ANNEX B3.1.1

Environmental Assessment: Minworth and SLR SSSI

Minworth SRO

Severn Trent Water & Affinity Water

Environmental Assessment for the Trent Strategic Resource Options (SRO)

Minworth SRO and South Lincolnshire Reservoir (SLR) SRO

Appendix A: SSSI Interaction

Affinity Water, Anglian Water Services Ltd and Severn Trent Water Ltd

Project number: 60669746
REP-003A

September 2022

Produced for Affinity Water in association with Anglian Water and Severn Trent Water

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Quality information

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1.1 Background

1.1.1 AECOM previously completed the Hydrology, Environment and Ecological (HEE) gap analysis of the River Tame, River Trent and Humber (TTH) system for Gate 1, carried out jointly for Minworth and the South Lincolnshire Reservoir (SLR). Subsequent investigations completed for Gate 2 include baseline Aquatic Ecological Monitoring (July 2022), water quality monitoring in the River Tame (July 2022), and Hydrological, Aquator and Hydraulic Modelling of the rivers Tame and Trent (July 2022). The latter has been completed in parallel with these assessments and has provided modelling outputs to inform the assessment of potential environmental impacts.

1.1.2 The HEE baseline study for the Tame, Trent and Humber in support of the Minworth and SLR for Gate 1 encompassed 19 in-depth topic reports and an overall summary report to inform further environmental assessment for the Minworth and SLR Strategic Resource Options (SRO).

1.1.3 The Gate 1 work involved considering Water Framework Directive (WFD) related impacts and benefits, baseline ecological data, and in particular the potential impacts of changes in flow to ecological receptors such as designated sites and their qualifying features, protected and notable species, and particular constraints from the presence or future spread of Invasive Non-Native Species. Also assessed were Navigation, Sedimentation, Assets along the Trent, Abstraction and Discharge Licences, Saline Intrusion, fish habitats and migration, Biodiversity Net Gain, Natural and Social Capital, and Soil and Humidity. Some of these topics have been carried forward for further detailed assessment at Gate 2, as presented here and in the overall Environmental Assessment report (60669746_REP_003_Env-Ass_Trent_SRO_V5[1], Annex B3.1), to which this report forms an appendix.

1.1.4 This report presents the assessment of interaction of the SRO schemes with Sites of Special Scientific Interest (SSSI).

1.2 Assessment Rationale

1.2.1 This report details the assessment of SSSI Interaction, including any links and interdependencies with other topics, any gaps, or limitations to the assessment (e.g., the availability of supporting information, which would have been established and flagged at an early stage), and any recommendations for further work required to incorporate into further assessment for Gate 3. This will inform the next stage of environmental assessment of the Trent Strategic Resource Options (SRO) in support of the two related SRO schemes:

- Minworth; and
- South Lincolnshire Reservoir (SLR).

1.2.2 The Services to be delivered are for Affinity Water, Anglian Water Services Limited and Severn Trent Water Limited.

1.2.3 The purpose of the Gate 2 assessment is to assess the impact of the reduction of discharge to the River Tame and Trent system, where Minworth currently discharges a Dry Weather Flow (DWF) of 417 Ml/d (as per Concept Design Report CDR, Jacobs 2022), separately and in-combination with the potential abstraction of up to 300 Ml/d (as an absolute maximum) for the SLR SRO. This assessment is critical to supporting concept design and scheme environmental assessment for key SROs at Gate 2.

1.2.4 A key element of the related SROs, Minworth and SLR, is to investigate the environmental risks and opportunities associated with delivery of the schemes.

[1] AECOM (April 2022). Environmental Assessment for the Trent Strategic Resource Options (SRO): Minworth SRO and South Lincolnshire Reservoir (SLR) SRO. Results and Recommendations.

1.3 Objectives

1.3.1 The key objectives of the Gate 2 Environmental Assessments are as follows:

- Build on the work completed in Gate 1 to provide a robust impact assessment of the discharge reduction from Minworth in to the TTH system and surrounding environment (particularly, SSSIs and interaction with SSSIs), and assess the impact the proposed transfers could have on these designated sites.
- Build on the work completed in Gate 1 to provide a robust impact assessment of the abstraction of up to 300Ml/d for the SLR, to the TTH system and surrounding environment and assess the impact the proposed transfer could have on SSSIs.
- Define what mitigation measures need to be implemented to satisfy regulators that the SROs are viable (Section 6). Any mitigation measures that require engineering solutions such as modification to fish passes or weirs, should be fed back into the Engineering workstream.
- Support engagement with key stakeholders including the Environment Agency, Natural England, Canal and River Trust, Water Resources East, and the River Trent Working Group. This has taken the form of monthly workshops to present findings and/or discuss key themes, risks, or mitigations, and site visits to inform the assessment of specific features.
- Produce an environmental scoping checklist (Section 6) to ensure identification of the likely significant environmental effects of the proposed projects and ensure all data collection is completed to allow further assessment to be carried out during Gate 3.

1.3.2 This report sets out the findings of field surveys, monitoring, and desk-based environmental assessments; to drive engagement with relevant regulators and other decision-makers; to agree the survey specifications and locations for any further data collection or studies.

1.3.3 This report covers the key theme of SSSI Interaction.

1.4 Environmental Assessment

1.4.1 The outcome of the environmental assessments supports an assessment of the potential impact and changes to the environment and ecology within the River Tame and Trent and associated water bodies and habitats as a result of activity associated with the SROs. This technical appendix and other supporting reports detail the assessment and demonstrate a clear line of sight to further assessment, identifying potential significant effects, and informing the scope for future detailed assessments as set out in the Strategic regional water resource solutions guidance for gate two (RAPID, April 2022[2]), including:

- Water Framework Directive (WFD) Compliance Assessment;
- Informal Habitats Regulations Assessment (HRA);
- Environmental Appraisal (including Strategic Environmental Assessment (SEA)); and
- Other Environmental Considerations including Biodiversity Net Gain (BNG) and Natural Capital Assessment (NCA).

1.4.2 The results of the environmental assessments are collated into the single overall report (see *Environmental Assessment for the Trent Strategic Resource Options (SRO), Minworth SRO and South Lincolnshire Reservoir (SLR) SRO Results and Recommendations, AECOM, September 2022*), supported by technical appendices, informed by regular liaison with the project teams and stakeholder engagement, for incorporation into the Gate 2 submission. This includes the results and recommendations from each topic within the environmental assessment.

1.4.3 The overall approach to the assessment and monitoring specification includes, but is not limited to, the extent of designated sites and Priority Habitats for ground truthing and walkover surveys, the extent of

[2] Regulators' Alliance for Progressing Infrastructure Development (RAPID) (April 2022). Strategic regional water resource solutions guidance for gate two.

fluvial walkover surveys, and the range of data and supporting information required to support the assessment.

1.4.4 This technical appendix supports the overall environmental assessment report, the focus of which is as follows:

i. Results and recommendations of the topic assessment;

ii. A detailed assessment of the potential impacts and changes to the environment and ecology within the Rivers Tame and Trent, and associated water bodies, habitats, and species, as a result of activities associated with the SROs;

iii. The overall environmental assessment report and technical appendices will support subsequent assessment for RAPID Gate 2;

iv. Ensure a clear line of sight toward future environmental assessments and any additional planning requirements, e.g., HRA, SEA, WFD compliance assessment, etc. This will include identifying receptors to potential impacts, the likely extent, scale, and significance of impacts according to industry standards, and preliminary recommendations for appropriate mitigation;

v. A key component of the final report will be an environmental scoping checklist to identify and grade likely significant environmental effects, to form the basis of and inform future Environmental Assessment at Gate 3;

vi. Clear identification of any gaps and limitations in the assessment, which would have been identified and discussed with the Clients and stakeholders at an early stage.

1.4.5 The key objective of this topic is to complete a baseline study that will inform further appraisal of the potential impact of SRO abstractions on the water regime and associated impacts on Sites of Special Scientific Interest (SSSI), habitats and species that are sensitive to humidity and soil moisture levels. This includes identifying (i) any evidence gaps and (ii) further work (e.g., baseline monitoring) that is required to reduce uncertainty in the future appraisal of potential impacts.

1.4.6 At Gate 2 the objective is develop a conceptual model for each SSSI as detailed as possible with the available information, to determine the relative importance of groundwater and surface water inflows to the SSSI, groundwater-surface water interactions, and how water moves through the SSSI, including whether any water level management occurs. Other influences of water levels are considered alongside the potential effects from the SROs.

1.5 Assessment Scenarios

1.5.1 Assessment of different scenarios for operation of the SRO schemes will be undertaken. This is based on the likely seasonal operation and operational regime requirements for the Minworth transfers and SLR abstraction, as described in detail in the overall assessment report (60669746_REP_003_Env-Ass_Trent_SRO_V5[3], Annex B3.1), and briefly summarised as follows:

Minworth SRO

1.5.2 The Minworth SRO supports two options for transfer of final effluent, resulting in corresponding reductions in the discharge of effluent to the River Tame. These are transfer to the Grand Union Canal (GUC) SRO, and transfer to the River Avon for the Severn to Thames Transfer (STT) SRO. This is currently divided into the following volume options:

- 115 Ml/d discharge to GUC SRO;
- 115 Ml/d discharge to River Avon for STT SRO; or
- Combined 230 Ml/d transfer to both River Avon and GUC (115 Ml/d to each).

[3] AECOM (April, 2022). Environmental Assessment for the Trent Strategic Resource Options (SRO): Minworth SRO and South Lincolnshire Reservoir (SLR) SRO. Results and Recommendations.

1.5.3 Therefore, the current approximately 417 Ml/d (DWF) discharge of final treated effluent from Minworth will reduce by a maximum of 230 Ml/d.

SLR SRO

1.5.4 The SLR SRO includes an option for abstraction from the River Trent to the River Witham, supported by further abstraction from the River Witham downstream. The Trent transfer has a maximum capacity of 300 Ml/d, with abstraction subjected to the Hands-off Flow (HoF) on the River Trent – when the HoF level is reached, abstraction will cease. The Trent transfer will support the SLR when there is insufficient flow in the River Witham.

1.5.5 Further details on the operation of both SROs are given in the main report Section 2.5.

2. Scope and Approach

2.1 Introduction

2.1.1 This section sets out the approach to Environmental Assessment of the Minworth and SLR SRO schemes, informed by RAPID guidance for Gate 2 and on-going stakeholder engagement.

2.2 Projects and Work Completed to Date

2.2.1 Key findings and recommendations from the Tame, Trent and Humber baseline assessment for Gate 1 included:

- Identification of ecologically sensitive designated sites, Priority Habitats, protected/notable species, hydro-geomorphological features, WFD statuses.
- Recommendations to complete and maintain the baseline assessment, inform subsequent impact assessment, and data refresh.

2.2.2 The literature search involved contacting statutory and local bodies, scientific literature databases, with data sources listed.

2.2.3 Reports set out the literature review and baseline information for each topic, including data gaps/recommendations, links to the consistent methodology (including SEA framework) currently being developed for the environmental assessment of SROs. This helped to demonstrate to regulators and stakeholders that the evidence effectively informed the strategic assessments.

2.2.4 These reports critically evaluated the information gathered and identified gaps in knowledge, reviewed areas of uncertainty or conflicting opinion, and formed the basis for further environmental investigation and impact assessment, including recommendations for the next stages (Gate 2) of the assessment process.

2.2.5 The Gate 1 assessment prioritised SSSIs based on water dependency, likely water level, flow, and ecological impacts. This involved identifying proximity of sites close to the Rivers Tame and Trent, their ecological sensitivity, and whether they are over aquifers or within flood zone 3, and whether the Cranfield University soil data implies greater humidity and soil moisture levels.

2.3 Scope of Field Surveys, Monitoring and Desk-Based Environmental Assessments

2.3.1 Critical to the assessment is the requirement to liaise with stakeholders and decision makers to agree the monitoring specification and purpose for discussion with the Regulators. This will be an on-going and iterative process through on-going engagement, and consideration of each stage of the assessment as it progresses.

2.3.2 Through the assessments for the Gate 1 Tame, Trent and Humber baseline study, it was noted that constraints and limitations may be encountered, for example due to the availability and completeness of available data, and therefore it has been critical to engage stakeholders at each stage to resolve potential issues, and tailor the assessment methodology to maximise the benefits of available data and information. This is critical to ensure the success of the assessment through Gate 2.

2.3.3 The outcomes of the Gate 1 baseline assessment and outputs of parallel monitoring and modelling work also underway have been used to support the large-scale environmental assessment.

2.4 SSSI Interaction

Objectives

2.4.1 Key objectives for the SSSI assessment, as identified by the Client, are as follows:

- *Identify the likely impacts for soil moisture links to SSSIs through flow changes as a result of the SRO schemes, in order to prioritise SSSIs for impact assessment.*
- *Once SSSIs have been prioritised based on likely impacts from the SRO schemes, investigate further whether relevant literature exists in relation to those sites, i.e., refresh and widen data searches/requests.*
- *Additional information for SSSIs may be held by NE that is not in the public domain i.e., there may be ongoing works to develop a water-level management plan. Recommend that for any SSSIs scoped into the assessment consultation is undertaken with the relevant Responsible Officer for the designated site.*
- *Once SSSIs have been prioritised based on likely impacts from the SRO schemes, further investigation should be made to source soil moisture, groundwater level and surface water level monitoring data and documents to inform the impact assessment.*

2.4.2 Early engagement and consultation during the development of this study with the Environment Agency, and Natural England, did not identify any additional specific objectives but was crucial in confirming the scope of assessment. It was understood by all parties that no site-specific monitoring had been conducted at any of the sites except the River Mease where the Environment Agency was undertaking their own study[4], and spot flow data from this study was provided to incorporate into the River Mease SSSI assessment.

Scope of Assessment

2.4.3 The Minworth SRO will result in a significant reduction to the existing discharge from Minworth treatment works into the River Tame and Trent system. The separate SLR SRO will abstract up to 300 Ml/d from the River Trent with an indicative location upstream of Cromwell Weir, close to East Stoke.

2.4.4 The Gate 1 baseline assessment prioritised SSSIs based on water dependency, likely water level, flow, and ecological impacts. This involved identifying proximity of sites close to the Rivers Tame and Trent, their ecological sensitivity, and whether they are over aquifers or within flood zone 3, and whether the Cranfield University soil data implies greater humidity and soil moisture levels.

2.4.5 The likely significant impacts of the Minworth SRO have been identified using the same approach as that used for the SLR SRO (refresh and widen data searches/requests, development of SSSI conceptual models, site walkovers and development of the scoping checklist).

Stakeholder engagement

2.4.6 Natural England and the Environment Agency have been involved in the assessment process from the outset at Gate 1 and have contributed to the methodology described herein.

2.4.7 Site walkover surveys were organised with the intention to involve all relevant stakeholders, however due to the reporting schedule it was only possible to visit Attenborough Gravel Pits with stakeholders: Natural England and Nottinghamshire Wildlife Trust.

2.4.8 Workshops with Natural England and the Environment Agency have been conducted throughout the collation of the SSSI baselines and development of the conceptual models at each site, with the addition of the Tame Valley Wetlands with regard to SSSIs along the River Tame.

2.4.9 Stakeholders have been engaged to determine further monitoring requirements and potential mitigation measures for likely significant effects, where these are identified, for example in relation to further assessment required for the River Blythe SSSI, which was scoped out of further assessment at Gate 1.

Priority SSSIs

2.4.10 In the Gate 1 study the SSSIs downstream of the Minworth discharge along the rivers Tame and Trent were classified to identify priority sites for consideration at Gate 2 and were reviewed by the Environment Agency and Natural England. Gate 1 reports were reviewed by these key stakeholders,

[4] River Mease Hydrological Analysis: Draft Final Report 14 October 2021

and this subsequently informed the scope of the Gate 2 assessment, including confirmation of the priority sites for further investigation.

2.4.11 Sites that are within 100m of the River Tame / Trent and within flood zone 3, or associated with a highly productive aquifer, are assumed to have the greatest potential to be impacted by the proposed SROs with respect to soils and humidity; these are shaded Red in Table 2.1.

2.4.12 The second highest category of potential impact includes sites within 500m of the rivers Tame / Trent within flood zone 3, associated with higher productivity aquifers, with higher ecological sensitivity scores (>3), and naturally wet soils; these sites are shaded Amber.

2.4.13 These SSSIs are presented in Table 2.1 below.

Table 2.1: Identified SSSIs with potential for SRO related humidity and soil moisture impacts

Name	Overlap with flood risk zone 3 (yes / no) & distance to River Tame/ Trent	Overlap with bedrock aquifer (yes / no) & productivity level & distance to River Tame / Trent	Ecological sensitivity score (if within 500 m) (1 = lowest and 5 = highest)	Relevant Cranfield University soil data
Humber Estuary	Yes. Within 100m.	Yes – low productivity aquifer. Within 100m.	4	Loamy and clayey soils of coastal flats with naturally high groundwater: Naturally Wet
Lea Marsh	Yes. Within 100m.	Yes – low productivity aquifer. Within 100m.	4	Loamy and clayey floodplain soils with naturally high groundwater: Naturally Wet
Donington Park	Yes. Within 100m.	Yes – highly productive aquifer. Within 100m.	N/A – scoped out of ecological assessment as not surface water dependent habitats	Freely draining
Attenborough Gravel Pits	Yes. Within 100m.	Yes – low productivity aquifer. Within 100m.	3	Areas of Water & Freely draining floodplain soils
Whitacre Heath	Yes. Within 100m.	Yes – low productivity aquifer. Within 100m.	3	Areas of Water & Loamy and clayey floodplain soils with naturally high groundwater: Naturally Wet.
River Mease	Yes. Within 100m.	Yes – low productivity aquifer. Within 100m.	1	Loamy and clayey floodplain soils with naturally high groundwater: Naturally Wet.
Mother Drain, Misterton	Yes. Between 100m and 500m.	Yes – low productivity aquifer. Within 500m.	2	Loamy and clayey soils of coastal flats with naturally high groundwater: Naturally Wet.
Besthorpe Meadows	Yes. Between 100m and 500m.	Yes – low productivity aquifer. Within 500m.	3	Areas of Water & Loamy and clayey floodplain soils with naturally high groundwater: Naturally Wet
Holme Pit	Yes.	Yes – low productivity aquifer. Within 500m.	2	Areas of Water & Slightly acid

Name	Overlap with flood risk zone 3 (yes / no) & distance to River Tame/ Trent	Overlap with bedrock aquifer (yes / no) & productivity level & distance to River Tame / Trent	Ecological sensitivity score (if within 500 m) (1 = lowest and 5 = highest)	Relevant Cranfield University soil data
	Between 100m and 500m.			loamy and clayey soils with impeded drainage
Lockington Marshes	Yes. Between 100m and 500m.	Yes – low productivity aquifer. Within 500m.	2	Loamy and clayey floodplain soils with naturally high groundwater: Naturally Wet
River Blythe	Yes. Between 100m and 500m.	Yes – low productivity aquifer. Within 500m.	1	Areas of Water & Loamy and clayey floodplain soils with naturally high groundwater: Naturally Wet

2.4.14 At Gate 2 the objective is to develop a conceptual model for each SSSI as detailed as possible with the available information, to determine the relative importance of groundwater and surface water inflows to the SSSI, groundwater-surface water interactions, and how water moves through the SSSI, including whether any water level management occurs.

2.5 Assessment Methodology

2.5.1 The Gate 1 environmental baseline assessment for these SROs comprised a desk study to inform further appraisal of the potential impact of SROs on the water regime and associated impacts on SSSIs, habitats and species that are sensitive to humidity and soil moisture levels.

2.5.2 The impacts of the SLR SRO will be downstream of the indicative abstraction location at East Stoke. The Gate 1 assessment identified that the key SSSIs with potential for humidity and soil moisture impacts from the SLR SRO were the Humber Estuary SSSI and Lea Marsh SSSI. The assessment also identified Mother Drain Misterton SSSI and Besthorpe Meadows SSSI as having some potential for SRO-related impacts. However, these were not taken forward for further assessment after initial conceptual model development and workshop consultation with Natural England.

2.5.3 The Gate 1 assessment identified Donington Park SSSI, Attenborough Gravel Pits SSSI, Whitacre Heath SSSI and River Mease SSSI as key sites with potential for humidity and soil moisture impacts from the Minworth SRO. In addition, it was agreed during workshop consultation with Natural England to investigate Holme Pit SSSI, Lockington Marshes SSSI and River Blythe SSSI.

2.5.4 The locations of the SSSIs taken forward to Gate 2 are given in Annex I.

2.5.5 The Gate 2 assessment builds upon the baseline assessment, including via the identification of likely significant effects (including cumulative effects) and additional monitoring required under RAPID Gate 3 at the next stage of assessment.

2.5.6 The approach was to develop conceptual models for each of the SSSIs, building on information gathered for the baseline assessment. This includes a review of the available LiDAR, geological, hydrological, and hydrogeological data and re-confirming with Natural England and the Environment Agency whether other relevant reports or monitoring data exist for the SSSIs that was not available at Gate 1.

2.5.7 An AECOM water specialist and a terrestrial ecology specialist undertook site walkovers of the SSSIs during January and February 2022. The walkovers were used to ground truth the emerging conceptual models. The Attenborough Gravel Pits SSSI visit also benefited from the guidance of a Natural England ecologist on site.

2.5.8 Once the conceptual models and site walkovers were complete, a source-pathway-receptor approach was used to identify whether likely significant effects will occur on the water regime and sensitive ecology at SSSI sites. Hydraulic modelling (AECOM, June 2022) estimated the fall in water levels as a result of the SROs which was incorporated into the assessment. This included the alone and in-combination assessment for the Minworth and SLR SROs.

2.5.9 Monthly stakeholder engagement workshops were held with the Environment Agency and Natural England to discuss the conceptual models and the developing source-pathway-receptor linkages. Representatives of Severn Trent Water and Affinity Water were also present.

2.6 Limitations

SSSI Assessment

2.6.1 The following limitations have been identified in terms of the SSSI assessment:

- There is no monitoring of groundwater levels, water feature levels, and river levels at each of the sites. Therefore, there is no quantitative assessment of the relationship between the SSSI water features, and the river affected by the SRO.
- The assessment is based on hydrological and hydrogeological principles used to develop a conceptual model of each site; and a source-pathway-receptor assessment as to whether river level changes as a result of the SROs could impact SSSI water features.
- Changes to river levels are based on hydraulic modelling. The assumptions are described in the final modelling report (AECOM, June 2022).
- Modelled water levels and consideration of historic seasonal patterns has not included predictions of changes to the natural cycles as a result of climate change.

3. Summary of Results

3.1.1 This section provides a summary of the conceptual model and impact assessment.

3.1.2 Baseline data has been compiled and interpreted for each site in Annex II. Site visits are described in Section 4. A conceptual understanding and conclusions regarding the potential impacts of the SROs on each of the SSSIs is presented in Section 5. Hydraulic modelling (AECOM, June 2022) refers to the River Tame and River Trent 1D and 2D models provided to AECOM by the Environment Agency and updated.

3.1.3 The assessment has considered whether surface waters in the SSSIs may be affected directly from lower flows in the rivers Tame and Trent, and whether changing water levels will affect groundwater levels that then may affect surface water features in the SSSIs. This has then been considered in the context of natural seasonal variation in water levels in the rivers and aquifers, and other features controlling water levels near the SSSIs such as weirs, abstractions, and discharges. This assessment has not considered climate change impacts.

3.1.4 Whitacre Heath was found to have had all the superficial deposits removed by quarrying except for in the immediate vicinity of the River Tame and a thin outcrop across the site. The surface water features on site, consisting of ponds, are not connected to the superficial deposits, and so are hydraulically disconnected from the River Tame. The ponds are dependent on rainfall ponding on the low permeability ground comprising mudstone and pulverised fuel ash. The ponds are anticipated to also be supported by flooding of the site. The reduction in flow due to the Minworth SRO is not anticipated to prevent flooding of the site to support water features, being 8% of Q5 flows.

3.1.5 The River Mease is designated SSSI for it's in-river habitats. It has been established that the River Mease does not gain flow from the River Tame across the superficial deposits aquifer. Hydraulic modelling predicts an insignificant reduction in water levels in the River Trent near the confluence with the River Mease. Groundwater levels in the superficial deposits aquifer are not expected to fall to levels that may cause flow loss from the River Mease to the aquifer. Therefore, the in-river habitats in the lower Mease are not considered to be affected by level changes in the rivers Tame and Trent.

3.1.6 Donington Park was found to not contain a hydrogeological or hydrological link with the River Trent, due to the SSSI being located on bedrock at significantly higher elevation that the River Trent. River levels can interact with the superficial aquifer and the Helsby Sandstone principal aquifer, but these are hydraulically separated from the bedrock underlying the SSSI, which comprises mudstone.

3.1.7 Attenborough, Holme Pit, Lockington Marshes, and Lea Marsh SSSIs contain surface waters that have been found to not be directly connected to the River Trent. At high river levels streams on site were found to be at higher elevation and discharging under gravity. Sluices also control outflows, and therefore surface waters on the site are not supported by high river levels backing up across the SSSIs. Changes in river level may propagate through the superficial aquifer toward surface water features at the SSSIs. The groundwater level changes predicted by hydraulic modelling are not considered to be significant in the context of the natural seasonal variation and may not persist as far as SSSI water features considering local recharge and rainfall events affecting river levels.

3.1.8 Lea Marsh SSSI and Humber Estuary SSSI are in the tidal reaches of the River Trent. Hydraulic modelling of River Trent flows predicts a change in flow over Cromwell Weir (combined effect of Minworth and SLR) that is insignificant relative to the daily change in water levels resulting from the tides. As described above, streams on site at Lea Marsh were found to be at higher elevation and discharging under gravity to the River Trent, controlled by a sluice. Therefore, the Minworth and SLR SROs are not anticipated to have a significant effect on water levels at the SSSIs along the tidal River Trent.

3.1.9 The River Blythe is designated SSSI for its in-river habitats. The River Blythe is designated SSSI for the in-river environment, and therefore the overall impact assessment relates to riverine habitats and fisheries. Changes to River Tame levels are not considered to affect groundwater levels in the superficial deposits aquifer significantly to cause a significant change in base flow in the River Blythe. The river level changes and effects of the surface water abstraction and weirs in the lower Blythe may affect fish passage. Further assessment of the effect of the SROs on the River Blythe SSSI is discussed in other appendices.

4. Site Visits

4.1 Overview

4.1.1 From January – February 2022 several site visits were undertaken to priority SSSIs to better understand the surface water interactions and the relationship between the sites and the rivers Trent and Tame. This focused on seven sites: Attenborough Gravel Pits, Holme Pit, Whitacre Heath, Lower River Blythe, Lower River Mease, Lockington Marshes, and Lea Marsh. The walkovers were constrained to accessible locations, such as bridges, or reaches where the sites could be accessed through public footpaths.

4.1.2 AECOM requested a representative from Natural England, the Environment Agency, and local wildlife trusts to attend but there was limited availability during the time frame of this study except for Attenborough Gravel Pits.

4.1.3 Site visits were undertaken during a period of high river levels where there was more opportunity for connection to SSSI water features than in summer. The visits (described in this section) found no direct surface water connections and therefore in summer, when higher volumes would be utilised by the SRO, water features are expected to be more disconnected. Conceptual models are discussed in detail in section 5.

4.2 First site visit (26.01.2022)

4.2.1 The initial site visits were undertaken on 26 January 2022 to Attenborough Gravel Pits and Holme Pit to inform on water interactions between the site and the main rivers potentially affected by the SROs.

Attenborough Gravel Pits

4.2.2 A site visit was undertaken of Attenborough Gravel Pits SSSI on 26th January 2022 This visit was undertaken by an AECOM Water Scientist and Ecologist, led by a Natural England and Nottinghamshire Wildlife Trust who help manage the site. A summary of the observed areas is shown in Table 4.1 and Figure 4.1.

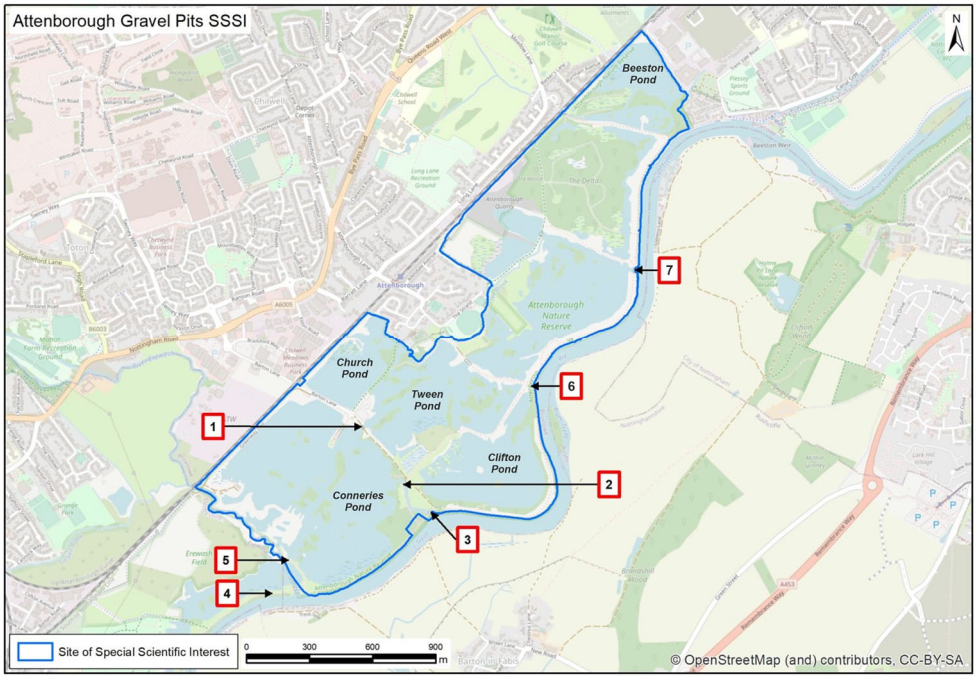

Figure 4.1 Map of locations visited during the Attenborough Gravel Pits site visit

Table 4.1. Locations visited during the Attenborough Gravel Pits SSSI site visit

SSSI	Location Reference	Reason for visit	National Grid Reference (NGR)
Attenborough Gravel Pits	1	Connection between Coneries Pond and Tween Pond	[redacted]
	2	Coneries Pond outflow weir	
	3	Coneries flow outflow sluice	
	4	Erewash sluice	
	5	Coneries Pond and Erewash connection	
	6	Outflow from Clifton Pond	
	7	Outflow from Main Pond	

Location 1

4.2.3 This location was chosen to identify the relationship between how Coneries Pond is connected to Tween Pond. The connection between the two ponds is continuous, with a clear span concrete bridge dividing the two waterbodies (Plate 1 and Plate 2).

Plate 1 Looking towards Coneries Pond from clear span footbridge

Plate 2 Looking towards Tween Pond from clear span footbridge

Location 2

4.2.4 This site is the beginning of the outflow of Coneries Pond, which is the original channel of the River Erewash before the construction of the gravel pits in the 1970s. Controlling the outflow is a weir that was raised in the early 2000s using sandbags to help encourage the flow of the Erewash to discharge through the sluice downstream of the Erewash channel (Plate 3 - Plate 5).

Plate 3 Coneries weir looking upstream from LHB[5]

Plate 4 Looking across Coneries weir from LHB

Plate 5 Looking downstream from LHB at Coneries outflow, the original Erewash outflow channel to the Trent

[5] LHB = Left-hand Bank

Location 3

4.2.5 This site lies downstream of Location 2 and is the original outflow of the River Erewash to the River Trent. A concrete bridge culvert crosses the channel from which a sluice gate controls the flow (Plate 6 - Plate 9).

Plate 6 Looking upstream from footbridge at original Erewash outflow (now Coneries Pond outflow)

Plate 7 Looking downstream towards River Trent from footbridge at original Erewash outflow (now Coneries Pond outflow)

Plate 8 Looking at sluice gate from LHB

Plate 9 Looking towards LHB at sluice contraption

Location 4

4.2.6 This site lies downstream of the River Erewash outflow (Plate 10). Here the flow is controlled by weir and slap sluice that has a fish pass built into (Plate 12 and Plate 13). The water level within the pond here was higher than the water level within the River Trent (Plate 11 and 12). The representative from the Nottinghamshire Wildlife Trust informed that during the summer months, the discharge amount into the Trent from the ponds stays relatively continuous, however the amount of water discharging from the fish pass decreases. During the winter months when flooding is more likely, the sluice flaps are turned on to prevent flooding of the pond, which would likely wash away the banks which are primarily composed of superficial deposits.

Plate 10 Looking upstream towards Erewash outflow and barge gap from weir

Plate 11 Looking towards Erewash outflow weir

Plate 12 Downstream of Erewash weir outflow

Plate 13 Looking at outflow from Erewash weir towards the River Trent

Location 5

4.2.7 This location lies directly upstream from the mouth of the River Erewash, where River Erewash flows are connected through the barge gap into Coneries Pond (Plate 14 - Plate 16). The Erewash was breached in the 1970s to allow travel of barges between the gravel pits. Due to polluted water previously entering the gravel pits, much of the Erewash was embanked, therefore this is the only connection of the River Erewash to the pits (and therefore the main hydrological supply to the SSSI), and thereafter to the River Trent. Proposals to close the barge gap have been in the pipeline since 2016, with discussions on-going over its closure. There are plans for a penstock sluice to be installed between the closure to allow for controlled flows between the River Erewash and the pits.

Plate 14 Outflow of the Erewash to gravel pits

Plate 15 Barge gap to the gravel pits

Plate 16 The barge gap looking towards Coneries Pond

Location 6

4.2.8 This site was an example of one of the small outflows from the ponds to the River Trent, located at the furthest reach of Clifton Pond towards Main Pond (Plate 17 and Plate 18). It is a very small outlet that is controlled by a sluice. At the time of the survey, water was not flowing. From this site, the areas which receive flood overflow from the River Trent were visible (Plate 19).

Plate 17 Small controlled outflow from Clifton Pond looking towards Clifton Pond

Plate 18 Outflow of Clifton Pond looking towards the River Trent

Plate 19 Area that received flood overflow from the River Trent

Location 7

4.2.9 The last location visited on the survey was the weir/sluice that controls the outflow from Main Pond into the River Trent. The weir is located below the footbridge, from where the water is controlled downstream of this by a flap sluice gate. Unlike the Erewash sluice, this does not have a fish pass. This is the only outflow from the Main Pond to the River Trent, however it is likely that water percolates through 'The Bund' that dissect the Main Pond from The Delta Sanctuary as it is primarily composed of superficial deposits (Figure 6.11).

Plate 20 Looking from left bank at weir/sluice-controlled outflow of Main Pond to the River Trent

Plate 21 Weir structure of Main Pond outflow taken from footbridge

Plate 22 Footbridge between Main Pond and outflow to the River Trent

Plate 23 Sluice gates controlling outflow of Main Pond to the River Trent

Holme Pit

4.2.10 A site visit was undertaken of Holme Pit SSSI on 26th January 2022 to inform on water interactions between the site and the surrounding waterbodies. This visit was undertaken by an AECOM Water Scientist and Ecologist. A summary of the observed areas is shown in Figure 4.2 and Table 4.2

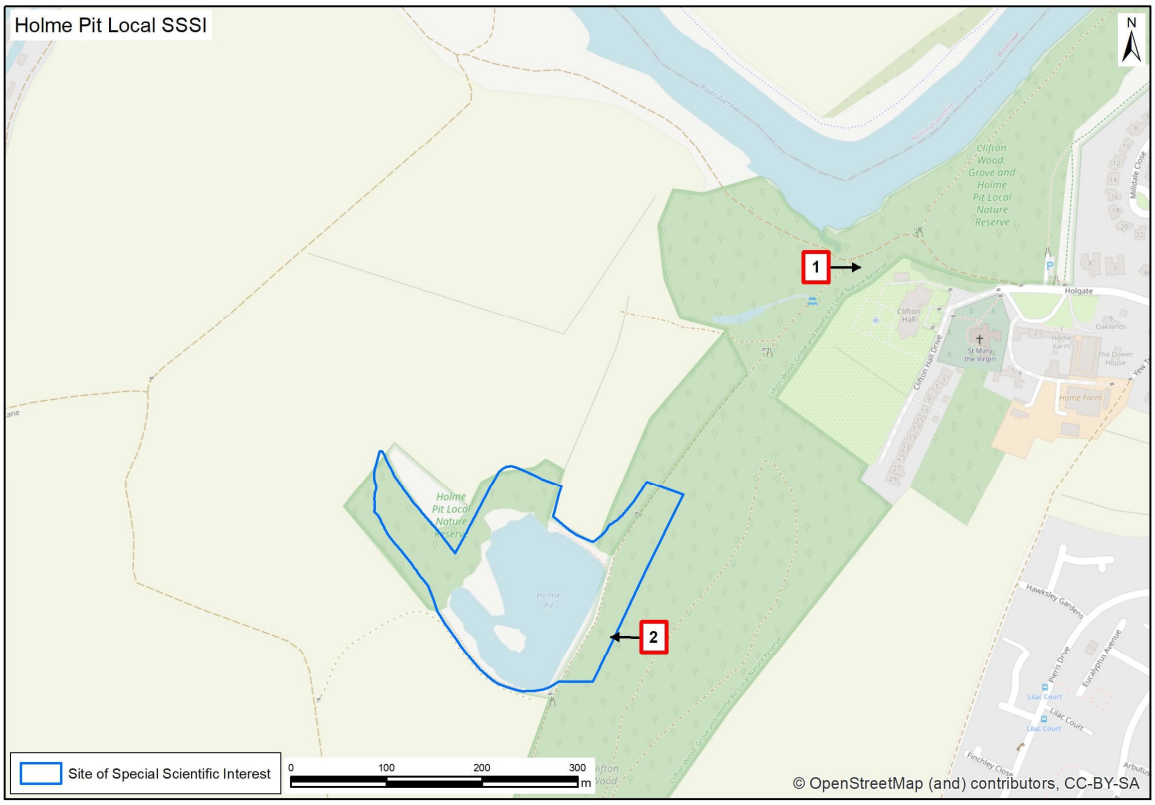

Figure 4.2 Map of locations visited during the Holme Pit site visit

Grid references for continued monitoring locations redacted

Table 4.2 Locations visited during the Holme Pit site visit

SSSI	Location Reference	Reason for visit	National Grid Reference (NGR)
Holme Pit	1	Outflow channel of Holme pit to the River Trent	[redacted]
	2	Holme Pit	

Location 1

4.2.11 This location was chosen to identify the relationship between the outflow channel of Holme Pit and the River Trent and if flood defences were present. From the walkover, it was observed that the channel was receiving flow from Holme Pit pond (Plate 24 - Plate 27). The riparian vegetation around the downstream reach towards the confluence with the River Trent had been flattened away from the channel (Plate 24 and Plate 25) which is suggestive that flows from the Trent 'back-up' into the overflow channel during flooding or very high flow events.

