



Grand Union  
Canal Transfer

# GUC SRO Gate 3 Annex 4.4: Water Quality Modelling Report

January 2025  
Published version: 1

© 2025 Affinity Water, Severn Trent and the Canal & River Trust

This document has been written in line with the requirements of the RAPID gate three guidance and to comply with the regulatory process pursuant to Severn Trent's and Affinity Water's statutory duties. The information presented relates to material and data which is still in the course of completion, is indicative, and may change as the scheme develops. Should the scheme progress to the next stages, Severn Trent and Affinity Water will be subject to the statutory duties pursuant to the necessary consenting process, including environmental assessment and consultation. This document should be read with those duties in mind.

# **GUC SRO Gate 3 Annex 4.4: Water Quality Modelling Report**

**Final Report**

January 2025



**Grand Union  
Canal Transfer**

Bringing water from the  
Midlands to the Southeast

## Document Status

Issue date 10/01/2025  
Issued to Affinity Water, Severn Trent, Canal & River Trust  
BIM reference KCX-JBAU-XX-XX-RP-WQ-0020-  
Gate3\_WQ\_Modelling\_Report  
Revision D1-C01

Prepared by

[REDACTED]

[REDACTED]

What has been redacted? Author names.  
Reason: Information relating to the private  
affairs of an individual

Reviewed by

[REDACTED]

[REDACTED]

Authorised by

[REDACTED]

[REDACTED]

---

## Carbon Footprint

The format of this report is optimised for reading digitally in pdf format. Paper consumption produces substantial carbon emissions and other environmental impacts through the extraction, production and transportation of paper. Printing also generates emissions and impacts from the manufacture of printers and inks and from the energy used to power a printer. Please consider the environment before printing.

---

## Contract

JBA Project Manager	██████████	
Address	JBA Consulting, Pipe House, Lupton Road, Wallingford, OX10 9BS	What has been redacted? Author names. Reason: Information relating to the private affairs of an individual
JBA Project Code	2023s0307	

This report describes work commissioned by Affinity Water Limited, by an instruction dated 03 March 2023. The Client's representative for the contract was ██████████. ██████████ ██████████ and ██████████ of JBA Consulting carried out this work.

### Purpose and Disclaimer

Jeremy Benn Associates Limited ("JBA") has prepared this Report for the sole use of Affinity Water Limited and its appointed agents in accordance with the Agreement under which our services were performed.

JBA has no liability for any use that is made of this Report except to Affinity Water Limited for the purposes for which it was originally commissioned and prepared.

No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by JBA. This Report cannot be relied upon by any other party without the prior and express written agreement of JBA.

---

### Copyright

© Jeremy Benn Associates Limited 2025

---

# Contents

<b>1</b>	<b>Introduction</b>	<b>10</b>
	1.1 Overview	10
	1.2 Gate 2 modelling and recommendations	10
	1.3 Gate 3 modelling objectives	12
	1.4 Software	13
<b>2</b>	<b>Methodology</b>	<b>14</b>
	2.1 Approach	14
	2.2 Modelling assessment for discharges to the Coventry Canal	14
	2.3 Modelling assessment for discharges to the Daventry and Drayton reservoirs	22
	2.4 Changes to the scheme during Gate 3	24
<b>3</b>	<b>Flow data analysis</b>	<b>27</b>
	3.1 Canal flow	27
	3.2 Discharge flow	27
	3.3 Correlation of canal and Minworth discharge flow	29
<b>4</b>	<b>Water quality data analysis</b>	<b>32</b>
	4.1 Data sources	32
	4.2 Data checks for site 1 Minworth WwRC - final recycled water.	36
	4.3 Data checks for site 3 Coventry Canal at Atherstone	37
	4.4 Data checks for site 5 GUC at Daventry	38
	4.5 Data checks for site 6 GUC at Leighton Buzzard	39
<b>5</b>	<b>Results for Site 3, Coventry Canal at Atherstone</b>	<b>41</b>
	5.1 Introduction	41
	5.2 Impact of the discharge at existing concentrations	41
	5.3 Sensitivity testing	45
	5.4 Future treatment requirements	49
<b>6</b>	<b>Results for Site 5, GUC at Daventry</b>	<b>52</b>
	6.1 Introduction	52
	6.2 Impact of the discharge at existing concentrations	52
	6.3 Future treatment requirements	55

<b>7</b>	<b>Results for Site 6, GUC at Leighton Buzzard</b>	<b>58</b>
	7.1 Introduction	58
	7.2 Impact of the discharge at existing concentrations	58
	7.3 Future treatment requirements	61
<b>8</b>	<b>Results for Temperature at Site 3, Coventry Canal at Atherstone</b>	<b>64</b>
	8.1 Overview	64
	8.2 Standards	64
	8.3 Modelling temperature	64
	8.4 Temperature impact assessment results	66
<b>9</b>	<b>Preliminary scheme impact assessment using bench-trial treatment results</b>	<b>68</b>
	9.1 Introduction	68
	9.2 Methodology	70
	9.3 Impact of the bench-trial discharge	74
	9.4 Discharge quality required to meet no deterioration and the permissible deterioration	77
	9.5 Environmental impact	81
<b>10</b>	<b>Results for Dissolved Oxygen in the Coventry Canal</b>	<b>82</b>
	10.1 Overview	82
	10.2 Applicable standards for assessing compliance	83
	10.3 Scenarios	84
	10.4 Input parameters	85
	10.5 Impact assessment results	85
	10.6 Improving DO during transfer operation	88
<b>11</b>	<b>Conclusions and recommendations</b>	<b>92</b>
	11.1 High-level summary of H1 screening and modelling	92
	11.2 Combining the results for sites 3, 5, and 6	92
	11.3 Conclusions	94
	11.4 Recommendations	97
<b>A</b>	<b>Appendix: RQP Input data</b>	<b>A-1</b>
	A.1 Site 1 and 3 input data	A-1
	A.2 Site 5 and 6 input data	A-2
<b>B</b>	<b>Appendix: Modelling results</b>	<b>B-1</b>



B.1	Modelling results, site 3	B-1
B.2	Modelling results, site 5	B-2
B.3	Modelling results, site 6	B-3
B.4	Combined water quality impact results for all sites	B-4
B.5	Bench trial assessment results	B-5
<b>C</b>	<b>Appendix: Qualified values</b>	<b>C-1</b>
<b>D</b>	<b>Appendix: DO modelling input values</b>	<b>D-1</b>
<b>E</b>	<b>Flow comparisons: RQP inputs and results</b>	<b>E-1</b>
E.1	Continuous only flow	E-1
E.2	Continuous and intermittent flow	E-5

## List of Figures

Figure 2-1: Modelling process for Hazardous Substances	20
Figure 3-1: Monthly utilisation	28
Figure 3-2: Correlation of canal and discharge flow at site 3	30
Figure 3-3: Correlation of canal and discharge flow at site 5	30
Figure 3-4: Correlation of canal and discharge flow at site 6	31
Figure 4-1: Plan of GUC SRO water quality sampling stations	33
Figure 4-2: Cypermethrin ( $\mu\text{g/l}$ ) at site 1	37
Figure 9-1: Table 6 from Minworth bench trial summary report	68
Figure 9-2: PFOS bench trial results	71
Figure 10-1: Example DO results graph, future, one month, low decay coefficient	86
Figure 10-2: DO modelling results graphs	87
Figure 10-3: Illustration of TOC reduction in the AWTP	88
Figure 10-4: Results of the tests for reduced BOD and increased DO in the discharge	90
Figure 10-5: Test 4: BOD reduced to 2.0mg/l, DO increased to 7.27mg/l and Ammonia at 0.02mg/l	91

## List of Tables

Table 1-1: Structure of the Gate 3 modelling workstream reporting	10
---	----

Table 1-2: Recommendations for Gate 3 in the Gate 2 report	11
Table 2-1: Relevance of tests to different determinands and scenarios	17
Table 3-1: Canal flow statistics from Aquator model	27
Table 3-2: Minworth deployable output levels	28
Table 4-1: Qualified results based on LOD and EQS	35
Table 4-2: Outliers, Site 1 Minworth WwRC Discharge	36
Table 4-3: Outliers. Site 3 Coventry Canal at Atherstone	38
Table 4-4: Outliers, Site 5 GUC at Daventry	39
Table 4-5: Outliers, Site 6 GUC at Leighton Buzzard	40
Table 5-1 Hazardous chemicals modelling test results	41
Table 5-2 EQS deterioration allowance	42
Table 5-3: Determinands with a predicted percentage deterioration on upstream quality	43
Table 5-4: Sensitivity test - outliers - results	46
Table 5-5: Correlation coefficients - diazinon	48
Table 5-6 Treatment percentage reduction required to meet AA EQS	49
Table 5-7 Treatment percentage reduction required to prevent deterioration (det.) to the annual average concentration.	50
Table 6-1 Hazardous chemicals modelling test results	52
Table 6-2 Determinands with a predicted percentage deterioration	54
Table 6-3 Treatment percentage reduction required to meet AA EQS	55
Table 6-4 Treatment percentage reduction required to prevent deterioration to the annual average concentration.	56
Table 7-1 Determinands which fail one or more of the hazardous chemicals modelling test	58
Table 7-2 Determinands with a predicted percentage deterioration	60
Table 7-3 Treatment percentage reduction required to meet AA EQS	61
Table 7-4 Treatment percentage reduction required to prevent deterioration to the annual average concentration.	62
Table 8-1: Temperature standards for rivers receiving thermal discharges, cyprinid fishery	64
Table 8-2: Temperature statistics	65
Table 8-3: Flow statistics for temperature simulations	66
Table 8-4: Impact of discharge temperature downstream, 98 <sup>th</sup> percentile	67

Table 9-1: Review of LODs used in bench-trials	69
Table 9-2: Coefficient of Variation (CoV) calculations	70
Table 9-3: Impact of data processing on mean and standard deviation values for mancozeb	72
Table 9-4: Comparison of results between the two flow representations	73
Table 9-5 Determinands which fail one or more of the hazardous chemicals modelling test	75
Table 9-6 Determinands with a predicted percentage deterioration	76
Table 9-7: Concentrations required to meet no deterioration and the permitted deterioration (AA)	77
Table 9-8: Concentrations required to meet no deterioration and the permitted deterioration (MAC)	79
Table 10-1: FIS for dissolved oxygen (mg/l) for a sustainable cyprinid fishery	83
Table 10-2: Decay rates modelled	84
Table 10-3: Summary of scenarios modelled	84
Table 10-4: DO re-aeration models and applicable velocities and depths	85
Table 11-1 Comparison of treatment reductions required to prevent deterioration at sites 3, 5, and 6.	93
Table 11-2: Summary of results	94

## Abbreviations

AWTP	Advanced Water Treatment Plant
BOD	Biochemical Oxygen Demand
DCO	Development Consent Order
DO	Dissolved Oxygen
EA	Environment Agency
EQS	Environmental Quality Standards
FIS	Fundamental Intermittent Standards
LOD	Limit of Detection
MPER	Metals Permitting (software package)
MRV	Minimum Reporting Value
NLS	National Laboratory Service
GUC	Grand Union Canal
PEC	Predicted Environmental Concentration



# Grand Union Canal Transfer

RQP	River Quality Planning
SRO	Strategic Resource Option
WFD	Water Framework Directive
WTW	Water Treatment Works
WwRC	Wastewater Recycling Centre

# 1 Introduction

## 1.1 Overview

This report documents the water quality modelling undertaken at Gate 3 of the Grand Union Canal Transfer, which comprises the Grand Union Canal (GUC) Strategic Resource Option (SRO) and the Minworth SRO. The Grand Union Canal Transfer proposes to use the Coventry, Oxford and Grand Union Canals to transfer up to 115 megalitres per day (Ml/d) of high quality recycled water from the Minworth SRO into the Affinity Water supply area, where it will be abstracted, treated and put into supply.

The Gate 3 modelling report will summarise and synthesise the findings of five key technical reports, as illustrated below in Table 1-1. This is report A4.4.

Table 1-1: Structure of the Gate 3 modelling workstream reporting

Document reference	Title
A4	Gate 3 Modelling Report
A4.1	Water Resources Model Validation and Impact Assessment
A4.2	Hydraulic Modelling Report
A4.3	CFD Modelling Report
A4.4	Water Quality Modelling Report
A4.5	Investigating the relationship between vegetation and in-channel velocity

## 1.2 Gate 2 modelling and recommendations

At Gate 2, the Monte Carlo and MPer (Metals Permitting) statistical water quality models within RQP were used to assess the impact of the transfer discharge at Atherstone, and any additional water quality impacts downstream in the canal at Daventry and Leighton Buzzard. At the request of the EA, all determinands were modelled, by-passing the screening assessment defined in EA guidance. It concluded that, of the 160 water quality determinands which have been modelled, 47 may require additional treatment at Minworth to higher than present standards in order to prevent deterioration in the receiving canal system, with a further 27 determinands failing at least one modelling test but not being subject to deterioration. The remaining 86 determinands passed all tests and in many cases would lead to improved water quality in the canals.

Table 1-2 lists the Gate 2 recommendations made for Gate 3, drawing on feedback from key stakeholders including the Environment Agency:

Table 1-2: Recommendations for Gate 3 in the Gate 2 report

Recommendation for Gate 3 in the Gate 2 report	Actual Gate 3 approach
<p>Work closely with Minworth process design team. If the conservative Gate 2 modelling assumptions for Daventry and Leighton Buzzard (no dilution, degradation or speciation) are a key driver of treatment costs (capital and or operational) then consider more detailed water quality modelling of sensitive determinands.</p>	<p>Minworth design consultant (Jacobs) has led the H1 assessment, working in collaboration with modelling consultant (JBA).</p>
<p>The impact assessment has focussed on a demand and discharge curve peaking at 115MI/d. Further testing may be required to assess water quality impact for a peak discharge of 57.5MI/d.</p>	<p>No longer relevant as the SRO is now focussed on a 115MI/d scheme.</p>
<p>The Aquator model may under-estimate feeder flows into the Atherstone top lock. Further collaborative work with the Canal &amp; River Trust (The Trust) should be undertaken to review the control curves at this location, although sensitivity testing suggests that the water quality assessment is not sensitive to changes in flow, because the proposed discharge flow is an order of magnitude greater than the background canal flow.</p>	<p>Extensive work has been undertaken to validate the inputs from the feeder at Gate 3. See report A4.1 for details.</p>
<p>Full testing was not possible for those determinands where an EQS has not been set. The Environment Agency has advised that it may be preferable to use the Probable No-Effect Concentration (PNEC) as a de-facto EQS in these cases. If the EA confirm this approach and provide a list of PNEC values these should be tested at Gate 3.</p>	<p>All of the substances modelled in this report have an EQS.</p>
<p>The recycled water concentrations required to meet the target EQS or to prevent deterioration are presented to assist the outline process design and are not intended to represent possible future environmental permit limits.</p>	<p>The work at Gate 3 is intended to progress the scheme towards a Development Consent Order (DCO) application. At the DCO it will be necessary to demonstrate that the scheme can be permitted and is capable of meeting permitted limits.</p>

Recommendation for Gate 3 in the Gate 2 report	Actual Gate 3 approach
<p>Where the treatment reduction of a determinand required to meet no-deterioration downstream at Daventry or Leighton Buzzard is greater than that required to prevent deterioration at Atherstone, it is recommended that for initial process design, the higher reduction values are considered.</p>	<p>This has been reassessed and reported at Gate 3.</p>
<p>Ongoing consultation with the Environment Agency is recommended. This should cover, amongst other issues:</p> <ul style="list-style-type: none"> <li>• The emerging national approach to water quality and permitting of SROs,</li> <li>• The approach to assessing determinands which do not have an EQS,</li> <li>• Modelling the impacts of climate change, including lower summer flows and higher temperatures, in assessing water quality,</li> <li>• How to consider the risk of future deterioration of the recycled water quality in permitting, and</li> <li>• Any local water body issues (in liaison with the Canal &amp; River Trust).</li> </ul>	<p>This scoping document forms part of the Gate 3 consultation with the EA.</p> <p>Modelling of climate change impacts will be undertaken in Aquator, from which flow statistics used in the water quality modelling are derived.</p>
<p>It is recommended that the water quality monitoring regime be continued at sites 1, 3, 5 and 6. Developing a longer time-series of water quality data at these sites will improve statistical confidence in the data and hence any further modelling, and will enable any trends or step-changes in the quality both of the Minworth recycled water and of the Canal.</p>	<p>Monitoring has been extended until November 2024 under the Stage 5 SRO water quality monitoring programme. This is likely to continue past November 2024 into Gate 4, however is only currently contracted up to the Gate 3 submission date.</p>

### 1.3 Gate 3 modelling objectives

The objectives of the Gate 3 modelling were to:

- Continue engagement with the Environment Agency to establish the approach to permitting for the GUC SRO, in particular with respect to emerging substances.
- Update the assessment using results from the continuing water quality monitoring programme.
- Extend the assessment to include the Daventry and Drayton reservoirs.
- Use the results of the further refinement of the hydrological modelling in Aquator to update the flow boundaries in the canals and reservoirs.

- To work closely with the consultants designing the "Minworth" Advanced Water Treatment Plant (AWTP) to define treatment requirements.
- Similarly to work with the consultants designing the new Water Treatment Works (WTW) to define the quality of water arriving at Leighton Buzzard.
- Inform Gate 3 environmental assessments for GUC including aquatic ecology, fisheries, sedimentation, etc

#### 1.4 Software

The following models were used in the preparation of this report:

- River Quality Planning Monte Carlo version 6.0
- River Quality Planning MPer version 6.0
- Streeter-Phelps dissolved oxygen spreadsheet, supplied by Environment Agency (EA) on 05/02/2024.
- "OECD" model based on the Vollenweider regression equation for nutrients in the Daventry and Drayton reservoirs, supplied by the Environment Agency on 29/01/2024.

## 2 Methodology

### 2.1 Approach

The approach to this assessment was primarily developed from the Environment Agency operational instructions:

- The Environment Agency’s operational instruction on permitting of hazardous chemicals and elements in discharges to surface waters (LIT13134) (Environment Agency, 2019). This includes advice on screening, cleaning quality data, modelling and tests to apply to assess whether a discharge is “potentially significant”. It includes details of Environmental Quality Standards (EQSs) for hazardous substances, although these were updated in 2022 (Environment Agency, 2022).
- Instructions for modelling surface water pollution to surface waters, LIT 10419 (Environment Agency, 2014).
- Guidance for assessing continuous discharges of sanitary determinands (Biological Oxygen Demand (BOD), ammonia, suspended solids) and nutrients (phosphorous and nitrogen). This includes Water Framework Directive (WFD) class standards for these determinands (Environment Agency, 2014).
- EA operational instruction 50\_12 on assessing no deterioration under the WFD. (Environment Agency, 2012)
- A draft operational instruction on modelling discharges to lakes and reservoirs (Environment Agency, Undated).

The approach was further developed through liaison with the EA, including three meetings and review of a draft water quality modelling method statement.

### 2.2 Modelling assessment for discharges to the Coventry Canal

#### 2.2.1 H1 screening assessment

An H1 surface water pollution risk screening assessment for all sampled determinands was undertaken by the Minworth SRO design consultants (Jacobs, 2023). This identified 14 determinands which were confirmed as being potentially significant and liable to cause pollution. These determinands were screened-in for modelling:

- Cypermethrin
- Diazinon
- Formaldehyde
- Hexabromocyclo-dodecane (HBCDD)
- Hydrogen sulphide
- Mancozeb
- Maneb
- Mercury and its compounds - (Total)

- Nickel and its compounds - (Total) (bioavailable)
- Nonylphenol (4-nonylphenol)
- Perfluorooctane sulfonic acid and its salts (PFOS)
- Permethrin
- Triclosan
- Zinc - (Total) (bioavailable)

Thirty-four determinands were identified as potentially requiring modelling in the H1 assessment but have not been included at this modelling stage for the following reasons:

- Minworth concentration is below the LOD for all samples; the EQS has either an equivalent or more stringent limit than the LOD (15 no.)
- Minworth results are below the LOD, and also the EQS (17 no.)
- Minworth final recycled water concentration is less than the EQS (2 no.)

In parallel with this Gate 3 water quality modelling workstream, the water quality sampling workstream has reviewed LODs with commercial laboratories, and has confirmed the latest list of LODs achievable in final effluent and canal water, with the National Assessment Unit (NAU). These revised LODs are being applied to samples taken from June 2024 onwards (July 2024 in the case of one chemical). Further water quality modelling will be required at Gate 4 which will use these improved LODs.

### 2.2.2 Additional parameters for modelling

Following engagement with the EA, it was agreed that dissolved oxygen (DO), Biochemical Oxygen Demand (BOD) and temperature should also be modelled. This is due to lower concentrations of DO in the existing Minworth WwRC effluent than in the canal which could cause a DO sag.

### 2.2.3 Software selection

Monte Carlo and MPer models were selected for the Gate 2 assessment because they enabled modelling of 160 determinands in a consistent and reliable manner, aligned with the EA's standard approach to modelling for permit applications. This approach was accepted by the EA, although it was noted that, for assessing the impact downstream in the canals at Daventry and Leighton Buzzard, the approach was conservative in that it did not allow for any dilution, degradation or speciation along the route. We also note the EA's comment in their response to the Jacobs H1 assessment that *"Modelling the impact of discharges on canals and other still waters requires a highly site-specific modelling approach. Given the water management within canals careful consideration must be taken on the appropriate modelling approach to use. This should take account of accumulation and the extent to which the water body is impacted. This should include assessment of the mixing zone(s) in the water body and any potential breaches of EQS. Further guidance is included in LIT 13134."*

Monte Carlo / MPer were again selected for the impact assessment at Gate 3, for the following reasons:

- Monte Carlo / MPer is a simple, relatively quick approach, not prone to delays as a result of instabilities within dynamic models. As such it is a pragmatic approach within the challenging timescale of the RAPID gated process.
- It is the EA's preferred approach for assessment at the point of discharge. Being a stochastic approach, it is able to calculate permit values which enable EQSs to be met.
- Whilst we accept that canals are low velocity channels, they are not entirely static water bodies, as evidenced by Gate 2 and Gate 3 hydrometric surveys and modelling. In addition, they are narrow, shallow water bodies where the passage of boats assists the mixing of water. As such, we do not consider that they are prone to temperature stratification or zones of differential mixing.
- Further to this, the transfer will introduce a flow an order of magnitude greater than the existing flows within the canals, and as such will change the flow regime. We consider, therefore, that it is reasonable to assume that the canal flow and discharge flow will be fully mixed within a relatively short distance of the point of discharge at Atherstone. The discharge flow is outlined in Section 3.2.
- Between Atherstone and the other water quality sampling stations at Daventry and Leighton Buzzard, there are numerous gravity and pumped feeders, and numerous points of overflow at waste weirs. The intermediate water quality monitoring stations have not sampled all of the determinands screened-in for modelling, and hence any dynamic model which attempted to model water quality along the canal would need to make some "heroic assumptions" about the quality of inflows. In short, it would result in a need to force-fit the model at numerous locations, in order to represent the downstream quality observed at Daventry and Leighton Buzzard, and would not, therefore, be reliable for assessment of water quality impacts at intermediate locations along the GUC SRO route.

#### 2.2.4 Modelling at the point of discharge

Modelling was undertaken within the EA's River Quality Planning (RQP) suite. The Monte Carlo model was used for this assessment, with the exception of bioavailable metals (copper, lead, manganese, nickel and zinc) which used the Metals Permitting (MPer) tool. The MPer bioavailable calculation requires mean values for pH, calcium and Dissolved Organic Carbon (DOC) in the canal, and DOC in the recycled water discharge. These parameters were collected as part of the manual sampling and sonde monitoring programme, and the mean calculated for the same time period, April 2021 to October 2023.

Flow statistics were determined for the proposed discharge and the receiving waterbody (see section 3).

Modelling was undertaken using checked and processed data, as described in section 4.

For all determinands with an EQS, Tests 1 and 2 as defined in Figure 2-1 were applied. In addition, the WFD class deterioration test was applied.

As identified in Figure 2-1, the final two tests of whether there is likely to be deterioration in the recycled water quality and whether there are locally-specific sensitivities were not performed. The rationale for this is addressed in sections 5.3.4 and 5.4.2.

For each determinand three scenarios were modelled;

- Impact of the discharge at existing concentrations,
- Treatment required to meet the target (EQS), and
- Treatment required to prevent deterioration.

The tests relevant to each scenario and determinands type are summarised in Table 2-1..

Table 2-1: Relevance of tests to different determinands and scenarios

Scenario	Test	Test relevant to Hazardous Chemicals?	Test relevant to other determinands with an EQS?	Test relevant to determinands without an EQS?
Impact of the discharge at existing concentrations	Hazardous chemicals test 1a – is AA EQS exceeded or met with <95% confidence?	✓		
	Hazardous chemicals test 1b – is MAC EQS exceeded?	✓ (where MAX EQS is defined)		
	Hazardous chemicals test 2a – is d/s water quality >80% of EQS?	✓		
	Hazardous chemicals test 2b – is >50% of remaining EQS Headroom used?	✓		
	WFD – is a class deterioration predicted?	✓	✓	

Scenario	Test	Test relevant to Hazardous Chemicals?	Test relevant to other determinands with an EQS?	Test relevant to determinands without an EQS?
	WFD – Is deterioration >10% (or >3% where EQS already exceeded)?	✓	✓	✓
Treatment required to meet the target (EQS)	What percentage treatment reduction is required to meet the AA EQS?	✓	✓	
	What percentage treatment reduction is required to meet the MAC EQS?	✓ (where MAX EQS is defined)	✓	
Treatment required to prevent deterioration	What percentage treatment reduction is required to prevent deterioration?	✓	✓	✓

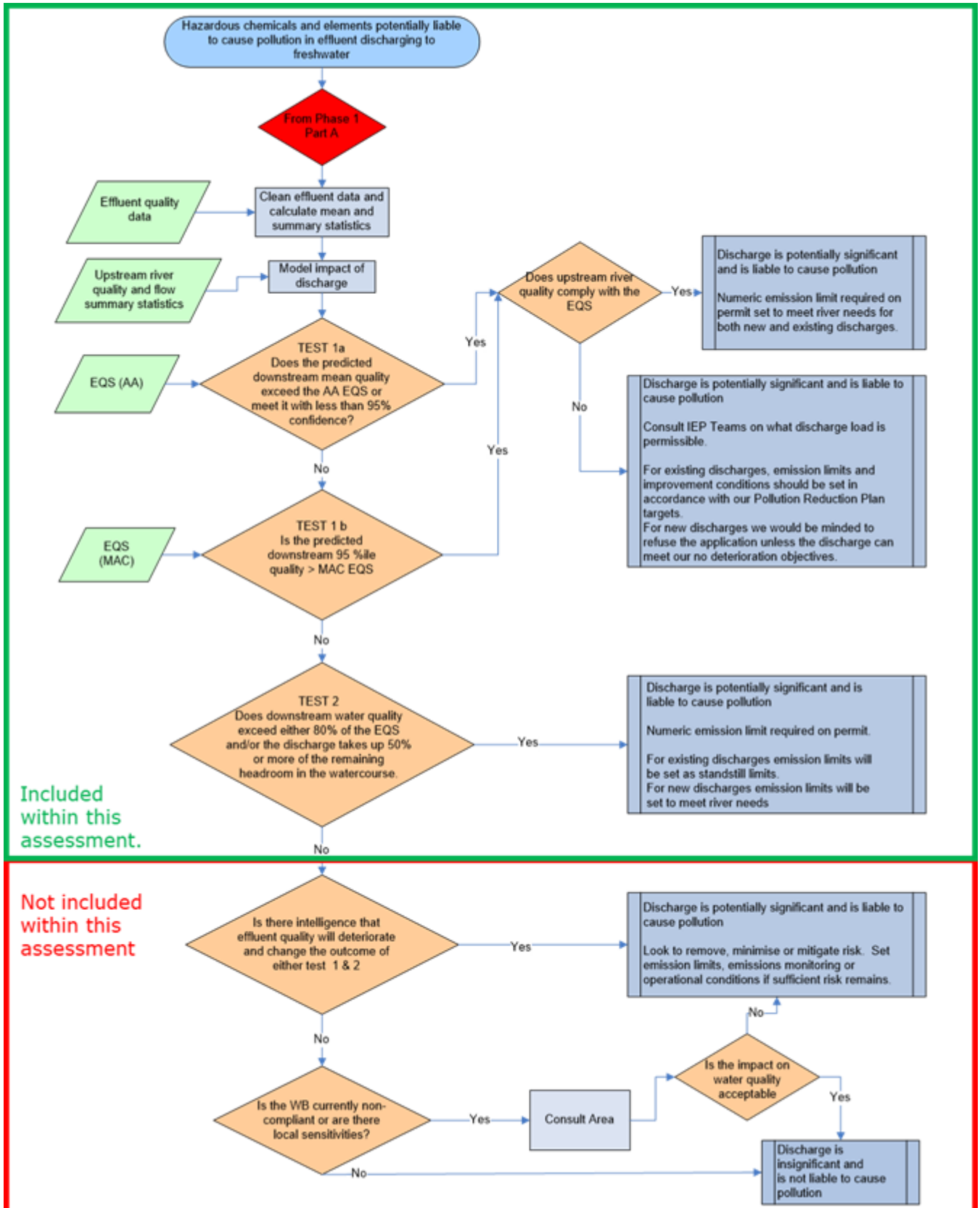
### 2.2.5 Modelling downstream sites

For the downstream sampling sites 5 (Daventry) and 6 (Leighton Buzzard), the following additional assumptions were made:

- The “upstream” (background) water quality and flow in the canal at these locations would be defined using the water quality sampling and the Aquator model.
- The “discharge” flow would be the flow statistics for the Minworth recycled water transfer, in other words no gains or losses of flow would be allowed for.
- The “discharge” quality statistics for each determinand at site 5 (Daventry) would be taken from the modelled, mixed results for that determinand at site 3 (Atherstone). So, whilst dilution, deposition and decay of substances along the canal route was not accounted for, the dilution occurring at the point of discharge was represented.

- Likewise, the “discharge” quality statistics for each determinand at site 6 (Leighton Buzzard) would be taken from the modelled, mixed results for that determinand at site 5 (Daventry).

As several determinands are not sampled at site 5, the mixed quality cannot be calculated here, and the mixed quality at site 3 would be used instead.



© Environment Agency

Figure 2-1: Modelling process for Hazardous Substances

### 2.2.6 Dissolved oxygen

The assessment of dissolved oxygen (DO) in the canal requires a different approach, because:

- Dissolved oxygen is prone to reduce downstream of a recycled water discharge as a result of the up-take of oxygen from the biochemical oxygen demand (BOD) and the oxidation of ammonia to nitrite and then nitrate, and will hence be at its lowest concentration some distance downstream of the outfall.
- The timing and distance downstream of this "oxygen sag" is impacted by the temperature, the rates of BOD and ammonia decay and reaeration, the latter varying according to the flow, velocity and surface area of the channel.
- Rather than the mean, MAC and 95%ile EQSs applied to other parameters, compliance can be judged against the Fundamental Intermittent Standards (FIS). These set out permissible minimum concentrations of DO. (Foundation for Water Research, 2018)
- Dissolved oxygen within the discharge can be increased by design of an outfall structure at Atherstone which promotes re-aeration.

