Oxfordshire Strategic Water Cycle Study – Phase 1 Scoping

July 2021

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Revision History

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S3-P01 – 14/06/2021	First draft	Oxfordshire Plan 2050 water group
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D1-C01 – 23/07/2021	FINAL	Oxfordshire Plan 2050 water group

Contract

This report describes work commissioned by Oxford City Council on behalf of the Oxfordshire Plan 2050 Team, a partnership between Cherwell District Council, Oxford City Council, South Oxfordshire District Council, Vale of White Horse District Council and West Oxfordshire District Council in June 2019.

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Purpose

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Executive summary

Introduction

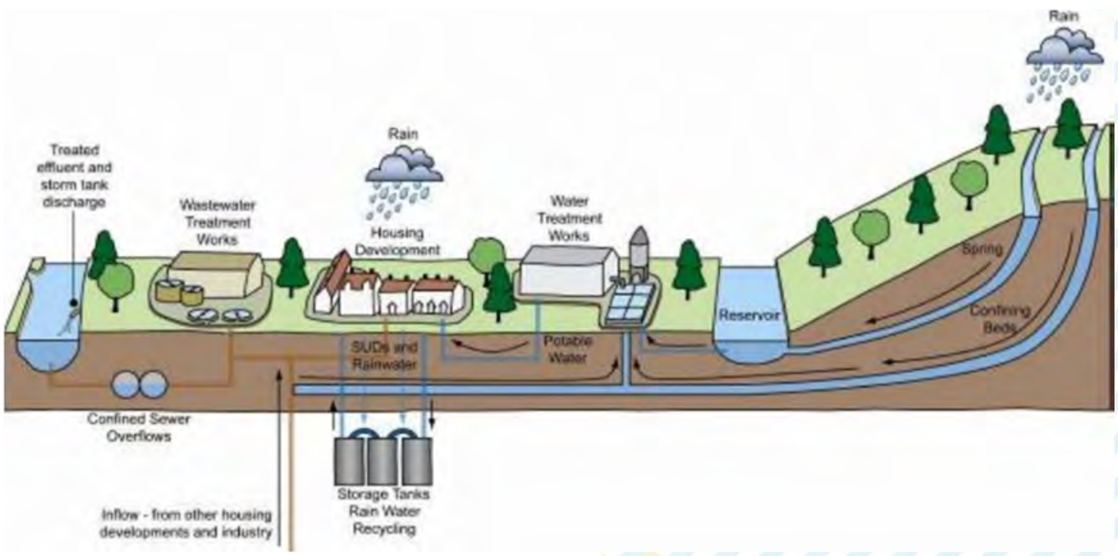
JBA Consulting were commissioned by Oxford City Council on behalf of the Oxfordshire Plan 2050 Team (OPT) a consortium of councils in Oxfordshire (Cherwell District Council, Oxford City Council, South Oxfordshire District Council, West Oxfordshire District Council and Vale of White Horse District Council), to produce a Strategic Water Cycle Study. The aim of this study is to provide evidence to support the Oxfordshire Plan 2050.

The purpose of the WCS is to form part of a comprehensive and robust evidence base for the Oxfordshire Plan which will set out a vision and framework for development in the area up to 2050 and will be used to inform decisions on the location of future strategic development.

Unmitigated future development and climate change can adversely affect the environment and water infrastructure capability. A WCS will provide the required evidence, together with an agreed strategy to ensure that planned growth can occur within environmental constraints, with the appropriate infrastructure in place in a timely manner so that planned growth is deliverable.

The Water Cycle

The figure below shows the main elements that comprise the Water Cycle and how the natural and man-made processes and systems interact to collect, store or transport water in the environment.



The benefits of a Water Cycle Study

New homes require the provision of clean water, safe disposal of wastewater and protection from flooding. The building of large numbers of new homes in certain locations may result in the capacity of existing available infrastructure being exceeded, a situation that could cause service failures to water and wastewater customers, adverse impacts to the environment, or high costs for the upgrade of water and wastewater assets being passed on to the bill payers.

In addition to increased housing demand, climate change presents further challenges to the existing water infrastructure network, including increased intensity rainfall events and a higher frequency of drought events. Sustainable planning for water must now take this into account.

Increased wastewater flows into collection systems due to growth in population or per-capita consumption can lead to overload of infrastructure, increasing the risk of sewer flooding and, where present, increase the frequency of discharges from Combined Sewer Overflows (CSOs). Likewise, headroom at wastewater treatment works can be eroded by growth in population or per-capita consumption, requiring investment in additional treatment capacity. As the volume of treated effluent rises, even if the effluent quality is maintained, the pollutant load discharged to the receiving watercourse will increase. In such circumstances the Environment Agency, as the environmental regulator, may tighten the permitted effluent permits in order to achieve a "load standstill" i.e. ensuring that as effluent volumes increase the pollutant load discharged does not increase. Again, this would require investment by the water company to improve the quality of the treated effluent.

National Planning Practice Guidance requires that, in preparing Development Plans, Local Planning Authorities (LPAs) must have regard to the Water Framework Directive (WFD) and the Environment Agency's River Basin Management Plans which implement the WFD at the river basin scale.

Developers require early assurances that water and wastewater services will have sufficient capacity to serve new developments prior to occupation. The primary route for this is through early engagement with the water company, and for large developments this should occur well in advance of submitting a planning application and should be evidenced with the application. Developers should also be given clear guidance on what is required in the Surface Water Drainage Strategies, to be provided with planning applications for all major developments. For developers, the Development Plan should point out specific water environment issues, for example the need to protect an adjacent designated site or to restore a channel and floodplain.

Conclusions

- The existing water cycle studies for the five Oxfordshire councils have been reviewed. There is value in a full WCS review to support the Oxfordshire Plan 2050, both because elements of the existing studies are becoming out of date, and because of the extended timescale over which the 2050 plan extends.
- The three housing growth options and five spatial scenarios have permitted some quantitative and qualitative assessments to be carried out. These assessments can be used to inform development of the spatial and growth scenarios, but further assessments will be required in a detailed water cycle study, to be undertaken once broad locations for growth are selected, and ahead of Reg. 19 consultation.
- The Abstraction Licensing Strategies indicate there is restricted water available in Oxfordshire for additional abstractions, and existing abstractions may not be available all year.
- The Thames Water WRMP demonstrates how the Swindon and Oxfordshire (SWOX) water resource zone has moved into a situation of supply-demand deficit and, without intervention, this will increase as a result of population growth, climate change and sustainability reductions.
- The WRMP goes on to outline a set of demand management and supply improvement measures to address this. Key to this is development of the Abingdon Reservoir (SESRO) by 2037, a key component of improving supply within Oxfordshire and the wider south east, although it should be noted that this is currently being evaluated alongside other Strategic Resources Options.
- The Standard Method and Business-As-Usual household growth forecasts being considered by the Oxfordshire Plan are all at or below the Thames Water forecast. The Transformational rate of growth would be above what Thames Water has

planned for; however, this is a long-term plan with opportunity for Thames Water to respond to changing demands. Furthermore, demand for water in the SWOX and Henley zones is also dependent upon growth in neighbouring planning authorities.

- An assessment of wastewater treatment capacity found that there are significant differences in the percentage of existing treatment capacity which would be used up by growth, depending on the spatial option selected, with the greatest pressure coming from Option 2 which focusses all growth around Oxford. Whilst this spatial scenario would be highly likely to require a very significant expansion of treatment capacity at Oxford, and possibly at Abingdon and other smaller works close to the City, this does not necessarily make this an unfavourable option. Large upgrades at a small number of key works may be more efficient than upgrading large numbers of much smaller treatment works, as might be required by the more widely distributed spatial scenarios 3, 4 and 5.
- Broad-scale water quality modelling, which increased effluent discharges by 10% and 20% at every WwTW, has identified locations which are sensitive to such change.
- An assessment of present-day effluent flows compared to the 1 in 100-year flood flows in the receiving watercourse identified four treatment works (Henley, Oxford, Watlington and Witney) which may be sensitive to increasing flood risk as a result of increased effluent discharges.
- Climate change is predicted to have significant detrimental impacts on water resources, wastewater and the water environment which must be carefully considered in all plans, particularly longer-term plans such as the OP2050.

Recommendations

Aspect	Action	Responsib-ility	Timescale
Water resources	Continue to regularly review forecast and actual household growth across the supply region through WRMP Annual Update reports, and where significant change is predicted, engage with Local Planning Authorities.	Thames Water	Ongoing
	Provide yearly profiles of projected housing growth to water companies to inform the WRMP update.	Oxfordshire Plan team / individual LPAs	Ongoing
	Use planning policy to continue to require the 110l/person/day water consumption target permitted by National Planning Policy Guidance in water-stressed areas.	Oxfordshire Plan team / individual LPAs	Ongoing
	Consider the case for tighter water efficiency targets, through the Oxfordshire Plan policies, in particular for strategic-scale developments such as major	Oxfordshire Plan team / individual LPAs	Ongoing

Aspect	Action	Responsib-ility	Timescale
	urban extensions and/or new towns/villages.		
	A detailed stage WCS should revisit this assessment once details of the spatial strategy to be taken forward to Regulation 19 consultation become available and to inform the selection of broad locations for growth.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
	The concept of water neutrality has potentially a lot of benefit in terms of resilience to climate change and enabling all waterbodies to be brought up to Good status. Explore further with Thames Water and the Environment Agency how the Oxfordshire Plan can encourage this approach.	Oxfordshire Plan team / individual LPAs, EA, Thames Water	In line with a detailed WCS, ahead of Reg 19.
	Water companies should advise the LPAs of any strategic water resource infrastructure developments, where these may require safeguarding of land to prevent other types of development occurring (note – land for an Abingdon reservoir is already safeguarded in the Vale of White Horse Local Plan)	Thames Water, Anglian Water, Severn Trent Water	Ahead of Reg 19.
Wastewater collection and treatment	A detailed stage WCS should revisit the assessment of wastewater collection and treatment once details of the spatial strategy to be taken forward to Regulation 19 consultation become available and to inform the selection of broad locations for growth.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
	Water companies should advise the LPAs of any strategic wastewater developments, where these may require safeguarding of land to prevent other types of development occurring.	Thames Water, Anglian Water, Severn Trent Water	Ahead of Reg 19.
Water quality	A detailed stage WCS should revisit the assessment of water quality impact once details of the spatial strategy to be taken forward to Regulation 19 consultation become available	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.

Aspect	Action	Responsib-ility	Timescale
	and to inform the selection of broad locations for growth. This should use the updated EA SIMCAT model (if available), and should consider the impacts of the proposed development, whether deterioration can be prevented by application of improved treatment, and whether the proposed development could prevent any watercourses from achieving Good status in the future.		
	The Plan policies need to recognise planners' responsibilities regarding the Water Framework Directive and also the Habitats Directive. Further engagement with Natural England (either through the Habitats Regulations Assessment or separately) is recommended ahead of Regulation 19 consultation.	Oxfordshire Plan team / individual LPAs / Natural England	Ahead of Reg 19.
Flood risk	A detailed stage WCS should revisit the assessment of flood risk once indicative areas of growth become available.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
Climate change	A detailed stage WCS should consider the impacts of climate change on all aspects of water supply and wastewater treatment. This is an area of rapidly evolving guidance, so the latest guidance should always be reviewed and applied.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
	Consider "no regrets" decision-making when developing policy for the Oxfordshire Plan, for example Nature-Based Solutions which can mitigate some impacts of climate change alongside delivering other benefits and services.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
Odour	A detailed stage WCS should include an assessment of odour impacts once indicative areas of growth become available.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.

Aspect	Action	Responsib-ility	Timescale
	Carry out an odour assessment for development proposals identified as being at risk of nuisance odour	Site Developers	To be submitted with planning applications
Environmental constraints and opportunities	The Oxfordshire Plan should include policies that require developments to adopt SuDS to manage water quality of surface runoff.	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19
	The Oxfordshire Plan should include policies that require all development proposals with the potential to impact on areas with environmental designations to be considered in consultation with Natural England (for national and international designations)	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19
	The detailed WCS should link the water quality assessment to sites with environmental designations which are hydrologically connected to water bodies receiving wastewater effluent to identify whether there is a risk of detriment to designated sites from increased effluent discharges.	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19
	In partnership, identify opportunities for incorporating SuDS into open spaces and green infrastructure, to deliver strategic flood risk management and meet WFD water quality targets.	LPAs TW / AW / STW EA	Ongoing
	Developers should include the design of SuDS at an early stage to maximise the benefits of the scheme	Developers/LPA's	Ongoing
	Work with developers to discourage connection of new developments into existing surface water and combined sewer networks. Prevent connections into the foul network, as this is a significant cause of sewer flooding.	LLFA LPAs TW / AW / STW Developers	Ongoing
	Opportunities for Natural Flood Management that include schemes aimed at reducing /	LLFA LPAs	Ongoing

Aspect	Action	Responsib-ility	Timescale
	managing runoff should be considered to reduce nutrient and sediment pollution alongside reducing flood risk.	EA NE	

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1 Introduction

1.1 Terms of reference

JBA Consulting were commissioned by Oxford City Council on behalf of the Oxfordshire Plan 2050 Team (OPT) a consortium of councils in Oxfordshire (Cherwell District Council, Oxford City Council, South Oxfordshire District Council, West Oxfordshire District Council and Vale of White Horse District Council), to produce a Strategic Water Cycle Study. The aim of this study is to provide evidence to support the Oxfordshire Plan 2050.

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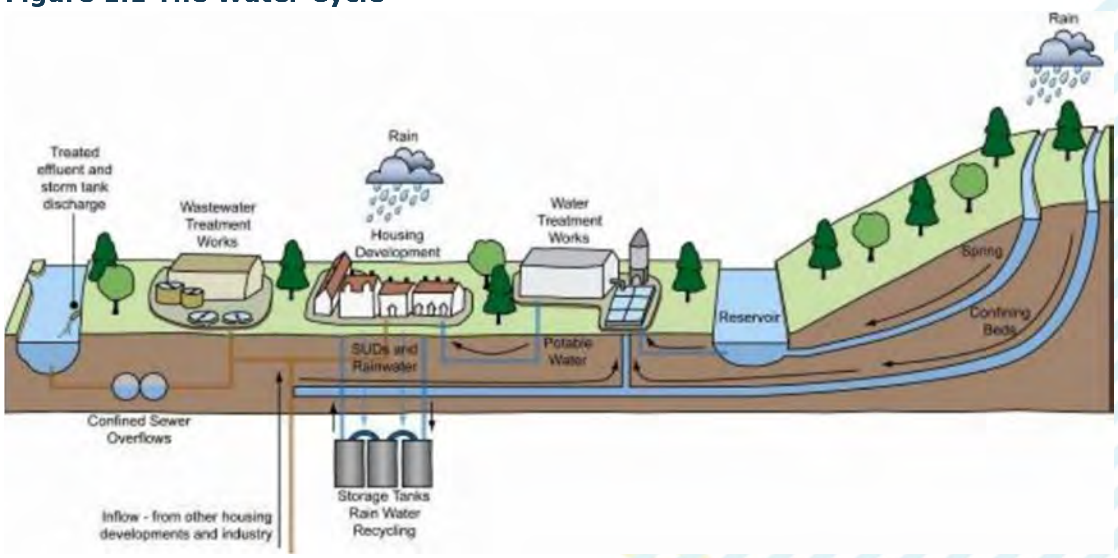
Unmitigated future development and climate change can adversely affect the environment and water infrastructure capability. A WCS will provide the required evidence, together with an agreed strategy to ensure that planned growth can occur within environmental constraints, with the appropriate infrastructure in place in a timely manner so that planned growth is deliverable.

1.2 The Water Cycle

Figure 1.1 below shows the main elements that compromise the Water Cycle and shows how the natural and man-made processes and systems interact to collect, store or transport water in the environment.

Figure 1.1 The Water Cycle



1.3 The benefits of a Water Cycle Study

New homes require the provision of clean water, safe disposal of wastewater and protection from flooding. The allocation of large numbers of new homes in certain locations may result in the capacity of existing available infrastructure being exceeded, a situation that could cause service failures to water and wastewater customers, adverse impacts to the environment, or high costs for the upgrade of water and wastewater assets being passed on to the bill payers.

In addition to increased housing demand, climate change presents further challenges to the existing water infrastructure network, including increased intensity rainfall events and a higher frequency of drought events. Sustainable planning for water must now take this into account.

Increased wastewater flows into collection systems due to growth in population or per-capita consumption can lead to overload of infrastructure, increasing the risk of sewer flooding and, where present, increase the frequency of discharges from Combined Sewer Overflows (CSOs). Likewise, headroom at wastewater treatment works can be eroded by growth in population or per-capita consumption, requiring investment in additional treatment capacity. As the volume of treated effluent rises, even if the effluent quality is maintained, the pollutant load discharged to the receiving watercourse will increase. In such circumstances the Environment Agency, as the environmental regulator, may tighten the permitted effluent permits in order to achieve a "load standstill" i.e. ensuring that as effluent volumes increase the pollutant load discharged does not increase. Again, this would require investment by the water company to improve the quality of the treated effluent.

National Planning Practice Guidance requires that, in preparing Local Plans, Local Planning Authorities (LPAs) must have regard to the Water Framework Directive (WFD) and the Environment Agency's River Basin Management Plans which implement the WFD at the river basin scale. This should include:

- Preventing deterioration. Deterioration in the current class of a water body, for any of the criteria measured for the WFD, is not permitted. Whilst individual allocations may have specific impacts on the water environment, at the plan scale it is also important to consider the cumulative impacts of increased wastewater effluent discharges from all developments to the environment. The Oxfordshire Plan evidence base should, therefore, demonstrate that, for the plan period, deterioration will not occur or that, where it could, this can be addressed, in time, within current Technologically Achievable Limits (TAL) of wastewater treatment.
- That the planned development will not prevent a water body from achieving Good status by 2027.
- That, through the plan making process and the plan policies, opportunities are taken to improve the water environment through development. For example, where redevelopment of currently developed land is proposed, there is an opportunity to move from a situation of unattenuated urban runoff to a redeveloped site which utilises Sustainable Drainage Systems (SuDS) to manage the volume and quality of runoff from the site.

Developers require early assurances that water and wastewater services will have sufficient capacity to serve new developments prior to occupation. The primary route for this is through early engagement with the water company, and for large developments this should occur well in advance of submitting a planning application and should be evidenced with the application. Developers should also be given clear guidance on what is required in the Surface Water Drainage Strategies, to be provided with planning applications for all major developments. For developers, the Development Plan should point out specific water environment issues, for example the need to protect an adjacent designated site or to restore a channel and floodplain.

Uses and Benefits of a Strategic Water Cycle Study

- **It raises awareness amongst Council Officers and Elected Members with regards to the implications of development on the wider water environment, and water and wastewater infrastructure.**
- **It considers the cumulative impact of development and opportunities for strategic level policies.**
- **Information is provided to inform wider infrastructure planning by the Oxfordshire District Councils and others, for example by providing clear information on growth plans in the study area, the WCS can assist Thames Water to plan for investing in the necessary new infrastructure and upgrades to accommodate growth.**
- **Support can be provided to identify areas of land to safeguard against future development where land is required for water infrastructure.**

1.4 Study Area

The study area is the county of Oxfordshire. Planning within the county is the responsibility of Cherwell District, Oxford City, South Oxfordshire District, Vale of White Horse District and West Oxfordshire District Councils, as illustrated in Figure 1.2. Water supply and wastewater services for the majority of the county are provided by Thames Water, with small areas in the north west supplied by Severn Trent Water and in the north east by Anglian Water.

1.5 Record of Engagement

1.5.1 Introduction

Preparation of a WCS requires significant engagement with stakeholders, including with the Local Planning Authorities, with water and wastewater utilities, with the Environment Agency and Natural England, and where there may be cross-boundary issues, with neighbouring local authorities. This section forms a record of engagement for the WCS.

1.5.2 Engagement

The preparation of this WCS was supported by the following engagement:

Inception meeting

Engaged parties	Oxfordshire Plan 2050 Team, Cherwell District Council, Oxford City Council, South Oxfordshire District Council, Vale of White Horse District Council, West Oxfordshire District Council, Oxfordshire County Council, Environment Agency, Thames Water, Anglian Water
Details	Scope of works and data collection requirements reviewed.

Draft review

Engaged Parties	Oxfordshire Plan 2050 Team, Cherwell District Council, Oxford City Council, South Oxfordshire District Council, Vale of White Horse District Council, West Oxfordshire District Council, Oxfordshire County Council, Environment Agency, Thames Water, Anglian Water, Severn Trent Water
Details	Review of draft scoping WCS

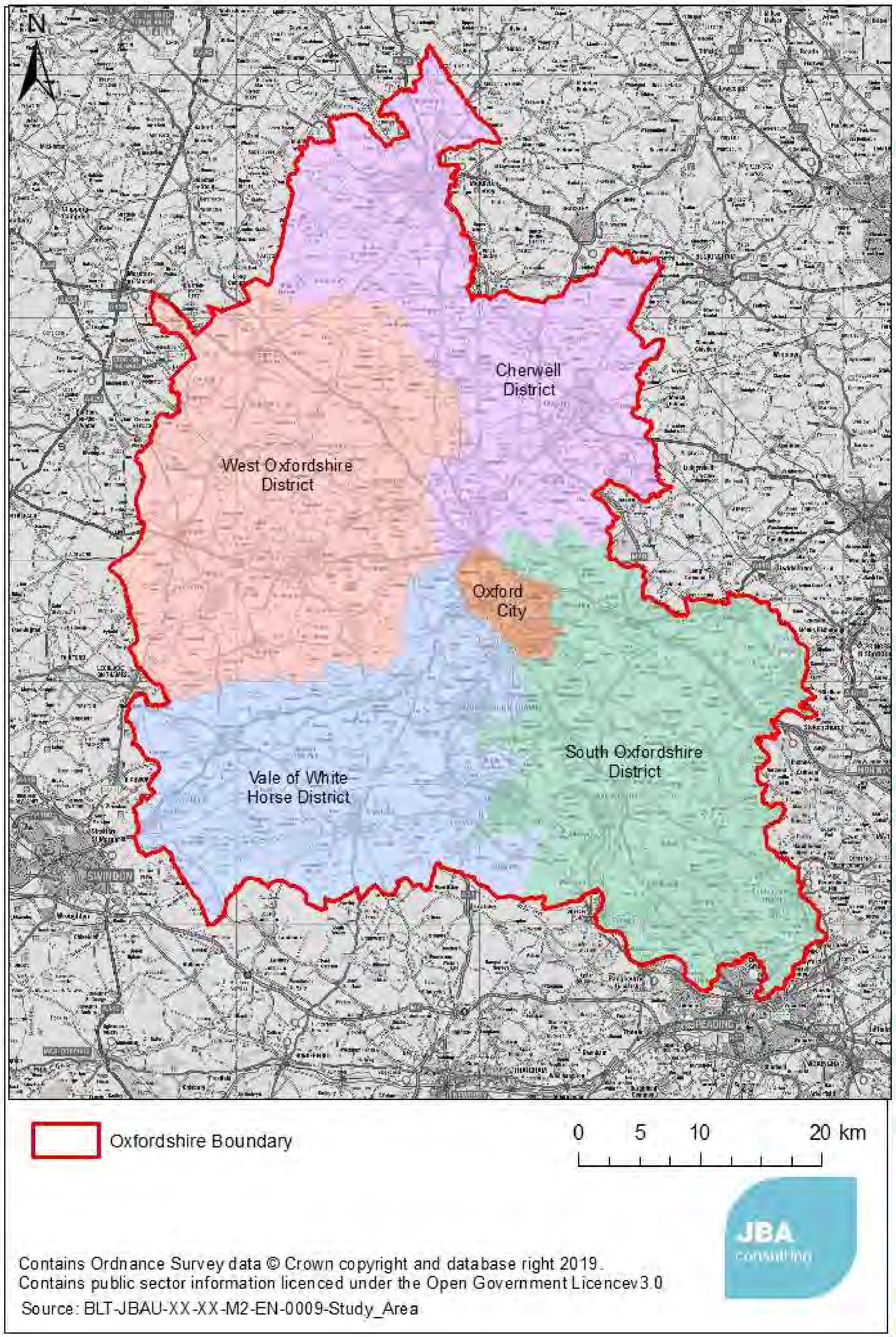


Figure 1.2 Study area

2 Future Growth in Oxfordshire

2.1 Introduction to the Oxfordshire Plan 2050

The five District and City councils in Oxfordshire have agreed to collaborate on a Joint Statutory Spatial Plan, known as the Oxfordshire Plan 2050. The Oxfordshire Plan will provide a strategic planning framework for Oxfordshire to 2050 and will be used to inform the next round of Local Plans.

The Oxfordshire Plan 2050 is working towards a Regulation 18 (part 2) consultation on policy and spatial growth options in summer 2021, and this WCS will be part of the evidence base published as part of that consultation. The Regulation 18 (part 2) consultation will explore five spatial growth options and options for the quantum of growth to 2050. The WCS study is required to evaluate these options and to identify positive and negative aspects of each option, as far as they impact upon the delivery of water and wastewater services and of the impacts of providing those services on the water environment.

2.2 Quantum of growth

The Oxfordshire Plan 2050 has reviewed the housing growth committed within the adopted Local Plans, and in the case of Cherwell, South Oxfordshire and Vale of White Horse has also identified commitments beyond the Local Plan period (Table 2.1). In total this amounts to 82,866 new homes already planned for delivery in Oxfordshire between 2020 and 2050.

Table 2.1: Committed housing growth

Council	Local Plan period	Committed growth using Plan trajectories	Completions since start of LP to 2011-2019/20	Remaining to be built 2020/21 – end of Local Plan	Beyond end of Local Plan
Cherwell	2011 - 2031	22,840 (pt1) 4,400 (PRev)	11,202	16,038	2,707 (NW Bicester)
Oxford	2016 - 2036	10,884	1,948	8,936	None
South	2011 - 2035	30,056	7,178	22,878	2,815 (Chalgrove: 895 after 2035) (Grenoble Rd: 520 after 2035) (Culham: 1,400 after 2035)
Vale	2011 - 2031	25,359	9,112	16,247	1,883 (Valley Park, Didcot: 713) (Grove Airfield: 1,042) (NW Valley Park: 128)

Council	Local Plan period	Committed growth using Plan trajectories	Completions since start of LP to 2011-2019/20	Remaining to be built 2020/21 – end of Local Plan	Beyond end of Local Plan
West	2011 - 2031	15,799	4,437	11,362	None
Totals		**109,338**	**33,877 approx.**	**75,461 approx.**	**7,405**
			Committed Growth 2020/21 onwards = 82,866		

The Oxfordshire Growth Needs Assessment (OGNA) modelling focusses on three levels of growth, as illustrated in Table 2.2.

Table 2.2: Housing growth scenarios 2020 to 2050

Housing growth scenario	Total	Residual (OGNA minus Committed Growth)
Standard Method	101,580	18,714
Business as usual trajectory	123,390	40,524
Transformational trajectory	152,780	69,914

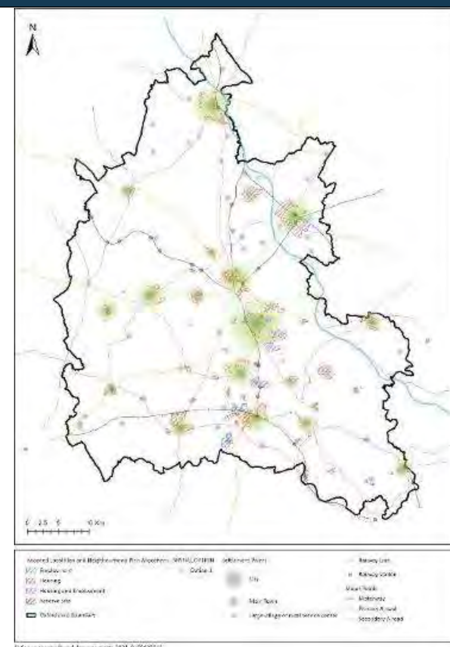
Please note: It is recognised that the figures in Table 2.1 and Table 2.2 do not entirely align with the figures in the Regulation 18 (part 2) consultation document. The residual growth figures tested in this Water Cycle Study are slightly higher than those in the Regulation 18 (part 2) consultation document. This is considered acceptable at the Regulation 18 (part 2) options stage as it represents the testing of a 'worst case scenario' of the possible effects of growth on water cycle matters. Further, more detailed Water Cycle Study work will be undertaken to inform the production of the draft plan for publication at the Regulation 19 stage. The matter of alignment will be addressed in full at that stage.

2.3 Spatial Options

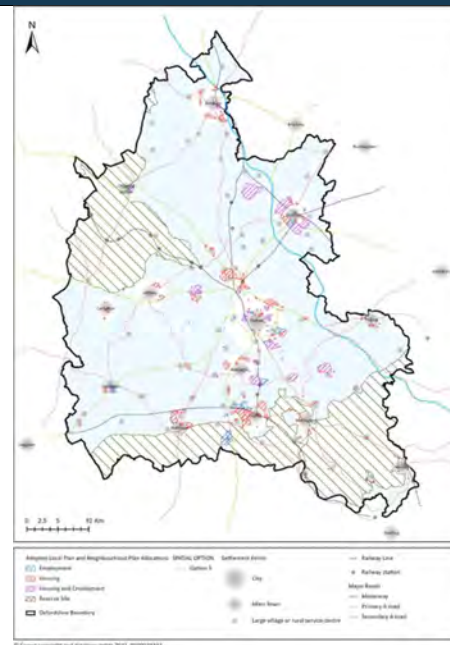
The Regulation 18 (part 2) consultation will consider the five spatial options for distributing housing and economic growth in Oxfordshire to 2050 summarised in Table 2.3. Each aligns with particular aspects of the Strategic Vison[1]. It may be that the Regulation 19 submission will comprise of components from different options.

[1] Oxfordshire Growth Board (2021) Oxfordshire Strategic Vision. Accessed online at https://www.oxfordshiregrowthboard.org/projects/oxfordshire-strategic-vision/ on 08/07/2021

Table 2.3: Spatial growth scenarios

Option	Key characteristics	Thumbnail
Option 1: Focus on opportunities at larger settlements and planned growth locations.	Focuses on areas accommodating most growth in the first phase of the Plan period e.g., towns, Oxford City (including urban extensions) and former MoD sites. Adds to adopted Local Plan strategies. Includes areas with a high concentration of jobs, infrastructure & affordable housing need. Opportunities for urban renewal, intensification and brownfield redevelopment. Does not include new settlements.	
Option 2: Focus on Oxford-led growth	Growth aims to support and strengthen Oxford's role as a global centre for knowledge and innovation. Incorporates urban renewal and transformation within city. Could include urban intensification and new or extended urban extensions on the edge of the city. Does not include new settlements. Focus on 'levelling-up' within the city to support economic productivity and deliver inclusive growth. Could include enhancement of the Green Belt adjoining the city for beneficial uses.	

Option	Key characteristics	Thumbnail
Option 3: Focus on opportunities in sustainable transport corridors & at strategic transport hubs	Growth focused in the most sustainable transport corridors, where frequent bus services operate and rail stations act as transport hubs. This includes new rail stations being planned through strategies such as the Oxfordshire Rail Corridor Study. Aligns with Oxfordshire County Council's emerging Local Transport and Connectivity Plan. Future growth aligned with transport infrastructure investment. Could include new settlements.	
Option 4: Focus on strengthening business locations	Aligns with the Local Industrial Strategy (LIS). Focus on key locations within Oxfordshire's 'innovation ecosystem'. Development to support growth in key economic sectors. Intensification and expansion of employment locations with co-location of other land uses. Could include new settlements where economic use is at heart.	

Option	Key characteristics	Thumbnail
Option 5: Focus on supporting rural communities	This option focuses on the villages and areas between the villages (with the exception of the Areas of Outstanding Natural Beauty). Aims to address rural inequalities in terms of access to housing and services. Could include new settlements & growth at existing. Consideration of cross-boundary relationship with major settlements outside Oxfordshire, especially Swindon.	

2.4 Economic growth options

The preferred option in the Regulation 18 (Part 2) consultation document is for the Oxfordshire Plan to support the creation of jobs, but to not identify specific requirements for job numbers as there is too much uncertainty later in the plan period. This detail would be provided by future local plans. Therefore, at this stage, there are no specific economic growth options for the WCS to test. It should be noted, however, that the spatial options identified in Table 2.3 are options for distributing both housing and economic development in Oxfordshire to 2050.

2.5 Cross boundary growth

Water and wastewater supply, collection and treatment systems may operate across local authority boundaries. Where this is the case, the water cycle study needs to consider all growth which might contribute additional demand to a water or wastewater system.

The Local Plans produced by Oxfordshire's neighbouring authorities have been reviewed to assess the cross-boundary impacts of growth. There does not seem to be any planned development that will significantly affect the Oxfordshire wastewater networks or supply, and any necessary upgrades to water infrastructure appear to remain outside the Oxfordshire boundary.

3 Legislative and Policy Framework

3.1 Introduction

The following sections introduce several national, regional and local policies that must be considered by the LPAs, water companies and developers through plan-making and development planning. Key extracts from these policies relating to water consumption targets and mitigating the impacts on the water from the new development are summarised below.

Given that the Oxfordshire Plan looks ahead to 2050, it is working on a considerably longer timescale than regular Local Plans. This provides the opportunity to consider how legislation and policy may need to evolve both locally and nationally to support sustainable development and use of water resources.

3.2 National Policy

3.2.1 National Planning Policy Framework

The National Planning Policy Framework (NPPF)[2] was published on 27th March 2012, as part of reforms to make the planning system less complex and more accessible, to protect the environment and to promote sustainable growth. A comprehensive revision was issued in July 2018. This was further revised in February 2019 and July 2021[3], but the changes were not significant from the July 2018 version for policy areas relevant to the WCS. The NPPF requires planning authorities to take account of flood risk and water and wastewater infrastructure delivery in their Development Plans. References to the NPPF hereafter are to the July 2021 version. Key paragraphs include:

Paragraph 34:

> *"Plans should set out the contributions expected from development. This should include setting out the levels and types of affordable housing provision required, along with other infrastructure (such as that needed for education, health, transport, flood and water management, green and digital infrastructure). Such policies should not undermine the deliverability of the plan."*

Paragraph 153:

> *"Plans should take a proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk, coastal change, water supply..."*

Paragraph 174 (e):

> *"…preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans".*

In March 2014, the Planning Practice Guidance was issued by the Department for Communities and Local Government, with the intention of providing guidance on the

2 National Planning Policy Framework, Department for Communities and Local Government (2012)
3 National Planning Policy Framework, Ministry of Housing, Communities and Local Government (2019). Accessed online at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 on: 23/07/2021

application of the National Planning Policy Framework (NPPF) in England. The MHCLG is in the process of updating the Guidance to consider the necessary 2018, 2019 and 2021 updates of the NPPF. Of the sections relevant to this study, only the Water Supply, Wastewater and Water Quality section has been updated.

- Flood Risk and Coastal Change[4]
- Water Supply, Wastewater and Water Quality[5].
- Housing - Optional Technical Standards[6].

3.2.2 Planning Practice Guidance: Flood Risk and Coastal Change

Diagram 1 in the Planning Practice Guidance sets out how flood risk should be considered in the preparation of Local Plans (Figure 3.1). These requirements will be addressed principally in the Strategic Flood Risk Assessment to be published at the Regulation 19 stage.

3.2.3 Planning Practice Guidance: Water Supply, Wastewater and Water Quality

A summary of the specific guidance on how infrastructure, water supply, wastewater and water quality considerations should be accounted for in both plan-making and planning applications is summarised below in Figure 3.2.

3.2.4 Planning Practice Guidance: Housing – Optional Technical Standards

This guidance advises planning authorities on how to gather evidence to set optional requirements, including for water efficiency. It states that "all new homes already have to meet the mandatory national standard set out in the Building Regulations (of 125 litres/person/day). Where there is a clear local need, local planning authorities can set out Development Plan policies requiring new dwellings to meet the tighter Building Regulations optional requirement of 110 litres/person/day. Planning authorities are advised to consult with the EA and water companies to determine where there is a clear local need, and also to consider the impact of setting this optional standard on housing viability. A 2014 study[7] into the cost of implementing sustainability measures in housing found that meeting a standard of 110 litres per person per day would cost only £9 for a four-bedroom house.

3.2.5 Building Regulations

The Building Regulations (2010) Part G[8] was amended in early 2015 to require that all new dwellings must ensure that the potential water consumption must not exceed 125 litres/person/day, or 110 litres/person/day where required under planning conditions.

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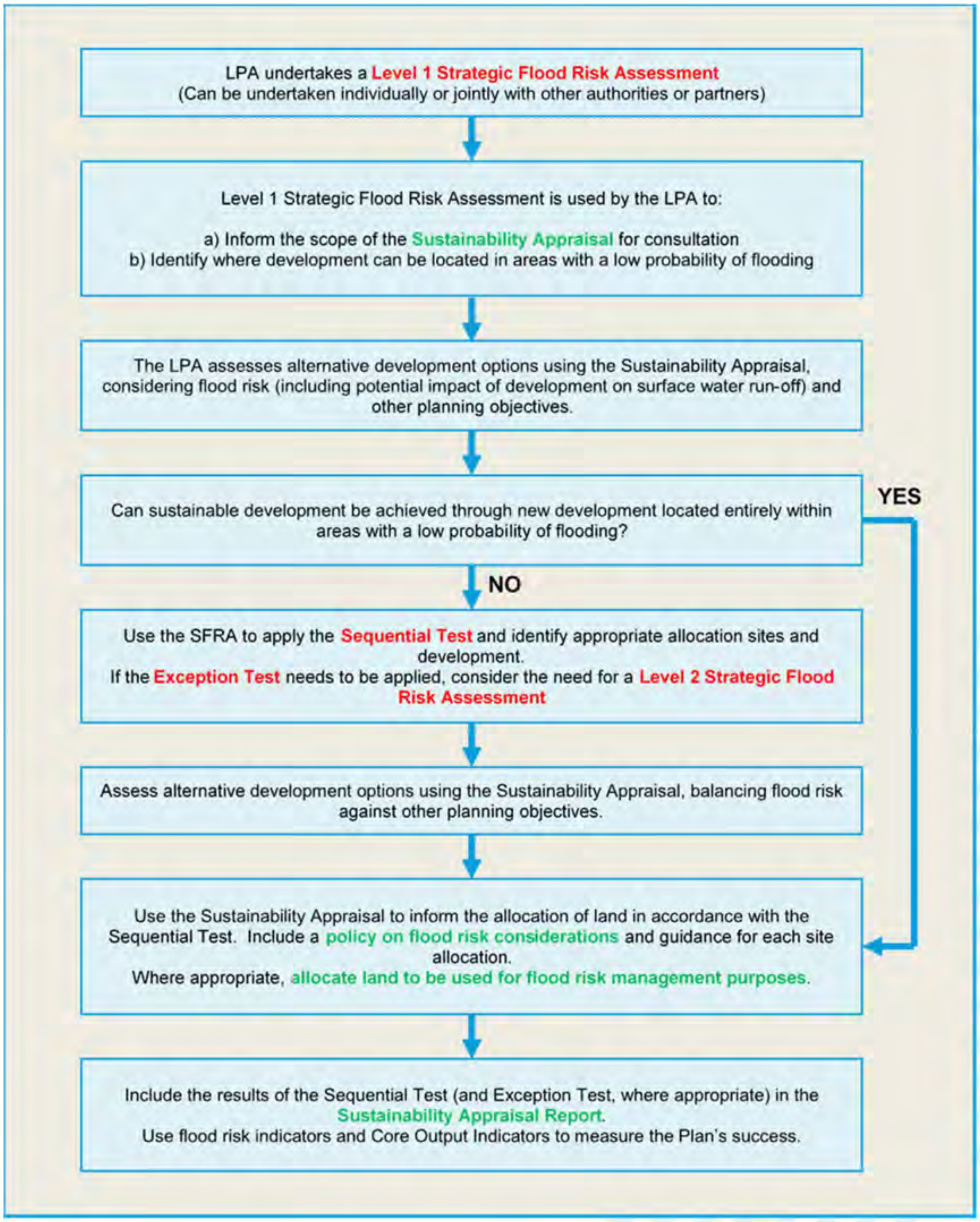
4 Guidance: Flood Risk and Coastal Change, Ministry of Housing, Communities & Local Government (2014). Accessed online at: https://www.gov.uk/guidance/flood-risk-and-coastal-change on: 13/04/2021
5 Planning Practice Guidance: Water supply, wastewater and water quality, Ministry of Housing, Communities & Local Government (2019). Accessed online at: https://www.gov.uk/guidance/water-supply-wastewater-and-water-quality on: 13/04/2021
6 Planning Practice Guidance: Housing - Optional Technical Standards, Ministry of Housing, Communities & Local Government (2014). Accessed online at: https://www.gov.uk/guidance/housing-optional-technical-standards on: 13/04/2021
7 Housing Standards Review: Cost Impacts, Department for Communities and Local Government (2014). Accessed online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/353387/021c_Cost_Report_11th_Sept_2014_FINAL.pdf on: 13/04/2021
8 The Building Regulations (2010) Part G - Sanitation, hot water safety and water efficiency, 2015 edition with 2016 amendments. HM Government (2016). Accessed online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/504207/BR_PDF_AD_G_2015_with_2016_amendments.pdf on: 13/04/2021

Figure 3.1 Flood Risk and the Preparation of Local Plans[9]



9 Based on Diagram 1 of NPPF Planning Practice Guidance: Flood Risk and Coastal Change (paragraph 004, Reference ID: 7-021-20140306

Figure 3.2 PPG: Water supply, wastewater and water quality considerations for plan-making and planning applications

	Plan-making	Planning applications
Infrastructure	Identification of suitable locations for new or enhanced infrastructure. Consider whether new development is appropriate near to water and wastewater infrastructure. Phasing new development so that water and wastewater infrastructure will be in place when needed.	Wastewater considerations include: First presumption is to provide a system for foul drainage discharging into a public sewer. Phasing of development and infrastructure, ensuring no occupation of properties until adequate infrastructure is in place. Circumstances where package sewage treatment plants or septic tanks are applicable.
Water supply	Not Specified	Planning for the necessary water supply would normally be addressed through the Development Plan, exceptions might include: Large developments not identified in Development Plans; Where a Development Plan requires enhanced water efficiency in new developments. This is recommended in all areas of water stress.
Water quality	How to help protect and enhance local surface water and groundwater in ways that allow new development to proceed and avoids costly assessment at the planning application stage. The type or location of new development where an assessment of the potential impacts on water bodies may be required. Expectations relating to sustainable drainage systems.	Water quality is only likely to be a significant planning concern when a proposal would: Involve physical modifications to a water body; Indirectly affect water bodies, for example as a result of new development such as the redevelopment of land that may be affected by contamination etc. or through a lack of adequate infrastructure to deal with wastewater. Directly or indirectly result in a deterioration in water quality or a breach of environmental legislation as a result of adequate infrastructure in place to accommodate additional development pressures.
Wastewater	The sufficiency and capacity of wastewater infrastructure. The circumstances where wastewater from new development would not be expected to drain to a public sewer.	If there are concerns arising from a planning application about the capacity of wastewater infrastructure, applicants will be asked to provide evidence of initial liaison with STW with reference to plans to accommodate additional wastewater flows or provide information about how the proposed development will be drained and wastewater dealt with.
Cross-boundary concerns	Water supply and water quality concerns often cross local authority boundaries and can be best considered on a catchment basis. Recommends liaison from the outset.	No specific guidance (relevant to some developments).
SEA and Sustainability	Water supply and quality are considerations in strategic environmental assessment and sustainability appraisal ... sustainability appraisal objectives could include preventing deterioration of current water body status, taking climate change into account and seeking opportunities to improve water bodies.	No specific guidance (should be considered in applications).

