NW Bicester

An application for the exemplar phase of the
NW Bicester Eco Development proposals submitted by
P3Eco (Bicester) Limited and the A2Dominion Group

Drainage Strategy

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NW Bicester Eco Development

Drainage Strategy - Exemplar Site

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1 INTRODUCTION

1.1 Terms of Reference

Hyder Consulting (UK) Ltd. (Hyder) has been instructed by A2Dominion Group (A2Dominion) and P3Eco (Bicester) Ltd. (P3Eco) to provide engineering and infrastructure design in support of the masterplanning and planning for the proposed new eco development on the north-western periphery of the town of Bicester, Oxfordshire. The proposed eco development site will comprise approximately 5,000 homes with supporting employment and education infrastructure. The Exemplar Site is the first phase of the development, located at the north eastern end.

The NW Bicester development is identified in the Planning Policy Statement PPS 1 supplement as one of four eco-towns which have received support from central government. The scheme is also supported locally by Cherwell District Council and Oxfordshire County Council, and is identified as a strategic allocation within CDC draft Core Strategy. The NW Bicester development is proposed to comprise some 5000 homes, a secondary school, a number of primary schools, retail and commercial space along with health care and other community facilities. 40% of the overall site will be green open space, including sports playing fields, semi private and public open space. The development will meet the requirements of the PPS 1 supplement on Eco Towns; which sets out the key sustainability principles.

The first phase of the NW Bicester eco development, the Exemplar Site, will comprise 394 homes, a primary school, nursery and local retail centre, and areas of commercial offices.

This report contains details of the drainage strategy proposed to manage surface water runoff and foul water generated by the Exemplar Site development only. The remainder of the NW Bicester eco development will be covered within a separate drainage strategy.

1.2 Location

The town of Bicester lies approximately 24km to the north east of Oxford and 28km to the south east of Banbury. The M40 motorway lies 2km to the south west, with established access to the town from Junction 9.

The eco development will be situated on the north-western periphery of Bicester, beyond the A4095 (which forms part of the Bicester Ring Road), approximately 1.5km from the town centre.

The Exemplar Site is situated at the northeast end of the development and covers an area of approximately 21.1ha of Grade 3 agricultural land. To the west of the Exemplar Site is the village of Bucknell, with Caversfield located on the north-eastern Exemplar Site boundary, beyond the B4100 highway.

The locations of the eco development and Exemplar Site are presented on drawing 7006 within Appendix A.

2 EXISTING SITE

2.1 Topography

A topographical survey has been completed for the Exemplar Site. Ordnance Survey DTM (Digital Terrain Model) data and Mastermap have been used to provide ground profile and mapping information respectively for the remainder of the surrounding area.

Drawing 7013 (Appendix A) shows contours and topological details of the Exemplar Site produced from the topographical survey.

The existing topography of the Exemplar Site falls by approximately 4m from the north-western boundary to the south-eastern boundary (from ~92m AOD to ~88m AOD), with watercourses lying in central depressions reaching a depth of 82.5m AOD.

2.2 Ground Conditions

Ground conditions have been assessed within a desk study (Phase 1 Desk Study, document 2501-UA001881) and a factual report summarising the findings of onsite ground investigation (Exemplar Site Factual Report, document 2504-UA001881).

In summary, the investigations indicate that the site comprises stratum of sand and gravel overlying clay bands and limestone.

No significant contamination issues or risks have been identified within the reports and it is considered that ground contamination will not impact on the potential for drainage and ground infiltration.

2.3 Local Hydraulic Conditions

Drainage and Water Features

Within the eco development there are several water features: the Bure and its associated tributaries, field drains, ponds and springs. The Bure (a main river) flows in a southerly direction from Caversfield House to a culvert beneath the A4095. Downstream from this it flows in an open channel between Lucerine Avenue and Purslane Drive. There is a tributary flowing in an easterly direction from Bucknell which converges with the Bure downstream of Home Farm. The Langford Brook (an ordinary watercourse) flows in an easterly direction from Crowmarsh Farm, which converges with the Bure at the A4095 culvert. There is a field drain south of Gowell Farm flowing in a southerly direction to a culvert under the A4095 and the downstream urban area. There are several ponds within the boundary of the eco development, most notably at Crowmarsh Farm and south of Himley Farm and a spring is shown to present east of Himley Farm.

In addition to these prominent water features, it is likely that a number of ditches and other smaller features drain individual fields and feed in to the network. The existing water features are identified on Drawing 7019 within Appendix A.

Isolated properties across the eco development are likely to discharge runoff from roofs and paved areas to ditches or piped networks discharging to the watercourses. Roads crossing and adjacent to the site shed surface water to their grassed verges, from where it infiltrates the ground.

Mapping obtained from Thames Water Utilities indicates that urban areas surrounding the eco development are drained by a positive drainage network of surface water pipes and manholes which discharge to nearby watercourses, and a network of foul sewers discharging by both gravity and pump to Bicester Treatment Works.

