Cambridgeshire Horizons

Detailed Water Cycle Strategy up to 2031
Major Growth Areas in and around Cambridge
Phase 2 – Detailed Strategy

Choosing a water services infrastructure future

October 2010

Halcrow Group Limited

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Cambridgeshire Horizons

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Major Growth Areas in and around Cambridge

Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Signed
3	0	Final report	08.08.10	EJG
3	1	Revised final report	29.10.10	AJC

Executive Summary

A significant number of new homes are planned for Cambridge and South Cambridgeshire before 2031. Cambridgeshire Horizons has worked with the local planning authorities (Cambridge City Council, South Cambridgeshire District Council and Cambridgeshire County Council) and key stakeholders (The Environment Agency, Anglian Water, Cambridge Water, Natural England,and the Internal Drainage Boards) to plan the water services infrastructure necessary to: provide new homes with drinking water; manage surface water runoff; and safely treat and dispose of wastewater. The phase 1 Water Cycle Strategy (August 2008) presented a 'business as usual' response to providing the infrastructure to support major growth at development sites in and around Cambridge, totalling some 50,000 new homes. This phase 2 Water Cycle Strategy goes further; it defines and provides evidence in support of a more aspirational vision for water management which will enhance the experience of living in new developments and ensure the community is better able to resist climate change shocks in the future.

More specifically, the long-term vision is to:

- achieve the highest levels of water efficiency in all new homes through implementation of Code for Sustainable Homes Level 5/6 for water (a water consumption 80 litres of potable water per head per day), and similar levels of efficiency in non-domestic dwellings;
- aspire to water neutrality through implementation of water efficient measures in the existing housing stock, to offset the increase in demand from new development;
- achieve 100% above ground surface water drainage in all future developments, where it is feasible;
- ensure that above ground surface water drainage provides amenity and biodiversity benefit and contributes to the provision of green infrastructure, and;
- protect water quality to ensure no deterioration of current status and maximise opportunities to improve water quality, where possible.

Some of the benefits that will arise from implementing the vision are:

- Full or partial offsetting of an additional 8,600,000 litres (8.6 megalitres) per day of potable water supply that will be needed by new residential development (equivalent to 1300 Olympic swimming pools per year).

- Businesses utilising rainwater harvesting for their premises can recover the investment in approximately three years and thereafter make significant savings on water bills.
- A household which is achieving with Code for Sustainable Homes Level 5/6 will save approximately £60 per year on water bills compared to Level 3/4 homes. As the price of water rises in future years these benefits will become greater.
- Above ground drainage reduces emitted and embodied carbon by 15%-20% compared to conventional piped drainage systems. Across the development sites this is equivalent to a saving of 400 tonnes of carbon each year, which is approximately equivalent to the offsetting of a one single transatlantic flight with approximately 250-300 passengers.
- Good design of drainage systems and their integration with green infrastructure can greatly enhance quality of life, amenity and biodiversity in development areas. Making space for water rather than burying it underground engages the community and improves local stewardship of the infrastructure.

Existing policies and leadership are already delivering a more sustainable water services infrastructure in Cambridge and the surrounding growth areas. For example the Lamb Drove scheme in Camborne is a nationally recognised surface water drainage demonstration site. In the Southern Fringe development, water efficiency measures will ensure that consumption is at 105 l/h/day, far in excess of current building regulations (125 l/h/day). The NIAB 1 site will be drained using 100% above ground with no buried pipes for surface water runoff. There is now an opportunity to take this trend further and make developments such as Northstowe (a proposed eco-town), the University site and Cambridge East, exemplar locations for sustainable water management.

The phase 2 water cycle strategy is a point of reference for planning policy makers and officers reviewing planning applications. It is thematically structured covering the areas of water resources, surface water management, water quality, wastewater and ecology. It provides comparative data for development sites and the reasoning and evidence in support of the recommendations. The key recommendations from the phase 2 water cycle strategy are presented in the box below.

Water resources recommendations

REC WR 1: Planning policy recommendations: water resources

- New domestic dwellings should achieve 80 l/h/d (potable consumption) through implementation of water efficient measures and rainwater/greywater systems, unless meeting 80 l/h/d is not viable due to the small size of development. Where 80 l/h/d is not considered to be viable the development should justify why it is unable to deliver this level of water efficiency and provide evidence of the level that can be delivered as well as minimise water consumption through use of water efficient appliances.
- New non-domestic buildings should meet the BREEAM 'excellent' standard with respect to water efficiency, through installation of water efficient measures and rainwater/greywater systems.
- As a minimum, the additional demand for water due to new development should be *partially* offset, through the implementation of measures in the existing housing stock, including, but not limited to, retrofit of water efficient measures and marketing/awareness campaigns with local residents and businesses.

REC WR 2: Establishing initiatives to work with local communities and businesses

- In partnership with Cambridge Water, Environment Agency and Waterwise East, Cambridge City Council, South Cambridgeshire District Council and Cambridgeshire County Council should promote a number of initiatives to promote the value of water in local communities and businesses.

REC WR 3: Undertake water audits & retrofit water efficient measures

- In partnership with Cambridge Water, Environment Agency and Waterwise East, Cambridge City Council and South Cambridgeshire District Council should promote water audits in domestic and non-domestic buildings, with the objective of retrofitting water efficient measures into existing buildings.
- Relevant partners should carry out an investigation of the mechanisms by which retrofitting of the existing housing stock to achieve water neutrality could be facilitated.

Surface water management recommendations

REC SWM 1: Planning policy recommendations: Surface water management

- Development should aspire towards 100% above ground surface water drainage except where this is not feasible due to housing densities, land take, ground conditions, topography, or other circumstances outlined within the development proposals.
- Where 100% above ground drainage is not feasible due to the size of development (i.e. windfall and non-strategic developments) or proposed high densities, the development proposals should maximise opportunities to use SUDS measures which require no additional land take, i.e. green roofs, permeable surfaces and water butts
- Development proposals should ensure that surface water drainage is integrated within the built environment. In addition, surface water drainage proposals should maximise opportunities to create amenity, enhance biodiversity, and contribute to a network of green (and blue) open space.

Managing pollutants in surface water runoff recommendations

REC P1: Planning policy recommendations: management of pollutants in surface water runoff

- Development must ensure that an appropriate number of SUDS treatment stages are provided to treat surface water runoff; 1 treatment stage is required for roof runoff only, 2 treatment stages are required for residential roads, parking areas and commercial zones, and 3 treatment stages are required for refuse collection, industrial areas, loading bays, lorry parks, highways.
- Consideration should be given to sources of pollution in the urban environment to demonstrate that appropriate SUDS measures have been incorporated into the development to protect water quality from polluted surface water runoff.
- Within contaminated land development should allow for measures to remove, reduce or render the contaminants harmless. Within contaminated sites a lined SUDS system should generally be used to prevent infiltration of surface water runoff.

Wastewater recommendations

REC WW1: Planning policy recommendation: wastewater infrastructure

- Planning permission will only be granted for developments which increase the demand for off-site service infrastructure where:
  - sufficient infrastructure or environmental capacity already exists or
  - extra capacity can be provided in time to serve the development which will ensure that the environment and the amenities of local residents are not adversely affected.
- When there is a capacity problem and improvements in off-site infrastructure are not programmed, planning permission will only be granted where the developer funds appropriate improvements which will be completed prior to occupation of the development, or where the water company confirms the off-site infrastructure can be provided in a timely manner.

REC WW2: Ensure sufficient infrastructure capacity exists within the wastewater network

- Anglian Water should progress their preferred solution for Cambridge and Uttons Drove WwTW and the wastewater networks which drain to them

REC WW3: Protection of receiving watercourses from wastewater discharges

- New development should not cause deterioration of receiving water quality or an increase in flood risk from increased wastewater discharges. The Environment Agency should confirm the discharge consents required at both works and progress this through the National Environment Programme.
- The preferred land drainage solution at Uttons Drove and Webbs Hole Sluice (north of Uttons Drove WwTW) should be progressed to enable development at Cambourne and Northstowe.

Contents

1 Introduction

1.1.1 Significant growth is being planned for in the Cambridge sub-region. Cambridge City Local Plan and the South Cambridgeshire Local Development Framework (LDF) include a number of major developments, including urban extensions to the city of Cambridge and the new settlements of Cambourne and Northstowe.

1.1.2 Delivering the right infrastructure is critical to sustainable and economic development, and well planned and well delivered water services infrastructure can contribute to achieving a low carbon and resource efficient society. Excellent water services infrastructure and a vibrant water environment can add significantly to the attractiveness of a development and contribute to a high quality of life for residents.

1.1.3 Phase 1 of the Water Cycle Strategy identified the baseline infrastructure required to serve the proposed new development without detriment to the environment, in accordance with current legislation. This fulfilled the requirements of the LDF evidence base and facilitated partnership working between the key stakeholders as required by former East of England Plan policy WAT2. One of the key issues raised during the consultation with key stakeholders[1] on the Phase 1 WCS was that of enhanced sustainability and future-proofing of new development. The Phase 1 WCS provides summary information regarding the sort of changes to established thinking that will be needed to move toward more sustainable and flexible water services infrastructure. It was agreed by the stakeholder group that the Phase 2 WCS should progress this further, to identify a strategy which would show how new water services infrastructure for the Major Sites in and around Cambridge could be delivered to maximise three opportunities:

- aspiring to water neutrality[2];
- improving biodiversity by protecting environmental water quality and hydromorphology, and;
- protecting and enhancing communities through sustainable surface water management.

1.1.4 The Phase 2 Water Cycle Strategy provides a clear evidence base for the three key elements, and has identified a strategy to ensure development in Cambridge City and South Cambridgeshire balances the social, economic and environmental pillars of sustainability. The Phase 2 Water Cycle Strategy focuses on the major growth sites in and around Cambridge (see

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[1] Cambridgeshire Horizons, Cambridgeshire County Council, Cambridge City Council, South Cambridgeshire District Council, Environment Agency, Anglian Water Services Ltd, Cambridge Water Company, Swavesey Drain; Old West and Swaffham Internal Drainage Boards, Halcrow Group Ltd

[2] Water neutrality has been defined by Government and the Environment Agency: 'for every new development, total water use across the wider area after the development must be equal or less than total water use across the wider area before the development'

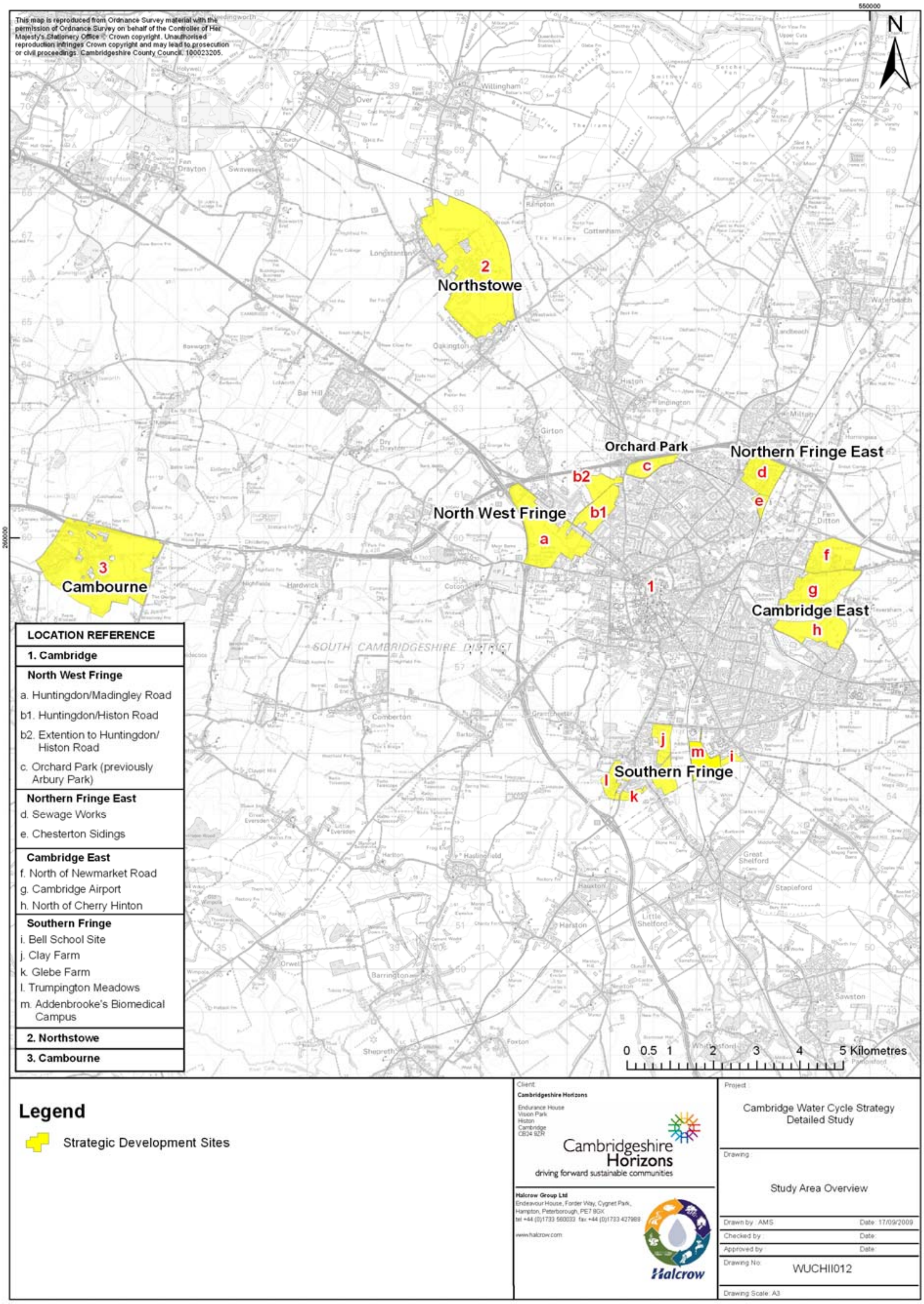

Figure 2-2 for map). These are

- the existing Cambridge urban area.

- land between Madingley Road and Huntingdon Road (also known as the University site);
- land between Huntingdon Road and Histon Road (also known as NIAB 1);
- extension to land between Huntingdon Road and Histon Road (also known as NIAB 2);
- Cambridge Northern Fringe West - Orchard Park (site has been partly built out);
- Northern Fringe East – consists of sewage works and Chesterton Sidings, and will now be developed as employment land;
- Cambridge East – made up of 3 areas: Cambridge Airport; North of Newmarket Road & North of Cherry Hinton;
- Cambridge Southern Fringe - consists of main sites: Clay Farm, Glebe Farm, Trumpington Meadows (which has outline planning permission and a signed Section 106 agreement for 1,200 dwellings and associated infrastructure), Bell School site, and the Addenbrooke's Biomedical Campus;
- Northstowe - the former Oakington Airfield and adjacent land near Longstanton (site has a pending planning application of 10,000 dwellings). Northstowe has been proposed as a second wave Eco-town[3], and;
- The new settlement at Cambourne – this development is well established and has been included where relevant in the baseline analysis (there is a planning application under consideration for a further 950 dwellings).

1.2 Vision for sustainable water management

1.2.1 Delivering sustainable water services infrastructure can contribute to achieving a low carbon and resource efficient society, and ensure high quality of life for people. The Cambridgeshire Quality Charter for Growth sets out core principles of the level of quality to be expected in new developments in four key areas including climate change, community, character and connectivity. The Quality Charter has three overriding aims:

- to inspire innovation and the pursuit of higher standards by using examples of what works;
- to help communication by crossing professional boundaries and providing a simple common framework, and;
- to support a genuinely cooperative approach between stakeholders and consequently secure better value from investment by helping investors align their spending plans.

1.2.2 The Water Cycle Strategy for the Major Sites in and around Cambridge supports the delivery of the Quality Charter and its ambition for sustainable development and place making by setting a strong vision for water services infrastructure.

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[3] Eco-towns are a government-sponsored programme of new towns to be built in England, which are intended to achieve exemplary standards of sustainability

1.2.3 This vision is focussed around three key areas including water efficiency, sustainable surface water management and protecting water quality. More specifically, the long-term vision is to:

- achieve the highest levels of water efficiency in all new homes through implementation of **Code for Sustainable Homes Level 5/6 for water (a water consumption 80 litres of potable water per head per day), and similar levels of efficiency in non-domestic dwellings**;
- **aspire to water neutrality** through implementation of water efficient measures in the existing housing stock, to offset the increase in demand from new development;
- **achieve 100% above ground surface water drainage** in all future developments, where it is feasible;
- ensure that above ground surface water drainage **provides amenity and biodiversity benefit and contributes to the provision of green infrastructure**, and;
- protect water quality to ensure **no deterioration of current status** and maximise opportunities to **improve water quality**, where possible.

1.2.4 This long-term vision for delivering sustainable water services infrastructure seeks to go further than a business as usual approach. This is summarised below in Table 1-1.

Criteria	Business as usual	Vision
Water efficiency in new developments	125 litres/head/day (Building Regulations Part H)	80 l/h/d (Code for Sustainable Homes level 5/6) through rainwater/greywater systems
Measures in existing housing stock to reduce demand	Metering in line with Cambridge Water's WRMP10[4] proposals	Aspire to water neutrality through enhanced metering, variable tariffs and retrofitted water efficiency measures
Surface water management	Separate storm water piped network which leads to attenuation / infiltration areas prior to discharge to receiving watercourse Runoff rate and volume controlled to greenfield equivalent Nominal 30 year return period standard of service is provided by pipe work Homes protected from flooding for 1 in	100% above ground drainage through SUDS, where feasible SUDS integrated with biodiversity, amenity and linked to green infrastructure Homes protected from flooding for 1 in 100 year critical storm (with allowance for climate change)

[4] WRMP10 (or Water Resources Management Plan 2010) sets out how Cambridge Water "will manage its resources to meet the needs of existing and future customers, and those of the environment, over the next 25 years". More information on Cambridge Water's WRMP10 is available at http://www.cambridge-water.co.uk/customers/water-resources-management-plan

Criteria	Business as usual	Vision
	100 year critical storm (with allowance for climate change) Highways protected for a 1 in 30 year critical storm (with an allowance for climate change)	
Water quality	No deterioration of class in receiving water downstream of wastewater treatment Compliance with discharge consents at combined sewer overflows and storm tanks.	No deterioration of class in receiving water downstream of wastewater treatment Compliance with discharge consents at combined sewer overflows and storm tanks. Measures put in place to improve water quality in surface water runoff from developments

Table 1-1 Comparison of current standards and the future ambition for sustainable development

1.2.5 It is recognised that there are currently some technological, regulatory, social, and economic barriers to achieving the long-term vision of sustainable water services infrastructure; the Phase 2 WCS assesses these barriers and identifies potential mitigation options. Where the implementation of the long-term vision is dependant on changes outside the control of key stakeholders, the Phase 2 WCS considers what changes are required and how this might be achieved. It is important to note that achieving this long-term vision will require continued collaborative working across the different stakeholder groups and full engagement with the community.

1.3 How to read the Phase 2 Water Cycle Strategy

1.3.1 The Phase 2 WCS provides the technical evidence base to support implementation of the long-term vision for sustainable water services infrastructure and makes recommendations for policy makers. Principally, the Phase 2 WCS has been written to provide the evidence to inform local planning policy but it can also be used by case officers to help identify whether planning applications have considered the necessary measures with respect to water services infrastructure.

1.3.2 The Phase 2 WCS is structured on a topic-by-topic basis, for five topic areas:

- water resources, including water efficiency in new development and aspiring to water neutrality;
- surface water management;
- environmental water quality, specifically this covers managing pollutants in surface water runoff;
- wastewater, and;
- ecology.

1.3.3 For the three key areas of water efficiency, sustainable surface water management and protecting water quality the Phase 2 WCS is structured to provide the justification, the technical evidence base, and policy recommendations to work towards achieving the long-term vision. With regards to wastewater, the Phase 2 WCS provides a summary of the preferred wastewater strategy and an assessment of the impact of additional wastewater treatment discharges on water quality and flood risk. The assessment of ecology analyses the potential impact of growth in European designated sites to inform any future review of the Habitats Regulations Assessment (HRA); the Phase 1 WCS undertook a thorough review of local wildlife sites, SSSIs and other local designated sites, and the user is referred back to the Phase 1 WCS for recommendations with respect to other non-European designated sites.

1.3.4 Although the Phase 2 WCS is structured around the five topic areas outlined, it is recognised that some readers will need to use the WCS to support the planning process for a specific development site (e.g. NIAB 2). Within the water resources, surface water management, and environmental water quality sections, the justification and policy recommendations cut across all of the development sites and are applicable for all development sites which are seeking to work towards the vision for sustainable water management. Within these chapters, the technical evidence base provides greater focus on site specific requirements, where necessary and possible.

1.3.5 Due to the high profile nature and size of the proposed development at Northstowe the Phase 2 WCS provides the evidence to fulfil the requirements of eco-towns and support the development of Northstowe as an exemplar of sustainable development. During January 2010, Halcrow Group Ltd analysed the gap between the eco-town PPS requirements and the sustainable water management strategy presented by the joint promoters of the Northstowe site in December 2007 ('gap analysis'). The evidence from gap analysis and the Phase 2 WCS can both be used to help support the development of Northstowe as an exemplar of sustainable development. Table 1-2 below indicates how the Phase 2 WCS provides the evidence base against the Eco-Town PPS requirements.

Eco-Town PPS requirement	Evidence base in Phase 2 WCS
Limit additional water demand from new housing and non-domestic buildings and in areas of serious water stress achieve CSH level 5/6 for housing and non-domestic buildings should "meet similar high standards of water efficiency" (ET 17)	Table 3-2 demonstrates the additional water demand from the Northstowe development Section 3.3 provides technical evidence to support implementation of CSH level 5/6 and high levels of water efficiency in non-domestic development
Aspire towards water neutrality in an area of serious water stress (ET 17.5)	Section 3.4 outlines the measures to aspire to water neutrality Table 3-11 outlines the measures required to aspire to water neutrality from the Northstowe development
Reduce and avoid flood risk wherever practicable and not increase flooding elsewhere (ET 18.1)	Table 4-8 provides indicative storage volumes for the Northstowe site to ensure runoff from the site is managed to greenfield equivalent
Use opportunities to address existing flooding	*Existing proposals contained in the site specific Flood Risk*

problems (ET 18.1)	*Assessment (FRA) outline the proposals to mitigate flood risk in Oakington and Longstanton*
Ensure development is located in flood zone 1 (ET 18.2)	The Phase 1 WCS outlined the flood risk to the Northstowe development
Incorporate SUDS, except where not feasible (ET 17.3)	Section 4.3 discusses the practical considerations for implementing SUDS, including ground conditions, applicability of SUDS measures and potential land take required by SUDS approaches
Avoid surface water flooding (ET 17.2(c))	*This requirement will need to be identified by the site master plan*
Set out a strategy for the long-term maintenance, management and adoption of SUDS (ET 17.4)	Section 4.3.20-4.3.23 provides a summary of the adoption and maintenance routes for SUDS
Ensure no deterioration of surface/ground waters (ET 17.2)	Chapter 5 (pollutants in surface water) and Chapter 6 (wastewater) sets out measures to protect and enhance (where possible) surface and ground waters
Set out measures for improving water quality (where there is scope to do so) (ET 17.2(c))	
Result in a net gain in local biodiversity (ET 16.1)	Table 4-5 highlights the amenity and biodiversity of more aspirational surface water drainage measures

Table 1-2 Evidence base in Phase 2 WCS to support Northstowe development site

2 Project History

2.1 The Phase 1 Water Cycle Strategy

2.1.1 Phase 1 of the WCS for the Major Sites in and around Cambridge was completed in August 2008 by Halcrow Group Ltd on behalf of Cambridgeshire Horizons and the WCS project steering group, comprising:

- Cambridgeshire Horizons
- Cambridgeshire County Council
- Cambridge City Council
- South Cambridgeshire District Council
- Anglian Water Services Ltd (AWS)
- Cambridge Water Company (CWC)
- Environment Agency
- The technical advisor to the Swavesey, Old West and Swaffham Internal Drainage Boards

2.1.2 The Phase 1 WCS provided an overview of the existing water services infrastructure, and identified the infrastructure upgrades required to serve proposed strategic development to 2021. The infrastructure requirements identified in Phase 1 are summarised in Figure 2-1 and Table 2-1.

2.1.3 Phase 1 was undertaken when the East of England Plan provided the key policy background; the East of England Plan or Regional Spatial Strategy (RSS) has now been revoked. However, in anticipation of the Review of the RSS, the Phase 1 WCS (shown in Figure 2-1 and Table 2-1) did assess the potential capacity for additional growth of up to 20%to be accommodated between 2021 and 2031, in existing or additional strategic development areas in and surrounding the City. The results of this assessment are shown in Table 2-2.

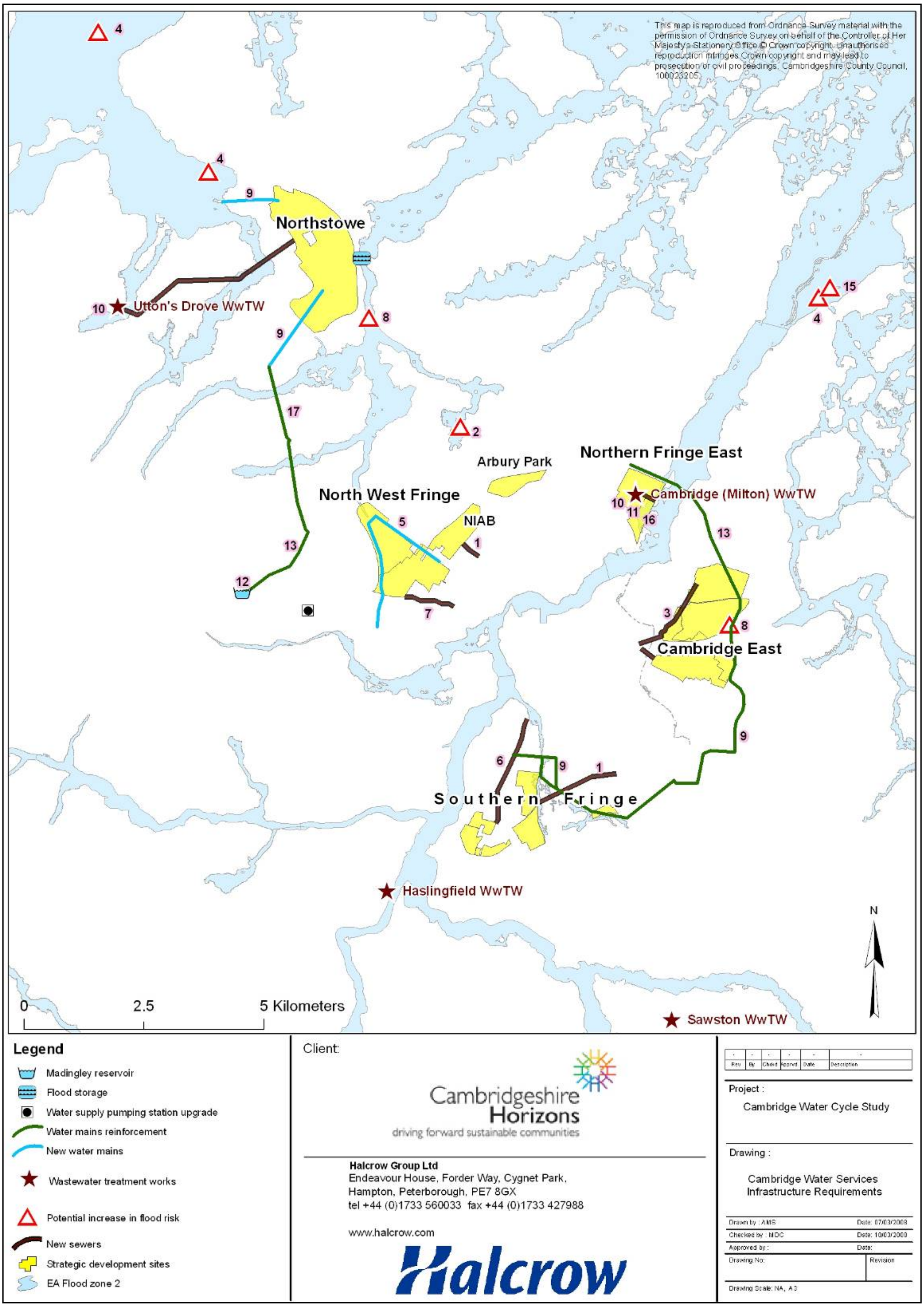

Figure 2-1 Water services infrastructure upgrades required to serve proposed development (Phase 1 WCS)

I.D.	Year	Site	Aspect	Description of Infrastructure	Phase 1 Report Reference
1	2008/09	NIAB 1 site Southern Fringe sites	Sewerage	Increased sewer capacity	Section 7.3
2	2008/09	NIAB 1 site	Flood Risk	Flood risk mitigation measures	Section 5.6
3	2009/10	North of Newmarket Rd	Sewerage	Connection of site into existing system	Section 7.3
4	2009/10	Northstowe North of Newmarket Rd	Flood Risk	Flood risk mitigation measures	Section 5.6
5	2009/10	NIAB 1 site Huntingdon/Madingley Rd	Water	New water transfer infrastructure	Section 8.8
6	2010/11	Trumpington Meadows	Sewerage	Increased sewer capacity and storage	Section 7.3
7	2010/11	North of Cherry Hinton Huntingdon/Madingley Rd	Sewerage	Increased sewer capacity required	Section 7.3
8	2010/11	North of Cherry Hinton Huntingdon/Madingley Rd	Flood Risk	Flood risk mitigation measures	Section 5.7 Section 5.6
9	2010/11	Southern Fringe sites North of Cherry Hinton/Newmarket Rd Northstowe	Water	Reinforcement of southern ring main Reinforcement of eastern ring main Connecting mains into Northstowe	Section 8.8
10	2011/12	Milton WwTW Uttons Drove WwTW	Wastewater Treatment Works	Capacity upgrades	Section 7.2
11	2013/14	Milton WwTW	Wastewater Treatment Works	Capacity upgrades	Section 7.2
12	2014/15	Northstowe	Water Pumping	Upgrading Coton Pump station	Section 8.8
13	2014/15	Northstowe Chesterton Sidings	Water	Reinforcement of transfer mains	Section 8.8
14	2016/17	Cambridge Airport	Sewerage	Increased sewer capacity	Section 7.3
15	2016/17	Cambridge Airport	Flood Risk	Flood risk mitigation measures	Section 5.7
16	2016/17	Milton WwTW	Wastewater Treatment Works	Capacity upgrades	Section 7.2
17	2019/20	Northstowe	Water	Reinforcement of transfer mains	Section 8.8

Table 2-1 Summary of water services infrastructure upgrades required to serve proposed development – as identified by Phase 1 WCS

	North / West of Cambridge City	North / East of Cambridge City	South / West of Cambridge City	South / East of Cambridge City
Flood Risk	Likely to drain into Cottenham Lode or Bin Brook increasing existing downstream flood risk. Opportunity exists for developer to fund mitigative improvements.	Would require careful site placement and sound flood risk strategies.	Incurs no unacceptable increase in flood risk if located out of Bin Brook catchment.	Incurs no unacceptable increase in flood risk.
Wastewater	Likely to increase the sewer flooding to existing properties. Opportunity to strengthen the case for a strategic sewer solution to serve Sites A&B which could connect into a branch of the tunnel sewer network.	This would be suited to direct connection to Cambridge WwTW rather than into the existing network. This has the potential to increase the risk of sewer flooding in the centre of Cambridge.	Potential available capacity in the large diameter sewers in Coldhams Lane or MowbrayRd/Perne Rd/Brooks road may accommodate development. Alternatively development in this area may support the case for a strategic sewer to serve Cambridge East.	Least sewer capacity of the options. It is likely that a new strategic sewer would be required to serve development in this location.
Water Supply	Possible connection to existing system	Possible connection to existing system	Possible connection to existing system	Possible connection to existing system
Ecology	Unlikely to have significant negative impacts on water / wetland ecology.	Likely to lead to significant increase in negative impacts on otter / water vole populations in River Cam / Cherry Hinton Brook. Impacts on floodplain grazing marsh. Increased risk of river pollution. Potential risk to great crested newt in adjacent LNR.	Likely to present greatest risk to water / wetland species and habitats. This area is an otter stronghold due to lack of human disturbance. There are also water vole populations and areas of floodplain grazing marsh. Potential for great crested newt populations in Byron's Pool LNR.	Unlikely to have significant impacts on water / wetland ecology, although potential risk to water voles. Limekiln Close and West Pit LNR is located to the south east of the city but has no wetland ecology features.

Table 2-2 Assessment of potential to accommodate additional 20% growth, 2021-2031 (Phase 1 WCS)

2.1.4 Consideration of the major development areas looked at in the Phase 1 WCS has formed the core of the Phase 2 WCS, including an update on the planning status and proposed numbers of dwellings for some sites. An additional development was allocated in the South Cambridgeshire Site Specific Policies DPD, adopted in January 2010, known as NIAB 2 (an extension to land between Huntingdon Road and Histon Road). The North West Cambridge Area Action Plan was jointly adopted by Cambridge City and South Cambridgeshire in October 2009, and the inspectors report leading up to the adoption of the plan increased the scale and area of the development.

2.2 Impact of revised housing trajectories

2.2.1 The quantity and timing of development planned in the study area have undergone some revision since the Phase 1 WCS was completed. Both AWS and CWC have indicated that their infrastructure strategies for the study area are not expected to change significantly as a result. Both companies have agreed that whilst there are likely to be amendments to some of the details (such as pipe sizes or asset upgrade specifics), their overall strategies for serving the proposed development sites remain the same and can therefore be used to inform the Phase 2 WCS. The quantity and timing of residential development used in the Phase 2 WCS is shown in Table 2-3 (based on 2009 housing trajectories). The windfall rate was estimated based on past rates to ensure an allowance was made for smaller developments. Table 2-4 also provides an update of the current planning status of the strategic development sites (correct as of July 2010).

2.2.2 It should be noted that Table 2-2 remains broadly relevant to the Phase 2 WCS, but that it does not reflect wholly current development proposals. The 'Chesterton Sidings' site has changed status from housing-led to employment-led since the Phase 1 WCS was completed.