3.2.6 BRE Standards

The Building Research Establishment (BRE) publish an internationally recognised environmental assessment methodology for assessing, rating and certifying the sustainability of a range of buildings.

New homes are most appropriately covered by the Home Quality Mark[10], and commercial, leisure, educational facilities and mixed-use buildings by the Building Research Establishment Environmental Assessment Methodology (BREEAM) UK New Construction Standard[11].

Using independent, licensed assessors, BREEAM/HQM assesses criteria covering a range of issues in categories that evaluate energy and water use, health and wellbeing, pollution, transport, materials, waste, ecology and management processes.

In the Homes Quality Mark, 400 credits are available across 11 categories and lead to a star rating. 18 credits are available for water efficiency and water recycling. A greater number of credits are awarded for homes using water efficient fittings (with the highest score achieving 100l/p/d or less), and further credits are awarded for the percentage of water used in toilet flushing that is either sourced from rainwater or from grey water.

The BREEAM New Construction Standard awards credits across nine categories, four of which are related to water: water consumption, water monitoring, leak detection and water efficient equipment. This leads to a percentage score and a rating from "Pass" to "Outstanding".

The Councils have the opportunity to seek BREEAM or HQM status for all new, residential and non-residential buildings.

3.2.7 Sustainable Drainage Systems (SuDS)

From April 2015, Local Planning Authorities (LPAs) have been given the responsibility for ensuring that sustainable drainage is implemented on developments of ten or more homes or other forms of major development through the planning system. Under the new arrangements, the key policy and standards relating to the application of SuDS to new developments are:

- The National Planning Policy Framework, which requires that development in areas already at risk of flooding should give priority to sustainable drainage systems.
- The House of Commons written statement[12] setting out government's intentions that LPAs should "ensure that sustainable drainage systems for the management of run-off are put in place, unless demonstrated to be inappropriate" and "clear arrangements in place for ongoing maintenance over the lifetime of the development." This requirement was incorporated in the 2019 update of the NPPF (now paragraph 169 of the 2021 version). In practice, this has been implemented by making Lead Local Flood Authorities (LLFAs) statutory consultees on the drainage arrangements of major developments.
- The Defra non-statutory technical standards for sustainable drainage systems[13]. These set out the government's high-level requirements for managing peak flows and runoff volumes, flood risk from drainage systems and the structural integrity

10 Home Quality Mark, BRE, (2018). Accessed online at: https://www.homequalitymark.com/professionals/standard/ on: 13/04/2021
11 BREEAM UK New Construction, BRE, (2018). Accessed online at: https://www.breeam.com/NC2018/ on: 13/04/2021
12 Sustainable drainage systems: Written statement - HCWS161, UK Government (2014). Accessed online at: http://www.parliament.uk/business/publications/written-questions-answers-statements/written-statement/Commons/2014-12-18/HCWS161/ on: 13/04/2021
13 Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage systems, Defra (2015). Accessed online at: https://www.gov.uk/government/publications/sustainable-drainage-systems-non-statutory-technical-standards on: 13/04/2021

and construction of SuDS. This very short document is not a design manual and makes no reference to the other benefits of SuDS, for example water quality, habitat and amenity.

- Oxfordshire County Council is the LLFA and plays a key role in ensuring that the proposed drainage schemes for all new developments comply with technical standards and policies in relation to SuDS. The "Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire"[14] contains guidance for the design and application of SuDS in the county.
- An updated version of the CIRIA SuDS Manual[15] was published in 2015. The guidance covers the planning, design, construction and maintenance of SuDS for effective implementation within both new and existing developments. The guidance is relevant for a range of roles with the level of technical detail increasing throughout the manual. The guidance does not include detailed information on planning requirements, SuDS approval and adoption processes and standards, as these vary by region and should be checked early in the planning process.
- CIRIA also publish "Guidance on the Construction of SuDS" (C768)[16], which contains detailed guidance on all aspects of SuDS construction, with specific information on each SuDS component available as a downloadable chapter.
- As of April 2020, the new Design and Construction Guidance (DCG) came into force in England. This contains details of the water sector's approach to the adoption of those SuDS which meet the legal definition of a sewer. The guidance replaces Sewers for Adoption 8. It differs from previous Sewers for Adoption guidance as compliance by water companies in England is now mandatory.

3.3 Existing Oxfordshire Water Cycle Studies

All five of the District and City councils have prepared Water Cycle Studies as part of the evidence base for their adopted Local Plans. These have been reviewed in detail. Recommendations for further development of the WCS evidence base to support the Oxfordshire Plan to 2050 will:

- extend the water resources assessment to 2050 to take account of additional growth,
- explore new strategic water resources and water neutrality,
- quantify WwTW headroom,
- assess flood risk from WwTWs,
- odour screening around WwTWs,
- include catchment-scale water quality modelling and
- further information on funding sources.

3.4 Regional Policy

3.4.1 Catchment Flood Management Plans

Catchment Flood Management Plans (CFMP) are high level policy documents covering large river basin catchments. They aim to set policies for sustainable flood risk

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14 Oxfordshire County Council (2018). Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire. Accessed online at: https://www.oxfordshirefloodtoolkit.com/wp-content/uploads/2018/12/LOCAL-STANDARDS-AND-GUIDANCE-FOR-SURFACE-WATER-DRAINAGE-ON-MAJOR-DEVELOPMENT-IN-OXFORDSHIRE.pdf on: 07/06/2021
15 The SuDS Manual (C753), CIRIA (2015).
16 Guidance on the Construction of SuDS (C768), CIRIA (2017), Accessed online at: https://www.ciria.org/ItemDetail?iProductcode=C768&Category=BOOK on: 13/04/2021

management for the whole catchment covering the next 50 to 100 years. Oxfordshire is covered by the River Thames CFMP[17].

3.4.2 Surface Water Management Plans (SWMPs)

SWMPs outline the preferred surface water management strategy in a given location and establish a long-term action plan to manage surface water. SWMPs are undertaken, when required, by LLFAs in consultation with key local partners who are responsible for surface water management and drainage in their area. There are currently no SWMPs for Oxfordshire.

3.5 Local Policy

3.5.1 Localism Act

The Localism Act (2011) changes the powers of local government, it re-distributes the balance of decision making from central government back to councils, communities and individuals. In relation to the planning of sustainable development, provision 110 of the Act places a duty to cooperate on Local Authorities. This duty requires Local Authorities to *"engage constructively, actively and on an ongoing basis in any process by means of which development plan documents are prepared so far as relating to a strategic matter"*[18].

The Localism Act also provides new rights to allow local communities to come together and shape the development and growth of their area by preparing Neighbourhood Development Plans, or Neighbourhood Development Orders, where the ambition of the neighbourhood is aligned with strategic needs and priorities for the area. This means that local people can decide where new homes and businesses should go and also what they should look like. As neighbourhoods draw up their proposals, Local Planning Authorities are required to provide technical advice and support.

3.6 International Environmental Policy

3.6.1 Ramsar

The Convention on Wetlands of International Importance, more commonly known as the Ramsar convention after the city where it was signed in 1971, aims to protect important wetland sites. Under the treaty, member counties commit to:

- Wise use of all their wetlands
- Designating sites for the Ramsar list of "Wetlands of International Importance" (Ramsar Sites) and their conservation
- Cooperating on transboundary wetlands and other shared interests.

"Wise use" of wetlands is defined under the convention as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development". A handbook on the wise use of wetlands is available from the Ramsar Convention Secretariat[19].

Ramsar Sites are designated by the National Administrative Authority, responsible for the Ramsar Convention in each country. In the case of the UK this is the Joint Nature Conservation Committee (JNCC).

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17 River Thames Catchment Flood Management Plan, environment Agency (2009). Accessed online at: https://www.gov.uk/government/publications/thames-catchment-flood-management-plan on: 07/06/2021
18 Localism Act 2011: Section 110, UK Government (2011). Accessed online at: http://www.legislation.gov.uk/ukpga/2011/20/section/110/enacted on: 13/04/2021
19 Wise use of wetlands, Ramsar Convention Secretariat (2010). Accessed online at: https://www.ramsar.org/sites/default/files/documents/library/hbk4-01.pdf on: 13/04/2021

In general, the designation of UK Ramsar sites is underpinned through prior notification of these areas as Sites of Special Scientific Interest (SSSIs) and as such receive statutory protection under the Wildlife and Countryside Act 1981 (as amended). More recently, Paragraph 181 of the NPPF (2021) states that Ramsar sites should be given the same protection in the planning process as sites designated under the EU Habitats Directive.

3.7 European Environmental Policy

3.7.1 Urban Wastewater Treatment Directive (UWWTD)

The UWWTD[20] is an EU Directive that concerns the collection, treatment and discharge of urban wastewater and the treatment and discharge of wastewater from certain industrial sectors. The objective of the Directive is to protect the environment from the adverse effects of wastewater discharges. More specifically Annex II A(a) sets out the requirements for discharges from urban wastewater treatment plants to sensitive areas which are subject to eutrophication. The Directive has been transposed into UK legislation through enactment of the Urban Waste Water Treatment (England and Wales) Regulations 1994 and 'The Urban Waste Water Treatment (England and Wales) (Amendments) Regulations 2003'.

3.7.2 Habitats Directive

The EU Habitats Directive aims to protect the wild plants, animals and habitats that make up our diverse natural environment. The directive created a network of protected areas around the European Union of national and international importance called Natura 2000 sites. These include:

- Special Areas of Conservation (SACs) - support rare, endangered or vulnerable natural habitats, plants and animals (other than birds).
- Special Protection Areas (SPAs) - support significant numbers of wild birds and habitats.

Special Protection Areas and Special Areas of Conservation are established under the EC Birds Directive and Habitats Directive respectively. The directive also protects over 1,000 animals and plant species and over 200 so called "habitat types" (e.g. special types of forests, meadows, wetlands, etc.), which are of European importance.

3.7.3 The Water Framework Directive

The Water Framework Directive (WFD) was first published in December 2000 and transposed into English and Welsh law in December 2003. It introduced a more rigorous concept of what "good status" should mean than the previous environmental quality measures.

River Basin Management Plans (RBMP) are required under the WFD and document the baseline classification of each waterbody in the plan area, the objectives, and a programme of measures to achieve those objectives. Oxfordshire falls within the Thames River Basin District (RBD)[21]. Under the WFD the RBMPs, which were originally published in December 2009, were reviewed and updated in December 2015. Consultation on the next update is due to start in 2021. A primary WFD objective is to ensure 'no deterioration' in environmental status, therefore all water bodies must meet the class limits for their status class as declared in the Thames River Basin Management

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20 UWWTD. Accessed online at: https://ec.europa.eu/environment/water/water-urbanwaste/index_en.html On: 13/04/2021

21 Thames River Basin District River Basin Management Plan: 2015, Environment Agency (2015). Accessed at: https://www.gov.uk/government/collections/river-basin-management-plans-2015#thames-river-basin-district-rbmp:-2015 on:07/06/2021

Plan and on the Environment Agency's Catchment Data Explorer website[22]. Another equally important objective requires all water bodies to achieve good ecological status. Future development needs to be planned carefully so that it helps towards achieving the WFD and does not result in further pressure on the water environment and compromise WFD objectives. The WFD objectives as outlined in the updated RBMPs are summarised below:

Main Issues

- Physical modifications
- Pollution from wastewater
- Pollution from towns, cities and transport
- Changes to the natural flow and level of water
- Negative effects of invasive non-native species
- Pollution from rural areas
- Pollution from abandoned mines

Objectives

- Prevent deterioration of the status of surface waters and groundwater
- Achieve objectives and standards for protected areas
- Achieve good status for all water bodies or, for heavily modified water bodies and artificial water bodies, good ecological potential and good surface water chemical status
- Reverse any significant and sustained upward trends in pollutant concentrations in groundwater
- Stop discharges/emissions of priority hazardous substances into surface waters
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants

Local Planning Authorities (LPAs) must have regard to the Water Framework Directive and associated statutory objectives as implemented in the Environment Agency's River Basin Management Plans. It is of primary importance when assessing the impact of additional wastewater flow discharges on local river quality.

3.7.4 Protected Area Objectives

The WFD specifies that areas requiring special protection under other EC Directives, and waters used for the abstraction of drinking water, are identified as protected areas. These areas have their own objectives and standards.

Article 4 of the WFD required Member States to achieve compliance with the standards and objectives set for each protected area by 22 December 2015, unless otherwise specified in the Community legislation under which the protected area was established. Some areas may require special protection under more than one EC Directive or may have additional (surface water and/or groundwater) objectives. In these cases, all the objectives and standards must be met.

The types of protected areas are:

- Areas designated for the abstraction of water for human consumption (Drinking Water Protected Areas)

22 https://environment.data.gov.uk/catchment-planning/

- Areas designated for the protection of economically significant aquatic species (Freshwater Fish and Shellfish)
- Bodies of water designated as recreational waters, including Bathing Waters;
- Nutrient-sensitive areas, including areas identified as Nitrate Vulnerable Zones under the Nitrates Directive or areas designated as sensitive under Urban Waste Water Treatment Directive (UWWTD)
- Areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection including relevant Natura 2000 sites

Many WFD protected areas coincide with water bodies; these areas will need to achieve the water body status objectives in addition to the protected area objectives. Where water body boundaries overlap with protected areas the most stringent objective applies; that is the requirements of one EC Directive should not undermine the requirements of another. The objectives for Protected Areas relevant to this study are as follows:

Drinking Water Protected Areas

- Ensure that, under the water treatment regime applied, the drinking water produced meets the requirements of the Drinking Water Directive plus any UK requirements to make sure that drinking water is safe to drink
- Ensure the necessary protection to prevent deterioration in the water quality in the protected area in order to reduce the level of purification treatment required

Economically Significant Species (Freshwater Fish Waters)

- Protect or improve the quality of running or standing freshwater to enable them to support fish belonging to indigenous species offering a natural diversity; or species, the presence of which is judged desirable for water management purposes by the competent authorities of the Member States

Nutrient Sensitive Areas (Nitrate Vulnerable Zones)

- Reduce water pollution caused or induced by nitrates from agricultural sources
- Prevent further such pollution

Nutrient Sensitive Areas (Urban Waste Water Treatment Directive)

- Protect the environment from the adverse effects of urban wastewater discharges and wastewater discharges from certain industrial sectors

Natura 2000 Protected Areas (water dependent SACs and SPAs)

The objective for Natura 2000 Protected Areas identified in relation to relevant areas designated under the Habitats Directive or Birds Directive is to:

- Protect and, where necessary, improve the status of the water environment to the extent necessary to achieve the conservation objectives that have been established for the protection or improvement of the site's natural habitat types and species of importance

3.7.5 Groundwater Source Protection Zones

The Environment Agency has a Groundwater Protection Policy to help prevent groundwater pollution. In conjunction with this the Environment Agency have defined groundwater Source Protection Zones (SPZs) to help identify high risk areas and implement pollution prevention measures. The SPZs show the risk of contamination from activities that may cause pollution in the area, the closer the activity, the greater the risk. There are three main zones (inner, outer and total catchment) and a fourth zone of special interest which is occasionally applied.

Zone 1 (Inner protection zone)

This zone is designed to protect against the transmission of toxic chemicals and water-borne disease. It indicates the area in which pollution can travel to the borehole within 50 days from any point within the zone and applies at and below the water table. There is also a minimum 50 metre protection radius around the borehole.

Zone 2 (Outer protection zone)

This zone indicates the area in which pollution takes up to 400 days to travel to the borehole, or 25% of the total catchment area, whichever area is the largest. This is the minimum length of time the Environment Agency think pollutants need to become diluted or reduce in strength by the time they reach the borehole.

Zone 3 (Total catchment)

This is the total area needed to support removal of water from the borehole, and to support any discharge from the borehole.

Zone of Special Interest

This is defined on occasions, usually where local conditions mean that industrial sites and other polluters could affect the groundwater source even though they are outside the normal catchment.

The Environment Agency's approach to Groundwater protection[23] sets out a series of position statements that detail how the Environment Agency delivers government policy on groundwater and protects the resources from contamination. The position statements that are relevant to this study with regard to discharges to groundwaters, include surface water drainage and the use of SuDS, discharges from contaminated surfaces (e.g. lorry parks) and from treated sewage effluent.

3.7.6 European Derived Legislation and Brexit

Much of the legislation behind the regulation of the water environment derives from the UK enactment of European Union (EU) directives. The UK government has signalled that "the UK will in future develop separate and independent policies in areas such as … the environment … maintaining high standards as we do so."[24]

As the details of future changes to environmental regulation are not yet known, this study has used existing, European Union derived environmental legislation, most significantly the Water Framework Directive, to assess the environmental impacts of planned development during the plan period. Should this situation change, a review of this Water Cycle Study may be required considering any new emerging regulatory regime.

3.8 UK Environmental Policy

3.8.1 Conservation of Habitats and Species Regulations 2017 (as amended)

The Conservation of Habitats and Species Regulations 2010 (commonly referred to as the Habitats Regulations) consolidated the Conservation (Natural Habitats, &c.) Regulations 1994, and transposed the EU Habitats Directive in England and Wales. This was further amended in 2017 and 2019[25].

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23 The Environment Agency's approach to groundwater protection, Environment Agency (2018). Accessed online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/598778/LIT_7660.pdf on: 13/04/2021

24 The Future Relationship between the UK and the EU (2020) Accessed online at: https://www.gov.uk/government/speeches/the-future-relationship-between-the-uk-and-the-eu on 13/04/2021

25 Defra (2021) Changes to the Habitats Regulations 2017. Accessed online at: https://www.gov.uk/government/publications/changes-to-the-habitats-regulations-2017/changes-to-the-habitats-regulations-2017

The Habitats Regulations define the requirement for a Habitats Regulations Assessment (HRA) to be carried out. The purpose of this is to determine if a plan or project may affect the protected features of a "habitats site". These include:

- A special area of conservation (SAC)
- A site of Community Importance
- A site hosting a priority natural habitat type or priority species protected in accordance with Article 5(4) of the Habitats Directive
- A Special Protection Area (SPA)
- A potential SPA

All plans and projects (including planning applications) which are not directly connected with, or necessary for the conservation management of a habitat site require consideration of whether the plan or project is likely to have significant effects on that site.

This is referred to as the "Habitats Regulations Assessment screening" and should consider the potential effects of both the plan/project itself and in combination with other plans or projects.

Part 6 of the conservation of Habitats and Species Regulations 2017 states that where the potential for likely significant effects cannot be excluded, a competent authority must make an appropriate assessment of the implications of the plan or project for that site, in view of the site's conservation objectives.

The competent authority may agree to the plan or project only after having ruled out adverse effects on the integrity of the habitats site.

If adverse effects cannot be ruled out, and where there are no alternative solutions, the plan or project can only proceed if there are imperative reasons of over-riding public interest and if the necessary compensatory measures can be secured.

The "People over Wind" ECJ ruling (C-323/17) clarifies that when making screening decisions for the purposes of deciding whether an appropriate assessment is required, competent authorities cannot take into account any mitigation measures. This must be part of the appropriate assessment itself.

3.8.2 Wildlife and Countryside Act 1981

Sites of Special Scientific Interest (SSSI) are designated and legally protected under the Wildlife and Countryside Act 1981. Section 28G places a duty to take reasonable steps, consistent with the proper exercise of the authority's functions, to "further the conservation and enhancement of the flora, fauna or geological or physiographical features by reason of which the site is of special scientific interest."[26]

The Government's 25-year Environment Plan[27] has a target of "restoring 75% of our one million hectares of terrestrial and freshwater protected sites to favourable condition, securing their wildlife value for the long term." In line with this, and the Wildlife and Countryside Act 1981, Local Authorities should look to put forward options that contribute to conservation or restoration of favourable condition, and at the very least must not introduce policies that hinder the restoration of favourable condition by increasing existing issues.

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26 Wildlife and Countryside Act 1981, HM Government (1981). Accessed online at: http://www.legislation.gov.uk/ukpga/1981/69 on: 13/04/2021
27 A Green Future: Our 25 Year Plan to Improve the Environment, HM Government (2018). Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf on: 13/04/2021

A site is said to be in "favourable condition" when the designated feature(s) within a unit are being adequately conserved and the results from monitoring demonstrate that the feature(s) in the unit are meeting all the mandatory site specific monitoring targets set out in the favourable condition targets (FCT).

3.8.3 The Natural Environment Rural Communities Act (NERC)

The Natural Environment and Rural Communities Act 2006 (commonly referred to the as the NERC Act), was intended to implement key aspects of the Government's Rural Strategy published in 2004 and established Natural England as a new independent body responsible for conserving, enhancing and managing England's natural environment.

Section 40 of the NERC Act places a duty to conserve biodiversity on public authorities, including Local Planning Authorities and water companies. "The public authority must, in exercising its functions, have regard, so far as is consistent with the proper exercise of those functions, to the purpose of conserving biodiversity."[28]

Section 41 requires the Secretary of State to publish and maintain a list of species and types of habitat which in the Secretary of State's opinion (in consultation with Natural England) are of "principal importance for the purpose of conserving biodiversity."

3.9 Water Industry Policy

3.9.1 The Water Industry in England

Water and sewerage services in England and Wales are provided by 10 Water and Sewerage Companies (WaSCs) and 12 'water-only' companies. The central legislation relating to the industry is the Water Industry Act 1991. The companies operate as regulated monopolies within their supply regions, although very large water users and developments are able to obtain water and/or wastewater services from alternative suppliers - known as inset agreements.

The Water Act 2014 aims to reform the water industry to make it more innovative and to increase resilience to droughts and floods. Key measures which could influence the future provision of water and wastewater services include:

- Non-domestic customers will be able to switch their water supplier and/or sewerage undertaker (from April 2017)
- New businesses will be able to enter the market to supply these services
- Measures to promote a national water supply network
- Enabling developers to make connections to water and sewerage systems

3.9.2 Regulations of the Water Industry

The water industry is primarily regulated by three regulatory bodies;

- The Water Services Regulation Authority (OfWAT) – economic/ customer service regulation
- Environment Agency - environmental regulation
- Drinking Water Inspectorate (DWI) - drinking water quality

Every five years the industry submits a Business Plan to OfWAT for a Price Review (PR). These plans set out the companies' operational expenditure (OPEX) and capital expenditure (CAPEX) required to maintain service standards, enhance service (for example where sewer flooding occurs), to accommodate growth and to meet environmental objectives defined by the Environment Agency. OfWAT assesses and

28 Natural Environment and Rural Communities Act 2006, HM Government (2006). Accessed online at: http://www.legislation.gov.uk/ukpga/2006/16/section/40 on: 13/04/2021

compares the plans with the objective of ensuring what are effectively supply monopolies and operating efficiently. The industry is currently in Asset Management Plan 7 (AMP7) which runs from 2020 to 2025.

When considering investment requirements to accommodate growing demand, water companies are required to ensure a high degree of certainty that additional assets will be required before funding them. Longer term growth is, however, considered by the companies in their internal asset planning processes and in their 25-year Strategic Direction Statements and WRMPs.

3.9.3 Water Resource Management Plans

Water Resource Management Plans (WRMPs) are long-term plans looking ahead up to 80 years and developing 25-year strategies that water companies are required to prepare, with updates every five years. In reality, water companies prepare internal updates more regularly. WRMPs are required to assess:

- Future demand (due to population and economic growth)
- Future water availability (including the impact of sustainability reductions)
- Demand management and supply-side measures (e.g., water efficiency and leakage reduction, water transfers and new resource development)
- How the company will address changes to abstraction licences
- How the impacts of climate change will be mitigated

Where necessary, they set out the requirements for developing additional water resources to meet growing demand and describe how the balance between water supply and demand will be balanced over the period 2020 to 2045 and beyond.

- Using cost-effective demand management, transfer, trading and resource development schemes to meet growth in demand from new development and to restore abstraction to sustainable levels.
- In the medium to long term, ensuring that sufficient water continues to be available for growth and that the supply systems are flexible enough to adapt to climate change.

The Thames Water Final Water Resources Management Plan 2019[29] covers practically all of Oxfordshire, and is discussed in Section 4.

3.9.4 Regional Water Resource Planning

Water resource planning is taking an increasingly regional focus, recognising the need for collaboration between water companies and sectors in order to address the challenges of climate change, increasing demand for water and protecting the water environment. Five regional groupings having been formed, including the Water Resource South East (WRSE) group which covers Oxfordshire. WRSE is a group of abstractors, their representatives and their regulators, with a core group consisting of Thames Water, Affinity Water, Portsmouth Water, SES Water, South East Water, Southern Water and the Environment Agency. Their aim is to provide strategic oversight and co-ordination of water resources matters across the South East, and strategic transfers with neighbouring regions.

WRSE is preparing a regional water resource plan for publication in 2023, which in turn will inform the next round of company WRMPs to be published in 2024. As part of this process, they have published an initial assessment of the regions water resource

29 Thanes Water (2019) Water Resource Management Plan. Accessed online at: https://www.thameswater.co.uk/about-us/regulation/water-resources on 07/06/2021.

requirements[30] which sets out the water resources challenges and opportunities within the region.

3.9.5 Drainage and Wastewater Management Plans

The UK Water Industry Research (UKWIR) "21st Century Drainage" programme has brought together water companies, governments, regulators, local authorities, academics and environmental groups to consider how planning can help to address the challenges of managing drainage in the future. These challenges include climate change, population growth, urban creep and meeting the Water Framework Directive.

The group recognised that great progress has been made by the water industry in its drainage and wastewater planning over the last few decades, but that, in the future, there needs to be greater transparency and consistency of long-term planning. The Drainage and Wastewater Management Plan (DWMP) framework[31] sets out how the industry intends to approach these goals, with the objective of the water companies publishing plans by the end of 2022, in order to inform their business plans for the 2024 Price Review.

DWMPs will be prepared for wastewater catchments or groups of catchments and will encompass surface water sewers within those areas which do not drain to a treatment works. The framework defines drainage to include all organisations and all assets which have a role to play in drainage, although, as the plans will be water company led, it does not seek to address broader surface water management within catchments.

LPAs and LLFAs are recognised as key stakeholders and will be invited to join, alongside other stakeholders, the Strategic Planning Groups (SPGs) organised broadly along river basin district catchments.

Thames Water[32], Anglian Water[33] and Severn Trent Water[34] have published the early stages of their DWMPs, with the following key messages for Oxfordshire:

- Thames Water's Baseline Risk and Vulnerability Assessment (BRAVA) scores a range of performance metrics from 0 (lowest) to 2 (highest). Oxfordshire score as follows: internal flooding (2), pollution (2), sewer collapse (2), risk of sewer flooding in a 1 in 50 year storm baseline (0), risk of sewer flooding in a 1 in 50 year storm in 2050 (0) and storm overflow performance (1).
- Sibford Ferris, the sole Severn Trent treatment works within Oxfordshire, was screened for a BRAVA assessment by the risk-based screening process.

3.9.6 Developer Contributions and Utility Companies

Developments with planning permission have a right to connect to the public sewerage systems, however, there is no guarantee that the capacity exists to serve a development.

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30 Water Resources South East (2021) Future Water Resource Requirements for South East England - an update. Accessed online at: https://www.wrse.org.uk/media/3h5p0dzo/future-water-resource-requirements-for-south-east-england-update-2021-final.pdf on: 07/06/2021

31 A framework for the production of Drainage and Wastewater Management Plans, UK Water Industry Research (2018). Accessed online at: https://www.water.org.uk/wp-content/uploads/2018/12/Water-UK-DWMP-Framework-Report-Main-Document.pdf on: 13/04/2021.

32 Thames Water Drainage and Wastewater Management Plan (DWMP). Accessed online at: https://www.thameswater.co.uk/about-us/regulation/drainage-and-wastewater-management on: 13/04/2021

33 Anglian Water (2020) Drainage and Wastewater Management Plan. Accessed online at: https://www.anglianwater.co.uk/siteassets/drainage-and-wastewater-management-plan.pdf on 07/06/2021.

34 Severn Trent Water Drainage and Wastewater Management Plan (DWMP). Accessed online at: https://www.stwater.co.uk/content/dam/stw/about_us/pr19-documents/sve_appendix_a9_drainage_and_wastewater_management_plan.pdf on: 13/04/2021

Developers may requisition a water supply connection or sewerage system or self-build the assets and offer these for adoption by the water company or sewerage undertaker. Self-build and adoption are usually practiced for assets within the site boundary, whereas requisitions are normally used where an extension or upgrading the infrastructure requires construction on third party land. The cost of requisitions is shared between the water company and developer as defined in the Water Industry Act 1991.

Where a water company is concerned that a new development may impact upon their service to customers or the environment (for example by causing foul sewer flooding or pollution) they may request the LPA to impose a Grampian condition, whereby the planning permission cannot be implemented until a third-party secures the necessary upgrading or contributions.

The above arrangements are third party transactions because the Town and Country Planning Act Section 106 agreements and Community Infrastructure Levy agreements may not be used to obtain funding for water or wastewater infrastructure.

3.9.7 Changes to Charging Rules for New Connections

OfWAT, the water industry's economic regulator, introduced new rules covering how water and wastewater companies may charge customers for new connections from April 2018[35]. The key changes included:

- More charges are fixed and published on water company websites. This will provide greater transparency to developers and will also allow alternative connection providers to offer competitive quotations more easily.
- There is a fixed infrastructure charge for water and one for wastewater.
- The costs of network reinforcement are no longer charged directly to the developer in their connection charges. Instead, the combined costs of all of the works required on a company's networks, over a five-year rolling period, are covered by the infrastructure charges payed for all new connections.
- The definition of network reinforcement has changed and now applies only to works required as a direct consequence of the increased demand due to a development. Where the water company has not been notified of a specific development, for example when developing long-term strategic growth schemes, the expenditure cannot be recovered through infrastructure charges.
- Thames Water[36], Anglian Water[37] and Severn Trent Water[38] have published their 2021/22 charges for connections.

3.9.8 Design and Construction Guidance (DCG)

The Design and Construction Guidance contains details of the water sector's approach to the adoption of SuDS, which meet the legal definition of a sewer. This subsumed the work which would have fed into Sewers for Adoption 8 as the government made the decision not to implement Schedule 3 of the Flood and Water Management Act 2010.

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35 Charging rules for new connection services (English undertakers), OfWAT (2020). Accessed online at: https://www.ofwat.gov.uk/publication/charging-rules-new-connection-services-english-undertakers/ on: 13/04/2021

36 Charging arrangements for new connection services, Thames Water (2021). Accessed online at: https://www.thameswater.co.uk/media-library/home/developers/charges/2021/new-connection-charges-2021-22.pdf on: 13/06/2021

37 Developer charging arrangements 2021-21, Anglian Water (2021). Accessed online at: https://www.anglianwater.co.uk/developing/help-and-advice/services-and-charges/ on: 13/06/2021

38 Charging Arrangements for Development Services and New Connections, Severn Trent Water (2021). Accessed online at: https://www.stwater.co.uk/content/dam/stw/stw_buildinganddeveloping/new-connections/2021-charges/new-connections-charging-arranging-document-21-22.pdf on: 13/04/2021

The new guidance will come into force in April 2020 and will differ from previous sewers for adoption guidance as compliance by water companies in England will be mandatory.

The standards, up to and including Sewers for Adoption version 7, have included a narrow definition of sewers to mean below-ground systems comprising of gravity sewers and manholes, pumping stations and rising mains. This has essentially excluded the adoption of SuDS by water companies, with the exception of below-ground storage comprising of oversized pipes or chambers.

The new guidance provides a mechanism for water companies to secure the adoption of a wide range of SuDS components which are now compliant with the legal definition of a sewer. There are however several non- adoptable components such as green roofs, pervious pavements and filter strips. These components may still form part of a drainage design so long as they remain upstream of the adoptable components.

The Design and Construction Guidance states that the drainage layout of a new development should be considered at the earliest stages of design. It is hoped that the new guidance will lead to better managed and more integrated surface water systems which incorporate amenity, biodiversity and water quality benefits.

4 Water Resources

4.1 Introduction

4.1.1 Surface Waters

The main watercourses within the Oxfordshire area can be seen in Figure 4.1. The rivers largely drain into the Thames Basin, though a section to the North-East makes up part of the River Ouse catchment and a small proportion of watercourses to the North-West drain into the Severn.

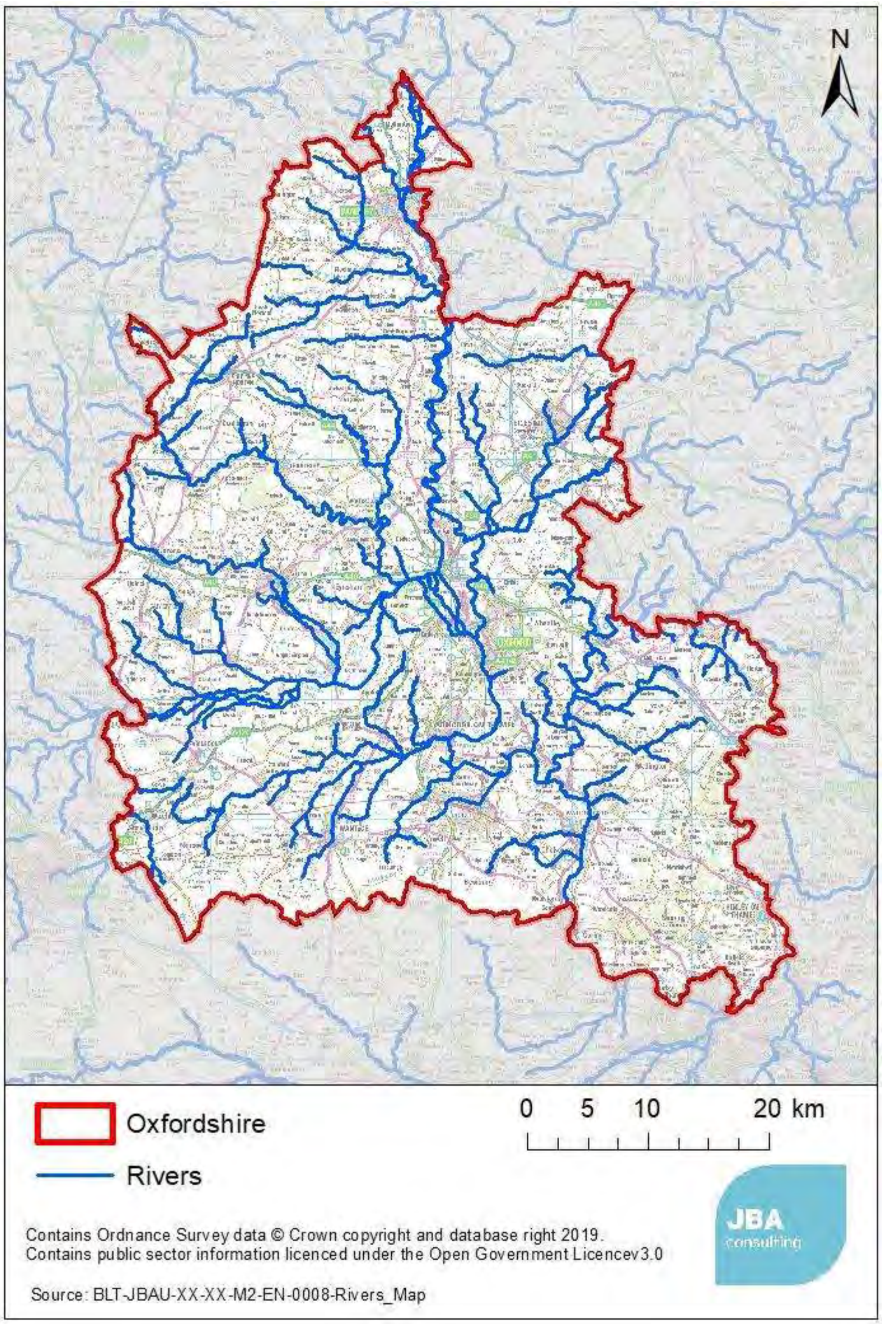

Figure 4.1 Surface waterbodies in Oxfordshire

4.1.2 Groundwater

There are 18 groundwater bodies within the study area which are shown in Figure 4.2 and their corresponding WFD classification is summarised in Table 4.1 below. The Berkshire Downs Chalk groundwater body has poor quantitative status, which is stated as being due to groundwater abstraction by the water industry. The effect of further abstraction in this area could be a reduction in river flow in dependent surface waterbodies, or a deterioration in dependent water sensitive ecosystems. This and 12 other groundwater bodies are also assessed to be in poor overall status as a result of their chemical status.

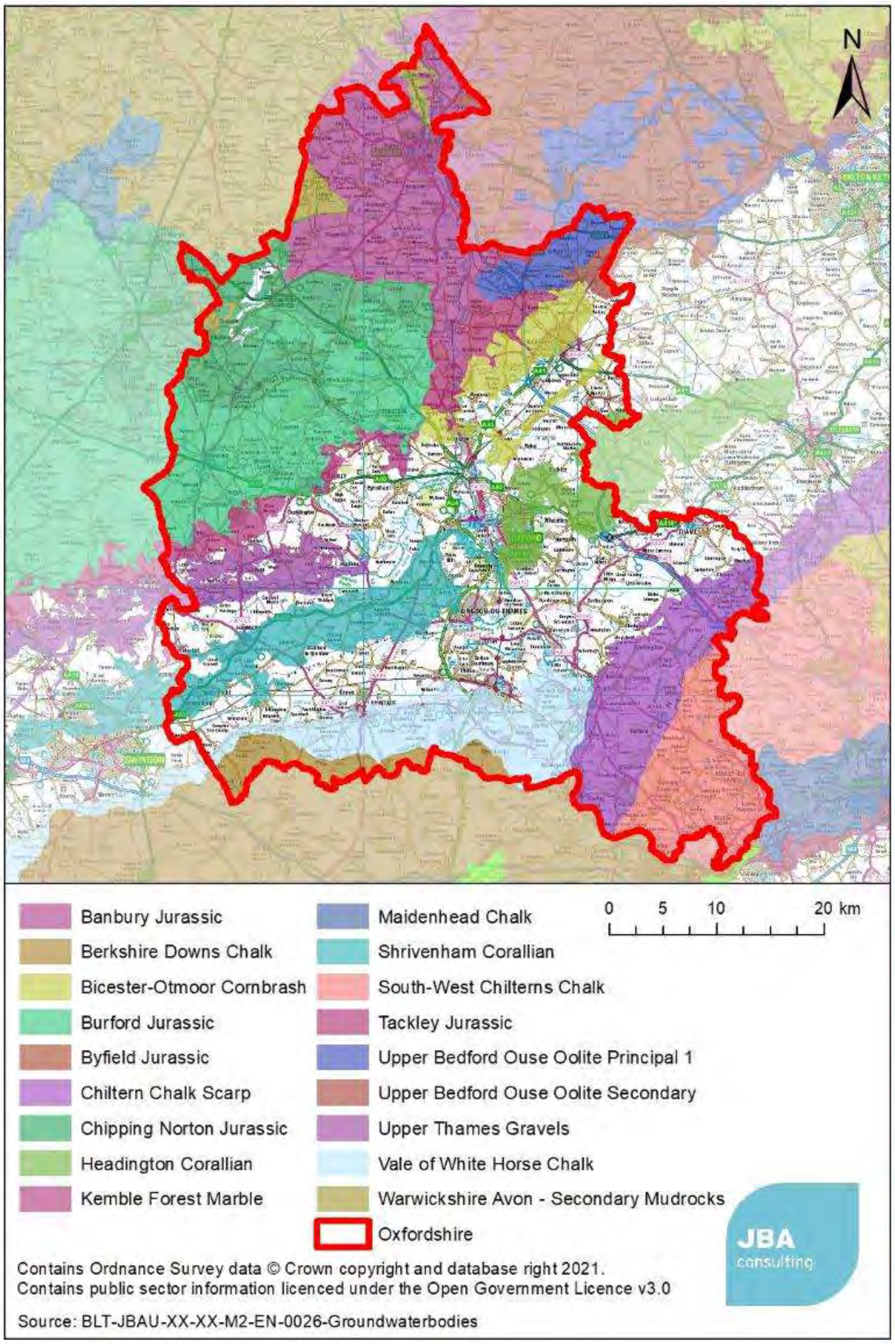

Figure 4.2 Groundwater bodies in Oxfordshire

Table 4.1 Groundwater body classifications in Oxfordshire

Groundwater Body	Quantitative Status	Chemical Status	Overall Status - WFD Cycle 2 (2019)
Banbury Jurassic	Good	Poor	Poor
Berkshire downs Chalk	Poor (Groundwater abstraction – Water industry)	Poor	Poor
Bicester-Otmoor Cornbrash	Good	Poor	Poor
Burford Jurassic	Good	Poor	Poor
Byfield Jurassic	Good	Poor	Poor
Chiltern Chalk Scarp	Good	Poor	Poor
Chipping Norton Jurassic	Good	Poor	Poor
Headington Corallian	Good	Poor	Poor
Kemble Forest Marble	Good	Poor	Poor
Maidenhead Chalk	Good	Poor	Poor
Shrivenham Corallian	Good	Good	Good
South-West Chilterns Chalk	Good	Good	Good
Tackley Jurassic	Good	Good	Good
Upper Bedford Ouse Oolite Principle 1	Good	Poor	Poor
Upper Bedford Ouse Oolite Secondary	Good	Good	Good
Upper Thames Gravels	Good	Poor	Poor
Vale of White Horse Chalk	Good	Poor	Poor
Warwickshire Avon – Secondary Mudrocks	Good	Good	Good

4.1.3 Geology

Catchment geology can affect the way that water interacts with the ground surface. Variations in surface permeability and bedrock stratigraphy will have a large influence on the run-off and infiltration of water. The Oxfordshire bedrock geology can be seen in Figure 4.4. Several bands of bedrock run through the area. The North is largely covered by the Great Oolite and Lias groups, whilst the Thames group (clay, silt, sand and gravel) cuts across the centre of the county. The Southern portion contains 5 main geologic bands: the Corallian Group, West Walton formation, Gault and Upper Greensand formations and two chalk subgroups (grey and white). The catchment also contains patches of Lower Greensand group (sandstone and mudstone) and Purbeck limestone.