Existing Drainage Mechanism

Rainfall on the Site discharges predominantly through the following mechanisms:

- Ground Infiltration - water seeps into the ground
- Surface Water Runoff – water discharges along the surface of the ground forming surface water features such as streams, rivers and ponds
- Evaporation and Transpiration – water evaporates from the surface of the ground or is taken up by plants

During large rainfall events, surface water runoff from the Site will contribute to flow in the watercourses, both on Site and further downstream, directly via surface water runoff and indirectly via ground infiltration, by flowing along impermeable stratum and seeping into watercourses.

Assessment of the hydrological conditions provides information regarding the proportion of water discharging by these mechanisms.

Greenfield Runoff Rates

The proportion of rainfall discharging as surface water runoff across the surface of the pre-development site to watercourses has been estimated. These results are expressed as greenfield runoff rates and have been agreed with the Environment Agency. The results are shown within Table 2.1 below.

The IoH124 method has been used to derive these figures, as recommended by the Environment Agency and set out within the SuDS Manual for sites up to 200ha. Further details of their derivation are provided within the Flood Risk Assessment (document 3501-UA001881).

Return Period	(l/s/ha)
Mean Annual Flood	2.29
1 in 30 year	5.12
1 in 100 year	7.29

Table 2.1 Calculated Greenfield runoff rates for the predevelopment site

Ground Infiltration Rates

Desk study of the hydrological conditions at the site indicates that the eco development has relatively low surface water runoff rates, with 1ha of land typically producing a peak discharge of only 7.29l/s. The results indicate that the majority of rainfall discharges from the surface via ground infiltration and therefore infiltration rates at the site are considered to be moderate to good. Ground infiltration methods are therefore considered to be viable as part of the drainage strategy.

Surveyed data on site provides further evidence of the potential to discharge surface water from the development via ground infiltration. Tests were undertaken and completed in accordance with the requirements of BRE365 (Soakaway Design, March 2007, Building Research Establishment) and used to derive ground infiltration rates across this drainage strategy. To achieve ground infiltration rates that reflect the likely depth of soakaway features, the soakaway tests were conducted at depths of approximately 1m below ground level. The results indicate that ground infiltration is feasible within the superficial deposits and that soakage will also be feasible between depths of 1-2m below ground level. Table 2.2 sets out the ground infiltration rates derived which are of relevance to the Exemplar Site and Table 2.3 provides additional ground infiltration information from subsequent testing. Appendix B contains the soakaway test results and test locations. The results reinforce the hydrological assessment and indicate moderate ground infiltration rates.

Discharge of surface water runoff via ground infiltration is considered feasible at the site. However, it is anticipated that some areas of site may not be practical or feasible to discharge via ground infiltration due to the presence of shallow impermeable stratum.

Trial Pit	Infiltration Rate (mm/hr)	Stratum Tested
SP1	180	Slightly clayey sandy limestone GRAVEL
SP2	56	Slightly clayey gravelly SAND
SP3	64	Gravelly CLAY

Table 2.2 Ground infiltration rates

Trial Pit	Infiltration Rate (mm/hr)
SA1	78
SA2	12.2
SA3	66
SA4	131
SA5	-
SA6	54

Table 2.3 Additional ground infiltration rates

2.4 Planning Context

2.4.1 Cherwell District Draft Core Strategy

The vision for the Core Strategy is to achieve a sustainable balance between water supplies and demand. Policies are being developed through the draft Core Strategy to make sure development:

- Addresses issues of water supply and sewage disposal;
- Reduces the consumption of energy and water, minimizes the production of pollution and waste and incorporates facilities for recycling water and waste; and
- Reduces flood risk – Cherwell District Council will seek to allocate development beyond the floodplain. Flood risk assessments will be required for appropriate sites and management sought.

2.4.2 PPS 1

The supplement to Planning Policy Statement 1 states that Eco-towns should:

a Incorporate measures for improving water quality and managing surface water, groundwater and local watercourses to prevent surface water flooding from those sources;

b incorporate sustainable drainage systems (SuDS) and, except where this is not feasible, as identified within a relevant Surface Water Management Plan, avoid connection of surface water run-off into sewers;

c include a strategy at planning stage for the long term maintenance, management and adoption of the SuDS; and

d reduce and avoid flood risk wherever practicable through consideration of the location, layout and construction, whilst not increasing the risk of flooding elsewhere and using opportunities to address and reduce existing flooding problems.

3 SURFACE WATER DRAINAGE STRATEGY

3.1 Principles

The aim of the drainage strategy is to demonstrate that it would be feasible to develop detailed drainage proposals for the development that meet the flood risk requirements of the Environment Agency and the requirements for Eco-towns as set out within PPS1, and requirements to achieve level 5 of the Code for Sustainable Homes (CSH).

The drainage strategy is based on the masterplan submission and site investigation, and sets out proposals for key drainage features and the principles in line with which detailed design should be carried out, based on currently available information. At detailed design stage further site investigations would be conducted providing additional detail of ground conditions and the findings used in conjunction with the drainage strategy to develop a detailed design.

The strategy includes proposals for a surface water drainage system based on Sustainable Drainage System (SuDS) principles, ensuring that following large rainfall events the developed site presents no greater flood risk to the surrounding area than the predevelopment site.