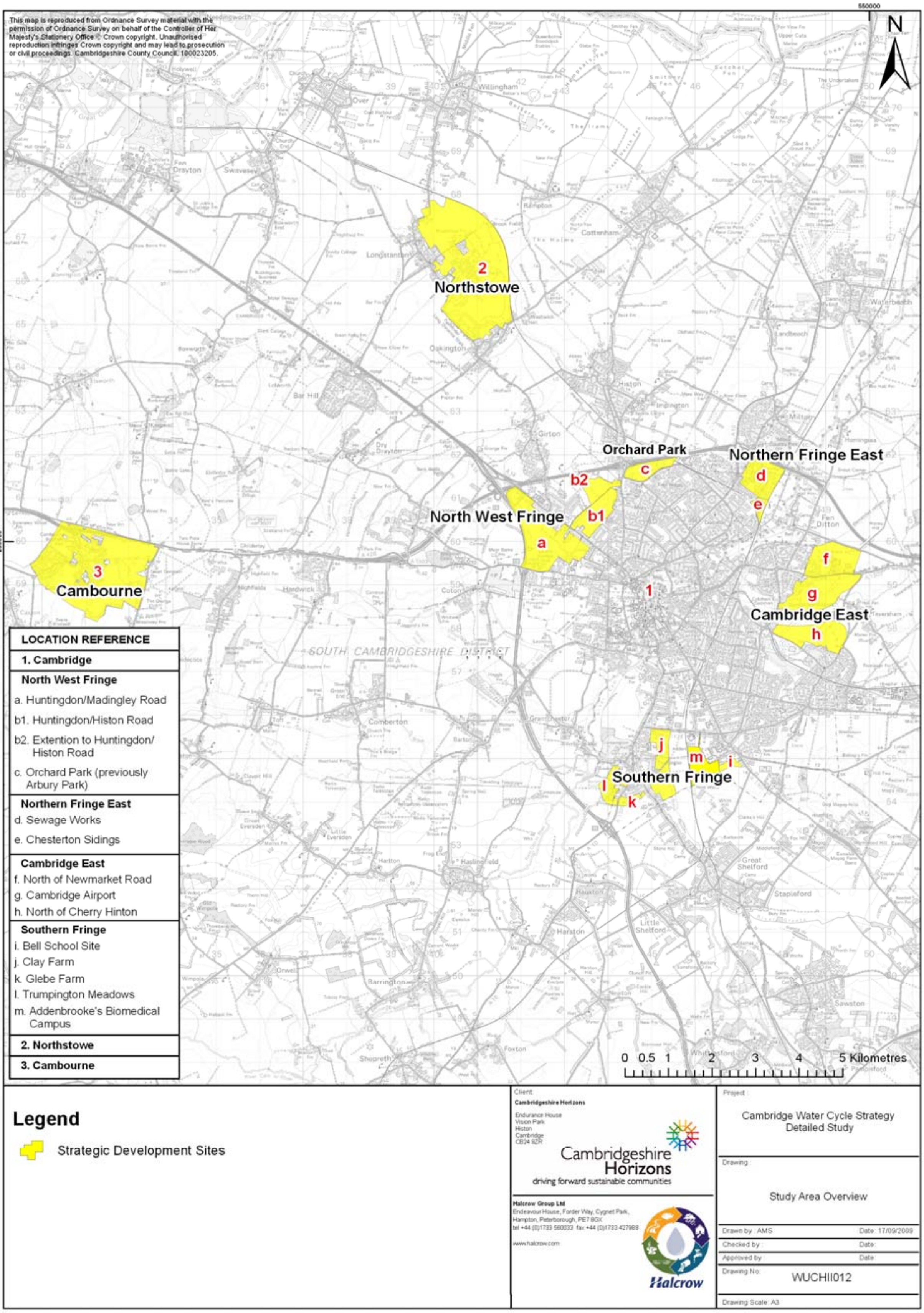

Figure 2-2 Major growth sites considered in Phase 1 and Phase 2 WCS

Strategic Sites	Completions 2001 to end 2007/08	2008/09-2010/11	2011/12-2015/16	2016/17-2020/21	2021/22-2023/24	TOTAL to 2024	Additional comments	Overall site housing expectation (to 2031)
Land between Madingley Road & Huntingdon Road (University site) (site a)	0	0	1,050	1,950	0	**3,000**	From trajectory in FINAL North West Cambridge AAP Inspectors Report.	**3,000**
Land between Huntingdon Road & Histon Road (NIAB 1) (site b1)	0	281	1,182	317	0	**1,780**	-	**1,780**
Extension to land between Huntingdon Road & Histon Road (NIAB 2) (site b2)	0	0	630	470	0	**1,100**	From information in DRAFT Site Specific Policies DPD Inspectors Report.	**1,100**
Cambridge Northern Fringe West - Orchard Park (site c)	401	267	452	0	0	**1,120**	900 from existing allocation plus 220 additional from FINAL North West Cambridge AAP Inspectors Report (July 2009). No dwellings expected after 2016.	**1,120**
N.B. consider in conjunction with the North West sites			*(232 original +220 from additional application)*					
Northern Fringe East – sewage works and Chesterton Sidings (site d and e)	Site will be developed as employment land							
Cambridge East (sites f, g and h)	0	50	3,050	3,950	2,230	**9,280**	A further **2,720** dwellings are expected at Cambridge East between 2024/25 and 2027/28.	**12,000**
Southern Fringe (sites i, j, k, l and m)	0	300	2,697	1,100	0	**4,097**	-	**4,097**
Northstowe (site 2)	0	0	2,450	3,250	1,950	**7,650**	A further **2,350** dwellings are expected at Northstowe between 2024/25 and 2027/28 (estimated total capacity may differ from initial planning application).	**10,000**
Cambourne (site 3)	2,186	703	1,050	0	0	**3,939**	Original outline for 3,300, additional outline expected for 950 dwellings. Figure comprises: [Cambourne extra density (950)] + [Cambourne left to build from 2008 (803)] + [Cambourne built 2001-2008 (2186)] = 3939. A further 403 dwellings were built pre- 2001.	**3,939**
Student dwellings, not counted toward RSS total (site a)	No trajectory information					2000	-	2000
Strategic sites total	2,587	**1,601**	**12,561**	**11,037**	**4,180**	**31,966**	-	**37,036** (39,036 inc. student dwellings)
Non-strategic sites and windfall (est.) (Includes ALL PROPOSED development in S Cambs and Cambridge City Districts not on strategic sites	6,727	**2,940**	**4,604**	**1,331**	**696**	**16,298**	A further **1,624** are estimated up to 2031. GIS data were provided by Councils and used to inform incorporation of relevant development in technical assessment.	**17,922**
				For information: RSS allocation to 2021		*42,500*		

Table 2-3 Quantity and timing of development used for Phase 2 WCS

Site	Map Ref	Planning Status	Key Relevant (Adopted) Site Specific Policy	Additional info
North West Cambridge				
Huntingdon/ Madingley (University site)	a	Awaiting application (expected early 2011)	North West Cambridge AAP (2009)	AAP adopted Oct 09 allocates up to 3,000 homes, 50% of which will be University Key Worker housing. Masterplanning progressing.
NIAB 1	b1	Outline approved subject to completion of Section 106 agreement	Cambridge Local Plan (2006)	
NIAB 2	b2	Awaiting application	South Cambs DC Site Specific Policies DPD; South Cambs DC Development Control Policies DPD	Allocation adopted January 2010. No application expected until main NIAB site is well underway.
Orchard Park (formerly Arbury Park)	c	Development approved for original application, planning permission not yet granted for additional 220 homes	South Cambs DC Site Specific Policies DPD; South Cambs DC Development Control Policies DPD	Development well underway on original application site. Allocation adopted January 2010.
Northern Fringe	d/e	Not expected to proceed as housing development	Cambridge Local Plan (2006)	Further consideration is being taken forward in the form of a Joint Area Action Plan.
Cambridge East	f/g/ h	Awaiting applications	Cambridge East AAP (2008)	Discussions ongoing.
Southern Fringe				
Trumpington Meadows	l	Outline planning permission granted and Section 106 agreement complete	Cambridge Local Plan (2006), Southern Fringe AAP; South Cambs DC Development Control Policies DPD	
Bell School Site	i	Outline approved subject to completion of Section 106 agreement	Cambridge Local Plan (2006)	
Clay Farm	j	Outline planning permission granted and Section 106 agreement complete	Cambridge Local Plan (2006)	
Glebe Farm	k	Full planning application approved	Cambridge Local Plan (2006)	.

		for 286 homes and Section 106 agreement complete		
Addenbrooke's Biomedical Research Campus	m	Planning permission granted	Cambridge Local Plan (2006)	
Northstowe	2	Awaiting revised outline application	Northstowe AAP; National Eco-town Policy; South Cambs DC Development Control Policies DPD	Included in the second wave of Eco-Towns.New application will need to conform to National Eco-town Policy.
Cambourne	3	Outline planning permission for original 3,300 granted in 1994 (of that 2,700 homes constructed as of July 2010)	South Cambs DC Site Specific Policies DPD; South Cambs DC Development Control Policies DPD	Application submitted for further 950 homes (as at July 2010)

Table 2-4 Planning update of strategic sites (October 2010)

2.2.3 The impact of the increased housing numbers in the North West Cambridge major development area on the Phase 1 WCS flood risk findings is also limited. The Phase 1 WCS recommended 'to ensure that flood risk in the Cottenham Lode catchment is not increased it is necessary for a single study to look at the combined effects of the developments in the Cottenham Lode catchment.' However, from the Phase 2 WCS it is clear that the potential impact of development in the Cottenham Lode catchment will be mitigated by ensuring that runoff from each development site is greenfield equivalent[5] or less; therefore the need for a cumulative impact study is not required provided that all sites manage runoff to greenfield equivalent or less. The method of achieving this will be through conventional or SUDS approaches which will be subject to the agreement of the Environment Agency and other relevant stakeholders through a site specific Flood Risk Assessment (FRA).

2.2.4 Since the Phase 1 WCS, Northstowe has been proposed as a second wave eco-town and therefore the water services infrastructure at Northstowe should be in line with the requirements of the Eco-Town Planning Policy Statement[6]. The Phase 2 WCS will provide the water services evidence base to demonstrate how Northstowe could be delivered as an Eco-Town.

2.2.5 In addition, since the inception of the Phase 2 WCS, a new UK Government is in place and in May 2010 the new Secretary of State for Communities and Local Government informed council

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[5] 'Greenfield equivalent' is the rate and volume of the discharge from an undeveloped site

[6] CLG (2009), Planning Policy Statement: Eco-Towns, A Supplement to Planning Policy Statement 1, http://www.communities.gov.uk/housing/housingsupply/ecotowns/

leaders of the proposals to rapidly abolish the Regional Spatial Strategies[7]. As a result, 'decisions on housing supply (including the provision of travellers' sites) will rest with Local Planning Authorities without the framework of regional numbers and plans.' At the time of writing the Phase 2 WCS (September 2010) there is uncertainty of the practical implications for growth in Cambridgeshire as a result of the abolition of the RSS. The Cambridgeshire authorities have recently re-stated their commitment to the spatial strategy for the County, originally adopted in the Cambridgeshire and Peterborough Structure Plan (2003), and now as embedded in the Cambridge Local Plan and District Council's Development Plan Documents. Thus, the current statutory policies are set out in the South Cambridgeshire Development Plan Documents, the Cambridge Local Plan, and saved policies from the Cambridgeshire and Peterborough Structure Plan 2003.

2.3 Progression to Phase 2 WCS

2.3.1 Since completion of the Phase 1 WCS, the WCS steering group partners have continued working together to progress the necessary infrastructure for growth. Regular steering group correspondence and meetings have helped to facilitate continued partnership working. The partners also collaborated to develop the scope for the Phase 2 WCS and a steering group has helped to guide the direction of the Phase 2 WCS throughout.

2.3.2 In January 2009 Halcrow Group Ltd was commissioned to undertake the Phase 2 WCS for Cambridge and the surrounding major growth areas. The main focus of the Phase 2 WCS is to enhance the evidence base and identify a strategy for the major growth sites with respect to three key themes:

- aspiring to water neutrality;
- improving biodiversity by protecting environmental water quality and hydromorphology, and;
- protecting and enhancing communities through sustainable surface water management.

2.4 Direction of Phase 2 WCS

2.4.1 During Phase 1 of the Water Cycle Strategy a number of ways in which the future water services infrastructure for the Major Sites in and around Cambridge could be made more sustainable and future-proof were identified. In addition, the potential impediments which may need to be overcome in order to achieve this future water vision were identified. Significant change to legislation has taken place. This is now starting to steer the UK water industry toward a more sustainable approach, for example; Future Water[8], Integrated Urban Drainage[9], River Basin

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[7] http://www.planning-inspectorate.gov.uk/pins/rss/10-05-27%20-%20SofS%20to%20Council%20Leaders%20-%20Abolition%20of%20Regional%20Strategies.pdf

[8] http://www.defra.gov.uk/environment/quality/water/strategy/pdf/future-water.pdf

[9] http://www.defra.gov.uk/environment/flooding/manage/surfacewater/urbanrisk.htm

Management Plans[10], the Flood and Water Management Act[11], Code for Sustainable Homes[12], and new building regulations. The general trend is towards greater environmental sustainability and more efficient use of natural resources. In order to achieve these objectives, it is crucial that water services infrastructure that we are building today considers the future, taking account of projected climate change impacts to help factor in resilience. This infrastructure will be with us for many years to come and what shape it takes now will influence how quickly and effectively we can move towards delivering sustainable water management.. Whilst it is not realistic to expect overnight change, the legacy of the infrastructure that we build now will determine the future of our water environment.

2.4.2 Phase 2 builds on the baseline scenario identified in Phase 1, but focuses on developing a long term, sustainable strategy for meeting the water services infrastructure needs of proposed new development in South Cambridgeshire and Cambridge City which is both ambitious and deliverable. To achieve this goal, we need to consider alternative options for infrastructure provision and develop an infrastructure and implementation plan to ensure the delivery of sustainable water services infrastructure. Figure 2-3 summarises this approach.

Figure 2-3 Phase 2 WCS - key technical strands (horizontal) and themes (vertical pillars)

2.4.3 The Phase 2 WCS provides the following:

- an overview of the strategic sites which are significantly progressed through the planning system, and identifying the key lessons learnt to inform future development in and around Cambridge
- an evidence base for the sites which have yet to be determined through the planning system, and seeking to maximise opportunities to enhance water management through innovation and promoting alternative systems;

[10] http://www.environment-agency.gov.uk/research/planning/33106.aspx

[11] http://www.defra.gov.uk/environment/flooding/policy/fwmb/

[12] http://www.communities.gov.uk/publications/planningandbuilding/codeguide

- an assessment of the need to meet water efficiency in new developments, and the cost implications for meeting various levels of water efficiency in new developments as set out by the Code for Sustainable Homes;
- an assessment of how water neutrality can be achieved within the study area, the measures which can be taken to move towards water neutrality, the benefits and costs associated with these measures, and an implementation strategy to work towards water neutrality;
- a strategy for ensuring sustainable surface water management is adopted in the major growth sites, including the applicability and costs associated with different surface water management measures, and the adoption and ownership of these measures in the short and long term;
- a strategy to ensure that water quality and biodiversity are integrated into sustainable surface water management, and to ensure that water quality does not deteriorate due to development;
- a summary of the ecological risks posed by development on European designated sites, and any mitigation options needed;
- the basis for an assessment of the strategic green infrastructure opportunities identified in the draft Second Edition Green Infrastructure Strategy for Cambridgeshire to identify opportunities for supporting the vision for sustainable water management;
- an overview of Anglian Water's preferred strategy for wastewater;
- a policy pathway to help move towards more sustainable water management, and;
- an implementation strategy, including the responsibilities and actions of different stakeholders.

3 Water resources

3.1 Vision for water resources

3.1.1 There is an increased awareness and movement towards more sustainable use of water in the UK. In Defra's Future Water Strategy[13], part of the vision for water usage by 2030 is for 'water efficiency playing a prominent role in achieving a sustainable supply demand balance, with high standards of water efficiency in new homes, and water efficient products and technologies in existing buildings'.

3.1.2 Under a business as usual scenario, new housing development across Cambridge Water's Water Resource Zone (WRZ)[14] could increase demand by 12.5 Megalitres per day (Ml/d) up to 2031[15], which represents a 33% increase in 2006 demand across the WRZ. To minimise the potential increase in demand for water through new development a twin-tracked approach to water resources will be required; ensuring new developments are built to a high standard of water efficiency through implementation of **Code for Sustainable Homes Level 5/6 for water[16] and similar levels of water efficiency in non-domestic buildings**, and seek opportunities to implement measures in the existing housing stock to offset the additional demand for water. To aspire towards water neutrality as part of the longer term vision, the Local Authorities including Cambridge City Council and South Cambridgeshire District Council will need to identify a local policy intention of **aspiring to water neutrality** through implementation of water efficient measures in the existing housing stock.

3.1.3 A number of strategic development sites have significantly progressed through the planning system; therefore the Phase 2 WCS has limited influence over the provision of water services infrastructure to these sites. Some of these sites still have reserved matters coming through on a plot by plot basis which will offer an opportunity to employ water efficiency measures as and where feasible.

3.1.4 For the strategic development sites which have significantly progressed through the planning system the Phase 2 WCS has undertaken an audit of the water efficiency measures proposed/built, to identify how existing development is progressing towards the vision for

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[13] http://www.defra.gov.uk/environment/quality/water/strategy/pdf/future-water.pdf

[14] This is the only WRZ serving Cambridge and the major growth areas

[15] This is based on development numbers presented in Table 3-2. consumption of 125 l/h/d (Building Regulations) and occupancy of 2.15 people per household

[16] The Code for Sustainable Homes is a national environmental assessment method for rating and certifying the performance of new homes over 6 levels for a range of categories including energy & carbon dioxide, water materials, surface water runoff, waste, pollution, health & wellbeing, management & ecology. For water the Code rating is based on consumption of potable water (in litres) per head per day

water resources. Table 3-1 provides a comparison of these development sites against the vision for water resources. There is clear evidence from this analysis that progress is already being made on the pathway towards the vision for water efficiency in new developments. The development sites which have received planning permission more recently (Southern Fringe, NIAB 1) are achieving a higher standard of water efficiency when compared to development sites such as Cambourne and Orchard Park which came forward earlier (1994 and 2005, respectively). None of the strategic development sites have achieved CSH level 5/6 for water, but for the University site there is a development plan policy in place to ensure this happens. Both Northstowe and Cambridge East are subject to development plan policies requiring between 33% and 50% reductions in main water use compared to conventional housing (adopted before the Code was introduced). As a proposed second wave Eco-town, Northstowe development proposals will be considered against the Eco-town PPS.

3.1.5 To date, there is no evidence that measures have been applied to the existing housing stock to offset the additional water from the development sites which have progressed through the planning system; this can partly be attributed to the implementation barriers which exist. The Phase 2 WCS considers the implementation barriers and explores potential options to install measures in the existing housing stock to offset the impact of new development on demand for water.

<table>
<tr><th>Development site</th><th>Proposed water efficiency</th><th>Other information</th></tr>
<tr><td>Trumpington Meadows</td><td>Phase 1 of development built to 105 l/h/d, Phase 2 may be built to a higher CSH specification</td><td rowspan="4"></td></tr>
<tr><td>Bell School</td><td rowspan="3">CSH level 3 for market homes, CSH level 4 for affordable homes (both 105 l/h/d)</td></tr>
<tr><td>Clay Farm</td></tr>
<tr><td>Glebe Farm</td></tr>
<tr><td>Addenbrooke's Biomedical Campus</td><td>BREEAM[17] Excellent standard and NEAT standard (NHS Environmental Assessment Tool)[18]</td><td></td></tr>
<tr><td>Cambourne</td><td>125 l/h/d (Building Regulations)</td><td>Water butts used extensively in affordable housing and Lamb Drove SUDS site, thereby reducing the use of potable water for garden use</td></tr>
<tr><td>Orchard Park</td><td>EcoHomes[19] Good Standard (110-125 l/h/d)</td><td></td></tr>
</table>

[17] BREEAM is an environmental assessment method for buildings, more information is available at http://www.breeam.org/page.jsp?id=66

[18] NEAT is a NHS environmental assessment tool to raise awareness of the impacts of NHS facilities and services and to estimate the environmental impact of NHS buildings, more information is available at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4119943

NIAB 1	CSH level 3 for market homes, CSH level 4 for affordable homes (both 105 l/h/d)	

Table 3-1 Water efficiency proposed/implemented in development sites

3.2 Justification

Although CWC's WRMP10 forecasts a positive supply-demand balance up to 2035, there are significant arguments for ensuring that new domestic and non-domestic development minimises the increase in demand for water, including:

- ensuring opportunities are taken to avoid *potential* future supply-demand deficit in the WRZ;
- the study area is in an area of serious water stress as designated by the Environment Agency, and;
- if abstraction licences are reduced when they are renewed in 2015 this would reduce the amount of water available.

In addition, there are a number of national (Future Water, Building a Greener Future, Eco-towns PPS) and local policy (Northstowe AAP, Cambridge East AAP & North West Cambridge AAP) drivers to achieve greater water efficiency in both new and existing buildings.

3.2.1 In their Water Resource Management Plan (WRMP10) Cambridge Water (CWC) identified that forecast demand can be met and the company is predicted to maintain a positive supply-demand balance up to 2035 (see Appendix A). Although the forecast demand to 2035 can be met according to CWC WRMP10, there are significant arguments for doing more to limit the increase in water demand associated with new development. These are:

3.2.2 **Future headroom –** over the WRMP10 planning period (up to 2035) the positive supply-demand balance is forecast to reduce year on year, such that the dry year demand forecast gradually moves closer to the total water available for use. If this trend were to continue beyond 2035, then CWC *could* have a supply-demand deficit (unless CWC could increase the total water available for use); therefore every effort should be made to reduce the impact of new domestic and non-domestic buildings on the supply-demand balance.

3.2.3 **Water stress –** the study area is in an area of serious water stress as designated by the Environment Agency, and any increase in population numbers will lead to an unwelcome increase in the demand for water unless demand is managed.

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[19] Ecohomes is a part of the BREEAM environmental assessment toolkit, but it specifically for homes, more information is available at http://www.breeam.org/page.jsp?id=21

3.2.4 **Climate change** – the single most cost effective step in water resources climate change resilience is to manage demand downwards. Reduced demand provides flexibility and resilience to shocks and uncertainty.[20]

3.2.5 **Renewal of abstraction licences** – CWC has assumed, in accordance with Environment Agency guidelines, that there will be no change to existing licence agreements or headroom allowances (other to any already proposed). The current relevant Catchment Abstraction Management Strategies (CAMS)[21] do not recommend any sustainability reductions on existing CWC licences, and the Environment Agency's water resources planning team has stated that it does not expect to introduce any until at least 2014. This means that the existing licensed levels of abstraction are secure, to the best of current knowledge, until at least 2014. If CWC's abstraction licences are not renewed to their current quota in 2015, this could reduce the water available for use. In addition, if demand were to increase beyond current projections, for example due to additional population growth or increasing consumption, this could also have serious implications for the availability of water resources. Whilst CWC is required to operate on a presumption of renewal, it is nonetheless highly recommended that all practicable measures are taken to reduce future consumption across the study area.

3.2.6 **River Basin Management Plans (RBMPs)** – the Anglian RBMP includes a number of actions which refer to promoting and educating water efficiency with developers and through the Local Development Framework.

3.2.7 **Water Act (2003)**[22] – Section 83 of the Act states that 'in exercising its function and conducting its affairs, each public authority shall take into account, where relevant, the desirability of conserving water supplied or to be supplied to premises'

3.2.8 **Local / national policy drivers** – there are a number of national and local policy drivers which are promoting more efficient use of water, including:

- **Future Water** - Governments Water Strategy for England (Defra) which aims to reduce water consumption in existing homes to 130 or 120 l/h/d by 2030 dependant on technological developments and innovation – this will require retrofitting of water efficient measures in the existing homes and business;
- **Building a Greener Future** - Policy Statement (CLG, 2007) - Target of all homes to be zero carbon by 2016 (CSH Level 6), aided by progressive tightening of Building Regulations;

[20] The Environment Agency regional Water Resources Strategy for Anglian Region states that: 'Our work shows that by 2050, climate change could reduce water resources by 10-15% in an average year, and could reduce summer river flows by 50-80%." More information is available at http://www.environment-agency.gov.uk/research/library/publications/40731.aspx

[21] Cam and Ely Ouse; Upper Ouse and Bedford

[22] http://www.legislation.gov.uk/ukpga/2003/37/contents

- **Planning Policy Statement: Eco-towns – A supplement to PPS1[23] -** (CLG, 2009) – In areas of serious water stress, 'new homes will be equipped to meet the water consumption requirement of Level 5 of the Code for Sustainable Homes', and 'new non-domestic buildings will be equipped to meet similar high standards of water efficiency with respect to their domestic water use' –this applies to the Northstowe development as a proposed second wave Eco-Town, and;
- **North West Cambridge AAP** – requires that homes meet CSH level 5.
- **Northstowe AAP and Cambridge East AAP** – require between 33% and 50% reductions in mains water use compared with conventional housing.

3.2.9 Although their WRMP10 indicated a positive supply-demand balance up to 2035, Cambridge Water recognise the value of conserving water in both new and existing developments:

3.2.10 'Grey water recycling and rainwater harvesting: in our Strategic Direction Statement (SDS), published in December 2007, we pledged to support the development of rainwater and grey water use to help reduce demands. The Company is exploring ways of promoting the use of such schemes on appropriate development sites.'

3.2.11 'We acknowledge water neutrality as a worthwhile concept, and will continue to work towards greater savings through appropriate demand management measures[24].'

3.2.12 Planning Policy Statement 1 (PPS1): Planning and Climate Change – Supplement to PPS1[25] allows local planning authorities to implement higher sustainability standards than required in the Building Regulations, provided that:

- there is a robust evidence base through WCS, CAMS, water stress classification, environmental assessment, or the Habitats Directive and Appropriate Assessment;
- the standards used are nationally recognised, including Code for Sustainable Homes and BREEAM;
- the standards can be viably achieved, and;
- the policies are appropriately focussed and embedded within the Core Strategy and Development Plan Documents (DPDs).[26]

3.3 Practical considerations – water efficiency in new development

3.3.1 Overview

3.3.2 The number of new homes built to each distinct water efficiency level has been calculated over the planning period. This was achieved by summing the number of homes built to the assumed

[23] http://www.communities.gov.uk/publications/planningandbuilding/pps-ecotowns

[24] The WRMP10 also highlights the challenge of achieving water neutrality in the water resource zone

[25] http://www.communities.gov.uk/publications/planningandbuilding/ppsclimatechange

[26] Edited from the Water Efficient Building website, more information is available at http://www.water-efficient-buildings.org.uk/?page_id=191

efficiency level at each development site. The efficiency levels at each development site vary over the planning period according to the relevant water efficiency policy affecting them at the time of build, as set out in Appendix B. This has been included within the calculation and the totals are shown below:

- Homes built at CSH 3 or 4 (105 l/h/d) = 10,267
- Homes built at CSH 5 or 6 (80 l/h/d) = 31,655

3.3.3 The WCS has used 2010/11 as the base year for future development, and has made assumptions about development from 2006/2007 (Cambridge Water's WRMP10 base year) at the major growth sites. In total the assumed growth from 2006/07 to 2010/11 was 4,836 homes were built at 105 l/h/d. This is broken down by each growth site in Table 3-2 (occupancy assumed to be 2.15 people per property). It has been assumed that the minimum CSH level for new homes will be Level 6 from 2016 across the WCS area.

Development site	Homes built at 105 l/h/d (2006/07 – 2030/31)	Homes built at 80 l/h/d (2006/07 – 2030/31)	Additional water demand (Ml/d)
Cambourne	2378		0.54
Northstowe		10000	1.72
Southern Fringe	2997	1100	0.87
Cambridge East		12000	2.07
Orchard Park	1120		0.25
University site		3000	0.52
NIAB 1	1463	317	0.39
NIAB 2	630	470	0.22
Student dwellings		2000	0.16
Windfall development	6337	2445	1.86
		Total increase in demand	**8.6**

Table 3-2 Additional water demand from each development site

3.3.4 Using 2006 as a base year (as per CWCs WRMP10), growth to 2031 will result in a new increase in water demand in the WCS study area of **8.6** Mega litres per day (Ml/d). This can be considered to be the additional water demand due to development at the major growth sites.

3.3.5 Table 3-3 below displays a comparison of water usage, by component, for a standard home and the same home fitted with various water saving products, with progressing resultant levels of water efficiency.

Component	Water Use (l/d/capita)					
	150 Standard Home	130	120 CSH Level 1/2	115	105 CSH Level 3/4	80 CSH Level 5/6
Toilet Flushing	28.8	19.2[b]	19.2[b]	16.8[d]	16.8[d]	8.4 + 8.4[f]
Taps[a]	42.3	42.3	31.8	31.8	24.9	18
Shower	30	24	24	22	18	18
Bath	28.8	25.6[c]	25.6[c]	25.6[c]	25.6[c]	22.4[e]

Washing Machine	16.7	15.3	15.3	15.3	15.3	7.65 + 7.65(f)
Dishwasher	3.9	3.6	3.6	3.6	3.6	3.6
Recycled Water(f)	-	-	-	-	-	-16.1
Total per Capita	**150.5**	**130**	**119.5**	**115.1**	**104.2**	**78**
Outdoor(g)	11.5	11.5	11.5	11.5	11.5	11.5
Total per Home	**366.68**	**319.3**	**293.52**	**284.136**	**257.412**	**195.58**

Table 3-3 Targets for Water Use and Efficiency Measures[27]

Notes:
(a) combines kitchen sink and wash hand basin
(b) 6/3 litre dual-flush toilet
(c) 160 litre bath filled to 40% capacity, frequency of use 0.4/day
(d) 4.5/3 litre dual flush toilet
(e) 120 litre bath
(f) recycled water (rainwater/greywater harvesting)
(g) assumed garden use

3.3.6 From the table, it can be seen that meeting CSH levels 3 and 4 can be achieved through water efficiency measures such as low flush toilets, and more water efficient taps, shower heads, washing machines and dishwashers. However, the evidence suggests that to achieve CSH levels 5 or 6 requires water recycling through rainwater harvesting or greywater recycling.

3.3.7 *Water Supply Infrastructure*

3.3.8 A baseline water supply network strategy was identified by CWC for Phase 1 and this has not been re-considered for the Phase 2 strategy. The way that water companies are currently regulated does not permit them to reduce water supply network infrastructure provision on the assumption that savings will be realised through policy led demand management measures. As and when savings start to be realised this will be reflected in CWCs June return figures, on which future rounds of planning will be based. This means that successful reduction in demand in real terms will eventually filter through into water supply network infrastructure planning, but it cannot currently be anticipated, or forced, by reducing supply capacity.

3.3.9 *Meeting CSH level 3/4*

3.3.10 The local development plan policy basis for achieving CSH levels 3/4 would benefit from being strengthened. To aid this, there is a increasing evidence base for achieving CSH levels 3/4 for new developments. For example, market housing at the Clay Farm development will be built at CSH level 3, which was agreed with developers in advance of this being mandatory and without the firm development plan policy to require it.

3.3.11 However, it is important to note that to achieve CSH levels 3/4 will also require associated changes in behaviours by the occupants. However water efficient a home is designed to be, behaviour will ultimately dictate the consumption level. For example, reducing shower usage assumptions in Table 3-2 are partially due to the introduction of lower flow showers but mainly

[27] Table based upon Environment Agency Publication - Science Report – SC070010: Greenhouse Gas Emissions of Water Supply and Demand Management Options, 2008.

due to reducing showering times. An Environment Agency/Energy Saving Trust report (Quantifying the energy & carbon effects of water saving; April 2009) emphasises the dependence of demand management on behaviour:

3.3.12 *'From the perspective of the individual householder, the potential CO2 and cost savings due to simple appliance retrofits are much lower than from behavioural changes such as using a bowl for washing dishes or taking a shorter shower.'*

3.3.13 To calculate the financial and carbon costs for achieving CSH levels 3/4 the following assumptions have been made

- The additional cost of building a new home to CSH Level 3 (for water, 105 l/h/d) compared to building to the Building Regulation standard of 125 l/h/d has been assumed to be £268. This is averaged from estimated figures supplied by CLG in 2008 and developers Countryside Properties and Taylor Wimpey.[28]
- It is assumed that water efficient devices will be installed into new homes as standard and existing homes at end of life of existing equivalent devices; therefore they have been assumed to incur no net additional cost or carbon impact.
- The unit carbon cost of CO_2 for water supplied by the water company (including potable treatment, distribution, wastewater removal and wastewater treatment) has been assumed to be 0.747 tCO_2e/Ml[29].
- Carbon savings due to water not supplied to homes (i.e. reduced consumption) include water supply and wastewater treatment carbon (as above).
- Savings on energy bills associated with reduced hot water use (as a result of demand management) will generally at least match, and often exceed, the savings on metered water bills, but this is a very complex issue and has not been accounted for in this report[30].

3.3.14 The capital and carbon costs of meeting CSH level 3/4 for water services are illustrated in Table 3-4. The total costs of building homes to meet CSH level 3/4 have been calculated to be £2.75 million. The carbon cost of supplying water to homes is 1.73 tonnes of carbon dioxide per day (tCO^2/d). If development was uncontrolled, it is estimated the carbon cost from an equivalent

[28] The cost of meeting CSH 3/4 will drop as demand increases. Bathroom manufacturers Grohe have estimated that, assuming bulk supply of the fittings and fixtures, the cost of meeting CSH 3/4 could drop to as little as £12.50 (see http://www.water-efficient-buildings.org.uk/?page_id=1146 for more information).

[29] Environment Agency Publication - Science Report – SC070010: Greenhouse Gas Emissions of Water Supply and Demand Management Options, 2008

[30] A recent study by the Environment Agency and the Energy Saving Trust (Quantifying the energy & carbon effects of water saving; April 2009) considers the energy savings associated with reduced hot water usage in the home in more detail.

number of homes (10,267 homes x 150 l/h/d[31]) would be 2.48 tCO^2/d; therefore building new homes at CSH level 3/4 equates to a 30% 'saving' in carbon costs.

3.3.15 It should be noted that the cost estimates for achieving higher code levels are being revised continually. A recent revision by CLG[32] found that achieving a water consumption of 105 l/h/d does still incur an additional cost relating to specifying more water efficient fittings that are not yet mainstream in the making. CLG found that the average cost (provided by developers) of achieving 105 l/h/d was now around £200 per home. CLG also noted that some developers (volume house builders) reported that by placing high volume orders, and because Code 3 minimum requirements are now set as standard specifications, 105 l/h/d could be achieved at no extra cost.

Cost	No. homes at level 3/4 (2010/11 base year)	Cost	Total costs
Capital cost of meeting CSH level 3/4	10,267	£268 (per home)	£2.75 million[33]
Carbon cost of water supply	10,267	0.747 tCO^2 per day (per Ml of water supplied)	1.73 tCO^2/d

Table 3-4 Costs of meeting CSH level 3/4

3.3.16 In addition to the carbon savings achieved by reducing potable water demand, there will also be savings in water bills for householders. The average unit price for a metered water customer in 2008 was approximately 0.3 pence per litre, including wastewater charges. Average per capita consumption without any water efficiency is 150 l/h/d. Therefore, assuming that actual water use in the home meets CSH 3/4 (105 l/h/d), savings in water bills can be estimated by the following equation:

3.3.17 Water saving (45 l/h/d) * unit cost of water (0.3 pence per litre) * days in year (365) * occupancy rate (2.15) / 100 (to convert from pence to pounds) = **£105.94 saving in water bills per property per year**[34].

3.3.18 For water bills, the payback time for meeting CSH level 3/4 will be between 2-3 years.

3.3.19 *Meeting CSH 5/6*

3.3.20 Based on Table 3-3 moving from CSH level 3/4 (105 l/h/d) to 5/6 (80 l/h/d) requires:

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[31] 150 l/h/d is the current average water usage from a household within Cambridge Water Company's boundaries.

[32] http://www.communities.gov.uk/documents/planningandbuilding/pdf/1501290.pdf

[33] This is the total capital cost (undiscounted) to install water efficient measures into new homes. When a discount rate is applied (3.5%), based on the time of build in the planning period, the net present value (discounted) is £2.51 million).

[34] Calculation adapted from http://www.water-efficient-buildings.org.uk/?page_id=179

- further efficiency in household taps (18 l/h/d demand for level 5/6 compared to 24.9 l/h/d for level 3/4);
- installation of 120 litre bath (compared to 160 litre bath for level 3/4) to give a further 3.2 l/h/d saving, and;
- use of greywater recycling (GWR) or rainwater harvesting (RWH) (could be achieved by connecting toilets only, assuming all other water efficient measures are maximised).

3.3.21 CLG currently state that a greywater recycling system is required to achieving the 80 l/h/d required by Code Level 5/6. Greywater recycling (and rainwater harvesting) systems can help obtain high levels of sustainability but have delivery and maintenance cost implications. CLG estimated in 2010[35] that the cost of meeting CSH Level 5/6 for water adds between £1,750 (for a flat) and £4,500 to the cost of construction (Table 3-6). The large increase in cost from Code Level 3/4 is due to the cost of implementing greywater/rainwater systems. As the technology advances and more widely implemented it is likely that there will be reduced costs for greywater and rainwater systems. A recent Waterwise East[36] report suggested that it would be possible to achieve 80 l/h/d purely through a fittings-based strategy by installing extremely efficient washing machines, toilets, taps and a 120 litre bath (this avoiding the need for greywater/rainwater systems). This would significantly reduce the cost of achieving Code Level 5/6 and is of particular relevance to Cambridgeshire Local Authorities and developers in Cambridgeshire as they consider the costs of delivering new developments. It should be noted that achieving 80 l/h/d through a fittings-based is based on an assumption that shower times are just under 4 ½ minutes, whereas the current average shower time in the UK is approximately 10 minutes[37]. Achieving 80 l/h/d through a fittings-based strategy would rely on changes in user behaviour and this is considered to represent a lower certainty of achieving the target in practice.

3.3.22 To support the implementation of CSH level 5/6 in the major growth sites in and around Cambridge, the WCS has examined the costs, infrastructure requirements and adoption and maintenance of GWR and RWH on an individual household and community scale. The WCS has pulled together the best available evidence; although there is limited evidence in the UK of GWR and RWH on a large-scale. There are many existing informal greywater (e.g. using bathwater to water the garden) and rainwater systems (e.g. water butts). The WCS needs to develop the evidence base for more formal and widespread systems which are applicable across a large scale.

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[35] http://www.communities.gov.uk/documents/planningandbuilding/pdf/1501290.pdf

[36] Waterwise East (2010), Water efficiency in new developments: A best practice guide, http://www.waterwise.org.uk/images/site/waterwise_east/water_efficiency_low%20res.pdf

[37] http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/press_releases/shower_power_press_release.html

3.3.23 Rainwater harvesting involves capturing rain water that lands on the roof and storing it in a tank for later use. In this way rainwater harvesting can reduce the volume of water leaving a site, and be a direct source of water. Rainwater harvesting consists of a catchment surface (usually a rooftop), a way to transport the collected water to a storage tank (gutters, down spouts and pipes), a storage container (these vary significantly) and a means to get the water from the storage container to the taps (pipes, pump and pressure tanks or gravity flow). A treatment system may be included, depending on the rainwater quality desired and the source.

3.3.24 Greywater recycling involves treating and re-using water from the shower, bath and sinks. Unlike rainwater systems, the supply (greywater) is available on a daily basis, so the storage volumes necessary for greywater systems are much lower and storage is typically in a tank in the house, in some cases concealed above a WC cistern (e.g. in a system manufactured by Ecoplay[38]).

3.3.25 A summary of some key relevant technical information related to RWH and GWR is presented in Table 3-5; the purpose of this summary is not to provide an exhaustive technical summary of RWH and GWR, rather to present some of the key principles which should be considered. A review of some recent case studies for RWH and GWR, both in the UK and internationally, is provided in Appendix C.

[38] http://www.ecoplay-systems.com/

Information	Rainwater harvesting	Greywater recycling
Source of water supply	Rainfall	Showers, hand basins / taps (not kitchen sink which makes up about 75% household use from taps) & baths
Appliances for which they are suitable	Toilets Washing machines	Toilets Washing machines (depending on level of treatment and public acceptability)
Volume of water available / potential water saving	Depends entirely on rainfall Latest sustainable water management strategy for Northstowe indicated typical water saving could be **12.1 l/h/d**[39] Calculations in Phase 2 WCS indicates water savings of **8-16 l/h/d** depending on roof area, and occupancy rate – with RWH alone it is **unlikely that** CSH 5/6 could be met for water	Water available: • Based on water available from showers, baths & hand basins in Table 3-3 the potential volume of greywater is: • Shower (18 l/h/d) + Bath (25.6 l/h/d) Taps (6 l/h/d – assuming 25% available as greywater) = 49.6 l/h/d * 80% efficiency = **40 l/h/d available as greywater**[40] Potential water saving: • If used only on toilets water saving could be **16.8 l/h/d** (based on Table 3-3) – this **would not** achieve CSH 5/6 • If used for toilets and washing machines water saving could be **32.1 l/h/d** (based on Table 3-3) – this **would** achieve CSH 5/6
Suitable size of tanks	Tanks should be sized based on: **Catchment area (m^2) * drainage coefficient (0.9) * filter coefficient (0.9) * 5%**	Tanks should be sized to store up to 40 l/h/d of greywater Therefore based on an occupancy rate of 2.16 tanks should be sized at:

[39] The latest sustainable water management strategy for Northstowe (December 2007) indicated that with average annual rainfall of 550mm, typical roof area of 25 m^2, a baseline demand of 110 l/h/d, a runoff coefficient of 90% and a filter coefficient of 90%, rainwater harvesting at Northstowe would not achieve CSH level 5/6 (typical saving calculated to be 12.1 l/h/d). Using the same parameters (except with historical rainfall) the WCS findings gives similar findings.