Oxfordshire is underlain by two main types of superficial deposits (Figure 4.3). The first is made up of clay, silt and sand and the second contains sand and gravel. These deposits largely cover the southern half of the county.

4.1.4 Availability of Water Resources

The Environment Agency (EA), working through their Catchment Abstraction Management Strategy (CAMS) process, prepare an Abstraction Licensing Strategy (ALS) for each sub-catchment within a river basin. This licensing strategy sets out how water resources are managed in different areas of England and contributes to implementing the Water Framework Directive (WFD). The ALS report provides information on the resources available and what conditions might apply to new licenses. The licences require abstractions to stop or reduce when a flow or water level falls below a specific threshold, as a restriction to protect the environment and manage the balance between supply and demand for water users. The CAMS process is published in a series of ALSs for each river basin.

All new licences, and some existing licenses, are time limited. This allows time for a periodic review of the specific area as circumstances may have changed since the licences were initially granted. These are generally given for a twelve-year duration, but shorter license durations may also be granted. This is usually based on the resource assessment and environmental sustainability. In some cases, future plans or changes may mean that the EA will grant a shorter time limited licence, so it can be re-assessed following the change. If a licence is only required for a short time period, it can be granted either as a temporary licence or with a short time limit. If a licence is considered to pose a risk to the environment it may be granted with a short time limit while monitoring is carried out. The licences are then replaced with a changed licence, revoked or renewed near to the expiry date.

The ALS are important in terms of the Water Resource Management Plan (WRMP) as this helps to determine the current and future pressures on water resources and how the supply and demand will be managed by the relevant water companies[39]. Oxfordshire is covered by six ALS areas: Thames Corridor, Cotswolds, Warwickshire Avon, Upper Bedford Ouse, Cherwell, Thame and Wye, and Kennet and Vale of White Horse. These are shown in the Catchment Abstraction Management Strategy (CAMS) boundaries in Figure 4.5.

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39 Environment Agency (2018) Managing Water Abstraction. Accessed Online at: https://www.gov.uk/government/collections/water-abstraction-licensing-strategies-cams-process on: 12/04/2019

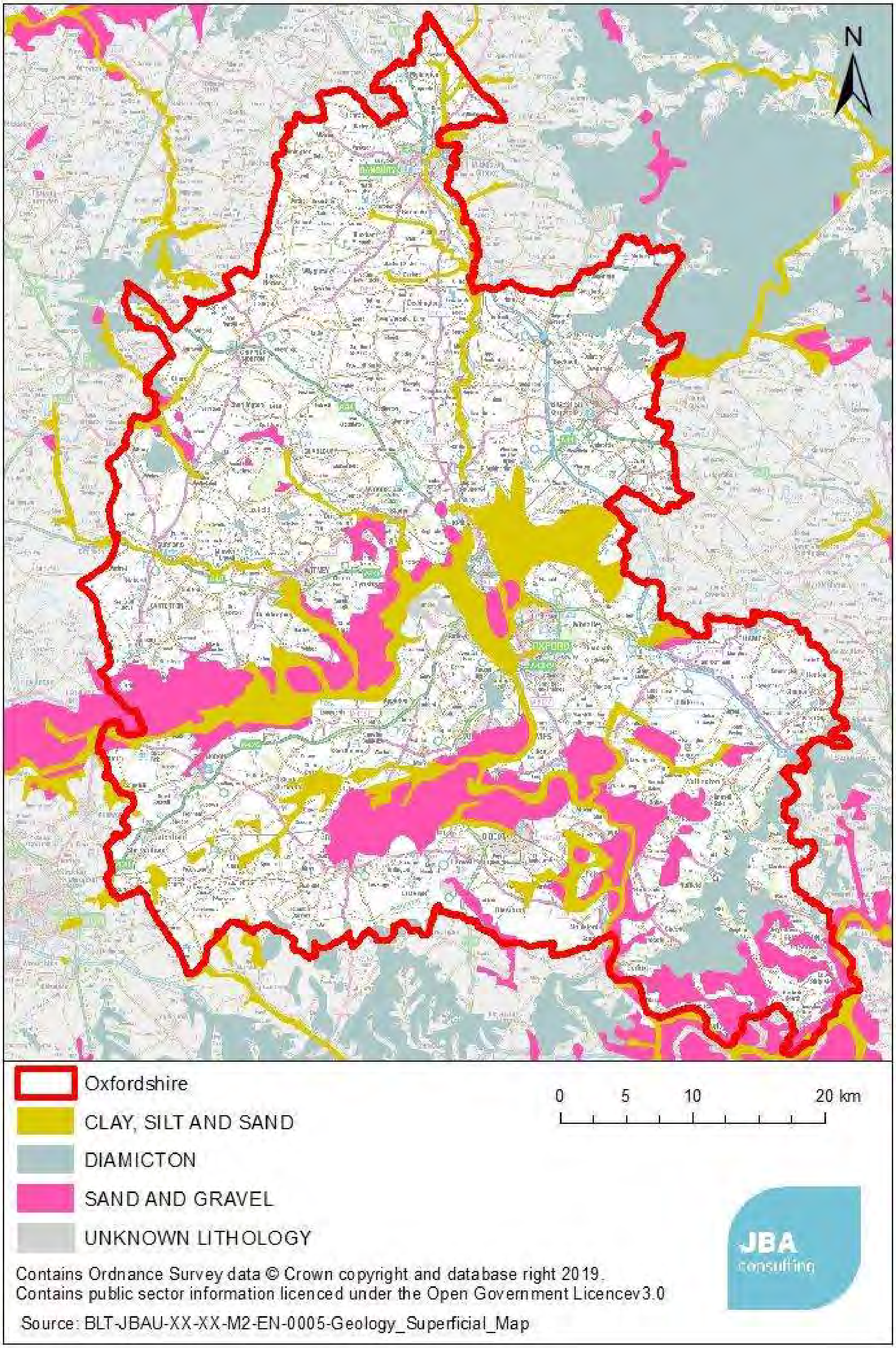

Figure 4.3 Superficial deposits

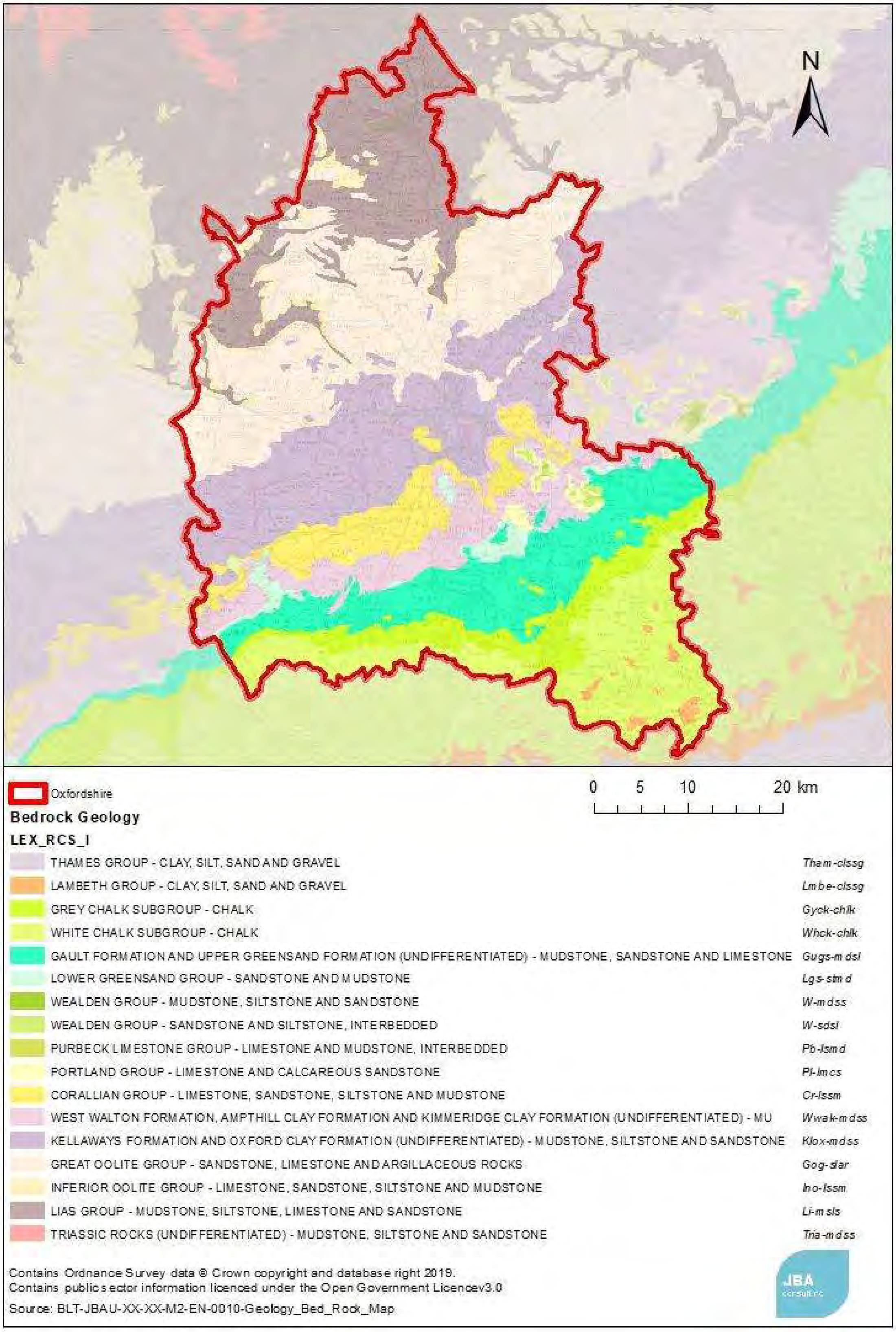

Figure 4.4 Oxfordshire bedrock geology

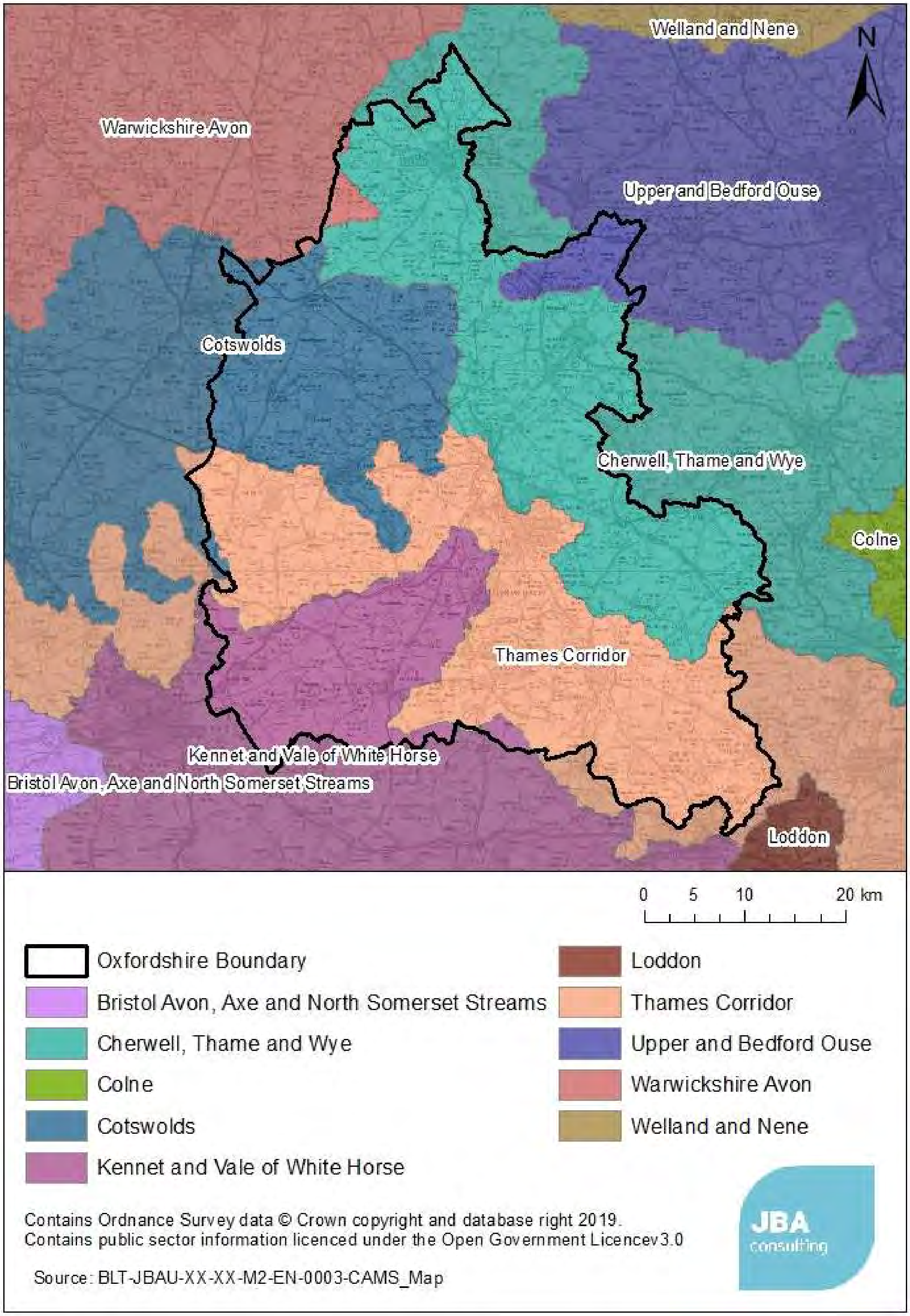

Figure 4.5 Oxfordshire Catchment Area Management Schemes (CAMS)

4.2 Resource Availability Assessment

In order to abstract surface water, it is important to understand what water resources are available within a catchment and where abstraction for consumptive purposes will not pose a risk to resources or the environment. The Environment Agency has developed a classification system which shows:

- the relative balance between the environmental requirements for water and how much has been licensed for abstraction;
- whether there is more water available for abstraction in the area; and
- areas where abstraction may need to be reduced.

The availability of water for abstraction is determined by the relationship between the fully licensed (all abstraction licences being used to full capacity) and recent actual flows (amount of water abstracted in the last 6 years) in relation to the Environmental Flow Indicator (EFI). Results are displayed using different water resource availability colours, further explained in Table 4.2. In some cases, water may be scarce at low flows, but available for abstraction at higher flows. Licences can be granted that protect low flows, this usually takes the form of a "Hands-off Flow" (HOF) or Hands-off Level (HOL) condition on a licence.

Groundwater availability as a water resource is assessed similarly, unless better information on principle aquifers is available or if there are local issues that need to be taken into account.

Table 4.2 Implications of Surface Water Resource Availability Colours

Water Resource Availability Colour	Implications for Licensing
High hydrological regime	There is more water than required to meet the needs of the environment. Due to the need to maintain the near pristine nature of the water body, further abstraction is severely restricted.
Water available for licensing	There is more water than required to meet the needs of the environment. Licences can be considered depending on local/downstream impacts.
Restricted water available for licensing	Fully Licensed flows fall below the Environmental Flow Indicator (EFI). If all licensed water is abstracted there will not be enough water left for the needs of the environment. No new consumptive licences would be granted. It may also be appropriate to investigate the possibilities for reducing fully licensed risks. Water may be available via licence trading.
Water not available for licensing	Recent Actual flows are below the Environmental Flow Indicator (EFI). This scenario highlights water bodies where flows are below the indicative flow requirement to help support Good Ecological Status. No further licences will be granted. Water may be available via licence trading.
HMWBs (and /or discharge rich water bodies)	These water bodies have a modified flow that is influenced by reservoir compensation releases or they have flows that are augmented. There may be water available for abstraction in discharge rich catchments.

4.2.1 Cherwell, Thame and Wye ALS

The Cherwell, Thame and Wye ALS[40] includes both the River Cherwell and its main tributary the River Ray, which both flow South, largely over mudstone and clay, to join the River Thames in Oxford. The River Thame also meets the Thames in this catchment as it flows South-West to Dorchester on Thames. Finally, the River Wye rises from groundwater influenced chalk springs though does not intersect with the Oxfordshire boundary.

The Thames area has its own bespoke licencing strategy which is applicable to the Cherwell, Thame and Wye ALS. This adopts a multi-tier HOF where for consumptive abstraction licences below 2 Ml/day, no abstraction will occur if the preceding 5 days have daily mean flows less than or equal to Q50. When abstractions are 2 Ml/day or larger, a HOF between Q30 and Q50 will be applied based on the perceived level of risk to the water body. The HOF implemented to protect the Lower Thames is highly restrictive and consequently has a significant on resource availability in this catchment.

Table 4.3: Cherwell, Thame and Wye ALS resource availability

Name	Water Resource Availability	HOF Restriction (Ml/day)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Upper Cherwell	Restricted water available for licencing	23.9	205 (Thames Q50 HOF (182 days))	4.7	Banbury
Sor Brook	Restricted water available for licencing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	3.4	No
Middle Cherwell	Restricted water available for licencing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	17.4	Enslow
Ray	Restricted water available for licencing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	12.7	Islip
Lower Cherwell	Restricted water available for licencing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	32.9	Oxford
Upper Thame	Restricted water available for licencing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	0.8	No

40 Environment Agency (2019) Cherwell, Thame and Wye Abstraction Licencing Strategy. Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/796136/Cherwell-Thame-and-Wye-Abstraction-Licensing-Strategy.pdf on 13/06/2021

Name	Water Resource Availability	HOF Restriction (Ml/day)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Middle Thame	Restricted water available for licencing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	28.6	Wheatly
Lower Thame	Restricted water available for licencing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	33.4	No

4.2.2 Thames Corridor ALS (TCAMS)

The Thames Corridor ALS[41], referred to as CAMS, covers the length of the non-tidal Thames, from its source near to Kemble, through to the non-tidal limit at Teddington, covering a large proportion of central and South-Eastern Oxfordshire. The area supports significant public water, industry and agriculture abstractions both from the river and groundwater supplies.

Anyone wishing to abstract more than 20 m^3 per day from a water body in this catchment must have an abstraction licence. The Thames area has its own bespoke licencing strategy that has several levels:

- New consumptive licences below 2 Ml/d – no abstraction will take place when the average of the daily mean flows of the proceeding 5 days gauged at Kingston is less than or equal to Q50 (1780 Ml/d).
- New consumptive licences above 2 Ml/d – an HOF between Q21 and Q50 will be applied based on perceived risk to the waterbody. The applicant must provide a WFD assessment to show the abstraction will not cause environmental deterioration under the WFD or prevent the achievement of "Good ecological status/potential".
- For abstractions of all sizes – additional HOFs may be applied to protect local features or existing abstractors.

There are four Assessment Points (APs) within Oxfordshire, used to investigate resource availability. The HOFs for each AP have been investigated both before and after the application of the TCAMS bespoke licensing strategy.

Table 4.4: Thames Corridor ALS resource availability

Name	Water Resource Availability	HOF Restriction (Ml/day)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Inglesham	Water not available	Q21 @ Kingston (7209 Ml/day)	77	605	No, upstream gauging stations used

41 Environment Agency (2014) Thames Catchment Abstraction Licencing Strategy. Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321005/LIT_1855.pdf on 13/06/2021

Name	Water Resource Availability	HOF Restriction (Ml/day)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Eynsham Lock and Weir	Water not available	Q21 @ Kingston (7209 Ml/day)	77	1568	Yes
Days Lock and Weir	Water not available	Q21 @ Kingston (7209 Ml/day)	77	3318	Yes
Reading Gauging Station	Water not available	Q21 @ Kingston (7209 Ml/day)	77	3224	Yes

HOFs for the APs of the TCAMS, after application of the TCAMS bespoke licensing strategy. Indicative volume available at restriction has been taken at 10% of Q50 so as to have a negligible risk of licence and environment derogation.

Table 4.5 Thames Corridor ALS resource availability after TCAMS bespoke licencing strategy has been applied

Name	Water Resource Availability	HOF Restriction (Ml/day)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Inglesham	Restricted Water Available	Q50 @ Kingston (1780 Ml/d) if <2Ml/d	183	178	No, upstream gauging stations used
Eynsham Lock and Weir	Restricted Water Available	Q50 @ Kingston (1780 Ml/d) if <2Ml/d	183	178	Yes
Days Lock and Weir	Restricted Water Available	Q50 @ Kingston (1780 Ml/d) if <2Ml/d	183	178	Yes
Reading Gauging Station	Restricted Water Available	Q50 @ Kingston (1780 Ml/d) if <2Ml/d	183	178	Yes

4.2.3 Kennet and Vale of White Horse ALS

The Kennet and Vale of White Horse Catchment[42] largely drains the Rivers Kennet, Pang and Ray in Wiltshire, though also contains the River Ock in Oxfordshire.

The Thames area bespoke licencing strategy is also applicable here, which modifies water resource availability. Consumptive abstraction is available less than 30% of the time.

There are two APs within this catchment that are within the Oxfordshire boundary, both have restricted water available for licencing.

Table 4.6 Kennet and Vale of White Horse ALS resource availability

Name	Water Resource Availability	HOF Restriction (Ml/day)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Cole	Restricted water available for licensing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	3.9	No
Ock	Restricted water available for licensing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	13.6	No

4.2.4 Cotswolds ALS

The Cotswolds catchment[43] contains a collection of rivers formed by springs in the Limestone of the Cotswold hills, these then flow South-East to join the Thames. The main rivers are the Churn, Coln, Leach, Windrush, Evenlode and Apney Brook.

Five of the Cotswold APs are within Oxfordshire.

Table 4.7 Cotswold ALS resource availability

Name	Water Resource Availability	HOF Restriction (Ml/day)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Upper Windrush and Unconfined Oolites	Restricted water available for licensing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	1.1	Bourton-on-the-water
Middle Windrush	Restricted water available for licensing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	4.6	Worsham

42 Environment Agency (2019) Kennet and Vale of White Horse Abstraction Licencing Strategy. Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/796172/Kennet-and-Vale-of-White-Horse-Abstraction-Licensing-Strategy.pdf on 13/06/2021

43 Environment Agency (2019) Cotswolds Abstraction Licensing Strategy. Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/796112/Cotswolds-Abstraction-Licensing-Strategy.pdf on 13/06/2021

Name	Water Resource Availability	HOF Restriction (Ml/day)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Lower Windrush	Restricted water available for licensing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	19.7	Newbridge
Evenlode	Restricted water available for licensing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	15.3	Cassington Mill
Glyme and Unconfined Oolites	Restricted water available for licensing	Thames Q50 HOF (182 days)	Thames Q50 HOF (182 days)	1.6	Woodstock

4.2.5 Warwickshire Avon ALS

The Warwickshire Avon catchment[44] covers a small portion of Oxfordshire to the North-West. The river Avon is the main tributary of the River Severn, which it meets in Tewkesbury after flowing South-West for 179 kilometres.

There are significant groundwater resources found in both principal and secondary aquifers, as well as an Avon confined aquifer near Stratford-upon- Avon and several Oolitic Limestone aquifers along the South-West edge of the catchment, though these are outside the Oxfordshire boundary.

To abstract more than 20m^3/day a licence is required, which will often be reviewed at a common end date. Some licences will contain a condition relating to the HOF.

4.2.6 Upper and Bedford Ouse ALS

The Upper and Bedford Ouse ALS[45] intersects Oxfordshire in its North-Eastern corner. This region reviews ground water resource availability on a case by case basis, and water is only available for abstraction under Q30 conditions.

Table 4.8 Upper Bedford and Ouse ALS resource availability

Name	Water Resource Availability	HOF Restriction (Ml/d)	Day p.a. abstraction may be available	Volume available at restriction (Ml/d)	Gauging station at AP?
Buckingham	Q30 (Green) Q50 (Yellow) Q70 (Red) Q95 (Red)	98.4 (Q33)	120	38.0	No

44 Environment Agency (2013) Warwickshire Avon Abstraction Licencing Strategy. Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291400/LIT_2604_7a244e.pdf on 13/06/2021

45 Environment Agency (2017) Upper Ouse and Bedford Ouse Abstraction Licencing Strategy. Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/636744/ALS_2017_Upper_Ouse_and_Bedford_Ouse.pdf on: 13/06/2021

4.2.7 Summary of water resource availability

Figure 4.6 below shows the availability of water resources in Oxfordshire during a Q30 flow (the flow that is exceeded in the river 30% of the time) and Figure 4.7 shows the reliability of water resources in Oxfordshire. This indicates the percentage of days in an average year that water is available for abstraction. These two maps together show the limited water available in Oxfordshire from surface water sources. Both maps are reproduced from the EA's "Water Resource Availability and Abstraction Reliability Cycle 2" dataset[46]. They indicate that there is restricted water available in Oxfordshire for additional abstractions, and existing abstractions may not be available all year. The data also shows that there is minimal variation within Oxfordshire.

46 Water Resource Availability and Abstraction Reliability Cycle 2, Environment Agency (2015). Accessed online at: https://environment.data.gov.uk/dataset/62514eb5-e9d5-4d96-8b73-a40c5b702d43 on: 13/06/2021

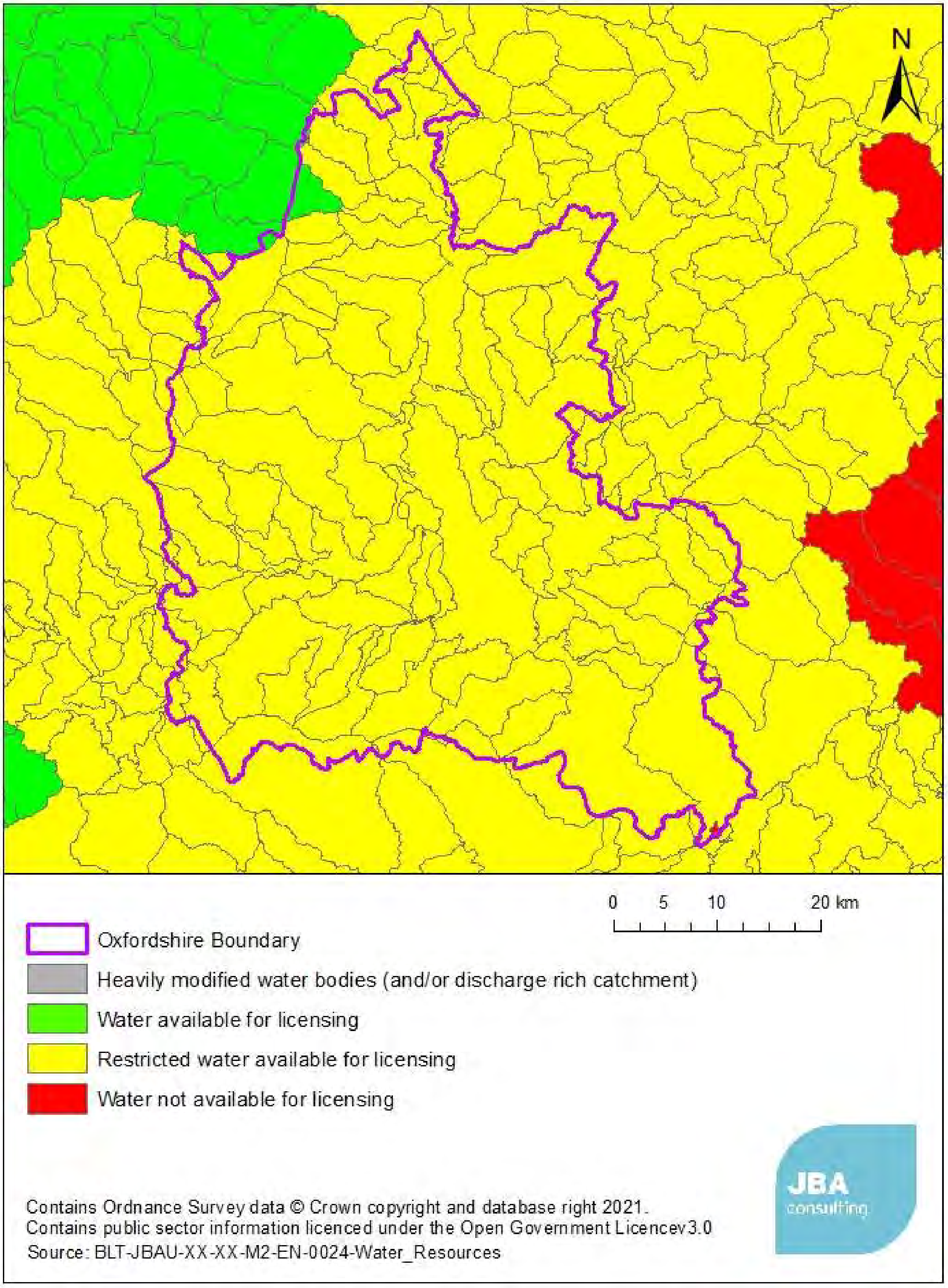

Figure 4.6: Water resources availability at Q30 flow

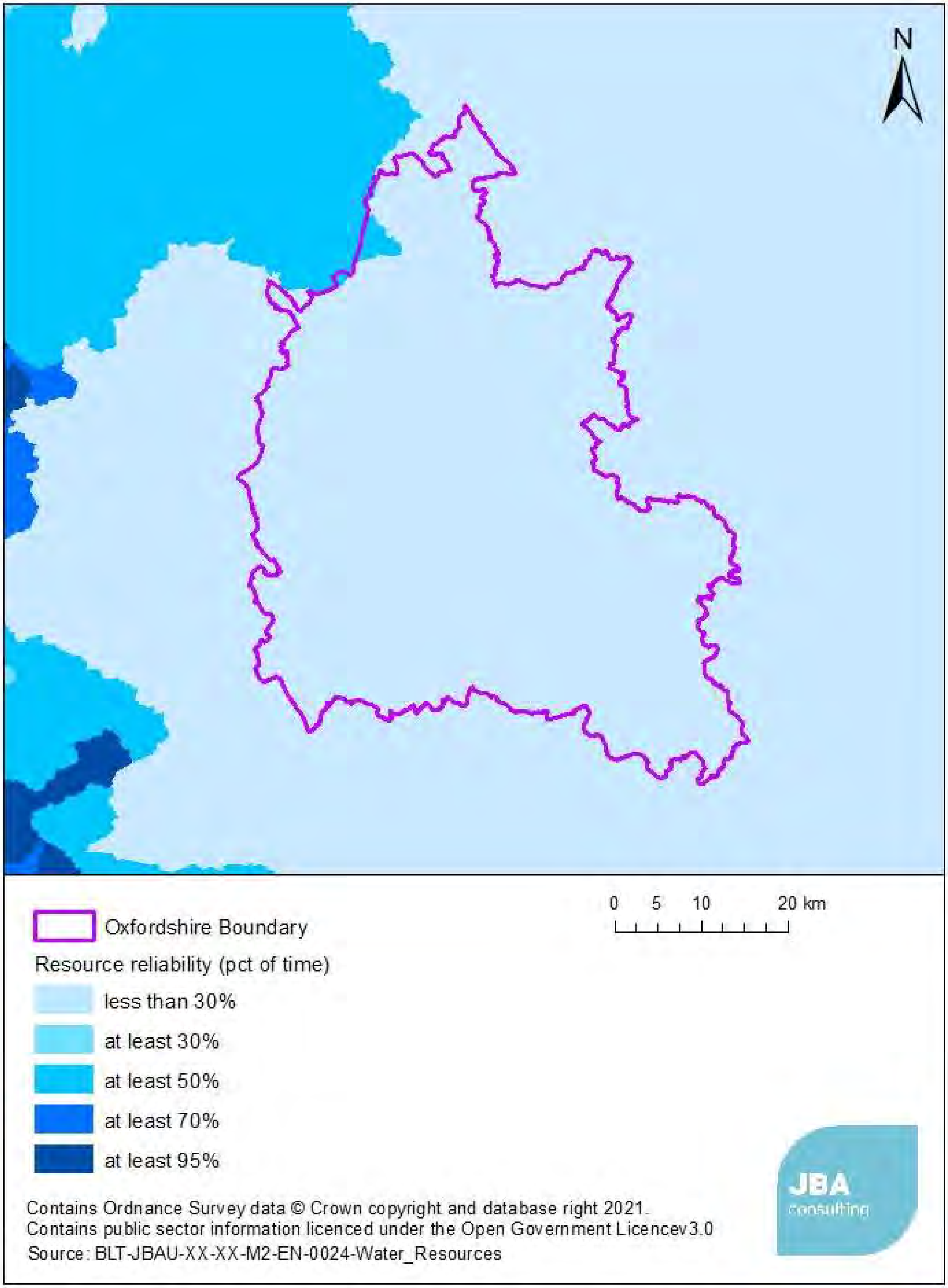

Figure 4.7: Resource reliability

4.3 Water Resource Management Plans

4.3.1 Planning for housing and population growth

The Water Resource Zone (WRZ) boundaries of Thames Water, Anglian Water and Severn Trent Water were reviewed. Whilst there are very small areas on Oxfordshire's north west and north east boundaries which are served by Severn Trent Water and Anglian Water, for this strategic-scale study the whole county is, for practical purposes, served by Thames Water (see Figure 4.8). The following section therefore draws upon Thames Water's WRMP[47], and the published Water Resources Market Information Tables[48].

Indicative GIS mapping of the five spatial options (as shown in Table 2.3) was overlaid with the Thames Water WRZ boundaries. This identified that options 2 and 4 are located wholly within Thames Water's SWOX (Swindon and Oxfordshire) WRZ. For options 1 and 3, some 3% of the option is located within the Henley Zone, and for Option 5 just 0.5% is within Henley WRZ. Assuming an even distribution of development within the spatial options areas, these percentages were applied to calculate indicative housing growth numbers by WRZ (based on the housing growth options outlined in Table 2.2), as follows:

Table 4.9: Indicative distribution of housing growth by Water Resource Zone

Spatial Option	Housing Growth Option	Water Resource Zone				
		SWOX		Henley		Total
		% of growth	Units	% of growth	Units	Units
1 - Larger settlements and planned growth locations	Standard method	97%	98,533	3%	3,047	101,580
	Business-as-usual	97%	119,688	3%	3,702	123,390
	Transformational	97%	148,197	3%	4,583	152,780
2 - Oxford-led growth	Standard method	100%	101,580	0%	-	101,580
	Business-as-usual	100%	123,390	0%	-	123,390
	Transformational	100%	152,780	0%	-	152,780
3 - Sustainable transport corridors and hubs	Standard method	97%	98,533	3%	3,047	101,580
	Business-as-usual	97%	119,688	3%	3,702	123,390
	Transformational	97%	148,197	3%	4,583	152,780
4 - Strengthening business locations	Standard method	100%	101,580	0%	-	101,580
	Business-as-usual	100%	123,390	0%	-	123,390
	Transformational	100%	152,780	0%	-	152,780
5 - Supporting rural communities	Standard method	99.5%	101,072	0.5%	508	101,580
	Business-as-usual	99.5%	122,773	0.5%	617	123,390
	Transformational	99.5%	152,016	0.5%	764	152,780

47 Thames Water (2020) Water Resource Management Plan 2020-2100. Accessed online at: https://www.thameswater.co.uk/about-us/regulation/water-resources#current on: 09/06/2021
48 Thames Water (2021) Water Resource Market Information Tables. Accessed online at: https://www.thameswater.co.uk/about-us/regulation/water-resources#market on: 09/06/2021

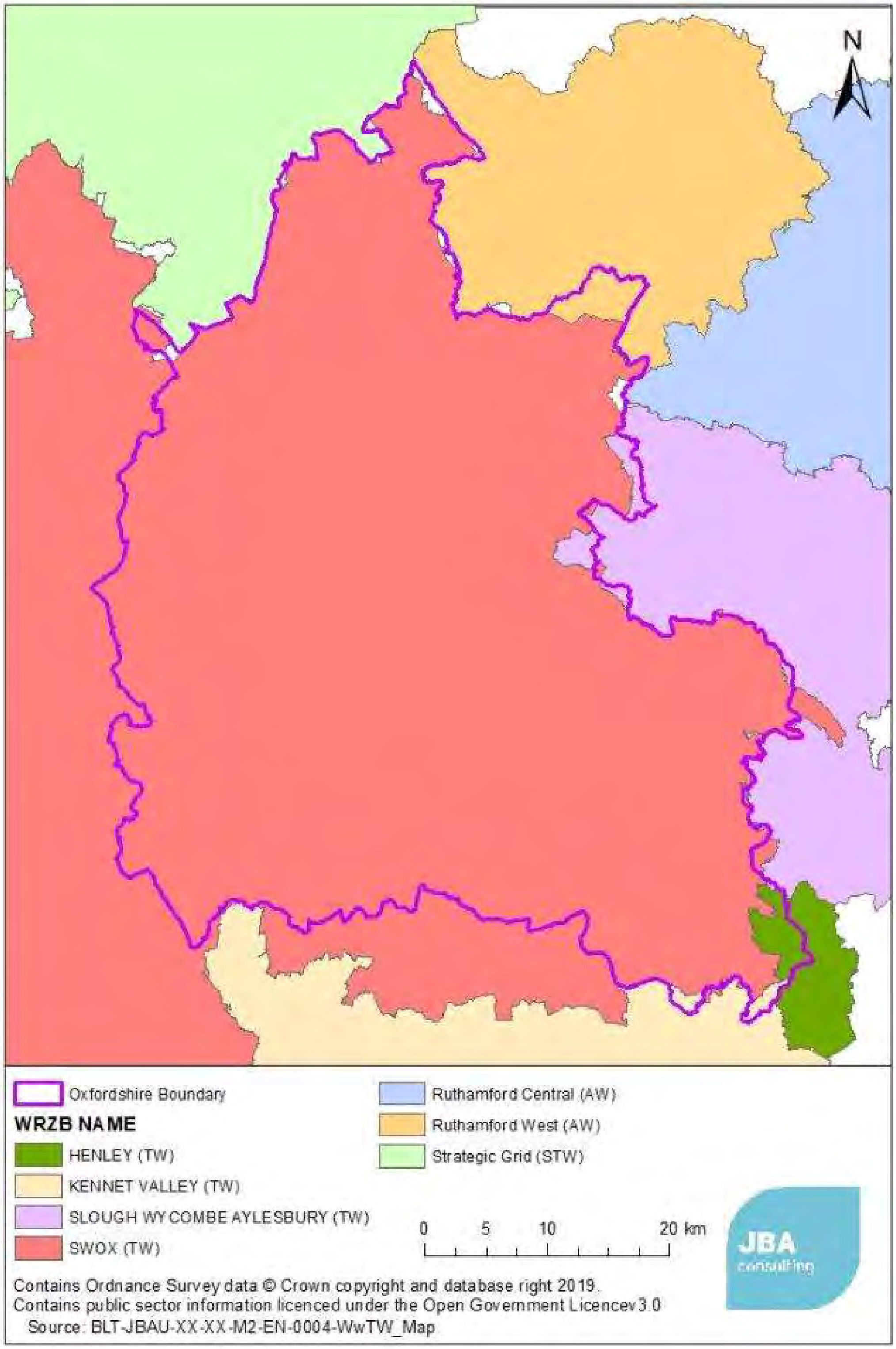

Figure 4.8: Water suppliers and water resource zones

In the SWOX WRZ, the growth forecast used by Thames Water exceeds most of the Oxfordshire Plan growth scenarios, with an estimated 27% growth in households by 2050. Of the Oxfordshire Plan scenarios, only the transformational growth scenarios exceed Thames Water's growth estimate, with 30-31% growth in households served over the plan period.

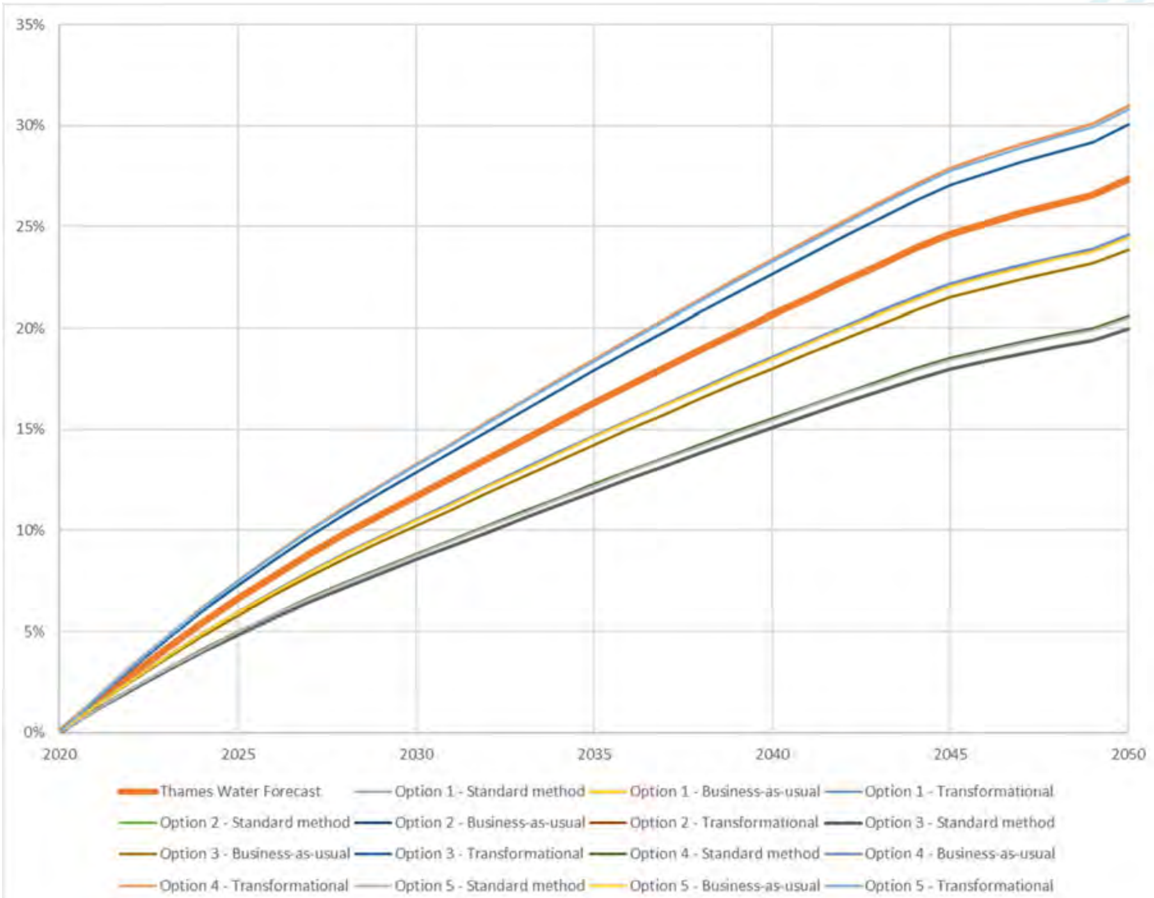

Figure 4.9: Comparison of Thames Water growth estimates with range of OP2050 scenarios, SWOX water resource zone

Within the Henley Zone, no significant household growth is forecast for spatial options 2 and 4. Of the remaining, only Option 1 with transformational growth (20%) and Option 3 with transformational growth (20%) exceed the Thames Water forecast of 14% growth by 2050.