Residential property would be designed in accordance with the requirements of the CSH, whilst non-residential property such as schools and commercial premises are likely to be specified in accordance with and assessed using BREEAM (BRE Environmental Assessment Method). BREEAM sets targets for flood risk depending on type of property and awards credits against the level achieved for other drainage criteria. For example, for educational establishments, credits can be achieved for the following:

- Rainwater and greywater recycling
- Use of SUDS to minimise flood risk

The non-residential property would be expected to meet very similar criteria to residential property and therefore, for the purposes of the drainage strategy, a common set of criteria based on CSH has been used.

Mandatory requirements are set out within CSH for the management of peak runoff rates and the volume of runoff, which can be met by ensuring that:

1 the peak rate of runoff into watercourses is no greater for the developed site than it was for the pre-development site for rainfall events having return periods ranging between 1 and 100 years.

2 the additional predicted volume of rainwater discharge caused by the new development, for a 1 in 100 year event of 6 hour duration, including an allowance for climate change, is entirely reduced using infiltration or rainwater harvesting/recycling. Where conditions make these two options infeasible, the peak discharge rate to watercourses from the entire site should be substantially reduced to a defined minimal level.

Two credits are available under CSH for the management of surface water run-off by ensuring that:

1 no discharge to the watercourse occurs for rainfall depths up to 5mm.

OR

2 agreements are established for the ownership, long term operation and maintenance of all sustainable drainage elements used.

CSH supports the drainage hierarchy which is also encouraged within other guidance documents such as the SuDS Manual and the Building Regulations, through which infiltration is to be used as far as is practicably feasible. Where it is not feasible, surface water is to be discharged in a controlled manner to nearby watercourses.

PPS25 states that an allowance for climate change should be incorporated within SuDS proposals, applied by increasing rainfall intensity within calculations. The rate recommended depends on the anticipated lifespan of the proposals in question. A value of 30% is recommended by PPS25 for the period 2085-2115, reflecting building lifespans of 75years and over. This would be appropriate for the majority of development being considered as residential property typically has a lifespan of 100years and commercial property of 75 years. Therefore, across the site an allowance for climate change of 30% has been made within calculations.

The drainage strategy has been designed to meet the requirements set out above and to prove that such a scheme is feasible, based on the currently available information.

3.2 SuDS Strategy

The development has been designed to mitigate flood risk from surface water through use of SuDS, comprising a system of devices designed to manage both the quality and quantity of surface water runoff. The system would be used in conjunction with effective site management to prevent flooding and pollution.

The SuDS strategy is primarily based on discharge via ground infiltration, in accordance with the drainage hierarchy, minimising surface water discharges to nearby watercourses and the risk of flooding due to surface water. Ground conditions are suitable for use of ground infiltration methods as outlined in Section 2.3. Soakaways and site drainage infrastructure would be designed to minimal depths to allow a broad range of SuDS techniques to be applied and which suit the site ground conditions. A conservative approach has been adopted and appropriate spaces have been set aside for open attenuation features within the site layout. Further ground infiltration investigations would be completed at the specific locations of soakaway features in future design phases.

The watercourses crossing the site are generally dry or have minimal flow. The Langford Brook and River Bure are considered “at risk” of failing WFD standards principally because of high phosphate and nitrate concentrations. These are nutrients which can feed algal growth (leading to de-oxygenation and smothering of aquatic plants) and come from both sewage effluent and agricultural runoff. The eco development would lead to a reduction in agricultural runoff to the watercourses, reducing the phosphate and nitrate concentrations, whilst presenting opportunities to increase the regularity and quantity of flows within the watercourses on site, and therefore offers the potential to improve the status of these waterbodies by reducing nutrient release and increasing dilution. These measures will be developed further at detailed design stage in line with Environment Agency requirements.

Direct discharges would be required to the watercourses at controlled rates for the purpose of enhancing the flow regime of watercourses crossing the site and would also be used as a contingency for areas not being feasible for use of ground infiltration methods.

PPS25 advises that a key component of SuDS is that drainage infrastructure should be spread across a site and discharge close to the source of runoff, mimicking the natural diffuse nature of greenfield site drainage (source control). A variety of forms of soakaway have therefore been proposed across the site as appropriate and to suit the particular location requirements. Each of these would collect and discharge surface water from nearby buildings and paved areas.

SuDS can be formed from many potential components, each having a variety of attributes and strengths which make them suitable or unsuitable for use in differing situations. SuDS systems often comprise chains of linked SuDS components which complement one another and can be combined to form the optimal solution for each situation, often referred to as treatment trains.

The critical requirements of the SuDS system are to control water quantity and improve water quality. A number of treatment trains that meet the criteria are proposed and described within Sections 3.2.3 and 3.2.4. Each treatment train has been assessed hydraulically using WinDES to model their control of water quantity, with further details provided within Section 3.2.9. The treatment trains have been assessed in terms of water quality using a matrix to ensure that the best water quality is achieved through feasible and practical proposals, as set out within Section 3.2.6.

The strategic layout for surface water drainage infrastructure is shown on Drawings 7060 and 7061 within Appendix A. Key elements of the strategy are outlined further in this section.