[40] The calculations for greywater for the latest sustainable water management strategy for Northstowe (December 2007) indicated that approximately 37 l/h/d would be available as greywater

Information	Rainwater harvesting	Greywater recycling
	For a 25 m^2 roof area the tank size would be approximately **600 litres** (see Appendix D for calculations)	**40 l/h/d * 2.16 occupancy = 86 litres (approximately)**
Types of systems available	Rainwater is collected from the roof area or hard standing areas, goes through a filter and smoothing inlet to the storage tanks. From the storage tanks rainwater is supplied to appliances by: • direct feed systems where rainwater is supplied direct to appliances under pressures, or; • header tank systems, where rainwater is supplied to a header tank in the loft. Gravity-fed systems also exist, where rainwater is collected in a wall-mounted tank; Welsh Water are currently trialling such a system[41]	Short retention systems – Apply basic treatment such as skimming of debris and allowing particles to settle (water automatically released if stored for too long) Basic physical and chemical treatment – Using a filter to remove debris prior to chemical disinfection (chloride or bromide)[42] Biological systems – bacteria are used to remove contamination in the water (sometimes it also passes through UV system) Bio-mechanical systems – Combination of biological and physical treatment
Water quality treatment required	There are no regulatory standards for non-potable water but a study by Government in 2007[43] recommended three categories of water quality required depending on the risk associated with intended use: • **Category A - External cleansing** requires the highest level of water quality as this usage creates aerosols that can be inhaled, increasing the risk of pathogens entering the body. • **Category B - Drip irrigation** allows considerably more bacteria per 100 ml than Category A because human exposure is lower. It also does not require the water to be as clear as required for Category A • **Category C - WC flushing** allows the same level of bacterial contamination as Category B, but allows a higher residual chlorine or bromine concentration. It also specifies how clear the water should be because the water has to be visually and practically acceptable for toilet flushing.	
Maintenance	Maintenance requirements outlined in British Standards and should be used to ensure good practice is adopted	

[41] http://www.dwrcymru.com/English/Company/Operations/surfacewater/index.asp

[42] Some pilot projects have identified problems with this type of treatment (e.g. noise, performance, odour and water quality). More information is available in 'Environment Agency (2008) – Greywater: an information guide'

[43] Market Transformation Programme (MTP), 2007 Rainwater and Grey Water: Review of Water Quality Standards and Recommendations for the UK

Information	Rainwater harvesting	Greywater recycling
requirements		
Uncertainties	Seasonal variation in rainfall remains one of the main barriers, i.e. whether amount of water supplied by a RWH system will be sufficient during dry spells. Rainfall varies considerably in intensity, and a large part of a month's rainfall could fall within a limited number of rainfall events. In such cases it is likely that there would be significant fluctuations in the available water in the rainwater harvesting tank to provide recycled water. On a **community scale**, the storage tank could be sufficiently sized to accommodate larger rainfall events, and hence may be able to catch a greater proportion of rainfall.	Public acceptability remains the main barrier. However, recent research carried out by Cranfield University (in partnership with Cambridge Water) indicate the public would be willing to invest in GWR due to concerns for the environment and to ensure a reliable supply of water during times of water scarcity[44]. The public would need further information prior to investing in greywater recycling, and this is a role for local planning authorities and Cambridge Water.
Useful documents	Environment Agency (2008), Harvesting Rainwater for domestic uses: an information guide BSI: British Standards (2009), BS8515 Rainwater harvesting systems – Code of Practice	Environment Agency (2008), Greywater – an information guide BSI: British Standards (2009), BS8525 Greywater systems – Code of Practice
Adoption of systems	Household systems – householders Non-domestic buildings – private management company Communal systems – private management company or Cambridge Water	

Table 3-5 Summary of key information related to RWH and GWR

[44] Horton (2009), House buyer perceptions on the value of water and grey water recycling systems, Thesis for Master of Science Degree in Water Management - Water and Society, Cranfield University.

Costs of rainwater/greywater systems

3.3.26 There is a reasonable evidence base to support a build up of the capital, operational and carbon costs for RWH and GWR at the household scale. Table 3-6 presents the best estimates of capital and operational costs fort RWH and GWR for an individual household. To calculate the cost per house of RWH or GWR (at the household scale) over 100 years, we have built up a cost model based on the cost estimates presented in Table 3-6. Operational costs are assumed to occur year on year, and the assets have been assumed to be replaced every 25 years.

Cost	Cost per house[45]	Source of cost & other comments
Capital cost to install	£1,750 (for a flat)	Communities for Local Government (2010), Code for Sustainable Homes, A Cost Review
	£2,000	http://www.water-efficient-buildings.org.uk/?page_id=1056
	£2,650	Communities for Local Government (2008), Cost Analysis of the Code for Sustainable Homes
	£4,500	Communities for Local Government (2010), Code for Sustainable Homes, A Cost Review
Operational costs - greywater	£30 per year	Environment Agency Publication - Science Report – SC070010: Greenhouse Gas Emissions of Water Supply and Demand Management Options, 2008 Equates to £860 per house over 100 years (using discounting)
Operational costs – rainwater	£15 per year	Environment Agency Publication - Science Report – SC070010: Greenhouse Gas Emissions of Water Supply and Demand Management Options, 2008 Equates to £430 per house over 100 years (using discounting)
Replacement costs	£3000 to replace	Environment Agency Publication - Science Report – SC070010: Greenhouse Gas Emissions of Water Supply and Demand Management Options, 2008 Replacement required every 25 years Equates to £2,034 per house over 100 years (using discounting)[46]

Table 3-6 Costs of RWH/GWR per terraced/detached house

[45] When calculating the cost per house, most calculations are based on a detached or terraced house

[46] Because of natural fluctuations in home ownership the cost of replacing the rainwater/greywater would not be consistent for homeowners, and within the same house one owner may need to replace the infrastructure (thereby incurring £3000 of costs), whereas a future owner of the same house may not need to replace the asset. In this way, the costs are not spread equitably across the homeowners.

3.3.27 There is less evidence of the costs of RWH or GWR at a communal scale; however the available evidence does indicate that potentially significant savings can be achieved through communal recycling systems when compared to recycling on an individual household basis:

- estimates from CLG[47] indicate that capital costs of installing RWH/GWR in flats is approximately 60%-70% less expensive than for a detached/terraced house;
- the Water Efficient Buildings website[48] indicates a standard recycling scheme would add at least £2000 to the cost of a new home on an individual household basis, or £800 per dwelling if a communal recycling system is adopted;
- the Environment Agency report on rainwater harvesting[49] suggests that 'larger-scale housing developments with shared maintenance and infrastructure are more likely to make the systems financially attractive because of economies of scale and coordination of maintenance programmes', and;
- a feasibility study undertaken at Birmingham Eastside indicated payback periods for single dwelling rainwater harvesting systems were approximately 16 years, compared to a payback period of 3 years for a communal system; this indicates the potential capital costs which could be saved through communal systems[50].

3.3.28 GWR/RWH will result in significant savings in water bills for householders. The average unit price for a metered water customer in 2008 was approximately 0.3 pence per litre, including wastewater charges. Average per capita consumption without any water efficiency is 150 l/h/d. Therefore, assuming that actual water use in the home meets CSH 5/6, savings in water bills can be estimated by the following equation:

3.3.29 Water saving (70 l/h/d) * unit cost of water (0.3 pence per litre) * days in year (365) * occupancy rate (2.15) / 100 (to convert from pence to pounds) = **£164.80 saving in water bills per property per year**[51].

3.3.30 Given the initial installation costs of GWR/RWH systems has been estimated to be £2000-£4500, the payback period will be in the region of 12-30 years at a household scale. Communal GWR/RWH systems may have significantly shorter payback periods.

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[47] Communities for Local Government (2008), Code for Sustainable Homes, A Cost Review

[48] http://www.water-efficient-buildings.org.uk/?page_id=1056

[49] Environment Agency (2008), Harvesting Rainwater for domestic uses: an information guide

[50] http://www.sustainable-eastside.net/Greywater%20and%20Rainwater%20Feasibility%20Study.pdf

[51] Calculation adapted from http://www.water-efficient-buildings.org.uk/?page_id=179

Case study: Achieving water efficiency in new developments

The Beddington Zero Energy Development (BEDZED) is an exemplar sustainable development in Sutton. With respect to water usage on site, ongoing monitoring of the development has indicated that the average consumption for a BEDZED resident was 72 l/h/d, compared to an average in Sutton of 143 l/h/d. This has been achieved using the following mechanisms:

- toilets - 3-5 litre dual flush toilets have been installed;
- showers, baths and taps – no power showers have been fitted, baths are lower volume, and flow restrictors have been applied to taps;
- all properties are metered and users are reminded of their water use through water meters which are visible in the kitchens;
- residents and workers are given water saving ideas and have been provided with information on the environmental and financial advantages of saving water (residents following advice can cut their consumption by up to 50%);
- rainwater harvesting is provided and it is estimated that 18% of a resident's water consumption is provided by rainwater (the rainwater tanks are integrated into the foundations of homes), and;
- a small on-site sewage treatment works is capable of treating water to a sufficient standard to allow it to be used to supplement rainwater for toilet flushing

A typical household saves about £48 per year compared to a conventional household, but this could be as high as £106 per household.

More information is available at:

http://www.bioregional.com/files/publications/BedZEDBestPracticeReport_Mar02.pdf and

http://www.bioregional.com/what-we-do/our-work/bedzed/

Carbon and energy costs of rainwater/greywater systems

3.3.31 Some environmental impacts of rainwater/greywater systems are higher than those of traditional mains water supply. The energy cost of additional pumping of rainwater/greywater alone is higher than the total impact of supplying the equivalent volume of mains water. Pumping costs for RWH range from 1-3kWh/m^3, total energy cost for mains water 0.56kWh/m^3 [52]. However gravity fed systems will consume less energy and be cheaper to operate but would require installation of storage tanks in the loft or to the exterior of properties at a high level.

3.3.32 With regards to carbon costs the evidence indicates that rainwater/greywater at an individual household scale is nearly double the carbon costs of water supplied by the water company. A

[52] Quantifying the energy and carbon effects of water saving, Environment Agency and Energy Saving Trust, April 2009

recent study[53] which looked at a range of greywater and rainwater systems demonstrated that under all situations greywater and rainwater systems gave rise to additional net carbon emissions over their lifetimes. The study demonstrated a potential increase in operational emissions of 40% for rainwater systems, and over 100% for most greywater systems (except for short retention systems). At a community scale, with the need for longer pumping distances from a central tank to the individual household, even higher carbon costs could result although the evidence is currently inconclusive[53].

3.3.33 Carbon emissions needs to be viewed alongside other important factors associated with rainwater/greywater systems, most notably the water savings and savings on household bills. It is worth noting that the cost of supplying water is low compared to the cost of heating water, and that any additional carbon used by rainwater/greywater systems could be offset, either on-site (e.g. through reductions in amount of water being heated or through other energy efficient measures to reduce energy consumption or off-site.

Community and household rainwater/greywater systems

3.3.34 In addition to the financial and carbon implications of greywater recycling or rainwater harvesting at a household or community scale, there are a number of other potential positive and negative factors which should be incorporated into the decision making (Table 3-7). At the household scale it would be the responsibility of the homeowner to maintain the greywater or rainwater system; this poses a greater risk to adequate maintenance given that the majority of homeowners may not have the technical know-how or desire to ensure their system is operating effectively. In addition, at the household scale there is a higher risk that the homeowner may not replace the infrastructure at the end of its life, and there may be reluctance to re-fit the systems unless there are clear benefits to the homeowner.

3.3.35 At a community scale, there is greater potential for ensuring that ongoing and adequate maintenance is in place to ensure the greywater or rainwater systems are operating effectively. The main current barrier to community systems is that there is no established mechanism for the adoption of community greywater or rainwater systems. Provided that a local management company or Cambridge Water adopted and maintained the system, there is a greater likelihood of adequate maintenance and replacement of the systems as required. Furthermore, it is considered that community systems would represent a lower public health risk due to more consistent and effective water quality testing and maintenance.

Type of system	Positive factors	Negative factors
Household scale	Reduced need for expensive pumping costs – likely to require less additional infrastructure (& opportunities to use gravity-fed systems)	Greater risk of poor maintenance (because reliance on public acceptability), potentially resulting in: • inefficient system which fails to produce

[53] Environment Agency (2010) – Energy and carbon implications of rainwater harvesting and greywater recycling, available at http://www.nhbcfoundation.org/LinkClick.aspx?fileticket=D9%2BMcJanrbU%3D&tabid=339&language=en-GB

Type of system	Positive factors	Negative factors
		necessary water savings, and; • poor water quality – risk to public health Householders may be reluctant to replace the systems at the end of their life, especially given cost implications (£3000 to replace)
Community scale	Assuming an appropriate body is in place to maintain the system, it would be more easier to maintain than a household system Greater likelihood of public acceptance RWH tanks could be designed to capture larger rainfall events, therefore maximising rainwater Greater opportunity for combined GWR and RWH systems Economies of scale would be achieved	No current established mechanism for adoption and maintenance of system – can be adopted by private management company or Cambridge Water

Table 3-7 Positive and negative factors associated with GWR and RWH

3.3.36 *Achieving water efficiency in non-domestic dwellings*

3.3.37 Cambridgeshire Horizons Long Term Delivery Plan for the Cambridge Sub-Region outlines 600,000 m² of floor area for new health, education and community facilities. Major development sites in and around Cambridge will be supported by a range of these 'public' buildings. In line with the long-term vision for water efficiency, these facilities should be built to be highly water efficient through installation of water efficient measures and rainwater/greywater systems.

3.3.38 BREEAM is the most commonly used environmental assessment methods for non-domestic buildings. It sets out levels of development from 'Pass' to 'Outstanding'. There are a number of different assessment methods depending on the use of the building, including offices, retail, industrial, healthcare and education. There are ten categories within the BREEAM environmental assessment methodology, of which water is one of them.

3.3.39 BREEAM principally sets out three water use levels as follows:

- 1 credit: 4.5m3 to 5.5m3 per Full Time Employee (FTE) per year (19 to 23 litres per FTE per day)
- 2 credits: 1.5m3 to 4.4m3 per FTE per year (6 to 18 litres per FTE per day
- 3 credits: less than 1.5m3 per FTE per year (less than 6 litres per FTE per day)

3.3.40 Where the building is used for residential purposes (e.g. hospital) or for a water consuming industrial process, average water use would be expected to be higher.

3.3.41 In line with the vision for water resources non-domestic buildings should aspire to **the highest level of water efficiency**, where feasible. This can be achieved through installation of low flush toilets & urinals, aerated taps and showerheads, and through implementation of rainwater and greywater systems. Planning applications for new non-domestic buildings will be expected to outline proposals for water efficient appliances and rainwater/greywater systems. Planning applications will also need to provide evidence of the calculations to predict water usage per FTE per year.

3.3.42 In non-domestic buildings the roof area will generally be quite large, which offers significant opportunities to utilise rainwater harvesting systems. Evidence from the Environment Agency[54] provides two examples of rainwater harvesting systems in non-domestic dwellings; these examples demonstrate the water savings which can be achieved through rainwater harvesting. In addition, the findings show a very low payback period of approximately 3 years, compared to a payback period in the order of decades for individual household rainwater harvesting. Therefore, there are clear environmental benefits of reducing water demand, as well as financial benefits to the building owner/s. Further practical considerations of implementing rainwater/greywater systems are provided in Table 3-5.

3.4 Practical considerations – aspiring to water neutrality

3.4.1 An additional **8.6 Ml/d** of water would be required to serve the major growth sites in and around Cambridge. Therefore, to achieve water neutrality would require a reduction in 8.6 Ml/d in the existing housing stock. The concept of water neutrality has been developed as a measure or goal for water efficiency of new developments.

3.4.2 Water neutrality as defined by the Government and the Environment Agency is:

3.4.3 'for every new development, total water use across the wider area after the development must be equal or less than total water use across the wider area before the development'.

3.4.4 The concept of water neutrality is to be applied over an appropriate geographical area. Therefore, additional water demand from the development can be directly offset by reducing demand in the surrounding areas. The Phase 1 WCS suggested that achieving a reduction to 120 l/h/d in existing housing stock would approximate to water neutrality across Cambridge City and South Cambridgeshire districts. The Phase 2 WCS has refined this assessment, and looks at implementation of specific measures in the existing housing stock to work towards water neutrality in Cambridge City and South Cambridgeshire.

3.4.5 The Phase 2 WCS has assessed the use of metering, variable tariff structures, and retrofitting of water efficient measures to work towards water neutrality. An overview of these measures is provided in Table 3-8; a more detailed analysis of the measures is provided in Appendix E.

[54] http://publications.environment-agency.gov.uk/pdf/GEHO0108BNPN-E-E.pdf

Measure	Description	Water saving (l/h/d)	Cost of installation (£)	Other information	Source of evidence
Metering		20 l/h/d	£500 per property	In 2009/10 56% of properties in CWC WRZ were metered	Cambridge Water Company WRMP10
Retrofit water efficient measures	Based on retrofitting of: • Water butt • Tap aerators • Shower timer • Aerated showerhead • Dual flush toilet	8-19 l/h/d with a best estimate of 12 l/h/d	£86-£178 per property with a best estimate of £115 per property	Uptake rates range from 13% to 35% with a best estimate of 25%	Evidence base for large-scale water efficiency in homes, Waterwise, October 2008
Installation of variable tariffs	A variable tariff is one where the pricing scheme for water changes with levels of consumption.	5-12% additional saving in water demand over and above the savings from installing a meter	£5 per meter per year operating cost (to administer programme)[55]		Waste Not, Want Not - Sustainable Water Tariffs, A report by Paul Herrington for WWF-UK, 2007

Table 3-8 Overview of measures considered in Phase 2 WCS to work towards water neutrality

3.4.6 Given the range of potential options in the existing housing stock, and the range of potential water savings achievable through each option, it was necessary to identify a range of scenarios to identify whether water neutrality would be achievable. For the entire Cambridge City and South Cambridgeshire areas, four scenarios have been identified. These scenarios are based on the potential water savings, strategies and uptake rates of the measures described in Table 3-8 and Appendix E.

- Existing proposals – this scenario assumes 88% meter penetration as per Cambridge Water's WRMP10.
- Best case – this is the most optimistic scenario and assumes 100% meter penetration by 2020, a 35% uptake of retrofit measures, a water saving of 18.9 l/h/d (45 l/property/day) from retrofit measures, and a further 12% water saving achieved through implementation of variable tariffs.
- Best estimate – this is the mid-range of the scenarios, and assumes 100% meter penetration by 2030, a 25% uptake of retrofit measures, a water saving of 12 l/h/d

[55] Environment Agency (2009) Water neutrality: an economic assessment for the Thames Gateway Development, http://publications.environment-agency.gov.uk/pdf/SCHO1009BQZV-e-e.pdf

(28 l/property/day) from retrofit measures, and a further 8.5% water saving achieved through implementation of variable tariffs.

- Worst case – this scenarios assumes 88% meter penetration by 2035 (in line with CWC WRMP10), a 25% uptake of retrofit measures, a water saving of 8.3 l/h/d (20 l/property/day) from retrofit measures, and a further 5% water saving achieved through implementation of variable tariffs.

3.4.7 To achieve water neutrality will require a number of measures to be implemented, and no one measure in isolation can achieve water neutrality[56]. There is little existing evidence of the effectiveness of multiple measures to reduce demand for water[57], and it is possible that with multiple measures (i.e. metering *and* retrofit measures) there may be diminishing returns with respect of water savings. This has not been factored into the Phase 2 WCS analysis, but needs to be taken into account when implementing measures in the existing housing stock.

3.4.8 The water savings from the four scenarios are shown in Table 3-10 and Figure 3-1. Under Cambridge Water's metering proposals in their WRMP10 there would be a reduction in water demand in the region of approximately 1.5 Ml/d across Cambridge City and South Cambridgeshire. With additional measures put in place the potential reduction in water demand could be 3.3 Ml/d to 8.4 Ml/d by 2030/31, under the worst and best case scenarios respectively. The additional water from the major growth sites is approximately 8.6 Ml/d; therefore under the best case scenario water neutrality ***may be achievable***.

3.4.9 Table 3-11 shows how the potential water use savings could be made for each of the major development sites in the Cambridge area.

3.4.10 In reality the water savings achieved from a combination of these measures is likely to lie somewhere in between the worst case and best case scenarios. Achieving the best case scenario will be highly dependant on behavioural changes. Working with local communities to promote sustainable use of water will be a crucial success factor in aspiring to water neutrality.

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[56] For example, to achieve water neutrality through retrofitting alone would require between 4 and 10 homes to be retrofitted for every 1 new home built. This is significantly more homes than the existing housing stock in Cambridge Water's Water Resource Zone.

[57] Professor David Butler, *pers. comm.*.

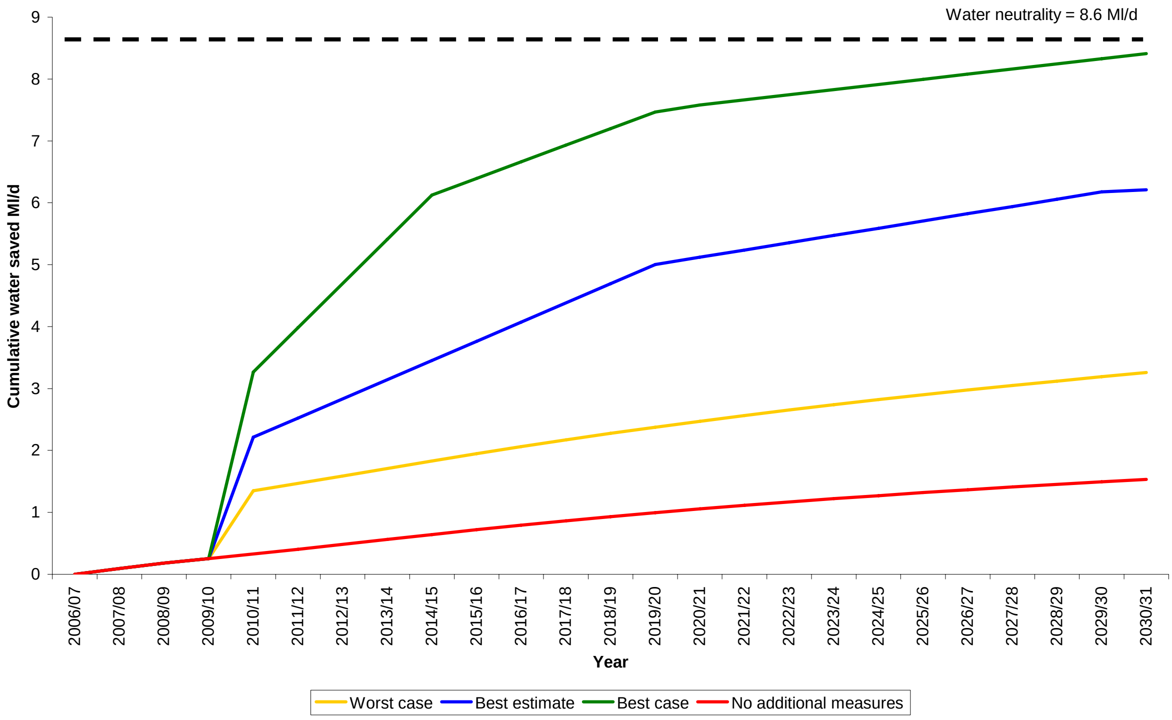

Figure 3-1 Potential water savings from measures in the existing housing stock

3.4.11 The Phase 2 WCS has also assessed the potential costs of measures in the existing housing stock. We have only assessed the cost of installation of measures up to 2030/31. Ongoing maintenance and replacement costs have not been included based on the following assumptions:

- the cost of replacement of meters (every 15 years) would be incurred by Cambridge Water or individual householders;
- ongoing operational costs associated with variable tariffs (£5 per meter per year) would be included in customers' water bills, and;
- water efficient measures would be replaced at the end of asset life, therefore incurring no net additional costs.

3.4.12 The total costs for the different scenarios are presented in Table 3-9. Under Cambridge Water's proposals for 88% meter penetration the total costs from 2010/11 to 2030/31 would be £13 million (£10 million when discount rate applied). This is based on meter costs of £500 per property. However, it is worth noting that there would be economies of scale if a widespread metering programme was undertaken (i.e. metering a whole neighbourhood at the same time) which would lead to cost reductions not considered in the Phase 2 WCS. Under the best case scenario total costs for installing meters and undertaking a retrofit programme would be £26.4 million, an increase of £13.4 million compared to the existing proposals in the region.

3.4.13 If an enhanced metering programme and/or retrofit measures in the existing housing stock are funded by developers to 'offset' the additional demand from new development, it is important to estimate the additional cost per new dwelling to implement these measures. This can be calculated by dividing the cost of the measures (over and above Cambridge Water's WRMP10 proposals) by the number of new homes in the major growth sites (as illustrated in Table 3-9.

The indicative additional cost per new dwelling would range from £57 to £320 depending on the scenario.

3.4.14 Table 3-12 gives a summary of the measures available to implement water efficiency measures in existing housing stock, and shows how measures could be implemented. It is also important to recognise the role of the Local Authorities in facilitating and supporting the implementation of measures, and where support through regulatory or legislative intervention may be needed. The recommendations at Section 3.6 relate to this issue.

		Existing proposals	Best case	Best estimate	Worst case
Baseline information	No. new homes from major growth sites (2006/07 to 2030/31)	41922 (assumed no. houses included in study area assumed to be built from 2010/11 to 2030/31)			
	No. additional homes metered by 2030/31	27000	46500	46500	27000
	No. homes with retrofit WEMs by 2030/31	N/A	36947	26390	13723
Undiscounted cost (£ million)	Metering	£13[58]	£23.3	£23.3	£13
	Retrofit	N/A	£3.1	£3	£2.4
	Total	**£13**	**£26.4**	**£26.3**	**£15.4**
	Indicative average cost per new house (£)	**N/A**	**£320**	**£317**	**£57**

Table 3-9 Capital costs of metering and retrofit WEMs under different scenarios

[58] The cost of metering in line with CWCs proposals in their WRMP10 will be met by the water company who offer free water meters to all household customers.

Scenario	Metering			Variable tariffs			Retrofit water efficient measures			Predicted total water savings 2030/31 (Ml/d)
	Description	No. existing homes metered by 2030/31 (approx)	Additional water savings at 2030/31 (Ml/d)	Description	No. existing homes installed by 2030/31 (approx)	Additional water savings at 2030/31 (Ml/d)	Description	No. existing homes retrofitted by 2030/31 (approx)	Additional water savings at 2030/31 (Ml/d)	
Existing proposals	88% meter penetration by 2035	85505	1.53	Not applicable under this scenario						1.53
Best case	Universal metering by 2020	105562	2.46	12% additional water saving	105562	4.29	35% uptake, 19 l/h/d additional water saving	36947	1.66	8.41
Best estimate	90% metering by 2020, and universal by 2030	105562	2.45	8.5% additional water saving	105562	3.02	25% uptake, 12 l/h/d water saving	26390	0.74	6.21
Worst case	88% meter penetration by 2035	85505	1.53	5% additional water saving	85505	1.45	13% uptake, 8 l/h/d water saving	13723	0.27	3.25

Table 3-10 Potential water savings from measures in the existing housing stock

Development site	Additional water from site (Ml/d)	Additional water from site (as % of total 'new water demand' from major growth sites)	Potential water saving from measures under 'best case' scenario (Ml/d)			
			Metering	Variable Tariffs	Retrofit WEMs	Total water saving
Cambourne	0.54	6%	0.15	0.27	0.10	0.53
Northstowe	1.72	20%	0.49	0.86	0.33	1.68
Southern Fringe	0.87	10%	0.25	0.43	0.17	0.85
Cambridge East	2.07	24%	0.59	1.03	0.40	2.02
Orchard Park	0.25	3%	0.07	0.12	0.05	0.24
University site	0.52	6%	0.15	0.26	0.10	0.51
NIAB 1	0.39	5%	0.11	0.19	0.08	0.38
NIAB 2	0.22	3%	0.06	0.11	0.04	0.22
Student dwellings	0.16	2%	0.05	0.08	0.03	0.16
Windfall development	1.86	22%	0.53	0.93	0.36	1.82
Total	**8.6**	**100%**	**2.46**	**4.29**	**1.66**	**8.41**
% of total water saving	**-**	**-**	**29%**	**51%**[59]	**20%**	**-**

Table 3-11 Breakdown of measures to achieve 'best case' scenario (proportioned by additional water demand from major growth site)

[59] Based on assumption that variable tariffs are installed on all homes with meters; therefore resulting in a significant impact on water consumption

3.4.16 *Implementing water neutrality*

3.4.17 To achieve water neutrality would require implementation of all the measures described and a public awareness/education campaign to encourage changes in user behaviour. No existing model exists to deliver and fund water neutrality and therefore it will require new and innovative approaches, which will need to be taken forward collaboratively. Water companies will not be able to entirely fund measures to achieve water neutrality for a number of reasons[60]:

- water neutrality is untested and represents an additional risk to water companies compared to providing additional water supply;
- the benefits of water neutrality do not fall entirely on water companies and if they paid for all water neutrality measures they would not be able to recoup their costs;
- current regulations require water companies to provide the least-cost solutions and water neutrality may not be seen to be the least-cost solution, and;
- under current regulations large-scale retrofitting would be classified as operational expenditure and therefore would not be recouped in water bills.

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[60] See Environment Agency briefing note at http://www.environment-agency.gov.uk/static/documents/Research/Water_Neutrality_measures_and_funding.pdf for more information

Strategy to work towards water neutrality	How could this be implemented	LPAs role in implementing	Regulatory/Legislative changes needed which are outside control of LPAs
Enhanced metering programme to ensure universal metering by 2030	• Cambridge Water would need to present a business case to Ofwat in the next Periodic Review (in 2014) to undertake an enhanced metering programme and would need to demonstrate the costs and benefits	• Metering can only be carried out by Cambridge Water, so LPAs role is limited	CWC metering strategy in their WRMP10 has been signed off by the Environment Agency, Defra and the Secretary of State – therefore CWC would need to present revised evidence to Ofwat to justify additional investment which they fund
Retrofitting programme across Cambridge City and South Cambridgeshire, accompanied by a public awareness campaign in local communities to increase uptake rates	• Cambridge Water would need to present a business case to Ofwat in the next Periodic Review (in 2014) to undertake an enhanced metering programme and would need to demonstrate the costs and benefits OR • LPAs should consider raising funds through developer contributions to the Community Infrastructure Levy (CIL) or through S106 agreements to enable measures to be put in place in the existing housing stock to 'offset' the additional water demand – whilst the S106 approach is unlikely to meet success given the exiting demands on developer contributions, models for offsetting carbon are being explored in the UK[61].	• Co-ordinate collaborative working group with Cambridge Water and developers • Fund measures in existing housing stock through CIL (or S106) – LPAs would need to develop a CIL charging schedule that included a requirement for retrofitting programmes and prioritise these, and implement CIL, to obtain funds via this route. • Many councils offer council tax rebates to residents who install energy efficient measures (rebates jointly funded by council and energy company) – a similar scheme could be adopted for water efficient products; this would require buy-in from Cambridge Water	

[61] An example of carbon offsetting in new development is in Milton Keynes, see http://www.homesandcommunities.co.uk/milton-keynes-contributes-low-carbon-living for more background information

Strategy to work towards water neutrality	How could this be implemented	LPAs role in implementing	Regulatory/Legislative changes needed which are outside control of LPAs
Implementation of variable block tariffs in all houses which are metered by 2030/31	• Cambridge Water would need to present proposals to Ofwat in the next Periodic Review (in 2014) to move towards a variable tariff system	Implementation of variable block tariffs is outside the control of LPAs and would need Cambridge Water to identify the need for variable tariffs and to present the business case to Ofwat. New coalition Government is seeking views in advance of their Water White Paper in 2011 – stakeholder should use opportunity to contribute to the current (October 2010) preliminary consultation and full White Paper consultation (June 2011) to influence the direction of the water industry	
Audit of public buildings	• Undertaking a structured audit of all public buildings and implement measures where recommended to reduce water consumption.	• Does not require policy to implement, but funds would need to be set aside to pay for audits and any associated measures	N/A
Engage with local communities to encourage sustainable use of water	• Within local communities seek to identify local champions who will help to raise public awareness of using water wisely (CIRIA research on retrofitting surface water management measures has identified that a local champion is a key success factor for helping to drive forward retrofitting. A similar approach could be useful for water efficiency) OR • Appoint a co-ordinator to work with Cambridge Water, housing authorities and local communities to encourage sustainable use of water. Waterwise are currently in the process of appointing a number of such facilitators and may be able to provide assistance OR • Work within local schools to educate people about the value of water	• LPAs should underpin any retrofit measures with a widespread marketing and engagement campaign to persuade householders to use less water through behavioural change • Establish working group to co-ordinate measures in the existing housing stock	N/A

Table 3-12 Implementation of water efficient measures in the existing housing stock

3.5 Summary of evidence base

3.5.1 Additional development in the Major Sites in and Around Cambridge places an increased burden on finite water resources. Cambridge and its surroundings is in an area of serious water stress, and future uncertain climate change means that every effort should be made to minimise additional water demand from new development. In the context of housing growth there are two critical components to minimising the need for additional water resources:

- ensuring new homes are built to be as water efficient as possible, and;
- implementing measures in the existing housing stock.

3.5.2 By incorporating water efficiency into new developments we can ensure that the need for additional water resources are minimised which will reduce the burden on finite water in the environment. The Ph2 WCS has assessed the requirements to build new homes at CSH level 3/4 or 5/6, and it has assumed that after 2016 all new homes will be built to CSH level 5/6. Based on this approach, approximately 8.6 Ml/d of additional water will be required to serve the major growth sites in and around Cambridge.

3.5.3 To meet CSH level 5/6 will require progressive implementation of greywater recycling (GWR) and/or rainwater harvesting (RWH) systems at either a household or community scale, in addition to implementation of water efficient appliances and changes in consumers' behaviours/attitudes towards water consumption. GWR and RWH are not currently widely implemented in the UK. Challenges remain with widespread implementation of GWR and RWH, not least because of the issues surrounding adoption of GWR or RWH systems; no consistent model or legislation is currently in place to support consistent adoption and water companies are currently not permitted to charge for non-potable water.

3.5.4 In non-domestic buildings there is a high potential to utilise RWH due to large roof areas, and the available evidence indicates payback periods could be in the order of three years, as opposed to decades for individual household systems.

3.5.5 The evidence for the Phase 2 WCS indicates that to install GWR/RWH at a household scale would be in the region of £2500-£4000 per house, and savings on water bills has been estimated to be £165 per house per year, resulting in a payback period of 12-30 years for GWR/RWH systems at the household scale. There is less evidence on the capital and operational costs of communal GWR/RWH systems, but the available evidence does indicate potential significant economies of scale of communal systems (approximately 50%). There are several other advantages which make community systems more attractive than household systems:

- single ownership of infrastructure, which presents less maintenance and health & safety risks;
- for RWH systems there will be greater resilience to variable rainfall, they can sustain water supply through dry spells, and they can capture a greater proportion of rainfall in wet periods;
- greater opportunity for combined greywater/rainwater systems, and;
- greater likelihood of public acceptability.

3.5.6 In the existing housing stock measures can be implemented to reduce demand and to 'offset' the additional demand from new developments. The Phase 2 WCS has assessed metering, variable tariffs and retrofitting water efficient measures in the existing housing stock to offset additional water demand.

3.5.7 Based on the analysis for the Phase 2 WCS it may be possible to achieve water neutrality under the best case scenario, which assumes universal metering by 2020 alongside a further 12% reduction in demand through variable tariffs, and a further reduction in demand through retrofitting of water efficient measures (35% uptake, water saving of 19 l/h/d). However, at different scales and with a more conservative estimate of the effectiveness of measures it would still be possible to significantly offset the additional demand for water required by new development through metering, implementation of variable tariffs, and retrofitting of water efficient measures.

3.5.8 There are existing barriers which hinder the implementation of enhanced programmes of measures in the existing housing stock. An enhanced metering programme or implementation of variable tariffs remains outside the control of local planning authorities. The use of planning obligations (through the Section 106 process) as a funding mechanism is attractive as it is an existing funding mechanism, but unlikely to be successful given both the revisions to the tests determining appropriate planning obligations, and the challenge of developments paying for all S106 requirements. It is therefore important that relevant partners should carry out additional work to investigate mechanisms by which retrofitting of the existing housing stock to achieve water neutrality could be facilitated. Potential measures that should be explored include an equivalent to CERT obligations on energy suppliers (as suggested by the Institute of Public Policy Research back in 2006), and an offsetting mechanism that might work along the lines of emerging Carbon Offset Mechanisms. In October 2009 the Environment Agency produced a report "Delivering water neutrality: measures and funding strategies"[62], which provides an overview of some options.

3.5.9 The PPS on Eco-towns contains a section on water neutrality and has a policy (ET 17.5) that Eco-towns in areas of serious water stress should aspire to water neutrality. This provides a stronger opportunity to explore developer contributions as a mechanism for funding a retrofitting programme in the surrounding area.

3.5.10 However, there are opportunities for local planning authorities to undertake a campaign to retrofit water efficient appliances in the existing housing stock through developer contributions; the Phase 2 WCS indicates that under a best case scenario this could 'offset' approximately 20% of the additional demand for water due to new development.

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[62] http://www.environment-agency.gov.uk/static/documents/Research/Water_Neutrality_measures_and_funding.pdf

Case study: Water efficiency and behavioural change

Achieving water efficiency in both new and existing domestic and non-domestic developments is heavily dependant on changes to consumers' behaviour and attitudes towards water usage. Behaviour and attitude towards water efficiency is complex and inherently uncertain, and it is difficult to quantify the effect of marketing/awareness campaigns on consumers' behaviour. The Preston Water Efficiency initiative undertook a promotional and awareness campaign to encourage people to reduce their water consumption. It should be noted that this was a retrofit initiative, but the principles can be applied to both new build and retrofit. Some of the methods used to promote and raise awareness included:

- a water conservation officer, who visited people in their homes to explain the initiative and the benefits of saving water;
- literature: leaflets were distributed to households and local venues and an editorial was provided in the local community newsletters;
- givewaways were provided to residents for a range of products including tea towels and digital shower timers;
- neighbourhood shop: the local shop promoted the initiative, and;
- educational work was carried out by the local water company with pupils at a local school, to teach them about using water wisely

Further information about this initiative is available at: http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

3.6 Recommendations

3.6.1 *Actions within the control of Steering group members*

3.6.2 There are three specific recommendations and implementation themes from the Phase 2 WCS that are within the control of the steering group, which are considered to be necessary to work towards achieving the vision for water resources. These are summarised in the box below and expanded upon in subsequent paragraphs illustrating actions and responsibilities

REC WR1: Planning policy recommendations: water resources

- New domestic dwellings should achieve 80 l/h/d (potable consumption) through implementation of water efficient measures and rainwater/greywater systems, unless meeting 80 l/h/d is not viable due to the small size of development. Where 80 l/h/d is not considered to be viable the development should justify why it is unable to deliver this level of water efficiency and provide evidence of the level that can be delivered as well as minimise water consumption through use of water efficient appliances.
- New non-domestic buildings should meet the BREEAM 'excellent' standard with respect to water efficiency, through installation of water efficient measures and rainwater/greywater systems.
- As a minimum, the additional demand for water due to new development should be *partially* offset, through the implementation of measures in the existing housing stock, including, but not limited to, retrofit of water efficient measures and marketing/awareness campaigns with local residents and businesses.

REC WR2: Establishing initiatives to work with local communities and businesses

In partnership with Cambridge Water, Environment Agency and Waterwise East, Cambridgeshire County Council, Cambridge City Council and South Cambridgeshire District Council should promote a number of initiatives to promote the value of water in local communities and businesses.

REC WR3: Undertake water audits & retrofit water efficient measures

- In partnership with Cambridge Water, Environment Agency and Waterwise East, Cambridge City Council and South Cambridgeshire District Council should promote water audits in domestic and non-domestic buildings, with the objective of retrofitting water efficient measures into existing buildings.
- Relevant partners should carry out an investigation of the mechanisms by which retrofitting of the existing housing stock to achieve water neutrality could be facilitated.

