1 – FEH Catchment Descriptors

Table 2 – FEH Default Pooling Group

Table 3 – Final FEH Pooling Group

Table 4 – FEH Catchment Characteristics Areal Weighting Calculations

Appendix E

ISIS Model Output, WinDes Outputs and Hampton Leys FRA

Appendix E

ISIS Model Data - Output Hydrographs

ISIS Model Data - Tabular Data (on CD)

WinDes Storm, Source Control and Simulation files (on CD)

Hampton Strategic Flood Study Report (on CD)