3.2.1 Soakaways

During large rainfall events, hard paved areas would discharge surface water to soakaways at a greater rate than it is possible to discharge to the ground. Storage volumes are therefore required to store accumulating surface water whilst it steadily discharges to ground.

Storage is generally provided integral with the soakaway but it can take a number of forms, including surface features, such as basins, ponds or swales, or subsurface features, such as tanks, cellular units and permeable pavements, with incoming water filling the soakaway and gradually discharging to the ground through the base and sides. It is likely that a range of forms would be constructed at the site depending on factors local to the soakaway, including the depth of incoming drainage, water treatment requirements, land use and adoption requirements. Wherever feasible, soakaways will be designed which offer benefits beyond surface water control, such as wildlife habitat and public amenity.

As key elements of the strategy set out, each indicative soakaway has been designed and modelled to support the feasibility of the proposal principles, specifically the use of ground infiltration on site. Further details of each type of soakaway proposed are set out in Sections 3.2.3 and 3.2.4.

3.2.2 Controlled Discharge to Watercourse

Discharge Rate

The controlled discharge of surface water to watercourses would be required where inflow to watercourses is desirable and ground infiltration and soakaways are not likely to be feasible. Discharge control would be provided by a flow control device restricting discharges to the mean annual greenfield runoff for the site for all rainfall events up to the 100 year event (including 30% allowance for climate change). During large rainfall events, surface water would enter the drainage system at a greater rate than can be discharged, requiring storage to accommodate the resulting volume of water.

The mean annual greenfield runoff rate has been derived using the IH124 methodology, as outlined in Section 2.3. The whole site comprises areas affected by the proposals and those which remain unaffected/undeveloped, such as the green corridor adjacent the watercourses. The areas affected by the proposals account for 17.5ha of the development and have been used to establish greenfield runoff rates for the developed areas, as shown in Table 3.1.

Total discharges from the developed areas to watercourses would be limited to the mean annual greenfield runoff rate of 40.1l/s, to significantly reduce flood risk as outlined in Section 3.2.7.

Areas containing storage structures such as basins would be landscaped and hydraulically designed to achieve an integrated layout suitable to the spatial requirements of both uses, meeting the functional and maintenance requirements of the soakaways and the aesthetic and amenity requirements of landscaping.

Return Period	Greenfield Runoff	
	(l/s/ha)	(l/s)
Mean Annual	2.29	40.1
1 in 30 year	5.12	89.6
1 in 100 year	7.29	127.6

Table 3.1 Greenfield runoff rates for the predevelopment site

Discharge Volume

As set out in Section 3.1, CSH encourages SuDS to be designed such that the volume of surface water discharged during a 100 year rainfall event is not increased following development, through use of soakaways and rainwater harvesting. CSH recognises that many sites cannot achieve due to unsuitable ground conditions and other overriding issues. In such cases, CSH recommends that the increased risk of flooding that increased volumetric discharge presents, is mitigated through additional restrictions on site discharge rates.

The existing site discharges approximately 1,270m^3 of surface water during the 1 in 100 year event of 6 hour duration. This existing discharge volume is the equivalent to approximately 2.5ha of impermeable area. Calculations of this volume are provided within Appendix D.

Soakaways and ground infiltration are to be used at the eco development wherever feasible, which will combine with extensive rainwater harvesting and recycling to minimise the volume of water discharged to watercourses. However, it is not possible in advance of detailed design to determine the quantity of impermeable developed area that will require discharge to watercourses, particularly due to the unknown requirements of deliberately discharging some areas to watercourses to provide an improved flow regime, as outlined on Section 3.2. Therefore, in anticipation that the discharge volume could potentially exceed the greenfield volume, to mitigate the risk of flooding caused by this increase, discharges to the watercourses during the large rainfall events that might cause flooding will be restricted to the peak rate of the mean annual runoff, in accordance with best practice and the Code for Sustainable Homes. Table 3.1 shows that the peak discharge rate for a 100 year rainfall event (plus 30% allowance for climate change) would be substantially lowered from 127.6l/s for the predevelopment site to 40.1l/s from the eco development.

Discharge Summary

The eco development has the potential to discharge a total volume of water less than or equal to the existing discharge volume. If not feasible, due to the considerations outlined above, the peak discharge rate has been significantly reduced to mitigate any increase in flood risk, as set out in Table 3.2.

	Pre-development	Post-development
6hour duration 1 in 100 year discharge volume (m^3)	1,270	1,270[1]
1 in 100 year peak discharge rate (l/s)	127.6	40.1

1. Target figure for detailed design stage.

Table 3.2 Pre-development and post-development discharge

3.2.3 Roads, Paved and Parking Areas

Adopted roads within the site would drain via a mixture of permeable and impermeable paving. Permeable block paving would be used extensively across site allowing infiltration to the ground. Areas adjacent to some SuDS features will use impermeable surfaces to provide regular inflow to encourage desirable wetland habitat and to feed ponds with fresh water. Private roads, parking, driveways and other areas of paving would drain surface water via permeable block paving and soakaways within the private plot.