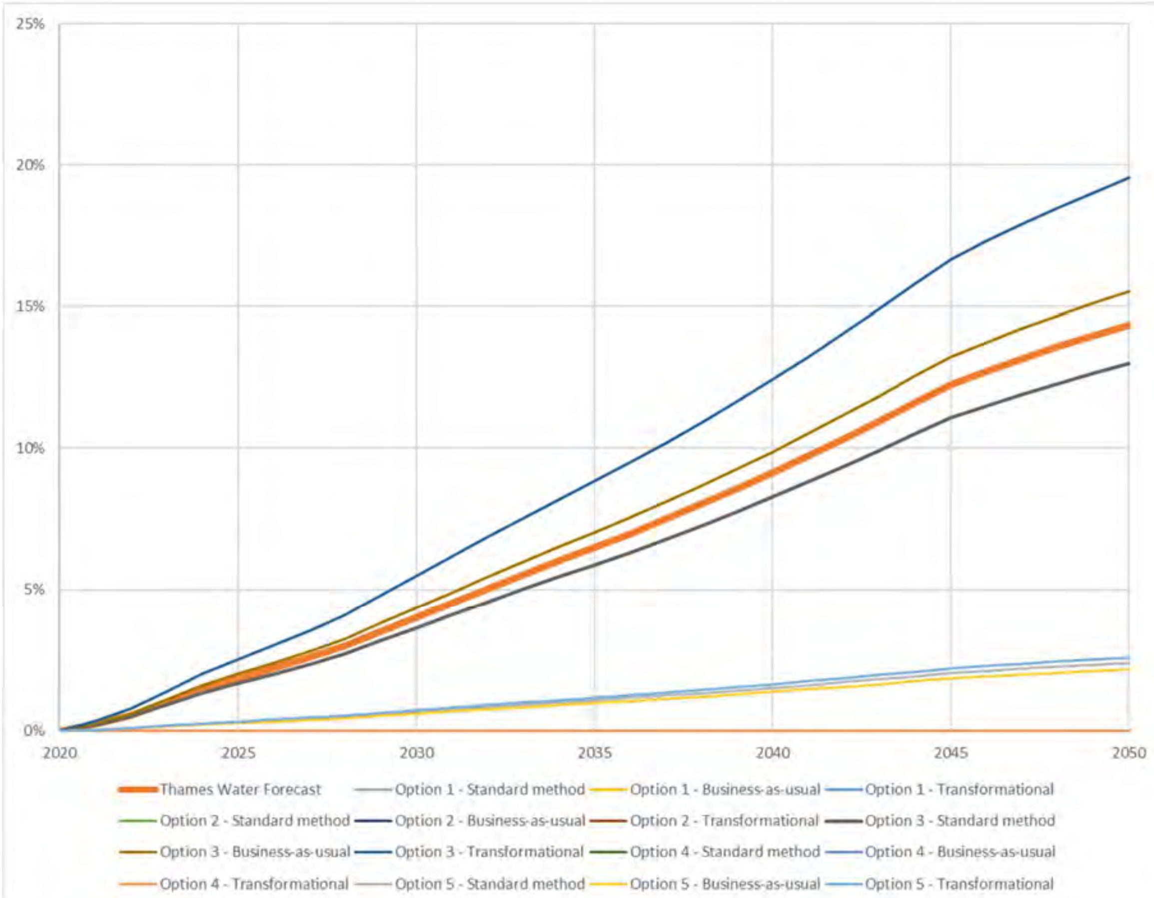

Figure 4.10: Comparison of Thames Water growth estimates with range of OP2050 scenarios, SWOX water resource zone

In conclusion, the standard method and business-as-usual housing growth forecasts being considered by the Oxfordshire Plan 2050 are generally below or in line with household growth forecasts used by Thames Water in their water resource planning. However, the "transformational" housing growth scenarios do exceed Thames Water's forecasts by an additional 4% growth in SWOX and 6% in Henley WRZ. These would increase the planned demand for water and could require Thames Water to bring forward demand management and strategic supply options earlier than currently planned.

Thames Water noted at the inception meeting that it was significant where growth was coming from, i.e. was it people moving into Thames Water's supply area from a different part of the country which would be seen as new water demand, or moving within the water resource zone from a neighbouring local authority, which is new water demand for supply infrastructure, but not overall water resource demand. This regional-scale household and population growth forecasting is being considered by Water Resources South East to inform the next round of WRMPs.

4.3.2 Overview of the WRMP

- Water Available for Usage (WAFU), a measure of water available for public water supplies in a Dry Year Critical Period (DYCP) condition is predicted to reduce from 354.82 to 349.52 MLD by 2044/45 in SWOX, a reduction of 2%. This is as a result of climate change and sustainability reductions, where reduced abstraction is required in order to reduce negative impacts on sensitive environments. Within the

Henley WRZ, WAFU is predicted to remain stable through the plan period at 25.54MLD.

- Over the same period, demand for water is predicted to increase by around 5% over the Oxfordshire Plan period. This accounts for factors such as population growth, overall reductions in per-capita water usage and non-household demand, but also the effects of climate change on water demand during hotter, dryer summers.

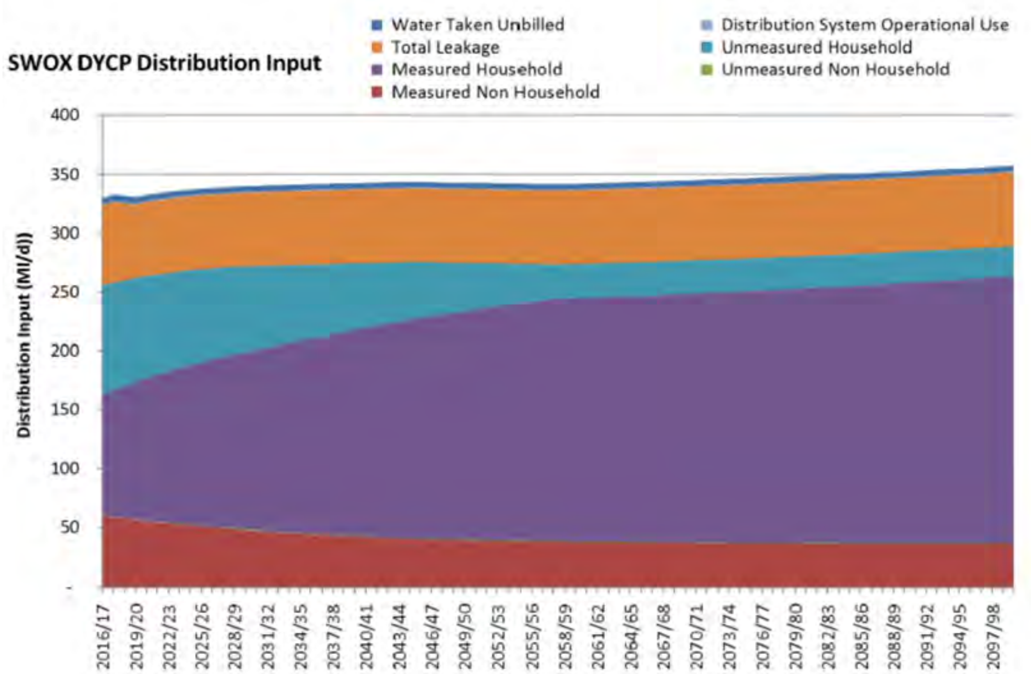

Figure 4.11: SWOX distribution input, Thames Water WRMP

- The Thames Water WRMP takes into account the uncertainties in predicting the future, including, as illustrated in Figure 4.12, in population forecasts.
- Declining water availability and increasing demand mean that the SWOX WRZ has recently moved into a supply-demand deficit situation, and, without interventions, this is forecast to increase significantly through the plan period. The Henley zone is not forecast to move into deficit.
- The WRMP then reviews a wide range of supply-side and demand-side options, considering their reliability, feasibility, costs, environmental impacts (though a Strategic Environmental Appraisal). This has included a much-increased focus on regional water resource planning and resource transfers. As Figure 4.13 illustrates, the water industry is considering a number of large-scale inter-regional transfers, some of which are inter-dependent. Specifically, the proposed reservoir to the west of Abingdon would be part of a South East Strategic Resource Option, with potential to enable transfers into other parts of the region served by Affinity, Southern, South East and SES Water.

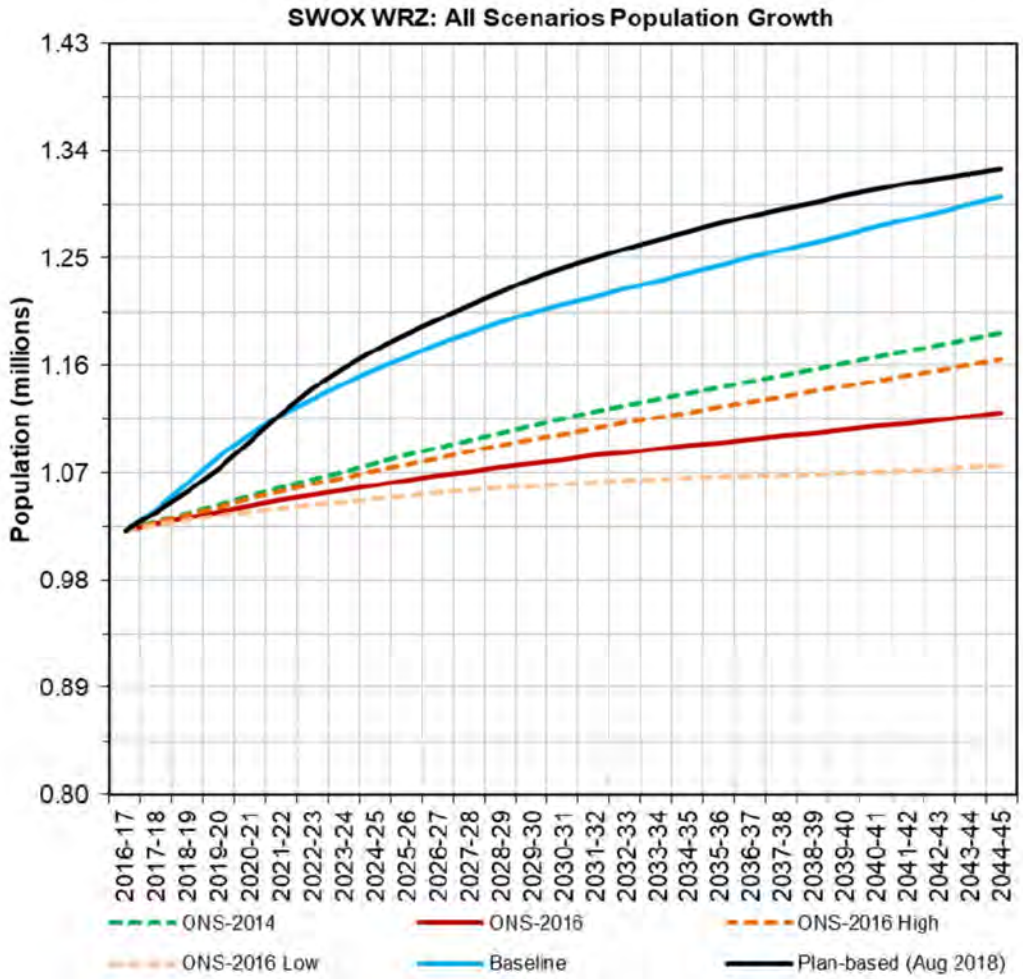

Figure 4.12: Population growth scenarios considered in SWOX, Thames Water WRMP

- Analysis of Strategic Resource Options (SROs) continues through the Regulators' Alliance for Progressing Infrastructure Development (RAPID) process developed by OfWAT, the EA and Drinking Water Inspectorate. This is using consistent assessment methodologies to enable the various SROs to be compared and selected. It is a gated process, from initial concept design at Gate 1 (July 2021) through to Gate 4 - planning applications, procurement and land purchases (summer 2024), leading to construction of selected schemes from 2025.
- Thames Water's plans for SWOX and Henley zones is summarised in Table 4.10. Of particular relevance to Oxfordshire is the current plan to have an Abingdon reservoir (SESRO) in place by 2037/38, although this is subject to the review of strategic resource options following the RAPID process described above. Land for the reservoir is safeguarded in the Vale of White Horse Local Plan[49].

49 Vale of White Horse District Council (2019) Local Plan 2031 Adopted Policies Map Abingdon-on-Thames and Oxford Fringe Sub-Area Accessed online at: https://www.whitehorsedc.gov.uk/wp-content/uploads/sites/3/2020/10/Adopted-October-2019-constraint-sub-area-abingdon-north-v3.pdf on: 09/06/2021.

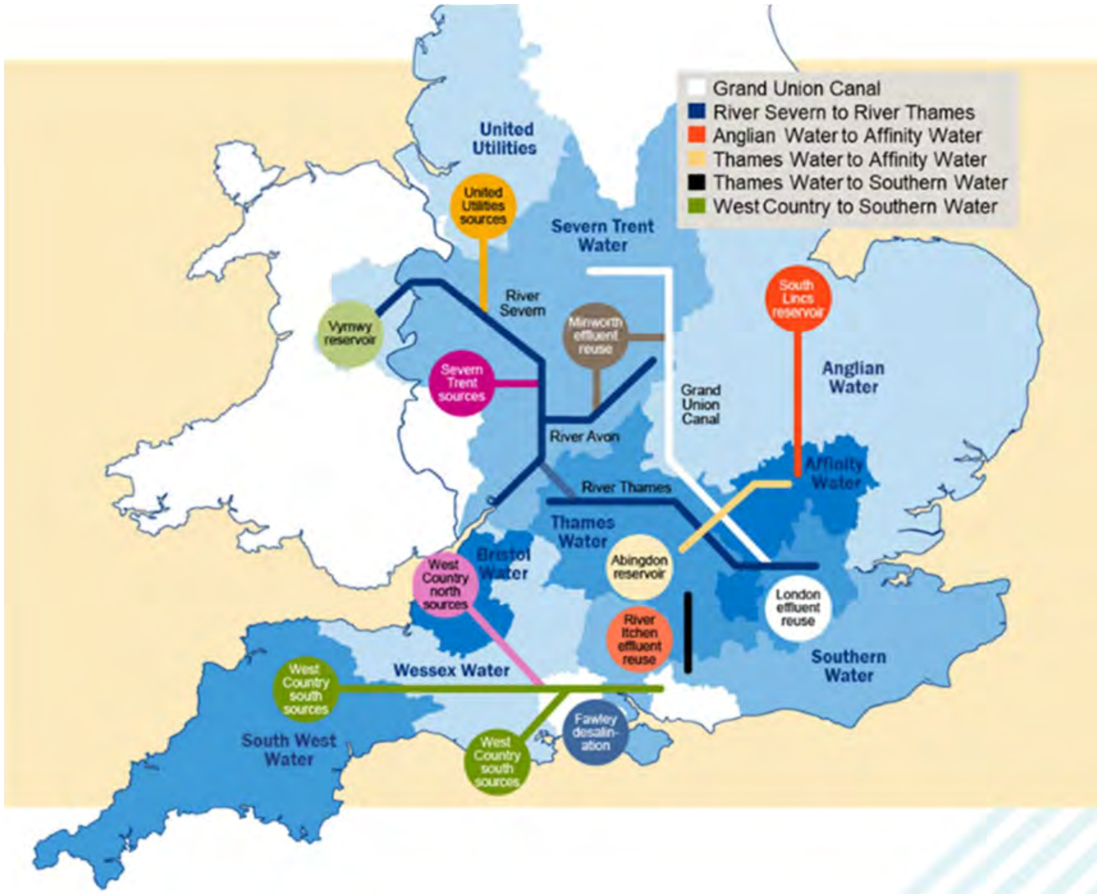

Figure 4.13: Strategic Resource Options under consideration in England and Wales (OfWAT)

Table 4.10: WRMP planned interventions in SWOX and Henley zones

Timescale	SWOX WRZ	Henley WRZ
Short (2020-2024)	Metering programme targeting 79% of households by 2025 Continued promotion of water efficiency 15% reduction in leakage	No specific actions
Medium (2024-2045)	SESRO online by 2037 Reduced abstraction at Farmoor Smart meter penetration at >90% by 2035 to further reduce consumption using incentive-based tariffs.	Integrated demand management implemented from 2030-2040, reducing both demand and leakage. Smart meter penetration at >90% by 2035 to further reduce consumption using incentive-based tariffs.
Long (2045 - 2099)	A transfer from SWOX into the Slough, Wycombe and Aylesbury (SWA) zone at Medmenham	No specific actions

4.3.3 Summary of the WRMP review

The WRMP demonstrates how the Swindon and Oxfordshire (SWOX) water resource zone has moved into a situation of supply-demand deficit under a dry year critical period scenario, and, without intervention, this will increase as a result of population growth, climate change and sustainability reductions.

The Standard Method and Business-As-Usual household growth forecasts being considered by the Oxfordshire Plan are all at or below the Thames Water forecast. The Transformational rate of growth would be above what Thames Water has planned for; however, this is a long-term plan with opportunity for Thames Water to respond to changing demands. Furthermore, demand for water in the SWOX and Henley zones is also dependent upon growth in neighbouring planning authorities.

4.4 Water efficiency and water neutrality

4.4.1 Introduction

It is widely recognised that the climate is changing and in response all five councils have declared a climate emergency. Climate change is predicted to increase pressure on water resources, increasing the potential for a supply-demand deficit in the future, and making environmental damage from over abstraction of water resources more likely. Furthermore, the delivery of water and wastewater services and the heating of water in the home require high energy inputs, and therefore contribute directly to emissions of greenhouse gases. Water efficiency therefore reduces energy use and carbon emissions.

It is important therefore that new development does not result in an unsustainable increase in water abstraction. This can be done in a number of ways from reducing the water demand from new houses through to achieving “water neutrality” across local authority areas by offsetting a new development’s water demand by improving efficiency in existing buildings.

4.4.2 Required evidence

All five of the existing adopted Local Plans in Oxfordshire include policies requiring all new residential development to be designed to the 110 litres per person per day water efficiency standard. This section sets out the latest evidence to support the Local Authorities to establish a clear need to retain this tighter water efficiency target through the building regulations. This should be based on:

- Existing sources of evidence such as:
  - The Environment Agency classification of water stress
  - Water resource management plans produced by water companies
  - River Basin Management Plans which describe the river basin district and the pressure that the water environment faces. These include information on where water resources are contributing to a water body being classified as ‘at risk’ or ‘probably at risk’ of failing to achieve good ecological status, due to low flows or reduced water availability.
- Consultations with the local water and sewerage company, the Environment Agency and catchment partnerships
- Consideration of the impact on viability and housing supply of such a requirement

4.4.3 Water Stress

Water stress is a measure of the level of demand for water (from domestic, business and agricultural users) compared to the available freshwater resources, whether surface or groundwater. Water stress causes deterioration of the water environment in both the quality and quantity of water, and consequently restricts the ability of a waterbody to achieve a "Good" status under the WFD.

The Environment Agency has undertaken an assessment of water stress across the UK. This defines a water stressed area as where:

- "The current household demand for water is a high proportion of the current effective rainfall which is available to meet that demand; or
- The future household demand for water is likely to be a high proportion of the effective rainfall available to meet that demand."

The EA's 2013 assessment[50] identified the Thames Water supply area as one of "serious" water stress.

An updated water stress classification is being developed by the EA and was recently published for consultation[51]. In this assessment the entire Thames Water supply region (and most of southern England and the Midlands) is classified as "serious", although it should be noted that this is provisional at the time of writing this WCS.

4.4.4 River Basin Management Plans

One of the challenges identified in the River Basin Management Plan (RBMP) for the Thames River Basin[52] is "changes to natural flow and levels of water". The management recommendations from the RBMP are listed below:

- All sectors take up or encourage water efficiency measures, including water industry work on metering, leakage, audits, providing water efficient products, promoting water efficiency and education.
- Local Government sets out local plan policies requiring new homes to meet the tighter water efficiency standard of 110 litres per person per day as described in Part G of Schedule 1 to the Building Regulations 2010.
- Industry manufacturing and other business implement tighter levels of water efficiency, as proposed by changes to the Building Regulations.
- Agriculture and rural land management manage demand for water and use water more efficiently to have a sustainable water supply for the future.
- Local government commissions water cycle studies to inform spatial planning decisions around local water resources.

The RBMP goes on to state that "dealing with unsustainable abstraction and implementing water efficiency measures is essential to prepare and be able to adapt to climate change and increased water demand in the future."

4.4.5 National Water Resources Framework

A new National Framework for Water Resources was published by the Government in March 2020. This outlines the water resources challenges facing England and sets out the strategic direction for the work being carried out by regional water resource groups. It includes recognition of the impacts of abstraction upon chalk streams, a globally rare

50 Areas of water stress: final classification, Environment Agency (2013). Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/244333/water-stressed-classification-2013.pdf on: 13/06/2021

51 Updating the determination of water stressed areas in England: consultation document, environment Agency (2021). Accessed online at: https://www.gov.uk/government/consultations/determining-areas-of-water-stress-in-england on: 06/04/2021

52 Part1: Thames river basin district River basin management plan (LIT 10319), Environment Agency 2015. Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/718342/Thames_RBD_Part_1_river_basin_management_plan.pdf on: 13/04/2021

habitat, some 80% of which are located in the UK. There are a number of chalk streams in South Oxfordshire and Vale of White Horse (see Figure 10.2).)

A range of options were explored, and the most ambitious scenarios rely on policy change to introduce mandatory labelling of water using fittings and associated standards. The Government is currently reviewing policy on water efficiency following a recent consultation. The framework proposes that regional groups plan to help customers reduce their water use to around 110 l/p/d. This is achievable without policy interventions.

This aligns with the tighter standard of 110 l/p/d per day as described in Building Regulations. A water efficiency target higher than 110 l/p/d would make the overall target for the UK harder to achieve.

4.4.6 Impact on viability

As outlined in section 3.2.5, the cost of installing water-efficient fittings to target a per capita consumption of 110l/d has been estimated as a one-off cost of £9 for a four-bedroom house. Research undertaken for the devolved Scottish and Welsh governments indicated potential annual savings on water and energy bills for householders of £24-£64 per year as a result of such water efficiency measures[53]. Water efficiency is therefore not only viable but of positive economic benefit to both private homeowners and tenants.

4.4.7 Summary of evidence for tighter efficiency standard

The strategic direction in the UK set out in the new National Water Resources Framework is to attain an average household water efficiency of 110 l/p/d by 2050. This also aligns with the recommendation in the River Basin Management Plan aimed at reducing the impact of abstraction. There would also be a positive economic impact for residents in terms of reduced energy and water bills.

It is therefore recommended that the tighter water efficiency standard of 110 litres per person per day as described in Part G of Schedule 1 to the Building Regulations 2010 is applied in policy in the OP2050, as it has been in the five existing adopted Local Plans.

4.4.8 Water neutrality concept

Water neutrality is a relatively new concept for managing water resources, but one that is receiving increased interest as deficits in future water supply/demand are identified. The definition adopted by the Government and the Environment Agency[54] is:

> ***"For every development, total water use in the wider area after the development must be equal to or less than total water use in the wider area before development".***

It is useful to also refer to the refined definition developed by Ashton:

"For every new significant development, the predicted increase in total water demand in the region due to the development should be offset by reducing demand in the existing community, where practical to do so, and these water savings must be sustained over time" (V Ashton, 2014)[55]

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53 Waterwise (2018) Advice on water efficient new homes in England. Accessed online at: https://waterwise.org.uk/wp-content/uploads/2019/10/Advice-on-water-efficient-homes-for-England061118.pdf on 06/04/2020

54 Water Neutrality: An improved and expanded water resources management definition (SC080033/SR1), Environment Agency, 2009. Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291675/scho1009bqzr-e-e.pdf on: 07/07/2020

55 Water Resources in the Built Environment, edited by Booth and Charlesworth (2014). Published by Wiley.

This definition states the need to sustain water saving measures over time, and the wording "predicted increase in total water demand" reflects the need for water neutrality to be designed in at the planning stage.

Both definitions refer to water use in the region or "wider area", and the extent of this area should be appropriate to local authority boundaries, water resource zones, or water abstraction boundaries depending on what is appropriate for that particular location. For instance, if a development site is in an area of water stress relating to a particular abstraction source, offsetting water use in a neighbouring town that is served by a different water source will not help to achieve water neutrality.

In essence water neutrality is about accommodating growth in an area without increasing overall water demand.

Water neutrality can be achieved in a number of ways:

- Reducing leakage from the water supply networks
- Making new developments more water-efficient
- "Offsetting" new demand by retrofitting existing homes with water-efficient devices
- Encouraging existing commercial premises to use less water
- Implementing metering and tariffs to encourage the wise use of water
- Education and awareness-raising amongst individuals

Suggestions for water-efficiency measures are listed in Figure 4.14.

Many interventions are designed to reduce water use if operated in a particular way, and so rely on the user being aware and engaged with their water use. The educational aspect is therefore important to ensure that homeowners are aware of their role in improving water efficiency. Implementation of many of these measures is beyond the remit of the planning system and the Oxfordshire Plan, and achieving water neutrality would require alignment amongst a range of partners, in particular the water companies.

4.4.9 Consumer water efficiency measures

Measure	Examples
Education and promotional campaigns	• Encourage community establishments (e.g. schools, hospitals) to carry out self audits on their water use • Deliver water conservation message to schools and provide visual material for schools • Building awareness with homeowners/tenants
Water-efficient measures for toilets	• Cistern displacement devices to reduce volume of water in cistern • Retro-fit or replacement of dual flush devices • Retro-fit interuptable flush devices • Replacement low-flush toilets
Water-efficient measures for taps	• Tap inserts, such as aerators • Low flow restrictors • Push taps • Infrared taps
Water-efficient measures for showers and baths	• Low-flow shower heads • Aerated shower heads • Low-flow restrictors • Shower timers • Reduced volume baths (e.g. 60 litres) • Bath measures
Rainwater harvesting and water reuse	• Large-scale rainwater harvesting • Small-scale rainwater harvesting for example with a water butt, or rainwater tank for toilet flushing • Grey water recycling
Water-efficient measures addressing outdoor use	• Hosepipe flow restrictors • Hosepipe siphons • Hose guns (trigger hoses) • Drip irrigation systems • Mulches and composting

Commercial properties

- Commercial water audits
- Rainwater recycling
- Grey water recycling
- Optimising processes
- Provide water efficiency information to all newly metered businesses

Metering

- Promote water companies free meter option
- Compulsory metering (in water stressed areas)
- Smart metering (to engage customers with their consumption)
- Provide interactive websites that allow customers to estimate the savings associated with metering (environmental and financial).
- Innovative tarrifs (seasonal, peak, rising block).
- Customer supply pipe leakage - supply pipe repair and replacement

Other

- Household water audits, including DIY or with help of plumber
- Seek-and-fix internal leaks and/or dripping taps.
- Water efficient white goods, included washing machines and dishwashers
- Ask customers to spot and report leaks

Figure 4.14 Consumer water-efficiency measures

Source: Adapted from Booth and Charleswell 2014

4.4.10 Rainwater Harvesting and Greywater Recycling

Rainwater harvesting

Rainwater recycling or rainwater harvesting (RwH) is the capture of water falling on buildings, roads or pathways that would normally be drained via a surface water sewer, infiltrate into the ground or evaporate. In the UK this water cannot currently be used as a drinking water supply as there are strict guidelines on potable water, but it can be used in other systems within domestic or commercial premises.

Systems for collection of rainwater can be simple water butts attached to a drainpipe on a house, or it could be a complex underground storage system, with pumps to supply water for use in toilet flushing and washing machines. By utilising rainwater in this way there is a reduced dependence on mains water supply for a large proportion of the water use in a domestic property.

Benefits of RwH

- **RwH reduces the dependence on mains water supply – reducing bills for homeowners and businesses.**
- **Less water needs to be abstracted from river, lakes and groundwater.**
- **Stormwater is stored in a RwH system reducing the peak runoff leaving a site providing a flood risk benefit (for smaller storms).)**
- **By reducing surface water flow, RwH can reduce the first flush effect whereby polluted materials adhering to pavement surfaces during dry periods are removed by the first flush of water from a storm and can cause pollution in receiving watercourses.**

Challenges of RwH

- **Dependency on rainfall can limit availability of harvested rainwater during drought and hot weather events.**
- **Increased capital (construction) costs to build rainwater harvesting infrastructure into new housing (£2,674 for a 3/4 bed detached home).**
- **Payback periods are long as the cost of water is low so there is little incentive for homeowners to invest. For further information see:** https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachme

Greywater Recycling

Greywater refers to water that has been "used" in the home in appliances such as washing machines, showers and hand basins. Greywater recycling (GwR) is the treatment and re-use of this water in other systems such as for toilet flushing. By their nature, GwR systems require more treatment and are more complex than RwH systems, and there are limited examples of their use in the UK.

Greywater re-use refers to systems where wastewater is taken from source and used without further treatment. An example of this would be water from a bath or shower being used on plants in the garden. This sort of system is easy to install and maintain, however as mentioned above the lack of treatment to remove organic matter means the water cannot be stored for extended periods.

Greywater recycling refers to systems where wastewater undergoes some treatment before it is used again. These systems are complex and require a much higher level of maintenance than RwH or greywater re-use systems.

Domestic water demand can be significantly reduced by using GwR, and unlike with a RwH system where the availability of water is dependent on the weather, the source of water is usually constant (for instance if it is from bathing and showering). However, the payback period for a GwR system is usually long, as the initial outlay is large, and the cost of water relatively low. Viability of greywater systems for domestic applications is therefore currently limited. Communal systems may offer more opportunities where the cost can be shared between multiple households.

4.4.11 Energy and water use

According to EU statistics (Eurostat 2017), 17% of the UK's domestic energy usage is for water heating. If less water was being used within the home, for instance through more water efficient showers, less water would need to be heated, and overall domestic energy usage would be reduced.

The Government is currently analysing the results of a 2019 consultation on a Future Homes Standard that will involve changes to Part L (conservation of fuel and power) of the Building Regulations for new dwellings. Whilst there is no direct mention of water efficiency in this consultation, there is an important link between water use and energy use, and therefore between water use and carbon footprint.

4.4.12 Funding for water neutrality

Water neutrality is unlikely to be achieved by just one type of measure, and likewise it is unlikely to be achieved by just one funding source. Funding mechanisms that may be available could be divided into the following categories:

- Infrastructure-related funding (generally from developer payments)
- Fiscal incentives at a national or local level to influence buying decisions of households and businesses
- Water company activities, either directly funded by the five-year price review or as a consequence of competition and individual company strategies
- Joint funding through energy efficiency schemes (and possibly to integrate with the heat and energy saving strategy).

Currently in the UK, the main funding resource for the delivery of water efficiency measures is the water companies, with some discretionary spending by property owners or landlords. For water neutrality to be achieved, policy shifts may be required in order to increase investment in water efficiency. Possible measures could include:

- Further incentivisation of water companies to reduce leakage and work with customers to reduce demand
- Require water efficient design in new development
- Developer funding to contribute towards encouraging water efficiency measures
- Require water efficient design in refurbishments when a planning application is made
- Tighter standards on water using fittings and appliances.

4.5 Conclusions

- The Abstraction Licensing Strategies indicate there is restricted water available in Oxfordshire for additional abstractions, and existing abstractions may not be available all year.
- The Thames Water WRMP demonstrates how the Swindon and Oxfordshire (SWOX) water resource zone has moved into a situation of supply-demand deficit and, without intervention, this will increase as a result of population growth, climate change and sustainability reductions.
- The WRMP goes on to outline a set of demand management and supply improvement measures to address this. Key to this is the proposed development of the Abingdon Reservoir (SESRO) by 2037, a key component of improving supply within Oxfordshire and the wider south east, although it should be noted that this is currently being evaluated alongside other Strategic Resources Options.
- The Standard Method and Business-As-Usual household growth forecasts being considered by the Oxfordshire Plan are all at or below the Thames Water forecast. The Transformational rate of growth would be above what Thames Water has planned for; however, this is a long-term plan with opportunity for Thames Water

to respond to changing demands. Furthermore, demand for water in the SWOX and Henley zones is also dependent upon growth in neighbouring planning authorities.

- There is sufficient evidence to support the continuation of the tighter water efficiency target of 110 l/p/d allowed for in building regulations, already a policy of the five adopted Local Plans.
- Policies to reduce water demand from new developments, or to go further and achieve water neutrality in certain areas, could be defined to reduce the potential environmental impact of additional water abstractions in Oxfordshire, and also help to achieve reductions in carbon emissions.

4.6 Recommendations

The recommendations for water resources are provided in Table 4.11 below.

Table 4.11 Recommendations for water resources

Action	Responsibility	Timescale
Continue to regularly review forecast and actual household growth across the supply region through WRMP Annual Update reports, and where significant change is predicted, engage with Local Planning Authorities.	Thames Water	Ongoing
Provide yearly profiles of projected housing growth to water companies to inform the WRMP update.	Oxfordshire Plan team / individual LPAs	Ongoing
Use planning policy to continue to require the 110l/person/day water consumption target permitted by National Planning Policy Guidance in water-stressed areas.	Oxfordshire Plan team / individual LPAs	Ongoing
Consider the case for tighter water efficiency targets, through the Oxfordshire Plan policies, in particular for strategic-scale developments such as major urban extensions and/or new towns/villages.	Oxfordshire Plan team / individual LPAs	Ongoing
A detailed stage WCS should revisit this assessment once details of the spatial strategy to be taken forward to Regulation 19 consultation become available and to inform the selection of broad locations for growth.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
The concept of water neutrality has potentially a lot of benefit in terms of resilience to climate change and enabling all waterbodies to be brought up to Good status. Explore further with Thames Water and the Environment Agency how the Oxfordshire Plan can encourage this approach.	Oxfordshire Plan team / individual LPAs, EA, Thames Water	In line with a detailed WCS, ahead of Reg 19.
Water companies should advise the LPAs of any strategic water resource infrastructure developments, where these may require safeguarding of land to prevent other types of development occurring (note – land for an Abingdon reservoir is already safeguarded in the Vale of White Horse Local Plan).	Thames Water, Anglian Water, Severn Trent Water	Ahead of Reg 19.

5 Wastewater Collection and Treatment Capacity Assessment

5.1 Wastewater Treatment Works in Oxfordshire

The majority of the WwTW within the study area are operated by Thames Water. There are a further six managed by Anglian Water, and one managed by Severn Trent Water. Growth on the periphery of the County may also be served by treatment works in neighbouring areas, and growth in neighbouring areas may likewise be treated at works within Oxfordshire. The locations of these WwTW are shown in Figure 5.1 below.

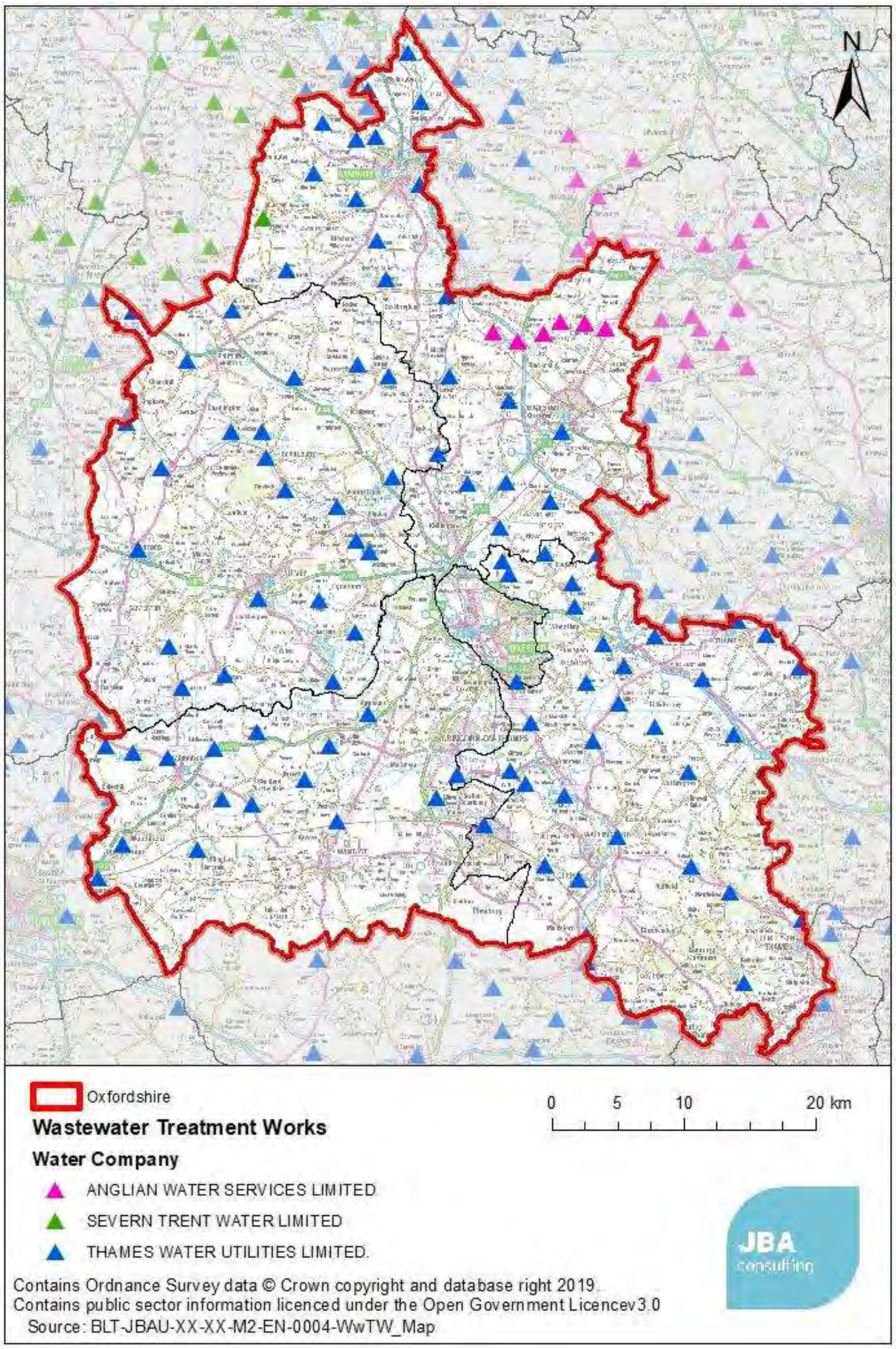

Figure 5.1 Location of WwTWs

The capacity of existing WwTWs to serve additional flows as a result of growth has been assessed by Thames Water and JBA Consulting.

5.2 Thames Water assessment of WwTW capacity

At the first stage of this study, prior to the Oxfordshire Plan team developing growth and spatial scenarios, Thames Water provided an assessment of their WwTW capacity. Appendix A shows the capacity of each WwTW included in the study, as scored by Thames Water based on available capacity. The associated sewer catchments have been colour coded to match their status. The following red / amber / green traffic light definition was used by Thames Water to score each WwTW:

Capacity available	Infrastructure and/or treatment upgrades would be required to provide additional capacity. No significant constraints to the provision of this infrastructure have been identified	Infrastructure and/or treatment upgrades would be required to provide additional capacity. Major constraints have been identified.

Where a catchment is classed as red, this does not indicate that no development can take place in this location, rather that significant infrastructure and/or upgrades may be required at the WwTW. 12% of the WwTWs in Oxfordshire are classified as red, 3% amber and 81% green.

5.3 JBA assessment of WwTW capacity

Wastewater treatment works boundaries were provided by the three sewerage undertakers. These were buffered by 500m, and intersected with the spatial growth option areas. Where a buffered WwTW catchment intersected with a spatial growth option area, it was considered that WwTW may be required to serve growth generated by that option.

