A46 Newark Bypass

TR010065/APP/6.3

6.3 Environmental Statement

Appendix 13.3 HEWRAT Assessment

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Planning Act 2008

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A46 Newark Bypass

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ENVIRONMENTAL STATEMENT

APPENDIX 13.3 HEWRAT ASSESSMENT

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Planning Inspectorate Scheme Reference	TR010065
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Contents

1 Introduction

1.1 Purpose of the report

1.1.1 This report forms a technical appendix to Chapter 13 (Road Drainage and the Water Environment) of the Environmental Statement (ES) **(TR010065/APP/6.1)** for the A46 Newark Bypass Scheme (the Scheme). This report presents a summary of the water quality assessment undertaken to assess potential impacts of routine runoff and accidental spillage risk to watercourses resulting from the Scheme.

1.1.2 A detailed description of the Scheme is contained within Chapter 2 (The Scheme) of the ES **(TR010065/APP/6.1)**. The Scheme would increase the impermeable road surface area and will also alter the current traffic flows through the creation of new road sections consisting of dualling of the existing carriageways. This has the potential to increase the volume of surface water runoff as well as affecting the water quality of the surface water runoff.

1.1.3 The purpose of the Highways England Water Risk Assessment Tool (HEWRAT) is to assess the potential impacts that the Scheme would have on water quality in the receiving watercourses. The assessment confirms whether the proposed mitigation measures within the drainage strategy are necessary, and if so, whether they adequately reduce the impact on the water quality for the receiving watercourses. Details of the drainage strategy mitigation can be found in Appendix 13.4 (Drainage Strategy Report) of the ES Appendices **(TR010065/APP/6.3)**.

1.1.4 The assessment does not consider the construction phase of the Scheme, only the operational phase. This is because the HEWRAT tool does not have a capability for temporary construction assessments and only considers the operational impact on water quality.

2 Methodology

2.1 Guidance

2.1.1 The assessment methodology follows the guidance set out in the Design Manual for Roads and Bridges (DMRB) LA 113 – Road drainage and the water environment[1].

2.1.2 Table 2-1 is an extract from DMRB LA 113 Table 3.2, detailing the methods of assessment.

Table 2-1: Levels and methods of assessment

Potential impact	Mechanism(s)	Level and methods of assessment		
		Scoping	**Simple**	**Detailed**
Water quality (surface water)	Routine runoff (acute impacts from soluble pollutants and chronic impacts from sediment related pollutants)	Following requirement in DMRB LA 103: Scoping projects for Environmental Assessment	Routine runoff and surface water quality assessment (HEWRAT)	No detailed assessment method available – pass or fail at simple assessment
	Routine runoff (annual average soluble concentrations)			Bioavailability assessment using UKTAG Rivers and Lakes Metal Bioavailability Assessment Tool (M-BAT)
	Spillage		Spillage assessment	No detailed assessment method available – pass or fail at simple assessment
Water quality (groundwater)	Routine runoff		Routine runoff and groundwater quality assessment	Site specific method to be devised. Approach to be discussed and agreed with the relevant consultation body.
	Spillage		Spillage assessment	No detailed assessment method available – pass or fail at simple assessment

Source: DMRB LA 113 Table 3.2

[1] National Highways (2023) Design Manual For Roads and Bridges LA113 Road drainage and the water environment [online]. Available at: LA 113 - Road drainage and the water environment (standardsforhighways.co.uk) (Last accessed December 2023).

2.2 HEWRAT

2.2.1 The HEWRAT assessment tool assesses the impact of soluble pollutants (associated with acute pollution impacts) and sediment related pollutants (associated with chronic pollution impacts on surface water).

Soluble (acute impacts)

2.2.2 HEWRAT uses Runoff Specific Thresholds (RSTs) developed for dissolved copper and dissolved zinc. The RSTs are intended to protect organisms in receiving waters from short-term (acute) exposure (six hours and 24 hours) to these pollutants. The approach used to generate the RSTs is consistent with that adopted for the derivation of Environmental Quality Standards (EQSs) under the Water Environment (WFD) (England and Wales) (Amendment) Regulations WFD 2017[2].

2.2.3 An assessment of the long-term risks is also required to complete the risk assessment process. HEWRAT estimates in-river annual average concentrations for dissolved copper and dissolved zinc, taking into account current background concentrations. These concentrations can be compared with published EQSs as shown in Table 2-2, to assess whether there is likely to be a long-term impact on ecology.

Table 2-2: EQS limits for copper and zinc required to achieve 'Good' under the Water Environment Regulations

Pollutant	Annual mean bioavailable concentrations (µg/l)
Dissolved copper	1
Dissolved zinc	10.9

2.2.4 HEWRAT calculates concentrations for total dissolved copper and zinc, and in the absence of long-term water quality data, a comparison is made for exceedance against EQS for bioavailable copper and zinc. This results in a conservative 'worst-case' assessment, assuming that all dissolved copper and zinc is bioavailable and therefore has the potential to have long-term negative environmental impacts on aquatic flora and fauna.

2.2.5 The Metal Bioavailability Assessment Tool (M-BAT) removes this limitation as it calculates the bioavailable copper and zinc concentrations. This is described in more detail in Section 2.3 of this report.

[2] The Water Environment (Water Framework Directive) (England and Wales) Regulations (2017) His Majesty's Government [online]. Available at: The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (legislation.gov.uk) (Last accessed December 2023).

Sediment (chronic impacts)

2.2.6 The procedure for assessing sediment impacts is based on Threshold Effect Levels (TELs) and Probable Effect Levels (PELs), as well as toxicity thresholds. A calculation is also made about whether sediments will accumulate in the stream / river downstream of the outfall. This calculation is based on estimating the stream velocity under low flow conditions and comparing this with a threshold velocity. Velocity thresholds and deposition index thresholds are shown in Table 2-3 and Table 2-4 respectively. If sediment is predicted to accumulate, the potential extent of sediment coverage (i.e. the deposition index) is also considered.

Table 2-3: Velocity thresholds for sediment

Estimated stream velocity at low flow conditions	Type of site
≤0.1m/s	Accumulating
>0.1m/s	Dispensing

Table 2-4: Deposition index thresholds for sediment

Estimated deposition index	Type of site
<100	Low extent of deposition
≥100	High extent of deposition

Three step approach

2.2.7 The HEWRAT assessment adopts a stepped approach as follows:

- Step 1: Runoff quality. Predicts concentrations of pollutants in untreated and undiluted highway runoff prior to any treatment and dilution in a waterbody.
- Step 2: In-river impacts. Predicts concentrations of pollutants after mixing within the receiving waterbody. At this stage, the ability of the receiving watercourse to disperse sediments is considered. Step 2 also incorporates 2 'tiers' of assessment for sediment accumulation, based on different levels of input parameters. If 1 or more risks are defined as unacceptable at Tier 1, i.e. ‘fail’, then a more detailed Tier 2 assessment is undertaken, requiring values for additional parameters relating to the physical dimensions of the receiving watercourse.
- Step 3: In-river impacts with mitigation. Steps 1 and 2 assume that the road drainage system incorporates no mitigation measures to reduce the risk. Step 3 includes mitigation in the form of Sustainable Drainage Systems (SuDS), taking into account the risk reduction associated with any existing measures or any proposed new measures.

2.2.8 Table 2-5 defines all outcome combinations for the routine runoff and surface water quality assessment and the action shall be applied to the relevant scenario.

Table 2-5: Assessment outcomes and actions

Acute-soluble and chronic-sediment impacts	Annual average concentrations (compliance with EQS)	Action
Pass	Pass	No further action
Fail	Pass	Factor in effect of proposed mitigation and reassess Determine implications of redesign and reassess Weigh up benefits over whole project Discuss with Overseeing Organisation and EPA (Environmental Protection Agency) and agree action
Pass	Fail	Factor in effects of proposed mitigation and reassess Check sensitivity of modelling to input parameters e.g. Q95 Discuss with Overseeing Organisation and EPA and agree action
Fail	Fail	Factor in effect of proposed mitigation and reassess Redesign and assess Discuss with Overseeing Organisation and EPA and agree action

2.3 M-BAT

2.3.1 Where the discharge fails the HEWRAT simple assessment for annual average concentrations of soluble pollutants, and proportionate mitigation cannot be readily incorporated, a detailed assessment must be carried out using the UKTAG Rivers and Lakes Metal Bioavailability Assessment Tool (M-BAT) to provide a representative picture of bioavailability.

2.3.2 The M-BAT takes account of the water chemistry, particularly the pH, dissolved calcium and dissolved organic carbon, to calculate the bioavailable copper and zinc, since these factors influence the toxicity of metals to aquatic organisms.

2.3.3 To comply with the Water Environment (WFD) (England and Wales) (Amendment) Regulations WFD 2015 the annual average concentrations predicted by HEWRAT, or M-BAT, must be lower than the EQS given in those regulations (see Table 2-2 for the EQS limit).

2.4 Spillage Risk Assessment

2.4.1 The assessment aims to ensure provision of appropriate drainage design measures where the risk of a serious pollution incident is more frequent than the 1% Annual Exceedance Probability (AEP) (or more frequent than a 1 in 100-year return period). For more sensitive watercourses (which are located within approximately 1 kilometre of the Scheme), a higher level of protection is applied, up to the 0.5% AEP (or more frequent than 1 in 200 years).

2.4.2 The receiving watercourses – the River Trent, the Old Trent Dyke and The Fleet are not sensitive watercourses since they are not within 1 kilometre of a designated site therefore the accidental spillage must be less than or equal to 1% AEP.

2.4.3 The results of the assessment are reported as ‘pass’ or ‘fail’. The risk of an acute pollution incident, due to accidental spillage or vehicle fire, is considered proportionate to the risk of a Heavy Goods Vehicle (HGV) road traffic collision, and the volume of traffic. Therefore, the percentage of HGVs on a given road is the main parameter used in the assessment of the risk of serious pollution incidents.

2.4.4 To calculate the annual probability of a spillage, the following formula (from DMRB LA 113) is used:

$$\mathbf{P_{SPL} = RL \times SS \times (AADT \times 365 \times 10^{-9}) \times (\%HGV/100)}$$

where:

- PSPL = annual probability of a spillage with potential to cause pollution incident
- RL = road length (km)
- SS = spillage rates (from table D1.1, DMRB LA113)
- AADT = annual average daily traffic
- %HGV = percentage of heavy goods vehicles

2.4.5 To calculate the predicted annual probability of a serious pollution incident on each section of road, the following formula is used:

$$\mathbf{P_{INC} = P_{SPL} \times P_{POL}}$$

where:

- PINC = probability of a spillage with associated risk of a serious pollution event occurring
- PPOL = the probability, given a spillage, that a serious pollution incident will result. Dependant on sensitivity of watercourse and response time of emergency services

2.4.6 The Spillage Risk Assessment will determine what the ‘risk of accidental spillage’ and a ‘risk of pollution incident’. If the risk of accidental spillage is less than or equal to 1% AEP, the risk is considered acceptable. The assessment will also provide a ‘return period', which calculates the risk of a pollution incident with and without pollution reduction measures.

2.4.7 It should be noted that mitigation measures which are to be implemented in the drainage design have not been applied to these calculations. Therefore, the assessment follows a precautionary approach.

2.5 Groundwater Assessment

2.5.1 Basins are formed with material, where appropriate, to impede ingress from ground water or water from land drainage interactions or to impede the infiltration of pollutants. However, where not possible or not appropriate there is a risk that groundwater will be affected by the surface runoff within the basins. Therefore, a groundwater assessment was undertaken.

2.5.2 Impacts of infiltration of routine road runoff on the quality of the underlying groundwater at surface water drainage networks have been assessed in accordance with the assessment method set out in Method C of LA 113[3].

2.5.3 The DMRB (Table C1.2) sets out a matrix that has been designed to assess the potential overall risk to groundwater and to highlight any sites at high risk, where additional measures may be required. The risk assessment matrix uses the Source-Pathway-Receptor (S-P-R) protocol developed for use in risk assessment procedures for contaminated land evaluation. For road systems, the road drainage provides the source term. The pathway is represented by the processes by which road drainage is transported and discharged. The receptor is the groundwater. The parameters used in the risk assessment matrix are taken from Table C.1 within Appendix C of DMRB guidance document LA 113: Road Drainage and the Water Environment and are shown in Table 2-6 below.

Table 2-6: Groundwater assessment parameters (Table C.1 of LA 113)

	Weighting Factor	Parameter	Input			Source
			Low Risk (Score 1)	Medium Risk (Score 2)	High Risk (Score 3)	
Source	10	Traffic flow	<= 50,000 AADT	50,000 to 100,000 AADT	>= 100,000 AADT	Obtained from traffic model

[3] National Highways (2023) LA113 DMRB Vol. 11, Section 3, Part 10 Road Drainage and the Water Environment [online]. Available at: d6388f5f-2694-4986-ac46-b17b62c21727 (standardsforhighways.co.uk) (Last accessed December 2023).

	Weighting Factor	**Parameter**	**Input**			**Source**
			Low Risk (Score 1)	**Medium Risk (Score 2)**	**High Risk (Score 3)**	
	10	Rainfall depth (annual averages)	<= 740mm	740mm to 1060mm	>= 1060mm	SAAR from FEH data
	10	Drainage area ratio	<= 50	50 to 150	>= 150	Calculated by dividing the surface area of basins by the catchment area.
Pathway	15	Infiltration method	"Continuous", shallow linear (e.g. unlined ditch, swale, grassed channel)	"Region", shallow infiltration systems (e.g. infiltration basin)	"Point" systems (e.g. chamber soakaways, deep shafts)	Drainage design
	20	Unsaturated zone	Depth to water table >=15 m	Depth to water table <15 m to >5 m	Depth to water table <=5 m	Groundwater assessments.
	20	Flow type (Incorporates flow type an effective grain size)	Dominantly intergranular flow (e.g. non-fractured consolidated deposits or unconsolidated deposits of fine-medium sand or finer)	Mixed fracture and intergranular flow (e.g. consolidated deposits or unconsolidated deposits of medium – coarse sand)	Flow dominated by fractures/ fissures (e.g. well consolidated sedimentary deposits, igneous and metamorphic rocks or unconsolidated deposits of very coarse sand and coarser)	Based on superficial deposit description on BGS and UK Soil Observatory maps.
	5	Unsaturated Zone Clay Content	>=15% clay minerals	<15% to >1% clay minerals	<=1% clay minerals	Based on historical borehole logs in the vicinity of the Scheme

	Weighting Factor	Parameter	Input			Source
			Low Risk (Score 1)	Medium Risk (Score 2)	High Risk (Score 3)	
	5	Organic Carbon	>=15% SOM	<15% to >1% SOM	<=1% SOM	Based on the UK Soil Observatory online maps
	5	Unsaturated zone soil pH	pH >=8	pH <8 to >5	pH <=5	Based on the UK Soil Observatory maps

2.5.4 The corresponding category risk score (low risk – 1, medium risk – 2, high risk – 3) is multiplied by the weighting factor for each parameter, then summed. The overall risk of impact to groundwater is determined as:

- Overall risk score <150 – Low risk of impact
- Overall risk score 150 to 250 – Medium risk of impact
- Overall risk score >250 – High risk of impact.

2.6 Assumptions and Limitations

2.6.1 The following limitations and assumptions apply to this assessment:

- Water quality surveys were undertaken to obtain the EQS values however, the results were imprecise for the criteria needed for the HEWRAT assessment. The water quality survey results for copper were <8 µg/s. These results were deemed less precise than those found on the UK-SCAPE hydrological sensor data[4], therefore the EQS values for this report were taken from the nearest data source to each outfall catchment; at 'MD-36732350, Non-Tidal Trent Hoval Farrar Ltd intake' (0.7 kilometres east of Cattle Market Roundabout, on the River Trent), 'MD-36731820, River Trent at Winthorpe (new)' (0.7 kilometres Northwest of Winthorpe village, on the River Trent) and 'MD-42980429, Slough Dyke at Langford' (2 kilometres north of Winthorpe village, on The Fleet).
- Stream flow data is required for each receiving watercourse; however, gauge flow data was not available for all receiving watercourses as not all receiving watercourses are classified as 'main rivers'. Commissioning surveys for every ditch and stream is not economically feasible. The Flood Estimation Handbook (FEH) catchment

[4] UK Centre for Ecology & Hydrology (2023) UK-SPACE hydrological sensor data integration tool [online]. Available at: https://eip.ceh.ac.uk/hydrology-ukscape/#close (Last accessed December 2023).

descriptors have therefore been used from the nearest gauging station (listed above).