Permeable Block-Paving

Permeable block paving are designed systems comprising block paviors underlain by a permeable sub-base. The block paving is spaced with permeable joining medium such as sand which allows rainfall to infiltrate and enter the sub-base, in which it is stored as it slowly infiltrates the ground beneath. A typical detail of permeable block paving is provided on drawing 7163 within Appendix A.

Should an area not be suitable for the use of permeable paving discharging via ground infiltration, the paving can be used to percolate water, slowly conveying water to a nearby swale, pond or basin.

During normal rainfall events, areas of permeable paving would discharge via ground infiltration alone, as described above. During exceptionally large rainfall events, beyond normal design horizons, and in the event of blockages and other such failures, water would overflow and flow to adjacent areas of permeable paving or flow overland following roads to a nearby channel, swale, pond or basin.

Permeable paving provides a high level of treatment of runoff, with filtration trapping and biologically breaking-down particles and pollutants such as suspended solids and hydrocarbons.

Swales

Swales are linear, vegetated depressions which store and infiltrate or slowly convey surface water to other SuDS features.

Swales are proposed to be used across the site within suitable areas of open ground, soaking wherever feasible and conveying surplus water to other nearby features such as ponds and basins.

Swales can provide excellent habitat through creation of marshy and wetland conditions within the swale.

Ponds

Ponds would be incorporated as permanent water features in some areas. Ponds would be supplied with water from the nearby road network and would incorporate an element of attenuation storage.

Excess water would be discharged by ground infiltration through the fringes of the pond or to a nearby SuDS feature such as a basin or swale.

Basins

Following large rainfall events, basins located around the site would receive and store surface water runoff from other SuDS features, discharging by ground infiltration. The basins would be designed to incorporate small areas for relatively frequent inundation allowing the creation of wetlands, and larger and less frequently inundated areas which would provide additional storage volume during less frequent, very large rainfall events. It is anticipated that during such events the basins would typically discharge all water within a maximum of 12 hours. The basins would be modelled in detail at detailed design stages, but it may be possible to achieve a frequency of inundation of 12 hours once every two years for the area less frequently inundated, allowing use of the area for amenity.

Basins would be designed to form a part of the landscaping, shaped to allow their safe use as amenity areas and preventing the build up of unsafe volumes and depths of water.

Infiltration SuDS Feature

Infiltration trenches are proposed to be located adjacent the primary roads within the site and comprise an excavation with permeable base, backfilled with granular filter and plant bedding material. A typical detail of one option for this feature is provided on drawing 7163 within Appendix A, though the final design and details would be finalised at detailed design stage through consultation with OCC.

By incorporating a flat vegetated verge between the road and infiltration trench, particles can be trapped and removed by filtration as the water passes through the vegetation and then percolates down through the bedding medium or granular filter material. Surface water would discharge directly to ground, infiltrating the base and sides of the trench, with infiltration trapping and biologically break-down particles and pollutants such as suspended solids and hydrocarbons.

Village Street SuDS Feature

The commercial hub of the Exemplar site is the village High Street. A SuDS feature incorporating attractive planting would serve this area. A narrow, relatively deep and vertically faced channel could be formed within the paved area, backfilled with planting and filter medium. A grill near the surface would provide a resilient surface through which would protrude vegetation, such as reeds planted in the base. A typical detail is provided on drawing 7163 within Appendix A, though the final design and details would be finalised at detailed design stage through consultation with OCC to ensure that the feature is safe and practical to maintain.

Surface water would run off the surrounding paved area over the edge of the channel from where it would be filtered by the vegetation and planting medium, stored and treated, whilst slowly being discharged by ground infiltration. Particles would be trapped by the vegetation or drawn into the plants thus improving the water quality, whilst filtration in the planting medium would trap and biologically break-down particles and pollutants such as suspended solids and hydrocarbons.

3.2.4 Property

Surface water runoff from the roofs and paved areas of residential and commercial property would be discharged via soakaways within the curtilage of the property or to nearby SuDS features.

Each residential property would incorporate a combined rainwater harvesting and soakaway system within the back garden. Rainfall would be retained within the rainwater harvesting tank, ready for future reuse within the property. Excess rainwater would discharge to a soakaway structure within the garden should the tank capacity be exceeded. Smaller properties with shared courtyards for parking have the potential to incorporate shared soakaways beneath the courtyards.

Affordable housing and flats may benefit by allowing a number of properties to discharge to shared soakaway and rainwater harvesting features, allowing substantial volumes of water to be stored for reuse.

Commercial property, the school and other areas would be served by separate private drainage systems incorporating basins, ponds and other soakaways within open areas of the property boundary. Many forms of soakaway could be used and the selection would be made to suit each property, varying in form to suit land availability and the quality of the runoff water. Rainwater harvesting would also be incorporated.

Rainwater Harvesting

The development is in an area subject to water stress. Rainwater harvesting allows reuse of collected rainwater within the home to supply toilets and washing machines, and for use in gardens and landscaped areas, reducing demand on water supply infrastructure.