The current Dry Weather Flow (DWF) permit for each WwTW was then obtained from the Environment Agency's database of discharges to surface water and groundwater. These are listed below:

Table 5.1: WwTWs potentially impacted by spatial growth options

WwTW	Sewerage undertaker	Op 1	Op 2	Op 3	Op 4	Op 5	Permitted DWF (m^3/d)
Abingdon	Thames	Y	Y	Y	Y	Y	8,335
Appleton	Thames	Y	Y	Y	Y	Y	2,559
Ardley	Anglian			Y	Y	Y	267
Bampton	Thames				Y	Y	853
Banbury	Thames	Y		Y	Y	Y	20,394
Barford	Thames					Y	191
Beckley	Thames		Y		Y	Y	83
Benson	Thames	Y		Y	Y	Y	2,517
Bicester	Thames	Y		Y	Y	Y	13,724
Bledington	Thames			Y			249

WwTW	Sewerage undertaker	Op 1	Op 2	Op 3	Op 4	Op 5	Permitted DWF (m^3/d)
Bletchingdon	Thames			Y	Y	Y	382
Bloxham	Thames					Y	1,000
Bourton Oxon	Thames			Y	Y	Y	64
Broughton	Thames	Y			Y	Y	485
Buckingham	Anglian					Y	4,268
Buckland	Thames			Y		Y	91
Burford	Thames			Y		Y	467
Buscot	Thames					Y	16
Carterton	Thames	Y		Y	Y	Y	3,884
Cassington	Thames	Y	Y	Y	Y	Y	4,000
Chadlington	Thames			Y			180
Chalgrove	Thames	Y				Y	1,231
Charlbury	Thames			Y			727
Charlton-On-Otmoor	Thames			Y	Y	Y	195
Charney Bassett	Thames				Y	Y	66
Chinnor	Thames					Y	3,310
Chipping Norton	Thames	Y		Y		Y	3,725
Chipping Warden	Thames	Y		Y		Y	765
Cholsey	Thames	Y		Y	Y	Y	3,200
Church Hanborough	Thames	Y		Y	Y	Y	1,455
Clanfield	Thames				Y	Y	463
Claydon	Thames			Y		Y	56
Clifton	Thames			Y		Y	50
Coleshill	Thames				Y	Y	43
Combe	Thames			Y		Y	175
Cropredy	Thames	Y		Y	Y	Y	788
Cuddesdon	Thames				Y	Y	137
Culham	Thames	Y		Y	Y	Y	889
Didcot	Thames	Y		Y	Y	Y	12,931
Dorchester	Thames	Y		Y	Y	Y	605
Drayton	Thames			Y	Y	Y	1,672
Eaton Hastings	Thames					Y	9
Elsfield	Thames	Y	Y	Y	Y	Y	27
Enstone	Thames			Y		Y	450

WwTW	Sewerage undertaker	Op 1	Op 2	Op 3	Op 4	Op 5	Permitted DWF (m^3/d)
Faringdon	Thames	Y		Y	Y	Y	2,812
Finstock	Thames			Y	Y	Y	635
Forest Hill	Thames		Y	Y	Y	Y	169
Foscot	Thames			Y			40
Fringford	Anglian					Y	92
Fritwell	Anglian			Y	Y	Y	149
Goring	Thames			Y			1,289
Great Milton	Thames			Y		Y	243
Great Rollright	Thames						128
Hanwell	Thames	Y		Y	Y	Y	51
Henley	Thames	Y		Y		Y	2,950
Hethe	Anglian					Y	150
Hook Norton	Thames					Y	633
Horley (Oxon)	Thames					Y	113
Hornton	Thames					Y	114
Horton-Cum-Studley	Thames					Y	125
Huntercombe	Thames						155
Islip	Thames		Y	Y	Y	Y	219
Kings Sutton	Thames			Y	Y	Y	57
Kingston Bagpuize	Thames			Y		Y	633
Lewknor	Thames					Y	117
Little Compton	Thames			Y			90
Little Milton	Thames					Y	309
Littleworth	Thames			Y		Y	18
Long Wittenham	Thames			Y	Y	Y	265
Middle Barton	Thames					Y	1,188
Middleton Stoney	Thames				Y	Y	50
Milton-Under-Wychwood	Thames			Y			1,165
Mollington	Thames			Y		Y	107
Nettlebed	Thames						104
Nuneham Courtenay	Thames		Y	Y	Y	Y	116
Oxford	Thames	Y	Y	Y	Y	Y	50,985
Pangbourne	Thames			Y		Y	2,333

WwTW	Sewerage undertaker	Op 1	Op 2	Op 3	Op 4	Op 5	Permitted DWF (m^3/d)
Reading	Thames			Y		Y	177,275
Sandford St Martin	Thames					Y	36
Shellingford	Thames					Y	56.5
Shrivenham	Thames			Y	Y	Y	2,842
Shutford	Thames					Y	566
Sibford Ferris	Severn Trent					Y	230
Sonning Common	Thames			Y		Y	1,650
South Leigh	Thames	Y		Y	Y	Y	82
South Moreton	Thames			Y	Y	Y	836
Spelsbury	Thames			Y			60
Stadhampton	Thames	Y		Y		Y	440
Standlake	Thames					Y	737
Stanford in the Vale	Thames					Y	650
Stanton Harcourt	Thames				Y	Y	760
Stanton St John	Thames		Y	Y	Y	Y	182
Stoke Lyne	Anglian					Y	Not specified
Streatley	Thames			Y			187
Tackley	Thames			Y	Y	Y	209
Tetsworth	Thames			Y		Y	324
Thame	Thames	Y		Y		Y	2,792
Tiddington	Thames			Y		Y	218
Towersey	Thames					Y	247
Uffington	Thames			Y	Y	Y	162
Upper Heyford	Thames	Y		Y	Y	Y	789
Wantage	Thames	Y		Y	Y	Y	9,800
Wargrave	Thames	Y		Y		Y	30,000
Watlington	Thames					Y	2,000
Westbury	Anglian					Y	333
Weston-On-The-Green	Thames			Y		Y	243
Wheatley	Thames		Y	Y	Y	Y	1,239
Whitchurch	Thames			Y			259
Witney	Thames	Y		Y	Y	Y	11,883
Woodeaton	Thames		Y		Y	Y	23

WwTW	Sewerage undertaker	Op 1	Op 2	Op 3	Op 4	Op 5	Permitted DWF (m^3/d)
Woodstock	Thames	Y		Y	Y	Y	1,808
Worminghall	Thames					Y	821

The total DWF capacity of all works potentially impacted by each option was then calculated, and compared to the additional wastewater flow as a result of the three housing growth options. This was calculated assuming:

- Additional growth was calculated using the residual growth figures for the three housing growth scenarios outlined in Table 2.2. This was done as the impact of committed growth has already been considered in the existing WCSs of the individual LPAs, and to specifically assess the impacts of the residual growth, the scale and geography of which will be considered through the Oxfordshire Plan.
- 110 litres per person per day.
- 2.3 average occupancy.
- 95% of water consumed returned to sewer.
- 10% additional allowance for infiltration.
- The capacity of Reading and Wargrave WwTWs was not included within the assessment, as it was considered that using either of these large WwTWs to serve significant growth within Oxfordshire would be problematic, possibly requiring in both cases extensive new sewers crossing the River Thames and urban areas. Hence their inclusion within the assessment of available capacity was considered likely to give an overly optimistic assessment.
- The DWF capacity of Stoke Lyne WwTW is not recorded in its permit. It is a small works and therefore this omission is not expected to significantly alter the results.

The results are summarised in Table 5.2. This illustrates that there are significant differences in the percentage of existing treatment capacity which could be used up depending on the spatial option selected, with the greatest pressure coming from Option 2 which focusses all growth around Oxford. Whilst this spatial scenario would be highly likely to require a very significant expansion of treatment capacity at Oxford, and possibly at Abingdon and other smaller works close to the City, this does not necessarily make this an unfavourable option. Large upgrades at a small number of key works may be more efficient than upgrading large numbers of much smaller rural treatment works, as might be required by the more widely distributed spatial scenarios 3, 4 and 5.

Table 5.2: Additional wastewater flows from housing growth as a percentage of existing treatment capacity

			Housing growth option					
			Standard method		Business-as-usual		Transformational	
Spatial Option	Number of WwTWs	Total DWF capacity (m3/d)	Additional DWF (m3/d)	% of existing DWF capacity	Additional DWF (m3/d)	% of existing DWF capacity	Additional DWF (m3/d)	% of existing DWF capacity
1	30	165,906	4,948	3%	10,714	6%	18,484	11%
2	12	67,937	4,948	7%	10,714	16%	18,484	27%
3	72	185,154	4,948	3%	10,714	6%	18,484	10%
4	50	166,141	4,948	3%	10,714	6%	18,484	11%

5	99	202,414	4,948	2%	10,714	5%	18,484	9%

5.4 Impact of development on collection system capacity

No information is available at this stage on the capacity of the sewer network. However, in general terms, development in areas where there is limited wastewater network capacity will increase pressure on the network, increasing the risk of a detrimental impact on existing customers, and increasing the likelihood of Combined Sewer Overflow (CSO) operation. In areas of the network where combined sewers are present, separation of the foul and surface water may be required, as well as suitably designed SuDS.

Five spatial options are being considered at this stage of the Oxfordshire Plan. Below we consider how different spatial approaches to development offer different opportunities and challenges for the wastewater collection systems that serve them.

Infill and regeneration options (a possible feature of spatial options 1, 2, 3, 4 and 5) provide opportunities for betterment where surface water can be managed through SuDS when previously it was discharging to a surface water or combined sewer. Often the scale of infill development is less so may be able to be served by existing infrastructure, however it may not deliver the levels of growth required. Where infill development is planned where sewer capacity is more limited, it may exacerbate existing sewer flooding issues and will be highly dependent on the existing network.

In general terms **growth distributed widely around the periphery of existing settlements** (a possible feature of spatial options 1, 2, 3, 4 and 5) can be difficult to accommodate. The sewer infrastructure is likely to have grown organically with the settlement and may not have the capacity to accommodate additional flows. This growth option may therefore require many upgrades spread across the whole of the study area in order to accommodate growth which may not be the most efficient way to deliver capacity.

Large urban extensions (a possible feature of spatial options 1, 2, 3 and 4) focus the growth in a few locations and therefore one large upgrade scheme may serve a considerable quantity of growth. Different settlements may have different levels of existing capacity in the adjacent sewer network and treatment capacity. The favourability of each scheme will therefore depend on which settlement is being extended.

New settlements (a possible feature of spatial options 3, 4 and 5), are likely to require the highest level of new infrastructure, up to an including a new WwTW depending on the new settlement's position relative to the existing network. This needs to be factored in early in the process to ensure that new infrastructure can be accommodated.

Sewerage Undertakers have a duty under Section 94 of the Water Industry Act 1991 to provide sewerage and treat wastewater arising from new domestic development. Except where strategic upgrades are required to serve very large or multiple developments, infrastructure upgrades are usually only implemented following an application for a connection, adoption, or requisition from a developer. Early developer engagement with water companies is therefore essential to ensure that sewerage capacity can be provided without delaying development.

Further consideration of the pros and cons of the five spatial options in relation to providing wastewater collection services is included in section 11.

5.5 Recommendations

The recommendations for wastewater collection and treatment are provided in Table 5.3 below.

Table 5.3 Recommendations for wastewater collection and treatment

Action	Responsibility	Timescale
A detailed stage WCS should revisit the assessment of wastewater collection and treatment once details of the spatial strategy to be taken forward to Regulation 19 consultation become available and to inform the selection of broad locations for growth.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
Water companies should advise the LPAs of any strategic wastewater developments, where these may require safeguarding of land to prevent other type of development occurring.	Thames Water, Anglian Water, Severn Trent Water	Ahead of Reg 19.

6 Water Quality

6.1 Water Framework Directive Status

The objective of the Water Framework Directive (WFD) is to provide a framework for the protection of inland surface waters, estuaries, coastal waters and groundwater. It commits all European Union member states to achieve good qualitative and quantitative status for all water bodies. Whilst improvements have been seen in some water bodies in Oxfordshire[56], there are some that have deteriorated in overall class. Figure 6.1 below shows the waterbodies where a deterioration in water quality between WFD Cycle 1 (2009)[57] and Cycle 2 (2016)[58] has been recorded.

Although the Water Framework Directive originates in EU law, it was transposed into UK law and implemented through the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003. Brexit will therefore have no short-term impact on our obligations under the WFD as Parliament would have to specifically repeal those regulations. Over time they are likely to be updated and replaced, however the principal of all waterbodies aiming to achieve good ecological status is broadly in line with the principles set out in the Government's 25-Year Environment Plan[59].

6.2 Water Quality Analysis

In England, the Environment Agency has set standards of water quality below which an Environmental Permit review may be triggered. These include a deterioration of more than 10%, a class deterioration leading to a drop in ecological status or a deterioration of more than 3% on any waterbody classed as having a "bad" ecological status. SIMCAT is a water quality modelling tool developed and maintained by the EA and water industry which simulates the impact on water quality of point and diffuse sources of contaminants and nutrients. The model allows the cumulative impact of increased effluent flow at multiple WwTW to be assessed.

At this stage in the development of the Oxfordshire Plan 2050, with three growth options and five spatial scenarios, it was considered unrealistic to undertake water quality modelling of every possible option. Instead, in order to assess the sensitivity of the receiving watercourses to increased effluent flows, prior to spatial growth options being available, the following methodology was used:

- Run SIMCAT with current flow data and extract water quality outputs for ammonia, biochemical oxygen demand (BOD) and phosphate downstream of relevant WwTWs, to establish a baseline.
- Increase effluent flows at WwTW by 10% and 20% to account for potential development scenarios.
- Re-run SIMCAT with higher effluent flows and extract relevant river water quality data.
- Compare the two model runs for all three water quality indicators and categorise the percentage change.
- Compare outputs to WFD standards and identify any class deteriorations.

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56 The EA data reports improvements in individual assessment elements and not overall status so the improvement data has not been added to the map in Figure 4-1.
57 WFD cycle 1 surface water classification status and objectives, Environment Agency (2009). Accessed online at: https://environment.data.gov.uk/dataset/19bd07e7-f172-44ae-9552-eda5a41b451b
58 WFD Classification Status Cycle 2, Environment Agency (2016). Accessed online at: https://environment.data.gov.uk/dataset/c9586690-71da-48bf-bc92-d359d38bedc5
59 HM Government (2018) A Green Future: Our 25 Year Plan to Improve the Environment.

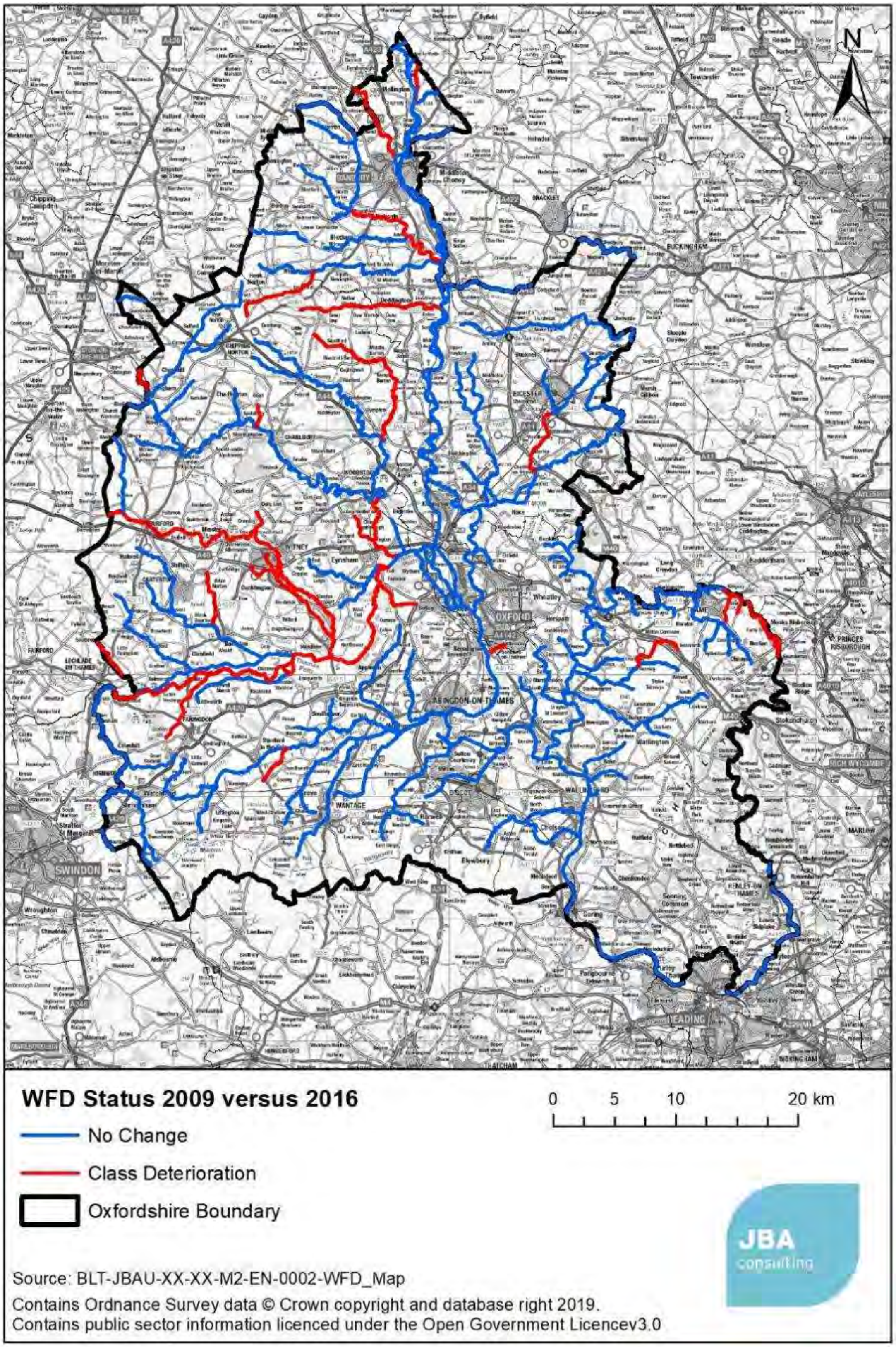

Figure 6.1 WFD deterioration

Appendix B presents the water quality results produced using this methodology. Where water quality downstream of a WwTW in any given determinand deteriorates by 10% or more in response to a 10% or 20% increase in effluent flow, the sewer catchment can be said to be "more sensitive" to changes in effluent flow, and therefore growth.

Those shown with a blue circle are predicted to experience a class deterioration in at least one determinand (listed in Table 6.1) in response to a 10% or 20% increase in flow. The model is based on a combination of observed data and assumptions, and therefore this deterioration in class may not occur in reality, but indicates that the river downstream of a particular WwTW may be close to the WFD class boundary.

It should be noted that this assessment takes the existing SIMCAT model based on 2010-12 data, and increases flow by a consistent figure across the whole model. In some cases, a WwTW may be able to accommodate a higher flow, in other cases, a 10% or 20% increase may not be likely or feasible. This assessment therefore just highlights the relative risk of deterioration. It should also be noted that some combinations of spatial and growth scenarios would lead to flow increases in excess of 20%, in particular Option 2, which focuses all growth around Oxford, and the Transformational growth scenarios for Options 4 and 5 (see Table 5.2 for estimates of percentage effluent growth for each combination of options).

Table 6.1 Risk of class deterioration predicted

+10% additional flow scenario			+20% additional flow scenario		
Ammonia	**Biochemical Oxygen Demand (BOD)**	**Phosphate**	**Ammonia**	**Biochemical Oxygen Demand (BOD)**	**Phosphate**
Buckland	Chinnor	Horton-cum-Studley	Buckland	Chinnor	Abingdon (Thames)
Chipping Norton		Long Wittenham	Chipping Norton	Church Hanborough	Horton-cum-Studley
Forest Hill			Forest Hill	Horton-cum-Studley	Long Wittenham
Horton-cum-Studley			Horton-cum-Studley	Weston on the Green	Tackley
Milton-under-Wychwood			Milton-under-Wychwood		
			Uffington		

Some of the receiving waterbodies already have "bad" overall ecological status. In these cases, it is Environment Agency policy that no further deterioration is acceptable – for practical purposes this is assessed as no greater than 3% deterioration. The following WwTWs show a 3% greater deterioration with "bad" class:

Table 6.2: WwTWs with "bad" class and deterioration greater than 3%

+10% additional flow scenario	+20% additional flow scenario
Appleton	Appleton
Bletchington	Bletchington
Bloxham	Bloxham
Chalgrove	Buscot
Chinnor	Chalgrove
Chipping Warden	Chinnor
Clanfield	Chipping Norton

+10% additional flow scenario	+20% additional flow scenario
Cuddesden	Chippng Warden
Culham	Clanfield
Great Milton	Cuddesden
Kings Sutton	Faringdon
Kingston Bagpuize	Faringdon
Little Compton	Great Milton
Little Milton	Kings Sutton
Pangbourne	Kingston Bagpuize
Tetsworth	Little Compton
Tiddington	Little Milton
Towersey	Pangbourne
Wargrave	Reading
Weston on the Green	Tetsworth
Worminghall Grave	Tiddington
	Towersey
	Wargrave
	Weston on the Green
	Worminghall Grave

BOD seems to be the water quality indicator least sensitive to increased effluent flows. There are only four WwTWs that experience a class deterioration and only 2 of the 106 treatment works have an increase in BOD concentration that exceeds 10%.

Ammonia appears to be the most sensitive determinand, with 56 of the 106-treatment works experiencing a decrease of more than 10%, and six WwTWs that experience a class deterioration.

In general terms, large urban extensions and new/expanded settlements will concentrate growth at just a few WwTW so the increase in effluent flow, and its potential impact could be large. Smaller scale growth on the periphery of a large number of existing settlements distributes growth across the study area, using many treatment works. This may allow the impact on water quality to be distributed, reducing the likelihood of WFD deterioration, however the total effluent load in the study area would be the same, and upgrading multiple WwTW to prevent deterioration would not be as cost effective as providing a strategic upgrade to a limited number of WwTW.

Water quality modelling, using a catchment-wide approach is required in order to understand the current capacity of the water environment and the impact of each of the growth options.

6.3 Recommendations

The recommendations for water quality are provided in Table 6.3 below.

Table 6.3 Recommendations for water quality

Action	Responsibility	Timescale
A detailed stage WCS should revisit the assessment of water quality impact once details of the spatial strategy to be taken forward to Regulation 19 consultation become available and to inform the selection of broad locations for	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.

Action	Responsibility	Timescale
growth. This should use the updated EA SIMCAT model (if available), and should consider the impacts of proposed development, whether deterioration can be prevented by application of improved treatment, and whether the proposed development could prevent any watercourses from achieving Good status in the future.		
The Plan policies need to recognise planners' responsibilities regarding the Water Framework Directive and also the Habitats Directive. Further engagement with Natural England (either through the Habitats Regulations Assessment or separately) is recommended ahead of Regulation 19 consultation.	Oxfordshire Plan team / individual LPAs / Natural England	Ahead of Reg 19.

7 Flood Risk

7.1 Methodology

In order to assess the increase in flood risk that may be attributable to an increase in effluent from planned growth, Flood Estimation Handbook (FEH) flow estimates have been compared to WwTW effluent flows to identify those treatment works that account for a significant proportion of the flow at each outfall point.

The FEH flow estimates have been calculated using the FEH CD-ROM v1.0 catchment descriptors and effluent flows have been extracted from SIMCAT. Treatment works with effluent flows of less than 0.432 Ml/day (equivalent to 5 litres per second) have not been considered since JBA's flood estimation tool JFes (which has been used to estimate discharge using the FEH statistical method) cannot resolve flows below this. It is important to bear in mind that the FEH method in these cases has been used to produce an estimate of flow in the river and is not a formal flood risk assessment.

7.2 Results

Additional effluent flows accounting for more than 5% of the 1 in 100-year river discharge have been classified as potential risks, and this is presented in Appendix C. There are four WwTWs that fall into this category in Oxfordshire (Henley, Oxford, Watlington and Witney), suggesting that growth in these catchments might increase the risk of flooding. Those that are within the amber category (Benson, Chinnor and Didcot) might be tipped over the threshold if growth is planned in the catchment. A red or amber assessment does not necessarily mean that flooding will occur if development occurs within these catchments, but that the increased effluent flow will require further consideration within a site-specific Flood Risk Assessment as part of any planning application to expand these WwTWs.

Proposals to increase discharges to a watercourse may also require a flood risk activities environmental permit from the EA (in the case of discharges to a main river), or a land drainage consent from the Lead Local Flood Authority (in the case of discharges to an ordinary watercourse).

7.3 Recommendations

The recommendations for flood risk are provided in Table 7.1 below.

Table 7.1 Recommendations for flood risk from additional wastewater effluent

Action	Responsibility	Timescale
A detailed stage WCS should revisit the assessment of flood risk once indicative areas of growth become available.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.

8 Climate Change Impacts

8.1 Summary of UK Climate Projections

The UK Climate projections 2018 (UKCP18), released November 2018, provide updated projections of how the climate might change in the UK over the 21st Century. This section provides an overview of the main differences between UKCP18 and UKCP09, and the key issues raised. A detailed analysis can be found in Appendix D. The projections benefit from a new set of emissions scenarios (known as RCPs) that consider mitigation efforts, updated methodology using the newest climate models and climate data and an updated baseline period of 1981-2000.

General climate change trends projected over UK land for the 21st century are broadly consistent with UKCP09 projections, showing an increased chance of milder, wetter winters and hotter, drier summers along with an increase in the frequency and intensity of extremes. Cold, drier winters and cooler, wet summers will still occur due to natural climate variability, but these are likely to become less frequent over the 21st Century. However, there are some differences between UKCP09 and UKCP18 (e.g. temperature and rainfall) that may be important for climate risk assessments. These differences depend on season, location and greenhouse gas emission scenarios and there is a large overlap of projected ranges for the majority of climate metrics. The biggest differences are within the highest (95th) and lowest percentiles (5th) (so in the lower probability, extreme range)[60].

The UKCP18 probabilistic projections for the South East of England, for RCP 8.5 (high emissions scenario, to represent a worst-case scenario) by 2080 are as follows:

- Drier summers with a change in average summer precipitation of between -2% and -76%. Trends over the 21st century indicate dry summers are going to become much more frequent by 2100.
- Hotter summers will become much more common with a change in average summer temperatures of between 2.9°C and 8.6°C.
- Wetter winters with a change in average winter precipitation of between -2% and 57% (central estimate: 24%). Trends over the 21st century indicate that in general wet winters will become more frequent by 2100.
- Milder winters will become more common with a change in average winter temperatures of between 1.5°C and 5.7°C.

The key differences between UKCP09 and UKCP18 for this region vary dependent on climate metric, season and percentile ranges. For seasonal and annual trends in precipitation, there are some relatively big differences between the two sets of projections in the low and high percentiles. UKCP18 shows slightly larger reductions in precipitation than UKCP09. UKCP18 also shows slightly smaller increases in precipitation (90th percentile) in comparison to UKCP09. For seasonal and annual temperature, the differences between the two sets of projections appear to be dependent on season. The biggest differences are in winter with UKCP18 showing slightly less warming than UKCP09.

8.2 Implications for Oxfordshire

8.2.1 Overview

This section details the impacts that the UKCP18 latest projections of climate change in the UK may have on flood risk management, wastewater treatment and water resources

60 Lowe et al., 2018. UKCP18 Science Overview Report. Available at: https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf

in Oxfordshire. As UKCP18 was only released in November 2018, the guidance surrounding these areas is still in the process of being updated and detailed analysis of the projections is still required to better assess implications of UKCP18 projections.

8.2.2 Flood risk management

Analysis of the projections is still required to understand the impact that the new projections will have on flood risk management in England and using the UKCP18 data available now it is not possible to comment on how this will or could change. The high resolution (2.2km grid) climate model of local projections, released in 2019, will have a big impact on our understanding of how flood risk is likely to change, and analysis of this data will be used to inform the rainfall and peak flow uplifts used in future, and there is on-going research in this area. At the time of writing, the Environment Agency recommends using the current guidance on incorporating climate change into flood risk studies, which was released in 2016 using data from the UKCP09 projections. The allowances used in this are still the best representation to date of how climate change is likely to effect flood risk for peak river flow. New fluvial flood risk guidance is due to be released in 2021.

8.2.3 Water Resources

Drawing from the UKCP18 projections, Oxfordshire is likely to experience drier summers than was originally estimated in the UKCP09 by 2080. It can be assumed that hot, dry summers are likely to become more frequent over the 21st Century, which may have an impact on water demand and on the availability of water for abstraction from rivers during summer months. An overall increase in wet winters over the 21st century, as consistent with UKCP09, should be beneficial for aquifer recharge and the availability of groundwater resources. However, dry winters will still occur due to natural climate variability and it is not possible to estimate the relative probability of multiple dry seasons occurring consecutively (both summer and winter) from the data presented and the impact this will have on water availability. A detailed study of UKCP18 data would be required to fully understand the impact that the UKCP18 projections will have on water resources in Oxfordshire.

The National Infrastructure Commission has analysed the UK's long-term infrastructure needs in response to predicted drought. In order to maintain the current standard of resilience (the worst historic drought), the system would require 2,700- 3,000 million additional litres of water per day (Ml/day) to account for a rising population and the environmental and climate pressures expected by 2050. Figure 8.1 displays the spatial variation of the need for additional water capacity. Depending on the drought scenario (0.5% to 0.2% annual probability) an additional shortage as large as 1,000 Ml/day may be encountered. The 'Preparing for a Drier Future' report suggests that a 'twin-track' approach of reducing demand and increasing supply is the most cost efficient and sustainable way to deliver resilience. It is suggested that a minimum of 1,300 Ml/day of additional supply infrastructure will be required, which might be achieved using transfers, reservoirs, re-use and desalination. Comparatively, demand can be reduced by introducing additional metering and reducing leakages.

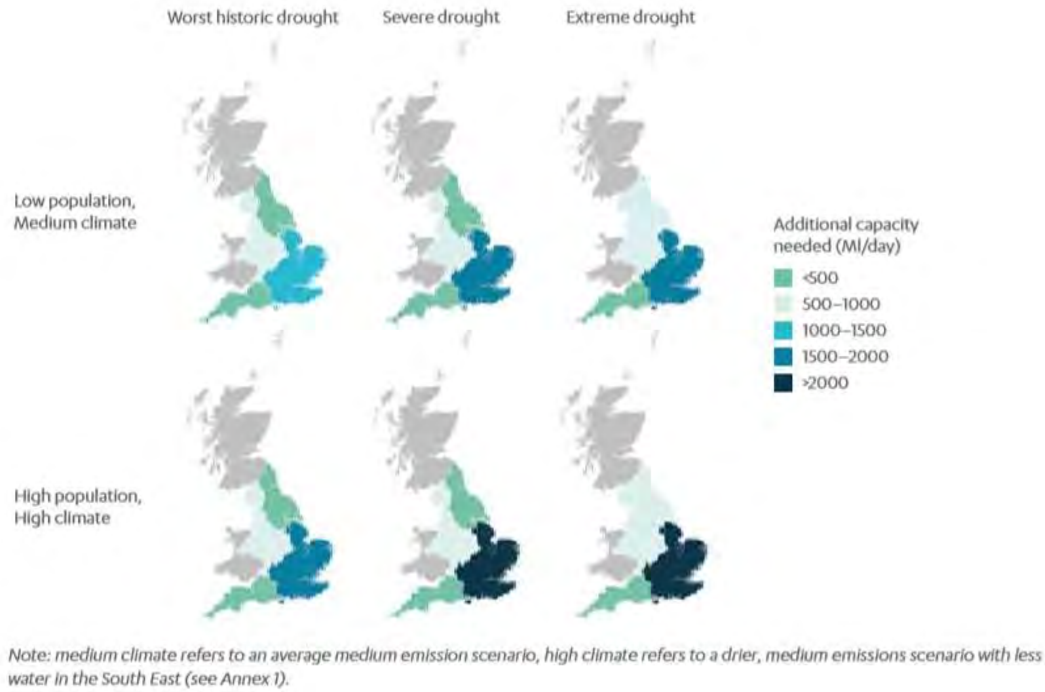

Figure 8.1 Source: 'Preparing for a drier future', National Infrastructure Commission[61]

8.2.4 Wastewater infrastructure

The current outputs from UKCP18 do not provide projections for short duration heavy rainfall (i.e. convective storms) which affect urban drainage systems. This was provided in the high resolution (2.2km grid) regional projections, but additional analysis will be needed before these projections can be translated into any guidance. Again, it is not possible to comment on how this may change wastewater management in the future. At the time of writing, the most up-to-date projections for future short duration high intensity rainfall are those from the UKWIR (UK Water Industry Water Research) 2017 project 'Rainfall intensity for sewer design - Stage 2', which should be used for wastewater management projects. Thames Water was a member of the project steering group for this research and has access to the report.

8.3 Recommendations

The recommendations for assessing climate change impacts are provided in Table 8.1 below.

Table 8.1 Recommendations for assessing climate change impacts

Action	Responsibility	Timescale
A detailed stage WCS should consider the impacts of climate change on all aspects of water supply and wastewater treatment. This is an area of rapidly evolving guidance, so the latest guidance should always be reviewed and applied.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.

61 National Infrastructure Commission (2018) Preparing for a drier future. Accessed Online at: https://www.nic.org.uk/wp-content/uploads/NIC-Preparing-for-a-Drier-Future-26-April-2018.pdf on 13/09/2019

Action	Responsibility	Timescale
Consider “no regrets” decision-making when developing policy for the Oxfordshire Plan, for example Nature-Based Solutions which can mitigate some impacts of climate change alongside delivering other benefits and services.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.

9 Odour Assessment

9.1 Introduction

Where new development is within close proximity to an existing Wastewater Treatment Works (WwTW), odour from that works may become a cause for nuisance and complaints from residents. Managing odour at WwTWs can add considerable capital and operational costs, particularly when retro-fitted to existing WwTWs. National Planning Practice Guidance[62] recommends that plan-makers consider whether new development is appropriate near to sites used (or proposed) for water and wastewater infrastructure, due to the risk of odour nuisance.

Sewerage undertakers recommend that an odour assessment may be required if the site of a proposed development is close to a WwTW and is encroaching closer to the WwTW than existing urban areas. For Thames Water, this is defined as development sites less than 800m from the WwTW. Figure 9.1 below shows the 800m buffer applied around each WwTW in the study area. In other WCSs conducted in Severn Trent Water's area an 800m buffer has also been applied. Anglian Water have a methodology for assessing odour risk that takes into account the size of the WwTW, but due to the limited number of Anglian Water WwTWs in the study area an 800m buffer was kept for consistency but may be conservative.

9.2 Recommendations

The recommendations for odour assessment are provided in Table 5.3Table 9.1 below.

Table 9.1 Recommendations for managing odour nuisance

Action	Responsibility	Timescale
A detailed stage WCS should include an assessment of odour impacts once indicative areas of growth become available.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
Carry out an odour assessment for development proposals identified as being at risk of nuisance odour.	Site Developers	To be submitted with planning applications

62 Planning Practice Guidance – Water supply, wastewater and water quality – considerations in plan making – Para 005. UK Government (2014). Accessed online at: https://www.gov.uk/guidance/water-supply-wastewater-and-water-quality

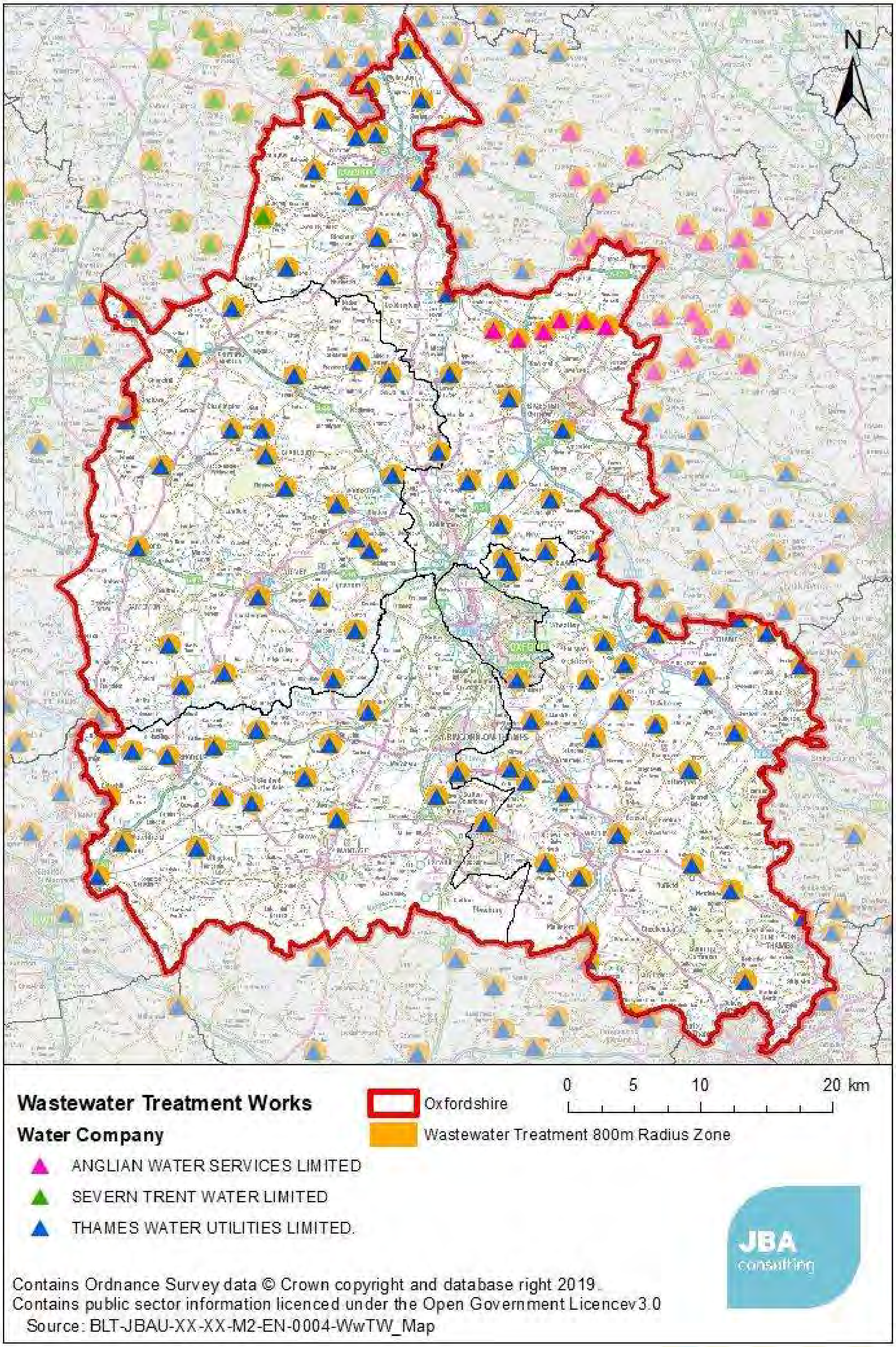

Figure 9.1 800m radius buffer zone surrounding each Wastewater Treatment Works.

10 Environmental Opportunities and Constraints

10.1 Introduction

Development has the potential to cause an adverse impact on the environment through a number of routes such as worsening of air quality, pollution to the aquatic environment, or disturbance to wildlife. Of relevance in the context of a Water Cycle Study is the impact of development on the aquatic environment. It also brings opportunities if for instance surface water can be managed sustainably, best practice on SuDS is followed, and green infrastructure can be incorporated. This is particularly the case for the redevelopment of brownfield sites. It is an objective of the 25 Year Environment Plan that the principle of environmental net gain as a result of development should be embedded within the planning system.

Water pollution is usually categorised as either diffuse or point source. Point source sources come from a single well-defined point, an example being the discharge from a WwTW.

Diffuse pollution is defined as "unplanned and unlicensed pollution from farming, old mine workings, homes and roads. It includes urban and rural activity and arises from industry, commerce, agriculture and civil functions and the way we live our lives."[63]

Examples of diffuse sources of water pollution include:

- Contaminated runoff from roads – this can include metals and chemicals
- Drainage from housing estates
- Misconnected sewers (foul drains to surface water drains)
- Accidental chemical / oil spills from commercial sites
- Surplus nutrients, pesticides and eroded soils from farmland
- Septic tanks and non-mains sewer systems

After or during heavy rainfall, the first flush of water carrying accumulated dust and dirt is often highly polluting. Development has the potential to increase the diffuse pollution by providing additional sources from roads and housing estates.

Potential impacts on receiving surface waters include the blanketing of riverbeds with sediment, a reduction in light penetration from suspended solids, and a reduction in natural oxygen levels, all of which can lead to a loss in biodiversity.

10.2 Environmentally Sensitive Sites

The Habitats Regulations Assessment process is designed to ensure that consideration is given to sites protected by European Directives, including Ramsar sites, Special Areas of Conservation (SAC) and Special Protection Areas (SPA). Other types of sites are also protected under these regulations, but at this stage of the WCS we have focussed on SACs and SPAs. SSSIs are not subject to the HRA process, but are protected under the Wildlife and Countryside Act, and the impact of development on these sites must also be considered. There are several SSSIs within the study area boundary.

The south of the county contains three chalk streams identified on EA mapping (Figure 10.2), although this is acknowledged to be a low-resolution dataset and numerous other chalk streams exist along and downstream of the chalk hills of the Chilterns and Berkshire Downs, including ephemeral streams such as the Assendon Stream in the Stonor valley. Over recent years there has been increased focus on these globally

63 "Tackling water pollution from the urban environment Consultation on a strategy to address diffuse water pollution from the built environment", Defra (2012). Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/82602/consult-udwp-doc-20121120.pdf on: 16/03/2020

extremely rare habitats, some 80% of which are found in the UK. Chalk streams are highly vulnerable to the impacts of unmitigated development, in particular from groundwater abstraction, increased surface runoff and sediment loads as a result of urban drainage, and nutrient discharges as a result of wastewater effluent discharges. Of the three mapped chalk streams in the county, only the Ewelme Brook has partial protection, with a Local Nature Reserve at Ewelme water cress beds.

10.3 Groundwater Protection

Groundwater is an important source of water in England and Wales. The Environment Agency is responsible for the protection of "controlled waters" from pollution under the Water Resources Act 1991. These controlled waters include all watercourses and groundwater contained in underground strata. The Groundwater Source Protection Zones (SPZs) are based on an estimate of the time it would take for a pollutant which enters the saturated zone of an aquifer to reach the source of abstraction or discharge point (Zone 1 = 50 days, Zone 2 = 400 days, Zone 3 is the total catchment area). The Environment Agency will use SPZs (alongside other datasets such as the Drinking Water Protected Areas (DrWPAs) and aquifer designations) as a screening tool to show:

- areas where it would object in principle to certain potentially polluting activities, or other activities that could damage groundwater;
- areas where additional controls or restrictions on activities may be needed to protect water intended for human consumption; and
- how it prioritises responses to incidents.

The EA has published a position paper[64] outlining its approach to groundwater protection which includes direct discharges to groundwater, discharges of effluents to ground and surface water runoff. This is of relevance to this water cycle study where a development may manage surface water through SuDS.

Sewage and trade effluent

Discharge of treated sewage of 2m^3 per day or less to ground are called small sewage discharges (SSDs). The majority of SSDs do not require an environmental permit if they comply with certain qualifying conditions. A permit will be required for all SSDs in source protection zone 1 (SPZ1).

For treated sewage effluent discharges, the EA encourages the use of shallow infiltration systems, which maximise the attenuation within the drainage blanket and the underlying unsaturated zone. Whilst some sewage effluent discharges may not pose a risk to groundwater quality individually, the cumulative risk of pollution from aggregations of discharges can be significant. Improvement or pre-operational conditions may be imposed before granting an environmental permit. The EA will only agree to developments where the addition of new sewage effluent discharges to ground in an area of existing discharges is unlikely to lead to an unacceptable cumulative impact.