Plate 24 Looking downstream from the public footpath at the outflow of Holme Pit into the River Trent. [redacted]

Plate 25 Downstream outflow channel of Holme Pit. [redacted]

Plate 26 Looking upstream the outflow channel towards Holme Pit. [redacted]

Plate 27 Looking across outflow channel from RHB[6]

Location 2

4.2.12 This site consisted of the main pond of Holme Pit. Due to access limitations, the outflow of the pit into the channel was unable to be observed.

[6] RHB = Right-hand Bank

Plate 28 Gypsum beds visible in a cliff outcrop across from the outflow channel of Holme Pit

Plate 29 Looking upstream to Holme Pit [redacted]

Plate 30 Looking downstream to outflow channel of Holme Pit [redacted]

4.3 Second site visit (09.02.22 and 10.02.22)

4.3.1 On the 9th and 10th February 2022, a second site visit was undertaken to five SSSIs under investigation. These were (from upstream to downstream): lower River Blythe, Whitacre Heath, lower River Mease, Lockington Marshes and Lea Marsh. These were undertaken to inform on water interactions between the site and the main rivers affected by the SROs. This visit was undertaken by an AECOM Water Scientist and Aquatic Ecologist.

Lower River Blythe

4.3.2 A summary of the observed areas in the Lower Blythe area is shown in Figure 4.3.

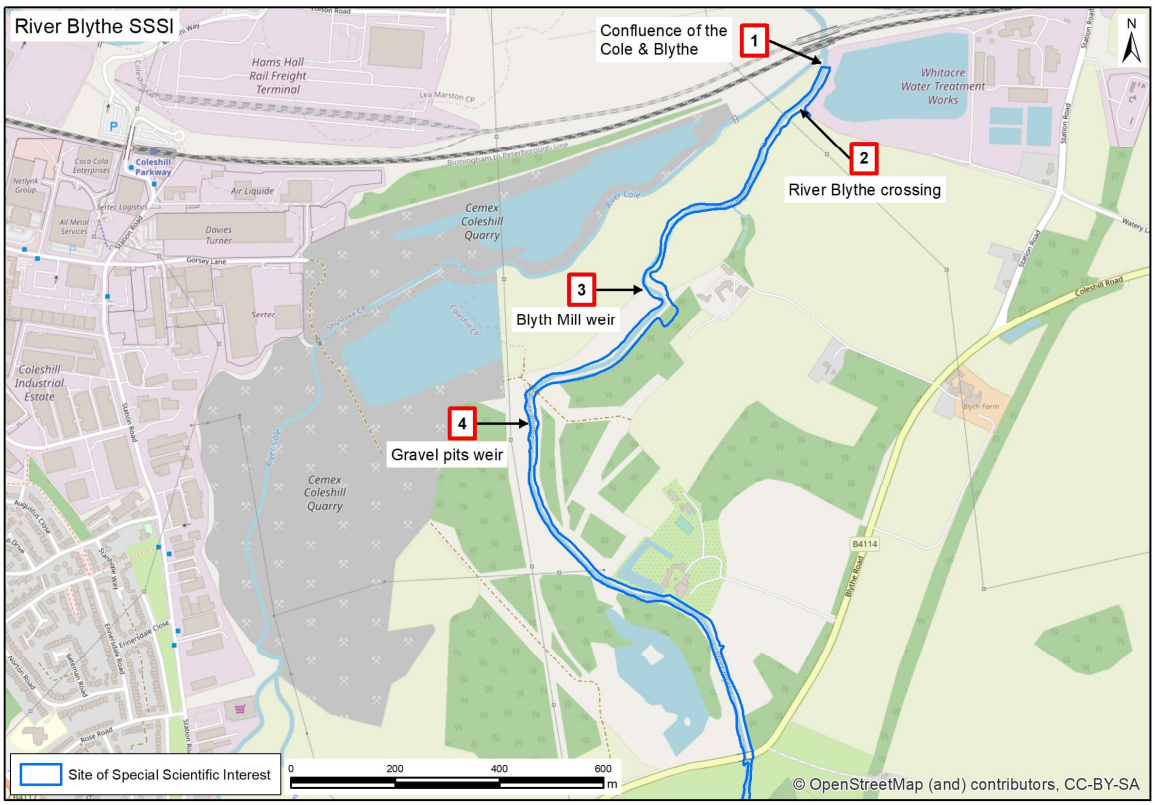

Figure 4.3: Map of locations visited during the lower River Blythe site visit

Conditions on the day of site visit

4.3.3 Level records in the River Blythe channel were reviewed to establish approximate flow conditions at the time of the survey as this SSSI is designated for its in-river habitats. The days leading up to the survey had been relatively wet. The nearest gauging station to the site is Castle Farm.

4.3.4 Long term water level monitoring data is available at this station between late November 2012 and February 2022. Levels at this site were also obtained on the day of the survey via River Levels UK[7]. Level statistics were determined for this site and the levels on the day of the survey were compared to these.

4.3.5 A summary of the level analysis is presented in Table 4.3 while levels on the survey day are indicated in green. Levels at River Blythe at Castle Farm gauging station were around the H_{50} (slightly higher) on 9 February 2022.

Table 4.3: Level statistics for River Blythe at Castle Farm gauging station (mAOD)

Gauge station	River Blythe at Castle Farm (mAOD)
Level 09/02/2022 average	**0.726**
H_{95}	0.589
H_{70}	0.660
H_{50}	0.707
H_{10}	1.217
H_{5}	1.441

[7] River Levels UK – River Blythe at Castle Farm. Available at: https://riverlevels.uk/river-blythe-coleshill-castle-farm#.Yg0XlP7P2Uk (Accessed February 2022)

Location 1 – Confluence of the River Cole and River Blythe

4.3.6 This location was chosen to see the relationship between the River Cole and the River Blythe. From the walkover, levels in both the River Cole and Blythe were high due to the high levels of precipitation in the previous days to the survey.

Plate 31 Looking downstream at the confluence of the River Cole and the River Blythe from the LHB of the River Cole [redacted]

Plate 32 Looking upstream at the confluence of the River Cole and the River Blythe from the LHB of the River Cole [redacted]

Plate 33 Looking downstream at the River Blythe, directly downstream of the confluence of the River Cole and the River Blythe from the LHB of the River Cole [redacted]

Location 2 – Lower River Blythe

4.3.7 This site gave access to the shared floodplain of the River Blythe and River Cole (Plate 34 - Plate 36).

Plate 34 Looking upstream at the River Blythe from a footbridge [redacted]

Plate 35 Shared floodplain of the River Blythe (LHB) and River Cole (RHB) [redacted]

Plate 36 Looking downstream at the River Blythe from footbridge [redacted]

Location 3 - Blythe Mill weir

4.3.8 This location was chosen to see if the 'backing-up' effect of water levels on the River Tame into the River Blythe was observable over the lower weir. From Plate 38 it can be seen that the historic sluice gates have been removed and the weir is partially submerged.

Plate 37 Looking upstream at a drainage channel discharging into the River Blythe [redacted]

Plate 38 Looking upstream at the main channel of the River Blythe towards Blythe Mill weir [redacted]

Plate 39 Looking downstream at the main channel of the River Blythe from the LHB [redacted]

Location 4 – Gravel pits weir

4.3.9 This is the second weir within the lower River Blythe. Observable levels within the upper channel were high (Plate 40 and Plate 41).

Plate 40 Looking upstream from the LHB at the River Blythe [redacted]

Plate 41 Looking from the LHB across the River Blythe channel at the gravel pits weir [redacted]

Plate 42 Looking downstream at the River Blythe from the LHB

Plate 43 Flooded gravel pits near the River Blythe [redacted]

Whitacre Heath

Location 1

4.3.10 The northern part of the reserve was chosen to view the connection between the River Tame and Whitacre Heath and the likelihood of the site receiving surface flow via flooding. At this location, the river was not embanked and whilst there was no evidence to suggest that the river had flooded the site recently, due to the good connection to the banks, it likely the site frequently receives flood flow from the Tame. Due to the nature of the terrain of the site, this was the only area accessible to view the River Tame, however the Aquatic Ecologist on the survey had previously walked the site and said that the character of the river is consistent along the site.

Plate 44 Looking upstream at the River Tame from RHB. Taken outside of the SSSI [redacted]

Plate 45 Looking upstream at the River Tame from the right-hand bank. The northern pastures of Whitacre Heath nature reserve on the RHB [redacted]

Plate 46 Looking upstream at the River Tame from RHB. The northern pastures of Whitacre Heath nature reserve on the RHB [redacted]

Location 2

4.3.11 The pools and woodland were visited during the survey (Plate 47 - Plate 49). According to the BGS Geo Index viewer, there are no superficial deposits within the site, which would suggest a groundwater disconnection from the River Tame. Throughout the reserve were blocks of clay/mudstone that would have likely been sourced from the quarry that have been used to pave the site (Plate 50 - Plate 52), which likely indicates that during the historic quarrying of the area, most gravels had been excavated and bedrock was reached, as indicated on the geological map.

Plate 47 Whitacre Heath standing pools [redacted]

Plate 48 Whitacre Heath standing pools [redacted]

Plate 49 Topographic differences within Whitacre Heath due to historic quarrying [redacted]

Plate 50 Footpaths around Whitacre Heath [redacted]

Plate 51 Blocks of bedrock in Whitacre Heath [redacted]

Plate 52 Block of bedrock in Whitacre Heath [redacted]

Lower River Mease

4.3.12 The confluence of the River Mease and the River Trent was visited.

Conditions on the day of site visit

4.3.13 Level records in the River Mease channel were reviewed to establish approximate flow conditions at the time of the survey as this SSSI is designated for its in-river habitats. The days leading up to the survey had been relatively wet. The nearest gauging station to the site is Clifton Hall.

4.3.14 Long term water level monitoring data is available at this station between October 2014 and March 2022. Levels at this site were also obtained on the day of the survey via River Levels UK[8]. Level statistics were determined for this site and the levels on the day of the survey were compared to these.

4.3.15 A summary of the level analysis is presented in Table 4.4 while levels on the survey day are indicated in green. Levels at River Mease at Clifton Hall gauging station were around the H_{35} (slightly higher) on 9th February 2022.

Table 4.4. Level statistics for River Mease at Clifton Hall gauging station (mAOD)

Gauge station	River Mease at Clifton Hall (mAOD)
Level 09/02/2022 average	**0.256**
H_{95}	0.125
H_{70}	0.164
H_{50}	0.194
H_{35}	0.243
H_{10}	0.558
H_5	0.816

[8] River Levels UK – River Mease at Clifton Hall. Available at: https://riverlevels.uk/derbyshire-netherseal-clifton-hall-flow#.Yh94wpTP2Uk (Accessed March 2022)

Plate 53 Looking across the River Mease channel from LHB [redacted]

Plate 54 Looking downstream at the confluence of the River Mease and River Trent[redacted]9

Plate 55 Looking upstream at the River Trent[redacted]

Lockington Marshes

4.3.16 Three sites were visited on the survey; the confluence of the River Soar and the River Trent, the outflow of Hemington Brook and the wetlands as shown in Figure 4.4.

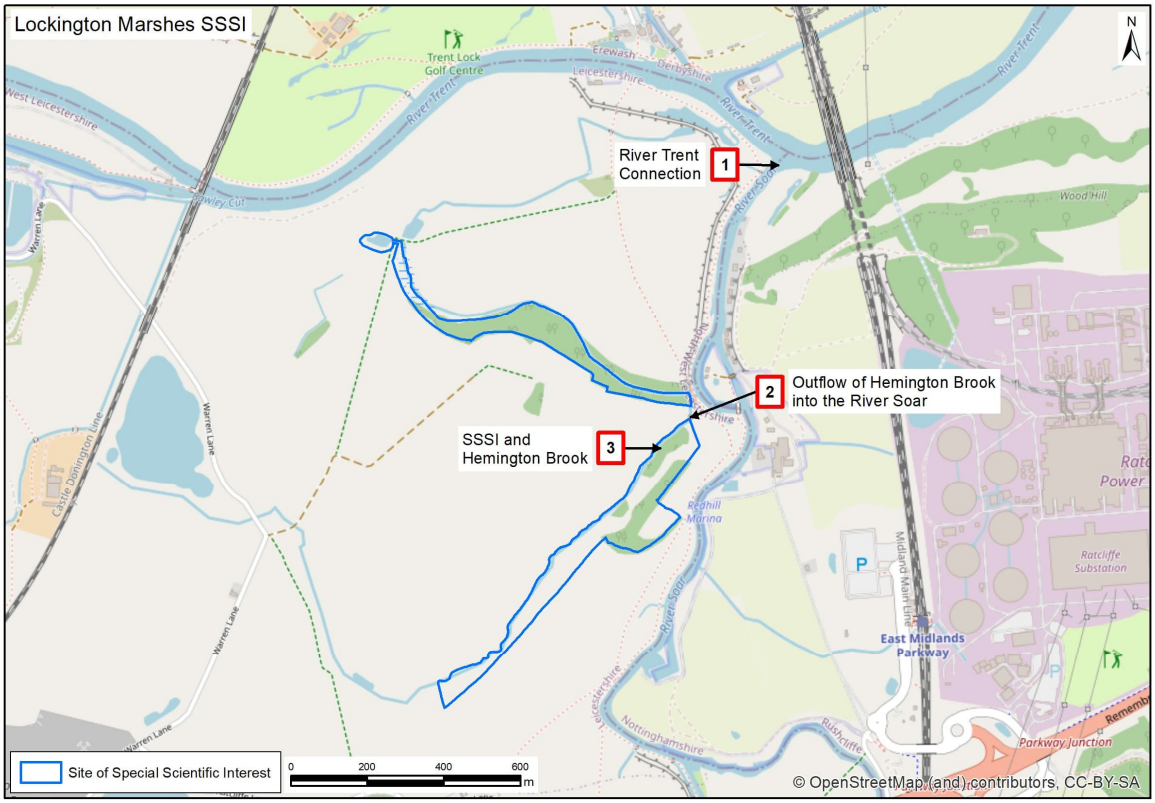

Figure 4.4: Map of locations visited during the Lockington Marshes site visit

Location 1

4.3.17 This site was chosen to observe the connection of the River Soar and the River Trent (Plate 56 - Plate 60). The rivers are both well connected to their floodplains which are likely to frequently experience flooding during high flows. An embankment was observed that lies parallel to the Trent and the Soar (Plate 58 and Plate 60).

Plate 56 Looking downstream from LHB of the River Soar towards the confluence with the River Trent [redacted]

Plate 57 Looking upstream towards the River Trent from a drainage ditch on LHB of River Soar [redacted]

Plate 58 Looking upstream towards the River Trent and its floodplain. Embankments are visible towards Lockington Marshes [redacted]

Plate 59 Looking across the River Soar channel from LHB [redacted]

Plate 60 Erosion of LHB of River Soar, looking upstream towards Lockington Marshes [redacted]

Location 2

4.3.18 This site was chosen to examine the outflow of the Hemington Brook into the River Soar. During the time of the survey, flows in the channel were high (Plate 61). The outflow is controlled by a sluice gate (Plate 63). On the public footpath a planning notice for future gravel extraction works near the site (Plate 65).

Plate 61 Looking downstream the River Soar from LHB towards the confluence of Hemington Brook and the River Soar [redacted]

Plate 62 Looking downstream at Hemington Brook from RHB towards sluice gate [redacted]

Plate 63 Sluice gate controlling outflow of Hemington Brook to the River Soar [redacted]

Plate 64 Looking downstream at River Soar from LHB [redacted]

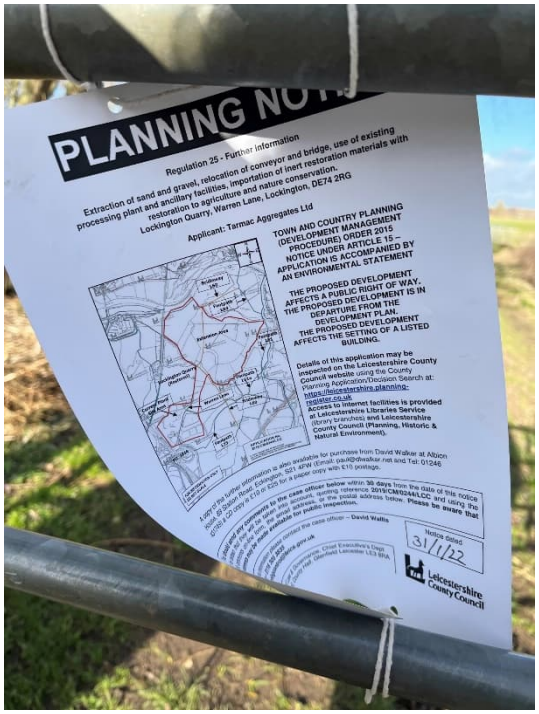

Plate 65 Planning notice of potential future gravel extraction near Lockington Marshes

Location 3

4.3.19 This site focused on the two 'limbs' of wetland of the SSSI. Hemington Brook, which borders the southern 'limb' of the site had breached its banks and flooded the adjacent farmland and SSSI (Plate 66 - Plate 69).

Plate 66 Looking upstream at southern arm of SSSI at Hemington Brook [redacted]

Plate 67 Looking upstream at southern arm of SSSI at Hemington Brook [redacted]

Plate 68 Looking downstream at southern arm of SSSI at Hemington Brook[redacted]

Plate 69 Looking across at southern arm of SSSI at Hemington Brook[redacted]

Plate 70 Looking across at northern arm of SSSI at Hemington Brook[redacted]

Lea Marsh

4.3.20 During the site visit, Lea Marsh was only accessible via the public footpath that runs parallel to the site, therefore the channel and drains that run through the site were not observed (Plate 71). Lea Marsh main drain borders the site (Plate 72 - Plate 74) and is culverted from the border of the SSSI to the River Trent, where the outflow is controlled by a sluice gate (Plate 75)

Plate 71 Looking across Lea Marsh SSSI site SK 81607 87339

Plate 72 Looking upstream at Lea Marsh main drain [redacted]

Plate 73 Culverted Lea Marsh main drain taken from RHB [redacted]

Plate 74 Looking towards culverted Lea Marsh main drain and the River Trent [redacted]

Plate 75 Sluice controlled outfall of Lea Marsh main drain into the River Trent [redacted]

Plate 76 Looking towards the culverted Lea Marsh main drain from the bank of the River Trent

Plate 77 Second drain that borders Lea Marsh SSSI [redacted]

Plate 78 Second sluice gate [redacted]

Plate 79 Looking at outflow of second drain downstream of sluice gate across the River Trent [redacted]

5. Conceptual models, modelling results and impacts

5.1 Introduction

5.1.1 The following information sources have been used to inform this section in conjunction with data received from the Environment Agency and Natural England:

- British Geological Society's Online Mapping Viewer 'GeoIndex'
- Online Ordnance Survey Maps
- Centre for Ecology and Hydrology (CEH). National River Flow Archive
- Defra. Multi-Agency Geographic Information for the Countryside (MAGIC)
- Environment Agency Catchment Data Explorer website
- Environment Agency Water Quality Archive website
- Environment Agency. Flood Risk Maps for Planning
- Environment Agency. River level data
- Met Office. Climate averages data
- Cranfield University's Soilscapes Website
- Environment Agency, Long Term Flood Risk Mapping

5.2 Modelling Results

5.2.1 Partly calibrated hydraulic models (at the time of reporting) were simulated for the Rivers Tame and Trent to assess the potential reduction in water level under two scenarios. These outputs are based on a partly calibrated model - only 2 locations on the Tame had Aquator outputs or reasonable gauged estimates to calibrate against - updates will be made when disaggregated Aquator outputs for additional locations are available.

- Only Q50 and Q95 flow conditions have been simulated for these partly calibrated runs.
- All runs are steady state flow - but this summary uses the mean outputs across the simulation time steps for water level and max wetted perimeter values.
- All baseline runs included 417 Ml/d dry weather flow at Minworth WwTW (worst case - measured flow is lower and likely to be changed for calibrated run).
- **Scenario A** = 115 Ml/d flow reduction at Minworth WwTW (equivalent to either GUC or STT operated at its maximum).
- **Scenario B** = 230 Ml/d flow reduction at Minworth WwTW (equivalent to both GUC and STT operating at their maximum).

Table 5.1 Modelling results of the Red Priority SSSI sites under investigation showing changes in water depth across Scenario A and B at Q95 and Q50.

			Q95					Q50				
SSSI	**River**	**Cross Section Reference (refer to the Hydrological, Aquator and Hydraulic Modelling report referenced in Section 1.1)**	**Baseline water max depth (m)**	**Scenario A water level reduction from baseline (m)**	**Scenario A maximum water depth change (%)**	**Scenario B water level reduction from baseline (m)**	**Scenario B maximum water depth change (%)**	**Baseline water max depth (m)**	**Scenario A water level reduction from baseline (m)**	**Scenario A maximum water depth change (%)**	**Scenario B water level reduction from baseline (m)**	**Scenario B maximum water depth change (%)**
Whitacre Heath	Tame	TM061662	1.16	0.09	7.82%	0.19	16.42%	1.323	0.074	5.59%	0.152	11.49%
		TM060792	1.04	0.08	7.21%	0.16	15.10%	1.182	0.063	5.33%	0.13	11.00%
		TM060201	1.62	0.05	3.40%	0.11	6.80%	1.738	0.049	2.82%	0.101	5.81%
River Mease	Trent	316130020U	1.017	0.04	3.93%	0.082	8.06%	1.29	0.031	2.40%	0.061	4.73%
		316130020D	1.017	0.04	3.93%	0.082	8.06%	1.29	0.031	2.40%	0.061	4.73%
Attenborough Gravel Pits	Trent	405013200 (U/S Beeston weir)	2.740	0.009	0.33%	0.018	0.66%	2.920	0.008	0.27%	0.015	0.51%
		405011730 (U/S Beeston weir)	3.362	0.008	0.24%	0.016	0.48%	3.522	0.006	0.17%	0.012	0.34%
		405010030 (U/S Beeston weir)	4.255	0.007	0.16%	0.015	0.35%	4.395	0.005	0.11%	0.011	0.25%
		4040113530 (D/S Beeston weir)	1.582	0.021	1.33%	0.042	2.65%	2.006	0.018	0.90%	0.034	1.69%

Table 5.2 Modelling results of the Amber Priority SSSI sites under investigation showing changes in water depth across Scenario A and B at Q95 and Q50.

			Q95					Q50				
SSSI	**River**	**Cross Section Reference**	**Baseline water max depth (m)**	**Scenario A water level reduction from baseline (m)**	**Scenario A maximum water depth change (%)**	**Scenario B water level reduction from baseline (m)**	**Scenario B maximum water depth change (%)**	**Baseline water max depth (m)**	**Scenario A water level reduction from baseline (m)**	**Scenario A maximum water depth change (%)**	**Scenario B water level reduction from baseline (m)**	**Scenario B maximum water depth change (%)**
River Blythe	Tame	TM063654	0.955	0.068	7.12%	0.144	15.08%	1.035	0.063	6.09%	0.129	12.46%
Lockington Marshes	Trent	4050110810	0.397	0.011	2.77%	0.021	5.29%	0.61	0.013	2.13%	0.026	4.26%
Holme Pit	Trent	405013200 (U/S Beeston weir)	2.740	0.009	0.33%	0.018	0.66%	2.920	0.008	0.27%	0.015	0.51%
		405011730 (U/S Beeston weir)	3.362	0.008	0.24%	0.016	0.48%	3.522	0.006	0.17%	0.012	0.34%
		405010030 (U/S Beeston weir)	4.255	0.007	0.16%	0.015	0.35%	4.395	0.005	0.11%	0.011	0.25%
		4040113530 (D/S Beeston weir)	1.582	0.021	1.33%	0.042	2.65%	2.006	0.018	0.90%	0.034	1.69%

5.3 Red Priority SSSIs

Whitacre Heath

5.3.1 Whitacre Heath, at approximately 44 Ha in size, is designated with the main habitat being standing open water and canals in which assemblages of breeding birds is the monitored feature. The River Tame flows in a southerly to northerly direction along the western boundary of the SSSI, in which the SSSI lies within the floodplain zone of the waterbody. The topographic elevation of the SSSI ranges, on average, between 68 and 71 mAOD, with the River Tame measuring at 67 mAOD.

5.3.2 The River Tame primarily has two superficial deposits that border its channel around the SSSI: river terrace deposits and alluvium. These have good hydraulic continuity with the surface water in the river channel. However, the entire SSSI is underlain by the Sidmouth Mudstone Formation (Secondary B aquifer) which predominantly consists of red-brown mudstone and siltstone, with the superficial deposits largely removed by quarrying. Due to this lithology's low permeability there will be limited hydraulic continuity between the superficial deposits associated with the river and the bedrock underlying the SSSI, and is indicative that the features within this area, such as the ponds within the site, are likely dependent on rainfall and runoff, rather than interaction with the superficial aquifer in hydraulic continuity with the River Tame, or local groundwater recharge. Flood events may also provide overland flow across the SSSI, augmenting the pond levels and soil saturation.

5.3.3 Flow and river levels are affected by weirs situated both upstream and downstream of the site. Approximately 400m downstream on the River Tame there is a weir at Lea Marston, and an additional 700m downstream is a weir and weir pool at Coton Road. Approximately 5.6 km upstream on the River Tame is the Water Orton weir. These weirs are considered to have a significant impact on water levels and flows in the River Tame passing the SSSI. At times of low flow, flow will still fill the weir pool before overtopping in both scenario A and B, therefore helping to maintain water levels near the site, and under persistently dry conditions water levels will be higher than without the downstream weirs.

5.3.4 This relatively small difference in elevation from the river to SSSI limits vertical drainage from the Sidmouth Mudstone, maintaining soil moisture and with the low permeability bedrock support the presence of surface water on the site.

5.3.5 Abstractions and discharges local to the site may influence flow and river levels. There is one large surface water abstraction located in the lower River Blythe catchment. This lies approximately 2km upstream from Whitacre Heath. Flows in the River Tame at the site are augmented by inflow from the River Blythe, which are therefore influenced by this abstraction reducing flow. Flows from the River Blythe into the River Tame contribute 3.09% to the Tame flows passing by the site at Q95 and 1.51% at Q50. Approximately 3.5 km upstream on the River Tame is the Severn Trent Coleshill STW discharge, which increases flow passing the site.

5.3.6 River Tame flows and water levels passing the site are influenced by weirs, the inflowing River Blythe, and an abstraction and a discharge situated closer to the site than the Minworth discharge. The discharge at Minworth is a significant proportion of River Tame flows passing the site, with modelling predicting a fall of 15.2 cm (11.5% of depth) at Q50 and 19.1 cm (16.4%) at Q95 at the upstream end of the SSSI under Scenario B. It is understood that Scenario B is not expected to be the typical Minworth SRO operation and so the predicted reduction in river level would not be a common occurrence. Scenario A predicted a fall of 7.4 cm (5.6%) at Q50 and 9.1 cm (7.8%) at Q95.

5.3.7 At the downstream end of the SSSI modelling predicting a fall of 10.1 cm (5.8%) at Q50 and 11 cm (6.8%) at Q95 at the upstream end of the SSSI under the Scenario B. Scenario A predicted a fall of 4.9 cm (2.8%) at Q50 and 5.5 cm (3.4%) at Q95.

5.3.8 The approximate seasonal variation in levels is 0.5m with the predicted falls generally up to 20% of this, with the exception of the upstream Tame under Scenario B, which is expected to only be occasionally in operation. These changes are not expected to be significant for groundwater interaction with the river and groundwater levels. Changes in flow are likely to delay levels reaching the current weir levels, but once reached water levels should not be significantly different to the current flow regime. During drought levels will take longer to rise to current weir levels.

5.3.9 In conclusion, the SSSI surface water features are considered to be dependent on rainfall and runoff and potentially flooding from the River Tame. The superficial aquifer has been largely removed by quarrying leaving no significant connection between river levels and the superficial aquifer at the river, and the water features on the site. Any reduction in flow due to the Minworth SRO is not anticipated to prevent flooding of the site to support water features, being 8.5% of Q5 flows.

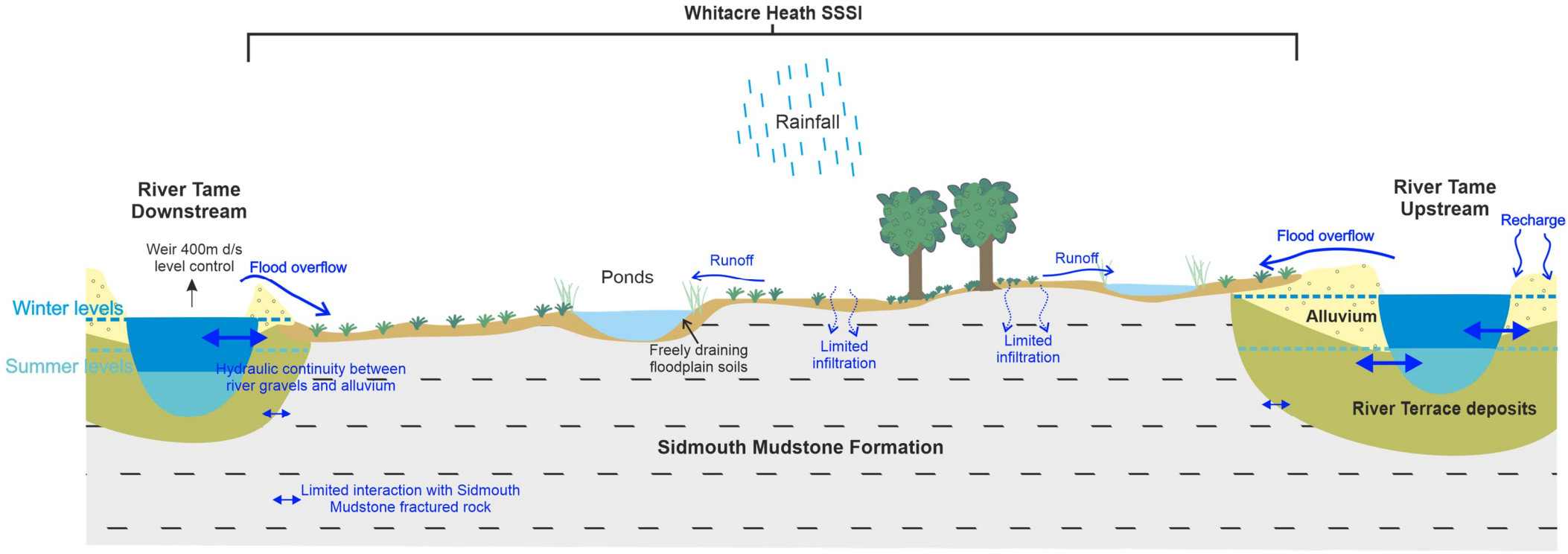

Figure 5.1: Conceptual model of Whitacre Heath SSSI

River Mease

5.3.10 The River Mease flows across Leicestershire, Derbyshire, and Staffordshire for approximately 25 km. It is designated as a SSSI and Special Area of Conservation (SAC) due to the river ('Watercourses of plain to montane levels with *Ranunculus fluitantis*' vegetation) providing a supporting environment for a range of habitats and species such as spined loach, bullhead, otter and white-clawed crayfish. The focus is on the lower end of the River Mease as it flows into the River Trent, covering approximately 3 km of the River Mease.

5.3.11 The topography within the River Mease has an average elevation of 50 metres above ordnance datum (mAOD) and elevations generally range between 48 and 50 mAOD. The area surrounding the River Mease is composed of floodplains that also have an average elevation of 50 mAOD and flooded quarries which are at a considerably lower elevation.

5.3.12 The underlying geology for the River Mease consists of superficial river terrace deposits overlying the Gunthorpe Member (comprising mudstone). The river terrace deposits allow for more groundwater movement and infiltration of surface water due to their high permeability, whereas the Gunthorpe member has very low permeability, therefore allows limited amounts of groundwater movement and there is limited infiltration from surface water. Due to the high permeability of the river terrace deposits, it is expected that these deposits will have relatively high hydraulic conductivity and interact with the River Mease, providing base flow.

5.3.13 Spot flow gauging shows steady accretion along the River Mease, gaining base flow from the Helsby Sandstone principal aquifer in its upper reaches and from the river terrace deposits secondary aquifer over much of its length. In the lower reaches where the river terrace deposits connect with the River Tame accretion does not increase significantly, and during the summer recession can lose flow to the secondary aquifer. Here the river terrace deposits are of similar extent to upstream reaches, indicating that if the Mease gained additional base flow due to losses from the River Tame to the aquifer, the rate of accretion would increase.

5.3.14 The accretion data therefore indicates that the Mease does not gain additional base flow from the superficial aquifer in the Tame surface water catchment and any flow losses to this aquifer from the River Tame but continues to accrete from base flow from the superficial aquifer within the Mease surface water catchment. If the Tame can lose flow to the aquifer it may flow north easterly to discharge to the River Trent.

5.3.15 The quarrying along the west of the River Mease has removed the gravel from the area, increasing the superficial aquifer storage and lowering the groundwater level; while also increasing loss of groundwater by evaporation. Therefore, the current flow and level condition in the River Mease has been affected by quarrying activities where hydraulic continuity remains in place. However, it is understood that water levels are managed at the flooded quarry sites according to water level management plans. In some lake locations complete hydraulic disconnection from the superficial aquifer has occurred based on the geology, such as around the lake at the National Arboretum between the rivers Tame and Mease. The Environment Agency understand that the lake on the west side of the Mease near the Trent confluence is also hydraulically disconnected though the geological map indicates the superficial aquifer is still present.

5.3.16 Abstractions and discharges local to the site may influence flow and river levels. There are no significant surface water abstractions near the mouth of the River Mease, as it flows into the River Trent identified in Gate 1. There are however five discharge points close to the mouth of the River Mease which are associated with Barton quarry and Alrewas quarry, discharging to the River Tame and River Trent, which locally augment flow near the River Mease and may support local groundwater levels in the superficial aquifer.

5.3.17 In conclusion the flows and levels in lower River Mease are not anticipated to be influenced by changes in River Tame levels via hydraulic continuity with the river terrace gravels secondary aquifer, and therefore are not expected to be affected by reduction in discharge at Minworth. River flows are dependent on local recharge to the superficial aquifer and the sandstone principal aquifer in its upper reaches, and upstream discharges.

5.3.18 Modelling predicts a fall in River Trent levels of 8.2 cm at Q95 and 5.2 cm at Q50 at the confluence with the River Mease under Scenario B. Scenario A predicts a fall in River Trent levels of 4.0 cm at Q95 and 3.1 cm at Q50.

5.3.19 This change is not considered significant to lower groundwater levels below the lower Mease to lead to flow losses to the aquifer, compared to seasonal variation in river levels, aquifer recharge, and the influence of discharges and evaporative losses from former quarry lakes on river levels.