- To calculate the Q95 values, an area scaling method was used due to the absence of gauge data. This took flow rates from a gauge upstream of the Scheme for which online data is available and scales the measured Q95 value by the contributing areas for each outfall compared to the total catchment area for this gauge[5].
- Long and side slopes, river width and bed width have had to be estimated from topographical data.
- Due to lack of detail for stream and river dimensions in the topographical survey, the same values have been used for bed width (for the Tier 2 assessments) and river width (used in Tier 1 assessments).
- The split between the permeable and impermeable areas used in step 2 of the HEWRAT calculations, has been assumed based on available information for the proposed system.
- Annual Average Daily traffic (AADT) data received from the traffic model was taken from the design year 2028- ‘Do something’ scenario. The 2028 AADT value is at an average of 32,719 (compared to 38,044 from the 2028 ‘Do Minimum’ scenario). Traffic flows reduce with the Scheme because the new bridge over the A1 would carry all of the mainline A46 flow.

[5] National River Flow Archive (2018) Catchment Rainfall data [online]. Available at: Catchment Info for 28022 - Trent at North Muskham (ceh.ac.uk) (Last accessed December 2023).

3 HEWRAT Assessment

3.1 Model input parameters

3.1.1 The HEWRAT assessment requires a series of inputs to determine the impacts of routine runoff from the Scheme. The HEWRAT adopts a tiered, consequential approach to the assessment and reports results at three different stages:

- Step 1 – runoff quality (prior to any pre-treatment)
- Step 2 – in river impacts (after dilution and dispersion)
- Step 3 - in river impacts (post mitigation)

3.1.2 The inputs required for each stage of the routine runoff assessment (used to run the HEWRAT model) are summarised in Table 3-1.

Table 3-1: HEWRAT – Model input parameters

Stage of assessment	Inputs
Step 1 (run off quality)	Outfall information (location) Traffic volume (AADTs) Geographic location 10 years of rainfall data (Standard Annual Average Rainfall (SAAR) values embedded in HEWRAT) for various areas around the country
Step 2 (in river impacts)	Area draining to outfall (impermeable and permeable) Characteristics of receiving watercourse: Q956 Base flow index[7] Water hardness EQS values River width Bed width Manning's coefficient[8] Side slope

[6] The flow within the watercourse in cubic metres per second that is equalled or exceeded for 95% of the flow record i.e. the low flow value.

[7] Base flow index is a measure of the ratio of long term base flow to a watercourse and gives an indication of the groundwater contribution to river flow.

[8] A measure of the roughness of the riverbed, and the effects that this friction has on flow speeds.

Stage of assessment	Inputs
	Long slope
Step 3 (post mitigation)	Existing and proposed mitigation measures Treatment of soluble pollutants Flow attenuation Settlement of sediments

3.2 Baseline drainage conditions

3.2.1 The existing drainage mitigation measures in place for the existing A46 are kerb, gullies, and concrete ditches alongside the majority of the existing highway. Site visits show that the existing system does not appear to be working as designed. The proposed drainage strategy will retrofit or replace the majority of the existing drainage.

3.2.2 As a sensitivity check, five HEWRAT assessments were run, with and without the existing mitigation measures. All assessments showed that there were no differences in the results since the existing measures did not have any treatment capacity and are therefore not working as designed. The HEWRAT assessments therefore assumed that the existing mitigation measures reflect a “no existing mitigation measures” scenario.

3.2.3 Therefore, the ‘Step 2’ results which show the impact of pollution at the outfall without mitigation represent the ‘Baseline’ conditions for the Scheme and ‘Step 3’ which refers to in river impact with mitigation represents the proposed mitigation measures with the Scheme.

3.3 Proposed Drainage Strategy

3.3.1 Infiltration of runoff to ground is not considered to be a viable option for the Scheme therefore Appendix 13.4 (Drainage Strategy Report) of the ES Appendices **(TR010065/APP/6.3)** proposes to drain the highway runoff to multiple watercourses within the vicinity of the Scheme – The River Trent, The Old Trent Dyke and The Fleet.

3.3.2 SuDS treatment features have been proposed throughout the Scheme design to maximise the treatment efficiency as well as providing environmental co-benefits such as biodiversity.

3.3.3 Attenuation features have been designed to accommodate the 1 in 30 year pluvial storm event (plus a 20% climate change allowance). This reduction in attenuation volume, from the 1 in 100 year (plus 20% climate change allowance) was accepted by the lead local flood authority if it could be shown that the proposal had no significant detrimental impact on the surrounding areas. For full details of the reduction please refer to Appendix 13.4 (Drainage Strategy Report) of the ES appendices **(TR010065/APP/6.3)**. Attenuation features will discharge at a restricted green field runoff rate, Qbar.

3.3.4 A raised toe swale with baffles will act as the primary treatment stage. Most road catchments will also receive treatment through the attenuation basins, forebays and ponds.

3.3.5 One catchment features a filter drain rather than a swale due to space restrictions.

3.3.6 Two catchments receive treatment only via the swale and baffles.

3.3.7 Two catchments do not receive treatment.

Catchment descriptions

3.3.8 Figure 3-1 shows the proposed outfall locations assessed in the HEWRAT.

Figure 3-1: Outfall locations assessed during HEWRAT assessment

3.3.9 The outfalls shown in Figure 3-1 take in the catchments of the Scheme as described in Table 3-2.

Table 3-2: Catchment descriptions for proposed drainage strategy

Outfall	Receiving Watercourse	Catchment description
O1	River Trent	West carriageway and embankment from Farndon roundabout to the River Trent.
O2	Old Trent Dyke	West carriageway and embankment from the River Trent to the Old Trent Dyke.
O3	Old Trent Dyke	East carriageway and embankment from the River Trent to Nottingham to Lincoln railway bridge.
O4	Old Trent Dyke	West carriageway and embankment from the Old Trent Dyke to Nottingham to Lincoln railway bridge.
O5	Old Trent Dyke	West carriageway and embankment from Nottingham to Lincoln railway bridge to the Old Trent Dyke.
O6	Old Trent Dyke	West carriageway and embankment from Old Trent Dyke to Kelham Road underpass.
O7	Tributary of the River Trent	Southeast carriageway and embankment from Kelham Road underpass to Cattle Market Roundabout and Southeast quadrant of roundabout.
O8	Tributary of the River Trent	Northwest carriageway and embankment from Kelham Road underpass to Cattle Market Roundabout, Roundabout and carriageway and embankment up to East Coast Mainline railway bridge, carriageway up to River Trent
O9	River Trent	Embankment from East Coast Mainline railway bridge to the River Trent.
O9A	River Trent	Bridge deck of Nether Lock Viaduct
O10	Tributary of the River Trent	West carriageway and embankment from the River Trent to Alexander Avenue.
O11	Slough Dyke	Slip road and slip road roundabout by flyover.
O12	Slough Dyke	Southern slip roads and A46 flyover until A1.
O13	NH Drain	Southern embankment from A1 to Friendly Farmer Roundabout slip road.
O14	Tributary of the Fleet (1)	Carriageway and northern embankment from A1 to Friendly Farmer Roundabout slip road.
O15	Tributary of the Fleet (1)	Carriageway from friendly farmer roundabout to Winthorpe roundabout
O16	Tributary of the Fleet (1)	North eastern lane from Friendly Farmer Roundabout slip road to Winthorpe Roundabout.

Outfall	Receiving Watercourse	Catchment description
O17	Tributary of The Fleet (2)	Winthorpe Roundabout.

3.3.10 Details of the drainage strategy can be found in Appendix 13.4 (Drainage Strategy Report) of the ES appendices **(TR010065/APP/6.3)**.

Treatment efficiencies

3.3.11 Treatment efficiencies values as shown in Table 3-3 have been determined from Table 8.3.2N1 'Pollution and flow control measures options'[9].

Table 3-3: Indicative treatment efficiencies taken from DMRB CG 501 guidance Table 8.3.2N1 Pollution and Flow control measures options

Measure	Suspended solids (% removal)	Treatment of Solutes (% removal, average of copper and zinc removal efficiencies)
Swale/ grassed channel	80	50
Baffle	0	0
Penstock	0	0
Catchpit	0	0
Detention Basin	50	0
Pond	60	35
Filter Drain	60	22.5

3.3.12 The cumulative effect of mitigation measures was calculated by the method outlined in the CIRIA SuDS Manual[10]:

Total mitigation index = mitigation index1 + 0.5 (mitigation index$_2$)

3.3.13 Where the mitigation indices are considered in the order of the treatment train.

Outfall O1, O9A and O15

3.3.14 Outfalls O1, O9A and O15 penstocks which do not provide any treatment.

[9] Design Manual for Roads and Bridges (2022). CG 501 Design of highway drainage systems [online]. Available at: 6355ee38-413a-4a11-989b-0f33af89c4ed (standardsforhighways.co.uk) (Last accessed December 2023).

[10] CIRIA (2015) Report C753 The SuDS Manual V6 [online]. Available at: The SuDS Manual - CIRIA - [PDF Document] (vdocuments.mx) (Last accessed December 2023).

3.3.15 No flow restriction is provided for these outfalls.

3.3.16 The combined suspended solid treatment (CSST) for these outfalls is 0%.

3.3.17 The combined solute removal (CSR) for these outfalls is 0%.

3.3.18 Outfall O15 is a volume displacement catchment. Although it takes catchment from a new section of the highway, there is insufficient space to attenuate this. Therefore, O16 attenuates the same volume of existing highway to compensate. However, this means that runoff from O15 is not treated.

Outfalls O11 and O13

3.3.19 O11 and O13 are treated by swales only.

3.3.20 The CSST for these outfalls is 80%.

3.3.21 The CSR for these outfalls is 50%.

Outfall O16

3.3.22 Outfall O16 has a filter drain, wetland, detention basins, penstocks, ponds and catchpits.

3.3.23 The CSST was calculated as:

$CSST\ (\%) = 60_{\text{filter drain}} + 0.5\ (50_{\text{detention basin}} + 60_{\text{pond}}) = 115\%$

3.3.24 Therefore, a value of 100% was used.

3.3.25 The CSR was calculated as:

CSR (%) = 22.5filter drain + 0.5 (35pond) = 40%

All other outfalls

3.3.26 All outfalls, apart from O1, O11, O13, O15 and O16, have swales, baffles, detention basins, penstocks, ponds and catchpits.

3.3.27 The CSST was calculated as:

$CSST\ (\%) = 80_{\text{swale}} + 0.5\ (50_{\text{detention basin}} + 60_{\text{pond}}) = 135\%$

3.3.28 Therefore, a value of 100% was used.

3.3.29 The CSR was calculated as:

$CSR\ (\%) = 50_{\text{swale}} + 0.5\ (35_{\text{pond}}) = 67.5\%$

Discharge rates

3.3.30 Greenfield runoff rates have been used for all outfalls unless these were calculated to be below 5 litres per second.

3.3.31 Five litres per second has been used as the minimum discharge rate due to physical practicalities in terms of maintenance and operation.

Table 3-4: Restricted discharge rate

Outfall	Restricted discharge rate (l/s)
O1	No restriction
O2	5.00
O3	5.61
O4	5.00
O5	5.00
O6	5.00
O7	9.65
O8	13.04
O9	7.07
O9A	No restriction
O10	5.00
O11	5.47
O12	11.46
O13	5.00
O14	5.00
O15	No restriction
O16	5.00
O17	5.00

3.4 HEWRAT parameters

3.4.1 Steps 1 and 2 assume that the existing road drainage system incorporates no mitigation measures, which therefore demonstrates the 'baseline' of what currently exists at each outfall. The input parameters to run the HEWRAT model are summarised in Table 3-5 for Step 1 and Table 3-6 for Step 2.

Table 3-5: HEWRAT step 1 parameters

HEWRAT parameters	Parameter	Source
AADT	AADT was used for the design year 2028. The AADT flows for the Scheme fall within the >10,000 and <50,000 category. (The AADT are approximate).	Project traffic team
Climatic region	Colder Dry	HEWRAT Help Guide v1.0
Rainfall site	SAAR rainfall has been taken from the Lincoln rainfall series (600mm). This is close to the Scheme and best reflects the nearest SAAR rainfall measurement at North Muskham gauging station (28022) (received from FEH catchment descriptor data) which is 574mm[11].	HEWRAT Help Guide v1.0

[11] National River Flow Archive (2018) Catchment Rainfall data [online]. Available at: Catchment Info for 28022 - Trent at North Muskham https://nrfa.ceh.ac.uk/data/station/spatial/28022 (Last accessed December 2023).

Table 3-6: HEWRAT step 2 parameters

Outfall	Q95 (m^3/s)	Impermeable road area drained (ha)	Permeable road area drained (ha)	Baseflow index	Water Hardness	Proximity of designated sites	Ambient background copper concentration	Structure in vicinity	Estimated river width (m)	Outfall watercourse
Source	FEH Catchment descriptors	Project drainage team	Project drainage team	FEH Catchment descriptors	UK-Scape Hydrological sensor data integration tool[4]	MAGIC Maps	UK-Scape Hydrological sensor data integration tool	Obtained from topographical survey	Obtained from topographical survey	Online mapping
O1	0.004	0.281	0.191	0.58	High	No	4.39	No	30.62	River Trent
O2	0.004	1.036	0.717	0.58	High	No	4.39	No	1.17	Old Trent Dyke
O3	0.004	1.033	0.972	0.58	High	No	4.39	No	2.00	Old Trent Dyke
O4	0.004	1.036	0.717	0.58	High	No	4.39	Yes	1.83	Old Trent Dyke
O5	0.006	0.418	0.205	0.58	High	No	4.39	No	4.61	Old Trent Dyke
O6	0.006	0.523	0.243	0.58	High	No	4.39	No	4.61	Old Trent Dyke
O7	0.007	1.660	1.787	0.58	High	No	4.39	No	2.22	Tributary of the River Trent
O8	0.007	3.424	1.233	0.58	High	No	4.39	No	2.22	Tributary of the River Trent
O9	1.346	0.000	2.526	0.58	High	No	4.39	No	47.59	River Trent
O9A	1.346	0.268	0.000	0.58	High	No	4.39	No	29.12	River Trent
O10	0.003	1.086	0.000	0.58	High	No	4.39	Yes	1.50	Tributary of the River Trent

Outfall	Q95 (m^3/s)	Impermeable road area drained (ha)	Permeable road area drained (ha)	Baseflow index	Water Hardness	Proximity of designated sites	Ambient background copper concentration	Structure in vicinity	Estimated river width (m)	Outfall watercourse
O11	0.003	0.397	1.558	0.58	High	No	2.64	No	1.45	Slough Dyke
O12	0.003	3.311	0.781	0.58	High	No	2.64	No	0.80	Slough Dyke
O13	0.003	0.000	0.316	0.58	High	No	2.64	No	1.04	NH Drain
O14	0.002	0.895	0.320	0.58	High	No	2.64	No	1.68	The Fleet
O15	0.002	3.181	0.000	0.58	High	No	2.64	No	1.68	The Fleet
O16	0.002	1.271	0.000	0.58	High	No	2.64	No	1.68	The Fleet
O17	0.002	1.665	0.000	0.58	High	No	2.64	No	0.94	Tributary of The Fleet

3.4.2 Step 3 of the HEWRAT assessments assesses in-river impacts with mitigation. Step 3 included mitigation in the form of SuDS, taking into account the risk reduction associated with any proposed new measures (refer to section 3.3 of this report for the mitigation measures at each outfall).

3.5 HEWRAT Results

3.5.1 An individual assessment has been carried out for the 18 outfalls required for the Scheme, to assess the potential effects from sediments and soluble pollutants within the surface water runoff.

3.5.2 Acute impact of soluble pollutants and chronic impact of sediments is shown as either pass or fail based on the inbuilt thresholds for each pollutant. When a downstream structure that has potential to reduce velocity within 100 metres of the point of discharge is present, no overall result for the sediment impact could be obtained by the HEWRAT and is thus shown as “Alert. D/S Structure” in the results in Table 3-7 below.

3.5.3 The EQS assessment compares the annual average concentration of copper and zinc to the threshold values published by the Environment Agency. These are 1 µg/l for copper and 10.9 µg/l for zinc.

