8 Water Resources and Flood Risk

8.1 Introduction

8.1.1 This chapter was prepared by Johns Associates Ltd and presents an assessment of the likely significant effects of the Proposed Development on water resources and flood risk. Mitigation measures are identified, where appropriate, to avoid, reduce or offset any significant adverse effects identified and/or enhance likely beneficial effects. The nature and significance of the likely residual effects are reported.

8.1.2 The chapter is supported by the following appendices:

- Appendix 8.1: Relevant Legislation and Policy;
- Appendix 8.2: Flood Risk, Drainage and Sequential Assessment (including topographic and bathymetric data);
- Appendix 8.3: Groundwater Risk Assessment;
- Appendix 8.4: Water Framework Directive Assessment;
- Appendix 8.5: Lake Water Column Profiles;
- Appendix 8.6: Bathing Water Assessment; and
- Appendix 8.7: Draft Lake Management Plan.

8.1.3 Impacts on lake ecology / water dependant habitats have been assessed by suitably competent individuals and is reported in Chapter 7: Biodiversity.

Competence

8.1.4 This assessment has been overseen and approved by Matt Johns. Matt has 25 years of experience managing environmental impact assessments including for strategic infrastructure projects and has a particular focus on the water environment. His educational background includes a combined honours BSc in Geography and Geology (University of Manchester), an MSc in Aquatic Resource Management (King College, University of London), and he has maintained Chartered Environmentalist (CEnv) status since 2006. He is a Fellow of the Geological Society (FGS) and holds full membership of the Chartered Institute of Ecology and Environmental Management (MCIEEM).

8.1.5 This work has been supported by Liz Johns. Liz has 25 years of experience undertaking environmental impact assessments for a range of development projects across several sectors. She has a BSc honours degree in Environmental Biology (University of Liverpool), an MSc in Aquatic Resource Management (King College, University of London), and has maintained Chartered Environmentalist (CEnv) status since 2005. Liz has held full membership of the Chartered Institute of Ecology and Environmental Management (MCIEEM) since 2001 and is a full member of the Royal Society of Biology (MRSB).

8.2 Legislation, Planning Policy and Guidance

8.2.1 Appendix 8.1: Relevant Legislation and Policy, provides a summary of legislation and policy of relevance to the assessment.

Legislation Context

8.2.2 The following legislation is relevant to the Proposed Development:

- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (Water Framework Directive).[1]
- Groundwater (England and Wales) Regulations 2009.[2]
- The Flood Risk Regulations 2009[3].
- Nitrates Directive (91/676/EEC) ('Nitrates Directive')[4];
- Flood and Water Management Act 2010[5].
- The Water Resources Act 1991[6].
- Land Drainage Act 1994[7].
- The Climate Change Act 2008[8].
- The Environment Act 2021[9].
- The Environmental Permitting (England and Wales) Regulations 2016 (as amended)[10].
- Reservoirs Act1975 (as amended)[11].
- Environmental Protection Act 1990[12].

Planning Policy Context

8.2.3 The following national, regional and local planning policy is relevant to the Proposed Development:

National

- National Planning Policy Framework (2023)[13].
- National Planning Practice Guidance (NPPG)[14]:
- Climate change (Updated 2019)[15].
- Flood risk and coastal change (Updated 2021)[16].
- Flood risk assessments: climate change allowances (Updated 2021)[17].
- Natural environment (Updated 2019)[18].
- Renewable and low carbon energy (2015)[19].
- Water supply, wastewater, and water quality (Updated 2019)[20].

Regional

- London Plan (March 2021)[21].

Local

- London Borough of Hillingdon Council Local Plan (2020)[22].

Guidance

8.2.4 The following guidance is relevant to the Proposed Development and this chapter:

- Canal and River Trust (2017) Code of Practice for Works Affecting the Canal and River Trust[23].
- CIRIA (2001) C532: Control of water pollution from construction sites[24].
- CIRIA (2004) C624: Development and flood risk – guidance for the construction industry[25].
- CIRIA (2010) C688: Flood resilience and resistance for critical infrastructure[26].
- CIRIA (2015) C741: Environmental good practice on site[27].
- CIRIA (2015) C753: The SuDS Manual including the Simple Index Approach (SIA) to assessing water quality management requirements[28].
- Colne Valley Regional Park. Our Vision and Objectives[29].
- Defra (2015) Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage systems[30].
- Environment Agency. (2018) Approach to Groundwater Protection[31].
- Highways England (2020) Design Manual for Roads and Bridges (DMRB) LA113 Road Drainage and the Water Environment[32,]
- Joint Nature Conservation Committee JNCC (2015) Common Standards Monitoring Guidance for Freshwater Lakes. IISN 1743-8160[33].
- Netregs. (2022) Guidance for Pollution Prevention (GPP) – replacing Pollution Prevention Guidance (2009-2015 now withdrawn)[34].
- Environment Agency. (2022) Thames Basin District River Management Plan[35].
- London Borough of Hillingdon (2016) Local Flood Risk Management Strategy[36].
- UK Government. (2022 – latest update) Flood Risk and Coastal Change PPG[37].
- West London Alliance (2018) West London Strategic Flood Risk Assessment[38].
- WFD UK TAG (2008) UK Environmental Standards and Conditions (Phase 2) Final[39].

8.3 Assessment Methodology

Consultation

Pre-Application Consultation

8.3.1 The Environment Agency (EA) has been consulted through their Discretionary Advisory Service (DAS) as part of the pre-application process regarding flood risk and other matters related to the Water Environment.

8.3.2 Table 8.1 summarises key comments raised by consultees of relevance to this assessment during pre-application meetings and/or communication exchanges and how the assessment has responded to them.

Table 8.1: Consultation Response Summary

Consultee and Comment	Response
Environment Agency: Meeting held on 30 June 2023	
Contamination of groundwater and surface water: Waste (including ash/burnt waste) was deposited outside of the regulated landfill identified to be present in the south-east of the peninsula. If any physical disturbance to this material is proposed, including removal of concrete, channels for pipework, foundation then this would be considered waste recovery/waste disposal. The priority is to minimise the amount of disturbance of this waste mass.	No disturbance will occur to the areas of regulated and potential unregulated waste. An impermeable (e.g., clay) barrier will be introduced and suitable amounts/depths of clean cover placed on top, separating the development from the waste and breaking the pathway between surface water infiltration, the waste and the surface/groundwater bodies. A wide range of pollution prevention and response proposals are included as embedded measures for both the construction and operational phases of the Proposed Development. These include a sequence of suitably designed SuDS and interceptors, together with monitoring of water quality (notably nutrients and hydrocarbons) where the SuDS enter the lake. Please refer to Appendix 6.1: Outline CEMP, Appendix 8.2: Flood Risk, Drainage and Sequential Assessment (including topographic and bathymetric data), Appendix 8.3: Groundwater Risk Assessment; and Appendix 8.7: Draft Lake Management Plan and for further information on these measures.
Consideration of how surface water quality will be maintained with pollution prevention to surface and ground water. This includes any car parking. Interceptors will be required, and these could be conventional hydrocarbon interceptors, but further treatment will be required prior to runoff entering the lake. There is a list of contaminants of concern within Surface Water Safeguarding Zones – the project should demonstrate how these contaminants will not be generated/mobilised from its construction/operation.	See above response.
Water Framework Directive (WFD): The SSSI features of interest (notably birds) for which Broadwater Lake was notified, is also of importance in relation to the WFD Surface Water Body.	A detailed ecological impact assessment including baseline surveys, design evolution and inclusion of embedded mitigation, compensation and enhancement measures, and assessment of residual effects has been completed. This is provided as Chapter 7: Biodiversity. A WFD

Consultee and Comment	Response
The lake has failed in terms of WFD status in several areas including chemical quality and physical modification. In particular, this physical modification failure is attributed to recreation and specifically boating impacts (waves caused by sailing wash resulting in bank erosion). As such there is already a negative impact from the current levels of sailing. A key part of the WFD assessment will be showing how this will not be made worse and how this status could be improved. Concerns were also noted in relation to short and long-term impacts of sediment mixing with the water column as a result of wash and scour from boating and fine sediment input resulting in an increase in water contamination. Concern was also noted in relation to changes in wetland habitat and how lake marginal areas can be made more resilient to changes including climate changes. An increase in boating/water sports activity could result in an increase in bank erosion if lake access was more dispersed. Invasive Non-Native Species including floating pennywort is of concern. How will the project mitigate invasive species and prevent their spread?	Assessment has also been undertaken and this is provided as Appendix 8.4: Water Framework Directive Assessment. The Proposed Development has been designed with consideration of the WFD failure status of the lake and has sought to improve both chemical quality and physical modification. The Proposed Development will introduce a single and centralised system of managing water activities and boat launching areas. The proposals will increase the depth of water within sailing zones thereby reducing the effect of boat movements on wave generation and associated shoreline erosion. This will also reduce the potential for fine sediment mobilisation and decrease in water quality. Sailing is mostly in central areas and only near the lake edge at the north east end of the lake. Embedded mitigation measures include the provision of additional in-lake solid and floating islands, together with restoration of marginal and littoral aquatic macrophytes that will also serve to absorb wave energy and reduce erosion to acceptable levels. These measures will also increase wetland habitat provision and extent and when combined with the continued runoff of surface water to the lake and ongoing monitoring and management, wet habitats will be made more resilient. An Invasive Species Management Plan will be implemented and enforced as part of the Lake Management Plan (see Appendix 8.7: Draft Lake Management Plan).
A range of priority habitats and species are present that contribute to the ecological status of the WFD water body.	Long term studies of lake condition have been recommended, in Chapter 7: Biodiversity, using the Common Standards JNCC 2015 method, and carefully planned lake management works to improve the zooplankton and achieve the best water quality possible. For more information, please refer to Chapter 7: Biodiversity, Appendix 8.4: Water Framework

Consultee and Comment	Response
	Directive Assessment and Appendix 8.7: Draft Lake Management Plan.
There is a clear requirement to demonstrate how the project will address on and off-site flood risk and that the works will not affect lake flood water storage capacity. The Flood Risk Assessment should model to both the 1:20 and 1:30 event (new standard that could be in place by the time the works are delivered). The EA Flood Risk Team would be able to review the flood risk modelling work. The Lead Local Flod Authority (LLFA) (and EA) will want to see the proposals relating to safe access/egress from the Site in the event of a flood. A Flood Risk Activity Permit (FRAP) will be required for the demolition of the existing sailing club building. The in-lake works may also require a FRAP if issues are likely to occur to the adjacent Main River (Colne). Canal and Rivers Trust should be contacted for feedback if works will affect the Grand Union Canal.	A detailed Flood Risk assessment (FRA) has been completed which is compliant with NPPF and NPPG. This was used to influence the project design and concludes that there would be no significant change in either on-site or off-site flood risk as a consequence of the Proposed Development. The Proposed Development would also not affect lake flood water storage capacity (only a 0.6 to 0.15cm increase in lake level within a 1 in 100 annual exceedance probability (AEP) fluvial event +20% climate change which is within the capacity of the lake). Please refer to Appendix 8.2: Flood Risk, Drainage and Sequential Assessment for further information. The EA provided its approved hydraulic model of the River Colne (December 2010) to Weetwood in January 2023, and this constitutes the best available information for the area. The December 2010 model that has been referenced in the Flood Risk and Sequential Assessment report (see Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) is therefore the best available information. The 1 in 30 AEP event relates to the revised definition of the functional floodplain within the PPG. This considered not relevant to the assessment of flood risk as the modelled outputs provided by the EA (refer to Figure 6 of the Flood Risk and Sequential Assessment report in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) indicate that the existing peninsula remains flood free in up to a 1 in 1,000 AEP event (a more extreme event), with the 1 in 100 AEP event plus an allowance for climate change utilised to inform mitigation measures. A Flood Warning and Evacuation Plan will be prepared in consultation with LBH. The Site is included in an EA flood alert and warning area.

Consultee and Comment	Response
	This provides the opportunity for the relevant response procedures set out in the plan to be invoked in response to receipt of a flood warning from the EA. The Applicant notes the requirement for FRAPs as required. The Canal and Rivers Trust were consulted during pre-application discussions (as detailed below).
Environment Agency – Meeting Comments from meeting held 28th September 2023	
The Environment Agency raised comments in regard to their review of submitted reports, including the DRAFT Groundwater Risk Assessment. The EA noted that further works are required as the Proposed Development progresses. The EA suggested that the EA National Permitting Team is contacted to open discussion in regard to permit requirements for the proposed works.	These reports have been updated (September 2023), with the updates addressing a number of comments raised by the EA within their letter dated 26th September 2023. The project team recognise that further works will be required as a condition of planning together with continued regulatory discussions with the EA, Local Authority CLO and Affinity Water ahead of the progression of further intrusive site investigation and monitoring works.

EIA Scoping Opinion

8.3.3 A request for a Scoping Opinion was submitted by the Applicant to LBH in February 2023. An EIA Scoping Report (the 'Scoping Report') accompanied the request (Appendix 3.2: EIA Scoping Report (February 2023) and scoping correspondence). A Scoping Opinion was issued by the LBH on 19th May 2023 (Appendix 3.3: LBH EIA Scoping Opinion) which included comments from statutory consultees. Table 8.2 summarises key comments raised by consultees of relevance to this assessment by the EIA Scoping Opinion and how the assessment has responded to them.

Table 8.2: EIA Scoping Opinion Response

Consultee and Comment	Response
Natural England (6 April 2023)	
<u>Water Quality</u> The assessment should take account of the risks of water pollution and how these can be managed or reduced. A number of water dependent protected nature conservation sites have been identified as failing condition due to elevated nutrient levels and nutrient	A wide range of pollution prevention and response proposals are included as embedded measures for both the construction and operational phases of the Proposed Development. The Flood Risk, Drainage and Sequential Assessment (Appendix 8.2: Flood Risk, Drainage and Sequential Assessment)

Consultee and Comment	Response
neutrality is consequently required to enable development to proceed without causing further damage to these sites. The ES needs to take account of any strategic solutions for nutrient neutrality of Diffuse Water Pollution Plans, which may be being developed or implemented to mitigate and address the impacts of elevated nutrient levels. Further information can be obtained from the Local Planning Authority."	describes how foul drainage will be directed to public sewer for appropriate treatment, and surface runoff via appropriate vegetated features into the lake. Please also refer to Appendix 6.1: Outline CEMP for measures designed to minimise / avoid nutrient mobilisation/entry to surface/groundwater, Appendix 7.4: Draft Mitigation and Ecological Management Plan (MEMP) Volume 1 and Appendix 7.5: Draft Mitigation and Ecological Management Plan (MEMP) Volume 2 Parts A-D, Appendix 8.3: Groundwater Risk Assessment and Appendix 8.7: Draft Lake Management Plan for further details.
Climate Change The ES should identify how the development affects the ability of the natural environment (including habitats, species and natural processes) to adapt to climate change, including its ability to provide adaptation for people. This should include impacts on the vulnerability or resilience of a natural feature (i.e., what's already there and affected) as well as impacts on how the environment can accommodate change for both nature and people… Nature-based solutions, such as providing green infrastructure on-site and in the surrounding area (e.g., to adapt to flooding, drought and heatwave events) should be considered. The ES should set out measures that will be adopted to address impacts.	The Proposed Development has evolved through a rigorous process of design iteration informed by site specific information and consultation, adopting wide-ranging sustainability criteria and standards. This includes certain measures associated with flood management and responding to climate change including minimising change in lake volume/capacity during extreme events and retention of water during drought periods, use of suitable naturalised attenuation features/habitats, an increase in vegetation that is suitable for the on shore and in-lake conditions, adoption of suitable design levels for ground and buildings, flood resilience measures associated with buildings, and adoption of a suitable Flood Warning and Evacuation Plan. In particular, please refer to Chapter 7: Biodiversity (including Appendix 7.4: Draft MEMP Vol I and Appendix 7.5: Draft MEMP Vol II), Appendix 8.2: Flood Risk, Drainage and Sequential Assessment and Appendix 8.7: Draft Lake Management Plan.
Environment Agency (30 March 2023)	

Consultee and Comment	Response
Flood Risk As the indicated site is located within Flood Zone 3 you will need to submit a Flood Risk Assessment (FRA) as part of your planning application… In accordance with the NPPF and associated NPPG, a site-specific FRA must clearly demonstrate how you intend to manage flood risk on site to ensure that the proposed development will be safe for its lifetime and that flood risk is not increased on site and elsewhere. As part of your FRA, we would expect you to address the following issues: • Consideration of the level of flood risk and whether the proposed use would be appropriate in accordance with its vulnerability classification. • Identification of the level of flood risk on the site and consideration of the impact a range of flood events would have on the proposed development. • Ensure the correct climate change allowances have been used. • Whether adequate floodplain compensation is required. • Proximity to flood defences (most notably the natural high ground along the west of the site adjacent to the River Colne). Climate Change We would like to see stronger wording and discussion around the impact of climate change.	A detailed and compliant FRA has been completed and used to influence the project design, concluding no significant change in both onsite and off-site flood risk. The FRA considers all requirements listed by the EA in their Scoping Opinion response. For more information, please refer to Appendix 8.2: Flood Risk, Drainage and Sequential Assessment. The Proposed Development has evolved through a rigorous process of design iteration informed by site specific information and consultation, adopting wide-ranging sustainability criteria and standards. This includes certain measures associated with flood management and responding to climate change including minimising change in lake volume/capacity during extreme events and retention of water during drought periods, use of suitable naturalised attenuation features/habitats, an increase in vegetation that is suitable for the on shore and in-lake conditions, adoption of suitable design levels for ground and buildings, flood resilience measures associated with buildings, and adoption of a suitable Flood Warning and Evacuation Plan. In particular, please refer to Chapter 7: Biodiversity (including Appendix 7.4: Draft Mitigation and Ecological Management Plan (MEMP) Volume 1), Appendix 8.2: Flood Risk, Drainage and Sequential Assessment, and Appendix 8.7: Draft Lake Management Plan.
Thames Water (20 March 2023)	
The applicant is advised that their development boundary falls within a Source Protection Zone for groundwater abstraction. These zones may be at particular risk from polluting activities on or below the land surface. To prevent pollution, the EA and Thames Water will use a tiered, risk-based approach to regulate activities that may impact groundwater resources. The applicant	The team has included a range of embedded mitigation measures to mitigate effects on the Source Protection Zone for abstraction. A detailed Groundwater Risk Assessment, following best practice guidance (including that provided by the EA) has been completed and used to influence the project design which concludes that there would be no significant change to groundwater resources. For more information, please refer to Appendix 6.1: Outline

Consultee and Comment	Response
is encouraged to read the EA's approach to groundwater protection.	CEMP, Appendix 8.3: Groundwater Risk Assessment and Appendix 8.7: Draft Lake Management Plan.
The EIA Regulations 2017 set out in Schedule 4 that water and wastewater issues may need to be covered in an EIA. Thames Water consider the following issues should be considered and covered in either the EIA or planning application submission: The developments demand for Sewage Treatment and network infrastructure both on and off site and can be met. The surface water drainage requirements and flood risk of the development both on and off site and can it be met. Build – out/ phasing details to ensure infrastructure can be delivered ahead of occupation. Any piling methodology and will it adversely affect neighbouring utility services.	A detailed and compliant Groundwater Risk Assessment (Appendix 8.3) has been completed and used to influence the project design, concluding no significant change to groundwater resources and potable supply of water. Given the nature of the proposal, the cessation of other LBH activities/demand, and the local catchment of the users, the recreational demand for water is unlikely to result in a significant increase. Clean surface water will re-enter the lake and the in-continuity groundwater. A detailed FRA has also been completed which has informed the project design. For more information, please refer to Appendix 8.2: Flood Risk, Drainage and Sequential Assessment and Appendix 8.7: Draft Lake Management Plan. A Drainage Strategy has been prepared (see Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) which confirms foul waste will be directed to the public sewer for appropriate treatment and that there is sufficient capacity for this Proposed Development (N.B. inputs from the previous LBH outdoor facility will no longer be entering the system). Construction systems will ensure no existing services (considered to be absent) will be affected. Piling is restricted to the perimeter of the proposed land reclamation and therefore in the bed of the former gravel pit where no service runs would be present. Please refer to Chapter 6: Construction for further information.
Arup (on behalf of LBH) (19 May 2023)	
Baseline The baseline should also include a review of the surface water drainage arrangements. Assessment Approach	The baseline conditions section of this chapter includes a review of the current surface water drainage arrangements.

Consultee and Comment	Response
The significance criteria used to assess the potential effects of the development on the receptors should be defined in the methodology clearly defined for all the various receptors. Water quality of runoff generated by proposed development should be assessed in adherence with CIRIA C753 Simple Index Approach. The impact of Climate Change should be fully assessed within the Water Resources chapter, this is of particular importance for the subtopics flood risk and surface water hydrology. As part of this Water Resources chapter, detailed information is required on the dredging of the lake, this should include but is not limited to the volume of fill, where it will be moved to, the composition of the removed material and likely contaminants present. <u>Mitigation Measures</u> Mitigation measures should be identified to reduce the impact of the Proposed Development on water resources and groundwater and identify the resultant significance of the impact. <u>Consultation</u> A summary of the consultation responses should be provided and how these have been addressed and/or responded to within the assessment. Recommended consultees are the Environment Agency, Thames Water and the LLFA.	A detailed Flood Risk, Drainage and Sequential Assessment (Appendix 8.2) has been completed which has informed the project design. Water quality of runoff and the design of the surface water drainage solution (See Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) has drawn on guidance in CIRIA C753 Simple Index Approach. Detailed consideration of the impact of climate change has been considered within the FRA (Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) and the detailed assessment of effects. Consideration of effects on biodiversity and water dependant habitats forms part of Chapter 7: Biodiversity. Lake bed sampling and laboratory analysis has been completed to inform the project design and impact assessment. Information on this can be found in Appendix 8.3: Groundwater Risk Assessment and the proposed dredging procedure, volumes, sources and receptor locations in the detailed scheme design and construction methodology (Chapter 5: Description of Development and Chapter 6: Construction). A Draft Lake Management Plan incorporating all embedded water – related mitigation/compensation/enhancement measures have been produced (see Appendix 8.7: Draft Lake Management Plan), which has informed the assessment of residual effects. Addressed by Tables 8.1 and 8.2.