Consequently the RQP models are not suitable for modelling DO. Three alternatives were considered:

- Flood Modeller Pro (FMP): An FMP hydrodynamic model has been developed to assess the hydraulics of the baseline and with-scheme canal system (see A4.2). FMP has the capability to model DO and other water quality parameters. However, initial testing at Gate 2 suggested that this could be difficult to set up and stabilise, with no previously known implementations of the FMP water quality functions in a model of the size and complexity of the transfer route.
- SIMCAT: This stochastic model is used by the EA nationally to assess and set permit conditions across river basins. It follows a similar approach to Monte Carlo, but simulates whole river systems, allowing the cumulative impact of all continuous and intermittent wastewater outfalls, as well as rural and urban diffuse sources, to be assessed. SIMCAT is theoretically suitable for modelling of a canal system, and is not prone to the instabilities of a hydrodynamic model, however it models dissolved oxygen in quite a simple way, for example by only including depletion from BOD not ammonia and so is not commonly used for permitting when issues with dissolved oxygen need to be addressed or mitigated..
- The EA's simple Street-Phelps spreadsheet model.

Following engagement with the Environment Agency (EA), the agreed approach was to initially test the DO impact of the scheme using a simple Streeter-Phelps spreadsheet model provided by the EA. If the results of this analysis indicated potential issues for the canal as a result of the transfer, further consideration would be given to modelling using more sophisticated techniques.

## 2.3 Modelling assessment for discharges to the Daventry and Drayton reservoirs

### 2.3.1 Overview

The potential for the GUC SRO to use the Daventry and Drayton reservoirs as additional storage to provide greater resilience to shocks was identified late in Gate 2. This would include providing resilience during periods when Minworth final recycled water is diverted back to the River Tame in order to avoid causing earlier breaches of the Hands-off-Flow (HOF) on the River Trent at North Muskham.

This would involve diverting some or all of the transfer flow from the bottom of the Braunston flight into Daventry and Drayton reservoirs via a new pumping station and rising main, such that they remain full. In the event of any outage which prevented the transfer to operate to the north of Daventry, this stored water would then be released back to the GUC in order to meet demand for the scheme in the Affinity Water region.

The Daventry and Drayton reservoirs are Canal & River Trust assets, whose primary purpose is to provide water to maintain canal water levels for navigation. In discussions held with the Environment Agency, they confirmed that they consider that the proposed discharges from the GUC into the reservoirs would be likely to require new environmental permits, and that the change of operating regime may also require abstraction licenses to be agreed for the reservoirs.

### 2.3.2 H1 screening assessment

The EA have indicated that the transfer of water from the Grand Union Canal at Braunston into the Daventry and Drayton reservoirs will likely require new environmental permits for discharges to surface water. In line with EA guidance, a screening assessment should first be carried out to identify substances potentially significant and liable to cause pollution.

As the quality of the water to be transferred from Braunston to the reservoirs will be dominated by the quality of the Minworth recycled water discharge at Atherstone, the following approach was taken to the screening:

- Where a substance has been modelled at site 5 (Welton Lane Daventry, a short distance downstream of Braunston), the results of this modelling were used to define the quality of water being discharged to the reservoirs.
- Where a substance has not been modelled, the Predicted Environmental Concentration (PEC) calculated for the Atherstone H1 screening will be used for the H1 screening assessment. This is a conservative approach since it assumes no further dilution downstream of Atherstone.

Discussions around the required consents for the reservoirs are ongoing.

### 2.3.3 Software selection

#### **Nutrients**

Following initial discussions with the Environment Agency, an alternative approach will be followed for nutrients in the Daventry and Drayton reservoirs, if the screening assessment indicates that the transfer could increase nutrient levels in the reservoirs.

Under the existing situation, the residence time in the reservoirs is approximately five months. Once the transfer scheme is in place, the residence time will drop to one month. For the proposed transfer scheme, the residence time is so short that the water quality of the reservoirs will be driven by the quality of the inflowing water. That means that the water quality can be assessed using a simple spreadsheet model. The residence time for the existing case is significantly longer which may mean issues such as stratification and internal water quality processes could be more dominant. However, the proposed data collection exercise is limited so there will be insufficient information against which to calibrate a more complex model. Therefore, the same simple spreadsheet model will be used to represent the existing case. The proposed approach means there will be a consistent approach to modelling the existing and proposed cases. As such, comparisons between the two cases will be dependable.

The EA guidance suggests the OECD model which is based on the Vollenweider regression equation. The model predicts the annual average chlorophyll-a from the estimated nutrient concentrations. This model will be used to assess the nutrient input to the reservoirs for existing conditions based on the observed quality in the reservoirs. The nutrient input will be then used in a mass balance model to simulate the observed variation in water quality of the lakes.

The mass balance model will be first calibrated for continuity of flow through the reservoirs. This will require the inflow to the reservoirs (predicted using rainfall-runoff models of the reservoir catchments), the outflow from and the level in the reservoirs.

Once the mass balance model has been calibrated for continuity of flow, the model will then be calibrated for mass balance of nutrients (nitrogen and phosphate) over the data collection period. The nutrient loading of the outflow will be based on the outflow discharge and the nutrient concentration measured in the reservoirs. The models will be calibrated for the nutrient concentration of the inflow and the sedimentation rate (loss of nutrients to the reservoir bed).

Having calibrated the model for the existing case the impact of the transfer flows will be tested. The quality of the water being transferred from the canal to the reservoir has already been investigated. The calibrated model can then be tested with the changed inflow pattern that the scheme will entail.

The impact of the inflows will depend on whether they increase the concentration of nutrients in the reservoirs. If the nutrient concentration of the new inflows to the reservoirs is less than the existing concentration in the reservoir, we would anticipate a reduction in the nutrient concentration of the waterbody. That is because the residence time of the reservoir will be decreased and the existing nutrient concentrations in the reservoir will be diluted.

If the nutrient concentration of the new inflows to the reservoirs is more than the existing concentration in the reservoir, the situation will be more complicated. Although there will be increased flushing there will be higher nutrient concentrations in the reservoirs. The effect on the quality of the waterbody will be a balance between the flushing that would be expected to improve quality and the risk of increased eutrophication due to the availability of nutrients.

### ***Other chemicals***

For other chemicals screened in by the H1 assessment, the Monte Carlo approach will be followed.

### ***Temperature***

The assessment of temperature impacts at the point of discharge at Atherstone has concluded that the change in temperature will remain within allowable limits (see section 8). The Daventry and Drayton Reservoirs are some 50km downstream from Atherstone, so some normalisation of canal temperature with ambient temperature would be expected to occur as water is transferred over this distance. A check will be made to confirm that adverse temperature impacts aren't anticipated at the reservoirs. Initially a conservative approach will be taken, assuming no change in temperature between Atherstone and the reservoirs, and taking into consideration any temperature stratification observed in the reservoirs.

## **2.4 Changes to the scheme during Gate 3**

### **2.4.1 Location of discharge**

Figure 2-2 provides an overview of the geography of the GUC Transfer. Following treatment at the "Minworth" Advanced Water Treatment Plant (AWTP), recycled water will be pumped, via the "Minworth" to Atherstone pipeline to a break pressure tank (BPT) located close to the Atherstone outfall to Coventry Canal. The location of the outfall structure was, at the time of writing (May 2024), subject to the outputs of a non-statutory consultation to gather stakeholder and public opinions on two potential pipeline route alignments via either Coleshill Road or Atherstone Golf Course.

These two locations are a short distance apart and both to the same canal pound. We therefore consider that the modelling results presented herein are equally valid to both candidate sites for the discharge location.

### **2.4.2 Location of abstraction**

Water quality sampling site 6, south of Leighton Buzzard, is close to the WTW candidate site 30. During Gate 3, a further assessment of locations for the abstraction, raw water reservoir and Bletchley WTW has been carried out. These cover a long section of the GUC, from site 400 just south of Bletchley to site 300 at Slapton Lock. At the time of writing (July 2024), this site selection process was ongoing.

Given that the alternative sites under consideration would abstract from different canal pounds, we would recommend that a review of the water quality analysis is carried out at Gate 4, once the preferred location for the WTW is confirmed.

#### 2.4.3 Tick-over flow

This Gate 3 assessment has used 29MI/d (28.75MI/d) as the 'tick-over' scheme flow during winter months. The tick-over flow has evolved during Gate 3, largely as a result of further analysis of the treatment processes at "Minworth" AWTP and Bletchley WTW, and of operating costs. 23MI/d is now the preferred tick-over flow, and this will be adopted into further modelling at Gate 4. A summary of the likely implications of this small change is provided in the Gate 3 modelling report (Annex A4).

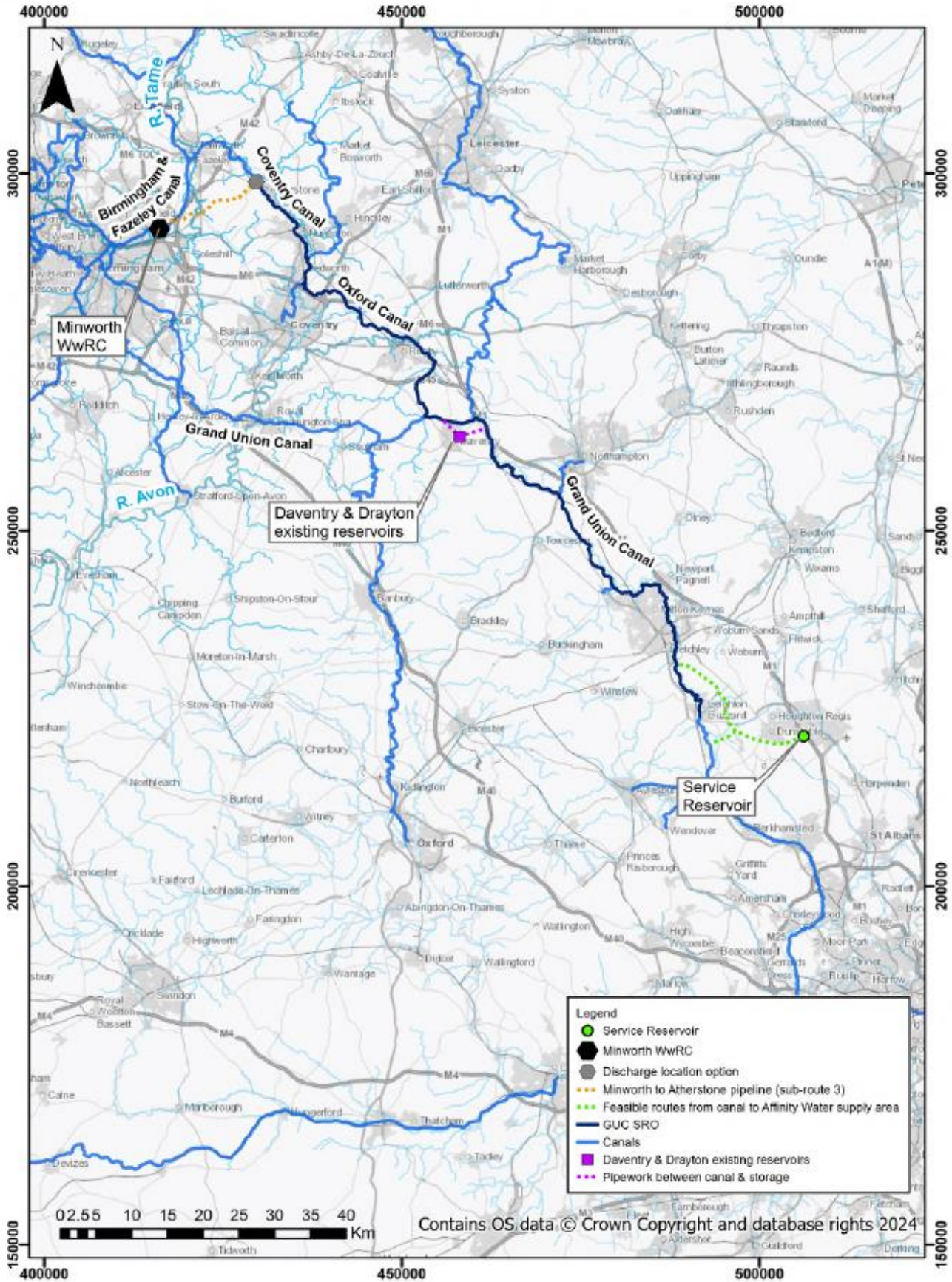


Figure 2-2: Overview of the Grand Union Canal Transfer

## 3 Flow data analysis

### 3.1 Canal flow

The Monte Carlo models require Mean and 95-percentile exceedance flows for the canal at the point of inflow. These were derived from a 61-year modelled period (1961-2022) from the calibrated 'with scheme' Aquator model.

Further refinement of the Aquator model has been carried out at Gate 3. This has included:

- Improvements to elevation-volume curves and control curves
- Improved representation of the Daventry and Drayton reservoirs.
- Flow gauging at key junctions, including at the junction of the Coventry and Ashby Canals.
- Improvements to the representation of gravity feeders to include the influence of structures which control flows at both low and high flow states.

See A4.1 for full details of the development of the Aquator model at Gate 3.

The modelled flow statistics applied in the water quality model are summarised in Table 3-1. As a result of the changes to the Aquator model listed above, the flow estimates are higher than those applied at Gate 2 for all sites, in particular at sites 5 and 6 (the Gate 2 flows are shown in brackets for sites 3, 5 and 6. They were not calculated for sites 17 and 18 at Gate 2). The increase in flows between Gates 2 and 3 is because only the by-weir flows at each location were used within Gate 2 whereas at Gate 3, to get more accurate estimates of dilution, we have taken the approach to sum all the inflows to the pound using the with-scheme Aquator model results (excluding the scheme as this is transferred in and out of the pound).

Table 3-1: Canal flow statistics from Aquator model

Sampling location	Aquator model reference	Mean flow MI/d (Gate 2)	95-percentile flow MI/d (Gate 2)
3 - Atherstone top lock	CC Atherstone Top Lock	5.671 (5.364)	1.774 (0.307)
5 - Daventry	GU Lock 7	19.796 (3.89)	7.079 (0.320)
6 - Leighton Buzzard	GU Locks 28-29	22.203 (3.63)	6.839 (1.53)
17 - Daventry reservoir	Daventry reservoir	6.1	1.05
18 - Drayton reservoir	Drayton reservoir	1.133	0.195

### 3.2 Discharge flow

The demand profile for the GUC SRO developed in the Affinity Water assessment "Capacity Needs and Utilisation Profile for Strategic Options" (Affinity Water, 2022) was

simplified into a typical discharge value for each month. This is the same demand which has been applied to the "with-scheme" Aquator and hydraulic models. The monthly demand values relate to two levels of deployable output as shown in Table 3-2. In all cases it was assumed that there will be a continuous discharge of 28.75MI/d<sup>1</sup> with an intermittent discharge of up to 86.25MI/d (totalling 115MI/d) during summer months when demand is higher.

Table 3-2: Minworth deployable output levels

Continuous discharge	Intermittent discharge	Notes
28.75 MI/d	Up to 86.25 MI/d	n/a

The monthly utilisation is shown in Figure 3-1. The intermittent flow was applied to the model as a non-parametric distribution (NPD) file, from which RQP randomly selects flow 'shots'. RQP also calculates the following summary statistics for the intermittent discharge:

Mean: 70.15MI/d  
 Standard Deviation: 22.05MI/d  
 Percentage time in operation: 41.67%

The continuous flow was applied as the discharge flow in RQP as:

Mean: 28.75MI/d  
 Standard Deviation: 0.00MI/d

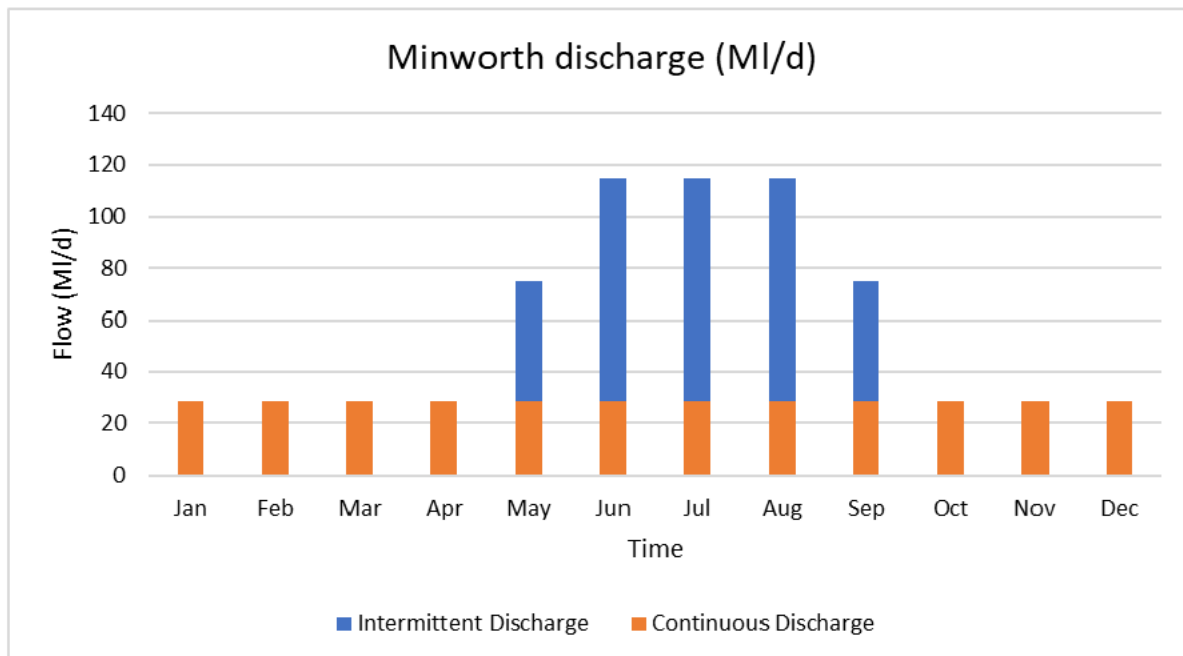


Figure 3-1: Monthly utilisation

<sup>1</sup> See section 2.4.3 for an explanation of the continuous discharge (AKA the trickle-flow) and how it has changed to 23MI/d during Gate 3.

### 3.3 Correlation of canal and Minworth discharge flow

The Monte Carlo and MPer models include a measure of correlation between data sequences. Where data sequences are closely related they are said to be correlated. An example would be a flow discharge from a WWTW into a river with a similar catchment area and time of concentration as the urban drainage system, in which case it is likely that there would be a higher degree of correlation between river flow and discharge. The 'r' value is used to express the degree of correlation between two data sequences - a value of one means the two datasets are totally correlated, a value of zero means that they are completely unrelated.

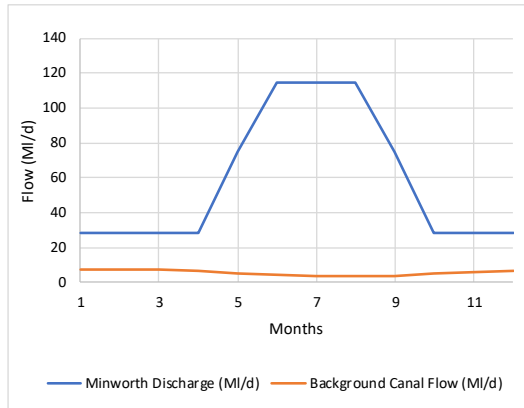
The correlation between canal flow and discharge flow was assessed as follows:

The 61-year flow results for the Aquator model at the three locations were further analysed to identify monthly mean flows.

Using the excel correlation tool, the correlation of monthly mean canal flow and monthly discharge from Minworth was correlated. Results indicate a strong negative correlation of -0.79 at site 3, and site 6, whereas there is a positive correlation of 0.68 at site 5. Data for sites 3, 5, and 6 are shown in Figure 3-2 to Figure 3-4. Figure 3-4: Correlation of canal and discharge flow at site 6. This strong negative correlation is largely explained by the full discharge flow being applied in summer when canal flow is at its lowest. Site 6 is a trough pound and in winter receives more inflows from uncontrolled feeders. Site 5 is a busy area for navigation and its location at a summit means there are limited gravity inflows into the canal hence the strong correlation.

### Monthly Flows

Month	Minworth Discharge (MI/d)	Background Canal Flow (MI/d)
Jan	28.75	7.42
Feb	28.75	7.52
Mar	28.75	7.45
Apr	28.75	6.45
May	74.75	5.39
Jun	115	4.74
Jul	115	3.96
Aug	115	4.00
Sep	74.75	3.91
Oct	28.75	4.81
Nov	28.75	5.92
Dec	28.75	6.51



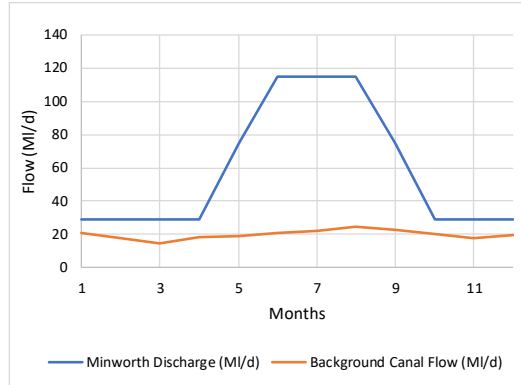
### Correlation

	Minworth Discharge (MI/d)	Background Canal Flow (MI/d)
Minworth Discharge (MI/d)	1	-0.79
Background Canal Flow (MI/d)	-0.79	1

Figure 3-2: Correlation of canal and discharge flow at site 3

### Monthly Flows

Month	Minworth Discharge (MI/d)	Background Canal Flow (MI/d)
Jan	28.75	20.66
Feb	28.75	17.53
Mar	28.75	14.55
Apr	28.75	18.59
May	74.75	18.72
Jun	115	20.82
Jul	115	21.88
Aug	115	24.44
Sep	74.75	22.92
Oct	28.75	20.39
Nov	28.75	17.56
Dec	28.75	19.38



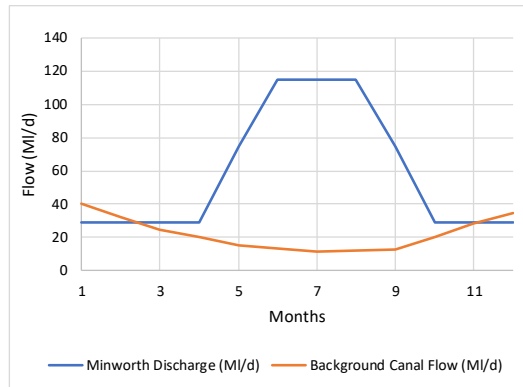
### Correlation

	Minworth Discharge (MI/d)	Background Canal Flow (MI/d)
Minworth Discharge (MI/d)	1	0.68
Background Canal Flow (MI/d)	0.68	1

Figure 3-3: Correlation of canal and discharge flow at site 5

### Monthly Flows

Month	Minworth Discharge (Ml/d)	Background Canal Flow (Ml/d)
Jan	28.75	39.98
Feb	28.75	32.21
Mar	28.75	24.89
Apr	28.75	20.30
May	74.75	15.31
Jun	115	13.26
Jul	115	11.43
Aug	115	12.40
Sep	74.75	13.05
Oct	28.75	20.55
Nov	28.75	28.26
Dec	28.75	34.76



### Correlation

	Minworth Discharge (Ml/d)	Background Canal Flow (Ml/d)
Minworth Discharge (Ml/d)	1	-0.79
Background Canal Flow (Ml/d)	-0.79	1

Figure 3-4: Correlation of canal and discharge flow at site 6

## 4 Water quality data analysis

### 4.1 Data sources

#### 4.1.1 Water quality monitoring

The water resources, hydraulic and water quality models for the Gate 3 submission have all modelled the point of abstraction south of Leighton Buzzard, representing the Gate 2 abstraction site. As part of the DCO Non-Statutory Consultation (Autumn 2024), a number of other WTW and abstraction locations are being consulted on, both to the north and south. Once selected, the preferred location should be retested in the models at Gate 4.

The data examined and modelled was taken from the Water Quality Monitoring database - Round 33 v1.0 (Atkins, 2023), which included samples up to December 2023. As shown in Figure 4-1, sampling was undertaken at eleven locations, of which six sampling locations are of interest to this study (based on the Gate 2 abstraction site south of Leighton Buzzard):

- Site 1, Minworth WwRC final recycled water. Note that this is sampling the present-day final recycled water (which will receive further treatment prior to discharge into the canal).
- Site 3, Coventry Canal at Atherstone Top Lock.
- Site 5, Grand Union Canal at Daventry.
- Site 6, Grand Union Canal at Leighton Buzzard.
- Site 17, Daventry Reservoir (note, sampling commenced on 28/02/2024. Analysis of this site to be presented at Gate 4).
- Site 18, Drayton Reservoir (note, sampling commenced on 28/02/2024. Analysis of this site to be presented at Gate 4).

32 rounds of sampling were undertaken for sites 1, 3, 5 and 6, all were monthly spot samples taken between April 2021 and October 2023, except June 2021, in which 2 samples were taken. Laboratory analysis of samples was undertaken to confirm the concentration of each determinand.

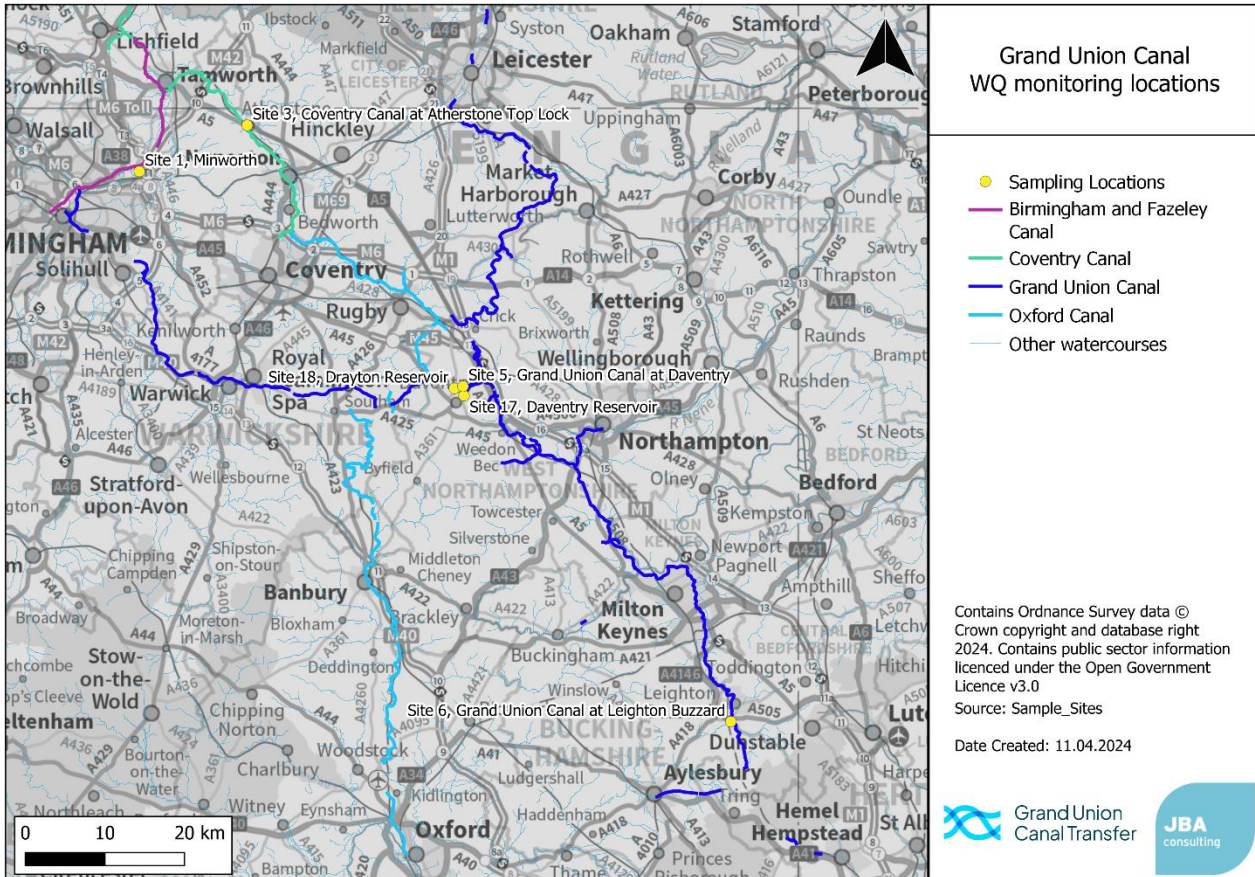


Figure 4-1: Plan of GUC SRO water quality sampling stations

#### 4.1.2 Data checks and preparation

The following data checks and preparation steps were undertaken prior to modelling:

- Treatment of "less-than" values
- Outliers
- Step changes

Note that the screening assessment was undertaken using the raw data prior to data checks being undertaken.

#### 4.1.3 Treatment of "less-than" values

For each determinand, the laboratory sets a Limit of Detection (LOD). This is the lowest concentration in which the test undertaken can reliably determine. Where this limit is reached, the laboratory results state that the value is said to be "qualified" as "less-than" the LOD. So, for example, the LOD for cypermethrin is 0.00008µg/l. This concentration was not detected in the Coventry Canal at Atherstone, so the results are reported as <0.00008µg/l.

For modelling, the EA recommend that samples which are less than the LOD are considered to be half of the LOD. In the example of cypermethrin, this resulted in the sample values being adjusted to 0.00004µg/l.

Where a high proportion of samples are qualified, there is a significant risk that this will influence the reliability of the results. In the presentation of results (tables in sections 5, 6, 7, and 9), determinands where 50% or more of the canal samples are qualified as less than the LOD, and the LOD is >10% of the EQS, are marked with a (Q). Whilst it is possible to model these determinands, we can never be sure of the actual concentrations as they cannot be measured and as such, results for these determinands should be treated with extra caution. A summary of qualified values is provided in Appendix C.

Note that for two determinands (formaldehyde and hydrogen sulphide), the LOD is greater than the average EQS. For these determinands it is not possible to reliably assess current or future performance compared to the EQS.

#### 4.1.4 Outliers

Outliers are values which differ significantly from the normal range of values encountered, inclusion of which in the Monte Carlo modelling might skew the results. Time series graphs were generated for all determinands to be assessed in the water quality impact assessment. Outliers were identified where they were 3 times the standard deviation above or below the mean value. Due to the way concentrations of some determinands were reported, we chose to include these statistical outliers in the modelling. This is because when examined they present little variation from the other values that were sampled. This reasoning for the inclusion or exclusion is outlined below.

#### 4.1.5 Step changes

Step changes are permanent increases or decreases in the range of concentrations sampled. They may represent a new discharge, improved treatment at an existing discharge, or additional, unknown changes to the sources of contaminants. Step changes were identified visually using graphs for each determinand, when these were identified the corresponding graph has been included below. The graphs for every determinand are available if required.

#### 4.1.6 Qualified results

The Environment Agency have advised the SRO that, where possible, the Limit of Detection (LOD) should be ≤10% of the EQS. Table 4-1 shows whether the LOD for each determinand exceeds 10% of the EQS.

For the purpose of this report, an additional check was added to identify where 50% or more of the samples are qualified as less-than the LOD, because there is less uncertainty in the modelling where samples are consistently above the LOD. Within this report, where 50% or more of the samples are qualified as less-than the LOD, *and* the LOD is >10% of

the EQS, qualified results are marked with a **(Q)** and should be treated with additional caution.