3.6.3 **REC WR1: Implement planning policies**

3.6.4 In line with the PPS1 supplement on climate change the requirement to meet CSH 5/6 in domestic dwellings and high levels of water efficiency in non-domestic buildings should be established in Development Plan Documents (DPDs).

3.6.5 In addition to taking forward the recommendations to inform policy making, local planning authorities and other technical stakeholders (including the Environment Agency) should ensure the following considerations have been demonstrated in planning applications and at the appropriate point in the planning application process:

- Has the planning application included proposals for low flush toilets, low volume baths, aerated spray taps, and water efficient dishwashers/washing machines?
- Has the planning application demonstrated the proposed water efficiency measures and the water savings that could be achieved? Planning applications should provide calculation of the predicted water consumption with the water efficient measures in place using industry standard water calculator tools.[63]

3.6.6 With regards to the use of rainwater/greywater systems in both domestic and non-domestic buildings has the planning application:

- outlined the suitability of RWH or GWR, as well as the potential water savings which can be achieved?
- provided indicative plans of what infrastructure will be put in place to support RWH/GWR (e.g. size of tanks, location of infrastructure, clear labelling of pipes)?
- outlined who would be responsible for adopting and maintaining the RWH/GWR?
- provided an indicative maintenance schedule to ensure adequate maintenance of RWH/GWR will be carried out, in accordance with the British Standards?
- included water quality treatment as an integral part of the design (if using GWR water should not be kept for longer than 24 hours and the application should identify the mechanism for ensuring this is achieved)?

3.6.7 **REC WR2: Establish initiatives to engage with local communities**

3.6.8 Specific initiatives which could be promoted in Cambridge and South Cambridgeshire by the planning authorities include:

- implementing a schools initiative to raise awareness of water usage amongst young people;
- working with and engaging neighbourhood trusts, community groups and local interest groups to promote the efficient use of water – in Shropshire the Council have run a training course for individuals, organisations and community groups to help them promote water efficiency in their local communities[64];
- providing residents/businesses with information such as leaflets about the financial and environmental benefits of saving water;
- ensuring that developers provide 'welcome packs' to new residents with information about saving water and how to use and maintain the water efficient appliances in new homes;

[63] For domestic buildings this is the CLG 'water efficiency calculator for new dwellings' (http://www.planningportal.gov.uk/uploads/br/water_efficiency_calculator.pdf) and for non-domestic buildings the BREEAM water calculator tool can be used (http://www.breeam.org/pdf/OFF_DP_Pre-assessmentEstimator2006Rev00.pdf)

[64] http://shropshirevcs.org.uk/site/blog/events/water-efficiency-workshop/

- installing water meters in highly visible locations in buildings to enable consumers' to easily monitor their water usage – this was undertaken as part of the BEDZED development [65];
- Cambridge Water have a number of initiatives committed as part of their Water Resource Management Plan, including environmental road shows, customer literature and leaflets, and there is a discretionary fund to support local initiatives for water conservation projects[66], and;
- working with retailers and manufacturers to provide discounts on more water efficient products – this was undertaken as part of the Preston Water Initiative[67].

3.6.9 These initiatives should be promoted by the local authorities (South Cambridgeshire, Cambridge City and Cambridgeshire County) in partnership with other local stakeholders including Cambridge Water, Environment Agency and Waterwise East to ensure initiatives are 'joined up' amongst different stakeholder groups.

3.6.10 **REC WR3: Undertake audits in existing buildings and retrofit water efficient measures**

3.6.11 In existing buildings, water audits should be undertaken to establish water usage within domestic and non-domestic buildings, and to make recommendations for improving water efficiency measures. The water audits should be followed up by retrofitting water efficient measures in these buildings. This recommendation must work in parallel with the initiative to promote more sustainable use of water in local communities and businesses. Cambridge City Council and South Cambridgeshire District Council should be responsible for leading and promoting the water audits across domestic and non-domestic buildings.

3.6.12 Local authority owned housing could be targeted first to most easily showcase the programme and promote the benefits. Good practice is for the local authorities to collaborate with the water company and Waterwise to promote and implement a retrofit programme. For example, Cambridge City Council is taking opportunities within its building stock to retrofit water efficiency measures, including grey water recycling at Simon House and Brandon Court sheltered housing units and the Mill Road depot 'wash down' facilities. Three of the City Council's public toilet facilities have rainwater harvesting systems, as well as the Brown Fields Community Centre.

3.6.13 In public buildings the asset owner should be responsible for funding the water audit and implementing actions. Several public organisations involved in the Water Cycle Study have premises within the study area and could show their commitment to the water resources vision by improving their own water efficiency: Cambridge City Council, South Cambridgeshire District Council, Cambridgeshire County Council, Natural England and the Environment Agency.

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[65] http://www.bioregional.com/files/publications/BedZEDBestPracticeReport_Mar02.pdf

[66] http://www.cambridge-water.co.uk/customers/water-resources-management-plan

[67] http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

3.6.14 In private non-domestic buildings (offices, retail, and industrial buildings) water audits and any implementation could be funded by the asset owner; this could be justified by significant financial savings which can be achieved through implementation of water efficient measures. As an example, for an office in Manchester which employed 550 employees, implementation of rainwater harvesting for WCs saved approximately £4000 per annum[68].

3.6.15 In domestic dwellings[69] water audits can be offered to householders. This should be jointly promoted by the local planning authorities, Waterwise East and Cambridge Water.

3.6.16 Mechanisms for funding water efficiency auditing and retrofitting to contribute towards a water neutral position should be explored. Mechanisms might include the Community Infrastructure Levy (CIL), but need to look beyond developer contributions, possibly to the water companies.

3.6.17 *Actions outside steering group control*

3.6.18 It is recognised that there are current technological, economic and regulatory barriers outside of the control of the steering group, which will affect the ability to meet the vision for water resources. These barriers are scoped out in Table 3-13, alongside actions which can be taken by the steering group to help influence change.

Description of existing barrier	Potential response	Actions steering group can take to influence change
Householders are not currently incentivised to use less water	Introduction of variable tariffs Phasing out of less water efficient appliances	Steering group to contribute to Government's Water White Paper[70] consultation to influence the introduction of water efficiency incentives
There is limited expertise and experience in the UK of rainwater harvesting and greywater recycling. This results in low confidence to provide large scale implementation.	Ensure that plumbers are adequately trained in installing rainwater/greywater systems Implement and promote large scale UK pilot studies.	Work with the Environment Agency and Waterwise to promote capacity building in RWH and GWR.
There is no established mechanism for the adoption and maintenance of	Allow water companies to charge for	Steering group to contribute to Government's Water White Paper

[68] http://publications.environment-agency.gov.uk/pdf/GEHO0108BNPN-E-E.pdf

[69] In Swindon, a partnership with WWF-UK, Waterwise and Thames Water is seeking to reduce demand, by offering householders free water saving products for taps, showers and toilets. Householders can install the water saving products themselves or get a trained fitter to visit and carry out a water audit for free. This is the first town-wide water efficiency initiative in England. More information is available at http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/10351.htm

[70] http://ww2.defra.gov.uk/news/2010/09/09/future-water-policy/

Description of existing barrier	Potential response	Actions steering group can take to influence change
communal rainwater/greywater systems – water companies cannot currently charge for non-potable water from within their regulated business.	non-potable water	to change current rules
Building Regulations are not currently aligned with other policy (e.g. Code for Sustainable Homes)	Ensure that Building Regulations are aligned with other national policy drivers	Steering group to contribute to Government's White Paper

Table 3-13 Existing barriers to implementation of vision for water resources

3.6.19 Development where vision for water resources may not be achievable

3.6.20 It is recognised that in some developments it may not be possible to achieve CSH 5/6. This is likely to be particularly prevalent on windfall sites where CSH 5/6 may not be achievable on grounds of viability because the additional costs of such homes cannot be supported by the market without economies of scale. In such cases planning applications should demonstrate proposals to install water efficient appliances and water butts (to reduce garden uses) as a matter of course.

3.6.21 It may not be possible for developer contributions to fund retrofitting of water efficient appliances to partially offset the additional water demand from new development. In such cases developers should, as a minimum, outline their proposals to undertake a marketing/awareness campaign in the local communities to raise awareness of using water wisely. It is important that the recommendation to explore alternative funding mechanisms for retrofitting programmes is followed.

4 Sustainable surface water management

4.1 Vision for sustainable surface water management

4.1.1 Well planned and well designed surface water management infrastructure can contribute to creation of sustainable communities by providing flood risk management functions, as well as being integrated with amenity, biodiversity and linked to a network of green (and blue) open spaces. There is an increasing recognition of the need to move away from conventional approaches to surface water drainage, and ensure surface water drainage is integrated within the built environment. The vision is therefore to achieve **100% above ground drainage for all future developments, where feasible**. In addition, above ground drainage **should include environmental enhancement and should provide amenity, social and recreational value.**

4.1.2 With respect to flood risk management in new developments, sustainable surface water management is concerned with three key principles: runoff **onto** the development site from outside the site, runoff **within** the development site, and runoff **from** the development site to neighbouring areas. Table 4-1 outlines how the Phase 2 WCS provides additional information with respect to the three key areas of flood risk management in new developments, and the interaction with other key documents.

Surface water planning of new developments	Role of the Phase 2 WCS and other documents
A strategy to manage surface water runoff from the development sites to control flood risk to drainage of river systems downstream	The Phase 2 WCS provides indicative storage volumes for each of the strategic development sites to manage surface water to greenfield equivalent. The Phase 2 WCS also identifies, at a strategic level, the potential for infiltration of surface water runoff. These will need to be confirmed in **site specific flood risk assessments**[71]
A strategy to manage runoff within the development sites	This is principally the concern of the site specific flood risk assessment, although the Phase 2 WCS does set the vision (100% above ground drainage) and provide some indication of the types of above ground surface water drainage measures which are applicable depending on site conditions
A strategy to manage flood risk in the development site from surface water runoff entering from outside the development site	Not directly considered within Phase 2 WCS; there are other strategies and mapping which provide this information, including: • Strategic Flood Risk Assessments • Phase 1 WCS • Surface Water Management Plan for Cambridge and

[71] More information on site specific flood risk assessments is contained within Planning Policy Statement 25, http://www.communities.gov.uk/documents/planningandbuilding/pdf/planningpolicystatement25.pdf

Surface water planning of new developments	Role of the Phase 2 WCS and other documents
	Milton • Preliminary Flood Risk Assessment for Cambridgeshire

Table 4-1 Surface water management in new developments

4.1.3 A number of strategic development sites have significantly progressed through the planning system; the Phase 2 WCS has limited influence over these sites in provision of water services infrastructure. Some of these sites have reserved matters coming through on a plot by plot basis which will offer an opportunity to employ SUDS as and where feasible. The sites also have conditions which require a detailed drainage strategy to be agreed prior to development commencing on the sites (in the case of Trumpington Meadows this is conditions no.16). The local planning authorities will need to ensure that opportunities to maximise above ground drainage are demonstrated in these detailed drainage strategies.

4.1.4 For the strategic development sites which have significantly progressed through the planning system the Phase 2 WCS has undertaken an audit of the surface water drainage infrastructure proposed/built, to identify how existing development is progressing towards the vision for surface water management. Table 4-2 provides a comparison of the surface water management measures achieved at each development site. Full details of the proposed/built surface water drainage infrastructure are provided in Appendix G. For 'short term' sites that are well advanced through the planning process (including Trumpington Meadows and Clay Farm), as individual plots come forward for development opportunities will be sought to provide both source control and site control before the water discharges to the strategic system.

4.1.5 The evidence indicates that progress is being made towards achieving the vision for surface water management. Surface water runoff has been controlled to greenfield (or lower) across many of the sites through a series of balancing ponds; these balancing ponds have frequently been designed with consideration to biodiversity and ecology (e.g. in Cambourne one of the ponds was designed for kingfisher habitats, and another fenced off to encourage newt populations). Furthermore, there is an increasing move towards promotion of above ground drainage to manage surface water at source and to convey it to balancing ponds, and the proposals at the NIAB 1 development site allow for 100% above ground drainage through a network of 'green fingers' swales (roof runoff connected via pipes and road runoff via gullies) which drain by gravity to a large balancing pond to the north-east of the development site.

4.1.6 For the sites which have significantly progressed through the planning system the biggest area of uncertainty has been in relation to the adoption and long-term maintenance of SUDS. The evidence from the audit of these sites indicates there has been no consistent model for adoption and maintenance of SUDS. Together, the Cambridge City Council SUDS design guide[72], Flood and Water Management Act (giving new responsibilities to the County Council as Lead Local

[72] http://www.cambridge.gov.uk/ccm/content/planning-and-building-control/urban-design/sustainable-drainage-systems.en

Flood Authority), and the forthcoming National Sustainable Drainage standards[73] will provide greater clarity on the nature and ownership of surface water drainage for future developments.

Development site	Summary of strategic surface water management measures
Trumpington Meadows	Roof runoff drains via conventional piped network, but primary road will be drained by swale. Balancing ponds in country park will discharge at less than greenfield equivalent
Bell School	Runoff will drain via conventional piped network, which connect to 2 balancing ponds (designed to maintain peak runoff from the site)
Clay Farm	Runoff will be drained via conventional piped network to a series of balancing ponds (runoff will be controlled to less than greenfield equivalent). The site will have an element of swales and permeable surfaces. Balancing ponds have been designed to encourage bird life and biodiversity
Glebe Farm	Hydraulically linked to Clay Farm, and runoff drains to Clay Farm through piped network alongside Addenbrooke's access road. Some attenuation basins on-site will reduce peak flows to Clay Farm, and swales, rainwater harvesting and permeable paving are also proposed
Addenbrooke's Biomedical Campus	Combination of above ground drainage and conventional piped drainage. Main boulevard which runs through the site will be drained by two swales which will convey the road runoff to two balancing ponds (which will manage runoff rates to greenfield equivalent). There are also proposals for attenuation storage beneath car parks.
Cambourne	Piped surface water network which drains to series of balancing ponds (discharging at greenfield equivalent). Some of the balancing ponds have been specifically designed to encourage biodiversity (e.g. kingfisher habitats) Lamb Drove SUDS site is an entirely above ground drainage network
Orchard Park	Below ground piped network; SUDS were not considered to be applicable due to the high water table. Flow is attenuated in a series of underground tanks.
NIAB 1	Above ground drainage achieved through network of 'green finger' swales draining to a balancing pond to the north-east of the site

Table 4-2 Comparison of 'short-term' sites for surface water management

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[73] http://ww2.defra.gov.uk/environment/flooding/legislation/

4.2 Justification

Development which utilises 100% above ground drainage provides several benefits compared to conventional drainage systems:

- reduced capital and operational costs;
- reduced carbon emissions;
- enhanced water quality treatment (see chapter 5 for more information);
- opportunities to integrate surface water management into amenity areas and enhance biodiversity through development;
- contribute to a 'network of protected sites, nature reserves, greenspaces and greenways' (as defined in Cambridgeshire Horizons Green Infrastructure Strategy), and;
- they are considered 'best practice' as advocated by the CIRIA SUDS Manual

4.2.1 Capital and operational costs

4.2.2 To compare the costs of conventional and more aspirational SUDS approaches, the Phase 2 WCS has assessed the costs of four SUDS scenarios. The SUDS scenarios represent a range of approaches, from conventional drainage approaches where surface water is stored in attenuation/infiltration basins but the majority of surface water drainage is a piped system, through to the vision where 100% surface water drainage is above ground. The purpose of this assessment is to provide the evidence for more aspirational SUDS approaches. Given the large number of assumptions made in the calculations these costs should not be used as an indication of true costs, but instead as a comparative measures.

4.2.3 In order to estimate economic costs, it was necessary to make a number of simplifying assumptions regarding the specific surface water drainage infrastructure and associated costs to be provided in each scenario. These assumptions are listed in Table 4-3. These assumptions were considered reasonable for the purposes of this assessment: to provide a high-level overview comparison of potential costs without a detailed site-by-site design for each scenario. Infrastructure that would be constant across all scenarios (for example, the use of household soakaways for all permeable sites) has not been included. It was assumed that all sites will drain by gravity and that no pumped solutions will be required. The costs for each infrastructure type are provided in Appendix F. It should be noted that although permeable surfaces can result in a reduction in regional attenuation storage required this has not been accounted for in the analysis, and would need to be confirmed by detailed assessment at the detailed design stage. In addition, the costs of permeable surfaces have not been accounted for in the cost breakdown, based on the assumption that the whole life cost of permeable surface is equivalent (or less) than conventional asphalt[74].

4.2.4 Table 4-4 sets out the four scenarios in more detail and the parameters considered for each scenario. The scenarios are applicable to all major growth sites where there is still potential to

[74] Interpave (2006), Whole life cost analysis for various pavement and drainage options

influence the eventual surface water management regime (i.e. University Site, NIAB2, Orchard Park, Cambridge East, Northstowe, and Cambourne 950), totalling 27,270 new dwellings.

Scenario	Simplified surface water infrastructure
Business As Usual	All sites are drained by a piped underground network that leads to attenuation / infiltration storage areas, which restrict rates and volumes of runoff to greenfield conditions.
On the pathway to deliver the Vision	A portion (25%) of the underground sewer network will be replaced by open channels (impermeable sites), or swales and infiltration trenches (permeable sites).
Significant progress towards the Vision	A larger portion (50%) of the underground sewer network will be replaced by open channels (impermeable sites), or swales and infiltration trenches (permeable sites). A portion of properties (5%) will have green roofs.
Vision	All of the underground drainage (100%) will be replaced by open channels (impermeable sites), or swales and infiltration trenches (permeable sites), excluding an allowance for connections, road crossings, outfall systems etc. A larger portion of properties (10%) will have green roofs.

Table 4-3 Simplified surface water infrastructure for each scenario

4.2.5 The costs have been calculated for the major growth sites where there is still potential to influence surface water drainage (excluding windfall development sites, which will need to be considered on a case by case basis depending on locality, space available etc).

Criteria	Business as Usual	On the Pathway	Significant progress	Vision
Total site area (ha)	707	707	707	707
Total no. dwellings	27270	27270	27270	27270
% of area that is impermeable	66%	66%	66%	66%
% of area that is permeable	34%	34%	34%	34%
% by which drainage network will be oversized (100% = no oversize)	100%	100%	100%	100%
Total storage volume (impermeable sites) m3	268222	268222	268222	268222
Total storage volume (permeable sites) m3	126820	126820	126820	126820
% of drainage pathway as sewers	100%	75%	50%	0%
% of drainage pathway as open	0%	17%	33%	66%

channels				
% of drainage pathway as swales	0%	6%	13%	25%
% of drainage pathway as infiltration trenches	0%	2%	4%	8%
% of dwellings with green roofs	0%	0%	5%	10%

Table 4-4 Parameters for SUDS scenarios

4.2.6 Based on the scenarios outlined, the capital and operational costs over 100 years have been calculated, and the results illustrated in Figure 4-1. The results indicate that application of the vision for surface water management (100% above ground drainage) could result in approximately 11% cost savings over and above business as usual.. It should be noted that limited consideration has been given at this high level analysis stage to the feasibility of achieving this on a site by site level (individual site topography, permeability etc). Further consideration of how site factors may affect the ability to meet the vision is provided in section 4.5.

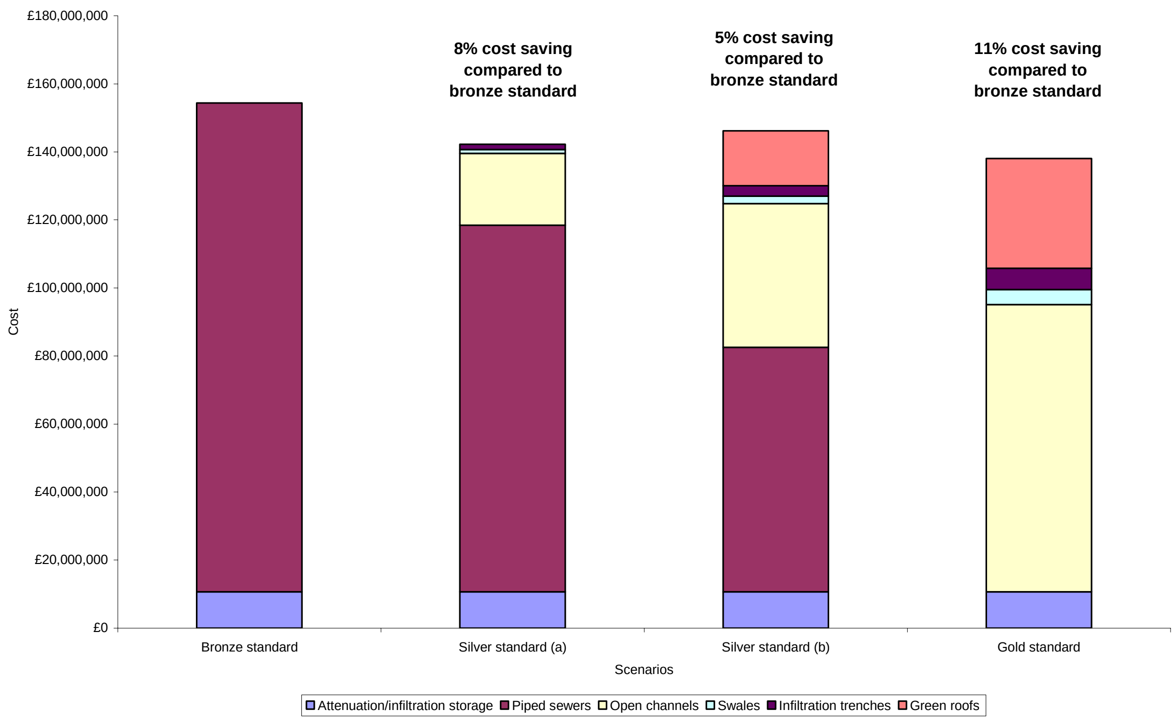

Figure 4-1 Costs of SUDS strategies

4.2.7 *Carbon emissions*

4.2.8 Based on the same SUDS scenarios outlined in Table 4-3, the total carbon emissions (embodied and operational over 100 years) has been calculated. The analysis (presented in Figure 4-2) demonstrates the potential carbon savings for the SUDS strategies compared to business as usual. The vision could result in a 15-20% saving in total carbon over 100 years. Appendix F has the calculations for this.

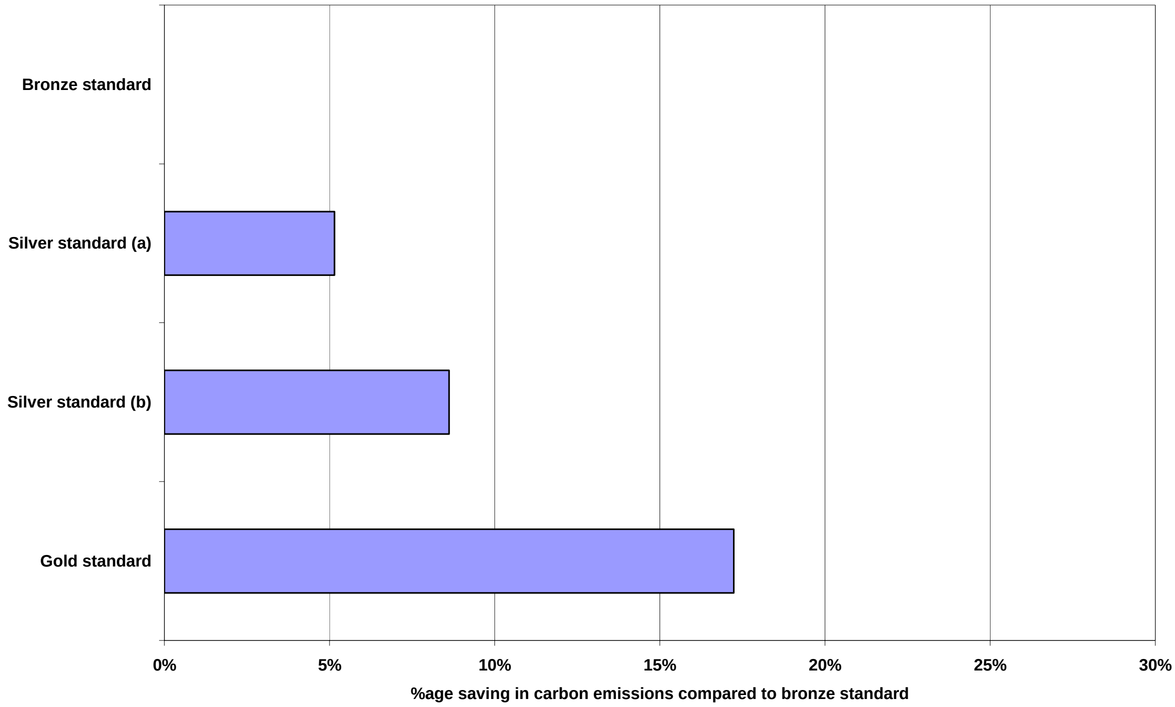

Figure 4-2 Percentage saving in carbon for different SUDS strategies

4.2.9 *Amenity, biodiversity and green infrastructure*

4.2.10 A qualitative analysis of the amenity, biodiversity and green infrastructure benefits of more aspirational above ground drainage is provided in Table 4-5. This table highlights both the positive and negative factors associated with the four surface water management scenarios. The analysis demonstrates the significant opportunities to creation of amenity and biodiversity associated with above ground drainage infrastructure, as well as opportunities to integrate water and recreational space.

Scenarios	Amenity		Biodiversity	
	Positive factors	Negative factors	Positive factors	Negative factors
Business as Usual	Modest amenity benefit associated with above ground ponds	Absence of deliberate habitat creation and dominance of underground pipe work limits amenity benefits; although amenity is never worsened	No detriment to bio-diversity	Limited enhancement to bio-diversity because of predominantly piped infrastructure Ponds or sub-surface storage provides no new habitat
On the pathway	Some benefit from 'dual use' for water and amenity	Limited opportunities for deliberate and planned integration of green and recreational space with water uses Prevalence of underground pipe work detracts from achieving full amenity linkages	New habitats created where possible in design of attenuation structures Limited 'above ground' drainage provides some bio-diversity enhancement Some 'dual use' green infrastructure though this is coincidental not deliberate	Underground drainage still dominates and delivers no bio-diversity benefits No deliberate 'dual use' green infrastructure
Significant progress	Adoption of Cambridge SUDS design standards over large proportion of new development raises integration of water and recreational space Significant opportunities for deliberate and planned integration of green and recreational space with water uses	Significant proportion of underground pipe work detracts from achieving full amenity linkages	New habitats created where possible and full integration with Green Infrastructure recognising 'dual use' potential Swales, ditches etc. provide plentiful bio-diversity opportunity	Underground drainage still prevalent and delivering no bio diversity benefits
Vision	As for significant progress, and: Considerable opportunities for innovative masterplanning to fully integrate space for water management with green and recreational space (i.e. developers will need to do this if water management features are to be accommodated without increasing housing densities)	Risk of above ground drainage features becoming overly deep (depending on topography of sites) and requiring edge protection, which could detract from amenity value		

Table 4-5 Analysis of amenity, biodiversity and green infrastructure factors for surface water management scenarios

4.3 Practical considerations

4.3.1 *Geological environment*

Overview of geological environment

4.3.2 The underlying geology of the study area will influence the nature of SUDS systems. The bedrock and superficial geology, the location of groundwater source protection zones (SPZ's), and the location of designated aquifers have been considered. It is assumed that areas with predominately permeable bedrock and superficial geology that are designated as aquifers are potentially suitable for design of an infiltration system. Infiltration systems are generally preferred in reducing and attenuating run-off in areas where there are suitable ground and groundwater conditions. Whilst this gives an indication of the SUDS design that may be suitable, site specific investigations are needed to identify the best SUDS design.

4.3.3 A geological map is shown in Figure 4-3. The majority of the south, south east and parts of the east of the study area are underlain by permeable Chalk bedrock; therefore infiltration of surface water runoff should be possible. The Chalk is classified by the Environment Agency as a Principal Aquifer and as such, supports a number of groundwater abstractions in the area.

4.3.4 A band of Upper Greensand and Gault bedrock runs across the area from south-west to north-east, with small pockets of chalk geology. The Gault (clay) is generally of low permeability whereas the Upper Greensand is an important Secondary Aquifer. This means that infiltration drainage may be possible in these areas, dependent on the permeability of the ground. The northern part of South Cambridgeshire District Council's political area (including Northstowe) is underlain by ampthill clay, kimmeridge clay and corralian, which is considered to be impermeable. Therefore infiltration techniques will be less applicable in these locations.

4.3.5 The superficial geology and soils underlying a site will also affect whether infiltration approaches are applicable. The superficial geology of the study area comprises Alluvium, Till and River Terrace Deposits. Till is generally of low permeability, whereas Alluvium can be variable and River Terrace Deposits are often highly permeable and classified as a Secondary Aquifer. The permeability characteristics of soils are generally influenced by those of the underlying geology. To consider the implications of soils and geology in combination, the Environment Agency's Groundwater Vulnerability mapping should be consulted.

4.3.6 Infiltration drainage at any location may pose a risk to groundwater quality; therefore a hydro-geological risk assessment should be undertaken. Where a development site lies within a SPZ the following Environment Agency policies should be taken into consideration:

- there will be a presumption away from infiltration of surface water runoff (other than 'clean' roof drainage) in SPZ1, in order to protect the water quality of the borehole;
- infiltration drainage may be permitted in SPZ2 and SPZ3 subject to a detailed groundwater risk assessment which demonstrates that the abstraction will not be adversely affected by the proposed drainage system.

4.3.7 In addition to water quality issues, the potential for groundwater flooding should be considered at any site where infiltration drainage is proposed. Low-lying sites situated on an aquifer (particularly Chalk) and in close proximity to a river are likely to be most at risk. There is also a risk that infiltration of surface water could result in localised groundwater flooding in other locations, particularly where permeable superficial deposits overlie impermeable bedrock.

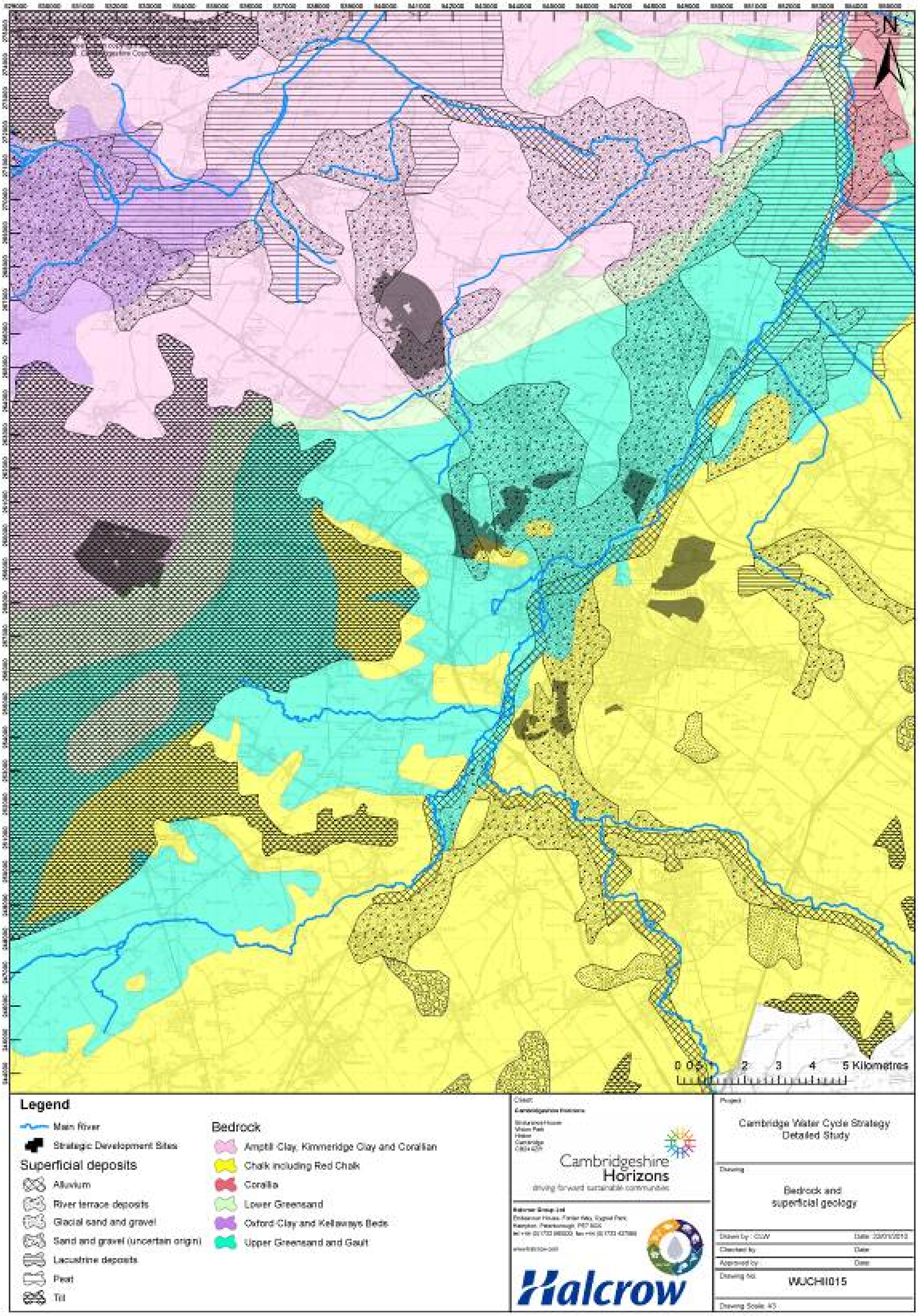

Figure 4-3 Bedrock and superficial geology

Site-by-site ground conditions

4.3.8 A summary of the ground conditions at each of the major growth sites is illustrated in Table 4-6. The summary is based on the SPRHOST[75] and the bedrock and superficial geology. This potential for infiltration of surface water will need to be confirmed by local infiltration tests during the preparation of the site specific Flood Risk Assessment.

Development site	SPRHOST	Permeability (based on SPRHOST)	Geology	Suitability for infiltration of surface water
University site	53.8	Low	Upper Greensand and Gault (clay), although the SE of the site is underlain by chalk	✓✓
NIAB 1	38.43	Low	Upper Greensand and Gault (clay) Superficial geology = River terrace deposits	✓
NIAB 2	38.43	Low		✓
Orchard Park	41.8	Low	Upper Greensand and Gault Superficial geology = River terrace deposits	✓
North of Newmarket Road	2.8	High	Chalk, including red chalk	✓✓✓
Cambridge Airport	5.7	High		
North of Cherry Hinton	6.6	High		
Southern Fringe	N/A – significantly progressed through the planning system			
Northstowe	53.1	Low	Ampthill Clay, Kimmeridge Clay & Corralian Superficial geology = River terrace deposits to the south of the site	✓
Cambourne 950	47.2	Low	Ampthill Clay, Kimmeridge Clay & Corralian Superficial geology = till	✓

Table 4-6 Ground conditions at the major growth sites

NB: ✓ = low infiltration potential, ✓✓✓ = high infiltration potential

[75] SPRHOST is the standard percentage runoff associated with each HOST soil class. The HOST (Hydrology of Soil Types) soil class is a delineation of UK soil types according to their hydrological properties. A low SPRHOST indicates the soil is highly permeable, whereas a high SPRHOST indicates the soil is less permeable

4.3.9 *SUDS approaches*

Storage volumes to maintain greenfield runoff

4.3.10 To manage surface water to greenfield rate and volume will require the storage of surface water runoff within the development site. Estimates for the storage volumes required to mitigate the impacts of development on runoff were made in the Phase 1 Water Cycle Strategy following the methodology of the Defra/EA report 'Preliminary rainfall runoff management for developments' (W5-074/A/TR/1 Revision D). Climate change was included in all storage estimates following the methodology recommended in the report. The following volumes were calculated:

- Attenuation storage. This must be provided to limit the runoff from the site to greenfield rates.
- Long term / infiltration storage. This must be provided to address the additional volume of runoff from the development, either through infiltration to the ground or by attenuation and discharge at very low rates of flow to the receiving watercourse.

4.3.11 Updates to these storage volumes were required to reflect changes in site boundaries, housing densities and available information on open (undeveloped) space. To estimate the revised area to be drained, the following methodology was followed:

- Site area was extracted from GIS layers showing their boundaries.
- The percentage of the site that could be expected to be left in greenfield drainage conditions as open space was estimated by assuming an average of 3.25 ha of open space per 1000 people (based on the average of 3.7 ha per 1000 people taken from the Cambridge City Council Open Space & Recreation Standards, applicable in the urban extensions and is not achievable in large parts of the City, and 2.8 ha per 1000 people taken from the South Cambridgeshire Open Space Standards). An average occupancy of 2.2 people per dwelling was assumed (based on the South Cambridgeshire Open Space in New Developments SPD).

4.3.12 Reality checks of the implied garden and house size for the remaining developed areas indicated that the open space area estimates are most likely under-estimated. The resulting storage volume estimates are therefore likely to be overestimates; nevertheless they provide an improvement to the original Phase 1 estimates which did not make any allowance for green space within the sites.

4.3.13 Storage volumes were calculated following the Defra methodology, assuming that 75% of the development sites (excluding open space) will be impermeable. The recommended allowance for climate change was included. It is emphasised that these storage volumes are indicative only and the estimates are not suitable for use by developers in the detailed design of drainage for individual sites. Developers will be required to prepare their own site-specific detailed calculations. In addition the use of source control and conveyance measures to manage surface water may help to reduce the storage requirements; this would need to be evaluated by developers during master planning.

4.3.14 The information on site storage areas is shown in Table 4-7.

Site	No. dwellings to 2031	% dwellings within WCS influence	Total site area from GIS outlines (ha)	Site area that may be influenced by WCS (ha)	Estimated open space (ha)	Site area for development (ha)
University site	3000 + 2000 students	100%	165	165	28	73[76]
NIAB 1	1780	0%	Not applicable			
NIAB 2	1100	100%	28	28	8	20
Orchard Park	1120	20%	32	6	2	5
North of Newmarket Road	12000	100%	78	78	26	52
Cambridge Airport			100	100	34	66
North of Cherry Hinton			78	78	26	52
Bell School (inc. Addenbrooke's	4097	0%	Not applicable			
Clay Farm						
Glebe Farm						
Trumpington Meadows						
Northstowe	10000	100%	434	434	75	359
Cambourne	4342	22%[77]	100	88	7	81

Table 4-7 Estimate of site area for storage calculations

4.3.15 The estimated storage requirements to manage runoff to greenfield equivalent are presented in Table 4-8. In addition, the estimated land take required to store surface water runoff has been calculated (NB: the average depth of attenuation and infiltration ponds was assumed to be 0.6m, based on the maximum pond depth recommended in the Cambridge City Council SUDS design guide).