Tier 1

3.5.4 A Tier 1 assessment uses the estimated river width to calculate the water quality impacts. For each outfall a Step 1 (runoff quality), Step 2 (in-river impacts) and Step 3 (in-river impacts with mitigation) approach was used, as described in Section 2.2 HEWRAT - Three step approach for the EQS – annual average concentration results. All results failed for Step 1 therefore these were not included in the results table. These results are outlined in Table 3-7.

Table 3-7: Tier 1 HEWRAT results for the Scheme

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall Result
		Copper (µg/l)	Zinc (µg/l)	Copper	Zinc	Accumulating? And low flow velocity	Extensive? If yes, % settlement needed to pass, and deposition index	Result	
O1	Step 2	**Fail - 4.46**	Pass - 0.11	Pass	Pass	Yes - 0.00 m/s	No - 1.72	Pass	**Fail**
	Step 3	**Fail - 4.46**	Pass - 0.11				No - 1.72		
O2	Step 2	**Fail - 4.50**	Pass - 0.39	Pass	Pass	Yes - 0.03 m/s	No - 83.70	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.13				No - 0.00		
O3	Step 2	**Fail - 4.49**	Pass - 0.38	Pass	Pass	Yes - 0.01 m/s	No - 79.75	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.13				No - 0.00		
O4	Step 2	**Fail - 4.50**	Pass - 0.39	Pass	Pass	Yes - 0.01 m/s	No - 82.56	Alert. D/S Structure	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.13				No - 0.00		
O5	Step 2	**Fail - 4.46**	Pass - 0.11	Pass	Pass	Yes - 0.00 m/s	No - 16.47	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.04				No - 0.00		
O6	Step 2	**Fail - 4.46**	Pass - 0.14	Pass	Pass	Yes - 0.00 m/s	No - 20.60	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.05				No - 0.00		
O7	Step 2	**Fail - 4.49**	Pass - 0.35	Pass	Pass	Yes - 0.02 m/s	**Yes - 101.17 - 2%**	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.12				No - 0.00		
O8	Step 2	**Fail - 4.54**	Pass - 0.67	Pass	Pass	Yes - 0.02 m/s	**Yes - 208.68 - 53%**	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.22				No - 0.00		
O9	Step 2	**Fail - 4.44**	Pass - 0.00	Pass	Pass	Yes - 0.02 m/s	No - 0.00	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.00				No - 0.00		
O9A	Step 2	**Fail - 4.44**	Pass - 0.00	Pass	Pass	Yes - 0.04 m/s	No - 0.47	Pass	**Fail**
	Step 3	**Fail - 4.44**	Pass - 0.00				No - 0.47		
O10	Step 2	**Fail - 4.52**	Pass - 0.53	Pass	Pass	Yes - 0.01 m/s	**Yes - 103.87 - 4%**		**Fail**

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall Result
		Copper (µg/l)	**Zinc (µg/l)**	**Copper**	**Zinc**	**Accumulating? And low flow velocity**	**Extensive? If yes, % settlement needed to pass, and deposition index**	**Result**	
	Step 3	**Fail - 4.39**	Pass - 0.17				No - 0.00	Alert. D/S Structure	
O11	Step 2	**Fail - 2.70**	Pass - 0.20	Pass	Pass	Yes - 0.01 m/s	No - 38.60	Pass	**Fail**
	Step 3	**Fail - 2.65**	Pass - 0.10				No - 7.72		
O12	Step 2	**Fail - 2.91**	Pass - 1.28	Pass	Pass	Yes - 0.04 m/s	**Yes - 248.25 - 60%**	Pass	**Fail**
	Step 3	**Fail - 2.67**	Pass - 0.42				No - 0.00		
O13	Step 2	**Fail - 2.67**	Pass - 0.00	Pass	Pass	Yes - 0.02 m/s	No - 0.00	Pass	**Fail**
	Step 3	**Fail - 2.64**	Pass - 0.00				No - 0.00		
O14	Step 2	**Fail - 2.78**	Pass - 0.62	Pass	Pass	Yes - 0.01 m/s	No - 92.35	Pass	**Fail**
	Step 3	**Fail - 2.66**	Pass - 0.20				No - 0.00		
O15	Step 2	**Fail - 2.99**	Pass - 1.68	Pass	Pass	Yes - 0.01 m/s	**Yes - 328.23 - 70%**	Pass	**Fail**
	Step 3	**Fail - 2.99**	Pass - 1.68				**Yes - 328.23 - 70%**		
O16	Step 2	**Fail - 2.83**	Pass - 0.85	Pass	Pass	Yes - 0.01 m/s	**Yes - 131.15 - 24%**	Pass	**Fail**
	Step 3	**Fail - 2.72**	Pass - 0.51				No - 0.00		
O17	Step 2	**Fail - 2.86**	Pass - 1.05	Pass	Pass	Yes - 0.02 m/s	**Yes - 220.12 - 42%**	Pass	**Fail**
	Step 3	**Fail - 2.67**	Pass - 0.34				No - 0.00		

3.5.5 The results from the HEWRAT Tier 1 assessment (runoff quality) acute impacts indicate both copper and zinc would pass the assessments after step 2. However, the results the EQS – Annual Average Concentration indicated that runoff from all outfalls would fail for copper and a pass for zinc. This failure is largely due to high existing background concentrations within the catchments. The Tier 1 assessment indicates that all outfalls, bar outfall 15, pass the sediment accumulation assessment at step 3.

3.5.6 Outfall 15 fails the sediment assessment at step 3.

3.5.7 The overall result for all outfalls was 'Fail' due to the copper values failing the EQS assessment, therefore a Tier 2 assessment was carried out.

Tier 2

3.5.8 A Tier 2 assessment uses the channel dimensions (including the longitudinal slope), in addition to the river width from Tier 1. The channel dimensions used for the Tier 2 assessment are summarised in Table 3-8.

Table 3-8: Watercourse dimensions used in Tier 2 assessments

Outfall	**Outfall watercourse**	**Bed width (m)**	**Manning's n**	**Side slope (m/m)**	**Long slope (m/m)**
Source		Measured from the topo surface	Obtained from Table 4-6 in Appendix B of Appendix 13.2 (Flood Risk Assessment) of the ES Appendices (TR010065/APP/6.3)	Measured from the topo surface	Measured from the topo surface
O1	River Trent	30.62	0.0290	0.524	0.0001
O2	Old Trent Dyke	1.17	0.0400	0.691	0.0100
O3	Old Trent Dyke	2.00	0.0400	0.416	0.0001
O4	Old Trent Dyke	1.83	0.0400	0.467	0.0008
O5	Old Trent Dyke	4.61	0.0400	0.368	0.0007
O6	Old Trent Dyke	4.61	0.0400	0.368	0.0007
O7	Tributary of the River Trent	2.22	0.0400	0.579	0.0001
O8	Tributary of the River Trent	2.22	0.0400	0.579	0.0001
O9	River Trent	47.59	0.0290	1.802	0.0001
O9A	River Trent	29.12	0.0290	1.802	0.0001
O10	Tributary of	1.50	0.0400	0.238	0.0001

Outfall	Outfall watercourse	Bed width (m)	Manning's n	Side slope (m/m)	Long slope (m/m)
Source		Measured from the topo surface	Obtained from Table 4-6 in Appendix B of Appendix 13.2 (Flood Risk Assessment) of the ES Appendices (TR010065/APP/6.3)	Measured from the topo surface	Measured from the topo surface
	the River Trent				
O11	Slough Dyke	1.45	0.0300	0.909	0.0018
O12	Slough Dyke	0.80	0.0300	1.249	0.0010
O13	NH Drain	1.04	0.0300	0.572	0.0056
O14	The Fleet	1.68	0.0300	0.333	0.0050
O15	The Fleet	1.68	0.0300	0.333	0.0050
O16	The Fleet	1.68	0.0300	0.333	0.0050
O17	Tributary of The Fleet	0.94	0.0300	0.784	0.0018

3.5.9 The results from the Tier 2 assessment are outlined in Table 3-9.

Table 3-9: Tier 2 HEWRAT results for the Scheme

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall result
		Copper (µg/l)	Zinc (µg/l)	Copper	Zinc	Accumulating? And low flow velocity	If yes, % settlement needed to pass, and deposition index	Result	
O1	Step 2	**Fail - 4.46**	Pass - 0.11	Pass	Pass	Yes - 0.02 m/s	No - 1.72	Pass	**Fail**
	Step 3	**Fail - 4.46**	Pass - 0.11				No - 1.72		
O2	Step 2	**Fail - 4.50**	Pass - 0.39	Pass	Pass	No - 0.20 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.13				No - -*		
O3	Step 2	**Fail - 4.49**	Pass - 0.38	Pass	Pass	Yes - 0.04 m/s	No - 82.00	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.13				No - 0.00		
O4	Step 2	**Fail - 4.50**	Pass - 0.39	Pass	Pass	Yes - 0.08 m/s	No - 33.68	Alert. D/S Structure	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.13				No - 0.00		
O5	Step 2	**Fail - 4.46**	Pass - 0.11	Pass	Pass	Yes - 0.06 m/s	No - 10.28	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.04				No - 0.00		
O6	Step 2	**Fail - 4.46**	Pass - 0.14	Pass	Pass	Yes - 0.06 m/s	No - 12.87	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.05				No - 0.00		
O7	Step 2	**Fail - 4.49**	Pass - 0.35	Pass	Pass	Yes - 0.05 m/s	**Yes - 110.55 - 10%**	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.12				No - 0.00		
O8	Step 2	**Fail - 4.54**	Pass - 0.67	Pass	Pass	Yes - 0.05 m/s	**Yes - 228.02 - 57%**	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.22				No - 0.00		
O9	Step 2	**Fail - 4.44**	Pass - 0.00	Pass	Pass	No - 0.14 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.00				No - -*		
O9A	Step 2	**Fail - 4.44**	Pass - 0.00	Pass	Pass	No - 0.17 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 4.44**	Pass - 0.00				No - -*		
O10	Step 2	**Fail - 4.52**	Pass - 0.53	Pass	Pass	Yes - 0.04 m/s	No - 98.80	Alert. D/S Structure	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.17				No - 0.00		

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall result
		Copper (µg/l)	Zinc (µg/l)	Copper	Zinc	Accumulating? And low flow velocity	If yes, % settlement needed to pass, and deposition index	Result	
O11	Step 2	**Fail - 2.70**	Pass - 0.20	Pass	Pass	No - 0.11 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 2.65**	Pass - 0.10				No - -*		
O12	Step 2	**Fail - 2.91**	Pass - 1.28	Pass	Pass	No - 0.12 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 2.67**	Pass - 0.42				No - -*		
O13	Step 2	**Fail - 2.67**	Pass - 0.00	Pass	Pass	No - 0.37 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 2.64**	Pass - 0.00				No - -*		
O14	Step 2	**Fail - 2.78**	Pass - 0.62	Pass	Pass	No - 0.13 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 2.66**	Pass - 0.20				No - -*		
O15	Step 2	**Fail - 2.99**	Pass - 1.68	Pass	Pass	No - 0.13 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 2.99**	Pass - 1.68				No - -*		
O16	Step 2	**Fail - 2.83**	Pass - 0.85	Pass	Pass	No - 0.13 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 2.72**	Pass - 0.51				No - -*		
O17	Step 2	**Fail - 2.86**	Pass - 1.05	Pass	Pass	No - 0.11 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 2.67**	Pass - 0.34				No - -*		

*The automated HEWRAT assessment results for Outfall O2, O9, O9A, O11, O12, O13, O14, O15, O16 and O17 displayed '-'. A deposit index was not calculated as the low flow velocities were too great and settlement does not accumulate.

3.5.10 The results from the HEWRAT Tier 2 assessment (in-river impacts) acute impacts indicate both copper and zinc would pass the assessment at step 2. However, the results the EQS – Annual Average Concentration from outfall would fail for copper and pass for zinc. The Tier 2 assessment indicates that all outfalls pass the sediment accumulation assessment at step 3.

3.5.11 The overall result for all outfalls was 'Fail' due to the copper values failing the EQS assessment, therefore a Tier 2 assessment with M-BAT was carried out.

3.6 M-BAT

Input parameters

3.6.1 A M-BAT assessment was required due to all outfalls failing for the EQS annual average concentration of copper, at both Tier 1 and Tier 2 with mitigation.

3.6.2 The Tier 1 and Tier 2 HEWRAT assessment assume that all dissolved copper is bioavailable.

3.6.3 The M-BAT is a tool to estimate the bioavailable concentrations of a metal under the conditions found on site, which can then be compared to the EQS limits to assess compliance.

3.6.4 Copper concentration was obtained from the HEWRAT assessment results for Tier 2. Dissolved organic carbon (DOC), pH and calcium have been obtained from the UK-SCAPE hydrological sensor data integration. Median values were used for DOC.

3.6.5 The resulting bioavailable copper concentrations, output from the M-BAT, are recorded in Table 3-10.

Table 3-10: Input parameters for the M-BAT assessment

Outfall	Input parameters				Results
	Measured Copper Concentration (µg/l)	pH	DOC (mg/l)	Calcium (mg/l)	Bioavailable Copper Concentration (µg/l) results from M-BAT
O1	4.46	8	6.2	89.48	0.22
O2	4.50	8	6.2	89.48	0.22
O3	4.49	8	6.2	89.48	0.22
O4	4.50	8	6.2	89.48	0.22
O5	4.46	8	6.2	89.48	0.22
O6	4.46	8	6.2	89.48	0.22
O7	4.49	8	6.2	89.48	0.22
O8	4.54	8	6.2	89.48	0.23
O9	4.44	8	6.2	89.48	0.22
O9A	4.44	8	6.2	89.48	0.22

Outfall	**Input parameters**				**Results**
	Measured Copper Concentration (µg/l)	**pH**	**DOC (mg/l)**	**Calcium (mg/l)**	**Bioavailable Copper Concentration (µg/l) results from M-BAT**
O10	4.52	8	6.2	89.48	0.22
O11	2.70	8.1	6.2	89.48	0.15
O12	2.91	8.1	6.2	89.48	0.16
O13	2.67	7.9	5.22	89.97	0.15
O14	2.78	7.9	5.22	89.97	0.15
O15	2.99	7.9	5.22	89.97	0.16
O16	2.83	7.9	5.22	89.97	0.16
O17	2.86	7.9	5.22	89.97	0.16

Results

3.6.6 A Tier 2 assessment (with mitigation) was re-run with results of the dissolved copper values from the M-BAT assessment. The Tier 1 and Tier 2 HEWRAT assessments failed as the measured copper values (4.46 µg/l for outfall 1 for example) were higher than the EQS limits. For outfall 1, only 0.22 µg/l is bio-available, as calculated by the M-BAT seen above, therefore this is below the EQS limit of 1 µg/l. Table 3-11 outlines these results.