Table 4-1: Qualified results based on LOD and EQS

Determinand	EQS (µg/l)	10% of EQS (µg/l)	LOD (µg/l)	Qualified (Y/N)
4-n-nonylphenol	0.3	0.03	0.04	Yes
cypermethrin	0.00008	0.000008	0.00008	Yes
diazinon	0.01	0.001	0.01	Yes
formaldehyde	5	0.5	50	Yes
hexabromocyclododecane (HBCDD)	0.0016	0.00016	0.00014	No
mancozeb	2	0.2	0.1	No
maneb	3	0.3	0.1	No
mercury total	0.07	0.007	0.001	No
nickel total	4	0.4	0.5	Yes
perfluorooctane sulfonic acid (PFOS)	0.00065	0.000065	0.00065	Yes
permethrin	0.001	0.0001	0.001	Yes
sulphide or hydrogen sulphide	0.25	0.025	10	Yes
triclosan	0.1	0.01	0.01	No
zinc total	10.9	1.09	0.9	No

Where a sampled value for a determinand is at the limit of detection (LOD), the value has been taken at half the face value. This is in line with the EA guidance (Environment Agency, 2019).

In parallel with this modelling study, work has been underway with the laboratories to identify whether reporting down to 10% of EQS or the EA's Minimum Reporting Value (MRV) could be achieved for all determinands. Where this is technically and economically feasible, it is recommended that further sampling at these lower Limits of Detection should be undertaken, to allow these determinands to be remodelled at Gate 4.

## 4.2 Data checks for site 1 Minworth WwRC - final recycled water.

### 4.2.1 Outliers

Table 4-2 identifies 12 possible outliers in the site 1 data, and whether they are included (7) or excluded (5) when calculating the mean and standard deviation in the Monte Carlo analysis.

Table 4-2: Outliers, Site 1 Minworth WwRC Discharge

Determinand	Outlying data point value	Date of sample(s)	Include in modelling	Reason for decision
diazinon	0.02 0.02	12/06/2022 11/04/2023	yes	Only result that is above 0.01
formaldehyde	81	28/11/2022	yes	Only non-qualified result that is above 50
Hexabromo-cyclododecane (HBCDD)	0.00904	13/03/2023	No	Only result that is above 0.004
mancozeb	9.5	12/06/2023	no	Only result that is above 3.2
maneb	33.6	12/06/2023	no	Only value that is >5
mercury - total	3.7	15/08/2022	no	Only result that is above 0.1
nickel - total	61	07/03/2022	no	Only result that is above 35
perfluorooctane sulfonic acid (PFOS)	0.034	19/04/2021	yes	Only result not <0.025
permethrin	0.008 0.009	19/04/2021 01/06/2021	yes	Only result that is above 0.005
triclosan	0.07	07/02/2022	yes	Next lowest value 0.05 - most values <0.02

### 4.2.2 Step changes in data

There is potentially a step-change or a seasonal trend for cypermethrin, an insecticide used in farming and domestic settings to control pests<sup>2</sup>, in the 2023 rounds of sampling as shown in Figure 4-2. No data has been excluded in the modelling.

<sup>2</sup> [https://consult.environment-agency.gov.uk/++preview++/environment-and-business/challenges-and-choices/user\\_uploads/cypermethrin-pressure-rbmp-2021.pdf](https://consult.environment-agency.gov.uk/++preview++/environment-and-business/challenges-and-choices/user_uploads/cypermethrin-pressure-rbmp-2021.pdf)

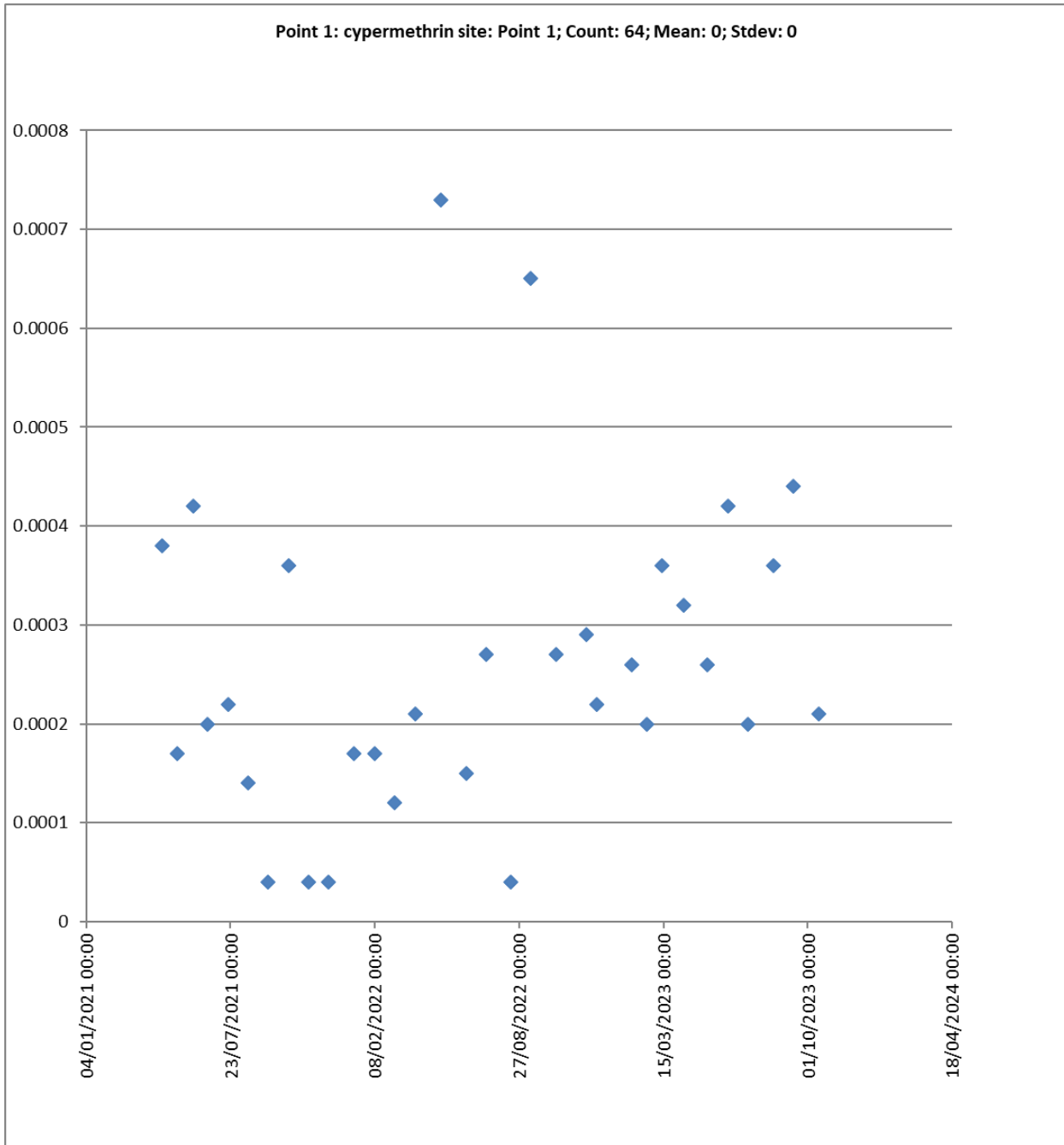


Figure 4-2: Cypermethrin (µg/l) at site 1

### 4.3 Data checks for site 3 Coventry Canal at Atherstone

#### 4.3.1 Outliers

Table 4-3 identifies 13 potential outliers identified in site 3 data, and whether they are included (6) or excluded (7) when calculating the mean and standard deviation in the Monte Carlo analysis.

Table 4-3: Outliers. Site 3 Coventry Canal at Atherstone

Determinand	Outlying data point value	Date of sample(s)	Include in modelling	Reason for decision
cobalt - total	95	30/01/2023	no	only result that's above 45
cypermethrin	0.0000 0.0002	28/11/2022 12/07/2022	yes yes	0 result sampled as 0.00014 - error in sampling spreadsheet
hexambromo-cyclododecane (HBCDD)	0.0024 0.0024	07/02/2022 17/10/2022	yes yes	Within three times the St Dev
mancozeb	1.3 1.5	07/02/2022 12/12/2022	no no	Next lowest value 0.5 - most values <0.2
maneb	1.5 1.4	07/02/2022 12/12/2022	no no	Only value not <0.3
mercury - total	0.25	12/09/2022	no	Next closest value 0.082 - most values <0.05
nickel - total	220	30/01/2023	no	Next lowest value 120 - most values <50
4-n-nonylphenol	0.4	13/03/2023	no	Only non-qualified value not <0.04
permethrin	0.002	19/07/2021	yes	Only non-qualified value not <0.001
triclosan	0.02	19/04/2021	yes	Only non-qualified value not <0.01
zinc - total	430	30/01/2023	no	Next closest value 270 - most values <100

#### 4.3.2 Step changes in data

No strong step changes were detected for any determinand at this site.

### 4.4 Data checks for site 5 GUC at Daventry

#### 4.4.1 Outliers

Table 4-4 identifies 14 potential outliers in the site 5 data, and whether they are included (6) or excluded (9) when calculating the mean and standard deviation in the Monte Carlo analysis.

Table 4-4: Outliers, Site 5 GUC at Daventry

Determinand	Outlying data point value	Date of sample(s)	Include in modelling	Reason for decision
cypermethrin	0.00009	10/05/2021	yes	Only value not 0.00004
	0.00009	28/11/2022	yes	
	0.00008	13/03/2023	yes	
fluoranthene	0.0292	13/03/2023	no	Only value not <0.0038
Hexabromo-cyclododecane (HBCDD)	0.00014	20/02/2023	yes	Only non-qualified value not <0.00014
sulphide or hydrogen sulphide	51	28/11/2022	yes	most values <36
mercury - total	0.21	12/09/2022	no	Next closest value 0.088 - most values <0.015
nickel - total	15	07/03/2022	no	most values <6.5
4-n-nonylphenol	0.4	11/04/2023	no	Only non-qualified value not <0.04
	0.4	11/09/2023	no	
perfluorooctane sulfonic acid (PFOS)	0.000045	28/11/2022	no	Outside of St Dev tolerance - at LOD
triclosan	0.02	19/04/2021	yes	Only non-qualified value not <0.01
zinc - total	110	10/01/2022	no	Only value not <33

#### 4.4.2 Step changes in data

No strong step changes were identified for any determinand at this site.

### 4.5 Data checks for site 6 GUC at Leighton Buzzard

#### 4.5.1 Outliers

Table 4-5 identifies 11 potential outliers identified in site 6 data, and whether they are included (5) or excluded (7) when calculating the mean and standard deviation in the Monte Carlo analysis.

Table 4-5: Outliers, Site 6 GUC at Leighton Buzzard

Determinand	Outlying data point value	Date of sample(s)	Include in modelling	Reason for decision
cobalt - total	18	16/10/2023	no	Next closest value 2.6 - most values <1
cypermethrin	0.00125	12/06/2023	no	Next closest value 0.00059 - most values <0.00033
Hexabromo-cyclododecane (HBCDD)	0.00035 0.00037	07/12/2021 13/03/2023	yes yes	Next closest value 0.00019 - most values <0.00015
sulphide or hydrogen sulphide	210 68	12/10/2022 28/11/2022	no no	Next closest value 42 - most values <30
mercury - total	0.71	12/09/2022	no	Next closest value 0.087 - most values <0.01
nickel - total	9.4 6.9	20/10/2021 16/10/2023	yes yes	Next closest value 4.1 - most values <3
zinc - total	46 70	20/10/2021 05/04/2022	yes no	Next lowest value 25 - most values <20. 50 is within 3x St Dev

#### 4.5.2 Step changes in data

No strong step changes were identified for any determinand at this site.

#### 4.5.3 Data checks for site 17 at Daventry Reservoir

Sampling at Daventry Reservoir commenced on 28/02/2024. Analysis of this site to be presented at Gate 4.

#### 4.5.4 Data checks for site 18 at Drayton Reservoir

Sampling at Daventry Reservoir commenced on 28/02/2024. Analysis of this site to be presented at Gate 4.

## 5 Results for Site 3, Coventry Canal at Atherstone

### 5.1 Introduction

Three scenarios have been tested on the determinands within Monte Carlo / MPer:

- Impact of input on discharge quality
- Required discharge quality to meet target/EQS.
- Required discharge quality to prevent deterioration.

### 5.2 Impact of the discharge at existing concentrations

#### 5.2.1 Hazardous chemicals modelling tests

For the hazardous chemicals modelling tests 1a,1b and 2, Figure 2-1 outlines each hazardous chemical test and whether a determinand passes or fails a test. A summary of the overall pass/fail is presented below and the results of each individual test are shown in Appendix B.

Of the 14 determinands modelled:

- 4 pass all of the hazardous chemicals modelling tests (diazinon, maneb, mercury total and triclosan).
- All of the determinands have an AA EQS, and all except zinc have a MAC EQS. Hazardous chemical tests have been undertaken for all determinands.
- 10 determinands fail one or more of the modelling tests. Results are listed in Table 5-1. For 5 of these, the AA EQS is already exceeded in the Coventry Canal.

Table 5-1 Hazardous chemicals modelling test results

Determinand	Fails AA EQS modelling tests?	Does the water body pass AA EQS at present?	Fails MAC EQS modelling tests?	Does the water body pass MAC EQS at present?
cypermethrin (Q)	Fail	Pass	Fail	Pass
diazinon (Q)	Pass	Pass	Pass	Pass
formaldehyde (Q)	Fail	Fail	Fail	Pass
hexabromocyclododecane (HBCDD)	Fail	Pass	Pass	Pass
sulphide or hydrogen sulphide (Q)	Fail	Fail	Fail	Fail
mancozeb	Fail	Pass	Pass	Pass
maneb	Pass	Pass	Pass	Pass

Determinand	Fails AA EQS modelling tests?	Does the water body pass AA EQS at present?	Fails MAC EQS modelling tests?	Does the water body pass MAC EQS at present?
mercury total	Pass	Pass	Pass	Pass
nickel total	Fail	Fail	Fail	Fail
4-n-nonylphenol (Q)	Fail	Pass	Pass	Pass
perfluorooctane sulfonic acid (PFOS)	Fail	Fail	Pass	Pass
permethrin (Q)	Fail	Pass	Pass	Pass
triclosan	Pass	Pass	Pass	Pass
zinc total	Fail	Fail	No MAC EQS	No MAC EQS

### Notes

- **(Q)** denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD, and the LOD is >10% of the EQS. Results for these determinands should be treated with extra caution.
- For Test 1, risk to EQS, the upper confidence range results are used to assess whether a determinand passes or fails. For information, the results for this test state “Pass (face value)” where the test is failed using the upper confidence value but passes using the face value. However, the overall outcome of the modelling tests is considered to be a fail in these cases. Note that for MAC and 95-percentile EQSs, only the face value result is assessed in Test 1.

### 5.2.2 River needs limits

The EA's Permitting of hazardous pollutants in discharges to surface waters (LIT13134) has been used to assess the river needs limits of each determinand based on the upstream river quality as a percentage of the EQS. This is presented in Table 7 of LIT13134 (Environment Agency, 2019) and summarised in Table 5-2 below.

Table 5-2 EQS deterioration allowance

Upstream quality as a % of EQS	% Deterioration on upstream quality
0 – 50	40
51 - 60	30
61 - 70	20
71 +	10
100 +	3

### Note:

- To calculate the percentage deterioration for a MAC EQS the deterioration should be compared against the 95%ile upstream quality. For AA EQS the deterioration should be compared against the mean upstream quality.

- above 70% make sure the EQS is not exceeded. When the current concentration is approaching 100% then care needs to be taken to ensure the EQS is not exceeded; in this situation the level of deterioration allowed will be less than 10%.

## Class deterioration

- All of the modelled determinands have an AA EQS,
- 7 determinands would not result in a class deterioration following the proposed discharge,
- 5 determinands are currently failing their EQS in the canal and would continue to do so with the discharge, and
- A new class deterioration is predicted for two determinands, cypermethrin (**Q**) and permethrin (**Q**).
- 13 of the modelled determinands have a MAC EQS. All of these determinands would not result in a class deterioration following the proposed discharge, with the exception of sulphide or hydrogen sulphide which is currently failing its EQS and would continue to do with the discharge.

## River needs limits

- The river needs limits permissible percentage deterioration allowance has been calculated based on the upstream quality as a percentage of the EQS, see Table 5-2,
- 4 determinands do not deteriorate by more than the percentage deterioration allowance based on the AA EQS, and 2 determinands do not deteriorate based on the MAC EQS,
- A percentage deterioration greater than the allowance is predicted for the remaining 10 determinands based on the AA EQS and 11 determinands based on the MAC EQS,
- A summary of the percentage deterioration results are presented below:

Table 5-3: Determinands with a predicted percentage deterioration on upstream quality

Determinand	Percentage deterioration (annual average)	Does the water body pass AA EQS at present?	Percentage deterioration > allowance (95-percentile)	Does the water body pass MAC EQS at present?
cypermethrin ( <b>Q</b> )	✓	Pass	✓	Pass
diazinon ( <b>Q</b> )	-	Pass	✓	Pass
formaldehyde ( <b>Q</b> )	✓	Fail	✓	Pass
hexabromocyclododecane (HBCDD)	✓	Pass	✓	Pass
sulphide or hydrogen sulphide ( <b>Q</b> )	✓	Fail	✓	Fail

Determinand	Percentage deterioration (annual average)	Does the water body pass AA EQS at present?	Percentage deterioration > allowance (95-percentile)	Does the water body pass MAC EQS at present?
mancozeb	✓	Pass	✓	Pass
maneb	✓	Pass	✓	Pass
mercury total	-	Pass	-	Pass
nickel total	-	Fail	-	Fail
4-n-nonylphenol <b>(Q)</b>	✓	Pass	✓	Pass
perfluorooctane sulfonic acid (PFOS)	✓	Fail	✓	Pass
permethrin <b>(Q)</b>	✓	Pass	✓	Pass
triclosan	✓	Pass	✓	Pass
zinc total	-	Fail	No MAC EQS	No MAC EQS

**(Q)** denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD, *and* the LOD is >10% of the EQS. Results for these determinands should be treated with extra caution.

### 5.2.3 Risk of effluent quality deteriorating significantly

The EA guidance for hazardous chemicals includes advice on protecting against future increases in the concentration of chemicals with treated effluent. Circumstances which could lead to this occurring include:

- Where trade effluent dischargers have only utilised a small percentage of their permitted discharge limits, but increase this due to a change in process or increased production.
- Where increased dosing of wastewater is required as part of the treatment process.

Managing these issues to ensure that the concentrations of chemicals are not inadvertently increased in the recycled water discharged to the Coventry Canal will require an integrated approach considering trade effluent licensing and management of the existing Minworth WwRC and the new "Minworth" AWTP. It is recommended that this issue be reviewed by Severn Trent Operations Process Team and the "Minworth" AWTP design consultants, and discussed with the Environment Agency.

### 5.2.4 Local water bodies issue

EA guidance recommends that, once modelling tests have been complete, permitting officers consult with local water quality staff to take account of local water body issues. In this case, the Canal & River Trust should also be consulted. Significant engagement

regarding the scope and findings of this water quality assessment has been carried out with the EA and Trust, through the Gate 3 engagement and review processes.

### 5.3 Sensitivity testing

#### 5.3.1 Overview

The draft results were reviewed in a meeting with the Environment Agency. The following sensitivity tests were identified to provide further understanding of the impact of uncertainties in the data:

- Sensitivity test 1 - Replacing outlier values removed from the observed data,
- Sensitivity test 2 - Test for the impact of the transfer running at maximum flow of 115MI/d, and
- Sensitivity test 3 - Test model sensitivity to the correlation coefficients used for river flow and quality and for recycled water flow and quality.

#### 5.3.2 Sensitivity test 1 - outliers

##### Test design

The aim of the assessment was to determine whether the removal of outlier values from the observed water quality data could have resulted in an over-optimistic assessment of the impact of the transfers.

##### Selection of determinands

The results for determinands where outliers have been removed (as defined in Sections 0 and 4.3) were reviewed. At sites 1 and 3, outliers were removed for 7 determinands. These have been remodelled with the outliers included.

##### Results

Comparing the results with outliers retained against those where it was removed, only had a significant impact on the results for maneb and mercury total, where a percentage deterioration is predicted and the hazardous chemicals tests are failed only when outliers are included. The results are summarised in Table 5-4.

**Table 5-4: Sensitivity test - outliers - results**

Determinand	Outliers removed			Outliers included			Conclusion
	Haz Chem Tests	Does canal pass EQS at present	WFD Tests	Haz Chem Tests	Does canal pass EQS at present	WFD Tests	
fluoranthene	Pass	Fail	No Det	Pass	Fail	No Det	Outlier inclusion has no impact
Hexabromo-cyclododecane (HBCDD)	Fail	Pass	Det	Fail	Pass	Det	Outlier inclusion has no impact
mancozeb	Fail	Pass	Det	Fail	Pass	Det	Outlier inclusion has no impact
maneb	Pass	Pass	Det	Fail	Pass	Det	Inclusion of outlier changes outcome
mercury total	Pass	Pass	No Det	Fail	Pass	Det	Inclusion of outlier changes outcome
nickel total	Fail	Fail	No Det	Fail	Fail	No Det	Outlier inclusion has no impact
zinc total	Fail	Fail	No Det	Fail	Fail	No Det	Outlier inclusion has no impact

### Conclusions

The inclusion of the discharge (site 1) and Atherstone Canal (site 3) outlier values for 'mercury - total' leads to a percentage deterioration and a failure of the hazardous chemical tests. The site 1 outlier value for mercury - total of 3.7µg/l is extreme when compared with the remaining samples which were all less than 0.1µg/l. This value may be due to an unregulated discharge of mercury, and is not representative of the typical discharge from Minworth. It was concluded that the without-outlier statistics should be used at the next stage for the calculation of treatment required to meet the target and no-deterioration.

For maneb, inclusion of outliers values leads to a failure of the hazardous substances modelling tests. Similarly to mercury total, this outlier value (33.6µg/l CS2) is significantly greater than the next lowest value (3.8µg/l CS2) and has not been included in the modelling.

The inclusion of the other outlier values previously removed did not impact the hazardous chemical or WFD results, and so no further action is recommended.

### 5.3.3 Sensitivity test 2 - maximum transfer flow

#### Test design

This test was requested to understand the impacts of the transfer operation at its maximum flow rate of 115MI/d. To model this, the following flow statistics were used:

- Mean upstream canal flow: 5.674 MI/d (annual mean calculated from the Aquator model)
- 95-percentile canal flow: 3.939 MI/d (calculated from the Aquator model)
- Mean discharge flow: 115MI/d
- Standard deviation of discharge flow: 0.1MI/d (nominal standard deviation resulting in effectively a constant 115MI/d flow)

This effectively represents the scheme running at its maximum capacity for 100% of the time. This is well beyond any predicted deployment of the scheme and therefore represents an extreme scenario.

#### Selection of determinands

The following filters were applied to identify determinands which might be sensitive to this test:

- Has an AA and MAC EQS specified.
- Passes all of the hazardous chemicals tests (so would not already have been identified as potentially significant) but exhibits some deterioration compared to the baseline.

Diazinon, maneb and triclosan meet these criteria and have been modelled.

#### Results

Results indicated only very minor changes as a result of the higher discharge value. None of these changes would have resulted in failure of one of the modelling tests which had been passed using the default, demand-based flow scenario.

#### Conclusions:

Results were not found to be sensitive to the transfer flow regime. This is probably because the transfer flow, even in the demand based scenario, is an order of magnitude greater than flow in the receiving water, so already dominates the downstream, mixed results. There are no recommendations for further action on this aspect of the modelling.

### 5.3.4 Sensitivity test 3 - correlation coefficients

#### Test design

This test aims to identify whether the model outputs are sensitive to the selection of correlation coefficient values. The modelling presented had used the default RQP values for river flow and quality (-0.3) and discharge flow and quality (-0.2), both indicating a weak negative correlation. Initially it was decided to test the most extreme positive (1.0) and negative (-1.0) correlations, in all possible combinations.

#### Selection of determinands

The determinands selected in test 2 (diazinon, maneb and triclosan) were appropriate in that they passed the hazardous chemicals tests but exhibited some deterioration, so might be expected to be sensitive.

#### Results

Initially diazinon was tested. Results indicated only very minor changes as a result of the various combinations of correlation coefficient. None of these changes would have resulted in failure of one of the modelling tests which had been passed using the default coefficients.

Table 5-5: Correlation coefficients - diazinon

Correlation: river flow and quality	Correlation: discharge flow and quality	Mean	Standard Deviation
-0.3	-0.2	0.0064	0.0034
-1.0	-0.2	0.0064	0.0034
1.0	-0.2	0.0064	0.0033
-0.3	-1.0	0.0066	0.0034
-0.3	1.0	0.0060	0.0030
-1.0	-1.0	0.0066	0.0034
-1.0	1.0	0.0061	0.0030
1.0	1.0	0.0061	0.0030
1.0	-1.0	0.0066	0.0034

#### Conclusions

Results were not found to be sensitive to flow and quality correlation coefficients. There are no recommendations for further action on this aspect of the modelling.

## 5.4 Future treatment requirements

Following the assessment of the impact of the present-day recycled water quality, the RQP backward-calculation method was used to calculate the treatment standards that would be required to either meet the EQS or to prevent deterioration. Please note that, subsequent to this assessment, it was identified that RQP incorrectly calculates overly strict treatment requirements when using a combination of continuous and intermittent discharges. Consequently, the results of this section should be treated with caution. Further details of this issued are discussed in section 9.2.3.

### 5.4.1 Treatment required to meet the target

This test identifies the treatment standard that would need to be met in order to meet the annual average (AA) EQS. In summary, results were:

- All determinands have an AA EQS,
- 7 determinands require no additional treatment to meet the AA EQS,
- 7 determinands would require a percentage reduction of between 49% and 100% to meet the EQS targets in the canal. These are shown in Table 5-6.

Table 5-6 Treatment percentage reduction required to meet AA EQS

Determinand	WW Treatment % reduction required to meet AA EQS	Conc. (µg/l) required to meet target quality
cypermethrin	77%	0.00006 (below existing LOD)
diazinon	None	None
formaldehyde	100%	0.05
hexabromocyclododecane (HBCDD)	None	None
sulphide or hydrogen sulphide	100%	0.003
mancozeb	None	None
maneb	None	None
mercury total	None	None
nickel total	76%	4.21
4-n-nonylphenol	None	None
perfluorooctane sulfonic acid (PFOS)	100%	0.000007 (below existing LOD)
permethrin	72%	0.0006
triclosan	None	None
zinc total	49%	27.1

### 5.4.2 Treatment required to prevent deterioration

This test identifies the treatment standard that would need to be met in order to prevent deterioration in the canal. Note that the test has been applied:

- a. to any determinands where a deterioration, however small, has been predicted, to test the treatment standard that would be required to prevent all deterioration, and
- b. where the predicted deterioration is greater than the EQS deterioration allowance set out in the river needs limits (see Table 5-2).

In combination, these two approaches indicate the strictest (a) and least strict (b) treatment standard that would be required to prevent deterioration. In summary, results were:

- No deterioration is predicted for 3 determinands and would require no treatment improvements to meet no deterioration.
- 9 determinands would require a percentage reduction of between less than 51% (formaldehyde) and 96% (mancozeb) to prevent a deterioration to their annual average values in the Canal. These are shown in Table 5-7.

Table 5-7 Treatment percentage reduction required to prevent deterioration (det.) to the annual average concentration.

Determinand	% reduction required to meet zero det. (Mean)	Conc. ( $\mu\text{g/l}$ ) required to meet zero det. (Mean)	% det. permitted (see Table 5-2)	% reduction required to meet permitted det. (Mean)	Conc. ( $\mu\text{g/l}$ ) required to meet permitted det. (Mean)
cypermethrin (Q)	88%	0.00003	10%	87%	0.000034
diazinon (Q)	59%	0.0026	40%	38%	0.004
formaldehyde (Q)	51%	13	3%	49%	13.6
hexabromocyclododecane (HBCDD)	95%	0.000046	40%	93%	0.000071
sulphide or hydrogen sulphide (Q)	53%	6.62	3%	51%	6.89
mancozeb	96%	0.051	40%	94%	0.079
maneb	91%	0.0029	40%	86%	0.16
mercury total	No Deterioration	No Deterioration	40%	21%	0.0074
nickel total	No Deterioration	No Deterioration	3%	No Deterioration	No Deterioration



Determinand	% reduction required to meet zero det. (Mean)	Conc. (µg/l) required to meet zero det. (Mean)	% det. permitted (see Table 5-2)	% reduction required to meet permitted det. (Mean)	Conc. (µg/l) required to meet permitted det. (Mean)
	n	n		n	n
4-n-nonylphenol (Q)	95%	0.013	40%	92%	0.02
perfluorooctane sulfonic acid (PFOS)	82%	0.00246	3%	81%	0.00256
permethrin (Q)	86%	0.0003	30%	80%	0.00043
triclosan	83%	0.0029	40%	75%	0.0044
zinc total	No Deterioration	No Deterioration	3%	No Deterioration	No Deterioration

## Notes

- The treatment standards required to meet the EQSs for bioavailable metals are shown as the dissolved metal concentration in the recycled water (as the bioavailable calculation is only applied by MPer to the watercourse upstream and downstream of the discharge).

## 6 Results for Site 5, GUC at Daventry

### 6.1 Introduction

Three scenarios have been tested on the determinands within Monte Carlo / MPer:

- Impact of input on discharge quality
- Required discharge quality to meet target/EQS.
- Required discharge quality to prevent deterioration.

Of the 14 determinands modelled at site 3, only 9 have been sampled at site 5 (Daventry). Diazinon, formaldehyde, mancozeb, maneb, and permethrin have not been assessed at site 5.

### 6.2 Impact of the discharge at existing concentrations

#### 6.2.1 Hazardous chemicals modelling tests

For the hazardous chemicals modelling tests, Figure 2-1 outlines each hazardous chemical test and whether a determinand passes or fails a test. A summary of the overall pass/fail is presented below and the results of each individual test are shown in Appendix B. Of the 9 determinands modelled:

- 3 determinands pass all of the hazardous chemicals modelling tests (hexabromocyclododecane (HBCDD), mercury total, and triclosan),
- All of the modelled determinands have an AA EQS, and all except zinc have a MAC EQS,
- Hazardous chemical tests have been undertaken for all determinands,
- 6 determinands fail one or more of the AA EQS modelling tests and 2 fail one or more of the MAC EQS modelling tests. These are listed in Table 6-1. For sulphide and PFOS, the EQS is already exceeded in the GUC.

Table 6-1 Hazardous chemicals modelling test results

Determinand	Fails AA EQS modelling tests?	Does the water body pass AA EQS at present?	Fails MAC EQS modelling tests?	Does the water body pass MAC EQS at present
cypermethrin (Q)	Fail	Pass	Fail	Pass
hexabromocyclododecane (HBCDD)	Pass	Pass	Pass	Pass
sulphide or hydrogen sulphide (Q)	Fail	Fail	Fail	Fail
mercury total	Pass	Pass	Pass	Pass
nickel total	Fail	Pass	Pass	Pass

Determinand	Fails AA EQS modelling tests?	Does the water body pass AA EQS at present?	Fails MAC EQS modelling tests?	Does the water body pass MAC EQS at present
4-n-nonylphenol ( <b>Q</b> )	Fail	Pass	Pass	Pass
perfluorooctane sulfonic acid (PFOS)	Fail	Fail	Pass	Pass
triclosan	Pass	Pass	Pass	Pass
zinc total	Fail	Pass	No MAC EQS	No MAC EQS

## Notes

- (**Q**) denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD. Results for these determinands should be treated with extra caution.
- For Test 1, risk to EQS, the upper confidence range results are used to assess whether a determinand passes or fails. For information, the results for this test state “Pass (face value)” where the test is failed using the upper confidence value but passes using the face value. However, the overall outcome of the modelling tests is considered to be a fail in these cases. Note that for MAC and 95-percentile EQSs, only the face value result is assessed in Test 1.

