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NORTH HYKEHAM RELIEF ROAD SUDS MANAGEMENT PLAN NORTH HYKEHAM RELIEF ROAD











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Breakdown North Hykeham Relief Road

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Water Quality Assessment Report

1. INTRODUCTION

1.1 Background

The North Hykeham Relief Road (NHRR), previously known as the Lincoln Southern Bypass (LSB), will link the recently constructed Lincoln Eastern Bypass (LEB) with the Lincoln Western Relief Road (LWRR) and the A46 on the Strategic Road Network (SRN) which is also the western end of the Lincoln Western Relief Road (LWRR). The NHRR is the last element of a complete ring road around the greater Lincoln urban area comprising both Lincoln and North Hykeham and is the last major highway scheme contained within the Lincoln Integrated Transport Strategy (LITS).

The completed ring road will comprise four sections of carriageway: the Lincoln Western Relief Road (LWRR), the Lincoln Northern Relief Road (LNRR), the Lincoln Eastern Bypass (LEB), and the NHRR. The NHRR will also form part of the Lincolnshire Coastal Highway.

1.2 Purpose and Objective

This report presents the Sustainable Drainage System (SuDS) Management Plan, developed to meet the requirements of the County Planning Authority. The plan outlines essential measures for the effective management and maintenance of SuDS features within the scheme. The plan also includes a long-term maintenance program, strategies to prevent blockages and details of proposed plant species for landscaping, to limit the potential of the site to attract and support populations of those large and/or flocking bird species that may cause detriment to aviation safety.

A detailed plan and section of the proposed infiltration basin are provided in Appendix 1 of this document.

This report also assesses the pollution risk to receiving water bodies from the proposed NHRR Drainage Networks 1 to 10, in line with CIRIA guidance. It evaluates the pollution mitigation effectiveness of the incorporated SuDS features and includes a screening of groundwater pollution risk, with a medium-risk score of 160 as per CG 501. Given the site's location within Source Protection Zone 2 and a groundwater safeguard zone, assessments have been carried out to address potential pollution from additional sources.

2. ASSESSMENT METHODOLOGY

2.1 SuDS Management Train

The SuDS Management Train involves the sequential use of multiple SuDS components to capture, convey, and store surface water, while also providing interception and managing pollution risks.

An assessment of the pollution loads associated with the proposed NHRR, as well as the pollution mitigation provided by the SuDS Train within each Highway Drainage Network, has been conducted in accordance with CIRIA Report C753 – *The SuDS Manual* and CG 501 – *Design of Highway Drainage Systems*.

2.2 Pollution Risk Assessment

The "Medium Risk to groundwater" screening result coupled with the SPZ2 and groundwater safeguard zone requires a detailed risk assessment to be considered. Risk assessments have been undertaken following Method D – Assessment of Pollution Impacts from Spillages within CG 501.

3. SUDS MANAGEMENT TRAIN ASSESSMENTS

3.1 Site location and Drainage catchments

The NHRR project will involve the construction of approximately 8 km of dual all-purpose, 2-lane carriageway, connecting the A46-Hykeham Road Roundabout to the Lincoln Eastern Bypass at A15 Sleaford Road Roundabout.

The route extends south of South Hykeham, crossing Station Road near Waddington, and then curves north around the northern side of RAF Waddington. A site location plan is provided in Figure 1.

To the west of river Witham, the NHRR crosses low-lying, predominantly flat farmland, it will intersect an extensive network of man-made ditches and straightened drains. These drainage systems, partially managed by an Internal Drainage Board (IDB), discharge into 'The Beck' a watercourse or the River Witham. The Witham, which flows south to north through the study area, will also be intersected by the proposed NHRR.

To manage the existing flood risk, levees have been constructed on both banks of the Witham, as the river level often exceeds that of the surrounding land. As a result, many of the ditches and drains direct water to an IDB pumping station, which elevates the water into the Witham. The Beck crosses the levees and flows directly into the Witham.

To the east of the Witham, the proposed road will cut through an escarpment, Grantham Road roundabout located on the eastern side represents the highest point of the scheme at approximately 73 meters above Ordnance Datum (mAOD), while the lowest point is at the River Witham at approximately 4.5 mAOD.

The proposed drainage for the new road is divided into ten catchments with the A46 Junction forming a first catchment. The catchments are split based on the alignment profile, the location of the existing watercourses, and future maintenance and ownership responsibilities. The proposed highway catchments from 1 to 9 each discharge to a dedicated attenuation basin before outfalling into an adjacent watercourse. Catchment 10 is discharged to an infiltration basin.

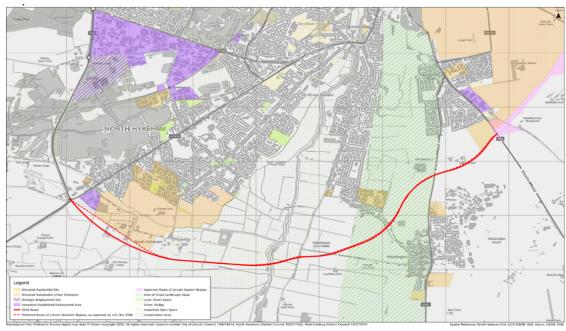


Figure 1- NHRR Route Plan

Proposed highway catchments and discharge points are shown in Table 3.1 Basin drawings are attached in Appendix 1 $\,$

3.2 HEWRAT Assessment

HEWRAT (Highways England Water Risk Assessment Tool) uses a three-step tiered approach to assess the impacts of both soluble and sediment-bound pollutants. A 'Pass' or 'Fail' result is recorded depending on whether the risk is within or exceeds the thresholds. Where a Fail result is recorded for one or more of the pollutant types, the next step is required based on increasing levels of inputs and assessment. Mitigation measures are inputted into the assessment to obtain a 'Pass'.

Detailed HEWRAT assessments are conducted in the water quality assessment report and refer to Appendix 2 for the water quality assessment report.

3.3 Spillage Risk Assessment

A risk assessment has been conducted to evaluate the likelihood of vehicular collisions leading to hazardous liquid spills, particularly from tankers and heavy goods vehicles (HGVs), using the methodology in LA113.

For spillage risk assessments refer to Appendix 2 water quality assessment report.

4. CONTAMINATED LAND

The ground conditions encountered across the site are generally comparable to the geology described by the British Geological Survey (BGS) map of the area. No significant contamination has been encountered during the ground investigation undertaken along the Proposed Scheme.

A chrysotile board ACM (at 0.052 %) was detected within one topsoil sample. Asbestos was not detected in the nearby trial pits and boreholes to where this was recovered. Perylene was detected within two locations (TP304 and BH129); and cyclooctasulphur was detected at 1,448 mg/kg in one location (BH108), which may be derived from the anaerobic biodigester plant or lagoon to the north of the site.

No exceedances in the soil concentrations were recorded above the relevant GAC. Cyanide, BTEX compounds (benzene, toluene, ethylbenzene, xylenes, and MTBE), VOCs, PCBs, herbicides, and pesticides have been analysed in the selected soil samples, and these were all below the limit of detection. As such, these determinants in soil are not considered to pose a risk to human health.

Leachate testing across the site revealed exceedances of Environmental Quality Standards (EQS) for pH, PAHs (including anthracene, benzo(a)pyrene, and fluoranthene), and metals (such as copper, hexavalent chromium, lead, and zinc), with the highest concentrations generally found in the former quarry area. These exceedances were observed in topsoil, made ground, and natural deposits. Groundwater analysis also showed elevated levels of PAHs, hexavalent chromium, lead, nickel, and hydrocarbons, likely linked to tarmacadam gravels. Groundwater monitoring detected high levels of ammoniacal nitrogen, sulphate, and other contaminants, some of which may be attributed to regional agricultural activity, natural mudstone geology, or the presence of an RAF fuel pipeline and an anaerobic biodigester on-site. Surface water testing also showed exceedances for various contaminants, including metals and naphthalene.

The findings of the preliminary gas assessment suggest the overall ground gas risk for road users and maintenance workers of the scheme is low to moderate. During the road development, cutting excavations might be considered to be confined spaces and the contractors should undertake the usual risk assessments/precautions that are required for work in such conditions.

4.1 Risks and Mitigation

The pollution risks to Protected Groundwater from the NHRR, exceed those typically associated with normal road operations. Table 4 identifies and assesses the sources and receptors of these pollution risks.

The table evaluates the likelihood of hazards and their receptors to determine the level of risk. Based on this risk assessment, the table includes proposed mitigating measures to reduce the risk to an acceptable level.

Source	Pathway	Receptor	Potential Consequence	Probability of Risk	Risk of Contaminant Linkage
On-site Current and historic land uses across the proposed	Dermal Contact / ingestion / inhalation of fibres etc	Site users	Medium	Unlikely	Low. The potential for future road users or adjacent site users to come into contact with the soils is unlikely.
development include farms and farmyards; sawmill; tramway sidings; former quarry and associated 'heap'; Made Ground and fill associated with existing road construction; roads and fuel pipeline serving RAF Waddington.		Adjacent site users	Medium	Unlikely	Low. Potential for contaminants on-site from current and historical land uses. Adjacent land uses include a park, residents and commercial workers. Potential exists for adjacent site users to be exposed to liberated soils during earthworks.
		Construction or maintenance workers during ground works	Medium	Low Likelihood	Moderate / Low. Potential for contaminants on-site from current and historical land uses. Potential exists for workers to have greater exposure to soils during ground works such as excavations.
Potential contaminants include ground gases, hydrocarbons, oils and solvents, Volatile and Semi-Volatile Organic Compounds (VOCs and SVOCs), heavy metals, PAHs, asbestos, pesticides and herbicides.	Inhalation of gas / vapours (including from peat within the River Witham valley)	Site users	Medium	Unlikely	Low. Potential for future road users to inhale gas / vapours is unlikely. There are no structures envisioned in the proposed development scheme where gases or vapours may accumulate.
		Adjacent site users	Medium	Low Likelihood	Moderate / Low. Gas concentrations associated with the historic infilled quarry and heap are currently unknown, and due to the proximity of this to residential properties, a low probability of risk exists.
		Construction or maintenance workers during ground works	Medium	Low Likelihood	Moderate / Low. Gas concentrations associated with the historic infilled quarry are currently unknown. Potential risk if confined spaces, including deeper excavations are required.

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Source	Pathway	Receptor	Potential Consequence	Probability of Risk	Risk of Contaminant Linkage
	Leaching to Groundwater & Groundwater Flow	Secondary A (Alluvium, Balderton Sand and Gravel Member, Grantham and Northampton Sand Formation) and Secondary B Aquifers (Scunthorpe and Charmouth Mudstone Formations)	Mild	Likely	Moderate / Low. Potential for contaminants on-site from current and historical land uses. The superficial deposits are expected at shallow depths where it is present. Where present, alluvium may limit leaching and migration to the underlying bedrock aquifer. However, alluvium is expected only around River Witham.
		Principal Aquifer (associated with the limestone formations)	Medium	Low Likelihood	Moderate/Low . The limestone formations are present on top of the escarpment. There is potential for contaminants on-site from current and historical land uses as sawmill, historical quarry, farmyards and existing road (A607).
	Surface water run-off	Surface water as controlled water	Medium	Low Likelihood	Moderate/Low. Potential for contaminants on-site from current and historical land uses. River Witham passes through the centre of the Proposed Scheme, classified by the EA under the WFD classification scheme of moderate ecological and fail chemical qualities. There are also various smaller rivers / drains / brooks within the study area.

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Source	Pathway	Receptor	Potential Consequence	Probability of Risk	Risk of Contaminant Linkage
Off-site Potential current and historical off-site contamination sources in the vicinity of the site include: Farms and farmyards; RAF Waddington Airfield and fuel pipeline (adjacent to A15); unspecified tanks (60 m south of Station Road and 140 m north) pre-2000s); Petrol Filling Station (90 m north-west); Brick Works (90 m north of Station Road); Railway / Tramway (210 m north of Station Road); Electrical substations; light engineering works	Leaching to Groundwater & Groundwater Flow	Groundwater in the underlying superficial and bedrock deposits (Secondary A, Secondary B and Principal Aquifers)	Medium	Low Likelihood	Moderate / Low. Potential presence of potential contamination sources from off-site activities. Alluvium, which may limit potential leaching is expected within a small area of the scheme. The remainder of the expected geology comprises of weathered limestone, mudstone and sands and gravels.
and unspecified depots (220 m north adjacent to east of A15); recycling facilities (200 m northeast) and brick yard (250 m south of Somerton Gate Lane). Potential contaminants include ground gases, hydrocarbons, oils and solvents, VOCs and SVOCs, heavy metals, PAHs, asbestos, pesticides and herbicides and PCBs.	Inhalation of vapours	Site users, construction workers and adjacent site users	Medium	Unlikely	Low. No significant sources of vapours identified within the surrounding area.

Table 4-1 Contamination Risk Scoring

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5. GROUNDWATER ASSESSMENT

5.1 Ground Investigation

At the eastern end of the scheme, Catchment 10 will discharge to an infiltration basin. The infiltration basin is located within the outer extent of an outer groundwater source protection zone (SPZ2). This zone is defined by the Environment Agency as having a 400-day travel time from a point below the water table. The associated SPZ1 is located 5.3km north-east of the proposed infiltration basin. Additionally, there are no active licenced groundwater abstractions or historical licenced groundwater abstractions used for drinking water identified within at least 1km according to the Insight report supplied by Groundsure.

A preliminary assessment of the risk to groundwater has been conducted using the methodology outlined in Appendix C of LA 113. For a more detailed groundwater risk assessment, please refer to the water quality assessment report in Appendix 2.

6. POLLUTION ASSESSMENT CONCLUSION

Water quality risk assessments for the North Hykeham Relief Road's operational phase identified surface water, spillage, and groundwater risks. Three assessment points were identified based on alignment and natural watercourse locations, with ten catchment areas discharging to these points.

Routine runoff assessments using HEWRAT showed that highway catchments 1, 2, and 3 discharge to the Beck tributary, where mitigation measures must achieve a 75% reduction in sediment to pass. This will be accomplished through grass surface channels, ditches, and vortex girt separators, meeting DMRB CG501 treatment efficiency standards. The remaining catchments discharge to the river Witham and pass both individual and cumulative water quality assessments.

Catchment 10 discharges into an infiltration basin located within an SPZ2. The risk assessment scored 160 indicating medium risk, referring to the groundwater risk assessment on the water quality assessment report in Appendix 2, however with embedded mitigation measures—grass-lined channels, a vortex separator, and a penstock—the groundwater risk is deemed acceptably low.

7. SUDS OPERATIONS AND MAINTENANCE

The operation of the Highway Drainage systems is as follows:

Network 1

- The surface water runoff is collected from the carriageway by kerb drains.
- Kerb drainage outlets with a sump will be provided for pre-treatment and silt collection. Form the outlet, the runoff will be directed to carrier drains.
- The surface runoff is intercepted by penstocks at the headwall to ditches or basins which offers a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- Surface water runoff is attenuated in a detention basin which includes a lined sedimentation forebay. This provides mitigation against suspended solids by 60% and dissolved copper & zinc by 40% and 30% respectively. The sedimentation forebay has a permanent water depth of 1m, is approximately 23m x 13.5m in dimension and has a top water level area of 1093m2. The detention basin has a sump of 0.5m, which will permanently hold water.
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the discharge is piped to a carrier ditch, which outfalls to the IDB ditch.

Network 2

- The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.
- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- A pollution control chamber (vortex grit separator) is incorporated into the system to effectively remove sediment and mitigate pollution.
- Surface water runoff is attenuated with a dry basin/pond, which as per CG501 provides a mitigation against suspended solids by 50%.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the outfall is scour-protected before falling out to the IDB ditch.

Network 3

- The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.
- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- A pollution control chamber (vortex grit separator) is incorporated into the system to effectively remove sediment and mitigate pollution.
- Surface water runoff is attenuated with a dry basin/pond, which as per CG501 provides a mitigation against suspended solids by 50%.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the outfall is scour-protected before falling out to the IDB ditch.

Network 4

- The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.
- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- Surface water runoff is attenuated with a dry basin/pond, which as per CG501 provides a mitigation against suspended solids by 50%.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the outfall is scour-protected before falling out to the IDB ditch.

Network 5

- The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.
- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- Surface water runoff is attenuated with a dry basin/pond, which as per CG501 provides a mitigation against suspended solids by 50%.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the outfall is scour-protected before falling out to the IDB ditch.

Network 6

- The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.
- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- Surface water runoff is attenuated with a dry basin/pond, which as per CG501 provides a mitigation against suspended solids by 50%.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the outfall is scour-protected before falling out to the IDB ditch.

Network 7

 The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.

- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- Surface water runoff is attenuated with a dry basin/pond, which as per CG501 provides a mitigation against suspended solids by 50%.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the outfall is scour-protected before falling out to the IDB ditch.

Network 8

- The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.
- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- Surface water runoff is attenuated with a dry basin/pond, which as per CG501 provides a mitigation against suspended solids by 50%.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the outfall is scour-protected before falling out to the IDB ditch.

Network 9

- The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.
- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- Surface water runoff is attenuated with a dry basin/pond, which as per CG501 provides a mitigation against suspended solids by 50%.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- A flow control device controls the discharge rate from the pond to the outfall ditch.
- From the control device, the outfall is scour-protected before falling out to the IDB ditch.

Network 10

- The surface water runoff is collected from the carriageway by a grassed surface water channel (GSWC) which provides mitigation against suspended solids by 80% and dissolved copper & zinc by 50% each.
- From GSWC the runoff goes to the carrier ditch which provides mitigation against suspended solids by 25% and dissolved copper & zinc by 15% each.
- The surface runoff is intercepted by penstocks at the headwall to the ponds outfall which offer a spillage containment. (Optimum spillage risk reduction factor Rf 0.4).
- Surface water runoff will be attenuated in an infiltration basin. This will be temporarily wet.