Site	Attenuation volume (100 year including climate change) (m^3)	Long term volume (100 year including climate change) (m^3)	Total storage volume (m^3)	% site area needed for storage
University site	24600	8600	33200	7.6%
NIAB 1	Not applicable			
NIAB 2	7600	3300	10900	9.1%
Orchard Park	1900	700	2600	8.7%

76 The NWAAP land budget indicated a developed area of 73 ha, which was used in preference for the University site

77 Equals 950 additional dwellings

Site	Attenuation volume (100 year including climate change) (m^3)	Long term volume (100 year including climate change) (m^3)	Total storage volume (m^3)	% site area needed for storage
North of Newmarket Road	24100	14700	38800	12.4%
Cambridge Airport	30500	18700	49200	
North of Cherry Hinton	24100	14700	38800	
Bell School (inc. Addenbrooke's	Not applicable			
Clay Farm				
Glebe Farm				
Trumpington Meadows				
Northstowe	136800	42400	179200	8.3%
Cambourne 950	30900	11500	42300	8.7%

Table 4-8 Storage volumes estimated for each growth site

Source control and conveyance of surface water

4.3.16 To provide a 100% above ground drainage network will require the use of above ground source control and conveyance measures, in addition to regional balancing ponds. The applicability of above ground measures to convey runoff or control runoff at source will be heavily dependant on how a development site is master planned as well as on-site conditions. To minimise additional land take required by such measures and to maximise their use will require integration at an early stage of the master planning process. Table 4-9 provides an over-arching assessment of different SUDS measures and considers their suitability under different conditions (e.g. densities, topography, and permeability). The table also provides some of the key benefits and design considerations of the SUDS measures. It should be noted that the County Council as SAB can delegate some responsibilities. Cambridge City Council will adopt SUDS in public open space, even after the formation of the SAB. In their Flood Risk Assessment, developers will need to consider the applicability of different SUDS measures and embed above ground drainage into the design of the development site.

SUDS measure	Roof drainage	Road drainage	Suitable in high density developments	Suitable for flat topography	Suitable for low permeable ground conditions	Costs	Adoption	Benefits	Design considerations
Green Roofs	✓		✓	N/A	✓	Capital - £35 per m^2 Operational - £200 per dwelling per year	Apartment – management company Commercial – private operators Public building – local councils	Attenuate up to 1 in 2 year rainfall event Storage capacity in green roof approximately 100 litre/m^2 Reduce urban heat island effect and provide insulation for buildings[78] Ecological benefits Improved aesthetic appearance of buildings No additional land take	Min. roof pitch 1 in 80 Max. roof pitch 1 in 3 Roof strength should allow for additional loads from green roof Should include multiple outlets to reduce risk of blockages Lightweight soil should be laid
Permeable surfaces		✓	✓	✓	✓	Capital - £30-£40 per m^2 Whole life costs of permeable surfaces similar (or lower) to conventional approaches[79] Operational – £0.5-£1 per m^3 of storage volume per year	Cambridgeshire County Council highways authority	Attenuate up to the 1 in 200 year rainfall event Can reduce regional storage requirements High pollutant removal through sand media (esp. in block paving) Water can be stored underneath for reuse at a local scale Stored water can be used as a direct source of heat[80] No additional land take	Suitable in for roads with speed limits of 30mph or less Where impermeable geology should line the system at bottom of the sub-base (include sub-surface drainage to drain the runoff) Can drain roof runoff direct to storage underneath permeable surfaces
Soakaways	✓		✓			Capital - >£100 per m^3 stored volume Operational – 0.1 per m^2 of treated area	Householders	Provides groundwater recharge Reduces volume and peak flow	Not suitable within 5m of building or road, draining polluted runoff, or in poorly draining soils
Trenches	✓	✓				Capital - £55-65 per m^3 stored volume Operational - £0.2-£1 per m^2 filter surface area per year		Reduce runoff volume through infiltration High removal of pollutants Can be incorporated into site and fit well adjacent to roads	Excavated trench 1-2m deep filled with stone aggregate Need effective pre-treatment to remove sediment and fine silts Infiltration should not be used where risk of groundwater pollution
Open channels	✓	✓	○	✓	✓	Capital - £300 per m Operational - £1 per m per year	Cambridgeshire County Council as the SUDS Approval Body (SAB) Cambridge City Council will adopt SUDS in public open space	Can help to reduce peak flow rates, and some infiltration may be possible to reduce volume of runoff Biodiversity and ecological benefits Amenity benefits and links to green infrastructure strategy	Suitable for high density developments if integrated into urban environment
Filter Drains/Filter	○	✓	✓	✓	✓	Capital - £100-140 per m^3 stored volume	Cambridgeshire County Council as the SUDS	Significant reduction in peak flow rates as runoff travels slowly through the filter drain	Drainage network design similar to conventional system with perforated

[78] In Paradise Park in the London Borough of Islington the use of green roof provided sufficient cooling of the building to avoid the need for air conditioning (see http://www.environment-agency.gov.uk/business/sectors/91970.aspx)

[79] Interpave (2006), Whole life cost analysis for various pavement and drainage options

[80] Research into the use of permeable paving and a ground source heat pump is available at http://www.hydrology.org.uk/Publications/exeter/56.pdf

SUDS measure	Roof drainage	Road drainage	Suitable in high density developments	Suitable for flat topography	Suitable for low permeable ground conditions	Costs	Adoption	Benefits	Design considerations
Carrier Drains						Operational - £0.2-£1 per m² filter surface area per year	Approval Body (SAB) Cambridge City Council will adopt SUDS in public open space	High removal of pollutants	pipes and trench filled with gravel
Filter strips	○	✓		✓	✓	Capital - £2-4 per m² filter strip area Operational -	Cambridgeshire County Council highways authority (if adjacent to highway) Cambridge City Council will adopt SUDS in public open space	Can promote infiltration of surface water depending on ground conditions Easily integrated with landscape and can be built to provide aesthetic benefits	Slopes should not exceed 1 in 20, minimum of 1 in 50 Minimum width of 6m Runoff should be evenly distributed across the filter strip
Swales	○	✓	○	✓	✓	Capital – £15 per m² Operational – £0.5-£1 per m² per year	Cambridgeshire County Council as the SUDS Approval Body (SAB) Cambridge City Council will adopt SUDS in public open space	Significant reduction in peak flow rates as runoff travels slowly through the swale High removal of pollutants Ecological benefits Links to green infrastructure	Channel needs to be shallow – side slope of 1 in 3 and base width of at least 0.5m to collect road runoff No gully pots or kerbs required Maximum velocity should be 0.3 m/s

Table 4-9 Summary of source control and conveyance measures for surface water management (adapted from CIRIA C609 and C907)

✓ = highly suitable, ○ = possibly suitable depending on on-site conditions

4.3.17 *Land take of SUDS scenarios*

4.3.18 An important factor in determining the feasibility of achieving 100% above ground drainage will be the additional land required for drainage features which are not buried. The Phase 2 WCS has estimated the potential land take required for different drainage strategies for individual development sites where the Phase 2 WCS still has influence over the drainage provision. To estimate the land take required a number of assumptions were made:

- the average depth of attenuation and infiltration ponds was assumed to be 0.6m, based on the maximum pond depth recommended in the Cambridge SUDS design guide;
- it was assumed that 90% of the piped drainage would be located beneath roads and therefore no land take would be required, but for the remaining 10% a 3m easement was assumed to allow machinery access;
- it was assumed that open channels would be 2m wide, which was consistent with the assumptions made to estimate costs of SUDS scenarios, and;
- there has been no allowance for infiltration of surface water

4.3.19 These calculations have been carried out specifically to inform a comparative assessment of different locations and different policy scenarios. As the land take calculations are based on a number of simplifying assumptions, it is prudent to use the findings only as a comparative measure of the indicative land take required for different SUDS scenarios. The actual additional land take required on each development site to incorporate above ground surface water drainage is likely to vary from the findings presented here when drainage designs are considered in parallel to the master planning of a development site.

4.3.20 The analysis (presented in Table 4-10) indicates that to achieve the vision scenario would require a total of 147 ha of land across all of the development sites, which represents a 70 ha increase in land above the business as usual scenario. This represents an average increase of 90% in land take above the business as usual scenario across all development sites, although this is higher in some sites (e.g. University site) and lower at other sites (e.g. Cambridge East). The percentage of proposed open space which would be taken up by SUDS varies across the development sites. At Northstowe the analysis indicates that approximately 90% of the assumed open space in the Phase 2 WCS would need to be set aside for SUDS to achieve the vision scenario.

4.3.21 It may be feasible for the required land take in all scenarios to be incorporated into the existing open space with no detrimental impact on housing densities. This is subject to detailed design and masterplanning employing good urban design to ensure multiple use green infrastructure is employed making best use of open space. Housing densities may have to increase by approximately 15% across the development sites in the unlikely scenario of no multiple use green infrastructure being employed with land reserved for drainage and storage functions only.

4.3.22 Integrating SUDS into urban design needs to be considered at the earliest stage of masterplanning to deliver the full benefits of multi-use. Some of the key methods for integrating SUDS into urban design are outlined below. We have also provided four examples where surface water management have been integrated into the urban fabric in the text box.

- Use of source control measures such as green roofs and permeable surfaces can play a significant role in storing and slowly conveying surface water runoff and do not require any net increase in land take.
- Infiltrating surface water, where feasible, to reduce the requirement to convey and store surface water above ground[81].
- Dual use space such as utilising sports pitches and recreation areas to store surface water in extreme rainfall events (as advocated in the CIRIA designing for exceedance – good practice guidance) or designing two stage channels which act as cycle/pedestrian routes under normal conditions but are used to convey surface water during rainfall events (as has been done in Cambourne, Pool and Redruth regeneration). It is good practice that SUDS are multi-functional spaces and this need not be to the detriment of the 'sharing' uses: attenuation basins sized for larger events will be dry for the majority of the time.

4.3.23 CIRIA are in the process of producing guidance for local authorities to support implementation of SUDS in development[82]. This guidance will be available in December 2010.

Site information	Assumed open space (from Table 4-7)	Scenarios			
		Business as Usual	On the Pathway	Significant progress	Vision
Land take (ha) required for different SUDS strategies					
University site	28	7	9	10	14
NIAB 2	8	2	3	3	4
Orchard Park	2	0.5	0.6	0.8	1
Cambridge East	86	24	28	32	41
Northstowe	75[83]	36	45	53	71
Cambourne 950[84]	7	8	10	12	16
Total	**206**	**78**	**95**	**112**	**147**

[81] Approved Document Part H of the Building Regulations 2000 establishes a hierarchy for surface water disposal, which encourages a SUDS approach. The preference should be infiltration and if this is not a viable option attenuation. This should be assessed on a site by site basis as part of planning applications.

[82] CIRIA RP784, Planning for SUDS – Making it happen, more information available at www.ciria.org

[83] The latest sustainable surface water management strategy (December 2007) proposed 91.3ha of 'informal open space' on the Northstowe development site.

[84] There may be opportunities for the Cambourne extension to connect into the existing surface water drainage network depending on capacity of the existing system, topography and site layout

Site information	Assumed open space (from Table 4-7)	Scenarios			
		Business as Usual	On the Pathway	Significant progress	Vision
% increase in land take required compared to business as usual					
University site			27%	53%	106%
NIAB 2			23%	46%	91%
Orchard Park			24%	47%	95%
Cambridge East			17%	35%	70%
Northstowe			25%	49%	98%
Cambourne 950			24%	47%	95%
Total			**22%**	**45%**	**90%**

Table 4-10 Indicative land take for different SUDS strategies

Integrating SUDS into urban design

Surface water management should form a key part of urban design. A report by the Commission for Architecture and the Built Environment (CABE) describes the need for green infrastructure strategies to 'incorporate the management of water, flood risk and water resources into wider green infrastructure networks.' Some examples of integrating surface water management into urban design include:

- **Upton, Northampton** – sustainable surface water management systems were fully integrated into the design of public open space and street design (http://www.cabe.org.uk/sustainable-places/examples/upton).
- **Portland, USA** – the Green Streets project involved retrofitting the street's pavements with specially designed plants that captured and treated surface water runoff (it should be noted that these planters capture and treat the majority of the street runoff) (http://www.cabe.org.uk/case-studies/green-streets).
- **Cambourne, Pool and Redruth redevelopment** – as part of the urban design the SUDS network was implemented as a 'blue corridor' which has footways for cyclists and pedestrians adjacent to the SUDS network. The design is for a two stage channel to allow lower flows to be accommodated in the primary channel, and for higher flows to spill over onto the cyclists and pedestrians footways (http://www.cprregeneration.co.uk/)
- **NIAB 1** - The NIAB 1 site is planned to be drained via a totally separate, above ground drainage network. Road and roof runoff drains directly to a network of 'green fingers' swales which drain to a balancing pond to the north-east of the site. The balancing pond has been designed to accommodate the 1 in 100 year rainfall event (plus a 30% uplift for climate change), with a discharge rate less than greenfield equivalent. The above ground drainage has been inter-linked with green open space to create green corridors within the development site.

4.3.24 *Adoption and maintenance of SUDS*

4.3.25 The Flood and Water Management Act has introduced clarity over the adoption and maintenance of SUDS. Commencement orders should confirm the exact arrangements during 2011. In the meanwhile the local authorities should assume that:

- Cambridgeshire County Council will become responsible for the adoption and maintenance of new build SUDS; new build includes all new development and redevelopment.
- Cambridgeshire County Council will become the SUDS approving body (SAB) for all new build SUDS. The requirements for approving new build SUDS will be outlined in forthcoming national standards on the construction and operation of surface water drainage.
- There will be a removal of the automatic 'right to connect' surface water drainage to the public sewerage network. New surface water drainage systems will need to be approved in line with forthcoming National Standards before any connection to the public sewerage network is allowed.

4.3.26 National Standards will be published in late 2010 and this element of the Act will be introduced through 2011 and 2012[85] . South Cambridgeshire District Council and Cambridge City Council should ensure that developer drainage proposals meet these requirements and will be accepted by the SAB. We anticipate that Cambridge City Council's SUDS design guide[86] will be very similar to the SUDS national standards.

4.3.27 Cambridge City Council and Anglian Water are both currently adopting SUDS features and it's likely that legislation will still allow a flexible approach to adoption to suit local circumstances and requirements.

4.4 Summary of evidence base

4.4.1 The Phase 2 WCS has assessed different surface water drainage scenarios, ranging from business as usual to the vision. The evidence presented in the Phase 2 WCS has demonstrated that utilising above ground drainage systems in preference to conventional piped systems would lead to:

- capital and operational cost savings – under the most aspirational scenario capital and operational costs were estimated to be 11% lower than a conventional piped drainage network, over 100 years;
- reductions in carbon emissions – under the most aspirational scenario carbon emissions were estimated to be 15%-20% lower than a conventional piped drainage network, over 100 years, and;

[85] http://ww2.defra.gov.uk/news/2010/07/29/benyon-flood-speech/

[86] http://www.cambridge.gov.uk/ccm/content/planning-and-building-control/urban-design/sustainable-drainage-systems.en

- significant opportunities to create or enhance amenity and biodiversity within the development sites, as well as providing opportunities for a network of green (and blue) open spaces.

4.4.2 The Phase 2 WCS has also assessed some of the practicalities associated with providing above ground drainage, including:

- the suitability of infiltrating surface water runoff depending on bedrock and superficial geology – the analysis has indicated that infiltration of surface water runoff will be most applicable to the south, south east and parts of the east of the study area which are underlain by permeable chalk bedrock;
- the storage volumes required to manage surface water runoff to greenfield equivalent at all of the strategic development sites – approximately 7-12% of the developable area on the strategic development sites would need to be set aside to store surface water runoff;
- the applicability of different SUDS techniques depending on ground conditions, topography, and densities of development, and;
- the potential land take of providing above ground drainage – to achieve 100% above ground drainage would require an increase land take required for drainage by 90%, which could result in an increase in housing densities of up to 15%, depending on whether above ground drainage can be integrated into public open multiple use green infrastructure. Good design can integrate SUDS within the available open space in the development and at the same time enhance the local environment.

4.4.3 For the development sites which have significantly progressed through the planning process the Phase 2 WCS has undertaken a review of proposed surface water drainage infrastructure. This review has demonstrated many examples of providing above ground drainage and integrating drainage with wider amenity, biodiversity and green infrastructure objectives. Indeed drainage at NIAB 1 has been proposed to be 100% above ground and is an example of best practice.

4.5 Recommendations

4.5.1 Actions within steering group control

4.5.2 The specific policy recommendations and implementation themes from the Phase 2 WCS are summarised in the box below and expanded upon in subsequent paragraphs illustrating actions and responsibilities.

REC SWM1: Planning policy recommendations: Surface water management

- Development should aspire towards 100% above ground surface water drainage except where this is not feasible due to housing densities, land take, ground conditions, topography, or other circumstances outlined within the development proposals.
- Where 100% above ground drainage is not feasible due to the size of development (i.e. windfall and non-strategic developments) or proposed high densities, the development proposals should maximise opportunities to use SUDS measures which require no additional land take, i.e. green roofs, permeable surfaces and water butts
- Development proposals should ensure that surface water drainage is integrated within the built environment. In addition, surface water drainage proposals should maximise opportunities to create amenity, enhance biodiversity, and contribute to a network of green (and blue) open space.
- Surface water drainage should be considered at an early stage of the master planning process, to allow maximum integration of drainage and open space, and to minimise the additional land take required by above ground drainage.

4.5.3 **REC SWM1: Implement planning policies**

4.5.4 Achieving the vision for sustainable surface water management relies on the development and subsequent implementation of planning policies and vigilant management of development through the planning process. Planning applications should:

- demonstrate the ambition for achieving 100% above ground drainage through implementation of a range of SUDS measures from source control (e.g. green roofs) to large-scale attenuation storage;
- provide justification and evidence where achieving 100% above ground drainage will not be feasible due to proposed densities, topography, ground conditions, or the location of development;
- demonstrate that drainage proposals are aligned with the forthcoming National SUDS Standards and will be accepted by Cambridgeshire County Council (as the new SUDS Approval Body);
- demonstrate that proposed SUDS measures will be integrated into the built environment to provide amenity and contribute to a network of open space, and;
- demonstrate that proposed SUDS measures will be used enhance the local environment and biodiversity.

4.5.5 The planning authorities will be responsible for implementing the recommendations through the development of planning policies and determination of planning applications, although other technical stakeholders (e.g. the Environment Agency) will provide technical advice and scrutiny of planning applications to support the planning authorities.

4.5.6 *Development where vision for sustainable surface water management may not be achievable*

4.5.7 Overall, the evidence base supports a local policy approach which aims for 100% above ground drainage for future developments, and using SUDS to create or enhance amenity and biodiversity and contribute to the provision of green infrastructure. However, it is recognised that there are a number of site-by-site circumstances which may make it difficult to achieve the aspiration with regards to surface water management. Some of the potential constraining circumstances are outlined below. Developers will need to consider all on-site issues when preparing their planning application.

- **Densities of proposed housing development** – in high density developments, such as Northstowe & Cambridge East, for example, achieving 100% above ground drainage is likely to be difficult due to the physical space on site – in these circumstances planning applications must demonstrate maximum use has been made of low land take drainage measures, such as green roofs, permeable surfaces and water butts. In addition, developers should demonstrate that all opportunities have been sought to integrate drainage in public open space. Lack of space is not a barrier to the attenuation of water (even if it has to be underground) and therefore the flood risk posed by any site will not be compromised.
- **Windfall development in town/city centre** – in town/city centre developments it is likely that surface water will need to be connected into the existing public sewer network due to available space and available discharge locations for the surface water. In such cases planning applications should demonstrate that surface water runoff will discharge to the public sewer at a rate lower than the existing rate; this can be achieved through source control measures such as green roofs and water butts, where feasible. The discharge to the public sewer should be discussed with the incumbent water and sewerage company.
- **Other windfall development** – achieving 100% above ground drainage in windfall development may not be achievable due to viability and available space – in these circumstances the planning applications must promote low cost and low land take drainage measures, such as water butts and soakaways.
- **High water table** – a high water table may preclude the use of above ground drainage[87], as was the case at the Orchard Park development. In such cases, the planning application must provide evidence that above ground drainage is not possible and provide a strategy which ensure surface water runoff to the receiving watercourse is greenfield equivalent (on greenfield sites) or at a reduced rate (on brownfield sites). In some locations with a high water table it may be possible to utilise SUDS at a shallow depth, although it must be noted that this could increase the potential land take required for drainage.
- **Topography** – where there is insufficient gradient to drain surface water and the potential to infiltrate surface water is poor, it may be necessary to utilise

[87] The base of the SUDS scheme should be at least 1.2 m higher than the water table elevation

underground drainage to ensure surface water is effectively drained away from domestic and non-domestic dwellings.

5 Environmental water quality

5.1 *Vision for protecting water quality*

5.1.1 Sustainable development can contribute to meeting the objectives of the Water Framework Directive (WFD) through provision of infrastructure to treat surface water runoff and wastewater. With respect to water quality, the vision for sustainable water management is **to ensure that development does not cause deterioration of water quality**, and **seeks opportunities to contribute to meeting good status[88], where feasible**. This chapter outlines the approaches to ensuring adequate treatment of surface water runoff; a strategy for wastewater is provided in Chapter 6.

5.1.2 To accurately understand the likely impact of development on water quality and whether proposed SUDS measures will improve water quality would require detailed modelling of runoff loads and modelling of the effectiveness of proposed SUDS measures in reducing pollutant loads. Without the use of detailed modelling, it is possible to identify a strategy and approaches to ensure surface water runoff is treated prior to discharges to watercourses.

5.1.3 A number of strategic development sites have significantly progressed through the planning system; therefore the Phase 2 WCS has limited influence over the provision of water services infrastructure. Some of these sites have reserved matters coming through on a plot by plot basis which will offer an opportunity to employ SUDS as and where feasible. The sites also have conditions which require a detailed drainage strategy to be agreed prior to development commencing on the sites (in the case of Trumpington Meadows this is conditions no.16).

5.1.4 Table 5-1 provides a summary of the approach to treatment of surface water runoff for the sites which have significantly progressed through the planning system. It is evident that treatment of surface water runoff has been included in development proposals, through implementation of SUDS treatment stages. The most thorough evidence of the effectiveness of SUDS in treating pollutants is available from the Lamb Drove SUDS site at Cambourne. Monitoring has been undertaken at Lamb Drove (with SUDS employed) and a control site (with no SUDS employed) to compare runoff quantity and quality. The results from the interim monitoring report[89] have demonstrated that:

- the SUDS treatment train at Lamb Drove is acting to improve water quality;

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[88] Under the Water Framework Directive the objective is for all water bodies to meet good ecological status by 2015. For surface waters (rivers, lakes, transitional waters), good ecological status can be defined as: good chemical status for the relevant substances (there are also a series of daughter directives), good physico-chemical status on the scale high, good, moderate, poor and bad, good biological class, and good hydro-morphological class

[89] Cambridgeshire County Council, January 2010, Lamb Drove SUDS showcase project, Cambourne, Interim Monitoring Report, available at http://www.cambridgeshire.gov.uk/NR/rdonlyres/59774E4C-CE12-4C2A-9A22-AE2781F3D55F/0/LambDroveSUDSMonitoringInterimReportv102Main.pdf

- concentrations of hydrocarbons are significantly lower at Lamb Drove compared to the control site;
- there is a reduction in metals as water travels through the SUDS system;
- Suspended Solids are generally below expected levels except where site specific conditions have affected the certain monitoring locations, and;
- there is evidence of a benefit (in terms of lower concentrations at Lamb Drove) for Phosphorus, Nitrogen, Chemical Oxygen Demand, Biological Oxygen Demand and Ammonia.

5.1.5 The results from the Lamb Drove SUDS site can be used to give confidence that SUDS systems will provide tangible improvements in water quality over and above conventional piped systems.

Development site	Approach to treatment of surface water runoff
Trumpington Meadows	Treatment of surface water runoff provided by swales and two balancing ponds
Bell School	Two treatment trains provided for development
Clay Farm	Treatment of surface water runoff provided by 'downstream defenders' (which trap up to 90% of silt in runoff) and four balancing ponds
Glebe Farm	Some treatment due to swale and proposed permeable paving Surface water then drains to Clay Farm, where treatment is provided by 'downstream defenders'[90] and balancing ponds
Addenbrooke's Biomedical Campus	Treatment of surface water runoff is provided by swales (road runoff) and two balancing ponds (road and roof runoff)
Cambourne	Petrol interceptor on road gullies and car parks Balancing ponds provide final treatment stage Lamb Drove SUDS site has demonstrated significant improvements in water quality compared to conventional drainage systems
Orchard Park	Underground drainage network – some treatment will be provided by attenuation tanks
NIAB 1	Treatment provided by network of swales and balancing pond

Table 5-1 Approaches to treatment of surface water runoff

[90] More information on Downstream Defenders can be found at http://www.hydro-international.biz/us/stormwater_us/downstream.php

5.2 Justification

The WFD establishes the framework for integrated management of water bodies throughout Europe. First, the WFD aims to ensure no deterioration of water bodies from their current status, and secondly to achieve good status by 2015.

Development can ensure that proposed development does not cause deterioration of water bodies and make a contribution to achieving good status through:

- effective management of pollutants in surface water runoff from development sites;
- ensuring additional foul flows entering the wastewater network do not cause an increase in the operation of combined sewer overflows (see section 6.4 for further discussion), and;
- ensuring final effluent discharges from wastewater treatment works are appropriately tightened (see section 6.3 for further discussion).

5.2.1 The WFD is the most substantial piece of European Commission water legislation to date and is designed to improve and integrate the way water bodies are managed throughout Europe. Under the WFD all Member States must:

- prevent deterioration in the classification status of aquatic ecosystems, protect them and improve the ecological condition of waters;
- aim to achieve at least good status for all waters. Where this is not possible, good status should be achieved by 2021 or 2027;
- promote sustainable use of water as a natural resource;
- conserve habitats and species that depend directly on water;
- progressively reduce or phase out releases individual pollutants or groups of pollutants that present a significant threat to the aquatic environment;
- progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants, and;
- contribute to mitigating the effects of floods and droughts.

5.2.2 The first principle of the WFD is to prevent deterioration in aquatic ecosystems. No deterioration must be met in all but very exceptional circumstances. Exceptional circumstances apply when the deterioration is caused by physical modifications or the result of sustainable new human development activities. Even in such cases it is necessary to demonstrate that there was no better way to achieve the desired development. No deterioration requires that a water body does not deteriorate from its current ecological or chemical classification, and applies to individual pollutants within a water body.

5.2.3 Under the WFD the objective is for all water bodies to meet good ecological status by 2015[91]. For surface waters (rivers, lakes, transitional waters), good ecological status can be defined as:

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[91] Although the WFD specifies that good status should be met by 2015 there are circumstances where it is possible to delay meeting good status until 2021 or 2027, or where a lesser objective will be required. These circumstances include technical feasibility, disproportional costs, or natural conditions (recovery times).

good chemical status for the relevant substances (there are also a series of daughter directives), good physico-chemical status on the scale high, good, moderate, poor and bad, good biological class, and good hydro-morphological class.

5.2.4 In England and Wales, the Environment Agency has prepared River Basin Management Plans (RBMPs), which set out the current status, objective, target and pressures for each water body, and an action plan outlining what will be required, by whom, and when to meet good ecological status

5.2.5 Annex J of the Anglian River Basin District RBMP states that: *'The role of spatial planning is hugely important in improving the water environment, and as a minimum, the activities of all public bodies must not lead to a deterioration of the water environment…. Public bodies should also identify opportunities for improvements and restoration work to maximise any contribution to meeting the Water Framework Directive objectives[92]'.*

5.2.6 Spatial planning, therefore, has an important role to play in contributing to the objectives of the WFD. Development adds pressure to water bodies in a number of ways and these pressures need to be addressed to ensure that water quality does not deteriorate due to development, and that opportunities are maximised to contribute to improving water quality.

Potential impact of development	Mitigation	Discussed in Phase 2 WCS
Increased pollutant loads from surface water runoff: • during construction (mobilisation of pollutants); • after construction through runoff from hard standing areas (e.g. roads, roofs), and; • risk of sewer misconnections	Where land may be contaminated ensure developers implement sustainable remediation to remove/reduce/render contaminants harmless Encourage sustainable construction practices which minimise risk of pollution occurring during development Implementation of SUDS to treat surface water runoff prior to discharge to ground or surface waters	Chapter 5
Increased pollutant loads from wastewater treatment works	Set discharge consents at the works to ensure no deterioration of water quality Ensure timing and phasing of development is aligned with delivery of infrastructure upgrades at wastewater treatment works	Chapter 6
Increased operation of combined sewer overflows (CSOs)	Ensure any additional surface water from development which connects to sewer does so at a rate equivalent or better than current runoff rate Ensure timing and phasing of development is aligned with delivery of required infrastructure upgrades to the wastewater network	Chapter 6

[92] Annex J: Aligning other key processes to river basin management, River Basin Management Plan Anglian River Basin District, available at http://wfdconsultation.environment-agency.gov.uk/wfdcms/en/anglian/Intro.aspx

Table 5-2 Pressures on water quality through development and potential mitigation

5.3 Practical considerations

5.3.1 To protect water quality in receiving watercourses and groundwater from surface water runoff, SUDS measures should be capable of removing the majority of pollution from frequent, small events, and from larger, rarer events. Using a treatment train will maximise the potential for treating pollutants from frequent, small events, and larger, rarer events. The CIRIA SUDS Manual recommends the following number of treatment stages:

- roofs only – 1 treatment stage;
- residential roads, parking areas, commercial zones – 2 treatment stages, and;
- refuse collection/industrial areas/loading bays/lorry parks/highways – 3 treatment stages

5.3.2 As 1 treatment stage is required for roof runoff this could be provided by green roofs, swales, filter drains, open channels, or regional attenuation storage. There are therefore multiple opportunities to treat roof runoff, ranging from source to regional controls.

5.3.3 For residential roads, parking areas or commercial zones, two treatment stages should be incorporated to the SUDS design. Regional attenuation storage will represent 1 treatment stage, and the additional treatment stage could be integrated with flood management controls through permeable surfaces, filter drains or swales. Alternatively oil/petrol interceptors could be included in highway gullies, car parks and commercial areas, to treat runoff, but these in isolation would offer no flood management benefits. The CIRIA SUDS Manual recognises that petrol interceptors have only limited benefits for water pollution treatment.

5.3.4 Table 5-3 and Table 5-4 illustrate the types of pollutants generated from different land uses and the types of SUDS measures needed to remove these pollutants. This information can be used by developers and planning officers to ensure that sufficient treatment has been provided through SUDS to protect surface water and groundwater quality. A treatment train which consists of SUDS measures such as green roofs, swales, filter drains, permeable surfaces, and regional storage will provide sufficient treatment to a large proportion of pollutants which are likely in runoff from development sites. Whilst source control and conveyance measures are capable of treating a large amount of the pollutants, the measures may not include all treatment processes, i.e. other than green roofs, none of the applicable measures use precipitation, uptake by plants, and volatilisation as removal mechanisms. Therefore, regional storage ponds or wetlands are vital as the final treatment stage to treat pollutants.

5.3.5 Runoff which is likely to be heavily contaminated must be treated by a proprietary device, which should be carefully considered to ensure the correct system is selected to remove pollutants. PPS23: Planning and Pollution Control (2004) discusses the requirements to consider the implications of contaminated land and pollution as a material planning consideration.

5.3.6 If the local soil is contaminated then a lined system is generally required. This may include a drainage design which allows infiltration in the upper layer, but should incorporate an impermeable layer at its base to prevent contamination. In such cases lined underground attenuation storage is used to store a 1 in 100 year plus climate change storm event and discharges into a nearby watercourse.

5.3.7 Planning applications should demonstrate that pollutants generated in the urban landscape will be adequately treated by the proposed SUDS measures. The developer-led Flood Risk Assessment should set out pollution control mechanisms, which will need to be agreed by the local planning authority and the Environment Agency

Land Use	Types of pollutants	Removal mechanisms							
		Sedimentation	Filtration	Adsorption	Biodegradation	Volatilisation	Precipitation	Uptake by plants	Nitrification
Traffic – exhausts	Cadmium, Hydrocarbons, Palladium, Platinum, Rhodium	●	●	●	●		●	●	
Traffic – corrosion & wear	Heavy metals, Sediment	●	●	●			●	●	
Leaks & spillages	Alcohols, Glycol, Heavy metals, Hydrocarbons, Phosphate	●	●	●	●		●	●	●
Roofs	Bacteria, Heavy metals, Organic matter	●	●	●	●		●	●	
Vegetation / landscape maintenance & Soil erosion	Ammonia, Fungicides, Herbicides, Insecticides, MTBE, Nitrogen, Organic matter (not soil erosion), Phosphorus	●	●	●	●	●	●	●	●
Cleaning activities	Ammonia, Detergents, Nitrogen, Phosphorus, Sediment	●	●		●		●	●	●
Wrong sewer connection	Ammonia, Bacteria, Detergents, Organic matter	●	●		●			●	●

Table 5-3 Pollutants and removal mechanisms from different land uses (adapted from SUDS manual)

● = high primary process ○ = some opportunities subject to design	Water quality								Environmental benefits		
SUDS technique	Sedimentation	Filtration	Adsorption	Biodegradation	Volatilisation	Precipitation	Uptake by plants	Nitrification	Aesthetics	Amenity	Ecology
Green roofs		●	●	●	●	●	●	●	●	○	●
Soakaway		●	●	●							
Water butts	○	○	○	○	○	○	○	○	○	○	○
Filter strips	●	●	●	●					○	○	○
Filter drains		●	●	●	●						
Infiltration trench		●	●	●	●						
Swales	●	●	●	●					○	○	○
Pervious surfaces	●	●	●	●	●				○	○	○
Infiltration basins		●	●	●	●				○	○	○
Detention basins	●			●					○	○	○
Ponds	●	●	●	●	●	●	●	●	●	●	●
Wetlands	●	●	●	●	●	●	●	●	●	●	●

Table 5-4 Pollutant removal by different SUDS techniques

5.4 *Summary of evidence base*

5.4.1 Protecting receiving surface and ground waters from pollutants in surface water runoff is an important element of sustainable water management. For the development sites which have significantly progressed through the planning system the evidence has indicated that overall treatment of surface water runoff is being embedded within the development proposals, through implementation of treatment stages, as recommended in the CIRIA SUDS Manual. At Lamb Drove, in Cambourne, monitoring of the SUDS system compared to a conventional piped system has demonstrated tangible and significant reductions in pollutant loads due to the SUDS system.

5.4.2 The Phase 2 WCS has also set out the evidence base (from the CIRIA SUS Manual) to ensure surface and ground waters are adequately protected from polluted surface water runoff, including:

- ensuring a sufficient number of treatment stages are provided depending on the source of surface water runoff:
    - roofs only – 1 treatment stage;
    - residential roads, parking areas, commercial zones – 2 treatment stages;
    - refuse collection/industrial areas/loading bays/lorry parks/highways – 3 treatment stages;
- ensuring that typical pollutants which are generated in the urban environment are considered and treated through SUDS approaches.

5.5 *Recommendations*

5.5.1 *Actions within steering group control*

5.5.2 Protecting surface and ground waters from pollutants in surface water runoff from development sites is dependant on the development and subsequent implementation of strong local planning policy and vigilance in enforcing this policy. The recommendations for consideration by policy makers are outlined in the text box below; these will ensure surface water runoff is adequately treated prior to discharge to surface and ground waters.

REC P1: Planning policy recommendations: management of pollutants in surface water runoff

- Development must ensure that an appropriate number of SUDS treatment stages are provided to treat surface water runoff; 1 treatment stage is required for roof runoff only, 2 treatment stages are required for residential roads, parking areas and commercial zones, and 3 treatment stages are required for refuse collection, industrial areas, loading bays, lorry parks, highways.
- Consideration should be given to sources of pollution in the urban environment to demonstrate that appropriate SUDS measures have been incorporated into the development to protect water quality from polluted surface water runoff.
- Within contaminated land development should allow for measures to remove, reduce or render the contaminants harmless. Within contaminated sites a lined SUDS system should generally be used to prevent infiltration of surface water runoff.

5.5.3 **REC P1: Implement planning policies**

5.5.4 In addition to developing and implementing planning policies , local planning authorities and the Environment Agency (through review of the site specific flood risk assessment) should ensure the following considerations have been demonstrated in planning applications:

- Has the planning application demonstrated an appropriate number of treatment stages to treat surface water runoff from different surfaces in line with the Phase 2 WCS and any requirements within the National SUDS Standards?
- Has the planning application demonstrated that the types of pollutants which will be mobilised in surface water runoff, and considered appropriate SUDS approaches to treat these pollutants prior to discharge to surface and/or ground waters?
- Has the planning application confirmed the presence/absence of contaminated land and recommended a strategy for remediating the contamination or rendering it harmless, where necessary?

6 Wastewater infrastructure

6.1 Wastewater treatment hydraulic capacity

6.1.1 Anglian Water Services Limited (AWS) is the incumbent wastewater services provider for the WCS study area.

6.1.2 The Phase 1 WCS, and subsequent wastewater capacity study undertaken by AWS, identified the planned water company strategy for serving proposed development in the study area. AWS' preferred strategy for wastewater treatment to serve development at the major growth sites in and around Cambridge is for all development from Cambourne and Northstowe to drain to Uttons Drove WwTW, and all other development draining to Cambridge (Milton) WwTW. A schematic of the preferred WwTW strategy is illustrated in Figure 6-1. AWS preferred strategy is also the preferred strategy in the County Council's submitted Minerals and Waste LDF.

6.1.3 *Cambridge WwTW*

6.1.4 Up to 2031 there could be over 30,000 new homes built which will drain to Cambridge WwTW, which will represent an increase of Dry Weather Flow (DWF) to the works of 7,000 m^3/d (an increase in DWF of approximately 25%). Cambridge WwTW needs to be upgraded to accommodate the additional load from developments. AWS' preferred option at Cambridge WwTW is to:

- extend the inlet works to accommodate the increased flow;
- extend the aeration plant (which currently treats approximately 30% of the flow);
- construct a new final settlement tank, and;
- extend the sand filters to meet future consent requirements.

6.1.5 *Uttons Drove WwTW*

6.1.6 AWS has identified Uttons Drove to as the preferred treatment location for foul flows from Cambourne and Northstowe. Uttons Drove is a small rural WwTW, which has a current population equivalent of approximately 15,000 and serves the settlements of Cambourne, Bar Hill, Girton, Hardwick, Oakington, Westwick and Dry Drayton.

6.1.7 Up to 12,000 new homes will be connected to Uttons Drove WwTW by 2031, which represents a 75% increase in DWF.

6.1.8 To accommodate these additional flows will require significant extension to the existing works; an entire new treatment stream will be required, and in view of current site restrictions, an aeration plant, which has a small footprint but high energy requirement is the preferred treatment option. The capacity of the Swavesey Drain, which receives the treated effluent, is an issue at present, and increased flow into this watercourse could create local problems.