### 6.2.2 River needs limits

#### Class deterioration

- All of the modelled determinands have an AA EQS,
- 4 determinands would not result in a class deterioration following the proposed discharge,
- 3 determinands are currently failing their EQS in the canal and would continue to do so with the discharge,
- A new class deterioration is predicted for two determinands, cypermethrin (**Q**) and nickel total,
- 8 of the modelled determinands have a MAC EQS. All of these determinands would not result in a class deterioration following the proposed discharge, with the exception of sulphide or hydrogen sulphide which is currently failing its EQS and would continue to do with the discharge.

#### River needs limits

- The river needs limits permissible percentage deterioration allowance has been calculated based on the upstream quality as a percentage of the EQS,

- 2 determinands do not deteriorate by more than the percentage deterioration allowance based on the AA EQS, and 3 determinands do not deteriorate based on the MAC EQS,
- A percentage deterioration greater than the allowance is predicted for the remaining 7 determinands based on the AA EQS and 5 determinands based on the MAC EQS,
- A summary of the percentage deterioration results are presented below:

Table 6-2 Determinands with a predicted percentage deterioration

Determinand	Percentage deterioration (annual average)	Does the water body pass AA EQS at present?	Percentage deterioration (95-percentile)	Does the water body pass MAC EQS at present?
cypermethrin <b>(Q)</b>	✓	Fail	✓	Pass
hexabromocyclododecane (HBCDD)	✓	Pass	✓	Pass
sulphide or hydrogen sulphide <b>(Q)</b>	✓	Fail	-	Fail
mercury total	-	Pass	-	Pass
nickel total	✓	Pass	✓	Pass
4-n-nonylphenol <b>(Q)</b>	✓	Pass	✓	Pass
perfluorooctane sulfonic acid (PFOS)	-	Pass	-	Pass
triclosan	✓	Pass	✓	Pass
zinc total	✓	Fail	No MAC EQS	No MAC EQS

**(Q)** denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD, *and* the LOD is >10% of the EQS. Results for these determinands should be treated with extra caution.

### 6.2.3 Risk of effluent quality deteriorating significantly

The EA guidance for hazardous chemicals includes advice on protecting against future increases in the concentration of chemicals within recycled water. Circumstances which could lead to this occurring include:

- Where trade effluent dischargers have only utilised a small percentage of their permitted discharge limits but increase this due to a change in process or increased production.
- Where increased dosing of wastewater is required as part of the treatment process.

Managing these issues to ensure that the concentrations of chemicals are not inadvertently increased in the recycled water discharged to the Coventry Canal will require an integrated approach considering trade effluent licensing and management of the existing Minworth WwRC and the new "Minworth" AWTP. It is recommended that this issue be reviewed by Severn Trent Operations Process Team and the "Minworth" AWTP design consultants, and discussed with the Environment Agency.

#### 6.2.4 Local water bodies issue

EA guidance recommends that, once modelling tests have been completed, permitting officers consult with local water quality staff to take account of local water body issues. In this case, the Canal & River Trust should also be consulted. Significant engagement regarding the scope and findings of this water quality assessment has been carried out with the EA and Trust, through the Gate 3 engagement and review processes.

### 6.3 Future treatment requirements

Following the assessment of the impact of the present-day recycled water quality, the RQP backward-calculation method was used to calculate the treatment standards that would be required to either meet the EQS or to prevent deterioration. Please note that, subsequent to this assessment, it was identified that RQP incorrectly calculates overly strict treatment requirements when using a combination of continuous and intermittent discharges. Consequently, the results of this section should be treated with caution. Further details of this issued are discussed in section 9.2.3.

#### 6.3.1 Treatment required to meet the target

This test identifies the treatment standard that would need to be met in order to meet the annual average (AA) EQS. In summary, results were:

- All determinands have an AA EQS.
- 4 determinands require no additional treatment to meet the AA EQS.
- 5 determinands would require a percentage reduction of between 32% and 100% to meet the EQS targets in the canal. These are shown in Table 6-3.

Table 6-3 Treatment percentage reduction required to meet AA EQS

Determinand	WW Treatment % reduction required to meet AA EQS	Conc. (µg/l) required to meet target quality
cypermethrin (Q)	73%	0.000071
hexabromocyclododecane (HBCDD)	None	None
sulphide or hydrogen sulphide (Q)	100%	0.003
mercury total	None	None
nickel total	44%	10
4-n-nonylphenol (Q)	None	None

Determinand	WW Treatment % reduction required to meet AA EQS	Conc. (µg/l) required to meet target quality
perfluorooctane sulfonic acid (PFOS)	100%	0.0000065
triclosan	None	None
zinc total	32%	36.1

#### Notes

- The treatment standards required to meet the EQSs for bioavailable metals are shown as the dissolved metal concentration in the recycled water, as the bioavailable calculation is only applied by MPer to the watercourse upstream and downstream of the discharge and not to the discharge itself.

#### 6.3.2 Treatment required to prevent deterioration

This test identifies the treatment standard that would need to be met in order to prevent deterioration in the canal. Note that the test has been applied:

- to any determinands where a deterioration, however small, has been predicted, to test the treatment standard that would be required to prevent all deterioration, and
- where the predicted deterioration is greater than the EQS deterioration allowance set out in the river needs limits (see Table 5-2).

In combination, these two approaches indicate the most strict (a) and least strict (b) treatment standard that would be required to prevent deterioration. In summary, results were:

- No deterioration is predicted for 1 determinand and would require no treatment improvements to meet no deterioration.
- 8 determinands would require a percentage reduction of between 17% (zinc total) and 98% (hexabromocyclododecane (HBCDD)) to prevent a deterioration to their annual average values in the Canal. These are shown in Table 6-4.

Table 6-4 Treatment percentage reduction required to prevent deterioration to the annual average concentration.

Determinand	% reduction required to meet zero det. (Mean)	Conc. (µg/l) required to meet zero det. (Mean)	% det. permitted (see Table 5-2)	% reduction required to meet permitted det. (Mean)	Conc. (µg/l) required to meet permitted det. (Mean)
cypermethrin (Q)	95%	0.000014	30%	94%	0.000016
hexabromocyclododecane (HBCDD)	98%	0.000023	40%	95%	0.000053
sulphide or hydrogen	70%	4.26	3%	67%	4.66

Determinand	% reduction required to meet zero det. (Mean)	Conc. (µg/l) required to meet zero det. (Mean)	% det. permitted (see Table 5-2)	% reduction required to meet permitted det. (Mean)	Conc. (µg/l) required to meet permitted det. (Mean)
sulphide (Q)					
mercury total	73%	0.00247	40%	40%	0.00554
nickel total	78%	4.01	10%	74%	4.55
4-n-nonylphenol (Q)	97%	0.0071	40%	94%	0.016
perfluorooctane sulfonic acid (PFOS)	No Deterioration	No Deterioration	3%	61%	0.0053
triclosan	90%	0.0018	40%	77%	0.004
zinc total	17%	44.2	3%	69%	16.7

**Notes**

- The treatment standards required to meet no deterioration for bioavailable metals are shown as the dissolved metal concentration in the required metal to meet the upstream bioavailable quality in the canal.

## 7 Results for Site 6, GUC at Leighton Buzzard

### 7.1 Introduction

Three scenarios have been tested on the determinands within Monte Carlo / MPer:

- Impact of input on discharge quality
- Required discharge quality to meet target/EQS.
- Required discharge quality to prevent deterioration.

Of the 14 determinands modelled at site 3, only 10 have been sampled at site 6 (Leighton Buzzard). Formaldehyde, mancozeb, maneb, and permethrin have not been assessed at site 6. As 5 determinands were not sampled at site 5, the mixed quality at site 5 could not be calculated and as such the mixed quality at site 3 has been used instead.

### 7.2 Impact of the discharge at existing concentrations

#### 7.2.1 Hazardous chemicals modelling tests

For the hazardous chemicals modelling tests, Figure 2-1 outlines each hazardous chemical test and whether a determinand passes or fails a test. A summary of the overall pass/fail is presented below and the results of each individual test are shown in Appendix B.

Of the 10 determinands modelled:

- 6 determinands pass all of the hazardous chemicals modelling tests (diazinon, hexabromocyclododecane (HBCDD), mercury total, 4-n-nonylphenol, triclosan, and zinc total),
- All of the modelled determinands have an AA EQS, and all determinands except zinc have a MAC EQS,
- Hazardous chemical tests have been undertaken for all determinands,
- 4 determinands fail one or more of the AA EQS modelling tests and 1 fail one or more of the MAC EQS modelling tests. These are listed in Table 7-1. For 4 of these, the EQS is already exceeded in the GUC.

Table 7-1 Determinands which fail one or more of the hazardous chemicals modelling test

Determinand	Fails AA EQS modelling tests?	Does the water body pass AA EQS at present?	Fails MAC EQS modelling tests?	Does the water body pass MAC EQS at present
cypermethrin (Q)	Fail	Fail	Pass	Pass
diazinon (Q)	Pass	Pass	Pass	Pass
hexabromocyclododecane (HBCDD)	Pass	Pass	Pass	Pass
sulphide or hydrogen sulphide	Fail	Fail	Fail	Fail

Determinand	Fails AA EQS modelling tests?	Does the water body pass AA EQS at present?	Fails MAC EQS modelling tests?	Does the water body pass MAC EQS at present
mercury total	Pass	Pass	Pass	Pass
nickel total	Fail	Pass	Pass	Fail
4-n-nonylphenol ( <b>Q</b> )	Pass	Pass	Pass	Pass
perfluorooctane sulfonic acid (PFOS)	Fail	Fail	Pass	Pass
triclosan	Pass	Pass	Pass	Pass
zinc total	Pass	Pass	No MAC EQS	No MAC EQS

## Notes

- (**Q**) denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD, *and* the LOD is >10% of the EQS. Results for these determinands should be treated with extra caution.
- For Test 1, risk to EQS, the upper confidence range results are used to assess whether a determinand passes or fails. For information, the results for this test state “Pass (face value)” where the test is failed using the upper confidence value but passes using the face value. However, the overall outcome of the modelling tests is considered to be a fail in these cases. Note that for MAC and 95-percentile EQSs, only the face value result is assessed in Test 1.

### 7.2.2 River needs limits

#### Class deterioration

- All of the modelled determinands have an AA EQS,
- 7 determinands would not result in a class deterioration following the proposed discharge,
- 3 determinands are currently failing their EQS in the canal and would continue to do so with the discharge,
- 9 of the modelled determinands have a MAC EQS. All of these determinands would not results in a class deterioration following the proposed discharge, with the exception of sulphide or hydrogen sulphide which is currently failing its EQS and would continue to do with the discharge, and.
- No new class deteriorations are predicted.

#### River needs limits

- The river needs limits permissible percentage deterioration allowance has been calculated based on the upstream quality as a percentage of the EQS,

- 4 determinands do not deteriorate by more than the percentage deterioration allowance based on the AA EQS, and 5 determinands do not deteriorate based on the MAC EQS
- A percentage deterioration greater than the allowance is predicted for the remaining 7 determinands based on the AA EQS and 5 determinands based on the MAC EQS.
- A summary of the percentage deterioration results are presented below

Table 7-2 Determinands with a predicted percentage deterioration

Determinand	Percentage deterioration (annual average)	Does the water body pass AA EQS at present?	Percentage deterioration (95-percentile)	Does the water body pass MAC EQS at present?
cypermethrin ( <b>Q</b> )	✓	Fail	-	Pass
diazinon ( <b>Q</b> )	-	Pass	✓	Pass
Hexabromocyclo-dodecane (HBCDD)	✓	Pass	✓	Pass
sulphide or hydrogen sulphide	-	Fail	-	Fail
mercury total	-	Pass	-	Pass
nickel total	✓	Pass	✓	Fail
4-n-nonylphenol ( <b>Q</b> )	✓	Pass	✓	Pass
perfluorooctane sulfonic acid (PFOS)	✓	Fail	✓	Pass
triclosan	✓	Pass	✓	Pass
zinc total	✓	Pass	No MAC EQS	No MAC EQS

**(Q)** denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD, *and* the LOD is >10% of the EQS. Results for these determinands should be treated with extra caution.

### 7.2.3 Risk of effluent quality deteriorating significantly

The EA guidance for hazardous chemicals includes advice on protecting against future increases in the concentration of chemicals with treated effluent. Circumstances which could lead to this occurring include:

- Where trade effluent dischargers have only utilised a small percentage of their permitted discharge limits, but increase this due to a change in process or increased production.
- Where increased dosing of wastewater is required as part of the treatment process.

Managing these issues to ensure that the concentrations of chemicals are not inadvertently increased in the recycled water discharged to the Coventry Canal will require an integrated approach considering trade effluent licensing and management of the existing Minworth WwRC and the new "Minworth" AWTP. It is recommended that this issue be reviewed by Severn Trent Operations Process Team and the "Minworth" AWTP design consultants, and discussed with the Environment Agency.

#### 7.2.4 Local water bodies issue

EA guidance recommends that, once modelling tests have been complete, permitting officers consult with local water quality staff to take account of local water body issues. In this case, the Canal & River Trust should also be consulted. Significant engagement regarding the scope and findings of this water quality assessment has been carried out with the EA and Trust, through the Gate 3 engagement and review processes.

### 7.3 Future treatment requirements

Following the assessment of the impact of the present-day recycled water quality, the RQP backward-calculation method was used to calculate the treatment standards that would be required to either meet the EQS or to prevent deterioration. Please note that, subsequent to this assessment, it was identified that RQP incorrectly calculates overly strict treatment requirements when using a combination of continuous and intermittent discharges. Consequently, the results of this section should be treated with caution. Further details of this issued are discussed in section 9.2.3.

#### 7.3.1 Treatment required to meet the target

This test identifies the treatment standard that would need to be met in order to meet the annual average (AA) EQS. The backward calculation method in RQP was applied. In summary, results were:

- All determinands have an AA EQS.
- 7 determinands require no additional treatment to meet the AA EQS.
- 3 determinands would require a percentage reduction of between 89% and 100% to meet the EQS targets in the canal. These are shown in Table 7-3.

Table 7-3 Treatment percentage reduction required to meet AA EQS

Determinand	WW Treatment % reduction required to mee AA EQS	Conc. (µg/l) required to meet target quality
cypermethrin (Q)	89%	0.000029
diazinon (Q)	None	None
hexabromocyclododecane (HBCDD)	None	None
sulphide or hydrogen sulphide	100%	0.003
mercury total	None	None

Determinand	WW Treatment % reduction required to meet AA EQS	Conc. (µg/l) required to meet target quality
nickel total	None	None
4-n-nonylphenol (Q)	None	None
perfluorooctane sulfonic acid (PFOS)	100%	0.000007
triclosan	None	None
zinc total	None	None

#### Notes

- The treatment standards required to meet the EQSs for bioavailable metals are shown as the dissolved metal concentration in the recycled water (as the bioavailable calculation is only applied by MPer to the watercourse upstream and downstream of the discharge).

#### 7.3.2 Treatment required to prevent deterioration

This test identifies the treatment standard that would need to be met in order to prevent deterioration in the canal. Note that the test has been applied:

- to any determinands where a deterioration, however small, has been predicted, to test the treatment standard that would be required to prevent all deterioration, and
- where the predicted deterioration is greater than the EQS deterioration allowance set out in the river needs limits (see Table 5-2).

In combination, these two approaches indicate the most strict (a) and least strict (b) treatment standard that would be required to prevent deterioration. In summary, results were:

- No deterioration is predicted for 2 determinands would require no treatment improvements to meet no deterioration.
- 8 determinands would require a percentage reduction of between 23% (zinc total) and 97% (hexabromocyclododecane (HBCDD)), to prevent a deterioration to their annual average values in the Canal. These are shown in Table 7-4.

Table 7-4 Treatment percentage reduction required to prevent deterioration to the annual average concentration.

Determinand	% reduction required to meet zero det. (Mean)	Conc. (µg/l) required to meet zero det. (Mean)	% det. permitted (see Table 5-2)	% reduction required to meet permitted det. (Mean)	Conc. (µg/l) required to meet permitted det. (Mean)
cypermethrin (Q)	89%	0.000029	3%	88%	0.000032
diazinon (Q)	77%	0.0015	40%	44%	0.0036

Determinand	% reduction required to meet zero det. (Mean)	Conc. (µg/l) required to meet zero det. (Mean)	% det. permitted (see Table 5-2)	% reduction required to meet permitted det. (Mean)	Conc. (µg/l) required to meet permitted det. (Mean)
hexabromocyclododecane (HBCDD)	97%	0.000029	40%	93%	0.000072
sulphide or hydrogen sulphide	No Deterioration	No Deterioration	3%	No Deterioration	No Deterioration
mercury total	No Deterioration	No Deterioration	40%	No Deterioration	No Deterioration
nickel total	79%	3.78	20%	73%	4.8
4-n-nonylphenol (Q)	97%	0.0067	40%	94%	0.016
perfluorooctane sulfonic acid (PFOS)	97%	0.00041	3%	97%	0.00046
triclosan	91%	0.0015	40%	79%	0.0036
zinc total	72%	14.8	3%	71%	15.4

#### Notes

- The treatment standards required to meet no deterioration for bioavailable metals are shown as the dissolved metal concentration in the required metal to meet the upstream bioavailable quality in the canal.

## 8 Results for Temperature at Site 3, Coventry Canal at Atherstone

### 8.1 Overview

Changes in temperature as result of new discharges into a waterbody have the potential to impact fish.

Temperature impacts are most likely to occur in the Coventry Canal, as temperature will tend to change, according to weather conditions, as the transfer moves south. Therefore the temperature modelling was limited to the Coventry Canal.

### 8.2 Standards

The EA have set temperature standards for rivers which receive thermal discharges in their advice on H1 assessments (Environment Agency, 2014), and in additional advice on modelling temperature (Environment Agency, 2024). The relevant standards for a cyprinid fishery such as the Coventry Canal are shown in Table 8-1.

Table 8-1: Temperature standards for rivers receiving thermal discharges, cyprinid fishery

Standard	Class (for rivers receiving thermal discharges)			
	High	Good	Moderate	Poor
River temperature (°c) as an annual 98-percentile standard	25	28	30	32
Increase or decrease in temperature (°c) in relation to the ambient river temp, as an annual 98-percentile standard	2	3	-	-

The EA advise modelling the impacts both annually and for the summer period. For the purpose of this assessment we have defined summer as June, July and August.

### 8.3 Modelling temperature

#### 8.3.1 Software selection

The EA advise the use of RQP for assessing the impacts of a thermal discharge to a river. In lakes and canals, where mixing may only be partial leading to the formation of temperature stratification and hot zones, more complex modelling may be required. However, due to the high volume of the GUC transfer, during operation the canal will function more like a slow-flowing river and transfer waters will dominate. RQP was therefore selected to model temperature impacts.

#### 8.3.2 Temperature data analysis

Temperature data was analysed from sondes monitoring sites 1 and 3 for the following periods:

- Site 1 (Minworth WwRC final effluent) 04/03/2021 - 31/12/2023
- Site 3 (Coventry Canal at Atherstone) 11/05/2022 - 31/12/2023

Temperature has been recorded every 30 minutes at Minworth and hourly at Atherstone. A single calendar year of data, 2023, was analysed in order to avoid data distortions as a result of different time periods at the two sites and to avoid some months being over-represented in the annual average. The observed data is shown in Figure 8-1. There is a period of drop-out at Atherstone between 1<sup>st</sup> and 13<sup>th</sup> June 2023.

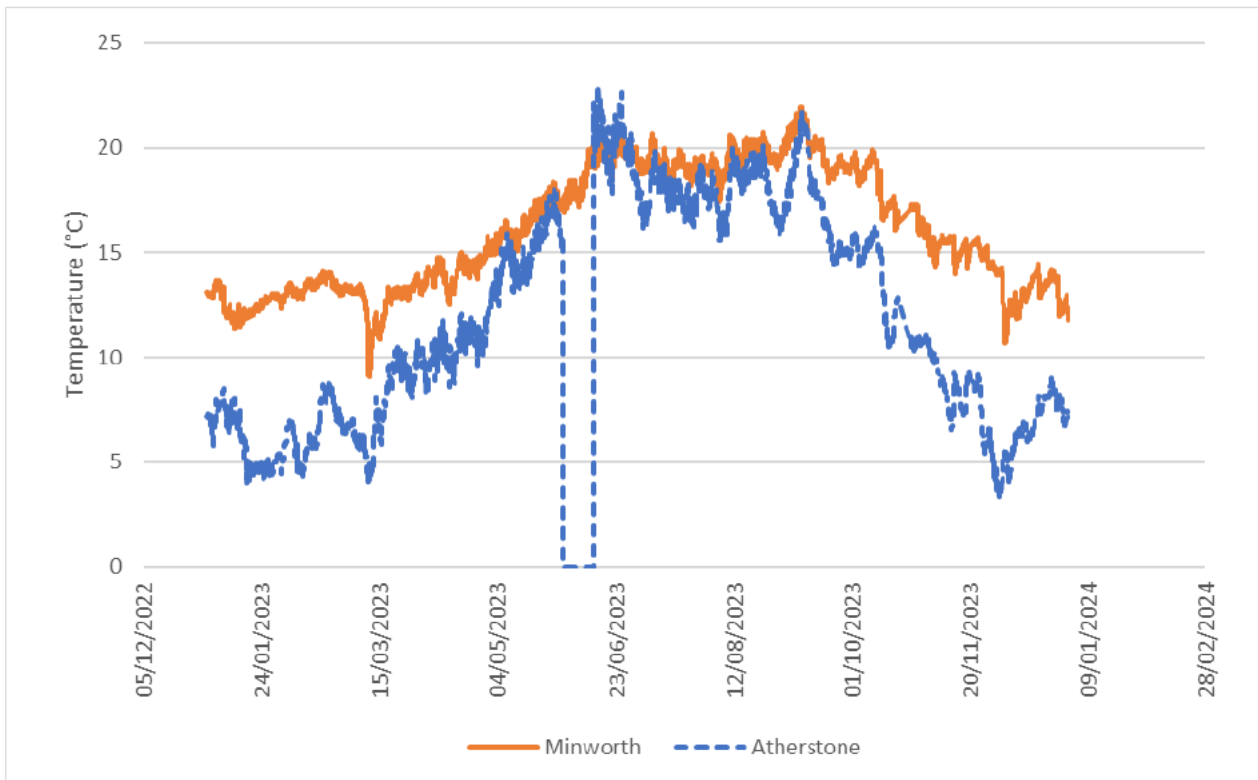


Figure 8-1: Water temperature at Minworth and Atherstone, 2023

The following baseline statistics were derived:

Table 8-2: Temperature statistics

Period	Statistic	Site 1 (Minworth WwRC) temperature (°C)	Site 3 (Coventry Canal at Atherstone) temperature (°C)
Annual	Mean	16.1	12.5
	Std. deviation	2.9	5.1
	98 <sup>th</sup> percentile	20.7	20.8
Summer (June - August)	Mean	19.3	18.3
	Std. deviation	0.7	1.3
	98 <sup>th</sup> percentile	20.4	21.4

RQP is unable to handle negative quality or flow data. To avoid this occurring, temperatures were converted to Kelvin for modelling, then converted back to Celsius for presentation of results.

### 8.3.3 Flow

A continuous recycled water flow discharge was applied,<sup>3</sup> with modelled flow statistics shown in Table 8-3. The correlations for flow and temperature were calculated by comparing the observed monthly mean temperatures with the modelled monthly mean flows.

Table 8-3: Flow statistics for temperature simulations

Period	Statistic	Site 1 (Minworth WwRC) temperature (°C)	Site 3 (Coventry Canal at Atherstone) temperature (°C)
Annual	Mean	57.98	5.67
	Std. deviation	38.49	1.40
	95th percentile	28.75	3.94
	Flow correlation	-0.79	
	Quality correlation	0.83	-0.92
Summer (June - August)	Mean	115.00	4.23
	Std. deviation	0.001	0.44
	95th percentile	115.00	3.97
	Flow correlation	-0.53	
	Quality correlation	0.31	-0.76

## 8.4 Temperature impact assessment results

Results indicate that the proposed recycled water discharge would pass the 98<sup>th</sup> percentile high class standard of 25°C and an increase of no more than 2°C, both annually and for the summer period. In the summer period, the 98<sup>th</sup> percentile temperature is actually predicted to decrease as a result of the discharge. Whilst this at first seems anomalous given the higher mean temperature of the discharge, as Figure 8-1 shows the highest temperatures observed at either location were observed in the Coventry Canal at Atherstone during late June and early July, and it is this period of high temperatures that contains the 98<sup>th</sup> percentile value.

<sup>3</sup> This was in order to avoid an issued identified with backward-calculation results identified in RQP when using a continuous and intermittent discharge. See section 9 for details.

Table 8-4: Impact of discharge temperature downstream, 98<sup>th</sup> percentile

Period	Site 3 observed (°C)	Target (°C)	Site 3 with-scheme result (°C)	Target pass / fail	Max allowable change (°C)	Change (°C)	Change pass / fail
Annual 90%ile	20.8	25	22.1	Pass	2	1.3	Pass
Summer 98%ile	21.4	25	20.7	Pass	2	-0.7	Pass

In conclusion, whilst the discharge will increase mean temperatures in the canal, the absolute temperature and the change in temperature will remain within permissible levels for both the annual period and the summer period.

## 9 Preliminary scheme impact assessment using bench-trial treatment results

### 9.1 Introduction

A bench trial has been undertaken by WatStech Laboratories to represent the potential treatment processes that would be present at the "Minworth AWTP" (see Minworth SRO Annex A3 for full details). Results from this assessment are presented in Table 6 in the bench testing summary report produced by WatStech and have been used to update the Site 1 (Minworth) discharge quality values used within the modelling. A summary of results from the WatStech report is presented below.



**Table 6: Bench scale testing average values with comparison to standards and % removals**

No.	Determinand	Units	GUC	STT	EQS		Minworth Final Effluent	Bench Testing		Bench Testing Average % Removal
			Long Term Average	Long Term Average	MAC	Annual Average AA	Long Term Average	Average Influent	Effluent Average	Minworth Influent used if bench-scale Influent not tested
1	Cobalt Total	µg/l	17.687	0.636	100	3	1.96	not tested	0.92	53
2	Cyanide, total	µg/l	<40	<40	5	1	<40	2.2	0.90	59
3	Cypermethrin	µg/l	0.000096	0.0002	0.0006	0.00008	0.00023	0.00030	<0.00008	73
4	Diazinon	µg/l	<0.01	<0.01	0.02	0.01	0.0106	not tested	<0.01	6
5	Fluoranthene	µg/l	0.0125	0.0153	0.12	0.0063	0.0023	not tested	0.001	57
6	Formaldehyde	µg/l	<50	<50	50	5	51	not tested	not tested	not tested
7	HBCDD	µg/l	0.0002	0.000606	0.5	0.0016	0.00107	0.00055	<0.00014	75
8	Hydrogen Sulfide	µg/l	15.174	16.292	1	0.25	16.226	not tested	<10	38
9	Mancozeb	µg/l	0.145	0.358	20	2	1.297	0.28	0.1	64
10	Maneb	µg/l	0.182	0.396	30	3	0.903	0.48	0.1	79
11	Mercury	µg/l	0.0226	0.0123	0.07	assume 0.07	0.1331	0.01575	<0.001	94
12	Nickel (Bioavailable)	µg/l	10.905	1.297	34	4	2.856	not tested	5.27	increases after bench-scale tests
13	Nonylphenol	µg/l	0.0409	0.13	2	0.3	0.31	0.19	<0.04	79
14	Permethrin	µg/l	0.00104	0.0012	0.01	0.001	0.00259	0.00125	<0.001	20
15	PFOS	µg/l	0.00496	0.0047	36	0.00065	0.0146	0.01157	<0.0002	98
16	Triclosan	µg/l	<0.01	0.0105	0.28	0.1	0.02	0.01	<0.01	no change
17	Zinc (Bioavailable)	µg/l	18.87	4.232	n/a	10.9	14.84	not tested	22.41	increases after bench-scale tests
18	Benzo (g,h,i)-perylene	µg/l	0.0075	0.0148	0.0082	assume 0.0082	0.0019	not tested	not tested	not tested

$$\text{Bench scale \% removal} = \frac{(\text{Influent} - \text{Effluent}) * 100}{\text{Influent}}$$

**Table 7: Key to Table 6**

KEY TO COLOURS	
Reduces conc. below EQS & satisfies no deterioration clause	Process reduces concentration in line with the EQS and No-Deterioration Clause
Reduces conc. but not below EQS & breaches no deterioration clause	Process reduces concentration however not below the EQS and/or still breaches the No-Deterioration Clause
Below EQS but breaches no deterioration clause	Process does NOT satisfy No-Deterioration Clause but below EQS
Not below EQS but satisfies no deterioration clause	Process satisfies, no deterioration clause but not below EQS
Conc. does not reduce below EQS & breaches no deterioration clause	Process does not reduce concentration, does NOT satisfy No-Deterioration Clause and NOT below EQS
Not Tested	Chemical not tested or influent below the limit of detection

Figure 9-1: Table 6 results from Minworth bench trial summary report

The Limits of Detection (LODs) applied in the bench-trials are compared to EQS values and National Laboratory Service (NLS) Minimum Reporting Values (MRVs) in Table 9-1. This identifies that:

- In all cases, where an MRV is defined by NLS, this has been met or bettered.
- For HBCDD, mancozeb, maneb, mercury, PFOS and triclosan, the LOD is  $\leq 10\%$  of the Annual Average EQS. For these determinands, the LOD is sufficient to apply the modelling tests with confidence.
- For cypermethrin, diazinon, 4-nonylphenols, permethrin and sulphide, the LOD is  $>$  the AA EQS, which may impact the ability to draw decisive conclusions from the modelling.

Table 9-1: Review of LODs used in bench-trials

Determinand	LOD applied in bench-trials ( $\mu\text{g/l}$ )	AA EQS ( $\mu\text{g/l}$ )	LOD $\leq 10\%$ of AA EQS?	MAC EQS ( $\mu\text{g/l}$ )	LOD $\leq 10\%$ of MAC EQS?	NLS MRV for final effluent ( $\mu\text{g/l}$ )	LOD $\leq$ MRV?
Cypermethrin	0.00008	0.00008	No	0.0006	Yes	0.03	Yes
diazinon	0.01	0.01	No	0.02	No	0.01	Yes
HBCDD	0.00014	0.0016	Yes	0.5	Yes	0.0002 (surface water)	Yes
mancozeb	0.1	2	Yes	20	Yes	None identified	N/A
maneb	0.1	3	Yes	30	Yes	None identified	N/A
mercury, total	0.0001	0.07	Yes	0.07	Yes	0.01	Yes
nonylphenols (4-nonylphenol technical mix)	0.04	0.3	No	2	Yes	0.2	Yes
permethrin	0.001	0.001	No	0.01	Yes	0.06	Yes
PFOS	0.00009	0.00065	Yes	36	Yes	0.00009 (surface water)	Yes
sulphide or hydrogen sulphide	10	0.25	No	0.28	No	None identified	N/A
triclosan	0.01	0.1	Yes	0.28	Yes	0.01 (surface water)	Yes

## 9.2 Methodology

### 9.2.1 Overview

This modelling follows the same methodology for the Site 3 analysis, see Section 2.2, but with an updated quality to represent the bench trial Minworth final recycled water.