7.1 Maintenance recommendations for the main components of the drainage features Maintenance recommendations are provided in the table below.

Grassed surface water channels to be maintained as per *DMRB*, *CD521*, *Appendix K. Maintenance* of surface water channels.

For bird hazard procedures regarding the basins, please refer to NHRR-TEP-EGN-HYKE-RP-LE-30022 (Bird Hazard Management Plan).

Component	Maintenance activity	Frequency
Gullies	Silt removal.	Annually
Kerbdrain	Inspect kerb face openings for blockage silting/ vegetation.	Six Monthly
Kerbdrain outlet	Silt removal.	Annually
GSWC	Inspect inlets and outlets for obstructions silts and any damage	Monthly
GSWC	Mow swales at 100mm (150mm maximum) to filter and control runoff – remove cutting from first and last cut in season.	Monthly or as required
GSWC	trim 1m min around structures and keep hard aprons free from silt and obstructions	Monthly or as required
GSWC	Repair / replace stone scour protection near inlet / outlet structures	As required
Catchpits	Silt removal.	Annually
Pollution Control Device	Silt / oil removal.	Annually
Detention Basin	Inspect inlets and outlets for obstructions silts and any damage	Monthly
Detention Basin	Mow grass access paths and verges surrounding basins, to maintain access.	Monthly or as required
Detention Basin	at 100mm (150mm maximum) to filter and control runoff – remove cutting from first and last cut in season.	2 cuts: July and September
Detention Basin	Bird Monitoring as section 3.3 NHRR- TEP-EGN-HYKE-RP-LE-30022	Monthly
Infiltration Basin	Inspect inlets obstructions silts and any damage.	Monthly
Infiltration Basin	Check penstock valve for damage and operation.	Monthly
Infiltration Basin	Where there is a build up of silt in the basin at inlets, i.e. 50mm or more above the design level then remove when the ground is damp in autumn or early spring and turf to the original design levels.	Annually

Infiltration Basin

Bird Monitoring as section 3.3 NHRR-TEP-EGN-HYKE-RP-LE-30022

Monthly

Table 7-1 Maintenance recommendations

8. LIMITING SUDS BASIN ATTRACTIVENESS

The Sustainable Drainage System (SuDS) includes a number of attenuation basins. Waterbodies of this size may be attractive to wildfowl and waterbirds which are considered a bird strike risk.

The most attractive water bodies to swans, geese, ducks, and gulls are open and large. The proposed attenuation basins will not hold large amounts of open water. Basins 2 to 9 specifically are designed to be irregularly wet and will be dry for the majority of the year, thus greatly reducing the appeal of the basins to these species.

Basin 1 is a wet basin and will permanently hold water. It comprises of a sedimentation forebay and a detention basin. The sedimentation forebay has a permanent water depth of 1m and the detention basin a permanent water depth of 0.5m.

Basin 10 comprises of an infiltration basin. Sediment and suspended solids will be removed by means of a vortex separator installed prior to the infiltration basin. The infiltration basin will be temporarily wet.

Both basins, 1 & 10, will be adjacent to busy roundabouts and associated roads, meaning there will be a high disturbance level. Additionally, infiltration basin 10 will be surrounded by woodland planting, thus further reducing its suitability for large groups of waders and wildfowl. Attenuation basin 1 is within an area of tree planting and surrounded by hedgerows, again limiting suitability.

As most of the attenuation basins are within sheltered areas, adjacent to small areas of woodland, hedgerow, or scrub planting at field edges, and will be disturbed by the proposed road that will reduce their attractiveness for wildfowl and waders. Waders prefer areas to feed with open sightlines and mallards prefer ponds with a loafing area that gives a good view of the surrounding landscape. To land in a water body species such as ducks, swans, geese, and cormorants require open flight lines, the planting designs surrounding the basins will reduce these, thus reducing their suitability.

Drainage will be well maintained, meaning there will be constant movement of water out of basins 2-9. All basins have a maximum volume much larger than their expected 'normal' volume, as 2-9 are expected to be dry throughout the majority of the year. The depth of the water is relevant to duck, goose and swan species. The expected depth of the attenuation basins 72 hours after a 1 in 1 year storm event are all low enough to not be attractive to geese or swans (See 8.1 below). Ducks do show preference for feeding in water more shallow than 50cm (excluding diving ducks) but due to the short period of time during which the basins are wet, the suitability is low.

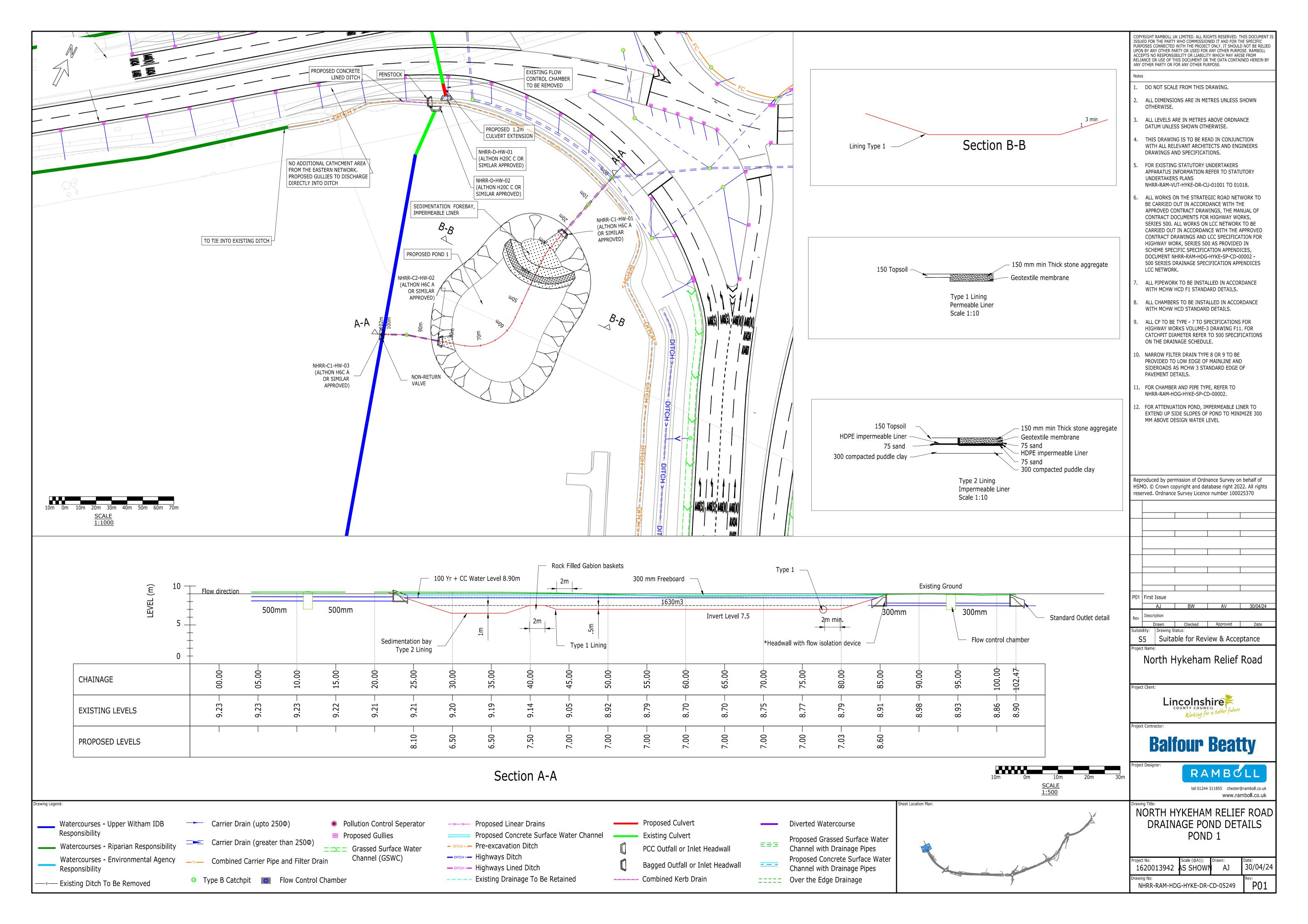
The very low levels of water also mean that the attenuation basins 2-9 have extremely limited potential for holding fish, so are less attractive to cormorant, heron and egret species for feeding.

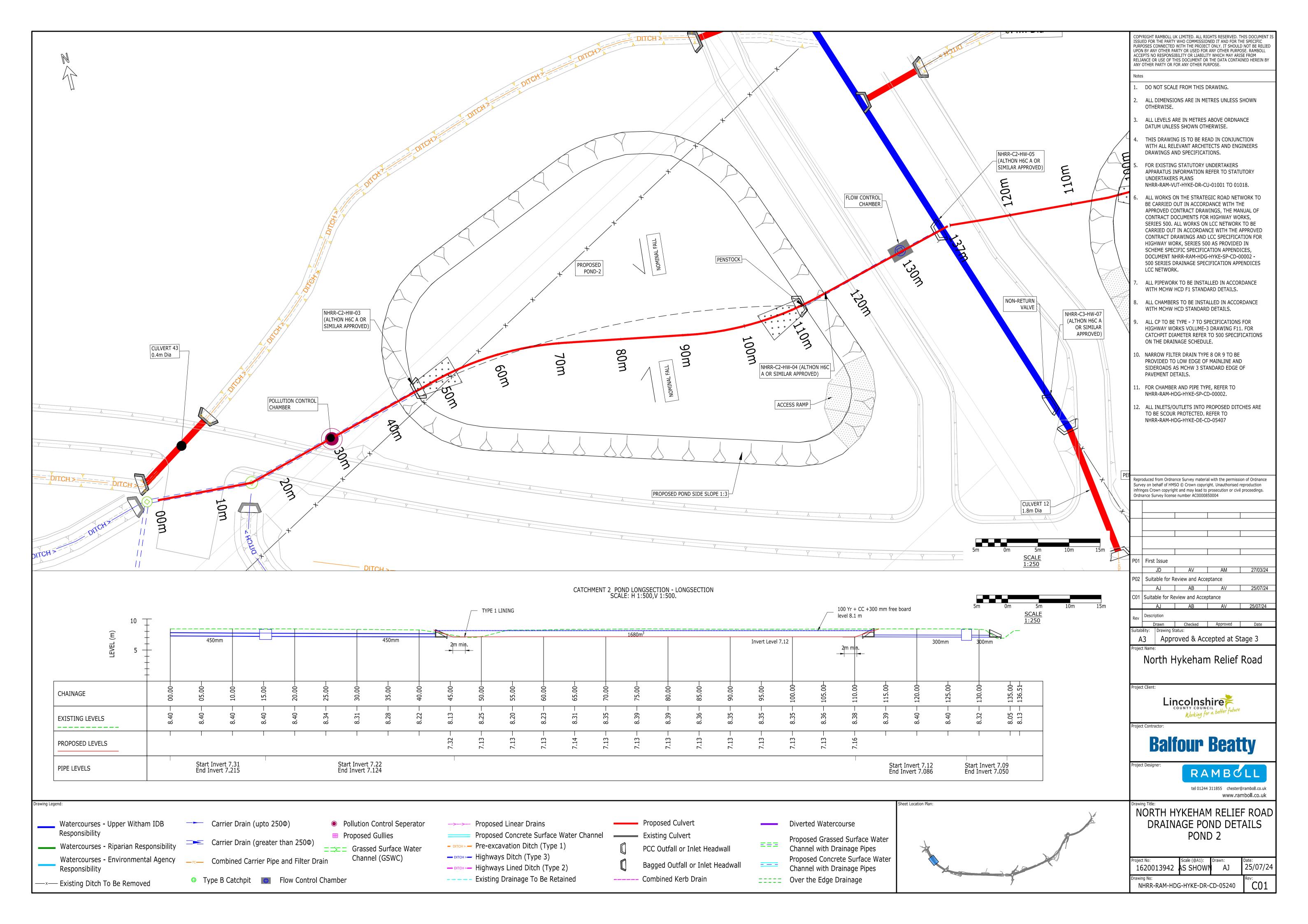
Attenuation Basin	Distance from RAF Waddington (m)	Plan Area (m2)	Maximum Pond Vol.*1	Depth 72 hours after a 1 in 1 year storm event (mm)
Basin 1	6422	2209	1638	-
Basin 2	6075	3098	1680	107
Basin 3	5958	5321	2331	119
Basin 4	5215	2680	913.5	11
Basin 5 (N1)	5088	717	283.5	4
Basin 5 (N2)	5181	568	126	15
Basin 5 (N3)	5190	385	77.7	0
Basin 6	3912	4398	3528	37
Basin 7	3738	2539	2310	128
Basin 8	2605	7299	3150	88
Basin 9	2301	13248	8085	185
Basin 10	765	9373	3339	-

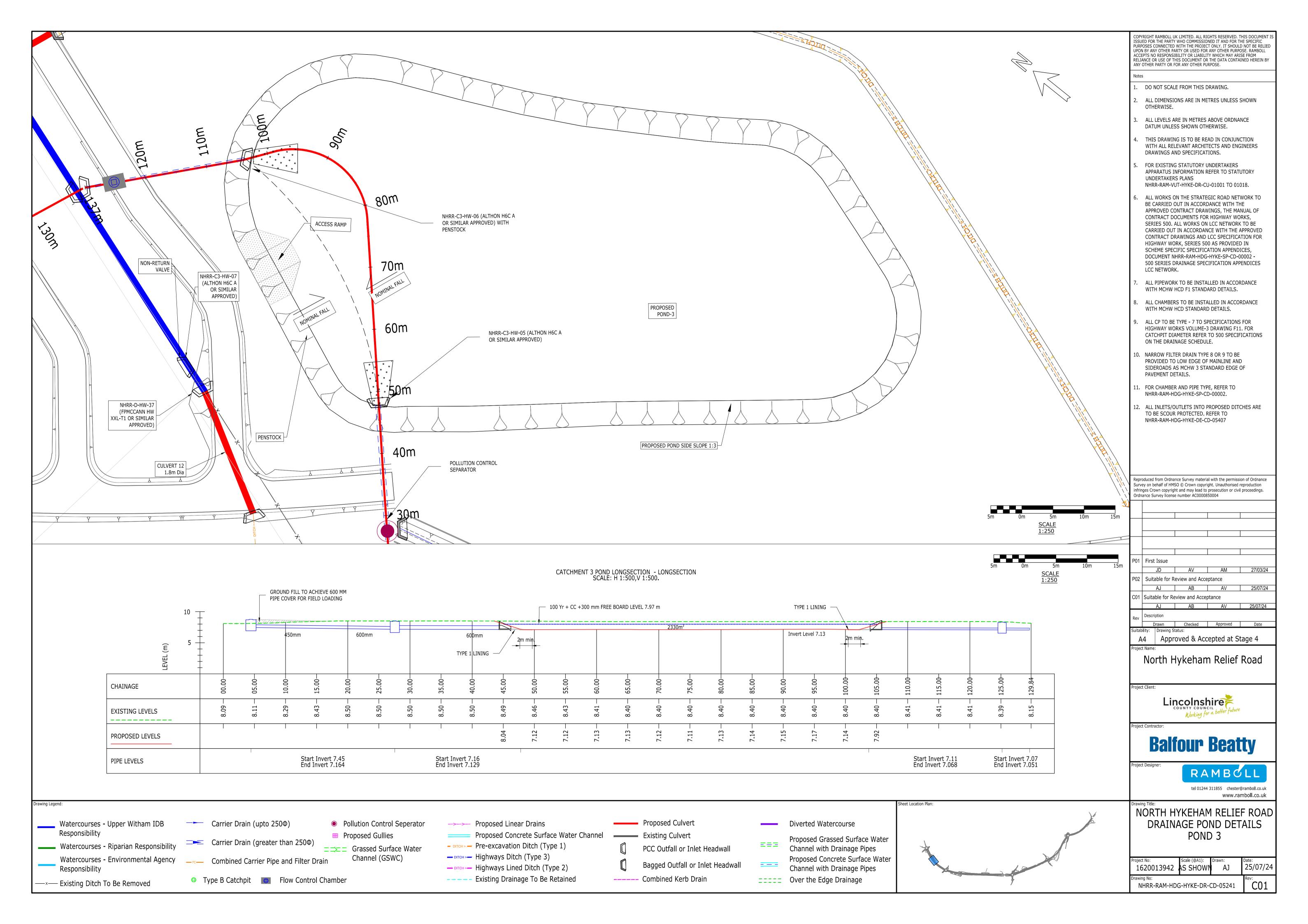
Table 8-1 Basin's Landscape Details

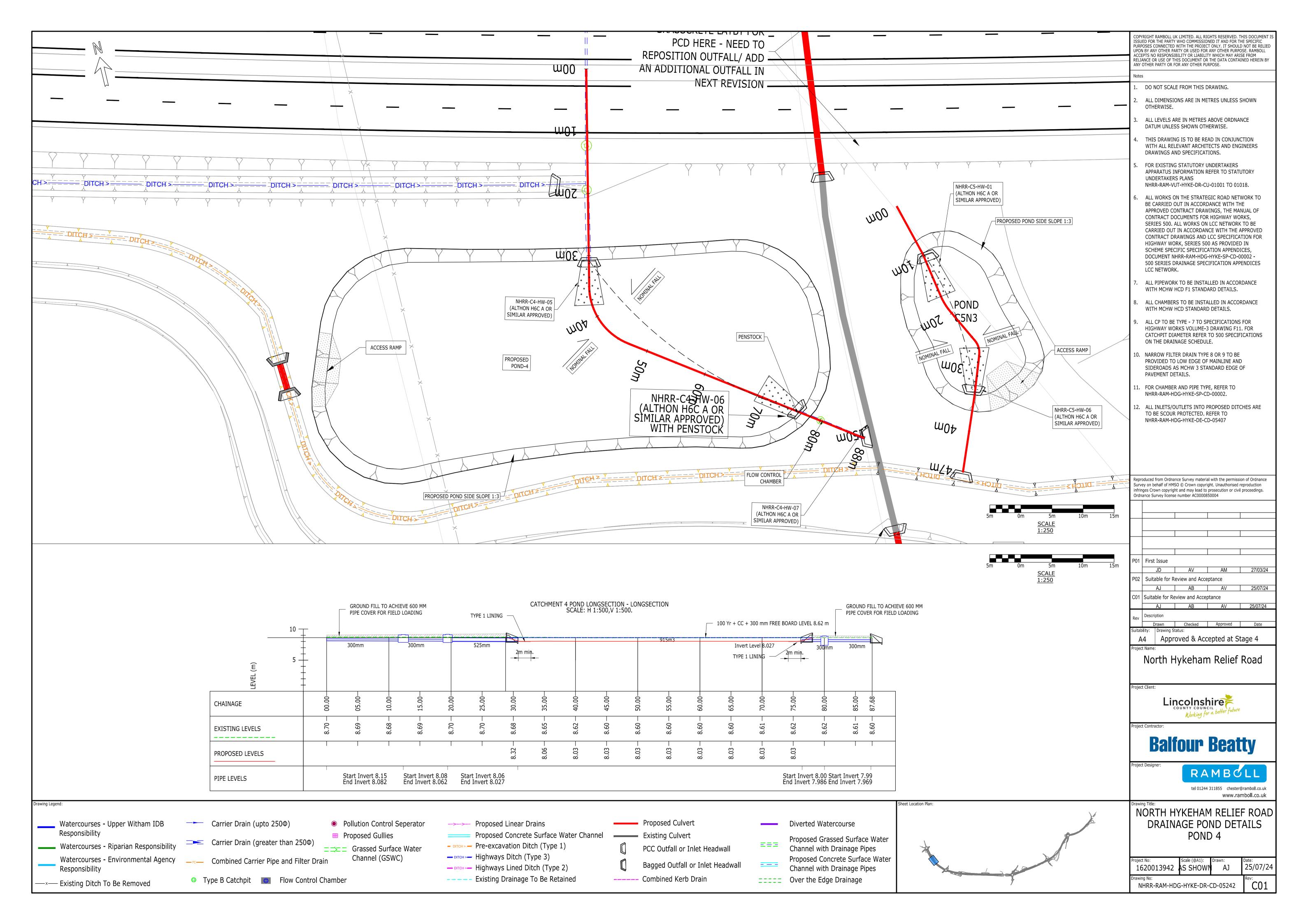
 $^{^{1*}}$ The attenuation basin is not expected to reach this level for a normal recurring rainfall event

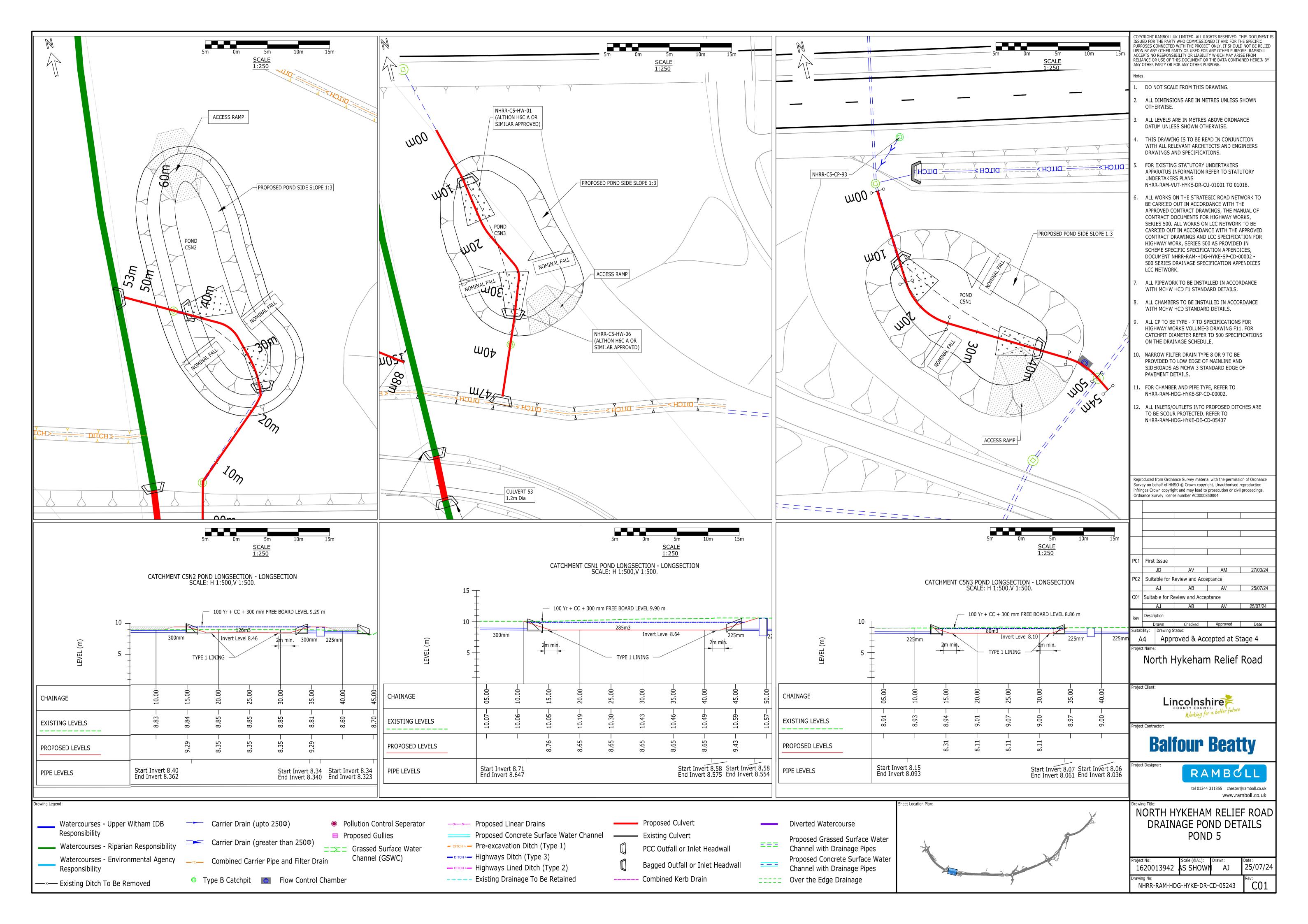
APPENDIX 1 BASIN PLAN & PROFILE DRAWINGS

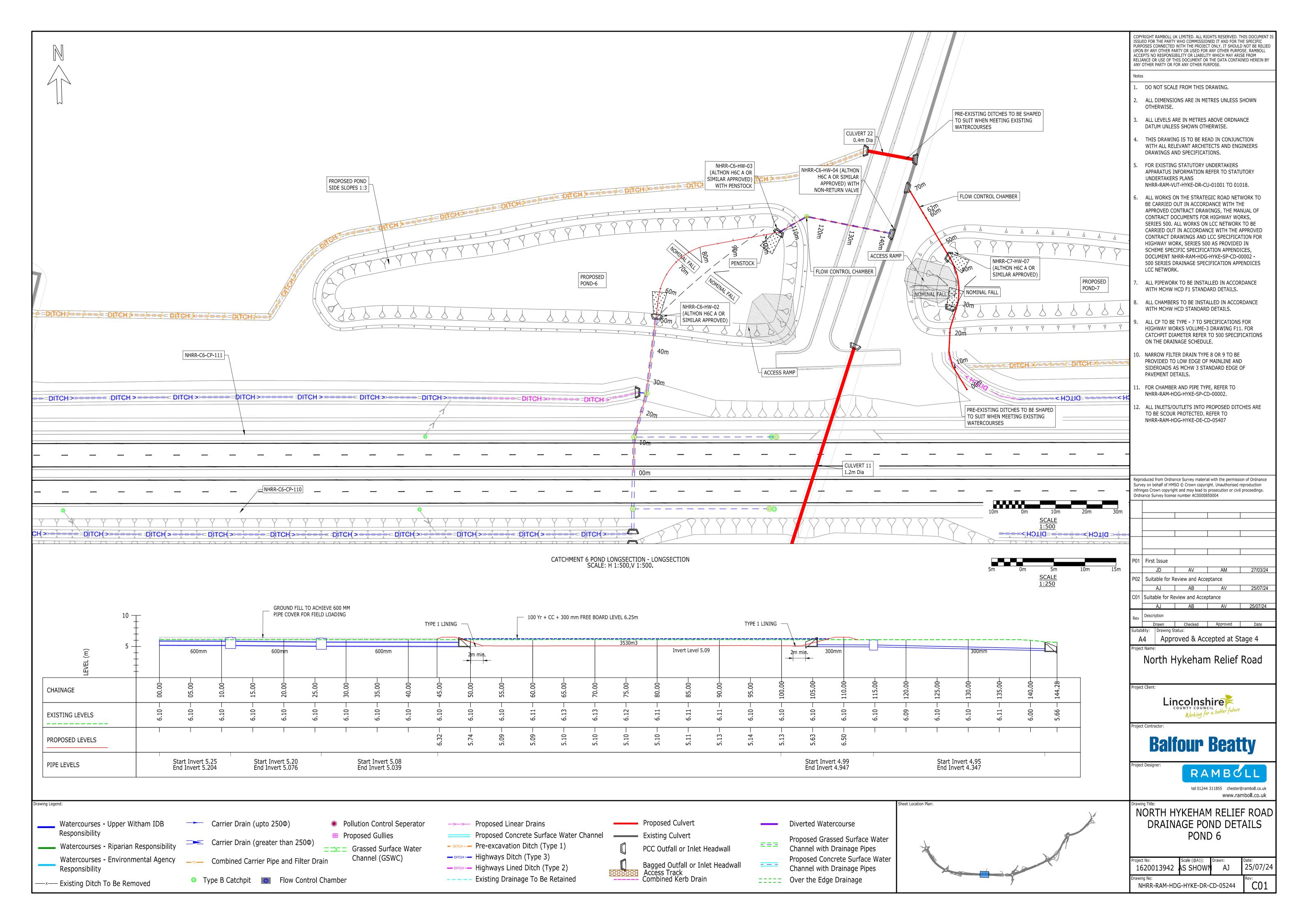


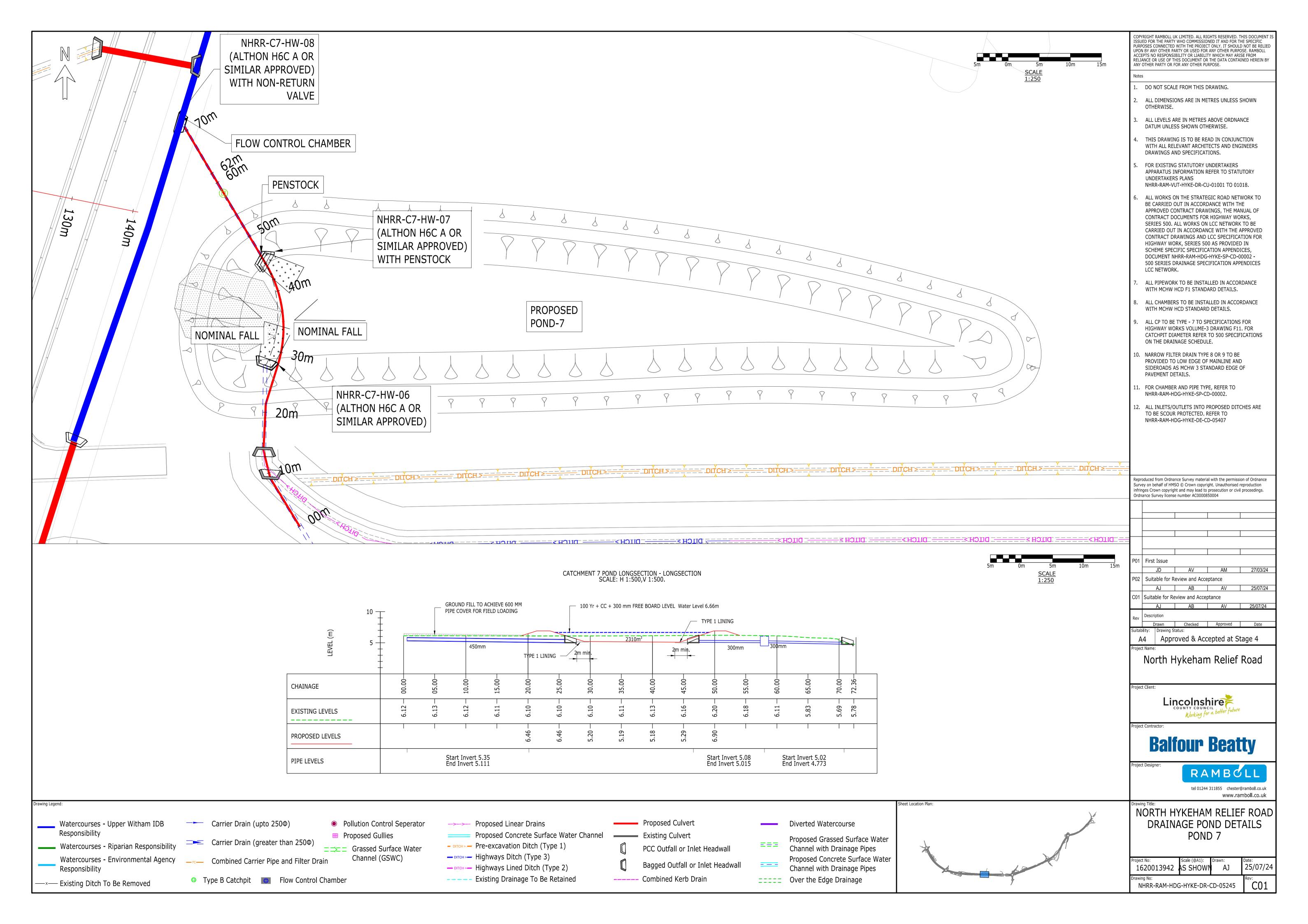


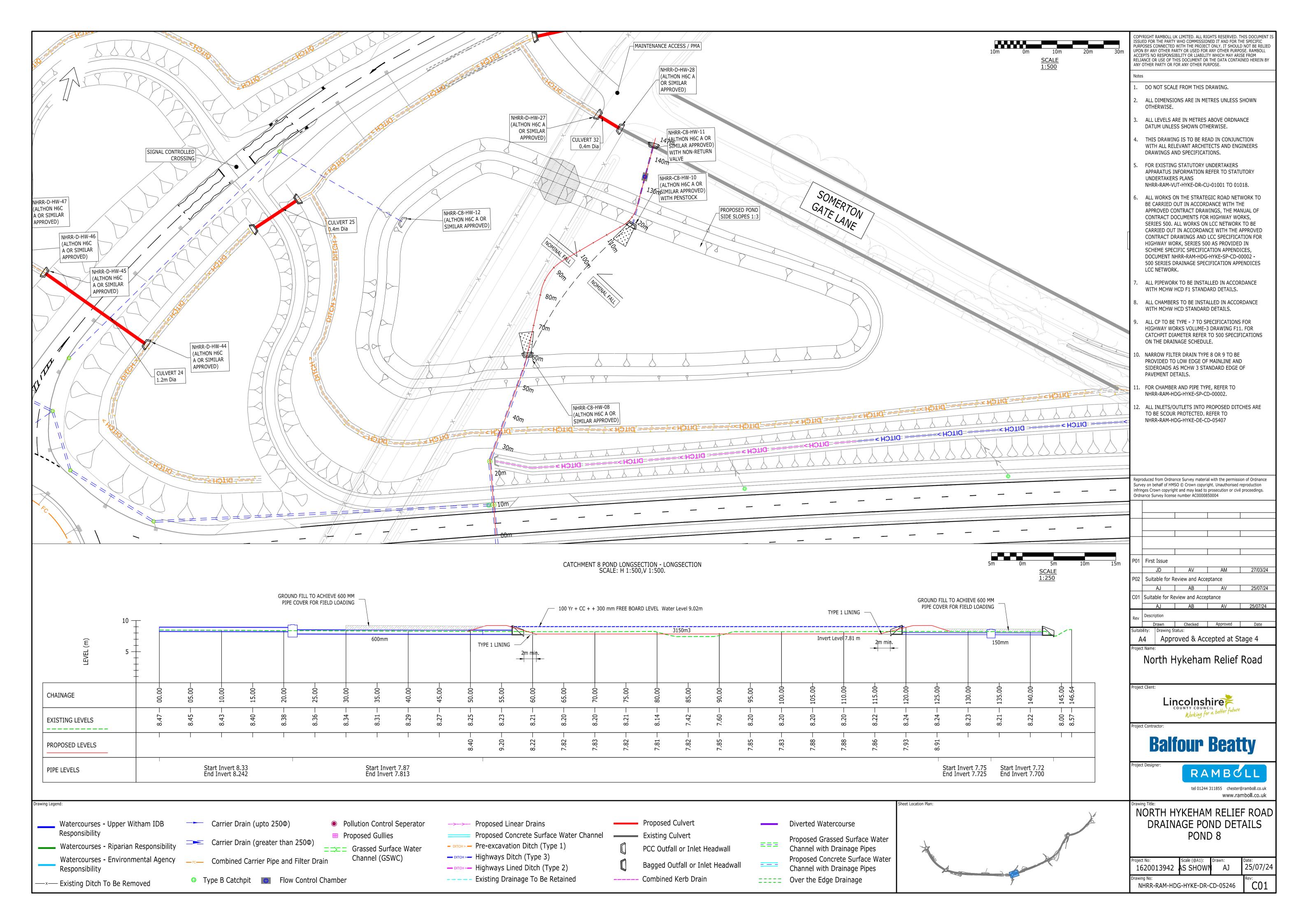


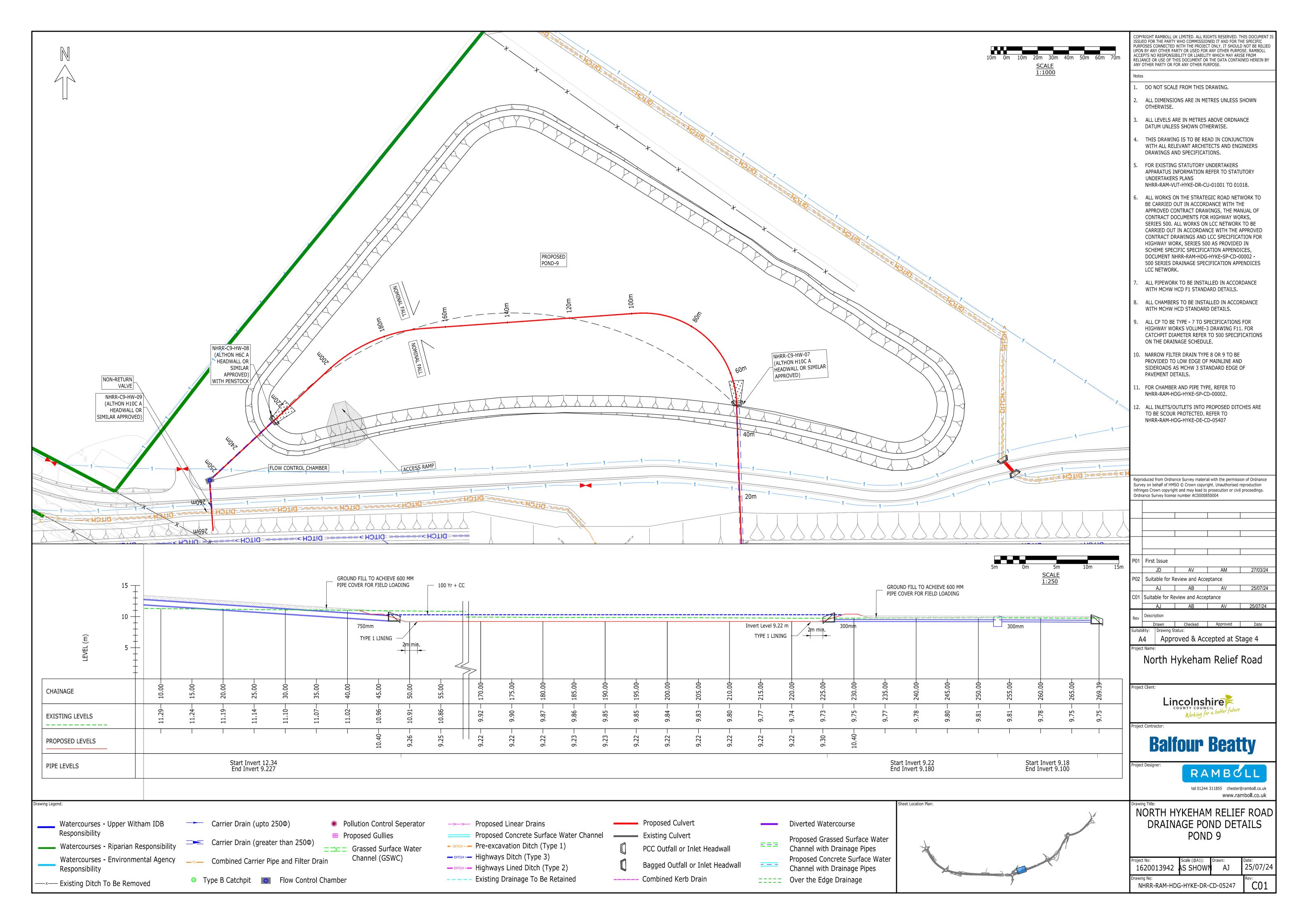


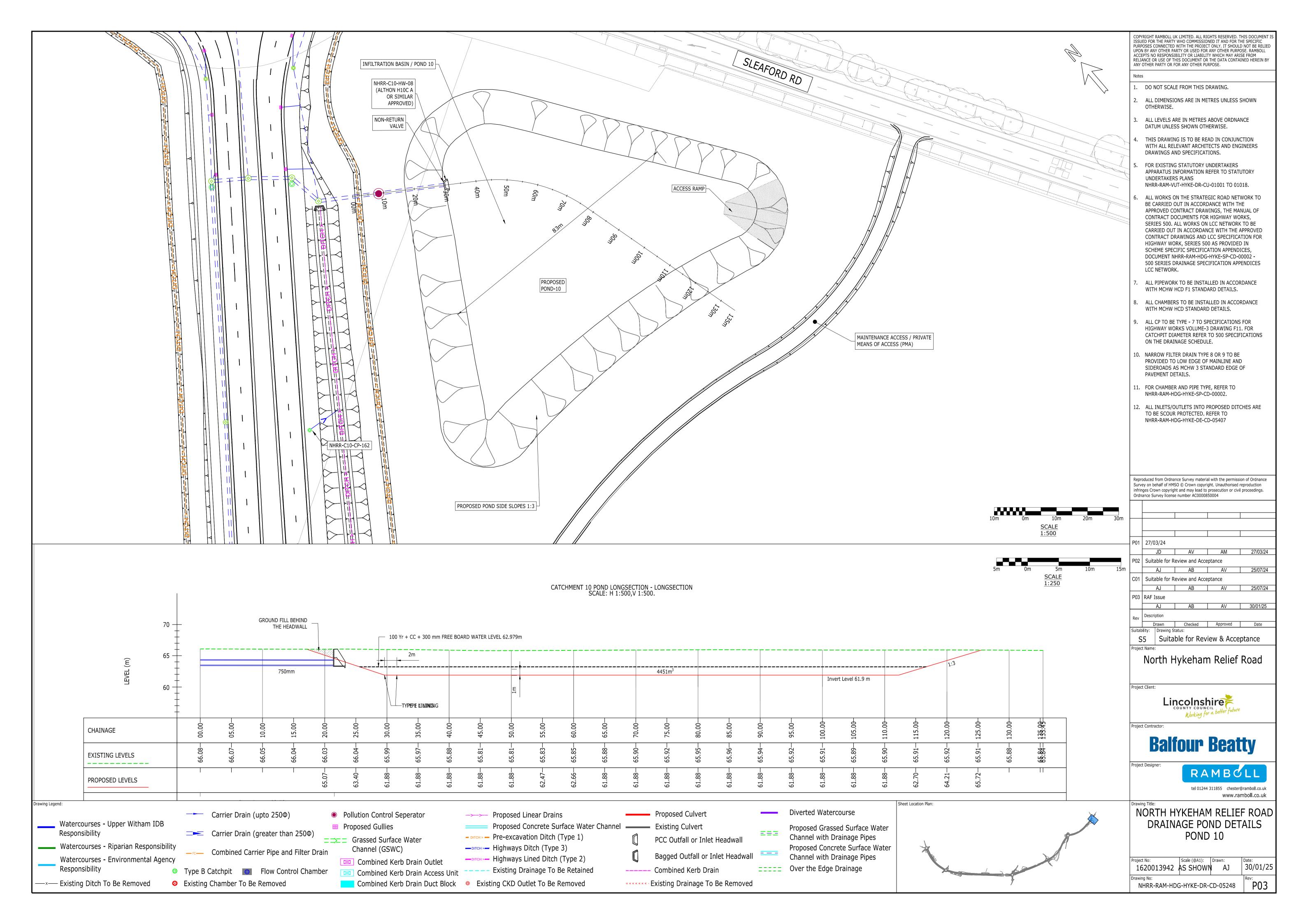












APPENDIX 2 WATER QUALITY ASSESSMENT REPORT

2/18



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Water Quality Assessment

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NORTH HYKEHAM RELIEF ROAD WATER QUALITY ASSESSMENT











NORTH HYKEHAM RELIEF ROAD WATER QUALITY ASSESSMENT

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1. INTRODUCTION

This report details the water quality risk assessment for the operational phase of the proposed North Hykeham Relief Road (NHRR). The report considers the risk of impacts to water quality which may arise from the scheme to determine whether these are acceptable or not and, where it is unacceptable, what mitigation is required to address the risk. The indicative drainage layout for the scheme is shown in Appendix 2.

The water quality assessment considers risks from routine runoff to both surface watercourses and groundwater. The risk of a spillage resulting in a pollution incident are also assessed. The assessment methods used are as described in National Highways' DMRB document 'Road Drainage and the Water Environment' (LA 113). The assessments utilise the Highways England Water Risk Assessment Tool (HEWRAT) as required by LA 113.

An overview of the methodologies is provided in the relevant sections below. Detailed information on methodology and calculations is available in DMRB LA 113 and, for treatment efficiencies, DMRB CG 501.

2. SITE INFORMATION

2.1 Site Location

The NHRR consists of the construction of approximately 8km of Dual All-Purpose 2lane Carriageway between the A46-Newark Road Roundabout and the Lincoln Eastern Bypass-Sleaford Road Roundabout.

The new road will pass to the south of South Hykeham and through Station Road near Waddington, before passing north around the north side of RAF Waddington. A site location plan can be found in Figure 2-1 below.

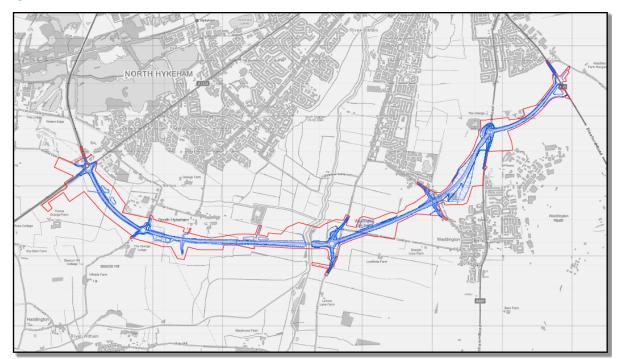


Figure 2-1 Site Location Plan

2.2 Site Description and Existing Drainage

The North Hykeham Relief Road (NHRR) crosses low-lying and largely flat farmland which is drained by man-made ditches or straightened drains. These drains are, in part, managed by an Internal Drainage Board (IDB). The ditches and drains discharge to either a watercourse named 'The Beck' (Figure 2-2) or the River Witham (Figure 2-3). The Witham flows south to north through the study area and will be crossed by the NHRR.

The Witham has levees on either bank to control flooding. The river level can often be higher than the surrounding land so many of the ditches and drains flow to an IDB pumping station which lifts the water into the Witham. The Beck is carried over the levees on embankment and flows into the Witham by gravity.

To the east of the Witham is an escarpment through which the proposed road will cut. The road rises to a proposed junction with the LEB. Grantham Road roundabout on the east is the highest point of the scheme at approximately 73 mAOD. The lowest point is at the River Witham at approximately 4.5 mAOD.



Figure 2-2 The Beck. Photo taken on 12/01/2023 at Beck lane.





2.3 Drainage Strategy and Discharge Points

The proposed drainage for the new road is divided into ten numbered catchments with the A46 Junction forming a first catchment. The catchments are split based on the alignment and the positions of the existing watercourses. The easternmost catchment (catchment 10) is proposed to discharge to an infiltration basin, while the other catchments discharge to surface watercourses. Proposed highway catchments and water quality assessment points are shown in appendix 2. Table 2-1 gives details of the catchment areas. Traffic flows for those catchments are also shown and are reported as Annual Average Daily Traffic (AADT).

Table 2-1 Drainage Catchments

Outfall Reference	Impermeable Catchment Area (ha)	Permeable Catchment Area (ha)	Description	AADT (Annual Average Daily Traffic)
Highway catchment1	1.839	0.414	Discharges to tributary of the Beck	32923, 3.43% HGV
Highway Catchment 2	1.210	0.653	Discharges to tributary of the Beck	32923, 3.43% HGV
Highway Catchment 3	1.754	0.688	Discharges to tributary of the Beck	32923, 3.43% HGV
Highway Catchment 4	1.052	0.586	Discharges to the Witham via ditches	36798, 2.32% HGV
Highway Catchment 5	0.90	0.286	Discharges to the Witham via ditches	36798, 2.32% HGV
Highway Catchment 6	3.049	1.436	Discharges to the Witham via ditches	49121, 2.68% HGV
Highway Catchment 7	2.155	0.892	Discharges to the Witham via ditches	49121, 2.68% HGV
Highway Catchment 8	2.882	1.459	Discharges to the Witham via ditches	49121, 2.68% HGV
Highway Catchment 9	6.92	1.812	Discharges to the Witham via ditches	49121, 2.68% HGV
Highway Catchment 10	4.35	2.116	Discharges to infiltration basin	32120, 3.23% HGV

3. SURFACE WATER QUALITY ASSESSMENT

3.1 Assessment Methodology for Routine Runoff

Highways England Water Risk Assessment Tool (HEWRAT) estimates the magnitude of potential short term and longer-term impacts to water quality associated with discharge of operational road drainage. Calculated concentrations of specific elements are compared against freshwater pollutant thresholds and Environmental Quality Standards (EQS) to assess compliance with the Water Framework Directive (WFD). HEWRAT considers the following:

- Short-term impacts in the form of runoff-specific thresholds (RST), which relate to the
 intermittent nature of road runoff (i.e. contaminants washed off the road surface in a
 rainfall event), over a typical exposure period of six hours (RST 6 hour) and for a worstcase scenario of 24 hours (RST 24 hour). Dissolved copper and dissolved zinc are used as
 indicators of the level of impact as they can result in acute toxic effects to aquatic life in
 certain concentrations.
- Chronic impacts (i.e. impacts which can persist for weeks or months) associated with sediment-bound pollutants on aquatic ecology. Two standards are used for metal and polycyclic aromatic hydrocarbon (PAH) concentrations within sediment; Threshold Effects Levels (TELs) (i.e. the concentration below which toxic effects are very rare) and Probable Effects Levels (PELs) (i.e. the concentration above which toxic effects are observed on most occasions).

• Longer-term in-river annual average concentrations for soluble pollutants (dissolved copper and dissolved zinc) which includes the contribution from road runoff. These concentrations are compared against published EQS for freshwaters to assess whether there is likely to be a long-term impact on ecology.

HEWRAT uses a three-step tiered approach to assess the impacts of both soluble and sediment-bound pollutants. A 'Pass' or 'Fail' result is recorded depending on whether the risk is within or exceeds the thresholds indicated above. Where a Fail result is recorded for one or more of the pollutant types, the next step is required based on increasing levels of inputs and assessment.

As well as assessing the risk of routine runoff from each drainage outfall in isolation, an incombination assessment is undertaken where more than one outfall discharges into the same reach of watercourse. This is the 'worst-case' scenario as the combined effects could be more significant. To aggregate the assessments, the total impermeable and permeable carriageway areas to be drained are added together, and the low flow of the watercourse is taken at the location furthest downstream (this is the assessment point of the combined outfall assessment). For drainage outfalls positioned between 100m and 1km apart, the cumulative assessment is for soluble pollutants only, whilst for outfalls positioned closer together (within 100m), the combined assessment includes soluble and sediment pollutants.

3.2 Discharge Points for Road Runoff

The discharge points to surface watercourses and HEWRAT assessment locations are shown in Figure 3-1 and Figure 3-2:

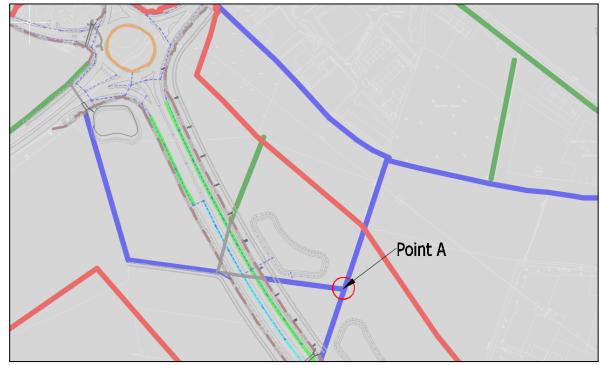


Figure 3-1 Discharge point A

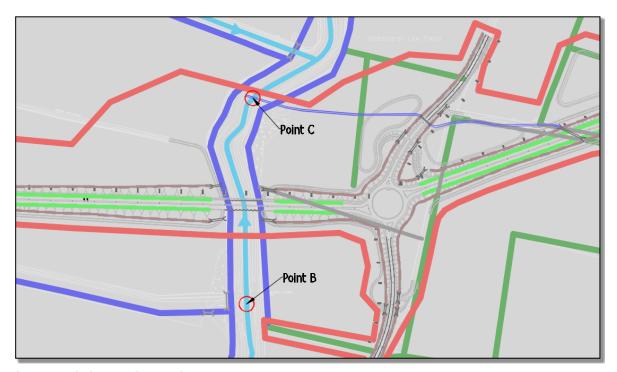


Figure 3-2 Discharge point B and C

Point A: The catchment area from highway catchment area 1 and part of catchment area 2 discharge to an existing ditch. The existing ditch has a small catchment area (the ditch originates at the A46 roundabout) such that the ditch is often dry. The location for the HEWRAT assessment of potential impacts on freshwater ecology has therefore been taken as the point downstream where the existing ditch joins another ditch with a larger catchment. The downstream location where the two ditches meet is marked 'Point A' on Figure 3-1 above.

The combined catchments of highway catchment area 1, catchment area 2 and the catchment area 3 meet at this confluence of ditches. As the discharge locations are within 100m for highway catchment 1 and 2 therefore a cumulative assessment is required at point A.

Point B: Discharge from highway catchment areas 4, 5, 6 and7 combine via local farm ditches and IDB drains at Point B. The water in these watercourses is discharged into the river Witham via a pumping station. The ditches and drains have a small contributing catchment area of less than 50 hectares such that they are often dry. The location for the HEWRAT assessment of potential impacts on freshwater ecology has therefore been taken as the point where the ditch network discharges to the river Witham (which always has water in).

Point C: Discharge from highway catchment areas 8 and 9 combine via local farm ditches and IDB drains at Point C. The water in these watercourses is discharged into the river Witham. The ditches and drains have a small contributing catchment area of less than 50 hectares such that they are often dry. The location for the HEWRAT assessment of potential impacts on freshwater ecology has therefore been taken as the point where the ditch network discharges to the river Witham (which always has water in). Watercourse parameters

Table 3-1 presents watercourses parameters which are required for the water quality risk assessment using HEWRAT. The parameters have been determined from:

- · topographical surveys of the watercourses;
- a detailed lidar survey; and

LowFlows software¹.

The Defra water hardness map(reproduced in appendix 3) shows the watercourse hardness (in terms of the concentration of calcium carbonate) to be between 200 and 300 mg $CaCO_3/I$. This is 'hard' in terms of the HEWRAT hardness bands.

Table 3-1 Watercourse Parameters for use HEWRAT assessment

Point	Grid Ref.	Watercourse	Catchment Area (km²)	Q ₉₅ (m³/s)	BFI	Bed Width (m)	Long slope	Side Slope (h/v)	Mannings n
А	492407 364909	Ditch/ tributary leading to the Beck	3.38	0.002	0.26	1	0.0001	1:1.4	0.03
В	495450 364700	River Witham	562	0.31	0.5	18	0.007	1:7	0.03
С	495249 364413	River Witham	562	0.31	0.5	18	0.007	1:7	0.03

3.3 Individual & Cumulative Assessments

In accordance with LA113 and depending on the proximity of outfalls, water quality assessments may need to be carried out for potential cumulative effects as well as for individual discharges. The assessments carried out are shown in Table 3-2.

Table 3-2 Individual and Cumulative Assessments

Catchment Reference	Assessment	Individual / Cumulative	Assessment Point
Highway Catchment 1	Soluble and sediment	Individual outfall	Point A
Highway Catchment 2	Soluble and sediment	Individual outfall	Point A
Highway Catchment 3	Soluble and sediment	Individual outfall	Point A
Highway Catchment 2 Highway Catchment 3	Sediment	Cumulative discharges	Point A
Highway Catchment 1 Highway Catchment 2 Highway Catchment 3	Soluble	Cumulative discharges	Point A
Highway Catchment 4	Soluble and sediment	Individual outfall	Point B
Highway Catchment 5	Soluble and sediment	Individual outfall	Point B
Highway Catchment 6	Soluble and sediment	Individual outfall	Point B

 $^{^1\} Walling for d\ Hydrosolutions, Low\ Flows\ 2\ software.\ Available\ at\ https://www.hydrosolutions.co.uk/software/lowflows2/\ [Accessed\ 31-03-2023]$

Highway Catchment 7	Soluble and sediment	Individual outfall	Point B
Highway Catchment 8	Soluble and sediment	Cumulative discharges	Point C
Highway Catchment 9	Soluble and sediment	Cumulative discharges	Point C
Highway Catchment 4 Highway Catchment 5 Highway Catchment 6 Highway Catchment 7 Highway Catchment 8 Highway Catchment 9	Sediment	Cumulative discharges	Point B & C
Highway Catchment 4 Highway Catchment 5 Highway Catchment 6 Highway Catchment 7 Highway Catchment 8 Highway Catchment 9	Soluble	Cumulative discharges	Point C
Highway Catchment 10	Groundwater Assessment	Infiltration Basin -	see section 5

3.4 **HEWRAT Assessments Outputs**

HEWRAT outputs are provided in Appendix 1 and summarised in Table 3-3. Table 3-3 HEWRAT Assessment Summary

		Soluble	Pollution			
	(Runoff	Impact Specific holds)		Impact al Ave. tration)	Sediment	Comment
	Copper	Zinc	Copper	Zinc	Chronic Impact	
Highway Catchn	nent 1, Poi	nt A				
Without mitigation	Pass	Pass	Pass	Pass	Fail	64% settlement of sediments required to pass
With mitigation	Pass	Pass	Pass	Pass	Pass	proposed sedimentation pond with a forebay and ditch to the outfall.
Highway Catchn	nent 2, Poi	nt A				
Step 2 (Tier 2)	Pass	Pass	Pass	Pass	Fail	38% settlement of sediments required to pass

		Soluble I	Pollution			
		Impact Specific holds)	(Annu	Impact al Ave. tration)	Sediment	Comment
	Copper	Zinc	Copper	Zinc	Chronic Impact	
Step 3	Pass	Pass	Pass	Pass	Pass	Proposed swale, carrier ditches, and grit separator
Highway Catchn	nent 3, Poir	nt A				
Step 2 (Tier 2)	Pass	Pass	Pass	Pass	Fail	58% settlement of sediments required to pass
Step 3	Pass	Pass	Pass	Pass	Pass	Proposed swale, sedimentation pond, carrier ditches, and grit separator
Cumulative asse	essment (se	ediment): (Catchment	1 Catchme	nt 2, Catchm	ent 3, Point A
Step 2 (Tier 2)	Pass	Pass	Pass	Pass	Fail	75% settlement of sediments required to pass
Step 3	Pass	Pass	Pass	Pass	Pass	Proposed swale, carrier ditches, and grit separator for Catchment 2 and 3
Cumulative ass	essment(so	oluble): Cat	chment 1	Catchment	2, Catchmen	t 3, Point A
Step 2 (Tier 1)	Pass	Pass	Pass	Pass	Pass	-
Highway Catchn	nent 4, Poir	nt B				
Step 2 (Tier 1)	Pass	Pass	Pass	Pass	Pass	-
Highway Catchn	nent 5, Poir	nt B				
Step 2 (Tier 1)	Pass	Pass	Pass	Pass	Pass	-
Highway Catchn	nent 6, Poir	nt B				
Step 2 (Tier 1)	Pass	Pass	Pass	Pass	Pass	-
Highway Catchn	nent 7, Poir	nt B				
Step 2 (Tier 1)	Pass	Pass	Pass	Pass	Pass	-
Highway Catchn	nent 8, Poir	nt B				

		Soluble l	Pollution			
	(Runoff	Impact Specific holds)	(Annu	Impact al Ave. tration)	Sediment	Comment
	Copper	Zinc	Copper	Zinc	Chronic Impact	
Step 2 (Tier 1)	Pass	Pass	Pass	Pass	Pass	-
Highway Catchn	nent 9, Poi	nt B				
Step 2 (Tier 1)	Pass	Pass	Pass	Pass	Pass	-
Cumulative asse	essment (se	ediment): H	Highway Ca	tchments 4	1, 5, 6, 7, 8 a	nd 9, Point B and C
Step 2 (Tier 1)	Pass	Pass	Pass	Pass	Pass	-
Step 2 (Tier 2)	Pass	Pass	Pass	Pass	Pass	-

Table 3-3 shows failure of sediment-bound pollutants at discharge point A. However, once the proposed mitigation measures are included, the assessments pass. The mitigation measures included in the drainage design are swales, ponds, and vortex separators.

4. SPILLAGE ASSESSMENT

4.1 Spillage Risk Assessment

Along a road there is always some risk of a vehicular collision that could result in the spillage of fuels, chemicals or other hazardous liquids, particularly if tankers and heavy goods vehicles (HGVs) are involved. A risk assessment of a serious spillage causing a pollution incident was undertaken using the methodology outlined in LA113.

The risk is calculated assuming that an accident involving spillage of pollutants onto the carriageway would occur at an assumed frequency (expressed as an annual probability), based on calculated traffic volumes and the type of road/junction. The annual probability of a serious accidental spillage also depends upon the emergency services response time, based on the location (i.e., urban, rural, or remote location).

Where spillage risk is calculated as less than 1% Annual Exceedance Probability (AEP) (less frequent than 1 in 100 years), the risk is regarded as acceptably low, and no mitigation is required. Where the risk is greater than 1% AEP, mitigation is required. Such mitigation would allow the drainage system to be shut off before the liquid reaches the discharge point.

Similar to the routine runoff assessment, a cumulative spillage risk assessment is undertaken where more than one outfall discharges into the same reach of watercourse (or groundwater body). To aggregate the assessments, the total length of road drained (split into each road/junction type) is combined for all outfalls and the highest AADT and %HGV values are taken for each road/junction type.

The spillage risk assessment results are detailed in Appendix 1 and summarised in Table 4-1.

Table 4-1 Spillage Risk Assessment Results

Asset Reference	Length of Side Road (m)	Length of Roundabout (m)	Length of 'A' Road (m)	Risk of Incident	Pass/ Fail
Point A (catchments 1,2 & 3)	315	485	1155	0.03%	Pass
Point B (catchments 4,5,6 & 7)	530	360	2336	0.03%	Pass
Point C (catchments 8 & 9)	824	196	3339	0.04%	Pass
Catchment 10	573	225	1145	0.02%	Pass

The spillage risk assessment considers the length and type of road. Different risk factors apply depending on the type of road, for example a roundabout has a higher risk factor than a straight road. The summarise table above shows the outcome of the assessment at the discharge points. All the assessments pass as the risk is below 1%, no mitigation measures are required.

5. GROUNDWATER ASSESSMENT

5.1 Catchment 10

5.1.1 Ground Investigation

The ground investigation describes the geology in the area of the proposed infiltration basin. No borehole logs were available within the extent of the proposed basin footprint; however, logs were available adjacent to it and nearby(<100m) The three closest borehole logs were selected, each within the limestone bedrock. These logs comprise rotary core boreholes RC125, RC126, and RC215. The borehole depths extended to a maximum of 10metres below ground level (mbgl) and are situated in a similar area of elevation at approximately 67.0 mAOD to 67.5 mAOD according to OS LiDAR data.

The available logs are summarised in Table 5-1.

Table 5-1: Borehole log summary

Strata Description	Range of depth to base (m)
Grass over TOPSOIL	0.05
SAND. Clayey fine to coarse sand, some angular gravel (limestone)	0.4-1.2
Weak sandy LIMESTONE and GRAVEL. Sand is course to fine.	1.6-2.1
Moderately weak weathered LIMESTONE with horizontal discontinuities, limestone COBBLES	2.2-2.5
Medium strong LIMESTONE with sub horizontal discontinuities. Some clay and gravel infill.	5.9-7.4
Extremely weak MUDSTONE with horizontal and sub horizontal discontinuities	Unproven (>10)

From boreholes: RC125, RC126, RC215

The borehole logs confirm the presence of limestone that ranged between 1.2 to 7.4 mbgl. Fractures and fissures were not indicated in the limestone and discontinuities were mainly horizontal and subhorizontal. Groundwater was not encountered in any of the boreholes (which extended to depths of 10.0 mbgl). However, groundwater monitoring conducted for the Lincolnshire Eastern Bypass scheme, east of Catchment, identified groundwater strikes of 59.08 mAOD (5m bgl) at borehole BH652 and 60.67 mAOD (4m bgl) rising to 61.67 (3 mbgl) at borehole A48, less than 150m from the proposed infiltration basin.

No soil organic carbon data was available at the time of writing, but the GI Results have indicated loamy topsoil in the upper stratum. Additionally, no pH data was available. BGS soil data indicates lime-rich soils, which are typically alkaline, therefore a pH greater than 8 is assumed for the assessment below.

5.1.2 Groundwater Risk Assessment

At the eastern end of the scheme, Catchment 10 will discharge to an infiltration basin. A simple assessment has been made of the risk to groundwater based on the methodology described in

Appendix C of LA 113. A level of risk is assigned to each parameter (1,2,3) which his multiplied by the weighting factor of the parameter, providing a risk score. The process is carried out for each parameter and the scores are summed to provide an overall risk score. The lowest possible score is 100 and the highest is 300. The score bands for determining risk are as follows:

- 1. <150 low risk
- 2. 150-250 medium risk
- 3. >250 high risk

The assessment is detailed in Table 5-2. Total scores above 150 necessitate further assessment per Section 3 of DMRB LA 113.

Table 5-2 Groundwater Risk Assessment

Parameter	Weighting	Score for	Reason for selected score	Weighting
i di dilictoi	Factor	Catchment 6	Reason for selected score	factor × score
		Infiltration basin		
Traffic Flow	10	1	<50,000 AADT band. Expected max AADT value approximately 32,120 AADT	10
Rainfall Depth (annual average)	10	1	<740mm band. Actual value 600mm from the SAAR (standard average annual rainfall) value for Lincoln in the catchment descriptors.	10
Drainage	10	1	<50 band.	10
area ratio			Infiltration area of basin approximately 0.5 ha (5000m²). Catchment area 48,776m². Actual drainage area ratio 1:9.35. The size of the basin is subject to confirmation following the GI, but any change to the basin size is unlikely to result in a change of the <50 ratio band.	
Infiltration method	15	2	Region method. Infiltration basin to be used.	30
Unsaturated zone	20	2	Depth to water table <15m to >5m approximated average. Based on the borehole data from the NHRR scheme, 500m west, no water was struck <10m However, borehole records from the adjacent Lincolnshire Eastern Bypass Scheme show groundwater at <5mbl.	40
Flow type	20	2	Sandy/gravelly clay overlaying limestone bedrock, however with no fractures or fissures observed. Assumed mixed fracture and intergranular flow.	40
Unsaturated zone clay content	5	1	>=15% clay minerals band selected. GI results indicate clay strata overlaying limestone with clay layers.	5
Organic carbon	5	2	Band selected is <15% to >1% soil organic matter. GI Results suggest loamy topsoil.	10
Unsaturated zone soil pH	5	1	BGS soil data indicates lime-rich soils 2 , therefore pH >=8 is assumed.	5
			Total Score	160

 $^{^2 \ \}mathsf{UK} \ \mathsf{Soil} \ \mathsf{Observatory, online} \ \underline{\mathsf{https://mapapps2.bgs.ac.uk/ukso/home.html?layer=mySoil}} \ [\mathsf{Accessed} \ \mathsf{March} \ \mathsf{2023}]$

The score of 160 indicates a 'medium' risk which, in line with LA113, warrants further assessment of the parameter(s) contributing most to the risk in terms of the source-pathway-receptor linkage. In this case the greatest contributing factor to the risk is groundwater flow being through mixed fracture and intergranular flow through weak limestone which could provide a potential pathway for soluble contaminants in the road runoff to reach the groundwater and groundwater abstraction points. In addition, an estimated unsaturated zone between 5 mbgl and 15 mbgl, which is estimated based on conflicting groundwater levels observed in the area of the proposed infiltration basin and east of the proposed infiltration basin, reduces the likelihood of contaminants being adsorbed and attenuated due to a more limited time and distance passing through the unsaturated zone.

The infiltration basin is also located within the outer extent of an outer groundwater source protection zone (SPZ2). This zone is defined by the Environment Agency as having a 400-day travel time from a point below the water table. The travel time is derived from consideration of the minimum time required to provide delay, dilution and attenuation of slowly degrading pollutants. The associated SPZ1 is located 5.3km north-east of the proposed infiltration basin. Additionally, there are no active licenced groundwater abstractions or historical licenced groundwater abstractions used for drinking water identified within at least 1km according to the Insight report supplied by Groundsure.

Importantly, mitigation is embedded into the drainage design based on the results set out by water quality assessment document. Highway runoff is to be intercepted by grass surface water channels at the edge of the carriageway and conveyed by carrier drain to a lined sediment forebay equating to approximately 10% of the volume of the infiltration basin, which is based on minimum sizing provided in the SuDS Manual (CIRIA C753). Additionally, a pollution control valve (isolation penstock) is proposed for infiltration basins, at the outlet from the sediment forebay, upstream of the infiltration basin. As detailed in section 4, the risk of a spillage in catchment 10 is acceptably low. Nonetheless, the penstock will allow isolation of the drainage system in the event of a spillage should there be one.

The groundwater assessment total score of 160 represents the low end of medium risk, where low risk is less than 150. Therefore, considering the embedded mitigation in the design the risk to the groundwater environment is considered acceptably low.

6. CONCLUSION

Water quality risk assessments have been undertaken for the operational phase of the proposed North Hykeham Relief Road. The assessment includes surface water quality, spillage risk and groundwater risk.

Based on the alignment design and the locations of the natural watercourses, three assessment points were identified. Ten catchment areas have been determined and these catchments discharge to their associated assessment points.

The routine runoff assessments for impacts on water quality were undertaken using the HEWRAT assessment tool. The highway catchment 1, and catchment 2 and catchment 3 discharge to a tributary of the Beck watercourse. Without mitigation, the assessments fail due to excessive sediment. Cumulative mitigation measures of 75% is required to pass the assessment. This will be achieved by treatment measures including swales within the road verge, ditches and vortex chambers adjacent to the carriageway. Applying the treatment efficiencies given in DMRB CG501, these mitigation measures are sufficient to sufficiently reduce the amount of highway-derived sediment reaching the receiving watercourse.

Assessment point B is the discharge point to River Witham, which has contributing highway catchments from areas 4, 5, 6, 7, 8 and 9. The water quality assessment (using HEWRAT) and it passed individually and cumulatively.

A risk assessment of a serious spillage causing a pollution incident was undertaken using the methodology outlined in LA113. All assessment points passed, with the spillage risk calculated as less than 1%.

Catchment 10 is proposed to discharge to the ground via an infiltration basin. The location of the infiltration is based within a SPZ2. A risk assessment was undertaken using estimated values and scored 160 which indicated a medium risk. In accordance with LA113, further consideration of the risk was undertaken. The mitigation incorporated into the design includes grass-lined surface water channels, a sediment forebay for the infiltration basin and inclusion of a penstock to enable isolation of the drainage system in the event of a spillage. With this mitigation incorporated into the design the risk to groundwater quality is considered to be acceptably low.

APPENDIX 1 HEWRAT ASSESSMENT EXTRACTS

lighway Cato								
highways england	Highways England	Water Risk Assessment To Soluble	ool		Version 2.0.4 June	2019		Sediment - Chronic Impact
	EQS - Annual Average Con				Acute Im	an ant		Sediment - Chronic impact
Step 2	Copper 0.23	Zinc 1.00	ugil		Copper Pass	Zinc Pass		Fail. 64 × settlement needed. Settlement needed = 64 ×, proposed Sediment deposition for this site is judged Accumulating? Yes 0.03 Low flox Extensive? Yes 271
to ad number		NHRR			HE Area / DBFO n	number		Area 7
ssessment type OS grid reference of assessmen	at a sint (m.)	Non-cumulative assessment Easting 492407	t (single outfall))		Northing	loo 4000	
DS grid reference of assessmen DS grid reference of outfall struc		Easting 492407				Northing	364909	•
Outfall number	valo (III)	Highway Catchment 2			List of outfalls in c			
Receiving watercourse		Tributary Leading to the B	eck		assessment			
A receiving water D etailed Riv	er Network ID				Assessor and affili			AJ
late of assessment		20-05-2024			Version of assess	ment		2
Step 1 Runoff Quality	AADT >10,000 and <50	0,000 ▼	Climatic reg	ion 🗀	older Dry	Rainfall site		Lincoln (SAAR 600mm)
Step 2 River Impacts	Annual Q ₉₅ river flow (m ³ /s)		0.002	F	reshwater EQS limits:			
(Enter zero in Annual Q ₀₅		ned (ha)	1.839			lyad conner (1 D
river flow box to assess	Impermeable road area drain				Bioavailable disso			
Step 1 runoff quality only)	Permeable area draining to	outtail (ha)	0.414	_ L	Bioavailable disso			10.9 D
	Base Flow Index (BFI)		0.26	Is ti	he discharge in or withi	in 1 km upstream of	a protec	ted site for conservation?
For dissolved zinc only	Water hardness	High = >200mg CaCO3/I		$-\top$	For dissolved copp	er only *	t hast-	ound concentration (ug/l)
Tor dissolved zinc only	vvater flatuliess	right = 7250mg Geocom			roi dissolved copp	er only Ambien	т раскуго	ound concentration (µg/l)
For sediment impact only	Is there a downstream struct	ture, lake, pond or canal that redu	uces the velocity	within	100m of the point of dis	scharge?		No 🔻 🗅
	○ Tier 1 Estimated riv	ver width (m)	1					
			1 1	Annina	g's n 0.07	Sin	lo alono ((m/m) 0.71 Long slope (m/m) 0.00
	© Tier 2 Bed width (n	")	, ,	viaiiiiiiiy	JS II 0.5/	310	ie slope (Long slope (IIIIII)
Existing measures Proposed measures		Brief description			0 D N	stricted discharge ratio		sediments (%)
highways england	Highways England	Water Risk Assessment To	ool		Version 2.0.4 June	2019		
		Soluble						Sediment - Chronic Impact
	EQS - Annual Average Con Copper	centration Zinc	— I		Acute Im	pact		Pass
Step 2	0.23	1.00 -	ug/l ug/l		Copper Pass	Zine Pass		Sediment deposition for this site is judged Accumulating? Yes 0.03 Low flow Extensive? No 98 Deposit
oad number		NHRR			HE Area / DBFO n	umber		Area 7
ssessment type		Non-cumulative assessmen	t (single outfall))	112770470070			Aled 1
S qrid reference of assessmen		Easting 492407				Northing	364909	l .
S grid reference of outfall struc	ture (m)	Easting				Northing		
utfall number eceiving watercourse		Highway Catchment 2 &3 Tributary Leading to the B	a ok		List of outfalls in co assessment	umulative		
A receiving water Detailed Riv	er Network ID	Inibutary Leading to the B	eck		Assessor and affili	ation		AJ
ate o fassessment		20-05-2024			Version of assess			2
te s								
tep 1 Runoff Quality	AADT >10,000 and <50	0,000	Climatic regi	ion Col	lder Dry 🔻	Rainfall site		Lincoln (SAAR 600mm)
tep 2 River Impacts	Annual Q ₉₅ river flow (m ³ /s)		0.002	F	reshwater EQS limits:			
(Enter zero in Annual Q ₉₅	Impermeable road area drain	ned (ha)	1.839		Bioavailable disso	lved copper (µg/l)		1 D
river flow box to assess Step 1 runoff quality	Permeable area draining to	outfall (ha)	0.414		Bioavailable disso	lved zinc (µg/l)		10.9
only)	Base Flow Index (BFI)		0.28	ls ti	he discharge in or withi	in 1 km upstream of	a protec	ted site for conservation?
For dissolved zinc only	Water hardness	High = >200mg CaCO3/I	•	-	For dissolved copp		-	ound concentration (μg/l)
							.,	
For sediment impact only	Tier 1 Estimated riv	ure, lake, pond or canal that redu ver width (m)	ices the velocity	within 1	100m of the point of dis	scharge?		No D
	Tier 2 Bed width (n	n)	1 N	Manning	y's n 0.07	Sid	e slope (m/m) 0.71 Long slope (m/m) 0.00
Step 3 Mitigation				Г		E stimated effective	ne ss	
				_	Treatment for solubles (%)	Attenuation for solu stricted discharge ra	bles -	Settlement of
		Brief description			GUILDIGS (70)	smow uistriarye ra	110 (1/8)	sediments (%)
Existing measures	64% Treatment required (Pond+ of					o restriction •	D	0 D
Proposed measures		umper in M.PS. on feation				o restriction -	4 1 m	64

Highway Catchment 2 Highways England Water Risk Assessment Tool Version 2.0.4 June 2019 Sediment - Chronic Impact EQS - Annual Average Concentration Acute Impact Zinc Zinc Sediment deposition for this site is judged as:
Accumulating?

Yes 0.05
Low flow Vel m/s
Yes 161
Deposition Index Step : Step 3 HE Area / DBFO number Area 7 Road number NHRR Non-cumulative assessment (single outfall) OS grid reference of assessment point (m) Northing 492407 364909 Northing cumulative OS grid reference of outfall structure (m) Outfall number Highway Catchment 2 Receiving watercourse Tributary leading to the Beck EA receiving water Detailed River Network ID Assessor and affiliation 09-07-2024 Date of assessment Version of assessment Step 1 Runoff Quality Lincoln (SAAR 800mm) >10,000 and <50,000 Climatic region Colder Dry -• -Rainfall site Step 2 River Impacts Annual Q_{cc} river flow (m³/s) 0.002 Freshwater FQS limits: (Enter zero in Annual Q₉₅ river flow box to assess Step 1 runoff quality only) Impermeable road area drained (ha) 1.21 Bioavailable dissolved copper (μg/l) **1** D 0.653 10.9 D Permeable area draining to outfall (ha) Bioavailable dissolved zinc (uq/l) Base Flow Index (BFI) 0.26 Is the discharge in or within 1 km upstream of a protected site for conservation? No -For dissolved zinc only Water hardness High = >200mg CaCO3/I • For dissolved copper only Ambient background concentration (µg/l) **0** D Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No ▼ D For sediment impact only 5 ○ Tier 1 Estimated river width (m) • Tier 2 Bed width (m) 1 Manning's n 0.03 Side slope (m/m) 0.71 Long slope (m/m) 0.0001 Step 3 Mitigation E stim ated effectiveness Attenuation for solubles -restricted discharge rate (I/s) Treatment for solubles (%) Settlement of sediments (%) Brief description Existing measures Proposed measures No restriction Highways England Water Risk Assessment Tool highways england Version 2.0.4 June 2019 EQS - Annual Average Concentration Acute Impact Zinc Copper Zinc Yes 0.05 Low flow Yel m/s
No 64 Deposition Index Step 2 Pass Nge Extensive? Step 3 Road number NHRR
Non-cumulative assessment (single outfall HE Area / DBFO number Area 7 Assessment type OS grid reference of assessment point (m) 364909 Easting 492407 OS grid reference of outfall structure (m) Easting Northing Easting
Highway Catchment 2 Receiving watercourse Tributary leading to the Beck EA receiving water Detailed River Network ID Date of assessment Assessor and affiliation 09-07-2024 Step 1 Runoff Quality Lincoln (SAAR 600mm) >10,000 and <50,000 Climatic region Colder Dry Rainfall site --Ŧ Step 2 River Impacts Annual Que river flow (m3/s) 0.002 Freshwater EQS limits: (Enter zero in Annual Q₉₅ river flow box to assess Step 1 runoff quality 1.21 Impermeable road area drained (ha) Bioavailable dissolved copper (µg/l) 0.653 10.9 D Permeable area draining to outfall (ha) Bioavailable dissolved zinc (ug/l) 0.28 Base Flow Index (BFI) Is the discharge in or within 1 km upstream of a protected site for conservation? No 🔻 D For dissolved zinc only Water hardness High = >200mg CaCO3/I -For dissolved copper only Ambient background concentration (µg/l) 0 D Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No ▼ For sediment impact only © Tier 1 Estimated river width (m) Bed width (m) 1 Manning's n 0.03 Side slope (m/m) 0.71 Long slope (m/m) 0.0001 Tier 2 Step 3 Mitigation E stim ated effective ness Attenuation for solubles -restricted discharge rate (I/s) Brief description Existing measures 38% Treatment Required (Pond+Ditch) is 60 mitigation

Proposed measures

No restriction

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Highway Catchment 3 Highways England Water Risk Assessment Tool Version 2.0.4 June 2019 Soluble Sediment - Chronic Impact EQS - Annual Average Concentration Copper Step 2 Accumulating? Extensive? Step 3 HE Area / DBFO number Road number Area 7 NHRR Assessment type OS grid reference of assessment point (m) Non-cumulative assessment (single outfall) Northing 364909 492407 OS grid reference of outfall structure (m) Easting Northing Highway Catchment 3 List of outfalls in Receiving watercourse Tributary leading to the Beck EA receiving water Detailed River Network ID Assessor and affiliation Date of assessment 09-07-2024 Step 1 Runoff Quality >10,000 and <50,000 Climatic region Colder Dry Lincoln (SAAR 600mm) ¥ AADT Rainfall site Step 2 River Impacts Annual Q_{ss} river flow (m³/s) 0.002 Freshwater EQS limits (Enter zero in Annual Qos Impermeable road area drained (ha) 1.754 Bioavailable dissolved copper (ug/l) 1 D river flow box to assess Step 1 runoff quality only) Permeable area draining to outfall (ha) 0.688 10.9 D Bioavailable dissolved zinc (µg/l) 0.28 No -Base Flow Index (BFI) Is the discharge in or within 1 km upstream of a protected site for conservation? High = >200mg CaCO3/l For dissolved zinc only Water hardness • For dissolved copper only Ambient background concentration (µq/l) 0 D For sediment impact only Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? Estimated river width (m) 5 ○ Tier 1 Side slope (m/m) 0.71 Long slope (m/m) 0.0001 ⊙ Tier 2 Bed width (m) 1 Manning's n 0.03 Step 3 Mitigation E stim ated effective ness Attenuation for solubles -restricted discharge rate (I/s) Existing measures Proposed measures Highways England Water Risk Assess Version 2.0.4 June 2019 Soluble Sediment - Chronic Impact EQS - Annual Average Concentration Acute Impact Copper Zinc Sediment deposition for this site is judged as: Accumulating? Yes 0.05 Low flow Vel m/s Extensive? No 93 Deposition Index Step 2 Pass Pass Step 3 Road number Assessment type HE Area / DBFO number NHRR Area 7 Non-cumulative assessment (single outfall) OS grid reference of assessment point (m) Easting 492407 Easting Highway Catchment 3 Northing 364909 OS grid reference of outfall structure (m) Outfall number Receiving watercourse Tributary leading to the Beck EA receiving water Detailed River Network ID 09-07-2024 Date of assessment Version of assessment Step 1 Runoff Quality Rainfall site AADT >10,000 and <50,000 ¥ Climatic region Colder Dry ¥ Lincoln (SAAR 600mm) ٧ Step 2 River Impacts Annual Q_{os} river flow (m³/s) 0.002 Freshwater EQS limits: (Enter zero in Annual Q₉₅ river flow box to assess Step 1 runoff quality only) Impermeable road area drained (ha) 1.754 1 D Bioavailable dissolved copper (µg/l) 0.688 10.9 D Permeable area draining to outfall (ha) Bioavailable dissolved zinc (µg/l) Base Flow Index (BFI) 0.26 Is the discharge in or within 1 km upstream of a protected site for conservation? No -• For dissolved zinc only Water hardness High = >200mg CaCO3/I For dissolved copper only Ambient background concentration (µg/l) **0** D No ▼ D For sediment impact only Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? ○ Tier 1 Estimated river width (m) ⊙ Tier 2 Manning's n 0.03 Side slope (m/m) 0.71 Long slope (m/m) 0.0001 Bed width (m) 1 Step 3 Mitigation E stim ated effective ness Treatment for solubles (%) Attenuation for solubles -estricted discharge rate (I/s) Settlement of sediments (%) Brief description Existing measures 58 % Treatment Rewuired (Pond+Ditch) is 60 % mitigation

Step 2 River Impacts (Enter zero in Annual Q _{so} five Impermeable reversities flow box to assess Step 1 runoff quality only) For dissolved zinc only For sediment impact only For sediment impact only Step 3 Mitigation Existing measures Proposed measures Froposed measures Figs. Annual Coper only Step 2 Step 3 Step 3 Step 3 Step 3 Step 1 Step 1 Runoff Quality AADT Step 1 Runoff Quality AADT Step 2 River Impacts Center zero in Annual Q _{so} fiver flow box to assess Step 1 runoff quality only) Step 2 River Impacts (Enter zero in Annual Q _{so} fiver flow box to assess Step 1 runoff quality only) Formeable are annual Q _{so} fiver flow box to assess Step 1 runoff quality only) For dissolved zinc only Water hardness Impermeable revenue 2 Step 3 Annual Q _{so} five flow box to assess Step 1 runoff quality only) For dissolved zinc only Water hardness Impermeable revenue 2 Step 3 Annual Q _{so} five flow box to assess Step 1 runoff quality Permeable are advantaged from the flow box to assess Step 1 runoff quality only)	>10.000 and //er flow (m³/s) //er flo</th <th>NHRR Cumulative assessment in Easting 492407 Easting 492407 Easting 492407 Tributary leading to the B Tributary leading to the B 09-07-2024 09-07-2024 High = >200mg CaCO34 Lucy, lake, pond or canal that recriver width (m)</th> <th>Climatic regio 0.002 2.964 1.341 0.26 duces the velocity v</th> <th>Is doubted by the discharge of the disch</th> <th>Area / DBFO n in 100m) of outfalls in o asserted asserte</th> <th>Pass Northing 364 Northing 364</th> <th>Fail 75 Settlement in Sediment deposit Accumulating? Lettensive? Area 7 Area 7 Lincoln (SAAR 800mm) 1 109 109 rotected site for conserva ckground concentration () No</th> <th>Yes 395 Deposition Deposition? No</th>	NHRR Cumulative assessment in Easting 492407 Easting 492407 Easting 492407 Tributary leading to the B Tributary leading to the B 09-07-2024 09-07-2024 High = >200mg CaCO34 Lucy, lake, pond or canal that recriver width (m)	Climatic regio 0.002 2.964 1.341 0.26 duces the velocity v	Is doubted by the discharge of the disch	Area / DBFO n in 100m) of outfalls in o asserted asserte	Pass Northing 364	Fail 75 Settlement in Sediment deposit Accumulating? Lettensive? Area 7 Area 7 Lincoln (SAAR 800mm) 1 109 109 rotected site for conserva ckground concentration () No	Yes 395 Deposition Deposition? No
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ep 3 Mitigation Step 3 Highways	Bed width (i	(m) Brief description		Tre atm soluble	nent for es (%)	E stimated effectiveness Attenuation for solubles stricted discharge rate (I	- Settlement of sediments (%)	Long slope (m/m) 0.0001
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ighways roposed measures FUS - Annual Copper 0.33 Step 2 Step 3 Step 3 Step 3 Step 1 Step 3 Annual Quality EQ S - Rever Impacts For Impacts Fo			Tool	soluble	nent for es (%)	Attenuation for solubles stricted discharge rate (1	Settlement of sediments (%)	
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Step 2 Step 3 Step 4 Step 4 Step 4 Step 4 Step 4 Step 5 Step 5 Step 5 Step 6 Step 6 Step 6 Step 7 Step 6 Step 7		Soluble					Sedir	ment - Chronic Impact
Step 2 Step 3 and number sessment type quid reference of assessment point (m) quid reference of outfall structure (m) staf number ceixing water Detailed River Network ID te of assessment les Enter zero in Annual Q _{sc} five les Annual Q _{sc} five les Permeable are per flow box to assess tep 1 runoff quality Base Flow Index Base Flo	al Average Co	oncentration Zinc			Acute li	mpact	Fail. 7	75 % settlement needed.
sessment type qnd reference of assessment point (m) qnd reference of outfall structure (m) tall number ceiving water Detailed River Network ID te of assessment tes tep 1 Runoff Quality AADT Annual Q ₁₀ five Enter zero in Annual Q ₁₀ ver flow box to assess tep 1 runoff quality Base Flow Index		1.40	ugil	Co	оррег	Zinc	Settlement	t needed = 75 %, proposed =
and number sessment type and reference of assessment point (m) and reference of assessment point (m) and reference of outfall structure (m) tall number cerving water Detailed River Network ID te of assessment tes The property of the prop				P.	ass	Pass	Sediment depos Accumulating?	Yes 0.05 Lowflow
ad number pleasment type quid reference of assessment point (m) quid reference of assessment point (m) quid reference of outfall structure (m) fail number powing watercourse receiving water Detailed River Network ID e of assessment es pleasment es annual Q _{sc} fiver limpermeable refer flow box to assess tep 1 runoff quality Base Flow Index Base F			ug/l				Extensive?	Yes 395 Deposition
essment type quid reference of assessment point (m) quid reference of outfall structure (m) fall number zeixing watercourse re ociving water Detailed River Network: D re of assessment res ep 1 Runoff Quality ADT ep 2 River Impacts cinter zero in Annual Q _{sc} rive reflow box to assess rep 1 runoff quality Base Flow Index Base								
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to I number Selving watercourse receiving wateroerse receiving wateroer		Easting 492407	moduling countries	to (outland this		Northing 36	64909	
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ep 1 Runoff Quality ap 2 River Impacts Annual Q _{ss} five Impermeable refer flow box to assess ep 1 runoff quality Base Flow Inde		09-07-2024		Ver	rsion of asses	sment	3	
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inter zero in Annual Q _{ss} Impermeable rurer flow box to assess tep 1 runoff quality Permeable are Base Flow Inde	ver flow (m³/s)	3)	0.002	Freshwat	ter EQS limits:	ν.		
ver flow box to assess tep 1 runoff quality Permeable are nly) Base Flow Inde			2.964			olved copper (µg/l)	1	D
nlý) Base Flow Inde			1.341			olved zinc (µg/l)	10.9	
			0.28				protected site for conserv	
	uon (DFI)		020	is the disch	iaige iii di Will	i kiii upsiieam oi a p	protocioù sile lut consetv	vation? No -
or dissolved zinc only Water hardnes	ess	High = >200mg CaCO3/I	<u>-</u>	For di	lissolved cop	per only Ambient ba	ackground concentration	(μg/l) 0
or sediment impact only Is there a down		ucture, lake, pond or canal that re	educes the velocity	within 100m of	f the point of d	lischarge?	No 🔻	D
	vnstream etro		caucos me venocity	IVUIII OI	. are point of a		140	
○ Tier 1		river width (m)	5	_				
● Tier 2	Estimated i		1 N	lanning's n 0.0	03	Side s	slope (m/m) 0.71	Long slope (m/m) 0.000
ep 3 Mitigation		(m)						
-pmagaaon	Estimated i	(m)				E stim ated effective nes		
	Estimated i	(m)		T	mont for		s - Settlement of	
xisting measures	Estimated i	(m) Brief description		Tre atri	ment for oles (%)	Attenuation for solubles estricted discharge rate ((I/s) sediments (%)	

highways england	Highways Engl		ter Risk Assessme	ent Tool		Version 2.0.4 June	essment 2019				
			Soluble						Sedir	nent - Ch	ronic Impact
	EQS - Annual Average	e Concen	tration			Acute II	mpact				
	Copper 0.49		Zinc 2.07	ug/l		Copper	Zine				
Step 2										ition for t	his site is judged as:
			-	ugil		Pass	Pass		Accumulating? Extensive?		Low flow Vel m Deposition Ind
Step 3				-3"				_			
ad number		N	IHRR			HE Area / DBFO	number		Area 7		
essment type			Cumulative assessme		ments (outfa	alls between 100m					
qrid reference of assessmen qrid reference of outfall struc		-	asting 4924	07			Northing Northing	364909			
qn a reneren ce o routnaii struc fall number	ure (m)	_	asting lighway C atchment	1 2 83		List of outfalls in					I
eiving watercourse			ributary Leading to			assessment	oom out to				
receiving water Detailed Rive	er Network ID					Assessor and affi	iliation		AJ		
e o fassessment		2	0-05-2024			Version of assess	sment		2		
es											
ep 1 Runoff Quality	AADT >10,000 a	and <50,000	0	Climatic	region Cold	ler Dry 🔻	Rainfall site		Lincoln (SAAR 600m	m)	¥
ep 2 River Impacts	Annual Q ₉₅ river flow (r	m ³ /s)		0.002	Fr	eshwater EQS limits:	:				
inter zero in Annual Q ₉₅	Impermeable road area		(ha)	5.35	i '		olved copper (µg/l)		1	D	
er flow box to assess					-					_	
tep 1 runoff quality nly)	Permeable area drainii	ng to outf	all (na)	1.76	<u>-</u>	Bioavailable diss				D	
**	Base Flow Index (BFI)			0.28	ls th	e discharge in or with	nin 1 km upstream of	a protecte	d site for conserv	ration?	No -
or dissolved zinc only	Water hardness		High = >200mg CaCO3/I			For dissolved copy	nor only 1-1:	i haatees	ind concentration	/#\	0
of dissolved zilic only	vvalei ilaiuliess		rigit = >200ing GacCost		11	roi dissolved copi	per only Ambien	t backgrou	ind concentration	(µg/I)	
or sediment impact only	Is there a downstream	structure	, lake, pond or canal th	at reduces the velo	ocity within 1	00m of the point of d	ischarge?		No 🔻	D	
	© Tier 1 Estima	ited river v	width (m)	1	1						
			,	4		-0.07	Cid		(m) 0.71		0.0004
	® Tier 2 Bed wi	idth (m)		1	Manning's	s n 0.07	510	le slope (m	vm) 0.71	Long si	lope (m/m) 0.0001
ep 3 Mitigation										\neg	
ep 5 mitigation							E stim ated effective				
						Treatment for solubles (%)	Attenuation for solu estricted discharge ra	bles -	Settlement of sediments (%)		
			Brief description			Solubles (76)	satircied discriarge re	110 (1/3)	accilinents (70)		
xisting measures					0		No restriction -	D	0 D		
Proposed measures					0	D 1	No restriction •	D	64		
highways england	nigliways Elig	gianu vv	later Risk Assessi Solub			Version 2.0.4	June 2019		1 :	Sediment	- Chronic Impact
	EQS - Annual Avera	ge Conce				Acu	te Impact				
	Copper 0.00		Zinc 0.01	ugi	JI .	Copper	Zine				Pass
Step 2											for this site is judged
							Pass		Accumulat	ing? Ye:	
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Step 3 Step 3 Step 3 Sand number seessment type S grid reference of assessme S grid reference of outfall structure utfall number see Mind watercourse see Mind watercourse The part of assessment Step 1 Runoff Quality Step 2 River Impacts (Enter zero in Annual Q _{sc} river flow box to assess Step 1 runoff quality For dissolved zinc only For sediment impact only Step 3 Mitigation Existing measures Proposed measures	AADT \$10,000 AADT Annual Q _{sc} river flow Impermeable road an Permeable area drair Base Flow Index (BFI Water hardness Is there a downstrear 'Tier 1 Estim	(m³/s) (m³/s) (m³/s) (m³/s) m structur m structur	Non-cumulative ass Easting 48 Easting 49 Easting 49 Easting 49 Easting 49 Easting 49 Easting 49 Edition 49 Easting 49	Clima	outfall) atic region is to be a considered at the constant of	List of ourfails assessment Assessor and Version of assi Freshwater EOS lin Bioavailable of Bioavailable of the discharge in or For dissolved on 100m of the point Treatment for solubles (%)	FO number Northing Northing In cumulative I affiliation sessment Rainfall sit sitssolved copper (µg dissolved zinc (µg/l) within 1 km upstrea copper only Am of discharge?	e e Bide slope Side slope Side slope Solubles	Area 7 O 0 AJ 2 Lincoln (SAAR 1 10.9 tected site for col ground concentr. No No Settlements (0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	nservation (µg/7 C	(? No) 0

Highway Catchment 5 Highways England Water Risk Assessment Tool Version 2.0.4 June 2019 Soluble Sediment - Chronic Impact EQS - Annual Average Concentration Acute Impact Copper nt deposition for this site is judged as:
ulating?
Yes 0.02 Low flow Vel m/s
No 4 Deposition Index ugil Step 3 HE Area / DBFO number Road number NHRR Area 7 ment type Non-cumulative assessment (single outfall OS grid reference of assessment point (m) 364700 Easting 495450 Northing OS grid reference of outfall structure (m) Easting Outfall number Highway Catchment 5 Riparian Watercourse Receiving watercourse EA receiving water Detailed River Network ID Date of assessment 08-05-2023 Version of assessment Step 1 Runoff Quality >10,000 and <50,000 Climatic region Colder Dry Lincoln (SAAR 600mm) ٠ Rainfall site ~ Step 2 River Impacts Annual Q₉₅ river flow (m³/s) 0.31 Freshwater EQS limits 0.9 1 D (Enter zero in Annual Q₉₅ Impermeable road area drained (ha) Bioavailable dissolved copper (µg/l) river flow box to assess Step 1 runoff quality only) Permeable area draining to outfall (ha) 0.286 Bioavailable dissolved zinc (μg/l) 10.9 D 0.26 No - D Base Flow Index (BFI) Is the discharge in or within 1 km upstream of a protected site for conservation? High = >200mg CaCO3/l For dissolved zinc only **0** D Water hardness For dissolved copper only Ambient background concentration (µg/l) Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? 18 ⊙ Tier 1 Estimated river width (m) ○ Tier 2 Bed width (m) Side slope (m/m) 0.71 Manning's n 0.03 Long slope (m/m) 0.0001 Step 3 Mitigation E stim ated effectiveness Attenuation for solubles -restricted discharge rate (I/s Brief description Existing measures No restriction **Highway Catchment 6** Highways England Water Risk Assessment Tool Version 2.0.4 June 2019 EQS - Annual Average Concentration Acute Impact Copper Step 2 Step : HE Area / DBFO number Road number Area 7 NHRR Non-cumulative assessment (single outfall OS grid reference of assessment point (m) 364700 Easting 495450 Northing OS grid reference of outfall structure (m) Fasting Northing Highway Catchment 6 Receiving watercourse Riparian Watercourse EA receiving water Detailed River Network ID Assessor and affiliation 08-05-2023 Date of assessment Version of assessmen Step 1 Runoff Quality >10,000 and <50,000 Lincoln (SAAR 600mm) Ŧ Climatic region Colder Dry • Rainfall site Step 2 River Impacts Annual Q₉₅ river flow (m³/s) 0.31 Freshwater EQS limits (Enter zero in Annual Q₉₅ 3.049 1 D Impermeable road area drained (ha) Bioavailable dissolved copper (µg/l) river flow box to assess Step 1 runoff quality only) Permeable area draining to outfall (ha) 1.438 Bioavailable dissolved zinc (µg/l) 10.9 D 0.26 No 🔻 D Base Flow Index (BFI) Is the discharge in or within 1 km upstream of a protected site for conservation? For dissolved zinc only Water hardness High = >200mg CaCO3/I -0 D For dissolved copper only Ambient background concentration (µq/I) Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No ▼ 18 ⊕ Tier 1 Estimated river width (m) Bed width (m) ○ Tier 2 Manning's n 0.03 Side slope (m/m) 0.71 Long slope (m/m) 0.00 Step 3 Mitigation E stim ated effectiveness Treatment for solubles (%) Attenuation for solubles -restricted discharge rate (I/s) Settlement of sediments (%) Brief description Existing measures Proposed measures

highways england	Highways E	England V	Vater Risk Assessn				V	ersion 2.0.4 Ju	ine 2019			
			Solub	ile							Sedime	nt - Chronic Impact
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A receiving water Detailed Riv	er Network ID							Assessor and a			AJ	
ate of assessment lotes			08-05-2023				٧	/ersion of asse	essment		2	
Step 1 Runoff Quality	AADT >10	0,000 and < 50,	.000	• (Climatic r	region	Colder Dry	у	Rainfall site		Lincoln (SAAR 600mm)	
Step 2 River Impacts	Annual Q ₉₅ river fl	low (m³/s)			0.31	1	Freshw	vater EQS limi	ts:			
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river flow box to assess	Permeable area d				0.892	1					10.9 D	
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For dissolved zinc only	Water hardness		High = >200mg CaCO3/I		v		For	dissolved co	pper only Ambie	ent backgr	ound concentration (μο	g/l) 0
For sediment impact only	Is there a downst-	ream struct-	ire, lake, pond or canal	that reduces	the velo	city wit	hin 100m	of the point of	discharge?		No ▼ D	
r or secument impact only				_	18	iny wii	anni room	or tile point of	discharge:		10	
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	○Tier2 Be	ed width (m)		1	Man	ning's n	0.03	S	ide slope	(m/m) 0.71	Long slope (m/m)
Step 3 Mitigation												1
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			Brief description					ubles (%)	restricted discharge		sediments (%)	
Existing measures							0	D	No restriction	▼ D	0 D	
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highways england			Vater Risk Assessn				V	ersion 2.0.4 Ju	ine 2019			
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england Step 2	Highways E EQS - Annual Av Copper	England V	Solub centration Zinc		ug/l ug/l			Acute Copper	· Impact Zinc		Sediment deposition	Pass on for this site is judge
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inighways england	Highways E EQS - Annual Av Copper	England V	Solub centration Zinc					Acute Copper	Zinc Pass		Sediment deposition	Pass on for this site is judge Yes 0.02 Lowflo
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highways england	Highways Engl	and Water Risk Assessment	Tool	Version 2.0.4 June 201	9		
		Soluble				Sedime	ent - Chronic Impact
	EQS - Annual Average Copper	e Concentration Zinc		Acute Impa	ct		Pass
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Step 3						_	
oad number		NHRR		HE Area / DBFO num	nber	Area 7	
ssessment type		Non-cumulative assessment	ent (single outfall)				
S qrid reference of assessmer	nt point (m)	Easting 495450		١	Northing .	364700	
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utfall number		Highway Catchment 8		List of outfalls in cum assessment	ulative		
e ceivin q watercourse A receivin q water Detailed Riv	er Network ID	Riparian Watercourse		Assessor and affiliation	nn	AJ	
ate o fassessment	or Hottielik ib	08-05-2023		Version of assessme		2	
otes							
tep 1 Runoff Quality	AADT >10,000 a	and <50,000 •	Climatic region	Colder Dry 🔻	Rainfall site	Lincoln (SAAR 600mm)	-
Step 2 River Impacts							
	Annual Q ₉₅ river flow (r	n-/s)	0.31	Freshwater EQS limits:			
(Enter zero in Annual Q ₉₅	Impermeable road area	a drained (ha)	6.92	Bioavailable dissolve	d copper (µg/l)	1 D	-
river flow box to assess Step 1 runoff quality	Permeable area drainii	ng to outfall (ha)	1.812	Bioavailable dissolve	d zinc (µg/l)	10.9 D	
only)			0.26				
	Base Flow Index (BFI)		V.20	Is the discharge in or within 1	an upsueam of a	a protected Site for Conservati	100 -
For dissolved zinc only	Water hardness	High = >200mg CaCO3/I		For dissolved copper	only Ambient	background concentration (μ	g/l) 0
For sediment impact only	Is there a downstream	structure, lake, pond or canal that re	educes the velocity w	rithin 100m of the point of disch	arge?	No ▼ D	
	Tier 1 Estima Estima Tier 1 Estima Tier 2 Estima Tier 3 Estima Tier 3 Estima Tier 3 Estima Tier 4 Estima Tier 5 Est	ited river width (m)	18				
					0:4-	alone (mlm) 0.74	I I (I) 0.0004
	○ Tier 2 Bed wi	idth (m)	1 Ma	nning's n 0.03	Side	slope (m/m) 0.71	Long slope (m/m) 0.0001
tep 3 Mitigation							7
					tim ated effective no tenuation for solub		
		Brief description		solubles (%) restri	cted discharge rat	e (I/s) sediments (%)	
Existing measures							
				O No se	atiatian	0 0	
Proposed measures					striction •	D 0 D	
Proposed measures						D 0 D	
	chment 4	5. 6. 7. 8 and	9 Cumu	0 D No re	striction •	D 0 D	
ighway Cate		5, 6, 7, 8 and		lative Sedim	ent As	D 0 D	
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ighway Cate	Highways Eng	land Water Risk Assessment Soluble		lative Sedim Version 2.0.4 June 201	ent As	sessment	ent - Chronic Impact
ighway Cato	Highways Eng EQS - Annual Averag Copper	land Water Risk Assessment Soluble Je Concentration Zinc	Tool	lative Sedim Version 2.0.4 June 20 Acute Impa	nent As	sessment	ent - Chronic Impact
ighway Cato	Highways Eng	land Water Risk Assessment Soluble ge Concentration		lative Sedim Version 2.0.4 June 201	ent As	sessment	Pass
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step 2 Step 3 Step 4 Step 4 Step 5 Sud of eference of assessme thoe so discovered to the step of the	EQS - Annual Average Copper 0.02 - Intpoint (m) chure (m) AADT >10.000 AADT >10.000 Annual Q ₅₆ river flow (Impermeable road are Permeable area drain Base Flow Index (BFI) Water hardness Is there a downstream Tier 1 Estimates	Indian Water Risk Assessment Soluble Per Concentration NHRR Cumulative assessment Easting 495450 Easting Highway catchments 4, Riparian Watercourse 08-05-2023 and <0,000 m'/s) a drained (ha) ing to outfall (ha) High = >200mg CaCOM	Ugfl Ugfl Ugfl Ugfl Ugfl Ugfl Ugfl Ugfl	Iative Sedim Version 2.0.4 June 20 Acute Impa Copper Pass HE Area / DBFO num s (outfalls within 100m) List of outfalls in cum assessment Assessor and affiliati Version of assessme In Colder Dry Freshwater EQS limits: Bioavailable dissolve Bioavailable dissolve Is the discharge in or within For dissolved copper	nent As: Pass Tine Pass Northing Northing Northing nulative Ion Rainfall site d copper (µg/l) 2d zinc (µg/l) 1 km upstram of only Ambient harge?	Sediment deposits Accumulating? Extensive? Area 7 Jack 17 Jack	Pass ion for this site is judged as Yes 0.02 Low flow Ve No 82 Deposition ion for this site is judged as Yes 0.02 Low flow Ve No 100 Low flow Ve
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step 2 Step 2 Step 3 Step 3 Step 2 Step 3 Step 3 Step 3 Step 3 Step 4 Step 4 Step 5 Step 6 Step 6 Step 7 Step 7 Step 7 Step 8 Step 9 Step 1 St	EQS - Annual Average Copper 0.02 - Intpoint (m) chure (m) AADT >10.000 AADT >10.000 Annual Q ₅₆ river flow (Impermeable road are Permeable area drain Base Flow Index (BFI) Water hardness Is there a downstream Tier 1 Estimates	Indian Water Risk Assessment Soluble Per Concentration NHRR Cumulative assessment Easting 495450 Easting Highway catchments 4, Riparian Watercourse 08-05-2023 and <50,000 m'/s) a drained (ha) ing to outfall (ha) High = >200mg CaCOM attentive width (m) attentive width (m)	Ugfl Ugfl Ugfl Ugfl Ugfl Ugfl Ugfl Ugfl	Ilative Sedim Version 2.0.4 June 20 Acute Impa Copper Pass HE Area / DBFO num s (outfalls within 100m) List of outfalls in cum assessment Assessment Version of assessme Version of assessme In Colder Dry Freshwater EQS limits: Bioavailable dissolve Bioavailable dissolve Is the discharge in or within For dissolved copper within 100m of the point of discharge in 100m of the 100m	Pass Tine Pass Tone	Sediment deposits Accumulating? Extensive? Area 7 364700 Lincoln (SAAR 600mm) 1	Pass ion for this site is judged at Yes 0.02 Low flow V. No 82 Deposition ion? No v.
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Spillage Assessment

highways england	View Parame	ters Rese	t Spillage Risk	Go To Interf	ace			
Assessment of Priority Outfalls								
Method D - assessment of risk from accidental spillage		Additional columns	for use if other roads	s drain to the same o	utfall		1	
	A (main road)	В	С	D	E	F	1	
D1 Water body type	Surface watercourse	Surface watercourse	Surface watercourse	Surface watercourse			1	
D2 Length of road draining to outfall (m)	1,155	355	130	315			1	
D3 Road Type (A-road or Motorway)	Α	A	Α	Α			1	
D4 If A road, is site urban or rural?	Rural	Rural	Rural	Rural				
D5 Junction type	No junction	Roundabout	Roundabout	Slip road				
D6 Location (response time for emergency services)	< 20 minutes	< 20 minutes	< 20 minutes	< 20 minutes				
D7 Traffic flow (AADT two way)	32,323	32,323	32,323	3,625				
D8 % HGV	3.43	3.43	3.43	1.12				
D8 Spillage factor (no/10 9 HGVkm/year)	0.29	3.09	3.09	0.93				
D9 Risk of accidental spillage	0.00014	0.00044	0.00016	0.00000	0.00000	0.00000]	
010 Probability factor	0.45	0.45	0.45	0.45				
D11 Risk of pollution incident	0.00006	0.00020	0.00007	0.00000	0.00000	0.00000		Return Period
D12 Is risk greater than 0.01?	No	No	No	No			Totals	(years)
D13 Return period without pollution reduction measures	0.00006	0.00020	0.00007	0.00000	0.00000	0.00000	0.0003	2977
D14 Existing measures factor	1	1	1	1				
D15 Return period with existing pollution reduction measures	0.00006	0.00020	0.00007	0.00000	0.00000	0.00000	0.0003	2977
D16 Proposed measures factor	1	1	1	1				
217 Residual with proposed Pollution reduction measures	0.00006	0.00020	0.00007	0.00000	0.00000	0.00000	0.0003	2977

highways england View Par		arameters Reset Spillage Risk		Go To Inter	face			
Assessment of Priority Outfalls								
Method D - assessment of risk from accidental spillage		Additional columns	for use if other road:	s drain to the same of	outfall		1	
	A (main road)	В	С	D	Е	F	1	
D1 Water body type	Surface watercourse	Surface watercourse	Surface watercourse				1	
D2 Length of road draining to outfall (m)	2,336	360	530]	
D3 Road Type (A-road or Motorway)	A	Α	Α]	
D4 If A road, is site urban or rural?	Rural	Rural	Rural		T			
D5 Junction type	No junction	Roundabout	Side road]	
D6 Location (response time for emergency services)	< 20 minutes	< 20 minutes	< 20 minutes					
D7 Traffic flow (AADT two way)	36,798	36,798	3,625					
D8 % HGV	2.32	2.32	1.12					
D8 Spillage factor (no/10 9 HGVkm/year)	0.29	3.09	0.93					
D9 Risk of accidental spillage	0.00021	0.00035	0.00001	0.00000	0.00000	0.00000]	
O10 Probability factor	0.45	0.45	0.45					
D11 Risk of pollution incident	0.00009	0.00016	0.00000	0.00000	0.00000	0.00000		Return Perior
D12 Is risk greater than 0.01?	No	No	No				Totals	(years)
D13 Return period without pollution reduction measures	0.00009	0.00016	0.00000	0.00000	0.00000	0.00000	0.0003	3933
D14 Existing measures factor	1	1	1					
D15 Return period with existing pollution reduction measures	0.00009	0.00016	0.00000	0.00000	0.00000	0.00000	0.0003	3933
D16 Proposed measures factor	1	1	1					
D17 Residual with proposed Pollution reduction measures	0.00009	0.00016	0.00000	0.00000	0.00000	0.00000	0.0003	3933

	•								
Meth	od D - assessment of risk from accidental spillage		Additional columns	for use if other roads	drain to the same of	outfall]	
		A (main road)	В	С	D	E	F	1	
D1	Water body type	Surface watercourse	Surface watercourse	Surface watercourse				1	
D2	Length of road draining to outfall (m)	3,339	196	824]	
D3	Road Type (A-road or Motorway)	Α	Α	A				1	
D4	If A road, is site urban or rural?	Urban	Rural	Rural				1	
D5	Junction type	No junction	Roundabout	Side road				1	
D6	Location (response time for emergency services)	< 20 minutes	< 20 minutes	< 20 minutes				1	
D7	Traffic flow (AADT two way)	49,121	49,121	6,727]	
D8	% HGV	2.68	2.68	1.96]	
D8	Spillage factor (no/10 9 HGVkm/year)	0.29	3.09	0.93			,		
D9	Risk of accidental spillage	0.00047	0.00029	0.00004	0.00000	0.00000	0.00000	1	
D10	Probability factor	0.45	0.45	0.45					
D11	Risk of pollution incident	0.00021	0.00013	0.00002	0.00000	0.00000	0.00000		Return Period
D12	Is risk greater than 0.01?	No	No	No				Totals	(years)
D13	Return period without pollution reduction measures	0.00021	0.00013	0.00002	0.00000	0.00000	0.00000	0.0004	2802
D14	Existing measures factor	1	1	1					
D15	Return period with existing pollution reduction measures	0.00021	0.00013	0.00002	0.00000	0.00000	0.00000	0.0004	2802
D16	Proposed measures factor	1	1	1					
D17	Residual with proposed Pollution reduction measures	0.00021	0.00013	0.00002	0.00000	0.00000	0.00000	0.0004	2802

Assessment of Priority Outfalls

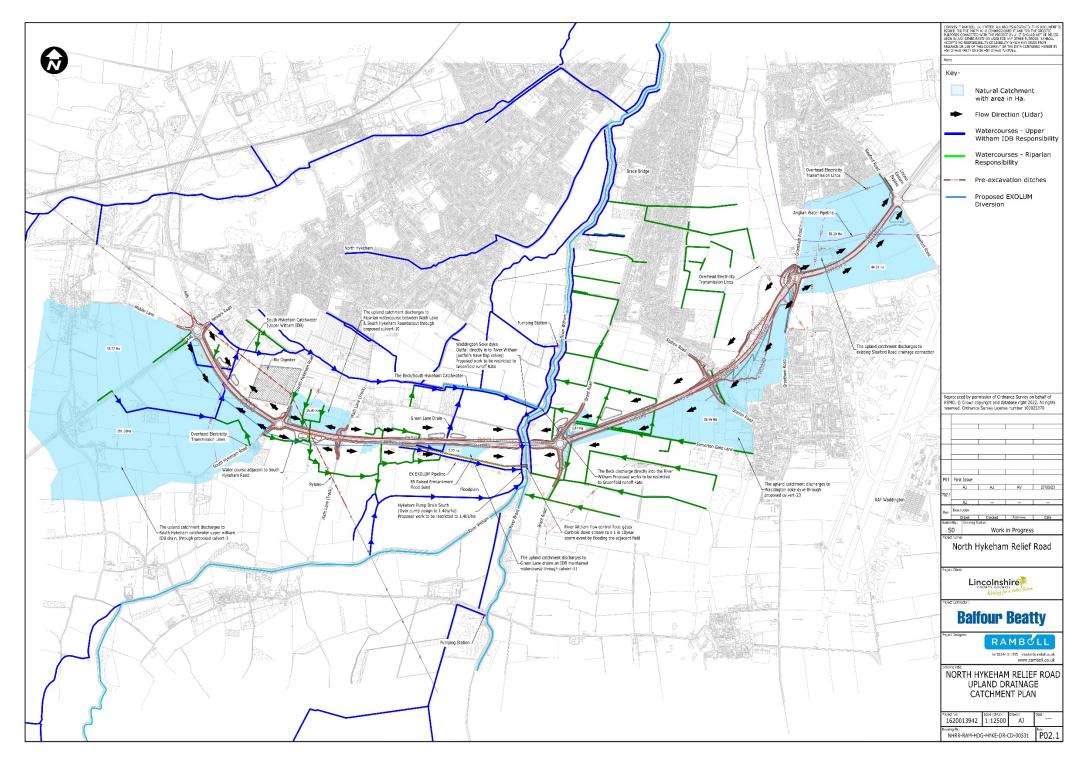
highways england View Para			ters Rese	t Spillage Risk	Go To Inter	face			
Assessment of Priority Outfalls									
Meth	nod D - assessment of risk from accidental spillage		Additional columns	for use if other roads	drain to the same or	utfall		1	
		A (main road)	В	С	D	E	F	1	
D1	Water body type	Groundwater	Groundwater	Groundwater]	
D2	Length of road draining to outfall (m)	1,145	225	573					
D3	Road Type (A-road or Motorway)	A	A	A					
D4	If A road, is site urban or rural?	Rural	Rural	Rural					
D5	Junction type	No junction	No junction	No junction					
D6	Location (response time for emergency services)	< 20 minutes	< 20 minutes	< 20 minutes					
D7	Traffic flow (AADT two way)	32,120	32,120	9,165]	
D8	% HGV	3.23	3.23	4.26					
	Spillage factor (no/10° HGVkm/year)	0.29	3.09	0.93		,	,		
	Risk of accidental spillage	0.00013	0.00026	0.00008	0.00000	0.00000	0.00000		
	Probability factor	0.45	0.45	0.45					
D11	Risk of pollution incident	0.00006	0.00012	0.00003	0.00000	0.00000	0.00000		Return Period
D12	Is risk greater than 0.01?	No	No	No				Totals	(years)
D13	Return period without pollution reduction measures	0.00006	0.00012	0.00003	0.00000	0.00000	0.00000	0.0002	4779
	Existing measures factor	1	1	1					
	Return period with existing pollution reduction measures	0.00006	0.00012	0.00003	0.00000	0.00000	0.00000	0.0002	4779
	Proposed measures factor	1	1	1					
017	Residual with proposed Pollution reduction measures	0.00006	0.00012	0.00003	0.00000	0.00000	0.00000	0.0002	4779

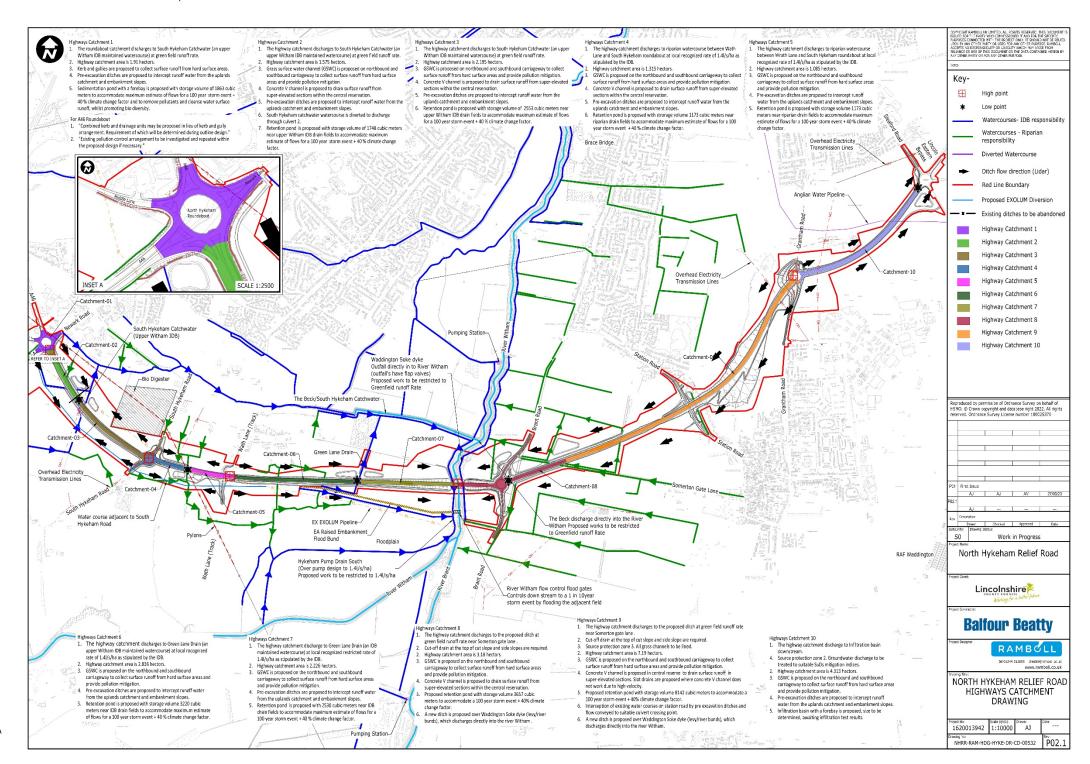
Catchment 10 Groundwater Assessment Groundwater Assessment

Component Number		Weighting Factor	Property or Parameter	Risk Score	Component score	Weighted component score
1		10	Traffic flow	<=50,000 AADT	1	10
2	SOURCE	10	Rainfall depth (annual averages)	<=740 mm rainfall	1	10
3		10	Drainage area ratio	<=50	1	10
4		15	Infiltration method	"Region", shallow infiltration systems (e.g. infiltration basin)	2	30
5		20	Unsaturated zone	Depth to water table <15 m to >5 m	2	40
6	PATHWAY	20	Flow type (Incorporates flow type an effective grain size)	Mixed fracture and intergranular flow (e.g. consolidated deposits or unconsolidated deposits of medium – coarse sand)	2	40
7	FAIRWAT	5	Unsaturated Zone Clay Content	>=15% clay minerals	1	5
8		5	Organic Carbon	<15% to >1% SOM	2	10
9		5	Unsaturated zone soil pH	pH >=8	1	5

TOTAL SCORE	160
RISK SCREENING LEVEL	Medium

APPENDIX 2 DRAWINGS





RR-RA

APPENDIX 3 WATER HARDNESS MAP

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Map showing the rate of hardness in mg/l as Calcium Carbonate in England and Wales

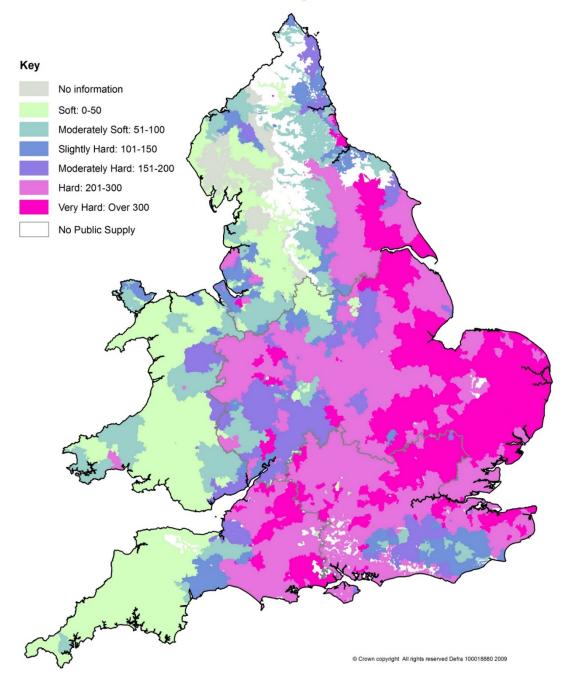


Figure 4 - Defra water hardness map