Summary of Assessment Scope

8.3.4 As outlined within the EIA Scoping Report (Appendix 3.2: EIA Scoping Report (February 2023) and scoping correspondence), and as agreed with the LBH and the EA via the EIA Scoping Opinion (Appendix 3.3: LBH EIA Scoping Opinion), the scope of the water resources and flood risk assessment within this chapter is limited to the following assessment of effects:

Construction

8.3.5 Construction phase effects (including enabling/ preparatory works) includes consideration of those elements of the associated water environment (both on Site, downstream and in hydrological continuity) that could be directly or indirectly affected by the Proposed Development.

8.3.6 The assessment will consider the following potential effects:

- Changes to surface water drainage, runoff, and associated flood risk from construction activity;
- Flood risk to construction activity from fluvial and surface water sources;
- Accidental pollution and contamination of surface water, lake sediment and connected groundwater/source protection zone from construction activities, including nutrients;
- Change in lake water quality associated with works to re-distribute lake sediment and form more optimal bathymetry for both the SSSI features of interest and the wider lake ecology;
- Change in surface water flow paths from construction and the construction of new infiltration features and lake dredging could introduce new pathways from the surface water environment to groundwater and vice versa;
- Change in lake morphology (dredging and land reclamation) and associated implications for water resources (including on water-dependant ecology); and
- Implications arising from climate change.

Completed Development

8.3.7 The assessment of the completed Proposed Development will consider a range of potential operational effects on the sensitive receptors, taking into account the scoping opinion and further stakeholder feedback, as set out below:

- Changes to site drainage, site runoff and the risk of increasing flood risk on site and to downstream receptors;
- Changes in the risk of on-site flooding associated with fluvial, surface water and groundwater sources;
- Changes in the risk of water pollution from the operation of the site to surface and groundwaters, including from site surface water drainage and foul waste, and the potential for increasing nutrient contributions to associated water dependent habitats;
- Changes to the hydrological and hydrogeological aspects of the natural environment's ability to adapt to climate change; and
- Implications associated with existing potable and foul water infrastructure, capacity and supply.

Non-Significant Effects

8.3.8 All other water resources and flood risk effects were scoped out of further assessment within this ES. See Section 6 of the EIA Scoping Report (Appendix: 3.2: EIA Scoping Report (February 2023) and scoping correspondence) for further details and justification.

Study Area

8.3.9 The study area for the Proposed Development has been established considering both good practice and the location and nature of the Proposed Development. The study area is considered to be the hydrological and hydrogeological 'Zone of Influence' (ZoI). The ZoI has been defined by the WFD units in which the Site is located and interacts with through direct pathways and linkages.

8.3.10 Broadwater Lake is a surface waterbody (Lake) under the WFD reference GB30641907. It is located adjacent to the River Colne (Confluence with Chess to the River Thames) WFD reference GB106039023090 and the Grand Union Canal, a Canal under the WFD reference GB70610252. Broadwater Lake is associated with the Thames River Basin District.

8.3.11 Broadwater Lake is located over, and likely is in continuity with the Mid-Chilterns Chalk Groundwater Body reference GB40601G601200.

8.3.12 The hydrological ZoI has been defined on the basis that there are direct pathways from the Site into the Colne Confluence with Chess to River Thames unit. The Grand Union Canal WFD unit is also included as work associated with an existing gantry over the Canal and adjacent to Broadwater Lake form part of the Proposed Development. The surface water body WFD units provide a thorough definition of the potential ZOI linking sources within the Site to these receptors, via flow pathways. These receptors are shown on Figure 8.1 together with the wider hydrological units/catchment.

8.3.13 The hydrogeological ZoI has been defined as the Mid-Chilterns Chalk Groundwater Body and associated Principal Aquifer beneath the Site. It includes the area beneath the Site and extends to groundwater abstraction at West Hyde Pumping Station G1 operated by Affinity Water some 1280m northwest. The groundwater body provides a thorough definition of the potential ZoI linking sources within the development area, via flow pathways to potential receptors situated downstream and off-site. These are shown on Figure 8.2.

Figure 8.1: Surface Water Zone of Influence

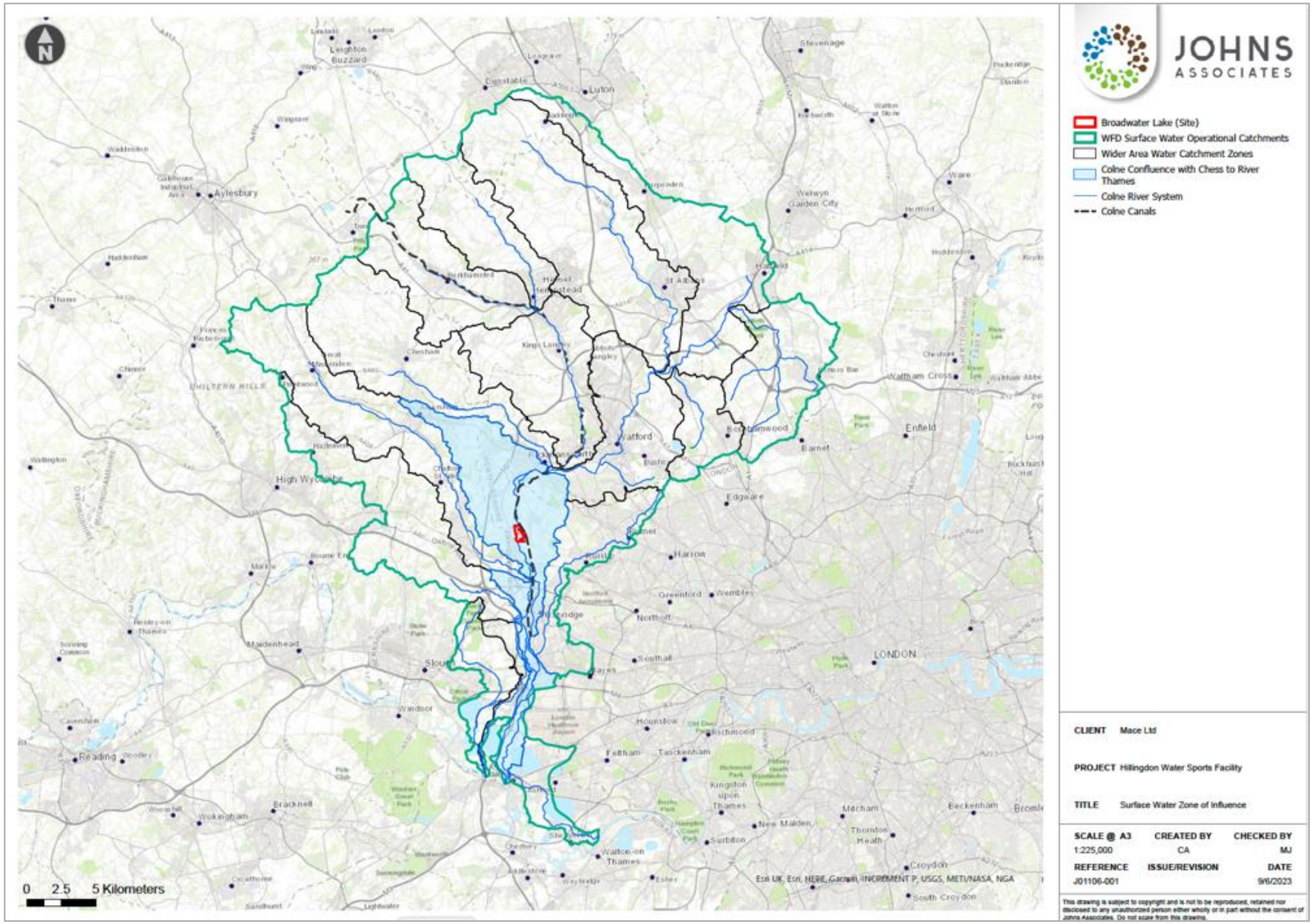
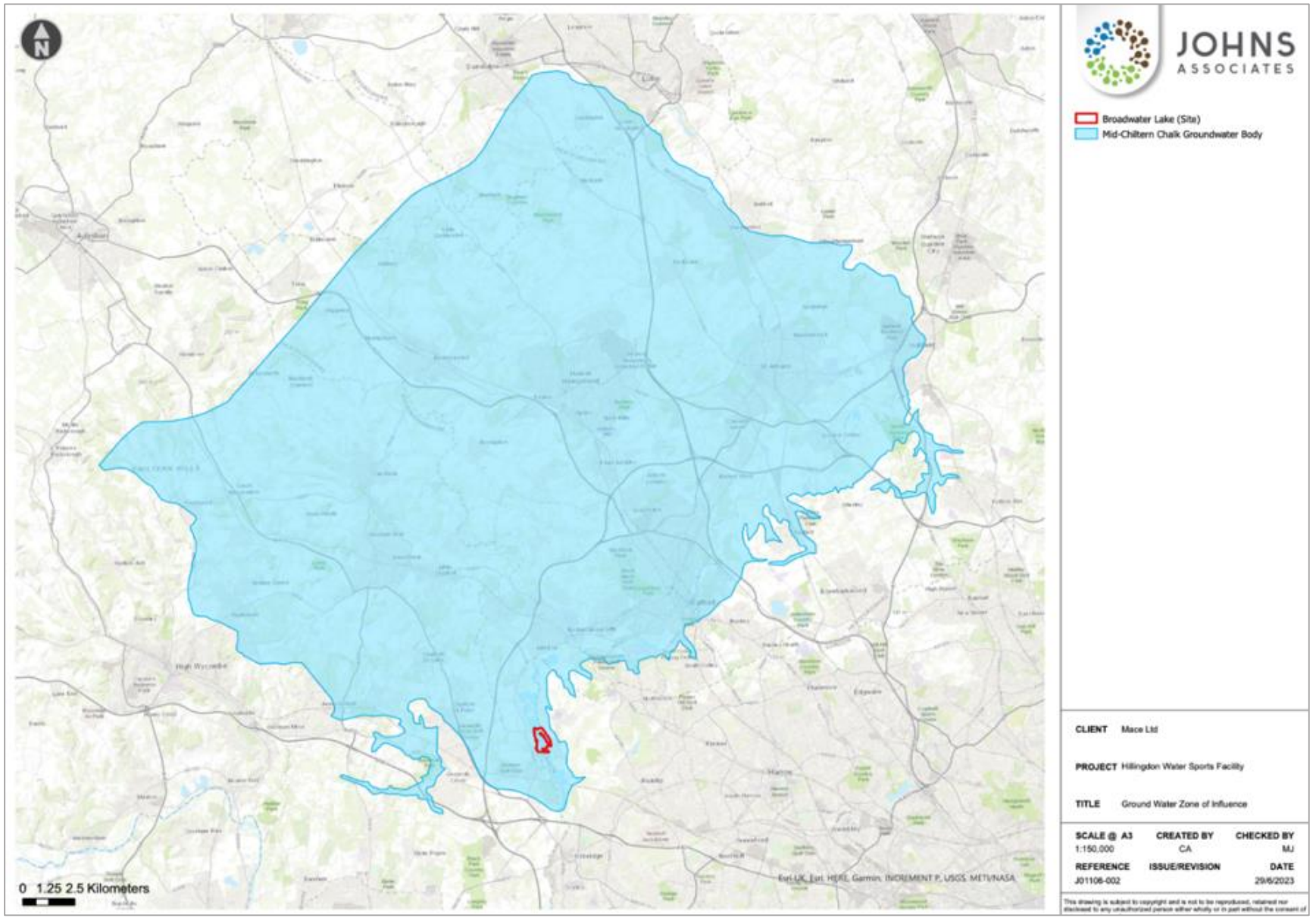


Figure 8.2: Groundwater Water Zone Influence



Establishing Baseline Conditions

8.3.14 The existing water environment baseline has been established through the following:

- Review of data provided by Groundsure Enviro-Geo Insight 2023 report reference GS-9256809 – Appendix 9.1: Relevant Planning Policy.
- EA catchment data explorer[40].
- Flood Risk Assessment (including calculation of surface water runoff and associated attenuation requirements and allowances for climate change) completed by Weetwood Ltd 2023– See Appendix 8.2: Flood Risk, Drainage and Sequential Assessment.
- Surface and Foul Water Drainage Strategy completed by Weetwood Ltd 2023 – see Appendix 8.2: Flood Risk, Drainage and Sequential Assessment.
- Groundwater risk assessment conducted by Hydrogeo Ltd 2023 – See Appendix 8.3: Groundwater Risk Assessment.
- Water Framework Directive Assessment completed by Johns Associates 2023 – see Appendix 8.4: Water Framework Directive Assessment.
- Water quality profiling conducted by Johns Associates in 2023 – see Appendix 8.5: Lake Water Column Profiles.
- Water quality sampling carried out by GEA Ltd in 2022 – see Appendix 8.6: Bathing Water Assessment.
- Sediment sampling and analysis of samples completed by Johns Associates and HydroGeo Ltd in 2023 – see Appendix 8.3: Groundwater Risk Assessment.
- Hydromorphology (from desk-based information and site-based assessments by Johns Associates and integrated within the various elements of Section 8.4).
- Bathymetric surveys by Survey Solutions in 2021 – included within the FRA (Appendix 8.2: Flood Risk, Drainage and Sequential Assessment).
- Thames river basin district river basin management plan: updated 2022 (UK Gov. 2022. Available at https://www.gov.uk/guidance/thames-river-basin-district-river-basin-management-plan-updated-2022 and accessed 12/9/23.
- Engagement with stakeholders in 2023 (e.g., Natural England, EA, London Borough of Hillingdon).

Assessing Likely Significant Effects

Construction

8.3.15 In terms of the surface water environment the assessment of likely significant effects associated with the construction phase has been largely based on professional judgement, based on experience and the use of best practice guidance (such as that published by CIRIA, Defra, the EA and the LLFA, including those listed in Section 8.2).

8.3.16 The assessment has been informed by detailed plans and assessments relating to the water environment which are located in the Appendices of this chapter of the ES.

8.3.17 Mitigation measures have been ‘embedded’ within the construction phase of Proposed Development (wherever possible), as well as carefully defined design principles of green/

blue infrastructure, landscaping, sustainable drainage and access. Full details are provided in Section 8.5 of this chapter.

8.3.18 An FRA has been prepared in accordance with LLFA, NPPF and EA requirements and has assessed all relevant sources of flood risk. The assessment relating to flood risk associated with the construction phase presented within this chapter draws upon the studies and conclusions made within the FRA which is provided as Appendix 8.2: Flood Risk, Drainage and Sequential Assessment to this ES chapter.

8.3.19 The assessment of construction phase impacts is also based on existing water quality and flow data provided by the EA and LLFA and water and sediment sampling and analysis.

8.3.20 The WFD assessment includes an assessment of the effects of the construction phase of the Proposed Development on various waterbody WFD quality criteria in relation to the main river that borders the Site, the groundwater underlying and in continuity with the Site and the adjacent Grand Union Canal.

8.3.21 A groundwater risk assessment has been completed to inform the assessment of construction related effects within this chapter of the ES. It has considered the potential that groundwaters (including aquifers and abstractions) are connected via the underlying gravels at Broadwater Lake and whether the construction phase activities could mobilise contaminants to these receptors and/or cause a change in water levels in the lake/ aquifer recharge if bed impermeable layers are breached or other surface flow paths modified. This has been informed by a review of relevant data and lake/ sediment monitoring.

8.3.22 Future baseline conditions have been predicted, taking into account the likely impacts of climate change on river flows and flood levels.

8.3.23 There is no standard guidance in place for the assessment of the potentially significant effects on the water environment from developments of this type. Based on professional judgement, the technical guidance referred to in Section 8.2, and experience of other similar schemes, a qualitative assessment of the potential effects on surface and ground water quality and resources has been undertaken.

8.3.24 With reference to best practice (i.e., those set out in Section 8.2) mitigation measures have been identified to manage and control works during construction. Water related licences/ consents/ permits that may be required for construction of the Proposed Development have also been set out.

8.3.25 The construction programme is to be confirmed but is likely to comprise a 14-month programme with an anticipated completion date in 2025 (see Chapter 6: Construction).

Completed Development

8.3.26 The assessment of likely significant effects associated with the operational phase has been largely based on professional judgement, based on experience and the use of best practice guidance (i.e., those set out in Section 8.2).

8.3.27 The assessment has been informed by detailed plans and details relating to the water environment. A Flood Risk, Drainage and Sequential Assessment (Appendix 8.2), Groundwater Risk Assessment (Appendix 8.3), Water Framework Directive risk

assessment (Appendix 8.4), Draft Lake Management Plan (Appendix 8.7). A Draft Mitigation and Ecological Management Plan (MEMP) has also been prepared and informs this assessment (this can be found in Appendix 7.4 and 7.5).

8.3.28 Mitigation measures have been 'embedded' within the Proposed Development, layout and operational procedures (wherever possible), as well as carefully defined design principles of green/ blue infrastructure, landscaping, sustainable drainage and access. Full details are provided in Section 8.5 below.

8.3.29 An FRA has been prepared by Weetwood Ltd in accordance with LLFA, NPPF and EA requirements and has assessed all relevant sources of flood risk taking into account climate change allowances. The assessment relating to flood risk presented within this chapter draws upon the studies and conclusions made within the FRA which is provided as Appendix 8.2: Flood Risk, Drainage and Sequential Assessment to this ES chapter. The FRA determines whether the operational development will be impacted by flooding (and associated future influences from climate change) and whether, in turn, adjacent properties will be impacted as a result of the Proposed Development during a flood event. It also provides recommendations for mitigating measures to alleviate the impact of flooding. The modelling study has also been used to inform the proposed ground and building floor levels across the Proposed Development.

8.3.30 The assessment is informed by existing water quality and flow data provided by the EA and LLFA (see Appendix 8.2: Flood Risk, Drainage and Sequential Assessment and Appendix 8.3: Groundwater Risk Assessment) and water and sediment sampling and analysis enabled by Johns Associates Ltd and HydroGeo Ltd.

8.3.31 The WFD assessment includes an assessment of the effects of the Proposed Development on various waterbody WFD quality criteria in relation to the main river that borders the Site, the groundwater beneath and in continuity with the Site and the adjacent Grand Union Canal.

8.3.32 A groundwater risk assessment has been completed to inform the assessment of operational related effects of the Proposed Development. The GRA has considered the potential that groundwaters (including aquifers and abstractions) are connected via the underlying gravels at Broadwater Lake and whether the operational phase activities could mobilise contaminants to these receptors and/or cause a change in water levels in the lake/ aquifer recharge if bed impermeable layers are breached or other surface flow paths modified. This has been informed by a review of relevant data and lake sediment and water column sampling.

8.3.33 Future baseline conditions have been predicted, taking into account the likely impacts of climate change on river flows, flood levels groundwater conditions and management of the Grand Union Canal.

8.3.34 With reference to best practice (i.e., as set out in Section 8.2) additional mitigation measures have been identified to manage and control works during the operational phase. Water related licences/ consents/ permits that may be required for operation of the Proposed Development have also been set out.

8.3.35 Operational activities will not commence until completion of the construction programme.

Cumulative Effects

8.3.36 The cumulative assessment of the water environment considers the cumulative schemes identified in Appendix 3.2: EIA Scoping Report (February 2023) and scoping correspondence. The cumulative assessment considered the same potential likely significant effects (where possible and where necessary information was available) as identified for the Proposed Development in Section 8.3.6 and 8.3.7 of this chapter. This assessment has been informed by a review of the planning application documentation for each cumulative scheme.

Determining Effect Significance

8.3.37 The EIA Regulations recognise that different developments will affect different environmental receptors, and the level of the impacts will also differ. Not all of these are of sufficient concern to warrant detailed investigation or assessment through the EIA process.

8.3.38 The EIA Regulations do not define significance; therefore, it is necessary to state how this will be established for the EIA. The significance of an effect resulting from a development is most commonly assessed with reference to the sensitivity/ value of a given receptor and the magnitude of change resulting from the Proposed Development. This allows areas where mitigation may be required to be identified, and to identify appropriate measures to alleviate the risk presented by the Proposed Development. This chapter of the ES will use this approach, and the effects of the Proposed Development on the water environment are evaluated assuming that the embedded environmental measures identified in Section 8.5 are fully implemented.

8.3.39 In terms of the water environment, the assessment of significance is largely based on professional judgement, experience, and the use of best practice guidance including DMRB[i]. The key assessment criteria for sensitivity and magnitude will relate to the surface water, groundwater and flood risk. In terms of more detail relating to ecology, where detailed assessments have been conducted, please refer to Chapter 7: Biodiversity.

Sensitivity of Receptor

8.3.40 The basis for assessing water environment receptor sensitivity is set out in Table 8.3.

Table 8.3: Receptor Sensitivity Descriptors

Value (Sensitivity)	Descriptor	Receptor Type	Examples
Very High	Feature with a high quality and rarity at an international or national scale with little potential for substitution.	Aquatic environment	Conditions supporting sites with international conservation designations (SACs, SPAs, Ramsar sites), where the designation is based specifically on aquatic features or where these are essential in supporting the designated features. Conditions supporting sites with national conservation designations (i.e., SSSI, National Nature Reserves (NNR))

[i] E.g., Design Manual for Roads and Bridges (DMRB) LA113 Road Drainage and the Water Environment (Highways England, 2020) (henceforth referred to as HD45/09).

Value (Sensitivity)	Descriptor	Receptor Type	Examples
			where the designation is based specifically on aquatic features or where these are essential in supporting the designated features. Receptor water body: all relevant WFD supporting elements (All biological quality elements e.g., fish, invertebrates etc.; All physio-chemical quality elements e.g., dissolved oxygen, phosphate etc.; and Hydro-morphological supporting elements) at least good status/ potential.
		Flood risk	Land use types defined as 'Essential Infrastructure' (i.e., critical national infrastructure) of 'Highly Vulnerable) in the NPPF flood risk vulnerability classification. For the purposes of this assessment this is considered to include all mainline railways and strategic roads managed by Highways England.
		Groundwater quality	Conditions supporting groundwater fed (Groundwater dependent terrestrial ecosystems – GWTDE) sites with international conservation designations (Special areas of Conservation (SACs), Special Protection areas (SPAs), Ramsar sites), where the designation is based specifically on water (or water dependent) features.
		Water resources	Regionally important public water supplies. SPZ1
High	Feature with a medium yield and/or quality at a local scale or good quality at a local scale, with some potential for substitution.	Aquatic environment	Sites with local conservation designations where the designation is based specifically on aquatic features or where these are essential in supporting the designated features. Species are protected under EU/UK legislation. Receptor water body: all relevant WFD elements at moderate or less status/potential.