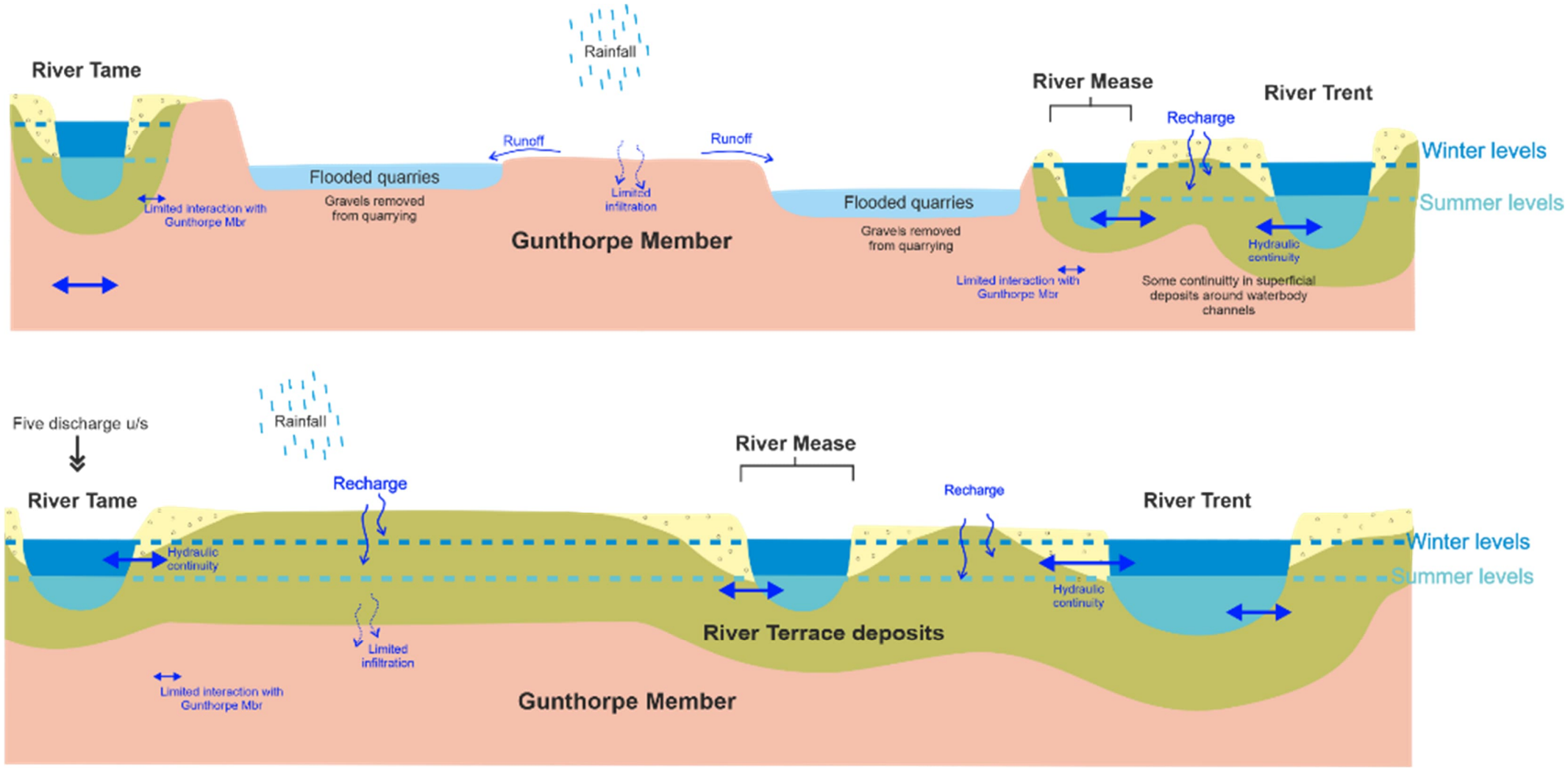

Figure 5.2: Conceptual model of River Mease SSSI (upper image: downstream where the Tame and Mease meet the Trent, lower image: upstream where the superficial aquifer may allow hydraulic continuity across the three rivers)

Donington Park

5.3.20 Donington Park is located in Leicestershire, 2 km west of Castle Donington and is approximately 43.40 Ha in size. It is classed as an SSSI due to the ancient oaks on site that provide a supporting environment for bats, deer herd and invertebrate fauna. The environment towards the north western side of the SSSI is classed as broadleaf woodland, which is characterised by trees such as the ancient oaks. The River Trent flows along the north west of the SSSI, adjacent to the broadleaf woodland. The rest of the SSSI is classed as improved grassland.

5.3.21 Within the SSSI, there is a hill towards the south that at its head is around 90 mAOD, which slopes north west towards the River Trent. The elevation of the SSSI is around 50 mAOD, near the River Trent, showing a fall of 40 mAOD from the hill. The River Trent is shown to be at approximately 35 mAOD on OS maps. Therefore, the site is steeply sided rising from the River Trent and is likely not dependent on river levels from either flooding or groundwater interactions between the river and superficial and bedrock geologies.

5.3.22 Donnington Park SSSI is underlain by solid geology, no superficial deposits have been noted. There are superficial deposits associated with the River Trent, namely the Hemington Member and alluvium. The Hemington Member is primarily composed of gravel, sands and loams which means they have good hydraulic connectivity to the River Trent. The bedrock geology that underpins the SSSI at this site consist of the Gunthorpe Member (mudstone), Tarporley Siltstone Formation, Helsby Sandstone Formation, as well as the Diseworth Sandstone towards the topographical high within the park. The Helsby Sandstone Formation, which has relatively good permeability in contrast to the other geologies within the area, is in hydraulic continuity with the Hemington Member and alluvium deposits that are anticipated to be in hydraulic continuity with the River Trent. This is suggestive that the water table / groundwater is likely present throughout this lithology. However, the geologies that overlie the sandstone; the Tarporley Formation and the Gunthorpe Member, which cover the majority of the SSSI, have low permeability and porosity which is suggestive that the SSSI is expected to be hydraulically disconnected from groundwater.

5.3.23 When this is considered with the topographical differences with the SSSI and the River Trent, it is therefore likely that the SSSI is not influenced by river levels, but rather by local rainfall, runoff, and soil conditions.

5.3.24 Abstractions and discharges local to the site may influence flow and river levels. At Shardlow approximately 2.5 km downstream water is abstracted for pond throughflow, and at Willington, approximately 14 km upstream for power station cooling. These abstractions will locally reduce flow and levels. A discharge was identified approximately 7 km upstream at Barrow upon Trent that will locally augment flow and water levels.

5.3.25 In conclusion, the site features are not dependent on groundwater and there is no hydraulic connection between the geology underlying the SSSI and the River Trent, therefore changes to the discharge at Minworth will not affect the SSSI.

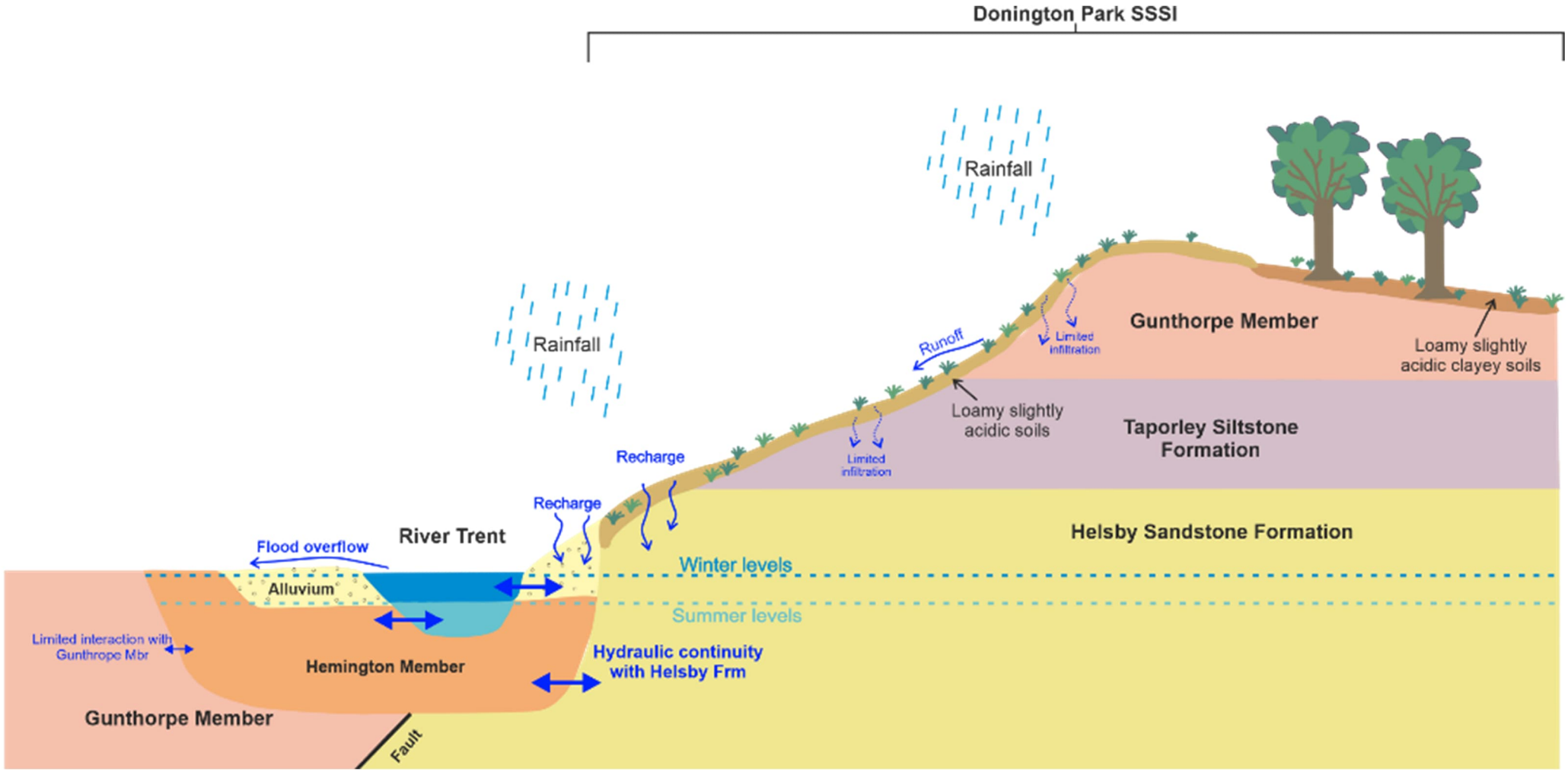

Figure 5.3: Conceptual model of Donington Park SSSI

Attenborough Gravel Pits

5.3.26 Attenborough Gravel Pits SSSI and Attenborough West Gravel Pits LWS comprise a series of flooded gravel pits with islands and connecting causeways that have been colonised by vegetation over many years producing a mosaic of habitats which also include Lowland Fen and Reedbed Priority Habitats, and larger areas of Deciduous Woodland in addition to those habitats mentioned above.

5.3.27 The topography within the gravel pits is subdued with average elevation of the area lying at 30 metres above ordnance datum (mAOD) and elevations generally range between 23 and 35 mAOD. The topographic highs are associated with the woodland islands (such as the Delta Sanctuary) whilst the topographic lows are associated with the interspersed ponds (such as Main Pond, Church Pond, Coneries Pond). The ponds contain weirs controlling lake levels, and controls overflow to the River Trent.

5.3.28 The site is located adjacent the River Trent to the east, with the River Erewash flowing along the southern boundary. It is understood that the River Erewash flows directly into the lakes and this connection is being removed. In future it is understood that a sluice will enable controlled inflows to the lakes from the River Erewash.

5.3.29 The lakes are formed from gravel extraction and reflect the water table in the superficial aquifer and are expected to be in hydraulic continuity with the River Trent and the River Erewash. The water table in the aquifer will approximate River Trent levels along the Trent valley and will be locally augmented by inflows to the aquifer (and present surface water connection) from the River Erewash.

5.3.30 The outflows from each of the main ponds were observed to be approximately 1m higher than the River Trent levels, which represent typical winter high levels at the time of the site visit. Pond levels are above River Trent levels due to the barrier of flood embankments and weirs, disconnecting pond surface waters from the River Trent. The water depth above the River Trent level may reflect the additional volume of water supplied from the connection to the River Erewash.

5.3.31 Therefore, lake levels are influenced by the groundwater connection from the two rivers to the ponds rather than a direct surface water level connection to the River Trent. The groundwater connection may have reduced over time due to the still-water conditions allowing deposition of silt entering the lakes from the River Erewash.

5.3.32 Seasonal changes in river flows will affect groundwater levels that will then affect lake levels. However, lake levels may not change significantly due to the flood embankments and weirs maintaining levels, with seasonal variation seen in a change in overflow from weirs.

5.3.33 Hydraulic modelling predicts a fall in River Trent levels of 1.5 – 1.8 cm at Q95 and 1.1 – 1.5 cm at Q50 upstream of Beeston weir in Scenario B. Scenario A predicts a fall in River Trent levels of 0.7 – 0.9 cm at Q95 and 0.5 – 0.8 cm at Q50 upstream of Beeston Weir. Modelling predicts a fall in River Trent levels of 4.2 cm at Q95 and 3.4 cm at Q50 downstream of Beeston weir in Scenario B. Scenario A predicts a fall in River Trent levels of 2.1 cm at Q95 and 1.8 cm at Q50 downstream of Beeston Weir.

5.3.34 River Trent levels are controlled by weirs upstream and downstream of the SSSI and are affected by abstractions in the reach containing the SSSI. Such a fall in river level is not anticipated to have a significant effect on groundwater levels considering local aquifer recharge.

5.3.35 This change is not expected to significantly affect lake levels due to the indirect connection via the superficial aquifer, where changes in river level are only slowly propagated through the aquifer; and because lake levels will remain supported by inflows to the aquifer from the River Erewash. The key control on lake levels is considered to be the weirs and sluices linking the lakes to the River Trent.

5.3.36 Therefore, changes at the Minworth discharge are not anticipated to affect water levels at the SSSI compared with the effect of weirs, abstraction, and seasonal variation.

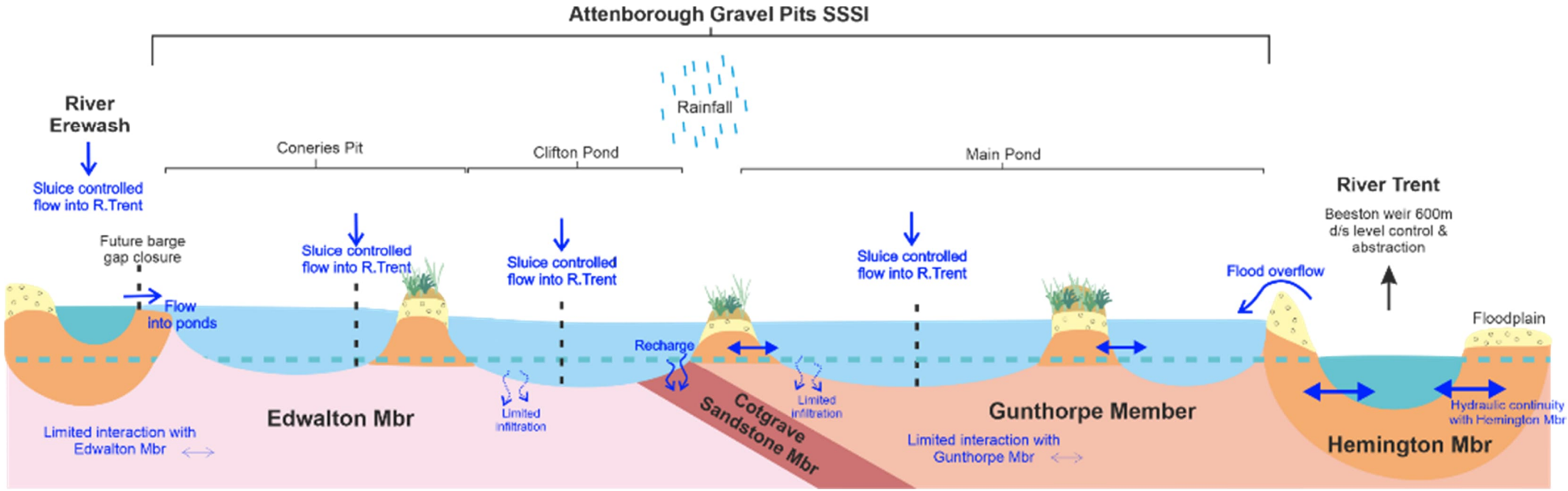

Figure 5.4: Conceptual model of Attenborough Gravel Pits SSSI

Lea Marsh

5.3.37 Lea Marsh is an important area of unimproved floodplain meadow and wet pasture adjacent to the River Trent in north-west Lincolnshire. The site lies on seasonally inundated alluvial soils and includes an unusually large area of a nationally rare grassland type. Populations of two nationally scarce plants with a restricted distribution in the East Midlands are particularly notable, whilst breeding waders provide additional interest. The entirety of the site is formed of Lowland Meadows Priority Habitat.

5.3.38 The site is very low lying, from approximately 2-4 mAOD, with the River Trent, located to the east and north of the site lying at approximately 3 mAOD. The limited difference in elevation is suggestive that the SSSI is subject to receiving flood flows from the Trent and therefore has some dependency on the river levels within the channel. The River Trent is tidal in this area.

5.3.39 The entirety of the area is underlain by superficial alluvium deposits associated with the floodplain of the River Trent. These deposits are expected to have good hydraulic connectivity to the River Trent due to their high permeability.

5.3.40 Tidal variation at the site is not known but is between approximately 1m and 7m recorded at significant distances up and downstream. Groundwater levels in the superficial aquifer will fluctuate with the tidal signal, with the range dissipating with distance from the river.

5.3.41 Small channels are present within the site that are visible from aerial imagery that drain to Lea Marsh main drain. This channel was observed during the site visits (Plate 71 - Plate 74) and was found to be culverted under the flood embankments in place that border the River Trent. The outflow of this channel is controlled by a sluice gate, which at the time of the survey was closed (Plate 75 and Plate 78). The outflow is gravity driven, rather than pumped. The presence of flood defences and a sluice-controlled outflow of the channel is suggestive that the site is disconnected to surface water connections to the River Trent.

5.3.42 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. Cromwell weir is situated approximately 27 km upstream, which influences discharge to the lower tidal section of the River Trent where the site is located. Therefore, water levels in the River Trent will be affected by this weir and the daily cycle of the tide.

5.3.43 Abstractions and discharges local to the site may influence flow and river levels. There are five significant surface water abstractions from Newton on Trent, approximately 15 km upstream, to West Burton, approximately 2 km upstream of the site, all within the reach below Cromwell Weir. These abstractions will locally reduce flow and levels passing the site. There are five significant discharges from Cromwell weir downstream toward the site, locally augmenting flows. The nearest is at Cottam power station, approximately 9 km upstream.

5.3.44 Modelling indicates the change in water level as a result of the decrease in discharge at Minworth and including the effect of abstraction on the River Trent for the SLR SRO (model scenario C) at the modelled cross-section (downstream of Newark) situated above Cromwell Weir is 4.8 cm at Q95 and 2.8 cm at Q50, which is considered negligible compared to the daily tidal variation and considering local aquifer recharge supporting river levels.

5.3.45 Therefore, water level changes as a result of the Minworth and SLR SROs are considered to be insignificant compared to the tidal cycle, the indirect connection between small channels within the SSSI and the River Trent, and Cromwell Weir regulating the flow into the tidal Trent, and abstractions near the SSSI.

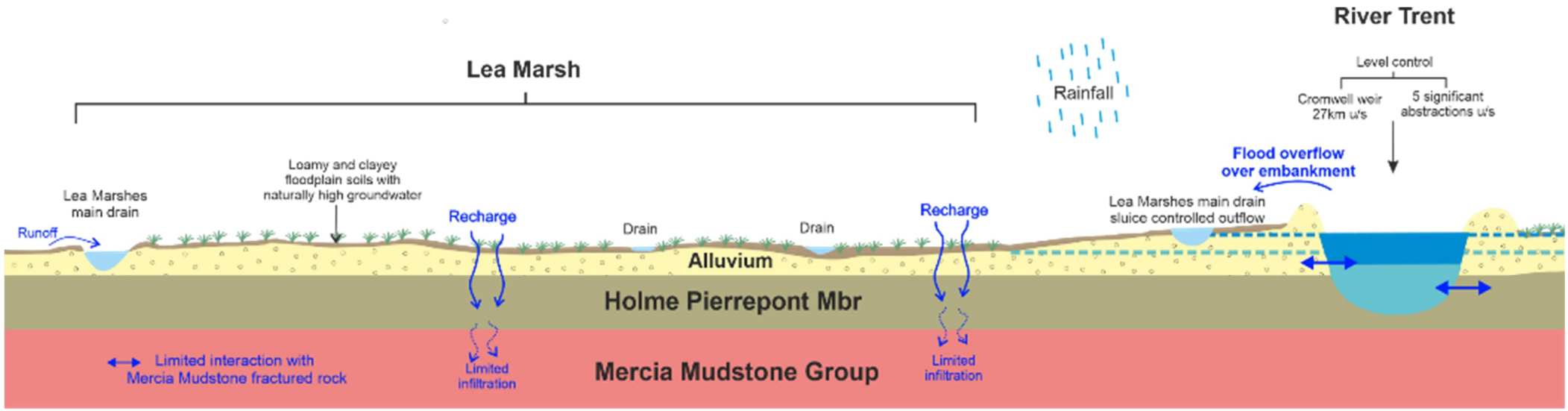

Figure 5.5: Conceptual model of Lea Marsh SSSI

Humber Estuary

5.3.46 The Humber Estuary is the second largest coastal plain estuary in the UK; the estuary is approximately 62.0 km in length and has a total catchment area of approximately 24,472 km^2. It contains features such as mud and sand flats, saline lagoons, salt marshes, and sub-tidal sandbanks. These features provide a thriving environment for various species fauna.

5.3.47 The Humber Estuary SAC/SSSI includes approximately 15 km of the River Trent, which is underlain by superficial alluvium deposits, underlying the alluvium and the entire SSSI is tidal flat deposits. The alluvium and tidal flat deposits are anticipated to have high hydraulic connectivity with the river throughout the SAC/SSSI. Due to potential effects on the Humber Estuary SAC, Habitats Regulations Assessment (HRA) is being undertaken for both Minworth and SLR SRO.

5.3.48 The superficial geology found under the River Trent is underlain by the Mercia Mudstone Group, which has limited interaction with groundwater and surface water due to its low permeability. The tidal deposits along the Humber Estuary are underlain by the Lias Group, Oolite Group, and Kellaway Formation.

5.3.49 The Oolite Group and Kellaway sand member are expected to have high hydraulic connectivity with the tidal flat deposits and are expected to be discharging groundwater to the superficial deposits, contributing base flow to the River Humber.

5.3.50 Abstractions and discharges along the river may influence flow, river levels and suppress or exaggerate tides within the SSSI. The SSSI has a daily tidal range of approximately 1-7 m, from upstream parts of the SSSI to downstream.

5.3.51 Modelling indicates the change in water level as a result of the decrease in discharge at Minworth and including the effect of abstraction on the River Trent for the SLR SRO (model scenario C) at the modelled cross-section (downstream of Newark) situated above Cromwell Weir is 4.8 cm at Q95 and 2.8 cm at Q50, which is considered negligible compared to the daily tidal variation and considering local aquifer recharge supporting river levels.

5.3.52 Therefore, water level changes as a result of the Minworth and SLR SROs are considered to be insignificant compared to the tidal cycle, and Cromwell Weir regulating the flow into the tidal Trent and abstractions near the SSSI.

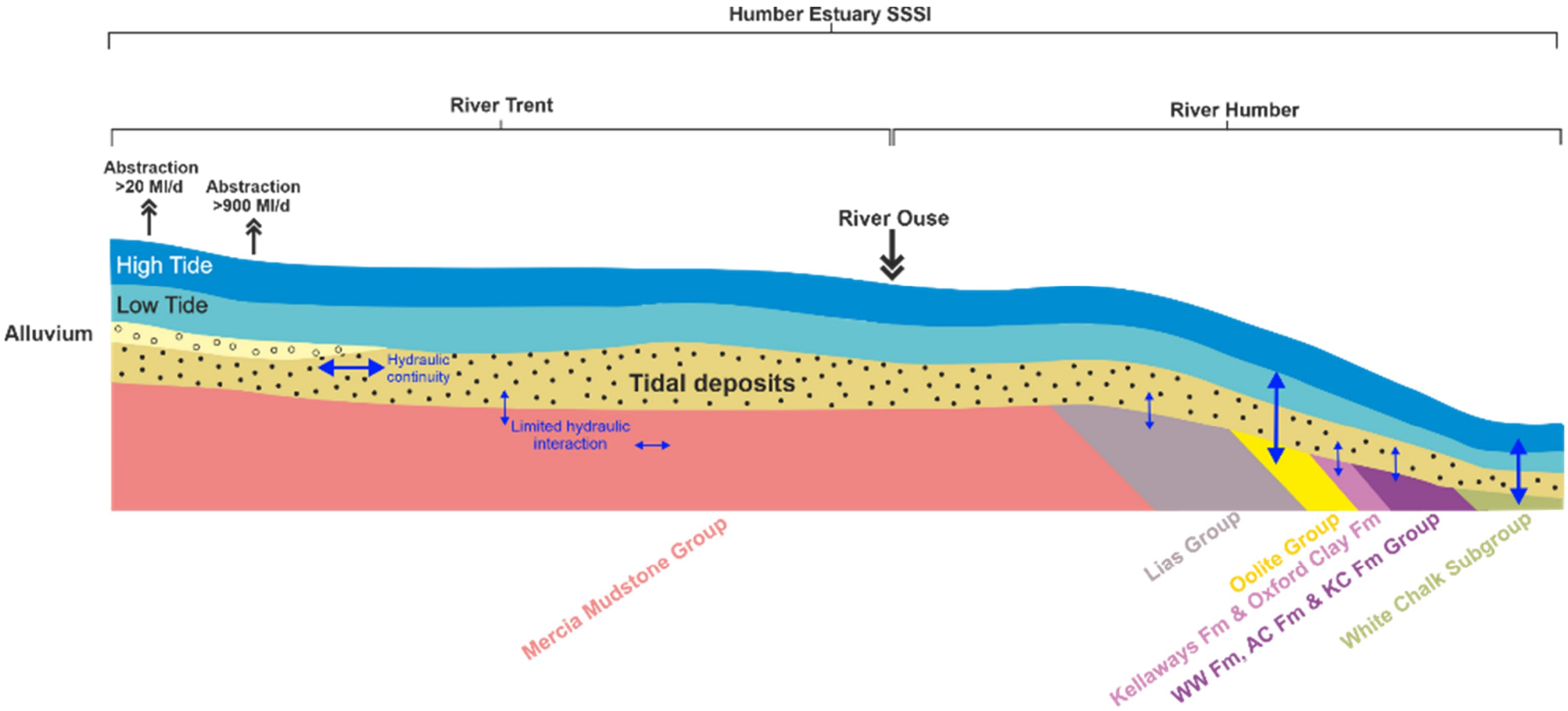

Figure 5.6: Conceptual model of Humber Estuary SSSI

5.4 Amber Priority SSSIs

River Blythe

5.4.1 The River Blythe is classified as an SSSI due to it being an example of lowland clay river that exhibits diverse bed substrates, hydromorphological features and ecological richness. Only 1 km of the River Blythe will be focused on, this will include the lower end of the River Blythe as it discharges into the River Tame and the discharge of the River Cole into River Blythe. The topography with the River Blythe has an average elevation of 70 mAOD, with the River Cole and River Tame at a similar average elevation.

5.4.2 The River Blythe and the surrounding area is underlain by superficial alluvium deposits and the Hemington Member. There are areas with no superficial deposits which consist of waterbodies. The solid geology underlying the River Blythe and its surrounding area, including the River Tame and River Cole is the Sidmouth Mudstone Formation. The Hemington Member is formed of sand, gravel and loams, the alluvium is formed of clay, silt, sand, and gravel. Both the Hemington Member and alluvium deposits have medium to high permeability, therefore there is expected to be good hydraulic continuity between the two lithologies and the River Blythe.

5.4.3 Flow and river levels are affected by weirs situated both upstream and downstream of the site. There are three weirs along the lower section of the River Blythe, which have caused the water levels to rise by 1.5 m (Plate 38). The weirs also influence the groundwater table in the superficial deposits, as the groundwater table would have been lower if the river was on a natural course. The second weir is submerged, it is located near the mouth of the River Blythe before it discharges into the River Tame. Previous studies show that the River Blythe downstream and upstream of the first weir are considered to be influenced by river levels in the Tame. Approximately 3.5km upstream of the of the confluence on the River Tame is the Water Orton weir. These weirs are considered to have a significant control on water levels and flows from the River Blythe into the River Tame.

5.4.4 Abstractions and discharges local to the site may influence flow and river levels. There is one significant surface water abstraction situated on the River Blythe near the confluence with the River Tame. The abstraction will cause a decrease in flow and level, below the lower weir where the River Cole discharges into the River Blythe. The combination of diurnal increases in Tame flow from Minworth discharges and abstraction in the lower Blythe is understood to cause a reverse flow into the River Blythe from the River Tame. Flows in the River Tame at the site will also be increased diurnally from the Coleshill STW discharge, located approximately 1.5km upstream of the confluence of the River Blythe.

5.4.5 These variations in river levels will also affect groundwater levels in the superficial aquifer that are expected to contribute base flow to the River Blythe.

5.4.6 The reduction in discharge at Minworth is a significant proportion of flow in the River Tame at the confluence with the River Blythe, and as River Tame levels are understood to influence flow and level in the River Blythe, may affect the water levels at the lower River Blythe. It is understood that this is not expected to be the typical operation. Scenario A predicted a fall of 6.8 cm (5%) at Q50 and 7.5 cm (5.9%) at Q95.

5.4.7 At the confluence with the River Blythe modelling predicts a maximum fall of 12.9 cm (12.5%) at Q50 and 14.4 cm (13.1%) at Q95 under the Scenario B. Scenario A predicted a fall of 6.3 cm (6.1%) at Q50 and 6.8 cm (7.2%) at Q95.

5.4.8 The approximate seasonal variation in levels in the River Tame is 0.5 m with the predicted falls less than 15% of this, with the exception of Scenario B where the fall in level at the confluence and upstream is approximately 30% of the seasonal variation, which is expected to only be occasionally in operation and therefore such a fall in levels should be an uncommon event.

5.4.9 The predicted fall in river level may lead to a fall in groundwater levels in the superficial aquifer which will have the effect of reducing base flow contributions to the lower Blythe. Groundwater levels are

supported by recharge and River Cole levels so the change in the groundwater level is not anticipated to be to the same degree as River Tame levels.

5.4.10 The changes predicted are not considered significant for groundwater base flow to the River Blythe. The river level changes in the lower reach of the Blythe where abstraction takes place may be exacerbated that the discharge currently may mitigate. The surging and upstream flow reported is likely to be a more significant change in level than that caused by reductions in Minworth discharge. If the water levels in the River Tame are decreased, it is likely to lower the reverse flow into the River Blythe.

5.4.11 The River Blythe is designated SSSI for the in-river environment, and therefore the overall impact assessment relates to riverine habitats and fisheries. Base flow from the superficial deposits aquifer is not expected to significantly alter Blythe flows, but the river level changes and effects of the surface water abstraction and weirs in the lower Blythe may affect fish passage and is discussed in Appendix B(ii) Section 4.

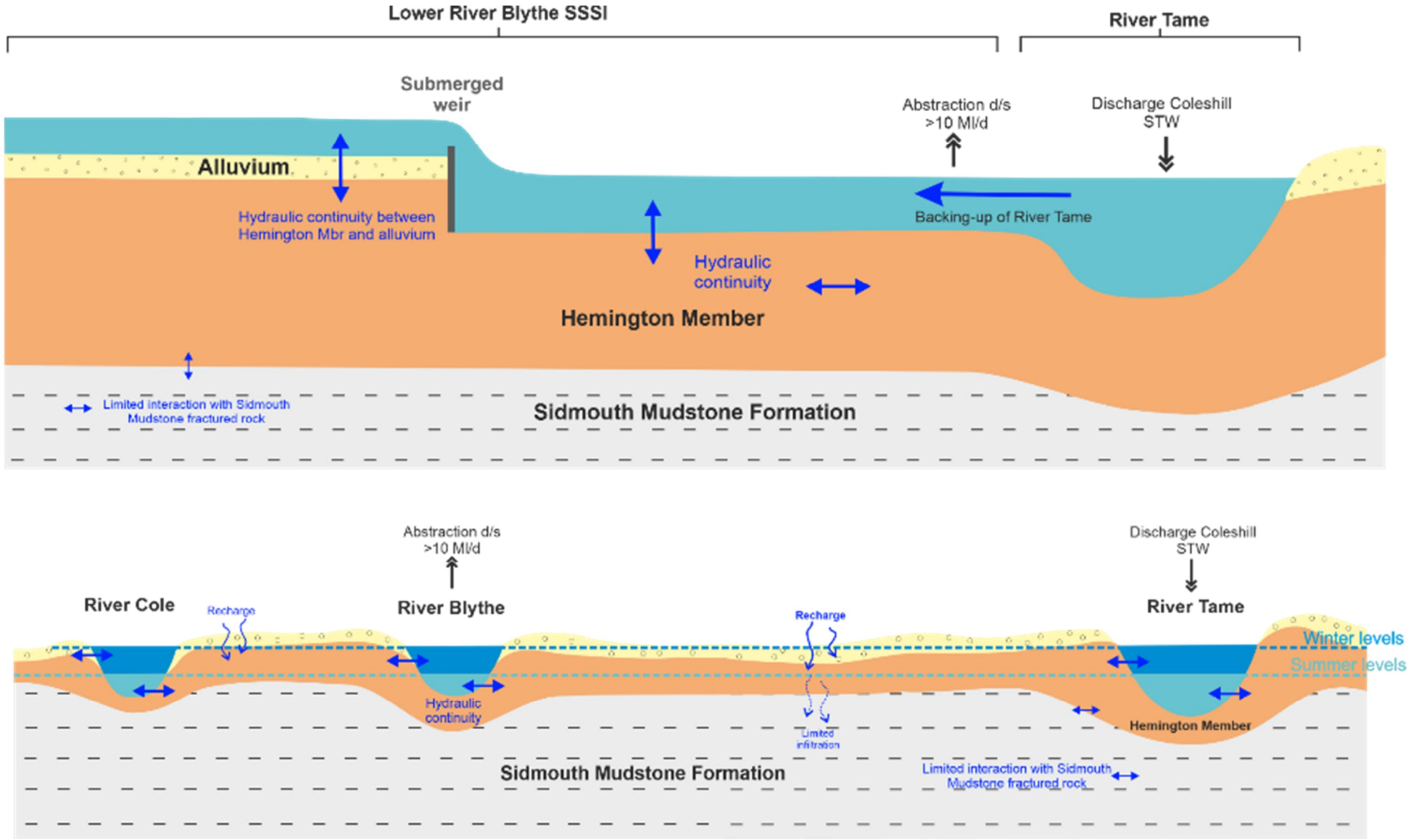

Figure 5.7: Conceptual model of River Blythe SSSI Upper image: along river profile. Lower image: interaction between rivers and superficial aquifers

Lockington Marshes

5.4.12 Lockington Marshes is a 11.3 Ha site, located north of Ratcliffe on Soar in Leicestershire. The main habitats associated with this SSSI are broadleaf, mixed and yew woodland, neutral grassland and standing open water and canals. The monitored features present within this area are permanent wet mire, lowland fens, and lowland mixed deciduous woodland.

5.4.13 The site is bordered on its eastern side by the River Soar, and to the north by the River Trent. It is a relatively low-lying site with elevations ranging from 28-30 mAOD. The River Soar lies at a similar elevation, at approximately 27 – 28 mAOD and the River Trent lies at approximately 28 mAOD. Due to this relatively low difference in elevation, the site lies within the floodplains of both rivers. Small streams cross the site and discharge to the River Soar. Some of the ponds are online to these streams while some are not directly connected to the River Soar. Site visit observed that Hemington Brook (trib of the Soar) was connected to the River Soar, but the outflow is controlled by a sluice gate (Plate 63). Embankments were identified on both the River Trent and River Soar floodplains, but due to the site lying within flood zone 3[9], means that the area still received flood flow from the two rivers. Concern has been expressed that the flood embankments have limited flooding since their construction, reducing saturation of the site and leading to drier conditions across the water features[10]. However, during the site visit, it was observed that Hemington Brook had breached its banks and flooded the southern limb of the site. This may be in response to the concerns around the site not receiving flood flow from the River Soar and River Trent (Plate 66 and Plate 67).

5.4.14 The entirety of the area is underlain by alluvium deposits associated with the floodplain of the River Trent and the River Soar. The alluvium is underlain by the Hemington Member, comprising silt and gravel, which extends across the Trent and Soar valleys. These lithologies have good hydraulic connectivity with both rivers, due to their high permeability. This is indicative that the site is anticipated to have shallow groundwater.

5.4.15 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. Approximately 2 km upstream on the River Soar, near Ratcliffe on Soar, is a weir that will affect water levels and flow in the lower reaches of the Soar passing the site. Approximately 300 m downstream of the confluence with the River Trent is a weir, controlling levels and flow in this reach of the River Trent.

5.4.16 Abstractions and discharges local to the site may influence flow and river levels. There is one surface water abstraction on the River Soar near of the confluence of the River Trent, which will reduce locally reduce river flow and level and potentially groundwater levels in the vicinity of the site. There is a discharge to Lockington Brook from Lockington quarry, which will supplement flows in this stream and potentially discharge to the superficial aquifer in the vicinity of the site.

5.4.17 Water features on the site are dependent on shallow groundwater, and pond levels and stream flow. The Minworth SRO may cause a fall in River Trent levels which may cause levels in the lower River Soar to fall. Persistent lower river levels will cause groundwater levels across the site to fall. Stream flow and level across the site may fall with lower groundwater levels and less potential for ‘backing up’ at the discharge point to the River Soar.

5.4.18 Modelling predicts a maximum fall in River Trent levels of 2.1 cm at Q95 and 2.6 cm at Q50 upstream of the confluence with the River Soar under Scenario B. Scenario A predicts a fall in River Trent levels of 1.1 cm at Q95 and 1.3 cm at Q50. These are both small proportions of the existing seasonal variation (up to 1m).