Generally, the EA will only agree to developments involving release of sewage effluent, trade effluent or other contaminated discharges to ground if it is satisfied that it is not reasonable to make a connection to the public foul sewer. The developer would have to provide evidence of why the proposed development cannot connect to the foul sewer in the planning application. This position will not normally apply to surface water run-off via sustainable drainage systems and discharges from sewage treatment works operated by sewerage undertakers with appropriate treatment and discharge controls.

64 The Environment Agency's approach to groundwater protection, Environment Agency (2018). Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/692989/Envirnment-Agency-approach-to-groundwater-protection.pdf on: 23/01/2019

Deep infiltration systems (such as boreholes and shafts) are not generally accepted by the EA for discharge of sewage effluent as they bypass soil layers and reduce the opportunity for attenuation of pollutants.

Discharges of surface water run-off to ground at sites affected by land contamination, or from sites for the storage of potential pollutants are likely to require an environmental permit. This could include sites such as garage forecourts and coach and lorry parks. These sites would be subject to a risk assessment with acceptable effluent treatment provided.

A septic tank or small sewage treatment plant should be used to treat the sewage and then discharge the effluent (treated liquid) to the ground via a drainage field. A soakaway, well or borehole cannot be used for discharging effluent to the ground. A permit from the Environment Agency or upgrade to a drainage field is required, whereby the risk of the system can be used in the specified location.

The treatment system must meet the relevant British Standard in force at the time of installation. The requirements are:

- CE mark;
- The manual or other documentation that came with tank or treatment plant has a certificate of compliance with a British Standard; and
- It is on British Water's list of approved equipment.

The treatment system must be installed correctly and have a capacity large enough to treat the maximum amount of sewage for the specified location.

Discharge of clean water

"Clean water" discharges such as runoff from roofs or from roads, may not require a permit. However, they are still a potential source of groundwater pollution if they are not appropriately designed and maintained.

Where infiltration SuDS schemes are proposed to manage surface runoff they should:

- be suitably designed;
- meet Government non-statutory technical standards[65] for sustainable drainage systems – these should be used in conjunction with the NPPF and PPG; and
- use a SuDS management treatment train (see sections 10.3.1 to 10.3.3).

A hydrogeological risk assessment is required where infiltration SuDS are proposed for anything other than clean roof drainage in a SPZ1.

65 Sustainable Drainage Systems: non-statutory technical standards, Department for Environment, Food & Rural Affairs (2015). Accessed online at: https://www.gov.uk/government/publications/sustainable-drainage-systems-non-statutory-technical-standards on: 23/01/2019

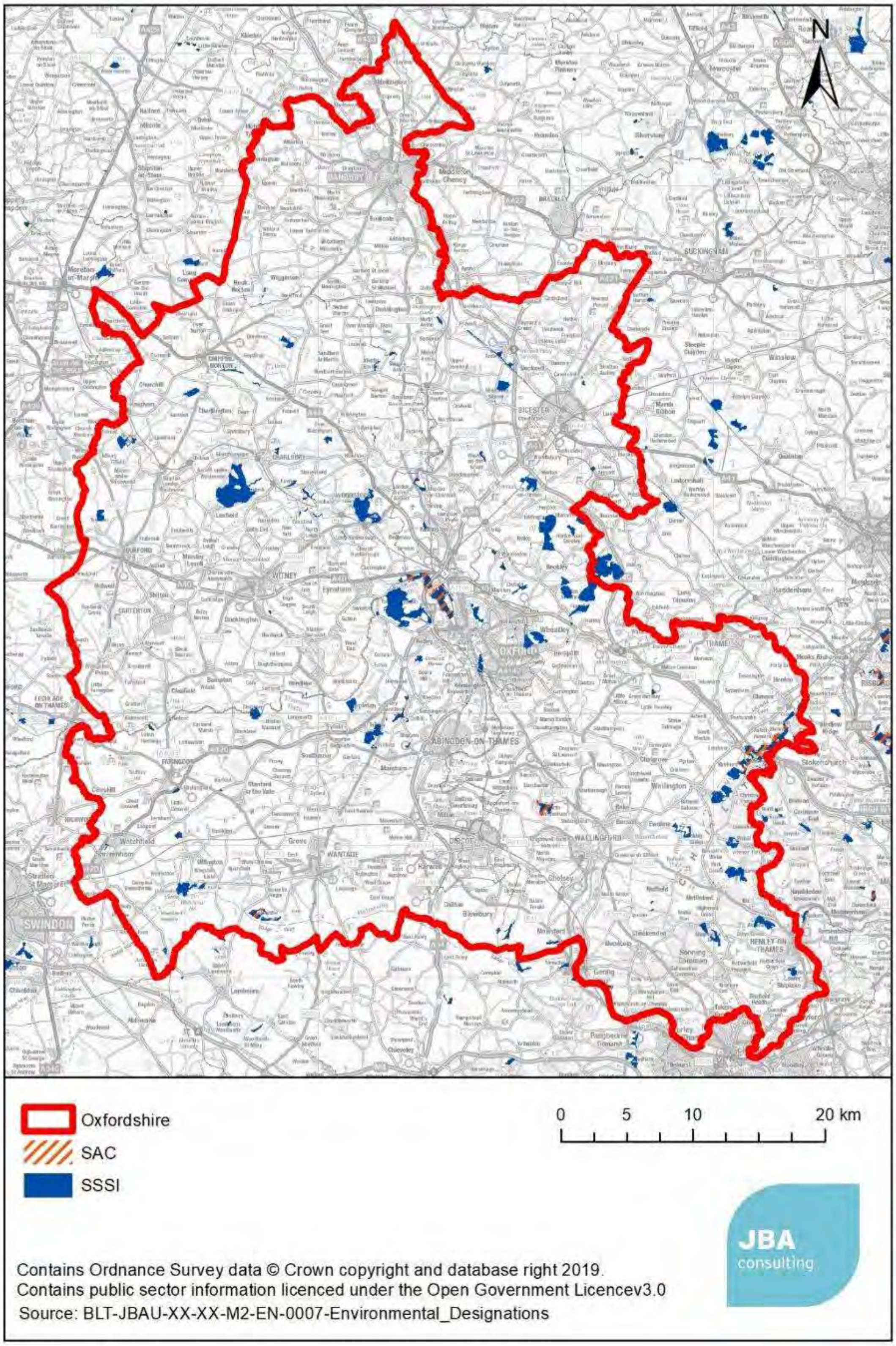

Figure 10.1: SACs and SSSIs in Oxfordshire

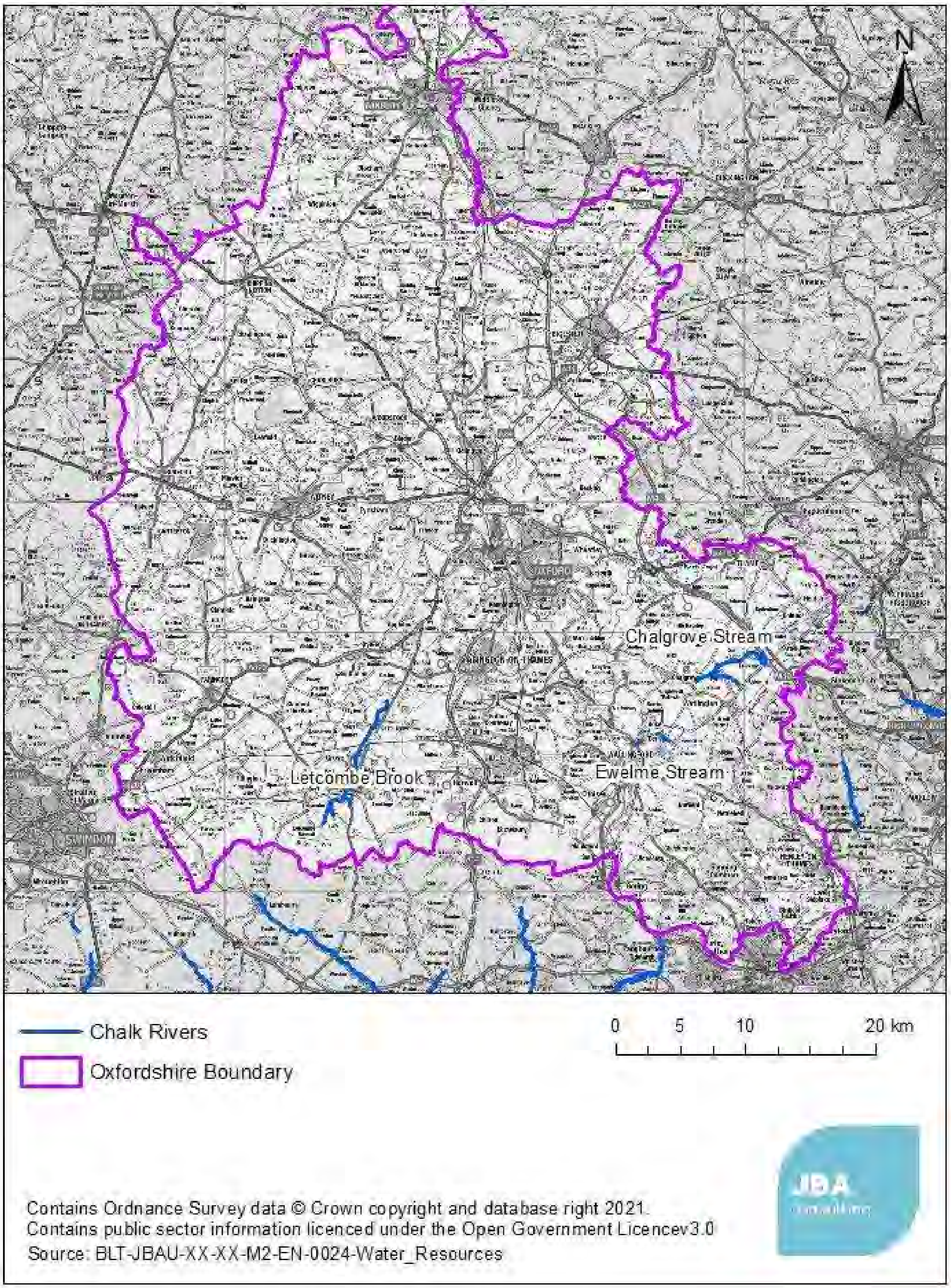

Figure 10.2: Chalk streams in Oxfordshire

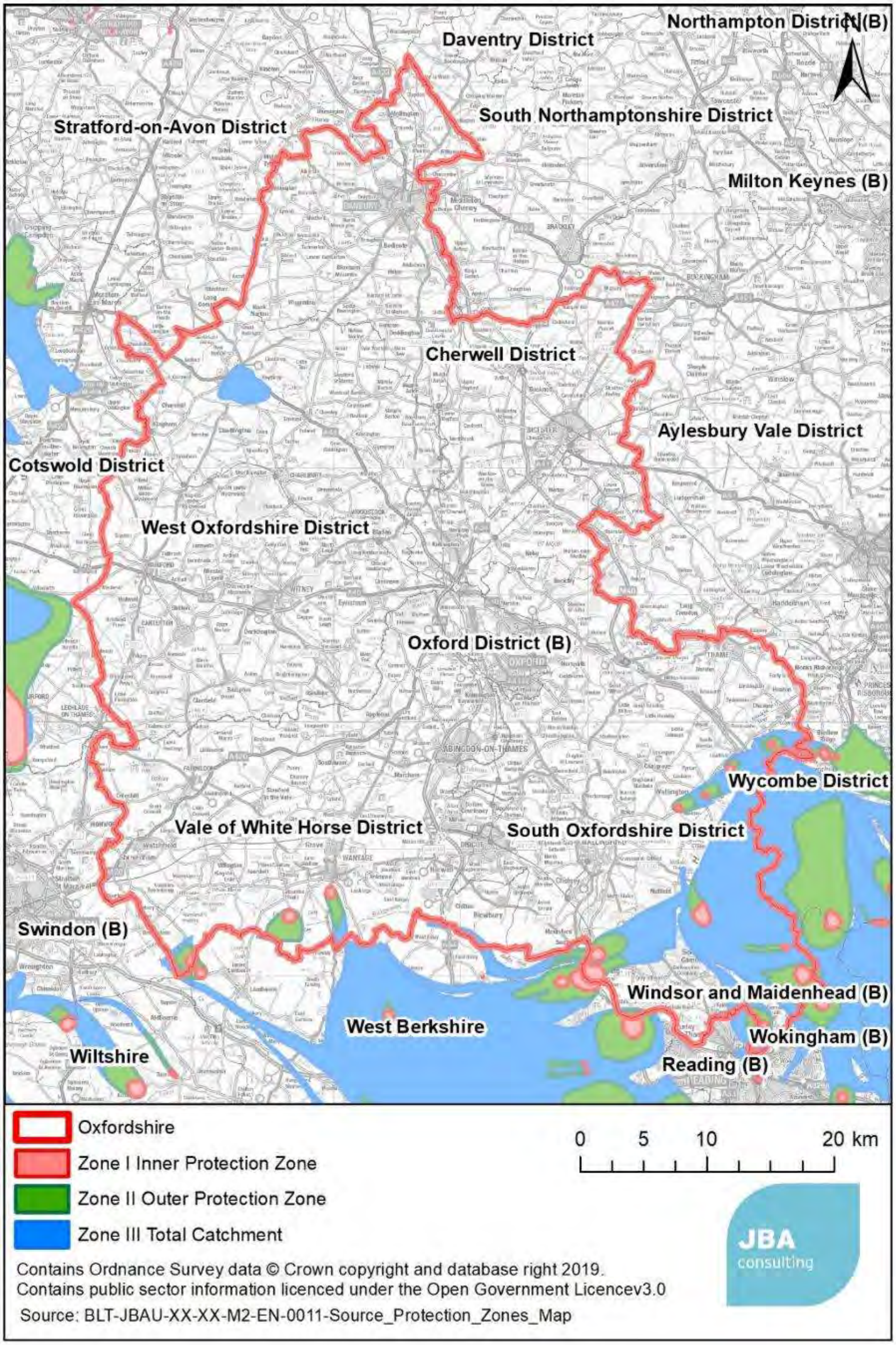

Figure 10.3 Source Protection Zones in Oxfordshire

Table 10.1 EA advice by protection zones

Source Protection Zone	Management advice / EA position statement
Zone 1 – Inner Protection Zone	G2 – Inside SPZ1 all sewage effluent discharges to ground must have an environmental permit. G4 – Inside SPZ1 the EA will object to any new trade effluent, storm overflow from sewage system or other significantly contaminated discharges to ground where the risk of groundwater pollution is high and cannot be adequately mitigated. G12 – Discharge of clean roof water to ground is acceptable both within and outside SPZ1, provided all roof water down-pipes are sealed against pollutants entering the system from surface runoff, effluent disposal or other forms of discharge. The method of discharge must not create new pathways for pollutants to groundwater or mobilise contaminant already in the ground. No permit is required if these criteria are met. G13 – Where infiltration SuDS are proposed for anything other than clean roof drainage in a SPZ1, a hydrogeological risk assessment should be undertaken, to ensure that the system does not pose an unacceptable risk to the source of supply. SuDS schemes must be suitably designed.
Zone 2 – Outer Protection Zone	A hydrogeological risk assessment is not a requirement for SuDS schemes, however they should still be "suitably designed", for instance following best practice guidance in the CIRIA SuDS Design Manual.
Zone 3 – Total Catchment	A hydrogeological risk assessment is not a requirement for SuDS schemes, however they should still be "suitably designed", for instance following best practice guidance in the CIRIA SuDS Design Manual.

10.3.1 Surface Water Drainage and SuDS

Since April 2015[66], management of the rate and volume of surface water has been a requirement for all major development sites, through the use of Sustainable Drainage Systems (SuDS).

As Lead Local Flood Authority (LLFA), Oxfordshire County Council is a statutory consultee for all planning applications for major development as defined in the National Planning Policy Framework as "For housing, development where 10 or more homes will be provided, or the site has an area of 0.5 hectares or more. For non-residential development it means additional floorspace of 1,000m2 or more, or a site of 1 hectare

66 Department for Communities and Local Government (2014) House of Commons: Written Statement (HCWS161) Written Statement made by: The Secretary of State for Communities and Local Government (Mr Eric Pickles) on 18 Dec 2014. Available at: https://www.parliament.uk/documents/commons-vote-office/December%202014/18%20December/6.%20DCLG-sustainable-drainage-systems.pdf on: 23/01/2019

or more, or as otherwise provided in the Town and Country Planning (Development Management Procedure) (England) Order 2015."[67]

SuDS are drainage features which attempt to replicate natural drainage patterns, through capturing rainwater at source, and releasing it slowly into the ground or a water body. They can help to manage flooding through controlling the quantity of surface water generated by a development and improve water quality by treating urban runoff. SuDS can also deliver multiple benefits, through creating habitats for wildlife and green spaces for the community.

National standards on the management of surface water are outlined within the Defra Non-statutory Standards for Sustainable Drainage Systems[68]. The CIRIA C753 SuDS Manual[69] provides the industry best practice guidance for design and management of SuDS. Oxfordshire Country Council has also published SuDS guidance[70].

10.3.2 Use of SuDS in Water Quality Management

SuDS allow the management of diffuse pollution generated by development through the sequential treatment of surface water reducing the pollutants entering lakes and rivers, resulting in lower levels of water supply and wastewater treatment being required. This treatment of diffuse pollution at source can contribute to meeting WFD water quality targets, as well as national objectives for sustainable development.

This is usually facilitated via a SuDS Management Train of a number of components in series that provide a range of treatment processes delivering gradual improvement in water quality and providing an environmental buffer for accidental spills or unexpected high pollutant loadings from the site. Considerations for SuDS design for water quality are summarised in Figure 10.4 below.

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67 National Planning Policy Framework, MHCLG (2019). Accessed online at: https://www.gov.uk/guidance/national-planning-policy-framework/annex-2-glossary on: 16/03/2020
68 Sustainable Drainage Systems, Non-statutory technical standards for sustainable drainage systems, DEFRA (2015). Accessed online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/415773/sustainable-drainage-technical-standards.pdf on: 12/07/2021
69 CIRIA Report C753 The SuDS Manual, CIRIA (2015). Accessed online at: https://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx on: 23/01/2019
70 Surface Water Drainage, Oxfordshire County Council (2020). Accessed online at: https://www.oxfordshirefloodtoolkit.com/planning/surface-water-drainage/ on: 16/03/2020

Manage surface water close to source

- Where practicable, treatment systems should be designed to be close to source of runoff
- It is easier to design effective treatment when the flow rate and pollutant loadings are relatively low
- Treatment provided can be proportionate to pollutant loadings
- Accidental spills or other pollution events can be isolated more easily without affecting the downstream drainage system
- Encourages ownership of pollution
- Poor treatment performance or component damage/failure can be dealt with more effectively without impacting on the whole site

Treat surface water runoff on the surface

- Where practicable, treatment systems should be designed to be on the surface
- Where sediments are exposed to UV light, photolysis and volatilisation processes can act to break down contaminants
- If sediment is trapped in accessible parts of the SuDS, it can be removed more easily as part of maintenance
- It enables use of evapotranspiration and some infiltration to the ground to reduce runoff volumes and associated total contamination loads (provided risk to groundwater is managed appropriately)
- It allows treatment to be delivered by vegetation
- Sources of pollution can be easily identified
- Accidental spills or misconnections are visible immediately and can be dealt with rapidly
- Poor treatment performance can be easily identified during routine inspections, and remedial works can be planned efficiently

Treat surface water runoff to remove a range of contaminants

- SuDS design should consider the likely presence and significance of any contaminant that may pose a risk to the receiving environment
- The SuDS component or combination of components selected should include treatment processes that, in combination, are likely to reduce this risk to acceptably low levels

Minimise risk of sediment remobilisation

- The SuDS design should consider and mitigate the risks of sediments (and other contaminants) being remobilised and washed into receiving surface waters during events greater than those which the component has been specifically designed for

Minimise impacts from accidental spills

- By using a number of components in series, SuDS can help ensure that accidental spills are trapped in/on upstream component surfaces, facilitating contamination management and removal.
- The selected SudS components should deliver a robust treatment design that manages risks appropriately - taking into account the uncertainty and variability of pollution loadings and treatment processes

Figure 10.4 Considerations for SuDS design for water quality

Managing pollution close to its source can help keep pollutant levels and accumulation rates low, allowing natural processes to be more effective. Treatment can often be delivered within the same components that are delivering water quantity design criteria, requiring no additional cost or land-take.

SuDS designs should control the 'first flush' of pollutants (usually mobilised by the first 5mm of rainfall) at source, to ensure contaminants are not released from the site. Best practice is that no runoff should be discharged from the site to receiving watercourses or sewers for the majority of small (e.g. less than 5mm) rainfall events.

Infiltration techniques will need to consider Groundwater Source Protection Zones (GSPZs) and are likely to require consultation with the Environment Agency.

Early consideration of SuDS within master planning will typically allow a more effective scheme to be designed.

10.3.3 Additional benefits

Flood Risk

SuDS are most effective at reducing flood risk for relatively high intensity, short and medium duration events, and are particularly important in mitigating potential increases in surface water flooding, sewer flooding and flooding from small and medium sized watercourses resulting from development.

Water Resources

A central principle of SuDS is the use of surface water as a resource. Traditionally, surface water drainage involved the rapid disposal of rainwater, by conveying it directly into a sewer or wastewater treatment works.

SuDS techniques such as rainwater harvesting, allow rainwater to be collected and re-used as non-potable water supply within homes and gardens, reducing the demand on water resources and supply infrastructure.

Climate Resilience

Climate projections for the UK suggest that winters may become milder and wetter and summers may become warmer, but with more frequent higher intensity rainfall events, particularly in the south east of England. This would be expected to increase the volume of runoff, and therefore the risk of flooding from surface water, and diffuse pollution, and reduce water availability.

SuDS offer a more adaptable way of draining surfaces, controlling the rate and volume of runoff leaving urban areas during high intensity rainfall, and reducing flood risk to downstream communities through storage and controlled release of rainwater from development sites.

Through allowing rainwater to soak into the ground, SuDS are effective at retaining soil moisture and groundwater levels, which allows the recharge of the watercourses and underlying aquifers. This is particularly important where water resource availability is limited, and likely to become increasingly rare under future drier climates.

Biodiversity

The water within a SuDS component is an essential resource for the growth and development of plants and animals, and biodiversity benefits can be delivered even by very small, isolated schemes. The greatest value can be achieved where SuDS are planned as part of a wider green landscape, providing important habitat, and wildlife connectivity. With careful design, SuDS can provide shelter, food, foraging and breeding opportunities for a variety of species including plants, amphibians, invertebrates, birds, bats and other animals.

Amenity

Designs using surface water management systems to help structure the urban landscape can enrich its aesthetic and recreational value, promoting health and well-being and supporting green infrastructure. Water managed on the surface rather than underground can help reduce summer temperatures, provide habitat for flora and fauna and act a resource for local environmental education programmes and working groups and directly influence the sense of community in an area.

10.4 Nutrient reduction options

10.4.1 Natural flood management

Natural Flood Management (NFM) is used to protect, restore and re-naturalise the function of catchments and rivers to reduce flood risk. A wide range of techniques can be used that aim to reduce flooding by working with natural features and processes in order to store or slow down flood waters before they can damage flood risk receptors (e.g. people, property, infrastructure, etc.). NFM involves taking action to manage flood and coastal erosion risk by protecting, restoring and emulating the natural regulating functions of catchments, rivers, floodplains and coasts. Techniques and measures, which could be applied include:

- Offline storage areas
- Re-meandering streams
- Targeted woodland planting
- Reconnection and restoration of functional floodplains
- Restoration of rivers and removal of redundant structures
- Installation or retainment of large woody material in river channels
- Improvements in management of soil and land use
- Creation of rural and urban SuDS

In 2017, the Environment Agency published an online evidence base[71] to support the implementation of NFM and with JBA produced maps showing locations with the potential for NFM measures[72]. These maps are intended to be used alongside the evidence directory to help practitioners think about the types of measures that may work in a catchment and the best places in which to locate them. There are limitations with the maps; however, it is a useful tool to help start dialogue with key partners.

10.4.2 Multiple benefits of NFM

In addition to flood risk benefits, there are also significant benefits in other areas such as habitat provision, air quality, climate regulation and of particular note for the water cycle study - Water Quality.

Many NFM measures have the ability to reduce nutrient and sediment sources by reducing surface runoff flows from higher ground, reducing soil erosion, trapping sediment at the edge of agricultural land, or encouraging deposition of sediments behind natural dams upstream in watercourses.

Suitable techniques may include:

- Leaky dams

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71 Working with natural processes to reduce flood risk, Environment Agency (2018). Accessed online at: https://www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk on: 13/04/2021
72 Mapping the potential for working with natural process, Environment Agency and JBA. Accessed online at: https://naturalprocesses.jbahosting.com/ on: 13/04/2021

- Woodland planting
- Buffer strips
- Runoff retention ponds
- Land management techniques (soil aeration, cover crops etc)

Case Study – Black Brook Slow the Flow

Four engineered log dams were installed on Black Brook at an estimated cost of £2,000, funded by Natural England and the Environment Agency to restore Stanley Bank SSSI. The scheme aimed to improve habitat and reduce the risk of flooding. However, the scheme also resulted in reduced levels of phosphate and nitrate in Black Brook, with phosphate concentrations falling by 3.6mg/l. By 2035, it is predicted that 792m^3 of sediment will be stored in three ponds retained by the jams.

Reproduced from Case study 17. Black Brook Slow the Flow, St Helens, Norbury, Rogers and Brown, EA WwNP Evidence Base 2017. Photograph taken on 8 May 2015; courtesy of Matthew Catherall

10.4.3 Integrated Constructed Wetlands

An integrated constructed wetland (ICW) is an artificial wetland created for the purpose of treating polluted water, whether this is municipal wastewater, grey water from residential properties, or agricultural runoff.

They are usually unlined, free surface flow wetlands, designed to contain and treat influents within emergent vegetated areas.

Defra carried out a systematic review of the effectiveness of various wetland types, including ICWs for mitigating agricultural pollution such as phosphate and nitrate. The overall conclusion was that all wetland types are very effective at reducing major nutrients and suspended sediments, with the exception of nitrite in ICWs. Nitrate is only reduced when passing through overland buffer strips and through constructed wetlands with vegetation, where the systematic review showed a mean reduction of 29% across the evidence included in the study.

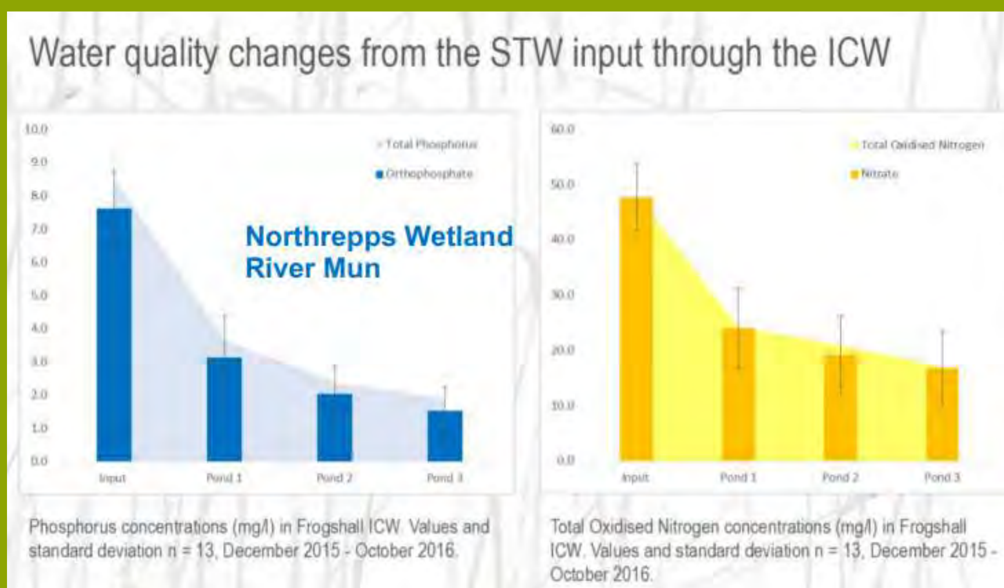
The mean reduction in Total Phosphorus across the evidence base was 78%.

Case Study – Frogshall ICW

The Upper River Mun in Norfolk was experiencing chronic pollution, and a loss in biodiversity in the river. Investigation found that nutrients from a Sewage Treatment Works upstream were contributing to this issue.

A pilot ICW was created consisting of three shallow ponds, filled with 18,000 emergent aquatic plants, and the outfall from the treatment works was diverted to pass through the wetland.

Early monitoring has shown that 90% of the phosphate is being removed by the wetland, and a large increase in biodiversity downstream observed.



Reproduced from "Stripping the Phosphate" a presentation by the Norfolk Rivers Trust (2018).
https://www.theriverstrust.org/media/2018/08/2.-Stripping-the-phosphate-David-Diggens-Norfolk-Rivers-Trust.pdf

10.4.4 Agricultural Management

There is a big potential to improve water quality by interventions aimed at agricultural sources, especially considering the measures already taken by STW to reduce their contribution to phosphate load.

Potential schemes could include:

- Buffer strips
- Cross slope tree planting

- Runoff retention basins
- Contour ploughing
- Cover crops

There is considerable overlap with NFM measures, and the challenges are also very similar. Exact impacts are difficult to measure, although modelling tools such as Farmscoper[73] exist to help with this. Once a scheme is implemented it relies on the landowner to continue to maintain it in order to maintain the mitigation benefit.

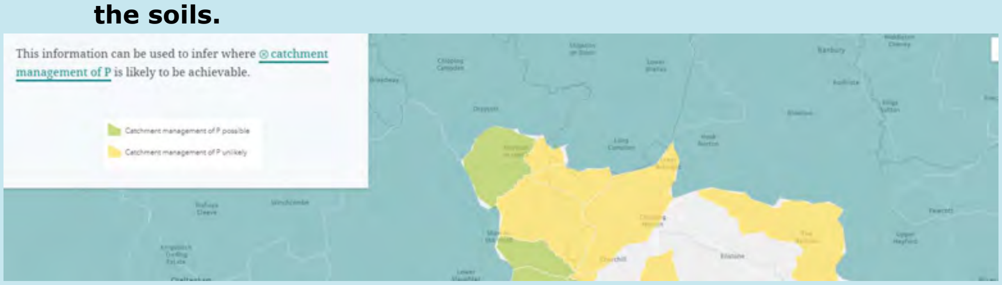
Funding for agricultural interventions could come from Catchment Sensitive Farming or a Payment for Ecosystem Services approach. Within Oxfordshire, a prominent example is the work of the Evenlode Catchment Partnership[74],[75].

Case Study – –Evenlode Catchment Partnership

The Evenlode Catchment Partnership is a grouping of environmental NGOs, the Environment Agency, Thames Water, farmers and landowners, local authorities and experts, which has been working together since 2014 to plan and implement catchment-based approaches. It has set out a 10-year programme of actions around the themes of point and diffuse pollution, river, floodplain and landscape restoration, sustainable farming, natural flood management, education, community and recreation.

Since 2016, the partnership has been trialling routes to tackling diffuse phosphorous pollution from agricultural sources, including:

- **A Catchment Fund for infrastructure and equipment;**
- **An advice service on making the most of existing agri-environment schemes;**
- **Funding for the design and analysis of land-based schemes, and**
- **A no-till and cover-crop trial, whereby stubble is retained post-harvest and new crops are planted directly into it, with the aim of reducing soil erosion and the release of phosphates within the soils.**



Mapping on the partnership website identifies areas in green with the greatest potential for catchment-based management of P.

73 Farmscoper webpage, ADAS (2020). https://www.adas.uk/Service/farmscoper Accessed on 13/04/2021
74 Evenlode Catchment Partnership Mapping Portal https://storymaps.arcgis.com/stories/b85878200d59479ab0217a9cc6f63c64 Accessed on 12/07/2021
75 Evenlode Catchment Partnership (2021) Smarter Water Catchment Plan. Accessed online at: https://www.thameswater.co.uk/media-library/home/about-us/responsibility/smarter-water-catchments/river-evenlode-smarter-water-catchment-plan.pdf on 12/07/2021

Wessex Water and United Utilities have both recently used a reverse auction approach[76], which enables farmers to bid for funding to plant cover crops in winter to manage runoff from agricultural land.

Case Study – Wessex Water - EnTrade

Wessex Water catchment team used EnTrade to invite farmers to bid to grow cover crops over winter to reduce the nitrogen leaching into the watercourse.

This avoided the need to upgrade Dorchester WwTW to provide the same nitrogen removal capacity.

A trial auction was held in 2015, and two further auctions have since taken place attracting 557 bids from 63 farmers to save 153 tonnes of nitrogen.

"Using EnTrade to create a market in measures to deliver reductions in nitrogen has delivered a 30% saving for Wessex Water compared to traditional catchment approaches."

Ruth Barden, Director of Environmental Strategy, Wessex Water

10.5 Recommendations

Table 10.2 Recommendations from environmental constraints and opportunities section

Action	Responsibility	Timescale
The Oxfordshire Plan should include policies that require developments to adopt SuDS to manage water quality of surface runoff.	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19
The Oxfordshire Plan should include policies that require all development proposals with the potential to impact on areas with environmental designations to be	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19

76 EnTrade webpage, Entrade (2020). https://www.entrade.co.uk/ Accessed on 13/04/2021

Action	Responsibility	Timescale
considered in consultation with Natural England (for national and international designations).		
The detailed WCS should link the water quality assessment to sites with environmental designations which are hydrologically connected to water bodies receiving wastewater effluent to identify whether there is a risk of detriment to designated sites from increased effluent discharges.	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19
In partnership, identify opportunities for incorporating SuDS into open spaces and green infrastructure, to deliver strategic flood risk management and meet WFD water quality targets.	LPAs TW / AW / STW EA	Ongoing
Developers should include the design of SuDS at an early stage to maximise the benefits of the scheme.	Developers	Ongoing
Work with developers to discourage connection of new developments into existing surface water and combined sewer networks. Prevent connections into the foul network, as this is a significant cause of sewer flooding.	LLFA LPAs TW / AW / STW Developers	Ongoing
Opportunities for Natural Flood Management that include schemes aimed at reducing / managing runoff should be considered to reduce nutrient and sediment pollution alongside reducing flood risk.	LLFA LPAs EA NE	Ongoing

11 Summary of Growth Options

11.1 Housing growth options

This section provides a summary of the potential impacts of the five spatial scenarios and three growth scenarios for housing to 2050.

11.1.1 Option 1: Focus on opportunities at larger settlements and planned growth locations.

Option:	1 - Focus on opportunities at larger settlements and planned growth locations
Water resources and supply	
Pros	Possibility of being served by existing supply networks where capacity exists.
Cons	Growth in multiple locations may require multiple infrastructure expansion schemes.
Assessed impacts	This option is anticipated to focus around 97% of growth within Thames Water's SWOX water resource zone. The standard method and business-as-usual growth options both have estimates of household growth at or below Thames Water's estimate of 27% growth in the zone by 2050. The transformational growth scenario of 30% growth in SWOX exceeds the Thames Water projection, so may require investments in demand management and supply-side interventions to be made earlier in order to maintain the supply-demand balance. The remaining 3% of growth is anticipated in the Henley water resource zone. The transformational growth scenario of 20% household growth within this zone would exceed Thames Water's projection of 14%, however this zone is predicted to remain in supply-demand balance through the plan period, so this would not be expected to require additional demand management or supply measures to be implemented, beyond those already in the WRMP.
Wastewater collection	
Pros	Possibility of being served by existing sewer networks where capacity exists.
Cons	Sewer network may have grown organically with settlements and capacity may be limited.
Assessed impacts	No qualitative assessment has been undertaken at this stage, as collection system capacity is highly specific to wastewater catchments and local infrastructure. Further assessment will be required in the detailed stage WCS.
Wastewater treatment (including flood risk)	
Pros	Possibility of being served by existing WwTW where capacity exists.
Cons	Growth in multiple locations may require multiple capacity upgrade schemes.
Assessed impacts	This spatial option has the potential to increase flows to around 30 WwTWs. This would represent an increase of 14% to 21% on the existing permitted capacity of these treatment works, which would be anticipated

	to require a capacity upgrade to treat these additional volumes at most of these works. This scenario is anticipated to lead to significant growth in treated effluent at Henley, Oxford and Witney WwTWs, all of which have been highlighted as contributing >5% of flow in a 1 in 100 year flood event, and are therefore sensitive to significant increases in effluent discharged.
Water quality	
Pros	Increases in effluent discharge may be distributed around the catchment, reducing the risk of a large deterioration in one place.
Cons	Multiple upgrade schemes may be required which may not be cost effective.
Assessed impacts	Water quality impact modelling has considered the potential impact of 10% and 20% across the board increases in wastewater effluent on water quality. Of the treatment works considered to be likely to experience significant household growth as part of this spatial scenario, Chipping Norton (10%) and Church Hanborough (20%) are predicted to experience WFD class deteriorations, and may require process upgrades to meet a tighter permit condition. Other works are predicted to experience >10% deterioration at their outfall and may also require upgrades.

11.1.2 Option 2: Focus on Oxford-led growth

Option:	2 - Focus on Oxford-led growth
Water resources and supply	
Pros	Large-scale, geographically focussed growth can justify large-scale infrastructure investment
Cons	Issues of funding infrastructure to developments which will take place over many years.
Assessed impacts	This option is anticipated to focus around 100% of growth within Thames Water's SWOX water resource zone. The standard method and business-as-usual growth options both have estimates of household growth at or below Thames Water's estimate of 27% growth in the zone by 2050. The transformational growth scenario of 31% growth in SWOX exceeds the Thames Water projection, so may require investments in demand management and supply-side interventions to be made earlier in order to maintain the supply-demand balance. Under this scenario there would be no significant additional growth in the Henley water resource zone.
Wastewater collection	
Pros	Large-scale, focussed growth can justify large-scale infrastructure investment.
Cons	Issues of funding infrastructure to developments which will take place over many years.
Assessed impacts	No qualitative assessment has been undertaken at this stage, as collection system capacity is highly specific to wastewater catchments and local infrastructure. Further assessment will be required in the detailed stage WCS.

Wastewater treatment (including flood risk)	
Pros	One large upgrade to one WwTW (or construction of a new works on an alternative site) could serve a large quantity of growth.
Cons	If capacity isn't present, a new WwTW may be required due to space constraints at Oxford WwTW.
Assessed impacts	This spatial option has the potential to increase flows to around 12 WwTWs, although Oxford WwTW might take the majority of additional flows. This would represent an increase of 40% to 59% on the existing permitted capacity of these treatment works, which would be anticipated to require a significant capacity upgrade to treat these additional volumes at most of these works, and possibly a new WwTW. This scenario is anticipated to lead to significant growth in treated effluent at Oxford WwTW, which has been highlighted as contributing >5% of flow in a 1 in 100-year flood event, and is therefore sensitive to significant increases in effluent discharged.
Water quality	
Pros	If upgrades to treatment processes are required, these can be focussed at a few WwTWs.
Cons	Increase in effluent discharge is concentrated at a few locations and could lead to a deterioration in water quality. It may not be possible to treat such a large increase in wastewater volume without causing a deterioration, using currently available treatment technologies.
Assessed impacts	Water quality impact modelling has considered the potential impact of 10% and 20% across the board increases in wastewater effluent on water quality. Of the treatment works considered to be likely to experience significant household growth as part of this spatial scenario, Abingdon (20%) and Forest Hill (20%) are predicted to experience WFD class deteriorations, and may require process upgrades to meet a tighter permit condition. Other works are predicted to experience >10% deterioration at their outfall and may also require upgrades.

11.1.3 Option 3: Focus on opportunities in sustainable transport corridors & at strategic transport hubs

Option:	3 - Focus on opportunities in sustainable transport corridors & at strategic transport hubs
Water resources and supply	
Pros	Easy to supply if major water supply mains run alongside sustainable transport corridors. Potential to provide infrastructure corridors alongside new or upgraded transport routes.
Cons	Likely to require longer lengths (and therefore higher cost) of pipelines compared to more concentrated development.
Assessed impacts	This option is anticipated to focus around 97% of growth within Thames Water's SWOX water resource zone. The standard method and business-as-usual growth options both have estimates of household growth at or below Thames Water's estimate of 27% growth in the zone by 2050. The transformational growth scenario of 30% growth in SWOX exceeds the Thames Water projection, so may require investments in demand management and supply-side

	interventions to be made earlier in order to maintain the supply-demand balance. The remaining 3% of growth is anticipated in the Henley water resource zone. The transformational growth scenario of 20% household growth within this zone would exceed Thames Water's projection of 14%, however this zone is predicted to remain in supply-demand balance through the plan period, so this would not be expected to require additional demand management or supply measures to be implemented, beyond those already in the WRMP.
Wastewater collection	
Pros	Easy to serve if major sewers run alongside sustainable transport corridors. Potential to provide infrastructure corridors alongside new or upgraded transport routes.
Cons	Likely to require longer lengths (and therefore higher cost) of pipelines compared to more concentrated development.
Assessed impacts	No qualitative assessment has been undertaken at this stage, as collection system capacity is highly specific to wastewater catchments and local infrastructure. Further assessment will be required in the detailed stage WCS.
Wastewater treatment (including flood risk)	
Pros	None identified.
Cons	Cost (financial and carbon) of pumping wastewater back along linear route could be considerable. Or multiple new or upgraded WwTW may be required.
Assessed impacts	This spatial option has the potential to increase flows to around 72 WwTWs, the largest number of all of the spatial scenarios. This would represent an increase of 12% to 19% on the existing permitted capacity of these treatment works, which would be anticipated to require a capacity upgrade to treat these additional volumes at some of these works. This scenario is anticipated to lead to significant growth in treated effluent at Henley, Oxford and Witney WwTWs, all of which have been highlighted as contributing >5% of flow in a 1 in 100 year flood event, and are therefore sensitive to significant increases in effluent discharged.
Water quality	
Pros	Discharges may be distributed rather than concentrated.
Cons	Upgrades may be required at multiple WwTWs.
Assessed impacts	Water quality impact modelling has considered the potential impact of 10% and 20% across the board increases in wastewater effluent on water quality. Of the treatment works considered to be likely to experience significant household growth as part of this spatial scenario, Abingdon (20%), Buckland (10%), Chipping Norton (10%), Church Hanborough (20%), Forest Hill (10%), Long Wittenham (10%), Milton-under-Wychwood (10%), Tackley (20%), Uffington (20%) and Weston-on-the-Green (20%) are predicted to experience WFD class deteriorations, and may require process upgrades to meet a tighter permit condition. Other works are predicted to experience >10% deterioration at their outfall and may also require upgrades.