Value (Sensitivity)	Descriptor	Receptor Type	Examples
		Flood risk	Land use types defined as 'More Vulnerable' in the NPPF flood risk vulnerability classification. For the purposes of this assessment this is considered to include residential housing, schools, hospitals, and all minor roads maintained by Buckinghamshire County Council.
		Groundwater quality	GWDTEs with local conservation designations where the designation is based on water features. Receptor groundwater body (chemical and/ or quantitative status) at least moderate status/potential.
		Water resources	Locally important public water supplies Supports a GWDTE and/or river ecosystem Un-licensed potable private domestic water supplies. SPZ2
Medium	Feature with a lower yield and/ or quality at a local scale, with some potential for substitution.	Aquatic environment	Small watercourses not classified as a WFD river water body.
		Flood risk	Land use types defined as 'Less Vulnerable' in the NPPF flood risk vulnerability classification. For the purposes of this assessment this is considered to include commercial/retail buildings and any agricultural land or buildings.
		Groundwater quality	Receptor groundwater body at less than moderate status/potential. Small groundwater fed watercourses not classified as a WFD water body.
		Water resources	Licensed abstractions which are not public water supply, e.g., industrial process water, for agriculture, spray irrigation.
Low	Feature with minimal yield and/or low quality at a local scale, with a high potential for substitution.	Aquatic environment	Minor water features such as ditches, not classified as a WFD river water body.
		Flood risk	Land use types defined as 'Water-compatible Development' in the NPPF flood risk vulnerability classification and undeveloped land.
		Groundwater quality	Receptor groundwater body at poor status/potential. Minor water features such

Value (Sensitivity)	Descriptor	Receptor Type	Examples
			as ditches, not classified as a WFD water body.
		Water resources	Unproductive strata

Magnitude of Impact

8.3.41 The next step is to assess the magnitude of change to each sensitive receptor arising from the Proposed Development as defined in Table 8.4.

Table 8.4: Magnitude of Impact Descriptors

Impact Magnitude	Descriptor	Receptor type	Examples of negative change
Major adverse	Results in loss/major change to feature, of sufficient magnitude to affect its use/integrity.	Surface Water	Failure of both acute-soluble and chronic-sediment related pollutants and compliance failure with EQS values. Risk of pollution from a spillage ≥2% annually. Loss or extensive change to a fishery. Deterioration in river flow regime, morphology or water quality, leading to sustained, permanent or long-term breach of relevant conservation objective (COs) or downgrading of WFD status (including downgrading of individual WFD supporting elements).
		Flood risk	Change in flood risk resulting in potential loss of life or major damage to property and infrastructure.
		Groundwater	Loss of, or extensive change to, an aquifer. Loss of regionally important water supply. Potential high risk of pollution to groundwater from routine runoff. Risk of pollution from spillages ≥2% annually. Loss of, or extensive change to GWDTE or baseflow contribution to protected surface water bodies. Reduction in water body WFD classification. Loss or significant damage to major structures through subsidence or similar effects.
Moderate adverse	Results in noticeable change to feature of sufficient magnitude to	Surface Water	Failure of both acute-soluble and chronic-sediment related pollutants in HEWRAT but compliance with EQS values. Risk of pollution from spillages ≥1% annually and <2% annually. Partial loss in productivity of a fishery.

Impact Magnitude	Descriptor	Receptor type	Examples of negative change
	affect its use/integrity in some circumstances.		Degradation of regionally important public water supply or loss of major commercial / industrial/agricultural supplies. Deterioration in river flow regime, morphology or water quality leading to periodic, short-term and reversible breaches of relevant COs, or downgrading of WFD status (including downgrading of individual WFD supporting elements or ability to achieve future WFD objectives).
		Flood risk	Change in flood risk resulting in potential for moderate damage to property and infrastructure.
		Groundwater	Partial loss or change to an aquifer. Degradation of regionally important public water supply or loss of significant commercial/ industrial/ agricultural supplies. Potential medium risk of pollution to groundwater from routine runoff Partial loss of the integrity of GWDTE. Contribution to reduction in water body WFD classification. Damage to major structures through subsidence or similar effects or loss of minor structures.
Minor Adverse	Results in minor change to feature, with insufficient magnitude to affect its use/integrity in most circumstances.	Surface Water	Failure of either acute soluble or chronic sediment related pollutants. Risk of pollution from spillages ≥0.5% annually and < 1% annually. Minor effects on water supplies. Measurable deterioration in river flow regime, morphology or water quality, but remaining generally within COs, and with no change to WFD status (of overall status or supporting element status).
		Flood risk	Change in flood risk resulting in potential for minor damage to property and infrastructure.
		Groundwater	Potential low risk of pollution to groundwater from routine runoff. Risk of pollution from spillages ≥0.5% annually and <1% Annually. Minor effects on an aquifer, GWDTEs, abstractions and structures. Minor reduction in resource availability and/or quality, but unlikely to affect the ability of water users to exercise licensed rights.

Impact Magnitude	Descriptor	Receptor type	Examples of negative change
Negligible	Results in no change to feature, with insufficient magnitude to affect its use/integrity.	Surface Water	No risk identified (both acute-soluble and chronic-sediment related pollutants). Risk of pollution from spillages <0.5%. No measurable deterioration in river flow regime, morphology or water quality and no consequences in terms of COs or WFD designations.
		Flood risk	No increase in frequency of flood flows, and no increase in risk to people, property and infrastructure.
		Groundwater	No measurable impact upon an aquifer and/or groundwater receptors and risk of pollution from spillages <0.5%. No measurable change in resource availability or quality and no change in ability of water users to exercise licensed rights.
Minor beneficial	Results in some beneficial effect on attribute or reduced risk of negative effect occurring	Surface water	Either acute soluble or chronic-sediment related pollutants becomes acceptable from an existing site where the baseline was a fail condition. Reduction in existing spillage risk by 50% or more (when existing spillage risk is <1% annually).
		Groundwater	Reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually). Reduction of groundwater hazards to existing structures. Reductions in waterlogging and groundwater flooding.
		Flood risk	Creation of flood storage and decrease in peak flood level (> 1 0mm).
Moderate beneficial	Results in moderate improvement of attribute quality	Surface water	Both acute-soluble and chronic-sediment related pollutants becomes acceptable from an existing site where the baseline was a fail condition. Reduction in existing spillage by 50% or more (when existing spillage risk >1% annually). Contribution to improvement in water body WFD classification.
		Groundwater	Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually). Contribution to improvement in water body WFD classification.

Impact Magnitude	Descriptor	Receptor type	Examples of negative change
			Improvement in water body catchment abstraction management Strategy (CAMS) (or equivalent) classification. Support to significant improvements in damaged GWDTE.
		Flood risk	Creation of flood storage and decrease in peak flood level1 (> 50mm).

Assessing Significance

8.3.42 Table 8.5 indicates how the level of effect will be categorised from the interaction of a receptor's sensitivity and the magnitude of change. In terms of the EIA Regulations, a level of effect of Very Large, Large or Moderate or greater are considered 'significant'. A Very Large or Large effect would trigger the need for further consideration, identification of a Moderate effect requires the application of professional judgement to ascertain the need for further measures. This serves as a precautionary approach for highly sensitive receptors and ensures that the embedded measures are robust in managing the degree of change. Where a level of effect is minor or negligible, these are typically considered to be 'Not Significant'.

8.3.43 For consistency, the following terms have been used when describing effects:

- Adverse: Detrimental or negative effect to an environmental resource or receptor;
- Negligible: No significant effect to an environmental resource or receptor; and
- Beneficial: Advantageous or positive effect to an environmental resource or receptor.

8.3.44 Following their identification, significant beneficial or adverse effects must be classified based on their nature and duration as follows:

- Temporary: Effects that persist for a limited period only (due, for example, to particular activities taking place for a short period of time);
- Permanent: Effects that result from an irreversible change to the baseline environment (e.g., land-take) or which will persist for the foreseeable future (e.g., noise from regular or continuous operations or activities);
- Direct: Effects that arise from the effect of activities that form an integral part of the scheme (e.g., direct employment and income generation);
- Indirect: Effects that arise from the effect of activities that do not explicitly form part of the scheme (e.g., off-site infrastructure upgrades to accommodate the development);
- Secondary: Effects that arise as a consequence of an initial effect of the scheme (e.g., induced employment elsewhere); and
- Cumulative: Effects that can arise from a combination of different effects at a specific location or the interaction of different effects over different periods of time.

8.3.45 In the context of the Proposed Development, short (up to 18 months duration) to medium (up to 36 months duration) term effects are generally determined to be those associated

with construction activities, and the long-term effects are those associated with the completed and occupied development.

Table 8.5: Significance of Effect Matrix

	Magnitude of Impact				
Sensitivity/Value of Receptor	No change	Negligible	Minor	Moderate	Major
Very High	Neutral	Minor	Moderate or Large	Large or very Large	Very Large
High	Neutral	Minor	Minor Moderate	Moderate or Large	Large or Very Large
Medium	Neutral	Negligible or Minor	Minor	Moderate	Moderate or Large
Low	Neutral	Neutral or Minor	Neutral or Minor	Minor	Minor or Moderate
Negligible	Neutral	Minor	Neutral or Minor	Neutral or Minor	Minor

Assumptions and Limitations

8.3.46 The following assumptions and limitations apply to the assessments set out in this Chapter of the ES:

- Water quality data has been collected at several different locations in Broadwater Lake and on different single sampling occasions. These are assumed to represent typical conditions across the lake and at different time of the year.
- The assessment of construction related effects on surface and groundwater and flood risk are based on the most intensive construction period and the construction methodology set out in Chapter 6: Construction, which would be in Year One of construction where lake-bed dredging coincides with land reclamation and onshore land-based construction.
- The assessment is based on reasonable assumptions regarding dredging and construction methods, based on information provided by the project team. Further refinement in this would be provided by contractors once appointed.
- The assessment of operational related activities on water resources and flood risk are based on the busiest period of facility usage where maximum occupancy occurs during a period of prolonged rainfall (generating the highest levels of foul waste and surface water runoff).
- It is assumed that the embedded/integrated mitigation measures set out in this chapter of the ES will be implemented in full and will be in place throughout the construction and operational periods.
- It is assumed that suitable monitoring will occur during construction and operational activities allowing positive and reactive management adjustments to be made to rectify and resolve and unforeseen negative effects from the Proposed Development. This is set out in the Outline CEMP (Appendix 6.1) and the Draft MEMP (Appendix 7.4 Volume 1 and 7.5 Volume 2 Parts A-D).

8.4 Baseline Conditions

Location, Topography and Land-Use

8.4.1 The Site lies approximately 5km north of Uxbridge town, within the London Borough of Hillingdon and within the Colne Valley Regional Park. South Harefield village lies to the east of the Site, immediately beyond the Grand Union Canal. The Site extends to 79.95 hectares and is situated within the Metropolitan Green Belt.

8.4.2 The majority of the Site (which is 79.9 ha in total) comprises Broadwater Lake, a 62.9 ha body of water with several small islands bordered by trees and scrub. The south of the lake includes an area of peninsula land ("the peninsula" - 16.151 ha) formerly utilised as a gravel washing/processing plant with a silt lagoon and a tip for inert quarry wastes. Since the quarry was decommissioned the silt lagoon, peninsula edges and small areas of remaining natural ground have colonised with native broadleaf woodland comprised of pioneer and wetland species (alder, silver birch, willows). There is also an area of separate standing water (referred to as "the lagoon") to the east of the peninsula within the Site.

8.4.3 Various structures remain on-site at the peninsula and in the surrounding area relating to aggregate extraction including a weighbridge, aggregate hoppers and pad foundations. The Site includes several small buildings including a single storey club house located on the northern shore of the lake which is currently used by the Broadwater Sailing Club (BSC).

8.4.4 Broadwater Lake is used for angling by the Gerrards Cross and Uxbridge District Angling Society and British Carp Study Group. The Site includes a small parcel of land immediately north of Moorhall Road (referred to as the "south parcel") comprising a mixture of grassland, shrub, hedgerows and scattered trees, and a parcel of land to the east (referred to as the "east parcel") comprising woodland, and a single carriageway brick and iron bridge across the Grand Union Canal. An unnamed single carriageway road provides access to the Site from Moorhall Road.

8.4.5 A topographic survey of the Site has been undertaken by Three Sixty Group and LiDAR data has been used to develop a digital terrain model of the Site and surrounding area. This can be found in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment. Flood Risk and Sequential Assessment. Site levels on the peninsula are shown to be in the region of 36.9 - 40.6 m AOD. Ground levels on the existing unnamed access road are in the region of 37.2 - 38.8 m AOD, with levels on Moorhall Road between 37.0 - 40.4 m AOD within the vicinity of the Site.

Geology – Solid and Drift Geology

8.4.6 The British Geological Survey (BGS) Geology of Great Britain Viewer shows that at a 1:50,000 scale the Site is underlain by Seaford chalk formation and Newhaven chalk formation (undifferentiated). This sedimentary bedrock was formed approximately 72 – 89 million years ago in the Cretaceous Period and comprises chalk with subsidiary calcareous mudstone and flint.

8.4.7 At the same scale, the Site is also shown to be overlain by Superficial Deposits. Also known as 'drift', these are the youngest geological deposits, formed up to 3 million years ago during the Quaternary Period. They rest on older deposits (the bedrock). For the Site itself, two Superficial Deposits are listed: Shepperton gravel member (gravel with subsidiary clay and sand) and alluvium (a general term for clay, silt, sand and gravel. It is the unconsolidated

detrital material deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope).

Artificial Geology

8.4.8 The Site is mapped as underlain by undivided worked ground. This is as a result of the Broadwater Lake area being formed through the surface excavation for sands and gravels historically. There are also areas across the Site which are mapped as infilled ground. These areas have been proven by a ground investigation undertaken by Geo-Integrity Site Investigation[41] in 2023 which has identified inert anthropogenic materials present in made ground soils.

8.4.9 The Geo-Integrity Site Investigation (2023 investigation has confirmed that the made ground thickness reaches a maximum of 3.45m within BH4. Further information on the site investigation and ground conditions is provided in Chapter 9: Ground Conditions and Contamination , Appendix 9.1: Relevant Planning Policy and Appendix 9.2: Geo-Integrity Phase I Geo-Environmental Assessment and Site Walkover September 2023.

Groundwater

8.4.10 This section provides a summary description of the groundwater conditions. Further information is available in Appendix 8.3: Groundwater Risk Assessment and Chapter 9: Ground Conditions and Contamination.

Aquifer Characteristics

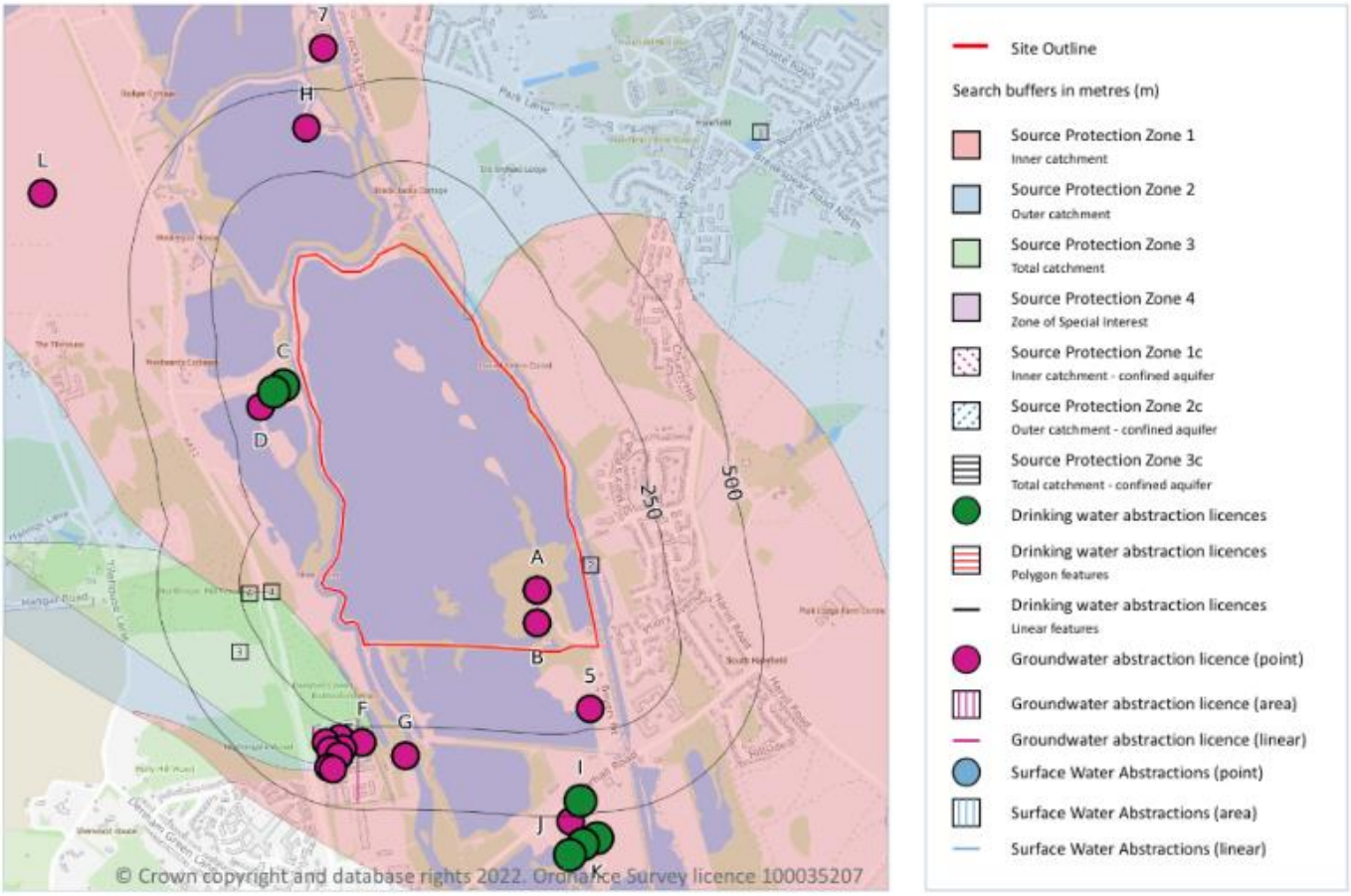
8.4.11 The Aquifer Designation Map (Bedrock)[42] is based on geological mapping provided by the BGS and shows that the Site is classified as a Principal Bedrock Aquifer (previously known as ‘Major Aquifers’). Principal Aquifers have a geology of high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/ river base flow on a strategic scale.

8.4.12 The Superficial Drift Aquifer Designation Map shows the Site being designated as a Secondary An Aquifer. Secondary A aquifers comprise permeable layers that can support local water supplies and may form an important source of base flow to rivers.

8.4.13 The Site is situated across two Source Protection Zones (SPZ): Type 1 (Inner Catchment, or SPZ1) which have a 50-day travel time of pollutant to source; and Type 2 (Outer

Catchment, or SPZ2) which have a 400-day travel time of pollutant to source. This is shown on Figure 8.3 (Source: Groundsure report reference GS-9256809).

Figure 8.3: Groundwater Source Protection Zones and Boreholes



8.4.14 Broadwater Lake is located over, and likely is in continuity with the Mid-Chilterns Chalk Groundwater Body reference GB40601G601200. Its most recent WFD (2019) Overall Rating is Poor, Chemical rating is Poor and Quantity rating is Poor. Objectives include achieving 'Good' classification for Chemical classification by 2027. For more information relating to the WFD, please refer to Appendix 8.4: Flood Risk, Drainage and Sequential Assessment.

Groundwater Vulnerability

8.4.15 The Groundsure Enviro-Geo Insight report (reference GS-9256809, obtained in 2023) (Appendix 9.1: Relevant Planning Policy) details the groundwater vulnerability of the Site and surrounding area. This assesses the vulnerability of groundwater to a pollutant discharged at ground level based on the hydrological, geological, hydrogeological and soil properties within a 1km grid square. The Groundsure Report reference: GS9256809 obtained to inform this chapter of the ES shows that features found within the Site include:

- Principal Bedrock Aquifer – High Vulnerability (Combined Classification: Productive Bedrock Aquifer, Productive Superficial Aquifer);
- Secondary Superficial Aquifer – High Vulnerability (Combined Classification: Productive Bedrock Aquifer, Productive Superficial Aquifer); and

- Principal Bedrock Aquifer – Medium Vulnerability (Combined Classification: Productive Bedrock Aquifer, Productive Superficial Aquifer).

8.4.16 High vulnerability is described as: areas able to easily transmit pollution to groundwater. They are likely to be characterised by high leaching soils and the absence of low permeability superficial deposits. Medium vulnerability is described as: intermediate between high and low vulnerability (where low vulnerability is defined as areas that provide the greatest protection from pollution, likely to be characterised by low-leaching soils and/or the presence of superficial deposits characterised by a low permeability).

Levels and Flow

8.4.17 The desk-based information reviewed (see Appendix 8.3: Groundwater Risk Assessment and Chapter 9: Ground Conditions and Contamination) indicates the presence of shallow groundwater within 2m below ground level. Borehole records indicate the presence of groundwater strikes at 1.2mbgl and 1.8mbgl respectively, with a single, minor groundwater level rise to rest from 1.8mbgl to 1.2mbgl.

8.4.18 Groundwater levels were encountered during the 2023 Phase 2 Geo-integrity Site Investigation works in the majority of exploratory positions, with groundwater strikes recorded during the drilling works between 1mbgl and 4.9mbgl, with rest water levels between 1.2mbgl and 4.6mbgl. Subsequent groundwater monitoring progressed between 9th March 2023 and 29th March 2023 within the standpipes installed at BH3, BH6 and BH9 recorded groundwater levels between 0.75m and 2.39m. Please refer to the 2023 Phase 2 Geo-integrity Site Investigation report for further details and plans showing sampling locations. The FRA for the Proposed Development (Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) highlights that the entire site is classified as High Risk for groundwater flooding, so these groundwater levels are not surprising and may even fluctuate to shallower levels over time.

8.4.19 From the Geo-integrity groundwater monitoring rounds, the groundwater flow direction has been determined to the south, which corresponds to the direction of the River Colne. The Site is mapped by the BGS within Map 14, Cambridge – Maidenhead 1:100,000Hydrogeological Sheet Map. This indicates that the regional groundwater flow direction based on the contours of the potentiometric surface of the underlying chalk is to the south east. More locally, based on the findings of the Geo-integrity 2023 groundwater monitoring rounds, the groundwater flow direction has been determined to the south, which corresponds to the direction of the River Colne.

Licenced Abstractions

8.4.20 There are a number of licensed groundwater abstractions mapped on-Site and within the immediate vicinity of the Site (a search within 2000m was made through the Groundsure Insight reporting service (report ref GS-9256809). 2no. On-site abstraction licenses pertain to the historical mineral extraction and concrete production operations across the Site, with the Applicant providing Hydrogeo with the EA documentation. The available information confirms that the original abstraction license was granted in March 1966, with another license granted in May 2006. The original 1966 abstraction license covered abstraction from 2no. points (Point A and B) for flow rates of 37.89l/s (litres per second) and 4.92l/s respectively. The abstraction points were located at NGRs: TQ 0470 8910 and TQ 0470 8920, respectively. These two abstractions are believed to be active but no longer in use. The Applicant advised that they have been unable to identify any active boreholes across the Site area at the time of reporting.

8.4.21 Affinity Water is licensed to abstract 88 million litres per day (Ml/d) from the underlying Chalk aquifer as part of the Blackford Group license. The Northmoor boreholes are the closest and located between 64m and 149m to the west and northwest of the Site. Affinity Water can abstract up to 37 Ml/day from these boreholes. Affinity Water Blackford boreholes and pumping station is located approximately 500m west of the Site.

Surface Water Features and Hydrology

8.4.22 All water bodies within the study area, except for the Grand Union Canal, fall entirely within the Colne catchment which itself is within the Thames River Basin District (RBD) as set out in the Thames River Basin Management Plan (RBMP).

8.4.23 The majority of the Site comprises a waterbody (Broadwater Lake) within the River Colne floodplain. Formed as a result of gravel extraction, Broadwater Lake is one of over 60 such waterbodies throughout the wider Mid-Colne Valley that together form a complex of wetland features and as such, many of these are likely to be in hydrological continuity with one another.

8.4.24 Broadwater Lake is bordered to the west and north by the River Colne, (Main River), and the Grand Union Canal is located to the east. Other former gravel pits/ sand pits are situated immediately to the north and south, with a narrow terrestrial perimeter forming the lake/ river shore and canal embankment.

8.4.25 A summary of the surface water features potentially affected by the Proposed Development is provided below:

- Broadwater Lake;
- River Colne; and
- Grand Union Canal.

Broadwater Lake Morphology (bathymetry and shape)

8.4.26 A review of data obtained from the Groundsure Insight Report (reference GS-9256809 dated 13/12/22) states that the 1865 County Series Ordnance Survey (OS) map shows the Site as part of an area referred to as Harefield Moor and of a series of field parcels separated by ditches and sluices, with the River Colne to the west and the Grand Union Canal to the east. The 1974 – 1976 OS 1:10,000 maps show the first phase of sand and gravel extraction extending across some two thirds of the Site. By 2001, the OS 1:10,000 map shows the majority of the Site (Broadwater Lake area) having been worked for sand and gravel (now completed), flooded and the lake being present, together with 30 islands of varying sizes.

8.4.27 APEM were commissioned by the ALIGN Joint Venture (ALIGN JV), to undertake a hydrographic survey of specified sections of Broadwater Lake (Align report ref 1MC05-ALJ-EV-REP-CS01_CL01-000178). The bathymetric survey showed the lake to have an undulating bed profile, typically ranging between 1 m to 3m, which is a relic of gravel extraction from the lakebed. The deepest area, in the survey area was observed toward the northwestern extent of the survey area where depths were approaching 5 m to 6 m.

8.4.28 Bathymetric data obtained for the purposes of the Proposed Development can be found within the FRA (Appendix 8.2: Flood Risk, Drainage and Sequential Assessment, of this Chapter of the ES). This broadly concurs with the APEM report and observations made on site in 2023 by Johns Associates.

8.4.29 The lake is artificial in form, but has naturalised somewhat since being flooded with small patches of marginal vegetation scattered along parts of the shoreline and associated with islands. Water Framework Directive

8.4.30 A summary of the issues relevant to the WFD which could be affected by the Proposed Development is set out below. Further information about the waterbodies is set out in Appendix 8.4: Water Framework Directive Assessment.

Water Framework Directive Baseline and Objectives

8.4.31 Please refer to the WFD Assessment for full details, which can be found in Appendix 8.4: Water Framework Directive Assessment.

Broadwater Lake Surface Water Body

8.4.32 Broadwater Lake is an artificial surface water body (Lake) under the WFD reference GB 3064 1907. It has a surface area of 33.985ha (so not the total area of Broadwater Lake surface water) and a total catchment area of 72,443.5ha. The most recent data from the EA from 2019 shows that their overall WFD rating is Moderate, Chemical rating is Fail and Ecological rating is Moderate.

8.4.33 The objectives for the Lake are shown below (EA Catchment Explorer – accessed 09/23).

Figure 8.4: Broadwater Lake EA Objectives

Objectives

Classification Item	Status	Year	Reasons
Ecological	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Biological quality elements	**Not assessed**	2015	
Physico-chemical quality elements	**Not assessed**	2015	
Hydromorphological Supporting Elements	**Supports good**	2015	
Hydrological Regime	**Supports good**	2015	
Supporting elements (Surface Water)	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Expert Judgement	**Good**	2015	
Mitigation Measures Assessment	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Specific pollutants	**Not assessed**	2015	
Chemical	**Good**	2063	Natural conditions: Chemical status recovery time; Technically infeasible: No known technical solution is available
Priority hazardous substances	**Good**	2063	Natural conditions: Chemical status recovery time; Technically infeasible: No known technical solution is available
Benzo(a)pyrene	**Good**	2015	
Dioxins and dioxin-like compounds	**Good**	2015	
Heptachlor and cis-Heptachlor epoxide	**Good**	2015	
Hexabromocyclododecane (HBCDD)	**Good**	2015	
Hexachlorobenzene	**Good**	2015	
Hexachlorobutadiene	**Good**	2015	
Mercury and Its Compounds	**Good**	2015	
Perfluorooctane sulphonate (PFOS)	**Good**	2039	Technically infeasible: No known technical solution is available
Polybrominated diphenyl ethers (PBDE)	**Good**	2063	Natural conditions: Chemical status recovery time
Priority substances	**Good**	2015	
Fluoranthene	**Good**	2015	
Other Pollutants	**Does not require assessment**	2015	

8.4.34 The Chemical Fail rating is as a result of Perfluorooctane Sulphonate (PFOS) associated with no-stick coatings, and polybrominated diphenyl ethers (PBDE) associated with flame retardants.

8.4.35 The hydromorphological elements are considered capable of supporting Good condition, and the hydrological regime is also able to support Good condition (see Figure 8.3: Bathymetric Surveys).

8.4.36 Reasons for not achieving good (RNAG) are PBDE and PFOS and physical modification.

Mid-Chilterns Chalk Groundwater Body

8.4.37 The Site is also located over, and likely is in continuity with, the Mid-Chilterns Chalk Groundwater Body (GB40601G601200), which covers an area of 72,974.352ha. In 2019 this groundwater body was classified as Poor overall, Poor for Chemical and Poor for Quantity. Reasons for not achieving Good are given as:

- Diffuse source pollution from agriculture and land management (poor nutrient management);
- Diffuse source pollution from urban and transport sources (contaminated land);
- Point source pollution from urban and transport sources (private sewage treatment);
- Point source pollution from the water industry (continuous sewage discharge); and
- Effects on flow due to groundwater abstraction by the water industry.

8.4.38 The objectives for the water body are shown below (EA Catchment Explorer accessed 09/23).

Figure 8.5: Mid-Chilterns Chalk Groundwater Body EA Objectives

Objectives

Classification Item	Status	Year	Reasons
Overall Water Body	**Poor**	2015	Disproportionately expensive: Disproportionate burdens; Disproportionately expensive: Unfavourable balance of costs and benefits
Quantitative	**Poor**	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Quantitative Status element	**Poor**	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Quantitative Dependent Surface Water Body Status	**Poor**	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Quantitative GWDTEs test	**Good**	2015	
Quantitative Saline Intrusion	**Good**	2015	
Quantitative Water Balance	**Poor**	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Chemical (GW)	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Chemical Status element	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Chemical Dependent Surface Water Body Status	**Good**	2015	
Chemical Drinking Water Protected Area	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Chemical GWDTEs test	**Good**	2015	
Chemical Saline Intrusion	**Good**	2015	
General Chemical Test	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens

8.4.39 Reasons for not achieving good (RNAG) are poor nutrient management, contaminated land, private sewage treatment, incidents, sewage discharge and groundwater abstraction.

Colne (Chess to Thames Confluence) Waterbody

8.4.40 The Site is also located adjacent to the Colne (GB106039023090), which covers a length of 51.489km. In 2019 this groundwater body was classified as Moderate overall, Moderate for Ecology and Fail for Chemical. Reasons for not achieving Good are given as:

- Diffuse source pollution from urban and transport sources (contaminated land);
- Point source pollution from general domestic public mis-connections;
- Point source pollution from the water industry (continuous sewage discharge);
- Point source pollution from the water industry (intermittent sewage discharge);
- Point source pollution from urban and transport sources (private sewage treatment);
- Physical modification associated with local and central government;
- Physical modification associated with recreation;
- Physical modification associated with urbanisation;
- Contamination by polybrominated diphenyl ethers (PBDE);
- Natural – drought; and
- Effects on flow due to groundwater abstraction by the water industry.

8.4.41 The objectives for the waterbody are set out below (EA Catchment Explorer accessed 09/23).

Figure 8.6: Colne (Chess to Thames Confluence) Waterbody EA Objectives

Classification Item	2019
Ecological	**Moderate**
Biological quality elements	**Moderate**
Fish	**Good**
Invertebrates	**High**
Macrophytes and Phytobenthos Combined	**Moderate**
Macrophytes Sub Element	**Moderate**
Physico-chemical quality elements	**Moderate**
Acid Neutralising Capacity	**High**
Ammonia (Phys-Chem)	**High**
Dissolved oxygen	**High**
Phosphate	**Poor**
Temperature	**Good**
pH	**High**
Hydromorphological Supporting Elements	**Supports good**
Hydrological Regime	**Does not support good**
Supporting elements (Surface Water)	**Moderate**
Mitigation Measures Assessment	**Moderate or less**
Specific pollutants	**High**
Arsenic	**High**
Copper	**High**
Iron	**High**
Manganese	**High**
Permethrin	**High**
Triclosan	**High**
Zinc	**High**

Chemical	**Fail**
Priority hazardous substances	**Fail**
Benzo(a)pyrene	**Good**
Cadmium and Its Compounds	**Good**
Dioxins and dioxin-like compounds	**Good**
Heptachlor and cis-Heptachlor epoxide	**Good**
Hexabromocyclododecane (HBCDD)	**Good**
Hexachlorobenzene	**Good**
Hexachlorobutadiene	**Good**
Hexachlorocyclohexane	**Good**
Mercury and Its Compounds	**Good**
Nonylphenol	**Good**
Perfluorooctane sulphonate (PFOS)	**Fail**
Polybrominated diphenyl ethers (PBDE)	**Fail**
Tributyltin Compounds	**Good**
Trifluralin (Priority hazardous)	**Good**
Priority substances	**Good**
1,2-dichloroethane	**Good**
Atrazine	**Good**
Cypermethrin (Priority)	**Good**
Fluoranthene	**Good**
Lead and Its Compounds	**Good**
Nickel and Its Compounds	**Good**
Pentachlorophenol	**Good**
Simazine	**Good**
Trichlorobenzenes	**Good**
Trichloromethane	**Good**
Other Pollutants	**Good**
Aldrin, Dieldrin, Endrin & Isodrin	**Good**
Carbon Tetrachloride	**Good**
DDT Total	**Good**
Tetrachloroethylene	**Good**
Trichloroethylene	**Good**
para - para DDT	**Good**

Other Pollutants	**Good**	2015	
Aldrin, Dieldrin, Endrin & Isodrin	**Good**	2015	
Carbon Tetrachloride	**Good**	2015	
DDT Total	**Good**	2015	
Tetrachloroethylene	**Good**	2015	
Trichloroethylene	**Good**	2015	
para - para DDT	**Good**	2015	

8.4.42 Reasons for not achieving 'Good' (RNAG) are urbanisation, misconnections, sewage discharge (continuous and point), private sewage treatment, unknown (PFOS), physical modification, drought, and groundwater abstraction.

Grand Union Canal, Maple Lodge to Uxbridge (Rivers Colne and Chess plus canal) Water Body (Grand Union Canal)

8.4.43 The Site is also located adjacent to the Grand Union Canal (Rivers Colne and Chess plus canal Water Body (GB70610252), which covers a length of 11.197km. In 2019 this groundwater body was classified as Moderate overall, Moderate for Ecology and Fail for Chemical. Reasons for not achieving Good are given as:

- Diffuse source pollution from urban and transport sources (Urbanisation);
- Point source pollution from urban and transport sources (private sewage treatment);
- Point source pollution from the water industry (intermittent and continuous sewage discharge);
- Point source pollution from misconnections associated with public general domestic sources;
- Unknown sources/sector releasing polybrominated diphenyl ethers (PBDE); and
- Physical modification associated with recreation.

8.4.44 The objectives for the waterbody are set out below (EA Catchment Explorer accessed 09/23).

Figure 8.7: Grand Union Canal, Maple Lodge to Uxbridge (Rivers Colne and Chess plus canal) Water Body (Grand Union Canal) EA Objectives

Classification Item	Status	Year	Reasons
Ecological	**Moderate**	2015	Disproportionately expensive: Disproportionate burdens; Disproportionately expensive: Unfavourable balance of costs and benefits
Biological quality elements	**Not assessed**	2015	
Physico-chemical quality elements	**Moderate**	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Acid Neutralising Capacity	**Good**	2015	
Ammonia (Phys-Chem)	**Good**	2015	
Dissolved oxygen	**Good**	2015	
Phosphate	**Poor**	2015	Disproportionately expensive: Unfavourable balance of costs and benefits
Temperature	**Good**	2015	
pH	**Good**	2015	
Hydromorphological Supporting Elements	**Not assessed**	2015	
Supporting elements (Surface Water)	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Mitigation Measures Assessment	**Good**	2027 - Low confidence	Disproportionately expensive: Disproportionate burdens
Specific pollutants	**High**	2015	
Arsenic	**High**	2015	
Chromium (VI)	**High**	2015	
Copper	**High**	2015	
Iron	**High**	2015	
Zinc	**High**	2015	
Chemical	**Good**	2063	Natural conditions: Chemical status recovery time
Priority hazardous substances	**Good**	2063	Natural conditions: Chemical status recovery time
Benzo(a)pyrene	**Good**	2015	
Cadmium and Its Compounds	**Good**	2015	
Dioxins and dioxin-like compounds	**Good**	2015	
Heptachlor and cis-Heptachlor epoxide	**Good**	2015	
Hexabromocyclododecane (HBCDD)	**Good**	2015	
Hexachlorobenzene	**Good**	2015	
Hexachlorobutadiene	**Good**	2015	
Mercury and Its Compounds	**Good**	2015	
Perfluorooctane sulphonate (PFOS)	**Good**	2015	
Polybrominated diphenyl ethers (PBDE)	**Good**	2063	Natural conditions: Chemical status recovery time
Priority substances	**Good**	2015	
Atrazine	**Good**	2015	
Fluoranthene	**Good**	2015	
Lead and Its Compounds	**Good**	2015	
Nickel and Its Compounds	**Good**	2015	
Simazine	**Good**	2015	
Other Pollutants	**Does not require assessment**	2015	

8.4.45 Reasons for not achieving 'Good' are urbanisation (phosphate), private sewage treatment (phosphate), sewage discharges (phosphate), misconnections (phosphate), other (recreation) and unknown (PBDE).

River Basin Management Plan

8.4.46 The Site falls within the Thames RBMP area, which covers an area of 16,133km^2 from the source of the River Thames in Gloucestershire through London to the North Sea. Dominated by Greater London, the eastern and northern parts of the river basin district are heavily urbanised, whereas the area to the west of London has considerable areas of rural land.

8.4.47 The Thames RBD is one of the driest in the UK with rainfall levels below the national average. The River Thames is an important water source, providing two-thirds of London's drinking water. Groundwater is very important providing around 40% of public water supplies, with chalk forming the predominant aquifer. Current assessments show that groundwater is fully used over much of the Thames RBD. Therefore, it is essential to maintain and improve the quantity and quality of groundwater.

8.4.48 The RBMP states that the significant management issues for the District include:

- Abstraction and other artificial flow regulation;
- Negative effects from invasive non-native species (INNS);
- Organic pollution;
- Pesticides;
- Phosphate;
- Physical modification;
- Sediment;
- Pollution from towns, cities and transport; and
- Chemicals (including priority hazardous substances, priority substances and specific pollutants).

8.4.49 Additionally, taking account of climate change is considered a significant water management issue.

8.4.50 The Site is situated within the Colne Catchment, which forms part of the Thames River Basin District. The RBMP states:

"The Colne catchment is dominated by its chalk streams and rivers. Many of these streams emerge from the areas surrounding the Chilterns Hills, which is designated an Area of Outstanding Natural Beauty (AONB).

The wetland resource of the Colne Valley is recognised at both European and national level by the South West London Water Bodies Special Protection Area (SPA) and the Mid-Colne Valley Site of Special Scientific Interest. These provide important sites for the feeding and roosting of wintering wildfowl.

The Grand Union Canal interacts with the Rivers Bulbourne, Gade and Colne and leads to stretches of these watercourses being considered as heavily modified.

Generally, water quality is moderate but can be influenced by factors such as rural and agricultural run-off, interactions with the canal network and pollution incidents. River modifications including over-widening, channel and bank engineering works and poor maintenance have also affected water quality. These issues have all had an impact on fish species and other wildlife currently found.

Climate change and future demands for water will almost certainly increase the pressure on water resources in these chalk streams and rivers. Low flows continue to be an issue which is exacerbated by abstraction pressures. This has influenced the diversity of the plants and invertebrates found."

Surface Water Quality Data

8.4.51 The EA and the Department for Environment and Rural Affairs (DEFRA) Online Water Quality Archive[2] indicates a sampling location (TH-PGWL0196) within Broadwater Lake, at NGR 504591 189093. 6No. samples have been collected 30th October 2019 – 26th April 2022, with 8No. chemical determinants measured (colour, conductivity, alkalinity, phosphorus, chlorophyll, nitrogen, orthophosphate and nitrogen total oxidised). This is reproduced below in Table 8.6.

Table 8.6: EA Water Quality Data

Notation	Determinant	Units	30 Oct 2019 09:51	5 Dec 2019 11:14	14 Sep 2021 11:59	12 Oct 2021 12:44	9 Feb 2022 13:19	26 Apr 2022 10:18
0072	Colour, Filtered	Hazen	7.9	6.3	11	8.9		23
0077	Conductivity at 25 C	µs/cm	563	594	466	488	542	
0162	Alkalinity to pH 4.5 as CaCO3	mg/l	140	150	95	120	140	
0348	Phosphorus, Total as P	mg/l	0.093	0.062	0.72	0.18	0.037	
7887	Chlorophyll: Acetone Extract	µg/l	3.6	0.63	230	47		13
9686	Nitrogen, Total as N	mg/l	2.3	2	5.8	0.92	1.1	
9856	Orthophosphate, filtered as P	mg/l	0.082	0.051	0.077	0.14	0.0042	
9943	Nitrogen, Total Oxidised, Filtered as N	mg/l	0.43	0.73	0.11	0.19	0.2	

[2] https://environment.data.gov.uk/water-quality/view/landing accessed 21/05/23.

8.4.52 In summary, these data show:

- A general upward trend in the colouration of the water – potentially influenced by the timing of the samples and abundance of phytoplankton.
- Relatively consistent level of conductivity suggesting no notable inputs of solute loads.
- Alkalinity/pH in 2019, 2020 were considered typical for this type of water body, but showed a drop in 2021 increasing a reduced ability to buffer acidity, before returning to near 2019 levels (increased buffering capacity) in 2022.
- Total phosphorous levels have declined since 2019.
- Chlorophyll levels have been variable – potentially reflecting the timing of samples and abundance of phytoplankton in the water column.
- Total nitrogen levels are broadly similar between 2019 and 2022, but increase in 2021.
- Othophosphate levels are broadly similar between 2019 and 2022, but increase in 2021.
- Total oxidised nitrogen levels have reduced between 2019 and 2021, with a slight rise in 2022.

8.4.53 Common Standards Monitoring Guidance for Freshwater Lakes, (JNCC, 2015) Table 17, highlights generic total phosphorous targets for lakes. Taking a precautionary approach of comparing the highest maximum annual mean total phosphorous target of 50 ug P L^{-1} or 0.005 mg L^{-1} for a eutrophic very shallow lake, it is clear that the indicative total phosphorous levels recorded by the EA between 2019 to 2022 exceeded this by at least an order of magnitude. Sources of phosphate within the lake that could contribute to these exceedances include: faeces and urine from birds and fish, lake bed sediment (e.g. from organic rich deposits in shallow areas either disturbed from wave action or if warmed in summer months), and nutrient rich rivers during flood events. Total phosphorus levels are not considered to be generally acceptable.

8.4.54 WFD UK TAG (2008) Table 18 highlights generic total nitrogen targets for lakes. It sets out that annual mean total nitrogen should not exceed 1.5 mg L^{-1}. Total nitrogen in Broadwater Lake recorded by the EA between 2019 and 2022 lie slightly above this up this in 2019, have an exceedance in September 2021, but fall below this threshold later in 2021 and 2022 and should be considered to be generally acceptable.