5.4.19 Such a fall is not anticipated to have a significant effect on groundwater levels considering local aquifer recharge, potential augmentation of groundwater levels from the Lockington Brook discharge; and the aquifer’s hydraulic connection to River Soar levels, which are not anticipated to be affected. Stream levels are not anticipated to be directly affected as the discharge from the site via Hemington Brook to the River Soar is controlled by a sluice.

5.4.20 River Trent levels are controlled by a nearby weir. Reduction in discharge at Minworth is not expected to significantly affect levels at the weir. Therefore, River Soar levels are not expected to be affected,

[9] Environment Agency. Flood Risk Maps for Planning. (Online) Available at: https://flood-map-for-planning.service.gov.uk/.
[10] MRB Ecology and Environment, 2000. Lockington Marshes SSSI Water Level Management Plan. Prepared for Environment Agency

and therefore levels of the stream on the site and online ponds are not expected to be affected. Groundwater level changes as a result of delay in the River Trent reaching its current level at the weir are considered to be insignificant, and within the natural seasonal variation.

5.4.21 Therefore, changes at the Minworth discharge are not considered to be significant to affect water levels at the SSSI compared with the effect of weirs, abstraction and discharges, and seasonal variation.

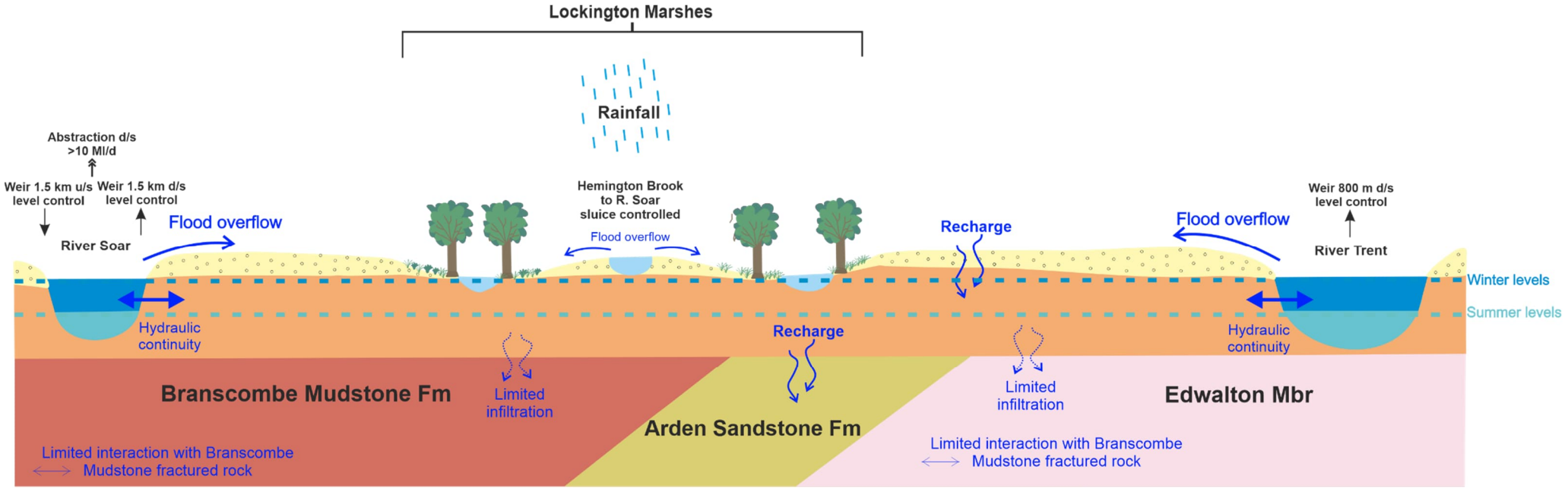

Figure 5.8: Conceptual model of Lockington Marshes SSSI

Holme Pit

5.4.22 Holme Pit comprises of a flooded pit that contains some of the best remaining areas of marsh, reed swamp and open water in Nottinghamshire and is of Regional importance. The site creates a supporting environment for variety of passage, wintering, and breeding bird species, while the reedbeds are a valuable bird roosting area.

5.4.23 The site is at an elevation of approximately 30 mAOD, and has a surface area of 0.019 km^2 and a mean depth of 1.96 m. The site forms part of Clifton Woods. There is a drain that is adjacent to the Holme Pit pond that is connected to the River Trent.

5.4.24 The entirety of the area is underlain by alluvium deposits associated with the floodplain of the River Trent. The alluvium is underlain by the Hemington Member which is formed of sand, gravel and loams, a similar composition to the alluvium. The solid geology of the site is formed of the Gunthorpe Member. The superficial deposits are likely to have relatively high permeability, meaning that these deposits are expected to have good hydraulic connectivity between the Holme Pit pond and River Trent and also receive rainfall recharge. There is limited interaction between the superficial deposits and the mudstone bedrock aquifer.

5.4.25 Flow and river levels may be affected by weirs situated upstream and downstream of the site. Approximately 200m downstream to the site there is a weir that controls water levels on the River Trent. There is also a weir located upstream approximately 4 km from the site. Water levels and flows in the reach of the River Trent associated with the site are controlled by weirs.

5.4.26 Abstractions and discharges local to the site may influence flow and river levels. There is one abstraction located adjacent to the site at Beeston weir that will affect river levels that may impact groundwater levels locally connected to the site.

5.4.27 The drain was observed to be flowing during the site visit and discharges to the River Trent. The River Trent was at lower elevation, and with observed levels representing typical winter highs, it is concluded that the drain is not usually directly connected to the River Trent. That is, drain flows are not influenced by Trent levels, such as by ‘backing-up’.

5.4.28 In conclusion Holme Pit is dependent on groundwater levels and there is no direct surface water connection to the River Trent, other than potential overbank flooding and backing-up of water along the drain to the pond when the River Trent is in flood. The pond levels will change with groundwater levels which may interact with river levels.

5.4.29 Hydraulic modelling predicts a fall in River Trent levels of 1.5 – 1.8 cm at Q95 and 1.1 – 1.5 cm at Q50 upstream of Beeston weir in Scenario B. Scenario A predicts a fall in River Trent levels of 0.7 – 0.9 cm at Q95 and 0.5 – 0.8 cm at Q50 upstream of Beeston Weir. Modelling predicts a fall in River Trent levels of 4.2 cm at Q95 and 3.4 cm at Q50 downstream of Beeston weir in Scenario B. Scenario A predicts a fall in River Trent levels of 2.1 cm at Q95 and 1.8 cm at Q50 downstream of Beeston Weir.

5.4.30 These reductions in water level are a small proportion of the existing seasonal variation (in excess of 2m). Such a fall in level is not anticipated to have a significant effect on groundwater levels considering aquifer recharge.

5.4.31 Therefore, changes at the Minworth discharge are not considered to be significant to affect water levels at the SSSI compared with the effect of weirs, abstraction, and seasonal variation.

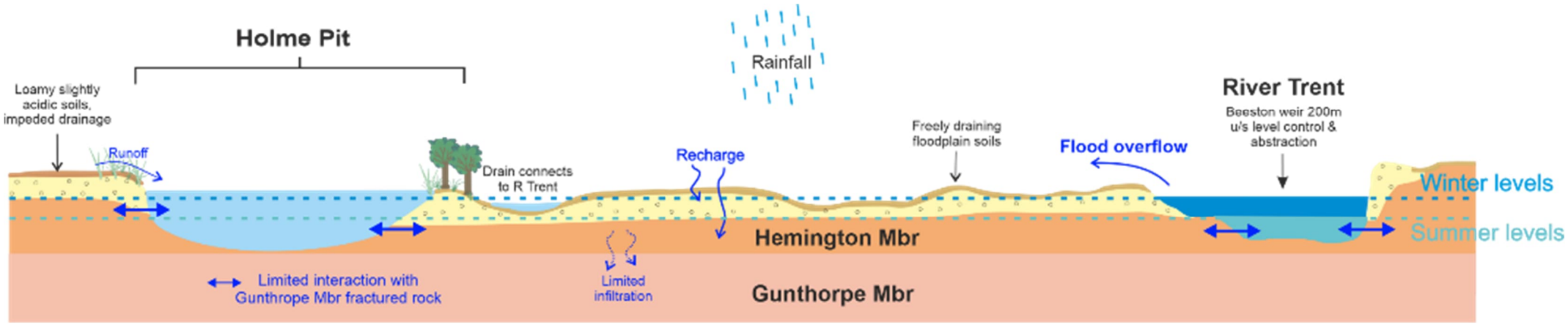

Figure 5.9: Conceptual model of Holme Pit SSSI

6. Scoping Checklist – Recommendations and Mitigation Options

6.1.1 This section summarises the requirements for further assessment and mitigation beyond Gate 2.

Table 6.1: Tame and Trent Strategic Resource Options – Scoping Checklist for post-Gate 2 assessment and mitigation

Receptor or Feature under Assessment	Significance	Impact Pathway and Source (Minworth and/or SLR)	Scale of Impact (Positive / Neutral / Negative)	Red/Amber/Green rating of Risk to SRO (High / Medium / Low)	Recommendations for Further Assessment	Mitigation Options
Donington Park	National	Impact from Minworth SRO felt in River Trent levels, superficial Secondary aquifer, and bedrock Principal aquifer. SSSI has no hydraulic connection to changing water levels related to River Trent.	Neutral	Low	None required	None required
Whitacre Heath SSSI	National	Impact from Minworth SRO felt in River Tame levels, and superficial Secondary aquifer. SSSI water features have no hydraulic connection to changing water levels related to River Tame. Ponds supported by rainfall and flooding. No significant change in high flows to affect inundation by flooding. Change in flow from Minworth discharge a small component of high flows.	Neutral	Low	None required	None required
Attenborough Gravel Pits SSSI	National	Impact from Minworth SRO felt in River Trent levels, and superficial aquifer.	Neutral	Low	None required	None required

Receptor or Feature under Assessment	Significance	Impact Pathway and Source (Minworth and/or SLR)	Scale of Impact (Positive / Neutral / Negative)	Red/Amber/Green rating of Risk to SRO (High / Medium / Low)	Recommendations for Further Assessment	Mitigation Options
		SSSI water features disconnected from river by flood embankments, weirs, sluices. Superficial Secondary aquifer groundwater levels supported by River Erewash as well as River Trent. Impact on superficial Secondary aquifer groundwater levels not significant compared to seasonal variation and with River Trent levels controlled by nearby weir.				
Holme Pit	National	Impact from Minworth SRO felt in River Trent levels, and superficial Secondary aquifer. SSSI water features at higher elevation than River Trent, no backing up in surface water levels caused by the River Trent that would support surface water features, Impact on superficial Secondary aquifer groundwater levels not significant compared to seasonal variation.	Neutral	Low	None required	None required
Lockington Marshes	National	Impact from Minworth SRO felt in River Trent levels, and superficial Secondary aquifer. SSSI water features disconnected from river by flood embankments, sluices. Superficial Secondary aquifer groundwater levels supported by River Soar as well as River Trent. River Trent levels controlled by nearby weir.	Neutral	Low	None required	None required for SRO. Breach in flood embankments would potentially improve SSSI condition. SSSI at risk from proposed new quarrying

Receptor or Feature under Assessment	Significance	Impact Pathway and Source (Minworth and/or SLR)	Scale of Impact (Positive / Neutral / Negative)	Red/Amber/Green rating of Risk to SRO (High / Medium / Low)	Recommendations for Further Assessment	Mitigation Options
		Impact on superficial Secondary aquifer groundwater levels not significant compared to seasonal variation.				
Lea Marsh	National	Impact from Minworth and SLR SROs felt in River Trent levels, and superficial Secondary aquifer. SSSI water features at higher elevation than River Trent, no backing up of River Trent levels that would support surface water features. Impact on superficial Secondary aquifer groundwater levels not significant. Cromwell Weir controlling flow into lower River Trent reaches. Tidal variation is a significant control on water levels. Change in level not significant compared to tidal range.	Neutral	Low	None required	None required
Humber Estuary	International	Impact from Minworth and SLR SROs felt in River Trent levels, and superficial Secondary aquifer. Cromwell Weir controlling flow into lower River Trent reaches. Tidal variation is a significant control on water levels. Change in level not significant compared to tidal range.	Neutral	Low	None required	None required
River Mease	International	Impact from Minworth SRO felt in River Tame and River Trent levels, and superficial Secondary aquifer.	Neutral	Low	None required	None required

Receptor or Feature under Assessment	Significance	Impact Pathway and Source (Minworth and/or SLR)	Scale of Impact (Positive / Neutral / Negative)	Red/Amber/Green rating of Risk to SRO (High / Medium / Low)	Recommendations for Further Assessment	Mitigation Options
		River Mease found not to gain flow from superficial aquifer at expense of River Tame. Change in River Trent levels will not lower groundwater levels in the lower Mease area significantly to cause loss of flow to superficial Secondary aquifer.				
River Blythe	National	Impact from Minworth SRO felt in River Tame levels, and superficial Secondary aquifer. Impact on superficial Secondary aquifer groundwater levels not significant. Groundwater levels in superficial Secondary aquifer supported by River Cole levels, River Blythe levels and aquifer recharge. May reduce backing up on lower River Blythe caused by abstraction. Influence on river levels from weirs.	Neutral (for groundwater interactions effect on SSSI) See other topic areas for other effects.	Low (for groundwater interactions effect on SSSI) See other topic areas for other effects.	None required (for groundwater interactions effect on SSSI) See other topic areas for other effects.	None required (for groundwater interactions effect on SSSI) See other topic areas for other effects.

A.1 Annex Figures

Humber Estuary (SSSI)

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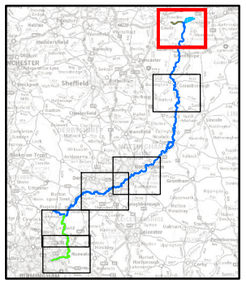

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LEGEND

- 5km Study Area
- River Humber
- River Ouse
- River Trent
- Site of Special Scientific Interest (SSSI)

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Figure 1A

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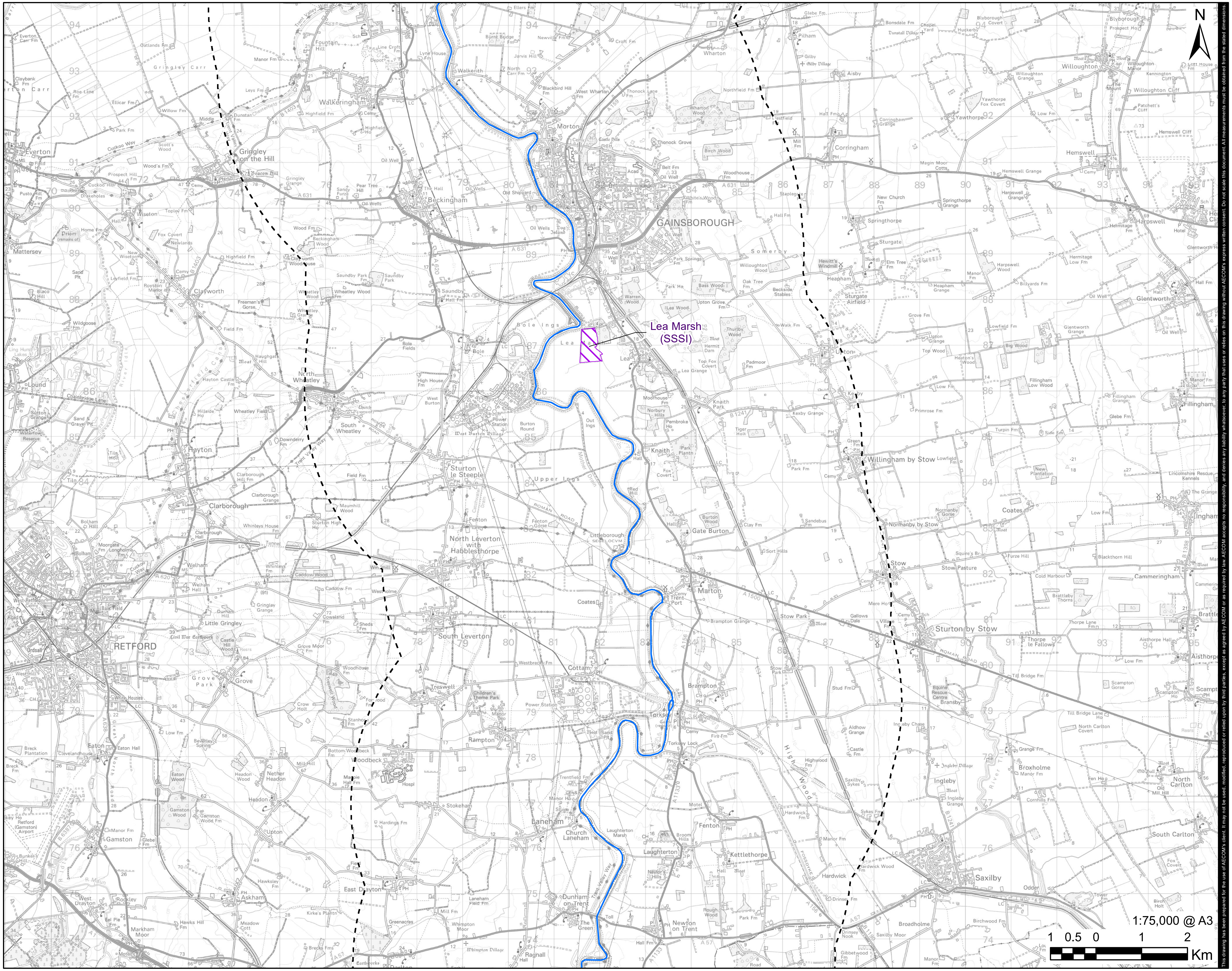

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LEGEND

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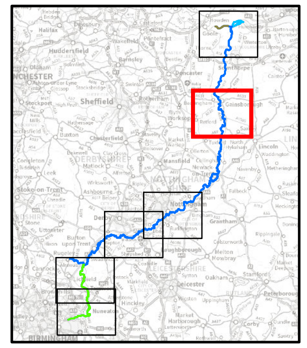
- River Trent
- Site of Special Scientific Interest (SSSI)



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Sites of Scientific Interest Scoped into Gate 2

SHEET NUMBER

Figure 1B

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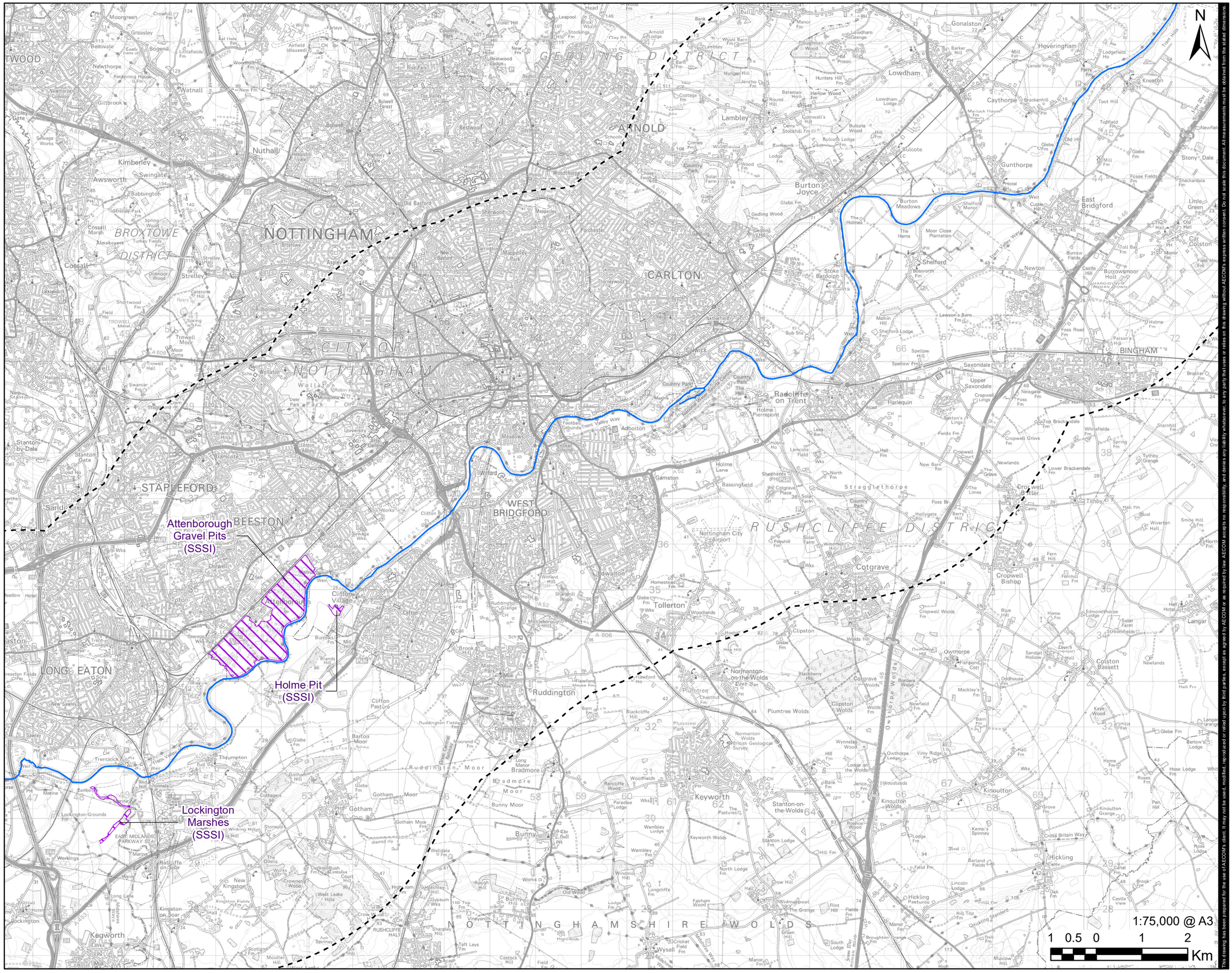

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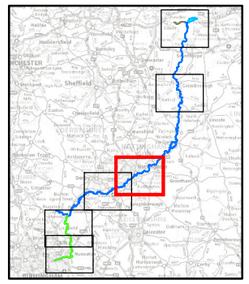
LEGEND

- 5km Study Area
- River Trent
- Site of Special Scientific Interest (SSSI)



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Sites of Scientific Interest Scoped into Gate 2

SHEET NUMBER

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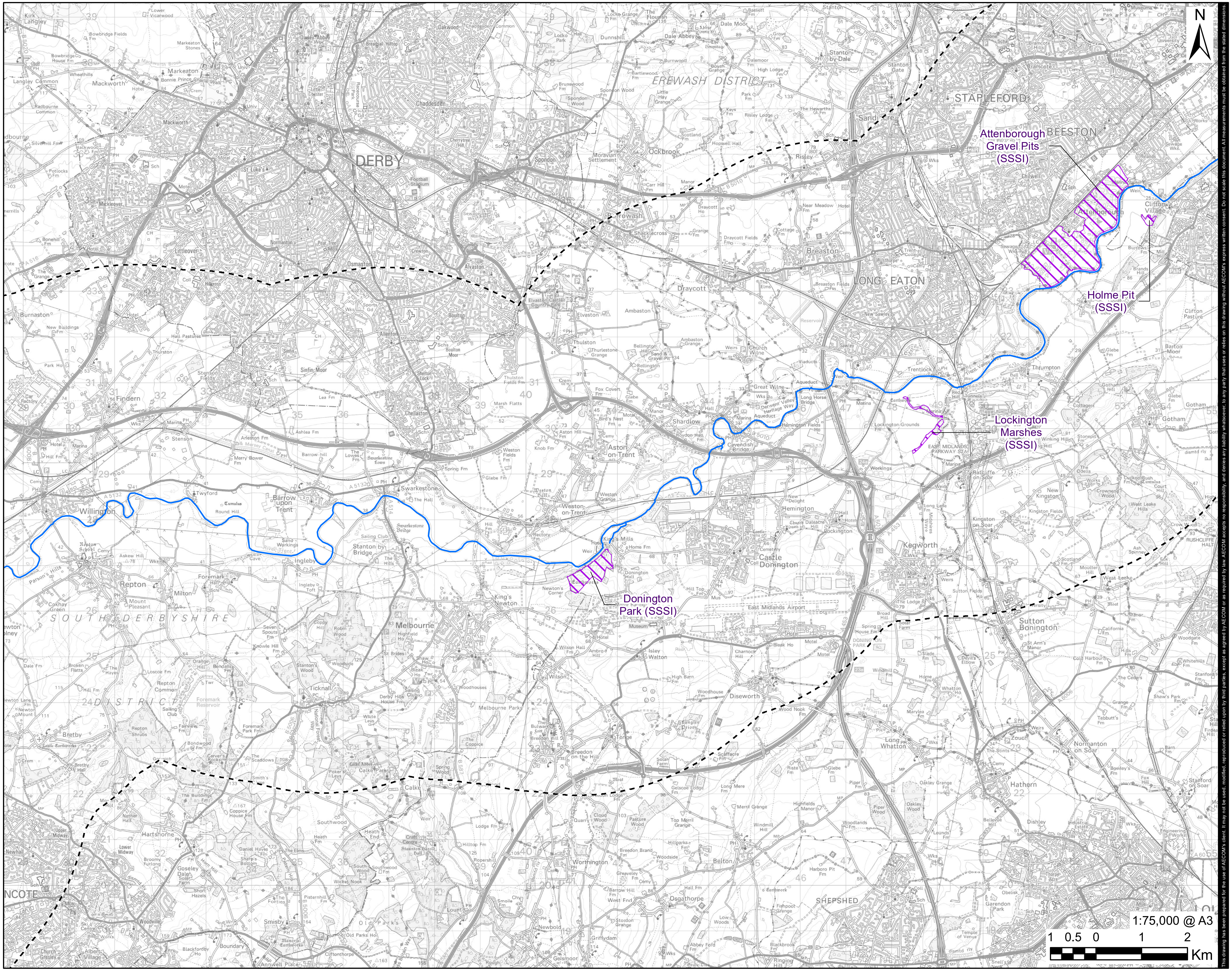

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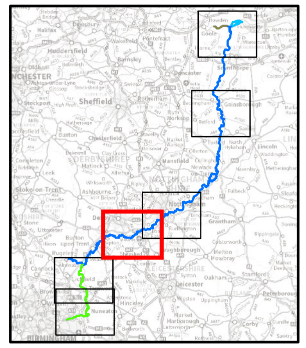
LEGEND

- 5km Study Area
- River Trent
- Site of Special Scientific Interest (SSSI)



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SHEET TITLE

Sites of Scientific Interest Scoped into Gate 2

SHEET NUMBER

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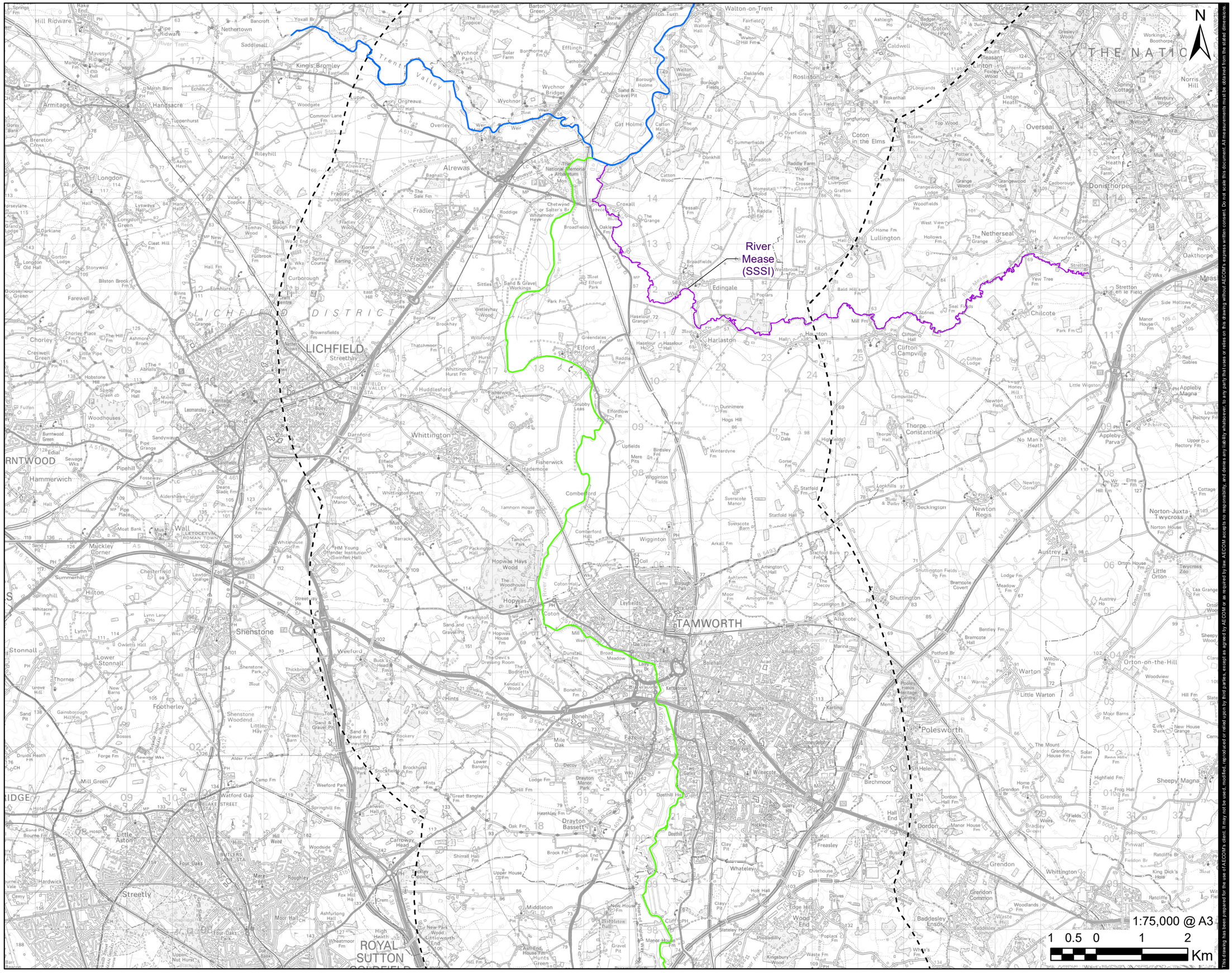

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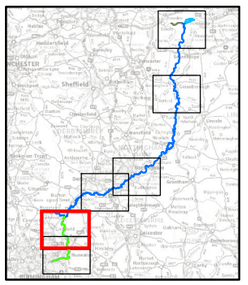
LEGEND

- 5km Study Area
- River Tame
- River Trent
- Site of Special Scientific Interest (SSSI)



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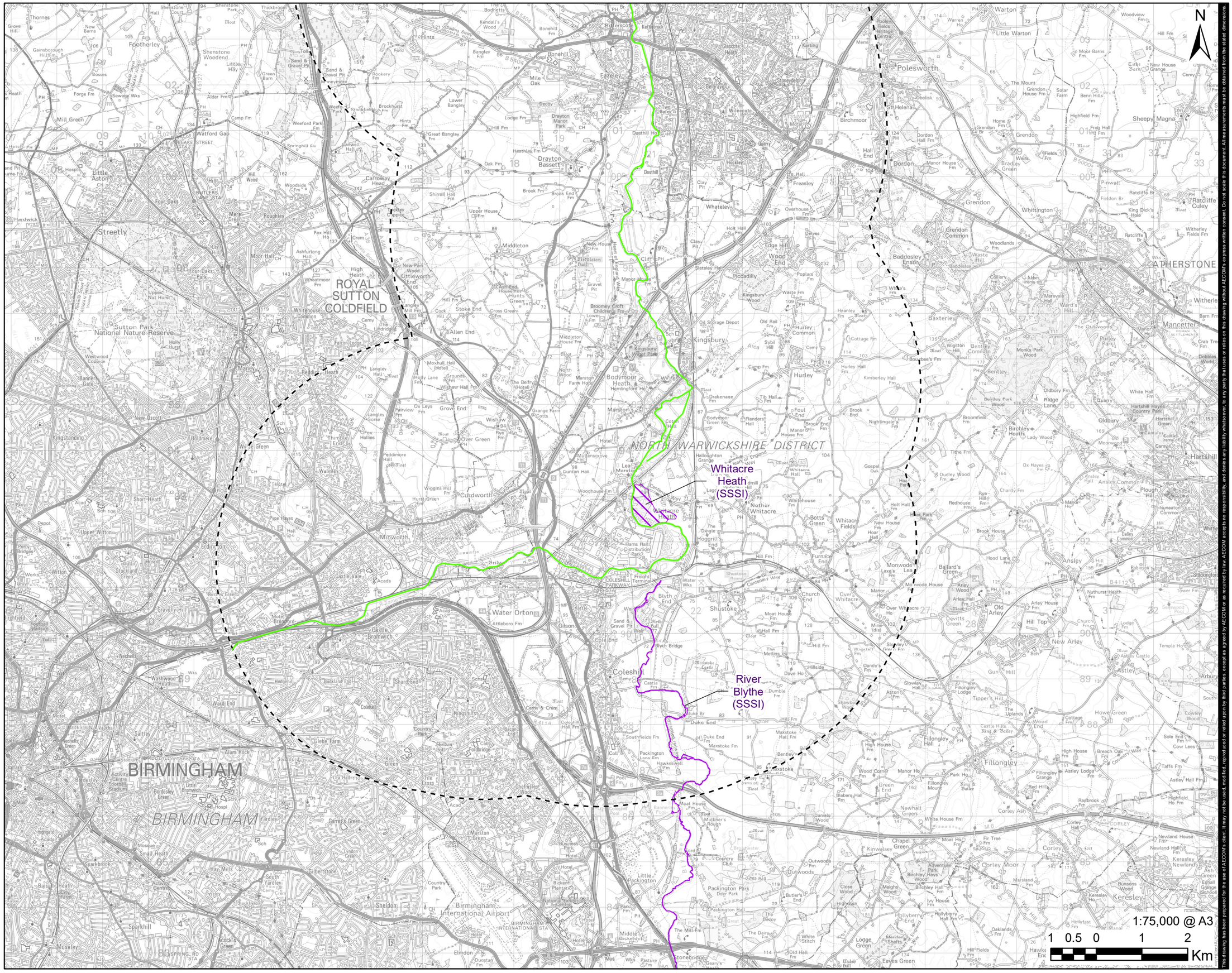
SHEET TITLE

Sites of Scientific Interest Scoped into Gate 2

SHEET NUMBER

Figure 1E



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LEGEND

- 5km Study Area
- River Tame
- Site of Special Scientific Interest (SSSI)

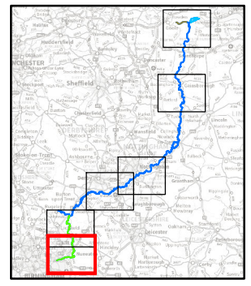

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Figure 1F

A.2 Annex 2 Baseline

6.2 Red Priority SSSIs

6.3 Whitacre Heath

Overview

6.3.1 Whitacre Heath is part of the Tame Valley Wetlands, located in county of Warwickshire in England and is approximately 44 Ha in size. The Whitacre Heath nature reserve is important for breeding water birds. The SSSI has developed from old gravel workings into three main features: freshwater pools, broadleaved woodland, and wet grassland. The northern area of the SSSI is dominated by pools, the middle by broadleaved woodlands and pools, and the south by wet grassland and broadleaved woodland. The topography elevation across the SSSI on average is between 65 mAOD to 70 mAOD, with the River Tame measuring at 67 mAOD. Lidar data from the Environment Agency identifies areas of higher elevation within the SSSI representing mounds.

6.3.2 The different environments support a large number of species, summarised in Table 6.2.

Table 6.2: The species supported by the environment in Whitacre Heath

Feature	Supporting species
Pools	Little grebe, tufted duck, water rail and teal. Frogs, toads, emperor dragonflies, broad-bodied chasers, and grass snakes.
Wet grassland	Waders; lapwing, redshank, curlew, and snipe. Alder, willow, fungi, beetle species, mosses, liverworts, and ground nesting birds.
Broadleaved Woodlands	Birds; great spotted and green woodpeckers.
Entire Whitacre Heath Reserve	Species of warblers, finches, tits, and thrushes. Southern march orchard, white-letter hairstreak butterfly and blue fleabane.

Geology

Superficial

6.3.3 Whitacre Heath is underlain by superficial deposits along most of the boundary area of the SSSI with no superficial deposits present across much of the site. These deposits consist of river terrace deposits (sand and gravel). The first river terrace deposits are detrital and ranging from fine- to coarse-grained. Along the south boundary of the SSSI is underlain by alluvium (clay, silt, sand, and gravel), deposited in the Quaternary Period. The River Tame is underlain by alluvium, which overlies river terrace deposits[11]. Historically the sands and gravels in some parts of the site have been quarried, and site levels were restored using waste material, inert pulverised fuel ash (PFA), tyres and domestic waste[12].

[11] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021
[12] Whitacre Heath SSSI Nature Reserve, Management Plan, Warwickshire Wildlife Trust, April 2008.

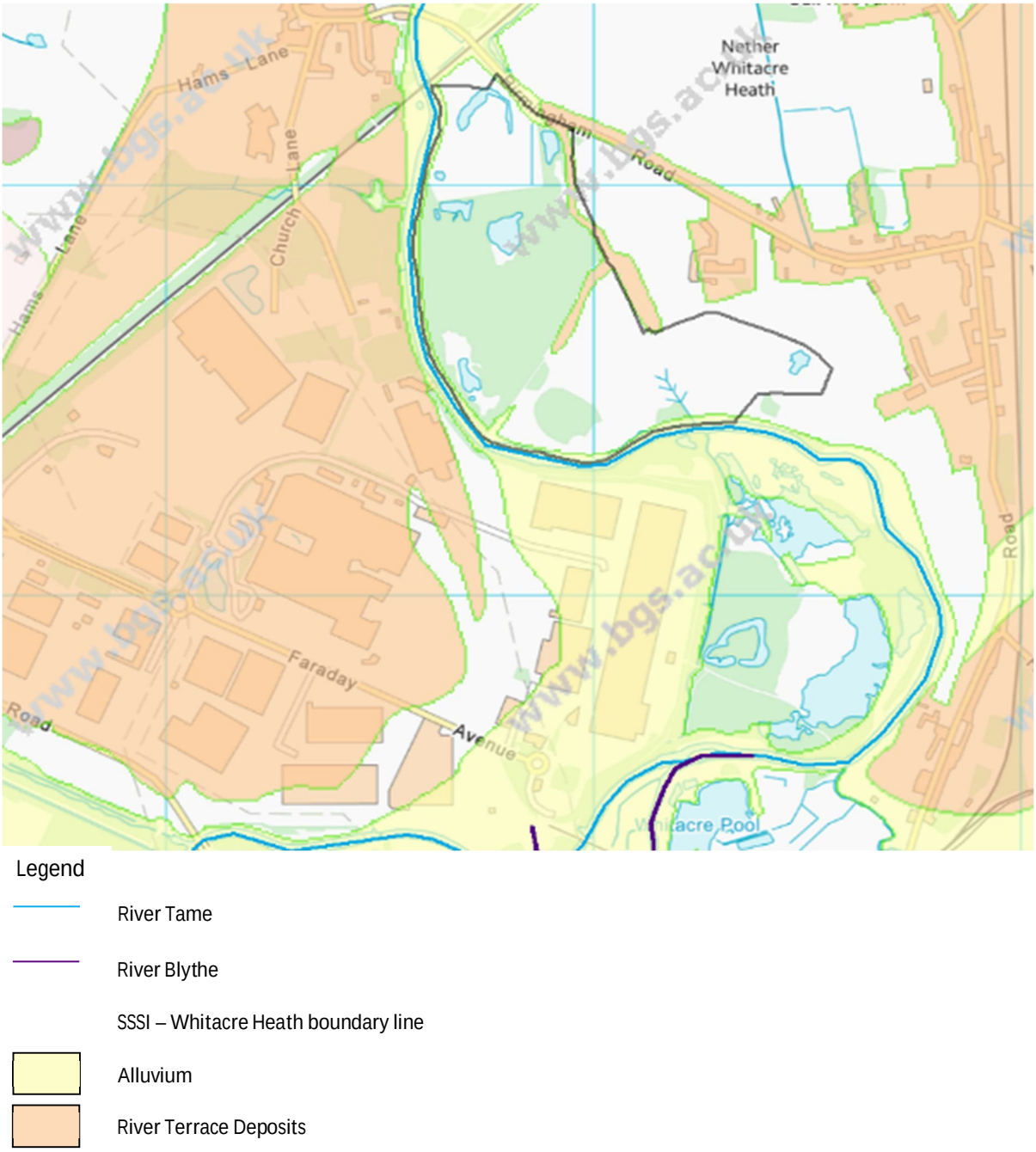


Figure 6.1: Superficial Geology Map for Whitacre Heath

Source: Underlying Map: Contains OS data © Crown Copyright and database right 2020. Superficial deposits: ArcGIS Map Service, https://map.bgs.ac.uk/arcgis/services

Bedrock

6.3.4 The SSSI and the River Tame is underlain by the Sidmouth Mudstone Formation, which predominantly consists of red-brown mudstone and siltstone. There are layers of fine-grained sandstone and dolomitic siltstone interbedded with mudstone that have been observed across the formation. The thickness of the formation ranges from 120 to 130 m in the East Midlands[13].

[13] The BGS Lexicon of Named Rock Units: Sidmouth Mudstone Formation (2021). Available from: https://webapps.bgs.ac.uk/lexicon/lexicon.cfm?pub=SIM Accessed 15/12/2021

6.3.5 No boreholes records are available for viewing within the SSSI boundary. The surrounding boreholes data shows that the alluvium deposits are approximately 6.20 to 11.50 m thick, the first river terrace deposits are 2 to 2.5 m thick. Therefore, although the Natural England citation refers to the site being associated with alluvial soils and glacial gravels in the flood plain of the River Tame, according to BGS geological mapping the site is largely devoid of superficial deposits, and the water features overlie Sidmouth Mudstone, the gravels having been removed.

Hydrogeology

6.3.6 The superficial deposits are designated as Secondary A aquifer, which is described by the Environmental Agency as 'Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers'. DEFRA has predominantly mapped the superficial deposits as Secondary A aquifer across the SSSI.

6.3.7 The bedrock underlying the SSSI and River Tame has been classed as Secondary B aquifer, which is described by the Environmental Agency as 'Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers. This aquifer is anticipated to have limited hydraulic continuity with the River Tame levels.

6.3.8 Groundwater vulnerability map shows that the groundwater within the SSSI is at medium - high to high risk. The SSSI is predominantly rated a medium-high groundwater vulnerability risk. The River Tame is rated a medium-high risk for groundwater vulnerability.

Soils

6.3.9 The soil within the SSSI boundary and in the River Tame is classed as floodplain soils that are loamy and clayey in texture. The drainage is described as 'Naturally wet' indicating the water table is high across the site. The soil on site is moderately fertile.

Hydrology

Surface Water Features

6.3.10 There are multiple surface water bodies within the SSSI boundary. There are two ponds located in the northern part of the SSSI and the area is classed as pool (marshy land). There is also a drain present in the marshy land area that runs north to south. There are six ponds located within the broadleaved woodlands, towards the south of the broadleaved woodlands a map produced by DEFRA shows the land gets marshier[14], leading to the south east of the site where a pond and drain are located. The drain is connected to the River Tame.

6.3.11 Springs within the SSSI boundary form a stream flowing to the River Tame which flows along the west boundary of the SSSI.

6.3.12 The Whitacre Heath SSSI is in the Tame Anker and Mease Management Catchment, within the Tame Lower Rivers and Lakes operational catchment. The site is within the Tame from R Blythe to River Anker Water Body 'GB104028046440'. The Hydrological Regime WFD element classification is 'Supports Good'.

6.3.13 The closest downstream gauging station along the River Tame is the Tame at Lea Marston Lakes (28080), approximately 0.25 km from site and lies at approximately 74.4 mAOD and is a simple crump profile weir.

6.3.14 The gauged daily flow data at Lea Marston from the UK National River Flow Archive for January 2019 – September 2020 is shown in Figure 6.2 and flow statistics are shown in Table 6.2.

[14] MAGIC (2021). Available at: https://magic.defra.gov.uk/MagicMap.aspx Accessed 15/12/2021.

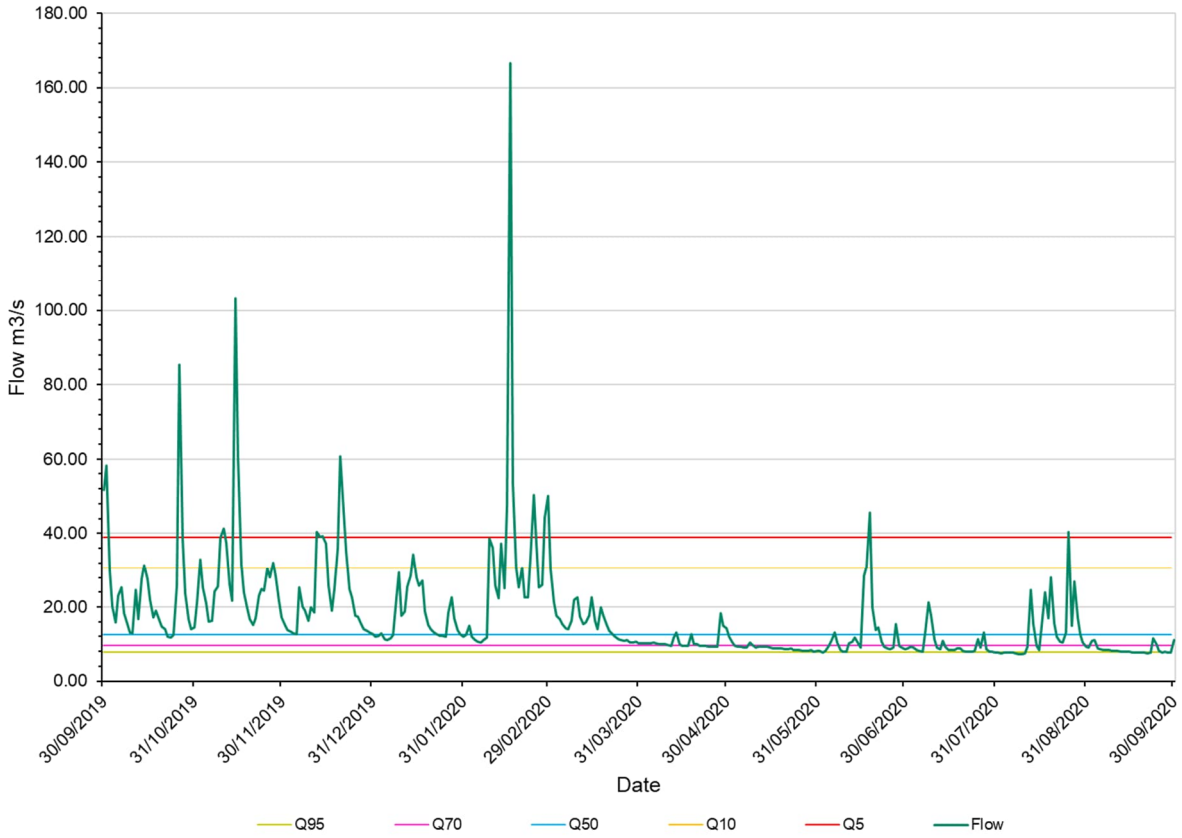


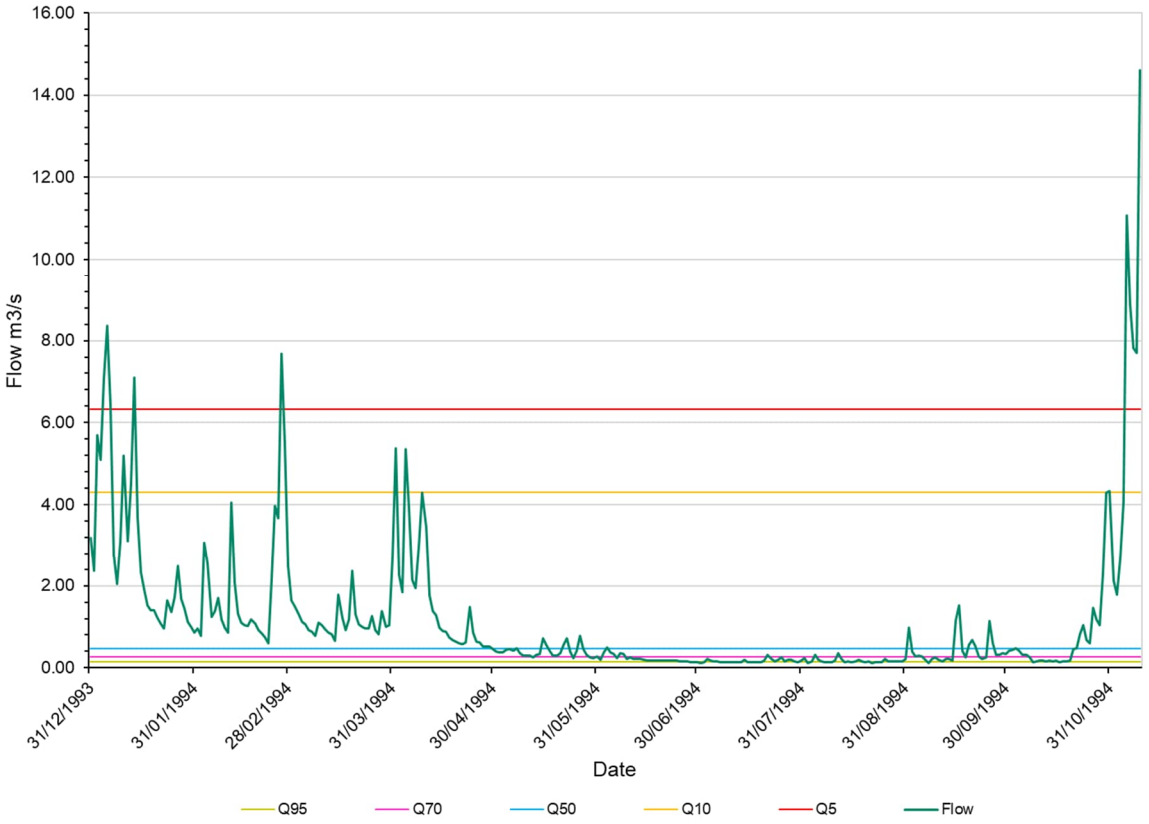
Figure 6.2: Gauged mean daily flow for the Tame at Lea Marston Lakes from 2019 – 2020

Table 6.3: Flow statistics for Tame at Lea Marston Lakes from 1957 - 2020

Flow Statistic	Data
Period of Record:	1957 - 2020
Percent Complete:	100 %
Base Flow Index:	0.68
Mean Flow:	13.827 m^3/s
95% Exceedance (Q95):	7.27 m^3/s
70% Exceedance (Q70):	9.067 m^3/s
50% Exceedance (Q50):	10.78 m^3/s
10% Exceedance (Q10):	23.5 m^3/s
5% Exceedance (Q5):	31.1 m^3/s

6.3.15 The River Blythe feeds into the River Tame approximately 1.5 km upstream from the Whitacre Heath site.

6.3.16 The nearest flow gauge according to the NRFA website on the River Blythe is Whitacre which is located immediately upstream of the confluence with the River Cole, approximately 0.5 km upstream of the confluence with the River Tame. The gauging station is described to be an electromagnetic gauging station and lies at 71.5 mAOD. The gauged daily flow data for December 1993 – December 1994 is shown in Figure 6.3.



6.3.17 Figure 6.3 and flow statistics are shown in Table 6.4.

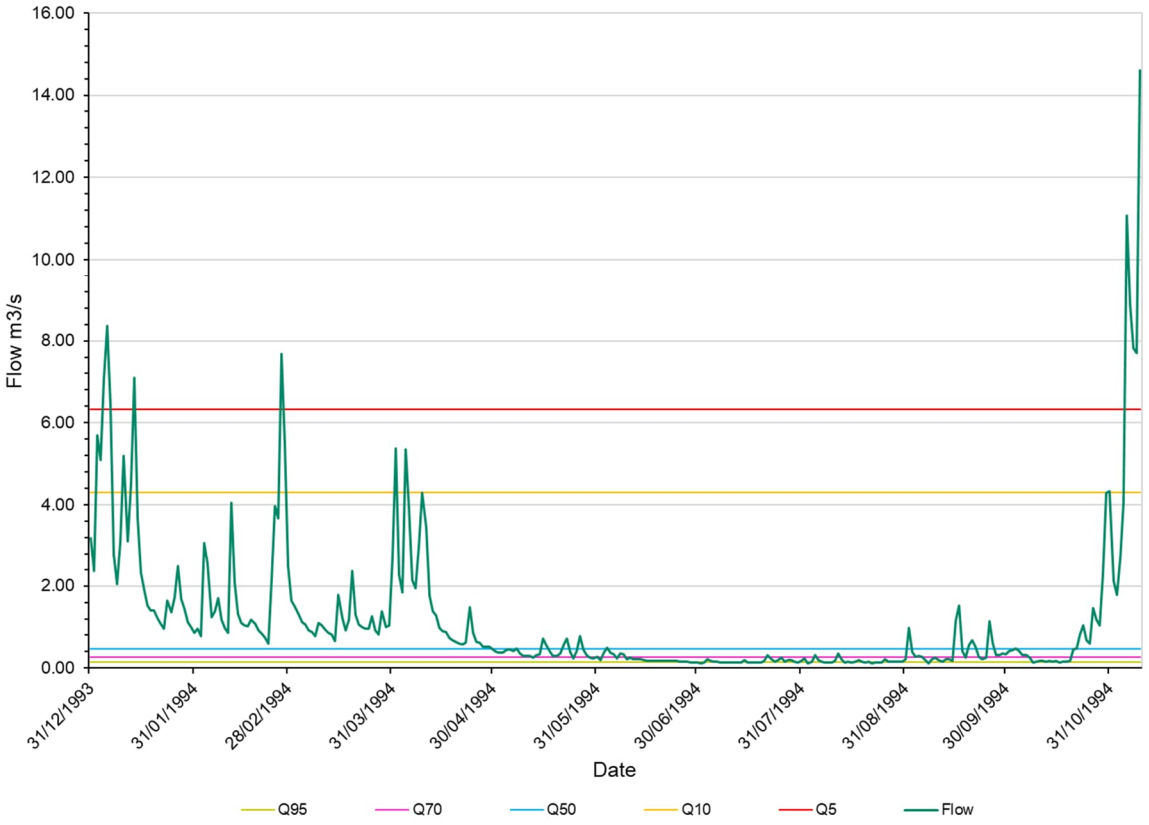


Figure 6.3: Gauged mean daily flow for the Blythe at Whitacre 1993 – 1994

Table 6.4: Flow statistics for Blythe at Whitacre from 1987 - 1996

Flow Statistic	Data
Period of Record	1987 - 1996
Mean Flow	1.203 m^3/s
95% Exceedance (Q95)	0.225 m^3/s
70% Exceedance (Q70)	0.354 m^3/s
50% Exceedance (Q50)	0.47 m^3/s
10% Exceedance (Q10)	2.883 m^3/s
5% Exceedance (Q5)	5.083 m^3/s

6.3.18 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. Approximately 400m downstream on the River Tame there is a weir at Lea Marston, and an additional 700m downstream is a weir and weir pool at Coton Road. Approximately 5.6 km upstream on the River Tame is the Water Orton weir. Water levels are recorded on the River Tame at Lea Marston above the weir (gaugemap.co.uk). Water levels show a typical seasonal variation of approximately 0.5m.

6.3.19 Abstractions and discharges local to the site may influence flow and river levels. The Gate 1 study identified only one surface water abstraction greater than 10 Ml/d upstream of the confluence of the River Tame with the River Trent. This is located in the lower River Blythe catchment. Flows in the River Tame at the site are augmented by inflow from the River Blythe, which are therefore influenced by this abstraction reducing flow. Approximately 3.5 km upstream on the River Tame is the Severn Trent Coleshill STW discharge, which increases flow passing the site.

6.3.20 The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 36.5% of Q95 flow in the River Tame, and 24.7% of flow at Q50 at Lea Marston. At high flows the reduction in flow due to Minworth is 8.5% at Q5 at Lea Marston.

Grid references for continued monitoring locations redacted

6.4 River Mease

Overview

6.4.1 The River Mease is a lowland clay river that flows across Leicestershire, Derbyshire and Staffordshire and approximately covers 25 km. It reaches the River Trent between Lichfield and Burton upon Trent. It is designated as a SSSI and a Special Area of Conservation (SAC). The river provides a supporting environment a range of habitats and species such as the bullhead, otter, spined loach, water crowfoot and white-clawed crayfish.

6.4.2 This section will focus on approximately 1 km of the River Mease, towards the lower end of the river from Croxall to where it flows into the River Trent. The topography within the SSSI has an average elevation of 50 mAOD, with elevations varying between 48 m to 50 mAOD. The surrounding area of the River Mease including the River Trent is also at an average elevation of 50 mAOD.

Geology

Superficial

6.4.3 The underlying superficial deposits of the River Mease are classed as alluvium (clay, silt, sand, and gravel). The surrounding area of the SSSI is dominated by alluvium deposits, but there are areas with no superficial deposits[15]. These areas largely consist of waterbodies such as lakes where sand and gravel deposits have been removed by quarrying. River Terrace Deposits (Sand and Gravel), outcrop in the area surrounding the upper part of this section of the River Mease.

6.4.4 The River Trent and River Tame which are in close proximity to the SSSI are also underlain by alluvium deposits. Sand and gravel deposits underlie alluvium and also outcrop across the area where the Tame and Mease meet the River Trent,

6.4.5 Borehole records ([redacted] approximately 0.74 km away from the SSSI shows the underlying superficial deposits consist of river gravels that are 3.9 m thick. Borehole records ([redacted]) approximately 0.44 km away from the SSSI describes the underlying superficial deposits as predominantly fine to coarse sand that is 26 m thick with a layer of small sub angular pebbles that is 14 m thick.

[15] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021

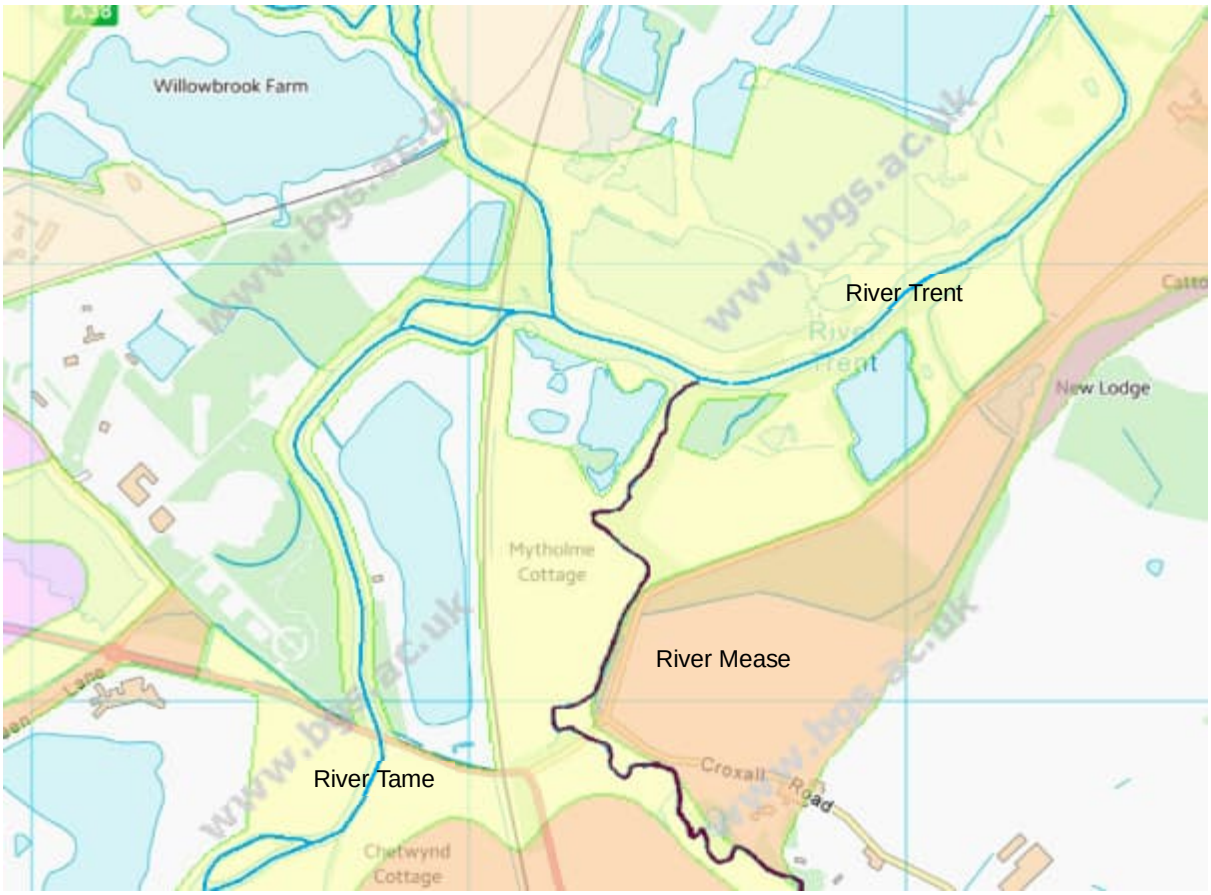


Figure 6.4: Superficial Geology Map for River Mease and its surrounding area.

Source: Underlying Map: Contains OS data © Crown Copyright and database right 2020. Superficial deposits: ArcGIS Map Service, https://map.bgs.ac.uk/arcgis/services

Bedrock

6.4.6 The underlying geology of the SSSI is composed of Gunthorpe Member (mudstone), this lithology is described as red-brown mudstone with dolomitic siltstone and fine-grained sandstone. The thickness of this lithology ranges between 70 m to 90 m. The parent unit for this lithology is the Sidmouth Mudstone Formation. The surrounding area of the SSSI including the River Trent and River Tame are also underlain by the Gunthorpe Member (mudstone).

Hydrogeology

6.4.7 The alluvium and river terrace deposits underlying the SSSI are classified as a Secondary A aquifer. Secondary A aquifer can store a large amount of groundwater, which can be used to support local water demands. Secondary A aquifers are formed of permeable layers and can be an important source of base flows to rivers by the EA.

6.4.8 The river terrace and glaciofluvial sand and gravel deposits of the nearby rivers Tame and Trent are also classified as a Secondary A aquifer, with the Mease, Tame and Trent deposits anticipated to form one hydraulically connected aquifer. This aquifer is anticipated to be in hydraulic continuity with river levels.

6.4.9 The hydraulic connection between the Tame and Mease is limited to a reach approximately 1.7 km in length to the east of the Whitemoor Lakes and terminating at the A513 because to the north and south superficial deposits are not continuously present between the rivers Tame and Mease. The potential hydraulically linked superficial aquifer may contribute base flow to the River Mease along the reach from Croxall village to the confluence with the River Trent.

6.4.10 The solid geology underlaying the SSSI is classified as Secondary B aquifer. Secondary B aquifer are formed of low permeability layers, which can only store a limited amount of groundwater.

6.4.11 The entire SSSI is at medium to high groundwater vulnerability from pollutant discharge.

Soils

6.4.12 The Soilscapes map viewer describes the soils within this SSSI as comprising of two units. The dominant soil unit is described as floodplain soils, with a loamy and clayey texture. The soil is naturally wet and has moderate fertility. The landcover is classified as grassland that is coastal and floodplain grazing marsh. The second soil unit is described as freely draining slightly acidic soils, with a loamy texture. The landcover is classified as arable and grassland.

Hydrology

Surface Water Features

6.4.13 There are multiple water bodies in close proximity to the River Mease. There are the Croxall Lakes Nature Reserve consisting of two lakes, which are located between the River Trent and its tributaries, the Tame and the Mease. The Croxall Lakes are home to a wide range wintering and breeding birds. The Croxall Lakes is a body of water classed as wetland, which supports a number of insects and harvest mice. Another water body is a large lake located towards the east of the SSSI, the waterbody is separated from the River Trent by an area of Deciduous woodland. There is a drain in the Coniferous woods that connects to the River Trent. The Coniferous woods follow along the east of the SSSI upstream for approximately 1 km.

6.4.14 The SSSI is located in the EA's Tame Anker and Mease Management Catchment. The lower Mease area is within the WFD surface water body called the Mease from Hooborough Brook to Trent Water Body (GB104028046560). The Hydrological Regime WFD element classification is 'Supports Good'.

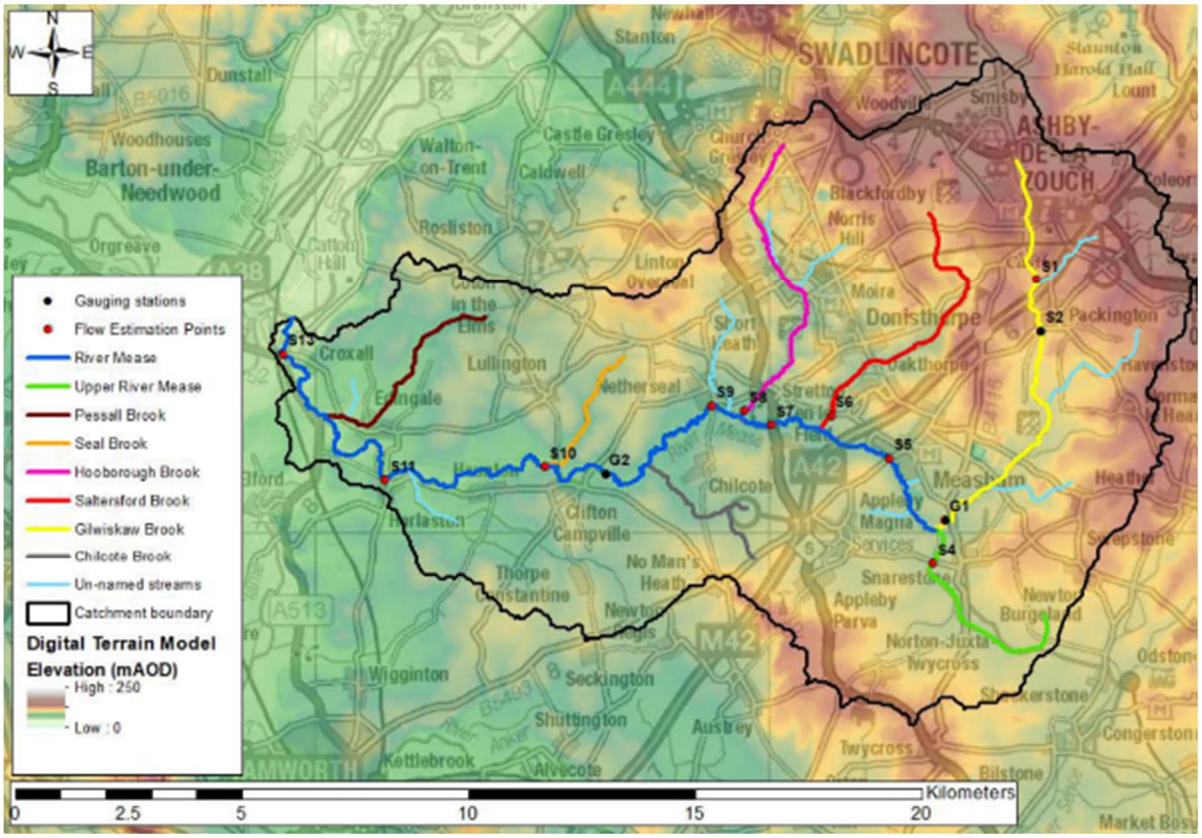
6.4.15 The River Mease and the surrounding area falls under a medium to high risk of flooding from rivers.

Surface Water Flow

There are no gauging stations along the lower River Mease. The Environment Agency[16] has conducted spot flow gauging along the Mease in 2020-21 as part of a hydrological investigation into the effects of removing treated effluent discharges upstream at Packington and Measham. The locations of spot flows are presented in

6.4.16 Figure 6.5. The area relevant to the Minworth SRO is between spot flow gauging sites 11 and 13 where the superficial aquifer providing base flow to the River Mease is anticipated to be in hydraulic continuity with the River Tame.

[16] Environment Agency, 2022 (ongoing). River Mease Hydrological Investigation



Contains OS data © Crown copyright and database right (2021). LIDAR data © Environment Agency (2018). JBA (2021)[17]

Figure 6.5: Environment Agency spot flow gauging in Mease catchment

6.4.17 Flows are presented in Figure 6.6 for the periods where most sites have recorded their highest (21/01/21) and lowest flows (20/07/21). The flows show steady accretion where the river overlies the sandstone principal aquifer in the upper reaches, and also where the river is overlying the secondary sand and gravel aquifers over much of its course to the confluence with the River Trent.

6.4.18 There is steady accretion along the River Mease from base flow from the secondary sand and gravel aquifers. The data indicates that the rate of accretion does not increase where this aquifer is also in hydraulic continuity with the River Tame. Additional accretion profiles derived by the Environment Agency at different flow percentiles also do not show a change in the rate of accretion where this aquifer is also in hydraulic continuity with the River Tame. Therefore, there is no evidence that the Tame loses flow to the aquifer which is then gained by the River Mease.

6.4.19 The rate of accretion reduces in the downstream reach at low flows where the gravel aquifer is connected to the River Tame. This may suggest the River Mease loses flow to the aquifer where groundwater flows northward to the River Trent.

6.4.20 Such losses are not apparent at high flows where there may not be a significant hydraulic gradient from the Mease to the Trent. Significant flood plain inundation will mean that the total flow is not recorded and is likely to be higher. Inundation will enable additional aquifer recharge across the floodplain between the Mease and Trent, which will also act to reduce the hydraulic gradient.

[17] River Mease Hydrological Analysis: Draft Final Report 14 October 2021

Grid references for continued monitoring locations redacted

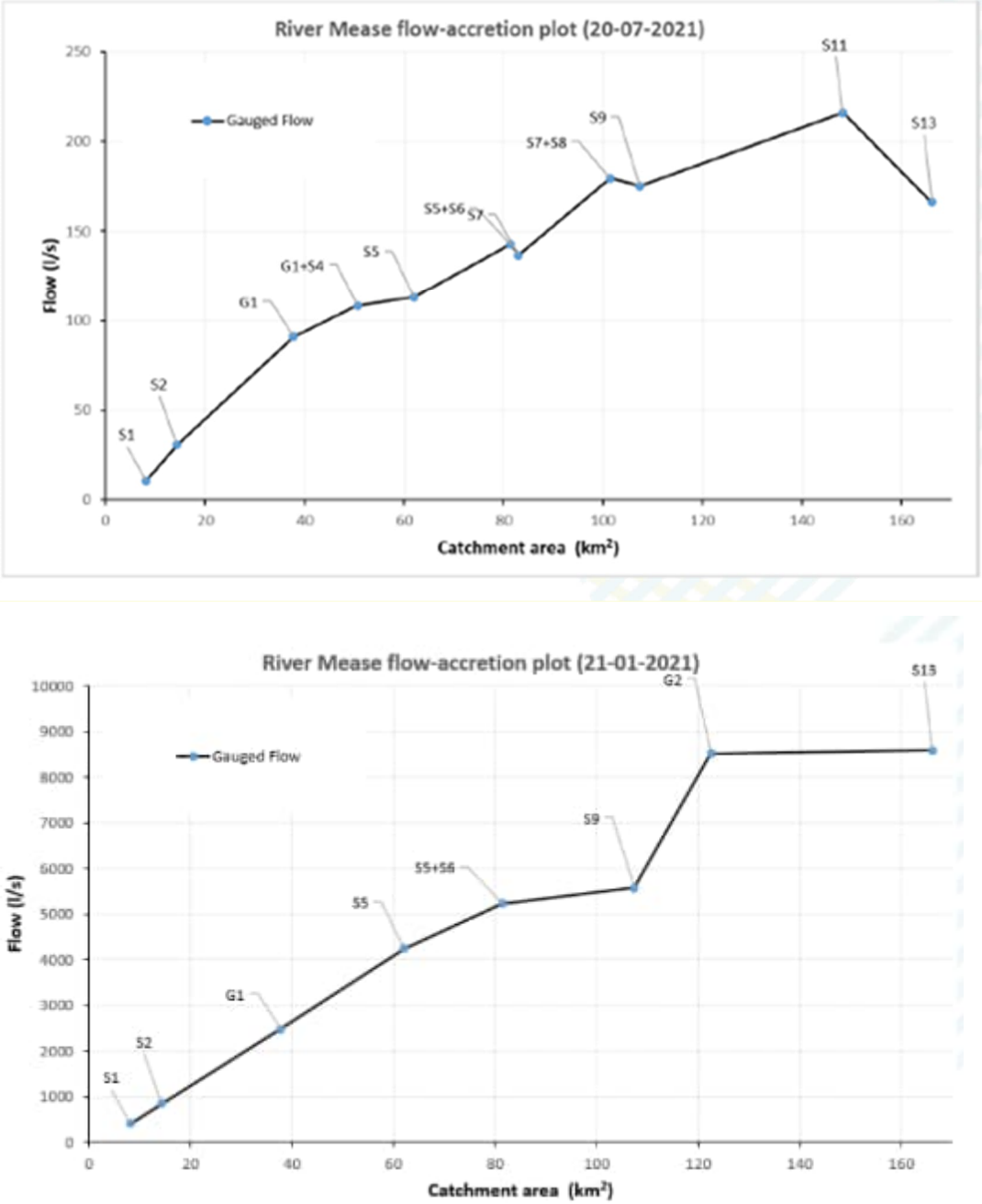


Figure 6.6: Spot flows in the River Mease at low (upper) and high flows (lower) © JBA (2021)[18]

6.4.21 The River Mease has previously been modified, there is a lack of morphological diversity due to straightening and re-sectioning in the lower part of the River Mease. The flow of the lower part of the River Mease is affected by over-deepening of the river impacting the floodplain connectivity. As part of the restoration plan, weirs along the River Mease are being removed in a bid to increase biodiversity and let the river flow more naturally[19].

6.4.22 The nearest downstream gauging station to where the River Mease meets River Trent, is the Trent at Drakelow Park (28019), approximately 10km downstream of the confluence with the Mease. The gauging station is located at 43 mAOD grid reference [redacted] and is described as a velocity area station. The gauged daily flow data for January 2019 – September 2020 is shown in 6.7 and flow statistics are shown in Table 6.5.

[18] River Mease Hydrological Analysis: Draft Final Report 14 October 2021
[19] River Mease SSSI/SAC Restoration Plan Technical Report March 2012 by Jacobs for Natural England.

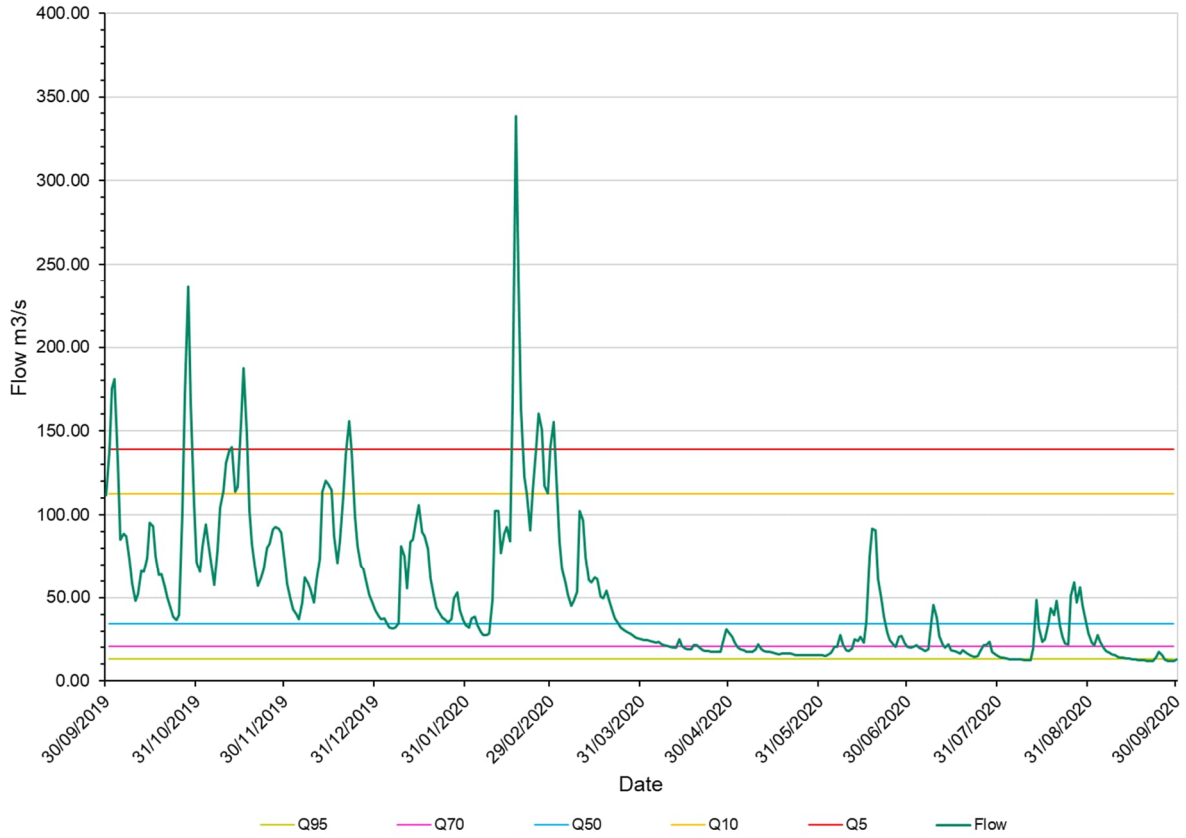


Figure 6.7 Gauged mean daily flow for the River Trent at Drakelow Park from September 2019 - 2020

Table 6.5: Flow statistics for River Trent at Drakelow Park from 1966 - 2020

Flow Statistic	Data
Period of Record:	1966 - 2020
Percent Complete:	>99 %
Base Flow Index:	0.66
Mean Flow:	36.227 m^3/s
95% Exceedance (Q95):	14.14 m^3/s
70% Exceedance (Q70):	21.1 m^3/s
50% Exceedance (Q50):	27.08 m^3/s
10% Exceedance (Q10):	67.18 m^3/s
5% Exceedance (Q5):	91.4 m^3/s

6.4.23 The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 18.8% of Q95 flow in the River Trent downstream of the Mease at Drakelow, and 9.8% of flow at Q50.

6.4.24 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. There are no weirs along the lower Mease. There are no weirs on the Tame or Trent in proximity to the lower River Mease and the confluence with the River Trent.

6.4.25 Water levels are recorded on the River Trent near the confluence with the River Mease at Croxall. Water levels show a seasonal variation in excess of 1m. Water levels are recorded on the River Tame at Tamworth, upstream of where River Tame water levels may interact with the superficial aquifer considered to be in hydraulic continuity with the lower River Mease. The gauge shows a typical

seasonal variation of approximately 0.3m, with occasional brief peaks in excess of 1m higher than the typical range.

6.4.26 Abstractions and discharges local to the site may influence flow and river levels. The Gate 1 study identified no significant surface water abstractions in the area of the Lower Tame or Trent near the confluence with the Mease and Trent. Five discharges were identified close to the Mease Trent confluence associated with quarrying at Barton quarry and Alrewas quarry, discharging to the River Tame and River Trent.

6.4.27 These discharges locally augment flow near the River Mease, which may increase river and groundwater levels in the superficial deposits. Meanwhile nearby quarrying activity have removed sand and gravel, thus increasing aquifer storage which has the effect of lowering groundwater levels and losing groundwater to evaporation. The most significant lake feature is to the east of the River Tame at the National Memorial Arboretum.

6.6 Donington Park

Overview

6.6.1 Donington Park is located in Leicestershire, approximately 2km west of Castle Donington and is approximately 43.40 Ha in size. It is classed as an SSSI due to the ancient oaks on site that provide a supporting environment for bats, deer herd and invertebrate fauna. The environment towards the north western side of the SSSI is classed as broadleaf woodland, which is characterised by trees which do not have needles such as the ancient oaks. The River Trent flows along the north west of the SSSI, adjacent to the broadleaf woodland. The rest of the SSSI is classed as improved grassland. Donington Park has no habitats that are dependent on surface water.

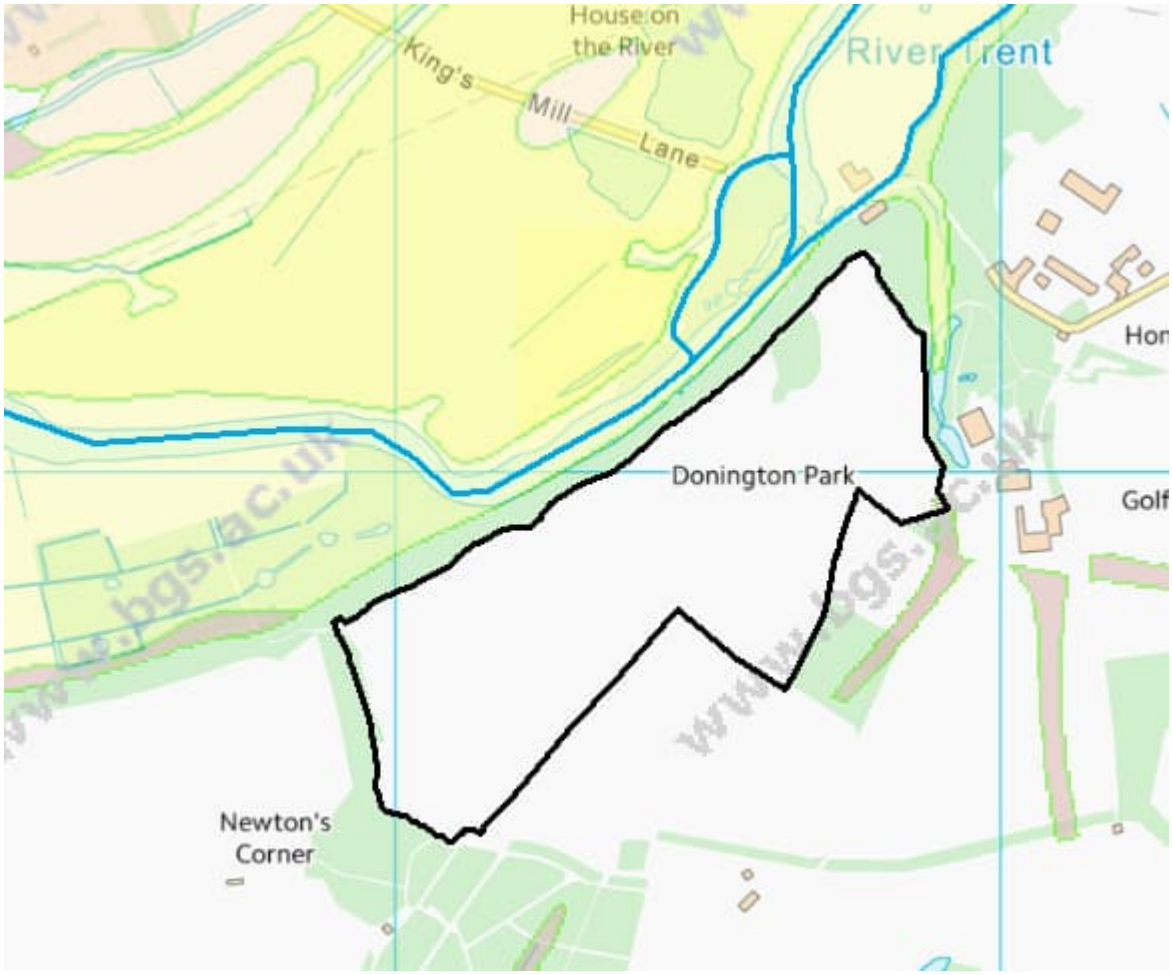
6.6.2 Within the SSSI, there is a hill towards the south that at its head is around 90 m Above Ordnance Datum (mAOD), which slopes north west towards the River Trent. The elevation of the SSSI is around 50 mAOD, near the River Trent, showing a fall of 40 mAOD from the hill. The River Trent is shown to be at approximately 35 mAOD on OS maps. Therefore, the site is steeply sided rising from the River Trent.

Geology

Superficial

6.6.3 There are no superficial deposits underlying the SSSI.

6.6.4 To the north of site, the River Trent is underlain by alluvium, comprising clay, silt, sand, and gravel. Beyond the northern bank of the River Trent Hemington Member outcrops, comprising silt and gravel. These superficial deposits are underlain by Gunthorpe Formation comprising Mudstone.



Legend

- River Trent
- SSSI – Donington Park Boundary Line
- Hemington Member
- Beeston sand and gravel member
- Alluvium
- Holme Pierrepont sand and gravel
- Head

Figure 6.8: Superficial Geology Map for Donington Park

Bedrock

6.6.5 Donington Park is underlain only by solid geology, no superficial deposits have been noted. The underlaying solid geology consist of; Tarporley Siltstone Formation, Gunthorpe Mudstone Formation, Helsby Sandstone Formation and Diseworth Sandstone Formation, which were all deposited during the Triassic period. Tarporley Siltstone Formation is formed of interbedded reddish-brown siltstones, mudstones and very fine- to fine grey-brown sandstones. The Helsby Sandstone Formation is formed of fine- to medium-grained cross bedded sandstones. The Gunthorpe Mudstone Formation is formed of two different members both of which are composed of mudstone, dolomitic siltstone, and fine-grained sandstone. The Diseworth Sandstone Formation is formed of grey siltstone and fine-grained sandstone[20].

6.6.6 The intersection of the topography with geological surfaces provides a marked outcrop pattern: bands of the mudstone and siltstone members of the Mercia Mudstone Group are ribboning around the hill rising from the site, comprising Tarporley Siltstone, Diseworth Sandstone, and Gunthorpe Mudstone. The strata are sub-horizontal. Towards the north east the Tarporley Siltstone is cut off by a fault and the Helsby Sandstone Formation is exposed. South west of the site has a band of Helsby Sandstone Formation runs south west to north east, along the River Trent. A band of Tarporley Siltstone Formation separates the Helsby Sandstone Formation from the Gunthorpe Mudstone.

6.6.7 In the Castle Donington area, the Tarporley Siltstone Formation Gunthorpe Mudstone Formation, and the Helsby Sandstone Formation are up to approximately 30m thick, and the Diseworth Sandstone Formation up to 4 m thick[21].

6.6.8 There are currently no boreholes in the SSSI site boundary, and the surrounding BGS boreholes are not representative of the underlying geology for the SSSI. Boreholes outside the site boundary towards the north east show Alluvium/ Fill material, River Terrace Deposits and Mercia Mudstone Group, all to varying depths.

Hydrogeology

6.6.9 According to Defra. Multi-Agency Geographic Information for the Countryside (MAGIC), the SSSI lies over a predominantly Secondary B bedrock aquifer, and within north east of the site there is an area that is classed as a Principal bedrock aquifer, reflecting the Helsby Sandstone, part of the Sherwood Sandstone aquifer.

6.6.10 Secondary B aquifers are described as ‘mainly lower permeability layers that may store and yield limited amounts of groundwater’. Principal aquifers are known to provide significant quantities of potable water.

6.6.11 The River Trent adjacent the site is underlain by a Secondary A superficial aquifer, which is anticipated to be in hydraulic continuity with the River Trent.

6.6.12 The Secondary A superficial aquifer is underlain by a Principal bedrock aquifer, reflecting the Helsby Sandstone. The Helsby Sandstone is anticipated to be in hydraulic continuity with the superficial aquifer surrounding the River Trent. Groundwater in the Helsby Sandstone is anticipated to be hydraulically isolated from overlying mudstone units on the site.

6.6.13 The groundwater vulnerability map shows groundwater being low vulnerability to pollution where the siltstone and mudstone geology outcrops, and where there is overlying alluvium, and high vulnerability where the sandstone outcrops.

[20] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021
[21] BGS, 2001 Geological Map Loughborough Solid and Drift Geology

Soils

6.6.14 There are two units of soils overlaying the solid geology at Donington Park. One unit is described as a freely draining slightly acidic soil, with a loamy texture. The soil has a low fertility rating due to its acidic nature. The unit is classed as freely draining; therefore, the soil is likely to absorb rainfall readily and allow it to drain to the underlying geology. This unit covers most of the SSSI.

6.6.15 The second unit found only in the north west part of the SSSI, is described as freely draining floodplain soil which has a loamy texture, reflecting deposition from the River Trent. The soil is freely draining and has a moderate to high fertility rating. The soil is likely to absorb rainfall readily and allow it to drain into the underlying geology.

Hydrology

Surface Water Features

6.6.16 OS maps show that the SSSI site has no surface water within its boundary and no direct connection to the River Trent. There are three surface water features near the SSSI.

6.6.17 There is a pond adjacent to the north eastern boundary of the SSSI. The River Trent, which flows alongside the north western boundary of the SSSI. The third water feature is the Mill Stream is runs into the River Trent, north of the SSSI.

6.6.18 Donington Park falls within the EA's Trent Lower and Erewash Management Catchment, in the River Trent operational catchment. The site is within the WFD waterbody Trent from Dove to Derwent (GB104028047420). The Hydrological Regime WFD element classification is 'Supports Good'.

6.6.19 Donington Park lies under a very low to low extent of flooding from surface water. In an event of surface flooding from the River Trent and the adjacent pond, the east and west boundaries of the SSSI are predicted to be affected.

Surface Water Flow

6.6.20 The nearest upstream gauging station to the SSSI is the Trent at Drakelow Park (28019), situated approximately 25 km from the site. The Trent at Drakelow Park station is located at 43 mAOD and is a velocity area station. The daily flow data available on the National River Flow Archive (NRFA), shows that the mean flow value is 36.23 m^3/s. The gauged daily flow data for January 2019 – September 2020 is shown in Figure 6.9 and flow statistics are shown in Table 6.6.

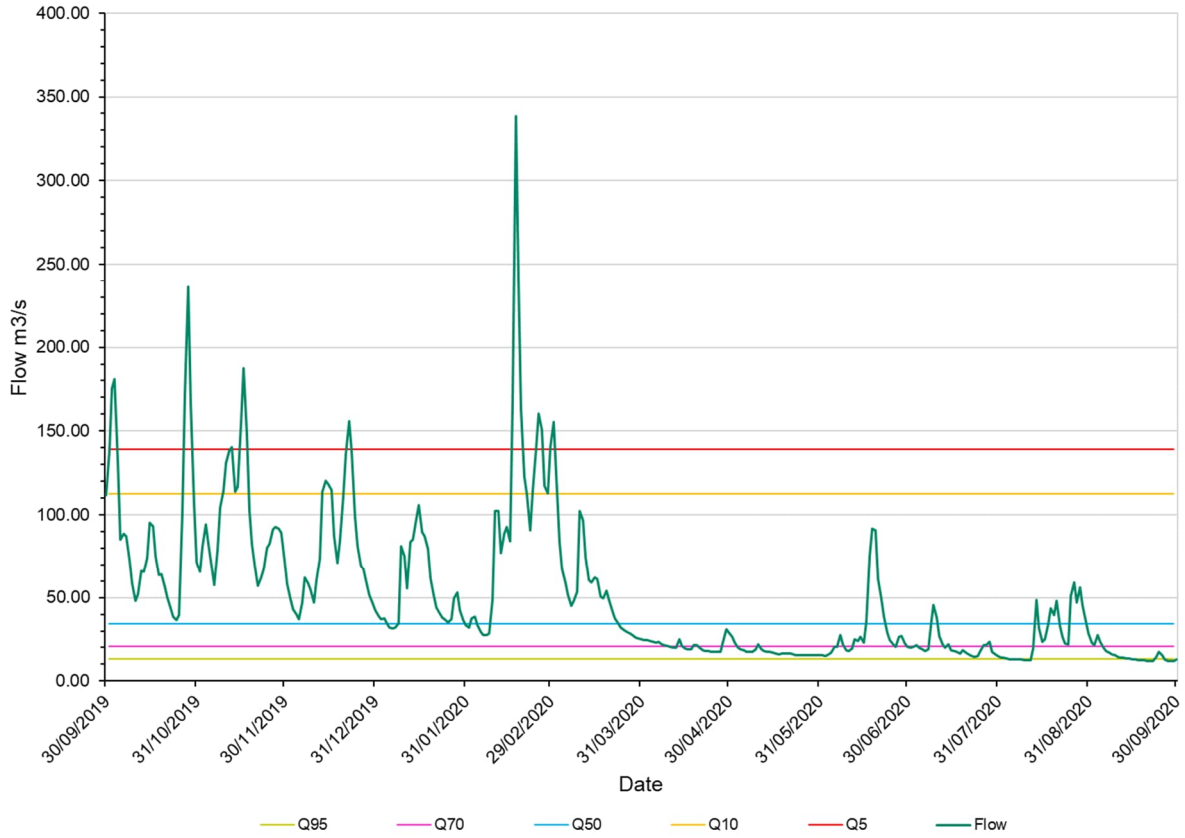


Figure 6.9: Gauged mean daily flow for the River Trent at Drakelow Park from 2019 – 2020

Table 6.6: Flow statistics for River Trent at Drakelow Park from 1958 - 2020

Flow Statistic	Data
Period of Record:	1966 - 2020
Percent Complete:	>99 %
Base Flow Index:	0.66
Mean Flow:	36.227 m^3/s
95% Exceedance (Q95):	14.14 m^3/s
70% Exceedance (Q70):	21.1 m^3/s
50% Exceedance (Q50):	27.08 m^3/s
10% Exceedance (Q10):	67.18 m^3/s
5% Exceedance (Q5):	91.4 m^3/s

6.6.21 The nearest gauging station to the SSSI along the River Trent is the Trent at Shardlow (28007) which is located downstream approximately 4 km. The Trent at Shardlow station is located at 29 mAOD and is a velocity area station. The daily flow data available on the National River Flow Archive (NRFA), shows that the mean flow value is 51.84 m^3/s. The gauged daily flow data for January 2019 – September 2020 is shown in Figure 6.10 and flow statistics are shown in Table 6.7.

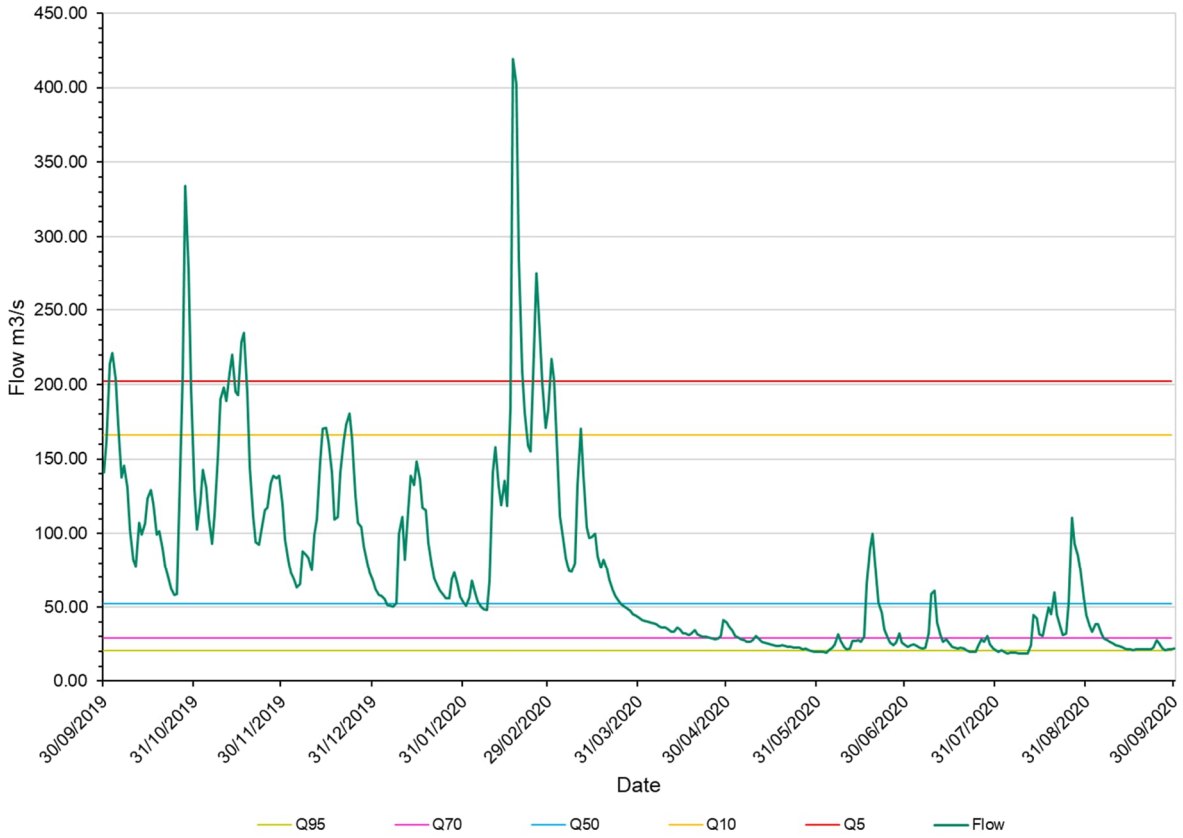


Figure 6.10: Gauged mean daily flow for the River Trent at Shardlow from September 2019 – 2020

Table 6.7: Flow statistics for River Trent at Shardlow from 1957 - 2020

Flow Statistic	Data
Period of Record:	1957 - 2020
Percent Complete:	61 %
Base Flow Index:	0.65
Mean Flow:	51.837 m^3/s
95% Exceedance (Q95):	17.54 m^3/s
70% Exceedance (Q70):	27.65 m^3/s
50% Exceedance (Q50):	36.53 m^3/s
10% Exceedance (Q10):	106.1 m^3/s
5% Exceedance (Q5):	143.9 m^3/s

6.6.22 The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 15% of Q95 flow in the River Trent at Shardlow, and 7.3% of flow at Q50. There are no weirs regulating levels and flow on the River Trent near the site. The nearest is at Sawley, approximately 9.2 km downstream.

6.6.23 Abstractions and discharges local to the site may influence flow and river levels. The Gate 1 study identified two surface water abstractions greater than 10Ml/d on the River Trent. At Shardlow approximately 2.5 km downstream water is abstracted for pond throughflow, and at Willington, approximately 14 km upstream for power station cooling. These abstractions will locally reduce flow and levels. A discharge was identified approximately 7 km upstream at Barrow upon Trent that will locally augment flow and water levels.

6.7 Attenborough Gravel Pits

Overview

6.7.1 Attenborough Gravel Pits SSSI and Attenborough West Gravel Pits LWS comprise a series of flooded gravel pits with islands and connecting causeways that have been colonised by vegetation over many years producing a mosaic of habitats which also include Lowland Fen and Reedbed Priority Habitats, and larger areas of Deciduous Woodland in addition to those habitats mentioned above.

6.7.2 The topography within the gravel pits is subdued with average elevation of the area lying at 30 metres above ordnance datum (mAOD) and elevations generally range between 23 and 35 mAOD. The topographic highs are associated with the woodland islands (such as the Delta Sanctuary) whilst the topographic lows are associated with the interspersed ponds (Main Pond, Church Pond, Coneries Pond for example). The ponds contain weirs controlling lake levels, and controls overflow to the River Trent.

6.7.3 The site is located adjacent the River Trent to the east, with the River Erewash flowing along the southern boundary. It is understood that the River Erewash flows directly into the lakes and this connection is being removed.

Geology

Superficial

6.7.4 The superficial deposits that underlay the SSSI are sparse, having largely been removed by gravel extraction. In the south-eastern reaches of the area (furthest downstream along the River Trent) alluvium deposits (clay, silt, sand, and gravel) are present which are associated with the River Erewash that borders the SSSI. The walkway that bisects the pits is underlain by the Holme Pierrepont Sand and Gravel Member (sand and gravel), the Hemington Member (silt and gravel) and alluvium. There is also a bar of the Hemington Member present at the north western reaches of the Delta sanctuary. The River Trent, which borders the eastern side of the SSSI is underlain by alluvium along its entire reach[22].

6.7.5 The Holme Pierrepont Sand and Gravel Member outcrops west of the site, and east across the River Trent.

6.7.6 Boreholes taken from the area show that the superficial deposits are approximately 4.3 – 8.4 m thick.

[22] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021

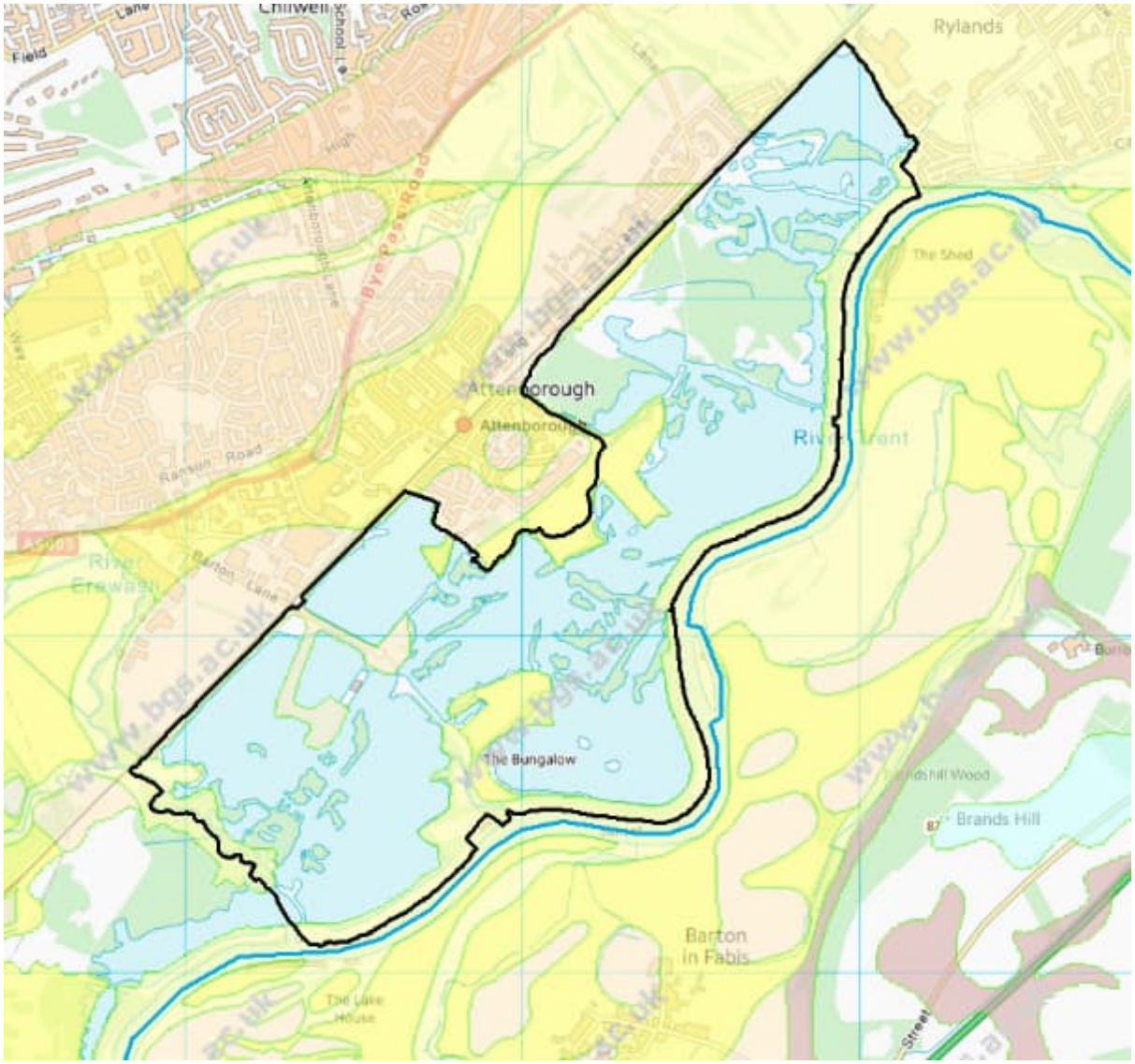


Figure 6.11: Superficial Geology Map for Attenborough Gravel Pits.

Source: Underlying Map: Contains OS data © Crown Copyright and database right 2020. Superficial deposits: ArcGIS Map Service, https://map.bgs.ac.uk/arcgis/services

Bedrock

6.7.7 The bedrock geology within the area is composed of three lithologies: the Edwalton Member (mudstone) in the southern reaches and the Gunthorpe Member (mudstone) in the northern reaches that is separated a thin band of the Cotgrave Member (sandstone). The parent unit for these three members is the Mercia Mudstone Group. A fault bisects the SSSI (NW-SE) that offsets the band of the Cotgrave sandstone, such that the Cotgrave member is not present in the northern areas of the SSSI or underlying the River Trent.

Hydrogeology

6.7.8 The superficial deposits that are present within this area are classified as Secondary A aquifers which relate to the Holme Pierrepont member and the Hemington member. The Environmental Agency classify these as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers. This aquifer is anticipated to be in hydraulic continuity with the lake levels and the River Trent.

6.7.9 The SSSI is primarily underlain by Secondary B bedrock aquifer. The Environmental Agency classes these as predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons, and weathering. These are generally the water-bearing parts of the former non-aquifers. This is associated with the Mercia Mudstone layers.

6.7.10 There is a thin band, associated with the Cotgrave sandstone member that is classified as a Secondary A aquifer. This unit is likely to be in hydraulic continuity with the superficial deposits aquifer. It may also be exposed in the lake floors and interact with the lake water levels and the superficial deposits aquifer.

6.7.11 The River Erewash, a tributary of the River Trent, flows adjacent to the southern border of this SSSI. It rises in Kirkby-in-Ashfield, Nottinghamshire where it is underlain by Cadeby Formation dolostone (limestones), classified as a Principal Aquifer (bedrock). Principal aquifers are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of groundwater storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

Soils

6.7.12 The Soilscapes map viewer describes the soils within this SSSI as comprising of two units. The first being freely draining floodplain soils that has a loamy texture. These soils have moderate to high fertility. They are found throughout the mosaic island areas of the SSSI. The second unit is associated with the River Erewash in the southern area of the SSSI. This is described as a loamy, clayey floodplain soil that has moderate fertility.

Hydrology

Surface Water Features

6.7.13 This section provides a summary of the surface water bodies within the vicinity of the SSSI, specifically those under the WFD. The Attenborough Pits lies within the Trent Lower and Erewash Management Catchment and is split between the Erewash River and the Nottingham Urban Operational catchments. There are two WFD waterbodies within the immediate area of the SSSI: the Trent from Dove to Derwent (GB104028047420) and the Erewash from Gilt Brook to Trent (GB104028052480). The Hydrological Regime WFD element classification for the Trent from Dove to Derwent water body is ‘Supports Good’, and for the Erewash from Gilt Brook to Trent waterbody is also ‘Supports Good’.

6.7.14 The ponds within the SSSI are classified as a WFD waterbody (Attenborough Nature Reserve - Main Pond Water Body, GB30434995). It has a hydromorphological designation as an artificial waterbody, has a surface are of 0.872 km2 and a mean depth of 1.675 m. Under Cycle 2 (2019), it has an Ecological classification of ‘poor’ however its Hydromorphological Supporting Elements were classified at ‘Supports Good’.

6.7.15 Sailing Pit, Coneries Pond, Church Pond, Clifton Pond, Main Pond, Tween Pond, Works Pond and Beeston Pond, are large lakes formed by the flooded pits.

6.7.16 The River Trent flows adjacent to the eastern border of the SSSI in which there are several sluices that connect the rivers and lakes. The first is located at the confluence of the River Erewash and the River Trent (SK 51316 33120), the second is located at the outflow of Coneries Pond (SK 51955 33487) and the third is located at the outfall of the Main Pond (SK 52922 34641)[23].

Surface Water Flow

6.7.17 The nearest gauging station for the Trent waterbody, according to the National River Flow Archive (NRFA) is Trent at Colwick (28009) which lies approximately 15 km downstream. The station level lies at 16 mAOD and is described to be a velocity area station. The average mean flow at this station is 85.75 m^3/s, with a maximum daily flow rate of 982 m^3/s on the 08/11/2021. The flow that is exceeded 95% of the time (Q_{95}) is 28.02 m^3/s. The gauged daily flow data for September 2019 – September 2020 is shown in Figure 6.12 and flow statistics are shown in Table 6.8.

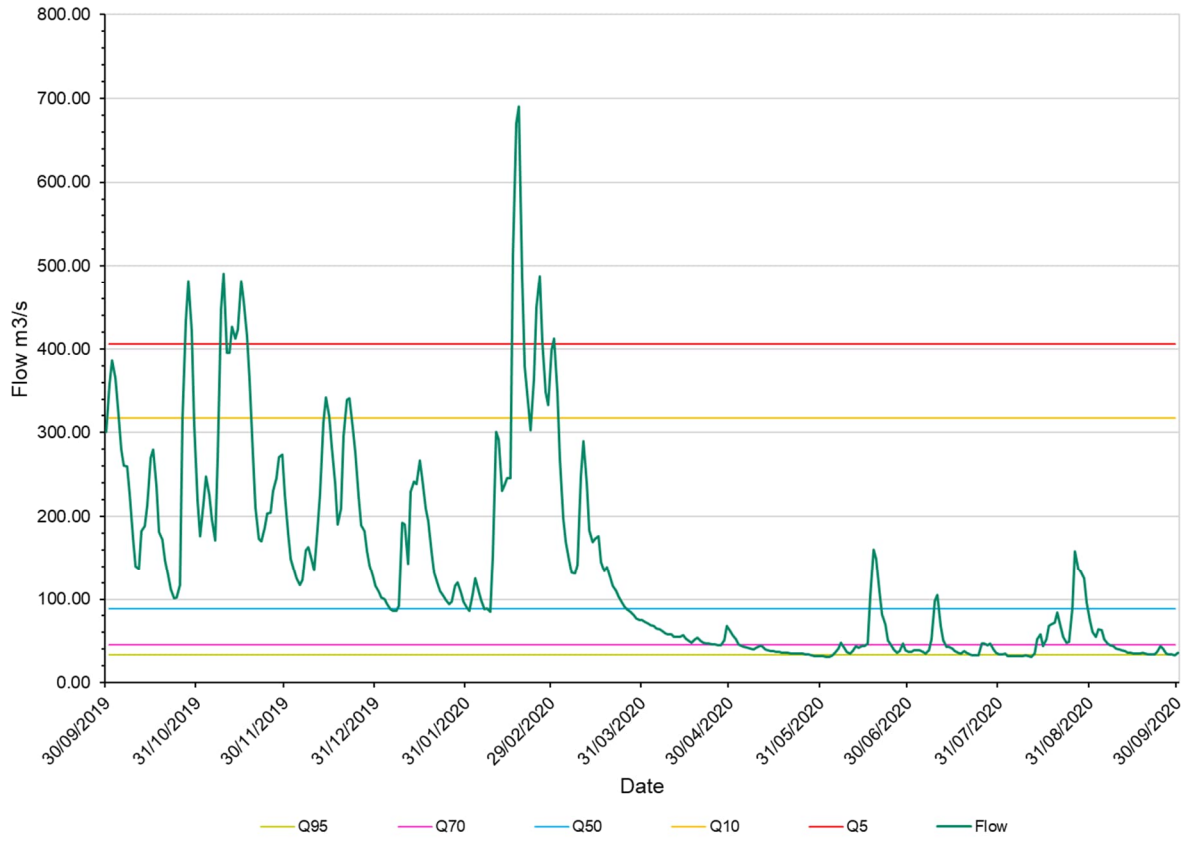


Figure 6.12: Gauged mean daily flow for the River Trent at Colwick 2019 - 2020

Table 6.8: Flow statistics for River Trent at Colwick from 1958 - 2020

Flow Statistic	Data
Period of Record	1958 - 2020
Mean Flow	85.75 m^3/s
95% Exceedance (Q95)	28.02 m^3/s
70% Exceedance (Q70)	42.4 m^3/s
50% Exceedance (Q50)	59.3 m^3/s
10% Exceedance (Q10)	177 m^3/s
5% Exceedance (Q5)	242.1 m^3/s

[23] Sayer.C and Roberts.N (2001) Establishing realistic restoration targets for nutrient-enriched shallow lakes: linking diatom ecology and palaeoecology at the Attenborough Ponds, U.K. Accessed 24/01/2022

6.7.18 The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 9.4% of Q95 flow in the River Trent at Colwick, and 4.5% of flow at Q50.

6.7.19 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. Beeston weir is approximately 200m downstream of the site controlling water levels on the River Trent. Thrumpton weir is situated approximately 4km upstream. Therefore, water levels and flows in the reach of the River Trent associated with the site are controlled by weirs. A weir is in the lower reaches of the River Erewash near the site controlling outflow to the River Trent.

6.7.20 The nearest gauging station for the River Erewash to the SSSI is Erewash at Sandiacre (28027) which lies approximately 5.5 km upstream from the SSSI. The station level lies at 33.4 mAOD and is a multi-path ultrasonic time-of-flight gauge where the river splits through two rectangular flood drainage channels. The average flow for this station is 1.92 m^3/s, with a maximum daily flow of 44.08 m^3/s on the 06/11/2000. Flow is shown in Figure 6.13 and flow statistics are shown in Table 6.9

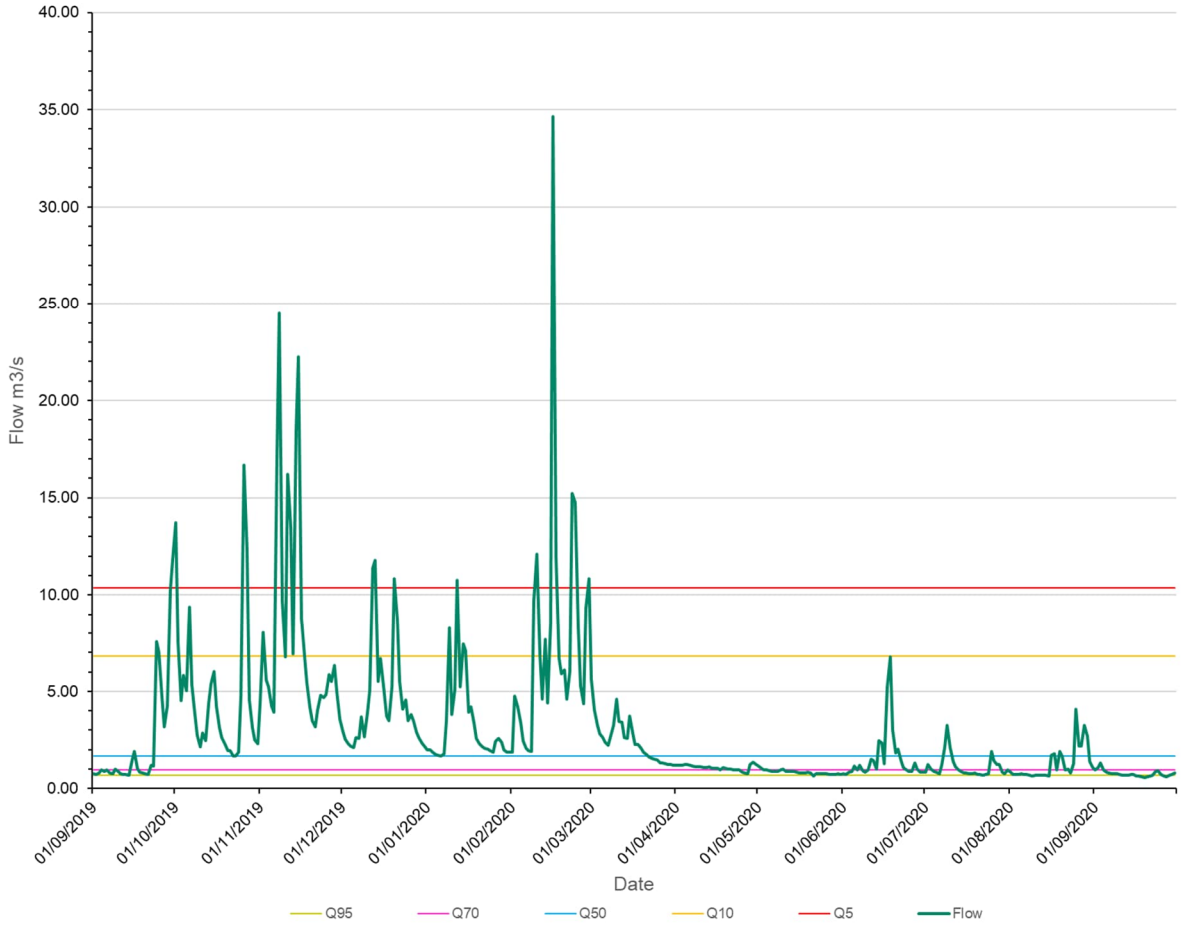


Figure 6.13: Gauged mean daily flow for the River Erewash at Sandiacre station 2019 – 2020

Table 6.9: Flow statistics for the Trent at River Erewash at Sandiacre station from 1958 - 2020

Flow Statistic	Data
Period of Record	1965 – 1984 and 1991 - 2020
Mean Flow	1.92 m^3/s
95% Exceedance (Q95)	0.51 m^3/s
70% Exceedance (Q70)	0.82 m^3/s
50% Exceedance (Q50)	1.18 m^3/s
10% Exceedance (Q10)	3.94 m^3/s
5% Exceedance (Q5)	5.82 m^3/s

Grid references for continued monitoring locations redacted

6.7.21 Abstractions and discharges local to the site may influence flow and river levels. The Gate 1 study identified a significant abstraction adjacent the site at Beeston weir, for hydroelectric power generation, which will have an effect of reducing water levels near the site. An additional abstraction is located approximately 4.3 km upstream on the River Trent, for process water, which will lower water levels on the River Trent to Thrumpton weir.

6.7.22 Adjacent the site boundary the Toton STW discharges treated effluent to the River Erewash, augmenting flow and water levels. Severn Trent Water intend to relocate the STW in coming years so that it discharges directly to the River Trent. Upstream approximately 6 km is a discharge from quarrying, discharging to the River Trent upstream of Thrumpton weir.

6.7.23 Water levels are recorded upstream of the SSSI at Cranfleet Lock below Thrumpton Weir and shows a typical seasonal variation in excess of 2m.

6.8 Lea Marsh

Overview

6.8.1 Lea Marsh is an important area of unimproved floodplain meadow and wet pasture adjacent to the River Trent in north-west Lincolnshire. The site lies on seasonally inundated alluvial soils and includes an unusually large area of a nationally rare grassland type. Populations of two nationally scarce plants with a restricted distribution in the East Midlands are particularly notable, whilst breeding waders provide additional interest. The entirety of the site is formed of Lowland Meadows Priority Habitat. The site is very low lying, from approximately 3-5 mAOD.

Geology

Superficial

6.8.2 The entirety of the area is underlain by alluvium deposits associated with the floodplain of the River Trent. A borehole ([redacted]) recorded the alluvium deposits to be approximately 4.2m thick which are underlain by river terrace deposits described to be 2.7 m in thickness and comprising sand and gravel[24].

[24] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021

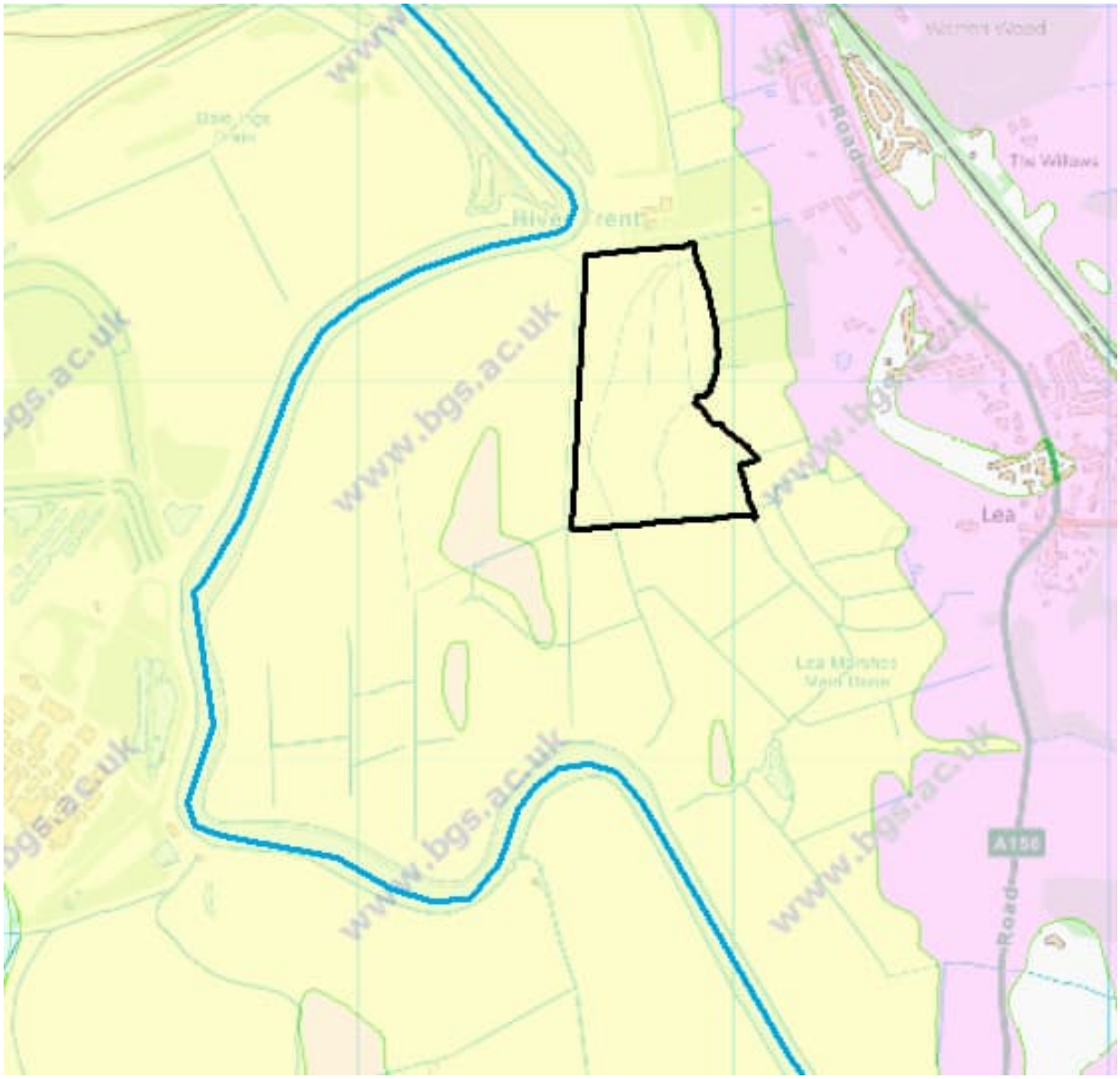


Figure 6.14: Superficial Geology Map for Lea Marsh

Source: Underlying Map: Contains OS data © Crown Copyright and database right 2020. Superficial deposits: ArcGIS Map Service, https://map.bgs.ac.uk/arcgis/services

Grid references for continued monitoring locations redacted

Bedrock

6.8.3 The entirety of the area is underlain by the Mercia Mudstone Group. A borehole ([redacted]) taken at the present-day sewage treatment works that are located immediately to the north of the marsh (approximately 500m north of the 1971 borehole), sampled a total depth of 1035 m. The Mercia Mudstone Group was identified to reach a depth of 231m which was subsequently underlain by the Sherwood Sandstone Formation to a depth of 498.40m.

Hydrogeology

6.8.4 The superficial deposits within this area are classified as Secondary A aquifer deposits. The Environmental Agency classify this as 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers'. These are generally aquifers formerly classified as minor aquifers. These cover the entire study area. This aquifer is anticipated to be in hydraulic continuity with the River Trent.

6.8.5 The bedrock is categorised as a Secondary B aquifer which covers the entire area of the SSSI. There is anticipated to be only limited groundwater interaction between the superficial deposits aquifer and bedrock aquifer.

Soils

6.8.6 The Soilscapes map viewer describes the soils within this SSSI as comprising of one unit. These are loamy and clayey floodplain soils with a moderate fertility.

Hydrology

Surface Water Features

6.8.7 This section provides a summary of the surface water bodies within the vicinity of the SSSI, specifically those under the WFD. The SSSI lies within the Trent from Carlton-on-Trent to Laughton Drain (GB104028058480) water body which has been given an artificial hydromorphological designation. The Hydrological Regime WFD element classification is 'Supports Good'.

6.8.8 There are five main drainage ditches throughout the area fan out across the SSSI from north to south. The main drain runs along the eastern border of the SSSI (Lea Marshes Main Drain), whilst the other four are dispersed throughout the centre. These appear on the OS map to be behind the flood embankment and not directly connected to the River Trent. River Trent levels are higher than the marsh drains.

Surface Water Flow

6.8.9 The nearest gauging station is the River Trent at North Muskham which lies approximately 26 km south (upstream) near the village of Collingham. There are no gauging stations downstream of this on the River Trent or its tributaries. The station is an ultrasonic gauging station and has been monitoring flows through this since 1996. Flows were previously recorded via a velocity area station from 1968. Annual mean flow at this station is 90.43 m^3/s, with a maximum daily flow of 962 m^3/s registered on 26/02/1997. The flow that is exceeded 95% of the time (Q95) is 28.9 m^3/s. The gauged daily flow data for May 2019 – May 2020 is shown in Figure 6.15 and flow statistics are shown in Table 6.10.

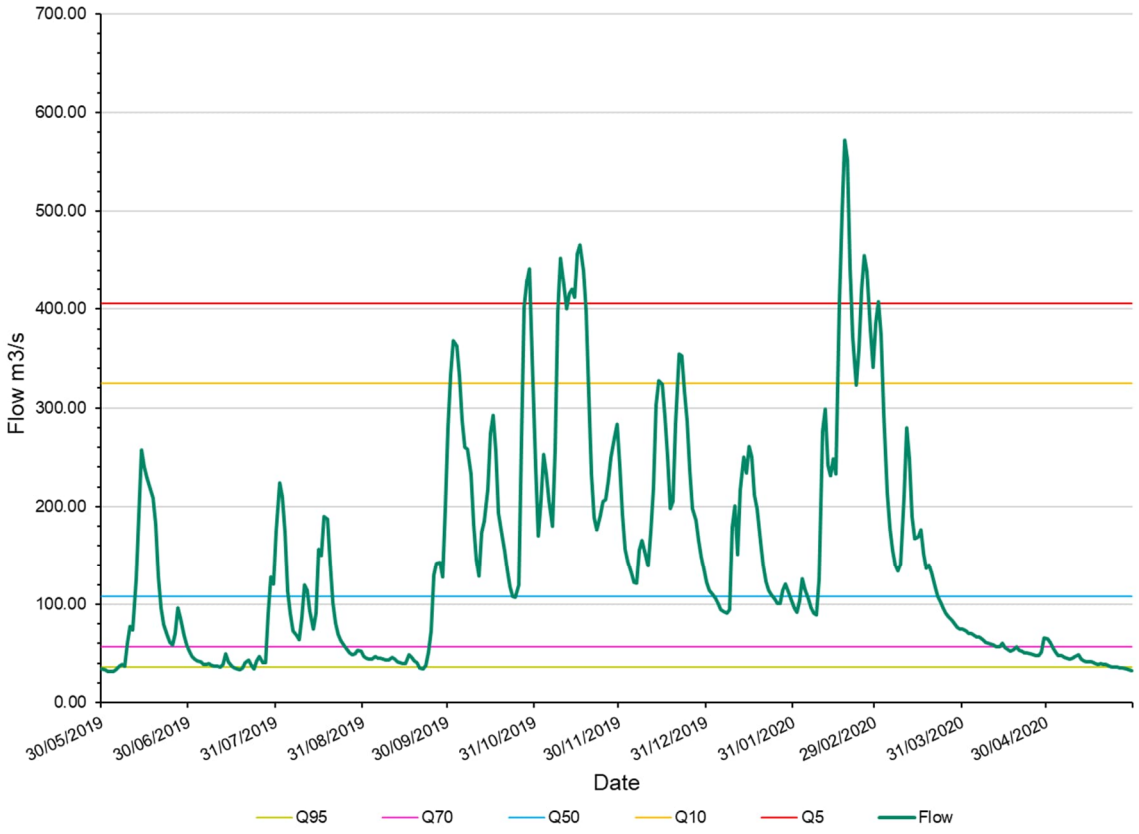


Figure 6.15: Gauged mean daily flow for the River Trent at North Muskham station 2019 – 2020

Table 6.10: Flow statistics for the River Trent at North Muskham station 1968 – 2020

Flow Statistic	Data
Period of Record	1968 - 2020
Mean Flow	90.431 m^3/s
95% Exceedance (Q95)	28.9 m^3/s
70% Exceedance (Q70)	45.5 m^3/s
50% Exceedance (Q50)	63.8 m^3/s
10% Exceedance (Q10)	183 m^3/s
5% Exceedance (Q5)	248 m^3/s

6.8.10 The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 9.2% of Q95 flow in the River Trent at North Muskham, and 4.2% of flow at Q50.

6.8.11 The South Lincolnshire Reservoir SRO abstraction will be situated upstream of the site and will reduce flows passing the SSSI. The proposed abstraction is up to 300 Ml/d. When combined with the reductions in discharge at Minworth (total 6.13 m^3/s) the reduction in flow is estimated to be 21.2% of Q95 flow in the River Trent at North Muskham, and 9.6% of flow at Q50.

6.8.12 However, the SLR will only be operating for between 7.5% and 28% of days from June to October, so the flow depletion is not continuous and lowered river levels will be partially mitigated on each tidal cycle (see Section 1.5).

6.8.13 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. Cromwell weir is situated approximately 27km upstream, which influences discharge to the lower tidal

section of the River Trent where the site is located. Therefore, water levels in the River Trent will be affected by this weir and the daily cycle of the tide.

6.8.14 Abstractions and discharges local to the site may influence flow and river levels. The Gate 1 study identified five significant surface water abstractions from Newton on Trent, approximately 15 km upstream, to West Burton, approximately 2 km upstream of the site, all within the reach below Cromwell Weir. These abstractions will locally reduce flow and levels passing the site.

6.8.15 The Gate 1 study identified five significant discharges from Cromwell weir downstream toward the site, locally augmenting flows. The nearest is at Cottam power station, approximately 9 km upstream.

Tidal variations

6.8.16 The SSSI is in the tidal reaches of the River Trent. The tidal range at Lea Marsh is not known.

6.8.17 The tidal variations within the Humber are shown below (Figure and Figure in Humber Estuary section below) at Immingham, downstream of the confluence with the River Trent. It shows the tide has a daily range of approximately 7m with most months over the years showing a similar minimum and maximum level.

6.8.18 The tidal range approximately 12 km upstream of the SSSI at Torksey shows a typical range in daily mean level of 0.8-1.3m, with usually several tides per year raising water levels 1-3m above the typical range (Figure 6.19).

6.10 Humber Estuary

Overview

6.10.1 The Humber Estuary is the second largest coastal plain estuary in the UK and drains a total catchment area of approximately 24,472 km^2. The main rivers that flow into the Humber are the Aire, Derwent, Don, Ouse, Trent, and Wharf. The estuary contains features such as mud and sand flats, saline lagoons, saltmarshes, and sub-tidal sandbanks. Some of the monitored features under this SSSI include aggregations of non-breeding birds, eutrophic lakes, fixed dune grassland, vascular plant assemblages' saline coastal lagoons and littoral sediment. Due to the large spatial nature of the SSSI, the description of the area has been split into two sections:

- Upper (River Ouse and River Trent)
- Lower (River Humber)

Geology

Superficial

Upper

6.10.2 The superficial deposits found within the two channels are primarily composed of alluvium and tidal flat deposits[25]. The largest of these deposits are associated with Blacktoft Sands wetland area at the confluence of the Ouse and the Trent (Trent Falls), on the south bank of the Ouse. Blacktoft Sands is managed by the Royal Society for the Protection of Birds (RSPB).

6.10.3 Borehole data available in the area suggests that the superficial deposits within the Ouse channel are approximately 15 m in thickness. Within the channel of the Trent, the superficial deposits are approximately 20 m in thickness at the southern extent of the SSSI (near Scunthorpe), with approximately 22m recorded in the north near Garthorpe.

Lower

6.10.4 The superficial deposits found within the Humber channel consist of tidal flat deposits. The largest of these deposits are associated with Whitton Island, Reads Island, Redcliff Middle Sand, Redcliff Channel, and the Water's Edge Country Park area. There is no available borehole data for the Humber Middle.

[25] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021

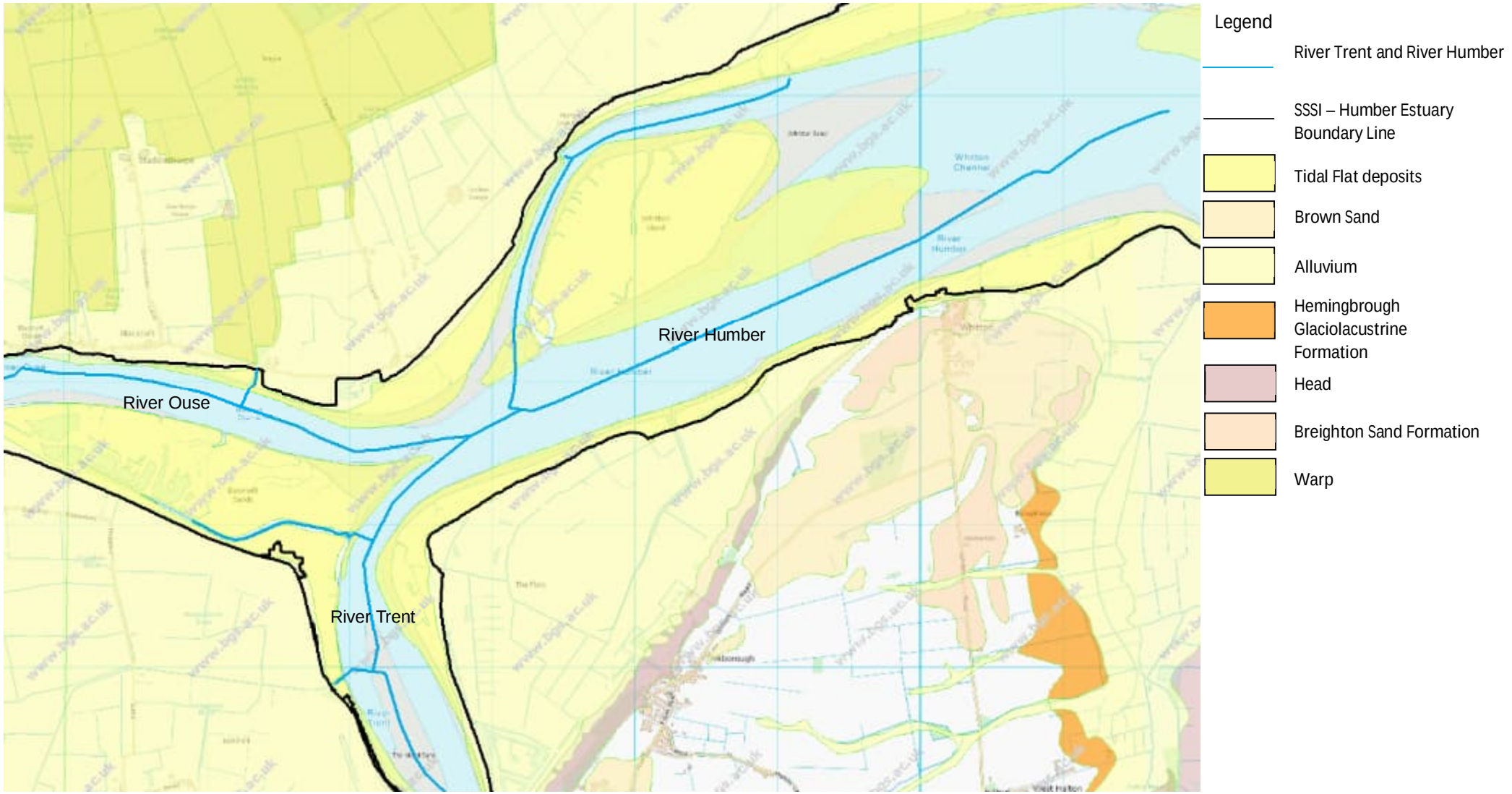


Figure 6.16: Superficial Geology Map for Humber Estuary.

Source: Underlying Map: Contains OS data © Crown Copyright and database right 2020. Superficial deposits: ArcGIS Map Service, https://map.bgs.ac.uk/arcgis/services

Bedrock

Upper

6.10.5 The Ouse channel is underlain by two geologies, the first being the Sherwood Sandstone at the upstream reaches near Howden (for approximately 1.2 km) and then the Mercia Mudstone Group until the confluence with the Trent. The Trent channel is solely underlain by the Mercia Mudstone Group.

Lower

6.10.6 The bedrock geology that underlies the Humber Middle section is highly variable directly downstream of the confluence of the Ouse and Trent. The confluence is underlain by the Mercia Mudstone Group. Downstream of this, the lithologies present (from upstream to downstream) are:

- Triassic rocks (undifferentiated)
  - Penarth Group (mudstone)
- Lias Group
  - Scunthorpe Mudstone Formation
  - Frodingham Ironstone Member
  - Charmouth Mudstone Formation
  - Pecten Ironstone (bed) – ironstone
  - Marlstone Rock Formation
  - Whitby Mudstone Formation
- Inferior Oolite Group
  - Lower Lincolnshire limestone member
  - Raventhorpe beds –
  - Upper Lincolnshire limestone member
- Great Oolite Group
  - Rutland formation, Blisworth limestone formation and Blisworth clay formation
  - Thorncroft sand member
- Ancholme Group
  - Kellaways clay member
  - Kellaways sand member

Hydrogeology

Upper

6.10.7 According to the Defra Magic Map, the first kilometre of the Trent channel that lies within the Humber SSSI is underlain by superficial drift Secondary A aquifer which are associated with alluvium. For the same reach, the area is underlain by bedrock Secondary B aquifer. Blacktoft Sands on the southern bank of the Ouse is also underlain by a Secondary B bedrock aquifer. This aquifer is anticipated to be in hydraulic continuity with river levels.

6.10.8 Upstream along the River Ouse at Howden the Sherwood Sandstone is classified as a Principal Aquifer. This aquifer is anticipated to be in hydraulic continuity with the River Ouse and provide base flow.

Lower

6.10.9 There are no superficial aquifer designations within the River Humber area. The bedrock deposits within the area that are classified as aquifers range from Principal to Secondary B, reflecting the significant variation in geology in this area. The principal aquifers are anticipated to be in hydraulic continuity with the River Humber and provide base flow.

Soils

6.10.10 The Humber SSSI only includes in-channel habitats and therefore there are no soils associated with this site.

Hydrology

Surface Water Features

6.10.11 This section provides a summary of the surface water bodies within the vicinity of the SSSI, specifically those under the WFD. The SSSI lies within the Humber Estuary TraC Operational Catchment and is split into three units: Humber Lower (GB530402609203, Ouse and Trent waterbodies), the Humber Middle (GB530402609202, River Humber) and the Humber Lower (GB530402609201, mouth of the Humber). All three waterbodies have been given a hydromorphological designation of heavily modified.

6.10.12 The Humber Upper's Ecological classification under Cycle 2 (2019) is Moderate whilst the Hydrological Regime WFD element classification is 'Supports Good'. The Humber Middle and Humber Lower Ecological classification under Cycle 2 are both Moderate.

6.10.13 The nearest gauging station is the River Trent at North Muskham situated upstream near the village of Collingham. There are no gauging stations downstream on the tidal River Trent. Flow statistics are given in Table 6.10 (Lea Marsh baseline section) and are indicative of flows into the tidal zone containing the SSSI.

6.10.14 The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 9.2% of Q95 flow in the River Trent at North Muskham, and 4.2% of flow at Q50.

6.10.15 The South Lincolnshire Reservoir SRO abstraction will be situated upstream and will reduce flows passing the SSSI. The proposed abstraction is up to 300 Ml/d. When combined with the reductions in discharge at Minworth (total 6.13 m^3/s) the reduction in flow is estimated to be 21.2% of Q95 flow in the River Trent at North Muskham, and 9.6% of flow at Q50.

6.10.16 However, the SLR will only be operating for between 7.5% and 28% of days from June to October, so the flow depletion is not continuous and lowered river levels will be partially mitigated on each tidal cycle (see Section 1.5).

Tidal variations

6.10.17 The SSSI is in the tidal reaches of the River Humber, Trent, and Ouse. The tidal variations within the Humber are shown below (Figure 6.17 and Figure 6.18) at Immingham, at the downstream end of the SSSI. It shows the tide has a daily range of approximately 7m with most months over the years showing a similar minimum and maximum level.

6.10.18 The tidal range in the upper parts of the River Trent tidal section is recorded at Torksey by the Environment Agency, which shows a typical range in daily mean level of 0.8-1.3m, with usually several tides per year raising water levels 1-3m above the typical range (Figure 6.19).

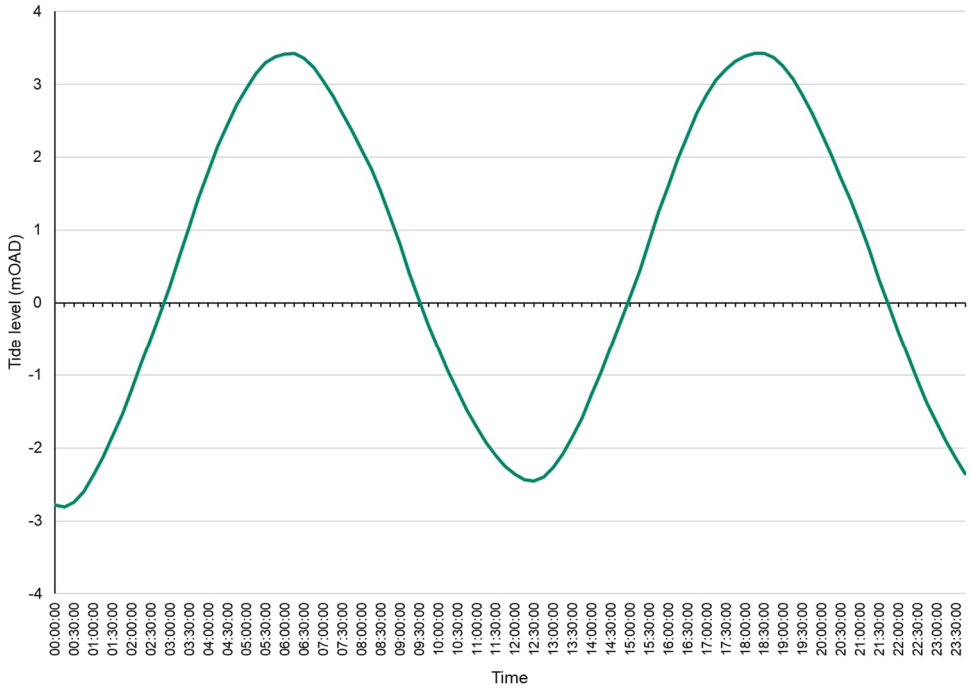


Figure 6.17: Tidal changes at Humber Immingham (NGR: [redacted]) for 30/04/2018

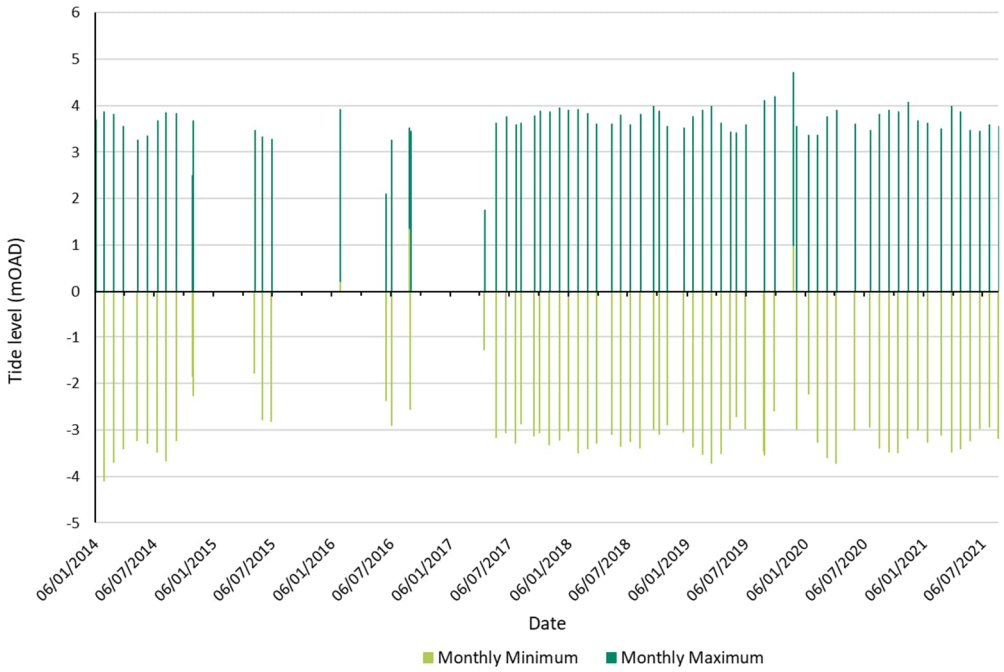


Figure 6.18: Monthly tidal range - Humber at Immingham from 2014 – 2021

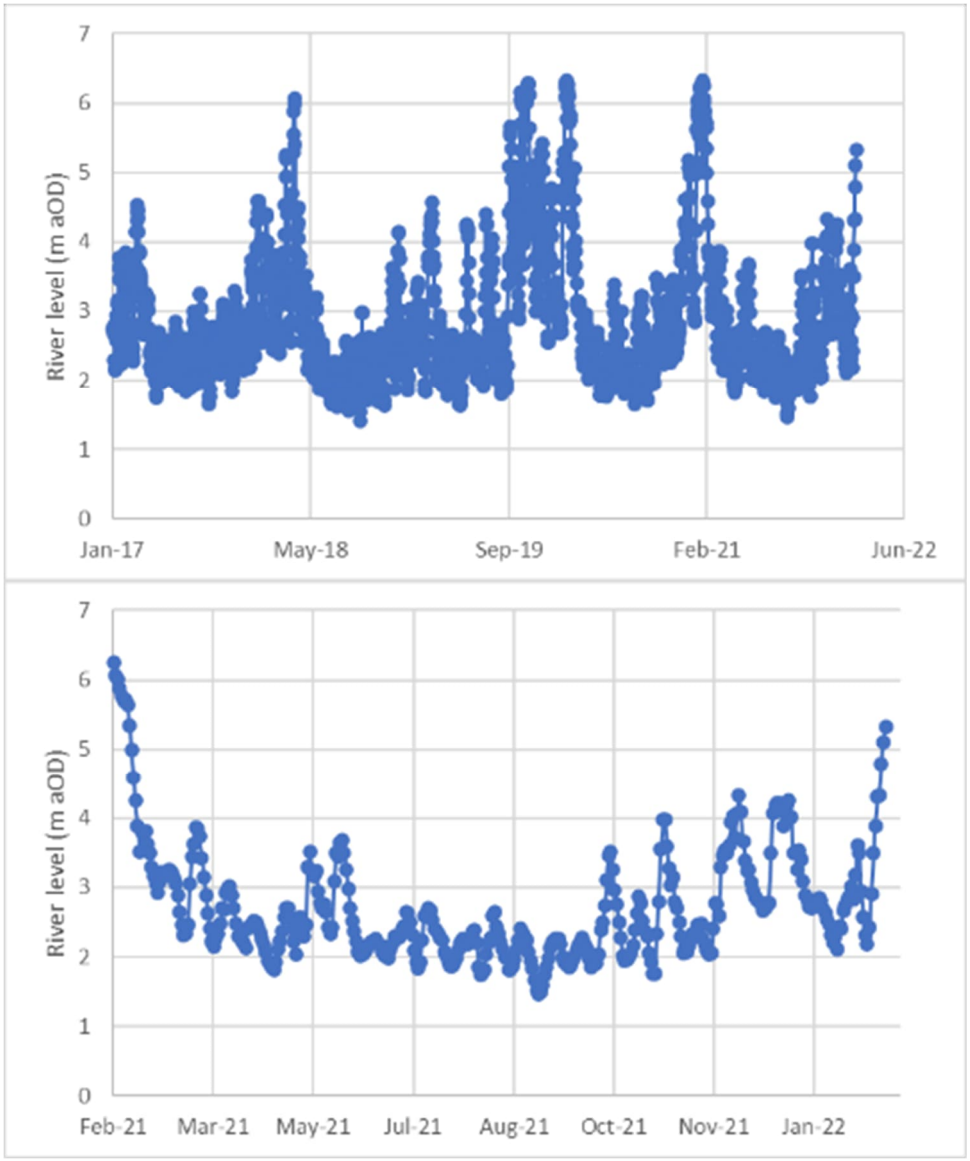


Figure 6.19: Tidal variation at Torksey over 5 years (upper) and 1 year (lower)

A.3 Baseline Amber Priority SSSIs

6.11 River Blythe

Overview

6.11.1 The River Blythe is a lowland river which rises near Earlswood Lakes, Warwickshire at Spring Brook and flows in a predominantly northerly direction where it discharges into the River Tame at Coleshill (NGR: SP 21203 91591). It is classified as an SSSI due to it being an example of lowland clay river that exhibits diverse bed substrates, hydromorphological features and ecological richness. The lower reaches are characterised by predominately flowing through farmland. The River Blythe SSSI is currently in an 'unfavourable no change' condition due to past physical modifications.

6.11.2 This section will focus on approximately 1 km of the River Blythe, towards the lower end of the river (from SP 20870 90748) to where it flows into the River Tame. The River Cole discharges into the River Blyth before the confluence with the River Tame (NGR: SP 21211 91182). The topography within the SSSI has an average elevation of 50 mAOD, with elevations varying between 48 m to 50 mAOD. The surrounding area of the River Blyth, including the Rivers Cole and Tame is also at an average elevation of 50 mAOD.

Geology

Superficial

6.11.3 The underlying superficial deposits of the River Blythe are classed as alluvium (Clay, Silt, Sand and Gravel). The surrounding area of the SSSI is dominated by alluvium deposits, but there are areas with no superficial deposits. These areas largely consist of waterbodies such as lakes where sand and gravel deposits have been removed by quarrying. The sand and gravel forms river terrace deposits that, where not removed by quarrying, are extensive across the Blythe and Tame confluence area. The River Tame, which is in close proximity to the SSSI are also underlain by alluvium deposits[26].

6.11.4 Borehole records ([redacted] approximately 0.32 km away from the SSSI at Whitacre Water Treatment Works, shows the underlying superficial deposits consist of stiff reddish brown and green-grey clay with some fine to coarse gravel at 2.85 m below surface level to 5.3 m where the borehole ends.

[26] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021

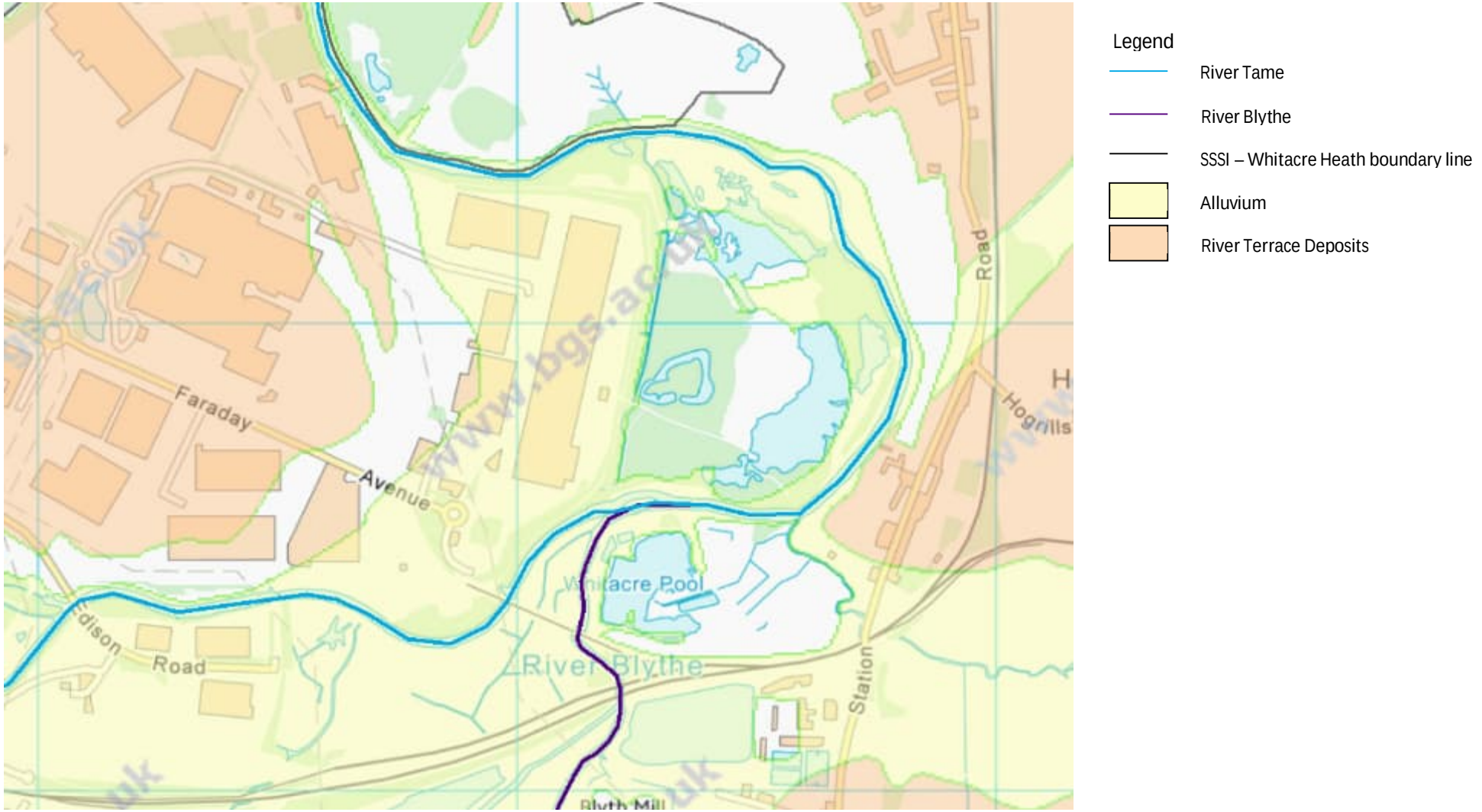


Figure 6.20: Superficial Geology Map for River Blythe

Source: Underlying Map: Contains OS data © Crown Copyright and database right 2020. Superficial deposits: ArcGIS Map Service, https://map.bgs.ac.uk/arcgis/services

Bedrock

6.11.5 The area under review is wholly underlain by the Sidmouth Mudstone Formation (part of the Mercia Mudstone Group). This is described as being predominantly composed of mudstone and siltstone layers with red-brown and grey-green reduction patches and spots. The Tame downstream of the SSSI is also wholly underlain by this lithology.

6.11.6 Borehole records for the Blythe Bridge (Ref [redacted] which is located approximately one kilometre south away from the area under consideration show that the Mercia Mudstone Group (Keuper Marl) being present at a depth of approximately 3m below drift deposits. The borehole recorded 930 m of this lithology.

Hydrogeology

6.11.7 The alluvium deposits underlying the SSSI are classified as a Secondary A aquifer. Secondary A aquifer can store a large amount of groundwater, which can be used to support local water demands. Secondary A aquifers are formed of permeable layers and can be an important source of base flows to rivers by the EA. The river terrace deposits are anticipated to provide hydraulic continuity across the Tame and Blythe confluence area, and also with river levels.

6.11.8 The Sidmouth Mudstone Formation underlying the SSSI are classified as a Secondary B aquifer. These are described by the Environmental Agency as ‘Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers and are anticipated to have limited hydraulic connection to the superficial deposits aquifer.

Soils

6.11.9 The Soilscape map viewer describes the soils within this SSSI and the River Trent as comprising of one unit. The dominant soil unit is described as floodplain soils, with a loamy and clayey texture. The soil is naturally wet, with a moderate fertility. The landcover is classified as grassland that is coastal and floodplain grazing marsh.

Hydrology

Surface Water Features

6.11.10 There are multiple waterbodies present within the vicinity of the last kilometre of the River Blythe before the confluence with the River Tame. The River Cole is located to the north of the River Blythe, where it discharges into the Blythe at Blyth End (NGR: SP 21211 91182). Directly to the north of the River Cole is Coleshill Quarry (NGR: SP 20704 90908) whilst although currently dry based on aerial photography, if excavated to similar depths as other local quarry sites is likely to provide significant local additional aquifer storage (mineral plans have not been reviewed). On the right bank of the Blythe, where the Cole discharges into the Blythe is a body of standing water associated with Whitacre TWT. Downstream of this, near the confluence of the Tame and Blythe is Whitacre Pool.

6.11.11 The River Blythe falls under the Blythe Rivers Operational Catchment and within the Blythe from Patrick Bridge to R Tame Surface Water Body. Under Cycle 2 2019, the waterbody was given an ecological classification of Poor, whereas the Hydrological Regime was classified as ‘Supports Good’.

Surface Water Flow

6.11.12 The nearest flow gauge according to the NRFA website is Blythe at Whitacre which is located immediately upstream of the confluence with the River Cole. The gauging station is described to be an electromagnetic gauging station and lies at 43 mAOD. The gauged daily flow data for December 1993 – December 1994 is shown in Figure 6.21.

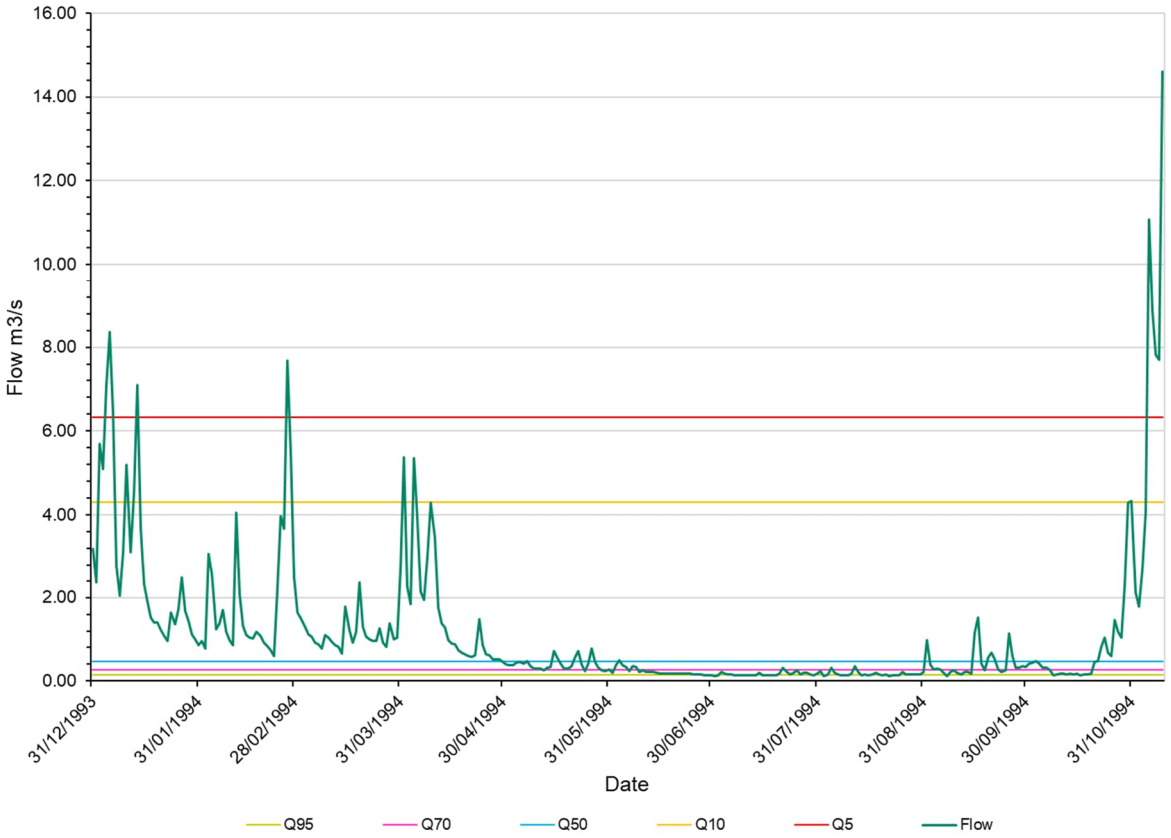


Figure 6.21 Gauged mean daily flow for the Blythe at Whitacre station 1993 - 1994

6.11.13 Flow statistics are shown in Table 6.4 in the Whitacre Heath SSSI baseline section.

6.11.14 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. There are three weirs marked on the OS map in the lower section of the River Blythe, near Blyth Hall. These weirs will affect water level and flow below to the confluence with the River Tame. Water levels rise 1m at the first weir upstream of the confluence with the River Tame, and another 0.5m at the second weir.

6.11.15 The weirs will influence groundwater levels in the superficial deposits aquifer, maintaining a groundwater level higher than if the river were in a naturalised condition. However, increasing aquifer storage by quarrying described above will lower groundwater levels across the lower Blythe, Cole, and Tame confluence area.

6.11.16 The lower weir is submerged, and the AMP6 study[27] found that during dry periods a diurnal fluctuation of approximately 0.1 m is seen, approximately doubling the minimum water depth over the weir for up to 12 hours at a time. This was thought to be due to 'backing up' of the stage effect of Minworth STW on the River Tame, as well as the smaller discharge at Coleshill STW. Therefore, the River Blythe downstream and upstream of the first weir are considered to be influenced by river levels in the Tame.

6.11.17 Approximately 3.5km upstream of the confluence on the River Tame is the Water Orton weir, which will influence water levels at the confluence of the Tame and Blythe, which may affect levels and discharge from the River Blythe into the River Tame. Water levels are recorded on the River Tame at Lea Marston above the weir (gaugemap.co.uk). Water levels show a typical seasonal variation of approximately 0.5m.

6.11.18 Abstractions and discharges local to the site may influence flow and river levels. The Gate 1 study one surface water abstraction greater than 10Ml/d in the area, situated on the River Blythe near the confluence with the River Tame (Whitacre WTW).

[27] ESI, 2016. Blythe & Bourne Site Baseline Investigation Plan (SIP)

6.11.19 The pumped intake volume at the Whitacre WTW exceeds flow at Q95, depleting flow below the lower weir to the confluence with the River Cole. Changes to the abstraction rate influences the diurnal signal, but does not override it (ESI, AMP6 study). Reverse flow in the lower Blythe was postulated to occur due to pumped abstraction exceeding the flow in the river downstream of the gravity intake, drawing in water from the River Tame, however the magnitude and frequency of this effect were not determined in the AMP6 study. A surging effect in the flows at Whitacre can occur under certain gravity abstraction intake operating conditions at Whitacre WTW, when rapid water flow can cause the abstraction to switch off and on (ESI, AMP6 study). Note that Whitacre WTW has licenced conditions to ensure water is passed downstream including a hands-off flow requirement.

6.11.20 Flows in the River Tame at the site are augmented locally by the Coleshill STW discharge, located approximately 1.5km upstream of the confluence of the River Blythe. The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 36.5% of Q95 flow and 24.7% of flow at Q50 in the River Tame at Lea Marston (downstream of the confluence with the River Blythe) which may affect water levels in the lower River Blythe.

6.12 Lockington Marshes

Overview

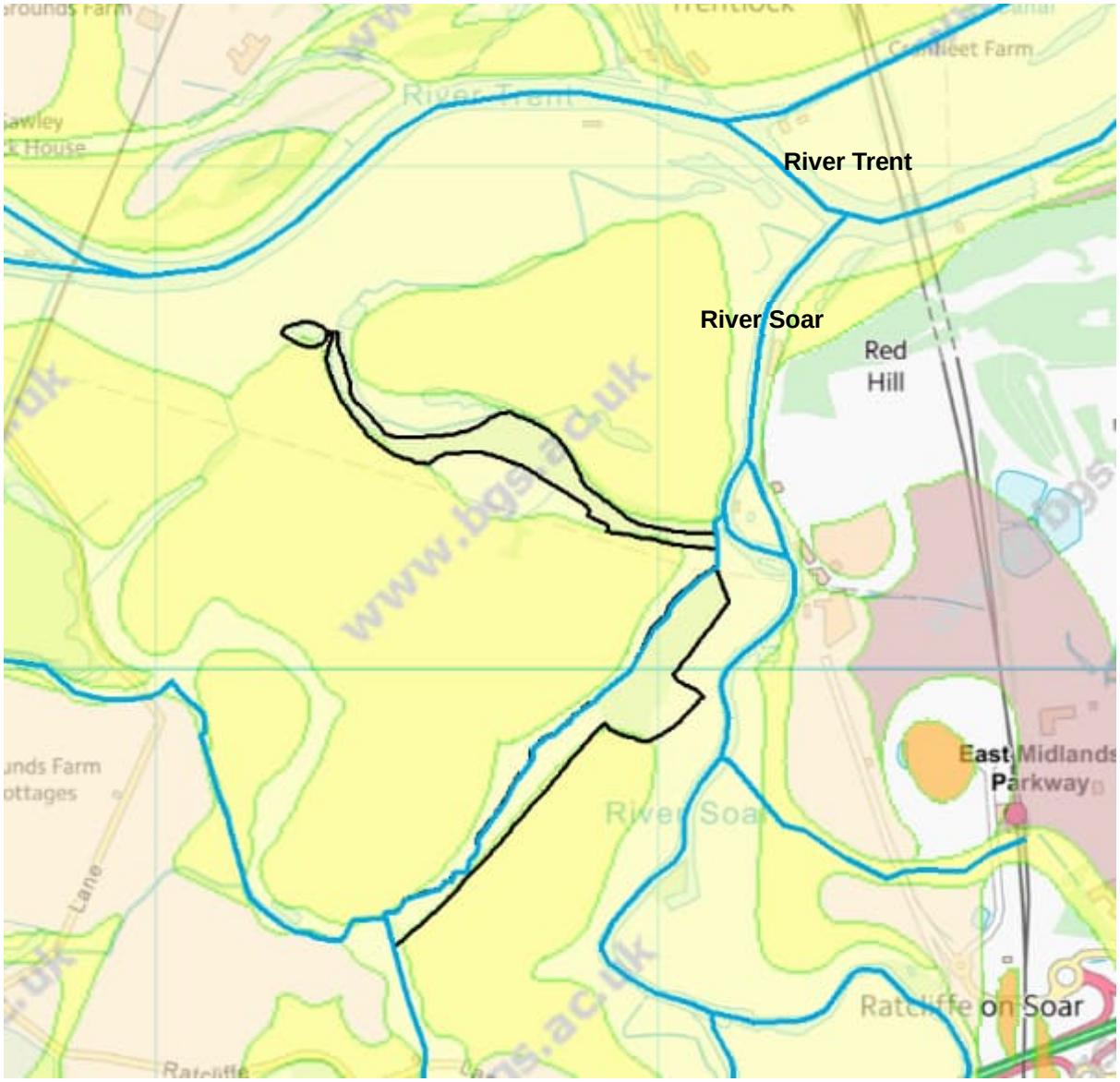
6.12.1 Lockington Marshes is a 11.3-hectare biological site, located north of Ratcliffe on Soar in Leicestershire. The main habitats associated with this SSSI are broadleaf, mixed and yew woodland, neutral grassland and standing open water and canals. The monitored feature present within this area are permanent wet mire, lowland fens, and lowland mixed deciduous woodland. The site is low lying, from 30 - 32 mAOD.

Geology

Superficial

6.12.2 The entirety of the area is underlain by alluvium deposits associated with the floodplain of the River Trent and the River Soar. A borehole ([redacted] recorded the alluvium deposits to be approximately 6.3 m in thickness and comprising gravelly clays. Alluvium is underlain by the Hemington Member, comprising silt and gravel, which extends across the Trent and Soar valleys[28].

[28] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021



Legend

- River Trent and River Soar
- SSSI – Lockington Marshes Boundary Line
- Hemington Member
- Syston Member
- Alluvium
- Holme Pierrepont sand and gravel
- Head
- Birstall Member
- Wanlip Member

Figure 6.22: Superficial Geology Map for Lockington Marshes.

Source: Underlying Map: Contains OS data © Crown Copyright and database right 2020. Superficial deposits: ArcGIS Map Service, https://map.bgs.ac.uk/arcgis/services

Bedrock

6.12.3 The bedrock geology within the area is composed of three lithologies: the Edwalton Member (mudstone) that underlies the end of the northern limb of the SSSI. The Branscombe Mudstone Formation covers the majority of the SSSI and is separated from the Edwalton Member by a thin bad of the Arden Sandstone Formation that is offset by a fault. The parent unit for these three members is the Mercia Mudstone Group. A borehole ([redacted] recorded the Mercia Mudstone deposits to be approximately 7 m in thickness before the borehole ends.

Hydrogeology

6.12.4 The alluvium deposits underlying the SSSI are classified as a Secondary A aquifer. Secondary A aquifer can store a large amount of groundwater, which can be used to support local water demands. Secondary A aquifers are formed of permeable layers and can be an important source of base flows to rivers by the EA. This aquifer is anticipated to be in hydraulic continuity with the River Trent and River Soar.

6.12.5 The Edwalton Member and the Branscombe Mudstone Formation underlying the SSSI are classified as a Secondary B aquifer. These are described by the Environmental Agency as 'Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers'. There is anticipated to be only limited groundwater interaction between the superficial deposits aquifer and mudstone bedrock aquifer.

6.12.6 The Arden Sandstone Formation is classified as a Secondary A aquifer. These are described by the Environmental Agency as 'Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. This unit is not laterally extensive in the area, being bound by faults, and therefore is not anticipated to provide significant aquifer inflows to the superficial deposits. The site does not provide a significant break in elevation compared to the low relief across the valley area that may lead to discharge from the aquifer to the superficial deposits underlying the site.

Soils

6.12.7 The Soilscape map viewer describes the soils within this SSSI and the River Trent as comprising of one unit. The dominant soil unit is described as floodplain soils, with a loamy and clayey texture. The soil is naturally wet and has moderate fertility. The landcover is classified as grassland that is coastal and floodplain grazing marsh.

Hydrology

Surface Water Features

6.12.8 There are four main waterbodies that lie within the vicinity of the SSSI. The first is Hemington Brook (tributary of the River Soar, ID: GB104028047410) which flows adjacent to the southern limb of the SSSI, until it discharges into the River Soar at SK 49115 30301. Under Cycle 2 2019, the waterbody was given an ecological classification of Bad, whereas the Hydrological Regime was classified as 'Supports Good'.

6.12.9 The second is a drain that discharges into the Hemington Brook (at SK 49112 30272) before reaching the River Soar, that appears to have ponds / wetland areas associated with it that runs through the northern limb of the SSSI. There also appears to be several ponds / drainage ditches that potentially drain into this channel (e.g., SK 48301 30681 and SK 48929 30465).

6.12.10 The third is the Soar from Long Whatton Brook to Trent Water Body (ID: GB104028047212) which flows to the east (north to southerly direction) before discharging into the Trent, past the SSSI. Under

Cycle 2 2019, the waterbody was given an ecological classification of Moderate, whereas the Hydrological Regime was classified as 'Supports Good'.

Surface Water Flow

6.12.11 The nearest gauging station to the SSSI on the River Trent is the River Trent at Shardlow (28007) which lies approximately 4.3 km to the west (upstream). The station is an index-velocity station and has been monitoring flows through this since 1996. Annual mean flow at this station is 51.84 m^3/s, with a maximum daily flow of 487.8 m^3/s registered on 16/11/2012. The flow that is exceeded 95% of the time (Q95) is 17.54 m3/s. The gauged daily flow data for September 2019 – September 2020 is shown in Figure 6.23 and flow statistics are shown in Figure 6.10 and Table 6.7 (in Donington SSSI baseline section).

6.12.12 The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 1115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 15% of Q95 flow in the River Trent at Shardlow, and 7.3% of flow at Q50.

6.12.13 The nearest gauging station for the River Soar is Soar at Kegworth (28074) which lies approximately 4 km to the south. The station is a multi-path ultra-sonic gauge that was rebuilt in 1991, therefore there is no data available in and January and February 1991. Annual mean flow at this station is 11.88 m^3/s, with a maximum daily flow of 128 m^3/s registered on 11/04/1998. The flow that is exceeded 95% of the time (Q95) is 3.45 m^3/s.

6.12.14 Therefore, the flows in the River Soar are approximately one fifth of the flows in the River Trent.

6.12.15 The gauged daily flow data for September 2019 – September 2020 are shown in Figure 6.23 and flow statistics are shown in Table 6.11.

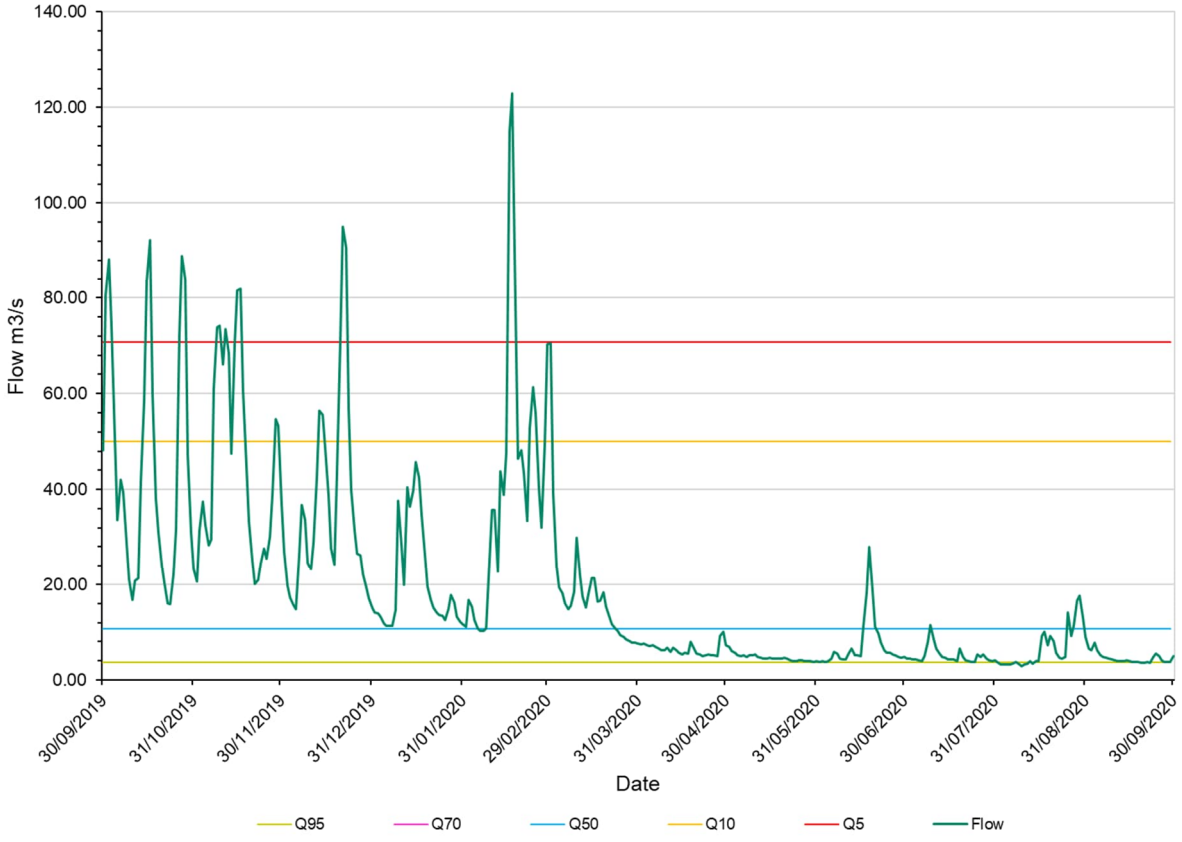


Figure 6.23: Gauged mean daily flow for River Soar at Kegworth 2019 – 2020

Table 6.11: Flow statistics for River Soar at Kegworth 1978 – 2020

Flow Statistic	Data
Period of Record	1978 - 2020
Mean Flow	11.884 m^3/s
95% Exceedance (Q95)	3.45 m^3/s
70% Exceedance (Q70)	5.13 m^3/s
50% Exceedance (Q50)	7.1 m^3/s
10% Exceedance (Q10)	25.6 m^3/s
5% Exceedance (Q5)	38.7 m^3/s

6.12.16 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. Approximately 2 km upstream on the River Soar, near Ratcliffe on Soar, is a weir that will affect water levels and flow in the lower reaches of the Soar passing the site. Approximately 300 m downstream of the confluence with the River Trent is a weir, controlling levels and flow in this reach of the River Trent.

6.12.17 Water levels are recorded in this reach of the River Trent upstream of the SSSI at Shardlow (gaugemap.co.uk), which shows a seasonal variation typically up to approximately 1m.

6.12.18 Abstractions and discharges local to the site may influence flow and river levels. The Gate 1 study identified one surface water abstraction greater than 10 Ml/d on the River Soar near of the confluence of the River Trent, for process water for the Ratcliffe on Soar power station. This abstraction will reduce river flow and level local to the site. There is a discharge to Lockington Brook from Lockington quarry, which will supplement flows in this stream and potentially discharge to the superficial aquifer.

Grid references for continued monitoring locations redacted

6.13 Holme Pit

Overview

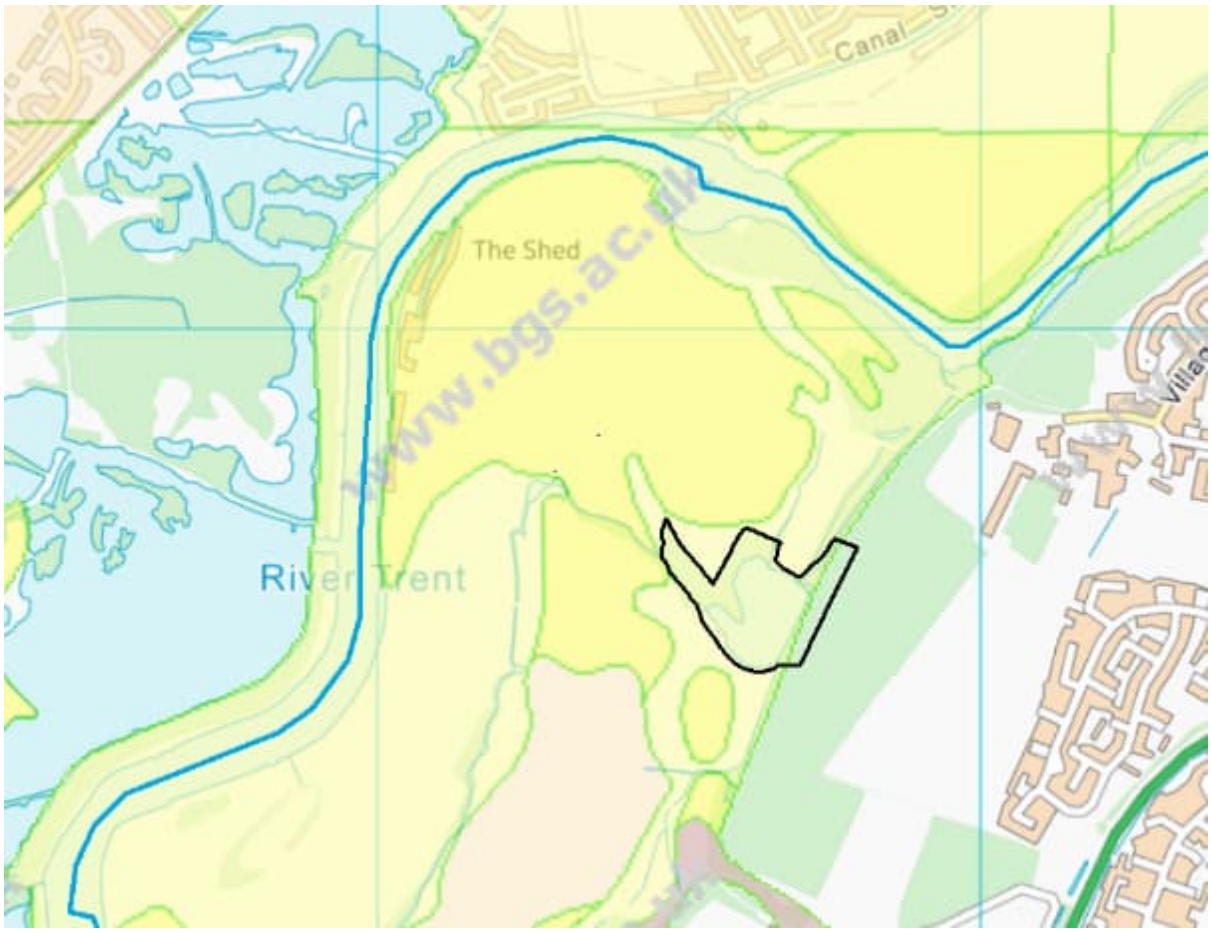
6.13.1 Holme pit is located near Clifton village, situated on the opposite bank of the River Trent from Beeston, Nottingham, and forms part of Clifton Woods. The site contains some of the best remaining areas of marsh, reed swamp and open water in Nottinghamshire and is of Regional importance. Holme Pit also contains areas of Lowland Fen and Deciduous Woodland Priority Habitats. Holme Pit and the adjacent areas of marsh provide a valuable habitat for a variety of passage, wintering and breeding bird species, while the reedbeds are a valuable bird roosting area. Bittern and water rail *Rallus aquaticus* are often recorded overwintering at the site.

Geology

Superficial

6.13.2 The entirety of the area is underlain by alluvium deposits associated with the floodplain of the River Trent. These deposits are underlain by Hemington Member (silt and gravel) which has been locally removed by quarrying. A borehole ([redacted]) recorded the alluvium deposits of silt and clay to be approximately 1 m thick, underlain by 4.65m sand and gravel reflecting the Hemington Member[29].

[29] British Geological Society Onshore Geonidex Map (2021). Available from: https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.110684551.302537671.1638869253-881808366.1621610537n Accessed 07/12/2021



Legend

- River Trent
- SSSI – Attenborough Gravel Pits Boundary Line
- SSSI – Holme Pit Boundary Line
- Hemington Member
- Alluvium
- Holme Pierrepont sand and gravel
- Head

Figure 6.24: Superficial Geology Map for Holme Pit

Source: Underlying Map: Contains OS data © Crown Copyright and database right 2020. Superficial deposits: ArcGIS Map Service, https://map.bgs.ac.uk/arcgis/services

Bedrock

6.13.3 The entirety of the area is underlain by the Gunthorpe Member (mudstone) which is a part of the Mercia Mudstone Group. A borehole ([redacted]) recorded the bedrock deposits to be approximately 10m+ thick and comprising of red-brown silty mudstones.

6.13.4 The Cotsgrave Sandstone outcrops along the eastern margin of the northern part of the site.

Hydrogeology

6.13.5 The superficial deposits are designated as Secondary A aquifer, which is described by the Environmental Agency as 'Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers'. This aquifer is anticipated to be in hydraulic continuity with the River Trent

6.13.6 The SSSI is underlain predominantly by a Secondary B bedrock aquifer. Secondary B aquifers are described as 'mainly lower permeability layers that may store and yield limited amounts of groundwater'. There is anticipated to be only limited groundwater interaction between the superficial deposits aquifer and mudstone bedrock aquifer.

6.13.7 The Cotsgrave Sandstone forms a small area of Secondary A bedrock aquifer along the eastern margin of the northern part of the site. This aquifer is anticipated to be in hydraulic continuity with the superficial deposits aquifer.

Soils

6.13.8 The area surrounding the surface water area of the SSSI composes of two soil units. The first is located towards the River Trent and is described to be a freely draining floodplain soils that have a loamy texture with moderate to high fertility.

6.13.9 The other unit, which is present on the eastern side of the SSSI is described to be slightly acidic loamy and clayey soils with impeded drainage. These soils have moderate to high fertility.

Hydrology

Surface Water Features

6.13.10 This section provides a summary of the surface water bodies within the vicinity of the SSSI, specifically those under the WFD. The SSSI hosts a small pond designated as a Lake waterbody called Holme Pit (waterbody ID GB30435028). It has a hydromorphological designation of being a heavily modified waterbody. It has a surface area of 0.019 km^2 and a mean depth of 1.96 m. Under Cycle 2 (2019), it has an Ecological classification of Moderate and the hydromorphological supporting elements of 'Supports Good'.

6.13.11 The pond appears to be fed from drains that are located to the south and south west of the SSSI that lies within the floodplain of the River Trent. On the north eastern side of the lake (SK 53698 34586) a channel appears to discharge from the lake into the River Trent downstream of Beeston Weir at SK 53973 34891. For flow statistics of the River Trent near this location, refer to Figure 6.12 and Table 6.8 for the station at Colwick.

6.13.12 The reductions in discharge from Minworth STW for the Grand Union Canal transfer is up to 115 Ml/d, while the Severn to Thames Transfer is 115 Ml/d. Combined, these reductions in discharge at Minworth (2.66 m^3/s) are 9.4% of Q95 flow in the River Trent at Colwick, and 4.5% of flow at Q50.

6.13.13 Flow and river levels may be affected by weirs situated both upstream and downstream of the site. Beeston weir is approximately 200m downstream of the site controlling water levels on the River Trent. Thrumpton weir is situated approximately 4km upstream. Therefore, water levels and flows in the reach of the River Trent associated with the site are controlled by weirs.

6.13.14 Water levels are recorded upstream of the SSSI at Cranfleet Lock below Thrumpton Weir and shows a typical seasonal variation in excess of 2m.

6.13.15 Abstractions and discharges local to the site may influence flow and river levels. The Gate 1 study identified a significant abstraction adjacent the site at Beeston weir, for hydroelectric power generation, which will have an effect of reducing water levels near the site. An additional abstraction is located approximately 4.3 km upstream on the River Trent, for process water, which will lower water levels on the River Trent to Thrumpton weir.

6.13.16 Approximately 2km upstream along the River Trent, the River Erewash discharges into the Trent. The Toton STW discharges treated effluent to the River Erewash, augmenting flow and water levels discharging to the River Trent locally. Upstream approximately 6 km is a discharge from quarrying, discharging to the River Trent upstream of Thrumpton weir.

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