Rainwater would run off a roof into guttering, protected by a leaf guard, and discharge via downpipes to a subsurface rainwater harvesting tank. The water would be filtered on entry to remove sediments and stored within the body of the tank. A small submersible pump would supply water to the property as required. When the tank is at capacity, additional rainwater would be discharged via a pipe to a soakaway.

When the rainwater harvesting tank is empty, the water supply would revert to the potable (Water Authority) network. The Water Cycle Study considers the demand for potable water in further detail (document 5003-UA001881, Hyder, March 2011). A typical detail is provided on drawing 7163 within Appendix A.

Overflow Soakaways

Should a rainwater harvesting tank exceed capacity during periods of consistent heavy rainfall, an overflow pipe would discharge excess water to a percolation tunnel, lined soakaway or similar structure within the property curtilage. A typical detail is provided on drawing 7163 within Appendix A.

Overflow Structures, Swales, Basins and Wetlands

Should it not be feasible to locate a soakaway within a property curtilage, overflow water from rainwater harvesting systems would be directed to nearby SuDS features located around the site, including swales, basins, ponds and wetlands, as outlined in Section 3.2.3. The depth and level of an overflow would be minimised and pipework avoided where possible to allow discharge to nearby areas of impermeable paving or shallow channels to convey runoff to the SuDS features.

Online Storage

During design development, some locations may become highly constrained and the provision of surface storage structures such as basins, ponds and wetlands may not be feasible to accommodate the entire storage volume required. Should such an occasion occur, online storage would be used to supplement the preferred surface storage structures. A variety of methods are available, including oversized pipes and cellular storage. Such methods would be employed only where other alternatives have been proven as impractical or infeasible and preference should always be given to open surface structures.

Should online storage be required, discharge to watercourse would be through a wetland area to provide additional enhancement to water quality. Such areas would be expected to receive regular inflow and would provide valuable wetland habitat.

3.2.5 Adoption and Maintenance

Soakaways on site would be adopted and maintained by a variety of parties. It is likely that soakaways serving residential and commercial properties would become the responsibility of property owners or the private maintenance company proposed to manage other shared facilities on the site, with residents and occupiers paying a maintenance fee. Community facilities such as schools would also be responsible for the drainage features within the property

Highway drainage, local and regional controls such as swales, basins and ponds, and any associated pipework and structures would be offered for adoption by OCC.

Whilst proposals have been set out for features across the site, the final design and details of all adopted features would be finalised at detailed design stage through consultation with OCC, to ensure that their requirements are met. For example, ponds and basins would incorporate banks not steeper than 1 in 3, maintenance strips and access roads to facilitate maintenance, and appropriate easement allowed for.

3.2.6 Water Quality and Treatment Trains

The proposed SuDS system has been formed using a broad range of components, each having a variety of attributes and strengths which make them suitable or unsuitable for use in differing situations. The SuDS system proposed comprises chains of linked SuDS components which complement one another and have been combined to form a treatment train.

The SuDS Manual provides advice on the relative merits of different components using ratings of Low, Medium and High. The treatment trains described within Sections 3.2.3 and 3.2.4 have been assessed in terms of water quality using the ratings of the SuDS Manual to ensure that the best water quality is achieved through feasible and practical proposals.

Where the major SuDS features would be unlikely to provide the required level of water quality treatment, pre-treatment methods would be used to supplement the treatment trains. Pre-treatment are components not subject to water treatment ratings within the SuDS Manual and include systems for water treatment such as bypass separators (petrol interceptors) to remove hydrocarbons, catchpits to remove sediments and vortex separators for sediment and pollutant removal.

It is important to consider the quality of runoff to be discharged when considering the treatment required. For example, relatively clean runoff from a roof would be likely to require less rigorous treatment than runoff from a road. Therefore, where it may be acceptable to treat roof runoff with SuDS features having low to moderate water quality treatment characteristics, it would be more desirable for road runoff to be treated by a SuDS feature having medium or high treatment characteristics for the appropriate contaminants.

Runoff from parking areas and roads would require some form of pollutant removal due to the presence of to remove hydrocarbons and other similar pollutants associated with motor vehicles. Treatment would be by filtration within SuDS features as it runs through vegetation and percolates through the surface stratum and via percolation through layers of filtration material such as grit within permeable paving. Bypass separators (petrol interceptors) or vortex separators could be used for discharges where space is insufficient for a suitable SuDS feature. Catchpits would be used within any piped networks to capture sediments.

The naturally high quality and unpolluted nature of runoff from roofs and paved areas is likely to require minimal treatment. Filtration and settlement of any solids and pollutants would naturally occur within soakaways, further improving the water quality.

It is important to also consider the treatment trains in the context of their function. Where structure perform vital SuDS functions but have low water treatment characteristics, such as detention basins providing storage, such features have been combined with complimentary features to provide suitable water treatment.

The treatment trains have been assessed and the findings presented within Appendix C.

3.2.7 Overland Flowpaths

The Code for Sustainable Homes requires that the site should be designed to accommodate all runoff for events up to the 100 year rainfall event (plus 30% allowance for climate change), with an appropriate allowance for climate change. The ponds, basins and other structures discharging directly to the watercourse would be designed to ensure this criterion is met and to ensure that surface water in excess of this event is discharged safely away from property to a watercourse via overland flowpaths. Such flow paths would include the local road network in some locations and direct overflow to watercourses in others.