8.4.55 Johns Associates undertook water quality measurements (temperature, pH, turbidity, electrical conductivity, dissolved oxygen) at 1m intervals through the water column at a number of locations on 19th January 2023. The photic depth beyond which photosynthesis is unlikely to occur was also measured using a secchi disc. The results from this survey are set out in detail in Appendix 8.5: Lake Water Column Profiles but demonstrated (at the time of sampling) that the lake is well mixed, had good levels of dissolved oxygen, relatively low turbidity, moderate electrical conductivity (as expected from a chalk catchment), a typically alkaline pH and light penetrates at least 2m through the water column.

8.4.56 Recent water quality sampling (for microbial and certain water quality parameters relating to use for water sport activity) taken from the south east margins of Broadwater Lake by Geotechnical and Environmental Associates (GEA) Ltd[43] in August 2022 show that the

results were generally found to meet the EC Bathing Water Directive (76/160/EEC and 2006/7/EC), with the exception of the concentration of Enterococci within the sample collected from Location No 1, which was classified as 'Poor (fail)'. None of the samples were found to contain salmonella, and all six samples were found to meet the requirements of the EC Bathing Water Directive (76/160/EEC and 2006/7/EC), with the exception of the concentration of Entercocci within the sample collected from Location No 1, which was classified as 'Poor (fail)'. All six samples were found to meet the World Health Organisation (WHO) guidance values[44] with respect to blue-green algae (cyanobacteria). The concentration of Clostridium perfringens recorded in one sample is considered to be elevated with respect to the adopted threshold for faecal coliforms, of 200 colony-forming units per 100ml. The EA's Catchment Data Explorer for the River Colne identifies that sewage from continuous and intermittent discharges are a reason for not achieving good status under the WFD.

Groundwater Quality Data

8.4.57 As part of the Geo-Integrity 2022 Phase 2 Site Investigation (Appendix 9.2: Geo-Integrity Phase I Geo-Environmental Assessment and Site Walkover September 2023), leachate tests were progressed on 2no. made ground samples captured from TP1 and TP2 and 0.5mbgl. The screening of the leachate results indicated marginally elevated levels of chromium, copper, nickel, lead and zinc when compared to the EQS values for freshwater, however when compared to UK Drinking Water Standards (UKDWS) none were significantly elevated.

8.4.58 Groundwater samples taken from BH3, BH6 and BH9 were tested and indicated marginally elevated concentrations of heavy metals including copper, manganese and nickel. All other chemical determinants were present at concentrations below either the Laboratory Level of Detection (LoD) or the respective Screening Criteria (Environmental Quality Standard). The exceedances are shown in Table 8.7.

Table 8.7: Summary of Groundwater Exceedances

Heavy Metal	Recorded Value Range (µg/)	Number of Exceedances	EQS Freshwater (µg/l)	UK DWS (µg/l)
Copper	<0.5 – 1.80	1	1 (bioavailable)	2000
Manganese	150 – 760	3	123 (bio	50
Nickel	3.2 – 4.8	2	4 (bioavailable)	20

Lake Sediment Quality

8.4.59 Lake sediment samples have been captured across Broadwater Lake and issued to an accredited laboratory facility for testing against a suite of chemical determinants (refer to Appendix 8.3: Groundwater Risk Assessment for details of the Lake Bed Sediment Analysis). In total, 20no. samples were captured from across Broadwater Lake, with all samples tested for a range of chemical determinants including:

- pH;
- Available phosphorus;
- Available potassium;
- Available magnesium;

- Potentially Toxic Elements – including copper, zinc, nickel, zinc, cadmium. Lead, chromium, mercury, molybdenum, selenium, arsenic, fluoride
- Conductivity;
- Organic matter loss on ignition;
- Total phosphorus;
- Total potassium;
- Total magnesium;
- Total calcium;
- Total sodium;
- Total carbon; and
- Total sulphur.

8.4.60 Potentially toxic elements (PTEs) tested for within the lake sediment samples included copper, zinc, nickel, zinc, cadmium. Lead, chromium, mercury, molybdenum, selenium, arsenic and fluoride. Screening of the laboratory chemical concentrations against the Category 4 Screening Levels (C4SL) screening criteria associated with human health did not identify any exceeding concentrations of potentially toxic elements across all 20no. lake sediment samples. Further detail on the methods used and results can be found in Appendix 8.3: Groundwater Risk Assessment and Appendix 8.7: Draft Lake Management Plan .

8.4.61 Screening of the potentially toxic element concentrations against the EA Ecological Soils Screening Values (SSVs) indicated several exceeding concentrations for cadmium, nickel and zinc. All other chemical determinants screened against the EA SSVs remain below the SSV concentration criteria. The soil chemical laboratory results included as Appendix 8.7: Draft Lake Management Plan, present the findings of the screening against the maximum permissible concentrations of the PTEs in arable/grassland soil. These screening values are derived from DEFRAs Code of Practice for Agricultural Use of Sewage Sludge[45].

Discharges of Water

8.4.62 There are no formal current discharges of water to or from Broadwater Lake. It is understood that during periods of high flow in the River Colne, fluvial water flows through sub-surface riparian gravel in the northern parts of Broadwater Lake (associated with the sailing club) and enters the lake (anecdotal evidence, LBH) but not via overbank flooding.

Flood Risk and Drainage

8.4.63 A FRA has been produced for the Proposed Development and is contained in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment to this chapter. It provides further baseline detail and key elements from the FRA are summarised here.

Historical Records of Flooding

8.4.64 The EA Historic Flood Map (refer to extract in Figure 3 associated with Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) and interactive web mapping for the 2018 SFRA (“Fluvial and Tidal Flood Risk”) indicate that there are no records of flooding at the

Site; however, there is a small, isolated area to the north of the Site which is indicated to have experienced flooding in 1987 as a result of channel exceedance.

Flood Risk from Rivers (Fluvial)

8.4.65 The River Colne is located to the north and west of the Site which is designated by the EA as a main river.

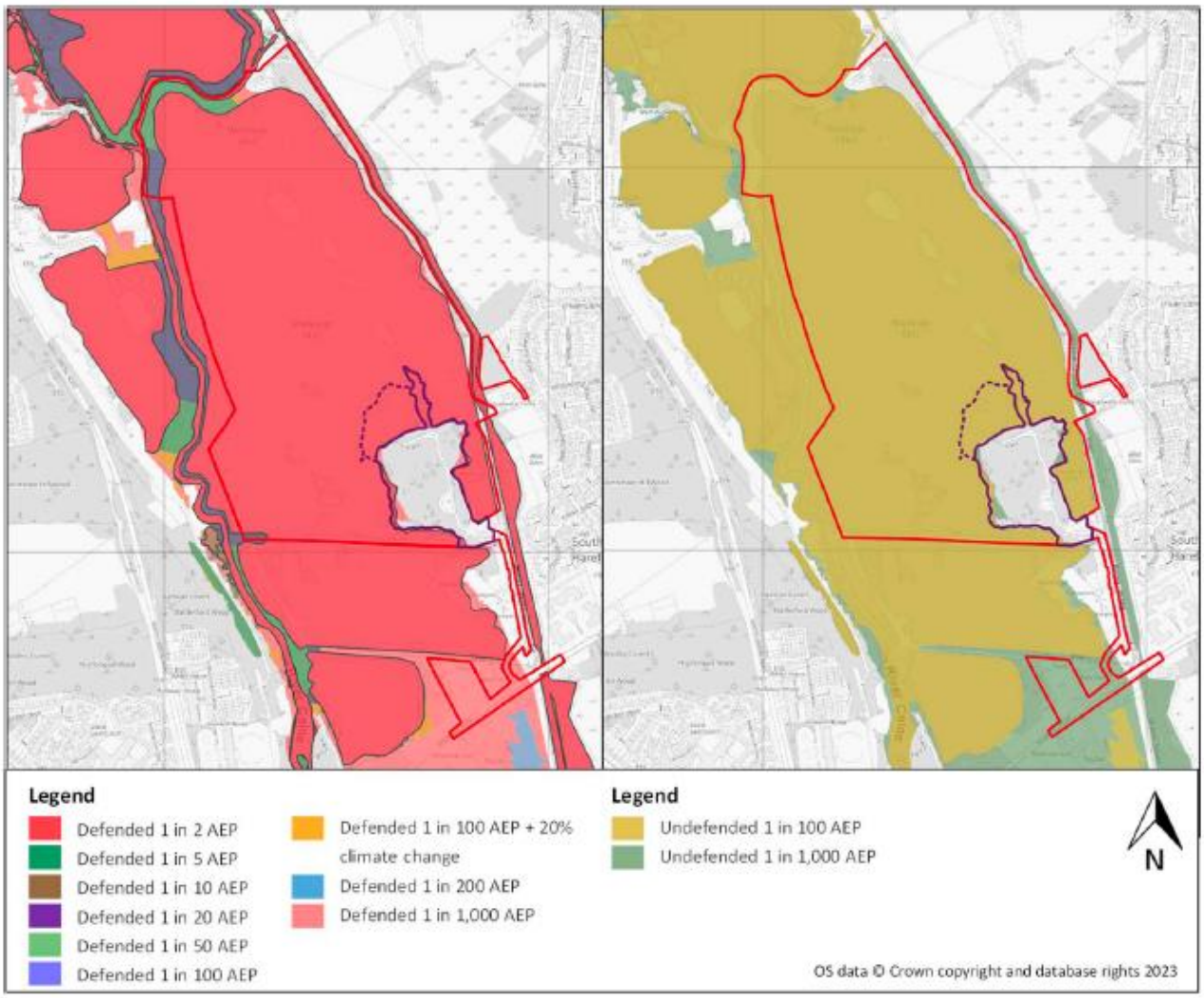
8.4.66 Flood Map for Planning (Rivers and Sea) (Refer to Figure 4 associated with Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) indicates the Site to be located primarily within Flood Zone 3; however, part of the existing unnamed access road and the south parcel are in Flood Zone 2, whilst the peninsula (excluding the northern island) and the east parcel are in Flood Zone 1. This is reiterated on the interactive web mapping for the 2018 Strategic Flood Risk Assessment ("Fluvial and Tidal Flood Risk").

8.4.67 The National PPG associated with flood risk defines Flood Zones within the vicinity of the Site as follows:

- Flood Zone 1: Low Probability. Land having a less than 1 in 1,000 annual probability of river flooding
- Flood Zone 2: Medium Probability. Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding
- Flood Zone 3a: High Probability. Land having a 1 in 100 or greater annual probability of river flooding
- Flood Zone 3b: Functional Floodplain. Land where water from rivers or the sea has to flow or be stored in times of flood. Land having a 1 in 30 or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively or land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as a 1 in 1,000 annual probability of flooding).

8.4.68 Flood Zone 3b is not separately distinguished on the Flood Map for Planning. The West London SFRA[46] (2018) defines Flood Zone 3b (the functional floodplain) as *"land within Environment Agency fluvial and tidal flood risk extents predicted for up to and including a 1 in 20-year return period events allowing for the impact of flood defences"*. As detailed in Section 4.2 and illustrated below in Figure 8.8, Broadwater Lake is at risk of flooding during a (defended) 1 in 2 Annual Exceedance Probability (AEP) event and as such this part of the Site may be defined as Flood Zone 3b.

Figure 8.8: River Colne Modelled ~ Flood Extents. Source: Upper Colne Flood Risk Mapping Study, EA December 2010.



8.4.69 The Flood Zones do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding.

8.4.70 There are no flood defences located within the vicinity of the Site.

8.4.71 A 1D ISIS hydraulic model of the Upper Colne was developed as part of the EA Upper Colne Flood Risk Mapping Study[47] (December 2010). In areas where complex floodplain flow paths were expected or where a high density of properties were at risk of flooding, the floodplain was modelled in 2D TUFLOW. This was not the case within the vicinity of the Site and as such 1D peak in-channel water levels were used for the purpose of flood mapping, with Broadwater Lake represented in the hydraulic model as a 'reservoir unit'.

8.4.72 The model assesses the risk of flooding from the River Colne for a range of events including the present day (defended) 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100, 1 in 200, and 1 in 1,000 AEP events and the 1 in 100 AEP event +20% climate change. The present day 1 in 100 and 1 in 1,000 AEP events were also assessed for the undefended scenario. These are set out in Table 8.8.

Table 8.8: River Colne Modelled Peak In-channel Water Levels

Model Node	AEP Event Water Level (m AOD)					
	Defended			Undefended		
	Present day 1 in 100	1 in 100 +20% climate change	Present day 1 in 1,000	Present day 1 in 100	1 in 100 +20% climate change*	Present day 1 in 1,000
UCL70_4423	37.83	37.89	38.23	37.84	37.90	38.24
UCL70_4318	37.67	37.73	38.17	37.68	37.74	38.18
UCL70_4214	37.51	37.58	38.13	37.52	37.59	38.14

** Derived by applying the difference between the present day (defended) 1 In 100 AEP even and 1 In 100 AEP event +20% climate change water levels at each respective node to the undefended present day 1 In 1000 AEP event water level.*

8.4.73 Modelled peak in-channel water levels provided by the EA for the model nodes to the west of the peninsula (as illustrated on Figure 5 in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) are provided in Table 8.15 and modelled flood extents are presented in Table 8.8 above.

8.4.74 The mapping from the 2010 study is consistent with the Flood Zone extents on the Flood Map for Planning (Figure 4 in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) and the interactive web mapping for the 2018 SFRA ("Fluvial and Tidal Flood Risk").

8.4.75 The 2010 mapping indicates that whilst Broadwater Lake may be at risk during a present day 1 in 2 AEP event and the south parcel in a present day 1 in 1,000 AEP event, no flooding of the peninsula (within which development is proposed), The east parcel would be expected in up to a present day 1 in 1,000 AEP event and in a 1 in 100 AEP event taking

into account an allowance for a 20% increase in storm even rainfall volume associated with climate change.

8.4.76 The existing unnamed access road is also shown to remain dry in up to a 1 in 100 AEP event +20% climate change. Whilst some flooding is indicated at its junction with Moorhall Road during a present day 1 in 1,000 AEP event, this is only over a relatively short section (approximately 130 m) beyond which dry access is provided east along Moorhall Road.

8.4.77 The current EA guidance on climate change allowances[48] (May 2022) advises that for Water Compatible development in Flood Zone 3, Flood Zone 2 and Flood Zone 1, the Central allowance should be used to assess flood risk for the lifetime of the Proposed Development. The Central allowance for the Colne management catchment is +21% (2080s). As such, the 2010 modelled outputs (+20% climate change) are considered to provide an accurate reflection of the flood risk to the Site when accounting for climate change.

8.4.78 It is concluded that the peninsula, within which development is proposed is at a Low risk of flooding from rivers (fluvial).

Flood Risk from Small Watercourses and Surface Water (Pluvial)

8.4.79 There are no small watercourses located within the vicinity of the Site.

8.4.80 The Flood Risk from Surface Water map (see Figure 7 in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) indicates that whilst areas of the Site are at a 'Low' to 'High' risk of surface water flooding, owing to the presence of the existing lake, the peninsula and existing unnamed access road are at a 'Very Low' risk.

8.4.81 It is concluded that the Site is not at risk of flooding from small watercourses and is at a Low to High risk of pluvial surface water flooding, albeit the peninsula is at a Very Low risk.

Flood Risk from Reservoirs, Canals and Other Water Impounding Structures

8.4.82 The Flood Risk from Reservoirs map (see Figure 8 in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) indicates that the Site is at risk of flooding from reservoirs, canals and water impoundment structures. However, all large reservoirs are regularly inspected by reservoir panel engineers with essential safety work carried out as required. As detailed on the gov.uk website, reservoir flooding is therefore extremely unlikely to occur and no further assessment is required. Further details can be found in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment.

8.4.83 The Grand Union Canal is located along the eastern boundary of the Site. Ground levels along the western canal bank adjacent to the peninsula are between 37.0 - 38.4 m AOD. Bank levels are higher than adjacent ground levels, which fall towards Broadwater Lake implying that should the bank level be exceeded, floodwater could be directed onto the adjoining land/lake(s).

8.4.84 However, the Canal and River Trust operates a comprehensive asset management system which enables it to manage the risks of such events occurring with the water level within the canal controlled by several weirs and sluice gates located along the pound length. The risk of the canal exceeding its bank level is therefore considered to be low. Furthermore, the Canal and River Trust has advised that it is not aware of any records of overtopping from,

or breaches of this section of the waterway. Broadwater Lake would also act to intercept any flows arising from the canal and as such further minimise any risk to the peninsula.

8.4.85 The risk of flooding to the peninsula from Broadwater Lake, and the other surrounding lakes and water impounding structures is considered to have been assessed as part of the 2010 Upper Colne Flood Risk Mapping Study (as discussed in Section 4.2 of Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) and in the derivation of the Flood Risk from Surface Water map (see Figure 7 of Appendix 8.2: Flood Risk, Drainage and Sequential Assessment).

8.4.86 It is concluded that the Site is at a Low risk of flooding from reservoirs, canals and water impounding structures.

Flood Risk from Groundwater

8.4.87 The JBA Groundwater Flood Risk Indicator map (see Figure 9 in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) indicates that groundwater levels at the Site (including the peninsula) may be <0.025 m bgl (defined as High risk) during a 1 in 100 AEP groundwater flood event.

8.4.88 The interactive web mapping for the 2018 SFRA ("Sewer, Groundwater and Artificial Flood Risk") also identifies the Site as being located in an area where >= 75% of the area may be susceptible to groundwater flooding.

8.4.89 However, due to the nature and topography of the Site, any groundwater emerging at the surface within the peninsula would be expected to be directed towards Broadwater Lake, away from the areas of Proposed Development and as such would not be expected to accumulate to any significant depth within this area of the Site. The Applicant has no knowledge of flooding on the peninsula since 2021 and the Broadwater Sailing Club also has no records of flooding of the northern parts of the lake shore where the Club is located.

8.4.90 It is concluded that the Site is classified as High risk of flooding from groundwater; however, the peninsula is at a Low risk.

Flood Risk Mitigation

8.4.91 The risk of flooding to the area of Proposed Development (i.e. the peninsula) from all identified sources is assessed to be negligible/low. However, the proposals include the creation of an extension to the peninsula (refer to Figure 1 in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment), which currently forms part of Broadwater Lake, an area at Very High risk of flooding from rivers (fluvial).

8.4.92 The risk of flooding to the proposed peninsula extension from the River Colne and any residual risk to the wider peninsula area from ll identified sources will be mitigated through a series of Embedded Mitigation measures as set out in Section 8.5.

Conceptual Model

8.4.93 A conceptual hydrogeological model showing likely source, pathway, receptor relationships at Broadwater Lake has been developed by HydroGeo Ltd and is set out in Appendix 8.3: Groundwater Risk Assessment. This is summarised below and integrates surface water hydrological aspects.

8.4.94 The peninsula element of the Site includes a thickness of concrete hardstanding, beneath which are made ground and reworked ground conditions. The concrete hardstanding is presently acting as a capping layer above the inert landfill made ground, and therefore limiting infiltration of rainwater and surface water. Riparian areas surrounding the lake and between adjacent gravel pit water bodies, the Grand Union Canal and River Colne comprise intact native soils and underlying gravels and sands, also characteristic of the islands within Broadwater Lake.

8.4.95 There are no surface watercourses within the Site or adjoining riparian areas, although to the north of the lake, the current Broadwater Sailing Club is located between the River Colne (right hand bank) and Broadwater Lake.

8.4.96 Rainwater and fluvial flows within the River Colne will percolate into the superficial sand and gravel deposits and migrate laterally, typically to the south following the hydraulic gradient. It is considered highly likely that this is not the case with the Grand Union Canal that has been constructed to minimise leakage (e.g. puddled clay) and maintain navigation.

8.4.97 The underlying Chalk is designated as a Principal Aquifer, and is extensively used for groundwater abstraction, including a significant quantity of public supply. The Chalk aquifer is a dual permeability aquifer which is characterised by very low flow rates through the rock matrix and much higher rates of flow through fissures.

8.4.98 The Chalk is likely to be heterogeneous with the principal mechanism of groundwater flow to occur through a network of interconnected fractures and solution enlarged voids.

8.4.99 Geophysical data available from different boreholes within the chalk of the Colne Valley indicates the presence of 3no. distinct fissure horizons at 14m-16mbgl, 26mbgl – 32mbgl and 48mbgl – 52mbgl.

8.4.100 The majority of groundwater movement within the chalk is likely to be within the top 50m of the saturated zone, and layering is likely, with some horizons more permeable than others.

8.4.101 BGS data indicates that transmissivity values within major valleys (Thames and Colne) in the Chalk in the Chilterns is high, typically in the range of 1500m 2 /d to 3000m 2/day.

8.4.102 Leakage from the overlying sands and gravels into the chalk aquifer may be part of the reason for high transmissivity values.

8.4.103 Groundwater levels within the chalk bedrock may be influenced by the proximity to the Affinity Water abstraction boreholes, and the associated pumping rate of these. This may increase the downward leakage of water into the underlying aquifers.

8.4.104 The groundwater is thought to only be in partial hydraulic continuity with surface water features due to the superficial gravels becoming very silty towards the base, and the upper surface of the Chalk can often be weathered to a clay like ‘putty.

Surface and Foul Water Drainage

8.4.105 Please refer to Appendix 8.2: Flood Risk, Drainage and Sequential Assessment for further details of the proposed surface and foul water drainage system.

8.4.106 Surface water: Runoff from the impermeable access road car parking areas are directed to vegetated swales. The swales discharge to the lake (2 no. outfalls), the lowland mixed deciduous woodland (boggy woodland) (3 no. outfalls), and the wildlife lagoon (2 no. outfalls). Runoff from the main car parking area passes from a vegetated swale through a shallow vegetated basin to provide additional quality treatment; provision of a basin obviates the requirement for traditional interceptors which are rejected due to the depth required, and because of the risk that they would not be maintained/emptied, and would therefore pose a significant pollutant risk.