The mean discharge quality modelled for site 1 has been set as the 'Bench Testing Effluent Average' in 'Table 6' of the Minworth SRO Bench Trial summary report.

In the absence of standard deviation values in Table 6, the Coefficient of Variation (CoV) has been calculated from the sampled site 1 mean and standard deviation. The 'Bench Testing Effluent Average', from Table 6 has then been multiplied by the CoV to calculate the standard deviation. 4 samples have been assumed for each determinand. The CoV calculated for each determinand is presented in Table 9-2.

Table 9-2: Coefficient of Variation (CoV) calculations

Determinand	Site 1 Mean (µg/l)	Site 1 St. dev	CoV
Cypermethrin	0.0003	0.0002	0.6031
diazinon	0.0064	0.0038	0.5929
hexabromocyclododecane (HBCDD), total	0.0010	0.0007	0.7624
mancozeb (as carbon disulfide)	1.2435	0.9134	0.7345
maneb (as carbon disulfide)	1.1435	1.1021	0.9638
mercury, total	0.0093	0.0185	1.9886
nonylphenols (4-nonylphenol technical mix)	0.2603	0.0074	0.0286
permethrin	0.0022	0.0020	0.9409
PFOS	0.0137	0.0064	0.4695
sulphide or hydrogen sulphide	14.1875	9.7930	0.6903
triclosan	0.0175	0.0151	0.8617

The bench testing report notes that the bioavailable calculations may not be representative of the Minworth final recycled water as zinc and nickel values may be inflated due to the small sample size. As such they have not been modelled. Formaldehyde was not included in the bench testing analysis and therefore has also not been modelled. For PFOS, the Rapid Small Scale Column Test (RSSCT) bench trial tested both Granular Activated

Carbon (GAC) F400 and an innovative media<sup>4</sup>, both separately and combined. All three of these tests showed that a reduction in concentration below the EQS (0.00065µg/l) is achievable providing each method is managed over time, PFOS has therefore been modelled with a discharge quality of 0.00065µg/l. The results of the bench trial for PFOS are shown below; outlet 2 was both F400 and the innovative media, outlet 3 was just the innovative media and outlet 4 just F400.

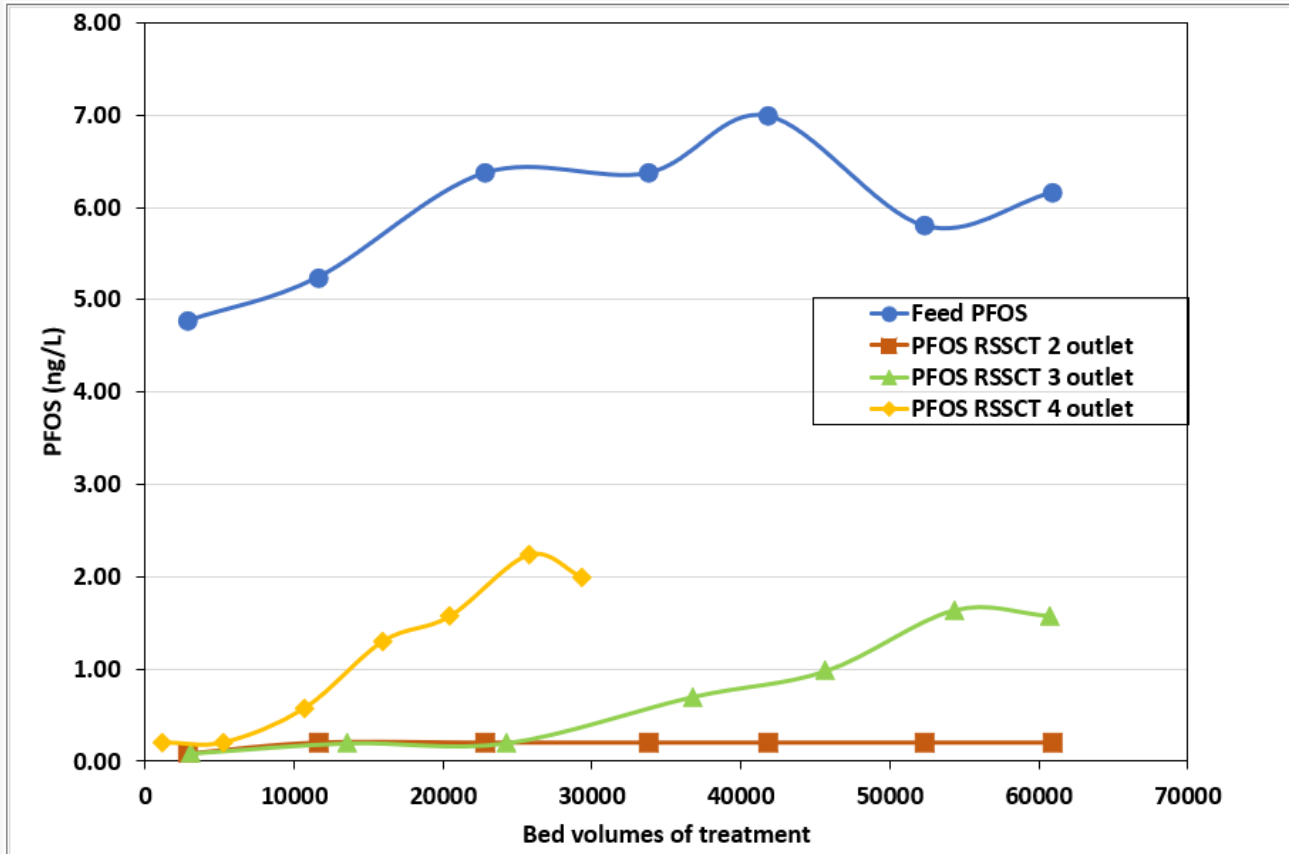


Figure 9-2: PFOS bench trial results

Source: redacted Minworth PFAS RSSCT (Severn Trent) Minworth SRO Annex A3.

### 9.2.2 Comparison with input values used in the bench trials

It was noted that the input values into the bench trial differ from inputs into the modelling. Following EA guidance (Environment Agency, 2019) for water quality impact modelling, outlier values have been removed and "less-than" values below the LOD were taken as half the face value. By contrast, at the screening assessment stage qualified values are taken at face value. These differences were investigated for mancozeb, which was modelled with a site 3 canal water quality of 0.098µg/l for the bench trial, a concentration of 0.145µg/l has been used.

It was determined that the differences in inputs between the two assessments were due to:

<sup>4</sup> The details of this innovative media are not known to JBA and are subject to a non-disclosure agreement between the supplier and Severn Trent.

- The number of rounds of samples available for each assessment. Samples up to round 33 have been used in the modelling. Mancozeb samples between 19/04/2021 and 16/10/2023 have been used in the modelling.
- Outliers removed from the sampled data. Sampled values of 1.5µg/l and 1.3µg/l have been removed for mancozeb in the modelling.
- Qualified samples (samples at the LOD) treated as half the face value. Qualified values for mancozeb have been halved from 1.0µg/l to 0.5µg/l.

The impact of these changes to the sample data on the mean and standard deviation are shown in Table 9-3.

Table 9-3: Impact of data processing on mean and standard deviation values for mancozeb

Parameter	Raw sample data	Outliers removed from sampled data	Qualified results taken as half face value	Bench trial (long term average) concentration
Mean	0.216µg/l	0.137µg/l	0.098µg/l	0.145µg/l
St dev	0.317µg/l	0.084µg/l	0.072µg/l	n/a

This is also believed to be the reason for differences in the Minworth discharge (site 1). For consistency with the modelling at sites 3, 5, and 6, and following EA guidance, the processing of values for modelling has been left unchanged and as such some differences between the results presented in this section and in the bench trials report are expected.

### 9.2.3 Modelling discharges as continuous and intermittent

Section 3.2 reports how, at the request of the Environment Agency, that the recycled water discharge has been modelled using both a continuous and intermittent flow. During testing it was identified that this approach produces excessively low requirements to meet target concentrations within RQP. In some cases, this is almost 50% tighter than the upstream river quality, see Table 9-4.

A trial was carried out, using mancozeb as an example, to compare the continuous and intermittent approach with a continuous-only approach.

A comparison of how the flows were represented in these two approaches is shown below.

Continuous only:

Mean (continuous) flow: 58.0MI/d

Standard deviation: 36.9MI/d

Continuous and Intermittent:

Mean (continuous) flow: 28.8MI/d

Mean (intermittent) flow: 70.2MI/d

Standard deviation: 0.0MI/d

Standard deviation: 21.1MI/d

% time in operation: 41.7%

Mean (Intermittent) flow:  $41.7\% * 70.2 = 29.27\text{MI/d}$

Note that both methods represent the annual variation of discharge. The concentration of mancozeb within the present day Minworth discharge is sampled as a mean value of  $1.24\mu\text{g/l}$ . When converted using a simple load calculation (flow \* discharge quality) based on the above flows, a similar load of approximately  $72\text{g/d}$  is calculated for both flow representation methods, see below:

Continuous Load:  $58.0 * 1.24 = 71.92\text{g/d}$

Continuous + Intermittent Load:  $58.07 * 1.24 = 72.01\text{g/d}$

As shown above, the loads calculated for both methods are similar for Mancozeb and this was considered likely to be the same for the other determinands.

Calculations of the required concentration to meet no deterioration and the permissible deterioration were undertaken using both methods and results are presented in Table 9-4. Inputs and results from the RQP assessment are provided in Appendix E.

Table 9-4: Comparison of results between the two flow representations

Minworth flow representation	Impact on DS quality	Quality to meet EQS	Quality to meet no deterioration	Quality to meet permitted deterioration	Bench trial achieved quality
Continuous + Intermittent	$1.12\mu\text{g/l}$	$1.42\mu\text{g/l}$	$0.051\mu\text{g/l}$	$0.079\mu\text{g/l}$	$0.1\mu\text{g/l}$
Continuous	$1.09\mu\text{g/l}$	$2.28\mu\text{g/l}$	$0.099\mu\text{g/l}$	$0.14\mu\text{g/l}$	$0.1\mu\text{g/l}$

Whilst the impact downstream is similar between both inflows, the quality required to meet the EQS, no deterioration and permitted deterioration are close to 100% tighter with a continuous and intermittent flow than with a continuous-only flow. As shown in the RQP calculations (Appendix E) when a continuous only flow is applied, the resultant downstream river quality matches the required quality, however when both a continuous and intermittent flow is applied, the resultant downstream river quality is a tighter quality than the target quality set in RQP. This is shown in Figure 9-3.



Figure 9-3: RQP required to meet no deterioration results for mancozeb (continuous and intermittent flows, left, continuous only flows, right).

As shown in Figure 9-3, when a target is set to the upstream water quality (0.098µg/l), the resultant mean downstream river quality only matches in the continuous-only scenario. It is believed that to meet the downstream target, the mean downstream river quality should match this target, however this does not occur in the continuous and intermittent combined flow scenario.

This is believed to be an anomaly with the addition of intermittent flows that causes RQP to calculate the required discharge mean for a different downstream target than the one specified, and hence the results indicate a different downstream river quality than expected. As such, the continuous-only method has been taken forward for this assessment.

### 9.3 Impact of the bench-trial discharge

One scenario has been tested on the determinands within Monte Carlo:

- Impact of input on discharge quality

Of the 14 determinands modelled at site 3, 5, and 6, only 13 have been considered within the bench trial. Of these 13, the bioavailable metal results for zinc total and nickel total were not reliable and have been excluded.

#### 9.3.1 Hazardous chemicals modelling tests

For the hazardous chemicals modelling tests, Figure 2-1 outlines each hazardous chemical test and whether a determinand passes or fails a test. A summary of the overall pass/fail is presented below and the results of each individual test are shown in Appendix B.

Of the 11 determinands modelled:

- 7 determinands pass all of the AA hazardous chemicals modelling tests (diazinon, hexabromocyclododecane (HBCDD), mancozeb, maneb, mercury total, 4-n-nonylphenol, and triclosan), and 9 determinands pass all the MAC hazardous chemical tests (4-n-nonylphenol, diazinon, HBCDD, mancozeb, maneb, mercury, PFOS, permethrin and triclosan).
- All of the modelled determinands have an AA EQS and a MAC EQS.
- Hazardous chemical tests have been undertaken for all determinands.
- 4 determinands fail one or more of the AA EQS modelling tests and 2 fail one or more of the MAC EQS modelling tests. These are listed in Table 9-5. For 2 of these (PFOS and sulphide), the EQS is already exceeded in the GUC.

Table 9-5 Determinands which fail one or more of the hazardous chemicals modelling test

Determinand	Fails AA EQS modelling tests?	Does the water body pass AA EQS at present?	Fails MAC EQS modelling tests?	Does the water body pass MAC EQS at present
cypermethrin (Q)	Fail	Pass	Fail	Pass
diazinon (Q)	Pass	Pass	Pass	Pass
hexabromocyclododecane (HBCDD)	Pass	Pass	Pass	Pass
sulphide or hydrogen sulphide (Q)	Fail	Fail	Fail	Fail
mancozeb	Pass	Pass	Pass	Pass
maneb	Pass	Pass	Pass	Pass
mercury total	Pass	Pass	Pass	Pass
4-n-nonylphenol (Q)	Pass	Pass	Pass	Pass
perfluorooctane sulfonic acid (PFOS)	Fail	Fail	Pass	Pass
permethrin (Q)	Fail	Pass	Pass	Pass
triclosan	Pass	Pass	Pass	Pass

### Notes

- (Q) denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD, and the LOD is >10% of the EQS. Results for these determinands should be treated with extra caution.
- For Test 1, risk to EQS, the upper confidence range results are used to assess whether a determinand passes or fails. For information, the results for this test state “Pass (face value)” where the test is failed using the upper confidence value

but passes using the face value. However, the overall outcome of the modelling tests is considered to be a fail in these cases. Note that for MAC and 95-percentile EQSs, only the face value result is assessed in Test 1.

### 9.3.2 River needs limits

#### Deterioration

- All of the modelled determinands have an AA EQS,
- 8 determinands would result in concentrations lower than the EQS downstream of the proposed discharge,
- 2 determinands (PFOS and sulphide or hydrogen sulphide) are currently failing their EQS in the canal and would continue to do so with the discharge,
- 1 determinand (cypermethrin), would result in an EQS failure following the proposed discharge. However, this is likely to be an anomalous result arising from the Limit of Detection applied to the bench-trials being equal to the EQS for cypermethrin.
- All of the modelled determinands have a MAC EQS. 9 of these determinands would result in concentrations lower than the EQS downstream of the proposed discharge.
- Sulphide or hydrogen sulphide is currently failing its MAC EQS and would continue to do with the discharge. A MAC EQS failure is predicted as a result of the discharge of cypermethrin.

#### River needs limits

- The river needs limits permissible percentage deterioration allowance has been calculated based on the upstream quality as a percentage of the EQS,
- 10 determinands do not deteriorate by more than the percentage deterioration allowance based on the AA EQS, and 7 determinands do not deteriorate based on the MAC EQS,
- A percentage deterioration greater than the allowance is predicted for the remaining determinand (cypermethrin) based on the AA EQS and 4 determinands (cypermethrin, diazinon, mancozeb and triclosan) based on the MAC EQS,
- A summary of the percentage deterioration results are presented below.

Table 9-6 Determinands with a predicted percentage deterioration

Determinand	Percentage deterioration (annual average)	Does the water body pass AA EQS at present?	Percentage deterioration (95-percentile)	Does the water body pass MAC EQS at present?
cypermethrin (Q)	✓	Pass	✓	Pass
diazinon (Q)	-	Pass	✓	Pass
hexabromocycl	-	Pass	-	Pass

Determinand	Percentage deterioration (annual average)	Does the water body pass AA EQS at present?	Percentage deterioration (95-percentile)	Does the water body pass MAC EQS at present?
ododecane (HBCDD)				
sulphide or hydrogen sulphide <b>(Q)</b>	-	Fail	-	Fail
mancozeb	-	Pass	✓	Pass
maneb	-	Pass	-	Pass
mercury total	-	Pass	-	Pass
4-n-nonylphenol <b>(Q)</b>	-	Pass	-	Pass
perfluorooctane sulfonic acid (PFOS)	-	Fail	-	Pass
permethrin <b>(Q)</b>	-	Pass	-	Pass
triclosan	-	Pass	✓	Pass

**(Q)** denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD, *and* the LOD is >10% of the EQS. Results for these determinands should be treated with extra caution.

#### 9.4 Discharge quality required to meet no deterioration and the permissible deterioration

The required discharge calculations have been undertaken using continuous flow only versions of the site 3 inputs from Section 5 to understand what concentration reductions are needed to meet these targets. The concentrations required to meet no deterioration, and the permitted deterioration, were compared against the 'Bench testing effluent average' column in Table 6. This is shown in Table 9-7 for the Annual Average results and in Table 9-8 for the Maximum Average Concentration results.

Table 9-7: Concentrations required to meet no deterioration and the permitted deterioration (AA)

Determinand	Concentration required to achieve no deterioration (µg/l)	Concentration required to achieve permitted deterioration (µg/l)	Concentration achieved in bench-test (µg/l)	Outcome
Cypermethrin	0.000059	0.000065	<0.0000800	Required targets below

Determinand	Concentration required to achieve no deterioration (µg/l)	Concentration required to achieve permitted deterioration (µg/l)	Concentration achieved in bench-test (µg/l)	Outcome
				bench trial LOD
Diazinon	0.0050	0.0073	<0.0100	Required targets below bench trial LOD
Formaldehyde	25.1	26.0	Not tested	N/A
Hexabromo cyclododecane HBCDD	0.000089	0.000130	<0.000140	Discharge <10% of EQS - not liable to cause pollution
Sulphide	12.8	13.3	<10.00	Deterioration can be prevented
Mancozeb	0.099	0.14	0.100	Deterioration can be kept within permitted limits
Maneb	0.2	0.3	0.1	Deterioration can be prevented
Mercury total	0.0093	0.0140	<0.0010	Deterioration can be prevented
Nickel total	51.8	53.5	5.27	Deterioration can be prevented
4-nonylphenol	0.025	0.026	<0.040	Required targets below bench trial LOD
PFOS	0.00475	0.00491	<0.00020	Deterioration can be prevented
Permethrin	0.00059	0.00079	<0.00100	Required targets below bench trial LOD
Triclosan	0.0056	0.0081	<0.0100	Discharge <10% of EQS -

Determinand	Concentration required to achieve no deterioration (µg/l)	Concentration required to achieve permitted deterioration (µg/l)	Concentration achieved in bench-test (µg/l)	Outcome
				not liable to cause pollution
Zinc total	69.60	71.90	22.41	Deterioration can be prevented

For assessing against the MAC bench trial results, a 95-percentile achieved concentration was not available. For the comparison in Table 9-8, the concentration achieved in the bench trial has been taken as the highest concentration recorded in the bench trial raw data at the filter outlet.

Table 9-8: Concentrations required to meet no deterioration and the permitted deterioration (MAC)

Determinand	Concentration required to achieve no deterioration (µg/l)	Concentration required to achieve permitted deterioration (µg/l)	Concentration achieved in bench-test (µg/l)	Outcome
Cypermethrin	0.000056	0.000083	<0.00008	Deterioration can be kept within permitted limits
Diazinon	0.0050	0.0074	<0.0100	Required targets below bench trial LOD
Formaldehyde	25	36.7	Not tested	N/A
Hexabromo cyclododecane HBCDD	0.000086	0.00012	<0.00014	Discharge <10% of EQS - not liable to cause pollution
Sulphide	12.2	12.7	12	Deterioration can be prevented
Mancozeb	0.094	0.14	<0.1	Deterioration can be kept within permitted limits
Maneb	0.17	0.27	0.2	Deterioration can be kept within permitted limits
Mercury total	0.0074	0.011	0.002	Deterioration can be prevented

Determinand	Concentration required to achieve no deterioration (µg/l)	Concentration required to achieve permitted deterioration (µg/l)	Concentration achieved in bench-test (µg/l)	Outcome
Nickel total	83.9	86.6	15	Deterioration can be prevented
4-nonylphenol	0.025	0.036	<0.04	Discharge <10% of EQS - not liable to cause pollution
PFOS	0.00462	0.00682	0.0017	Deterioration can be prevented
Permethrin	0.00057	0.00084	<0.001	Discharge <10% of EQS - not liable to cause pollution
Triclosan	0.0054	0.008	<0.01	Discharge <10% of EQS - not liable to cause pollution
Zinc total	N/A	N/A	N/A	N/A - no MAC EQS

In conclusion, the concentration required to prevent deterioration of the annual average was achieved in the bench trials for sulphide, maneb, mercury total, nickel total, PFOS and zinc total, and the concentration required to limit deterioration down to permissible levels was achieved for mancozeb. For cypermethrin, diazinon, hexabromocyclododecane (HBCDD), 4-n-nonylphenol, permethrin, and triclosan, the required targets were below the limit of detection used for the bench trials, so it is not possible to conclude whether the bench trial achieved the target concentration. However, for HBCDD and triclosan, the bench trial was achieving <10% of the EQS, so these are considered to be not liable to cause pollution.

Considering the MAC EQS, deterioration can be prevented for sulphide, mercury total, nickel total and PFOS, and kept within permitted limits for cypermethrin, mancozeb and maneb. For diazinon, hexabromocyclododecane (HBCDD), 4-n-nonylphenol, permethrin, and triclosan, the required targets were below the limit of detection used for the bench trials, so it is not possible to conclude whether the bench trial achieved the target concentration. However, for HBCDD, 4-nonylphenol, permethrin and triclosan, the bench trial was achieving <10% of the EQS, so these are considered to be not liable to cause pollution. There is no MAC EQS for zinc total, therefore this was not assessed.

The results of the bench-test exercise were the best available information as of April 2024 to inform this modelling. It is important to recognise that the outcomes from these bench tests still need to be replicated at pilot or full plant scale to determine feasibility of removal rates. Testing of effluent from the pilot plant should aim to achieve a LOD of 10% of EQS or lower wherever possible, in order to determine whether the concentration required to prevent deterioration has been achieved.

## 9.5 Environmental impact

The environmental impact of the discharge are being investigated in a separate report by AECOM, see Gate 3 Annex B3. The location of WFD waterbodies in relation to the GUC sample locations are shown in Table 9-9.

Table 9-9: WFD waterbodies in relation to the GUC water quality sampling locations

Site name	WFD waterbody	Waterbody ID
Site 3	Coventry and Asby Canals North Oxford Canal	GB70410212 GB70910513
Site 5	Grand Union Canal, Braunston to Leamington Spa Grand Union Canal, Braunston summit Grand Union Canal, Milton Keynes to Braunston summit Grand Union Canal, Milton Keynes trough pound	GB70910511 GB70510193 GB70510251 GB70510192
Site 6	Grand Union Canal, Tring summit to Milton Keynes	GB70510191

# 10 Results for Dissolved Oxygen in the Coventry Canal

## 10.1 Overview

As stated in the methodology (section 2.2.6), a simple spreadsheet-based Streeter-Phelps model was selected to make the initial assessment of the impact of the scheme on DO. Only if the results indicated a significant adverse impact would more detailed modelling be required.

Canal and discharge values of DO and temperature were derived from the continuous sonde monitoring. Figure 10-1 and Figure 10-2 show DO and water temperature for two-week periods in June and December 2023. Ammonium is also shown for reference, although the ammonia values used in the modelling were derived from sampling, not sondes. There is a clear diurnal variation of DO in the summer, related to plant respiration, which is not observed in the winter. Similarly, a diurnal variation in temperature is observed in the summer related to daily heating of the upper layer of water, which is not observed in the winter.

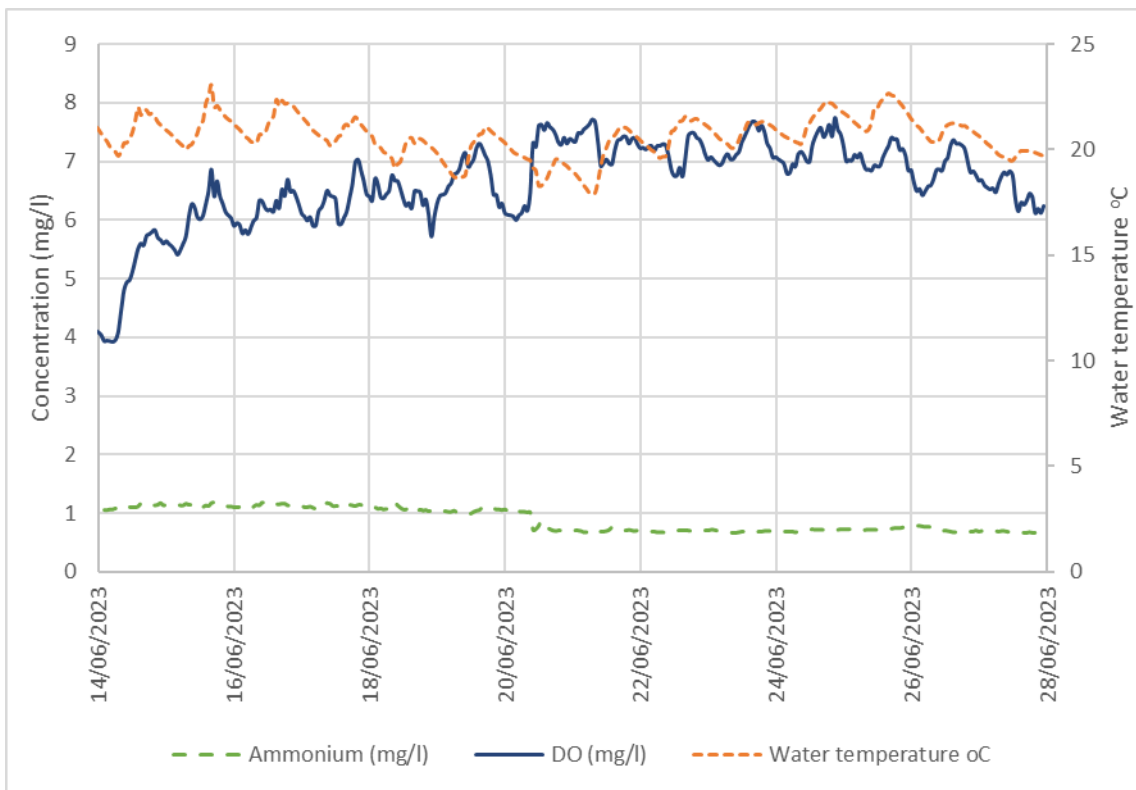


Figure 10-1: DO, ammonium and water temperature, site 3, June 2023

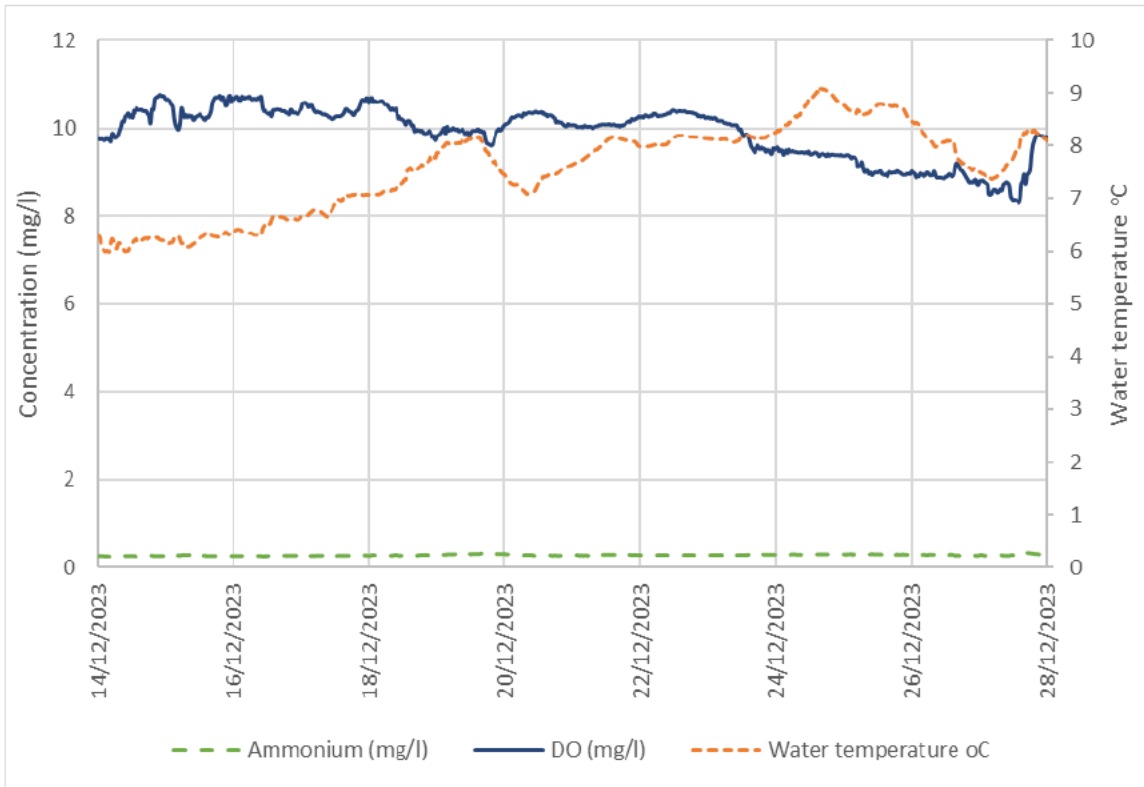


Figure 10-2: DO, ammonium and water temperature, site 3, December 2023

### 10.2 Applicable standards for assessing compliance

The Fundamental Intermittent Standards (FIS) (Foundation for Research, 2018) set concentration-duration-frequency standards for DO and unionised Ammonia. There are different sets of standards for the three fishery types; sustainable salmonid, sustainable cyprinid and marginal cyprinid. GUC environment consultants AECOM confirmed that the EA classify the canals on the transfer route as Cyprinid under the Freshwater Fisheries Directive (FFWD) classification. Therefore the FIS standard for sustainable cyprinid was selected for this assessment. The relevant standards are shown below in Table 10-1.

Table 10-1: FIS for dissolved oxygen (mg/l) for a sustainable cyprinid fishery

Return period	1 hour	6 hours	24 hours
1 month	4.0	5.0	5.5
3 months	3.5	4.5	5.0
1 year	3.0	4.0	4.5

The return periods were selected as follows:

- One month - August was selected, as it is one of the months when the 115MI/d transfer is most likely to be required, it sees the highest monthly average temperature and lowest DO in the Coventry Canal, and the second lowest DO in the Minworth recycled water.

- Three months - June to August were selected, as these are the three most likely months to require a 115MI/d transfer, and see the lowest DO and highest temperatures in both the Coventry Canal and Minworth recycled water.
- One year - data for the full year was applied.

Given that the transfer will typically operate over at least a number of weeks or months, the 24 hour FIS criteria were used to assess performance. These are also the most stringent criteria.