Individual drainage features would be designed to accommodate a variety of specific maximum rainfall events depending on the requirements of legislation, the adopting party and constraints local to the feature. Typically, drainage features would be designed to accommodate the 100 year rainfall event, including 30% allowance for climate change. However, where size prohibits the use of certain features to this standard, such as a soakaway in a garden, the 30 year rainfall event will be used instead. In such cases, surface water in excess of the design event could result in overland flows which would be directed to local SuDS features such as swales and basins, which would be designed to accommodate such flows, and permeable paving which would be likely to contain significant surplus storage within its substructure. Anticipated overland flowpaths have been shown on Drawings 7160 and 7161 in Appendix A.

3.2.8 Hydraulic Modelling

Key elements of the drainage strategy set out above have been modelled to demonstrate the feasibility of the proposals, specifically the ability of the site to discharge by ground infiltration and to accommodate suitable basins, swales and ponds. Typical elements have been modelled as the final designs would be determined at detailed design stage in consideration of the final site layout and additional information.

Modelling of the drainage network has been undertaken using industry standard software, MicroDrainage WinDES. WinDES uses the Modified Rational Method to analyse pipe networks, soakaways and other drainage features, running a suite of design storms through the system to comprehensively test a network or SuDS feature.

Each element has been designed at a strategic level to meet a variety of requirements including flood risk, adoption and health and safety, with amenity and habitat features incorporated where feasible. SuDS have been hydraulically tested as groups to provide a total storage volume required for a specific catchment using the appropriate protection (e.g. 100 years plus 30% for climate change) for a range of rainfall events with storm durations varying between 15 minutes and 10 days. The SuDS for each catchment would be broken down into smaller components if necessary, capable of providing the required storage within the context of the masterplan. Typical details are shown on Drawing 7163 within Appendix A, and calculations provided within Appendix D. Details of the proposed SuDS features to drain each catchment are provided within Table 3.3.

Site investigation indicates that the site would be able to discharge predominantly via ground infiltration extensively using private soakaways and permeable paving. Despite this, in some locations it is likely that ground infiltration will not be practical or feasible and therefore SuDS features have been proposed and designed throughout the eco development to accommodate runoff from such areas. Additionally, to provide regular inflows which would encourage development of valuable marshy and wetland habitat, impermeable surfacing would be used at some locations to feed adjacent or nearby SuDS. Each SuDS feature therefore has a defined catchment based on topography, comprising an area of adjacent impermeable paving and a proportion of the remainder of the topographical catchment. The topographical catchment has been assumed to contribute runoff from 20% of its area to the SuDS feature. Considering that each catchment area comprises landscape and garden areas, as well as permeable paving, this contribution of 20% is considered to be closer to 50% of the remaining impermeable areas. The catchments are shown on Drawings 7160 and 7161 within Appendix A.

Catchment	SuDS Type	Storage Volume (m^3)
1	Dry swale, swale, pond, basin	250
2	Swale, pond, basin	245
3	Roadside swale	120
4	Swale, pond, basin	190
5	Site edge swale	165
6	Basin, pond	55 - 590[1]
7	Pond, wetland scrape	135
8	Wetland scrapes, online storage	175
9	Roadside swales, Village Street SuDS, wetland scrape, online storage	405

1. Regional control with limited direct paved area catchment, size will vary depending on flow passed forward from other SuDS features (i.e. if upstream SuDS infiltrate to ground, storage requirement is 55m^3)

Table 3.3 SuDS Feature Design Summary

Rainwater harvesting would provide storage within the system. However, this storage has not been included within calculations as a worst-case scenario has been assumed in which the rainwater harvesting tanks are already at capacity when rainfall events begin.

The surface water drainage strategy on Drawings 7060 and 7061 in Appendix A shows a network of SuDS designed to discharge via ground infiltration and to accommodate anticipated runoff from the site. Each has been designed using the typical infiltration rate encountered during site investigation of 56mm/hr, as set out in Section 2.3. Modelling results are provided within Appendix D for each component.

As a contingency for some areas having lower infiltration rates than encountered during the site investigation, or being impractical for the use of ground infiltration methods, the network and individual components have also been tested to indicate how the system could discharge at controlled rates to the watercourses. In this assessment flow control devices have been assumed to be used at local SuDS features to ensure that storage is provided throughout the site, with regional and local SuDS features close to the watercourses discharging to watercourses at a combined rate that does not exceed the allowed discharge rate determined in Section 3.2.2. Modelling results are provided within Appendix D.

Ground infiltration rates from onsite assessment (see Section 2.3) indicate that all areas of the site are suitable for ground infiltration methods, excepting the area of a proposed regional pond/basin feature within Catchment 6 (indicated on drawing 7160 within Appendix A). This location is likely to require a discharge to a watercourse.

4 FOUL WATER DRAINAGE STRATEGY

4.1 Principles

Waste (foul) water at the Exemplar Site would discharge to a manhole on the existing nearby Thames Water network for treatment within Bicester Sewage Treatment Works. A pumping station would be located on site to pump foul flows via a rising main up to the level of the connection point.