11.1.4 Option 4: Focus on strengthening business locations

Option:	4 - Focus on strengthening business locations
Water resources and supply	
Pros	Large-scale, focussed growth can justify large-scale infrastructure investment.
Cons	Issues of funding infrastructure to developments which will take place over many years.
Assessed impacts	This option is anticipated to focus around 100% of growth within Thames Water's SWOX water resource zone. The standard method and business-as-usual growth options both have estimates of household growth at or below Thames Water's estimate of 27% growth in the zone by 2050. The transformational growth scenario of 31% growth in SWOX exceeds the Thames Water projection, so may require investments in demand management and supply-side interventions to be made earlier in order to maintain the supply-demand balance. Under this scenario there would be no significant additional growth in the Henley water resource zone.
Wastewater collection	
Pros	Large-scale, focussed growth can justify large-scale infrastructure investment.
Cons	Issues of funding infrastructure to developments which will take place over many years.
Assessed impacts	No qualitative assessment has been undertaken at this stage, as collection system capacity is highly specific to wastewater catchments and local infrastructure. Further assessment will be required in the detailed stage WCS.
Wastewater treatment (including flood risk)	
Pros	Major upgrades to a small number of WwTW could serve a large quantity of growth.
Cons	If capacity isn't present, a new WwTW, or pumping to a different catchment may be required.
Assessed impacts	This spatial option has the potential to increase flows to around 50 WwTWs. This would represent an increase of 16% to 24% on the existing permitted capacity of these treatment works, which would be anticipated to require a capacity upgrade to treat these additional volumes at many of these works. This scenario is anticipated to lead to significant growth in treated effluent at Oxford and Witney WwTWs, both of which have been highlighted as contributing >5% of flow in a 1 in 100 year flood event, and are therefore sensitive to significant increases in effluent discharged.
Water quality	
Pros	If upgrades to treatment processes are required, these can be focussed at a few WwTWs
Cons	Increase in effluent discharge is concentrated at a few locations and could lead to a deterioration in water quality.

Assessed impacts	Water quality impact modelling has considered the potential impact of 10% and 20% across the board increases in wastewater effluent on water quality. Of the treatment works considered to be likely to experience significant household growth as part of this spatial scenario, Abingdon (20%), Church Hanborough (20%), Forest Hill (10%), Long Wittenham (10%), Tackley (20%) and Uffington (20%) are predicted to experience WFD class deteriorations, and may require process upgrades to meet a tighter permit condition. Other works are predicted to experience >10% deterioration at their outfall and may also require upgrades.

11.1.5 Option 5: Focus on supporting rural communities

Option:	**5 - Focus on supporting rural communities**
Water resources and supply	
Pros	Constructing new infrastructure in a greenfield site is less costly / disruptive than in existing settlements.
Cons	May require major new supply pipelines prior to development. Size of development may not justify scale of new infrastructure required if growth is highly distributed.
Assessed impacts	This option is anticipated to focus around 99.5% of growth within Thames Water's SWOX water resource zone. The standard method and business-as-usual growth options both have estimates of household growth at or below Thames Water's estimate of 27% growth in the zone by 2050. The transformational growth scenario of 31% growth in SWOX exceeds the Thames Water projection, so may require investments in demand management and supply-side interventions to be made earlier in order to maintain the supply-demand balance. The remaining 0.5% of growth is anticipated in the Henley water resource zone. This equates to a 2-3% increase in the number of households within the zone, well below Thames Water's projection of 14% increase over the plan period. This zone is predicted to remain in supply-demand balance through the plan period, so this would not be expected to require additional demand management or supply measures to be implemented, beyond those already in the WRMP.
Wastewater collection	
Pros	Constructing new infrastructure in a greenfield site is less costly / disruptive than in existing settlements.
Cons	May require major new sewer pipelines prior to development. Size may not justify scale of new infrastructure required.
Assessed impacts	No qualitative assessment has been undertaken at this stage, as collection system capacity is highly specific to wastewater catchments and local infrastructure. Further assessment will be required in the detailed stage WCS.
Wastewater treatment (including flood risk)	
Pros	Constructing new infrastructure in a greenfield site is less costly / disruptive than in existing settlements.

Cons	Possible that a new WwTW will be required if a connection isn't possible to an existing works with capacity – however small size may not justify scale of new infrastructure.
Assessed impacts	This spatial option has the potential to increase flows to around 50 WwTWs. This would represent an increase of 17% to 26% on the existing permitted capacity of these treatment works, which would be anticipated to require a capacity upgrade to treat these additional volumes at many of these works. This scenario is anticipated to lead to significant growth in treated effluent at Watlington WwTW, which has been highlighted as contributing >5% of flow in a 1 in 100-year flood event, and is therefore sensitive to significant increases in effluent discharged.
Water quality	
Pros	Highly distributed growth has a dispersive effect on wastewater discharges.
Cons	Could require upgrades or new WwTWs at a large number of settlements. Most existing small WwTWs are not designed to treat to a high standard.
Assessed impacts	10% and 20% across the board increases in wastewater effluent on water quality. Of the treatment works considered to be likely to experience significant household growth as part of this spatial scenario, Abingdon (20%), Buckland (10%), Chinnor (10%), Chipping Norton (10%), Church Hanborough (20%), Forest Hill (10%), Horton-cum-Studley (10%), Long Wittenham (10%), Tackley (20%), Uffington (20%) and Weston-on-the-Green (20%) are predicted to experience WFD class deteriorations, and may require process upgrades to meet a tighter permit condition. Other works are predicted to experience >10% deterioration at their outfall and may also require upgrades.

12 Conclusions and recommendations

12.1 Conclusions

- The existing water cycle studies for the five Oxfordshire councils have been reviewed. There is value in a full WCS review to support the Oxfordshire Plan 2050, both because elements of the existing studies are becoming out of date, and because of the extended timescale over which the 2050 plan extends.
- The three housing growth options and five spatial scenarios have permitted some quantitative and qualitative assessments to be carried out, the results of which are summarised in section 11.1. These assessments can be used to inform development of the spatial and growth scenarios, but further assessments will be required in a detailed water cycle study, to be undertaken once broad locations for growth are selected, and ahead of Reg. 19 consultation.
- The Abstraction Licensing Strategies indicate there is restricted water available in Oxfordshire for additional abstractions, and existing abstractions may not be available all year.
- The Thames Water WRMP demonstrates how the Swindon and Oxfordshire (SWOX) water resource zone has moved into a situation of supply-demand deficit and, without intervention, this will increase as a result of population growth, climate change and sustainability reductions.
- The WRMP goes on to outline a set of demand management and supply improvement measures to address this. Key to this is development of the Abingdon

Reservoir (SESRO) by 2037, a key component of improving supply within Oxfordshire and the wider south east, although it should be noted that this is currently being evaluated alongside other Strategic Resources Options.

- The Standard Method and Business-As-Usual household growth forecasts being considered by the Oxfordshire Plan are all at or below the Thames Water forecast. The Transformational rate of growth would be above what Thames Water has planned for; however, this is a long-term plan with opportunity for Thames Water to respond to changing demands. Furthermore, demand for water in the SWOX and Henley zones is also dependent upon growth in neighbouring planning authorities.
- An assessment of wastewater treatment capacity found that there are significant differences in the percentage of existing treatment capacity which would be used up by growth, depending on the spatial option selected, with the greatest pressure coming from Option 2 which focusses all growth around Oxford. Whilst this spatial scenario would be highly likely to require a very significant expansion of treatment capacity at Oxford, and possibly at Abingdon and other smaller works close to the City, this does not necessarily make this an unfavourable option. Large upgrades at a small number of key works may be more efficient than upgrading large numbers of much smaller treatment works, as might be required by the more widely distributed spatial scenarios 3, 4 and 5.
- Broad-scale water quality modelling, which increased effluent discharges by 10% and 20% at every WwTW, has identified locations which are sensitive to such change.
- An assessment of present-day effluent flows compared to the 1 in 100-year flood flows in the receiving watercourse identified four treatment works (Henley, Oxford, Watlington and Witney) which may be sensitive to increasing flood risk as a result of increased effluent discharges.
- Climate change is predicted to have significant detrimental impacts on water resources, wastewater and the water environment which must be carefully considered in all plans, particularly longer-term plans such as the OP2050.

12.2 Recommendations

Table 12.1 below summarises the recommendations from each section of the report.

Table 12.1 Summary of recommendations

Aspect	Action	Responsib -ility	Timescale
Water resources	Continue to regularly review forecast and actual household growth across the supply region through WRMP Annual Update reports, and where significant change is predicted, engage with Local Planning Authorities.	Thames Water	Ongoing
	Provide yearly profiles of projected housing growth to water companies to inform the WRMP update.	Oxfordshire Plan team / individual LPAs	Ongoing
	Use planning policy to continue to require the 110l/person/day water consumption target permitted by National Planning	Oxfordshire Plan team / individual LPAs	Ongoing

Aspect	Action	Responsib-ility	Timescale
	Policy Guidance in water-stressed areas.		
	Consider the case for tighter water efficiency targets, through the Oxfordshire Plan policies, in particular for strategic-scale developments such as major urban extensions and/or new towns/villages.	Oxfordshire Plan team / individual LPAs	Ongoing
	A detailed stage WCS should revisit this assessment once details of the spatial strategy to be taken forward to Regulation 19 consultation become available and to inform the selection of broad locations for growth.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
	The concept of water neutrality has potentially a lot of benefit in terms of resilience to climate change and enabling all waterbodies to be brought up to Good status. Explore further with Thames Water and the Environment Agency how the Oxfordshire Plan can encourage this approach.	Oxfordshire Plan team / individual LPAs, EA, Thames Water	In line with a detailed WCS, ahead of Reg 19.
	Water companies should advise the LPAs of any strategic water resource infrastructure developments, where these may require safeguarding of land to prevent other types of development occurring (note – land for the Abingdon reservoir is already safeguarded in the Vale of White Horse Local Plan)	Thames Water, Anglian Water, Severn Trent Water	Ahead of Reg 19.
Wastewater collection and treatment	A detailed stage WCS should revisit the assessment of wastewater collection and treatment once details of the spatial strategy to be taken forward to Regulation 19 consultation become available and to inform the selection of broad locations for growth.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
	Water companies should advise the LPAs of any strategic wastewater developments, where these may require safeguarding	Thames Water, Anglian Water,	Ahead of Reg 19.

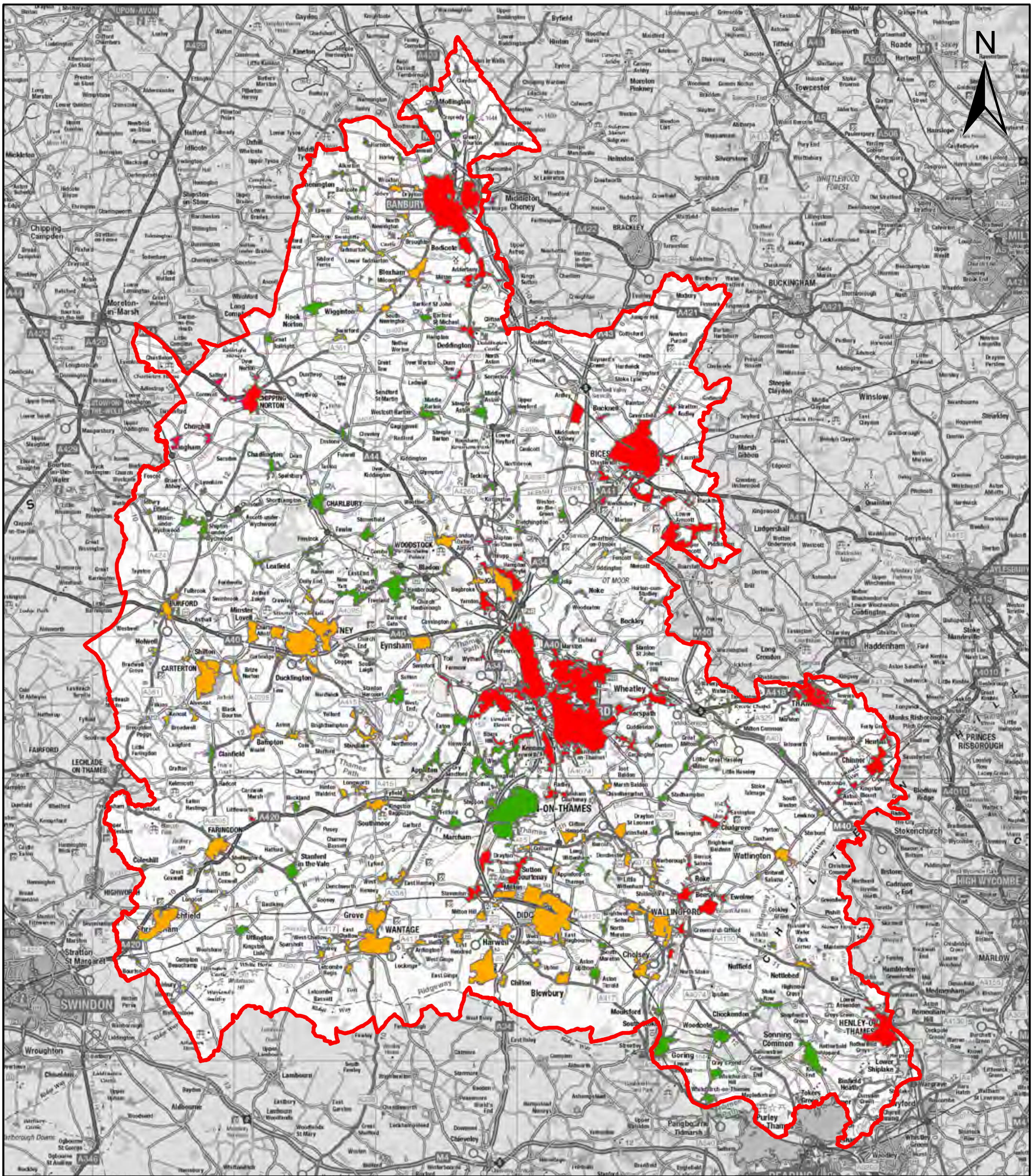
Aspect	Action	Responsib-ility	Timescale
	of land to prevent other types of development occurring.	Severn Trent Water	
Water quality	A detailed stage WCS should revisit the assessment of water quality impact once details of the spatial strategy to be taken forward to Regulation 19 consultation become available and to inform the selection of broad locations for growth. This should use the updated EA SIMCAT model (if available), and should consider the impacts of the proposed development, whether deterioration can be prevented by application of improved treatment, and whether the proposed development could prevent any watercourses from achieving Good status in the future.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
	The Plan policies need to recognise planners' responsibilities regarding the Water Framework Directive and also the Habitats Directive. Further engagement with Natural England (either through the Habitats Regulations Assessment or separately) is recommended ahead of Regulation 19 consultation.	Oxfordshire Plan team / individual LPAs / Natural England	Ahead of Reg 19.
Flood risk	A detailed stage WCS should revisit the assessment of flood risk once indicative areas of growth become available.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
Climate change	A detailed stage WCS should consider the impacts of climate change on all aspects of water supply and wastewater treatment. This is an area of rapidly evolving guidance, so the latest guidance should always be reviewed and applied.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
	Consider "no regrets" decision-making when developing policy for the Oxfordshire Plan, for example Nature-Based Solutions which can mitigate some impacts of climate change alongside	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.

Aspect	Action	Responsib-ility	Timescale
	delivering other benefits and services.		
Odour	A detailed stage WCS should include an assessment of odour impacts once indicative areas of growth become available.	Oxfordshire Plan team / individual LPAs	Ahead of Reg 19.
	Carry out an odour assessment for development proposals identified as being at risk of nuisance odour	Site Developers	To be submitted with planning applications
Environmental constraints and opportunities	The Oxfordshire Plan should include policies that require developments to adopt SuDS to manage water quality of surface runoff.	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19
	The Oxfordshire Plan should include policies that require all development proposals with the potential to impact on areas with environmental designations to be considered in consultation with Natural England (for national and international designations)	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19
	The detailed WCS should link the water quality assessment to sites with environmental designations which are hydrologically connected to water bodies receiving wastewater effluent to identify whether there is a risk of detriment to designated sites from increased effluent discharges.	Oxfordshire Plan 2050 team / individual LPAs	Ahead of s.19
	In partnership, identify opportunities for incorporating SuDS into open spaces and green infrastructure, to deliver strategic flood risk management and meet WFD water quality targets.	LPAs TW / AW / STW EA	Ongoing
	Developers should include the design of SuDS at an early stage to maximise the benefits of the scheme	Developers/LPAs	Ongoing
	Work with developers to discourage connection of new developments into existing surface water and combined sewer networks. Prevent	LLFA LPAs TW / AW / STW	Ongoing

Aspect	Action	Responsib-ility	Timescale
	connections into the foul network, as this is a significant cause of sewer flooding.	Developers	
	Opportunities for Natural Flood Management that include schemes aimed at reducing / managing runoff should be considered to reduce nutrient and sediment pollution alongside reducing flood risk.	LLFA LPAs EA NE	Ongoing

Appendices

A Appendix: WwTW capacity RAG assessment



WwTW Capacity Assessment (Thames Water)

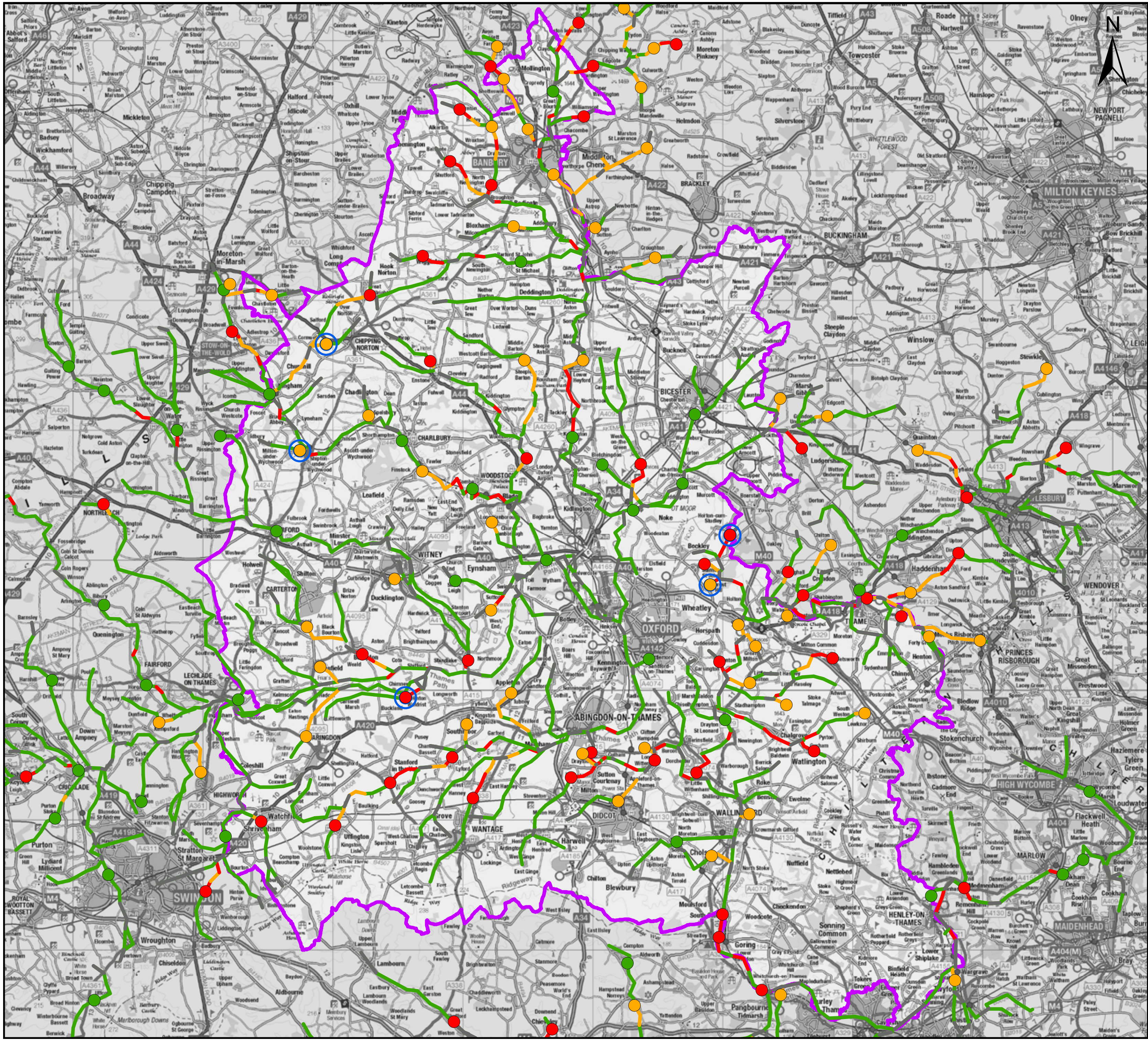
0 5 10 20 km

- Red
- Amber
- Green
- No Data
- Oxfordshire Boundary

JBA consulting

Source: BLT-JBAU-XX-XX-M2-EN-0023-RAG_Map

B Appendix: Water quality assessment



Ammonia Deterioration with +10% Flows

Oxfordshire Boundary

Deterioration at WwTW Outfall

- No Deterioration
- Deterioration <10%
- Deterioration >10%
- Class Deterioration

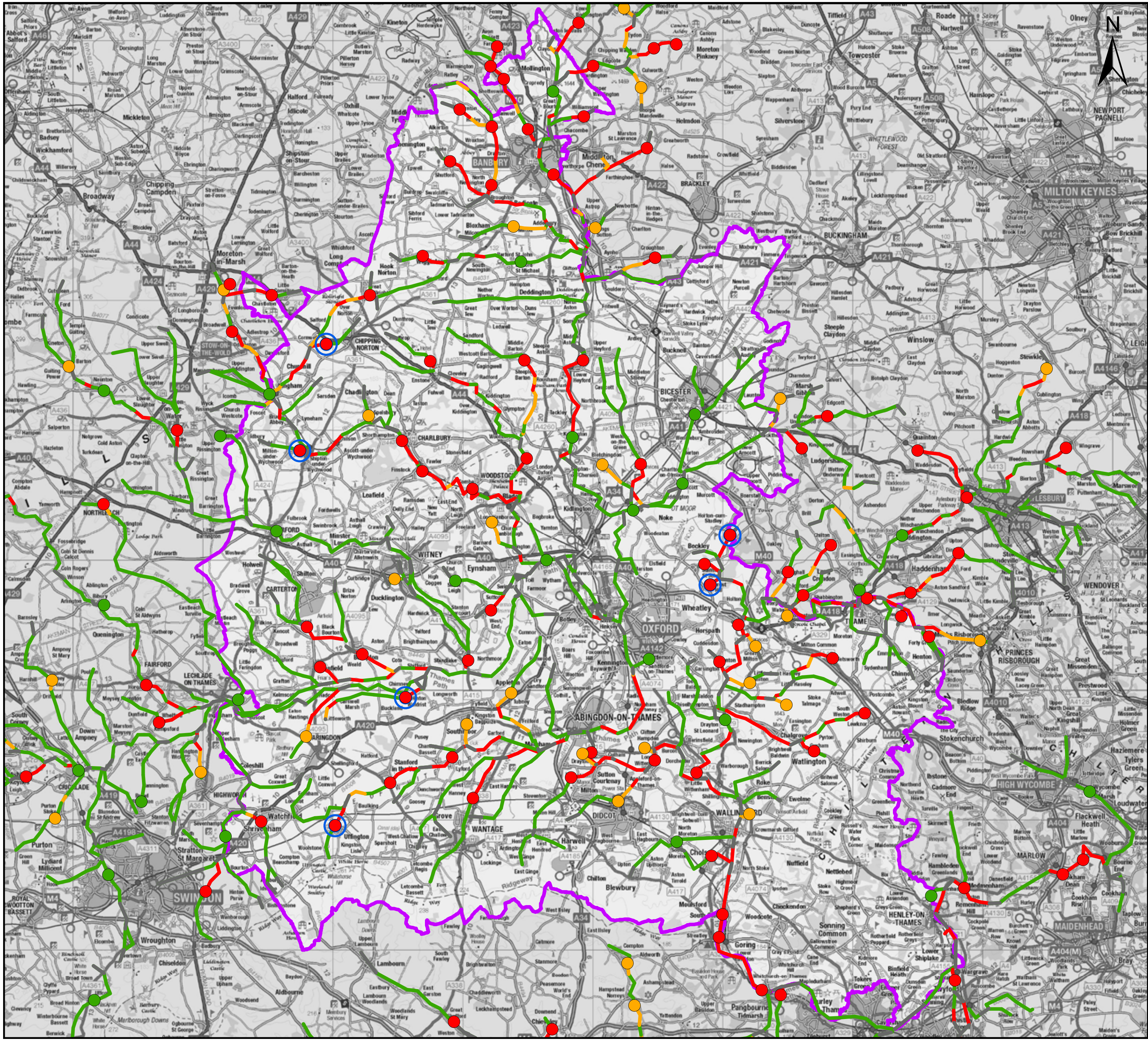
Deterioration in Watercourse

- No Data
- No Deterioration
- Deterioration <10%
- Deterioration >10%

0 2.5 5 10 km

Source: BLT-JBAU-XX-XX-M2-EN-0028-Ammonia_Deterioration_10PC

Ammonia Deterioration with +20% Flows



Oxfordshire Boundary

Deterioration at WwTW Outfall

- No Deterioration
- Deterioration <10%
- Deterioration >10%
- Class Deterioration

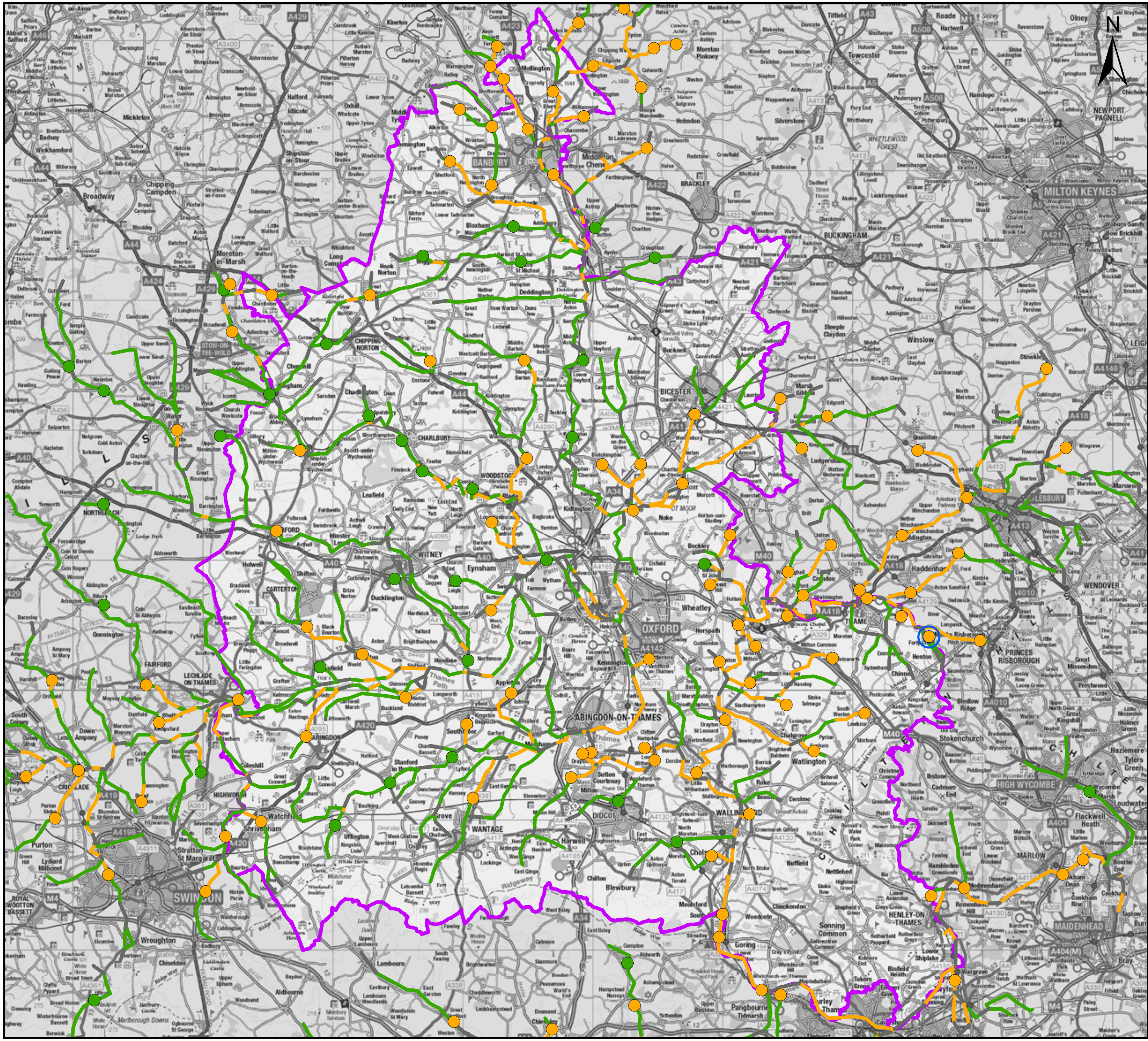
Deterioration in Watercourse

- No Data
- No Deterioration
- Deterioration <10%
- Deterioration >10%

0 2.5 5 10 km

Source: BLT-JBAU-XX-XX-M2-EN-0028-Ammonia_Deterioration_20PC

JBA consulting



BOD Deterioration with +10% Flows

Oxfordshire Boundary

Deterioration at WwTW Outfall

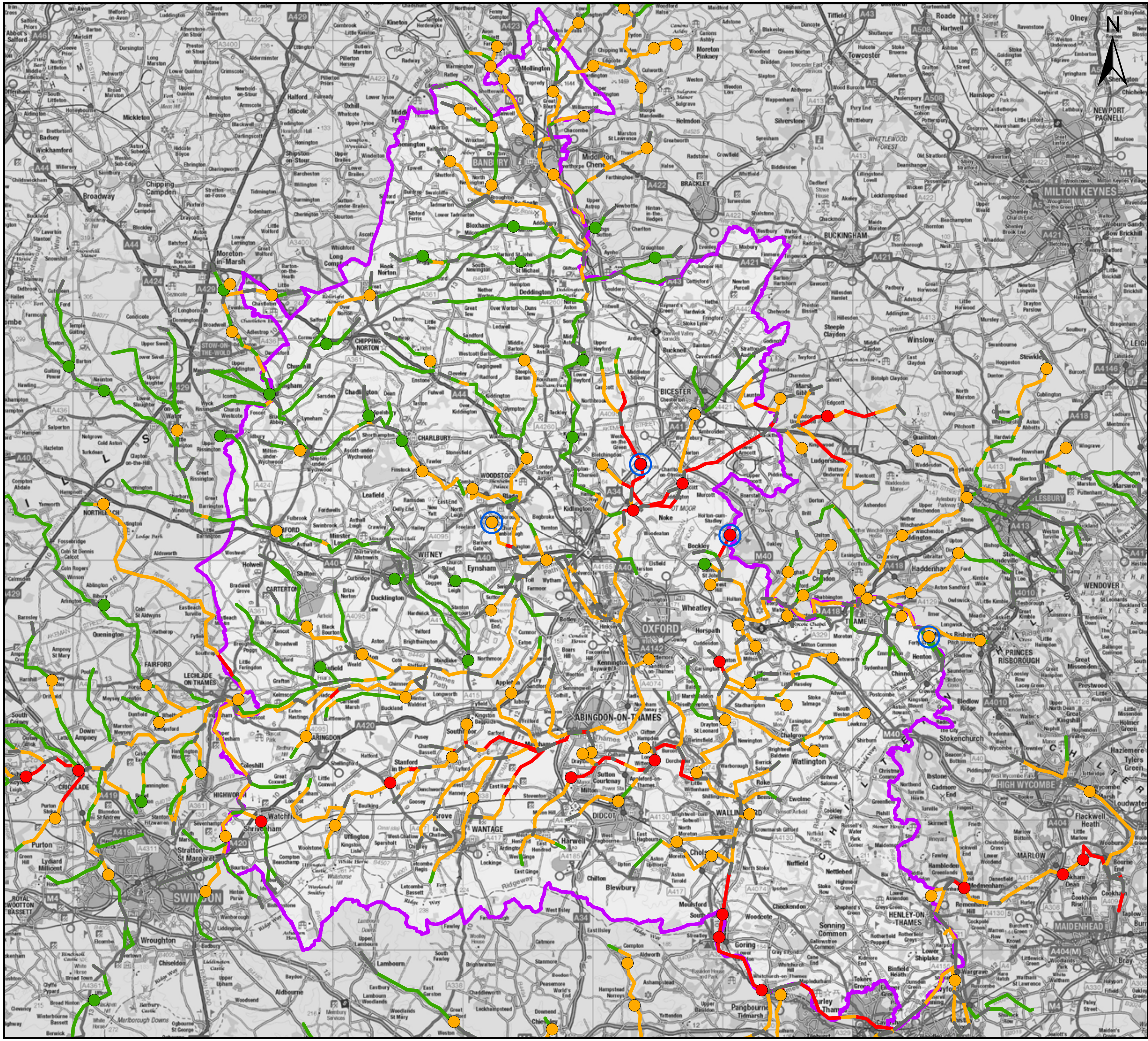
- No Deterioration
- Deterioration <10%
- Deterioration >10%
- Class Deterioration

Deterioration in Watercourse

- No Data
- No Deterioration
- Deterioration <10%
- Deterioration >10%

0 2.5 5 10 km

Source: BLT-JBAU-XX-XX-M2-EN-0028-BOD_Deterioration_10PC



BOD Deterioration with +20% Flows

Oxfordshire Boundary

Deterioration at WwTW Outfall

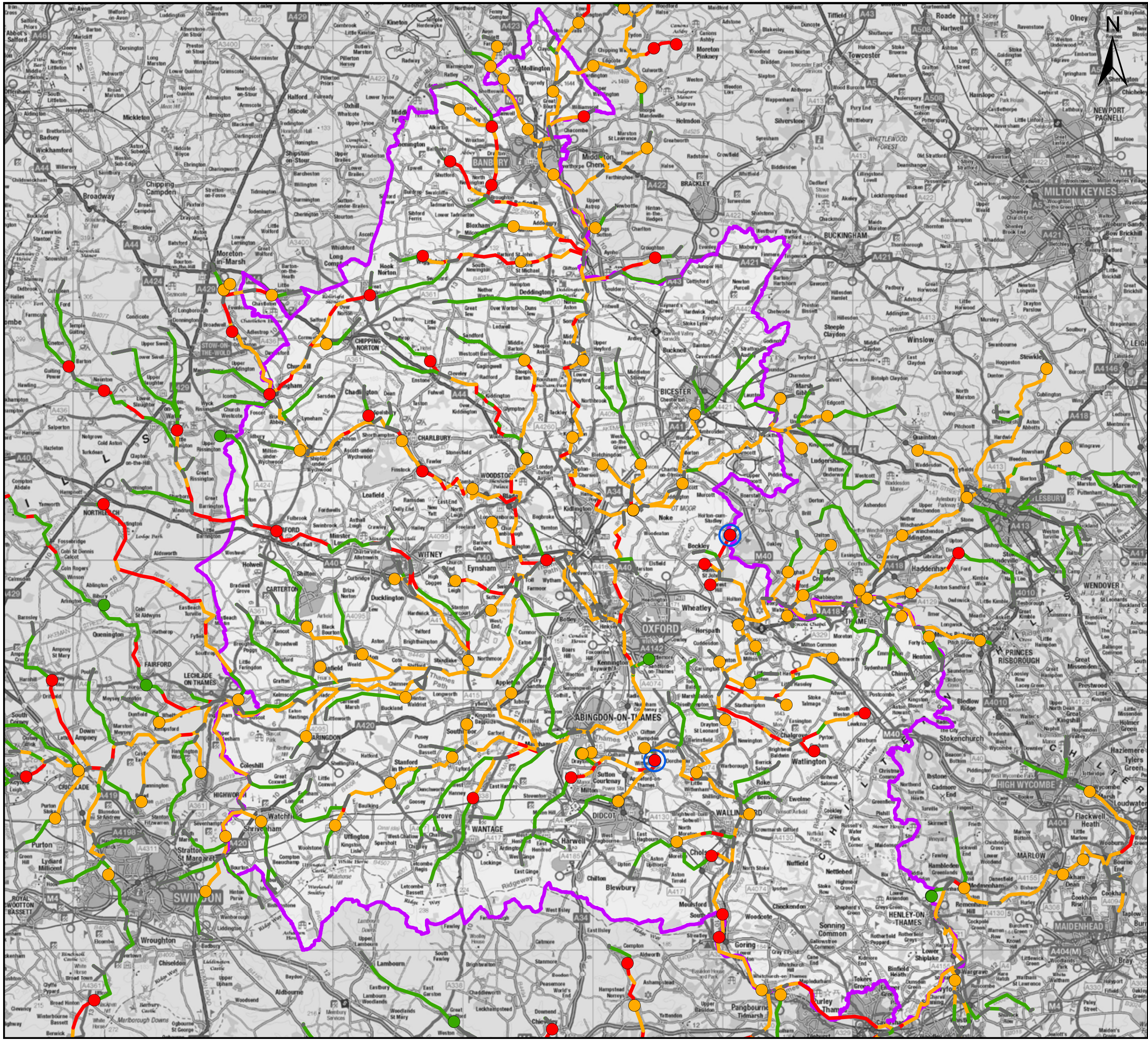
- No Deterioration
- Deterioration <10%
- Deterioration >10%
- Class Deterioration

Deterioration in Watercourse

- No Data
- No Deterioration
- Deterioration <10%
- Deterioration >10%

0 2.5 5 10 km

Source: BLT-JBAU-XX-XX-M2-EN-0028-BOD_Deterioration_20PC



Phosphate Deterioration with +10% Flows

Oxfordshire Boundary

Deterioration at WwTW Outfall

- No Deterioration
- Deterioration <10%
- Deterioration >10%
- Class Deterioration

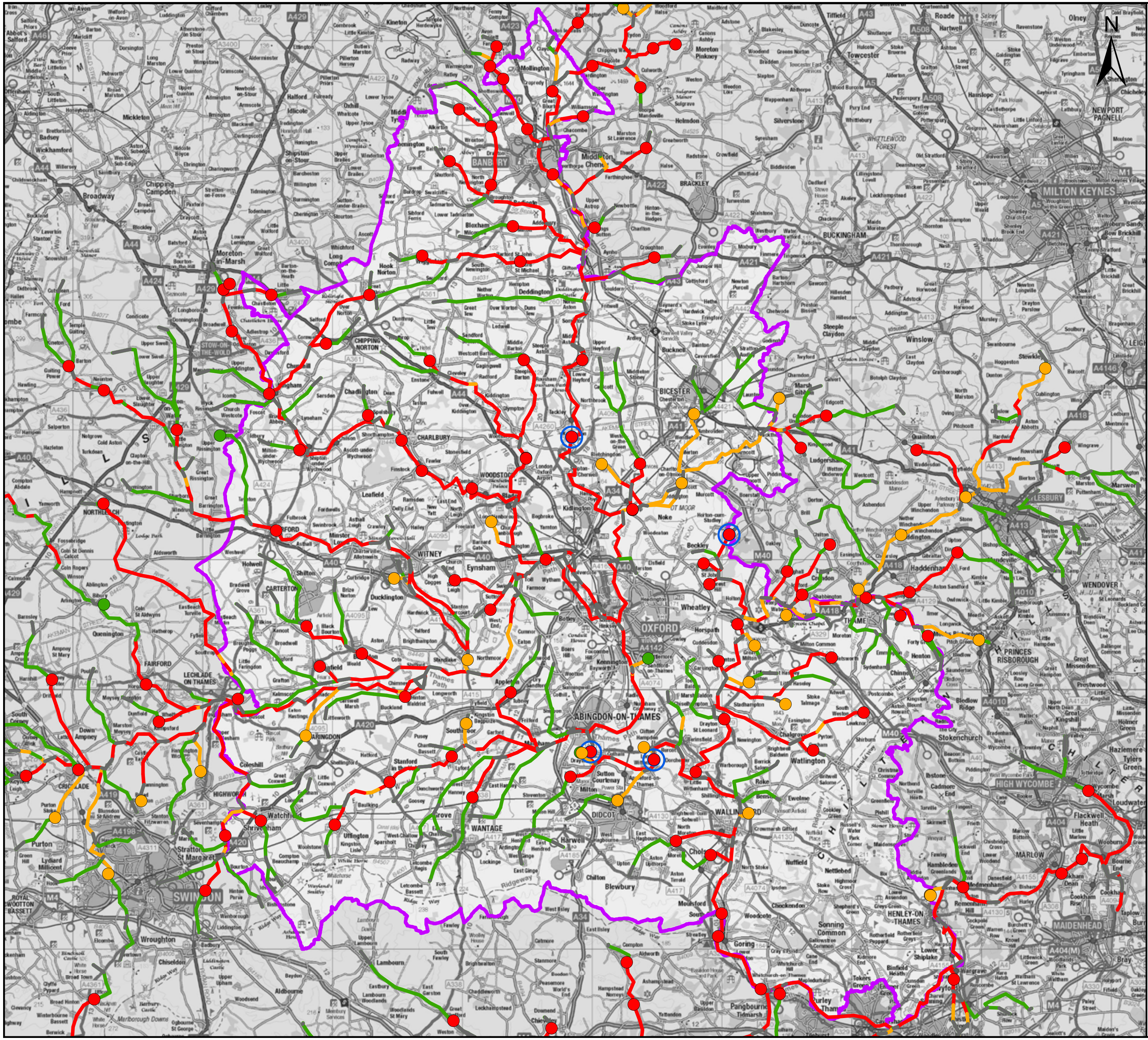
Deterioration in Watercourse

- No Data
- No Deterioration
- Deterioration <10%
- Deterioration >10%

0 2.5 5 10 km

Source: BLT-JBAU-XX-XX-M2-EN-0028-Phosphate_Deterioration_10PC

JBA consulting



Phosphate Deterioration with +20% Flows

Oxfordshire Boundary

Deterioration at WwTW Outfall

- No Deterioration
- Deterioration <10%
- Deterioration >10%
- Class Deterioration

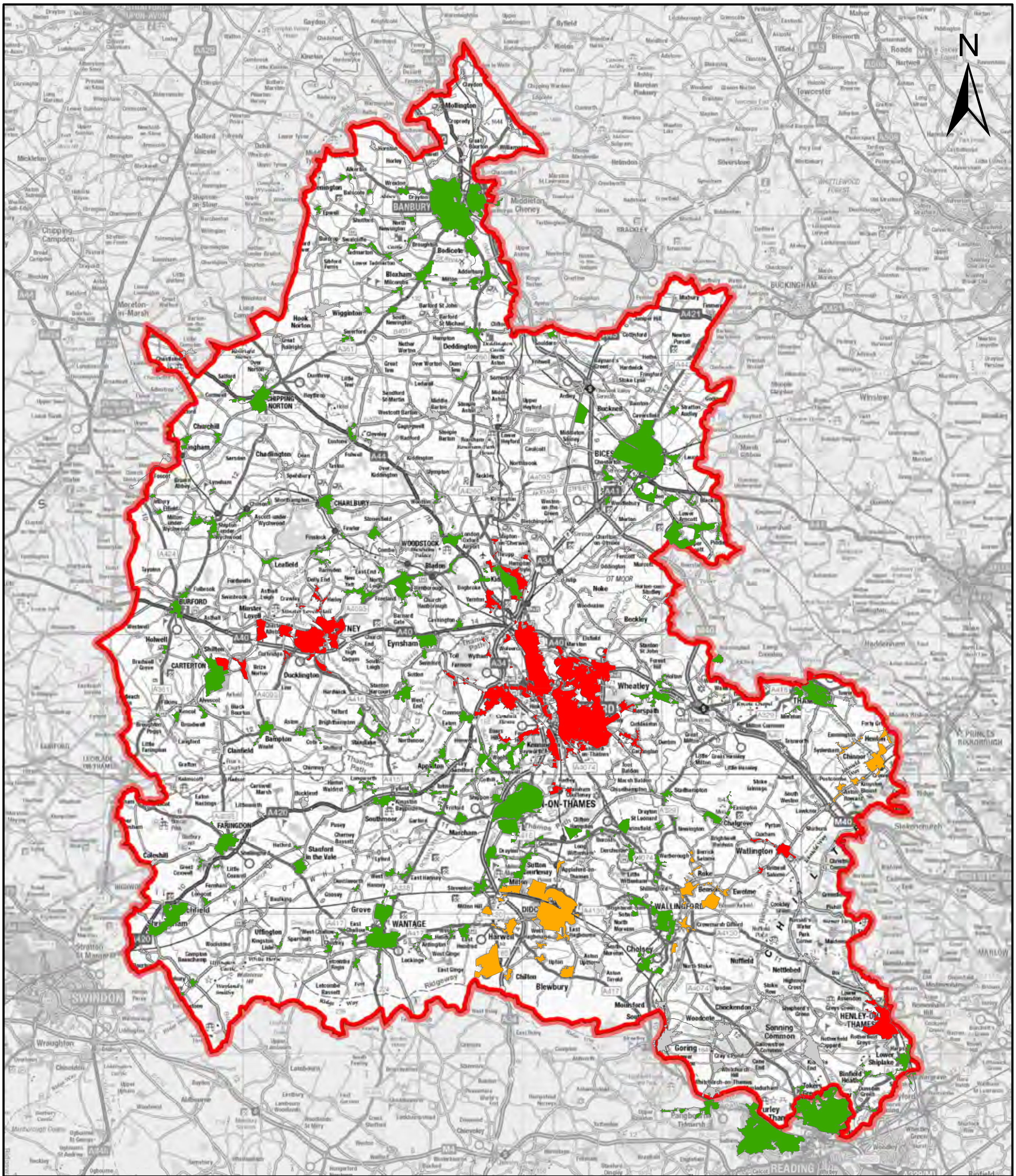
Deterioration in Watercourse

- No Data
- No Deterioration
- Deterioration <10%
- Deterioration >10%

0 2.5 5 10 km

Source: BLT-JBAU-XX-XX-M2-EN-0028-Phosphate_Deterioration_20PC

C Appendix: Flood risk from additional effluent



Effluent flow as a percentage of 1 in 100-year river flow at outlet

- >5
- 3 ≥ 5
- <3
- No Data Available / Flow unresolvable
- Oxfordshire

0 5 10 20 km

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Source: BLT-JBAU-XX-XX-M2-EN-0020-Flood_Risk

D Appendix: Comparison study of UKCP09 and UKCP18 in Oxfordshire

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Client	Oxfordshire County Council
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Author	Rhiannon Bryan
Reviewer / Sign-off	Richard Pardoe, Murray Dale
Subject	Comparison study of UKCP09 and UKCP18 in Oxfordshire

A comparison of UKCP09 and UKCP18 and its implications for water management in Oxfordshire.