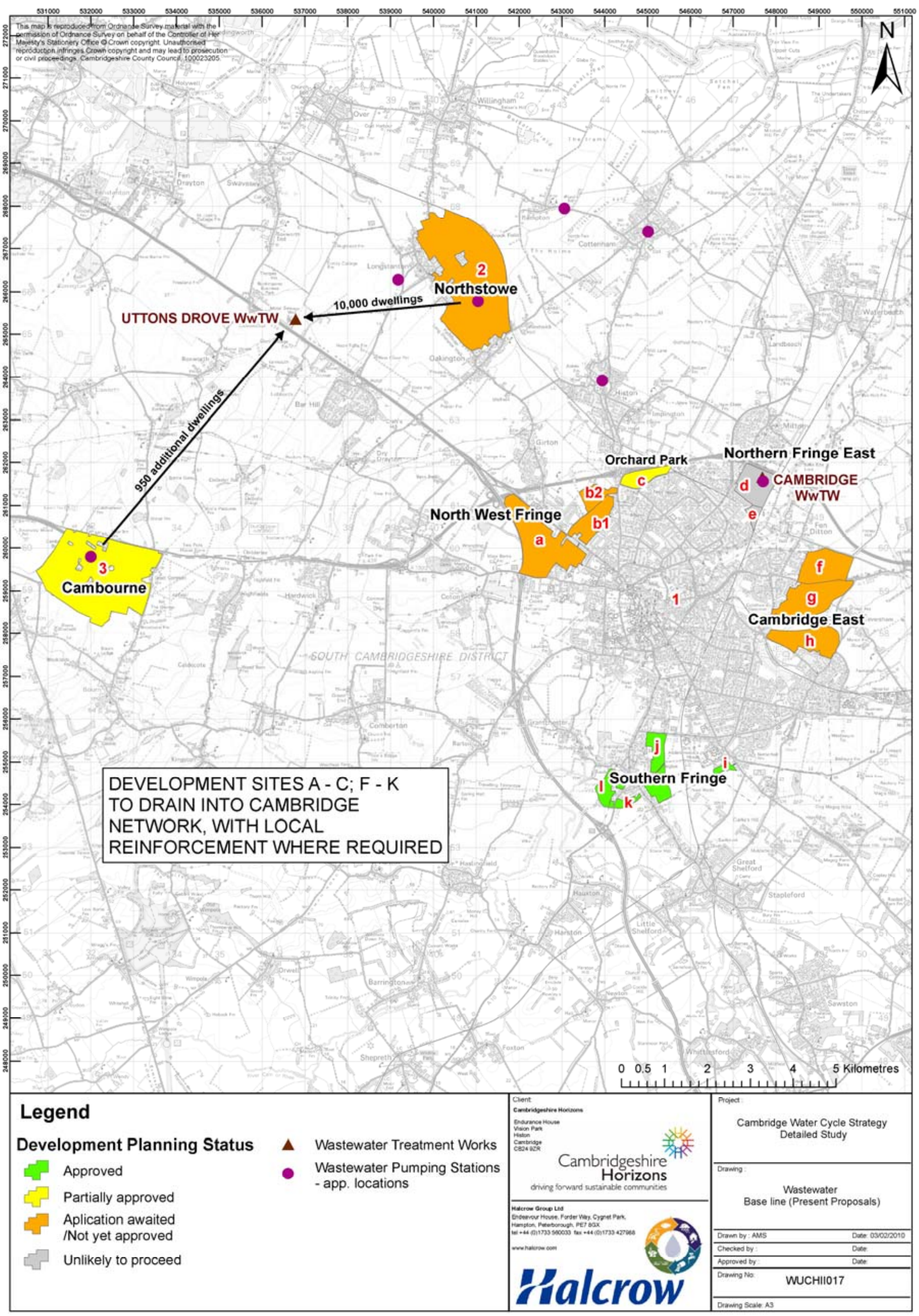

Figure 6-1 Preferred WwTW strategy for the major growth sites in and around Cambridge

6.2 Wastewater treatment & flood risk

6.2.1 Final effluent from WwTWs will increase due to housing growth, which could potentially increase flooding downstream of the works. For Cambridge WwTW the Phase 2 WCS has assessed the potential increase in flood risk downstream of the WwTW due to housing growth, using a risk based methodology. For Uttons Drove WwTW the Phase 2 WCS has summarised the preferred mitigation option downstream of the works.

6.2.2 *Cambridge WwTW*

6.2.3 To identify the potential increase in flood risk from Cambridge WwTW due to an increase in final effluent, a two stage process has been adopted.

6.2.4 First, an initial screening assessment was undertaken using the Environmental Capacity Study Tool methodology[93]. The initial screening methodology estimated that peak discharge levels in the receiving watercourse could increase by 1.07%, which is classified as medium risk in the methodology used; hence more detailed analysis was required.

6.2.5 Because the initial screening assessment indicated there could be a medium risk of increased flooding downstream of Cambridge WwTW, a more detailed analysis has been carried out which considers changes to peak flow levels, the sensitivity of the receiving watercourse to changes in flood levels, and the potential impact of flooding, to define a combined flood risk index. A summary of the methodology is provided below; more details on the methodology are provided in Appendix H.

Methodology

6.2.6 The detailed analysis comprises of three principal elements:

- quantification of the increase in peak flows – using the Flood Estimation Handbook methodology this element quantifies the increases in peak flow levels in the river for a 1 in 2 year rainfall probability event;
- evaluation of the likely sensitivity of flood levels to increases in flood flows – in order to understand the importance of any increase in peak flow levels this element identifies how flood levels may change with increase in peak flows, and assesses the channel shape and slope, and the presence of structures which may restrict flow (e.g. bridges) and;
- evaluation of the impact of increases in flood levels – the final element identifies the potential impact of an increase in flood levels both upstream and downstream of the WwTW.

Results

6.2.7 Table 6-1 indicates the results from the detailed analysis of flood risk downstream of Cambridge WwTW.

6.2.8 The results of the three analysis stages described above were combined in a multi-criteria analysis to indicate the relative risk of increased flooding due to increased discharge from the

[93] Halcrow (2009), Wastewater environmental capacity assessment

WwTW. It should be noted that these results are indicative and do not give an absolute quantification of the increase in flood levels. The detailed assessment indicated that there is a relatively low risk of increasing in flooding as the increase in flow is relatively insignificant when compared to the 1 in 2 year flood flow in the receiving watercourse, as illustrated in Table 6-1.

6.2.9 As agreed with the Environment Agency, when the assessment indicates there is a low risk of increasing in flooding due to increases in foul effluent, this should not represent a constraint to growth at the strategic planning stage, to the levels considered in the Phase 2 WCS. There may be specific cases where the Environment Agency considers that on-site measures may be required to ensure no increase in flood risk, as required by PPS25. However the assessment of a site as low risk confirms that any mitigation that may be required can be delivered through site specific design or local masterplanning. These will need to be discussed and agreed with Anglian Water and the Environment Agency through the normal development control process as specific development sites come forward.

<table>
<tr><th rowspan="2">WwTW</th><th rowspan="2">Receiving Watercourse</th><th colspan="3">Increase in flow</th><th colspan="3">Sensitivity</th><th colspan="3">Impact</th><th colspan="4">Total risk value (various weightings used)</th></tr>
<tr><th>m^3s^{-1}</th><th>% increase in flow</th><th>Risk Value</th><th>Comments</th><th>Assessment</th><th>Risk Value</th><th>Comments</th><th>Assessment</th><th>Risk Value</th><th>0.4 Inc flow</th><th>0.45 Inc flow</th><th>0.6 Inc flow</th><th>0.7 Inc flow</th></tr>
<tr><td rowspan="2">Cambridge WwTW</td><td rowspan="2">River Cam</td><td rowspan="2">0.24</td><td rowspan="2">0.93</td><td rowspan="2">1 (LOW)</td><td rowspan="2">No major channel constrictions identified within 500m of the WwTW. Wide channel (>5m)</td><td rowspan="2">LOW</td><td rowspan="2">1</td><td>u/s reach – no channel restriction within 500m.</td><td>LOW</td><td>1</td><td rowspan="2">1.6</td><td rowspan="2">1.55</td><td rowspan="2">1.4</td><td rowspan="2">1.3</td></tr>
<tr><td>d/s reach – Village in floodplain >5 properties but not greater than 50. Only a small increase in water level estimated. Impact risk level therefore reduced from medium to low.</td><td>LOW</td><td>1</td></tr>
</table>

Table 6-1 Summary of flood risk impact from Cambridge WwTW (detailed assessment)

6.2.10 Uttons Drove WwTW

6.2.11 A new DWF and discharge consent has been proposed in AMP5[94] to ensure there is sufficient environmental capacity at the works to accommodate proposed growth, and AWS have developed plans to upgrade the works to accommodate the additional flows. However, the critical waste water management issue at Uttons Drove is the question of flooding near Webb's Hole Sluice, which needs to be resolved to ensure downstream flood risk is mitigated.

6.2.12 The Environment Agency, Anglian Water, South Cambridgeshire District Council, Cambourne Consortium, Joint Promoters for Northstowe (Gallagher Estates and the Homes and Communities Agency) and Cambridgeshire Horizons have worked together to identify a preferred Land Drainage Solution for Uttons Drove WwTW.

6.2.13 To mitigate any increase in flood risk from the Cambourne development AWS previously agreed to install a temporary land drainage pumping system at Webb's Hole Sluice. However, a permanent solution is required to accommodate the Cambourne extension and the Northstowe development.

6.2.14 The preferred land drainage solution is the additional flow from the WwTW due to new development will be conveyed to the Webb's Hole Sluice via Swavesey Drain, where it would then be over pumped into the River Great Ouse. This is considered to represent the most sustainable solution; the alternative would be for AWS to construct a 14km main to the river (which would be fully pumped). The alternative option is not favoured in terms of environmental impact, carbon footprint, time constraints and costs. The following recommendations have been made:

- provision of either a 1.0 m^3/s permanent pump or two 0.5 m^3/s pumps (on a duty/assist regime) upstream of Webbs Hole Sluice;
- removal of constriction in the watercourse bed at the railway crossing;
- dredging the reach of the Uttons Drove Drain upstream of the confluence with the Swavesey Drain by 100mm;
- erosion control measures in the Uttons Drove Drain, and;
- other conveyance improvements

6.2.15 The Land Drainage Solution can be delivered in two phases. A phase 1, will provide for the additional capacity required for the additional 950 homes at Cambourne and a further 1000 homes in the area. At the Northstowe developer site progresses, a phase 2 of the Land Drainage Solution will be implemented to accommodate the additional homes..

6.3 Wastewater treatment & water quality

6.3.1 A review of water quality is required during the development process to ensure that development does not adversely affect water quality, and does not hinder the ability of a water

[94] Water companies' capital programme runs in five year Asset Management Plan (AMP) cycles. AMP5 is the firth cycle, and it runs from 2010-2015.

body to meet the WFD. Development can adversely affect water quality in two principal ways, with respect to wastewater:

- increases in final treated wastewater (or effluent) load from WwTW which causes a deterioration of water quality, and;
- increases in intermittent discharges from combined sewer overflows (CSOs), pumping stations, and storm tanks at WwTW – the potential for development to affect the operation of overflows has been assessed as part of the wastewater assessment.

6.3.2 The future expansion potential of a wastewater treatment works with respect to water quality is determined by assessing the discharge consent, set by the Environment Agency. This consent is based on the ecological sensitivity of the receiving watercourse and specifies a maximum flow and a minimum effluent quality that the WwTW has to achieve to meet water quality targets without causing environmental damage.

6.3.3 As the population connected to sewage treatment works increases, the amount of treated wastewater being discharged to the receiving water generally increases in proportion to the population increase. When this increased population causes the treatment works to exceed the consented maximum discharge volume allowed by the existing Environment Agency consent, improvements are likely to be required to the treatment works to improve the standard of treatment and to ensure river quality does not deteriorate.

6.3.4 The quantity of treated effluent discharged from each treatment works and its quality is specified by the legal discharge consent, issued by the Environment Agency under the Water Resources Act 1991. The consent is normally based upon the dry weather flow (DWF) of the treated effluent, and stipulates limits for the concentration of biochemical oxygen demand (BOD), total suspended solids (TSS) and ammoniacal nitrogen (NH3). Compliance is determined by means of statistical analysis of effluent quality data. To this end the DWF and quality of discharge from a WwTW forms the 'planned water quality'; that is the water quality the Environment Agency would expect if the WwTW was discharging at its DWF and discharge consent. The planned water quality has typically been based on the River Ecosystem Classification of a river reach.

6.3.5 In the foreseeable future, consent limits will be set with a view to meeting the requirements of the Water Framework Directive (WFD) whose aim is to ensure that good river quality standards are met throughout each waterbody. The intention is to set the discharge consent limits based upon the quality and volume of the receiving watercourse and the volume of wastewater effluent at the point of discharge. However, the means of applying these principles to an individual discharge when upstream quality is already unsatisfactory, or when upstream flow provides inadequate dilution to maintain 'good' quality status using best available techniques for treatment, is presently unclear.

6.3.6 To assess the impact of growth on water quality downstream of WwTW discharges, we have assessed the maximum number of houses likely to be connected to each WwTW. This has been used to identify whether a new consent would be required at the WwTW to accommodate proposed growth. If growth will not cause a breach of the current consented DWF then it is fair to assume that there will not be deterioration of planned water quality (that is the water quality the Environment Agency expects if a WwTW was discharging at its DWF and discharge consent).[95] To calculate the number of new houses and hence increases in DWF due to development the following assumptions have been made:

- proposed new housing draining to Cambridge WwTW = 30138 (including Southern Fringe, Cambridge East, North West sites, Orchard Park, Windfall development and student accommodation);
- proposed new housing draining to Uttons Drove WwTW = 11784 (including Cambourne and Northstowe);
- timing of development as outlined in Table 2-3 (based on 2009 housing trajectories);
- demand (in l/h/d) used the same assumptions as presented in the water resources evidence base;
- occupancy was assumed to be 2.1, and;
- infiltration was assumed to represent a further 30% increase in flows (to account for future infiltration)

6.3.7 A no deterioration assessment has then been carried out. This analysis has used the Environment Agency River Quality Planning (RQP) toolkit. The no deterioration assessment calculates the consent required at the WwTW to maintain the current WFD status with the addition of the 2031 growth flows. For this the upstream river flow and quality values and the future DWF are then entered into RQP with the current WFD status (as provided by the Environment Agency) used as the target value for downstream river quality. The future consents required to meet no deterioration of status are then calculated.

6.3.8 Further to the no deterioration analysis, an assessment has been made to establish whether growth is likely to make achievement of WFD good status unfeasible. To assess this, the consents required to meet good WFD status are calculated with the current consented flows and the 2026 growth flows. The difference between these consents determines whether the growth has an impact on the ability to meet good status.

6.3.9 This analysis has also used the Environment Agency River Quality Planning (RQP) toolkit. To calculate the consent required at the WwTW to meet WFD good status the upstream river flow and quality values and the current consented DWF are entered into RQP with WFD good status used as the target value for downstream river quality. The current consents required to meet WFD good status are then calculated. This process is then repeated with the 2026 growth DWF.

6.3.10 *Current environmental context*

6.3.11 The current WFD status has been assessed for each water body which the WwTW discharge into. As shown in the Swavesey Drain is currently meeting good ecological status. However, the

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[95] It is worth noting that even if growth will not cause breach of consented DWF at the WwTWs there may need to be tightening of discharge consents at the WwTWs to help meet the more stringent environmental standards required by the WFD. However, the purpose of the water quality assessment in a WCS is to identify where development may cause deterioration of water quality; the WCS does not consider the wider implications of meeting the WFD, which is beyond the scope and purpose of a WCS

River Cam is currently failing to meet good ecological status. The WFD states that all water bodies must reach good ecological status by 2027 at the latest.

	Water Framework Directive Classification Status of Waterbody						
Relevant WwTW	**Waterbody Name**	**Water Body ID**	**Overall Physico-chemical Status (EcoGen)**	**Overall Biological Status (EcoBio)**	**Overall HM Status (EcoHM)**	**Overall Ecological Status (EcoClass)**	**Ecological Status Objective (EcoObj)**
Uttons Drove WwTW	Swavesey Drain	GB105033042770	Not assessed	Good	Good	Good	Good ecological status by 2015
Cambridge WwTW	River Cam	GB105033042750	Poor (due to phosphate - other determinands are high	Moderate	Good	Moderate	Good chemical status by 2015; good ecological potential by 2027

Table 6-2 Current environmental context downstream of WwTWs

Symbol	Status
(blue)	High
(green)	Good
(yellow)	Moderate
(orange)	Poor
(white)	Not yet assessed
(black)	Other

6.3.12 Step 1 - Water quality and wastewater environmental capacity assessment

6.3.13 Table 6-3 shows the results of the initial environmental impact assessment.

6.3.14 Although Uttons Drove WwTW has a proposed revised AMP5 consent[96], the Phase 2 WCS has undertaken an assessment of the indicative consents needed to support planned growth. This can be used to provide information to support the application for a revised consent.

6.3.15 Cambridge WwTW also has a revised AMP5 consent. The revised consent includes an allowance for statistical variations but does not include any allowance for growth. To determine the environmental capacity for growth, we adopted the new flow compliance consent (37,330 m3/day) as the current baseline flow and consented quality and added the forecast flow from new residential and commercial developments to this up to and including 2031. This value includes the allowance for statistical variations, infiltration at its current rate, and has not assumed any per capita consumption reduction in demand for water, therefore is likely to be the maximum theoretical flow expected by 2031.

[96] Proposed revised consent: DWF = 6992 m3/d, BOD = 10 mg/l as a 95%ile, Ammonia = 5 mg/l as a 95%ile, Phosphate = no change

Relevant WwTW	Current consented information				Measured DWF (m3/d)	Predicted new dwellings to WwTW to 2031	Future DWF (m3/d)			
	BOD 95%ile mg/l	Amm 95%ile mg/l	P mean mg/l	DWF (m3/d)			2014 / 15	2019 / 20	2024 / 25	2030 / 31
Uttons Drove WwTW	17	9	2	3550	3333	11784	4,033	4,747	5,417	5,892
Cambridge WwTW	15	5	-	37330	27648	30138	40,199	42,428	43,624	44,248

Table 6-3 Initial environmental capacity assessment

6.3.16 Step 2 - Consents to meet no deterioration

6.3.17 No deterioration analysis has been carried out for both Cambridge WwTW and Uttons Drove WwTW to provide an estimate of the quality consent required to prevent a deterioration of the WwTW discharge.

6.3.18 Table 6-4 shows the results of the environmental capacity assessment for Cambridge WwTW. Where no consent change is needed, the value is **Green**. Where a consent change is needed, and the consent change can be achieved with future infrastructure provision, that is can be achieved with conventionally applied wastewater treatment technology, the consent value is ***Italicised Amber.*** Where a consent change is needed and it cannot be achieved with conventionally applied wastewater technology, the consent value is **Red.**

RIVER DOWNSTREAM OF DISCHARGE	Cambridge WwTW		
	BOD	Amm	P
Current Status			
Quality target (90-percentile mg/l)	4	1.1	1 (mean)
DISCHARGE QUALITY NEEDED			
Mean quality (mg/l)	-	-	3
95-percentile quality (mg/l)	***13***	**5**	-
Current Consent (95%ile)	15	5	-

Table 6-4 Consents required at Cambridge WwTW to ensure no deterioration

6.3.19 At Uttons Drove the physico-chemical status downstream of the WwTW has not been assessed as there has been no monitoring in Swavesey Drain prior to 2004. In the absence of observed water quality downstream of the works, the agreed approach with Anglian Water and the Environment Agency is to use undertake a Monte Carlo assessment using current upstream river flows and quality and measured WwTW flows and discharge to 'predict' what the downstream water quality might currently be. The assumptions made to predict downstream quality are shown in Table 6-5.

Determinand	Mean	Standard Deviation (unless otherwise stated)	Comments
Upstream river flow and quality			
River flow	Mean = 1210 m3/d	Q95 = 173 m3/d	
BOD	1.86 mg/l	1.12 mg/l	Assume mid-High Status u/s quality for all parameters. Mainly agricultural land with no major point source discharges. Likely optimistic for phosphate, but u/s quality unlikely to influence calculations due to v limited dilution.
Ammonia	0.07 mg/l	0.04 mg/l	
Phosphate	0.05 mg/l	0.05 mg/l	
Uttons Drove WwTW measured flow and discharge quality			
Flow	4332 m3/d	1430 m3/d	Anglian Water flow measurement gives DWF (10%) of 3333 m3/d. Mean flow calculated by DWF * 1.3, and standard deviation calculated by mean flow * 0.33
BOD	3.94 mg/l	2.40 mg/l	From EA sampling (Statistics include all sample data since last step change) BOD 16/07/04 – 26/03/10, Ammonia 10/09/04 – 19/03/10, Phosphate 03/02/05 – 26/03/10
Ammonia	2.85 mg/l	1.53 mg/l	
Phosphate	0.94 mg/l	0.33 mg/l	

Table 6-5 Parameters used to 'predict' WFD status downstream of Uttons Drove WwTW

6.3.20 The results of the assessment to predict downstream status indicate that for BOD the current predicted WFD status is ‘moderate’; therefore the no deterioration assessment should ensure no deterioration from ‘moderate’ status (target set at 6.5 mg/l as a 90%ile). For phosphate the current predicted WFD status is ‘poor’ (target for no deterioration set at 1 mg/l as an annual average mean). However, for ammonia the current predicted status is ‘bad’. No WFD target exists for bad status and therefore it was agreed to undertake a ‘load standstill’[97] calculation for ammonia.

[97] the load standstill calculation identifies the consents required at the WwTW to ensure no overall increase in load to the receiving watercourse with growth (where load = flow * concentration). These calculations provide an estimate of the quality consent required to prevent a deterioration of the WwTW discharge. They are not based on the requirements of the river (also known as ‘river needs consent’ or RNC), but will ensure that there will be no deterioration of water quality. They represent a worst-case scenario and will result in more stringent discharge consents than the 95% confidence assessment

6.3.21 The results of the no deterioration assessment are highlighted in Table 6-6. To ensure no deterioration of current predicted downstream WFD status for BOD would require a tightening of the BOD consent to 9 mg/l. The load standstill calculation for ammonia indicates that the consent would need to be tightened to 5 mg/l to maintain load from the WwTW. No tightening of the phosphate consent would be required to ensure no deterioration of current predicted WFD status. This assessment has been based on the best available information at the time of undertaking the Phase 2 WCS. As monitoring data becomes available downstream of the WwTW it will be necessary to re-assess the downstream WFD status and re-calculate the indicative revised consents. It is worth noting that the findings from the Phase 2 WCS assessment align with Anglian Water's proposed AMP5 consents of 10 mg/l for BOD, 5 mg/l for ammonia and 2 mg/l for phosphate.

RIVER DOWNSTREAM OF DISCHARGE	Uttons Drove WwTW		
	BOD	Amm	P
'Predicted' Current Status	Moderate	Bad	Poor
Quality target (90-percentile mg/l)	6.5	N/A	1 (mean)
DISCHARGE QUALITY NEEDED			
Mean quality (mg/l)	-	-	2
95-percentile quality (mg/l)	*9*	*5**	-
Current Consent (95%ile)	17	9	2 (mean)

Table 6-6 Consents required at Uttons Drove WwTW to ensure no deterioration

* = based on load standstill calculation

6.3.22 Step 3- Consents to achieve 'Good Status'

6.3.23 Further analysis has been undertaken to establish likely consents required to meet WFD good status and to assess whether growth will make it more difficult to achieve good status. These calculations are based on the assumption that the river upstream of the works is currently meeting WFD good status.

6.3.24 The River Cam downstream of Cambridge WwTW and Swavesey Drain downstream of Uttons Drove WwTW are classified as an upland and low alkalinity waterbody and therefore to meet WFD good status, must meet BOD 5 mg/l (90 percentile), ammonia 0.6 mg/l (90 percentile) and phosphate 0.12 mg/l (mean).

	Cambridge WwTW					
	Current consented DWF			2031 growth DWF		
RIVER D/S OF DISCHARGE	**BOD**	**Amm**	**P**	**BOD**	**Amm**	**P**
Quality Target (90-%ile) (mg/l)	5	0.6	0.12 (mean)	5	0.6	0.12 (mean)
DISCHARGE QUALITY NEEDED						
Mean Quality	-	-	**0.23**	-	-	**0.21**
95-%ile Quality (mg/l)	*11*	*2*	-	*10*	*2*	-
Current Consent (95%ile) (mg/l)	15	5	1 (mean)	15	5	1 (mean)

Table 6-7 WFD good ecological status analysis – Cambridge WwTW

	Uttons Drove WwTW					
	Current consented DWF			2026 growth DWF		
RIVER D/S OF DISCHARGE	**BOD**	**Amm**	**P**	**BOD**	**Amm**	**P**
Quality Target (90-%ile)	5	0.6	0.12 (mean)	5	0.6	0.12 (mean)
DISCHARGE QUALITY NEEDED						
Mean Quality	-	-	**0.13**	-	-	**0.12**
95-%ile Quality	*6*	*1*	-	*6*	*1*	-
Current Consent (95%ile)	17	9	2 (mean)	17	9	2 (mean)

Table 6-8 WFD good ecological status analysis – Uttons Drove WwTW

6.3.25 The results of this assessment, presented in Table 6-7 and Table 6-8, indicate that growth will **not** make it more difficult to achieve good physico-chemical status downstream of the WwTW. For BOD and ammonia the indicative consents would be within the current limits of conventional technology with and without growth. However, for both works, phosphate consents would need to be set significantly beyond the current limits of conventional technology with and without growth.

6.3.26 *Conclusions*

6.3.27 At Cambridge WwTW, up to and including 2031, no consent change is required for ammonia to ensure no deterioration of the current WFD status downstream of the treatment works. However, the BOD consent will require marginal tightening from 15mg/l to 13mg/l, and a phosphate consent of 3 mg/l would be required (current phosphate discharge is 0.73 mg/l).

6.3.28 However, to meet WFD good status at Cambridge WwTW with 2031 growth flows, the BOD and ammonia consent would require tightening and that this is achievable with conventionally applied wastewater treatment technology. This analysis therefore shows that BOD and ammonia are not constraints to growth.

6.3.29 To meet good status for phosphate at Cambridge WwTW with the current population, even assuming the river quality upstream of the treatment works is good status, would require a mean annual average discharge consent of 0.23 mg/l. This is significantly beyond what can be achieved by current sewage treatment technology (1 mg/l). To meet good status for phosphate with the 2031 population tightens this consent from 0.23mg/l to 0.21mg/l.

6.3.30 At Uttons Drove WwTW the no deterioration assessment has been based on a predictive assessment of downstream water quality. Nevertheless the analysis has indicated that the BOD consent would need to be tightened to 9 mg/l and ammonia consent would need to be tightened to 5 mg/l to ensure no deterioration, based on the growth numbers used in the Phase 2 WCS. The findings of the Phase 2 WCS WFD assessment are aligned with Anglian Water's proposed AMP5 consents.

6.3.31 To meet good status at Uttons Drove would require tightening of the BOD and ammonia consents; however this would be within the limits of conventional technology. To meet good WFD status for phosphate would require a consent of 0.12 mg/l with growth and 0.13 mg/l without any growth. This is significantly beyond what can be achieved by current sewage treatment technology.

6.3.32 Our interpretation of the current policy on assessing WFD consents in water cycle studies is that where WFD status cannot be met with the current population with conventionally applied sewage treatment technology, growth *per se* should not be considered a barrier to achieving good ecological status, subject to the assessment showing there will be no deterioration of current status.

6.3.33 Therefore, water quality environmental capacity and WFD compliance should not be a constraint to growth at Cambridge WwTW or Uttons Drove WwTW. The Environment Agency is responsible for determining through the RBMP if and when the consent will need to be tightened to achieve good ecological status for BOD and Ammonia, and securing water company funding for any infrastructure requirements that will be required as part of the National Environment Programme section of the appropriate Periodic Review.

6.4 Wastewater networks

6.4.1 Additional housing growth will cause an increase in foul flows to the wastewater network. If no mitigation is put in place there is a risk that flooding due to under capacity and pollution due to overflows from the network could increase. The Phase 2 WCS summarises AWS' preferred strategy to upgrade the wastewater networks to accommodate planned growth.

6.4.2 Cambridge catchment

6.4.3 The Phase 1 WCS and the Cambridge wastewater capacity study provided full details of the potential impact of growth on the wastewater network. For the Phase 2 WCS, a summary of the key issues and proposed mitigation are outlined in Table 6-9.

Site name	Impact on sewer network	Proposed mitigation
Huntingdon / Madingley Rd (university site)	Site would connect to sewer in Madingley Road, which would cause increase in sewer flooding.	Connect development downstream of Madingley Road (1000m from site) on the 600mm diameter sewer
NIAB 1 NIAB 2	Preferred drainage route is to drain to sewer in Windsor Road, and development would increase risk of flooding on Huntingdon Road or Windsor Road	Connect and upgrade the local sewer in Windsor Road to allow connection to the tunnel sewer
Orchard Park	Development served by 450mm trunk sewer which has capacity for the remainder of the development site	No mitigation required
North of Newmarket Road	Local sewer network in Newmarket Road could accommodate some of development, but there is insufficient current capacity to accommodate all development	Direct connection to WwTW is likely to be the preferred option There is also capacity in the sewer network at Coldhams Common (however a direct route to the sewer may need to pass through Cambridge Airport site)
Cambridge Airport	Preferred drainage route is to the sewer in Bramwell Road, which does not have sufficient capacity for the development	Connect site into tunnel sewer crossing Coldhams Common
North of Cherry Hinton	This site would connect to the sewer crossing Coldhams Common which has sufficient capacity	No mitigation required
Bell School (inc. Addenbrooke's Biomedical Campus)	This site connects to the sewer at Hills Road (and Mowbray Road), which should have sufficient capacity	Preferred option is not likely to require any upgrades to the network Depending on the flows from Addenbrooke's there may be a requirement to divert flows from Great Shelford to Sawston WwTW
Clay Farm	This site will connect to the sewer in Shelford Road, where there is limited capacity for growth	There is capacity available at the junction of Long Road and Mowbray Road for this site, and a new pumped sewer will be required to connect at this location
Glebe Farm	This site will connect to the sewer in Shelford Road, where there is limited capacity for growth	There is capacity available at the junction of Long Road and Mowbray Road for this site, and a new pumped sewer will be required to connect at this location
Trumpington	This site will connect to the sewer in High Street and will require upgrades	Two online storage tanks are proposed, but further assessments may be needed

Site name	Impact on sewer network	Proposed mitigation
Meadows	to accommodate development	to identify the cumulative impacts of Bell School, Clay Farm, Glebe Farm and Trumpington Meadows on the sewer at Mowbray Road

Table 6-9 Summary of impact of growth on wastewater network (adapted from Phase 1 WCS and Cambridge wastewater capacity study)

6.4.4 *Uttons Drove catchment*

6.4.5 As discussed in section 6.1.2, AWS' preferred strategy is to drain additional development from Cambourne and Northstowe to Uttons Drove WwTW. To accommodate additional flows from the Cambourne extension and the Northstowe development, the following upgrades to the wastewater network are proposed:

- upgrades to the Cambourne network to accommodate the additional 950 homes;
- a foul water pumping station at Northstowe;
- a new foul water rising main from Northstowe to Uttons Drove (6km in length at 400mm diameter to accommodate peak 3 x DWF);
- upgrading of pumping station which serves Swavesey Drain.

6.4.6 The wastewater network upgrades will need to be provided in line with the development to ensure that infrastructure is provided in a timely manner.

6.5 Summary of evidence base

6.5.1 AWS are progressing their preferred wastewater strategy to accommodate development of the major growth sites in and around Cambridge. Upgrades will be required at both Cambridge and Uttons Drove WwTW, and the networks which drain flows to these works will also require localised upgrading. Upgrades to the WwTW and the wastewater networks will be funded through Periodic Review process and Requisition under Section 98 of Water Industry Act[98].

6.5.2 With respect to wastewater and water quality, the Phase 2 WCS has demonstrated that there are no environmental constraints to growth. In particular:

- although new consents will be required at both Cambridge and Uttons Drove WwTWs to ensure no deterioration of current WFD status, these will be within the limits of conventional technology for sewage treatment;
- growth will not hinder the ability of the receiving water bodies achieving good physico-chemical status, as required by the WFD, and;

[98] Under Section 98 of the Water Industry Act (1991) it is the duty of water and sewerage companies to provide a public sewer for domestic purposes if required to do so by a requisitioner (the requisitioner will pay for the services [in the case of housing development the developer would be the requisitioner]). The water and sewerage company will be responsible for the design and construction of upgrades to the sewer network and adopting the sewer once built.

- the discharge volumes from the combined sewer overflows is not anticipated to increase due to the major growth sites, but there is a risk it could increase due to additional flows from infill development (see Phase 1 WCS).

6.5.3 Flood risk downstream of the WwTW due to an increase in treated sewage effluent has also been assessed in the Phase 2 WCS. At Cambridge WwTW the risk of increased flood risk has been assessed to be low due to planned development up to 2031; therefore no mitigation will be required.

6.5.4 At Uttons Drove, the preferred land drainage solution to resolve the flood risk issues, needs to be progressed prior to the additional development at Cambourne and Northstowe.

6.6 Recommendations

6.6.1 Actions within steering group control

6.6.2 The specific recommendations and implementation themes from the Phase 2 WCS are summarised in the box below and expanded upon in subsequent paragraphs illustrating actions and responsibilities.

REC WW1: Planning policy recommendation: wastewater infrastructure

- Planning permission will only be granted for developments which increase the demand for off-site service infrastructure where:
  - sufficient infrastructure or environmental capacity already exists or
  - extra capacity can be provided in time to serve the development which will ensure that the environment and the amenities of local residents are not adversely affected.
- When there is a capacity problem and improvements in off-site infrastructure are not programmed, planning permission will only be granted where the developer funds appropriate improvements which will be completed prior to occupation of the development, or where the water company confirms the off-site infrastructure can be provided in a timely manner.

REC WW2: Ensure sufficient infrastructure capacity exists within the wastewater network

Anglian Water should progress their preferred solution for Cambridge and Uttons Drove WwTW and the wastewater networks which drain to them

REC WW3: Protection of receiving watercourses from wastewater discharges

New development should not cause deterioration of receiving water quality or an increase in flood risk from increased wastewater discharges. The Environment Agency should confirm the discharge consents required at both works and progress this through the National Environment Programme, and the preferred land drainage solution at Uttons Drove and Webbs Hole Sluice should be progressed to enable development at Cambourne and Northstowe.

6.6.3 **REC WW1: Implement planning policies**

6.6.4 In addition to developing planning policies , local planning authorities should ensure the following considerations have been demonstrated in planning applications:

- there is a foul drainage strategy which outlines how foul drainage will drain and connect to the main wastewater network;

- there is sufficient infrastructure capacity at the relevant WwTW to accommodate the additional flows from the development site, or the capacity can be provided in a timely manner;
- there is sufficient infrastructure capacity in the wastewater network to accommodate the additional flows from the development site, or the capacity can be provided in a timely manner, and;
- provide evidence of negotiations with the incumbent water and sewerage company.

6.6.5 **REC WW2: Ensure sufficient capacity exists within wastewater network**

6.6.6 Anglian Water should progress their preferred solution at both WwTW and the wastewater networks, as outlined in the Phase 2 WCS.

6.6.7 Cambridge City Council and Anglian Water should continue to work together to confirm discharge rates from the biomedical campus, and hence identify the potential requirement to divert flows from Great Shelford to Sawston WwTW, as identified in the Southern Fringe capacity study.

6.6.8 As infill development comes forward, the potential impact on discharges from the CSOs should be evaluated, and if necessary upgrades to the network will be required to prevent an increase in CSO discharges.

6.6.9 **REC WW3: Protection of receiving watercourses from wastewater discharges**

6.6.10 To ensure no increase in flood risk downstream of development, and to protect water quality in the receiving watercourses (from wastewater discharges) the following actions should be progressed:

- the Environment Agency should confirm the discharge consents required at both Cambridge and Uttons Drove WwTW to ensure no deterioration of current WFD class and progress these consents with Anglian Water through the National Environment Programme;
- the Environment Agency should update the WFD assessment for Uttons Drove WwTW once monitoring sufficient monitoring data is available to identify the current WFD status downstream of the WwTW, and;
- the preferred land drainage solution at Webbs Hole Sluice should progress towards implementation.

7 Ecological assessment

7.1 Introduction

7.1.1 Habitats and species of European nature conservation importance are protected by *EU Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Flora and Fauna* (the 'Habitats Directive'). Member States are required to identify internationally important sites that are designated for their nature conservation value, known as Special Areas of Conservation (SAC). *EU Directive 79/409/EEC on the Conservation of Wild Birds* (the 'Birds Directive') similarly requires the identification of sites of international value for birds, known as Special Protection Areas (SPA). Collectively, SACs and SPAs are termed 'European (designated) sites'.

7.1.2 Articles 6 (3) and 6 (4) of the Habitats Directive require Appropriate Assessment (AA) to be undertaken on proposed plans or projects which are likely to have a significant effect on any European site. The purpose of AA is to assess whether a proposed plan or project, alone or in combination with other plans and projects, would have impacts on the conservation objectives of any European site and adversely affect a site's integrity. Where significant negative effects are identified, avoidance, mitigation measures or alternative options need to be adopted in order to prevent damaging effects. This requirement was transposed into UK law in 2007 in Part IVA of the Habitats Regulations, which defines the requirements for Habitats Regulations Assessments (HRA) to encompass the Habitats Directive AA requirement.

7.1.3 The HRA process is generally divided into three stages:

- Stage 1 - Screening – describes the plan or project, and identifies any European Sites which might potentially be affected. Where it can be concluded that effects are unlikely, this is reported via a 'finding of no significant effect report'. Where there is insufficient information to conclude this, or where effects are considered likely, proceed to Stage 2.
- Stage 2 – Appropriate Assessment – collates information sufficient to predict and evaluate impacts on European site conservation objectives. Where impacts are considered to affect qualifying features, Stage 2 should identify alternative options. If no alternatives exist, it should define and evaluate mitigation measures where necessary. If effects remain after all alternatives and mitigation measures have been considered proceed to Stage 3.
- Stage 3 – Where no alternatives exist and adverse impacts remain after taking into account mitigation, Stage 3 should confirm 'imperative reasons for overriding public interest' (IROPI) associated with the plan or project, and identify0020compensatory measures to offset the adverse impact on conservation objectives.

7.1.4 The Cambridge WCS is not in itself a recognised Habitats Regulation Assessment because it only considers specific water environment constraints and opportunities associated with delivering the strategy in the Cambridge Local Plan and South Cambridgeshire Local Development Framework. The assessment in the Phase 2 WCS is intended to inform any HRA needed for future reviews of the Local Development Frameworks for the Cambridge City and South Cambridgeshire areas..

7.2 *Scope of assessment*

7.2.1 The assessment in the Phase 2 WCS documents the conclusions of screening undertaken for the *water environment consequences only* of proposed development within and around Cambridge and at associated satellite sites at Northstowe and Cambourne. Proposals considered relate to the water supply, surface drainage and wastewater sewerage associated with potential development sites.

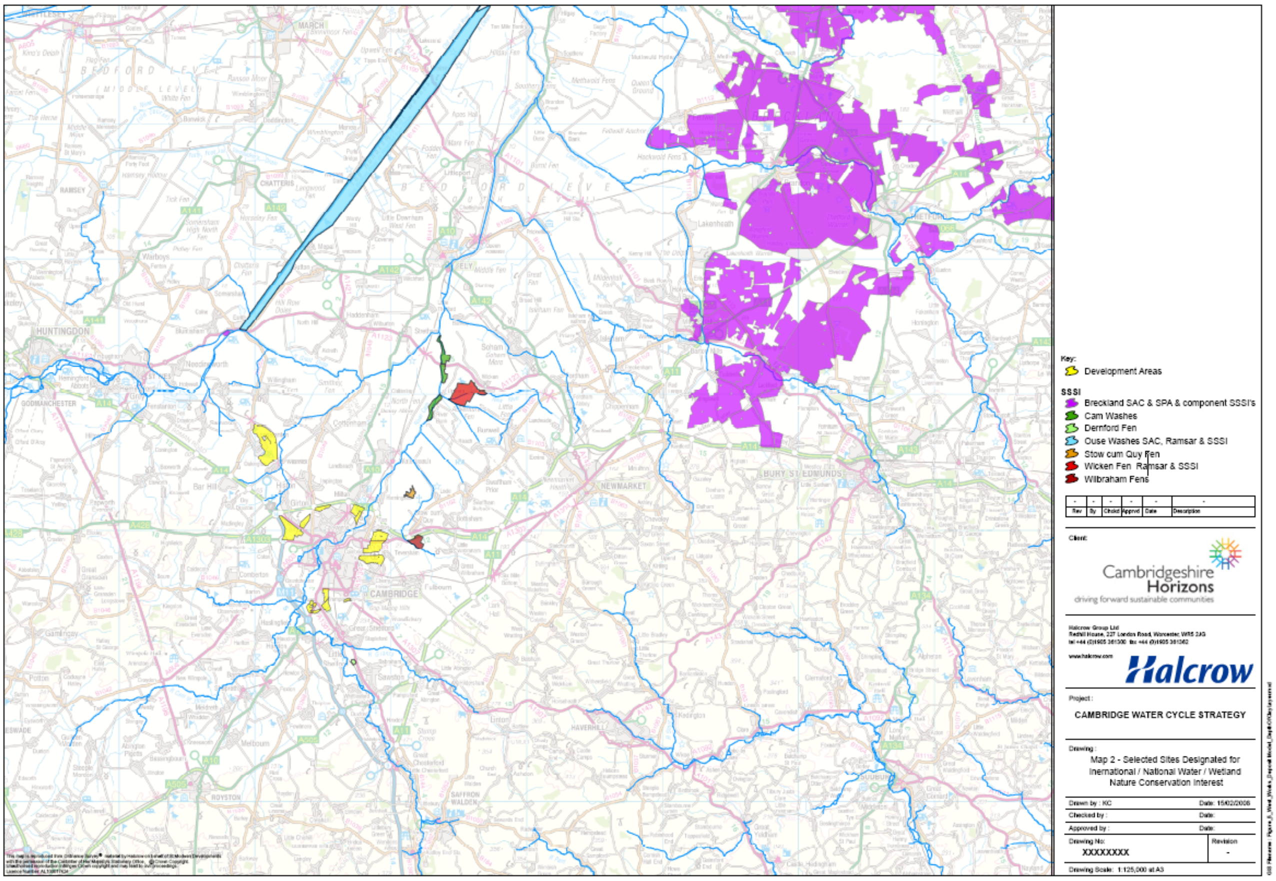

Figure 7-1 Locations of European Sites Subject to Detailed Screening Assessment (from Cambridge WCS Phase 1)

7.2.2 The approach follows that in *Planning for the Protection of European Sites: Appropriate Assessment*[99]. In relation to the Screening stage, the DCLG guidance proposes that the precautionary principle is used in assessing whether effects may be significant, meaning that where there is uncertainty in the possible effects it should be assessed in more detail.

[99] http://www.communities.gov.uk/archived/publications/planningandbuilding/planning2

7.2.3 The DCLG guidance also states that areas designated as globally important wetlands under the Ramsar Convention (1971) should also be given the same level of protection as SAC and SPA designations in the HRA process.

7.2.4 DCLG guidance states that HRA Screening must consider an appropriate level of information, and that best practice would be to collect information in relation to:

- European sites within and outside the plan that are potentially affected;
- The characteristics of these European sites;
- Their conservation objectives;
- Other relevant plans and projects.

7.2.5 This assessment applies two levels of screening. Initial coarse screening to identify sites potentially at risk due to hypothetical changes in the water cycle that could result from additional development in the area; followed by more detailed screening which considers the specific proposals that are encompassed within the Cambridge WCS and reported in the Phase 1 WCS Under this approach, the European sites' characteristics and conservation objectives would only be reported if there is a potential for any effects as a result of changes in water management.

7.2.6 The Habitats Regulations require that the competent authority consults the statutory nature conservation body (Natural England) as part of the HRA. The Cambridge WCS is not a plan or project in the context of the HRA, but Cambridgeshire Horizons has undertaken consultation with Natural England on the proposals and water cycle projections as detailed by Halcrow (2008).

7.3 Identification of the European Sites Relevant to Cambridge WCS

7.3.1 As part of the coarse screening, European sites were identified as potentially relevant to this assessment where:

- They are either:
  - directly associated with a proposed development site, and therefore potentially vulnerable to local changes in runoff, drainage etc; or
  - associated with an area from which new water abstraction would be required, and therefore potentially vulnerable to changes in water quantity; or
  - associated with a watercourse downstream of any potential development site or sewage treatment works serving any new development, and therefore potentially vulnerable to changes in water quantity and quality;
- And they are sensitive to changes in water quantity or water quality.

7.3.2 The European sites identified as potentially relevant to this assessment on the basis of these criteria (and shown on Figure 7-1) are:

- Breckland SAC and SPA;
- Ouse Washes SAC and Ramsar site;
- Wicken Fen Ramsar site.

7.3.3 Additional European sites which are within c.10km of any proposed development area have been screened out as they do not meet any of the criteria outlined above in Section 4.1, as follows:

- Eversden and Wimpole Woods SAC;
- Fenland SAC;
- Portholme SAC.

7.4 Coarse Screening Assessment

7.4.1 Wicken Fen Ramsar site

7.4.2 This wetland site is located c.1km at its nearest point east of the Cam valley, downstream of Cambridge. The Cam receives treated sewage discharges from Cambridge wastewater treatment works (WwTW), just south of the A11 at Cambridge. That WwTW would receive additional effluent in the future from proposed developments at Cambridge, with potential consequences for downstream flows and water quality.

7.4.3 However, analysis of hydrology[100] indicates that Wicken Fen is topographically higher than the Cam and drains via Wicken Lode then Burwell Lode towards it. As it is not fed by the Cam, there are no associated risks which could arise from additional sewage effluent discharge at Cambridge irrespective of any changes in effluent flow or quality from that site, so such scenarios have not been considered further in this assessment.

7.4.4 Wicken Fen Ramsar site can be **screened out** of any further assessment.

7.5 Detailed Screening Assessment

7.5.1 Breckland SAC and SPA

7.5.2 Breckland SPA occupies a large number of separate compartments over a wide area between Bury St Edmunds in the south and Swaffham in the north, encompassing Thetford between the two. Some of the compartments (or parts of compartments) are also designated as component sites of Breckland SAC, but these are considerably less extensive.

7.5.3 Breckland SPA is designated for stone curlew, nightjar and woodlark, none of which are associated with water or wetland habitats. Breckland SAC is mostly associated with dry grassland (59%) and heath (20%), plus various woodland types (19%). Water and wetland habitats are relatively limited, totalling only 1.5% of the area and comprising a mix of rivers, standing waters, fens, bog and marsh.

7.5.4 The HRA consideration under the Cambridge WCS relates to the *potential* to secure additional public water supply from existing major groundwater boreholes to the east of Thetford, and the effects that this could have on groundwater levels and on associated hydrological connections with habitats within the SPA or SAC.

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[100] Gilman, K. (1988), *The hydrology of Wicken Fen. Final Report.* NERC/Institute of Hydrology, 43pp & McCartney, M.P., de la Hera, A., Acreman, M.C. and Mountford, O. (2001) *An investigation of the water budget of Wicken Fen*. Wallingford, NERC/Centre for Ecology & Hydrology, 42pp

7.5.5 The existing boreholes are located near Euston in The Black Bourn valley and at Brettenham in the River Thet valley. Neither borehole site is directly associated with any Breckland SPA compartment. However, there are SPA compartments associated with the Little Ouse River valley downstream of Euston and the River Thet valley downstream of Brettenham.

7.5.6 Additionally, the Environment Agency's characterisation of river basins under the Water Framework Directive[101] has identified that Breckland has a number of groundwater-dependent terrestrial ecosystems (GWDTE), i.e. wetland systems that are supplied by groundwater as opposed to river water or direct rainfall and overland flow. Drawdown of groundwater levels as a result of additional abstraction could result in damage to associated GWDTEs.

7.5.7 Since the groundwater aquifer has been identified as vulnerable to over-abstraction, no new consumptive abstractions will be licensed by the Environment Agency.

7.5.8 Cambridge Water Company's strategy to provide additional public water supply to developments at Cambridge would include abstracting the full licensed amount from the boreholes in the Thetford area with no additional abstraction over and above this. Additionally, the bulk transfer infrastructure owned and operated by Cambridge Water Company to transfer water from Thetford to Cambridge would not require modification.

7.5.9 Between 2000 and 2010 the Environment Agency reviewed all permissions that were granted before the Habitats Regulations came into force (the 'review of consents'). Thus the abstraction licences currently in force at Euston and Brettenham have been considered to have acceptable levels of risk of groundwater drawdown within the Breckland European sites. Since this licensed abstraction will not change with the proposed developments at Cambridge, there is no risk that these would have an adverse impact on any Breckland SPA or SAC conservation objectives.

7.5.10 Thus, Breckland SPA and SAC can be **screened out** of any further assessment.

7.5.11 *Ouse Washes SAC and Ramsar site*

7.5.12 Ouse Washes SAC, Ramsar site and SSSI lies between the New Bedford River and the Old Bedford River to the east of Earith. The site is seasonally-flooded washland, internationally important for birds. Recent reports identify that water levels across the Ouse Washes are increasingly too high in the Spring and Summer as a result of impeded seasonal drainage which itself is consequent upon siltation in the Hundred Foot Drain.

7.5.13 Potential concerns associated with the Cambridge WCS are related to the discharge of sewage via the Uttons Drove WwTW, which would serve the proposed development at Northstowe. This discharges to the Swavesey Drain which in turn feeds into the River Great Ouse upstream of Ouse Washes. Significant additional flow could exacerbate the existing problem associated with high Spring / Summer water levels. Significant deterioration in sewage effluent quality could also have adverse effects on standing water quality at Ouse Washes. However, any such risks need to be considered in the context of the following:

[101] Environment Agency (2009), River Basin Management Plan for the Anglian River Basin District, December 2009

7.5.14 The distance from Uttons Drove WwTW to Ouse Washes is greater than 10 km by river, providing for considerable dilution and dispersal of any contamination between this potential source and potential receptor.

7.5.15 The WwTW can make only a very minor contribution to total flow at Ouse Washes, since the total catchment draining to the River Great Ouse at Earith is approximately 3000 km^2 [102]For comparison, the mean flow from the sewage works discharge is currently estimated at 4332 m^3/day compared a mean flow in the Ouse in excess of 1,185,408 m^3/day (which is the flow at Offord, upstream of Earith)[103].

7.5.16 The current consented dry weather flow (i.e. foul sewage excluding surface drainage) at the works is 3350 m^3/day. However, Anglian Water plc has submitted a proposal to Ofwat under PRO9 (i.e. spending proposals for the period 2010 to 2015) to increase the consent to 6992 m^3/day. Whilst the existing consent would not be able to accommodate additional influent from proposed development at Northstowe, the proposed new consent would.

7.5.17 The proposed revised consent would have associated improvements in effluent quality, to ensure no deterioration in downstream water quality, specifically tightening of effluent quality to:

- Biochemical Oxygen Demand - 10 mg/l (evidence in the Phase 2 WCS indicates the consent might need to be set to 9 mg/l to ensure no deterioration);
- Ammonia - 5 mg/l;
- Phosphate - 2 mg/l.

7.5.18 Thus, any requirement for HRA associated with additional sewage discharge arising at Northstowe rests with Anglian Water Services as the body promoting the change in consented discharge and the Environment Agency as the competent authority considering that revised consent. Subject to a favourable outcome, no further assessment would be required in relation to the Cambridge WCS.

7.5.19 Additional flow in the Swavesey Drain network could potentially result from an increase in the rate of surface runoff into watercourses as development is established at the Northstowe greenfield site. However, as this is being promoted as an Eco-Town it will have a high level of surface water attenuation which, with proposed on-site flood storage for events up to those with a 1 in 200 chance of occurring in any year, would result in run-off rates lower than existing greenfield.

7.5.20 Thus, Ouse Washes SAC and Ramsar site can be **screened out** of any further assessment, but it is noted that implementation of the Northstowe development as planned is subject to approval of the proposed consent revision at Uttons Drove sewage treatment works.

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[102] Environment Agency (2005), *The Upper Ouse and Bedford Ouse Catchment Abstraction Management Strategy*, March 2005

[103] http://www.nerc-wallingford.ac.uk/ih/nrfa/station_summaries/033/026.html

7.6 Summary of evidence base

7.6.1 The Major Sites in and around Cambridge WCS is not in itself a recognised Habitats Regulation Assessment because it only considers specific water environment constraints and opportunities associated with delivering the strategy in the Cambridge Local Plan and South Cambridgeshire Local Development Framework. The assessment in the Phase 2 WCS is intended to inform any HRA needed for future reviews of the Local Development Frameworks for the Cambridge City and South Cambridgeshire areas.

7.6.2 This assessment has followed DCLG guidance on HRA. Coarse screening has identified three European sites with the potential to be affected by hypothetical water management changes associated with proposed new developments around Cambridge. One of these (Wicken Fen Ramsar site) was discounted at the coarse screening stage since its hydrology cannot be affected by any of the proposed developments. The others (Breckland SAC and SPA and Ouse Washes SAC and Ramsar site) were discounted at the more detailed screening stage as it has been determined that the proposals will not have any discernible effect on their hydrology or water quality.

7.6.3 Thus, it can be concluded that No Significant Effect would result from implementing the proposals and projections that are identified in the Cambridge WCS, noting that this assessment has only considered water environment consequences

8 Appendix A Current water resources situation and water company strategy

8.1 Water Company Demand Forecast

8.1.1 Cambridge Water Company's (CWC) final Water Resource Management Plan (WRMP10) identifies that there is no immediate threat to water resources within the Cambridge Water Resource Zone, and that there is capacity within its current licensed abstractions for the forecast development. CWC's baseline supply-demand forecast to 2035 is shown in Figure 8-1. The forecast population used by CWC assumes that average build rates are closely aligned with the Regional Spatial Strategy (RSS) (now revoked), though total numbers predicted exceed the RSS target by 60%, based on historical data and the water company's experience. It must also be noted that the WRMP10 continues to 2035, whereas the RSS was only to continue to 2031.

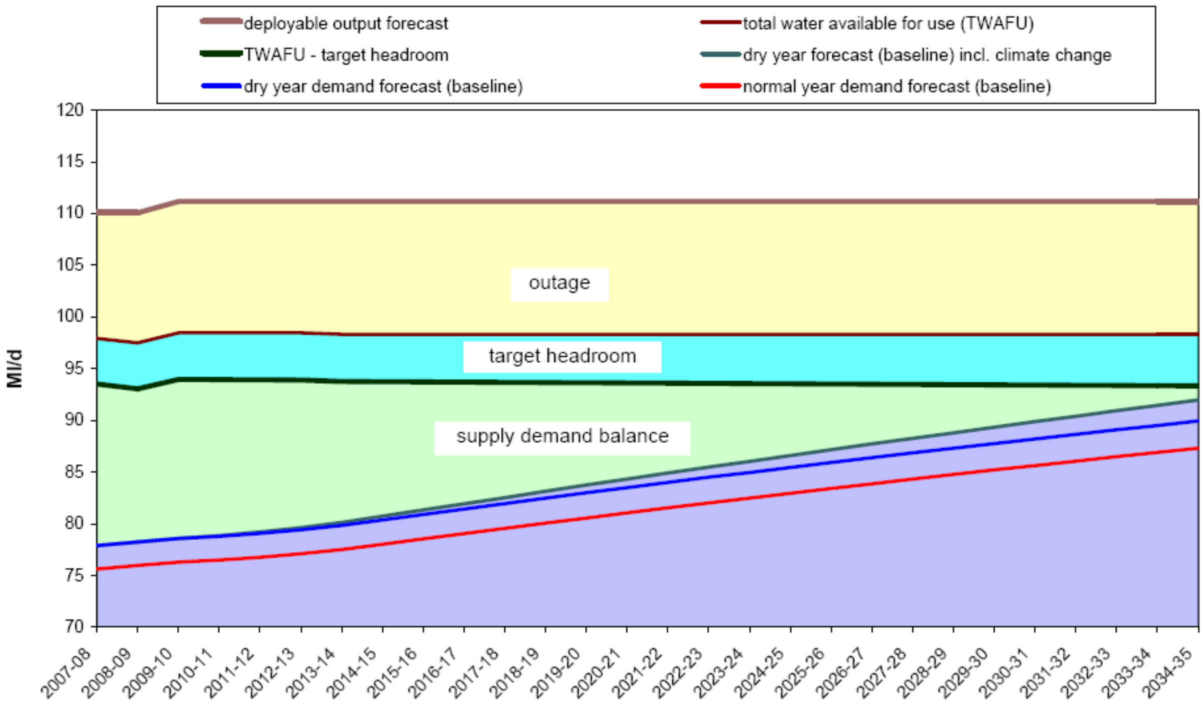

Figure 8-1 CWC Baseline Forecast (CWC WRMP, 2010)

8.1.2 All the analysis within the WRMP10 undergoes a rigorous testing and review process with Defra, Ofwat and the Environment Agency, as well as public consultation.

8.1.3 This Water Cycle Study (WCS) does not therefore include any additional testing of the WRMP10 itself. Instead it uses the information provided within the WRMP as a starting point to investigate and assess alternative scenarios which could be achieved through various water efficiency options within the study area.

8.1.4 The water company has a statutory requirement to supply water to a specific level of service. The way that it is regulated means that it cannot rely on promises by developers or local authorities to manage demand. Hence, the per capita consumption scenarios used by CWC in its demand assessment do not look at more aspirational demand management scenarios: these can only be achieved with strong planning policies and tend to be highly dependent upon behavioural change by the consumer, which means they have uncertain outcomes. It is also worth noting that CWC do not have a supply-demand driver to look at more aspirational demand management scenarios as the WRMP10 shows the company will remand in surplus up to 2035.

8.1.5 There is currently no supply-demand deficit within the CWC WRZ, and the WRMP10 indicates no immediate threat to water resources. Thus the WRMP10 contains no final planning solution or implementation of water efficiency measures beyond the following:

- A year on year reduction in average PCC of 1 l/h/d, by such means as: free Hippos (cistern displacement device), tap re-washering service, free metering, welcome packs, auditing and customer water awareness educational programs.
- Reduction in leakage to maintain a total leakage of 14 Ml/d, effectively reducing per property leakage by 35% (37 l/d) by 2035.

8.1.6 Nonetheless, CWC does continue to support water efficiency initiatives, educational projects and development of new technologies such as greywater and rainwater harvesting.

8.1.7 Although the forecast demand can be met according to CWC's WRMP10 planning scenarios, there are significant arguments in favour of doing more to limit the increase in water demand associated with new development. These include:

- The study area is in an area of serious water stress as designated by the Environment Agency, and any increase in population numbers will lead to an unwelcome increase in the demand for water unless demand is managed.
- The existing risk of sustainability reductions in deployable output that may be invoked by the Environment Agency under its Restoring Sustainable Abstractions Programme, reducing licensed abstraction capacity in the future.
- The high environmental cost of treating and supplying water (in terms of energy and carbon footprint).

8.1.8 Additionally, any further abstraction will have an impact on groundwater levels or river flows, even though these levels have been determined to be 'environmentally acceptable' by the Environment Agency by virtue of granting a licence.

8.1.9 CWC has assumed, in accordance with Environment Agency guidelines, that there will be no change to existing licence agreements or headroom allowances (other to any already proposed). The current relevant Catchment Abstraction Management Strategies (CAMS)[104] do not recommend any sustainability reductions on existing CWC licences, and the Environment Agency's water resources planning team has stated that it does not expect to introduce any until at

[104] Cam and Ely Ouse; Upper Ouse and Bedford

least 2014 (when the next CAMS cycle is complete and the final documents published). This means that the existing licensed levels of abstraction are secure, to the best of current knowledge, until at least 2014.

8.1.10 If CWC's abstraction licences are not renewed to their current quota in 2015, this could reduce the water available for use. In addition, if demand were to increase beyond current projections, for example due to additional population growth or increasing consumption, this could also have serious implications for the availability of water resources. Whilst CWC is required to operate on a presumption of renewal, it is nonetheless highly recommended that all practicable measures are taken to reduce future consumption across the study area.

8.1.11 Ultimately, the best demand management planning scenario is one which is 'water neutral' or lower. That is, over the entire study area the total demand for water does not increase with new development. This is difficult to achieve and often requires the retrofitting of extensive demand management measures within the existing urban area. There is a balance to be struck between desirability, achievability and cost. This WCS therefore considers potential alternative demand management scenarios to assess where this balance may lie for the study area under consideration.

9 Appendix B Water conservation policy

9.1 *Water Policy Summary*

9.1.1 New development within the WCS area is affected by a number of national, regional and local policies. These are summarised below:

<u>National</u>

- **Future Water**[105] – The Governments Water Strategy for England (DEFRA, 2008). Vision to reduce water to 130 or 120 l/h/d by 2030 dependant on technological developments and innovation.
- **Building Regulations**[106] - Part G, as amended 2009 (CLG, 2000). Limits calculated water consumption of a new building to 125 l/h/d.
- **Code for Sustainable Homes (CSH)**[107] – (CLG, 2006). Environmental assessment method for rating and certifying the performance of new homes over 6 levels. Mandatory rating for new homes required since 2008.
- **Building a Greener Future**[108] – Policy Statement (CLG, 2007). Target of all homes to be zero carbon by 2016 (CSH Level 6), aided by progressive tightening of Building Regulations.
- **Sustainable New Homes: The Road to Zero Carbon**[109] - (CLG, 2009). Proposals to update and align the requirements of the CSH with Policy Statement: Building a Greener Future.

<u>Local</u>[110]

- **Local Development Framework** - (SCDC, CCC). A suite of documents guiding future developments

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105 http://www.defra.gov.uk/environment/quality/water/strategy/pdf/future-water.pdf

106 http://www.planningportal.gov.uk/uploads/br/BR_PDF_draftADG_2009.pdf

107 http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf

108 http://www.communities.gov.uk/documents/planningandbuilding/pdf/building-greener.pdf

109 http://www.communities.gov.uk/documents/planningandbuilding/pdf/1415525.pdf

110 Under the coalition Government proposals the East of England Plan will no longer exist, and therefore there is a greater need for clear evidence and policy justification at the local level

Environment Agency

9.1.2 The Environment Agency has stated that in water stressed areas (including this study area) the introduction of universal metering needs to be undertaken earlier. The Environment Agency would like to see the majority of households in areas where water is scarce to be metered by 2015 with the remainder in water scarce areas being metered by 2020. It requires water resources plans to employ a 'twin track' management approach regarding supply and demand.

9.1.3 The Environment Agency recommends that measures are adopted to allow the efficient use of water in all new homes with water efficiency set at 105 litres pre head per day (i.e. level 3/4 for water within Code for Sustainable Homes) or better[111].

9.1.4 Generally, the time at which developments gain planning approval determines the water conservation policy that is applicable, due to the timeline of recent and future policy changes Table 9-1 below summarises the proposed and current development sites, planning status, relevant key policy for each and required water efficiency levels.

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[111] http://wfdconsultation.environment-agency.gov.uk/wfdcms/en/anglian/Intro.aspx (see Annex C, page 79)

Site	Map Reference	Planning Status	Key Relevant (Adopted) Site Specific Policy	Required Water Efficiency Level
Southern Fringe				
Trumpington Meadows	l	Outline approved and Section 106 agreement signed for 1,200 dwellings with associated infrastructure. First phase reserved matters application expected late 2010	Cambridge Local Plan (2006), Southern Fringe AAP; South Cambs DC Development Control Policies DPD	Required reduction on conventional housing demand of approximately 25%. Required consumption approximately 113 l/h/d. CSH Level 3 agreed through negotiations with developer (CSH Level 4 for affordable housing).
Bell School	i	Outline approved subject to completion of Section 106 agreement	Cambridge Local Plan (2006)	Target of CSH Level 3.
Clay Farm	j	Outline approved Section 106 agreement complete	Cambridge Local Plan (2006)	CSH Level 3 private housing agreed with developer. CSH Level 4 for affordable housing.
Glebe Farm	k	Full application approved Section 106 agreement complete	Cambridge Local Plan (2006)	CSH Level 3 private housing agreed with developer. CSH Level 4 for affordable housing.
Addenbrooke's Biomedical Research Campus	i	Application approved	Cambridge Local Plan (2006)	Target of CSH Level 3.

Site	Map Reference	Planning Status	Key Relevant (Adopted) Site Specific Policy	Required Water Efficiency Level
Northstowe		Outline application submitted, pending revisions to applications of 10,000 dwellings and associated infrastructure	Northstowe AAP; National Eco-town Policy; South Cambs DC Development Control Policies DPD	Need to conform to National Eco-town Policy. Required CSH Level 5 (if confirmed as Eco-town) Reduction of between 33% and 50% mains water use compared with conventional housing (Northstowe AAP)
North West Cambridge				
NIAB 1	b1	Outline approved Section 106 agreement complete	Cambridge Local Plan (2006)	Target of CSH Level 3.
NIAB 2	b2	Awaiting application	South Cambs DC Site Specific Policies DPD[112]; South Cambs DC Development Control Policies DPD	Target of CSH Level 3 (dependant on when planning permission is granted

[112] The Site Specific Policies DPD is due to be adopted on 28 January 2010.

Site	Map Reference	Planning Status	Key Relevant (Adopted) Site Specific Policy	Required Water Efficiency Level
Huntingdon/ Madingley (University site)	a	Awaiting outline application	North West Cambridge AAP (2009)	Homes built before 31 March 2013: <50 dwellings – Required CSH Level 4 >50 dwellings – Required CSH Level 5 Homes built after 1 April 2013: Required CSH Level 5.
Orchard Park (formerly Arbury Park)	c	Development approved for original application (900 dwellings and associated infrastructure), awaiting a further outline application for additional 220 homes	South Cambs DC Site Specific Policies DPD; South Cambs DC Development Control Policies DPD	Target of CSH Level 3.
Cambridge East	f/g/h	Awaiting outline applications	Cambridge East AAP (2008)	Required reduction on conventional housing demand of approximately 33% to 50%. Required consumption between 100 l/h/d and 75 l/h/d. Reduction of between 33% and 50% mains water use compared with conventional housing.
Northern Fringe	d/e	Not expected to proceed as housing development	Cambridge Local Plan (2006)	Target of CSH Level 3.

Site	Map Reference	Planning Status	Key Relevant (Adopted) Site Specific Policy	Required Water Efficiency Level
Cambourne	3	Planning permission for original 3,000 (plus 10% reserve making total development to 3,300). 2,700 homes completed in July 2010 and application for additional 950 homes pending	South Cambs DC Site Specific Policies DPD; South Cambs DC Development Control Policies DPD	Target of CSH Level 3.

Table 9-1 Major growth sites and planning policy for water resources

10 Appendix C Case Studies of rainwater/greywater systems

Project Name	Date	Background information	Installation costs (£)	Water savings (£)	Source for further information
Rainwater harvesting					
Upcher Close, Feltwell, Norfolk	Feb 2007-Feb 2008	12 homes – rainwater harvesting system (capacity of 3,300 litres) installed to each property. Rainwater falling on the roof is collected in rainwater gutters and is transported through the downpipes via a filter to an underground tank, located in the rear garden. This rainwater is then pumped into the dwellings and used for supplying WCs for flushing and supplying soft water to washing machines and external taps.	£3,500 per property	Savings ranged from zero to a saving of paying only £9.16 water bill a month	http://www.water-efficient-buildings.org.uk/wp-content/uploads4TQ/hastoe-ha-rainwater-harvesting-system-case-study.pdf
Hockerton Housing scheme, Nottinghamshire	1998	5 homes built to be independent of mains water supply – rainwater from roads, earth covered roofs and fields collected and transported to a 150 m^3. In addition the housing scheme collects rainwater from conservatory roofs	Total capital cost = £11,276 Labour cost = £3,248	Total savings across the five households for water supply and sewerage charges were £1,000 in first year	http://publications.environment-agency.gov.uk/pdf/GEHO0108BNPN-E-E.pdf

			Approximate cost per property = £2900		
Millennium Green, Newark	2001	24 homes built with various water efficiency measures, included rainwater harvesting systems on each house (3,500 litre underground storage tank) which was capable of storing non-potable water for up to 18 days (and could be topped up by mains supply if necessary)	Not provided	Rainwater harvesting accounted for 50% of household demand	http://www.freerain.co.uk/domestic-case-study.html
Severnside Housing, Shropshire	2009	10 homes – direct system collects rainwater from roofs (with an average surface area of 100-120 m^2), filtered, and stored in 3,000 litre underground tanks. During periods of low rainfall the system automatically switches to mains water supply	£4,000 per house	Residents can save up to 50% of their annual water consumption	
Non-household examples	2007	Office in Manchester (500 employees) with a roof area of 3,200 m^2 has installed a 110 m^3 rainwater tank for toilet flushing Community centre in Kent with a roof area of 950 m^2 has installed a 26 m^3 rainwater tank for toilet flushing and clothes washing	£12,000 to install £6,500 to install	£4,000 water saving per year £2,200 water savings a year	http://publications.environment-agency.gov.uk/pdf/GEHO0108BNPN-E-E.pdf

Greywater recycling					
Health Home, Gold Coast, Australia	2000	Single dwelling RWH/GWR . GWR is treated through a aerobic wastewater treatment system with re-circulating sand filter, followed by disinfection with UV light	Not provided	50% water savings compared to average Queensland house	http://www.yourhome.gov.au/technical/index.html
National Rainwater and Greywater Initiative, Australia		As part of their Water for the Future programme, the Australian Government is offering rebates of $400-$500 for householders who install rainwater/greywater systems (installed by a licensed plumber)			http://www.environment.gov.au/water/programs/nrgi/index.html
Doncaster Hill Green Civic Precinct, Melbourne, Australia	2009	As part of a suite of measures greywater and blackwater recycling systems have been installed (in addition to rainwater harvesting & water efficient fixtures	Not provided (Government grant for scheme)	Annual water saving in the precinct of 8 Ml (	http://www.environment.gov.au/water/publications/urban/pubs/green-precincts-doncaster-hill.pdf

Table 10-1 Examples of rainwater/greywater systems

11 Appendix D Calculations for rainwater harvesting

11.1 Rainwater harvesting

11.1.1 In Cambridge, the average annual rainfall from 2000-2009 (inclusive) was 578mm, with the highest annual rainfall in 2000 (699.3mm), and the lowest annual rainfall in 2003 (471.3 mm). Analysis of total monthly rainfall has been carried out to identify whether there is sufficient monthly rainfall to adopt a RWH system[113]. The following assumptions were made to identify whether RWH would be, in principle, possible to adopt for the major growth sites in and around Cambridge:

- occupancy rate was set to 2.16 people per property (consistent with demand scenarios;
- runoff coefficient from the roof was assumed to be 90% (i.e. 90% of rainfall falling onto the roof contributed to runoff);
- filter coefficient on the rainwater harvesting system was assumed to be 90% efficient[114];
- average roof area was set to 25 m^2 and 50 m^2, and;
- the analysis has been done using total monthly rainfall (rainfall intensity has not been factored in).

11.1.2 At the household scale rainwater tanks should normally be sized at 5% of the rainwater supply or of annual demand. Rainwater harvesting tanks should normally be sized using the following formula:

11.1.3 Tank size (litres) = catchment area (m^2) * drainage coefficient (0.9) * filter coefficient (0.9)* 5%.

11.1.4 Using the annual average rainfall over the 2000-2009 period, the tank size should be between 600 litres for a 25 m^2 roof area and 1200 litres for a 50 m^2 roof area.

11.1.5 The results from the analysis are illustrated in Table 11-1. With an average roof size of 25 m^2 it would not be possible to meet CSH level 5/6 using rainwater harvesting. Similarly, with a 50 m^2 roof area, and a baseline demand of 105 l/h/d, the analysis indicates it would not be possible to meet CSH level 5/6. However, if baseline demand was set to 94.1 (see Table 11-1), then it may be

[113] The original sustainable water management strategy for Northstowe (December 2007) indicated that with average annual rainfall of 550mm, typical roof area of 25 m^2, a baseline demand of 110 l/h/d, a runoff coefficient or 90% and a filter coefficient of 90%, rainwater harvesting at Northstowe would not achieve CSH level 5/6 (typical saving calculated to be 12.1 l/h/d). Using the same parameters (except with historical rainfall) the WCS findings gives similar findings.

[114] Environment Agency (2008), Harvesting rainwater for domestic uses: an information guide

possible to meet CSH level 5/6 with an average roof area of 50 m^2 although the ratio of occupancy to roof area will be important in determining the amount of water which can be used per person.

Average roof area (m^2)	Tank size (litres)	Baseline demand prior to RWH (l/h/d)	Saving per person (l/h/d)	Average consumption over 10 year period (l/h/d)
25	600	105 (assuming CSH level 3/4 has been met)	8.3	96.7
		94.1 (assuming CSH level 3/4 + additional efficiency measures		85.8
50	1200	105 (assuming CSH level 3/4 has been met)	16.5	88.5
		94.1 (assuming CSH level 3/4 + additional efficiency measures		77.6

Table 11-1 Use of rainwater harvesting to meet CSH level 5/6

12 Appendix E Water neutrality evidence base assumptions

12.1 Metering

12.1.1 To identify the impacts of metering on demand in the existing housing stock, we have made the following assumptions:

- using 2006/07 as the base year 51% of the properties were metered, and 49% unmetered[115];
- demand in unmetered properties was assumed to be 160.65 l/h/d, and in metered properties demand was assumed to be 140.94 l/h/d[115] and;
- three metering scenarios were assessed:
  - meter penetration assumed to be in agreement with CWC's WRMP10 proposals to 88% metering by 2035;
  - enhanced metering programme, bringing forward meter penetration to 90% to 2020 and total metering by 2030;
  - enhanced metering programme to achieve 90% meter penetration by 2015 and total metering by 2020.

12.1.2 To identify the total costs for installation of meters under the different scenarios, the costs of installing a meter has been assumed at £500 per property. Based on the predicted rates of metering for different scenarios (i.e. 88% meter penetration by 2035, total metering by 2030 or 2020), it is possible to identify the total costs to 2031 of installing meters into properties.

12.1.3 In addition to the capital costs of metering, it is important to consider the replacement costs for meters. For the Phase 2 WCS, we have assumed that the replacement costs will be the same as the installation costs (£500), and that meters would need to be replaced every 15 years[116]. Over 100 years (applying discount rates), the total costs for meter replacement at £707 per property.

12.2 Variable tariffs

12.2.1 A variable tariff is one where the pricing scheme for water changes with levels of consumption. The use of variable tariffs in conjunction with metering is estimated to result in a further 5-12% savings in water consumption[117]. Different types of variable tariffs are available, including seasonal tariffs (differential summer and winter rates), rising block tariffs (where water charges are progressively more expensive as more water is used), and declining block tariffs (where water

[115] From Cambridge Water's WRMP10

[116] Environment Agency Publication - Science Report – SC070010: Greenhouse Gas Emissions of Water Supply and Demand Management Options, 2008

[117] Waste Not, Want Not - Sustainable Water Tariffs, A report by Paul Herrington for WWF-UK, 2007

charges are progressively cheaper as more water is used). Evidence from the Walker report[118] indicates that seasonal tariffs seem to have the greatest potential for implementation in the UK.

12.2.2 For the Phase 2 WCS we have assumed that variable tariffs will be implemented alongside the metering strategy. We have built up three scenarios for the effectiveness of variable tariffs:

- best case – further 12% saving in water demand over and above metering;
- best estimate – further 8.5% saving in water demand over and above metering (best estimate assumed to be mid-point between worst and best case), and;
- worst case – further 5% saving in water demand over and above metering.

12.3 Retrofit water efficient measures

12.3.1 There have been a number of recent pilot studies which have assessed the water savings achievable through implementation of various retrofit measures. The evidence from these pilot studies is highly variable[119], because a successful retrofit relies heavily on changes in user behaviour which are not easy to predict and are highly variable. Due to the highly variable nature of user behaviour, any analysis which extrapolates from these pilot studies will need to be viewed with significant caution, and therefore there is likely to be a difference between the theoretical water savings due to retrofit, and the savings which are realised in practice. Table 12-1 presents the water savings from some of the pilot projects presented in the Waterwise report[119].

Project name	Reduction in water consumption (l/prop/d)	Cost per property (£)	% reduction in water per property
Preston water efficiency initiative	64.4	202.0	13.9
Wessex Water WET	33.9	49.0	6.6
UU Home audit trial	20.6	141.9	6.8
Anglian Water Ipswich WEM Trial	41.5	40.8	14.2
Thames Water MVF Trial	29.1	240.0	7.9
Yorkshire Water WET	27.6	220.2	8.4
Severn Trent Domestic WET	28.4	74.1	8.7
Thames Water self-audit	21.9	110.0	1.2
Average	33.4	135	8.5

Table 12-1 Water savings from various pilot projects

12.3.2 For the Phase 2 WCS, we have sought to identify what water savings could be achievable by retrofitting of water efficient measures. To identify the potential water savings we have built up a

[118] Walker, A (2009), The Independent Review of Charging for Household Water and Sewerage Services, http://www.defra.gov.uk/environment/quality/water/industry/walkerreview/documents/final-report.pdf

[119] See Evidence Base for Large-scale Water Efficiency in Homes, Phase II Interim Report, Waterwise, February 2010 for more details

model based on a scenario in the 2008 Waterwise report[120], which assessed the impact of retrofitting measures across a water resource zone. The key features of the scenario are presented in Table 12-2, and included retrofitting of a water butt, tap aerators, a shower timer, aerated showerhead and a dual flush toilet. The Waterwise scenario is closely aligned with the costs and water savings from the water efficiency trials illustrated in Table 12-1.

Criteria	Best case	Best estimate	Worst case
Uptake rate	35%	25%	13%
Equipment costs per property (£)	£36	£45	£54
Installation costs per property (£)	£37.5	£50	£100
Admin costs per property (£)	£2	£3	£4
Recruitment & project management costs per property (£)	£10	£17	£20
Total costs per property (£)	£86	£115	£178
Water savings (l/property/d)	45 litres/property/day	28 litres/property/day	20 litres/property/day

Table 12-2 Costs and water savings from Waterwise scenario

12.3.3 A higher uptake of retrofit schemes may be possible if the following actions are taken:

- Involvement of local government and housing association to make sure all properties managed by them take up WEM and they engage with their tenant to encourage change in behaviour with regard to water use. Sutton and East Surrey's Preston estate project achieved a 60% uptake rate.

- A coordinated campaign with local government, schools, environment Agency and energy companies to encourage residents to take up energy and water saving initiatives.

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[120] Evidence base for large-scale water efficiency in homes, Waterwise, October 2008, available at http://www.waterwise.org.uk/images/site/Policy/evidence_base/evidence%20base%20for%20large-scale%20water%20efficiency%20in%20homes%2C%20waterwise%2C%20october%202008.pdf

13 Appendix F Surface water management costing assumption

13.1 Assumptions

13.1.1 In order to allocate scores for each criteria, both generic design principles (e.g. linking surface SUDS features to green infrastructure) and specific infrastructure specifications (e.g. size of SUDS features for economic and carbon cost calculations) were required. It was necessary to make a number of simplifying assumptions regarding specific infrastructure specifications to allow the calculations to be made.

13.1.2 *Economic Cost*

13.1.3 In order to estimate economic costs, it was necessary to make a number of simplifying assumptions regarding the specific surface water drainage infrastructure and associated costs to be provided in each scenario. These assumptions were considered reasonable for the purposes of this assessment: to provide a high-level overview comparison of potential costs without a detailed site-by-site design for each scenario. Infrastructure that would be constant across all scenarios (for example, the use of household soakaways for all permeable sites) has not been included. It was assumed that all sites will drain by gravity and that no pumped solutions will be required.

13.1.4 The costs estimated for each infrastructure type are as follows:

- Attenuation and infiltration storage:
  - The total storage volume required by each site was estimated following the Defra/EA methodology ('Preliminary rainfall-runoff management for development'). This method is approximate only and likely to give overestimates of storage volumes required.
  - The CIRIA SUDS manual suggests costs of £20 per m^3 for attenuation ponds and £15 per m^3 for infiltration basins, plus an additional £0.3 per m^2 for annual maintenance. An average pond /basin depth of 1 m was used to estimate surface area for annual maintenance.
- Underground piped sewer networks:
  - A typical piped network density of 550 m per ha was assumed, based on recent drainage designs undertaken by Halcrow Group Limited. This includes main conveyance pipes, connective pipes between SUDS and pipes to collect house drainage. The drainage density is strongly dependent on the density of housing, location of discharge and location of SUDS elements, and therefore would in reality vary significantly between sites.
  - The cost of the typical piped network was estimated at £132,000 per hectare, based on an even distribution of pipe diameters for a range of construction conditions and including an allowance for manholes and concrete surrounds, contractors day work and methodologies but excluding site works. In reality, the

cost would vary significantly depending on design layout, pipe diameter, pipe depth, material costs, labour costs, etc.

- Annual maintenance costs for sewer networks were estimated from information available in AWS' draft business plan summary (PR09), as listed in Table 13-1. Items (1) and (3) were considered relevant for standard annual maintenance costs, giving an average annual cost of £137.26 per property for foul and surface water sewerage. For metered customers, sewerage standard charges per year are reduced to 53% for properties connected to foul drainage only. Therefore the maintenance costs were reduced to 47% to represent surface water sewerage only, giving an estimated average annual maintenance cost of £64.51 per property.

- Open channels, swales and infiltration trenches:
  - It was assumed that the length of open channels, swales and infiltration trenches would be the same as the length of sewer network replaced. In reality, the size and length of the features would vary across the site and most likely follow different drainage paths to the subsurface network. Alternative pathway SUDS control features could be used at both impermeable and permeable sites, depending on specific ground conditions.
  - The Ciria SUDS manual suggests costs of £15 per m^2 for swales and £65 per m^3 for infiltration trenches, plus an additional £0.1 per m^2 for annual maintenance of swales and £1 per m^2 for infiltration trenches. It was assumed that swales would have a typical width of 2.5 m, and infiltration trenches would have a typical width and depth of 1.5 m.
  - The Environment Agency Flood Risk Management Estimating Guide (2007) suggests typical costs of £300 per m for open earth channels of 1 km length (average width of 6.2 m and depth of 2.7 m), and approximately £1 per m for annual maintenance.

Expenditure item	Annual average for the 2010-2015 period (£/property/annum), based on 2007-2008 prices, for foul and surface sewerage
1. Operating costs to maintain current services to customers.	85.15
2. Operating costs to improve services to consumers and protect the environment.	6.89
3. Cost of maintaining assets to deliver current services to consumers.	52.11
4. Cost of improving assets to deliver improvements for the environment and consumers.	57.92

Table 13-1 AWS estimates of expenditure needs, taken from the draft business plan summary (PR09)

- Green roofs:
  - An average footprint of 80 m² for properties in England (Housing statistics in the European Union 2005/2006) was used to as an estimate for green roof area per dwelling. In reality, this would vary significantly depending on property size and type.
  - Typical green roof capital costs of £110 per m² were taken from 'Living Roofs and Walls, Technical Report Supporting London Planning Policy, Greater London Authority, February 2008'. A non-green roof was estimated to cost in the order of £75 per m² (based on internet search) and therefore the net additional cost to install a green roof was estimated at £35 per m². It was assumed that the roof would need replacing every 50 years and that there would be an annual maintenance cost of £200 per year per roof (weeding, fertilising, inspections, etc).

13.1.5 A discount rate of 3.5% was applied to future annual maintenance and replacement costs, assuming a total development lifetime of 100 years. Given the large number of assumptions made in the calculation, cost estimates are not intended to be used as an indication of true costs, but instead only as a comparative measure to distinguish between scenarios.

13.1.6 *Carbon Emissions*

13.1.7 Carbon emissions were estimated as two components: (1) embodied carbon, representing the amount of carbon used in the infrastructure materials and construction process; and (2) operational carbon, representing the amount of carbon used in maintaining the infrastructure. For consistency, the same simplified infrastructure and maintenance regimes as used in the economic cost estimates were used for the carbon cost estimates.

13.1.8 The following assumptions were made to estimate the embodied and operational carbon for each infrastructure type:

- Attenuation and infiltration storage:
  - For attenuation and infiltration storage, an estimated embodied carbon cost of 0.00853 CO2e T per m³ storage was used. This was estimated by assuming the storage consisted of geotextile lining and intake/outlet structures, with excavation construction works.
  - For attenuation storage, an estimated operational carbon cost of 0.00247 CO2e T per m³ storage was used. This was estimated using a maintenance carbon model for minor works for an 8.5 hour workday, assuming that 400 m³ storage could be maintained per day, twice per year.
  - For infiltration storage, an estimated operational carbon cost of 0.0000691 CO2e T per m² storage area was used, representing mowing costs. It was assumed that the storage areas were typically 1m deep and required mowing six times per year.
- Underground piped sewer networks:
  - Embodied carbon costs were estimated as 0.222 CO2e T per m length of piped network, assuming 300 mm diameter polyethylene pipes at a depth of 5 m. Manholes were assumed to be located once every 25 m with an embodied carbon cost of 1.639 CO2e T per manhole.

  - Operational carbon costs of 0.00116 CO2e T per m length of piped network were estimated using a maintenance carbon model and assuming 100 m of length could be maintained per hour, twice per year.
- Open channels, swales and infiltration trenches:
  - Embodied carbon costs for open channels were estimated as 0.016 CO2e T per m^3 channel storage for earth channels, and 0.059 CO2e T per m^3 channel storage for reinforced channels. It was assumed that 50% of channels would be reinforced. Channels were assumed to be 2m wide and 1m deep with a triangular shape. Operational carbon costs were assumed to be the same as piped sewer networks.
  - No allowance has been made for site specific topography, which in reality will influence feasibility of above ground drainage solutions (although this could be overcome by pumping, no pumping costs have been included for either above ground or below ground drainage).
  - For swales, embodied carbon costs were estimated as 0.106 CO2e T per m length, allowing for a geotextile lining, 5 cm depth gravel lining, and check dams of coarse aggregate every 5 m. Operational carbon costs were assumed to be the same as infiltration basins.
  - For infiltration trenches, embodied carbon costs were estimated as 1.368 CO2e T per m length, assuming a trench width and depth of 1.5m with geotextile lining and filled with coarse aggregate. Operational carbon costs were assumed to be the same as piped sewer networks.
- Green roofs:
  - Embodied carbon costs were estimated as 0.0065 CO2e T per m^2, estimated from the paper 'Carbon Sequestration Potential of Extensive Green Roofs' (Getter, K.L. et al, Environ. Sci. Technol. 43, 7564-7570, 2009). It was assumed that these carbon costs were applicable at every replacement interval (50 years). Operational carbon costs were assumed to be the same as infiltration basins.
  - The embodied and operational carbon costs were offset by carbon sequestration in the green roof biomass, estimated as 0.01875 CO2e T per m^2 per 100 years, take from the paper 'Carbon Sequestration Potential of Extensive Green Roofs' (Getter, K.L. et al, Environ. Sci. Technol. 43, 7564-7570, 2009).

14 Appendix GDetailed summary of 'short-term' sites

14.1 Introduction

14.1.1 Within Cambridge City and South Cambridgeshire a number of strategic development sites have significantly progressed through the planning system; therefore the Phase 2 WCS has limited influence over the provision of water services infrastructure. Although these sites have significantly progressed through the planning system, some have reserved matters coming through on a plot by plot basis which will offer an opportunity to employ water efficiency and additional surface water management measures as and where feasible.

14.1.2 For the strategic development sites which have significantly progressed through the planning system the Phase 2 WCS has undertaken an audit of the water efficiency measures proposed/built, to identify how existing development is progressing towards the vision for sustainable water management in Cambridge City and South Cambridgeshire.

14.2 Surface water management & environmental water quality

14.2.1 *Trumpington Meadows*

14.2.2 In Trumpington Meadows residential properties will be drained via a conventional piped drainage system, which will be adopted and maintained by Anglian Water. The primary road running through the development will be drained via swales which run parallel to one side of the road (connection via gullies to swale); the swales are to be adopted by Cambridgeshire County Council. The swales and conventional piped drainage converge in the country park, where the drainage will be adopted by the Wildlife Trust.

14.2.3 Surface water runoff from the development sites will be managed by 2 balancing ponds; 1 permanently wet pond and 1 dry pond. These balancing ponds are located to the south-west of the country park and it is proposed that they will be adopted by the Wildlife Trust. The balancing ponds have a design storm of 1 in 100 year attenuation plus an allowance for climate change, and the runoff rate from the balancing ponds has been set to 2 l/s/ha[121] which is less than the equivalent greenfield runoff rate and ensures extended attenuation storage is provided from the development.

14.2.4 *Bell School*

14.2.5 At Bell School the proposed drainage will be via conventional piped drainage (adopted by Anglian Water), which will connect to two off-line balancing ponds (1 permanently wet pond and 1 dry pond) to attenuate the surface water runoff. The balancing ponds have been design to maintain peak runoff rates from the development site. The two balancing ponds, which are proposed to be adopted by Cambridge City Council, have been designed to encourage biodiversity.

[121] QBAR is the estimated peak annual flow rate from the site prior to development (greenfield)

14.2.6 *Clay Farm*

14.2.7 At Clay Farm, runoff within the development site will be drained via a conventional piped system to four balancing ponds to the east of Hobsons Brook (this will require siphons under Hobsons Brook). The balancing ponds have been designed for a 1 in 100 year event with 30% allowance for climate change, and will ensure a runoff rate of <2l/s/ha which is less than greenfield runoff rate; therefore post-development surface water runoff rate will be less than pre-development. One of the ponds will be a dry pond, and it is located in an area which is more suitable for infiltration. It is proposed the balancing ponds will be adopted by Anglian Water

14.2.8 The balancing ponds have been shaped to encourage bird life and graded to encourage biodiversity, and the largest balancing pond has a dedicated 'hide area' to further encourage biodiversity. In addition, there are downstream defenders[122] at the inlet to the balancing ponds, which are designed to trap 90% of the sediment prior to discharge into the pond.

14.2.9 *Glebe Farm*

14.2.10 The site is drained via a conventional piped system to a number of attenuation tanks. These attenuation tanks attenuate the surface water prior to discharge to Clay Farm, and these will be adopted by Cambridge City Council. The attenuation tanks at Glebe Farm discharge to Clay Farm via an underground pipe alongside Addenbrooke's Access Road – limiting rate of pipe is 135 l/s although attenuation basins do provide some reduction in peak flows. In addition the attenuation tanks, there will be some infiltration through a swale, and an element of water re-use via rainwater harvesting on the adjacent allotments. At Glebe Farm, Cambridge City Council is also seeking to include permeable paving as part of the development.

14.2.11 *Addenbrooke's Biomedical Research Campus*

14.2.12 At the Addenbrooke's medical site, the proposed drainage is a combination of above ground drainage and conventional piped drainage. The main boulevard which runs through the site will be drained by two swales which will convey the road runoff to two balancing ponds (which will manage runoff rates to greenfield equivalent). The Water Strategy for the Addenbrooke's site also includes proposals for attenuation storage beneath car parks. It is proposed that all drainage in the Addenbrooke's site will be adopted and maintained by a private company.

14.2.13 *Flood risk to the River Cam*

14.2.14 Proposed development at Clay Farm, Glebe Farm and the Addenbrooke's Biomedical Research Campus all drain to the Hobsons Brook, which subsequently drains to the River Cam. An existing model of the River Cam was rerun to assess the potential impact of development on flooding on the River Cam due to changes in flows in Hobsons Brook, and was based on a discharge rate of 3 l/s/ha from the development sites[123]. The model results were compared to

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[122] More information on Downstream Defenders can be found at http://www.hydro-international.biz/us/stormwater_us/downstream.php

[123] Discharge rates are 2 l/s/ha or less in final proposals for Southern Fringe

the original model results (from 2005/6). The outputs from the modelling indicated that provided attenuation storage was provided in line with the Flood Risk Assessments (FRAs), 'the discharge from development would be unlikely to have any impact on the maximum flood levels in the River Cam.' In light of these findings, the proposed measures at the development sites will ensure that there should not be an increase in flood risk downstream of developments.

14.2.15 *Cambourne*

14.2.16 Drainage in Cambourne is via a separate foul and surface water piped system; however, it is worth noting that there has been some recent flooding from the main foul pumping station in response to rainfall which indicates that surface water was entering the foul drainage network. At the time of writing the promoters are working with all relevant parties in order to resolve the matter.

14.2.17 The surface water system drains to a series of 12 balancing ponds across Cambourne which are inter-linked and are predominantly gravity drained. The surface water runoff rates and volumes from across Cambourne have been designed to maintain status quo, with a discharge of 3 l/s/ha from the development. There is a complex ownership regime of the attenuation basins, with some being adopted and maintained by MCA developments, Cambourne Business Park Ltd, and the Wildlife Trust

14.2.18 To manage water quality from surface water runoff, petrol interceptors have been installed in road gullies and car parks. In addition, the surface water attenuation basins have been closely aligned with improvements in wildlife and biodiversity. For example:

- one of the lakes has been specifically designed for kingfisher habitats;
- one of the lakes has been fenced off to encourage newt populations;
- the margins of the lakes have been designed to encourage habitats in the shallows of the lakes, and;
- one of the lakes in the eco park incorporates a reed bed system.

14.2.19 *Lamb Drove SUDS project*

14.2.20 The Lamb Drove site in Cambourne has been developed to showcase the use of SUDS techniques and a wide range of SUDS measures have been implemented across the 35 residential dwelling site including:

- water butts;
- permeable paving;
- a green roof;
- swales;
- filter strips;
- underdrained swales, and;
- detention and wetland basins.

14.2.21 In order to assess the effectiveness of the SUDS measures at Lamb Drove, a control site was also set up at Friar Way (Cambourne) which did not include SUDS measures. A two-year monitoring programme is currently in progress (2009-2011) to analyse the benefits of the effectiveness of the SUDS measures at the Lamb Drove site. An interim monitoring report was published in January 2010[124], which contained the results from year one of the monitoring programme. A summary of the key findings from the report are summarised below:

- the Lamb Drove site showed significant attenuation in flows and volumes compared to the control site, following rainfall events;
- the SUDS features delay the discharge of water from the site;
- as the intensity of the rainfall increases there is less delay in peak flows from the SUDS site, but there is a pronounced reduction in flow volumes, and;
- the SUDS features are acting to improve water quality for a variety of pollutants including hydrocarbons, metals, suspended solids, phosphorus, nitrogen, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD) and ammonia.

14.2.22 In the first year of the monitoring programme there was evidence that the maintenance was not being carried out in accordance with the proposed maintenance regime; these issues have now been addressed with the Cambridge Housing Society and their contractor, Fordham Landscapes.

14.2.23 Overall, the monitoring programme has been able to demonstrate tangible and significant flow and volume and water quality improvements from the SUDS measures at Lamb Drove.

14.2.24 *NIAB 1*

14.2.25 The NIAB 1 site is planned to be drained via a totally separate, above ground drainage network. Road and roof runoff drains directly to and a network of 'green fingers' swales (roof runoff connected via pipes and road runoff via gullies) which drain by gravity to a large balancing pond to the north-east of the development site. Where feasible, the swales and 'green fingers' will be used to infiltrate surface water runoff, although the balancing pond has been sized on the basis of no infiltration. The above ground drainage has been inter-linked with green open space to create green corridors, and the network (including the balancing pond) will be adopted by Cambridge City Council. Cambridge City Council have secured a 12 year commuted sum from the developers for the maintenance of swales and 'green fingers' and a 30 year commuted sum for the maintenance of the balancing pond.

14.2.26 The balancing pond to the north-east of the development has been designed to accommodate the 1 in 100 year rainfall event (plus a 30% uplift for climate change). The allowable discharge rate from the balancing pond is 1.47 l/s/ha which is significantly less than greenfield runoff rate; the reduction in greenfield rate has been partly driven by concerns from downstream residents over potential for increased flood risk due to development.

14.2.27 A treatment train has been provided as part of the surface water management measures. The network of swales will be planted to treat surface water runoff, and additional treatment will be provided by the balancing pond. In addition, the balancing pond has been designed to incorporate ecology and biodiversity.

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[124] Cambridgeshire County Council, January 2010, Lamb Drove SUDS showcase project, Cambourne, Interim Monitoring Report, available at http://www.cambridgeshire.gov.uk/NR/rdonlyres/59774E4C-CE12-4C2A-9A22-AE2781F3D55F/0/LambDroveSUDSMonitoringInterimReportv102Main.pdf

14.2.28 *Orchard Park*

14.2.29 The existing drainage at Orchard Park is an entirely underground network, with a piped system draining to three attenuation tanks (located underneath open areas within the development). The water table within the site was very high, and the promoters of the site indicated that a SUDS network would not be feasible due to the high water table. The additional 220 homes which are likely to come forward on the site, will most likely to be connected into the existing underground piped network.

14.3 Water resources

14.3.1 *Southern Fringe*

14.3.2 With respect to water efficiency, development in Cambridge Southern Fringe will be built to the following specification:

- Trumpington Meadows – Phase 1 (350 dwellings) built to Code for Sustainable Homes (CSH) level 3 (105 l/h/d for water consumption), and phase 2 of the development may be built to a higher specification;
- Bell School – CSH level 3 for market homes and CSH level 4 for affordable homes (both at 105 l/h/d for water consumption);
- Clay Farm - CSH level 3 for market homes and CSH level 4 for affordable homes (both at 105 l/h/d for water consumption);
- Glebe Farm - CSH level 3 for market homes and CSH level 4 for affordable homes (both at 105 l/h/d for water consumption), and;
- Addenbrooke's Biomedical Research Campus – BREEAM neat and excellent standard

14.3.3 The implementation of CSH level 3/4 has been achieved through the implementation of water efficiency measures installed into the homes.

14.3.4 *Cambourne*

14.3.5 The initial application for Cambourne was received in 1994, which was prior to the development of the Code for Sustainable Homes. More recent developments in Cambourne have been built in accordance with the Building Regulations Part G to a specification of 125 l/h/d.

14.3.6 Water butts have been used extensively in the affordable housing in Cambourne and as part of the Lamb Drove SUDS monitoring project.

14.3.7 *North West Cambridge*

14.3.8 With respect to water efficiency, development in North-West Cambridge has been built to the following specification:

- NIAB 1 - CSH level 3 for market homes and CSH level 4 for affordable homes (both at 105 l/h/d for water consumption), and;
- Orchard Park – EcoHomes good standard was agreed for the planning application in 2005 (this involves water consumption of 110-125 l/h/d, NB: maximum credits

for internal water use could be earned by reducing water consumption to approximately 80 l/h/d).

15 Appendix H Supporting information for WwTW flood risk calculations

15.1.1 The detailed analysis comprises of three principal elements: quantification of the increase in peak flows; evaluation of the likely sensitivity of flood levels to increases in flood flows, and; evaluation of the impact of increases in flood levels.

15.1.2 The increase in peak flows from Cambridge WwTW is computed by calculating the baseline peak flows using the Flood Estimation Handbook (FEH) and estimating the increases in discharge from the WwTW using the population growth figures[125].

15.1.3 Following the methods described in the FEH manuals, an initial estimate of the 1 in 2 year peak flow was derived by applying an empirical equation with parameter values extracted from the FEH CDROM. This estimate was then refined using observations of flood flows measured against gauging stations. The FEH provides such information in the HiFlows-UK gauging station and WINFAP-FEH software, and the user must identify a suitable donor (nearby) or analogue (distant) sites for adjusting the initial estimates. A suitable site is one which replicates the key hydrological characteristics, these being catchment area, annual rainfall, and soil type. The initial estimates have therefore been improved, by applying an adjustment factor calculated from the observed data.

15.1.4 The analysis reported quantifies the likely increase in the 1 in 2 year flood flow. However, in order to evaluate the importance of these additional flows it is necessary to consider how flood levels may change. It is a change in flood levels which dictates whether flood flows may exceed bank tops or reach properties. Flood levels are very sensitive to channel shape and slope and to the presence of structures which may restrict flow, such as bridges. The location of a bridge immediately downstream of a WwTW discharge may result in increased flood levels for a significant distance upstream.

15.1.5 The adopted methodology has been to develop a decision tree (refer to Chapter 14). The length of reach affected by the increase in discharge from the WwTW was calculated by analysis of the slope and shape of the channel and by constrictions to flood flows such as bridges, weirs and sluices. The reach length decision tree uses engineering judgement to estimate both the upstream and downstream affected reach lengths based on channel widths and slopes extracted from OS maps at 1:10,000 scale.

15.1.6 Having identified the study reach, a second decision tree was developed and applied to identify the risk category. The decision trees, shown below, identify the most common controls of flood levels. The overall sensitivity of flood levels to increasing flows was recorded as high, medium or low.

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[125] To calculate the increase in flow to the WwTW due to growth the same assumptions were used as indicated in paragraph 6.3.15 and Table 6-3.

15.1.7 The final analysis considered the likely impact of the changes in flood levels, in particular, whether the affected reach of river was urban, sub-urban or rural in nature. After identifying the affected lengths, the third decision tree was applied to determine whether the impact was considered high, medium or low. High impact was considered to be an urban area containing at least 50 properties whilst low impact was considered to be a rural area with less than 5 properties affected. The higher of either the upstream or downstream reach was adopted.

CALCULATE REACH LENGTHS

Locate STW outfall

↓

Locate nearest u/s and d/s contours, and note NGR. Map scale 1:25,000

↓

Estimate chainage (river length) between contours and calculate slope %

↓

Measure channel width at outfall using map scale 1:10,000

↓

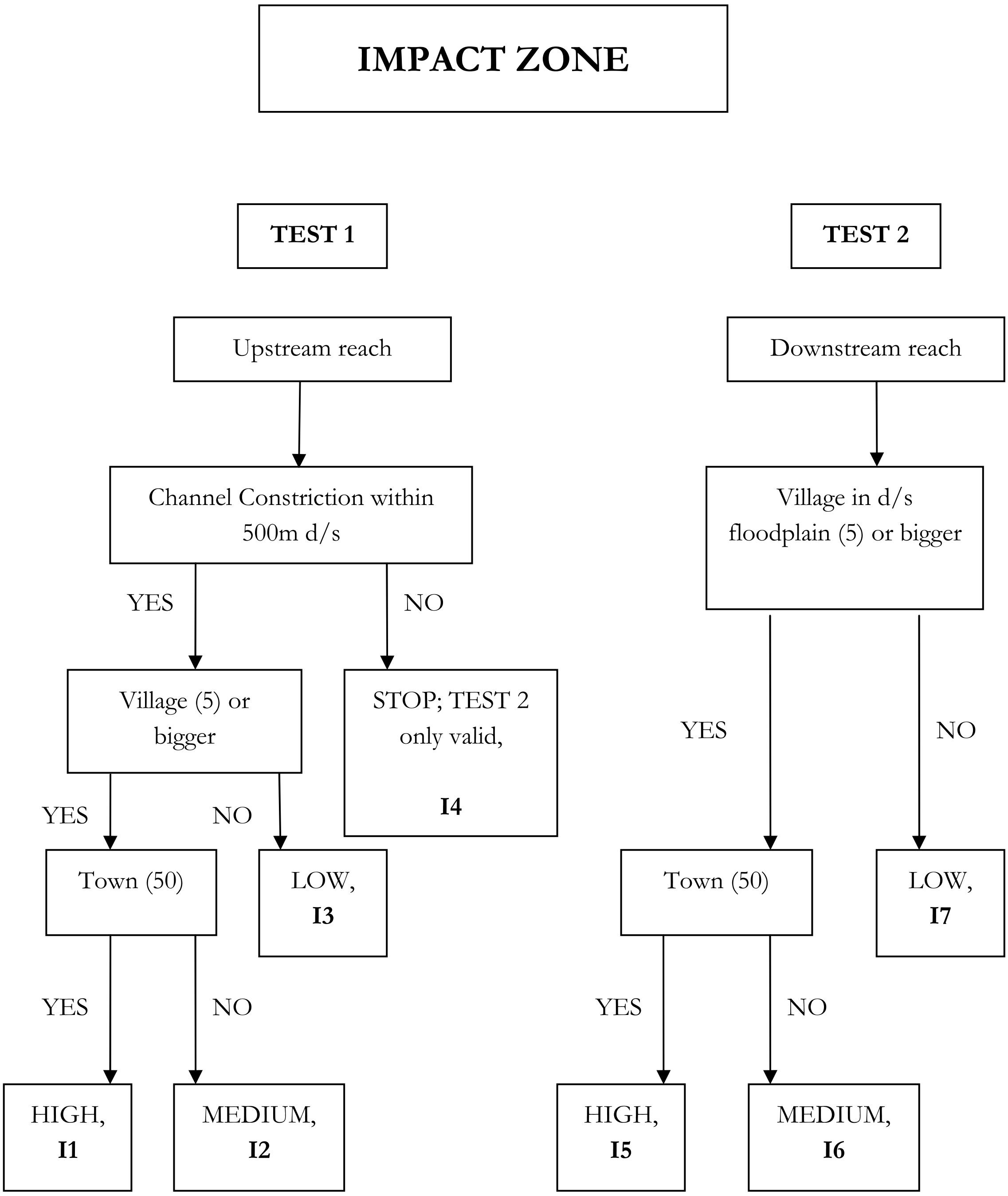
Calculate backwater (u/s) reach using steady state software

↓

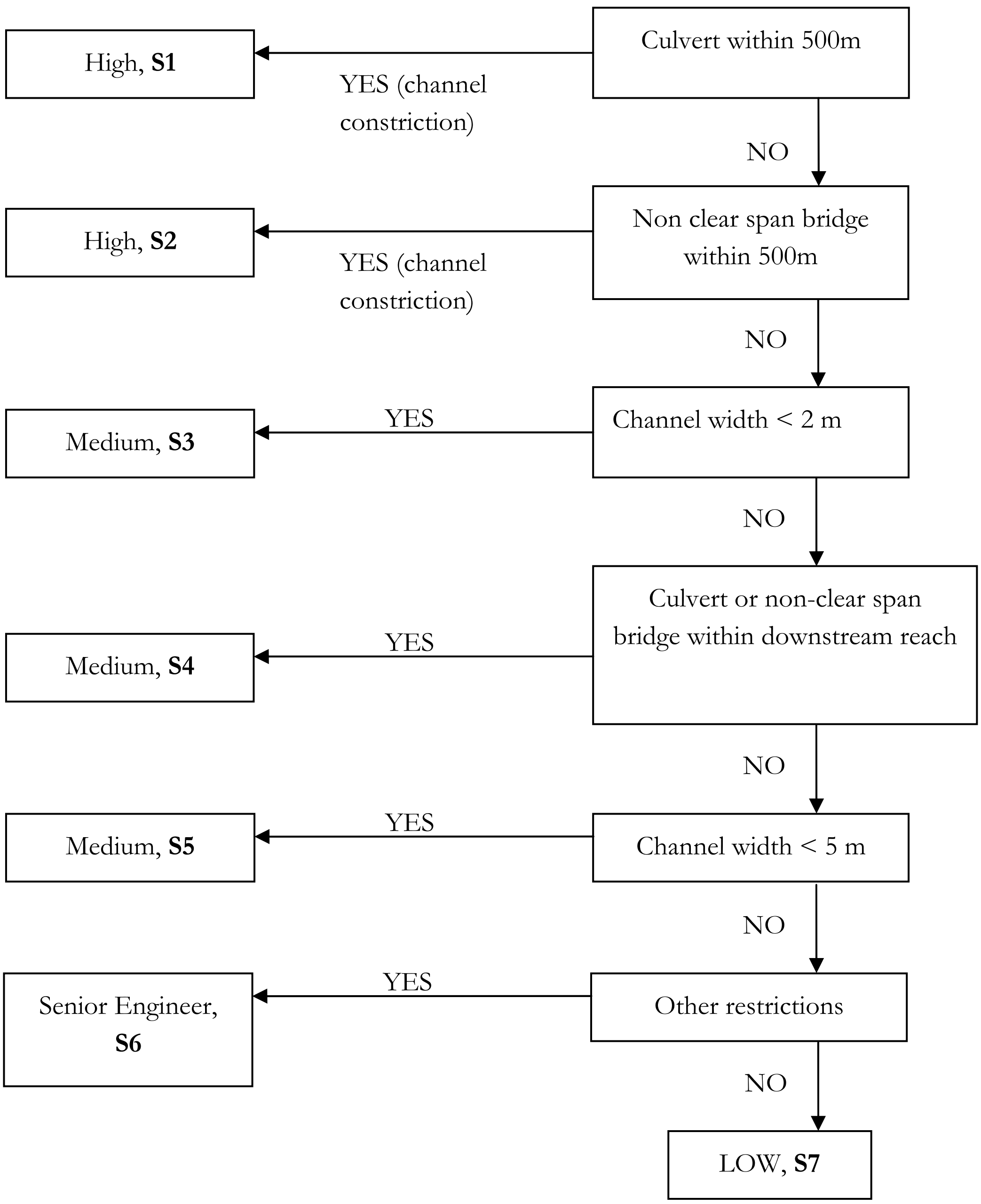
Use nomograph to identify multiplier and calculate d/s reach length

MULTIPLIER NOMOGRAPH

	< 5% increase in flow	>5% increase in flow
> 1 in 500 slope	2	4
< 1 in 500 slope	3	5


IMPACT ZONE
TEST 1
TEST 2
Upstream reach
Downstream reach
Channel Constriction within 500m d/s
Village in d/s floodplain (5) or bigger
YES
NO
Village (5) or bigger
STOP; TEST 2 only valid,
I4
YES
NO
YES
NO
Town (50)
LOW,
I3
Town (50)
LOW,
I7
YES
NO
YES
NO
HIGH,
I1
MEDIUM,
I2
HIGH,
I5
MEDIUM,
I6

SENSITIVITY OF WATER LEVELS



15.2 Multi criteria scoring

15.2.1 Sensitivity and impact assessment, the risk will be marked as followed:

- Low risk: 1
- Medium risk: 3
- High risk: 5

15.2.2 Percentage increase in flood flow due to growth:

- Flow increase between 0 and 1%: 1
- Flow increase between 1 and 3%: 2
- Flow increase between 3 and 10%: 3
- Flow increase between 10 and 20%: 4
- Flow increase greater than 20%: 5

15.2.3 Weights were given to each criterion as followed:

- Sensitivity assessment: 0.3
- Impact assessment: 0.3
- Percentage of increased flow: 0.4

15.2.4 This risk scoring system applies a 40% weighting on the increase in flow, a 30% weighting to the sensitivity of the watercourse to changes in flow, and a 30% weighting to the impact of increased flood risk. By using a higher weighting for the increase in flood flow, less emphasis is applied to sites where the increase in flow is low.

15.2.5 The colour coding to highlight the risk of increased flooding used is

- High (Risk factor greater than 3): Red
- Intermediate (Risk factor between 2.5 and 3): Amber
- Low (Risk factor below 2.5) Green

15.2.6 Sites which increase the flow by less than 0.2% are very unlikely to experience increased flood risk due to increased effluent discharges. This is due to the flow in question being insignificant when compared to the 1 in 2 year flood flow in the watercourse.

16 Appendix J Flood risk management principles for windfall development sites

16.1 Principles of flood risk management

16.1.1 For the purposes of development management, detailed policies will need to be set out to ensure that flood risk is taken account of appropriately for long term growth sites, and windfall development. The following reflects the minimum requirements under PPS25. It should be noted that PPS25 encourages 'using opportunities offered by new development to reduce the causes and impacts of flooding'[126].

16.1.2 *Development within flood zone 1*

16.1.3 In this zone, developers and local authorities should realise opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development. There is no significant flood risk constraint place upon future developments within the Low Probability Flood Zone 1, although for sites larger than one hectare, the vulnerability from other sources of flooding should be considered as well as the effect of the new development on surface water runoff.

16.1.4 Where watercourses are located within the site, the proposed development should be set-back from the watercourse with a minimum 8m wide undeveloped buffer zone, to allow appropriate access for routine maintenance and emergency clearance. This is an Environment Agency requirement for Main Rivers. For sites adjacent to 'Ordinary Watercourses,' under the jurisdiction of the Local Authority, a similar buffer strip of 8m would be required and should be determined in conjunction with the Local planning authority case officer.

16.1.5 *Development within flood zone 2*

16.1.6 Land use within Medium Probability Flood Zone 2 should be restricted to the 'water compatible', 'less vulnerable' and 'more vulnerable' category, with preference given to the lowest flood risk / vulnerability uses. Where other planning pressures dictate that 'highly vulnerable' land uses should proceed, it will be necessary to ensure that the requirements of the Exception Test are satisfied. The following should be considered:

- a detailed site-specific FRA should be prepared in accordance with PPS25 and planning policies;
- the development should be safe, meaning that dry pedestrian access to and from the development should be possible above the 1 in 100 year flood level and emergency vehicular access should be possible during times of flood, and;
- The proposed development should be set-back from the watercourse with a minimum 8m wide undeveloped buffer zone, to allow appropriate access for routine maintenance and emergency clearance, as outlined in paragraph 16.1.4.

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[126] http://www.communities.gov.uk/documents/planningandbuilding/pdf/planningpolicystatement25.pdf

16.1.7 In addition, the Cambridge City Council and South Cambridgeshire District Council Strategic Flood Risk Assessment[127] states that "Climate change impacts should also be considered for all types of flooding (including sewer flooding) and minimum finished floor levels for the development should be set above the 1 in 100 year flood level (incorporating climate change), with an allowance for freeboard. Typically this freeboard should be 300mm above the 1 in 100 plus climate change flood level or 600mm above the 1 in 100 year flood level."

16.1.8 *Development within high probability flood zone 3a*

16.1.9 Land-use with High Probability Flood Zone 3a should be restricted to the water compatible or 'less vulnerable' uses to satisfy the requirements of the Sequential Test. For 'more vulnerable' uses it is necessary to ensure that the requirements of the Exception Test are satisfied. The following should be considered:

- A detailed site-specific FRA should be prepared in accordance with PPS25 and planning policies. Properties situated within close proximity to formal defences or water retaining structures (reservoirs/canals) will require a detailed breach and overtopping assessment to ensure that the potential risk to life can be safely managed throughout the lifetime of the development. The nature of any breach failure analysis should be agreed with the Environment Agency.
- The development should not increase flood risk elsewhere, and opportunities should be taken to decrease overall flood risk (such as use of SUDS and de-culverting). This can be achieved by developing land sequentially, with areas at risk of flooding favoured for green space.
- Floor levels should be situated above the 100 year predicted maximum level plus a minimum freeboard of 600mm. Within defended areas the maximum water level should be assessed from a breach analysis.
- The development should allow dry pedestrian access to and from the development above the 1 in 100 year flood level and emergency vehicular access should be possible during times of flood. A flood management plan should be prepared where evacuation and rescue during a flood event is an issue, and managing flood risk is a factor. Those proposing developments should take advice from Cambridgeshire County Council's Emergency Planning Officer when producing a flood management plan as part of a FRA, in consultation with the Environment Agency. Reference should be made to Section 7.25 to 7.33 of the PPS25 Practice Guide (December 2009).
- Basements should not be used for habitable purposes. Where basements are permitted for commercial use, it is necessary to ensure that the basement access points are situated 600 mm above the 1 in 100 year flood level.

127 http://www.scambs.gov.uk/Environment/Planning/DistrictPlanning/LocalDevelopmentFramework/SFRA.htm

16.1.10 *Development within 'functional floodplain' flood zone 3b*

16.1.11 Prior to development within Flood Zone 3b, the LPA must demonstrate that the Sequential Test has been applied and that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed. A sequential approach should be used in areas known to be at risk of flooding from other sources.

16.1.12 Within Flood Zone 3b, development should be restricted to 'water-compatible uses' and 'essential infrastructure' that has to be there. It should be noted that 'essential infrastructure' includes essential transport infrastructure (including mass evacuation routes) which may have to cross the area at risk as well as strategic utility infrastructure such as electricity generating power station and grid and primary substations. 'Essential infrastructure' in this zone must pass the Exception Test and be designed and constructed to remain operational in times of flood and not impede water flow.