8.4.107 Foul water: Given the sensitivity of the Site, domestic foul water from the Site WC's and washbasins, and runoff from the 2 no. disinfection and washdown areas will be pumped off-site via a separate foul water drainage system to a point of connection to the public sewerage network approximately 100 m east of the Site. The foul drainage system will include dual redundancy (2 no. foul pumps) to minimise the impact of pump failure. In addition, emergency storage, designed in accordance with Part H of the Building Regulations, will be provided to store foul water for a period of up to 24 hours in the event of a site-wide power outage.

Future Baseline

8.4.108 In the absence of the Proposed Development, and assuming current land/ water use continues, the baseline conditions within the Site are expected to remain relatively constant in the short and medium term (e.g., a 5-year period). Beyond this time period, the impacts due to climate change will start to be more perceptible, to reflect warmer and dryer conditions, drying of wet woodland and other water-dependant habitats, a reduction in levels of the lake during periods of drought and potentially an increase in the presence of fluvial, surface water and groundwater flood water during periods of elevated rainfall.

8.4.109 In due course, the nearby High Speed Rail 2 (HS2) project will be completed and come into operation. The HS2 ES associated with the Colne Valley did not identify any changes to the future water baseline at Broadwater Lake including its surface water, groundwater and flood risk characteristics of Broadwater Lake. It did, however, identify that *"Until a management strategy is agreed with the Environment Agency in consultation with Affinity Water, a potentially significant residual effect on the Affinity Water groundwater abstractions remains".*

8.4.110 HS2 also identified *"Potential to impact groundwater quality at private licensed abstractions, as a result of turbidity, or fluids used in construction. Nonetheless, there is a substantial residual risk that the groundwater quality at any abstraction sources located close to underground works could be affected by circulation fluid, turbidity or possibly contamination from boring machinery. The location of greatest concern is the Affinity Water PWS source TH177, located very close to the viaduct piers and associated piles. The impact on this very high value receptor is potentially major if there are significant fractures linking the pier locations and the abstraction site, this will be likely to give rise to a very large effect"*.

8.4.111 HS2 confirms that *"The measures necessary to mitigate any temporary effect of piling on the groundwater quality at TH177 and other PWS sources will be agreed with the*

Environment Agency in consultation with Affinity Water. 5.2.29 For private licensed abstractions at significant risk due to underground works, provision of alternative temporary supplies will be agreed with the licensees if this is necessary "

8.4.112 Separately, the location and rate of surface and groundwater abstractions in the area could vary over time, leading to changes in groundwater and lake levels (influencing river flows, flood risk and the aquatic/wetland features of the SSSI), aquifer status and SPZ designations.

8.4.113 In its present condition, as a lake formed from a gravel extraction pit, Broadwater Lake has been shaped and constrained by the processes that created it. It is considered that in the absence of management intervention, the future baseline associated with water availability, morphology and water quality (and hydroecology) may deteriorate (e.g., under the influence of climate change). It has a relatively flat bottom with limited bathymetric (topographic) variation, formed mainly of hard clay although with intermittent patches of gravel. The lake also has artificial steeply banked sides with minimal shallow areas adjacent to the bank. This has created a fairly inhospitable substrate unsuited to supporting good numbers of plants and invertebrates and means that variations in water volume have a more profound effect on marginal water levels (as happened in the summer of 2022) with only limited littoral habitat present.

8.4.114 The current limiting factors preventing aquatic macrophytes (plants) from establishing and thriving are likely to worsen as average temperatures increase. The water is somewhat enriched with nutrients, evidenced by turbidity and green colour during the summer (the nutrients support the overgrowth of algae in the water column). The source of the nutrient enrichment is considered to be due to large numbers of waterfowl defecating into the water. The resultant green algal growth prevents light penetration into the water column, restricting plant growth below the surface.

8.4.115 The lack of plants, increase in algae and water temperatures are also likely to affect water quality, in particular nutrient levels, alkalinity (and pH), dissolved oxygen. The limited availability of organic matter and soft sediments, along with the water depth and lack of light to deeper levels, ensures that most of the lake bottom cannot support macrophytes which further limit opportunities to better water quality, shading and cooler lake temperatures.

Summary of Receptors and Sensitivity

8.4.116 A summary of potential sensitive receptors and their sensitivity according to the Sensitivity Matrix are set out in Table 8.9. This takes into account how these receptors might change over time as a result of the Proposed Development or surrounding developments (i.e., current and future receptors).

Table 8.9: Summary of Current and Future Receptor Sensitivity

Receptor	Sensitivity (Value)
Existing	
Mid-Chilterns Chalk WFD Groundwater Body	High
Source Protection Zone Type 1 (Inner Catchment)	High

Receptor	Sensitivity (Value)
Existing	
Source Protection Zone Type 2 (Outer Catchment)	High
On site abstraction licences	Medium
Principal Bedrock Aquifer	High
Secondary Superficial Aquifer	High
Affinity Water borehole within 150m off Site	High
Broadwater Lake WFD Surface Water Body	High
Broadwater Lake SSSI	High
Other Water Dependant Habitat	High
Grand Union Canal	High
River Colne (Chess to Confluence with Thames) Water Body	High
Existing on-site flood sensitive receptors	Low
Existing off-site flood sensitive receptors	High
Downstream Waste Water Treatment Works and receiving watercourses	Medium

8.5 Embedded Mitigation (Scheme Design and Management)

Construction

8.5.1 The Outline CEMP and Draft LMP set out the measures and standards of work that will be applied to the construction of the Proposed Development. These measures and standards of work will provide effective management and control of the impacts during the construction period. Some of these are likely to be associated with the Environmental Permit that would be needed to deliver the scheme. These measures are set out below:

Surface Water / Groundwater

- Adherence to the measures included in the Outline CEMP and all guidance from statutory consultees, appropriate training for all workforces including specialised toolbox talks where necessary, ongoing monitoring and management from suitably experienced Environmental Clerk of Works;
- Use of self-bunded refuelling facilities (or sufficient secondary containment with impermeable base and sides), provision of spill kits, well maintained/certificated plant and equipment, use of biodiesel only;
- Self-bunded facility for the storage of and chemicals/potentially contaminative materials being used during construction, including paints, lubricants, solvents etc. No on-site mixing of concrete, no vehicle washing on-site (apart from self-contained wheel washes if required). No discharge of construction runoff into the lake or groundwater (e.g., via soakaways);

- Cut-off ditches and/or geotextile silt-fences will be installed around excavations, exposed ground and stockpiles to prevent the uncontrolled release of sediments from the Site;
- Advanced provision of suitable operational SuDS measures that will also serve to treat suitable runoff during the construction period (that will include an agreed form of hydrocarbon interception, sediment detention and therefore phosphate capture, and wetland vegetation suitable for managing nitrogen nutrients (e.g. through the very shallow scraping of clean surface material (without disturbing any underlying potential/known waste), lining with impermeable clay layer, clean cover layer and pre-planted native wetland plant coir blankets (vegetation from a local provenance source and agreed with Natural England) to create shallow wetland features (that will be maintained);
- Sediment traps on all surface water drains in the surrounding region;
- Silty water abstracted during excavations will be discharged to settlement tanks or siltbusters as appropriate. Only clean run-off will be permitted to discharge to ground or to the lake via the pre-installed SuDS features. A temporary discharge consent will be agreed with EA prior to the commencement of works, if necessary;
- Provision of suitable facility to contain/remove and potential contaminated liquids, storage of materials and equipment at least 10m from the lake margin and 50m from any boreholes and in Flood Zone 1 and away from highlighted groundwater flood risk areas, protect any stockpiles so that materials are not blown or washed away, no use of herbicides or pesticides;
- The CEMP will set out specific measures in relation to spillage prevention and response. This will be disseminated to relevant site employees and associated training and equipment provided. On-site provisions will be made to contain a serious spill or leak using spill kits, booms, bunding and absorbent material, alongside appropriate monitoring;
- Contaminated soil will be identified by ground investigation prior to construction and either treated on-site and reused or removed and disposed of off-site by a licensed waste disposal operator at a correctly licensed waste depot. Contaminated water will be removed from the Site by tanker and disposed of at a suitably licensed location;
- Implementation in accordance with all legal and permitting requirements including Environmental Permit, Flood Risk Activity Permit, and SSSI Assent;
- No excavation of any areas associated with former regulated or potential unregulated waste activities. No removal of any concrete cover over these locations. Provision of a suitably designed/specified impermeable barrier over these areas (e.g., clay) and appropriate overlying clean cover to prevent new pathways to terrestrial areas including connected groundwater;
- Advanced construction and use of SuDS features to support the management of construction surface water runoff and discharge of this to Broadwater Lake only when at an acceptable water quality standard;
- Adoption of suitable established working method for dredging/re-use of sediment in SSSIs (e.g., use of long-reach excavators on pontoons and use of barges to extract/move and deposit dredged sediment from donor to pre-established receptor sites) will minimise the amount of lake-bed disturbance, water quality deterioration and duration of works (see the CEMP for more details on methods);

- GPS and CAD controlled dredging and land forming activities. This will prevent over-deepening/unnecessary excavation and therefore prevent any new pathways between lakebed dredging and groundwater from forming (also as this is believed to be already in hydrological continuity);
- Use of turbidity curtains or bubble curtains around each area of lake dredging/in-lake works to prevent dispersion of turbid water into adjacent parts of the lake. Turbidity within and outside of these features would be continuously monitored. They would only be removed when turbidity returns to levels (e.g., baseline turbidity) agreed with the EA and Natural England; and
- Monitoring and reporting of the success of these measures and interactive feedback to management regime. Implementation in accordance with all legal and permitting requirements.

Flood Risk

- The contractors will consult with the LLFA and EA and sign up to the EA's Floodline warning service for works within areas at risk of flooding;
- A suitable flood safe egress route will be agreed in advance and flood evacuation plan will be implemented in good time;
- Relocation of vehicle fuel and other materials that may cause water contamination from lower lying parts of the Site or off-Site, in the event of an appropriate flood warning;
- No compounds/excavated/dredged material or vehicles or materials will be stored in Flood Zones 2 or 3;
- No works will occur within 8m of the River Colne unless authorised under a Flood Risk Activity Permit. This is limited to the demolition of the existing Sailing Club House and habitat enhancements in this northern area of the lake shore; and
- No disturbance/modification to any bank levels / fluvial defences associated with the River Colne.

Completed Development

8.5.2 The following embedded measures as associated with the operational phase of the Proposed Development. Please refer to Draft LMP for more details on measures not associated with scheme design (e.g., operator/staff training, monitoring, management and maintenance).

Surface Water / Groundwater

- Implementation in accordance with all legal requirements such as SSSI Assents;
- Surface runoff from buildings, car parks and all other operational areas (including green infrastructure) will be directed through suitable SuDS features that will include hydrocarbon separators, sediment forebays, and suitable vegetated and permanently wet basins managed to attenuate runoff and maintain the growth of suitable plants that will be inspected and maintained to remove nutrients and other potential contaminants prior to discharge back to Broadwater Lake;
- The introduction of suitably designed/specified impermeable barrier over (e.g., clay) and appropriate overlying clean cover (located where future detailed Site Investigation indicates this is required) will prevent percolation of rainwater and surface runoff into

underlying areas of regulated and potentially unregulated waste, thereby reducing residual contaminant mobilisation and transport to groundwater and surface water providing the opportunity for water quality betterment;

- All potential contaminants will be adequately stored and monitored with minimised use and on-site storage of chemicals. All operational staff will be made aware of pollution responsibilities and be adequately trained. Continued monitoring will be used to demonstrate that groundwater is unaffected by the Proposed Development and to provide early warning of potential pollution;
- All foul waste to be directed to Thames Water sewage system and waste water treatment works for treatment to acceptable and permitted quality standards (including for nutrients) prior to discharge to the receiving watercourse. Implementation in accordance with all legal and permitting requirements; and
- No surface or groundwater abstraction is required as part of these proposals. Consequently, there is no reduction in groundwater quantity available for recharge from the lake for abstraction due to ongoing discharge of clean surface water runoff to lake.

Flood Risk

- The ground level of the extension to the peninsula should be set at a minimum of 37.89 m AOD. This is the peak modelled in-channel water level during a (defended) 1 in 100 AEP event +20% climate change;
- The finished floor level of all proposed buildings should be set at a minimum of 38.19 m AOD, i.e., 300 mm above the peak modelled in-channel water level during a (defended) 1 in 100 AEP event +20% climate change, and at least 0.15 m above adjacent ground levels following any reprofiling of the Site, with ground levels sloping down from the buildings; and
- The buildings should have designed in resilience to flooding up to a minimum level of 38.23 m AOD e.g., raised power sockets, non-return valves on ground floor drainage, in line with government guidance. This is the peak modelled in-channel water level during a (defended) 1 in 1,000 AEP event.

8.5.3 These measures will, subject to the implementation of an appropriately designed surface water drainage scheme (summarised below and in detail in Section 5 of Appendix 8.2: Flood Risk, Drainage and Sequential Assessment), enable any potential overland flows to be conveyed safely across the peninsula without affecting property and/or sensitive habitats.

8.5.4 Surface water drainage from buildings and areas of hard standing will be directed to a series of SuDS features designed to provide hydrocarbon separation, sediment interception and water quality treatment through managed and vegetated wet basins before discharging back into Broadwater Lake.

8.5.5 An introduced impermeable barrier (e.g., clay) and a suitable depth of clean cover will be placed over the existing surface where regulated and potentially unregulated waste exists. This will ensure that the pathway between rainfall and surface runoff does not continue to mobilise any contaminants into the lake or groundwater. Rain falling on these areas will be intercepted by vegetation and percolate into the clean cover before draining to Broadwater Lake.

8.5.6 All foul waste will be directed via the public sewer to a suitable Thames Water waste water treatment works.

8.5.7 Given the sensitivity of the Site, domestic foul water from the WC's and washbasins, and runoff from the 2 no. disinfection and washdown areas will be pumped off-site via a separate foul water drainage system to a point of connection to the public sewerage network approximately 100 m east of the Site. The foul drainage system will include dual redundancy (2 no. foul pumps) to minimise the impact of pump failure. In addition, emergency storage, designed in accordance with Part H of the Building Regulations, will be provided to store foul water for a period of up to 24 hours in the event of a site-wide power outage.

8.6 Assessment of Effects - Construction Stage

Flood Risk Impacts

Impacts on off-site receptors

8.6.1 The FRA identifies that the peninsula and existing unnamed access road are not at risk of flooding in up to a (defended) 1 in 100 AEP fluvial event including an allowance for climate change.

8.6.2 The construction phase will introduce an impermeable barrier (e.g., clay) over the known regulated waste and potential unregulated waste, together with a suitable clean cover. Whilst the impermeable layer will promote surface water flow to Broadwater Lake, because of the close proximity of groundwater to the current surface levels, this is only considered to result in a Minor magnitude of change in runoff volume or rate. When the potential storage of water in the clean cover, early provision of suitable SuDS, an increase in vegetation cover from new planting (intercepting rainfall and supporting evapotranspiration) and the surface water drainage strategy is taken into account, there is considered to be a negligible magnitude of change in the rate/volume of water entering Broadwater Lake. Consequently, the associated flood risk to off-site receptors even when future climate change is taken into account is very limited.

8.6.3 This outcome is supported because of the following limited changes predicted. The area of the proposed extension of the peninsula equates to approx. 16,400 m^2. A bathymetry survey of Broadwater Lake indicates that the bed level of the lake within the vicinity of the proposed extension is between 33.0 - 36.0 m AOD. In a (defended) 1 in 100 AEP fluvial event +20% climate change the proposed extension therefore has the potential to displace between approx. 30,996 - 80,196 m^3 of water (from bed level to flood level). However, given the size of Broadwater Lake (circa 60 ha - 600,000 sq. m) this would only equate to a potential 0.05 - 0.13 m increase in the water level of the lake (largely as a result of the morphology of the artificial lake). Such increases are considered to be capable of being accommodated within Broadwater Lake and would be partially offset by the proposed localised dredging of the lake.

8.6.4 It is concluded that the Proposed Development would therefore not be expected to have a detrimental impact flood risk elsewhere. With reference to Table 8.4 and taking into account the embedded measures, the magnitude of the impact would be negligible on the medium sensitivity receptors. The flood risk to off-site receptors would therefore be temporary, medium term and negligible (Not Significant).

Impacts to on-site receptors (construction activities / workers)

8.6.5 This section considers flood risk from all potential and credible sources.

8.6.6 The FRA indicates that whilst Broadwater Lake may be at risk during a present day 1 in 2 AEP event and the south parcel in a present day 1 in 1,000 AEP event, no flooding of the peninsula (within which development is proposed) and the east parcel would be expected in up to a present day 1 in 1,000 AEP event and in a 1 in 100 AEP event +20% climate change. The existing unnamed access road is also shown to remain dry in up to a 1 in 100 AEP event +20% climate change. Whilst some flooding is indicated at its junction with Moorhall Road during a present day 1 in 1,000 AEP event, this is only over a relatively short section (approximately 130 m) beyond which dry access is provided east along Moorhall Road.

8.6.7 The current EA guidance on climate change allowances (2022) advises that for Water Compatible development in Flood Zone 3, Flood Zone 2 and Flood Zone 1, the Central allowance should be used to assess flood risk for the lifetime of the Proposed Development. The Central allowance for the Colne management catchment is +21% (2080s). As such, the 2010 modelled outputs (+20% climate change) are considered to provide an accurate reflection of the flood risk to the Site when accounting for climate change. It is concluded that the location of the construction activity at Broadwater Lake is at a Low risk of flooding from rivers (fluvial) and is located in Flood Zone 1. No construction compounds, materials etc. will be located in Flood Zone 2 or 3 within the Site boundary.

8.6.8 The construction phase will introduce an impermeable barrier (e.g., clay) over the known regulated waste and potential unregulated waste on the peninsula, together with a suitable clean cover. This has the potential to temporarily store rain water / runoff. Whilst the impermeable layer will promote the surface flow to Broadwater Lake, because of the close proximity of groundwater to the current surface levels, this is only considered to result in a low magnitude of change in runoff volume or rate. When these factors, the early provision of suitable SuDS and the surface water drainage strategy is taken into account, a negligible magnitude of change in the rate/volume of water entering Broadwater Lake is predicted. As a consequence, the associated flood risk to both on-site and off-site receptors even when future climate change is negligible or minor adverse (and not significant).

8.6.9 The Flood Risk from Reservoirs map (Figure 8 in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) indicates that the Site is at risk of flooding from reservoirs. However, all large reservoirs are regularly inspected by reservoir panel engineers with essential safety work conducted as required. As detailed on the gov.uk website, reservoir flooding is therefore extremely unlikely to occur.

8.6.10 The Grand Union Canal is located along the eastern boundary of the Site. Ground levels along the western canal bank adjacent to the peninsula are between 37.0 – 38.4 m AOD. Bank levels are higher than adjacent ground levels, which fall towards Broadwater Lake implying that should the bank level be exceeded, floodwater could be directed onto the adjoining land/lake(s).

8.6.11 However, the Canal and River Trust operates a comprehensive asset management system which enables it to manage the risks of such events occurring with the water level within the canal controlled by a number of weirs and sluice gates located along the pound length. The risk of the canal exceeding its bank level is therefore considered to be low. Furthermore, the Canal and River Trust has advised that it is not aware of any records of overtopping from, or breaches of this section of the waterway. Broadwater Lake would also act to intercept any flows arising from the canal and as such further minimise any risk to the area

of construction works. Therefore, there is a low risk of flooding from the canal during construction.

8.6.12 It is concluded that the construction area/activity is at a Low risk of flooding from reservoirs, canals and water impounding structures and likely effects are negligible or minor adverse (and not significant).

8.6.13 Groundwater levels at the Site (including the construction area) may be <0.025 m bgl (defined as High risk) during a 1 in 100 AEP groundwater flood event. The interactive web mapping for the 2018 SFRA ("Sewer, Groundwater and Artificial Flood Risk") also identifies the Site as being located in an area where >= 75% of the area may be susceptible to groundwater flooding.

8.6.14 However, due to the nature and topography of the Site, any groundwater emerging at the surface within the peninsula would be expected to be directed towards Broadwater Lake, away from the areas of proposed construction and as such would not be expected to accumulate to any significant depth within this area of the Site.

8.6.15 It is concluded that Broadwater Lake is at a high risk of flooding from groundwater; however, the peninsula associated with the construction activity is at a Low risk and no mitigation is required.

8.6.16 Taking into account the natural conditions and the embedded measures, the magnitude of the impact of fluvial, groundwater or any other form of flooding would be Minor on the Low sensitivity receptors. The effect would therefore be temporary and be negligible or minor adverse (and not significant).

Surface Water – Broadwater Lake

Water Quality (accidental pollution and contamination of surface water from land-based construction activities)

8.6.17 Potential effects on surface water from construction activities are possible with the surface water associated with Broadwater Lake being a Very High sensitivity receptor. There is the potential for the accidental release of lubricants and fuel oils from construction machinery working in and adjacent to Broadwater Lake, through spillage, leakage and in-wash from vehicle storage areas after rainfall. There is also the potential for soil, dredged material or other run-off from construction areas (and thus sediment-associated contaminants) to re-enter the lake. To protect this receptor, a range of key measures are included as set out in Section 8.5 and Appendix 8.7: Draft Lake Management Plan.

8.6.18 The separation of construction activity from the underlying waste deposits and the retention of construction runoff within the construction area for suitable treatment before discharge via an agreed route/mechanism to agreed quality standards (i.e., to Broadwater Lake if uncontaminated, or disposed of off-site if this is not the case) forms part of the construction strategy. These water quality measures as incorporated in the construction works and will be managed through the implementation of a detailed CEMP. This approach will successfully manage the risk of pollution entering the surface water associated with Broadwater Lake and therefore potentially affecting this receptor.

8.6.19 As a result of these embedded measures (see Section 8.5 and in the Outline CEMP), the magnitude of change identified for this Very High sensitivity receptor is negligible. The

rationale being that the mitigation measures reflect current best practice, will be monitored and are known to be effective. These measures will manage the quality and quantity of runoff. within the construction areas, preventing effects to local water quality. Being constructed early in the construction program, the surface water drainage system and SuDS will function as detailed for the operational phase to ensure that effects on water quality are prevented.