Table 3-11: Tier 2 HEWRAT results with M-BAT for the Scheme

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall result
		Copper (µg/l)	Zinc (µg/l)	Copper	Zinc	Accumulating? And low flow velocity	Extensive? If yes, % settlement needed to pass, and deposition index	Result	
O1	Step 2	Pass - 0.25	Pass - 0.11	Pass	Pass	Yes - 0.02 m/s	No - 1.72	Pass	Pass
	Step 3	Pass - 0.25	Pass - 0.11				No - 1.72		
O2	Step 2	Pass - 0.31	Pass - 0.39	Pass	Pass	No - 0.20 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.25	Pass - 0.13				No - -*		
O3	Step 2	Pass - 0.31	Pass - 0.38	Pass	Pass	Yes - 0.04 m/s	No - 82.00	Pass	Pass
	Step 3	Pass - 0.25	Pass - 0.13				No - 0.00		
O4	Step 2	Pass - 0.31	Pass - 0.39	Pass	Pass	Yes - 0.08 m/s	No - 33.68	Alert. D/S Structure	Pass
	Step 3	Pass - 0.25	Pass - 0.13				No - 0.00		
O5	Step 2	Pass - 0.25	Pass - 0.11	Pass	Pass	Yes - 0.06 m/s	No - 10.28	Pass	Pass
	Step 3	Pass - 0.23	Pass - 0.04				No - 0.00		
O6	Step 2	Pass - 0.25	Pass - 0.14	Pass	Pass	Yes - 0.06 m/s	No - 12.87	Pass	Pass
	Step 3	Pass - 0.23	Pass - 0.05				No - 0.00		
O7	Step 2	Pass - 0.30	Pass - 0.35	Pass	Pass	Yes - 0.05 m/s	**Yes - 110.55- 10%**	Pass	Pass
	Step 3	Pass - 0.25	Pass - 0.12				No - 0.00		
O8	Step 2	Pass - 0.39	Pass - 0.67	Pass	Pass	Yes - 0.05 m/s	**Yes - 228.02 - 57%**	Pass	Pass
	Step 3	Pass - 0.28	Pass - 0.22				No - 0.00		
O9	Step 2	Pass - 0.22	Pass - 0.00	Pass	Pass	No - 0.14 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.22	Pass - 0.00				No - -*		
O9A	Step 2	Pass - 0.22	Pass - 0.00	Pass	Pass	No - 0.17 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.22	Pass - 0.00				No - -*		
O10	Step 2	Pass - 0.34	Pass - 0.53	Pass	Pass	Yes - 0.04 m/s	No - 98.80		Pass

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall result
		Copper (µg/l)	Zinc (µg/l)	Copper	Zinc	Accumulating? And low flow velocity	Extensive? If yes, % settlement needed to pass, and deposition index	Result	
	Step 3	Pass - 0.26	Pass - 0.17				No - 0.00	Alert. D/S Structure	
O11	Step 2	Pass - 0.20	Pass - 0.20	Pass	Pass	No - 0.11 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.17	Pass - 0.10				No - -*		
O12	Step 2	Pass - 0.46	Pass - 1.28	Pass	Pass	No - 0.12 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.25	Pass - 0.42				No - -*		
O13	Step 2	Pass - 0.15	Pass - 0.00	Pass	Pass	No - 0.37 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.15	Pass - 0.00				No - -*		
O14	Step 2	Pass - 0.30	Pass - 0.62	Pass	Pass	No - 0.13 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.20	Pass - 0.20				No - -*		
O15	Step 2	Pass - 0.55	Pass - 1.68	Pass	Pass	No - 0.13 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.55	Pass - 1.68				No - -*		
O16	Step 2	Pass - 0.36	Pass - 0.85	Pass	Pass	No - 0.13 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.28	Pass - 0.51				No - -*		
O17	Step 2	Pass - 0.40	Pass - 1.05	Pass	Pass	No - 0.11 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.24	Pass - 0.34				No - -*		

* The automated HEWRAT assessment results for Outfall O2, O9, O9A, O11, O12, O13, O14, O15, O16 and O17 displayed '-'. A deposit index was not calculated as the low flow velocities were too great and settlement does not accumulate.

3.6.7 Both the baseline and the post mitigation (step 2 and 3) results ‘Pass’ the HEWRAT soluble impact assessment with the M-BAT. The post-mitigation copper values are 0.058 µg/l lower than the baseline copper results on average.

3.6.8 The post-mitigation scenario passes the sediment chronic impact assessment for all outfalls.

3.6.9 The overall result for all outfalls is pass.

3.7 Cumulative HEWRAT Assessment

3.7.1 Input parameters

3.7.2 3.7.1 In accordance with DMRB methodology, the HEWRAT assessment should include a cumulative assessment that considers other outfalls located within 100 metre and 1 kilometre of each other that drain to the same watercourse, for sediment and soluble impacts respectively. Beyond 1 kilometre it is assumed dilution would take place and impacts would be less significant.

3.7.3 3.7.2 In the proposed drainage design, outfalls which are within 100 metre of each other are:

- O5 and O6
- O7 and O8
- O9 and O9A
- O14, O15 and O16

3.7.4 Outfalls which are between 100 metre and 1 kilometre from each other are:

- O2, O3 and O4
- O11 and O12

3.7.5 Input parameters used in the cumulative assessment are shown in Table 3-12. Impermeable and permeable areas for each outfall are summed, other values are worked out based on a weighted average of those values for each outfall.

3.7.6 For mitigation indices the percentage removal of copper and zinc and the percentage settlement of sediment was determined by weighting the proposed mitigation with the catchment areas.

3.7.7 The calculations for these values can be seen in section 3.3.14 and 3.3.11 respectively.

Table 3-12: Input parameters used in the cumulative assessment

Type of assessment	Outfall	Q95 (m^3/s)	Impermeable road area drained (ha)	Permeable road area drained (ha)	Baseflow index	Water Hardness	Proximity of designated sites	Ambient background copper concentration	Structure in vicinity	Estimated river width (m)	Treatment for sediments (%)	Treatment for solutes (%)	Restricted discharge rate (l/s)
	Source	FEH Catchment descriptors	Sum of cumulative areas	Sum of cumulative areas	FEH Catchment descriptors	UK-Scape Hydrological sensor data integration tool[4]	MAGIC Maps	UK-Scape Hydrological sensor data integration tool	Obtained from topographical survey	Obtained from topographical survey (average used)	See treatment efficiencies section of report		Weighted average of greenfield runoff rates
Outfalls within 100m	O5 and O6	0.006	0.941	0.448	0.58	High	No	4.39	No	4.61	100%	67.5%	5.00
	O7 and O8	0.007	5.085	3.019	0.58	High	No	4.39	No	2.22	100%	67.5%	11.35
	O9 and O9A	1.346	0.268	2.526	0.58	High	No	4.39	No	38.35	90.4%	61.0%	6.72
	O14, O15 and O16	0.002	5.347	0.320	0.58	High	No	2.64	No	1.68	43.9%	23.4%	2.19
Outfalls between 100m and 1km	O2, O3 and O4	0.004	3.105	2.406	0.58	High	No	4.39	Cumulative assessment of outfalls between 100m and 1km does not consider watercourse dimensions as this only assesses soluble cumulative			67.5%	5.20

Type of assessment	**Outfall**	**Q95 (m^3/s)**	**Impermeable road area drained (ha)**	**Permeable road area drained (ha)**	**Baseflow index**	**Water Hardness**	**Proximity of designated sites**	**Ambient background copper concentration**	**Structure in vicinity**	**Estimated river width (m)**	**Treatment for sediments (%)**	**Treatment for solutes (%)**	**Restricted discharge rate (l/s)**
	Source	FEH Catchment descriptors	Sum of cumulative areas	Sum of cumulative areas	FEH Catchment descriptors	UK-Scape Hydrological sensor data integration tool[4]	MAGIC Maps	UK-Scape Hydrological sensor data integration tool	Obtained from topographical survey	Obtained from topographical survey (average used)	See treatment efficiencies section of report		Weighted average of greenfield runoff rates
	O11 and O12	0.003	3.708	2.339	0.58	High	No	2.64	impact.			61.8%	5.15

HEWRAT Results for outfalls within 100 meters

Tier 1

3.7.8 Table 3-13 outlines the results from the Tier 1 assessment.

Table 3-13: Cumulative assessment of outfalls within 100 metres - Tier 1 results

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall result
		Copper	Zinc	Copper	Zinc	Accumulating? And low flow velocity	Extensive? If yes, % settlement needed to pass, and deposition index	Result	
O5 and O6	Step 2	**Fail - 4.48**	Pass - 0.25	Pass	Pass	Yes - 0.00 m/s	No - 37.07	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.08				No - 0.00		
O7 and O8	Step 2	**Fail - 4.57**	Pass - 0.92	Pass	Pass	Yes - 0.02 m/s	**Yes - 309.92 - 68%**	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.30				No - 0.00		
O9 and O9A	Step 2	**Fail - 4.44**	Pass - 0.00	Pass	Pass	Yes - 0.03 m/s	No - 0.64	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.00				No - 0.06		
O14, O15 and O16	Step 2	**Fail - 2.90**	Pass - 2.33	Pass	Pass	Yes - 0.01 m/s	**Yes - 551.73 - 82%**	**Fail**	**Fail**
	Step 3	**Fail - 3.01**	Pass - 2.31				**Yes - 309.52 - 82% needed 43.9% proposed**		

3.7.9 The results from the HEWRAT Tier 1 assessment for cumulative outfalls within 100m (runoff quality) acute impacts indicate both copper and zinc would pass the assessments. However, the results the EQS – Annual Average Concentration indicated that runoff from all outfalls would fail for copper and a pass for zinc. This failure is largely due to high existing background concentrations in the catchment. The Tier 1 indicates that the cumulative effects of outfalls O5 and O6, O7 and O8 and O9 and O9A passes the sediment deposit assessment.

3.7.10 The Tier 1 indicates that the cumulative effects of outfalls O14, O15 and O16 fails the sediment deposit assessment.

3.7.11 The Tier 1 assessment failed at step 3 for the EQS assessment of copper, therefore a Tier 2 assessment was carried out.

Tier 2

3.7.12 Table 3-14 outlines the results from the Tier 2 assessment.

Table 3-14: Cumulative assessment of outfalls within 100 metres - Tier 2 results

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall result
		Copper	**Zinc**	**Copper**	**Zinc**	**Accumulating? And low flow velocity**	**Extensive? If yes, % settlement needed to pass, and deposition index**	**Result**	
O5 and O6	Step 2	**Fail - 4.48**	Pass - 0.25	Pass	Pass	Yes - 0.06 m/s	No - 23.15	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.08				No - 0.00		
O7 and O8	Step 2	**Fail - 4.57**	Pass - 0.92	Pass	Pass	Yes - 0.05 m/s	**Yes - 338.70 - 71%**	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.30				No - 0.00		
O9 and O9A	Step 2	**Fail - 4.44**	Pass - 0.00	Pass	Pass	No - 0.16 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 4.39**	Pass - 0.00				No - -*		
O14, O15 and O16	Step 2	**Fail - 2.90**	Pass - 2.33	Pass	Pass	No - 0.13 m/s	No - -*	Pass	**Fail**
	Step 3	**Fail - 3.01**	Pass - 2.31				No - -*		

*The automated HEWRAT assessment results for Outfall**s** 'O9 **and** O9A' and 'O14, O15 and O16' displayed '-'. A deposit index was not calculated as the low flow velocities were too great and settlement does not accumulate.

3.7.13 The results from the HEWRAT Tier 2 assessment for cumulative outfalls within 100 metres (in-river impacts) acute impacts indicate both copper and zinc would pass the assessment. However, the results the EQS – Annual Average Concentration from both cumulative outfalls would fail for copper and pass for zinc. The Tier 2 indicates that the cumulative effects of all outfalls O5 and O6, O7 and O8, O9 and O9A and O14, O15 and O16 pass the sediment deposit assessment.

3.7.14 The Tier 2 assessment failed at step 3 for all EQS assessments of copper, therefore a Tier 2 assessment with M-BAT input criteria was carried out.

Tier 2 with M-BAT

3.7.15 A M-BAT assessment was required due to the cumulative assessments failing for the EQS annual average concentration of copper, at both Tier 1 and Tier 2 with mitigation.

3.7.16 The Tier 1 and Tier 2 HEWRAT assessment assume that all dissolved copper is bioavailable. However, the dissolved copper may be above the EQS limits, causing the HEWRAT to fail.

3.7.17 Copper concentration was obtained from the HEWRAT assessment results for Tier 2. Dissolved organic carbon (DOC), pH and calcium have been obtained from the UK-SCAPE hydrological sensor data integration. Median values were used for DOC.

3.7.18 The resulting bioavailable copper concentrations, output from the M-BAT, are recorded in Table 3-15.

Table 3-15: Input parameters for the M-BAT assessment

Outfalls	**Input parameters**				**Results**
	Measured Copper Concentration (µg/l)	**pH**	**DOC (mg/l)**	**Calcium (mg/l)**	**Bioavailable Copper Concentration (µg/l) results from M-BAT**
O5 and O6	4.48	8	6.2	89.48	0.22
O7 and O8	4.57	8	6.2	89.48	0.23
O9 and O9A	4.44	8	6.2	89.48	0.22
O14, O15 and O16	2.90	7.9	5.22	89.97	0.14

3.7.19 Table 3-16 outlines the results.

Table 3-16: M-BAT assessment results

Outfall	Step	EQS - Annual Average Concentration		Acute Impact		Sediment - Chronic Impact			Overall result
		Copper	Zinc	Copper	Zinc	Accumulating? And low flow velocity	Extensive? If yes, % settlement needed to pass, and deposition index	Result	
O5 and O6	Step 2	Pass - 0.28	Pass - 0.25	Pass	Pass	Yes - 0.06 m/s	No - 23.15	Pass	Pass
	Step 3	Pass - 0.24	Pass - 0.08				No - 0.00		
O7 and O8	Step 2	Pass - 0.43	Pass - 0.92	Pass	Pass	Yes - 0.05 m/s	**Yes - 338.70 - 71%**	Pass	Pass
	Step 3	Pass - 0.30	Pass - 0.30				No - 0.00		
O9 and O9A	Step 2	Pass - 0.22	Pass - 0.00	Pass	Pass	No - 0.16 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.22	Pass - 0.00				No - -*		
O14, O15 and O16	Step 2	Pass - 0.68	Pass - 2.33	Pass	Pass	No - 0.13 m/s	No - -*	Pass	Pass
	Step 3	Pass - 0.65	Pass - 2.31				No - -*		

***The automated HEWRAT assessment results for Outfalls 'O9 and O9A' and 'O14, O15 and O16' displayed '-'. A deposit index was not calculated as the low flow velocities were too great and settlement does not accumulate.**

3.7.20 The results for both cumulative outfalls state the bioavailability copper concentrations with the Scheme is less than the EQS, for both locations. Therefore, the Scheme with mitigation will not lead to an exceedance of EQS. The Tier 2 with M-BAT indicates that the cumulative effects of outfalls O5 and O6, O7 and O8, O9 and O9A and O14, O15 and O16 passes the sediment deposit assessment.

3.7.21 The Tier 2 with M-BAT assessment passed for the O5 and O6, the O7 and O8, O9 and O9A and O14, O15 and O16 cumulative assessments.

Outfalls between 100 metres and 1 kilometre

3.7.22 The cumulative assessment of outfalls between 100 metres and 1 kilometre does not consider river geometry, and therefore is run in only two stages – Tier 1 which considers dissolved copper and Tier 2 M-BAT (in case of failure at Tier 1) which considers bioavailable copper calculated with the M-BAT. The cumulative assessment for outfalls between 100 metres and 1 kilometre does not consider sediment deposit.

Tier 1

3.7.23 Table 3-17 outlines the results from the Tier 1 assessment.

Outfall	EQS - Annual Average Concentration			Acute Impact		Overall result
		Copper	Zinc	Copper	Zinc	
O2, O3 and O4	Step 2	**Fail - 4.57**	Pass - 0.96	Pass	Pass	**Fail**
	Step 3	**Fail - 4.38**	Pass - 0.32			
O11 and O12	Step 2	**Fail - 2.91**	Pass - 1.36	Pass	Pass	**Fail**
	Step 3	**Fail - 2.69**	Pass - 0.54			

3.7.24 The results from the HEWRAT Tier 1 cumulative assessment acute impacts indicate both copper and zinc would pass the assessments. However, the results the EQS – Annual Average Concentration indicated that runoff from all cumulative outfalls would fail for copper and a pass for zinc. This failure is largely due to high existing background concentrations in the catchment.

3.7.25 The Tier 1 assessment failed at step 3 for all cumulative EQS assessments of copper, therefore a Tier 2 M-BAT assessment was carried out.

Tier 2 M-BAT

3.7.26 A M-BAT assessment was required due to the cumulative assessments failing for the EQS annual average concentration of copper, at Tier 1 with mitigation.

3.7.27 The Tier 1 HEWRAT assessment assume that all dissolved copper is bioavailable. However, the dissolved copper may be above the EQS limits, causing the HEWRAT to fail.

3.7.28 Copper concentration was obtained from the HEWRAT assessment results for Tier 2. Dissolved organic carbon (DOC), pH and calcium have been obtained from the UK-SCAPE hydrological sensor data integration. Median values were used for DOC.

3.7.29 The resulting bioavailable copper concentrations, output from the M-BAT, are recorded in Table 3-18.

Table 3-18: Input parameters for the M-BAT assessment

Outfalls	Input parameters				Results
	Measured Copper Concentration (µg/l)	pH	DOC (mg/l)	Calcium (mg/l)	Bioavailable Copper Concentration (µg/l) results from M-BAT
O2, O3 and O4	4.57	8	6.2	89.48	0.23
O11 and O12	2.91	8.1	6.2	89.48	0.16

3.7.30 Table 3-19 outlines the results.

Table 3-19: Cumulative assessment of outfalls between 100m and 1km - Tier 2 M-BAT results

Outfall	EQS - Annual Average Concentration			Acute Impact		Overall result
		Copper	Zinc	Copper	Zinc	
O2, O3 and O4	Step 2	Pass - 0.45	Pass - 0.96	Pass	Pass	Pass
	Step 3	Pass - 0.30	Pass - 0.32			
O11 and O12	Step 2	Pass - 0.48	Pass - 1.36	Pass	Pass	Pass
	Step 3	Pass - 0.28	Pass - 0.54			

3.7.31 The results for all cumulative outfall assessments state the bioavailability copper and zinc concentrations within the Scheme are less than the EQS limits for all outfalls. Therefore, the Scheme with mitigation will not lead to an exceedance of EQS.