1 Introduction

The UK Climate projections 2018 (UKCP18), released November 2018, provides new projections of how climate might change in the UK over the 21st Century and covers all land and marine regions within the UK. It is the latest in a series of climate projections that began in 1998, produced by the Met Office, designed to inform and help decision-makers assess their risk exposure to climate.

The projections cover temperature and rainfall changes – for averages and extremes – as well as more specialist variables, such as specific humidity, air pressure and cloud cover. These are available for each month and season of the year, and for different emissions scenarios and future time periods throughout this century. The climate information products available in UKCP18 are summarised in Section 4[1]

Current guidance for England[2] on assessing future risk from climate change is based on the UKCP09 projections (e.g. flood uplift factors for flood risk assessments, guidance on how to incorporate climate change into water resource studies). In addition to this, most literature and evidence relating to the impact of climate change in the UK is based on the UKCP09 projections, which were used within the first and second national climate change risk assessments. Guidance is slowly changing and being updated in response to the new projections; however, analysis still needs to be completed on these projections before they can be translated fully into adaptation guidance. Understanding the differences between UKCP09 and UKCP18 is key in understanding how these projections may change climate change adaptation strategy in the future.

This note summarises UKCP18 and how it compares to UKCP09 in the South East of England and comments on what implications this may have for water management (flood risk management, wastewater treatment and water resources) in Oxfordshire.

[1] Lowe et al., 2018. UKCP18 Science Overview Report. Available at: https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf

[2] Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities, Environment Agency Horizon house, Deanery Road, Bristol BS1 5AH, 3 March 2016

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2 A recap of UKCP09

The main component of the UKCP09 projections over land was a set of probabilistic projections which expressed a broad range of realistic outcomes for the UK climate over the 21st century for key climate variables. These were provided for 3 emissions scenarios (SRES B1, A1B and A1F1) labelled low, medium and high on a 25km grid and for administrative regions and river basin districts. These projections were based on a 30-year baseline period from 1961-1990 and were available as 30-year monthly annual and seasonal averages. The UKCP09 projections were the first to contain quantitative estimates of uncertainty within them. [3]

3 UKCP18: Emissions scenarios

A key difference between UKCP09 and UKCP18 is the different emissions scenarios used and how they compare.

The SRES projections used in UKCP09 did not incorporate any policies to limit climate change and thus did not consider climate change mitigation. The increasing relevance of mitigation scenarios in climate science led to the development of Representative Concentration Pathways (RCPs) adopted by the IPCC for its 5th assessment report in 2014. These RCPs have also been adopted for use in UKCP18.

An RCP is a greenhouse gas concentration trajectory over the 21st century. Four pathways have been selected for climatic modelling and research (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5). These pathways describe different climate futures all of which are considered possible depending on how much greenhouse gases are emitted in the years to come, dependent on various socio-economic factors. Each pathway results in a different range of global mean temperature increases over the 21st century. These are summarised in Table 3-1.

[3] Murphy et al., 2019. UKCP18 Land Projections: Science Report. Available: https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Land-report.pdf

Table 3-1; The increase in global mean surface temperature averaged over 2081-2100 compared to the pre-industrial period for the RCP pathways (best estimate, 5-95% range). (adapted from IPCC AR5, WG1 Table 12.3).

RCP	Change in global temperature (°C) by 2081-2100
RCP 2.6	1.6 (0.9-2.3)
RCP 4.5	2.4 (1.7-3.2)
RCP 6.0	2.8 (2.0-3.7)
RCP 8.5	4.3 (3.2-5.4)

As a result of the different methods used to construct the SRES scenarios and the RCPs, it is not possible to directly compare the two sets. Figure 3-1Table 3-1 indicates the similarities between the scenarios in terms of median global temperature increase by 2100.

Figure 3-1 shows global mean temperature projections for RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 and how these relate to the older SRES projections in terms of temperature increase. RCP 2.6 represents a pathway where greenhouse gas emissions are heavily mitigated, limiting global average temperature rise to 1.6 °C (best estimate) by 2100. As the SRES projections do not consider the impact of mitigation there is no similar SRES scenario. RCP 4.5 and RCP 6.0 are two "medium" pathways, with varying levels of mitigation. In terms of temperature, they are most similar to SRES B1 (low emissions scenario) and SRES B2/SRES A1B (medium emissions scenario). RCP 8.5 represents a scenario where greenhouse gas emissions continue to grow unmitigated, this pathway is similar to SRES A1F1 (high emissions scenario) in terms of temperature increase over the 21st century.[4]

[4] Met Office, 2018. UKCP18 Guidance: Representative Concentration Pathways. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---representative-concentration-pathways.pdf

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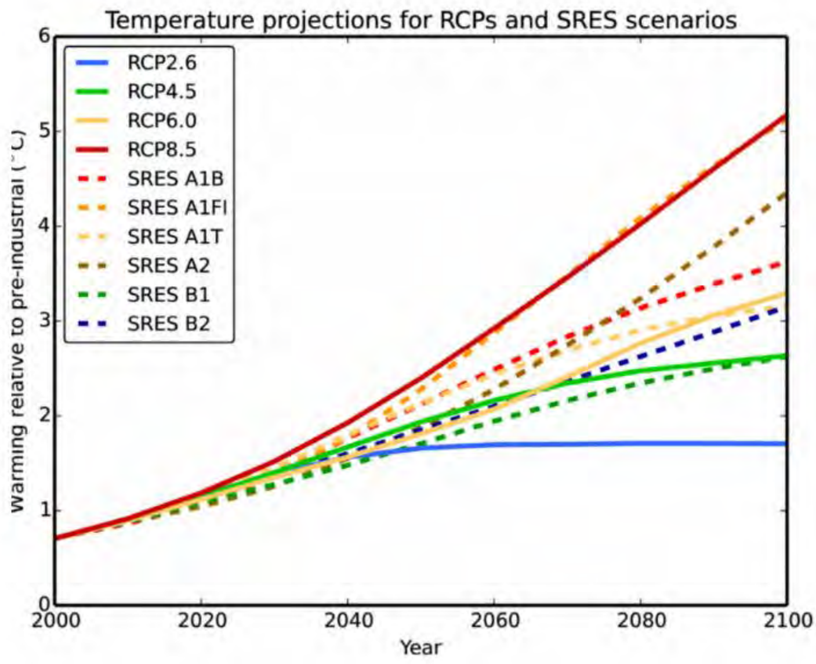
Figure 3-1;Global mean temperature projections from a climate model (called MAGICC6) relative to a pre-industrial average (1850-1900) for RCP2.6 (Met Office, 2018).



4 UKCP18: Types of projection[5]

There are three types of projection available through UKCP18: probabilistic, regional and global. These projections vary dependent on their intended use and have been developed in response to user needs.

4.1 Probabilistic Projections

The probabilistic projections give estimates of different future climate outcomes and their relative probabilities at a 25km resolution across the UK. These climate outcomes are available for a variety of climate metrics (e.g. temperature,

[5] Met Office, 2018. UKCP18 Guidance: How to use the UKCP18 land projections. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---how-to-use-the-land-projections.pdf

precipitation, humidity, cloud cover) averaged over a 20-year time periods, for all RCPs and SRES A1B (medium-high emissions scenario) to allow for direct comparison studies with UKCP09. It should be noted that the SRES A1B scenario used for comparison is an updated version using the UKCP18 methodology. The data is relative to a baseline of 1981-2000 and monthly, seasonal and yearly values are available. The probabilistic projections are most like the UKCP09 projections, however, there are some distinct differences.

The probabilistic projections are intended to be used for:

- Examining a broad set of future outcomes within the 10th-90th percentile range
- Carrying out a comparison study with UKCP09
- Carry out a robust risk assessment for a system

4.2 Global and Regional projections

The global and regional projections provide flexible datasets derived directly from climate model output; this means they are available as a time series rather than as values averaged over 20 years.

4.2.1 Global projections

These are available at a 60km resolution globally and provide daily, monthly, seasonal and annual data on a wider variety of climate metrics than available in the probabilistic projections. Data is only available for RCP 8.5.

4.2.2 Regional projections

These are available at a 12km resolution for the UK and Europe, 2.2km resolution projections are due to be released in September 2019. These projections provide sub daily (2.2km resolution data only), daily, monthly, seasonal and annual data over a wider variety of climate metrics than available in the probabilistic projections. Data is only available for RCP 8.5.

The 2.2km resolution regional projections are better able to represent some small-scale processes seen in the atmosphere, such as those important for large convective storms in the summer.

The regional projections are intended to be used for:

- Applications where local scales are essential (represent local effects i.e. land elevation)
- Calculate future river flows
- Improved simulation of extremes with higher temporal variability

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5 UKCP09 and UKCP18: General comparison

5.1 Probabilistic projections of future climate.

General climate change trends projected over UK land for the 21st century are broadly consistent with UKCP09 projections, showing an increased chance of milder, wetter winters and hotter, drier summers along with an increase in the frequency and intensity of extremes. Cold, drier winters and cooler, wet summers will still occur due to natural climate variability, but these are likely to become less frequent over the 21st Century. The broad similarity between the two datasets partially reflects the similar but improved methodology used to produce UKCP18 probabilistic projections in comparison to the UKCP09 probabilistic projections.

However, there are some differences between UKCP09 and UKCP18 (e.g. temperature and rainfall) that may be important for climate risk assessments. These differences depend on season, location and greenhouse gas emission scenario and there is a large overlap of projected ranges for the majority of climate metrics. The biggest differences are within the highest (95th) and lowest percentiles (5th) (so in the lower probability, extreme range) [6].

5.2 Products

Table 5-1 summarises the differences between UKCP09 and UKCP18 products.

Table 5-1; Summary of characteristics of UKCP09 and UKCP18 products.[7]

Product	UKCP09	UKCP18
Probabilistic projections	25km in rotated pole grid* Administrative regions and river basins	25km in Ordnance Survey's British National Grid + Countries, administrative regions and river basins
	Monthly, seasonal, annual	Same
	30-year averages	30-year averages and monthly time series

[6] Lowe et al., 2018. UKCP18 Science Overview Report. Available at: https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf

[7] Met Office, 2018. UKCP18 Guidance: How to use the UKCP18 land projections. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---how-to-use-the-land-projections.pdf

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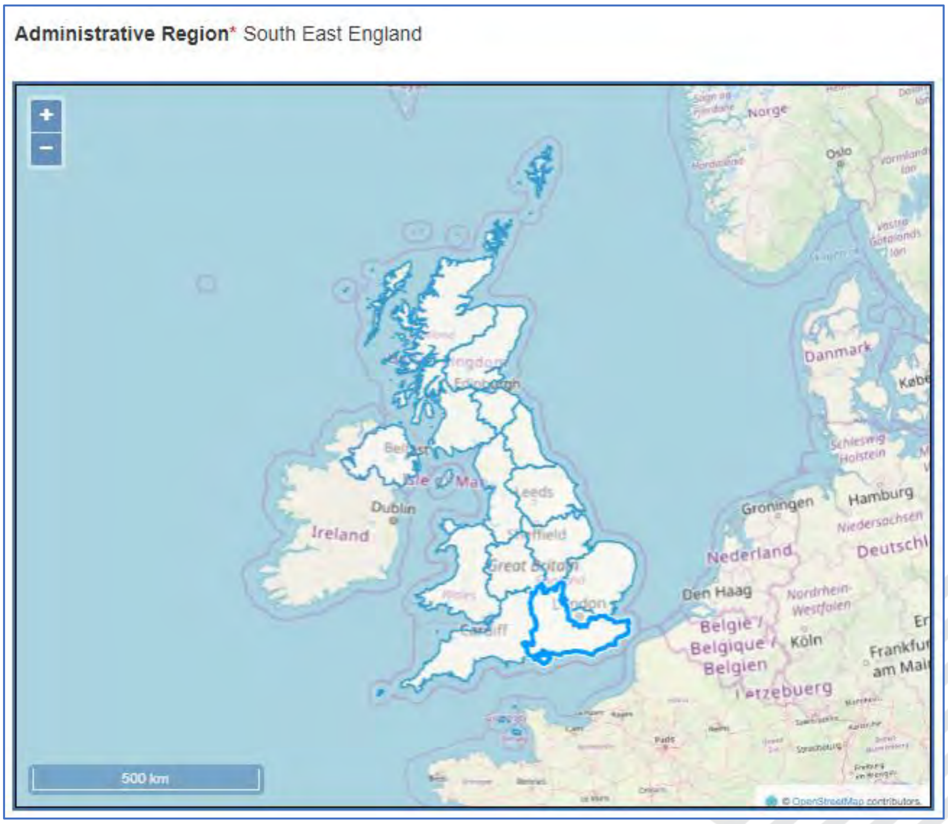
Product	UKCP09	UKCP18
	SRESB2 (low) SRESA1B (medium) SRESA1FI (high)	SRESA1B RCP2.6, RCP4.5, RCP6.0, RCP8.5
	10,000 samples	3,000 samples
Regional climate models	25km in rotated pole grid* Daily time series	60km global projections 12km regional projections over Europe 2.2km regional projections over UK
Spatially coherent projections	25km in rotated pole grid* 30-year averages	No longer available. Replaced by spatially coherent • 60km global projections • 12km regional projections over Europe • 2.2km regional projections over UK
Weather generator	Daily and hourly	No longer available. Replaced by • Daily from global and regional models • Hourly from regional 2.2km model

6 Key climate change projections for the South East and how they compare to UKCP09.

The tables presented in this section show a comparison between the UKCP09 and UKCP18 probabilistic projections for temperature and rainfall, by 2080 in the South-East of England. The South East administrative region (as defined in UKCP18) was used to allow comparison between the UKCP18 probabilistic projections and archived UKCP09 projections.

Figure 6-1 **Location of UKCP18 'South East England' Administrative Region**



All projections are shown for the 10th, 50th and 90th percentiles (or % probability levels in UKCP09 results). These 3 percentiles (or probability levels) reflect the relative probability of these values occurring under an emissions scenario. The 50th percentile is the median value or central estimate, across the results, while the 10th and 90th percentiles are representative of the lower probability, more extreme (but still realistic) values. These percentiles reflect the lowest 10% and the highest 10% of the results.

For the purposes of comparison between the two sets of projections, updated SRES A1B (medium emissions) scenario has been included in the UKCP18 projections. It should be noted that the UKCP09 and UKCP18 projections used in this brief have different baseline periods, which may contribute to some of the differences between the results; however, it is expected that the differences will predominantly be due to the different methodologies used to produce the results.

6.1 Precipitation

6.1.1 UKCP18 projections

The key impacts for Oxfordshire, drawn from the South East England UKCP18 results, in terms of precipitation change are:

- Drier summers
    - Change in average summer precipitation of between 4% and -41% (central estimate: -18%) for RCP 2.6
    - Change in average summer precipitation of between -2% and -76% (central estimate: -40%) for RCP 8.5
    - Figure 6-2 shows how average summer precipitation is projected to change over the 21st Century. This indicates that in general, dry summers are going to become more frequent by 2100 for RCP 8.5.
- Wetter winters
    - Change in average winter precipitation of between -9% and 25% (central estimate: 8%) for RCP 2.6.
    - Change in average winter precipitation of between -2% and 57% (central estimate: 24%) for RCP 8.5.

    - Figure 6-3, shows how average winter precipitation is projected to change over the 21st Century. This indicates that in general wet winters will become more frequent by 2100 for RCP 8.5.

We need to highlight, however, that the above results show general trends in seasonal precipitation in the South East region of England. As such, they are of use in water resources investigations but may not capture the future trends in flood risk due to intense rainfall. The way rainfall intensity is likely to change is better estimated with new, higher-resolution climate projections from UKCP18 that are due for release in September 2019. These have the benefit of being able to represent convective rainfall which results in the heaviest downpours and gives rise to surface water flooding; for example, the flood events of summer 2007. JBA is jointly leading research[8] with the new 2.2km high- resolution climate projections to investigate how rainfall intensities are likely to change – results are due in 2020.

Table 6-1; Projected change in Summer and Winter precipitation (%) for the South-East region in 2080-2099 compared to a 1981-2000 baseline period using the UKCP18 probabilistic projections (data sourced from MetOffice key results)

Climate variable	Emissions Scenario	**Percentile**		
		10th	50th	90th
Change in mean summer precipitation (%)	RCP2.6	-41	-18	4
	RCP4.5	-50	-25	0
	RCP6.0	-57	-29	0
	RCP8.5	-76	-40	-2
	SRES A1B (Medium)	-62	-30	1
Change in mean winter precipitation (%)	RCP2.6	-9	8	25
	RCP4.5	-5	14	35
	RCP6.0	-5	17	40
	RCP8.5	-2	24	57
	SRES A1B (Medium)	-8	19	49

-76% 0 +57%

[8] FUTURE-DRAINAGE – NERC funded research led by Newcastle University - https://gtr.ukri.org/projects?ref=NE%2FS017348%2F1

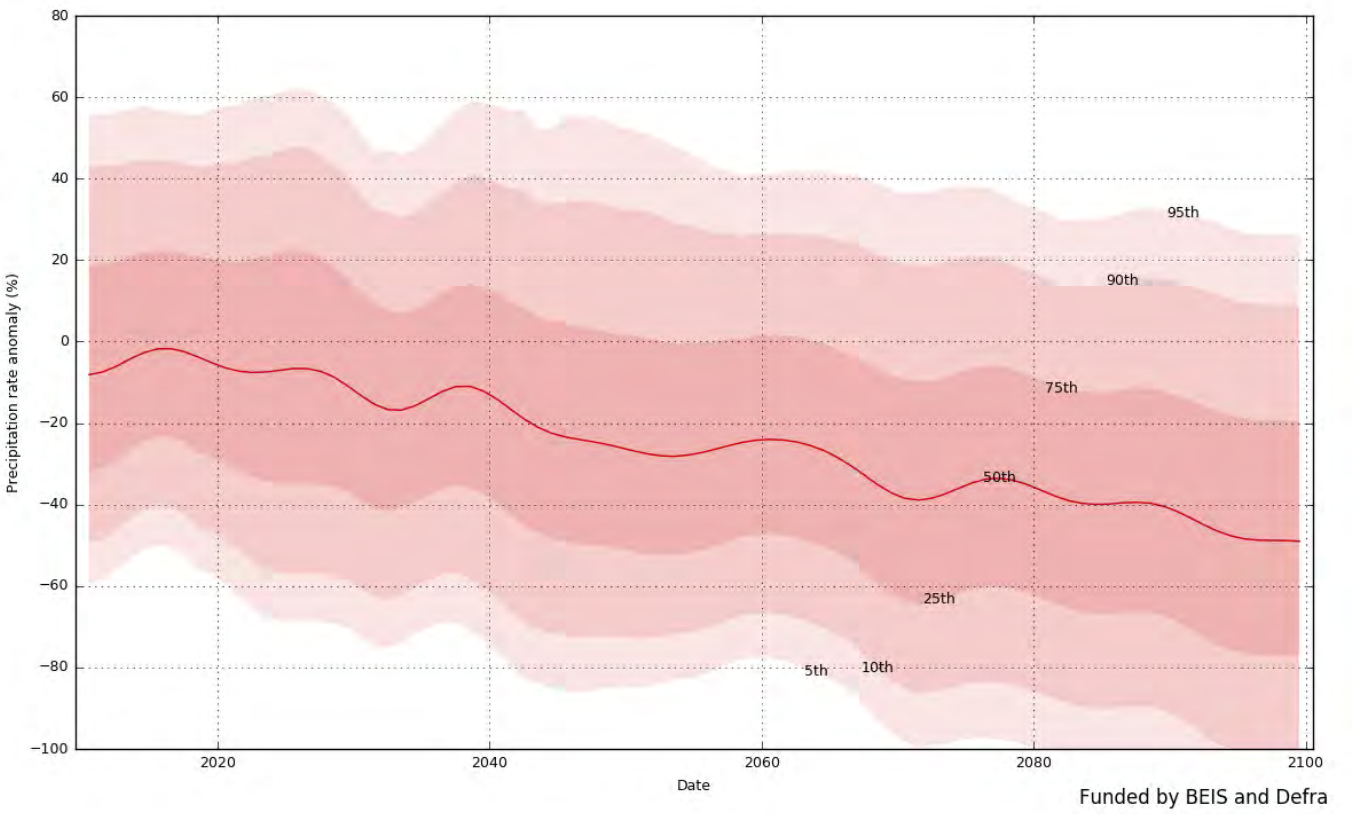


Figure 6-2; Plume plot of seasonal average precipitation anomaly (%) for summer from 2010-2100 for South East England in RCP 8.5

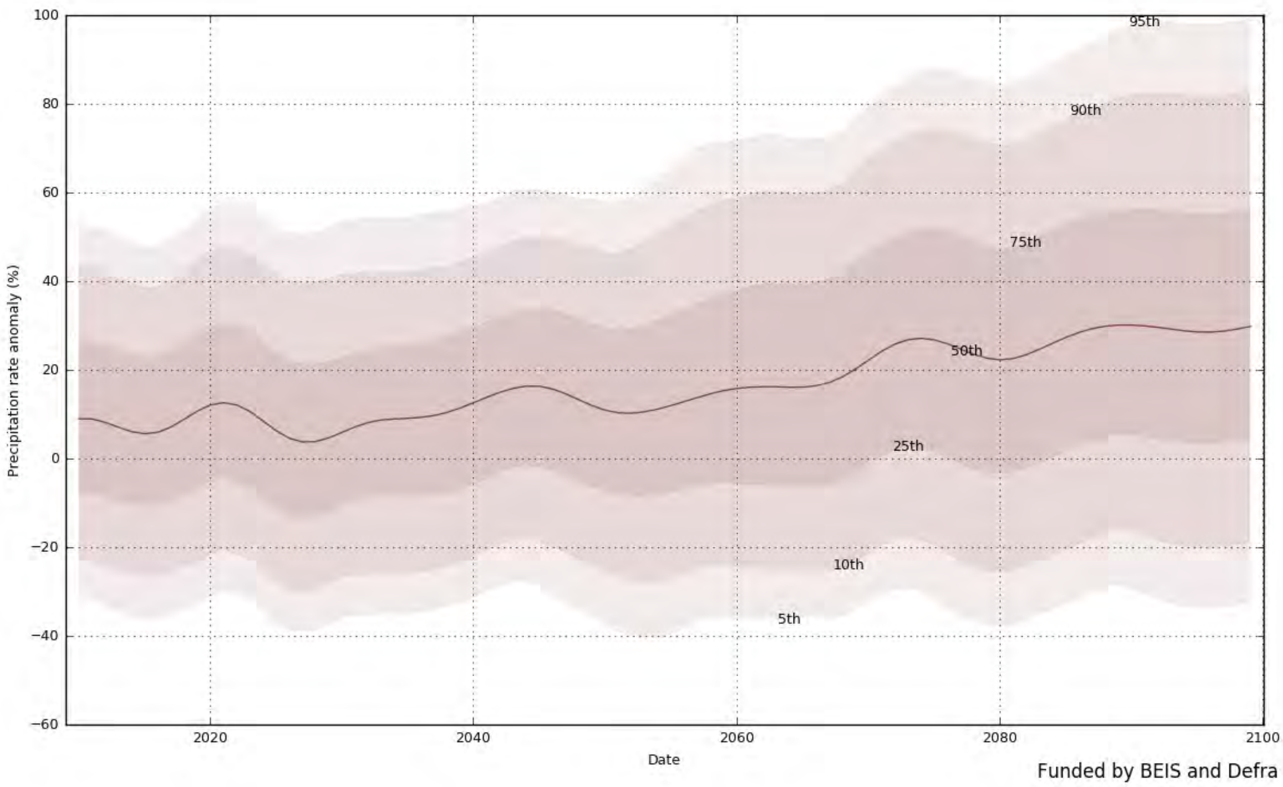


Figure 6-3; Plume plot of seasonal average precipitation anomaly (%) for winter from 2010-2100 for South East England in RCP 8.5.

6.1.2 UKCP09 and UKCP18 comparison

For seasonal and annual trends in precipitation, there are some relatively big differences between the two sets of projections in the low and high percentiles. This is most evident in the lower percentile (10th) with UKCP18 showing slightly larger reductions in precipitation than UKCP09. UKCP18 also shows slightly smaller increases in precipitation (95th percentile) in comparison to UKCP09. The central estimates (50th percentile) are broadly similar when comparing both sets of projections; however, the central estimate of change in average summer and winter precipitation is slightly lower in the UKCP18 projections in comparison to UKCP09.

In summer, UKCP18 shows a change of 1% - 62% in average precipitation the SRES A1B scenario. For the same scenario (medium in Table 6-2) UKCP09 shows a change of 7% to -48% in average precipitation. This indicates that the South East of England, and so Oxfordshire, could experience drier summers than was originally predicted in the UKCP09 projections. In winter, UKCP18 shows a change of between -8% - 49% in average precipitation for the SRES A1B scenario in comparison to the same scenario in UKCP09, which shows a change in average precipitation of between 4% - 51%.

Table 6-2; Projected change in Summer and Winter precipitation (%) for the South-East region in 2070-2099 compared to a 1961-1990 baseline period using the UKCP09 probabilistic projections (data sourced from archived UKCP09 key results data)

Climate variable	Emissions Scenario	10% probability level	50% probability level	90% probability level
Change in mean summer precipitation (%)	Low	-39	-15	13
	Medium	-48	-23	7
	High	-57	-29	5
Change in mean winter precipitation (%)	Low	4	18	40
	Medium	4	22	51
	High	7	30	67

-57% 6 +67%

6.2 Temperature

6.2.1 UKCP18 Projections

The key impacts for Oxfordshire in terms of average temperature change by 2080 are:

- Hotter summers
  - Change in average summer temperature of between 0.8°C and 3.4°C (central estimate: 2.1°C) for RCP 2.6.
  - Change in average summer temperature of between 2.9°C and 8.6°C (central estimate: 5.7°C) for RCP 8.5.
  - Figure 6-4 shows how average summer temperature is projected to change over the 21st Century. This indicates that in general warmer summers are going to become more frequent by 2100 for RCP 8.5.
- Milder winters

- Change in average winter temperature of between 0°C and 2.4°C (central estimate: 1.2°C) for RCP 2.6.
- Change in average winter temperature of between 1.5°C and 5.7°C (central estimate: 3.5°C) for RCP 8.5.
- Figure 6-5 shows how average winter temperature is projected to change over the 21st Century. This indicates that in general milder winters are going to become more frequent by 2100 for RCP 8.5.

Table 6-3; Projected change in Summer and Winter temperature (°C) for the South-East region in 2080-2099 compared to a 1981-2000 baseline period using the UKCP18 probabilistic projections (data sourced from MetOffice key results).

Climate variable	Emissions Scenario	**Percentile**		
		10th	50th	90th
Change in mean summer temperature (°C)	RCP2.6	0.8	2.1	3.4
	RCP4.5	1.5	3.5	5.6
	RCP6.0	1.9	4.1	6.5
	RCP8.5	2.9	5.7	8.6
	SRES A1B (Medium)	2	4	6.3
Change in mean winter temperature (°C)	RCP2.6	0	1.2	2.4
	RCP4.5	0.7	2.1	3.5
	RCP6.0	0.9	2.5	4.1
	RCP8.5	1.5	3.5	5.7
	SRES A1B (Medium)	0.8	2.4	4.3

0 8.6

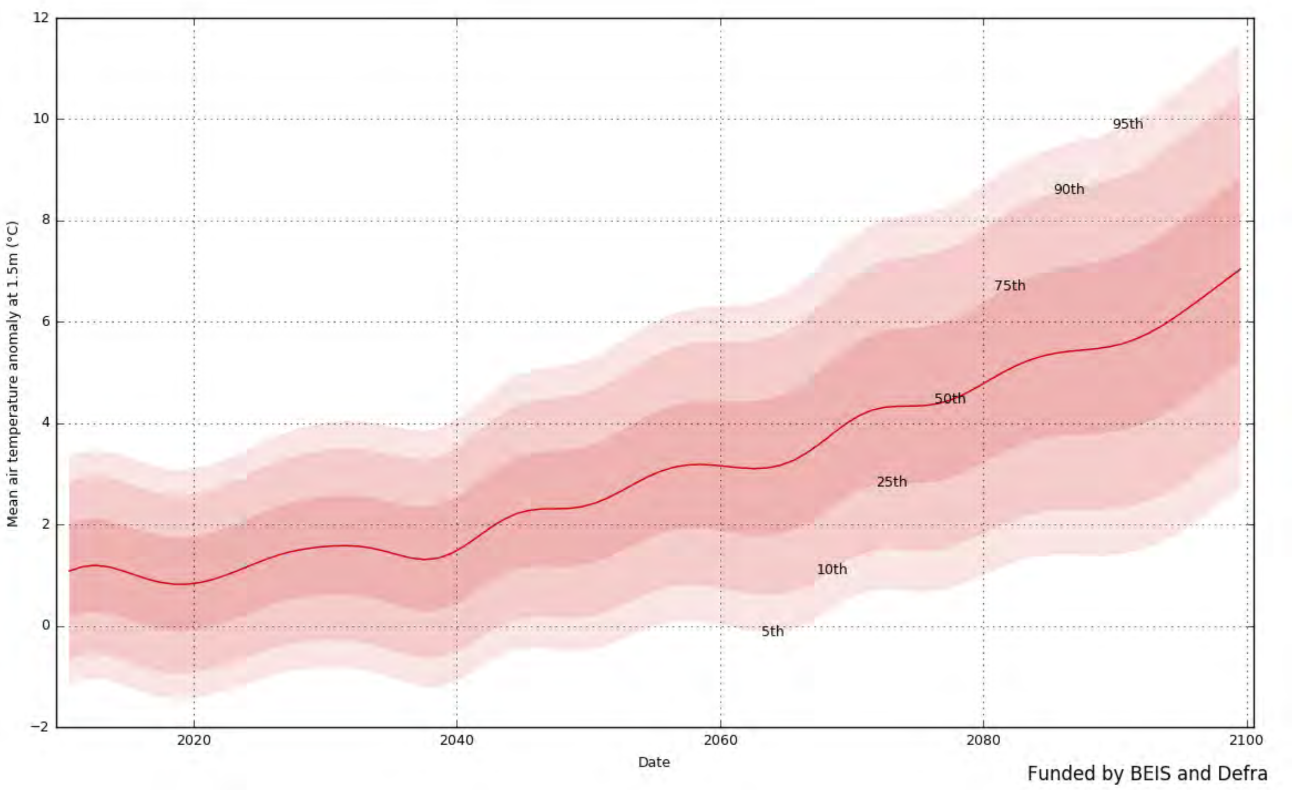


Figure 6-4; Plume plot of seasonal average temperature anomaly (°C) for summer from 2010-2100 for South East England in RCP 8.5

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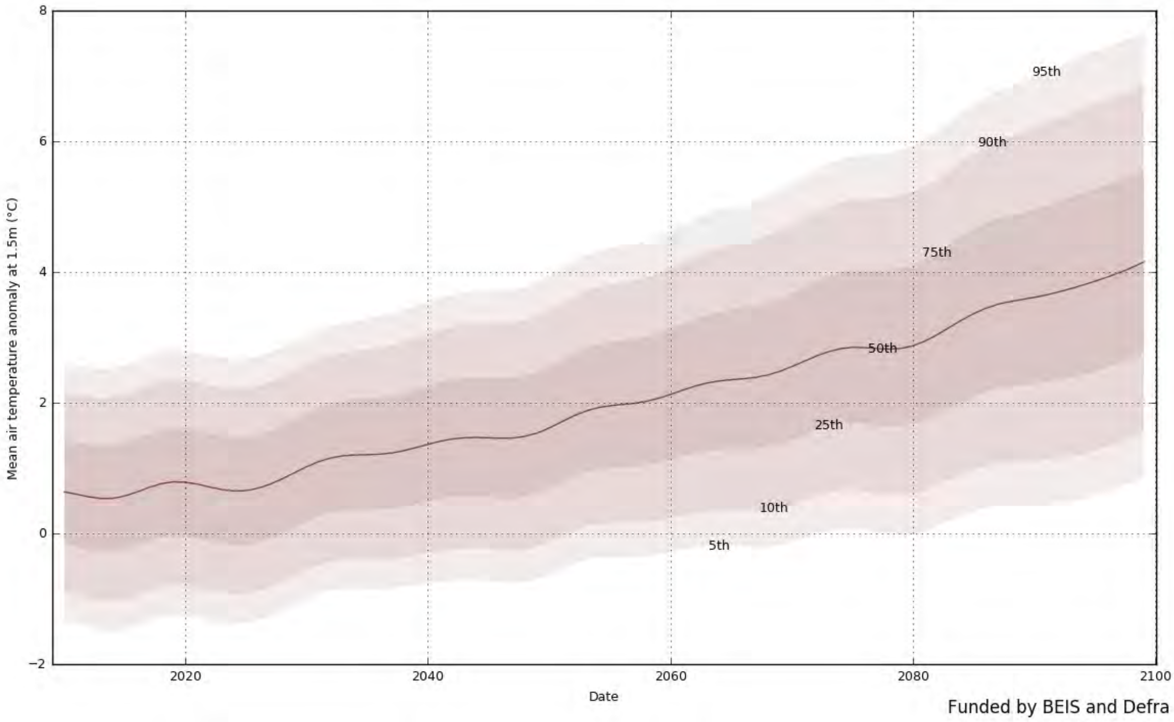

Figure 6-5;Plume plot of seasonal average temperature anomaly (°C) for winter from 2010-2100 for South East England in RCP 8.5

6.2.2 UKCP09 and UKCP18 comparison

For seasonal and annual temperature, the differences between the two sets of projections appear to be dependent on season. Overall the projections are similar, especially in summer, for the SRES A1B scenario (medium on Table 6-4). The biggest differences are in winter with UKCP18 showing slightly less warming than UKCP09. UKCP18 shows a predicted range in average winter temperature increase of 0.8°C to 4.3°C, with a central estimate of 2.4°C. In comparison UKCP09 shows a predicted range of temperature between 1.6°C to 4.7°C, with a central estimate of 3. This indicates that in the South-East of England winters could be less mild than originally predicted in the UKCP09 projections, with a smaller degree of warming than the general UK trend, however the differences are small.

It should be noted that these results do not consider 'hottest day' temperatures or daily extremes.

Table 6-4; Projected change in average Summer and Winter temperature (°C) for the South-East region in 2070-2099 compared to a 1961-1990 baseline period using the UKCP09 probabilistic projections (data sourced from archived UKCP09 key results data)

Climate variable	Emissions Scenario	10% probability level	50% probability level	90% probability level
Change in mean summer temperature (°C)	Low	1.4	3	5.1
	Medium	2	3.9	6.5
	High	2.6	4.9	8.1
Change in mean winter temperature (°C)	Low	2	2.6	4
	Medium	1.6	3	4.7
	High	2	3.7	5.7

1.4 8.1

7 Implications for water management in Oxfordshire

This section details the impacts that UKCP18 may have on flood risk management, wastewater treatment and water resources in Oxfordshire. As UKCP18 was only released in November last year, the guidance surrounding these areas is still in the process of being updated and detailed analysis of the projections is still required to better assess implications of UKCP18 projections.

7.1.1 Flood risk management

As mentioned previously, analysis of the projections is still required to understand the impact that the new projections will have on flood risk management in England and using the UKCP18 data available now it is not possible to comment on how this will or could change. The 2.2km regional projections, expected to be released in September 2019 will have a big impact on our understanding of how flood risk is likely to change, and analysis of this data will be used to inform the rainfall and peak flow uplifts used in future (please note previous comment on on-going research in this area). At the time of writing, the Environment Agency recommends using the current guidance on incorporating climate change into flood risk studies[9],

[9] Environment Agency, 2016. Flood risk assessments: climate change allowances. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

which was released in 2016 using data from the UKCP09 projections. The allowances used in this are still the best representation to date of how climate change is likely to effect flood risk for peak river flow. No new fluvial flood risk guidance is due to be released until 2020.

7.1.2 Wastewater management

The current outputs from UKCP18 do not provide projections for short duration heavy rainfall (i.e. convective storms) which affects urban drainage systems. This will be provided in the 2.2km regional projections, expected to be released in September 2019, but additional analysis will be needed before these projections can be translated into any guidance. Again, it is not possible to comment on how this may change wastewater management in the future. At the time of writing, the most up-to-date projections for future short duration high intensity rainfall are those from the UKWIR (UK Water Industry Water Research[10]) 2017 project 'Rainfall intensity for sewer design- Stage 2', which should be used for wastewater management projects. Thames Water was a member of the project steering group for this research and owns a copy of the report.

7.1.3 Water resources

Drawing from the UKCP18 projections presented in Section 0, Oxfordshire is likely to experience drier summers than was originally estimated in the UKCP09 by 2080. From Figure 6-2 we can assume that hot, dry summers are likely to become more frequent over the 21st Century, which may have an impact on water demand and on the availability of water for abstraction from rivers during summer months.

Figure 6-3, shows an overall increase in wet winters over the 21st century as consistent with UKCP09, which should be beneficial for aquifer recharge and the availability of groundwater resources. However, as mentioned earlier, dry winters will still occur due to natural climate variability and it is not possible to estimate the relative probability of multiple dry seasons occurring consecutively (both summer and winter) from the data presented here and the impact this will have on water availability. A detailed study of UKCP18 data would be required to fully understand the impact that the UKCP18 projections will have on water resources in Oxfordshire.

[10] Rainfall intensity for sewer design, UKWIR, 2017 https://ukwir.org/rainfall-intensity-for-sewer-design-stage-2-0

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