8.6.20 Therefore, for this Very High sensitivity receptor, with the expected magnitude of change of negligible, it is reasonable to conclude that temporary, short term, minor adverse (not significant) effects are likely to occur.

Water Quality (Deterioration in lake water quality associated with dredging works to re-distribute lake sediment and land reclamation)

8.6.21 The in-lake dredging works will take place over a period of two months in October and November 2024 and will be carefully managed through the implementation of the measures set out in this Chapter, the Draft LMP (Appendix 8.7: Draft Lake Management Plan) and the Outline CEMP (Appendix 6.1: Outline Construction Environmental Management Plan). Lake dredging will be carried out by a highly experienced operator with a proven track record of similar work in similar high sensitivity environments. Potential effects are largely associated with the resuspension of sediment and increase in turbidity in the vicinity of the works and a localised increase in sediment oxygen demand from fresh lakebed surfaces. The sediment sampling and analysis did not identify substances thought likely to have a notable effect on local water quality if re-suspended.

8.6.22 Embedded measures will include the separation of the dredging/deposition areas within turbidity barriers (which may include bubble curtains – also aerating the water) and monitoring to ensure effects are localised and temporary.

8.6.23 Dredging works will generate material to create the reclaimed peninsula. The potential impacts and embedded measures are the same for this aspect of the work and creation of additional islands within the lake.

8.6.24 Therefore, for Broadwater Lake, a Very High sensitivity receptor with the expected Slight magnitude of change in water quality from the proposed dredging and land reclamation (and only within the immediate area of works being managed and monitored), water quality effects are assessed as temporary, short term, minor adverse (not significant).

Impacts on lake morphology from construction

8.6.25 The area of the proposed extension of the peninsula equates to approx. 16,100 sq. m. A bathymetry survey of Broadwater Lake indicates that the bed level of Broadwater Lake within the vicinity of the proposed extension is between 33.0 - 36.0 m AOD. In a (defended) 1 in 100 AEP fluvial event +20% climate change the proposed extension therefore has the potential to displace between approx. 30,996 - 80,196 cu. m of water (from bed level to flood level). However, given the size of Broadwater Lake (circa 62 ha - 620,000 sq. m) this would only equate to a potential 0.05 - 0.13 m increase in the water level of the lake. Such increases are considered to be capable of being accommodated within Broadwater Lake, even with the other areas of proposed island creation (nb floating islands are not considered to displace any notable amount of water). This is considered to be offset by the proposed localised dredging of the lake (this volume would be used to create the reclaimed peninsular

and solid islands, include above-water extents), removal of the concrete slipways associated with the existing sailing club and existing island removal.

8.6.26 There would be no damage to lake shore areas away from the mobilisation points for the dredging equipment. The lakebed would be disturbed by the dredging, but this would be finished to increase the morphological diversity of the generally flat former gravel pit.

8.6.27 Early phase work to restore, protect and enhance the marginal habitats of the lake would be implemented (see Chapter 7: Biodiversity for further details).

8.6.28 It is concluded that the construction proposals would therefore not be expected to have a detrimental impact on lake morphology during construction that would result in a negative significant effect on its quality or condition. As a result of the proposed morphological and habitat enhancements (see Chapter 7: Biodiversity) and no notable change in lake volume or capacity, the magnitude of change to this Very High Sensitivity receptor is Minor. Consequently, a Minor Positive (Not Significant) effect is predicted.

Surface Water – Grand Union Canal

Accidental pollution and contamination of the Grand Union Canal from construction

8.6.29 Potential effects on the Grand Union Canal from construction activities (believed to be restricted to potential accidental pollution from associated enabling works/construction activity) are unlikely because of the spatial separation of the works and the measures prescribed to protect this High Magnitude sensitivity receptor. A range of key measures are included as set out in Section 8.5, Appendix 8.7: Draft Lake Management Plan and Appendix 6.1: Outline CEMP.

8.6.30 As a result of these embedded measures, there will be negligible change in the magnitude of predicted impacts. The rationale being that only a very small amount of work is associated with the canal (gantry) and its position elevated above Broadwater Lake will prevent any influence from the construction at Broadwater Lake. These measures reflect current best practice and are known to be effective.

8.6.31 Therefore, for this High sensitivity receptor, with the expected magnitude of change of Negligible, conclusions of temporary, short term, negligible (not significant) effects are reached.

Surface Water – River Colne / Thames River Basin District

Accidental pollution and contamination of the River Colne (Thames River Basin District) from construction

8.6.32 Potential effects on surface water, soil/lake sediment from construction activities are possible with the River Colne being a High sensitivity receptor. To protect this class of receptor, a range of key measures are included as set out in Section 8.5 and set out in full in Appendix 8.7: Draft Lake Management Plan.

8.6.33 The separation of construction activity from the underlying waste deposits and the retention of construction runoff within the construction area for suitable treatment before discharge via an agreed route to agreed quality standards (i.e., to Broadwater Lake if uncontaminated, or disposed of off-site) forms part of the construction strategy. These water quality measures, as incorporated in the construction works and managed through the

implementation of a detailed CEMP, will successfully manage the risk of pollution entering the surface water, soil and groundwater and therefore any effects on the River Colne.

8.6.34 As a result of these embedded measures (see Section 8.5 and in the Outline CEMP), the magnitude of change identified for this High sensitivity receptor is negligible. The rationale being that these measures reflect current best practice and are known to be effective. A conclusion of temporary, short term, and negligible (not significant) effect is likely.

Groundwater – Mid-Chilterns Chalk

Accidental pollution and contamination of connected groundwater from land-based construction activities

8.6.35 Potential effects on surface water, soil/lake sediment from construction activities (in particular piling) are possible with the groundwater being a Very Highly sensitive receptor. To protect this class of receptor, a range of key measures are included as set out in Section 8.5 and Appendix 8.7: Draft Lake Management Plan.

8.6.36 The separation of construction activity from the underlying waste deposits and the retention of construction runoff within the construction area for suitable treatment before discharge via an agreed route to agreed quality standards (i.e., to Broadwater Lake if uncontaminated, or disposed of off-site) forms part of the construction strategy. These water quality measures as incorporated in the construction works and managed through the implementation of a detailed CEMP will successfully manage the risk of pollution entering the surface water, soil and groundwater and therefore affecting these receptors.

8.6.37 As a result of these embedded measures (see Section 8.5 and in the Outline CEMP), the magnitude of change identified for this Very High sensitivity receptor is negligible. The rationale being that these measures reflect current best practice and are known to be effective. These measures will manage the quality and quantity of runoff. within the construction areas until the new drainage system is constructed, preventing effects to local water quantity and quality. Once constructed early in the construction program, the drainage system will function as detailed for the operational phase to ensure that effects on water quality and quantity are prevented.

8.6.38 Therefore, for the Mid-Chilterns Chalk Groundwater, the effect would be temporary, short term, negligible (not significant).

Deterioration in groundwater quality associated with piling

8.6.39 Please refer to Chapter 9: Ground Conditions and Contamination (and Sections 9.5 and 9.6) and Appendix 8.3: Groundwater Risk Assessment for details of embedded mitigation that will minimise the risk of creating new pathways to groundwater from piling and assessment of effects.

Deterioration in groundwater quality associated with dredging works

8.6.40 The construction proposals will take place over 1 to 2 years and will be carefully managed through the implementation of the LMP (Appendix 8.7: Draft Lake Management Plan) and the Outline CEMP (Appendix 6.1: Outline Construction Environmental Management Plan). Lake dredging will be carried out by a highly experienced operator with a proven track record of similar work in similar high sensitivity environments. Potential effects are largely associated with the resuspension of sediment and increase in turbidity in the vicinity of the

works (or to groundwater should any new pathways be created) and a localised increase in sediment oxygen demand from fresh lakebed surfaces. The sediment sampling and analysis did not identify substances thought likely to have a notable effect on local groundwater water quality if re-suspended.

8.6.41 Screening of 20no. Broadwater Lake sediment samples against stringent human health criteria did not indicate any exceeding concentrations, and it is not thought that this material poses a significant risk to the underlying groundwater and aquifers. Proposed dredging requirements indicate that the maximum depth of dredging is to be between 1.5m – 2m beneath the existing lake base. Based on the conceptual model and geology of the Site, dredging to this depth is not likely to significantly increase the continuity of the groundwater and Broadwater Lake as underlying low permeability silts and clays of the Alluvium depots will remain intact. Please refer to Appendix 8.3: Groundwater Risk Assessment for full details.

8.6.42 Embedded measures will include careful GPS controlled management of dredging locations and depths to prevent over-deepening the lake and creation of any new potential pathways to groundwater. It will also include the separation of the dredging/deposition areas within turbidity barriers (which may include bubble curtains – also aerating the water) and monitoring to ensure effects are localised and temporary.

8.6.43 Dredging works will generate material to create the reclaimed Peninsula. The potential impacts and embedded measures are the same for this aspect of the work and creation of additional islands within the lake.

8.6.44 Therefore, for the Mid-Chilterns Chalk Groundwater, a Very High sensitivity receptor with the expected magnitude of change of Low, the effect would be temporary, negligible (not significant).

Impacts on groundwater resources from construction

8.6.45 It is concluded that the proposals would not be expected to have a detrimental impact on lake volume and bathymetry during construction that would result in a negative significant effect on potential recharge to the underlying groundwater and therefore groundwater resource availability. For the identified groundwater receptors, sensitivities of high are identified (Table 12.10), therefore with the expected magnitude of change of negligible, conclusions of temporary, short term negligible (not significant) effects are reached.

Changes to the hydrological and hydrogeological aspects of the natural environment's ability to adapt to climate change

8.6.46 It is believed that the measures incorporated into the lake masterplan and operation of the completed development can play a crucial role in supporting resilience to climate change in several ways:

- Water Quality Improvement: improving the aquatic habitat, introducing more vegetated islands and macrophytes and proactively managing Broadwater Lake will support efforts to reduce pollution and provide clean runoff. This, in turn, can help maintain good water quality, which is essential for potable supply, recreation and aquatic ecosystems. Clean water is more resilient to the impacts of climate change, as it can better support various life forms and adapt to changing conditions.

- Ecosystem Health: A healthy lake ecosystem is more adaptable to climate change stressors. Well-managed lakes can support a diverse range of species and provide habitat for various organisms. A diverse ecosystem is more robust and can better withstand changes in temperature, precipitation, and other environmental variables and contribute to good water quality (e.g., plant growth to reduce nutrients and turbidity, zooplankton to improve transparency).
- Flood Mitigation: Regular lake water monitoring and management can help control water levels and mitigate the risk of flooding, which can be exacerbated by extreme weather events associated with climate change. Well-designed projects such the proposed development and it surface water drainage system, will enhance Broadwater Lake's capacity to regulate water flow and prevent inundation during heavy rainfall.
- Carbon Sequestration: Lakes can play a significant role in carbon cycling. Healthy lakes can sequester carbon and help offset greenhouse gas emissions, contributing to climate change mitigation. Broadwater Lake will continue to act as carbon sinks and through ongoing monitoring and management will support efforts to reduce carbon in the atmosphere.
- Recreation and Tourism: Sustainable management of Broadwater Lake as a result of the operational scheme will help ensures that these economic activities can continue in the face of changing climate conditions. Healthy lakes provide opportunities for outdoor recreation, which are be vital for community well-being and resilience.
- Cultural and Social Benefits: Broadwater Lake and the proposed community activities will provide cultural and social significance, replacing those lost elsewhere. They will be a future source of identity, history, and spiritual value. Well considered lake enhancement and management (such as proposed for Broadwater Lake) will help protect these cultural assets, fostering community resilience by maintaining important cultural and social ties.
- Education and Awareness: Broadwater Lake will can serve as an enhanced educational tools for raising awareness about climate change and environmental stewardship under the proposed development. Engaging communities in the ongoing lake and terrestrial habitat management efforts will enhance understanding of climate-related issues and promote active involvement in climate resilience measures.

8.6.47 In summary, the proposed effective Broadwater Lake enhancement and management practices contribute to climate resilience by improving water quality, supporting healthy ecosystems, controlling floods, sequestering carbon, promoting recreational and cultural activities, and raising awareness about climate change. These measures help communities and ecosystems better withstand the challenges posed by a changing climate.

Implications associated with existing potable and foul water infrastructure, capacity and supply

8.6.48 The surface and foul water drainage proposals (see Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) provide reassurance that the completed development will incorporate suitably robust measures (to be developed in detail through Planning Condition). These prevent poor surface runoff entering the lake and groundwater and foul water to be contained and pumped offsite for treatment at a suitable treatment facility. A programme of regular monitoring and maintenance and management intervention. (if necessary) will be implemented to ensure the systems efficacy.

Additional Mitigation, Monitoring and Residual Effects - Construction

Flood Risk Impacts to Off-site Receptors

8.6.49 No additional mitigation is required as there are negligible effects.

Flood Risk Impacts to On-site Receptors

8.6.50 No additional mitigation is required as there are negligible effects.

Flood Risk Monitoring

8.6.51 A suitable flood risk monitoring programme covering the construction phase will be developed and implemented as a planning condition. This will involve (as a minimum) the following components:

- **Rainfall and Water Level Monitoring:** Either install a rain gauge at site or use a suitable Met Office station that is local to Broadwater Lake. Additionally, install water level monitoring stations in nearby rivers, streams, or other water bodies to monitor changes in water levels during rainfall events;
- **Water level Measurement**: Regularly measure and record water level in Broadwater Lake. This includes monitoring both pre-development and post-development levels to assess any changes caused by altered drainage patterns or increased runoff;
- **Real-Time Monitoring:** Implement a real-time monitoring system that provides continuous data on rainfall and water levels. This system should be equipped with automated sensors and telemetry to allow for timely flood risk assessment;
- **Warning Systems:** Establish flood warning systems that utilise the real-time monitoring data, including signing up to the EA's Floodline service, to provide timely alerts and notifications to relevant stakeholders, including residents, emergency services, and local authorities. These systems should have clear protocols for issuing warnings and instructions for appropriate actions; and
- **Drainage Infrastructure Monitoring:** Monitor the performance of drainage infrastructure within the development, including SuDS. Regular inspections and maintenance should be conducted to ensure these systems are functioning effectively and not contributing to increased flood risk.

Water Quality (accidental pollution and contamination of surface water from land-based construction activities)

8.6.52 A suitable surface water monitoring programme covering the construction phase will be developed and implemented as a planning condition. This could include the following components:

- **Accidental Spill and Runoff Monitoring:** Implement measures to monitor and prevent spills, leaks, or accidental releases of pollutants from construction sites. Regularly inspect erosion control measures, sedimentation ponds, and containment systems to ensure their effectiveness in preventing runoff contamination;
- **Reporting and Mitigation:** Document and report the monitoring data collected throughout the construction project. Analyse the results to identify any trends or deviations from the baseline conditions. If adverse impacts are detected (e.g., reduced dissolved oxygen or raised turbidity for a longer period than anticipated post-

dredging), implement appropriate mitigation measures (e.g., localised aeration, flocculation) to minimise further harm to surface water resources; and

- **Compliance and Regulatory Requirements:** Ensure compliance with local and national environmental regulations and policy related to surface water protection. Remain updated on any permit requirements or guidelines set by regulatory bodies and incorporate them into the monitoring program.

8.6.53 The specific design and requirements of the surface water monitoring program will be defined by suitably qualified individual to ensure the program's effectiveness and compliance with applicable standards, which will be agreed with the EA, Thames Water and Affinity Water.

8.6.54 Through the adoption of the additional monitoring and reactive management, it is considered that an expected magnitude of change of negligible will occur, and conclusions of temporary, short term negligible (not significant) are reached.

Deterioration in lake water quality associated with dredging works to re-distribute lake sediment for island creation and land reclamation

- **Water Quality Monitoring Adjacent to Dredging/Reclamation Area:** Measure and record various water quality parameters pre and post works, including temperature, pH, turbidity, dissolved oxygen, total suspended solids, and nutrient levels. Conduct turbidity measurements using data loggers (e.g., 15-minute intervals) adjacent to dredged areas (outside turbidity curtains) throughout dredging/reclamation to track any changes over time and trigger intervention (such as further/modified turbidity barriers, water column aeriation and temporary cessation of works) if needed.

8.6.55 Through the adoption of the additional monitoring and reactive management set out above, it is considered that an expected magnitude of change of negligible will occur, and conclusions of temporary, short term negligible (not significant) are reached.

Reduction in groundwater quality arising from construction

8.6.56 A comprehensive suite of environmental monitoring will be implemented, before and during construction of the Proposed Development to ensure the measures are effective and that they can be reviewed and modified (in agreement with the EA, Natural England, the LPA and the LLFA) should this be necessary, and to demonstrate the effectiveness of the embedded measures and no significant residual effects. The suite of monitoring is outlined below.

- **Installation of Monitoring Wells:** Depending on the site conditions, it may be necessary to install monitoring wells strategically around the construction area (nb. it may be possible to use existing boreholes). These wells would be properly designed, constructed, and equipped with appropriate instruments to measure groundwater levels and quality accurately;
- **Baseline Monitoring:** Baseline monitoring involves collecting data on groundwater levels, water quality, and flow rates in the vicinity of the construction site before any work begins. This information could potentially be collected from existing boreholes/wells or new ones and would provide a reference point for comparison during and after construction;
- **Continuous Monitoring:** During construction, continuous monitoring of groundwater conditions will be undertaken. This typically involves installing automatic monitoring

equipment that provides real-time data on groundwater levels, flow rates, and water quality. Automated alarms can be set up to alert project personnel if any predetermined thresholds are exceeded;

- **Regular Sampling and Analysis:** Periodic sampling of groundwater would be conducted at designated intervals to assess changes in water quality throughout the construction process. The samples will be analysed in a laboratory to detect any potential contamination or changes in groundwater chemistry;
- **Construction Activity Tracking:** It is important to document construction activities that may have a potential impact on groundwater, such as excavation, dewatering, or underground utility installation. Keeping a detailed record of these activities will help correlate any changes in groundwater conditions with specific construction actions;
- **Response and Mitigation Measures:** If the monitoring program detects any adverse impacts on groundwater, appropriate response and mitigation measures will be implemented promptly. These will include adjusting construction techniques, altering dewatering methods, or implementing additional pollution control measures (including the cessation of related activities until resolved, if required); and
- **Documentation and Reporting:** A comprehensive record of the monitoring program, including data collected, analysis reports, and any mitigation measures taken, will be maintained. This documentation is critical for regulatory compliance, future reference, and potential legal requirements.

8.6.57 The specific design and requirements of the groundwater monitoring program will be defined by suitably qualified hydrogeologists or environmental consultants with expertise in groundwater monitoring to ensure the program's effectiveness and compliance with applicable standards, which will be agreed with the EA, Thames Water and Affinity Water.

8.6.58 Through the adoption of the additional monitoring and reactive management set out above, it is considered that an expected magnitude of change of negligible will occur, and conclusions of temporary, short term negligible (not significant) are reached.

Reduction in lake volume and altered bathymetry from construction and associated implications for water resources

8.6.59 No additional mitigation, monitoring is required as there are negligible (not significant) effects.

8.6.60 Changes to the hydrological and hydrogeological aspects of the natural environment's ability to adapt to climate change - please refer to the proceeding sections above for more details.

8.6.61 The magnitude of any increase in off-site flooding from the construction of the proposed development is considered to be low, being mitigated through the inherent design and the implementation of a range of suitable measures as set out in this Chapter of the ES. As such, there are considered to be negligible (not significant) **effects** arising from the construction of the Proposed Development on the ability of the hydrological aspects of the receiving environment to adapt to climate change.

8.6.62 In a similar way, the magnitude of any change in surface or groundwater quality or resource and its ability to adapt to climate change arising from the construction of the Proposed Development is also considered to be negligible (not significant).

8.7 Assessment of Effects - Completed Development

Flood Risk Impacts

Impacts on off-site receptors

8.7.1 The FRA identifies that the peninsula and existing unnamed access road are not at risk of flooding in up to a (defended) 1 in 100 AEP fluvial event including an allowance for climate change.

8.7.2 The impermeable layer underlying the completed Development will promote surface water flow to Broadwater Lake via suitable SuDS. Because of the close proximity of groundwater to the current surface levels, this is only considered to result in a Minor magnitude of change in runoff volume or rate. When the potential storage of water in the clean cover, early provision of suitable SuDS, an increase in vegetation cover from new planting (intercepting rainfall and supporting evapotranspiration) and the surface water drainage strategy is taken into account, there is considered to be a negligible magnitude of change in the rate/volume of water entering Broadwater Lake. Consequently, the associated flood risk to off-site receptors even when future climate change is taken into account is Minor Adverse, Not Significant and acceptable.

8.7.3 It is concluded that the Proposed Development would therefore not be expected to have a detrimental impact flood risk elsewhere. With reference to Table 8.4 and taking into account the embedded measures, the magnitude of the impact would be negligible on the Medium sensitivity receptors. The flood risk to off-site receptors would therefore be temporary, medium term and negligible (not significant).

Impacts to on-site receptors (visitors and staff)

8.7.4 This section considers all potential and credible sources of flooding (surface water, fluvial and groundwater). The Proposed Development has designed out all other potential sources of flooding.

8.7.5 The FRA indicates that whilst Broadwater Lake may be at risk during a present day 1 in 2 AEP event and the south parcel in a present day 1 in 1,000 AEP event, no flooding of the land-based operational areas of the Site would be expected in up to a present day 1 in 1,000 AEP event and in a 1 in 100 AEP event +20% climate change. The existing unnamed access road is also shown to remain dry in up to a 1 in 100 AEP event +20% climate change. Whilst some flooding is indicated at its junction with Moorhall Road during a present day 1 in 1,000 AEP event, this is only over a relatively short section (approximately 130 m) beyond which dry access is provided east along Moorhall Road.

8.7.6 The Proposed Development is defined by NPPF (Annex 3) as ‘Water Compatible Development’. The current EA guidance on climate change allowances (2022) advises that for Water Compatible Development in Flood Zone 3, Flood Zone 2 and Flood Zone 1, the Central allowance should be used to assess flood risk for the lifetime of the Proposed Development. The Central allowance for the Colne management catchment is +21% (2080s). As such, the 2010 modelled outputs (+20% climate change) are considered to provide an accurate reflection of the flood risk to the Site when accounting for climate change. It is concluded that the location of the completed development at Broadwater Lake is at a Low risk of flooding from rivers. This is supported by the scheme design and the embedded environmental measures, that have integrated appropriate robust building

resilience to flooding and the adoption of an appropriate finished floor level and level of key infrastructure/controls that minimise the risk of flooding. Please refer to Appendix 8.2: Flood Risk, Drainage and Sequential Assessment.

8.7.7 The impermeable layer will promote the surface flow to Broadwater Lake, because of the close proximity of groundwater to the current surface levels, this is only considered to result in a low magnitude of change in runoff volume or rate. When the potential storage of water in the clean cover and early provision of suitable SuDS and the surface water drainage strategy is taken into account, there is considered to be a negligible magnitude of change in the rate/volume of water entering Broadwater Lake and therefore associated flood risk to on-site receptors even when future climate change is taken into account.

8.7.8 The Flood Risk from Reservoirs map (Figure 8 in Appendix 8.2: Flood Risk, Drainage and Sequential Assessment) indicates that the Site is at risk of flooding from reservoirs. However, all large reservoirs are regularly inspected by reservoir panel engineers with essential safety work conducted as required. As detailed on the gov.uk website, reservoir flooding is therefore extremely unlikely to occur.

8.7.9 The Grand Union Canal is located along the eastern boundary of the Site. Ground levels along the western canal bank adjacent to the peninsula are between 37.0 - 38.4 m AOD. Bank levels are higher than adjacent ground levels, which fall towards Broadwater Lake implying that should the bank level be exceeded, floodwater could be directed onto the adjoining land/lake(s).

8.7.10 However, the Canal and River Trust operates a comprehensive asset management system which enables it to manage the risks of such events occurring with the water level within the canal controlled by a number of weirs and sluice gates located along the pound length. The risk of the canal exceeding its bank level is therefore considered to be low. Furthermore, the Canal and River Trust has advised that it is not aware of any records of overtopping from, or breaches of this section of the waterway. Broadwater Lake would also act to intercept any flows arising from the canal and as such further minimise any risk to the area of the operational Site. Therefore, there is a low risk of flooding from the canal during operation.

8.7.11 It is concluded that the land-based operational activity is at a Low risk of flooding from reservoirs, canals, and water impounding structures. No change in flood risk is predicted to water based operational areas.

8.7.12 Groundwater levels at the Site (including the construction area) may be <0.025 m bgl (defined as High risk) during a 1 in 100 AEP groundwater flood event. The interactive web mapping for the 2018 SFRA (“Sewer, Groundwater and Artificial Flood Risk”) also identifies the Site as being located in an area where >= 75% of the area may be susceptible to groundwater flooding.

8.7.13 However, due to the nature and topography of the Site, any groundwater emerging at the surface within the peninsula would be expected to be directed towards Broadwater Lake, away from the areas of proposed operation and as such would not be expected to accumulate to any significant depth within this area of the Site.

8.7.14 It is concluded that Broadwater Lake is at a high risk of flooding from groundwater; however, the land associated with the operational activity is at a Low risk and no mitigation is required.

8.7.15 Taking into account the natural conditions and the embedded measures, the magnitude of the impact of fluvial, groundwater or any other form of flooding on the water compatible completed development, including its users would be Minor on the Low sensitivity receptors. The effect would therefore be temporary, negligible, or minor adverse (not significant).

Surface Water – Broadwater Lake

8.7.16 Please refer to Appendix 8.4: Water Framework Directive Assessment for further details.

Water Quality (accidental pollution and contamination of surface water from land-based operational activities)

8.7.17 Potential effects on surface water from operational activities are possible with the surface water associated with Broadwater Lake being a Very High sensitivity receptor. To protect this class of receptor, a range of key measures are included as set out in Section 8.5 and set out in Appendix 8.7: Draft Lake Management Plan.

8.7.18 The separation of operational activity from the underlying waste deposits and the direction of operational runoff through SuDS for suitable treatment before discharge via an agreed route/mechanism to agreed quality standards (i.e., to Broadwater Lake for clean surface water and public sewer and treatment works for foul waste) forms part of the operational plan for the Site. These water quality measures are incorporated in the Site infrastructure and surface and foul drainage strategy and managed through the implementation of a detailed operational Lake Management Plan. This approach will successfully manage the risk of pollution entering the surface water associated with Broadwater Lake and therefore potentially affecting this receptor.

8.7.19 The Draft MEMP (please refer to Appendix 7.4: Draft Mitigation and Ecological Management Plan (MEMP) Volume 1 and Appendix 7.5: Draft Mitigation and Ecological Management Plan (MEMP) Volume 2 Parts A-D provides a range of natural-process based measures to improve surface water in Broadwater Lake. A detailed suite of monitoring is proposed as part of this.

8.7.20 As a result of these embedded measures (see Section 8.5 and in the Draft LMP), the magnitude of change identified for this Very High sensitivity receptor is negligible. The rationale being that the mitigation measures reflect current best practice, will be monitored and are known to be effective. These measures will manage the quality and quantity of runoff within the operational areas, preventing effects to local water quality.

8.7.21 Therefore, for this Very High sensitivity receptors, with the expected magnitude of change of Negligible, it is reasonable to conclude that long term, minor beneficial (not significant) effects are likely to occur.

Impacts on lake morphology from operational activities

8.7.22 The operation of the new facility at Broadwater Lake will fundamentally change the controls on how the lake is used and where activities take place. All activities will be located on the peninsula and will be managed by the operator. Currently, sailing is based in the north and angling around the lake. Unauthorised trespassing and recreation also take place around the lake with many opportunities to gain access. Access will be controlled using suitable hedging and some sections of fencing, and with increased security measures provided through management of the Site. All activities will be carefully controlled and planned, and

assigned to specific areas of the lake with only a limited number of designed and managed locations where access to the water will be permitted. This will ensure that the banks of the lake and its islands are protected from physical damage from unauthorized site uses during operation.

8.7.23 The Proposed Development will permit small sailing boats, rafts, and canoes that in the main will be non-motorised; on a daily basis 1-2 small, motorised craft for instructors will also use the lake (accompanying the children within the designated sailing areas and for safety / rescue reasons). All boats / craft will be small and have a very shallow draft. The defined sailing course / area will be physically defined by chains of floating reedbeds, new islands and emergent planting areas, creating sheltered refuge areas where boats cannot gain entry. Boats will only be able to sail close to the lake bank along the eastern lake edge towards the north-east corner; elsewhere the boats will be physically kept away from the lake edge. The minimally intrusive action of these small craft, combined with their operations being restricted to deeper water in the centre and north of the lake, will ensure no change to the morphology of the lake. Effects on habitats undergoing enhancement and management will be restricted to those placed at the edge of the sailing area, these have been designed and carefully placed to shield more sensitive habitats further away.

8.7.24 Early phase work to enhance the marginal habitats of the lake will be implemented and the remaining widespread ecological habitat creation and enhancement will be carefully managed and monitored throughout the life of the Site (see Chapter 7: Biodiversity for further details).

8.7.25 The Proposed Development and its associated lake and ecological/environmental management has the potential to improve the overall hydrology, geomorphology, water quality and ecology of the lake, such as reduced turbidity, better dissolved oxygen and increased lake bed complexity to enable greater diversity of submerged and floating aquatic plants and species biodiversity; and thus, improved morphological, water quality and ecological conditions.

8.7.26 The associated MEMP (see Appendix 7.4: Draft Mitigation and Ecological Management Plan (MEMP) Volume 1 and Appendix 7.5: Draft Mitigation and Ecological Management Plan (MEMP) Volume 2 Parts A-D) requires appropriate monitoring to ensure that the targets for favorable condition are being met in response to the lake being a SSSI.

8.7.27 It is concluded that as a result of the project design and embedded positive management / monitoring, morphological and habitat enhancements (also see Chapter 7: Biodiversity) and no notable change in lake volume or capacity, the magnitude of change to this Very High Sensitivity receptor is Minor. Consequently, a Permanent moderate beneficial (significant) effect will occur.

Surface Water – Grand Union Canal

Accidental pollution and contamination of the Grand Union Canal from operation

8.7.28 Potential effects on the Grand Union Canal from operational activities are unlikely because of the spatial separation of the works and the measures taken to protect this High Magnitude sensitivity receptor.

8.7.29 As a result of these embedded measures, there will be negligible change in the magnitude of predicted impacts. The rationale being that its position and site management will prevent

any influence from the operation at Broadwater Lake. These measures reflect current best practice and are known to be effective.

8.7.30 Therefore, for this High sensitivity receptor, with the expected magnitude of change of Negligible, conclusions of negligible (not significant) effects are reached.

Surface Water – River Colne / Thames River Basin District

Accidental pollution and contamination of the River Colne (Thames River Basin District) from operation

8.7.31 Potential effects on The River Colne from operational activities are possible with the River Colne being a High sensitivity receptor. To protect this class of receptor, a range of key measures are included as set out in Appendix 8.5: Lake Water Column Profiles and set out in Appendix 8.7: Draft Lake Management Plan.

8.7.32 The separation of operational activity from the underlying waste deposits and the use of SuDS for surface water discharge via an agreed route to agreed quality standards into Broadwater Lake is an integral part of the operational strategy. All foul waste will be directed to the public sewer and appropriate treatment. These measures will successfully manage the risk of pollution entering the River Colne.

8.7.33 As a result of these embedded measures (see Section 8.5 and in Appendix 6.1: Outline CEMP), the magnitude of change identified for this High sensitivity receptor is negligible. The rationale being that these measures reflect current best practice and are known to be effective. As such, minor beneficial (not significant) effects are likely.

Groundwater – Mid-Chilterns Chalk

Accidental pollution and contamination of connected groundwater from land-based operational activities

8.7.34 Potential effects on groundwater from operational activities are unlikely, although the groundwater is a Very Highly sensitive receptor. To protect this class of receptor, a range of key measures are included as set out in Section 8.5 and set out in Appendix 8.7: Draft Lake Management Plan.

8.7.35 The separation of operational activity from the underlying waste deposits and the suitable treatment of surface water before discharge to SuDS via an agreed route to Broadwater Lake and to agreed quality standards forms part of the operational strategy. All foul waste would be directed to public sewer and suitable treatment.

8.7.36 As a result of these embedded measures (see Section 8.5 and in Appendix 6.1: Outline CEMP), the magnitude of change identified for this Very High sensitivity receptor is negligible. The rationale being that these measures reflect current best practice and are known to be effective. The drainage system will function as detailed for the operational phase to ensure that effects on groundwater quality are prevented.

8.7.37 Therefore, for the Mid-Chilterns Chalk Groundwater, a conclusion of negligible (not significant) effect is reached.

Impacts on groundwater resources from operation

8.7.38 Water levels within Broadwater Lake (and therefore groundwater recharge) are influenced by two inflow sources of water (excluding direct precipitation and groundwater). These are throughflow of water from the River Colne, via riparian gravels during flood events, and from runoff from the land based areas.

8.7.39 The combined inflow is variable, responding to precipitation and flood events, resulting in seasonal and intermittent fluctuations in water levels. In the dry or summer periods the lake can receive little freshwater for several months, although in winter the water levels are relatively constant with very little water level fluctuations (London Borough of Hillingdon, pers.comm).

8.7.40 As a result of the proposals, no modification to the inflow route associated with the River Colne will occur and inflows and lake/groundwater levels may, in fact, increase slightly as a result of increased flood frequency/magnitude (although not causing an increase on site flood risk due to capacity in the lake). Runoff from the land-based areas will be directed through appropriate SuDs and into the lake and wet woodland as part of the completed development, maintaining levels in these areas.

8.7.41 However, the magnitude of the change upon water levels in the Very High sensitivity lake and therefore groundwater is considered to be negligible. Overall, based on the above, a negligible impact is predicted upon lake hydrogeological processes in response to the completed development.

8.7.42 Potable water use would come from mains water and in effect, replace that previously used by HOAC (i.e. replacement of water usage by this by the Proposed Development). As such, no notable change in water usage or demand on groundwater resources from the operation of the facility is expected.

8.7.43 It is concluded that operation of the Proposed Development would therefore not be expected to have a detrimental impact on groundwater that would result in a negative significant effect on water resource availability. For the identified groundwater receptors, sensitivities of Very High are identified (Table 12.10), therefore with the expected magnitude of change of negligible, conclusions of negligible (not significant) effects are reached.

Changes to the hydrological and hydrogeological aspects of the natural environment's ability to adapt to climate change - please refer to the proceeding sections above for more details

8.7.44 The magnitude of any increase in off-site flooding from the completed development is considered to be low, being mitigated through the inherent design and the implementation of a range of suitable measures as set out in this Chapter of the ES. As such, there are considered to be negligible (not significant) effects arising from the construction of the Proposed Development on the ability of the hydrological aspects of the receiving environment to adapt to climate change.

8.7.45 In a similar way, the magnitude of any change in surface or groundwater quality or resource and its ability to adapt to climate change arising from the completed development is also considered to be negligible (not significant).

Implications associated with existing potable and foul water infrastructure, capacity and supply

8.7.46 Foul water would be pumped to the mains sewer and on to the relevant Thames Water Waste Water Treatment Works. In effect, the foul water from the Proposed Development replaces that previously used by the previous HOAC (i.e. replacement of foul water emissions by this by the Proposed Development). As such, not notable change in foul water treatment demand on water treatment facilities from the operation of the facility is expected.

8.7.47 The magnitude of any change in associated with surface water and foul water drainage quality or resource will not result in any notable variations in the ability of the groundwater and any dependant surface water systems to adapt to climate change. Potential effects are considered to be negligible (not significant).

Additional Mitigation, Monitoring and Residual Effects

8.7.48 It is recommended that a Flood Warning and Evacuation Plan is prepared in consultation with Hillingdon Council emergency planning team. The Site is included in an EA flood alert and warning area. This provides the opportunity for the relevant response procedures set out in the plan to be invoked in response to receipt of a flood warning from the EA. This would form part of the Operational / Management Plans associated with the Proposed Development.

8.7.49 No further additional measures are required as there are no adverse / significant effects predicted.

8.8 Cumulative Effects

Construction

Assessment

8.8.1 The nearby HS2 project is the only cumulative scheme that has the potential to result in cumulative effects on the water environment with the Proposed Development with respect to the site enabling, demolition and construction works.

8.8.2 The HS2 ES associated with the Colne Valley did not identify any changes to the future water baseline at Broadwater Lake from construction, including its surface water, groundwater and flood risk characteristics of Broadwater Lake, subject to implementation of a suitable management plan.

8.8.3 No significant adverse effects on surface water, groundwater or flood risk are predicted from the Proposed Development, therefore it is highly unlikely that any cumulative effects with HS2 will arise.

Mitigation, Monitoring and Residual Effects

8.8.4 No additional secondary mitigation measures are required to avoid, prevent, reduce or offset any significant adverse cumulative effects.

Completed Development

Assessment

8.8.5 The nearby HS2 project is the only cumulative scheme with the potential for cumulative effects on the water environment with the Proposed Development with respect to the completed development. The HS2 ES associated with the Colne Valley did not identify any changes to the future water baseline at Broadwater Lake including its surface water, groundwater and flood risk characteristics of Broadwater Lake, subject to implementation of a suitable management plan.

8.8.6 No significant adverse effects on surface water, groundwater or flood risk from the Proposed Development, therefore it is highly unlikely that any cumulative effects will arise.

Mitigation, Monitoring and Residual Effects

8.8.7 No additional secondary mitigation measures are required to avoid, prevent, reduce or offset any significant adverse cumulative effects.

8.9 Summary

8.9.1 Table 8.10 sets out a summary of effects from the Proposed Development on the water environment.

Table 8.10: Summary of Effects

Effect	Receptor (Sensitivity)	Geographic & Temporal Scale	Magnitude of Impact	Significance of Effect	Additional Mitigation and Monitoring	Significance of Residual Effect
Construction						
Flood risk	Off-site properties, business and infrastructure (Medium)	Local, temporary	Negligible	Minor	None	Negligible and Not Significant
Flood risk	On site activities and workers, (Medium)	Local, temporary	Minor	Minor Adverse	Flood Risk Monitoring Programme	Negligible and Not Significant
Surface Water – Water Quality (accidental pollution)	Broadwater Lake (Very High)	Local, temporary	Negligible	Minor Adverse	None	Minor Adverse and Not Significant
Surface Water – Water Quality (accidental pollution)	Grand Union Canal (High)	Local, temporary	Negligible	Minor Adverse	None	Negligible and Not Significant
Surface Water – Water Quality (accidental pollution)	River Colne (High)	Local, temporary	Negligible	Minor Adverse	None	Negligible and Not Significant
Surface Water – Water Quality (dredging/land reclamation)	Broadwater Lake (Very High)	Local, temporary	Negligible	Minor Adverse	None	Minor Adverse and Not Significant
Surface Water – Lake Morphology	Broadwater Lake (Very High)	Local, permanent	Negligible	Minor Positive	None	Minor Positive and Not Significant
Ground Water – Water Quality (accidental pollution)	Mid-Chilterns Chalk (Very High)	District, temporary	Negligible	Negligible	None	Negligible, Not Significant

Effect	Receptor (Sensitivity)	Geographic & Temporal Scale	Magnitude of Impact	Significance of Effect	Additional Mitigation and Monitoring	Significance of Residual Effect
Ground Water – Water Quality (dredging)	Mid-Chilterns Chalk (Very High)	District, temporary	Negligible	Negligible	None	Negligible, Not Significant
Ground Water. - Resources	Mid-Chilterns Chalk (Very High)	District, temporary	Negligible	Negligible	None	Negligible, Not Significant
Natural Environment – (ability to adapt to climate change)	hydrology/hydrogeology function (Very high)	District, temporary	Negligible	Negligible	None	Negligible, Not Significant
Existing Potable and Foul Water Infrastructure, Capacity and Supply	Thames Water Waste Water Treatment Works (Medium)	Local	Negligible	Negligible	None	Negligible, Not Significant
Completed Development						
Flood risk	Off-site properties, business and infrastructure (Medium)	Local, temporary	Negligible	Negligible	None	Negligible and Not Significant
Flood risk	On site activities and workers, (Medium)	Local, temporary	Minor	Negligible or Minor Adverse	None	Negligible or Minor Adverse and Not Significant
Surface Water – Water Quality (accidental pollution)	Broadwater Lake (Very High)	Local, temporary	Negligible	Minor Beneficial	None	Minor Beneficial and Not Significant
Surface Water – Water Quality (accidental pollution)	Grand Union Canal (High)	Local, temporary	Negligible	Negligible	None	Negligible and Not Significant

Effect	Receptor (Sensitivity)	Geographic & Temporal Scale	Magnitude of Impact	Significance of Effect	Additional Mitigation and Monitoring	Significance of Residual Effect
Surface Water – Water Quality (accidental pollution)	River Colne (High)	Local, temporary	Negligible	Minor Beneficial	None	Minor Beneficial and Not Significant
Surface Water – Lake Morphology	Broadwater Lake (Very High)	Local, permanent	Minor	Moderate Beneficial	None	Moderate Beneficial and Significant
Ground Water – Water Quality (accidental pollution)	Mid-Chilterns Chalk (Very High)	District, temporary	Negligible	Negligible	None	Negligible, Not Significant
Ground Water. - Resources	Mid-Chilterns Chalk (Very High)	District, temporary	Negligible	Negligible	None	Negligible, Not Significant
Natural Environment – (ability to adapt to climate change)	Hydrology/hydrogeology function (Very high)	District, temporary	Negligible	Negligible	None	Negligible, Not Significant
Existing Potable and Foul Water Infrastructure, Capacity and Supply	Mains water supply, public sewer and Thames Water Waste Water Treatment Works (Medium)	District, permanent	Negligible	Negligible	None	Negligible, Not Significant

8.10 Climate Change

8.10.1 The risk of flooding to the area of proposed development (i.e., the peninsula) from all identified sources is assessed to be negligible/low. However, the proposals include the creation of an extension to the peninsula, which currently forms part of Broadwater Lake, an area at Very High risk of flooding from rivers (fluvial).

8.10.2 The risk of flooding to the proposed peninsula extension from the River Colne and any residual risk to the wider peninsula area from all identified sources will be mitigated through the implementation of the following measures:

- The ground level of the extension to the peninsula should be set at a minimum of 37.89 m AOD. This is the peak modelled in-channel water level during a (defended) 1 in 100 AEP event +20% climate change.
- The finished floor level of all proposed buildings should be set at a minimum of 38.19 m AOD, i.e.,300 mm above the peak modelled in-channel water level during a (defended) 1 in 100 AEP event+20% climate change, and at least 0.15 m above adjacent ground levels following any reprofiling of the Site, with ground levels sloping down from the buildings.
- The buildings should have designed in resilience to flooding up to a minimum level of 38.23 m AOD e.g., raised power sockets, non-return valves on ground floor drainage, in line with government guidance. This is the peak modelled in-channel water level during a (defended) 1 in 1,000 AEP event.
- It is recommended that a Flood Warning and Evacuation Plan is prepared in consultation with Hillingdon Council emergency planning team. The site is included in an EA flood alert and warning area. This provides the opportunity for the relevant response procedures set out in the plan to be invoked in response to receipt of a flood warning from the EA. These measures will, subject to the implementation of an appropriately designed surface water drainage scheme, enable any potential overland flows to be conveyed safely across the peninsula without affecting property.

8.10.3 Consequently, it is considered reasonable to conclude that the scheme has incorporated measures to respond to and be resilient to the effects of Climate Change, with respect to increased intensity/duration of rainfall and potential flood risk.

8.10.4 There is an increased likelihood of more frequent and pronounced droughts as a result of climate change. The Proposed Development incorporates a wide range of measures to help retain and direct clean surface back into the lake and has introduced more varied and well-managed aquatic habitats and features associated with Broadwater Lake and the peninsula that will help it to respond to and be resilient to the effects of drought associated with Climate Change. Please refer to Chapter 7: Biodiversity for more details on these). No change in Significant Effects is predicted.

8.10.5 Consequently, it is considered reasonable to conclude that the scheme has incorporated measures to respond to and be resilient to any drought effects of Climate Change, with respect to increased intensity/duration of rainfall and potential flood risk. No change in Significant Effects is predicted.

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