A significant reduction in discharges would be achieved through the implementation of water efficient measures, when compared to regular developments.

Due to the phased nature of the development, key elements of the foul drainage strategy, such as the pumping station, would need to be constructed at an early stage.

During future stages of the wider NW Bicester eco development, it may be possible and desirable to treat foul water on site. Foul water from the Exemplar site could be disconnected from the Thames Water network and redirected via the pumping station to a centrally located treatment plant, if this is found to be the most suitable option.

The foul water drainage strategy is shown on drawing 7162 within Appendix A.

4.2 Foul Loading

A breakdown of the types of property within the masterplan has been used to assess foul water discharges. Accommodation and non-residential building schedules have been provided within Appendix E. These figures were used to calculate the preliminary flow estimate based on the number of occupants for each dwelling, the number of end-users/floor plan area for non-residential property and typical usage rates provided by Thames Water (Thames Water Guidelines for Undertaking Sewerage Modelling (November 2005)). The peak foul water loading has been assessed based on the Thames Water rates as being 49l/s.

The Thames Water rates are conservative and actual discharges from site will be reduced by use of water efficient appliances, and potentially greywater recycling, which would offset potential increases due to retro-fitting of property with less efficient devices by home owners. The rates have been assessed and reduce the peak discharge to 28l/s.

4.3 Liaison with Thames Water

An extensive foul water network serves Bicester. Thames Water has advised that modifications to or extension of their network may be required to allow connection of the Exemplar Site and that further investigation by them would be necessary to identify the exact works required.

Thames Water have agreed (see correspondence in Appendix F) that the foul water connection could be conditioned on the understanding that discharge to the existing network would be feasible, subject to agreement of a set of works to be defined at detailed design stage.

5 CONCLUSION

A drainage strategy is set out that provides a framework for development of both foul and surface water management systems for the Exemplar Site and ensures that the requirements of level 5 of the Code for Sustainable Homes are achieved.

In summary:

- Ground conditions indicate an existing rainfall discharge mechanism based on ground infiltration, with low surface runoff rates (see Section 2);
- A SuDs network is proposed comprising shallow soakaways and ground infiltration features, mitigating flood risk, protecting the supply to local aquifers and providing valuable habitat and amenity areas (see Section 3);
- The eco development has potential to reduce the volumes of surface water discharged during large rainfall events to below predevelopment levels (see Section 3.2);
- Discharge to onsite watercourses may be required to allow for local conditions which may prohibit use of ground infiltration, and may be desirable to improve their flow regime and water quality (see Section 3.2);
- Peak discharges to watercourses would be reduced from 127.6 l/s to 40.1 l/s following development of the site during the 100 year rainfall event (including allowance for climate change) to mitigate against the potential for increased discharge volumes (see Section 3.2.2);
- The SuDS network proposed utilises permeable paving, swales, ponds and basins (see Sections 3.2.3 and 3.2.4);
- Online storage such as oversized pipes are not generally proposed but may be required as a final resort should some local areas not be feasible for locating open SuDS features due to additional constraints arising at detailed design stage;
- SuDS features have been designed to accommodate 100 year events, including a 30% allowance for climate change, and to discharge via ground infiltration alone, but have also been sized to allow for discharge to watercourses if required (see Section 3.2.8);
- Rainwater harvesting is proposed across the site, reducing discharges further (see Section 3.2.4);
- Treatment trains are proposed which provide appropriate treatment of runoff (see Section 3.2.6);
- Rainfall events beyond normal design consideration are likely to exceed the capacity of the SuDS network. The site will be developed to ensure that such flows are directed away from property onsite to safely discharge to watercourses;
- Foul water is to be discharged offsite through a piped system which connects to the local sewer network (see Section 4);
- A significant reduction in foul water discharge is to be achieved through the implementation of water efficient measures (see Section 4);
- The wider eco development offers the potential to redirect foul water arising from the Exemplar Site to a treatment area within the eco development, further reducing foul water discharges to the local sewer network and Bicester Treatment Works (see Section 4).

The widespread use of Sustainable Drainage Systems and rainwater harvesting would provide sustainable storm water management and create a sustainable resource from rainfall, whilst ensuring that flood risk is reduced for areas downstream and benefitting the local area. Ground infiltration would be used extensively throughout the Exemplar Site to ensure that discharge volumes to watercourses are kept to a minimum and that ground water resources continue to be recharged by the site, whilst attenuation features will ensure that discharge rates to watercourses are reduced during large rainfall events to far below existing rates, offsetting historical development within Bicester which would have increased surface water discharge rates to the local watercourses and consequently increased flood risk.

The use of SuDS would allow the creation of new wildlife spaces incorporating wetlands, ponds and a variety of vegetation, creating valuable open amenity areas whilst enhancing the local water environment.

The eco development would promote excellent water quality standards, enhancing the local environmental water quality where possible and improving the flow regime of the watercourses within the eco development. SuDS would be used to remove any polluted runoff from diffuse sources providing at source treatment prior to discharge into watercourses.