3.7.32 Both the cumulative and non-cumulative assessments passed the HEWRAT with the M-BAT input criteria for soluble pollutants and sediments.

4 Spillage risk assessment

4.1 Input parameters

4.1.1 DMRB LA113[1] states that when considering the risk of spillages from a highway and potential pollution to the receiving environment, the following factors must be considered:

- The calculated spillage risk return period must not be greater than 1 in 100 (1% AEP) years;
- The calculated spillage risk return period must not be greater than 1 in 200 (0.5% AEP) years where spillage could affect protected areas for conservation, important drinking water supplies or important commercial activities; and
- Spillage risk from existing outfalls must not be increased
- Parameters considered in the Method D assessment include:
  - The type, location and length of road draining to the watercourse;
  - 2-way AADT flow;
  - % HGV using the road;
  - Emergency services response time (dependent on whether a site is in an urban, rural, or remote setting); and
  - Spillage factor.

4.1.2 The receiving watercourses – the River Trent, the Old Trent Dyke and The Fleet are not sensitive watercourses since they are not within 1km of a designated site therefore the accidental spillage must be less than or equal to 1% AEP.

4.1.3 There are 38 active discharge consents registered on the Environment Agency's portal[12] within 1 kilometre of the study area, as of January 2023. The spillage risk assessment does not consider these, however, these have been addressed in Chapter 13 (Road Drainage and the Water Environment) of the ES Appendices **(TR010065/APP/6.3)**.

4.1.4 The values (and assumptions) used for each parameter as part of the Spillage Risk Assessment are described in Table 4-1 and Table 4-2:

Table 4-1: Parameters used for Spillage Risk Assessment

Input	Comment
Water body type	All outfalls to surface watercourses
Length of road draining to outfall	Measured from proposed drainage strategy drawings
Road type (A-road or motorway)	Whole Scheme is A-road

[12] Environment Agency's published data. Environmental Permitting Regulations – Discharges to Water and Groundwater [online]. Available at: Environmental Permitting Regulations – Discharges to Water and Groundwater (data.gov.uk) (Last accessed December 2023).

Input	Comment
Urban or rural site	All site designated as "urban" as worst case scenario.
Junction type	Determined from "No Junction", "Slip road", "Roundabout", "Cross road", "Side road".
Response time for emergency services	Assumed as <20 minutes due to proximity to town center and hospitals.
AADT (Two way)	Extracted from traffic modelling
Percentage of heavy goods vehicles use for each road	Extracted from traffic modelling
Spillage factor	Determined from following for urban sites: No Junction: 0.31 Slip road: 0.36 Roundabout: 5.35 Cross road: 1.46 Side road: 1.81
Existing and proposed measures factor	Lowest risk reduction factor of the applicable measure for each outfall from the following: Grassed Ditch/ Swale: 0.6 Pond: 0.5 Detention basin 0.6 Penstock/ Valve: 0.4 As the existing system is not assumed to be functioning as intending, no existing measures factor was included and the default value of 1 was used. The proposed measures factor was calculated using: Measures factor = 0.6_{swale} * 0.6_{basin} * 0.5_{pomd} * $0.4_{penstock}$ = 0.072 Measures factor for O1, O9A and O15 = $0.4_{penstock}$ Measures factor for O11 and O13 = 0.6_{swale} * $0.4_{penstock}$ =- 0.24 Measures factor for O16 = $0.6_{filter\ drain}$ * 0.6_{basin} * 0.5_{pomd} * $0.4_{penstock}$ = 0.072

Table 4-2: Spillage risk assessment values

Outfall	Water body	Length of road (m)	Road Type	Site	Junction type	Response time	AADT (two way)	% HGV	Spillage factor	Existing Measures factor	Proposed Measures factor
O1	Watercourse	220	A	Urban	No junction	<20 mins	42956	12	0.31	1	0.4
O2	Watercourse	720	A	Urban	No junction	<20 mins	43434	12	0.31	1	0.072
O3	Watercourse	720	A	Urban	No junction	<20 mins	43434	12	0.31	1	0.072
O4	Watercourse	390	A	Urban	No junction	<20 mins	43434	12	0.31	1	0.072
O5	Watercourse	330	A	Urban	No junction	<20 mins	43434	12	0.31	1	0.072
O6	Watercourse	380	A	Urban	No junction	<20 mins	43434	12	0.31	1	0.072
O7	Watercourse	510	A	Urban	Roundabout	<20 mins	29122	12	5.35	1	0.072
O8	Watercourse	1060	A	Urban	Roundabout	<20 mins	29122	12	5.35	1	0.072
O9	Watercourse	0	A	Urban	No junction	<20 mins	41967	13	0.31	1	0.072
O9A	Watercourse	180	A	Urban	No Junction	<20 mins	41967	13	0.31	1	0.4
O10	Watercourse	960	A	Urban	No junction	<20 mins	41967	13	0.31	1	0.072
O11	Watercourse	370	A	Urban	Roundabout	<20 mins	12014	12	5.35	1	0.24
O12	Watercourse	1100	A	Urban	Slip road	<20 mins	29954	13	0.36	1	0.072
O13	Watercourse	0	A	Urban	No junction	<20 mins	29323	14	0.31	1	0.24
O14	Watercourse	260	A	Urban	No junction	<20 mins	29954	13	0.31	1	0.072
O15	Watercourse	990	A	Urban	No junction	<20 mins	20732	11	0.31	1	0.4
O16	Watercourse	750	A	Urban	No junction	<20 mins	20732	11	0.31	1	0.072
O17	Watercourse	530	A	Urban	Roundabout	<20 mins	20732	11	5.35	1	0.072

4.2 Results

4.2.1 Table 4-3 outlines the results from the spillage risk assessment.

Table 4-3: Spillage risk assessment results

Outfall	Embedded mitigation	Spillage risk %	Spillage Risk Return Period (years)
O1	Existing mitigation / No mitigation	0.0060%	17,318
	Proposed mitigation: Penstock	0.0023%	43,296
O2	Existing mitigation / No mitigation	0.0191%	5,233
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0014%	72,687
O3	Existing mitigation / No mitigation	0.0191%	5,233
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0014%	72,687
O4	Existing mitigation / No mitigation	0.0104%	9,662
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0007%	134,191
O5	Existing mitigation / No mitigation	0.0088%	11,418
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0006%	158,590
O6	Existing mitigation / No mitigation	0.0101%	9,916
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0007%	137,723
O7	Existing mitigation / No mitigation	0.1566%	639
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0113%	8,868
O8	Existing mitigation / No mitigation	0.3255%	307
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0234%	4,267
O9	Existing mitigation / No mitigation	n/a - catchment does not have any road section - only embankment	
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond		
O9A	Existing mitigation / No mitigation	0.0050%	19,999
	Proposed mitigation: Penstock	0.0020%	49,998
O10	Existing mitigation / No mitigation	0.0267%	3,750
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0019%	52,081
O11	Existing mitigation / No mitigation	0.0469%	2,133
	Proposed mitigation: Swale, Baffles	0.0112%	8,889
O12	Existing mitigation / No mitigation	0.0253%	3,948
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0018%	54,836
O13	Existing mitigation / No mitigation	n/a - catchment does not have any road section - only embankment	
	Proposed mitigation: Swale, Baffles		
O14	Existing mitigation / No mitigation	0.0052%	19,398
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0004%	269,419
O15	Existing mitigation / No mitigation	0.0115%	8,699
	Proposed mitigation: Penstock	0.0046%	21,747
O16	Existing mitigation / No mitigation	0.0087%	11,483
	Proposed mitigation: Filter drain, Penstock,	0.0006%	159,480

	Catchpit, Detention Basin, Pond		
O17	Existing mitigation / No mitigation	0.1062%	942
	Proposed mitigation: Swale, Baffles, Penstock, Catchpit, Detention Basin, Pond	0.0076%	13,077

4.2.2 The Scheme passes the spillage risk assessment as all outfalls, with proposed mitigation factors applied, have a probability of a spillage risk event occurring below 1%. No additional mitigation factors are required.

5 Groundwater Assessment

5.1.1 Basins are formed with material, where appropriate, to impede ingress from ground water or water from land drainage interactions or to impede the infiltration of pollutants. However, where not possible or not appropriate there is a risk that groundwater will be affected by the surface runoff within the basins. Therefore, a groundwater assessment was undertaken.

5.1.2 A groundwater assessment was conducted using the HEWRAT Groundwater Assessment tool. Parameters are assumed to remain the same throughout the Scheme, therefore only one assessment was done.

5.1.3 A groundwater monitoring programme commenced in January 2023, but the available data to date does not represent baseline seasonal variability in groundwater levels. A depth to water table of less than 5 metres has been assumed.

5.1.4 Further assumptions made are detailed section 2.6.

5.2 Results

5.2.1 Table 5-1 outlines the results from the groundwater assessment.

Table 5-1: Results of groundwater assessment

Parameter	Source	Risk Score	Weighting Factor	Component Score	Weighted Component Score
Traffic Flow	Traffic flow	<=50,000 AADT	10	1	10
Rainfall Depth (annual average)	Rainfall depth (annual averages)	<=740mm rainfall	10	1	10
Drainage area ratio	Drainage area ratio	>=150	10	3	30
Infiltration Method	Infiltration method	"Region", shallow infiltration systems (e.g. infiltration basin)	15	2	30
Unsaturated zone	Unsaturated zone	Depth to water table <=5m	20	3	60
Flow type (incorporates flow type and effective grain size)	Flow type (Incorporates flow type an effective grain size)	Mixed fracture and intergranular flow (e.g. consolidated deposits or unconsolidated deposits of	20	2	40

Parameter	Source	Risk Score	Weighting Factor	Component Score	Weighted Component Score
		medium to coarse sand)			
Unsaturated zone clay content	Unsaturated Zone Clay Content	>=15% clay minerals	5	1	5
Organic carbon	Organic Carbon	>=15% SOM	5	1	5
Unsaturated zone soil pH	Unsaturated zone soil pH	Ph <8 to >5	5	2	10
Total Score					**200**
Risk Screening Level					**Medium**

5.2.2 The groundwater assessment demonstrates a medium groundwater risk. The HEWRAT groundwater analysis does not consider mitigation measures embedded into the drainage design of the Scheme, such as the primary treatment swale and the material that the basins are bunded with, and therefore the pollutant load and the overall risk are likely to be overestimated by the used method.

5.2.3 The dry weather channel and permanent wetted areas (ponds) proposed within the attenuation area will be formed out of an impermeable liner to prevent ingress of pollutants. As the attenuation basins will be formed above seasonal peak groundwater levels (or at existing ground if at ground level) groundwater ingress should therefore not be an issue within the larger basin area. Groundwater monitoring is continuing to determine seasonal peak groundwater levels and the design will be updated in detailed design. Conservatively, groundwater has been assumed to be at ground level for design purposes.

6 Summary

6.1.1 The introduction of the Scheme will impact the surface water runoff quality which will in turn impact the water quality of the receiving watercourses.

6.1.2 The HEWRAT was used to assess the short-term risk (acute and chronic pollutant impacts) of the receiving watercourses by comparing soluble pollutants and sediment pollutants runoff.

6.1.3 All outfalls failed both the Tier 1 and Tier 2 HEWRAT assessment for copper. The dissolved copper measured in the receiving water courses was above the Environmental Quality Standards (EQS) limits, causing the HEWRAT to fail.

6.1.4 An M-BAT assessment was carried out for all outfalls. This estimated the bioavailable copper concentration under the conditions found on site, which were then compared to the EQS limits to assess compliance. The Tier 2 HEWRAT assessments were re-run for all outfalls, with the results from the M-BAT assessment. The results state that all outfalls have passed the HEWRAT assessment, for non-cumulative and cumulative assessments. Therefore, the Scheme will not lead to an exceedance of EQS or sediment accumulation with the proposed mitigation.

6.1.5 The results from the spillage risk assessment indicate, without consideration of the Scheme, there would be no discharge with a spillage risk more frequent than the 1% (1 in 100 year return period). This is considered acceptable, and no mitigation is required for the spillage risk. The proposed mitigation is therefore considered sufficient to not cause a significant adverse effect on the receiving watercourses.

6.1.6 The groundwater assessment determined there was medium risk to groundwater. The groundwater analysis does not consider mitigation measures embedded into the drainage design of the Scheme and therefore the pollutant load and the overall risk are likely to be overestimated by the used method. The dry weather channel and permanent wetted areas (ponds) proposed within the attenuation area will be formed out of an impermeable liner to prevent ingress of pollutants. As the attenuation basins will be formed above seasonal peak groundwater levels (or at existing ground if at ground level) groundwater ingress should therefore not be an issue within the larger basin area.

7 References

[1] National Highways (2023) Design Manual For Roads and Bridges LA113 Road drainage and the water environment [online]. Available at: LA 113 - Road drainage and the water environment (standardsforhighways.co.uk) (Last accessed December 2023).

[2] The Water Environment (Water Framework Directive) (England and Wales) Regulations (2017) His Majesty's Government [online]. Available at: The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (legislation.gov.uk) (Last accessed December 2023).

[3] National Highways (2023) LA113 DMRB Vol. 11, Section 3, Part 10 Road Drainage and the Water Environment [online]. Available at: d6388f5f-2694-4986-ac46-b17b62c21727 (standardsforhighways.co.uk) (Last accessed December 2023).

[4] UK Centre for Ecology & Hydrology (2023) UK-SPACE hydrological sensor data integration tool [online]. Available at: [redacted] (Last accessed December 2023).

[5] National River Flow Archive (2018) Catchment Rainfall data [online]. Available at: [redacted] (Last accessed December 2023).

[9] Design Manual for Roads and Bridges (2022). CG 501 Design of highway drainage systems [online]. Available at: 6355ee38-413a-4a11-989b-0f33af89c4ed (standardsforhighways.co.uk) (Last accessed December 2023).

[10] CIRIA (2015) Report C753 The SuDS Manual V6 [online]. Available at: [redacted] (Last accessed December 2023).

[11] National River Flow Archive (2018) Catchment Rainfall data [online]. Available at: [redacted]

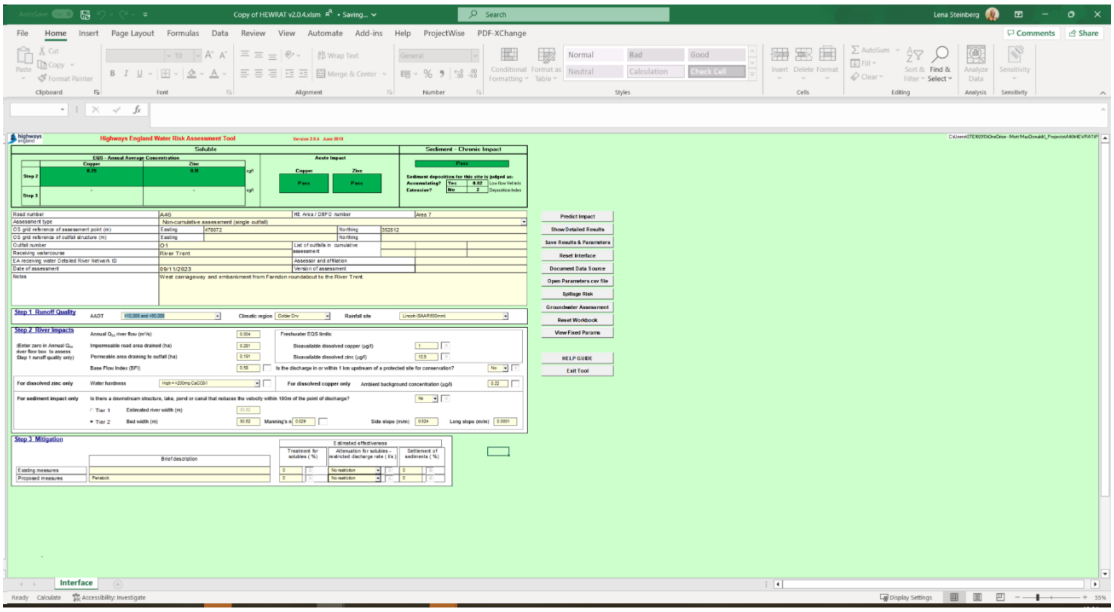
[redacted] (Last accessed December 2023).