### 10.3 Scenarios

Three scenario variables were identified:

- Baseline and with-scheme. The Streeter-Phelps model is not ideally configured for modelling the baseline since it assumes that the "discharge" is all in one location, whereas in reality there are multiple feeders bringing flow into the Coventry Canal. It was therefore decided to assume that baseline DO is consistent along the pound, so only the with-scheme scenario was modelled.
- All three FIS assessment periods (one month, three months and annual) were tested.
- Decay rates were unknown for ammonia and BOD, hence it was decided to test using the low and high end of the range of decay rates suggested in the spreadsheet model provided by the EA, as summarised in Table 10-2:

Table 10-2: Decay rates modelled

Determinand	Low decay rate	High decay rate
BOD	0.5	2.0
Ammonia	1.0	4.0

The resulting six scenarios are summarised in Table 10-3.

Table 10-3: Summary of scenarios modelled

System state	FIS standard	Decay rates
With-scheme	1 month	Low
		High
	3 months	Low
		High
	Annual	Low
		High

## 10.4 Input parameters

The input values and data sources are recorded in Appendix D. Water quality inputs were derived from the sonde and sampling data at sites 1 (Minworth) and 3 (Coventry Canal at Atherstone). Note that, following the example model provided by the EA, background canal water quality parameters used mean values, whilst discharge quality inputs used 90th percentile for BOD and ammonia and 10th percentile for DO.

The spreadsheet model calculates DO downstream of the point of discharge using three different equations. As shown in Table 10-4, only the O'Connor and Dobbins model is suitable for the range of depths and velocities encountered within the Coventry Canal, based on velocity and depth ranges stated in the spreadsheet model supplied by the EA. The Churchill and Owens methods were therefore discounted.

Table 10-4: DO re-aeration models and applicable velocities and depths

DO re-aeration model	Applicable Velocity (m/s)	Applicable Depths (m)	Suitable for this study?
Churchill	0.5-2	0.6-15	No - velocities are too low
O'Connor and Dobbins	0.03-0.5	0.6-15	Yes
Owens	0.03-0.2	0.3-0.6	No - depths are too high

## 10.5 Impact assessment results

Figure 10-3 illustrates an example results graph. The x-axis shows distance along the canal from the point of discharge at Atherstone. The y-axis shows concentrations of BOD and ammonia (primary) and DO (secondary). The relevant FIS criteria for DO is also shown, in this case 5.5mg/l. In this example, we see that BOD and ammonia levels increase immediately downstream of the discharge. These exert a demand for oxygen, resulting in a sag in oxygen levels to below the FIS criteria. Oxygen levels recover downstream, exceeding the FIS criteria approximately 8km downstream of the discharge.

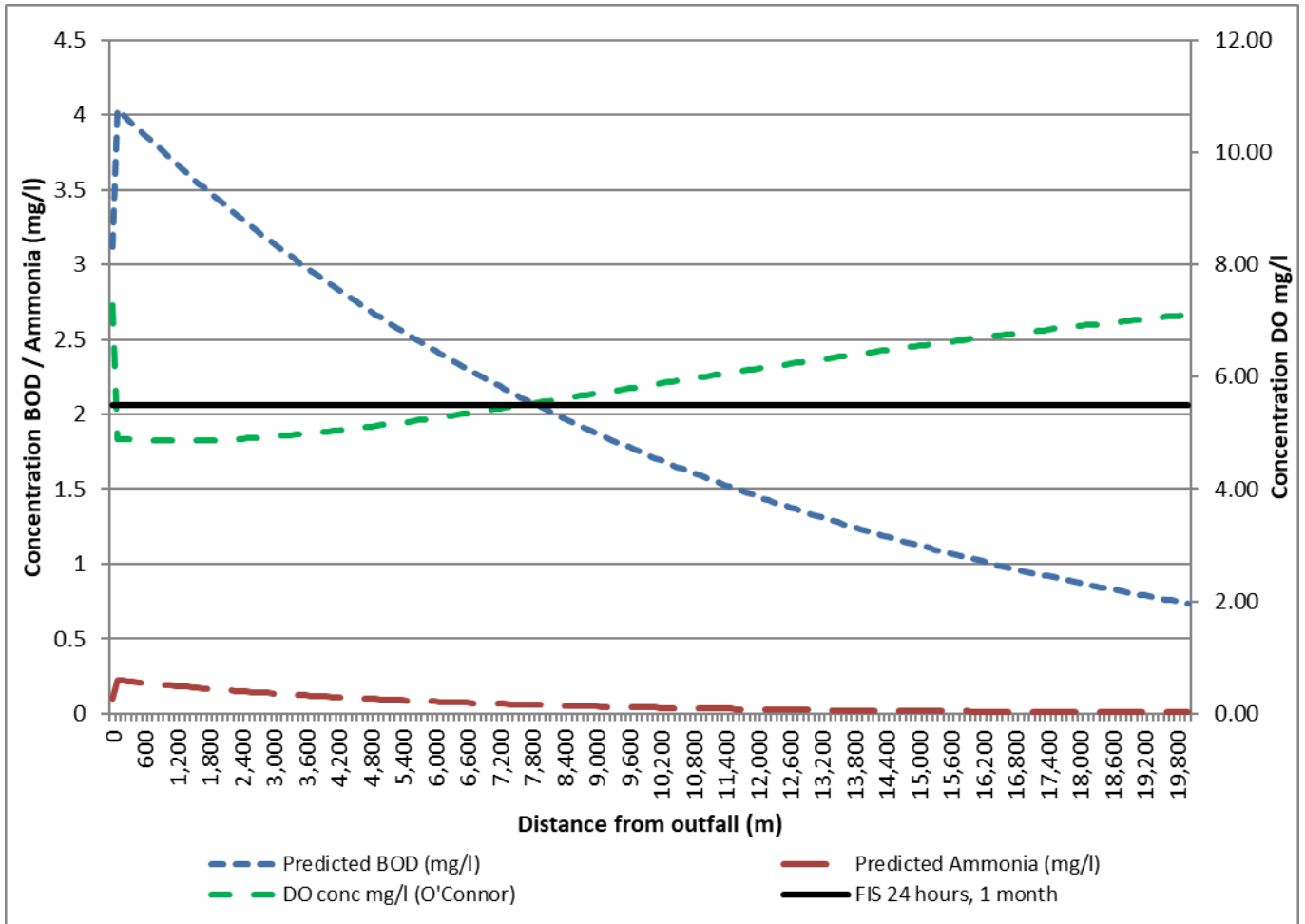
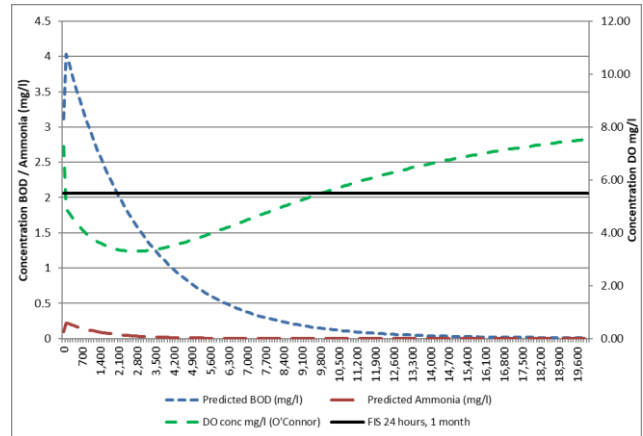
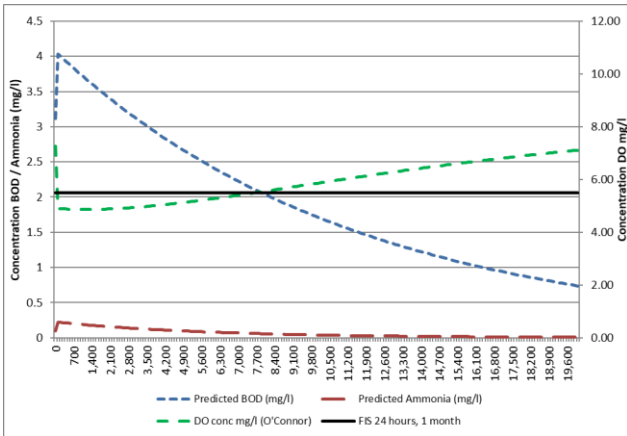


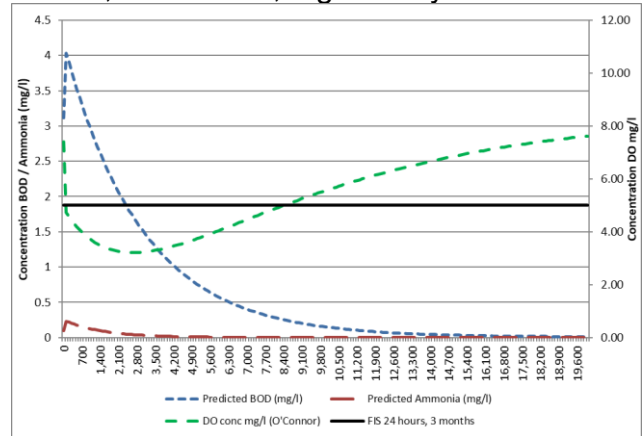
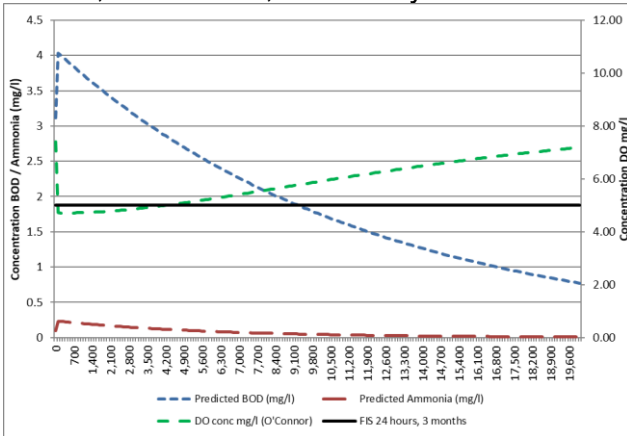
Figure 10-3: Example DO results graph, future, one month, low decay coefficient

The results for all six simulations are shown in Figure 10-4.



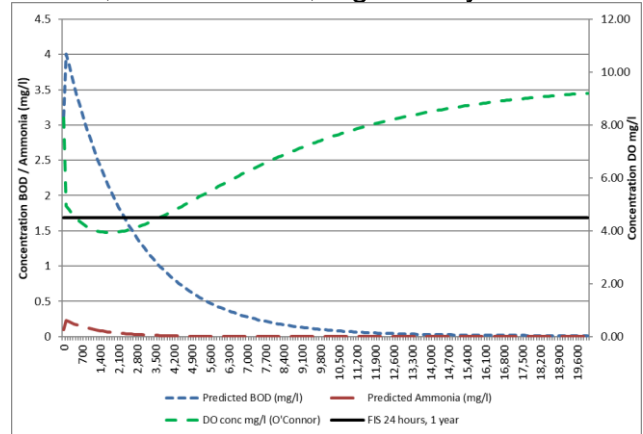
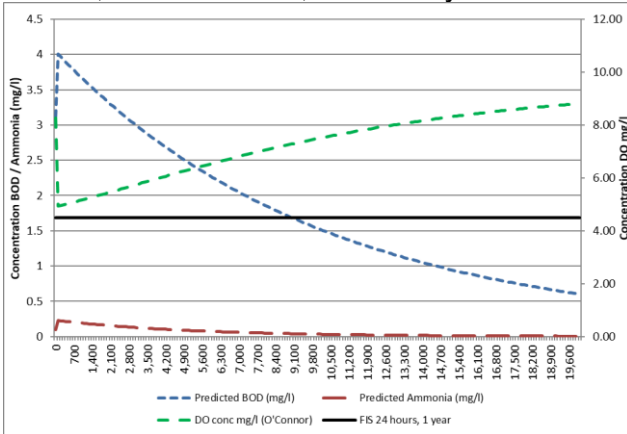
Future, one month, low decay rate

Future, one month, high decay rate



Future, three months, low decay rate

Future, three months, high decay rate



Future, one year, low decay rate

Future, one year, high decay rate

Figure 10-4: DO modelling results graphs

The key findings are:

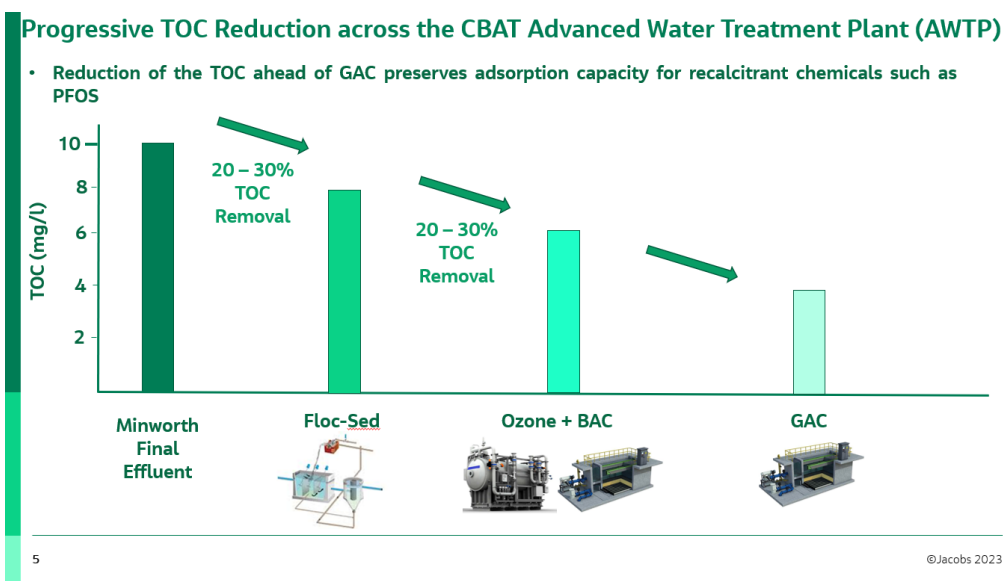
- The baseline 10th percentile DO in the Coventry Canal meets the FIS criteria for all return periods.
- Except in the one year, low decay rate scenario, DO is predicted to sag to below the appropriate FIS criteria immediately downstream of the discharge.
- The length and depth of the sag is highly dependent upon the decay rates selected, with the deepest, longest sag resulting from high decay rates.

- In the worst case scenario tested, the one month, high decay rate, DO is reduced to 3.3mg/l, and 10km of canal experiences DO concentrations below the FIS criteria.

## 10.6 Improving DO during transfer operation

There is limited opportunity to improve DO downstream of the discharge to the Coventry Canal, since the nearest lock, where aeration could be improved as a result of pumping, is some 18km downstream at Hawkesbury. Consequently, to ensure that the Coventry Canal meets FIS criteria for DO, improvements may be required to BOD and/or DO prior to discharge.

Minworth SRO design consultants Jacobs have confirmed that the AWTP treatment design aims to ensure the TOC discharged from the AWTP causes no deterioration to the receiving water course. As illustrated in Figure 10-5, the design is targeting approximately 60% organics removal, resulting in BOD in the recycled water being below the limit of detection. Further reductions in ammonia may be also possible, however it was not possible to confirm this in the bench testing since the ammonia concentration in the bench-test influent was extremely low (<0.02mg/l). The planned pilot plant will provide further information on this.



© Jacobs

Figure 10-5: Illustration of TOC reduction in the AWTP

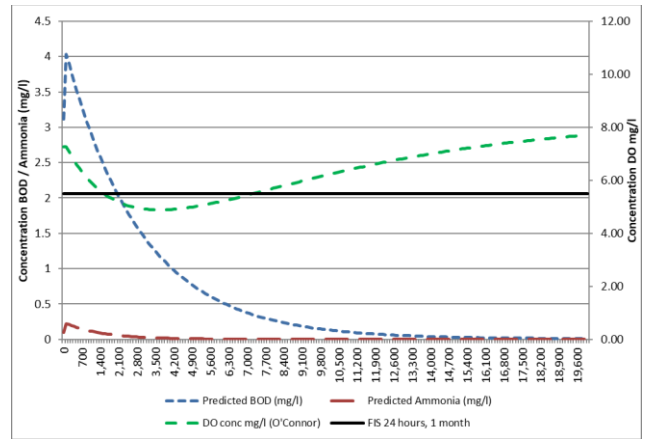
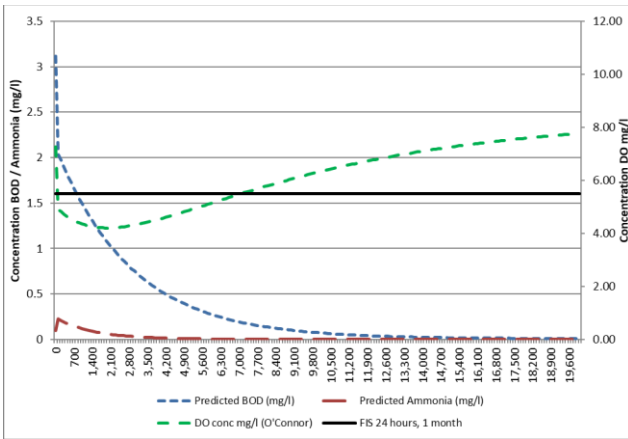
There are opportunities to improve the DO of the discharge prior to entering the canal, by designing the outfall structure to encourage aeration. At the time of this assessment the outfall structure at Atherstone had not been designed as the location is still under consideration.

The worst case model (future, one month, high decay rate) was used to apply three additional tests of reduced BOD and increased DO in the discharge:

- Test 1: Discharge BOD reduced to 2.0mg/l, the quality achieved by the jar tests undertaken by Jacobs.
- Test 2: Discharge DO increased to match the August mean value observed in the Coventry Canal, 7.27mg/l.
- Test 3: A combination of Test 1 and Test 2.

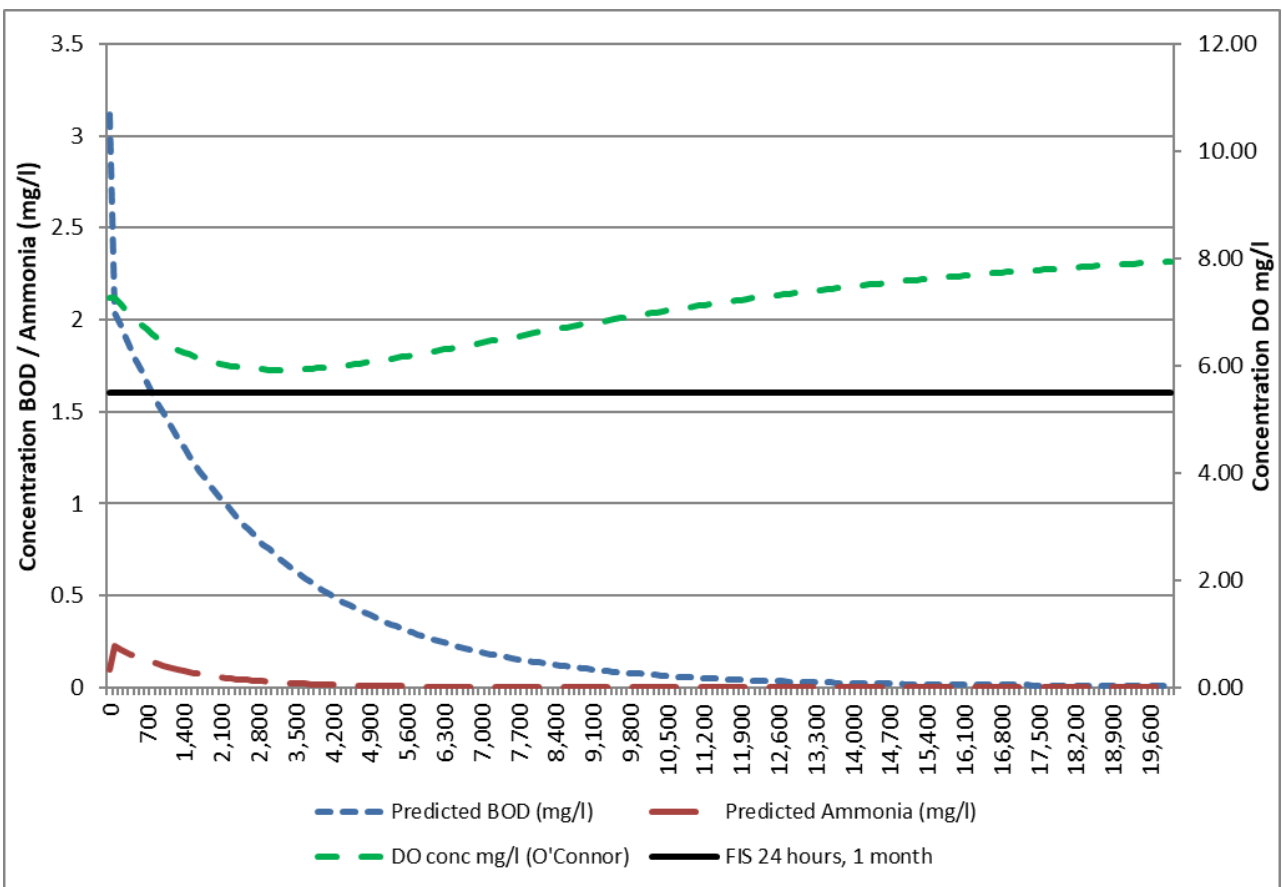
The results are graphed in Figure 10-6. These show that neither reducing BOD (Test 1) nor increasing DO (Test 2) can, on their own, prevent DO in the canal from going below the FIS criteria. However the combination of reduced BOD and increased DO (Test 3) would ensure suitable levels of DO in the canal for a sustainable cyprinid fishery.

As previously mentioned, the ammonia performance of the proposed "Minworth" AWTP could not be assessed in the bench-testing, as the concentration of Ammonia in the influent (from Minworth WwRC final effluent) was extremely low. An additional Test 4 was modelled, with BOD and DO improvements as per Test 3, but also with the influent concentration of Ammonia from the bench tests (0.02mg/l) used. Results (Figure 10-7) show that this further reduces the DO sag downstream of the recycled water discharge, however to a lesser extent than that achieved as a result of reducing BOD and increasing DO. The potential of the "Minworth" AWTP process to reduce Ammonia will need to be further investigated at the pilot-plant stage.



Test 1: BOD reduced to 2.0mg/l

Test 2: DO increased to 7.27mg/l



Test 3: BOD reduced to 2.0mg/l and DO increased to 7.27mg/l

Figure 10-6: Results of the tests for reduced BOD and increased DO in the discharge

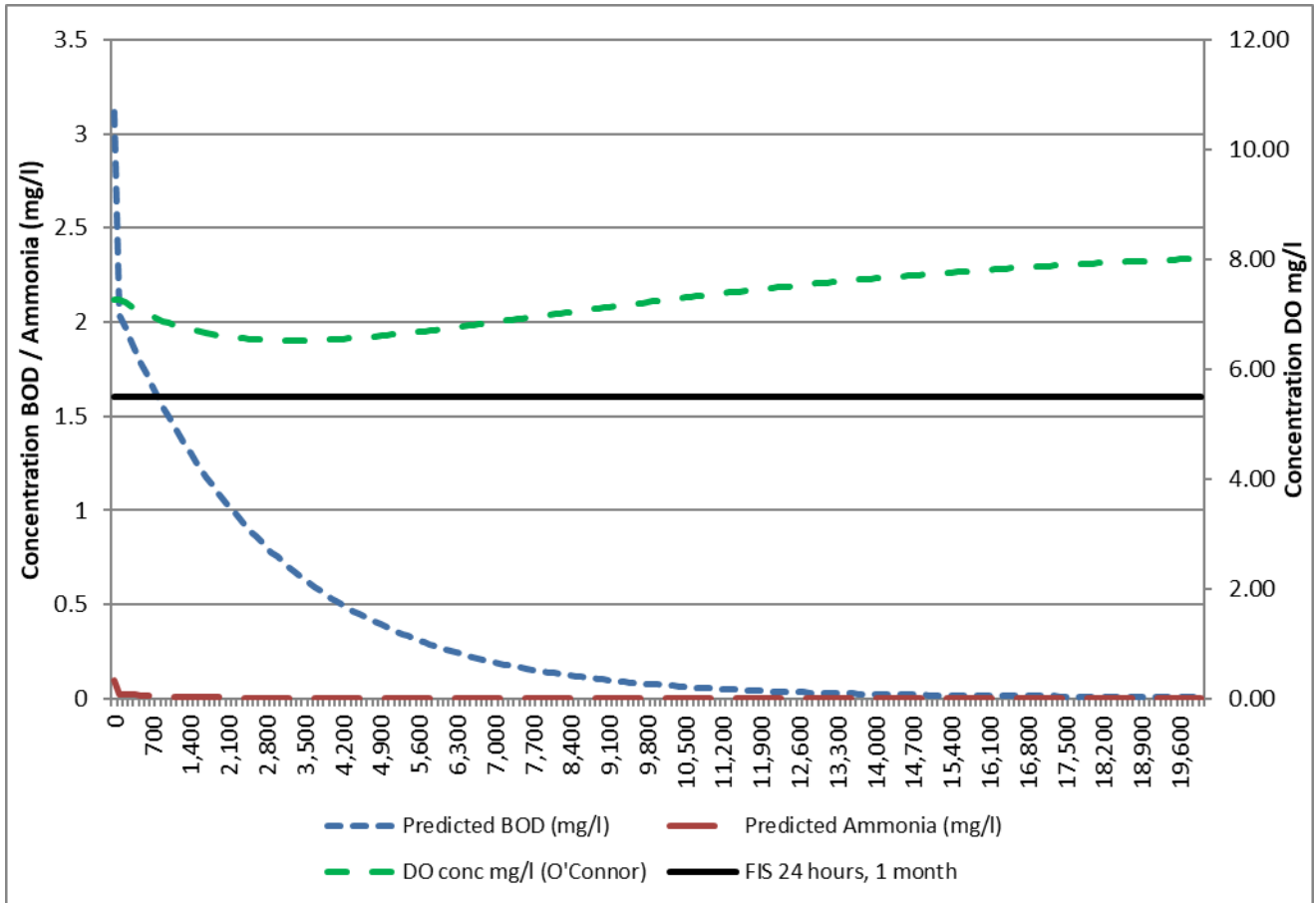


Figure 10-7: Test 4: BOD reduced to 2.0mg/l, DO increased to 7.27mg/l and Ammonia at 0.02mg/l

# 11 Conclusions and recommendations

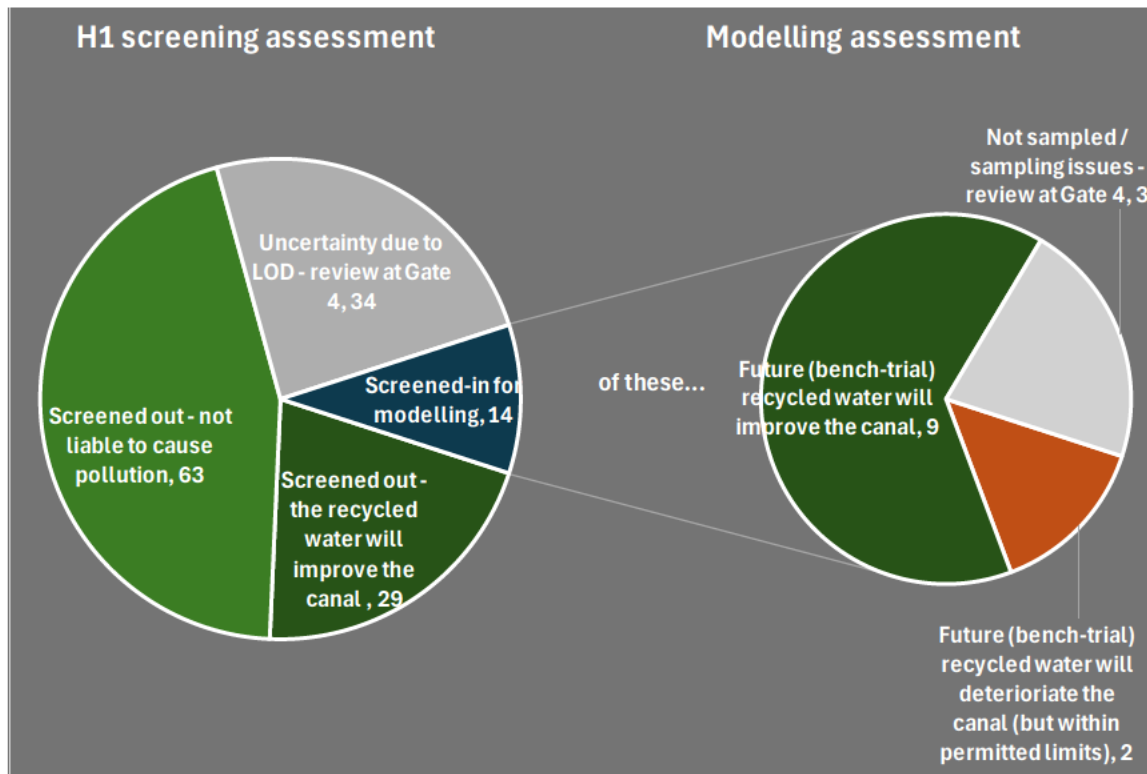
## 11.1 High-level summary of H1 screening and modelling

Figure 11-1 presents a high-level summary of the H1 screening and modelling results. Commencing with the H1 screening assessment (Jacobs, 2023), the impact of 140 substances sampled at site 1 (Minworth) and 3 (Coventry Canal at Atherstone) has been assessed. Of these, 92 were screened-out as not liable to cause pollution, 29 of which are likely to improve in the canal as a result of the transfer (based on their annual average concentrations).

14 substances were screened-in for modelling. Taking the bench-trial results as a guide to potential future performance of the AWTP, nine of these would result in improved water quality in the canal. Only two are predicted to lead to a deterioration, and this would be within the permissible deterioration limits set in the EA guidance.

34 substances were identified by the H1 screening as having uncertainties, primarily related to the LOD used by the laboratories. These will be addressed at Gate 4 following sampling using improved LODs. Additional, three of the modelled substances were not sampled, or had sampling issues in the bench trials. These will be addressed at Gate 4, which will also benefit from the results of a pilot plant of the proposed AWTP.

Figure 11-1: High-level summary of H1 screening and modelling



## 11.2 Combining the results for sites 3, 5, and 6

When using the results of this assessment to scope future treatment standards which may be applied to the proposed discharge at Atherstone, it is important to consider whether any determinands may need a tighter standard to prevent deterioration downstream than to prevent deterioration at Atherstone. EA guidance (Environment Agency, 2019) is focussed on the impact immediately downstream of the point of discharge. In the case of the GUC Transfer, the discharge flow is significantly greater than the background flow in the canal, and, because of the multiple pumped and gravity feeders and other discharges into the canals, water quality can be quite different "downstream" along the transfer route.

Table 11-1 compares the percentage treatment reduction required to prevent deterioration. For a number of determinands, the percentage reduction required to prevent deterioration at Daventry or Leighton Buzzard would be higher than to do so at Atherstone. It is acknowledged that the methodology for testing impact at Daventry and Atherstone is conservative, because it does not account for decay, dilution or deposition of chemicals along the canal route, however for initial planning purposes it is recommended that the highest percentage reduction values are considered in the process design. Note however that, as identified in section 9.2.3, modelling the discharge using a combination of continuous and intermittent discharges in RQP results in overly tight estimates of treatment concentrations required to prevent deterioration. Table 11-1 should, therefore, only be used to compare the three sites, and not as the definitive guide to treatment reduction requirements.

A final side-by-side summary of the water quality impact at all three sites for all tests (hazardous chemicals and WFD) is provided in Appendix B.4. The final column indicates whether the substance may require improved discharge quality. This is set to yes where any one of the modelling tests has been failed, at any of sites 3, 5 and 6. A total of 13 determinands fail one or more tests at one or more locations and might therefore require an increased level of treatment.

Table 11-1 Comparison of treatment reductions required to prevent deterioration at sites 3, 5, and 6.

Determinand	Site 3 (Atherstone)	Site 5 (Daventry)	Site 6 (Leighton Buzzard)
cypermethrin (Q)	88%	95%	89%
diazinon (Q)	59%	-	77%
formaldehyde (Q)	51%	-	-
hexabromocyclododecane (HBCDD)	95%	98%	97%
sulphide or hydrogen sulphide (Q)	53%	70%	None
mancozeb	96%	-	-
maneb	91%	-	-
mercury total	None	73%	None

Determinand	Site 3 (Atherstone)	Site 5 (Daventry)	Site 6 (Leighton Buzzard)
nickel total	None	59%	61%
4-n-nonylphenol <b>(Q)</b>	95%	97%	97%
perfluorooctane sulfonic acid (PFOS)	82%	None	97%
permethrin <b>(Q)</b>	86%	-	-
triclosan	83%	90%	91%
zinc total	None	17%	23%

(Q) denotes that 50% or more of the discharge or canal samples are qualified as less-than the LOD. Results for these determinands should be treated with extra caution.

### 11.3 Conclusions

- This report has presented the results of the modelling assessment of the impacts of 14 determinands present within Minworth recycled water on the proposed discharge to the Coventry Canal at Atherstone.
- The 14 substances were screened-in for modelling by the H1 screening assessment (Jacobs, 2023).
- Modelled mixed concentration downstream of the proposed discharge were used to test the impact downstream at Daventry and Leighton Buzzard.
- The modelling was undertaken using the River Quality Planning (RQP) suite of tools. Most determinands were assessed using the Monte Carlo tool, with bioavailable metals being assessed with the MPer tool.
- Three scenarios have been modelled for each determinand:
  - Impact of input on discharge quality,
  - Required discharge quality to meet target/EQS,
  - Required discharge quality to prevent deterioration.
- Impacts were assessed using a combination of operational instructions for hazardous chemicals and sanitary determinands. Results are summarised below:

Table 11-2: Summary of results

Test	Results	Site 3 (Atherstone)	Site 5 (Daventry)	Site 6 (Leighton Buzzard)
<b>Hazardous chemicals modelling tests</b>	Pass all tests (AA)	4	3	5
	Fail one or more test (AA)	10	6	6



Test	Results	Site 3 (Atherstone)	Site 5 (Daventry)	Site 6 (Leighton Buzzard)
	Pass all tests (MAC)	4	6	8
	Fail one or more test (MAC)	9	2	2
	No MAC EQS	1	1	1
<b>WFD class deterioration</b>	No class deterioration (AA)	7	4	7
	Continue to fail EQS (AA)	5	3	4
	New class deterioration (AA)	2	2	0
	No class deterioration (MAC)	12	7	9
	Continue to fail EQS (MAC)	1	1	1
	New class deterioration (MAC)	0	0	0
<b>WFD percentage deterioration</b>	No deterioration (AA)	4	2	4
	Deterioration (AA)	10	7	7
	No deterioration (MAC)	2	3	5
	Deterioration (MAC)	11	5	5
<b>Treatment required to meet AA EQS</b>	No additional treatment required	7	4	4
	EQS could be met with treatment reductions	7	5	7
<b>Treatment required to prevent deterioration</b>	No deterioration predicted	3	2	3

Test	Results	Site 3 (Atherstone)	Site 5 (Daventry)	Site 6 (Leighton Buzzard)
<b>(AA)</b>				
	Deterioration could be prevented with treatment reductions	11	7	8

- The impact of the discharge on temperature in the Coventry Canal was also analysed using the Monte Carlo. This predicts a +2.9°C change in the annual mean temperature, +5.4°C change in January and +1.9°C in August.
- Further testing was carried out using the results of the bench-tests of the proposed treatment processes at "Minworth" AWTP. The concentration required to prevent deterioration of the annual average was achieved in the bench trials for sulphide, maneb, mercury total, nickel total, PFOS and zinc total, and the concentration required to limit deterioration down to permissible levels was achieved for mancozeb. For cypermethrin, diazinon, hexabromocyclododecane (HBCDD), 4-n-nonylphenol, permethrin, and triclosan, the required targets were below the limit of detection used for the bench trials, so it is not possible to conclude whether the bench trial achieved the target concentration. However, for HBCDD and triclosan, the bench trial was achieving <10% of the EQS, so these are considered to be not liable to cause pollution.
- Considering the MAC EQS, deterioration can be prevented for sulphide, mercury total, nickel total and PFOS, and kept within permitted limits for cypermethrin, mancozeb and maneb. For diazinon, hexabromocyclododecane (HBCDD), 4-n-nonylphenol, permethrin, and triclosan, the required targets were below the limit of detection used for the bench trials, so it is not possible to conclude whether the bench trial achieved the target concentration. However, for HBCDD, 4-n-nonylphenol, permethrin and triclosan, the bench trial was achieving <10% of the EQS, so these are considered to be not liable to cause pollution. There is no MAC EQS for zinc total, therefore this was not assessed.
- The impacts of the discharge on dissolved oxygen in the Coventry Canal were modelled using a Streeter-Phelps spreadsheet model, taking into account current levels of dissolved oxygen, BOD and ammonia. This indicated that the discharge has the potential to cause DO sags which would fail the FIS criteria.
- A combination of reduced BOD and increased DO as a result of reaeration at the outfall would be required to maintain healthy levels of DO to support the sustainable cyprinid fishery.
- As an additional step, further analysis was conducted comparing the results of the bench-trials of the proposed treatment processes for the "Minworth" AWTP with the estimated quality required to achieve no deterioration or permissible deterioration at Atherstone (see section 9). This concluded that either no deterioration or permissible deterioration could be met if results of the bench trials

were reproduced by the AWTP, or that the required targets were below the limit of detection used for the bench trials, so it was not possible to conclude whether the bench trial achieved the target concentration.

- Water quality screening and modelling at Daventry and Drayton reservoirs will be carried out and presented at Gate 4, allowing sufficient time for water quality sampling at these two sites.

#### 11.4 Recommendations

- Sampling of these 14 substances of concern should continue in order to build a long, continuous series of water quality data.
- The results of this modelling should be used to inform the design of the AWTP at Minworth, and the WTW.
- The discharge structure at Atherstone should be designed to reaerate the recycled water prior to discharge. This would need to be designed in conjunction with any energy dissipation and/or energy recovery at this structure. In designing the reaeration structures, the high decay rates for BOD and ammonia should be assumed, unless further analysis is undertaken to calibrate these to observed rates of decay in the canal. Further sensitivity testing should also be carried out to account for variability in the canal water quality and temperature.
- Further mitigation to maintain levels of dissolved oxygen may be required, for example planting of marginal vegetation downstream of the recycled water discharge at Atherstone. This should be informed by the environmental assessments, and any additional hydraulic roughness accounted for in the hydraulic modelling and bank raising.
- In parallel with this Gate 3 water quality modelling workstream, the water quality sampling workstream has reviewed LODs with commercial laboratories, and has confirmed the latest list of LODs achievable in final effluent and canal water, with the National Assessment Unit (NAU). These revised LODs are being applied to samples taken from June 2024 onwards (July 2024 in the case of one chemical). Further water quality modelling will be required at Gate 4 which will use these improved LODs. Given that this will be building on from the two years of sampling at existing LODs, an additional six months of data should be sufficient to determine whether or not these chemicals are present at or close to the EQS value.
- A water quality impact assessment is also required at Gate 4 for the proposed transfer into the Daventry and Drayton reservoirs. This will commence with an H1 screening assessment to identify substances requiring modelling, but it is anticipated that nutrient and temperature modelling may be required.
- Further modelling may also be required once treatment results are available for the planned pilot plant.
- A review of the water quality analysis at site 6 (Leighton Buzzard) should be carried out at Gate 4, once the preferred location for the WTW is confirmed.

- The Gate 4 modelling should also consider the impacts of climate change, both on the background canal flows and the use of feeders (from the Aquator model), and on the impacts of higher temperatures on evaporation, water temperature and dissolved oxygen.

# A Appendix: RQP Input data

## A.1 Site 1 and 3 input data

Site 1 (cleaned)

Determinand	Units	Min	Mean	Max	95%ile	90%ile	10%ile	AA-EQS	MAC-EQS	MAC-EQS			EQS	PCV	Count	Standard Deviation
										Type	PCV	LOD				
4-n-nonylphenol	ug/l	0.02	0.2603125	0.51	0.3945	0.37	0.17	0.3	2	-	-	0.04	Fail	-	25	0.0074
cypermethrin	ug/l	0.00004	0.00026031	0.00073	0.0005345	0.00042	0.000048	0.00008	0.0006	-	-	0.00008	-	-	32	0.0002
diazinon	ug/l	0.005	0.00640625	0.02	0.0145	0.01	0.005	0.01	0.02	-	-	0.01	-	-	32	0.0038
formaldehyde	ug/l	25	26.75	81	25	25	25	5	50	-	-	50	Fail	-	32	9.7436
hexabromocyclododecane (HBCDD)	ug/l	0.00007	0.00097226	0.00362	0.00254	0.00178	0.00045	0.0016	0.5	-	-	0.00014	Fail	-	31	0.0007
mancozeb	ug/l CS2	0.05	1.24354839	3.2	2.7	2.6	0.05	2	20	-	-	-	-	-	31	0.9134
maneb	ug/l	0.05	1.14354839	3.8	3	2.7	0.05	3	30	-	-	0.1	-	-	31	1.1021
mercury total	ug/l	0.0005	0.00930968	0.1	0.032	0.022	0.0015	0.07	0.07	-	-	0.001	Fail	-	31	0.0185
nickel total	ug/l	11	17.8387097	35	28	26	11	4	34	-	-	0.5	Fail	-	31	5.7479
perfluorooctane sulfonic acid (PFOS)	ug/l	0.0001	0.01372917	0.034	0.025125	0.0208	0.006985	0.00065	36	-	-	0.00065	-	-	36	0.0064
permethrin	ug/l	0.0005	0.00215625	0.009	0.00635	0.004	0.0005	0.001	0.01	-	-	0.001	Fail	-	32	0.0020
sulphide or hydrogen sulphide	ug/l	5	14.1875	42	33.7	27.4	5	0.25	1	-	-	10	-	-	32	9.7930
triclosan	ug/l CS2	0.005	0.0175	0.07	0.0445	0.039	0.005	0.1	0.28	-	-	0.01	-	-	32	0.0151
zinc total	ug/l	18	53.125	110	101.75	85.7	29.1	10.9	-	-	-	0.9	Fail	-	32	23.8246

Site 3 (cleaned)

Determinand	Units	Sampled at								EQS	LOD	EQS	Count	Standard Deviation
		Site 3?	Min	Mean	Max	95%ile	90%ile	10%ile	EQS					
4-n-nonylphenol	ug/l	Yes	0.02	0.0246875	0.09	0.06	0.02	0.02	0.3	0.04	-	32	0.0000	
cypermethrin	ug/l	Yes	0.00004	5.7813E-05	0.0002	0.0001445	0.00012	0.00004	0.00008	0.00008	-	32	0.0000	
diazinon	ug/l	Yes	0.005	0.005	0.005	0.005	0.005	0.005	0.01	-	-	32	0.0000	
formaldehyde	ug/l	Yes	25	25	25	25	25	25	5	25	Fail	32	0.0000	
hexabromocyclododecane (HBCDD)	ug/l	Yes	0.00007	8.7813E-05	0.00024	0.000218	0.00016	0.00007	0.0016	0.00014	-	32	0.0000	
mancozeb	ug/l CS2	Yes	0.05	0.09833333	0.3	0.2275	0.2	0.05	2	-	-	30	0.0724	
maneb	ug/l	Yes	0.05	0.2	1.5	0.795	0.3	0.05	3	-	-	32	0.3417	
mercury total	ug/l	Yes	0.0005	0.00905484	0.082	0.0355	0.015	0.0005	0.07	0.001	-	31	0.0161	
nickel total	ug/l	Yes	8.4	40.1548387	120	110	100	11	4	0.5	Fail	31	31.4644	
perfluorooctane sulfonic acid (PFOS)	ug/l	Yes	0.000045	0.00471047	0.00961	0.008043	0.006982	0.002333	0.00065	0.00065	-	32	0.0022	
permethrin	ug/l	Yes	0.0005	0.00057813	0.002	0.001	0.0005	0.0005	0.001	-	-	32	0.0003	
sulphide or hydrogen sulphide	ug/l	Yes	5	12.71875	31	26.9	26	5	0.25	10	Fail	32	8.4122	
triclosan	ug/l CS2	Yes	0.005	0.00546875	0.02	0.005	0.005	0.005	0.1	-	-	32	0.0027	
zinc total	ug/l	Yes	10	56.1935484	270	170	100	17	10.9	-	-	31	55.3927	

A.2 Site 5 and 6 input data

Site 5 (cleaned)

Determinand	Units	Min	Mean	Max	95%ile	90%ile	10%ile	AA-EQS	MAC-EQ	MAC-EQS		LOD	EQS assessme	PCV assessme	Count	Standard Deviatio
										Type	PCV					
4-n-nonylphenol	ug/l	0.02	0.02212121	0.09	0.02	0.02	0.02	0.3	2	-	-	0.04	-	-	33	0
cypermethrin	ug/l	0.00004	4.4242E-05	0.00009	0.000084	0.00004	0.00004	0.00008	0.0006	-	-	0.00008	-	-	33	1.3491E-05
diazinon	ug/l	-	-	-	-	-	-	0.01	0.02	-	-	0.01	-	-	-	-
formaldehyde	ug/l	-	-	-	-	-	-	5	50	-	-	50	-	-	-	-
hexabromocyclododecane (HBCDD)	ug/l	0.00007	7.2121E-05	0.00014	0.00007	0.00007	0.00007	0.0016	0.5	-	-	0.00014	-	-	33	1.1999E-05
mancozeb	ug/l CS2	-	-	-	-	-	-	2	20	-	-	-	-	-	-	-
maneb	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mercury total	ug/l	0.0005	0.00759375	0.088	0.03445	0.0087	0.0005	0.07	0.07	-	-	0.001	-	-	32	0.01745421
nickel total	ug/l	1.6	3.0625	6.5	5.435	4.67	1.91	4	34	-	-	0.5	-	-	32	1.17519945
perfluorooctane sulfonic acid (PFOS)	ug/l	0.00236	0.015045	0.0361	0.03055	0.02305	0.00386	0.00065	36	-	-	0.00065	-	-	32	0.00799127
permethrin	ug/l	-	-	-	-	-	-	0.001	0.01	-	-	0.001	-	-	-	-
sulphide or hydrogen sulphide	ug/l	5	13.1212121	51	31.2	22.8	5	0.25	1	-	-	10	-	-	33	10.4294385
tridosan	ug/l CS2	0.005	0.00545455	0.02	0.005	0.005	0.005	0.1	0.28	-	-	-	-	-	32	0.00265165
zinc total	ug/l	3.5	13.025	33	24.15	20	6.54	10.9	-	-	-	0.9	-	-	32	6.70731876

Site 6 (cleaned)

Determinand	Units	Min	Mean	Max	95%ile	90%ile	10%ile	AA-EQS	MAC-EQ	MAC-EQS		LOD	EQS assessme	PCV assessme	Count	Standard Deviatio
										Type	PCV					
4-n-nonylphenol	ug/l	0.02	0.02272727	0.05	0.04	0.036	0.02	0.3	2	-	-	0.04	-	-	33	0
cypermethrin	ug/l	0.00004	0.00010031	0.00059	0.0003135	0.000208	0.00004	0.00008	0.0006	-	-	0.00008	-	-	32	0.00011658
diazinon	ug/l	0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.02	-	-	0.01	-	-	25	0
formaldehyde	ug/l	-	-	-	-	-	-	5	50	-	-	50	-	-	-	-
hexabromocyclododecane (HBCDD)	ug/l	0.00007	0.00010273	0.00037	0.000254	0.00015	0.00007	0.0016	0.5	-	-	0.00014	-	-	33	7.3124E-05
mancozeb	ug/l CS2	-	-	-	-	-	-	2	20	-	-	-	-	-	-	-
maneb	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mercury total	ug/l	0.0005	0.008225	0.087	0.03595	0.0163	0.00055	0.07	0.07	-	-	0.001	-	-	32	0.01660909
nickel total	ug/l	1.2	2.78484848	9.4	5.22	3.54	1.9	4	34	-	-	0.5	-	-	33	1.51739833
perfluorooctane sulfonic acid (PFOS)	ug/l	0.000045	0.00141288	0.00369	0.003104	0.002494	0.000325	0.00065	36	-	-	0.00065	-	-	33	0.00095055
permethrin	ug/l	-	-	-	-	-	-	0.001	0.01	-	-	0.001	-	-	-	-
sulphide or hydrogen sulphide	ug/l	5	16.5483871	42	35.5	29	5	0.25	1	-	-	10	-	-	31	10.3388984
tridosan	ug/l CS2	0.005	0.005	0.005	0.005	0.005	0.005	0.1	0.28	-	-	-	-	-	32	1.7625E-18
zinc total	ug/l	2.4	11.3625	46	21.7	17.9	5.23	10.9	-	-	-	0.9	-	-	32	7.85663533

## **B Appendix: Modelling results**

### **B.1 Modelling results, site 3**



		Site 3 Target quality required discharge (v1)																		
		Mean	Standard Deviation			95-percentile			99-percentile			99.5-percentile			WW treatment % reduction required to meet AA EQS					
Determinand	Units	Model	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper
4-n-nonylphenol	ug/l	Monte Carlo	0.21	0.21	0.21	0.01	0	0.01	0.22	0.22	0.22	0.23	0.22	0.23	0.23	0.23	0.23	0.22	0.23	None
cypermethrin	ug/l	Monte Carlo	0.00006	0.000049	0.000072	0.000037	0.000029	0.000045	0.00013	0.00011	0.00018	0.0002	0.00015	0.00029	0.00021	0.00016	0.00033	0.00033	0.033	76.95%
diazinon	ug/l	Monte Carlo	0.0062	0.0051	0.0073	0.0037	0.0029	0.0044	0.013	0.011	0.018	0.02	0.015	0.029	0.021	0.016	0.033	0.033	0.033	None
formaldehyde	ug/l	Monte Carlo	0.05	0.045	0.055	0.018	0.014	0.022	0.085	0.075	0.1	0.11	0.092	0.14	0.11	0.095	0.15	0.15	0.095	99.81%
hexabromocyclododecane (HBCDD)	ug/l	Monte Carlo	0.00113	0.00087	0.00139	0.00086	0.00068	0.00104	0.00282	0.00219	0.00408	0.00448	0.00328	0.00718	0.00495	0.00345	0.0085	0.0085	0.0085	None
mancozeb	ug/l CS2	Monte Carlo	1.42	1.1	1.73	1.03	0.81	1.25	3.46	2.71	4.95	5.41	4	8.56	5.96	4.2	10.1	10.1	10.1	None
maneb	ug/l	Monte Carlo	2.12	1.5	2.73	2.01	1.58	2.43	5.99	4.45	9.26	10.4	7.23	18.2	11.7	7.63	22.3	22.3	22.3	None
mercury total	ug/l	Monte Carlo	0.07	0.031	0.11	0.13	0.1	0.16	0.27	0.18	0.51	0.64	0.39	1.43	0.78	0.42	1.99	1.99	1.99	None
nickel total	ug/l	MPer	4.21	2.24	6.19	1.36	0	2.73	6.83	1.93	18.9	8.36	0	44.4	9.26	0	62.7	62.7	62.7	76.40%
perfluorooctane sulfonic acid (PFOS)	ug/l	Monte Carlo	0.000007	0.0000061	0.0000079	0.0000033	0.0000027	0.000004	0.000013	0.000011	0.000017	0.000018	0.000015	0.000024	0.00002	0.000016	0.000027	0.000027	0.000027	99.95%
permethrin	ug/l	Monte Carlo	0.0006	0.00044	0.00077	0.00056	0.00044	0.00068	0.00169	0.00126	0.00257	0.0029	0.00204	0.00496	0.00326	0.00215	0.00605	0.00605	0.00605	72.17%
sulphide or hydrogen sulphide	ug/l	Monte Carlo	0.003	0.0024	0.0036	0.0021	0.0016	0.0025	0.0071	0.0056	0.0099	0.011	0.0081	0.017	0.012	0.0085	0.019	0.019	0.019	99.98%
tridosan	ug/l CS2	Monte Carlo	0.071	0.053	0.088	0.058	0.046	0.071	0.19	0.14	0.27	0.3	0.22	0.5	0.34	0.23	0.6	0.6	0.6	None
zinc total	ug/l	MPer	27.1	21.4	32.8	12.1	8.19	16.1	50.9	37.5	77	67	42.2	121	77	46	147	147	147	48.99%

		Site 3 Required discharge quality to meet no deterioration (v1)																		
		Mean	Standard Deviation			95-percentile			99-percentile			99.5-percentile			WW treatment % reduction required to prevent deterioration (Mean)					
Determinand	Units	Model	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper
4-n-nonylphenol	ug/l	Monte Carlo	0.013	0.013	0.013	0.0004	0.0003	0.0005	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	95.01%
cypermethrin	ug/l	Monte Carlo	0.00003	0.000025	0.000036	0.000019	0.000015	0.000022	0.000067	0.000054	0.000091	0.000099	0.000076	0.00015	0.00011	0.00008	0.00017	0.00017	0.00017	88.48%
diazinon	ug/l	Monte Carlo	0.0026	0.0021	0.0031	0.0015	0.0012	0.0019	0.0057	0.0046	0.0076	0.0082	0.0064	0.012	0.0089	0.0067	0.014	0.014	0.014	59.41%
formaldehyde	ug/l	Monte Carlo	13	11.6	14.5	4.76	3.76	5.75	22.2	19.4	26.9	28.2	23.9	36.1	29.7	24.7	39.2	39.2	39.2	51.40%
hexabromocyclododecane (HBCDD)	ug/l	Monte Carlo	0.000046	0.000035	0.000056	0.000035	0.000027	0.000042	0.00011	0.000089	0.00017	0.00018	0.00013	0.00029	0.0002	0.00014	0.00034	0.00034	0.00034	95.27%
mancozeb	ug/l CS2	Monte Carlo	0.051	0.04	0.062	0.037	0.029	0.045	0.12	0.098	0.18	0.19	0.14	0.31	0.22	0.15	0.36	0.36	0.36	95.90%
maneb	ug/l	Monte Carlo	0.1	0.074	0.13	0.099	0.078	0.12	0.3	0.22	0.46	0.51	0.36	0.89	0.58	0.38	1.1	1.1	1.1	91.26%
mercury total	ug/l	Monte Carlo	0.0047	0.0021	0.0074	0.0087	0.0068	0.011	0.018	0.012	0.035	0.044	0.027	0.097	0.053	0.029	0.13	0.13	0.13	No Deterioration
nickel total	ug/l	MPer	87	65.8	108	28.1	13.3	42.9	141	89.2	246	173	72.5	404	191	64.3	497	497	497	No Deterioration
perfluorooctane sulfonic acid (PFOS)	ug/l	Monte Carlo	0.00246	0.00213	0.00278	0.00116	0.00093	0.00139	0.00473	0.00403	0.00593	0.00641	0.00526	0.00857	0.00685	0.00548	0.0095	0.0095	0.0095	82.08%
permethrin	ug/l	Monte Carlo	0.0003	0.00022	0.00039	0.00028	0.00022	0.00034	0.00084	0.00063	0.00128	0.00145	0.00102	0.00248	0.00163	0.00108	0.00303	0.00303	0.00303	86.09%
sulphide or hydrogen sulphide	ug/l	Monte Carlo	6.62	5.26	7.98	4.55	3.6	5.5	15.6	12.4	21.8	23.9	18	36.7	26.2	18.9	42.7	42.7	42.7	53.34%
tridosan	ug/l CS2	Monte Carlo	0.0029	0.0022	0.0036	0.0024	0.0019	0.0029	0.0075	0.0058	0.011	0.012	0.0089	0.02	0.014	0.0094	0.024	0.024	0.024	83.43%
zinc total	ug/l	MPer	169	137	201	75.7	53.3	98	318	243	457	418	286	697	480	317	837	837	837	No Deterioration

**B.2 Modelling results, site 5**



		Site 5 Target quality required discharge (v1)																
		Mean			Standard Deviation			95-percentile			99-percentile			99.5-percentile			WW treatment % reduction required to meet AA EQS	
Determinand	Units	Model	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	
4-n-nonylphenol	ug/l	Monte Carlo	0.29	0.28	0.3	0.025	0.02	0.031	0.33	0.32	0.35	0.35	0.34	0.37	0.36	0.34	0.38	None
cypermethrin	ug/l	Monte Carlo	0.000071	0.000059	0.000083	0.000038	0.00003	0.000047	0.00015	0.00012	0.00019	0.0002	0.00016	0.00029	0.00023	0.00017	0.00034	72.73%
diazinon	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
formaldehyde	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
hexabromocyclododecane (HBCDD)	ug/l	Monte Carlo	0.00157	0.00125	0.00189	0.00107	0.00084	0.00129	0.0037	0.00295	0.00515	0.00552	0.00414	0.00849	0.00622	0.00451	0.01	None
mancozeb	ug/l CS2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
maneb	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mercury total	ug/l	Monte Carlo	65.7	34.6	96.7	102	80.2	123	239	162	429	504	311	1075	629	361	1478	None
nickel total	ug/l	Mper	10	6.49	13.5	8.62	6.2	11.1	26.1	17.2	46.1	43	23.4	94.7	50.2	24.1	123	43.94%
perfluorooctane sulfonic acid (PFOS)	ug/l	Monte Carlo	0.0000065	0.0000057	0.0000073	0.0000027	0.0000021	0.0000032	0.000012	0.00001	0.000014	0.000015	0.000013	0.00002	0.000016	0.000013	0.000022	99.95%
permethrin	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
sulphide or hydrogen sulphide	ug/l	Monte Carlo	0.003	0.0025	0.0035	0.0017	0.0013	0.002	0.0064	0.0052	0.0084	0.0089	0.007	0.013	0.0099	0.0075	0.015	99.98%
triclosan	ug/l CS2	Monte Carlo	0.097	0.077	0.12	0.068	0.054	0.083	0.23	0.19	0.33	0.35	0.26	0.55	0.4	0.29	0.65	None
zinc total	ug/l	Mper	36.1	26.4	45.9	27.5	20.7	34.3	88.4	64.1	139	139	90.1	256	160	96.9	317	32.05%

		Site 5 Required discharge quality to meet no deterioration (v1)																
		Mean			Standard Deviation			95-percentile			99-percentile			99.5-percentile			WW treatment % reduction required to prevent deterioration (Mean)	
Determinand	Units	Model	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	
4-n-nonylphenol	ug/l	Monte Carlo	0.0071	0.007	0.0073	0.0006	0.0005	0.0008	0.0083	0.008	0.0087	0.0087	0.0084	0.0093	0.0089	0.0085	0.0095	97%
cypermethrin	ug/l	Monte Carlo	0.000014	0.000012	0.000017	0.0000077	0.0000061	0.0000094	0.00003	0.000025	0.000039	0.000041	0.000033	0.000056	0.000046	0.000035	0.000068	95%
diazinon	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
formaldehyde	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
hexabromocyclododecane (HBCDD)	ug/l	Monte Carlo	0.000023	0.000019	0.000028	0.000016	0.000013	0.000019	0.000055	0.000044	0.000077	0.000082	0.000062	0.00013	0.000093	0.000067	0.00015	98%
mancozeb	ug/l CS2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
maneb	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mercury total	ug/l	Monte Carlo	0.00247	0.0013	0.00363	0.00383	0.00301	0.00464	0.00898	0.00609	0.0161	0.0189	0.0117	0.0404	0.0236	0.0136	0.0555	73%
nickel total	ug/l	Mper	7.3	4.66	9.9	6.32	4.47	8.16	19.1	12.4	34.4	31.5	16.4	71.8	36.7	16.5	93.8	59%
perfluorooctane sulfonic acid (PFOS)	ug/l	Monte Carlo	0.00487	0.00428	0.00547	0.00199	0.00157	0.00241	0.00877	0.00757	0.0109	0.0113	0.0094	0.0149	0.0122	0.0099	0.0166	No Deterioration
permethrin	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
sulphide or hydrogen sulphide	ug/l	Monte Carlo	4.26	3.54	4.98	2.39	1.89	2.9	9.03	7.43	12	12.7	9.9	18.3	14	10.7	21.1	70%
triclosan	ug/l CS2	Monte Carlo	0.0018	0.0014	0.0022	0.0013	0.001	0.0015	0.0043	0.0034	0.006	0.0065	0.0048	0.01	0.0073	0.0053	0.012	90%
zinc total	ug/l	Mper	44.2	32.3	56.1	33.6	25.3	41.9	108	78.6	170	170	111	311	195	119	385	17%

**B.3 Modelling results, site 6**



Site 6 Target quality required discharge (v1)																			
		Mean	Standard Deviation			95-percentile			99-percentile			99.5-percentile			WW treatment % reduction required to meet AA EQ				
Determinand	Units	Model	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper		
4-n-nonylphenol	ug/l	Monte Carlo	0.3	0.29	0.31	0.046	0.037	0.056	0.38	0.36	0.42	0.43	0.4	0.47	0.44	0.4	0.49	None	
cypermethrin	ug/l	Monte Carlo	0.000029	0.000025	0.000033	0.00013	0.000011	0.000016	0.000055	0.000047	0.000069	0.000074	0.000061	0.000099	0.000079	0.000063	0.00011	89%	
diazinon	ug/l	Monte Carlo	0.0068	0.0058	0.0077	0.0032	0.0026	0.0039	0.013	0.011	0.017	0.018	0.014	0.024	0.019	0.015	0.027	None	
formaldehyde	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
hexabromocyclododecane (HBCDD)	ug/l	Monte Carlo	0.00162	0.00133	0.00191	0.00098	0.00078	0.00118	0.00357	0.00291	0.0048	0.00522	0.00405	0.00763	0.00568	0.00424	0.00873	None	
mancozeb	ug/l CS2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
maneb	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
mercury total	ug/l	Monte Carlo	0.068	0.0441	0.0919	0.0797	0.0631	0.0964	0.215	0.154	0.352	0.411	0.274	0.768	0.474	0.291	0.977	None	
nickel total	ug/l	mper	10.53	7.13	13.92	7.94	5.57	10.3	26.13	17.46	45	40.2	21.47	87.58	40.91	25.2	115.74	None	
perfluorooctane sulfonic acid (PFOS)	ug/l	Monte Carlo	0.000007	0.0000063	0.0000077	0.0000022	0.0000017	0.0000027	0.000011	0.00001	0.00013	0.000014	0.000012	0.000017	0.000014	0.000012	0.000018	100%	
permethrin	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
sulphide or hydrogen sulphide	ug/l	Monte Carlo	0.003	0.0026	0.0034	0.0013	0.001	0.0016	0.0056	0.0048	0.007	0.0074	0.0061	0.0099	0.0079	0.0063	0.011	100%	
triclosan	ug/l CS2	Monte Carlo	0.1	0.085	0.012	0.059	0.046	0.071	0.22	0.18	0.29	0.31	0.25	0.45	0.34	0.26	0.51	None	
zinc total	ug/l	MPer	38.79	30.11	47.47	23.1	17.04	29.15	84.58	63.61	125.82	120.46	80.92	208.4	143.86	94.23	258.92	None	

Site 6 Required discharge quality to meet no deterioration (v1)																			
		Mean	Standard Deviation			95-percentile			99-percentile			99.5-percentile			WW treatment % reduction required to prevent deterioration (Mean)				
Determinand	Units	Model	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper	Face Value	lower	upper		
4-n-nonylphenol	ug/l	Monte Carlo	0.0067	0.0064	0.007	0.001	0.0008	0.0012	0.0086	0.0081	0.0093	0.0095	0.0089	0.011	0.0097	0.009	0.011	97%	
cypermethrin	ug/l	Monte Carlo	0.000029	0.000025	0.000033	0.00013	0.000011	0.000016	0.000055	0.000047	0.000069	0.000074	0.000061	0.000099	0.000079	0.000063	0.00011	89%	
diazinon	ug/l	Monte Carlo	0.0015	0.0012	0.0017	0.0007	0.0006	0.0008	0.0028	0.0024	0.0036	0.0038	0.0031	0.0053	0.0041	0.0032	0.0059	77%	
formaldehyde	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
hexabromocyclododecane (HBCDD)	ug/l	Monte Carlo	0.000029	0.000024	0.000034	0.000018	0.000014	0.000021	0.000064	0.000052	0.000086	0.000094	0.000073	0.00014	0.0001	0.000076	0.00016	97%	
mancozeb	ug/l CS2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
maneb	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
mercury total	ug/l	Monte Carlo	0.0024	0.00156	0.00324	0.00281	0.00223	0.0034	0.0076	0.00544	0.0124	0.0145	0.00968	0.0271	0.0167	0.0103	0.0345	No Deterioration	
nickel total	ug/l	mper	6.92	4.64	9.2	5.22	3.63	6.81	17.17	11.35	29.93	26.42	13.73	58.77	32.8	16.02	77.91	61%	
perfluorooctane sulfonic acid (PFOS)	ug/l	Monte Carlo	0.00041	0.00037	0.00045	0.00013	0.0001	0.00016	0.00066	0.00059	0.00078	0.00081	0.0007	0.001	0.00085	0.00072	0.00108	97%	
permethrin	ug/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
sulphide or hydrogen sulphide	ug/l	Monte Carlo	4.81	4.19	5.43	2.11	1.67	2.54	8.94	7.65	11.2	11.9	9.8	15.8	12.6	10.2	17.4	No Deterioration	
triclosan	ug/l CS2	Monte Carlo	0.0015	0.0012	0.0017	0.0008	0.0007	0.001	0.0031	0.0025	0.0041	0.0045	0.0035	0.0065	0.0048	0.0036	0.0073	91%	
zinc total	ug/l	MPer	40.81	31.7	49.93	24.3	17.94	30.65	88.98	66.98	132.24	126.73	85.27	218.9	151.35	99.32	271.91	23%	



**B.4 Combined water quality impact results for all sites**

Determinand	Site 3, Atherstone						Site 5, Daventry						Site 6, Leighton Buzzard						May require improved discharge quality?
	Modelling results, AA EQS			Modelling results, MAC EQS			Modelling results, AA EQS			Modelling results, MAC EQS			Modelling results, AA EQS			Modelling results, MAC EQS			
	Outcome of hazardous chemicals modelling tests	Deterioration exceeds allowance	WFD Class Deterioration?	Outcome of hazardous chemicals modelling tests	Deterioration exceeds allowance	WFD Class Deterioration?	Outcome of hazardous chemicals modelling tests	Deterioration exceeds allowance	WFD Class Deterioration?	Outcome of hazardous chemicals modelling tests	Deterioration exceeds allowance	WFD Class Deterioration?	Outcome of hazardous chemicals modelling tests	Deterioration exceeds allowance	WFD Class Deterioration?	Outcome of hazardous chemicals modelling tests	Deterioration exceeds allowance	WFD Class Deterioration?	
Key	Fail	Deterioration	Deterioration	Fail	Deterioration	Deterioration	Fail	Deterioration	Deterioration	Fail	Deterioration	Deterioration	Fail	Deterioration	Deterioration	Fail	Deterioration	Deterioration	
	Pass	No Deterioration	Continues to exceed EQS	Pass	No Deterioration	Continues to exceed EQS	Pass	No Deterioration	Continues to exceed EQS	Pass	No Deterioration	Continues to exceed EQS	Pass	No deterioration	Continues to exceed EQS	Pass	No deterioration	Continues to exceed EQS	
	No EQS		No Class deterioration	No EQS		No Class deterioration	No EQS / not sampled	Not sampled	No Class deterioration	No EQS / not sampled	Not sampled	No Class deterioration	No EQS / not sampled	Not sampled	No Class deterioration	No EQS / not sampled	Not sampled	No Class deterioration	
			No EQS			No EQS			No EQS / not sampled			No EQS / not sampled			No EQS / not sampled			No EQS / not sampled	
4-n-nonylphenol																			Yes
cypermethrin																			Yes
diazinon																			Yes
formaldehyde																			Yes
hexabromocyclododecane (HBCDD)																			Yes
mancozeb																			Yes
maneb																			Yes
mercury total																			No
nickel total																			Yes
perfluorooctane sulfonic acid (PFOS)																			Yes
permethrin																			Yes
sulphide or hydrogen sulphide																			Yes
triclosan																			Yes
zinc total																			Yes



**B.5 Bench trial assessment results**

Site 1 (cleaned)

Determinand	Units	Min	Mean	Max	95%ile	90%ile	10%ile	MAC-EQS				EQS		PCV		Count	Standard Deviation
								AA-EQS	MAC-EQS	Type	PCV	LOD	assessment	assessment			
4-n-nonylphenol	ug/l	-	0.02	-	-	-	-	0.3	2	-	-	0.04	-	-	4	0.0006	
cypermethrin	ug/l	-	0.0004	-	-	-	-	0.00008	0.0006	-	-	0.00008	-	-	4	0.0002	
diazinon	ug/l	-	0.005	-	-	-	-	0.01	0.02	-	-	0.01	-	-	4	0.0030	
formaldehyde	ug/l	-	-	-	-	-	-	5	50	-	-	50	-	-	4	-	
hexabromocyclododecane (HBCDD)	ug/l	-	0.00007	-	-	-	-	0.0016	0.5	-	-	0.00014	-	-	4	0.0001	
mancozeb	ug/l CS2	-	0.1	-	-	-	-	2	20	-	-	-	-	-	4	0.0735	
maneb	ug/l	-	0.1	-	-	-	-	3	30	-	-	0.1	-	-	4	0.0964	
mercury total	ug/l	-	0.0005	-	-	-	-	0.07	0.07	-	-	0.001	-	-	4	0.0010	
nickel total	ug/l	-	-	-	-	-	-	4	34	-	-	0.5	-	-	4	-	
perfluorooctane sulfonic acid (PFOS)	ug/l	-	0.65	-	-	-	-	0.00065	36	-	-	0.00065	-	-	4	0.3052	
permethrin	ug/l	-	0.0005	-	-	-	-	0.001	0.01	-	-	0.001	-	-	4	0.0005	
sulphide or hydrogen sulphide	ug/l	-	5	-	-	-	-	0.25	1	-	-	10	-	-	4	3.4513	
triclosan	ug/l CS2	-	0.005	-	-	-	-	0.1	0.28	-	-	0.01	-	-	4	0.0043	
zinc total	ug/l	-	-	-	-	-	-	10.9	-	-	-	0.9	-	-	4	-	

Site 3 (cleaned)

Determinand	Units	Sampled at							EQS			Count	Standard Deviation
		Site 3?	Min	Mean	Max	95%ile	90%ile	10%ile	EQS	LOD	assessment		
4-n-nonylphenol	ug/l	Yes	0.02	0.0246875	0.09	0.06	0.02	0.02	0.3	0.04	-	32	0.0000
cypermethrin	ug/l	Yes	0.00004	5.7813E-05	0.0002	0.0001445	0.00012	0.00004	0.00008	0.00008	-	32	0.0000
diazinon	ug/l	Yes	0.005	0.005	0.005	0.005	0.005	0.005	0.01	-	-	32	0.0000
formaldehyde	ug/l	Yes	25	25	25	25	25	25	5	25	Fail	32	0.0000
hexabromocyclododecane (HBCDD)	ug/l	Yes	0.00007	8.7813E-05	0.00024	0.000218	0.00016	0.00007	0.0016	0.00014	-	32	0.0000
mancozeb	ug/l CS2	Yes	0.05	0.09833333	0.3	0.2275	0.2	0.05	2	-	-	30	0.0724
maneb	ug/l	Yes	0.05	0.2	1.5	0.795	0.3	0.05	3	-	-	32	0.3417
mercury total	ug/l	Yes	0.0005	0.00905484	0.082	0.0355	0.015	0.0005	0.07	0.001	-	31	0.0161
nickel total	ug/l	Yes	8.4	40.1548387	120	110	100	11	4	0.5	Fail	31	31.4644
perfluorooctane sulfonic acid (PFOS)	ug/l	Yes	0.000045	0.00471047	0.00961	0.008043	0.006982	0.002333	0.00065	0.00065	-	32	0.0022
permethrin	ug/l	Yes	0.0005	0.00057813	0.002	0.001	0.0005	0.0005	0.001	-	-	32	0.0003
sulphide or hydrogen sulphide	ug/l	Yes	5	12.71875	31	26.9	26	5	0.25	10	Fail	32	8.4122
triclosan	ug/l CS2	Yes	0.005	0.00546875	0.02	0.005	0.005	0.005	0.1	-	-	32	0.0027
zinc total	ug/l	Yes	10	56.1935484	270	170	100	17	10.9	-	-	31	55.3927



## C Appendix: Qualified values

Determinand	Site 1 samples	Site 1 unqualified samples	Site 1 percentage of unqualified samples	Site 3 samples	Site 3 unqualified samples	Site 3 percentage of unqualified samples
4-n-nonylphenol	25	0	0%	32	3	9%
cypermethrin	32	28	88%	32	6	19%
diazinon	32	5	16%	32	0	0%
formaldehyde	32	1	3%	32	0	0%
hexabromocyclododecane (HBCDD)	31	30	97%	32	4	13%
mancozeb	31	26	84%	30	11	37%
maneb	31	20	65%	32	8	25%
mercury total	31	28	90%	31	27	87%
nickel total	31	31	100%	31	31	100%
perfluorooctane sulfonic acid (PFOS)	36	35	97%	32	31	97%
permethrin	32	22	69%	32	3	9%
sulphide or hydrogen sulphide	32	19	59%	32	18	56%
triclosan	32	26	81%	32	0	0%
zinc total	32	32	100%	31	31	100%

Determinand	Site 5 samples	Site 5 unqualified samples	Site 5 percentage of unqualified samples	Site 6 samples	Site 6 unqualified samples	Site 6 percentage of unqualified samples
4-n-nonylphenol	33	0	0%	33	0	0%
cypermethrin	33	3	9%	32	11	34%
diazinon	N/A	N/A	N/A	25	0	0%
formaldehyde	N/A	N/A	N/A	N/A	N/A	N/A
hexabromocyclododecane (HBCDD)	33	1	3%	33	8	24%
mancozeb	N/A	N/A	N/A	N/A	N/A	N/A
maneb	N/A	N/A	N/A	N/A	N/A	N/A
mercury total	32	26	81%	32	28	88%
nickel total	32	32	100%	33	33	100%
perfluorooctane sulfonic acid (PFOS)	32	32	100%	33	26	79%
permethrin	N/A	N/A	N/A	N/A	N/A	N/A
sulphide or hydrogen sulphide	33	18	55%	31	22	71%
triclosan	32	1	3%	32	0	0%
zinc total	32	32	100%	32	32	100%

## **D Appendix: DO modelling input values**

Input Data	Units	With-scheme, 1 month, low decay	With-scheme, 1 month, high decay	With-scheme, 1 month, high decay - Options to meet FIS	With-scheme, 3 months, low decay	With-scheme, 3 months, high decay	With-scheme, 1 year, low decay	With-scheme, 1 year, high decay	Notes
Name of River:		Coventry Canal							
Name of Discharge:		Minworth SRO AWTW							
Upstream river flow:	MI/d	4.00	4.00	4.00	4.23	4.23	5.67	5.67	Calculated in Aquator
Upstream river flow:	m3/s	0.05	0.05	0.05	0.05	0.05	0.07	0.07	Calculated in Aquator
Upstream BOD concn:	mg/l	3.116	3.116	3.116	3.116	3.116	3.116	3.116	Mean of all samples to round 33, site 3, (no cleaning of outliers)
Upstream Ammonia concn:	mg/l	0.099	0.099	0.099	0.099	0.099	0.099	0.099	Mean of all samples to round 33, ammoniacal nitrogen, site 3.
Upstream DO concn:	mg/l	7.268	7.268	7.268	7.397	7.397	8.271	8.271	Mean DO, sonde at site 4
Temperature:	mg/l	19.963	19.963	19.963	19.356	19.356	16.294	16.294	Effluent (site 1) temperature used as this will dominate flow in the canal.
River slope:	km/km	0.0001							Canal is essentially flat, minimal gradient entered
River width:	m	12							Gate 2 Summary Report Pound Characterisation Table
River depth:	m	Calculated by tool							Calculated
Cross sectional Area	m2	Calculated by tool							Water depth x width (calculated automatically)
Discharge flow:	MI/d	115	115	115	115	115	58	58	Scheme demand profile
Discharge flow:	m3/s	1.331	1.331	1.331	1.331	1.331	0.671	0.671	Calculated
Discharge BOD:	mg/l	4.070	4.070	2.000	4.070	4.070	4.070	4.070	90%ile (advised by EA), site 1, round 33 (5no extreme outliers from 2021 removed)
Discharge Ammonia:	mg/l	0.227	0.238	0.238	0.238	0.238	0.238	0.238	90%ile (advised by EA), ammoniacal nitrogen, site 1
Discharge DO:	mg/l	4.810	4.810	7.268	4.617	4.617	4.680	4.680	10%ile (advised by EA), sonde at site 1
BOD decay rate:	/day	0.5	2	2	0.5	2	0.5	2	High and low of typical range (0.5 to 2 at 20C) tested.
Ammonia decay rate:	/day	1	4	4	1	4	1	4	1 to 4, calibrate v obs data
Diffuse flows:	m3/s/km	0.001	0.001	0.001	0.001	0.001	0.001	0.001	set to very low value
Diffuse flow BOD:	mg/l	3.116	3.116	3.116	3.116	3.116	3.116	3.116	Assumed same as "upstream" canal
Diffuse flow ammonia:	mg/l	0.099	0.099	0.099	0.099	0.099	0.099	0.099	Assumed same as "upstream" canal
Diffuse flow DO:	mg/l	7.268	7.268	7.268	7.397	7.397	8.271	8.271	Assumed same as "upstream" canal

# E Flow comparisons: RQP inputs and results

## E.1 Continuous only flow

### Results (Impact downstream)

discharge Minworth NPD up to 115MLD  
 river Coventry Canal at Atherstone To  
 pollutant mancozeb

MASS BALANCE: Monte Carlo  
 Calculations: 22 May 2024 at 03:25

mean upstream river flow 5.67  
 the 95-percentile low flow 3.94  
 mean discharge flow 28.8  
 standard deviation 0.0000  
 mean u/s river quality 0.098 (0.076 - 0.12)  
 standard deviation 0.072 (0.057 - 0.088)  
 number of samples 30

downstream target 2.0  
 mean M

calculate required discharge quality  
 calculate impact of input discharge quality

mean d/s river quality 1.12 (0.96 - 1.52)  
 standard deviation 0.74 (0.71 - 1.10)  
 number of samples 31

old data - WORD  
 old data - EXCEL  
 old data - NOTE  
 new discharge  
 calculate  
 sensitivity  
 intermittent results  
 Excel Word Note  
 menu quit  
 OUT

mean discharge quality 1.24 (0.96 - 1.52)  
 standard deviation 0.91 (0.72 - 1.10)  
 number of samples 31  
 the 95-percentile 2.94 (2.28 - 4.26)  
 the 99-percentile 4.60 (3.36 - 7.39)  
 the 99.5-percentile 5.42 (3.86 - 9.06)

correlation: river and discharge flow -0.790  
 correlation: river flow and quality -0.300  
 correlation: discharge flow and quality -0.200



[www.jbaconsulting.com](http://www.jbaconsulting.com)

# Results (required to meet AA EQS)

discharge Minworth NPD up to 115MLD  
 river Coventry Canal at Atherstone Top  
 pollutant mancozeb

MASS BALANCE: Monte Carlo  
 Calculations: 22 May 2024 at 03:27

mean upstream river flow 5.67  
 the 95-percentile low flow 3.94  
 mean discharge flow 28.8  
 standard deviation 0.0000  
 mean u/s river quality 0.098 (0.076 - 0.12)  
 standard deviation 0.072 (0.057 - 0.088)  
 number of samples 30

mean discharge quality 1.24 (0.96 - 1.52)  
 standard deviation 0.91 (0.72 - 1.10)  
 number of samples 31  
 the 95-percentile 2.94 (2.28 - 4.26)  
 the 99-percentile 4.60 (3.36 - 7.39)  
 the 99.5-percentile 5.42 (3.86 - 9.06)

correlation: river and discharge flow -0.790

downstream target mean M 2.0  
 calculate required discharge quality  
 calculate impact of input discharge quality

mean d/s river quality 1.23 (1.10 - 1.73)  
 standard deviation 0.82 (0.81 - 1.25)  
 number of samples 31

required discharge mean 1.42 (1.10 - 1.73)  
 standard deviation 1.03 (0.81 - 1.25)  
 number of samples 31  
 the 95-percentile 3.46 (2.71 - 4.95)  
 the 99-percentile 5.41 (4.00 - 8.56)  
 the 99.5-percentile 5.96 (4.20 - 10.1)

correlation: river flow and quality -0.300  
 correlation: discharge flow and quality -0.200

old data - WORD  
 old data - EXCEL  
 old data - NOTE  
 new discharge  
 calculate  
 sensitivity  
 intermittent results  
 Excel Word Note  
 menu quit  
 OUT



[www.jbaconsulting.com](http://www.jbaconsulting.com)

# Results (required to meet no deterioration)

discharge Minworth NPD up to 115MLD  
 river Coventry Canal at Atherstone Toj  
 pollutant mancozeb

mean upstream river flow 5.67  
 the 95-percentile low flow 3.94  
 mean discharge flow 28.8  
 standard deviation 0.0000  
 mean u/s river quality 0.098 (0.076 - 0.12)  
 standard deviation 0.072 (0.057 - 0.088)  
 number of samples 30

mean discharge quality 1.24 (0.96 - 1.52)  
 standard deviation 0.91 (0.72 - 1.10)  
 number of samples 31  
 the 95-percentile 2.94 (2.28 - 4.26)  
 the 99-percentile 4.60 (3.36 - 7.39)  
 the 99.5-percentile 5.42 (3.86 - 9.06)

correlation: river and discharge flow -0.790

downstream target 0.098  calculate required discharge quality  
 calculate impact of input discharge quality

mean M

mean d/s river quality	0.36	(0.040 - 0.062)
standard deviation	0.51	(0.029 - 0.045)
number of samples	31	

required discharge mean	0.051	(0.040 - 0.062)
standard deviation	0.037	(0.029 - 0.045)
number of samples	31	
the 95-percentile	0.12	(0.098 - 0.18)
the 99-percentile	0.19	(0.14 - 0.31)
the 99.5-percentile	0.22	(0.15 - 0.36)

correlation: river flow and quality -0.300  
 correlation: discharge flow and quality -0.200

MASS BALANCE: Monte Carlo  
 Calculations: 22 May 2024 at 03:29

old data - WORD  
 old data - EXCEL  
 old data - NOTE  
 new discharge  
 calculate  
 sensitivity  
 intermittent results  
 Excel Word Note  
 menu quit  
 OUT



[www.jbaconsulting.com](http://www.jbaconsulting.com)

# Results (required to meet permittable deterioration)

discharge Minworth NPD up to 115MLD  
 river Coventry Canal at Atherstone Toj  
 pollutant mancozeb

mean upstream river flow 5.67  
 the 95-percentile low flow 3.94  
 mean discharge flow 28.8  
 standard deviation 0.0000  
 mean u/s river quality 0.098 (0.076 - 0.12)  
 standard deviation 0.072 (0.057 - 0.088)  
 number of samples 30

mean discharge quality 1.24 (0.96 - 1.52)  
 standard deviation 0.91 (0.72 - 1.10)  
 number of samples 31  
 the 95-percentile 2.94 (2.28 - 4.26)  
 the 99-percentile 4.60 (3.36 - 7.39)  
 the 99.5-percentile 5.42 (3.86 - 9.06)

correlation: river and discharge flow -0.790

downstream target 0.1372  
 mean M

calculate required discharge quality  
 calculate impact of input discharge quality

old data - WORD  
 old data - EXCEL  
 old data - NOTE  
 new discharge  
 calculate  
 sensitivity  
 intermittent results  
 Excel Word Note  
 menu quit  
 OUT

MASS BALANCE: Monte Carlo  
 Calculations: 22 May 2024 at 03:46

mean d/s river quality	0.38	(0.062 - 0.097)
standard deviation	0.51	(0.046 - 0.070)
number of samples	31	

required discharge mean	0.079	(0.062 - 0.097)
standard deviation	0.058	(0.046 - 0.070)
number of samples	31	
the 95-percentile	0.19	(0.15 - 0.28)
the 99-percentile	0.30	(0.22 - 0.48)
the 99.5-percentile	0.33	(0.23 - 0.56)

correlation: river flow and quality -0.300  
 correlation: discharge flow and quality -0.200



[www.jbaconsulting.com](http://www.jbaconsulting.com)

E.2 Continuous and intermittent flow

# Results (Impact downstream)



discharge Minworth NPD up to 115MLD  
 river Coventry Canal at Atherstone Toj  
 pollutant mancozeb

mean upstream river flow 5.67  
 the 95-percentile low flow 3.94  
 mean discharge flow 58.0  
 standard deviation 36.9  
 mean u/s river quality 0.098 (0.076 - 0.12)  
 standard deviation 0.072 (0.057 - 0.083)  
 number of samples 30

mean discharge quality 1.24 (0.96 - 1.52)  
 standard deviation 0.91 (0.72 - 1.10)  
 number of samples 31  
 the 95-percentile 2.94 (2.28 - 4.26)  
 the 99-percentile 4.60 (3.36 - 7.39)  
 the 99.5-percentile 5.42 (3.86 - 9.06)

downstream target 2.0  
 mean M

calculate required discharge quality  
 calculate impact of input discharge quality

mean d/s river quality 1.09 (0.96 - 1.52)  
 standard deviation 0.78 (0.71 - 1.10)  
 number of samples 31

correlation: river and discharge flow -0.790  
 correlation: river flow and quality -0.300  
 correlation: discharge flow and quality -0.200

MASS BALANCE: Monte Carlo  
 Calculations: 22 May 2024 at 04:04

old data - WORD  
 old data - EXCEL  
 old data - NOTE  
 new discharge  
 calculate  
 sensitivity  
 intermittent results  
 Excel Word Note  
 menu quit  
 OUT



[www.jbaconsulting.com](http://www.jbaconsulting.com)

# Results (required to meet AA EQS)

discharge Minworth NPD up to 115MLD  
river Coventry Canal at Atherstone Toj  
pollutant mancozeb

MASS BALANCE: Monte Carlo  
Calculations: 22 May 2024 at 04.09

mean upstream river flow 5.67  
the 95-percentile low flow 3.94  
mean discharge flow 58.0  
standard deviation 36.9  
mean u/s river quality 0.098 (0.076 - 0.12)  
standard deviation 0.072 (0.057 - 0.088)  
number of samples 30

mean discharge quality 1.24 (0.96 - 1.52)  
standard deviation 0.91 (0.72 - 1.10)  
number of samples 31  
the 95-percentile 2.94 (2.28 - 4.26)  
the 99-percentile 4.60 (3.36 - 7.30)  
the 99.5-percentile 5.42 (3.86 - 9.06)

correlation: river and discharge flow -0.790

downstream target 2.0  calculate required discharge quality  
 calculate impact of input discharge quality

mean d/s river quality 2.00 (1.77 - 2.79)  
standard deviation 1.44 (1.31 - 2.02)  
number of samples 31

required discharge mean 2.28 (1.77 - 2.79)  
standard deviation 1.67 (1.31 - 2.02)  
number of samples 31  
the 95-percentile 5.57 (4.36 - 7.97)  
the 99-percentile 8.71 (6.44 - 13.8)  
the 99.5-percentile 9.60 (6.76 - 16.2)

correlation: river flow and quality -0.300  
correlation: discharge flow and quality -0.200

old data - WORD  
old data - EXCEL  
old data - NOTE  
new discharge  
calculate  
sensitivity  
intermittent results  
Excel Word Note  
menu quit  
OUT



[www.jbaconsulting.com](http://www.jbaconsulting.com)

# Results (required to meet no deterioration)

discharge Minworth NPD up to 115MLD  
 river Coventry Canal at Atherstone To  
 pollutant mancozeb

MASS BALANCE: Monte Carlo  
 Calculations: 22 May 2024 at 04:12

mean upstream river flow 5.67  
 the 95-percentile low flow 3.94  
 mean discharge flow 58.0  
 standard deviation 36.9  
 mean u/s river quality 0.098 (0.076 - 0.12)  
 standard deviation 0.072 (0.057 - 0.088)  
 number of samples 30

mean discharge quality 1.24 (0.96 - 1.52)  
 standard deviation 0.91 (0.72 - 1.10)  
 number of samples 31  
 the 95-percentile 2.94 (2.28 - 4.28)  
 the 99-percentile 4.60 (3.36 - 7.39)  
 the 99.5-percentile 5.42 (3.06 - 9.06)

correlation: river and discharge flow -0.790

downstream target 0.098  
 calculate required discharge quality  
 calculate impact of input discharge quality

mean d/s river quality 0.098 (0.077 - 0.12)  
 standard deviation 0.063 (0.057 - 0.088)  
 number of samples 31

required discharge mean 0.099 (0.077 - 0.12)  
 standard deviation 0.072 (0.057 - 0.088)  
 number of samples 31  
 the 95-percentile 0.24 (0.19 - 0.35)  
 the 99-percentile 0.38 (0.28 - 0.60)  
 the 99.5-percentile 0.42 (0.29 - 0.71)

correlation: river flow and quality -0.300  
 correlation: discharge flow and quality -0.200

old data - WORD  
 old data - EXCEL  
 old data - NOTE  
 new discharge  
 calculate  
 sensitivity  
 intermittent results  
 Excel Word Note  
 menu quit  
 OUT



[www.jbaconsulting.com](http://www.jbaconsulting.com)

# Results (required to meet permittable deterioration)

discharge Minworth NPD up to 115MLD  
 river Coventry Canal at Atherstone Toj  
 pollutant mancozeb

mean upstream river flow 5.67  
 the 95-percentile low flow 3.94  
 mean discharge flow 58.0  
 standard deviation 36.9  
 mean u/s river quality 0.098 (0.076 - 0.12)  
 standard deviation 0.072 (0.057 - 0.088)  
 number of samples 30

mean discharge quality 1.24 (0.96 - 1.52)  
 standard deviation 0.91 (0.72 - 1.10)  
 number of samples 31  
 the 95-percentile 2.94 (2.28 - 4.26)  
 the 99-percentile 4.60 (3.36 - 7.39)  
 the 99.5-percentile 5.42 (3.86 - 9.06)

correlation: river and discharge flow -0.790

downstream target 0.1372  calculate required discharge quality  
 mean M  calculate impact of input discharge quality

correlation: river flow and quality -0.300

correlation: discharge flow and quality -0.200

mean d/s river quality 0.14 (0.11 - 0.18)  
 standard deviation 0.091 (0.083 - 0.13)  
 number of samples 31

required discharge mean 0.14 (0.11 - 0.18)  
 standard deviation 0.11 (0.083 - 0.13)  
 number of samples 31  
 the 95-percentile 0.35 (0.28 - 0.50)  
 the 99-percentile 0.55 (0.41 - 0.87)  
 the 99.5-percentile 0.61 (0.43 - 1.03)

old data - WORD  
 old data - EXCEL  
 old data - NOTE  
 new discharge  
 calculate  
 sensitivity  
 intermittent results  
 Excel Word Note  
 menu quit  
 OUT

MASS BALANCE: Monte Carlo  
 Calculations: 22 May 2024 at 04:13



[www.jbaconsulting.com](http://www.jbaconsulting.com)



## References

- Affinity Water. (2022). Capacity Needs and Utilisation Profile for Strategic Options, Version 3.
- Environment Agency. (2012). Water quality planning: no deterioration and the Water Framework Directive. Operational Instruction 50\_12. Environment Agency.
- Environment Agency. (2014). H1 Annex D2: Assessment of sanitary and other pollutants within Surface Water Discharges. Environment Agency.
- Environment Agency. (2014). Modelling: surface water pollution risk assessment risk assessment. LIT 10419 . Environment Agency.
- Environment Agency. (2018, 12 31). Format for Channel Survey Data (EACSD format) Version 3.33. Retrieved from eacsd.co.uk: [http://www.eacsd.co.uk/Docs/EACSD\\_V3\\_33.pdf](http://www.eacsd.co.uk/Docs/EACSD_V3_33.pdf)
- Environment Agency. (2019). Permitting of hazardous chemicals and elements in discharges to surface waters. Operational instruction LIT13134. Environment Agency.
- Environment Agency. (Undated). PR24 WINEP supporting guidance – Modelling discharges into lakes and reservoirs. Version 0.3. Environment Agency.
- Foundation for Water Research. (2018, 09). Urban Pollution Management Manual Version 3. Retrieved from fwr.org: <http://www.fwr.org/UPM3/Section2.pdf>
- Jacobs. (2023). Surface water Pollution Risk Assessment. Minworth SRO. Document no: A7W13155-WT-REP-20029.
- National Laboratory Service. (2023). NLS Analysis October 2023 v3.xlsx. National Laboratory Service.

**Offices at**

Bristol  
Coleshill  
Doncaster  
Dublin  
Edinburgh  
Exeter  
Glasgow  
Haywards Heath  
Isle of Man  
Leeds  
Limerick  
Newcastle upon Tyne  
Newport  
Peterborough  
Portsmouth  
Saltaire  
Skipton  
Tadcaster  
Thirsk  
Wallingford  
Warrington

Registered Office  
1 Broughton Park  
Old Lane North  
Broughton  
SKIPTON  
North Yorkshire  
BD23 3FD  
United Kingdom

+44(0)1756 799919  
info@jbaconsulting.com  
www.jbaconsulting.com  
Follow us:  

Jeremy Benn  
Associates Limited

Registered in England  
3246693

JBA Group Ltd is  
certified to:  
ISO 9001:2015  
ISO 14001:2015  
ISO 27001:2013  
ISO 45001:2018