[12] Environment Agency's published data. Environmental Permitting Regulations – Discharges to Water and Groundwater [online]. Available at: Environmental Permitting Regulations – Discharges to Water and Groundwater (data.gov.uk) (Last accessed December 2023).

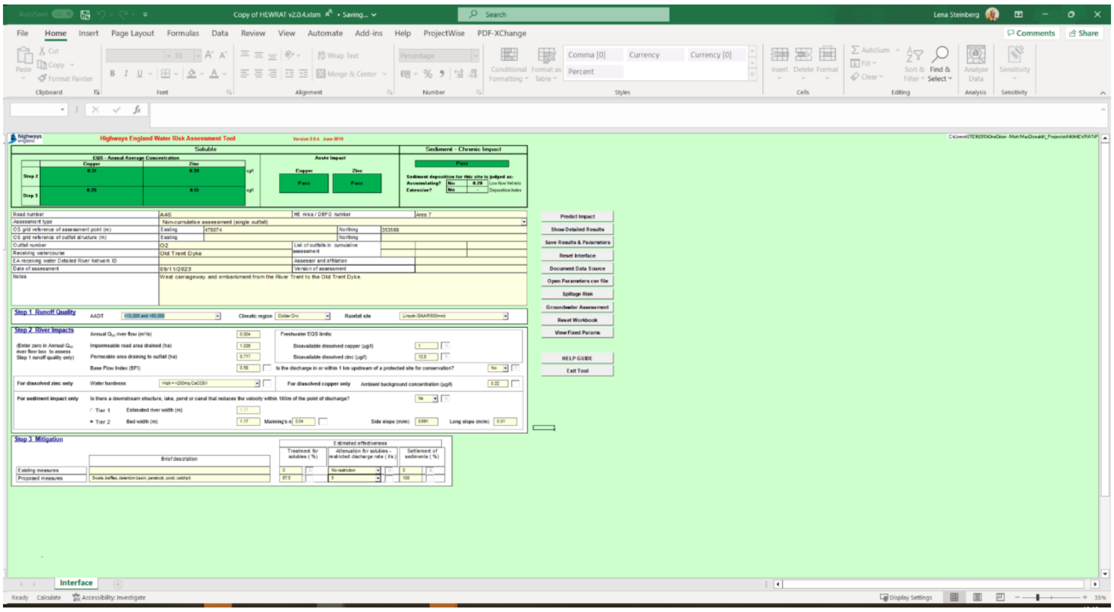
Appendix A: M-Bat Results

A.1 Non-cumulative assessments

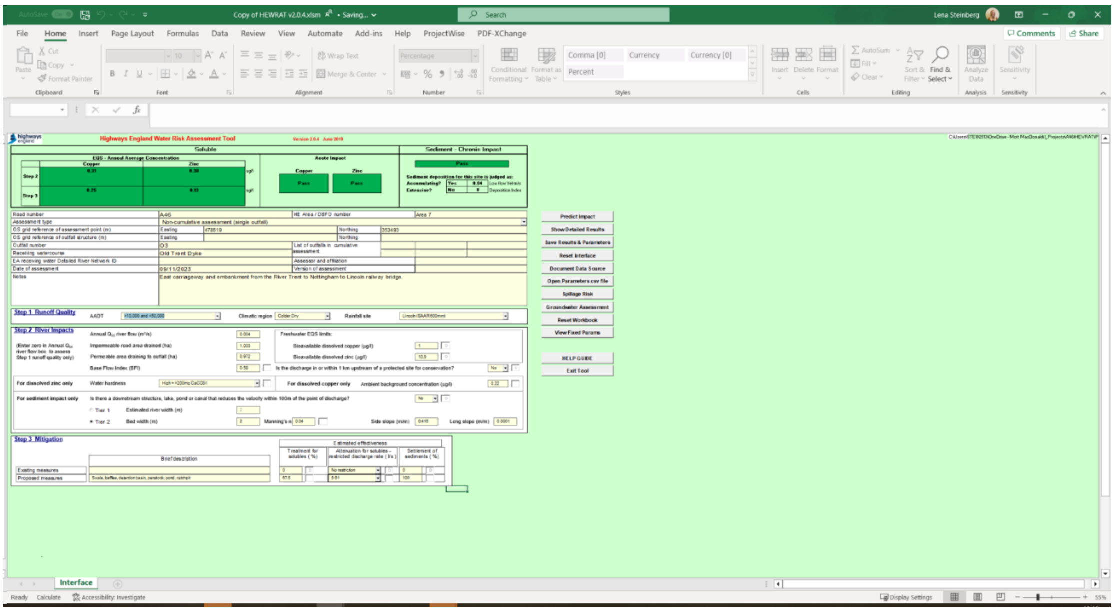
A.1.0.1 Outfall O1:



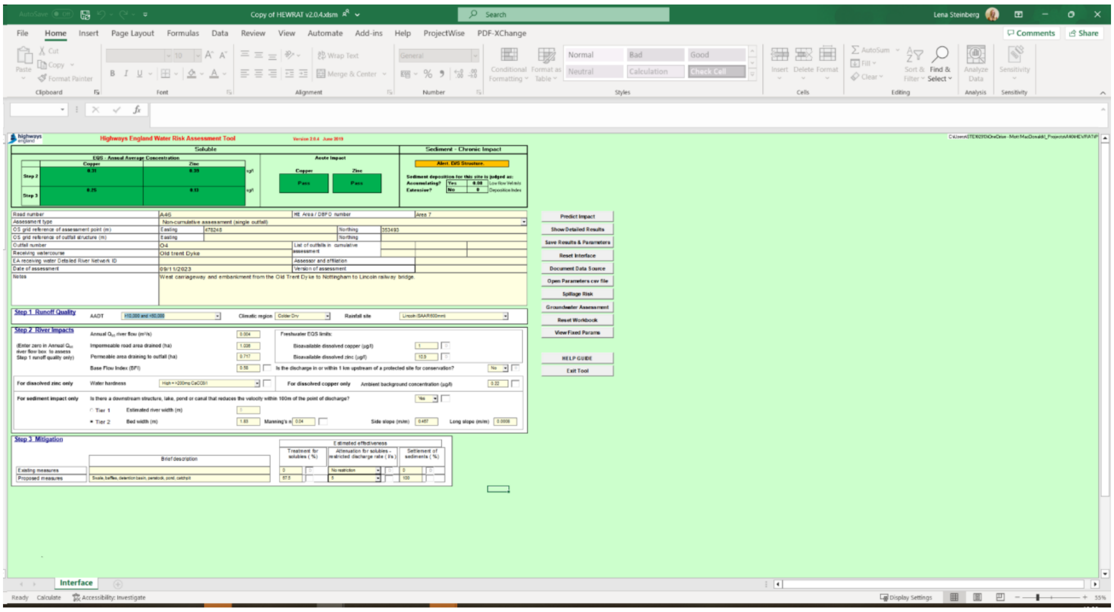
A.1.0.2 Outfall O2:



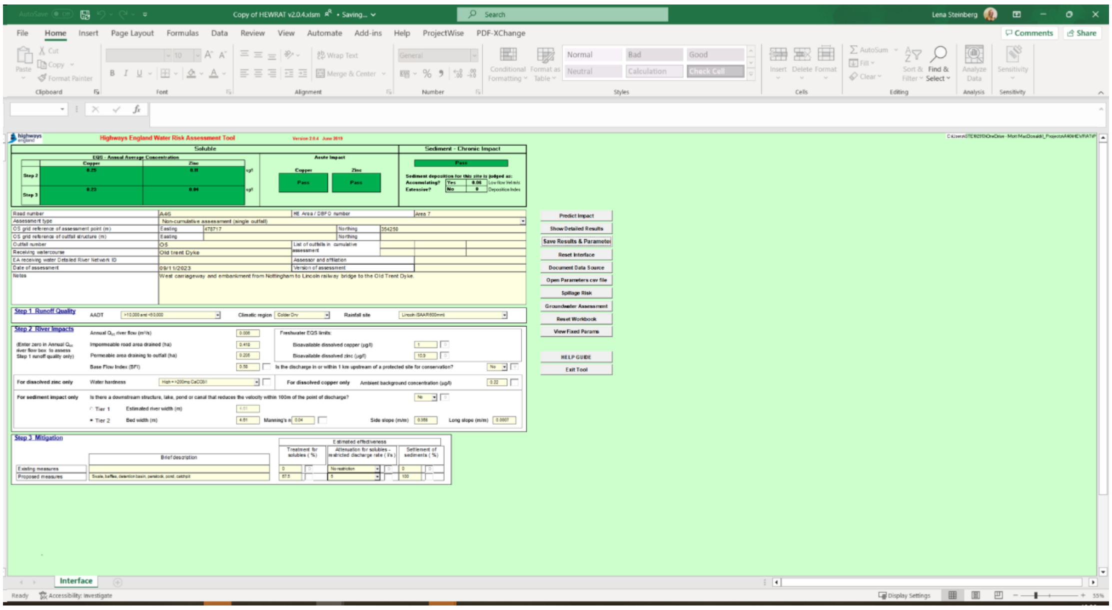
A.1.0.3 Outfall O3:



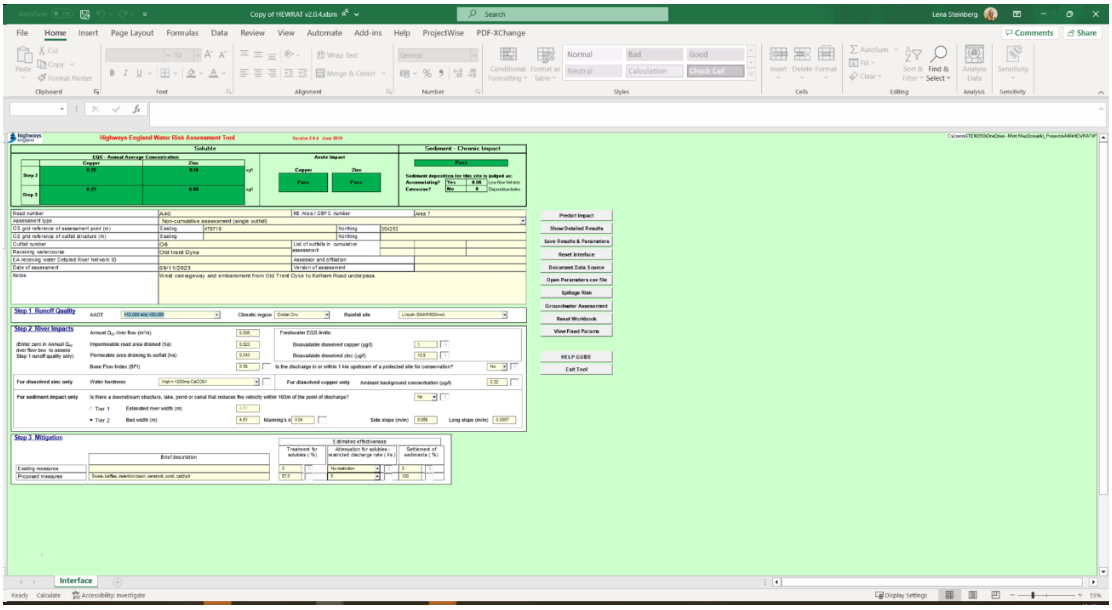
A.1.0.4 Outfall O4:



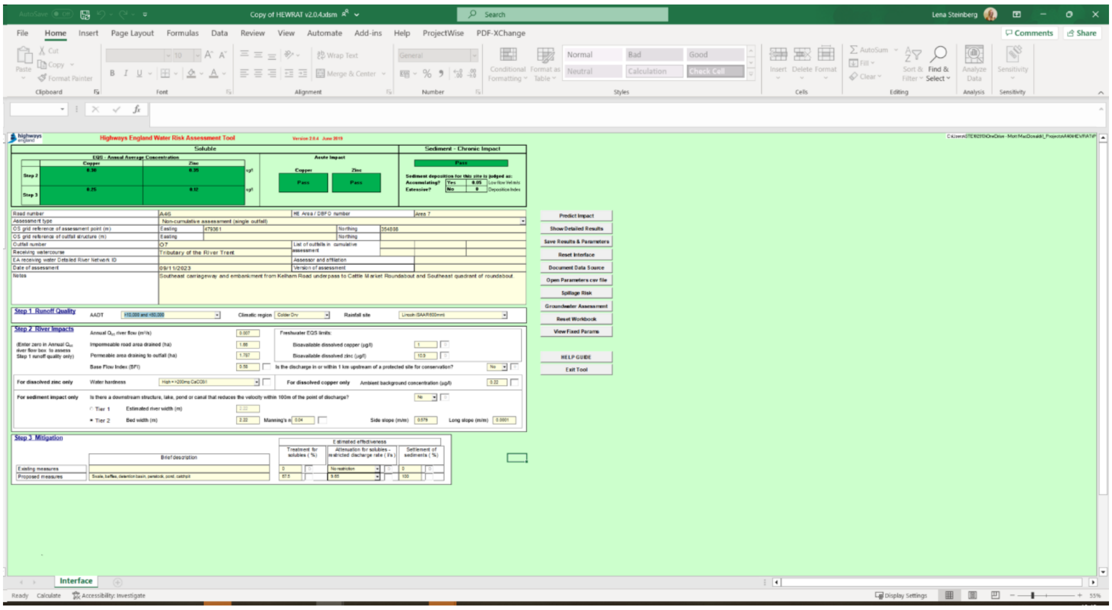
A.1.0.5 Outfall O5:



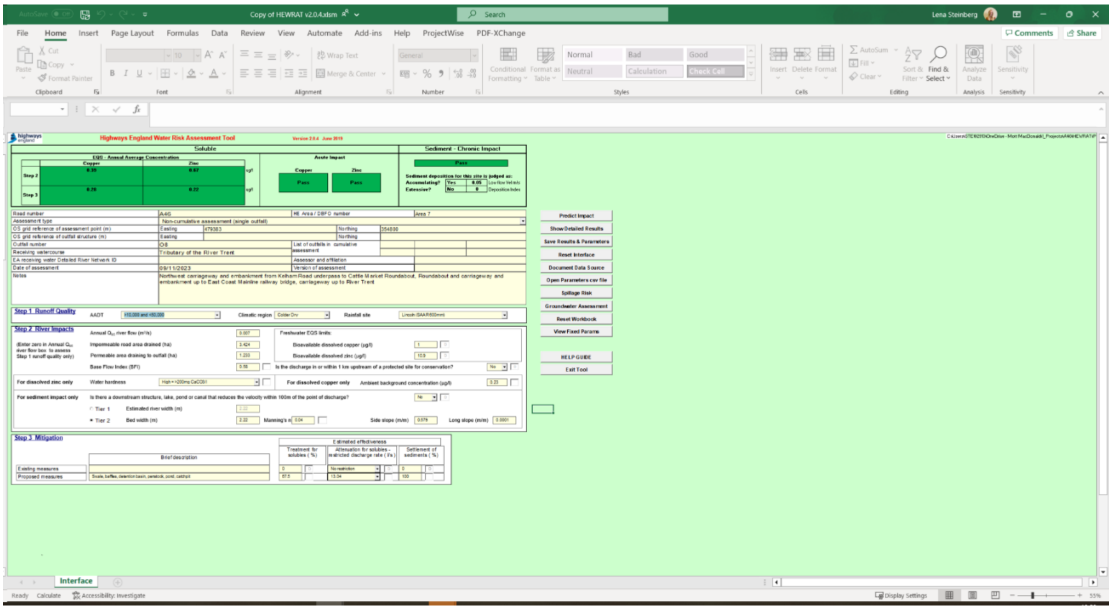
A.1.0.6 Outfall O6:



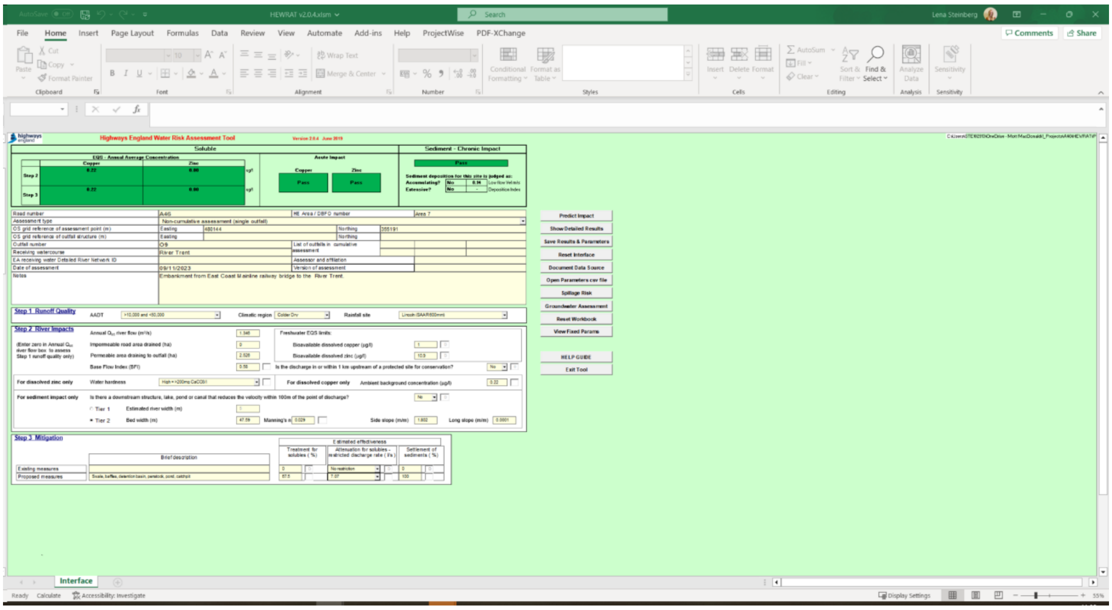
A.1.0.7 Outfall O7:



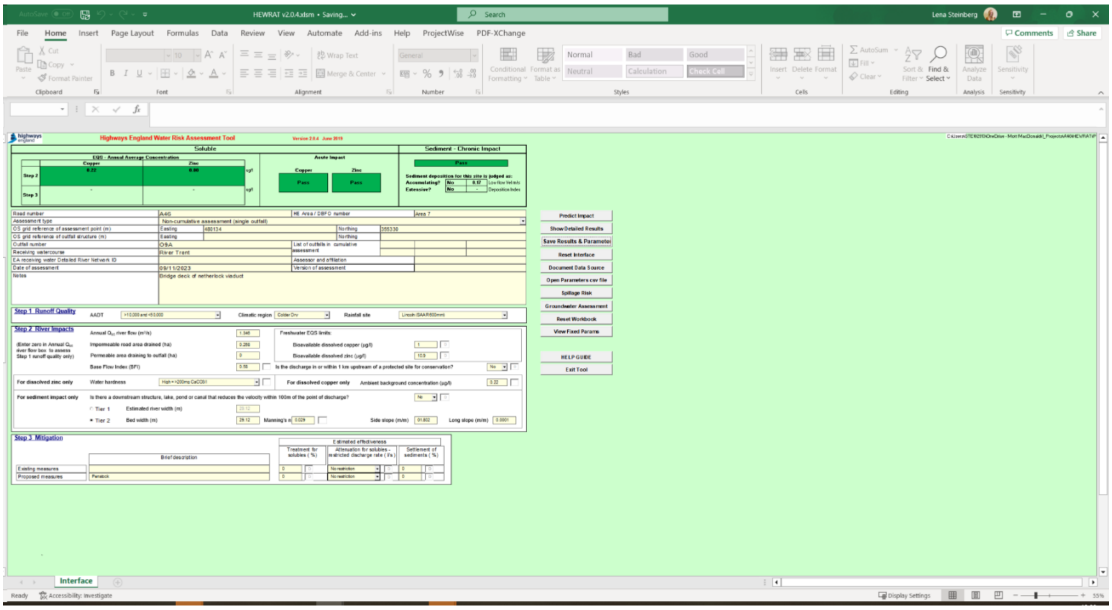
A.1.0.8 Outfall O8:



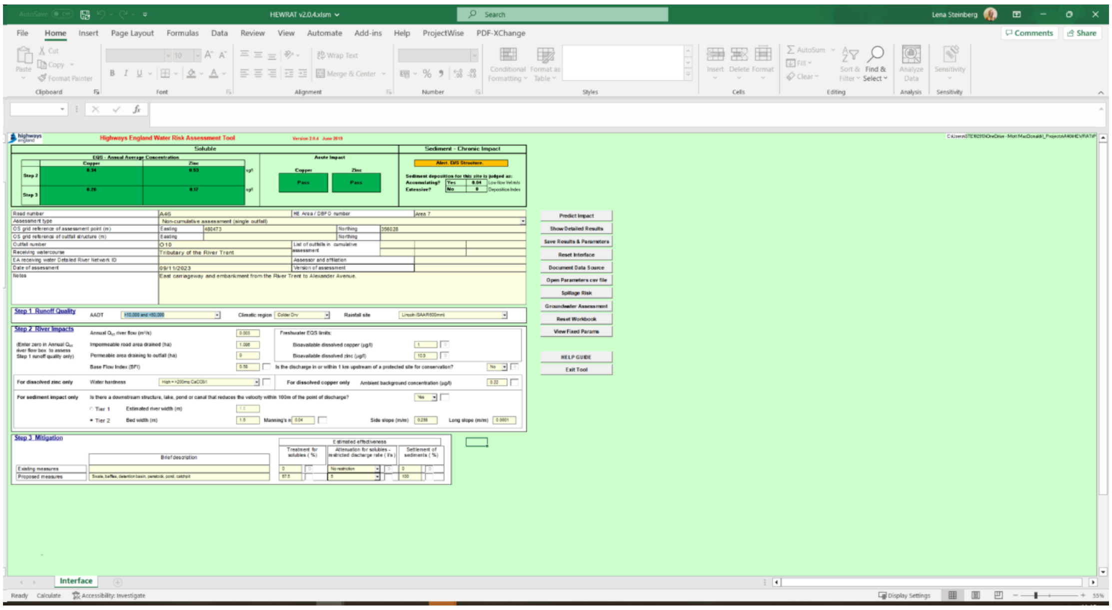
A.1.0.9 Outfall O9:



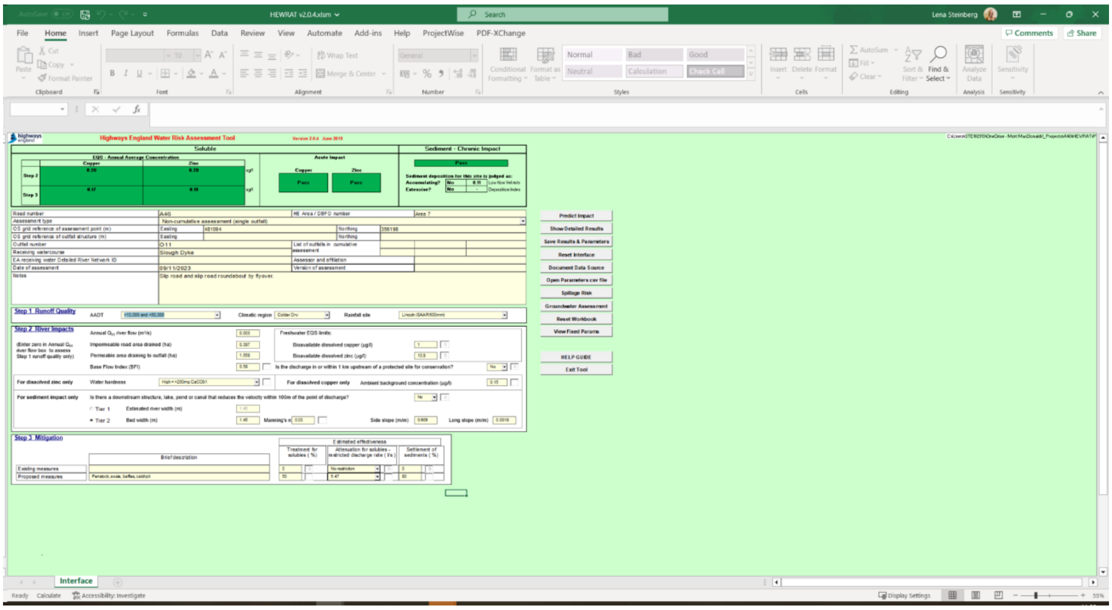
A.1.0.10 Outfall O9A:



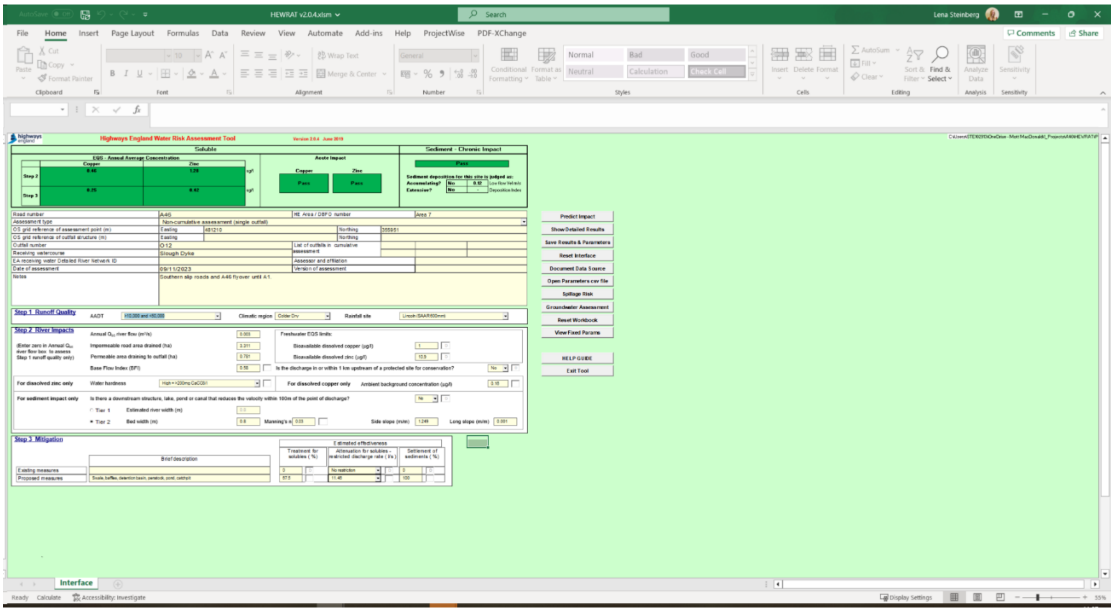
A.1.0.11 Outfall O10:



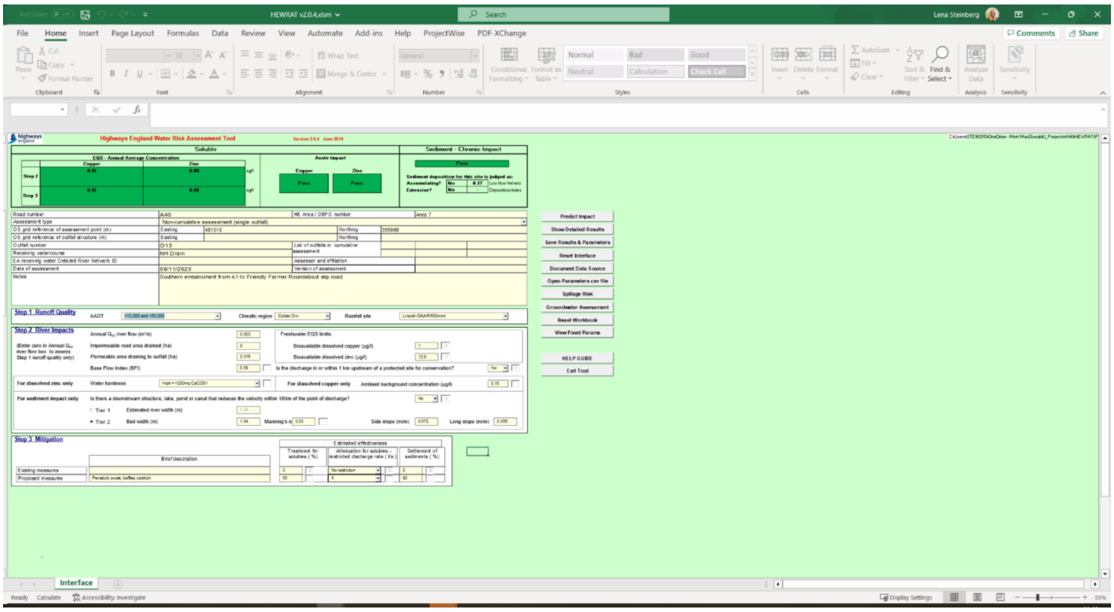
A.1.0.12 Outfall O11:



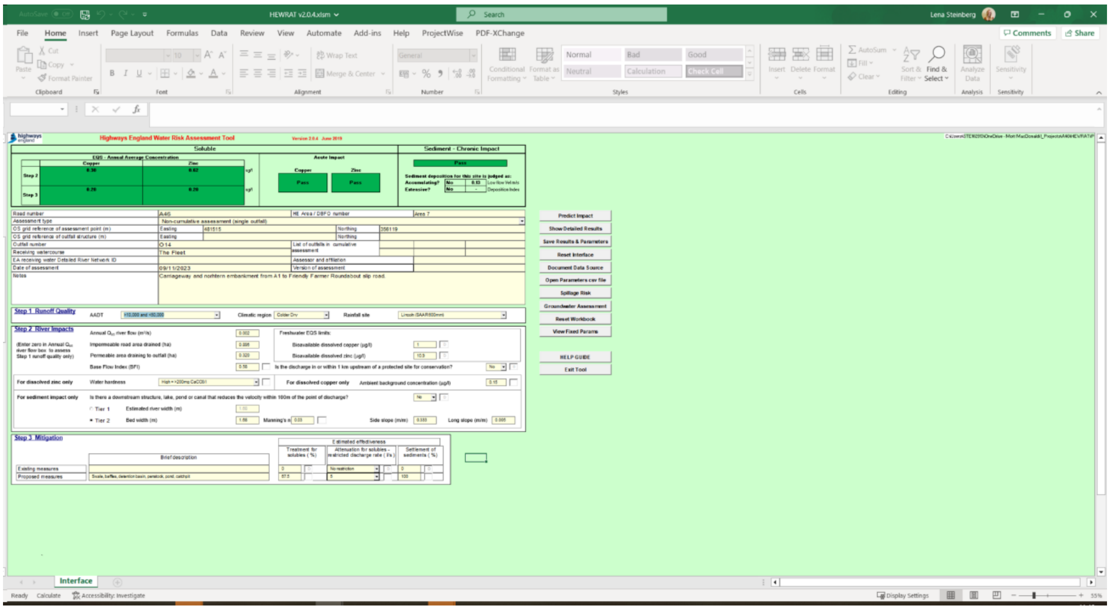
A.1.0.13 Outfall O13:



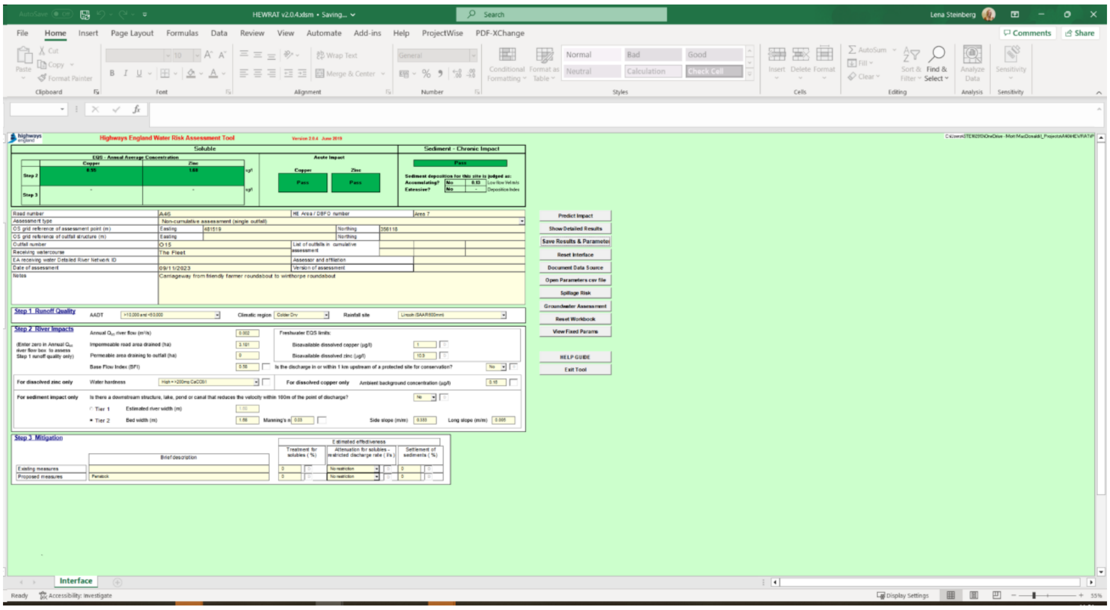
A.1.0.14 Outfall O13:



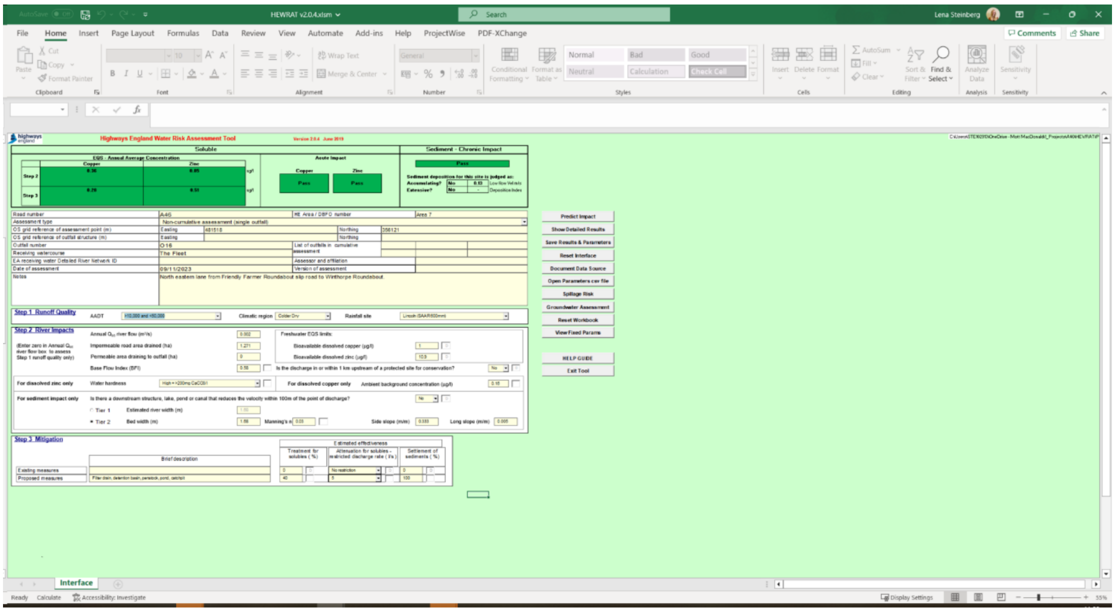
A.1.0.15 Outfall O14:



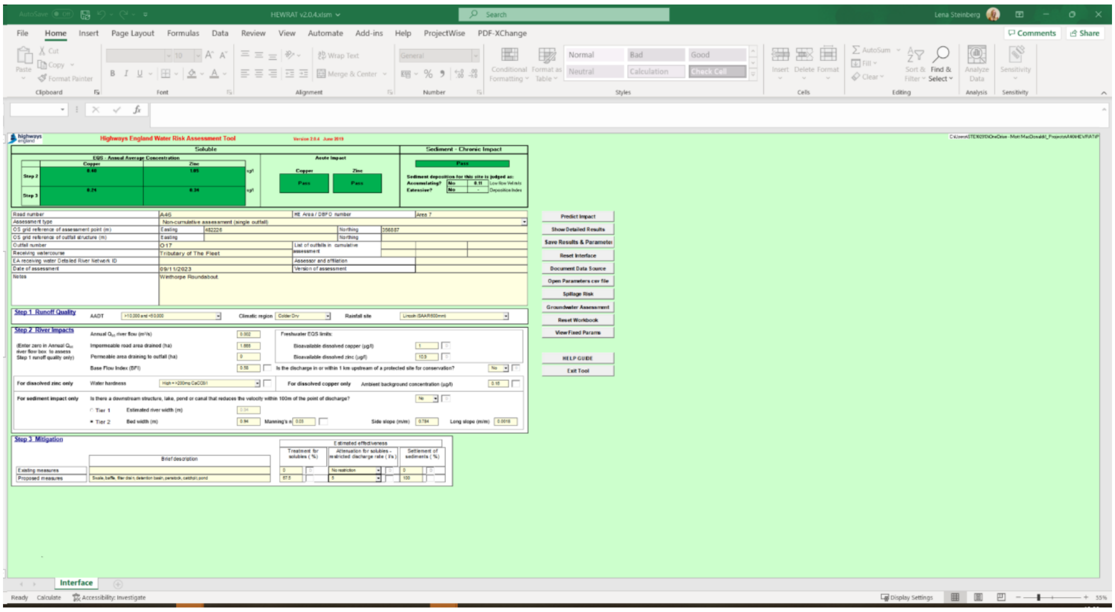
A.1.0.16 Outfall O15:



A.1.0.17 Outfall O16:



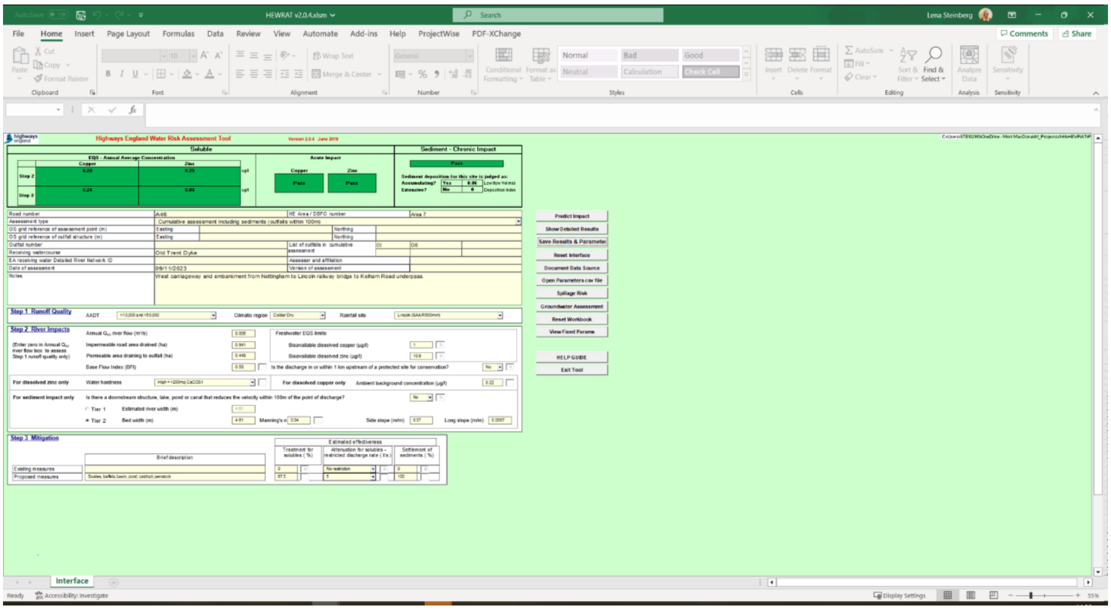
A.1.0.18 Outfall O17:



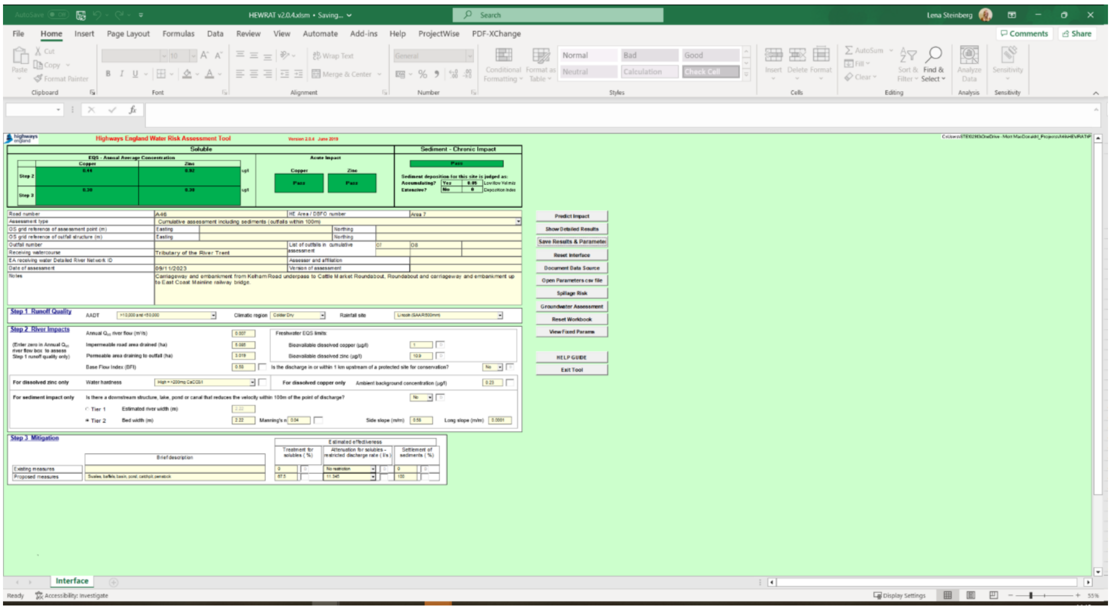
A.2 Cumulative assessments

A.2.1 Cumulative assessments within 100 metres

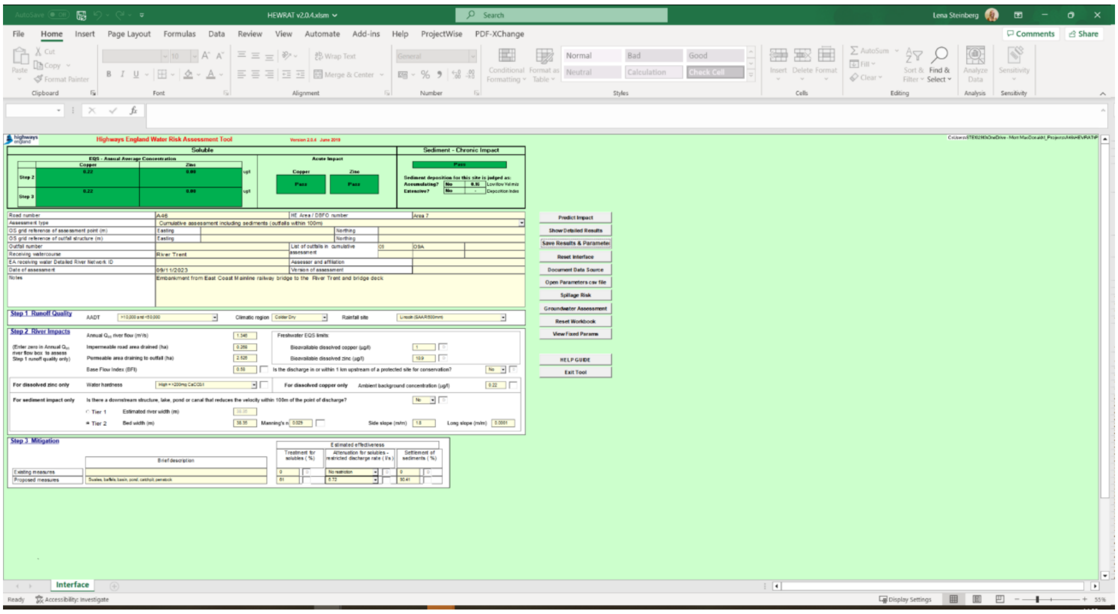
A.2.1.1 Outfalls O5 and O6:



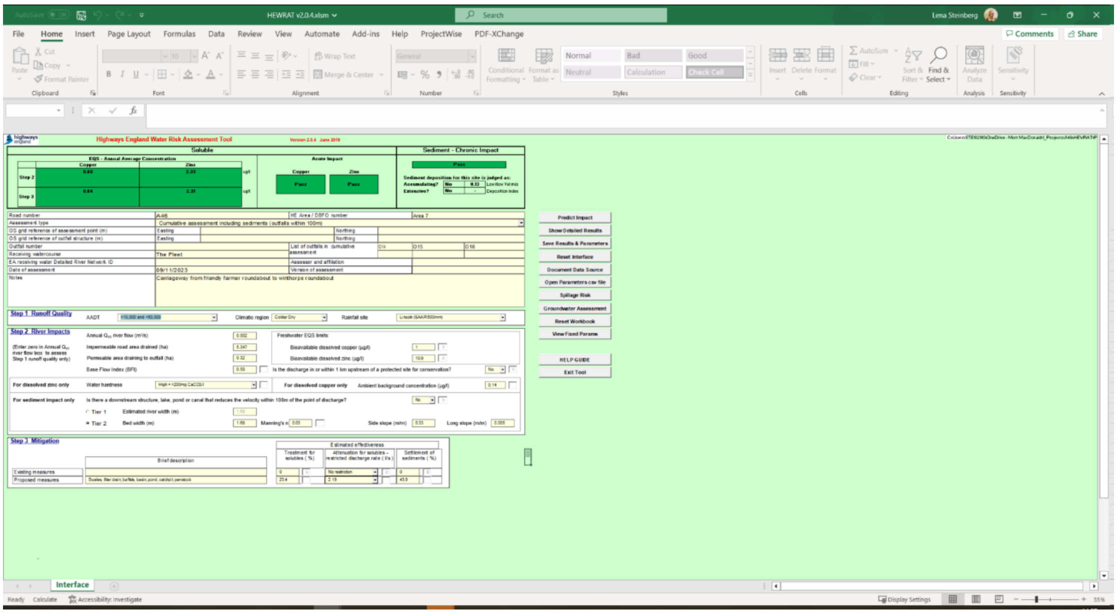
A.2.1.2 Outfalls O7 and O8:



A.2.1.3 Outfalls O9 and O9A:

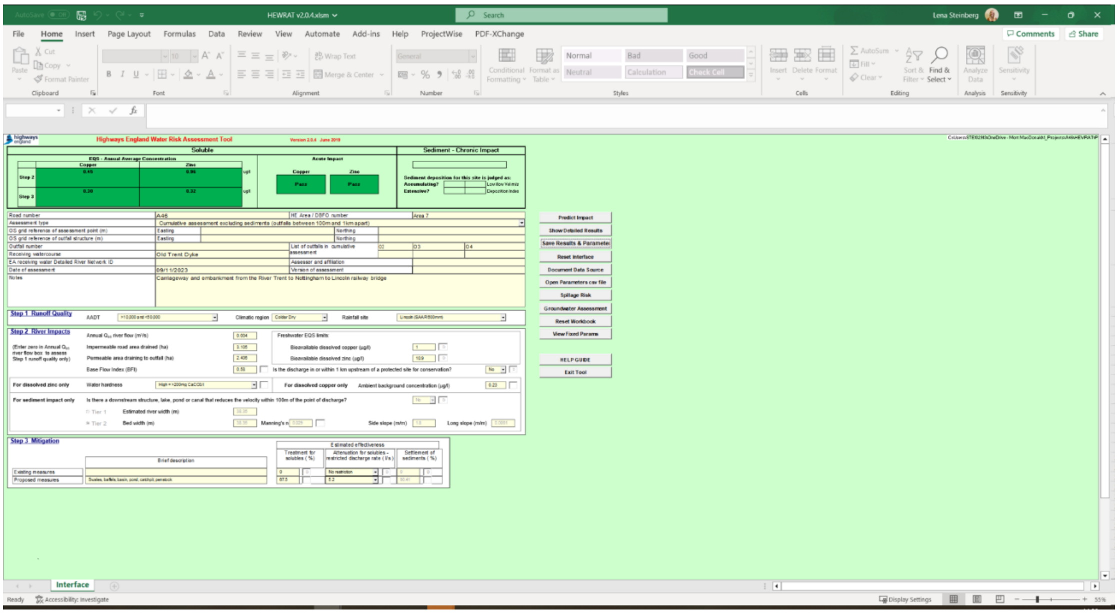


A.2.1.4 Outfalls O14, O15 and O16:



A.2.2 Cumulative assessments between 100 metres and 1 kilometre

A.2.2.1 Outfalls O2, O3 and O4



A.2.2.2 Outfalls O11 and O12: