M3 Junction 9 Improvement

Scheme Number: TR010055

6.3 Environmental Statement Appendix 13.2 - Hydrogeological Risk Assessment

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 6

November 2022

Infrastructure Planning

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

M3 Junction 9 Improvement
Development Consent Order 202[x]

6.3 ENVIRONMENTAL STATEMENT - APPENDIX 13.2: HYDROGEOLOGICAL RISK ASSESSMENT

Regulation Number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference:	TR010055
Application Document Reference:	6.3
BIM Document Reference:	HE551511-VFK-EWE-X_XXXX_XX-RP-LE-0003
Author:	M3 Junction 9 Improvement Project Team, National Highways

Version	Date	Status of Version
Rev 0	November 2022	Application Submission

Contents

1 Introduction 1
1.1 Background 1
1.2 Objectives 2
1.3 Scope of work 2
1.4 Competent expert 3
2 Drainage strategy and HEWRAT assessment 5
3 Baseline conditions 9
3.1 Site setting 9
3.2 Geology 9
3.3 Hydrology 23
3.4 Hydrogeology 26
3.5 Groundwater levels and flow 29
3.6 Contaminated land and pollution events 40
3.7 Groundwater quality 40
3.8 Other potential receptors 44
4 Conceptual site model 55
4.1 Sources 55
4.2 Pathways 56
5 Groundwater Impact Assessment 58
5.2 Road drainage 58
5.3 Filled areas 58
6 Detailed Quantitative Risk Assessment for EDBs 62
6.1 Introduction 62
6.2 Model Parameterisation 63
6.3 Model Results 69
7 Conclusions and recommendations 74
7.1 Conclusions 74
7.2 Recommendations 75
8 References 76

Figures

Figure 1.1 Site location and points of interest 4
Figure 2.1: Application boundary and locations of EDBs 8
Figure 3.1: Bedrock geology 11
Figure 3.2: Superficial geology and artificial ground 13

Figure 3.3: Superficial geology - central area 14
Figure 3.4: Local superficial geology superimposed on proposed drainage 19
Figure 3.5: Historical landfill areas..... 22
Figure 3.6: Surface water features 25
Figure 3.7: Groundwater dip data from final day of installation works in mbgl 30
Figure 3.8: Groundwater levels data from final day of installation works in mAOD... 31
Figure 3.9: Boreholes monitored for groundwater level 35
Figure 3.10: Groundwater level in Application Boundary SI boreholes in the Application Boundary (mAOD)..... 36
Figure 3.11: Groundwater level in Application Boundary SI boreholes in metres below ground level..... 37
Figure 3.12: Application Boundary overlaid on the Hydrogeological map (Institute of Hydrological Sciences, 1979) 39
Figure 3.13: Groundwater quality monitoring locations..... 41
Figure 3.14: Licenced and private abstractions and SPZs 46
Figure 3.15: Designated sites within 2 km 48

Tables

Table 2.1: Summary of attenuation structures..... 6
Table 3.1: Stratigraphy of the bedrock geology in the Winchester (based on the BGS Sheet 299 (British Geological Survey, 2002) and BGS memoir (Booth et al., 2008) .. 9
Table 3.2: Summary of cavities hazard for each basin (from Appendix A of the Ground Investigation Report (Document Reference 7.11)) 15
Table 3.3: Summary of lithologies encountered from Ground Investigation Report (Document Reference 7.11) 17
Table 3.4 Historical landfill areas..... 20
Table 3.5: Outline definitions of Source Protection Zones..... 26
Table 3.6: Calculated soil infiltration rates (from Table 9.5 in the Ground Investigation Report (Document Reference 7.11)) 28
Table 3.7: Groundwater level dip data during site investigation works in mAOD..... 32
Table 3.8: Groundwater monitoring locations 34
Table 3.9: Summary of groundwater levels (June 2019 to July 2020) 36
Table 3.10: Approximate depth to groundwater at unlined EDBs 37
Table 3.11: Pollution incidents within 2km (from Envirocheck, 2016) 40
Table 3.12: Summary of groundwater quality data (based on data in Controlled Waters Risk Assessment in Chapter 9 (Geology and Soils) of the ES (Document Reference 6.1))..... 42
Table 3.13: Private water abstractions (within 2km of initial scheme boundary)..... 45
Table 3.14: Designated Sites within 2km of the Application Boundary 47
Table 3.15: Licenced groundwater and surface water abstractions..... 49
Table 5.1: Summary of impacts..... 59
Table 6.1 Infiltration rates 63
Table 6.2: Source geometry 64
Table 6.3: Chronic Source terms (from HEWRAT) 65
Table 6.4: Acute source term concentrations (from HEWRAT – 95th percentile (mg/l)) 65
Table 6.5: Attenuation parameters 65
Table 6.6: Solubility parameters 66

Table 6.7: Target concentrations 66
Table 6.8: Hydrogeology parameters 67
Table 6.9: EDB2 Predicted concentrations (mg/l) 69
Table 6.10: EDB2 Predicted concentrations (mg/l) 69
Table 6.11: EDB2 Predicted concentrations (mg/l) 70
Table 6.12: EDB3B Predicted concentrations (mg/l) 70
Table 6.13: EDB3C Predicted concentrations (mg/l) 71
Table 6.14: Sensitivity run 1: fraction of organic carbon (mg/l) at 100 years 71
Table 6.15: Sensitivity run 2a: infiltration rate and unsaturated zone hydraulic conductivity (mg/l) at 100 years 72
Table 6.16: Sensitivity run 3: unsaturated zone thickness (mg/l) at 100 years 73

Appendices

Appendix A HE551511-VFK-HDG-X_XXXX_XX-DR-CD-0512_Drainage Schematic Plan

Appendix B HEWRAT screening assessments

Appendix C HE551551-VFK-HGT-X_XXXX_XX-DR-GE-004 Exploratory hole location plan

Appendix D HE551551-VFK-HGT-X_XXXX_XX-DR-GE-0020 Geological plan

Appendix E RAM model files

1 Introduction

1.1 Background

1.1.1 The M3 Junction 9 Improvement Scheme (the Scheme) is located at Junction 9 of the M3 to the east of Winchester, running north to south, centred in the Winnall area and extending north to Headbourne Worthy (Figure 1.1). The Scheme includes proposed motorway modifications including the introduction of a new on/off slip road to both northbound and southbound sides of the M3, new link roads between the A33, A34, A272 and M3 roads and a new overhead gyratory above the M3 corridor.

1.1.2 Parts of the Scheme are located in a low spot of the M3, towards which a total of approximately 1.6km of the existing M3 corridor drains. A separate Motorway Upgrade Project is currently being constructed immediately to the south of the Scheme, which also drains towards the land within the Scheme's application boundary (Application Boundary).

1.1.3 West of the Application Boundary are commercial and light industrial land uses associated with the Wykeham Trade Park and Winnall Industrial Estate. Most of the surrounding non-highway land is used for agricultural purposes, with arable grassland to the north, and a number of fisheries located to the west.

1.1.4 The Application Boundary is located in a sensitive hydrogeological environmental setting, located adjacent to the River Itchen, which underlies the M3 and A34 in the north. The River is a designated Main River, with the associated floodplain designated as a Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI). The Application Boundary is underlain by bedrock deposits of the White Chalk Subgroup, which are classified by the Environment Agency as a Principal Aquifer. Surrounding abstractions include thirty-one public abstractions, alongside nine abstractions for private water supplies within 2 km of the Scheme.

1.1.5 A ground investigation (GI) was previously undertaken, and additional works have been proposed by Stantec to provide supplementary information. Interpretation of the GI data is provided in the **Ground Investigation Report (Document Reference 7.11).**

1.1.6 The Drainage Strategy Report which forms **Appendix 13.1 (Drainage Strategy Report)** of the **Environmental Statement (ES) (Document Reference 6.3)** prepared for the planning application included a National Highways Water Risk Assessment Tool (HEWRAT) screening assessment. The results of the screening assessment are that all but one of the currently proposed Extended Detention Basins (EDT) present a 'medium risk' to groundwater and one has a high risk. LA113 (Road drainage and the water environment) (Highways England, 2020) states that where (HEWRAT) indicates a groundwater risk assessment is medium or high, a detailed assessment should be completed by a competent expert with the degree of detail being appropriate to the medium or high result.

1.1.7 A large area requires to be built up in the east of the Application Boundary (as shown in yellow on Drawing HE551511-VFK-HGN-X_XXXX_XX-SK-CH-0004_P03). It is expected that much of the material excavated from elsewhere in the Scheme will be used to fill this eastern area.

1.1.8 Piling will be undertaken as part of the works, and a piling risk assessment will be carried out prior to works commencing, in accordance with Environment Agency methodology. This risk assessment will consider impacts on the water environment.

1.2 Objectives

1.2.1 In its 'M3 Junction 9 Improvement – Environmental Impact Assessment (EIA) Scoping Notification and Consultation Reg 11' response to the Scoping Report the Environment Agency indicated concern, given the sensitivity of the groundwater environment beneath the Application Boundary.

1.2.2 Further comments were received from the Environment Agency in response to the Preliminary Environmental Information Report (PEIR). The Environment Agency states that its primary concern regarding the Scheme relates to the protection of groundwater, and protection / enhancement of the ecological balance and species within the River Itchen and surrounding areas.

1.2.3 This document has been prepared on behalf of National Highways to provide the appropriate assessment for potential impacts to groundwater from the Scheme and, in particular, to address the concerns raised by the Environment Agency in its consultation responses.

1.3 Scope of work

1.3.1 This report presents a Hydrogeological Risk Assessment (HgRA) to identify the significance of risks to the Chalk Aquifer and River Itchen. This HgRA is based on government guidelines appropriate to the geological and hydrogeological environment, which promote the protection of water bodies and related receptors from potential impact of development activities. Specific guidance referenced when undertaking the assessment include:

- Design Manual for Roads and Bridges (DMRB) LA 113 Road drainage and the water environment (Highways England, 2020)
- The Environment Agency's approach to groundwater protection (Environment Agency, 2018)
- Remedial Targets Methodology for contaminated land (Environment Agency, 2006)
- Contaminated Land Risk Assessment, A Guide to Good Practice (CIRIA, 2021)
- Guidance on land contamination risk management (Environment Agency, 2021)

1.3.2 The scope of work undertaken for this HgRA includes the following:

- Review of the baseline geology and hydrogeology for the Application Boundary and surrounding area
- Identification of receptors and assessment of potential impacts
- Recommendations for appropriate monitoring and mitigation measures
- Preparation of a Detailed Quantitative Risk Assessment (DQRA) for risks that are qualitatively assessed as significant

1.4 Competent expert

1.4.1 This report has been prepared by Stantec's Robert Sears, who is a hydrogeologist of over 30 years' experience. Robert is a Fellow of the Geological Society and is a Chartered Geologist.

Figure 1.1 Site location and points of interest

2 Drainage strategy and HEWRAT assessment

2.1.1 The Scheme's drainage strategy is described in **Appendix 13.1 (Drainage Strategy Report)** of the **ES (Document Reference 6.3).** The design approach is to install new gravity drainage for all new carriageway, or to replace existing highway drainage that is being built over by new impermeable highway, such as hardening of the central reserve and lane widenings.

2.1.2 In areas where existing carriageway is being overlaid only, then existing highway drainage is retained.

2.1.3 Areas of local, minor lane widenings proposed remote from the main works, are drained to existing highway drainage, which is modified, where required, to maintain existing discharge rates and no-flooding capacity.

2.1.4 All new drainage conveys run-off to extended detention basins (EDBs), which infiltrate to ground where the HEWRAT assessment of risk to groundwater, allows. These new EDBs are shown in **Figure 2.1**.

2.1.5 Runoff volumes are attenuated in the EDBs as far as space and acceptable draw-down times allow. Runoff volumes that are unable to drain to ground within a practical time period are discharged to the River Itchen.

2.1.6 Treatment of run-off before discharge is proposed as follows:

- Over-the-edge drainage of run-off from carriageways on embankments to filter strips and to infiltration ditches
- Collection of run-off at carriageway edges in linear drains, gullies or filter drains, which is piped to the following:
  - Attenuation and Primary Settlement treatment in filtration forebays and unplanted, lined EDBs
  - Attenuation, Secondary Settlement and Filtration treatment in vegetated EDBs, containing both wet and dry habitats
  - Tertiary treatment in a grassed swale prior to discharge to the River Itchen

2.1.7 The only areas where existing linear infiltration drainage, or sealed drainage, is retained (and enhanced where necessary to limit flooding), will be the A33/A34 carriageway to the north of the River Itchen (above northing 131500) and M3 carriageway (above northing 131500). Both these retained areas are proposed to discharge to the River Itchen via existing open ditches or filter trenches.

2.1.8 The proposed drainage design is shown on Drawing HE551511-VFK-HDG-X_XXXX_XX-DR-CD-0512 which is included here as **Appendix A**. A summary of the EDBs is included in **Table 2.1** and they are also labelled and shown on Figure 2.1.

Table 2.1: Summary of attenuation structures

Basin ref.	Type	Source	Inflows	Outfalls
1	EDB (lined)	Highway	From highway	To EDB 2
2	EDB (unlined)	Highway	From highway and EDB 1	To ground and river
3A	EDB (lined)	Highway	From highway	To EDB3B
3B	EDB (unlined)	Highway	From highway and EDB3A	To ground and EDB 3C
3C	EDB (unlined)	Highway	From highway and EDB3B	To ground and river via swale
4	EDB (lined)	Highway	From highway	To EDB 3A
5	EDB (unlined)	Rural overland flow and Highway runoff	From highway and rural land to east	To ground
6	EDB (unlined)	Rural overland flow	From rural land to east	To ground

2.1.9 Each EDB has been assessed using the HEWRAT. As detailed in the HEWRAT Help Guide (Highways England, 2015), the tool considers the following potential pollutants:

- Acute pollution impacts associated with copper and zinc
- Chronic pollution impacts associated with the following determinants in sediments: total copper, zinc, cadmium and total polycyclic aromatic hydrocarbons (PAH), including specific PAH's: pyrene, fluoranthene, anthracene, and phenanthrene

2.1.10 For groundwater risk, HEWRAT uses an empirical approach taking into account the following factors:

- Traffic flow rate
- Rainfall rate
- Ratio of drainage area of road to active surface area of infiltration device

- Infiltration method
- Unsaturated zone thickness
- Flow Type
- Unsaturated zone clay content
- Fraction of organic carbon
- Unsaturated zone soil pH

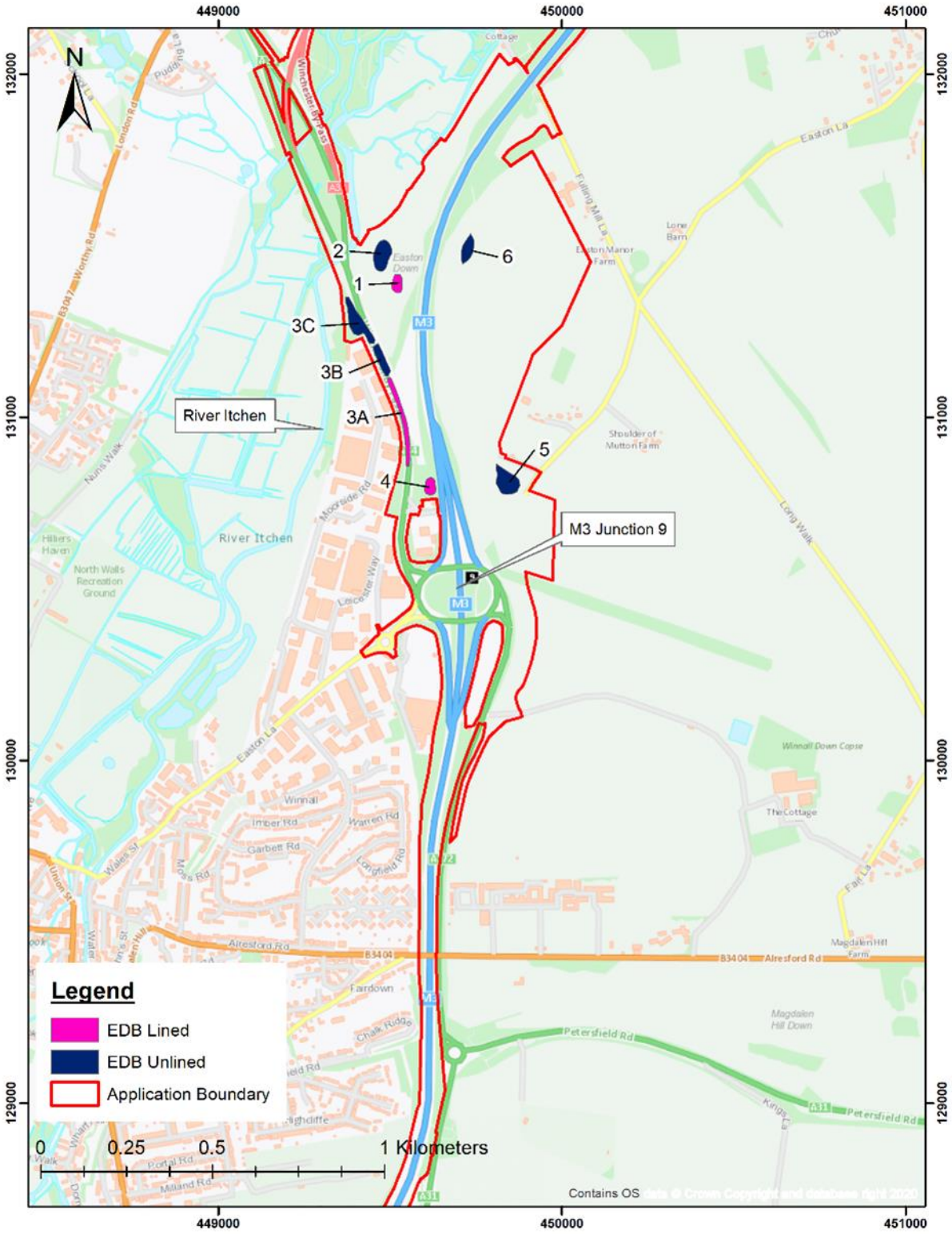
2.1.11 For each of these parameters, a component score between 1 and 3 is assigned and this is then multiplied by a weighting factor for that parameter to provide a score. This process is repeated for all parameters and the scores are then summed to provide an overall risk score.

2.1.12 The HEWRAT screening assessments for each of the EDBs are presented in **Appendix B**. For the EDBs that discharge to ground, the highest scores (high risk) are derived where the unsaturated zone is thin (<5 m) and the flow type is dominated by fractures and fissures. The basins that get medium risk scores are those which either:

a) Have a thicker unsaturated zone over fractures and fissures, or

b) Have intergranular flow through superficial deposits and / or the unsaturated zone is thicker

Figure 2.1: Application boundary and locations of EDBs



3 Baseline conditions

3.1 Site setting

3.1.1 The Application Boundary is located in the River Itchen valley. The elevation in the west of the Application Boundary is approximately 40m above ordnance datum (mAOD) and the land rises to the east up to a maximum of approximately 75mAOD.

3.2 Geology

Regional geology

Bedrock

3.2.1 The British Geological Survey (BGS) indicates that the bedrock geology underlying the Application Boundary comprises the White Chalk Subgroup and the upper part of the Grey Chalk Formation of the Late Cretaceous era (**Figure 3.1**). The stratigraphy of the rock units in the Application Boundary and surrounding area are summarised in **Table 3.1**. In the Application Boundary, the five lower formations of the White Chalk outcrop, with the Seaford Chalk Formation outcropping across the majority of the Application Boundary, including the central area around Junction 9 itself and the River Itchen. The Seaford Chalk Formation typically consists of firm white chalk, with nodular and tabular flint seams. Underlying the Seaford Chalk are the Lewes Nodular Chalk Formation, New Pit Chalk Formation, Holywell Nodular Chalk Formation (all of the White Chalk) and Zig Zag Chalk Formation (Grey Chalk Subgroup). These units crop out to the south of the Spitfire Roundabout (A31 and A272). Above the Seaford Chalk Formation is the Newhaven Chalk Formation, which outcrops in small areas in the north of the Application Boundary.

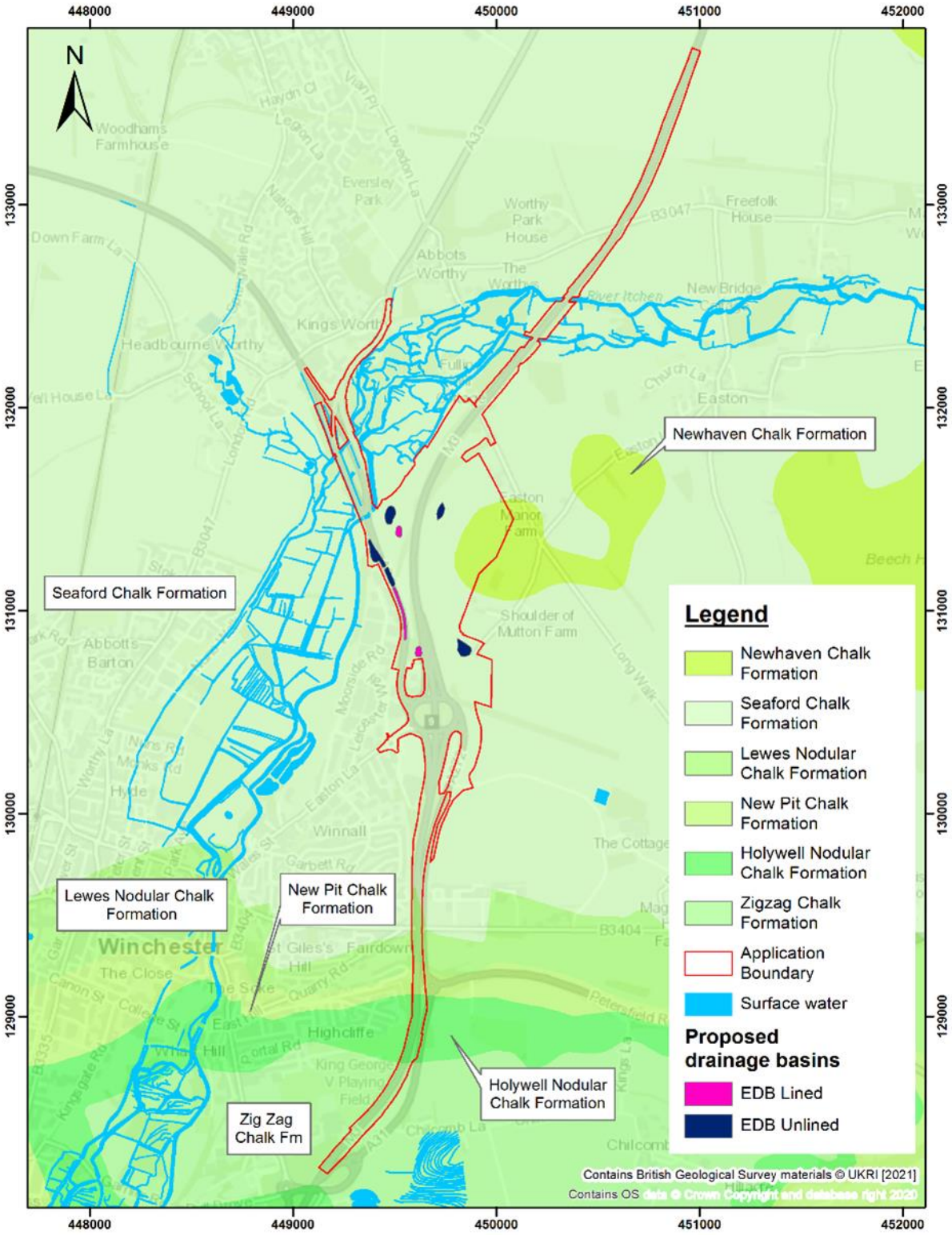
3.2.2 The Application Boundary lies on the Winchester-East Meon Anticline, an east to west trending fold. In the main central area of the Application Boundary, the strata dip 5-10 degrees to the north. In the south of the Application Boundary, south of the Spitfire Roundabout, the strata dip 4 degrees to the south.

Table 3.1: Stratigraphy of the bedrock geology in the Winchester (based on the BGS Sheet 299 (British Geological Survey, 2002) and BGS memoir (Booth et al., 2008)

	Name	Thickness	Description	Present at surface at Application Boundary?
White Chalk Sub-group	Portsdown Chalk Formation	5	White chalk with marl beds and a few flint bands	No
	Culver Chalk Formation	50-70	White chalk with flints and many thin marl beds. Comprises the Tarrant Chalk	No

	Name	Thickness	Description	Present at surface at Application Boundary?
			Member and the Spetisbury Chalk Member.	
	Newhaven Chalk Formation	40-70	Soft to medium hard, white chalk with flints and many thin marl beds (20-70 mm thick).	Yes – small areas in the north
	Seaford Chalk Formation	40-65	Soft white chalk with seams of large nodular and semi-tabular flint. Commonly blocky.	Yes – majority of central area
	Lewes Nodular Chalk Formation	55-65	White, interbedded hard, nodular chalks with soft-medium chalks and marls. Contains persistent seams of flints near the base. Conjugate fractures. Contains karstic features in the Twyford Down Cutting (approx. 500 m south of Application Boundary – See Figure 1.1 **Error! Reference source not found.**) including a partially sediment-filled paleaocave system and calcreted karst.	Yes
	New Pit Chalk Formation	40-45	White chalk with many regularly spaced marl beds. Massive and medium hard. Flint beds in the upper half of the succession. Conjugate fractures.	Yes
	Holywell Nodular Chalk Formation	25-30	Hard, nodular chalk with some shelly beds. Characterised by shell debris. Includes Melbourn Rock (c. 5 m) and Plenus Marls (1-3 m) at base.	Yes
Grey Chalk Sub-group	Zig Zag Chalk Formation			Yes

Figure 3.1: Bedrock geology



Superficial deposits

3.2.3 Superficial deposits are shown on **Figure 3.2** and **Figure 3.3**. The majority of the Application Boundary is not underlain by superficial deposits; however, in

the north of the Application Boundary, the M3 and A34 is underlain by alluvium and head deposits. Alluvium deposits of the River Itchen form a band that is crossed by the M3 and A34, within the Application Boundary, and also is located to the west of the Application Boundary. Alluvium is typically formed of unconsolidated detrital material deposited by a river or stream and comprises sorted or semi-sorted sediment within the riverbed or floodplain. This can have a variable lithology depending on the river environment and may comprise clay, silt, sand, peat or gravel. Borehole data available from the British Geological Survey (BGS) indicate that the Alluvium comprises 1 to 1.5 m of peaty silts and clays above 4.5 to 5.5 m of dense gravels (Booth, et al., 2008).

3.2.4 Head deposits are located beneath the north-eastern part of the Application Boundary beneath the M3 and in smaller lateral bands located north and south of the of the M3 Junction 9 roundabout (see **Figure 3.2**). To the northeast an area of the M3 crosses through superficial deposits of Head 1; this comprises clay, silt, sand and gravel, often poorly sorted and poorly stratified, formed mostly by solifluction and / or hillwash and soil creep. The smaller bands of Head are composed of clay, silt, sand and gravel that is poorly sorted and poorly stratified containing angular rock debris and clayey hillwash and soil creep that is mantling a hillslope and deposited by solifluction and gelifluction processes.

3.2.5 Except for a small area of Basin 3A (lined) and approximately half of Basin 5 (unlined), none of the other drainage features are shown by the BGS mapping to be underlain by superficial deposits (see **Figure 3.3**).

Figure 3.2: Superficial geology and artificial ground

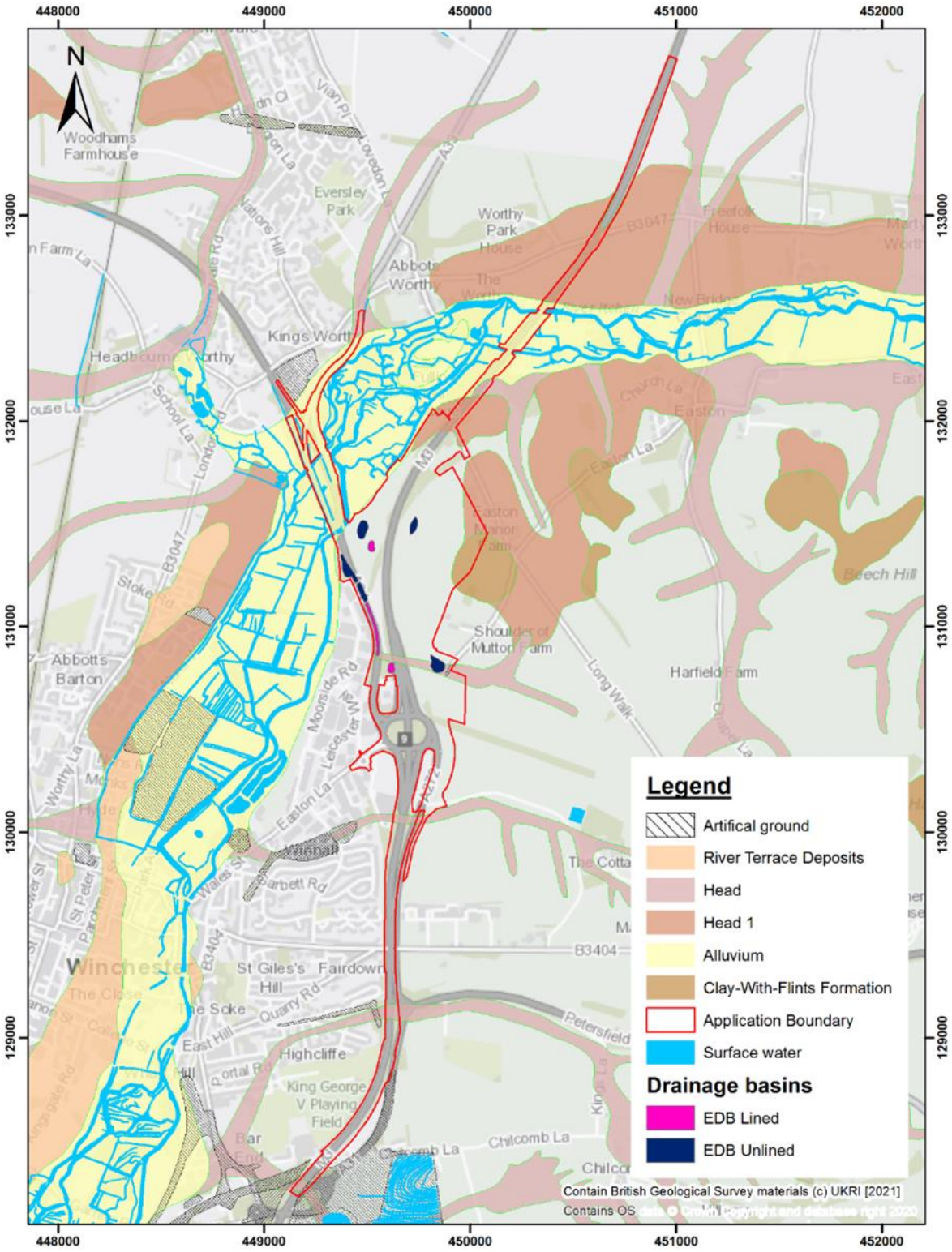
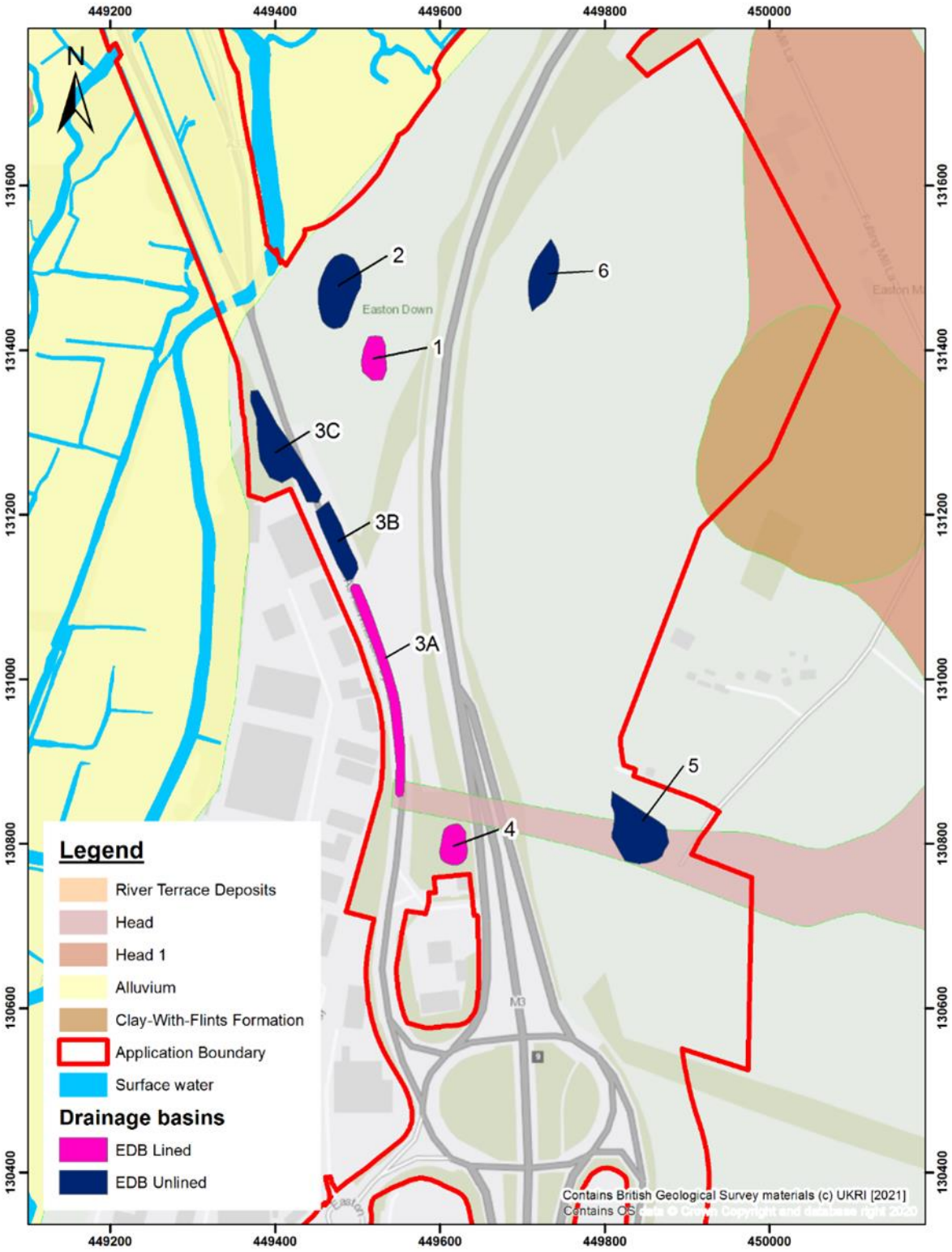


Figure 3.3: Superficial geology - central area



Soils

3.2.6 Soilscapes classifies the majority of the soils within the Application Boundary as being freely draining, shallow lime-rich soils over chalk limestone. The

agricultural land classification and soil resources report prepared for the Scheme by Reading Agricultural Consultants identifies these as being soils of the Andover 1 association (Reading Agricultural Consultants, 2021). Towards the northeast of the Application Boundary the soils become fen peat soils, classified as being Charity 2 association, which drain to local groundwater.

Underground cavities

3.2.7 A Cavities Risk Assessment has been undertaken as part of the **Ground Investigation Report (Document Reference 7.11).** There was one natural cavity record within 500 m of the Application Boundary, which was 10 solution pipes on the course of the River Itchen.

3.2.8 A summary of the Hazard ratings for each basin is given in **Table 3.2** below. The Hazard rating represents the likelihood for cavities to be present. Most basins are located in an area of Moderate-Low hazard for both natural and mining cavities which means they may occur but are unlikely. A Moderate hazard rating means that they may occur, but probably at a single location.

Table 3.2: Summary of cavities hazard for each basin (from Appendix A of the Ground Investigation Report (Document Reference 7.11))

Basin	Natural cavity hazard	Mining cavity hazard
1	Moderate-Low	Moderate-Low
2	Moderate-Low	Moderate-Low
3A	Moderate-Low and Moderate	Moderate-Low
3B	Moderate-Low	Moderate-Low
3C	Moderate-Low	Low and Moderate-Low
4	Moderate-Low and Moderate (small area)	Moderate-Low
5	Moderate and Moderate-Low (small area)	Moderate-Low
6	Moderate-Low	Moderate-Low

Encountered geology

3.2.9 The GI information is presented and reviewed in the **Ground Investigation Report (Document Reference 7.11).** A summary of the factual report of this investigation is given in **Table 3.3**. The borehole locations are shown in **Appendix C**.

3.2.10 The local superficial geology is shown in **Appendix D** and overlain onto Inset **Figure 3.4**.

3.2.11 In the central area around the drainage features, the Application Boundary is typically underlain by topsoil, Made Ground / Engineered Fill and Seaford Chalk Formation. This is in broad agreement with the publicly available BGS data.

In the central area of the Application Boundary where the EDBs are proposed, the superficial deposits extend further eastwards than indicated by BGS mapping. A summary is given below of the likely superficial geology at each of the EDBs, although it is noted that there is insufficient borehole coverage to make a detailed assessment.

- EDB1. Borehole DS203 shows that there is no superficial geology present close to this location. The EDB drains directly onto structured chalk.

- EDB2. Borehole DS112 suggests that alluvial deposits may be present under this EDB to a depth of 5 m, which is in turn underlain by structureless chalk to a depth of 6.23 m followed by structured chalk.

- EDB3A. Boreholes DS107 and DS114 and trial pits TP07 and TP09 are located to the east of this EDB. The trial pits show structureless chalk whilst the boreholes show structureless chalk to a depth of 1.2 m underlain by structured chalk.

- EDB3B. Borehole WS08 is located immediately west of the northern end of this EDB. This borehole recorded Made Ground to a depth of 5.11 m comprising predominantly white chalk recovered as silty clay with fractured flint. This is underlain by 1.89 m of head comprising a sandy, gravelly, silty clay. The base of the head deposits was not penetrated.

- EDB3C. Boreholes DS104 and DS105 and trial pit TP02 are located east of the southern end of this EDB. TP02 recorded 0.3 m of made ground comprising clayey sand. This is underlain by 3.7 m of alluvium to the base of the pit. The alluvium predominantly comprised a silty or sandy, gravelly clay. Borehole DS104 encountered made ground to 0.3 m, comprising clayey sand. This is underlain by 8.2 m of alluvium to the base of the borehole. The alluvium comprised a sandy gravelly clay with interbedded gravel. Borehole DS105 encountered made ground to 0.35 m, comprising clayey gravelly sand. This is underlain by 5.65 m of head which comprised a gravelly, silty clay. This is underlain by 2 m of structureless chalk followed by structured chalk.

- EDB4. There are no GI boreholes adjacent to this EDB. The nearest boreholes are DS217 and DS108. Both of these record structureless chalk overlying structured chalk. Given this EDBs location further to the east, it is likely that it is underlain by chalk.

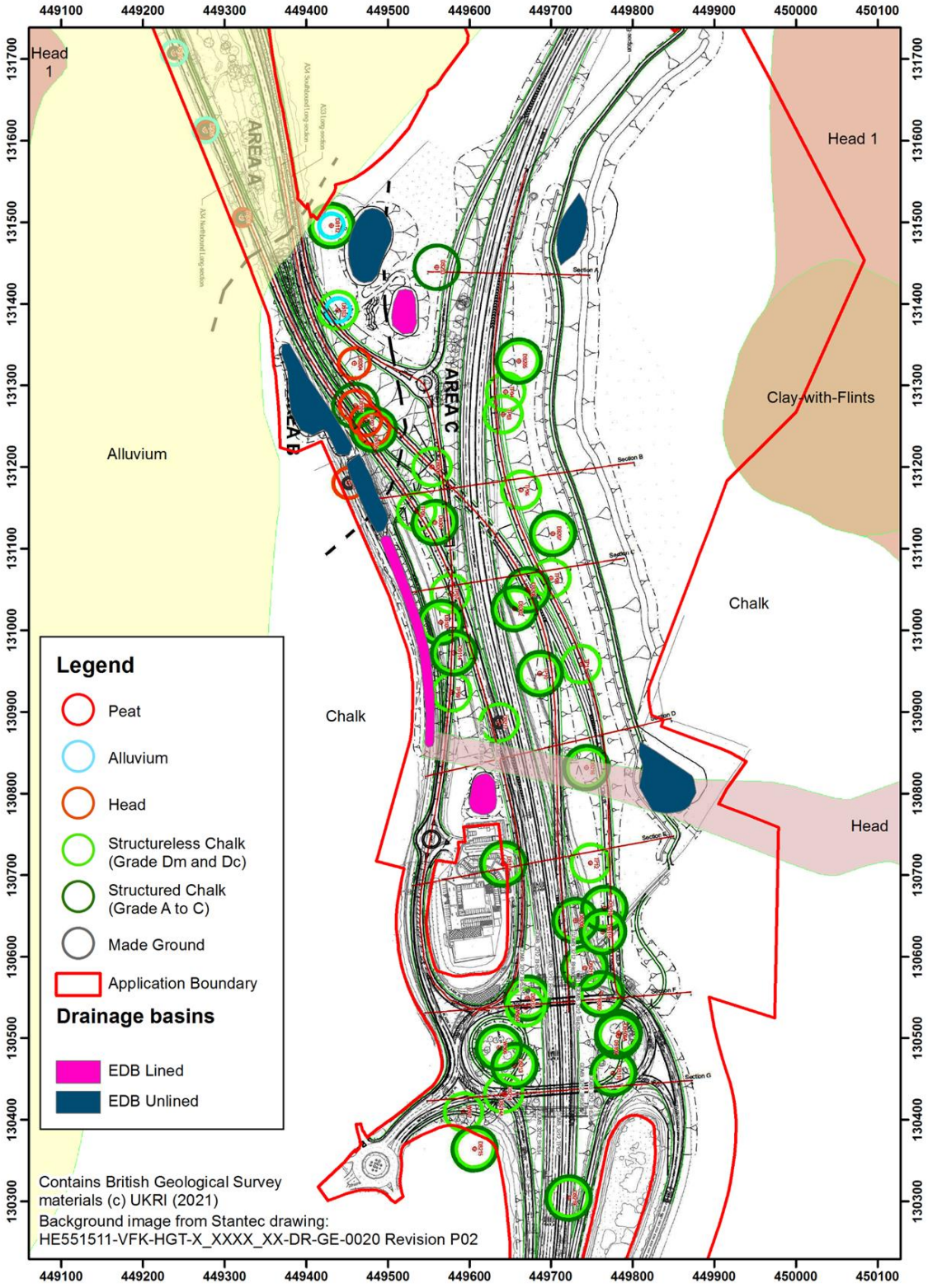
- EDB5 and EDB6. No GI data in the vicinity of these EDBs, but underlying geology is likely to be chalk.

Table 3.3: Summary of lithologies encountered from Ground Investigation Report (Document Reference 7.11)

Layer	Range of depths encountered (m)	Location and brief description
Topsoil	0.0 - 0.45	Encountered in 16 out of 53 boreholes. Grass over light- to dark- brown slightly gravelly clayey sand or sandy gravelly clay.
Made ground / Engineered fill	0.0 - 11.35	Varied across the Application Boundary, but typically comprised tarmac, sub-base, reworked chalk, gravelly sandy clay with flint cobbles, varying concrete and brick gravel content. It is noted in the **Ground Investigation Report (Document Reference 7.11)** that in some areas the strata identified by Soils Limited as Made Ground may also be Engineered Fill. Engineered Fill is typically structureless chalk recovered as slightly clayey silty sandy gravel. The Engineered Fill is likely to originate from the construction of the M3, A33 and A34.
Alluvium / Head	0.0m – 9.15,	Located in the north of the investigation area along the A34. Comprising clayey, sandy gravel with low flint cobble content, clayey gravelly sand or silty, sandy, gravelly clay. In places deposits comprised solely sands, gravels and cobbles, with the fines assumed to have been washed away. Peat was encountered as part of the alluvial deposits; this comprised firm brown mottled grey silty slightly sandy gravelly fibrous peat, with fragments of black organic material or plastic dark brown pseudofibrous peat. The **Ground Investigation Report (Document Reference 7.11)** has reclassified the Alluvium identified by Soils Limited as Head at some locations.
Head	0.0 and 7.0	Located in the north of the Scheme and comprising dark brown slightly clayey gravelly sand and firm to stiff silty sandy gravelly clay. Often interbedded cohesive and granular horizons.
Seaford Chalk	0.0 and 30.45 (base of borehole)	Consists primarily of very weak, low density white chalk recovered as gravelly silty clay; structureless silty gravel and cobbles (CIRIA Grade Dm or Dc); structureless chalk composed of slightly sandy silty gravel or clay; weak low

Layer	Range of depths encountered (m)	Location and brief description
		density white chalk (CIRIA Grade A3 to C5) or very weak to weak low to medium density speckled chalk (CIRIA Grades A to C). Rare cobbles and gravel comprised of angular flints were also present. It is noted in the **Ground Investigation Report (Document Reference 7.11)** that the classification of these chalks as structured or unstructured may not be consistent.

Figure 3.4: Local superficial geology superimposed on proposed drainage



Soil contamination

3.2.12 Geoenvironmental testing was carried out during the GI as detailed in the **Ground Investigation Report (Document Reference 7.11)** to determine the concentrations of contaminants of selected soil and groundwater samples. The testing suite comprised a range of heavy metals, inorganic and organic compounds, and for soils an asbestos screen.

3.2.13 The **Ground Investigation Report (Document Reference 7.11)** states that the vast majority of the soil results are below the selected assessment criteria. The exception to this is one sample out of the 126 samples tested which indicated a marginal exceedance of the Public Open Space assessment criteria for Beryllium (2.3mg/kg compared to an assessment criteria of 2.2 mg/kg). The **Ground Investigation Report (Document Reference 7.11)** does not consider this significant when compared to the Generic Assessment Criteria.

3.2.14 In addition, waste acceptance criteria (WAC) testing of 10 samples of near surface material was undertaken to allow a preliminary determination of the waste characterisation of any material to be disposed of to landfill. The results of the WAC tests analysis classify the near surface material tested as appropriate for disposal at an Inert Waste Landfill.

Infilled ground/landfilling and historical land use

3.2.15 Infilled ground, landfilling and other historical land uses may be sources of contamination to the water environment.

3.2.16 There are 13 historical landfill areas shown on Environment Agency mapping data in the vicinity of the Application Boundary. The information is summarised in **Table 3.4** and the locations are shown on Inset **Figure 3.5**. These data show there are four historical landfills within or directly adjacent to the Application Boundary:

Table 3.4 Historical landfill areas

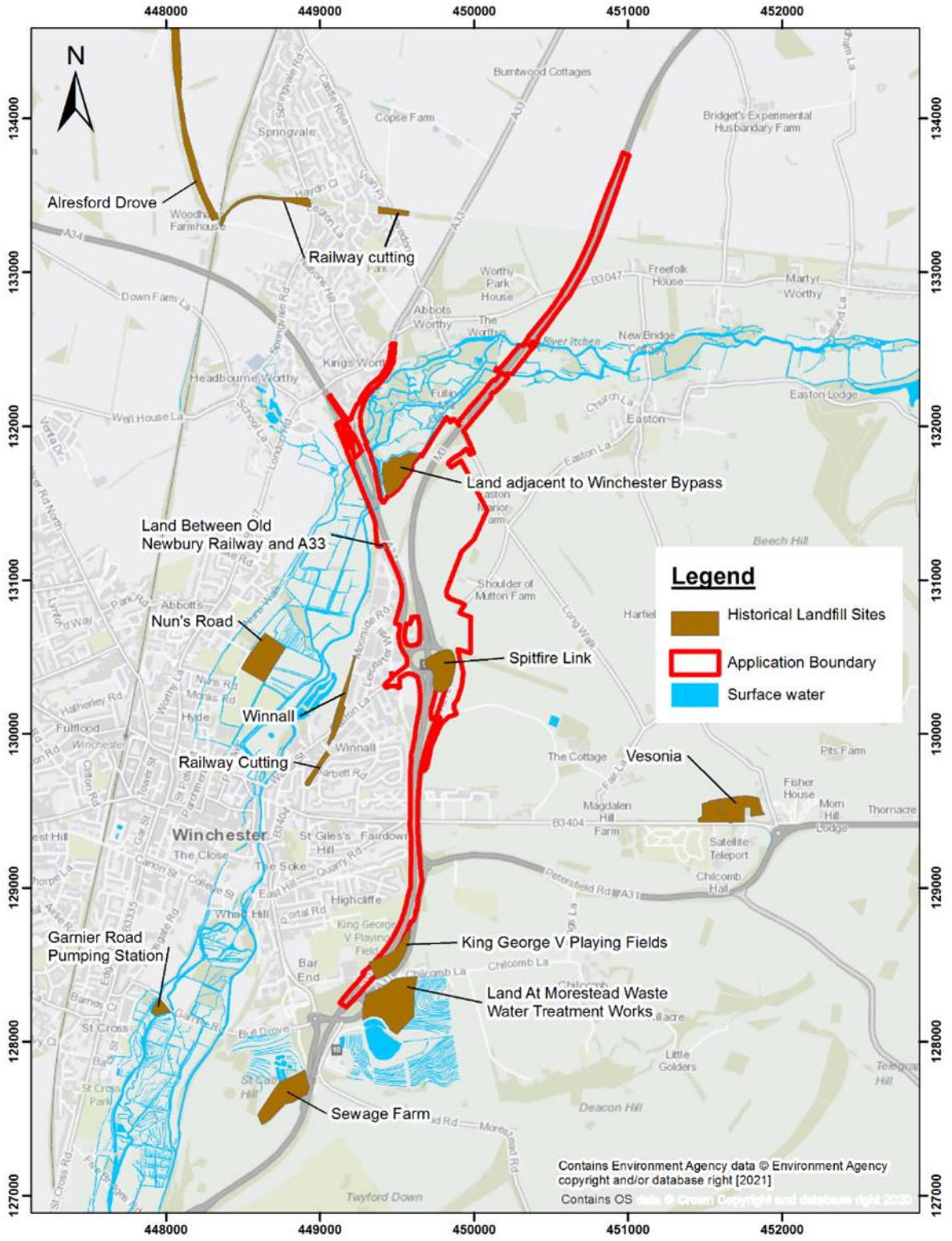
Name	Waste type	Dates active	Distance from site	Comments
Spitfire Link	No further information		On site	Soil Limited (2020) drilled six exploratory boreholes within or adjacent to the mapped boundary. No records of waste are indicated on borehole logs.
King George V Playing Fields	No further information		On site and adjacent to east	
Land adjacent to Winchester Bypass	Inert	1967-1968	Adjacent to north	Timings suggest related to Winchester Bypass widening.

Name	Waste type	Dates active	Distance from site	Comments
				Controlled Waters Risk Assessment in **Chapter 9 (Geology and Soils)** of the **ES (Document Reference 6.1)**
Land Between Old Newbury Railway and A33	No further information		Adjacent to west	Very small so likely to have been a commercial operation. Controlled Waters Risk Assessment **Chapter 9 (Geology and Soils)** of the **ES (Document Reference 6.1)**
Land At Morestead Wastewater Treatment Works	Inert	1993-2001	30 m southeast	-
Winnall	Commercial and household	1969-	220 m to west	-
Sewage Farm	Commercial and household	Not provided	490 m to south	-
Railway Cutting (near to Winnall landfill)	Inert and commercial	1978-	530 m west	-
Nun's Road	Inert and Industrial	1963-	730 m to west	-
Railway cutting (two parts)	No further information		850 m to north	-
Alresford Drove	Commercial and household	Not provided	1 km northwest	-
Vesonia	Inert and commercial	1979-	1 km east	-
Garnier Road Pumping Station	Commercial and household	1910-	1.1 km west	-

3.2.17 A Controlled Waters risk assessment in **Chapter 9 (Geology and Soils)** of the **ES (Document Reference 6.1**) has identified a number of other potential

sources of contamination that are relevant to this study. These comprise a former gas works and iron works, railways, and land of mixed industrial use within or close to the Application Boundary that may also be a source of contaminants in soils.

Figure 3.5: Historical landfill areas



3.3 Hydrology

Rainfall

3.3.1 The Standard Average Annual Rainfall (SAAR) for the area around the Itchen at Easton River monitoring point (42016) is 848 mm (NRFA, 2021).

Surface water features

3.3.2 Surface water features in the vicinity of the Application Boundary are shown on **Figure 3.6**.

Watercourses

3.3.3 The River Itchen flows east to west across the northern part of the Application Boundary and then flows south to the west of the Application Boundary approximately parallel with the M3. The River Itchen is a chalk stream comprising a number of anabranches in the area around Winchester and the Application Boundary. There is also a network of ditches that are connected with the Itchen that follow the boundaries of the former water meadows within the Itchen floodplain. The Itchen is a designated Main River, with the associated floodplain designated as a SAC and SSSI. Much of the floodplain to the west of the central part of the Application Boundary is managed as the Winnall Moors Local Nature Reserve.

3.3.4 According to the National River Flow Archive the mean flow data of the River Itchen upstream of the Application Boundary (location 42016 - Itchen at Easton) is 4.239 m3/s. Downstream of the Application Boundary (location 42010 - Itchen at Highbridge and Allbrook Total) mean flow is 5.539 m3/s, implying that the River gains within the Application Boundary. Both locations show evidence of substantial surface and groundwater abstraction and the presence of cress beds and fish farms. The baseflow index (BFIHOST) at the River Itchen at Easton is 0.95, indicating that it almost entirely groundwater fed.

3.3.5 To the west of the River Itchen is Nun's Walk Stream, which flows parallel to the track/road of the same name and the Itchen. This is also a designated Main River. Ordnance Survey mapping indicates that Nun's Walk Stream starts around springs at Headbourne Worthy in the north and flows southwest parallel with the Itchen on a straight course and joins with an Itchen anabranch at the north end of Park Road, Winchester, south of the River Park Leisure Centre, approximately 2.5 km to the south.

3.3.6 In the surrounding area, there are very few water courses or water features other than the River Itchen that lie on the Chalk, and this is generally due to the high secondary porosity and permeability of the Chalk allowing rainfall to infiltrate and recharge the aquifer directly.

Waterbodies

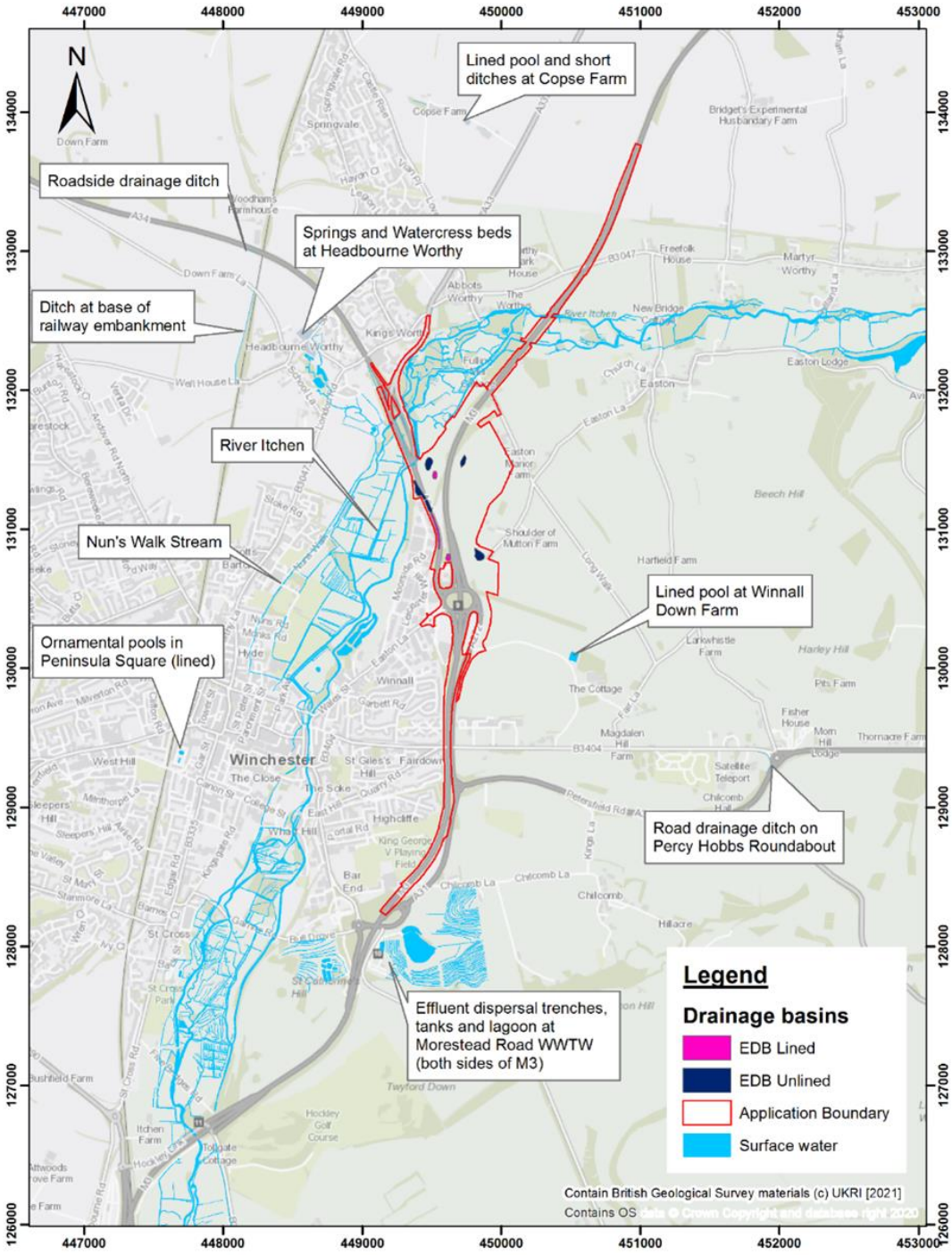
3.3.7 There are a number of water bodies that fall within the course of the River Itchen. There are three waterbodies located on the eastern side of the Itchen

south of the Junction 9 roundabout. There is also a square pond at Winnall Down Farm (125 m from the Application Boundary, that given its shape is very likely to be manmade, and it appears from satellite imagery that it is lined.

3.3.8 To the south around St Catherine's Hill and Chilcomb there are many effluent dispersal trenches, tanks and a lagoon forming part of the Morestead Road Wastewaster Treatment Works. These features are both to the west and east of the M3.

3.3.9 There are number of fisheries and water cress ponds in the surrounding area that rely on chalk-fed water features, such as those in Headbourne Worthy, 480 m to the west of the Application Boundary. These ponds are fed by springs from the chalk. There are also watercress ponds around New Alresford, 8 km to the east of the Application Boundary and upstream on the River Itchen.

Figure 3.6: Surface water features



Surface water quality

3.3.10 No surface water samples were taken as part of the site investigation undertaken by Soils Limited in 2019.

3.4 Hydrogeology

Groundwater classifications and systems

3.4.1 The Alluvium underlying the north of the Application Boundary is classified by the Environment Agency as a Secondary A aquifer, meaning it is a formed of permeable layers capable of supporting water supplies at a local rather than strategic scale, and can provide an important source of base flow to rivers.

3.4.2 The Head deposits are classified as Secondary Undifferentiated aquifer. These are layers for which it has not been possible to determine a permeability due to the variable characteristics of the rock type.

3.4.3 The Chalk Subgroup is classified by the Environment Agency as a Principal Aquifer, due to its high fracture permeability, and as such it supports water supply and river base flow on a strategic scale. The Chalk is a dual porosity aquifer with rapid flow occurring through fracture networks and slower flow through the porous matrix.

3.4.4 The top of the Chalk is logged as structureless chalk. Structureless chalk tends to have fewer fissures and fractures and the clayey matrix is often a barrier to groundwater flow.

3.4.5 The Groundwater Vulnerability maps from the Environment Agency indicates that the groundwater is of High vulnerability to pollutant discharge at the surface in areas without superficial cover and Moderate-High vulnerability in areas with superficial cover.

Groundwater Source Protection Zones (SPZs)

3.4.6 The Application Boundary lies within two overlapping groundwater Source Protection Zones (SPZ); which relate to groundwater sources that are used for public drinking water supply. The definitions of each zone are described in **Table 3.5** below. There is also another SPZ to the northwest and one to the south. The SPZs are shown on **Figure 3.14**.

Table 3.5: Outline definitions of Source Protection Zones

Zone	Outline definition (from Environment Agency website – (Environment Agency, 2019)
Zone 1 (Inner Zone)	Defined by a 50-day travel time from any point below the water table to the source. This zone has a minimum radius of 50 metres.
Zone 2 (Outer Zone)	Defined by a 400-day travel time from a point below the water table. This zone has a minimum radius of 250 or 500 metres around the source, depending on the size of the abstraction. Older SPZs may have used a different methodology.

Zone	Outline definition (from Environment Agency website – (Environment Agency, 2019)
Zone 3 (Total Catchment)	Defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source.

3.4.7 The SPZ in the northeast of the Application Boundary is for two Southern Water public water supply boreholes near Easton and lies mostly along the M3 north of the Application Boundary[1]. Where the Application Boundary is within the SPZ it is mostly in Zone 1, with the northernmost area in Zone 2 (c. 860 m of M3).

3.4.8 There is also an SPZ approximately 450 m to the northwest of the Application Boundary associated with the Headbourne Worthy Watercress Beds. These beds are fed by springs. The area closest to the Application Boundary is in Zone 1 with the 'tail' of Zone 2 and 3 spreading to the northwest away from the Application Boundary.

3.4.9 There is another SPZ 1 km southeast of the Application Boundary which is related to further Southern Water public water supply boreholes.

3.4.10 The Drinking Water Groundwater Safeguard Zone (DWGSZ) for the River Itchen Chalk covers Zone 1 and 2 of the SPZ.

Aquifer properties

3.4.11 The Chalk exhibits both matrix flow and fracture flow and the Seaford Chalk Formation has regular orthogonal joint sets (Allen, *et al*., 1997). The Seaford Chalk usually has high storage although not always high permeability due to the narrow apertures of the fractures (Allen, et al., 1997). Numerous fractures are identified in the chalk in borehole logs.

3.4.12 It is common for there to be higher permeability in chalk river valleys. Palaeogene sediments in river valleys tend to be quite acidic, enhancing dissolution (Allen, et al., 1997). Transmissivities in the Hampshire Basin area are reported in Allen *et al.,* (1997) from 0.55 to 29,000 m^2/d with a geometric mean of 1,600 m^2/d. Allen *et al.* (1997) note that these values are high due to higher number of tests near to rivers. Transmissivity values of 1,000 m^2/d are common in the valley areas. The Candover valley, a tributary of the Itchen to the east, has transmissivities of 1,000 - 3,000 m^2/d and a storage coefficient of 0.01-0.03. Folding tends to enhance fracturing of rocks. However, it also notes that in the axes of anticlines, such as is found here, aquifer properties are thought to be less well developed, with groundwater mounds and lower transmissivities of 100 m^2/d. (Entec, 2002) within (WPK, 2007) suggest transmissivities in the Winchester Anticline are 100-600 m^2/d.

[1] Note that co-ordinates are not available for the Itchen Valley PWS's near Easton.

3.4.13 At the Itchen Valley (Easton) Public Water Supply (PWS) to the north of the Application Boundary, transmissivities of 2,400 and 4,700 m^2/d have been calculated from pumping tests (Environment Agency, 1997 within WPK, 2007).

3.4.14 If we assume that the transmissivity is concentrated in the top 50 m of the Chalk, then a transmissivity of 1,000 m^2/d equates to a hydraulic conductivity of 20 m/d. Below 50 m, chalk fissures tend to be closed due to the mass of rock above them and yields decrease.

3.4.15 Variable head permeability tests were undertaken during the site investigation by Soils Limited. However, it is understood that these tests were undertaken above the water table and thus may not reflect the hydraulic conductivity of the strata tested. In the **Ground Investigation Report (Document Reference 7.11)** calculated soil infiltration rates to use as an indication for preliminary designs. Table 9.5 from the **Ground Investigation Report (Document Reference 7.11)** is reproduced here as **Table 3.6**. Based on these calculations a soil infiltration rate of 1 x 10^{-6} m/s was adopted for Alluvium, Head and Structured Chalk within 2 mbgl (metres below ground level), and 1 x 10^{-5} m/s for Structured Chalk below 2 mbgl.

Table 3.6: Calculated soil infiltration rates (from Table 9.5 in the Ground Investigation Report (Document Reference 7.11))

Location	Test depth range (mbgl)	Geology as per borehole record logs (mbgl)	Soil infiltration – calculated (m/s)	Soil infiltration(m/hr)
DS104	0 - 4	0.3 - 3.0 Sandy gravelly clay (Alluvium) 3.0 - 4.0 No description [Alluvium]	9.5 x 10^{-6}	3.4 x 10^{-2}
DS107	0 - 4	0.4 - 1.2 Structureless chalk 1.7 - 4.0 Chalk Grade B2	1.4 x 10^{-5}	5.2 x 10^{-2}
DS109	0 - 3	0.5 - 1.2 Structureless chalk 1.2 - 3.0 Chalk Grade B2	2.8 x 10^{-5}	1.0 x 10^{-1}
DS210	0 - 4	0 - 1.7 Structureless chalk (Grade Dc) 1.7 - 4.0 Chalk Grade B2	4.2 x 10^{-6}	1.5 x 10^{-2}
DS301	5.7 - 10.15	5.7 - 7.0 Chalk Grade A3-A4 7.0 - 10.15Chalk Grade A3	1.1 x 10^{-4}	4.1 x 10^{-1}

3.4.16 Yields in the Lewes to Portsdown Formations are typically 10.5 l/s in boreholes in the Winchester District (Booth, *et al*., 2008). Booth et al. also note that “rapid groundwater flows are sometimes found in the unconfined chalk aquifer where

karstic-type development has taken place. This is commonly associated with the proximity of thin cover, such as the Palaeogene deposits or clay-with-flints".

3.5 Groundwater levels and flow

Available data

3.5.1 Limited groundwater monitoring data are available. Monitoring wells were installed by Soils Limited during March and April 2019 at 23 locations and dips were taken at 13 from the installation until 15 April 2019. Four locations (DS104, DS114, DS301, DS302) were then monitored hourly using pressure transmitters and loggers for the period June 2019 to July 2020.

Groundwater levels

Dip data

3.5.2 Fourteen boreholes were dipped once installed and typically each day during the site investigation works by Soils Limited. The dips and levels on the final day (15th April 2019) are plotted on **Figure 3.7** and **Figure 3.8** respectively, which also shows the locations. The dip data is provided in Table 3.7 for the whole GI period (where available). These data are taken from the Soils Limited (2020) Factual Report and converted to metres above ordnance datum based on the groundwater elevations provided in the report. A number of boreholes were dry throughout the works period. These data indicate that the groundwater level across the central part of the Application Boundary is approximately 37.5 mAOD. Groundwater levels at DS208 are noticeably higher at 52.04 mAOD, which is because this borehole is screened in the Seaford Chalk at a higher elevation of 51.91-54.91 mAOD, whereas the other boreholes are screened below 30 mAOD. There is therefore a locally perched groundwater table at DS208.

3.5.3 Groundwater seepage was encountered during the Jacobs Application Boundary investigation at a depth of 3.10 mbgl in WS02 and 4.50 mbgl in WS03, and 7 mbgl in WS08.

Figure 3.7: Groundwater dip data from final day of installation works in mbgl

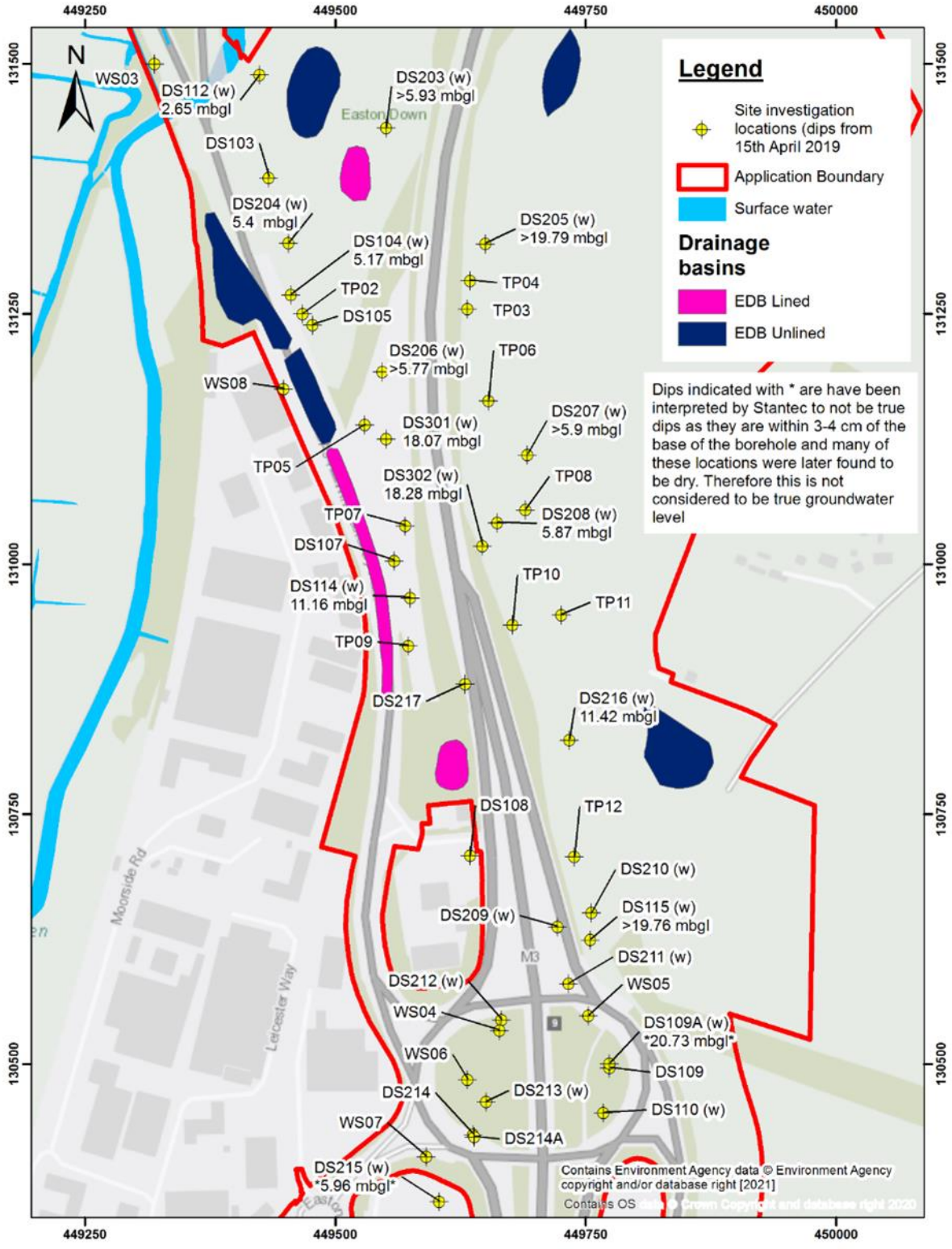


Figure 3.8: Groundwater levels data from final day of installation works in mAOD

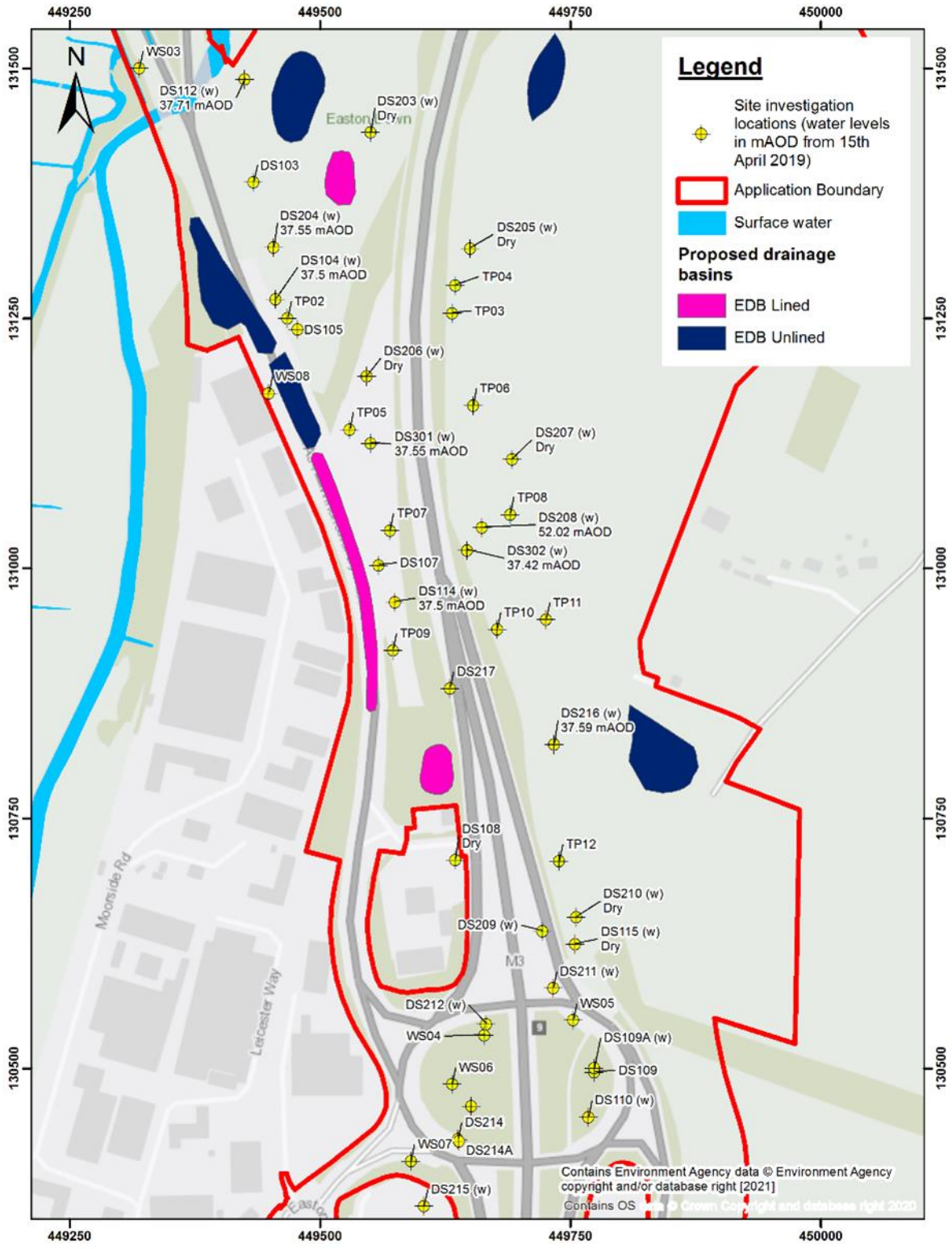


Table 3.7: Groundwater level dip data during site investigation works in mAOD

	Date	18/03/2019		19/03/2019		20/03/2019		22/03/2019		25/03/2019		26/03/2019		27/03/2019				28/03/2019		01/04/2019	
Trial Hole	**Ground level (mAOD)**	Water level	Base	Water level	Base	Water level	Base	Water level	Base	Water level	Base	Water level	Base	Water level	Base	Water level		Base		Water level	Base
DS104	42.67																				
DS112	40.36																			37.72	20.93
DS114	48.66													37.56	29.10	37.55		29.10		37.56	29.10
DS115	62.23					Installed		42.82	42.43			Dry	42.47	Dry	42.47	Dry	42.47	Dry		42.46	
DS203	57.43																				
DS204	42.95																			37.59	36.85
DS205	69.16	Dry	49.39	Dry	49.39	Dry	49.39	Dry	49.39	Dry	49.44	Dry	49.39	Dry	49.44	Dry		49.39		Dry	49.44
DS206	56.88															Installed		Dry		51.11	
DS207	64.65	Dry	58.45	Dry	58.77	Dry	58.71	Dry	58.77	Dry	58.78	Dry	58.75	Dry	58.73	Dry		58.78		Dry	58.78
DS208	57.91	Dry	51.74	Dry	51.92	52.02	51.98	Dry	51.89	52.01	51.97	52.05	52.01	52.00	51.98	52.05		52.01		52.04	52.02
DS210	61.41							Dry	55.63	Dry	55.63	Dry	55.62	Dry	55.62	Dry		55.62		Dry	55.63
DS216	49.01							Installed				37.64	34.28	37.47	33.96	37.65	34.29	37.48		33.98	
DS301	55.62													Installed						37.60	<25.62
DS302	55.7			Installed		37.66	<25.7	37.65	<25.7	37.76	<25.7	37.67	<25.7	37.61	<25.7	37.62	<25.7	37.63		<25.7	

(Continued on next page)

	Date	02/04/2019		03/04/2019		05/04/2019		09/04/2019		10/04/2019		11/04/2019		12/04/2019		15/04/2019	
Trial Hole	Ground level	Water level	Base	Water level	Base	Water level	Base	Water level	Base	Water level	Base	Water level	Base	Water level	Base	Water level	Base
DS104	42.67	Installed		37.54	27.96	37.75	28.04	37.55	27.94	37.53	27.95	37.66	28.05	37.54	27.95	37.50	27.95
DS112	40.36	37.70	20.95	37.74	21.08	37.87	20.95	37.80	20.95	37.73	21.00	37.71	21.00	37.70	20.89	37.71	21.02
DS114	48.66	37.56	29.10	37.54	29.38	37.64	29.22	37.56	29.10	48.66	48.66	37.61	29.09	37.52	29.51	37.50	29.42
DS115	62.23	Dry	42.68	Dry	42.68	Dry	42.82	Dry	42.68	Dry	42.82	Dry	42.46	Dry	42.46	Dry	42.47
DS203	57.43			Installed				Dry	51.48	Dry	51.48	Dry	51.48	Dry	51.53	Dry	51.50
DS204	42.95	37.58	36.87	37.58	36.87	37.77	36.91	37.78	36.87	37.60	36.89	37.69	36.89	37.56	36.90	37.55	36.89
DS205	69.16	Dry	49.44	Dry	49.44	Dry	49.44	Dry	49.44	Dry	49.44	Dry	49.67	Dry	49.69	Dry	49.37
DS206	56.88	Dry	51.11	Dry	51.10	Dry	51.10	Dry	51.01	56.88	56.88	Dry	51.01	Dry	51.10	Dry	51.11
DS207	64.65	Dry	58.78	Dry	58.78	Dry	58.78	Dry	58.76	Dry	58.74	Dry	58.73	Dry	58.74	Dry	58.75
DS208	57.91	52.04	52.03	52.03	52.01	Dry	52.03	Dry	63.79	52.04	52.03	Dry	52.02	Dry	52.02	52.04	52.02
DS210	61.41	Dry	55.62	Dry	55.63	Dry	55.63	Dry	55.63	Dry	55.52	Dry	55.51	Dry	55.51	Dry	55.52
DS216	49.01	37.48	34.14	37.47	34.23	37.74	34.14	37.19	34.14	37.45	34.16	37.61	34.26	37.60	34.26	37.59	34.26
DS301	55.62	37.59	<25.62	44.54	<25.62	37.59	<25.62	37.60	<25.62			37.69	<25.62	37.61	<25.62	37.55	<25.62
DS302	55.7	37.78	<25.7	37.62	<25.7	37.28	<25.7	37.49	<25.7	37.64	<25.7	37.46	<25.7	37.44	<25.7	37.42	<25.7

Red text indicates that the base of the borehole extended beyond the reach of the 30 m dip tape used.
Yellow highlighting indicates water levels that may be errors.

Logger data

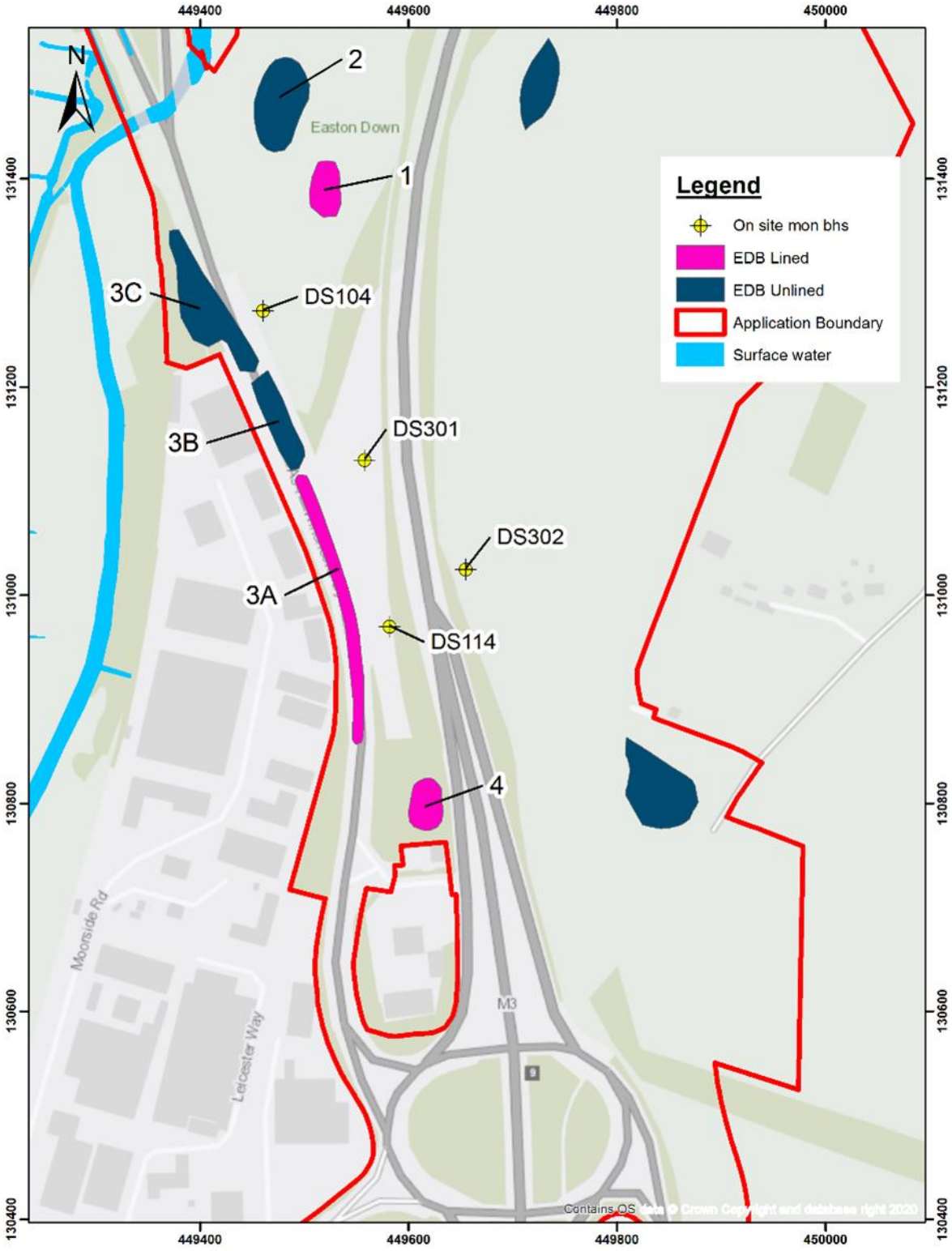
3.5.4 Groundwater monitoring points DS104, DS114, DS301 and DS302 are located close to the proposed drainage basins 2, 3A, 3B and 3C, as shown on Figure 3.9, and monitor the Seaford Chalk Formation. These boreholes are between 15 and 30.5 m in depth and are screened at their base within the Seaford Chalk Formation. A summary of the depths and horizons at the boreholes is given in **Table 3.8**.

3.5.5 These boreholes were monitored using loggers for one year from June 2019 to July 2020. The water level (in mbgl) is plotted in **Figure 3.11**. The barometrically adjusted groundwater level (in mAOD)) is plotted in **Figure 3.10**. A summary of the groundwater level is given in **Table 3.9**.

Table 3.8: Groundwater monitoring locations

Borehole	Ground level (mAOD)	Depth (mbgl)	Elevation of base (mAOD)	Screened interval (mAOD)	Geology summary
DS104	42.67	15.00	27.67	27.67-32.60 (Seaford Chalk)	Topsoil/Made Ground 0 to 0.3 mbgl Head 0.3 to 8.5 mbgl (some core not recovered). Typically sandy gravelly clay down to 3 mbgl and variable sand, gravels, and sandy gravelly clays at depth. No recovery 8.5 to 10.00 mbgl Seaford Chalk Formation 10.00-15.00 mbgl
DS114	48.66	19.95	28.71	29.16-32.16 (Seaford Chalk Formation)	Topsoil 0 to 0.3 mbgl Seaford Chalk Formation from 0.3 to 19.95
DS301	55.62	30.25	25.27	25.62-30.62 (Seaford Chalk Formation)	Topsoil to 0.4 mbgl. Seaford Chalk from 0.4 to 30.25 mbgl
DS302	55.70	30.45	25.25	25.70-30.70 (Seaford Chalk Formation)	Head from 0 to 0.27 mbgl. Head is composed of light brown slightly gravelly sandy clay. Seaford Chalk from 0.27 to 30.45 mbgl

Figure 3.9: Boreholes monitored for groundwater level



3.5.6 During the monitoring period the groundwater levels vary by approximately 2 m, with all locations showing almost identical trends. Groundwater level generally

increase gradually from June 2019 to December 2019, then rise more quickly from mid-December to February 2020 and decline from February to June 2020. Groundwater levels in DS301 and DS302 are approximately 0.3 m higher than those at DS104 and DS114. The groundwater levels range between 37.19 to 39.38 mAOD. This is the same elevation as the River Itchen and surrounding area to the west. We note that the Chalk groundwater level flow direction is likely to be towards the River Itchen (i.e. from east to west). These wells are located along an approximate north to south line (perpendicular to groundwater flow), making it difficult to assess flow directions or hydraulic gradients directly from these data.

Table 3.9: Summary of groundwater levels (June 2019 to July 2020)

Borehole	Groundwater level (mbgl)			Groundwater level (mAOD)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
DS104	3.83	4.97	5.43	37.24	37.70	38.84
DS114	9.67	10.98	11.49	37.17	37.68	38.99
DS301	16.41	17.68	29.21	37.43	37.94	39.21
DS302	16.32	17.73	28.90	37.42	37.98	39.38

Figure 3.10: Groundwater level in Application Boundary SI boreholes in the Application Boundary (mAOD)

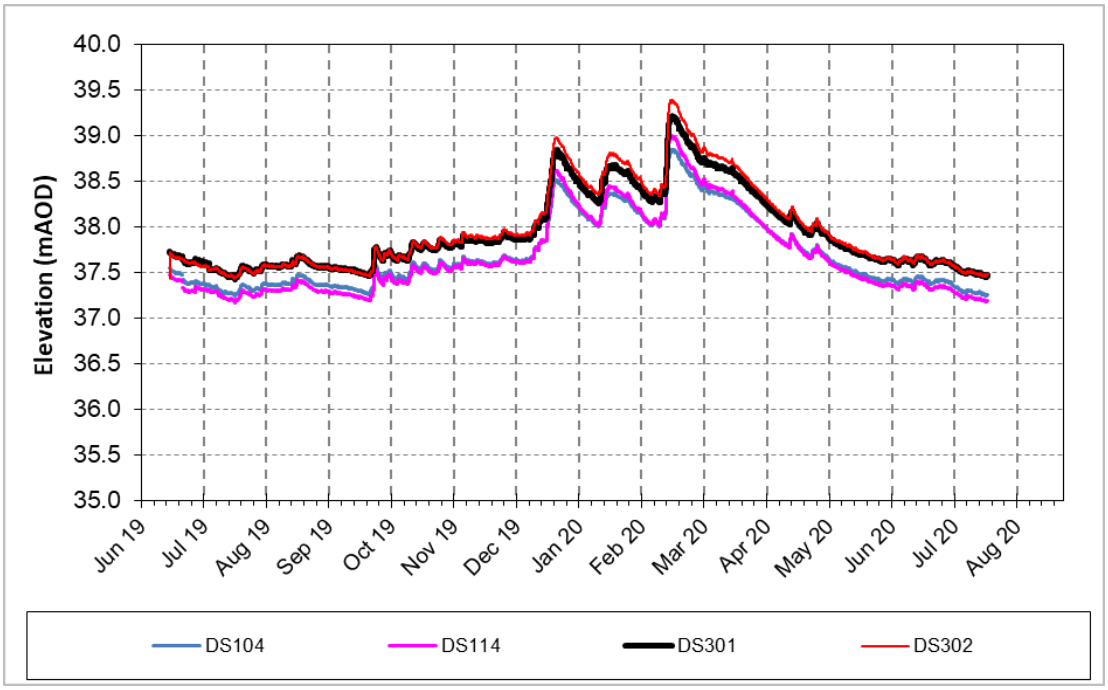
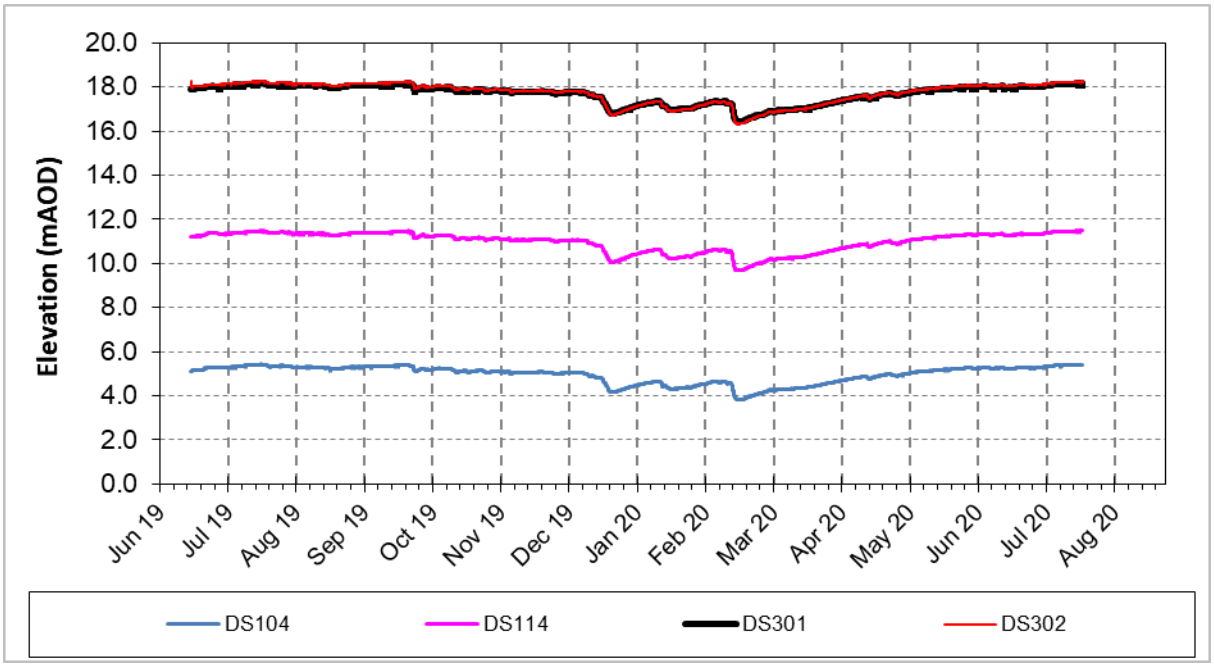


Figure 3.11: Groundwater level in Application Boundary SI boreholes in metres below ground level



Unsaturated zone thickness

3.5.7 Based on the available groundwater level data, the groundwater depth (unsaturated zone thickness) at each of the proposed EDBs can be estimated. These estimates are summarised in **Table 3.10**. Unsaturated zone thickness is based on the average groundwater level in the closest borehole to where the EDB is proposed. The logger data at four boreholes indicates that the average groundwater level over the year was 0.2 m higher than the water level recorded in April 2019 during the installation. Therefore, it has been assumed that variability is the same across all boreholes and so the average unsaturated thickness is taken to be 0.2 m smaller than was measured in April 2019.

Table 3.10: Approximate depth to groundwater at unlined EDBs

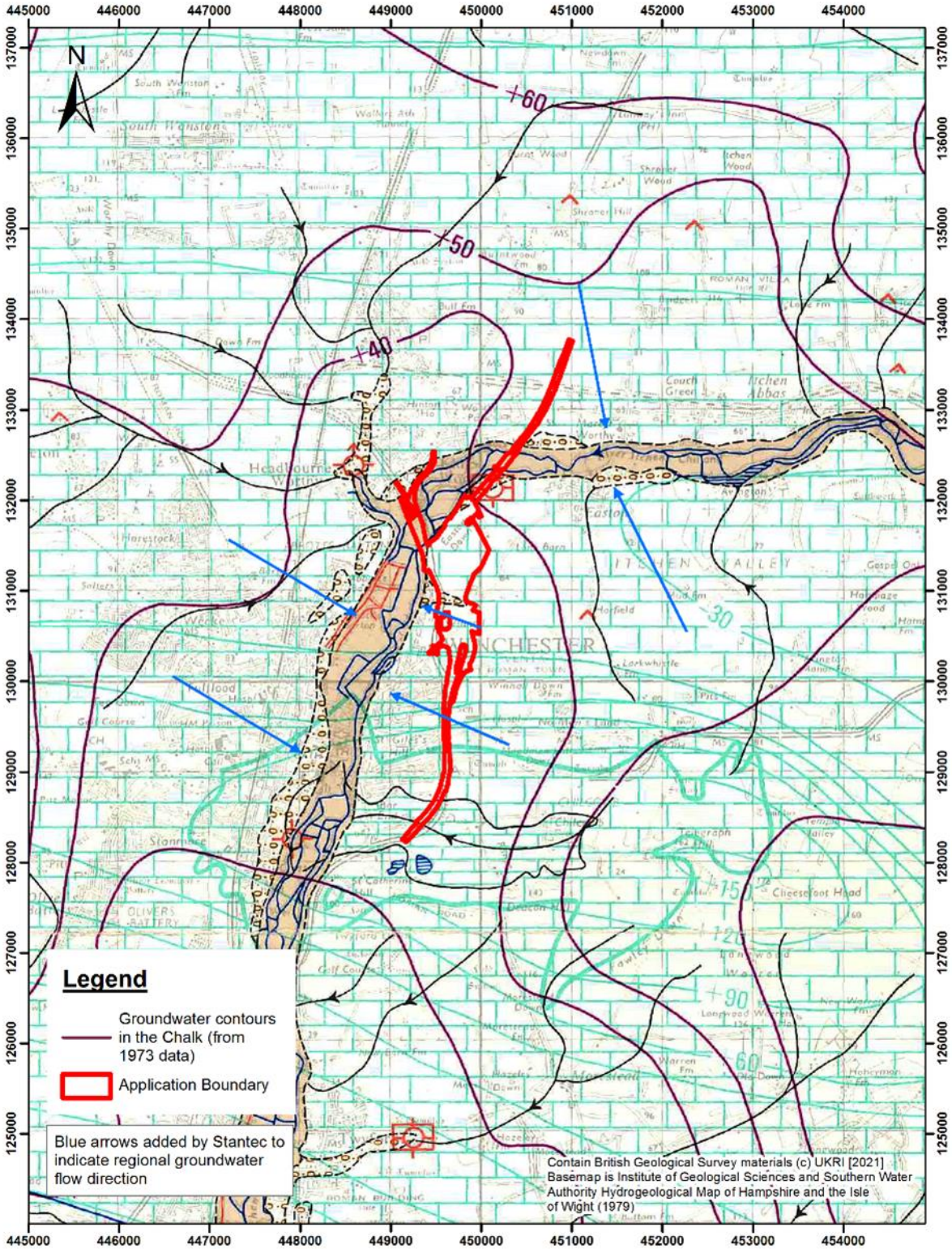
EDB	Approximate average elevation of EDB (mAOD)	Approximate average unsaturated thickness to nearest 0.1 m	Nearest borehole
1	45	7.1	DS112
2	51	13.1	DS203 DS112
3B	43.5	5.8	DS104
3C	41.5	3.8	DS104

Groundwater flow

3.5.8 The Hydrogeology map of Hampshire and the Isle of Wight (Institute of Geological Sciences and Southern Water Authority, 1979) shows the groundwater contours in the Upper Chalk around the Application Boundary to be generally mirroring the topography and indicates groundwater flow towards the River Itchen (**Figure 3.12**). In the area of the drainage features within the Application Boundary, groundwater flows to the southwest are indicated, towards the River. These contours suggest that groundwater discharges to the River.

3.5.9 The shape of the SPZs indicate a southeasterly flow at Headbourne Worthy which lies on the western side of the River Itchen. The Itchen Valley abstractions near Easton draw in water from the north of the River and also from the southeast.

Figure 3.12: Application Boundary overlaid on the Hydrogeological map (Institute of Hydrological Sciences, 1979)



3.6 Contaminated land and pollution events

3.6.1 An Envirocheck report was obtained to inform the Preliminary Sources Study Report (WSP, 2017). Envirocheck notes there are two petrol filling stations on Easton Lane, one 7 m (Shell) from the Application Boundary and one 66 m (Tesco) away. Stantec has also been made aware by Winchester City Council that there also is a former petrol station located within the Application Boundary along the A33 (letter reference 21/01483/NSIP, dated 7th July 2021).

3.6.2 Pollution incidents up to 2 km away from the Application Boundary are summarised in **Table 3.11** (Envirocheck, 2016). These pollution incidents occurred between 1992 and 1999.

Table 3.11: Pollution incidents within 2km (from Envirocheck, 2016)

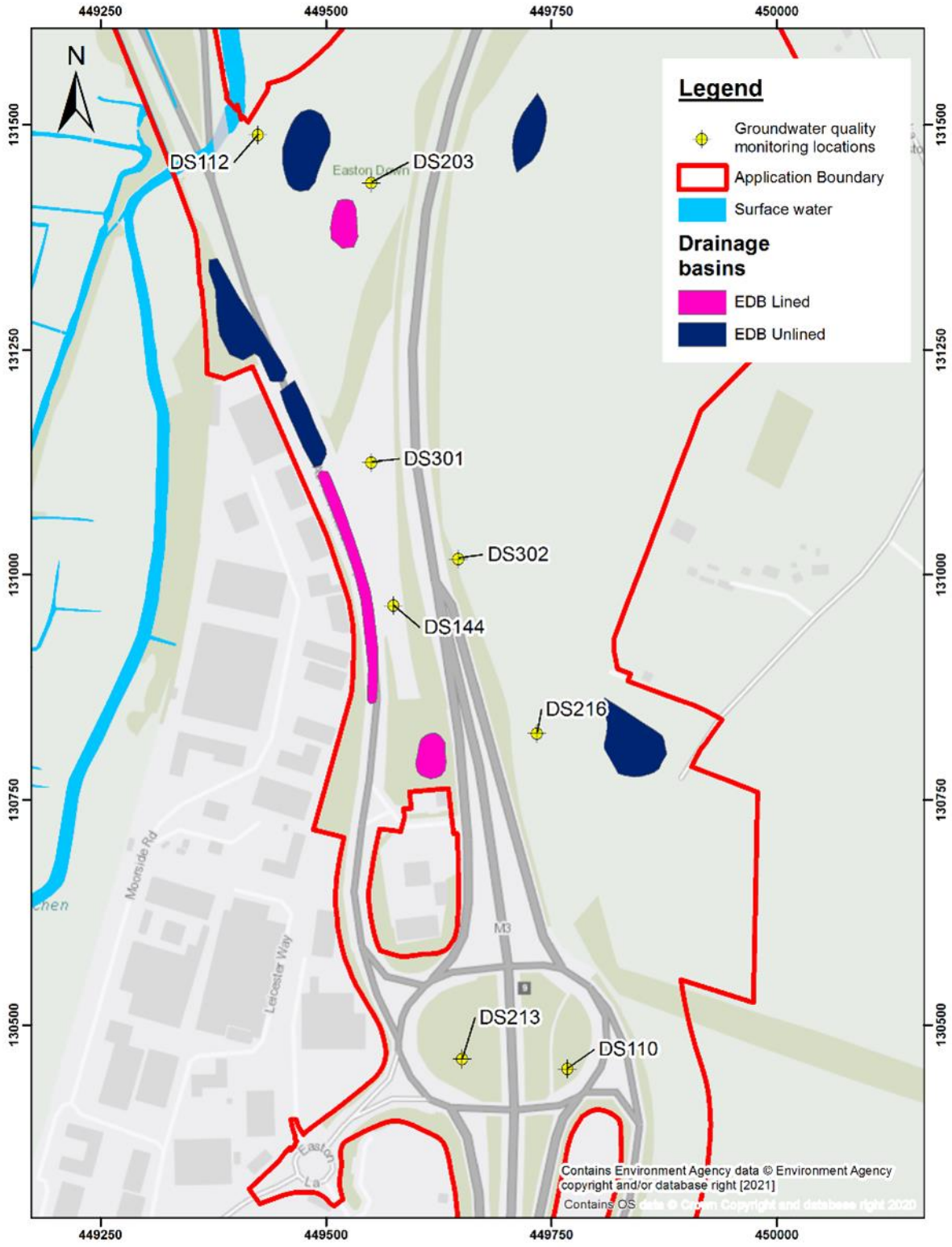
Distance	Number of recorded incidents	Summary of incidents
On site	1	Poultry manure
0-250 m	4	Petrol poured onto ground
		LPG tanker overturned
		Mineral and synthetic oil
		Inert suspended solids from cress beds
251-500 m	2	Slurry discharge
		Inert suspended solids from farm
501-2000 m	12	Slurry discharge
		Milky white discharge from construction
		Suspended solids from construction
		Industrial chemicals
		Waste oil
		River has turned black – inert solids

3.7 Groundwater quality

3.7.1 Groundwater samples were taken from eight boreholes on two occasions during the GI in 2019. The locations tested were DS110, DS112, DS114, DS203, DS213, DS216, DS301 and DS302, which are shown on **Figure 3.13**.

3.7.2 On each monitoring occasion, two samples were taken from DS110 at 12 mbgl and 29.5 mbgl, and one sample was taken at the other seven boreholes. Only results from one occasion are available for review by Stantec.

Figure 3.13: Groundwater quality monitoring locations



3.7.3 The Tier 2 Controlled Waters Risk Assessment in **Chapter 9 (Geology and Soils)** of the **ES (Document Reference 6.1)** identified one exceedance of

copper, two exceedances of mercury, one exceedance of nickel and one exceedance of zinc against the Environmental Quality Standards (EQS). Furthermore, the limit of detections (LOD) for cadmium, hexavalent chromium, copper, lead and cyanide are above the EQS. It also identified one exceedance of mercury, one exceedance of nickel and two exceedances of nitrate compared to the UK DWS (Drinking Water Standards). The nitrate exceedances were from wells sampling from the rural catchment to the east of the Scheme and the metal exceedances were from wells sampling close to historical landfills.

Table 3.12: Summary of groundwater quality data (based on data in Controlled Waters Risk Assessment in Chapter 9 (Geology and Soils) of the ES (Document Reference 6.1))

Analyte	Units	LOD	Fresh Water (EQS)	No. of Tests	Min	Max	No. > Limit	Locations with exceedances
Arsenic	µg/l	5	50	9	5	5		
Boron	µg/l	5	-	9	14	28		
Cadmium	µg/l	0.4	0.08	9	0.4	0.4	**9**	All
Chromuim (Total)	µg/l	5	-	9	5	10		
Chromium Hexavalant	µg/l	20	3.4	9	20	20	**9**	All
Copper	µg/l	5	1	9	5	9	**9**	All. Detected at DS103 only
Lead	µg/l	5	1.2	9	5	5	**9**	All
Mercury	µg/l	0.05	0.07	9	0.05	18.3	**2**	DS110 (0.24) and DS203 (18.3)
Nickel	µg/l	5	4	9	5	68	**9**	All. Detected at DS203 only
Selenium	µg/l	5	-	9	5	5		
Zinc	µg/l	2	10.9	9	2	27	**1**	DS203
Ammoniacal Nitrogen as NH4	µg/l	50	260	9	50	107		
Cyanide	µg/l	5	1	9	5	5	**9**	All
Nitrate as NO3	µg/l	500	-	9	14300	56000		
Sulphate	µg/l	1000	-	9	6000	31000		
pH	pH Units	1	-	9	7.7	7.8		
>C5 to C6 Aliphatic	µg/l	10	-	9	10	10		

Analyte	Units	LOD	Fresh Water (EQS)	No. of Tests	Min	Max	No. > Limit	Locations with exceedances
>C6 to C8 Aliphatic	µg/l	10	-	9	10	10		
>C8 to C10 Aliphatic	µg/l	10	-	9	10	10		
>C10 to C12 Aliphatic	µg/l	10	-	9	10	10		
>C12 to C16 Aliphatic	µg/l	10	-	9	10	10		
>C16 to C21 Aliphatic	µg/l	10	-	9	10	10		
>C21 to C35 Aliphatic	µg/l	10	-	9	10	18		
Total Aliphatic C5-35	µg/l	70	-	9	70	70		
>C7 to C8 Aromatic	µg/l	10	-	9	10	10		
>C8 to C10 Aromatic	µg/l	10	-	9	10	10		
>C10 to C12 Aromatic	µg/l	10	-	9	10	10		
>C12 to C16 Aromatic	µg/l	10	-	9	10	10		
>C16 to C21 Aromatic	µg/l	10	-	9	10	10		
>C21 to C35 Aromatic	µg/l	10	-	9	10	10		
Benzene	µg/l	1	10	9	1	1		
Ethylbenzene	µg/l	5	-	9	5	5		
Toluene	µg/l	5	74	9	5	5		
M- & P-Xylene	µg/l	10	-	9	10	10		
O-Xylene	µg/l	5	-	9	5	5		
Total Xylene (M, P & O)	µg/l	15	-	9	15	15		
MTBE	µg/l	10	-	9	10	10		
naphthalene	µg/l	0.01	2	9	0.01	0.04		
Acenaphthylene	µg/l	0.01	-	9	0.01	0.01		
Acenaphthene	µg/l	0.01	-	9	0.01	0.01		
Fluorene	µg/l	0.01	-	9	0.01	0.01		
Phenanthrene	µg/l	0.01	-	9	0.01	0.01		
Anthracene	µg/l	0.01	0.1	9	0.01	0.01		
Fluoranthene	µg/l	0.01	0.0063	9	0.01	0.01	**9**	All
Pyrene	µg/l	0.01	-	9	0.01	0.01		
Benzo(a)anthracene	µg/l	0.01	-	9	0.01	0.01		
Chrysene	µg/l	0.01	-	9	0.01	0.01		
Benzo(b)fluoranthene	µg/l	0.01	0.017	9	0.01	0.01		

Analyte	Units	LOD	Fresh Water (EQS)	No. of Tests	Min	Max	No. > Limit	Locations with exceedances
Benzo(k)fluoranthene	µg/l	0.01	0.017	9	0.01	0.01		
Benzo(a)pyrene	µg/l	0.01	0.00017	9	0.01	0.01	**9**	All
Benzo(g,h,i)perylene	µg/l	0.01	0.0082	9	0.01	0.01	**9**	All
Dibenzo(ah)anthracene	µg/l	0.01	-	9	0.01	0.01		
Indeno(1,2,3-c,d)pyrene	µg/l	0.01	-	9	0.008	0.008		
Sum (benzo b, k, ghi & indeno123cd)	µg/l	0.04	-	9	0.038	0.038		

Orange highlight means LOD > EQS

Red highlight means result > EQS

3.8 Other potential receptors

Licenced water abstractions and discharges

3.8.1 There are multiple public groundwater abstractions to the north and south of the Application Boundary. The majority of groundwater abstractions to the north are for potable water supply, with the abstractions to the south and west primarily used for water cress production and other agricultural purposes, see Table 3.15 and **Figure 3.14**.

3.8.2 Given the groundwater divide at the River Itchen, the impact from the EDBs on the boreholes to the west and north of the Itchen will be negligible and are not considered further here.

Private water supplies

3.8.3 Winchester City Council have previously provided information on private water supply abstractions and discharges, located within a 2 km radius of the Application Boundary. It is understood that the current Application Boundary has been revised and as a result some of these supplies now fall more than 2 km from the Application Boundary.

3.8.4 There are nine boreholes used for private water supplies, all of which are currently active and abstract from the underlying chalk aquifer; details of these can be seen in **Table 3.13**. The locations of private water supply boreholes are shown on **Figure 3.14**. Some abstractions to the north are beyond the extent of the map and are therefore not shown.

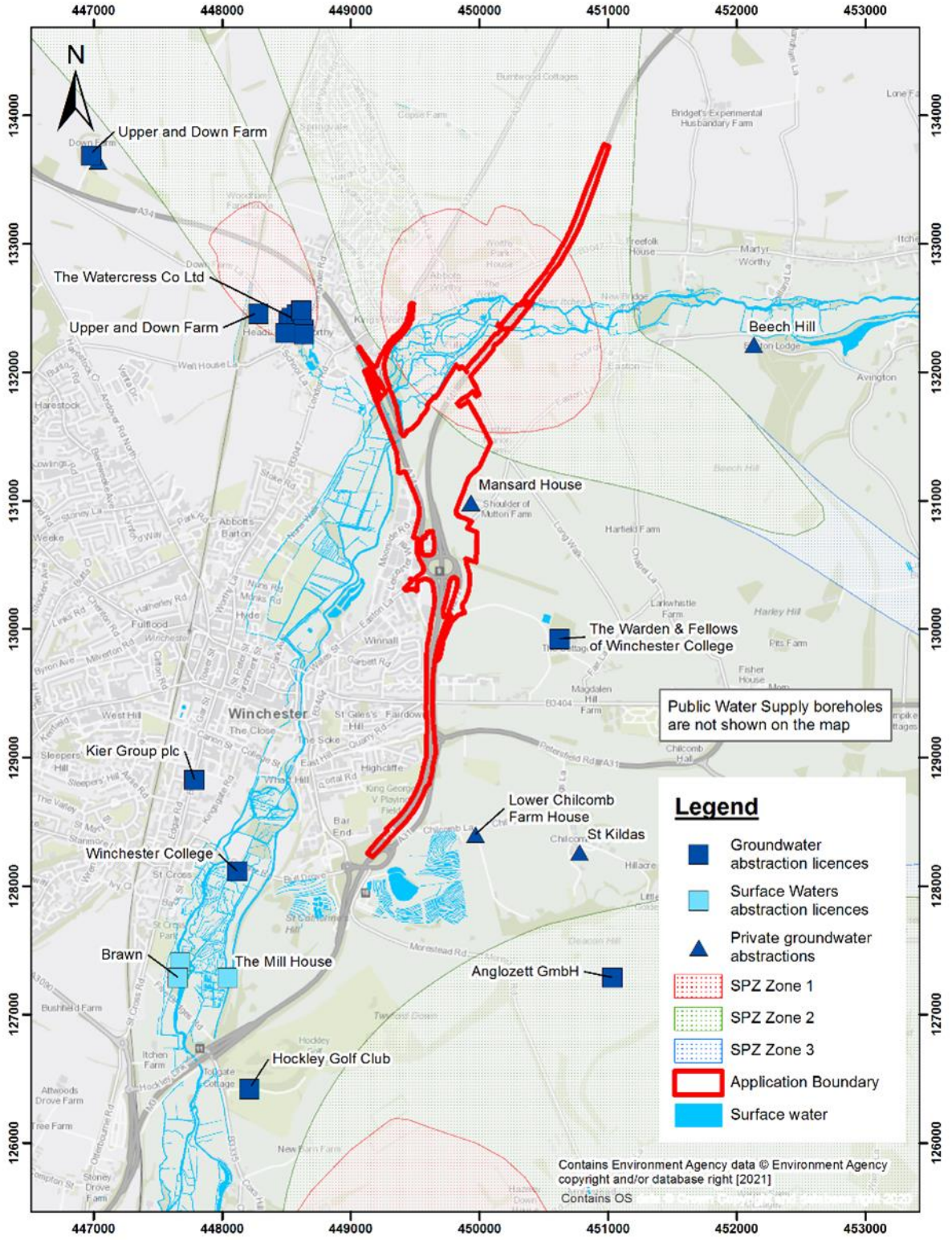
3.8.5 Since all of the private water supplies are on the western and northern side of the River Itchen, up hydraulic gradient, or across hydraulic gradient at a

sufficient distance of the EDBs, the Scheme will have a negligible impact upon them, and they are not considered further here.

Table 3.13: Private water abstractions (within 2km of initial scheme boundary)

FID	Supply Name	Supply Number	Source Type	Source Eastings	Source Northings	Distance from Application Boundary
Within Application Boundary						
	None					-
Identified outside of the Application Boundary						
19	Shroner Wood	PW000123	Borehole	451582	135626	2 km north
32	BurntwoodFarm	PW000118	Borehole	450500	134760	1 km to north
35	Downs Farm Cottages	PW000195	Borehole	447032	133651	2.5 km to north west
51	Mansard House	PW000120	Well	449931	130990	90 m to east
58	Shroner Hill Farmhouse	PW000122	Borehole	450989	135290	1.5 km north
77	Beech Hill	PW000117	Borehole	452132	132220	1.6 km to east
112	Lower Chilcomb FarmHouse	PW000186	Borehole	449967	128403	500 m to east
133	St Kildas	PW000107	Borehole	450776	128265	560 m to south east
136	The Beacon	PW000066	Borehole	450992	135448	1.65 km north

Figure 3.14: Licenced and private abstractions and SPZs



Designated environmental sites

3.8.6 There are three designated sites within 2km of the Application Boundary, two of which are within the Application Boundary itself.

3.8.7 The River Itchen is a SSSI and a SAC along all of its length. The SSSI extends to the surrounding water dependent habitats and environments. Part of the River Itchen SSSI is managed as the Winnall Moors Nature Reserve to the west of the Application Boundary. The River Itchen flows south to the Solent and Dorset Coast Special Protection Area (SPA) and the Solent and Southampton Water SPA / Ramsar Site.

3.8.8 The South Downs National Park forms part of the eastern side of the Application Boundary and extends to the east.

3.8.9 Only the River Itchen SSSI is groundwater dependent.

Table 3.14: Designated Sites within 2km of the Application Boundary

Name	Designation	Description	Groundwater dependent?	Closest distance from Application Boundary
River Itchen (multiple parts)	SSSI SAC	River Itchen and surrounding land. Multiple habitats and environments. Close to site: - Fen, marsh swamp, lowland - Broadleaved mixed and yew woodland - Neutral grassland - Rivers and streams	Yes	On site
South Downs	National Park	Chalk Hills and wooded sandstone and clay hills and vales.	Not generally. None within 5 km other than River Itchen (see above).	On site
St Catherine's Hill	SSSI (Biological)	Chalk grassland scrub	No	1.4 km south
Cheesefoot Head	SSSI (Biological)	Chalk downland with horseshoe shaped dry valley, with species rich grasslands.	No	1.8 km east

Figure 3.15: Designated sites within 2 km

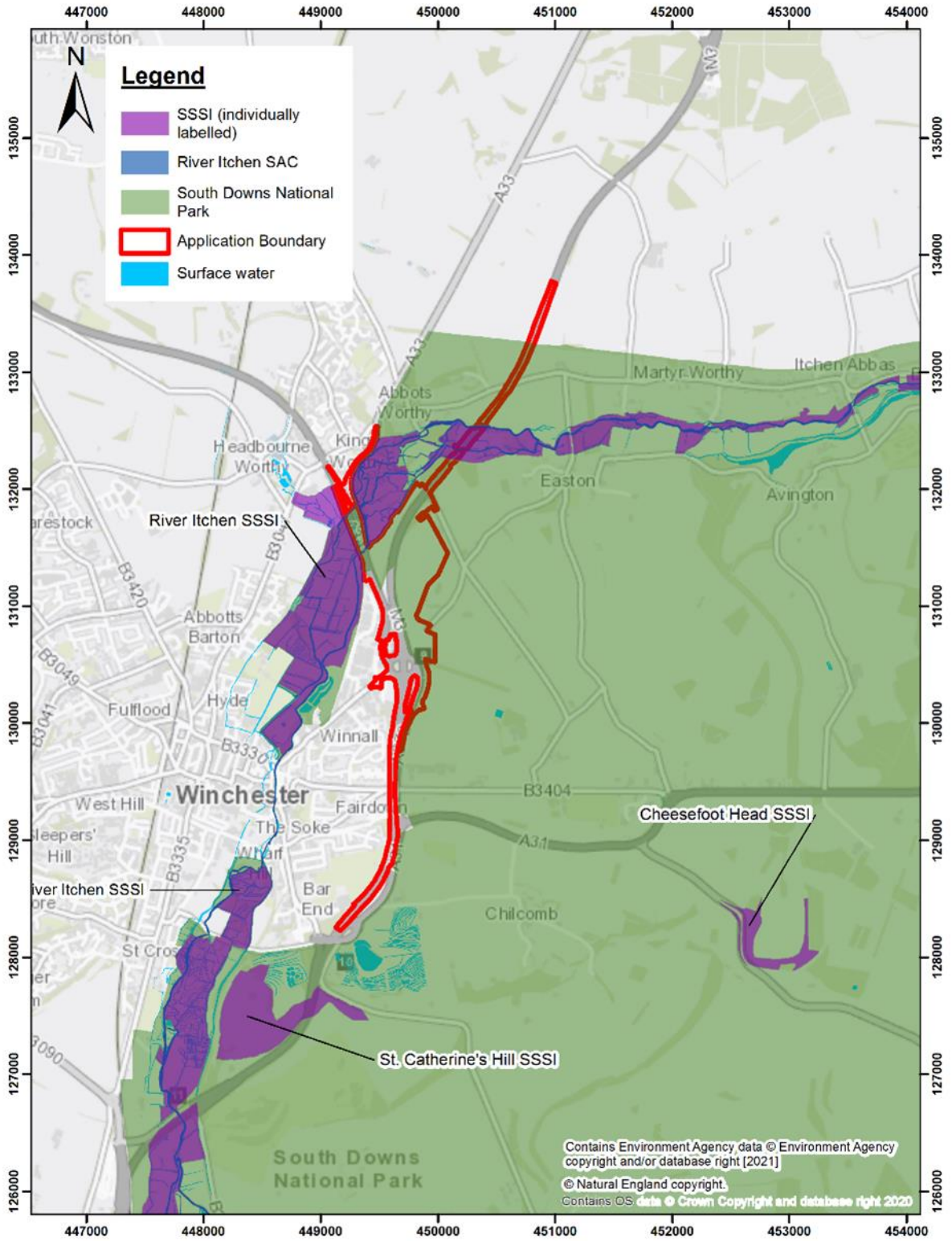


Table 3.15: Licenced groundwater and surface water abstractions

Supply Name		Licence number			Effective date	Purpose	Use	Source	Aquifer type	National Grid Reference
St Cross (Itchen)	31/086	23/04/1992	Aquaculture Fish	Fish Farm/Cress Pond Throughflow	Southern Region Surface Waters	-				SU47672741
Point A, Borehole At Garnier Road	SO/042/0031/019	17/02/2012	Aquaculture Fish	Fish Farm/Cress Pond Throughflow	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4811328115
Burntwood Farm, Martyr Worthy	11/42/22.5/76	23/12/1965	General Agriculture	General Farming & Domestic	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU50333501
Hazeley Estate, Twyford	11/42/22.6/89	23/12/1965	General Agriculture	General Farming & Domestic	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU51032729
Watercress Beds At Headbourne Worthy Point A	11/42/22.5/1	22/02/1966	Aquaculture Plant	Fish Farm/Cress Pond Throughflow	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4851732410

Supply Name		Licence number			Effective date	Purpose	Use	Source	Aquifer type	National Grid Reference
Watercress Beds At Headbourne Worthy Point B	11/42/22.5/1	22/02/1966	Aquaculture Plant	Fish Farm/Cress Pond Throughflow	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4853832428
Watercress Beds At Headbourne Worthy Point C	11/42/22.5/1	22/02/1966	Aquaculture Plant	Fish Farm/Cress Pond Throughflow	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4857832456
Watercress Beds At Headbourne Worthy Point D	11/42/22.5/1	22/02/1966	Aquaculture Plant	Fish Farm/Cress Pond Throughflow	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4861432487
Watercress Beds At Headbourne Worthy Point E	11/42/22.5/1	22/02/1966	Aquaculture Plant	Fish Farm/Cress Pond Throughflow	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4862732339
Watercress Beds At Headbourne Worthy Point F	11/42/22.5/1	22/02/1966	Aquaculture Plant	Fish Farm/Cress Pond Throughflow	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4863532303
Upper & Down Farms Point A, Headbourne Worthy	11/42/22.5/73	23/12/1965	General Agriculture	General Farming & Domestic	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU46983369

Supply Name		Licence number			Effective date	Purpose	Use	Source	Aquifer type	National Grid Reference
Upper & Down Farms Point B, Headbourne Worthy	11/42/22.5/73	23/12/1965	General Agriculture	General Farming & Domestic	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU48283246
Upper & Down Farms Point C, Headbourne Worthy	11/42/22.5/73	23/12/1965	General Agriculture	General Farming & Domestic	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU48493231
Point A Down Farm Hursley	31/108	22/07/2008	General Agriculture	General Farming & Domestic	Southern Region Groundwater	H5 Chalk				SU44402660
St Cross, Winchester (Itchen)	SO/042/0031/035	02/05/2014	Private Water Supply	Heat Pump	Southern Region Surface Waters	-				SU4765327288
Shawford Mill Headrace (Itchen Navigation)	SO/042/0031/018/R01	21/07/2020	Electricity	Hydroelectric Power Generation	Southern Region Surface Waters	-				SU4739724981
Carrier Channel (Itchen)	SO/042/0031/002	29/01/2010	Electricity	Hydroelectric Power Generation	Southern Region Surface Waters	-				SU5365232564

Supply Name		Licence number			Effective date	Purpose	Use	Source	Aquifer type	National Grid Reference
Twyford Ps Point D	11/42/22.6/92	26/11/1965	Public Water Supply	Potable Water Supply - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4824
Twyford Ps Point A	11/42/22.6/92	26/11/1965	Public Water Supply	Potable Water Supply - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4825
Twyford Ps Point C	11/42/22.6/92	26/11/1965	Public Water Supply	Potable Water Supply - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4924
Twyford Ps Point B	11/42/22.6/92	26/11/1965	Public Water Supply	Potable Water Supply - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4924
Itchen Valley Point D	11/42/22.4/80	26/11/1965	Public Water Supply	Potable Water Supply - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4932
Itchen Valley Point A	11/42/22.4/80	26/11/1965	Public Water Supply	Potable Water Supply - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU5032

Supply Name		Licence number			Effective date	Purpose	Use	Source	Aquifer type	National Grid Reference
Itchen Valley Point C	11/42/22.4/80	26/11/1965	Public Water Supply	Potable Water Supply - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU5032
Winnall Down Farm, Winchester	11/42/22.4/146	20/06/1977	General Agriculture	Spray Irrigation - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU50619929927
Hockley Golf Club	11/42/22.6/95	23/12/1965	Golf Courses	Spray Irrigation - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU48212642
Hockley Golf Club	11/42/22.6/95	23/12/1965	Golf Courses	Spray Irrigation - Direct	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU48212642
River Itchen At Shawford Park	SO/042/0031/003	09/10/2009	Remedial River/Wetland Support	Transfer Between Sources (Post Water Act 2003)	Southern Region Surface Waters	-				SU4740724753
Water Meadow Channel Off R Itchen	SO/042/0031/010	18/10/2010	Remedial River/Wetland Support	Transfer Between Sources (Post Water Act 2003)	Southern Region Surface Waters	-				SU4804127290

Supply Name		Licence number			Effective date	Purpose	Use	Source	Aquifer type	National Grid Reference
Lower Itchen Navigation At Shawford	SO/042/0031/020	27/03/2012	Non-Remedial River/Wetland Support	Transfer Between Sources (Pre Water Act 2003)	Southern Region Surface Waters	-				SU4711323809
Wellpoints At Winchester College	SO/042/0032/012	22/07/2020	Construction	Dewatering	Southern Region Groundwater	H5IT Itchen Chalk / UGS				SU4777928830

4 Conceptual site model

4.1 Sources

Carriageway drainage

4.1.1 Rainwater on the carriageway will wash any contaminants present into the drainage system. Contaminants may be in solution which are considered to provide an acute risk or sorbed onto solids which may present a chronic risk. The following pollutants have been identified by the HEWRAT (Highways England, 2015) as potential contaminants to receptors from road drainage schemes:

- Microplastics and other particulate matter (from brake and tyre wear)
- Soluble metals (copper and zinc)
- Sediment related pollutants associated with chronic pollution impacts (total copper, zinc, cadmium, PAH - including species pyrene, fluoranthene, anthracene and phenanthrene)

4.1.2 The drainage system discharges into the EDBs. Prior to entry into the EDBs large items are screened out within the lined Pollution Control Device (PCD) ditches and vertical separation forebays. Within the EDBs, finer suspended sediment will settle out as flow velocities diminish. EDBs 1, 3A and 4 are sealed and will not discharge to ground. There will also be an element of attenuation as soluble heavy metals and hydrocarbons will sorb onto sediment present within the EDBs.

4.1.3 Discharge from the lined EDBs is to the unlined EDBs 2, 3B, 3C, 5 and 6. Within these EDBs there will be secondary attenuation, settlement and filtration within vegetated EDBs which will contain both wet and dry habitats.

4.1.4 We note that un-lined EDB2 and EDB3C receive direct runoff from the carriageway via lined PCD ditches and forebays.

4.1.5 Sediment will not infiltrate through the superficial deposits or structureless chalk. Unless, the EDBs are constructed directly over transmissive fissures, we can expect there will be no infiltration of solids, even to structured chalk. Sediment (and any entrained contaminants) will remain trapped within the forebays or EDBs and be subject to periodic removal during maintenance events. Thus, it is contaminants that are directly soluble or that leach from the sediments within the EDBs that form the potential source of contamination for groundwater.

Placement of potentially contaminated materials via cut and fill operations

4.1.6 It is expected that much of the material excavated under the Scheme will be re-used as fill material to bring areas up to required levels. It is noted that a significant volume of material is required to raise levels in the eastern part of the Scheme.

4.1.7 As detailed in Section 3.2.2 this material may contain a proportion of Made Ground from previous road schemes.

Other sources of contamination

4.1.8 There are a number of potential sources of contamination within and adjacent to the Application Boundary. These include landfills, a former gasworks and ironworks, petrol stations, railways and land with mixed industrial use. Rainwater passing through these sources has the potential to leach contaminants into the groundwater.

4.2 Pathways

Unsaturated zone

4.2.1 Where the EDBs and retained highway soakaways are un-lined, they have the potential to discharge to ground. Site specific soil infiltration rates are presented in Section 3.4.3. On the basis of these limited data a maximum soil infiltration rate of 1 x 10-6 m/s was adopted for Alluvium, Head and Structured Chalk within 2 mbgl, and 1 x 10-5 m/s for Structured Chalk below 2 mbgl.

4.2.2 The other sources of contamination, including re-used material, may be located on superficial deposits or directly on the Chalk. Either way, contaminants will have to pass through the unsaturated zone to the water table.

4.2.3 Rainfall is estimated as 806 mm/a which represents a long-term average infiltration rate to the EDBs. So long as the unsaturated zone hydraulic conductivity is higher than this, recharge to the water table will occur. During storm events, when the EDBs become saturated, the infiltration rate could rise to a maximum rate that will be limited by the hydraulic conductivity of the underlying strata. However, such high infiltration rates will be relatively short lived as excess water within the EDBs will drain to surface water and it is expected that the EDBs will be dry for most of the time.

4.2.4 Within the unsaturated zone contaminant attenuation may occur. Attenuation comprises retardation and degradation processes. Heavy metals may be retarded via sorption. There are a number of mechanisms that control metal sorption which is often influenced by soil pH and redox conditions. Where sorption occurs due to cation exchange, the degree of sorption is influenced by the concentration gradient between the soluble contaminant and the solid matrix. If a more dilute flux subsequently passes through the unsaturated zone,

contaminants may de-sorb back into solution. Organic compounds, such as PAHs, adsorb onto clay particles and the sorption rate is largely controlled by the fraction of organic carbon present. Whilst this may be significant in alluvial material, chalk tends to have very low organic carbon contents and as such retardation may be limited. Organic compounds may also bio-degrade within the unsaturated zone.

Saturated zone

4.2.5 Once the contaminants reach the water table, they will migrate within the receiving groundwater, down the hydraulic gradient. Whilst the superficial deposits and structureless chalk may be saturated and act as contaminant transport pathways, contaminant transport will be greatest within fissures and fractures within the structured chalk.

4.2.6 Whilst it is possible that attenuation processes may occur during transport within fissured chalk, they tend to be relatively insignificant. The most likely process is diffusion from the fissure into the chalk matrix, which effectively retards contaminant migration within the Chalk. Given the difficulties in parameterising this process, it has conservatively been ignored for this assessment.

4.2.7 Estimating the volumetric flux in fissured chalk is difficult. Transmissivity data provides a weighted average of hydraulic conductivity in fissures and matrix and applying this across the entire chalk body provides a reasonable dilution estimate. However, in order to determine realistic travel times, it is often necessary to utilise very low effective porosity values. This latter parameter effectively determines the proportion of the chalk that is present as fissures where travel times can be very fast.

4.2.8 Based on the published chalk groundwater contours, the flow direction within the chalk is assessed as follows.

- Areas occupied by the EDBs and retained highway soakaways is to the southwest, towards the River Itchen
- Areas within the Itchen Valley (near Easton) PWS SPZ is to the northwest towards the PWS

Receptors

4.2.9 For the purposes of this assessment, the following receptors have been assessed.

- The water table is the receptor for Hazardous substances
- A distance of 50m from the Application Boundary is taken to be the receptor for non-hazardous pollutants

5 Groundwater Impact Assessment

5.1.1 The impact to groundwater from the developments in the Application Boundary has been assessed using the methodology outlined in Section 9.4 of the Preliminary Environmental Information Report (PEIR) (Stantec, 2021) and is detailed in **Table 5.1**. The receptor for all potential sources of contamination is groundwater.

5.2 Road drainage

5.2.1 The impact assessment has determined that, without mitigation, the road drainage has the potential to cause a significant impact (Moderate, Large or Very Large) on the groundwater receptor. To mitigate against the potential impacts, a DQRA will be undertaken to investigate the impact of the EBDs on the groundwater quality. This involves modelling of the EDBs following the Environment Agency Remedial Targets Methodology (RTM) approach. The findings of this modelling are provided in Section 6.3.

5.3 Filled areas

5.3.1 Soil samples from the Application Boundary were subject to geoenvironmental testing as detailed in the **Ground Investigation Report (Document Reference 7.11).** A comparison was made of the results to Generic Assessment Criteria which showed that the soils would not pose a hazard to human health. Water samples were also subject to testing. The water samples would contain any contaminants that have leached from the soils and are detailed in Section 3.4.6. These results were compared to EQS and DWS limits as part of a controlled waters risk assessment in **Chapter (Geology and Soils)** of the **ES (Document Reference 6.1)** which concluded that the risk to controlled waters was low.

Table 5.1: Summary of impacts

Source of Impact	Receptor	Pathways	Magnitude of impact	Value (sensitivity) of receptor/ resource	Potential degree of impact	Potential degree of impact following further assessment
Unlined EDBs 2, 3B & 3C	Groundwater	Unsaturated zone / saturated zone	Moderate (HEWRAT assessment is medium / high)	High	Moderate or Large	Yes – EBDs (the embedded mitigation) will prevent infiltration of solids and will sorb some contaminants. Further sorption and attenuation will occur in the unsaturated zone. It is demonstrated in the DQRA detailed in the next section that impacts are minor.

Source of Impact	Receptor	Pathways	Magnitude of impact	Value (sensitivity) of receptor/ resource	Potential degree of impact	Potential degree of impact following further assessment
Unlined EDBs 5 & 6	Groundwater	Unsaturated zone / saturated zone	Predominantly receive runoff from rural catchments to east of Application Boundary. – Negligible	High	Slight	N/A
Fill areas	Groundwater	Unsaturated zone / saturated zone	Soil and water testing on samples has shown no risk to human health or controlled waters. Negligible	High	Slight	N/A
Old petrol station	Groundwater	Unsaturated zone / saturated zone	Negligible	High	Slight	Investigation to determine if any tanks or residual contaminants in the ground
Operational petrol stations	Groundwater	Unsaturated zone / saturated zone	Negligible as any issues would be rapidly identified and remediated by	High	Slight	N/A

Source of Impact	Receptor	Pathways	Magnitude of impact	Value (sensitivity) of receptor/ resource	Potential degree of impact	Potential degree of impact following further assessment
			petrol station operator			
Historical land contamination	Groundwater	Unsaturated zone / saturated zone	Negligible as assessed by Controlled Waters Risk Assessment in **Chapter 9 (Geology and Soils)** of the **ES (Document Reference 6.1)**	High	Slight	N/A
Historical pollution events	Groundwater	Unsaturated zone / saturated zone	Negligible as short-lived events unlikely to cause gross contamination of groundwater	High	Slight	N/A

6 Detailed Quantitative Risk Assessment for EDBs

6.1 Introduction

6.1.1 Section 5 has identified a potential impact from the un-lined EDBs No's 2, 3B and 3C. The EDBs have been subject to a HEWRAT screening assessment. The results of the screening assessment are that all but one of the currently proposed EDBs have a 'medium risk' to groundwater and one has a high risk.

6.1.2 In accordance with the National Highways methodology these have been taken forward to a DQRA in order to provide a more robust assessment of the risk to the Chalk groundwater from these potential sources of contamination.

6.1.3 The DQRA follows the Remedial Targets Methodology (RTM) (Environment Agency, 2006). A Level 1 and Level 2 Assessment has been undertaken.

6.1.4 A Level 1 Assessment considers processes within the source term. For the acute source term, there is no process operating within the source term and the predicted concentrations will equal the source term concentrations. For the chronic source term, partitioning of the contaminants between soil and aqueous phase within the source term is taken into account and the estimated aqueous concentration is limited by the contaminants pure phase solubility.

6.1.5 A Level 2 Assessment considers attenuation processes within the unsaturated zone and dilution within the saturated zone. The input to the RTM is source concentrations for acute and chronic risk based on HEWRAT Step 2 output (i.e. representative concentrations within the EDBs). The output from the model is predicted concentrations at the identified groundwater receptors. These predicted concentrations are compared to receptor Target Concentrations. If the predicted concentration is lower than the Target Concentration, we conclude that the EDBs do not pose a risk to groundwater. Conversely, if they are higher, we conclude that they may pose a risk.

6.1.6 Modelling is undertaken using Stantec's (formally ESI) Risk Assessment Model (RAM) software (ESI, 2008). Electronic copies of the models are given in Appendix E.

6.1.7 The RAM software package, together with a number of groundwater risk assessment tools, has been benchmarked by ESI for the Environment Agency (ESI, 2001). Additionally, the equations used in RAM have been verified by comparison between direct evaluation of an analytical solution and the semi-analytic transform approach applied for more complex pathways, and by comparison with published solutions used for verification as part of the nuclear waste industry code comparison exercise INTRACOIN (Robinson & Hodgkinson, 1996).

6.2 Model Parameterisation

6.2.1 In the model, it is conservatively assumed that the EDBs are saturated for 50% of the year i.e. that the EDBs contain water for 6 months in each year and are dry of 6 months. During periods when the EDBs are saturated, the infiltration rate is limited to the maximum infiltration rate of the receiving strata. For the remaining 6 months of the year, it is assumed that there is no infiltration. The maximum infiltration rates are presented in **Table 6.1** and these rates are multiplied by 0.5 in the model to derive a conservatively appropriate annual average infiltration rate.

Table 6.1 Infiltration rates

Basin	Underlying geology	Infiltration rate into top of unsaturated zone (m/s)	Justification for infiltration rate
2	Alluvium, structured chalk,	1×10^{-6}	Calculated infiltration rate from **Ground Investigation Report (Document Reference 7.11)** for sediments
3B	Made Ground and head (base not penetrated)	1×10^{-6}	
3C	Made Ground, alluvium, structureless chalk and structured chalk.	1×10^{-6}	

6.2.2 The source geometry for each of the EDBs is given in **Table 6.2**. The area and width perpendicular to groundwater flow has been measured from GIS. The length is then obtained by dividing the width into the area. A sediment thickness of 1 m is assigned in order to estimate a volume.

Table 6.2: Source geometry

EDB	Parameter	Values	Units	Justification
All	Thickness	1	m	Parameter not used in model as a constant source (rather than declining source) assumed
2	Area	1351	m^2	Measured from GIS
	Width	55	m	Indicative measured width perpendicular to groundwater flow from plans (assumed to be rectangular in model)
	Length	24.6	m	Calculated from area divided by the width
3B	Area	2,046	m^2	Measured from GIS
	Width	93	m	Indicative measured width perpendicular to groundwater flow from plans (assumed to be rectangular in model)
	Length	22	m	Calculated from area divided by the width
3C	Area	4,205	m^2	Measured from GIS
	Width	150	m	Indicative measured width perpendicular to groundwater flow from plans (assumed to be rectangular in model)
	Length	28	m	Calculated from area divided by the width

6.2.3 Chronic source term concentrations are taken from the HEWRAT Step 2 output (i.e. representative concentrations within the EDBs) (**Table 6.3**). These represent soil concentrations within the sediments at the base of the EDBs. Following the RTM methodology, these are converted into aqueous concentrations on the basis of partitioning coefficients for solid and aqueous phases (**Table 6.5**) and the resulting aqueous concentration is limited by the contaminant solubility (**Table 6.6**). Acute source term concentrations are taken directly from HEWRAT Step 2 output (**Table 6.4**).

6.2.4 The attenuation parameters (**Table 6.5**) are also assigned for sorption within the unsaturated zone.

Table 6.3: Chronic Source terms (from HEWRAT)

	Sediment concentrations from HEWRAT assessment – 95th percentile (mg/kg)						
EDB	**Copper**	**Zinc**	**Cadmium**	**Pyrene**	**Fluoranthene**	**Anthracene**	**Phenanthrene**
2	968	3569	2	9.729	9.335	0.596	2.632
3B	1875	7101	3	9.729	9.335	0.596	2.632
3C	1875	7101	3	9.729	9.335	0.596	2.632

Table 6.4: Acute source term concentrations (from HEWRAT – 95th percentile (mg/l))

EDB	Copper	Zinc
2	0.069	0.255
3B	0.145	0.797
3C	0.145	0.797

Table 6.5: Attenuation parameters

Determinant	Parameter	Value	Units	Justification
Copper	Partition coefficient (Kd)	13,770	l/Kg	Mid-point of LandSim help
	Half life	No decay		-
Zinc	Partition coefficient (Kd)	301	l/Kg	Mid-point of LandSim help
	Half life	No decay		-
Cadmium	Partition coefficient (Kd)	751	l/Kg	Mid-point of LandSim help
	Half life	No decay		-
Pyrene	Partition coefficient (Koc)	6.8×10^4	l/Kg	USEPA (1999)
	Half life	1,925	days	Longest half life in Dallas et al (1999)
Fluoranthene	Partition coefficient (Koc)	4.91×10^4	l/Kg	USEPA (1999)
	Half life	462	days	Longest half life in Dallas et al (1999)

Determinant	Parameter	Value	Units	Justification
Anthracene	Partition coefficient (Koc)	2.35 x 10^4	l/Kg	USEPA (1999)
	Half life	365	days	Abiotic degradation rate Verschueren (2001)
Phenanthrene	Partition coefficient (Koc)	2.09 x 10^4	l/Kg	USEPA (1999)
	Half life	730	days	Abiotic degradation rate Verschueren (2001)

Table 6.6: Solubility parameters

Determinant	Solubility (mg/l)	Unit	Justification
Copper	2.93 x 10^5	mg/l	ConSim
Zinc	6.06 x 10^5	mg/l	ConSim
Cadmium	6.51 x 10^5	mg/l	ConSim
Pyrene	0.137	mg/l	USEPA (1999)
Fluoranthene	0.232	mg/l	USEPA (1999)
Anthracene	0.0537	mg/l	USEPA (1999)
Phenanthrene	1.28	mg/l	USEPA (1999)

6.2.5 The Target Concentrations are defined as follows (**Table 6.7**):

- Hazardous substances: UKTAG Concentrations in groundwater below which the danger of deterioration in the quality of the receiving groundwater is avoided (UKTAG, 2016)
- Non-hazardous pollutants: UK DWS taken from the 2016 Regulations, or 1989 Regulations as detailed in **Table 6.7**

Table 6.7: Target concentrations

Parameter	Value	Units	Justification
Copper	2	mg/l	Non-hazardous pollutant. The Water Supply (Water Quality) Regulations 2016
Zinc	5	mg/l	Non-hazardous pollutant. Water Supply (Water Quality Regulations) 1989

Parameter	Value	Units	Justification
Cadmium	5×10^{-3}	mg/l	Non-hazardous pollutant. The Water Supply (Water Quality) Regulations 2016
Pyrene	5×10^{-6}	mg/l	Hazardous substance. UKTAG Concentrations in groundwater below which the danger of deterioration in the quality of the receiving groundwater is avoided for benzo(a)pyrene.
Fluoranthene	5×10^{-5}	mg/l	Hazardous substance. UKTAG Concentrations in groundwater below which the danger of deterioration in the quality of the receiving groundwater is avoided for benzo(a)pyrene.
Anthracene	5×10^{-5}	mg/l	Hazardous substance. UKTAG Concentrations in groundwater below which the danger of deterioration in the quality of the receiving groundwater is avoided.
Phenanthrene	5×10^{-8}	mg/l	Hazardous substance. UKTAG Concentrations in groundwater below which the danger of deterioration in the quality of the receiving groundwater is avoided for benzo(a)pyrene.

6.2.6 Hydrogeological parameters are presented in **Table 6.8**. The Structured Chalk hydraulic conductivity and hydraulic gradient are used, along with the cross-sectional area, to calculate the groundwater flux. The groundwater flux is used to dilute non-hazardous pollutants.

6.2.7 The hydraulic conductivity of the fissured Chalk is likely to be significantly higher than the value of 1x10-5 m/s assigned in **Table 6.8** and, based on the data presented in Section 3.4.3, a value of between 1x10-5 m/s and 1x10-3 m/s may be more plausible. However, by using the value at the lower end of the plausible range, a conservative estimate for dilution is derived.

6.2.8 The effective porosity of the saturated zone is used to estimate travel times. For a Level 2 assessment only dilution is considered in the saturated zone, not attenuation, and so the travel time is for information only.

Table 6.8: Hydrogeology parameters

Parameter	Value	Unit	Justification
Hydraulic conductivity of Structured Chalk (saturated zone)	1×10^{-5}	m/s	Calculated infiltration rate from **Ground Investigation**

Parameter		Value	Unit	Justification
				Report (Document Reference 7.11).
Hydraulic gradient		0.0076	-	Based on topography in the area around the EDBs. From Lidar data
Effective porosity of aquifer	Unsaturated zone	0.1		Conservative assumption
	Saturated zone	0.01		Conservative assumption to ensure rapid travel time within fissured strata.
Unsaturated zone thickness	EDB 1	7.1	m	Based on average groundwater levels (see **Error! Reference source not found.**) and average elevation of EDB location
	EDB 2	13.1	m	Based on average groundwater levels (see **Error! Reference source not found.**) and average elevation of EDB location
	EDB 3B	5.8	m	Based on average groundwater levels (see **Error! Reference source not found.**) and average elevation of EDB location
	EDB 3C	3.8	m	Based on average groundwater levels (see **Error! Reference source not found.**) and average elevation of EDB location
Fraction of organic carbon – alluvial deposits		0.01	-	Assumption of 1%
Fraction of organic carbon – structureless Chalk deposits		0.001	-	Chalk has little organic carbon, so assigned 0.1%.
Unsaturated zone bulk density		2,385	kg/m^3	Estimated based on particle density of 2,650 and porosity of 0.1 (Freeze & Cherry, 1979)
Mixing depth		5	m	10 % of the travel distance (50 m)

6.3 Model Results

Level 1 Assessment

6.3.1 As detailed in **Section 6.1**, a Level 1 assessment considers processes operating within the source term.

Acute pollution from soluble contaminants

6.3.2 There are no processes operating in the source term for the acute source term. In this case an aqueous source term is considered, and these concentrations are compared directly with the Target Concentrations. The model has been run for EDBs 3B and 3C which have the highest source term concentrations. The predicted concentrations given in **Table 6.9** are the same as the source term concentrations given in **Table 6.4.** These concentrations are lower than the target concentrations given in **Table 6.7**. Thus, we conclude that the risk to groundwater from acute pollution within the EDBs is not significant.

Table 6.9: EDB2 Predicted concentrations (mg/l)

Copper	Zinc
1.450E-01	7.970E-01

Note blue cells below Target concentration, red cells above target concentration

Chronic pollution from sediments

6.3.3 For the chronic source term, following partitioning between the solid and aqueous phases within the EDB sediment, and limited by the pure phase solubility, **Table 6.10** shows that there is a predicted impact from zinc and all four PAH compounds. These determinants are therefore taken forward to the Level 2 assessment.

Table 6.10: EDB2 Predicted concentrations (mg/l)

Copper	Zinc	Cadmium	Pyrene	Fluoranthene	Anthracene	Phenanthrene
1.362E-01	2.359E+01	3.994E-03	1.431E-02	1.901E-02	2.536E-03	1.259E-02

Note blue cells below Target concentration, red cells above target concentration

Level 2 Assessment – chronic pollution

EDB 2

6.3.4 EDB 2 is located on alluvium overlying structured Chalk and it is estimated that the unsaturated zone thickness at this location is 13.1 m. The model predicts that no hazardous substances would be predicted to reach the water table at concentrations in excess of the Target Concentration and that there is no pollution by non-hazardous pollutants within 100 years (**Table 6.11**).

Table 6.11: EDB2 Predicted concentrations (mg/l)

Time(years)	Zinc	Pyrene	Fluoranthene	Anthracene	Phenanthrene
0.1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
100	2.134E-03	1.202E-21	4.616E-32	6.259E-26	4.661E-17

Note blue cells below Target concentration, red cells above target concentration

EDB 3B

6.3.5 EDB 3B is located on Made Ground and Head deposits and it is estimated that the unsaturated zone thickness at this location is 5.8 m. The model predicts that no hazardous substances would be predicted to reach the water table at concentrations in excess of the Target Concentration and that there is no pollution by non-hazardous pollutants within 100 years (**Table 6.12**).

Table 6.12: EDB3B Predicted concentrations (mg/l)

Time(years)	Zinc	Pyrene	Fluoranthene	Anthracene	Phenanthrene
0.1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10	4.616E-27	0.000E+00	0.000E+00	1.187E-27	5.555E-23
100	4.206E-01	4.070E-13	1.730E-21	1.019E-17	1.276E-11

Note blue cells below Target concentration, red cells above target concentration

EDB 3C

6.3.6 EDB 3C is located on Made Ground, Alluvium and Structureless Chalk deposits and it is estimated that the unsaturated zone thickness at this location is 3.8 m. The model predicts that no hazardous substances would be predicted to reach the water table at concentrations in excess of the Target Concentration and that there is no pollution by non-hazardous pollutants within 100 years (**Table 6.13**).

Table 6.13: EDB3C Predicted concentrations (mg/l)

Time(years)	Zinc	Pyrene	Fluoranthene	Anthracene	Phenanthrene
0.1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10	4.103E-17	0.000E+00	1.766E-34	7.760E-20	4.866E-16
100	3.338E+00	1.448E-10	1.711E-17	1.274E-14	1.393E-09

Note blue cells below Target concentration, red cells above target concentration

Sensitivity analysis

6.3.7 In order to demonstrate model sensitivity to key parameters, the EDB 3B base case model has been selected. We note that similar relative changes in predicted concentrations would be found for all the models and thus it is only necessary to run sensitivity analysis on one of the EDB models.

Fraction of organic carbon

6.3.8 The fraction of organic carbon is decreased by an order of magnitude from 0.01 to 0.001. The effect of this is to decrease retardation of organic compounds in the unsaturated zone by an order of magnitude, which allows less time for degradation to occur. Model results (**Table 6..14**) show that decreasing the fraction of organic carbon results in predicted concentrations rising by many orders of magnitude which demonstrates that the model is sensitive to this parameter. Pyrene and phenanthrene concentrations are predicted to be higher than the Target Concentration. Note that metals are not assessed as the model does not use fraction of organic carbon to estimate metal retardation rates.

Table 6.14: Sensitivity run 1: fraction of organic carbon (mg/l) at 100 years

	Target concentration	0.01 (base case)	0.001 (sens run 1)
Pyrene	5.000E-06	4.070E-13	8.102E-05
Fluoranthene	5.000E-05	1.730E-21	2.697E-07
Anthracene	5.000E-05	1.019E-17	8.754E-07

	Target concentration	0.01 (base case)	0.001 (sens run 1)
Phenanthrene	5.000E-06	1.276E-11	1.517E-04

Concentrations given in bold exceed the Target Concentration

Infiltration rate

6.3.9 In the base case model, the superficial strata hydraulic conductivity is assumed to be limiting the infiltration rate when the EDBs are full of water, and it is further considered that the EDBs are full of water for 50% of each year. For this sensitivity run, it is assumed that the EDBs are full of water for 100% of the year i.e. the infiltration rate is solely limited by the unsaturated zone hydraulic conductivity.

6.3.10 Model results (**Table 6.15**) shows that increasing the infiltration rate increases predicted concentrations. The reason for this is twofold. Firstly, for hazardous substances, the contaminants spend a shorter period within the unsaturated zone where they degrade. The retarded travel time non-hazardous pollutants through the unsaturated zone is decreased.

6.3.11 Secondly, for non-hazardous pollutants, the greater flux through the unsaturated zone results in a decrease in dilution applied at the water table.

6.3.12 The results show that the PAH compounds remain well below the Target Concentrations, but zinc is predicted to slightly exceed it.

Table 6.15: Sensitivity run 2a: infiltration rate and unsaturated zone hydraulic conductivity (mg/l) at 100 years

	Target concentration	50% (base case)	100% (sens run 2a)
Zinc	5.000E+00	4.206E-01	**7.894E+00**
Pyrene	5.000E-06	4.070E-13	2.678E-09
Fluoranthene	5.000E-05	1.730E-21	2.359E-15
Anthracene	5.000E-05	1.019E-17	5.761E-13
Phenanthrene	5.000E-06	1.276E-11	1.691E-08

Concentrations given in bold exceed the Target Concentration

Unsaturated zone thickness

6.3.13 For EDB 3B, the unsaturated zone has been estimated at 5.8 m thick. For this sensitivity run, the unsaturated zone thickness has been increased by 5 m to 10.8 m.

6.3.14 Model results (**Table 6.16**) show a decrease in concentrations for all contaminants. This is due to the longer travel time within the unsaturated zone pathway segment resulting in longer breakthrough times. We note that the maximum concentration (at any time) for the PAH compounds is reduced as the

longer time spent in the unsaturated zone provides more time for degradation. For zinc, however, which does not degrade, breakthrough would eventually occur to the same concentrations as in the base case model.

Table 6.16: Sensitivity run 3: unsaturated zone thickness (mg/l) at 100 years

	Target concentration	5.8 m (base case)	10.8 m (sens run 3)
Zinc	5.000E+00	4.206E-01	1.535E-03
Pyrene	5.000E-06	4.070E-13	5.244E-19
Fluoranthene	5.000E-05	1.730E-21	3.758E-29
Anthracene	5.000E-05	1.019E-17	1.144E-23
Phenanthrene	5.000E-06	1.276E-11	1.475E-15

7 Conclusions and recommendations

7.1 Conclusions

7.1.1 There are a number of potential sources of contamination within and adjacent to the Application Boundary. These include landfills, a former gasworks and ironworks, petrol stations, railways and land with mixed industrial uses. On the basis of the soil and water quality data obtained to date by the Scheme, these potential sources have been assessed as detailed in a Controlled Waters Risk Assessment in **Chapter 9 (Geology and Soils)** of the **ES (Document Reference 6.1)** and it was concluded that the potential for significant contamination to groundwater from these sources is low.

7.1.2 Some material will need to be excavated as part of the Scheme. It is envisaged that all this material will be used to raise levels along the eastern side of the Application Boundary and that there will be no surplus material from the Scheme.

7.1.3 GI has shown that there is a significant quantity of Made Ground within the Application Boundary, which is probably associated with previous road scheme construction.

7.1.4 On the basis of the soil and water quality data obtained to date by the Scheme, it is considered unlikely that placement of excavated material to raise levels will result in significant mobilisation of contamination. Thus, whilst no significant risk to human health or controlled waters is currently assessed for the in-situ materials, it is also considered that there will be no significant risk following excavation and placement.

7.1.5 The most significant risk to groundwater from the Scheme is considered to be the road drainage. Considerable thought has been put into designing an upgraded road drainage system, with as much drainage as possible captured and discharged to the EDBs. Where levels permit, discharge is routed first to a lined EDB for initial settlement and attenuation of contaminants, followed by discharge to un-lined and vegetated EDBs for further attenuation. Whilst the un-lined EDBs are designed to drain to ground, it is expected that a significant proportion of the discharge following storm events will be routed to the River Itchen.

7.1.6 A HEWRAT assessment has been undertaken for each of the EDBs. The results of the screening assessment show that all but one of the currently proposed Extended Detention Basins (EDT) have a ‘medium risk’ to groundwater and one has a high risk. In order to mitigate against the high risk EDB, it is proposed that this EDB will be lined, thus preventing discharge to groundwater. On this basis a DQRA has been undertaken to further assess the risk from the un-lined EDBs.

7.1.7 Acute risk from soluble contaminants present in the EDBs has been assessed as low. The contaminant concentrations in the EDBs, as derived from the HEWRAT assessment are below the UK DWS and thus pose no significant risk to groundwater.

7.1.8 The models demonstrate that none of the EDBs are likely to result in an impact on groundwater from determinants present within the sediment lining the base of the EDBs (chronic risk).

7.1.9 For the hazardous PAH compounds, the aqueous source term concentration leached from the EDB sediments is limited by the determinant pure phase solubility and the fact that these determinants are highly sorbed onto the sediment matrix. Thus, concentrations leaching from the sediment are modest. The model shows that there is likely to be a sufficient thickness of unsaturated zone, comprising material containing sufficient organic carbon, to provide sufficient attenuation and ensure that there is no discharge to the water table.

7.1.10 Copper and cadmium also sorb highly to the EDB sediment such that aqueous concentrations in the EDBs are unlikely to reach concentrations that would cause pollution of groundwater. Predicted aqueous source term zinc concentrations are higher, but attenuation within the unsaturated zone, combined with dilution in the receiving groundwater is sufficient to ensure there is no pollution by this determinant.

7.1.11 Sensitivity analysis has been undertaken of the DQRA models. These show that the models are sensitive to the faction of organic carbon (for organic compounds), infiltration rate and unsaturated zone thickness. Further data on these parameters should be collected as detailed in the next section.

7.2 Recommendations

7.2.1 Stantec has proposed additional GI at each of the EDBs. Geological data obtained from this GI will provide a better understanding of the superficial strata likely to underlie each of these structures. Once these data are available, the HgRA should be reviewed and updated based on the complete dataset.

7.2.2 A number of the boreholes will be completed as groundwater monitoring wells. Timeseries monitoring data will provide more confidence on the unsaturated zone thickness at each of these structures.

7.2.3 It is proposed to undertake soakaway tests at the proposed EDB locations. This will inform the understanding of the unsaturated zone hydraulic conductivity.

7.2.4 It is recommended that soil samples are taken from each of the strata encountered and subject to laboratory testing for fraction of organic carbon. These data can then be used to refine the DQRA model and inform predictions of the risk to groundwater from the Scheme's drainage design.

8 References

Allen, D. J., Brewerton, L. J., Coleby, L. M., Gibbs, B. R., Lewis, M. A., MacDonald, A. M., & Williams, A. T. (1997). The physical properties of major aquifers in England and Wales. British Geological Survey Technical Report WD/97/34.

Booth, K., Farrant, A. R., Hopson, P. M., Woods, M. A., Evans, D. J., & Wilskinson, I. (2008). Geology of the Winchester district. Sheet description of the British Geological Survey, 1:50 000 Series Sheet 299 (England and Wales).

British Geological Survey. (2002). Winchester. England and Wales Sheet 299. Solid and Drift Geology. 1:50 000. (Keyworth, Nottingham: British Geology Survey).

CIRIA. (2021). Contaminated Land Risk Assessment. A Guide to Good Practice.

Entec. (2002). River Itchen Catchment Groundwater Modelling Study Phase 2.

Envirocheck. (2016). Envirocheck Report, Site at Winnall Down Farm HampshireOrder Number 85178192_1_1 fo WSP.

Environment Agency. (2006). Remedial Targets Methodology. Hydrogeological Risk Assessment for Land Contamination.

Environment Agency. (2018). The Environment Agency's approach to groundwater protection V1.2.

Environment Agency. (2019). Guidance Groundwater source protection zones (SPZs). Retrieved August 2021, from https://www.gov.uk/guidance/groundwater-source-protection-zones-spzs

Environment Agency. (2021). https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm.

ESI. (2001). Benchmarking RAM: ESI'S Groundwater Risk Assessment Tool. Report Reference 5303R1D1.

ESI. (2008). RAM 3 User Guide.

Freeze, R. A., & Cherry, J. A. (1979). Groundwater. Prentice-Hall.

Highways England. (2015). HEWRAT V2.0 Help guide.

Institute of Geological Sciences and Southern Water Authority. (1979). Hydrogeological map of Hampshire and the Isle of Wight, Scale 1:100 000.

NRFA. (2021). 42016 - Itchen at Easton. Retrieved August 2021, from https://nrfa.ceh.ac.uk/data/station/spatial/42016

Reading Agricultural Consultants. (2021). Agricultural Land Classification and Soil Resources at M3 Junction 9 Winchester. For Stantec UK Limited.

Robinson, P. C., & Hodgkinson, D. P. (1996). Exact solutions for radionuclide transport in the presence of parameter uncertainty. Technical Report AERE R 12125. Harwell Laboratory, Oxfordshire.

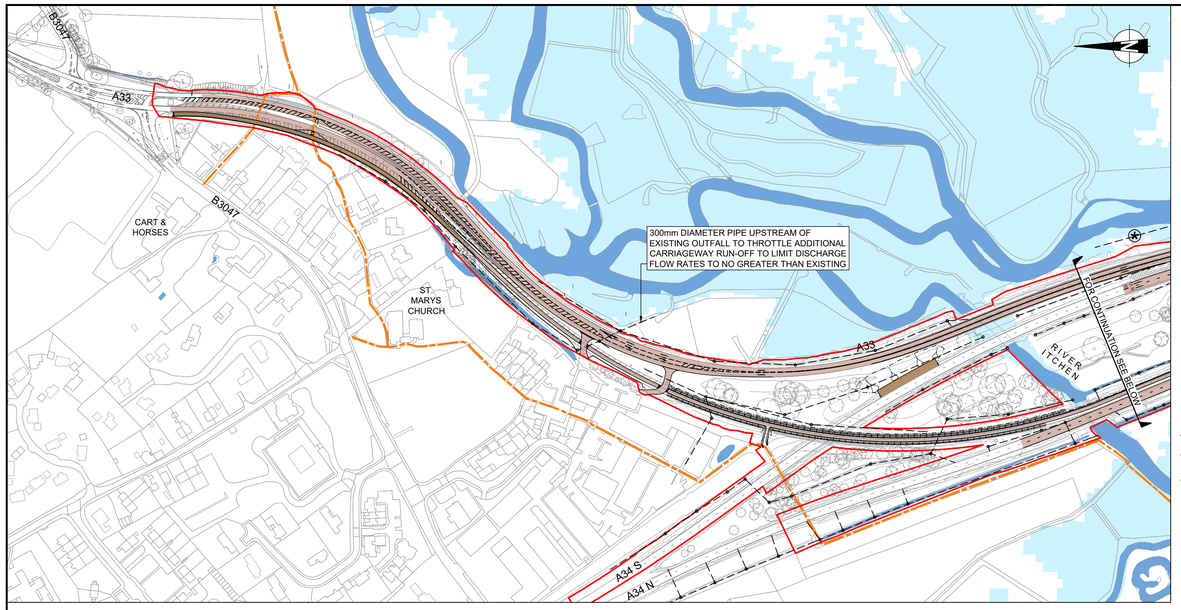
Stantec. (2021). M3 Junction 9 improvement scheme - Preliminary Environmental Information Report (PEIR).

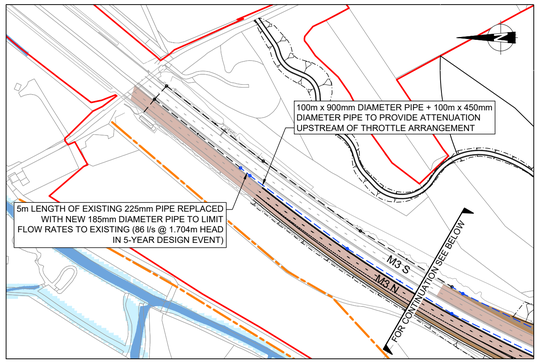
UKTAG. (2016). UK Technical Advisory Group on the Water Framework Directive: Technical report on Groundwater Hazardous Substances.

WPK. (2007). Wastewater discharges to ground Morestead Road Wastewater Treatment Works Groundwater Investigations - Interpretative Report prepared for Southern Water.

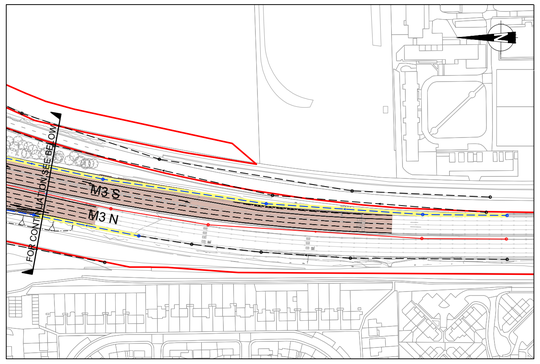
WSP. (2017). Preliminary Sources Study Report.

Appendix A HE551511-VFK-HDG-X_XXXX_XX-DR-CD-0512_Drainage Schematic Plan





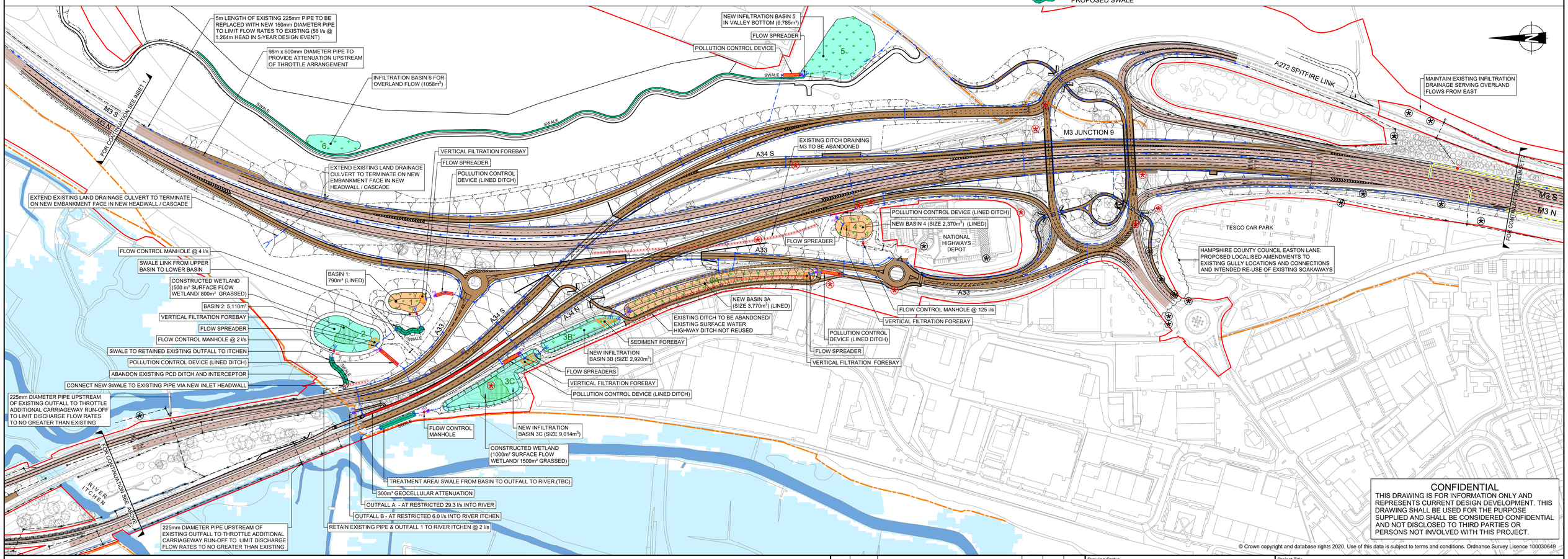
INSET 1: M3 NORTHBOUND CONTINUATION EXTRACT



INSET 2: M3 SOUTHBOUND CONTINUATION EXTRACT

KEY:

- DEVELOPMENT CONSENT ORDER BOUNDARY
- EXISTING FOOTPATH / PUBLIC RIGHT OF WAY
- PROPOSED HIGHWAY DRAINAGE NETWORK
- PROPOSED HIGHWAY DRAINAGE (INSTALLED AS PART OF M3 JUNCTION 9 TO 14 SAFETY BARRIER IMPROVEMENT SCHEME WORKS)
- PROPOSED ADDITIONAL DRAINAGE TO BE INSTALLED AS PART OF THE M3 JUNCTION 9 IMPROVEMENT SCHEME (FOLLOWING THE MANAGED MOTORWAY GOVERNMENT PAUSE)
- RETAINED EXISTING HIGHWAY DRAINAGE
- RIVER ITCHEN
- ENVIRONMENT AGENCY FLOOD ZONE 3 EXTENT
- PROPOSED GEOCELLULAR ATTENUATION
- 1 PROPOSED INFILTRATION BASIN AND REFERENCE NUMBER
- 4 PROPOSED LINED BASIN AND REFERENCE NUMBER
- PROPOSED GRASSED BASIN (ALL GRASSED EXCEPT BASIN 2 AND 3C)
- PROPOSED SWALE
- EXISTING CARRIAGEWAY AND DRAINAGE FEATURES TO BE RETAINED
- PROPOSED NEW CARRIAGEWAY / FOOTWAY / CYCLEWAY AREAS
- PS PROPOSED PENSTOCK
- PROPOSED SEDIMENT FOREBAY
- FC PROPOSED FLOW CONTROL MANHOLE
- EXISTING SOAKAWAY FEATURE REFURBISHED AND REUSED



NOTES:

1. THIS DRAWING SHOULD BE PRINTED IN COLOUR.
2. DO NOT SCALE FROM THIS DRAWING.
3. THE LAYOUT SHOWN IS PRELIMINARY AND SUBJECT TO DETAILED DESIGN.
4. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH ALL OTHER SGAR 3 SUBMISSION DRAWINGS AND DOCUMENTS.
5. FOR PROPOSED AND EXISTING HIGHWAY CATCHMENTS REFER TO DRAWING NUMBERS HE551511-VFK-HDG-X_XXXX_XX-DR-CD-0513 AND 0515 AND STANDARD NOTES.
6. FOR DETAIL OF M3 JUNCTION 9-14 MOTORWAY UPGRADE DRAINAGE DESIGN REFER TO MOTORWAY UPGRADE SCHEME DRAWING NUMBERS HE549338-MMSJV-HDG-000-DR-CD-31001 TO 31007.
7. PROPOSED DRAINAGE SCHEMATIC SHOWN IS SUBJECT TO REVIEW BY THE RESPECTIVE HIGHWAY AUTHORITIES, LEAD LOCAL FLOOD AUTHORITY AND THE ENVIRONMENT AGENCY.
8. PROPOSED RE-USE OF EXISTING DRAINAGE ASSETS IS SUBJECT TO REVIEW OF SURVEY DATA, ASSET RECORDS AND SITE VERIFICATION. THIS IS TO BE UNDERTAKEN DURING SGAR 5 (DETAILED DESIGN).
9. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH:
   - DRAINAGE STRATEGY REPORT REF: HE551511-VFK-HDG-X_XXXX_XX-RP-CD-0001
   - POLLUTION PREVENTION TECHNICAL NOTE REF: HE551511-VFK-HGN-X_XXXX_XX-TN-CH-0003
10. FIN DRAINS ARE NOT SHOWN ON THIS DRAWING. THESE SHALL BE DETAILED DURING SGAR 5 (DETAILED DESIGN).
11. CONTROL OF RUN-OFF AND SEDIMENT DURING CONSTRUCTION IS TO BE STRICTLY IN ACCORDANCE WITH THE CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN, WHICH MAY INCLUDE PIPES, SWALES AND BASINS NOT SHOWN ON THIS DRAWING. THIS IS TO BE DEVELOPED DURING SGAR 5 (DETAILED DESIGN).
12. PROPOSED FORM OF DRAINAGE SYSTEM REQUIRED TO COLLECT THE SURFACE WATER RUN-OFF FROM THE CARRIAGEWAY SURFACE (eg. GULLIES, FILTER DRAINS ETC.) IS TO BE DETERMINED DURING SGAR 5 (DETAILED DESIGN).

SEDIMENT FOREBAY AREA SCHEDULE

BASIN	FOREBAY AREA (m²)	FOREBAY DEPTH OF FREEBOARD (mm)
1	10	150
2	40	300
3A	40	300
3B	40	300
3C	135	300
4	36	300
5	36	300

0 50 100 150 200 250m

SCALE 1:2500

Rev.	Date	Description	Drawn	Chk'd	App'd
P04	10.06.22	UPDATED TO SUIT OMISSION OF MANAGED MOTORWAY SCHEME	JH	LC	TRA
P03	24.11.21	ISSUED FOR S3 SUBMISSION	ljj	AC	TRA
P02	15.10.21	UPDATES TO SUIT DESIGN DEVELOPMENT	RG	AC	TRA
P01	28.05.21	FIRST ISSUE	ME	AC	TRA

Drawing Status: S3 - FOR REVIEW & COMMENT

VolkerFitzpatrick

Client: national highways

Project Title: M3 JUNCTION 9 IMPROVEMENT

Drawing Title: SGAR 3 PRELIMINARY DESIGN PROPOSED SURFACE WATER DRAINAGE SCHEMATIC PLAN

Scale	Designed	Drawn	Checked	Approved
1:2500	PR	ME	AC	TRA
Original Size: Size	Date: 28.05.21	Date: 28.05.21	Date: 28.05.21	Date: 28.05.21

Drawing Number: HE PIN HE551511 - Originator VFK - Volume HDG - Location X_XXXX_XX - Type DR - Role CD - Number 0512

Project Ref. No.: 48176

Revision: P04

Appendix B HEWRAT screening assessments

EQS - Annual Average Concentration	Copper	Zinc	
Step 2	0.00	0.00	ug/l
Step 3	0.00	0.00	ug/l

Acute Impact	Copper	Zinc
	Pass	Pass

Alert. Protected Area.

Sediment deposition for this site is judged as:

Accumulating?	No	0.14	Low flow Vel m/s
Extensive?	No	-	Deposition Index

Road number		HE Area / DBFO number			
Assessment type	Non-cumulative assessment (single outfall)				
OS grid reference of assessment point (m)	Easting		Northing		
OS grid reference of outfall structure (m)	Easting		Northing		
Outfall number		List of outfalls in cumulative assessment			
Receiving watercourse					
EA receiving water Detailed River Network ID		Assessor and affiliation			
Date of assessment		Version of assessment			
Notes					

Step 1 Runoff Quality

AADT: >10,000 and <50,000 | Climatic region: Warm Wet | Rainfall site: Southampton (SAAR 820mm)

Step 2 River Impacts

(Enter zero in Annual Q_{95} river flow box to assess Step 1 runoff quality only)

Annual Q_{95} river flow (m^3/s)	2.8			
Impermeable road area drained (ha)	0.445	Freshwater EQS limits: Bioavailable dissolved copper (µg/l)	1	D
Permeable area draining to outfall (ha)	0.179	Bioavailable dissolved zinc (µg/l)	10.9	D
Base Flow Index (BFI)	0.89	Is the discharge in or within 1 km upstream of a protected site for conservation?	Yes	
For dissolved zinc only Water hardness	Medium = 50-200 CaCO3/l	**For dissolved copper only** Ambient background concentration (µg/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?			No	D
Tier 1 Estimated river width (m)	5			
Tier 2 Bed width (m)	17	Manning's n 0.07 D	Side slope (m/m) 0.5	Long slope (m/m) 0.0001

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0 D	No restriction D	0 D
Proposed measures		50	No restriction D	50

highways england

Reset GW Assessment | Go To Interface

Groundwater Assessment

Component Number		Weighting Factor	Property or Parameter	Risk Score	Component score	Weighted component score
1	SOURCE	10	Traffic flow	<=50,000 AADT	1	10
2		10	Rainfall depth (annual averages)	>740 to <1060 mm rainfall	2	20
3		10	Drainage area ratio	<=50	1	10
4	PATHWAY	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		20	Flow type (Incorporates flow type an effective grain size)	Flow dominated by fractures/ fissures (e.g. well consolidated sedimentary deposits, igneous and metamorphic rocks or unconsolidated deposits of very coarse sand and coarser)	3	60
7		5	Unsaturated Zone Clay Content	<=1% clay minerals	3	15
8		5	Organic Carbon	<=1% SOM	3	15
9		5	Unsaturated zone soil pH	pH <8 to >5	2	10

TOTAL SCORE	210
RISK SCREENING LEVEL	Medium

DETAILED RESULTS

Back To Top | Go To Interface

Summary of predictions

Prediction of impact	Soluble – Acute Impact: Copper	Zinc	Sediment – Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

In Runoff

Step 1

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
No. of exceedances/year	**67.90**	**62.20**
No. of exceedances/worst year	89	75
RST6 Allowable Exceedances/year	1	1
No. of exceedances/year	**21.70**	**25.30**
No. of exceedances/worst year	28	29
Thresholds RST24 (ug/l)	21	92
Thresholds RST6 (ug/l)	42	184
Event Statistics Mean	27.32	84.71
90%ile	52.94	172.88
95%ile	68.76	255.14
99%ile	113.86	446.19

Step 1 — Toxicity Threshold

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Allowable Exceedances/year	1	1	1	1	1	1	1	1
No. of exceedances/year	**75.30**	**98.00**	**1.50**	**17.00**	**56.00**	**17.00**	**14.80**	**31.10**
No. of exceedances/worst year	99	120	4	25	71	25	22	39
Toxicity Thresholds (mg/kg)	197	315	3.5	16770	875	2355	245	515
Mean	349	1168	1	11065	1914	1837	117	518
90%ile	786	2781	1	28184	4876	4679	299	1319
95%ile	968	3569	2	56234	9729	9335	596	2632
99%ile	1501	5477	4	112202	19411	18626	1189	5251

In River (no mitigation)

Step 2

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
No. of exceedances/year	**0**	**0**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
RST6 Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	**0**	**0**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.00	0.00
Thresholds RST24 (ug/l)	21	92
Thresholds RST6 (ug/l)	42	184
Event Statistics Mean	0.00	0.00
90%ile	0.00	0.00
95%ile	0.00	0.01
99%ile	0.01	0.02

Step 2

Velocity 0.14 m/s — Tier 2 is used for the calculation

DI -

Minimum % settlement needed - %

In River (with mitigation)

Step 3

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
No. of exceedances/year	**0.00**	**0.00**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0

DI -

highways england

View Parameters | Reset Spillage Risk | Go To Interface

		A (main road)	B	C	D	E	F
D1	Water body type	Surface watercourse					
D2	Length of road draining to outfall *(m)*	1,000					
D3	Road Type *(A-road or Motorway)*	A					
D4	If A road, is site urban or rural?	Rural					
D5	Junction type	Roundabout					
D6	Location (response time for emergency services)	< 1 hour					
D7	Traffic flow (AADT two way)	16,731					
D8	% HGV	15					
D8	Spillage factor *(no/10^9 HGVkm/year)*	3.09					
D9	Risk of accidental spillage	0.00283	0.00000	0.00000	0.00000	0.00000	0.00000
D10	Probability factor	0.60					
D11	Risk of pollution incident	0.00170	0.00000	0.00000	0.00000	0.00000	0.00000
D12	Is risk greater than 0.01?	**No**					
D13	Return period without pollution reduction measures	0.00170	0.00000	0.00000	0.00000	0.00000	0.00000
D14	Existing measures factor	0.7					
D15	Return period with existing pollution reduction	0.00119	0.00000	0.00000	0.00000	0.00000	0.00000
D16	Proposed measures factor	0.6					
D17	Residual with proposed Pollution reduction measures	0.00071	0.00000	0.00000	0.00000	0.00000	0.00000

Totals	Return Period
0.0017	589
0.0012	841
0.0007	1402

Justification for choice of existing measures factors

Justification for choice of proposed measures factors

Spillage Factor

Location	Serious Accidental Spillages (Billion HGV km/year)	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Indicative Pollution Risk Reduction Factors for Spillages

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

Runoff to Watercourses

Basin 2 HEWRAT

Infiltration to Groundwater

Basin 2 HEWRAT

highways england

Highways England Water Risk Assessment Tool

Version 2.0.4 June 2019

Soluble

EQS - Annual Average Concentration

	Copper	Zinc	
Step 2	0.00	0.00	ug/l
Step 3	0.00	0.00	ug/l

Acute Impact

Copper	Zinc
Pass	Pass

Sediment – Chronic Impact

Alert. Protected Area.

Sediment deposition for this site is judged as:

Accumulating?	No	0.14	Low flow Vel m/s
Extensive?	No	-	Deposition Index

Road number		HE Area / DBFO number	
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting	Northing	
OS grid reference of outfall structure (m)	Easting	Northing	
Outfall number		List of outfalls in cumulative assessment	
Receiving watercourse			
EA receiving water Detailed River Network ID		Assessor and affiliation	
Date of assessment		Version of assessment	
Notes			

Step 1 Runoff Quality

AADT: >10,000 and <50,000 | Climatic region: Warm Wet | Rainfall site: Southampton (SAAR 820mm)

Step 2 River Impacts

(Enter zero in Annual Q_{95} river flow box to assess Step 1 runoff quality only)

Annual Q_{95} river flow (m^3/s)	2.6
Impermeable road area drained (ha)	1.24
Permeable area draining to outfall (ha)	0.595
Base Flow Index (BFI)	0.89

Freshwater EQS limits:

Bioavailable dissolved copper (µg/l)	1
Bioavailable dissolved zinc (µg/l)	10.9

Is the discharge in or within 1 km upstream of a protected site for conservation? Yes

For dissolved zinc only — Water hardness: Medium = 50-200 CaCO3 mg/l

For dissolved copper only — Ambient background concentration (µg/l): 0

For sediment impact only — Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No

- ○ Tier 1 — Estimated river width (m): 5
- ◉ Tier 2 — Bed width (m): 17; Manning's n: 0.07; Side slope (m/m): 0.5; Long slope (m/m): 0.0001

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0	No restriction	0
Proposed measures		50	No restriction	50

Reset GW Assessment | Go To Interface

Groundwater Assessment

Component Number		Weighting Factor	Property or Parameter	Risk Score	Component score	Weighted component score
1	SOURCE	10	Traffic flow	<=50,000 AADT	1	10
2		10	Rainfall depth (annual averages)	>740 to <1060 mm rainfall	2	20
3		10	Drainage area ratio	<=50	1	10
4	PATHWAY	15	Infiltration method	"Region", shallow infiltration systems (e.g. infiltration basin)	2	30
5		20	Unsaturated zone	Depth to water table <=5 m	3	60
6		20	Flow type (Incorporates flow type an effective grain size)	Dominantly intergranular flow (e.g. non-fractured consolidated deposits or unconsolidated deposits of fine-medium sand or finer)	1	20
7		5	Unsaturated Zone Clay Content	<=1% clay minerals	3	15
8		5	Organic Carbon	<=1% SOM	3	15
9		5	Unsaturated zone soil pH	pH <8 to >5	2	10

TOTAL SCORE	190
RISK SCREENING LEVEL	Medium

Runoff to Watercourses

Basin 2 HEWRAT

Spillage Risks

Basin 2 HEWRAT

DETAILED RESULTS

Back To Top | Go To Interface

In Runoff

Step 1

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
RST24 No. of exceedances/year	67.90	62.20
RST24 No. of exceedances/worst year	83	75
RST6 Allowable Exceedances/year	1	1
RST6 No. of exceedances/year	21.70	25.30
RST6 No. of exceedances/worst year	28	23
Thresholds RST24 (ug/l)	21	32
Thresholds RST6 (ug/l)	42	184
Event Statistics Mean	27.32	84.71
90%ile	52.94	172.88
95%ile	68.76	255.14
99%ile	113.86	446.19

Step 1

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Toxicity Threshold	1	1	1	1	1	1	1	1
	75.30	38.00	1.50	17.00	56.00	17.00	14.80	31.10
	33	120	4	25	71	25	22	33
Toxicity (mg/kg)	197	315	3.5	16770	875	2355	245	515
	349	1168	1	11065	1314	1837	117	518
	786	2761	1	28184	4876	4673	233	1319
	968	3569	2	56234	3729	3335	536	2632
	1501	5477	4	112202	19411	18626	1189	5251

In River (no mitigation)

Step 2

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
RST24 No. of exceedances/year	0	0
RST24 No. of exceedances/worst year	0	0
RST24 No. of exceedances/summer	0	0
RST24 No. of exceedances/worst summer	0	0
RST6 Allowable Exceedances/year	0.5	0.5
RST6 No. of exceedances/year	0	0
RST6 No. of exceedances/worst year	0	0
RST6 No. of exceedances/summer	0	0
RST6 No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.00	0.00
Thresholds RST24 (ug/l)	21	32
Thresholds RST6 (ug/l)	42	184
Event Statistics Mean	0.00	0.00
90%ile	0.00	0.01
95%ile	0.01	0.02
99%ile	0.02	0.07

Step 2

Velocity: 0.14 m/s — Tier 2 is used for the calculation

DI: -

Minimum % settlement needed: - %

In River (with mitigation)

Step 3

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
RST24 No. of exceedances/year	0.00	0.00
RST24 No. of exceedances/worst year	0	0
RST24 No. of exceedances/summer	0	0
RST24 No. of exceedances/worst summer	0	0
RST6 Allowable Exceedances/year	0.5	0.5
RST6 No. of exceedances/year	0.00	0.00
RST6 No. of exceedances/worst year	0	0
RST6 No. of exceedances/summer	0	0
RST6 No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.00	0.00
Thresholds reshold RST24 (ug/l)	21	32
Thresholds RST6 (ug/l)	42	184

DI: -

highways england

View Parameters | Reset Spillage Risk | Go To Interface

		A (main road)	B	C	D	E	F	Totals	Return Period
D1	Water body type	Surface watercourse							
D2	Length of road draining to outfall *(m)*	1,000							
D3	Road Type *(A-road or Motorway)*	M							
D4	If A road, is site urban or rural?	Rural							
D5	Junction type	Roundabout							
D6	Location (response time for emergency services)	> 1 hour							
D7	Traffic flow (AADT two way)	50,000							
D8	% HGV	15							
D8	Spillage factor *(no/10^3 HGVkm/year)*	3.09							
D9	Risk of accidental spillage	0.00846	0.00000	0.00000	0.00000	0.00000	0.00000		
D10	Probability factor	0.75							
D11	Risk of pollution incident	0.00634	0.00000	0.00000	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	No							
D13	Return period without pollution reduction measures	0.00634	0.00000	0.00000	0.00000	0.00000	0.00000	0.0063	158
D14	Existing measures factor	0.7							
D15	Return period with existing pollution reduction	0.00444	0.00000	0.00000	0.00000	0.00000	0.00000	0.0044	225
D16	Proposed measures factor	0.6							
D17	Residual with proposed Pollution reduction measures	0.00266	0.00000	0.00000	0.00000	0.00000	0.00000	0.0027	375

Justification for choice of existing measures factors

Justification for choice of proposed measures factors

Spillage Factor

Location	Serious Accidental Spillages (Billion HGV km/year)	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Indicative Pollution Risk Reduction Factors for Spillages

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

Runoff to Watercourses

Basin 3A HEWRAT

Highways England Water Risk Assessment Tool

Version 2.0.4 June 2019

Soluble

EQS - Annual Average Concentration

	Copper	Zinc	
Step 2	0.00	0.02	ug/l
Step 3	0.00	0.01	ug/l

Acute Impact

Copper	Zinc
Pass	Pass

Sediment – Chronic Impact

Alert. Protected Area.

Sediment deposition for this site is judged as:

Accumulating?	No	0.14	Low flow Vel m/s
Extensive?	No	-	Deposition Index

Road number		HE Area / DBFO number			
Assessment type	Non-cumulative assessment (single outfall)				
OS grid reference of assessment point (m)	Easting		Northing		
OS grid reference of outfall structure (m)	Easting		Northing		
Outfall number		List of outfalls in cumulative assessment			
Receiving watercourse					
EA receiving water Detailed River Network ID		Assessor and affiliation			
Date of assessment		Version of assessment			
Notes					

Step 1 Runoff Quality

AADT: >=100,000 | Climatic region: Warm Wet | Rainfall site: Southampton (SAAR 820mm)

Step 2 River Impacts

(Enter zero in Annual Q_{95} river flow box to assess Step 1 runoff quality only)

Annual Q_{95} river flow (m^3/s)	2.6	Freshwater EQS limits:	
Impermeable road area drained (ha)	5.856	Bioavailable dissolved copper (µg/l)	1 D
Permeable area draining to outfall (ha)	0.435	Bioavailable dissolved zinc (µg/l)	10.9 D
Base Flow Index (BFI)	0.89	Is the discharge in or within 1 km upstream of a protected site for conservation?	Yes
For dissolved zinc only Water hardness	Medium = 50-200 CaCO3/l	**For dissolved copper only** Ambient background concentration (µg/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?			No D
Tier 1 Estimated river width (m)	5		
Tier 2 Bed width (m)	17	Manning's n: 0.07 D; Side slope (m/m): 0.5; Long slope (m/m): 0.0001	

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0 D	No restriction D	0 D
Proposed measures		50	No restriction D	50

Basin 3A HEWRAT Infiltration to Groundwater

Basin 3A HEWRAT

Reset GW Assessment | Go To Interface

Groundwater Assessment

Component Number		Weighting Factor	Property or Parameter	Risk Score	Component score	Weighted component score
1	SOURCE	10	Traffic flow	>=100,000 AADT	3	30
2		10	Rainfall depth (annual averages)	>740 to <1060 mm rainfall	2	20
3		10	Drainage area ratio	>50 to <150	2	20
4	PATHWAY	15	Infiltration method	"Region", shallow infiltration systems (e.g. infiltration basin)	2	30
5		20	Unsaturated zone	Depth to water table <=5 m	3	60
6		20	Flow type (Incorporates flow type an effective grain size)	Flow dominated by fractures/ fissures (e.g. well consolidated sedimentary deposits, igneous and metamorphic rocks or unconsolidated deposits of very coarse sand and coarser)	3	60
7		5	Unsaturated Zone Clay Content	<=1% clay minerals	3	15
8		5	Organic Carbon	<=1% SOM	3	15
9		5	Unsaturated zone soil pH	pH <8 to >5	2	10

TOTAL SCORE	260
RISK SCREENING LEVEL	High

Runoff to Watercourses

Basin 3A HEWRAT Spillage Risks

Basin 3A HEWRAT

DETAILED RESULTS | Back To Top | Go To Interface

Summary of predictions

Soluble – Acute Impact: Copper, Zinc

Sediment – Chronic Impact: Copper, Zinc, Cadmium, Total PAH, Pyrene, Fluoranthene, Anthracene, Phenanthrene

Prediction of impact: Step1, Step2, Step3

In Runoff

Step 1

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	**111.10**	**115.70**
No. of exceedances/worst year	134	143

RST6

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	**70.70**	**89.80**
No. of exceedances/worst year	91	113

		Copper [ug/l]	Zinc [ug/l]
Thresholds	RST24	21	92
Thresholds	RST6	42	184
Event Statistics	Mean	57.52	264.56
	90%ile	111.45	539.33
	95%ile	144.76	736.85
	99%ile	233.71	1393.53

Step 1

Toxicity Threshold

	Copper [mg/kg]	Zinc [mg/kg]	Cadmium [mg/kg]	Total PAH [ug/kg]	Pyrene [ug/kg]	Fluoranthene [ug/kg]	Anthracene [ug/kg]	Phenanthrene [ug/kg]
Toxicity	1	1	1	1	1	1	1	1
	113.50	124.90	6.30	17.00	56.00	17.00	14.80	31.10
	147	152	11	25	71	25	22	33
	766	2676	1	11065	1914	1837	117	518
	1573	5762	3	28184	4876	4679	299	1319
	1875	7101	3	56234	9729	9335	596	2632
	2727	10215	5	112202	19411	18626	1189	5251

In River (no mitigation)

Step 2

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	**0**	**0**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0

RST6

	Copper	Zinc
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	**0**	**0**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.00	0.02

		Copper [ug/l]	Zinc [ug/l]
Thresholds	RST24	21	92
Thresholds	RST6	42	184
Event Statistics	Mean	0.02	0.07
	90%ile	0.04	0.17
	95%ile	0.08	0.31
	99%ile	0.23	0.93

Step 2

Velocity: 0.14 m/s — Tier 2 is used for the calculation

DI: -

Minimum % settlement needed: - %

In River (with mitigation)

Step 3

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	**0.00**	**0.00**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0

DI: -

RST6

	Copper	Zinc
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	**0.00**	**0.00**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0

View Parameters | Reset Spillage Risk | Go To Interface

		A (main road)	B	C	D	E	F
D1	Water body type	Surface watercourse					
D2	Length of road draining to outfall (m)	2,250					
D3	Road Type (A-road or Motorway)	A					
D4	If A road, is site urban or rural?	Rural					
D5	Junction type	Roundabout					
D6	Location (response time for emergency services)	< 1 hour					
D7	Traffic flow (AADT two way)	28,000					
D8	% HGV	15					
D8	Spillage factor ($no/10^9$ HGVkm/year)	3.09					
D9	Risk of accidental spillage	0.01066	0.00000	0.00000	0.00000	0.00000	0.00000
D10	Probability factor	0.60					
D11	Risk of pollution incident	0.00639	0.00000	0.00000	0.00000	0.00000	0.00000
D12	Is risk greater than 0.01?	No					
D13	Return period without pollution reduction measures	0.00639	0.00000	0.00000	0.00000	0.00000	0.00000
D14	Existing measures factor	0.6					
D15	Return period with existing pollution reduction	0.00384	0.00000	0.00000	0.00000	0.00000	0.00000
D16	Proposed measures factor	0.4					
D17	Residual with proposed Pollution reduction measures	0.00153	0.00000	0.00000	0.00000	0.00000	0.00000

Totals	Return Period
0.0064	156
0.0038	261
0.0015	652

Justification for choice of existing measures factors:

Justification for choice of proposed measures factors:

Spillage Factor

Location	Serious Accidental Spillages (Billion HGV km/ year)	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Indicative Pollution Risk Reduction Factors for Spillages

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

highways england

Highways England Water Risk Assessment Tool

Version 2.0.4 June 2019

Soluble – EQS - Annual Average Concentration	Copper	Zinc		Soluble – Acute Impact	Copper	Zinc	Sediment – Chronic Impact
Step 2	0.00	0.02	ug/l		Pass	Pass	Alert, Protected Area.
Step 3	0.00	0.01	ug/l				Sediment deposition for this site is judged as:
							Accumulating? No 0.14 Low flow Vel m/s
							Extensive? No - Deposition Index

Road number		HE Area / DBFO number	
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting	Northing	
OS grid reference of outfall structure (m)	Easting	Northing	
Outfall number		List of outfalls in cumulative assessment	
Receiving watercourse			
EA receiving water Detailed River Network ID		Assessor and affiliation	
Date of assessment		Version of assessment	
Notes			

Step 1 Runoff Quality

AADT: >=100,000 | Climatic region: Warm Wet | Rainfall site: Southampton (SAAR 820mm)

Step 2 River Impacts

(Enter zero in Annual Q_{95} river flow box to assess Step 1 runoff quality only)

Annual Q_{95} river flow (m^3/s)	2.6	
Impermeable road area drained (ha)	6.147	
Permeable area draining to outfall (ha)	0.685	
Base Flow Index (BFI)	0.89	

Freshwater EQS limits:

Bioavailable dissolved copper (µg/l)	1
Bioavailable dissolved zinc (µg/l)	10.9

Is the discharge in or within 1 km upstream of a protected site for conservation? Yes

For dissolved zinc only — Water hardness: Medium = 50-200 CaCO3/l

For dissolved copper only — Ambient background concentration (µg/l): 0

For sediment impact only — Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No

Tier 1 — Estimated river width (m): 5

Tier 2 — Bed width (m): 17 | Manning's n: 0.07 | Side slope (m/m): 0.5 | Long slope (m/m): 0.0001

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0	No restriction	0
Proposed measures		50	No restriction	50

highways england

Reset GW Assessment | Go To Interface

Groundwater Assessment

Component Number		Weighting Factor	Property or Parameter	Risk Score	Component score	Weighted component score
1	SOURCE	10	Traffic flow	>=100,000 AADT	3	30
2		10	Rainfall depth (annual averages)	>740 to <1060 mm rainfall	2	20
3		10	Drainage area ratio	<=50	1	10
4	PATHWAY	15	Infiltration method	"Region", shallow infiltration systems (e.g. infiltration basin)	2	30
5		20	Unsaturated zone	Depth to water table <=5 m	3	60
6		20	Flow type (Incorporates flow type an effective grain size)	Dominantly intergranular flow (e.g. non-fractured consolidated deposits or unconsolidated deposits of fine-medium sand or finer)	1	20
7		5	Unsaturated Zone Clay Content	<=1% clay minerals	3	15
8		5	Organic Carbon	<=1% SOM	3	15
9		5	Unsaturated zone soil pH	pH <8 to >5	2	10

TOTAL SCORE	210
RISK SCREENING LEVEL	Medium

DETAILED RESULTS

Back To Top | Go To Interface

Summary of predictions

Soluble – Acute Impact: Copper | Zinc

Sediment – Chronic Impact: Copper | Zinc | Cadmium | Total PAH | Pyrene | Fluoranthene | Anthracene | Phenanthrene

Prediction of impact: Step 1 / Step 2 / Step 3

In Runoff

Step 1

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	111.10	115.70
No. of exceedances/worst year	134	143

RST6

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	70.70	89.80
No. of exceedances/worst year	91	113

		Copper (ug/l)	Zinc (ug/l)
Thresholds	RST24	21	92
Thresholds	RST6	42	184
Event Statistics	Mean	57.52	264.56
	90%ile	111.45	533.93
	95%ile	144.76	796.85
	99%ile	239.71	1393.53

Step 1

Toxicity Threshold

	Copper (mg/kg)	Zinc (mg/kg)	Cadmium (mg/kg)	Total PAH (ug/kg)	Pyrene (ug/kg)	Fluoranthene (ug/kg)	Anthracene (ug/kg)	Phenanthrene (ug/kg)
	1	1	1	1	1	1	1	1
	113.50	124.90	6.30	17.00	56.00	17.00	14.80	31.10
	147	152	11	25	71	25	22	33
Toxicity	137	315	3.5	16770	875	2355	245	515
	766	2676	1	11065	1914	1837	117	518
	1573	5762	3	28184	4876	4673	299	1319
	1875	7101	3	56234	3723	3335	536	2632
	2727	10215	5	112202	19411	18626	1189	5251

In River (no mitigation)

Step 2

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0

RST6

	Copper	Zinc
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.00	0.02

		Copper (ug/l)	Zinc (ug/l)
Thresholds	RST24	21	92
Thresholds	RST6	42	184
Event Statistics	Mean	0.02	0.08
	90%ile	0.04	0.18
	95%ile	0.08	0.32
	99%ile	0.25	1.04

Step 2

Velocity: 0.14 m/s — Tier 2 is used for the calculation

DI: -

Minimum % settlement needed: - %

In River (with mitigation)

Step 3

RST24

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	0.00	0.00
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0

DI: -

RST6

	Copper	Zinc
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	0.00	0.00
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0

highways england

View Parameters | Reset Spillage Risk | Go To Interface

		A (main road)	B	C	D	E	F
D1	Water body type	Surface watercourse					
D2	Length of road draining to outfall *(m)*	2,600					
D3	Road Type *(A-road or Motorway)*	A					
D4	If A road, is site urban or rural?	Rural					
D5	Junction type	Roundabout					
D6	Location (response time for emergency services)	< 1 hour					
D7	Traffic flow (AADT two way)	28,000					
D8	% HGV	15					
D8	Spillage factor *(no/10^8 HGVkm/year)*	3.09					
D9	Risk of accidental spillage	0.01232	0.00000	0.00000	0.00000	0.00000	0.00000
D10	Probability factor	0.60					
D11	Risk of pollution incident	0.00739	0.00000	0.00000	0.00000	0.00000	0.00000
D12	Is risk greater than 0.01?	No					
D13	Return period without pollution reduction measures	0.00739	0.00000	0.00000	0.00000	0.00000	0.00000
D14	Existing measures factor	0.6					
D15	Return period with existing pollution reduction	0.00443	0.00000	0.00000	0.00000	0.00000	0.00000
D16	Proposed measures factor	0.4					
D17	Residual with proposed Pollution reduction measures	0.00177	0.00000	0.00000	0.00000	0.00000	0.00000

	Totals	Return Period
	0.0074	135
	0.0044	226
	0.0018	564

Justification for choice of existing measures factors

Justification for choice of proposed measures factors

Spillage Factor

Location	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Indicative Pollution Risk Reduction Factors for Spillages

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

Runoff to Watercourses

Basin 3C HEWRAT

Highways England Water Risk Assessment Tool

Version 2.0.4 June 2019

Soluble

EQS - Annual Average Concentration

	Copper	Zinc	
Step 2	0.00	0.02	ug/l
Step 3	0.00	0.01	ug/l

Acute Impact

Copper	Zinc
Pass	Pass

Sediment - Chronic Impact

Alert. Protected Area.

Sediment deposition for this site is judged as:

Accumulating?	No	0.14	Low flow Vel m/s
Extensive?	No	-	Deposition Index

Road number		HE Area / DBFO number			
Assessment type	Non-cumulative assessment (single outfall)				
OS grid reference of assessment point (m)	Easting		Northing		
OS grid reference of outfall structure (m)	Easting		Northing		
Outfall number		List of outfalls in cumulative assessment			
Receiving watercourse					
EA receiving water Detailed River Network ID		Assessor and affiliation			
Date of assessment		Version of assessment			
Notes					

Step 1 Runoff Quality

AADT: >=100,000 | Climatic region: Warm Wet | Rainfall site: Southampton (SAAR 820mm)

Step 2 River Impacts

(Enter zero in Annual Q_{95} river flow box to assess Step 1 runoff quality only)

Annual Q_{95} river flow (m^3/s)	2.6	
Impermeable road area drained (ha)	7.107	
Permeable area draining to outfall (ha)	1.072	
Base Flow Index (BFI)	0.89	

Freshwater EQS limits:

Bioavailable dissolved copper (µg/l)	1	D
Bioavailable dissolved zinc (µg/l)	10.9	D

Is the discharge in or within 1 km upstream of a protected site for conservation? Yes

For dissolved zinc only — Water hardness: Medium = 50-200 CaCO3/l

For dissolved copper only — Ambient background concentration (µg/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? No D

Tier 1 — Estimated river width (m): 5

Tier 2 — Bed width (m): 17 | Manning's n: 0.07 D | Side slope (m/m): 0.5 | Long slope (m/m): 0.0001

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0 D	No restriction D	0 D
Proposed measures		50	No restriction D	D 50

Runoff to Watercourses

Basin 3C HEWRAT Infiltration to Groundwater

Basin 3C HEWRAT

highways england

Reset GW Assessment | Go To Interface

Groundwater Assessment

Component Number		Weighting Factor	Property or Parameter	Risk Score	Component score	Weighted component score
1	SOURCE	10	Traffic flow	>=100,000 AADT	3	30
2		10	Rainfall depth (annual averages)	>740 to <1060 mm rainfall	2	20
3		10	Drainage area ratio	<=50	1	10
4	PATHWAY	15	Infiltration method	"Region", shallow infiltration systems (e.g. infiltration basin)	2	30
5		20	Unsaturated zone	Depth to water table <=5 m	3	60
6		20	Flow type (Incorporates flow type an effective grain size)	Dominantly intergranular flow (e.g. non-fractured consolidated deposits or unconsolidated deposits of fine-medium sand or finer)	1	20
7		5	Unsaturated Zone Clay Content	<=1% clay minerals	3	15
8		5	Organic Carbon	<=1% SOM	3	15
9		5	Unsaturated zone soil pH	pH <8 to >5	2	10

TOTAL SCORE	210
RISK SCREENING LEVEL	Medium

Runoff to Watercourses

Basin 3C HEWRAT Spillage Risks

Basin 3C HEWRAT

DETAILED RESULTS | Back To Top | Go To Interface

Summary of predictions

Prediction of impact	Soluble - Acute Impact: Copper	Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

In Runoff

Step 1

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
RST24 No. of exceedances/year	111.10	115.70
RST24 No. of exceedances/worst year	134	143
RST6 Allowable Exceedances/year	1	1
RST6 No. of exceedances/year	70.70	89.80
RST6 No. of exceedances/worst year	91	113
Thresholds RST24	21	32
Thresholds RST6	42	184
Event Statistics Mean	57.52	264.56
90%ile	111.45	533.33
95%ile	144.76	796.85
99%ile	233.71	1393.53

Step 1

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Toxicity Threshold	1	1	1	1	1	1	1	1
No. of exceedances/year	113.50	124.90	6.30	17.00	56.00	17.00	14.80	31.10
No. of exceedances/worst year	147	152	11	25	71	25	22	39
Toxicity	197	315	3.5	16770	675	2355	245	515
Mean	766	2676	1	11065	1914	1837	117	518
90%ile	1573	5762	3	28184	4876	4679	299	1319
95%ile	1875	7101	3	56234	3729	3335	596	2632
99%ile	2727	10215	5	112202	13411	19626	1189	5251

In River (no mitigation)

Step 2

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
RST24 No. of exceedances/year	0	0
RST24 No. of exceedances/worst year	0	0
RST24 No. of exceedances/summer	0	0
RST24 No. of exceedances/worst summer	0	0
RST6 Allowable Exceedances/year	0.5	0.5
RST6 No. of exceedances/year	0	0
RST6 No. of exceedances/worst year	0	0
RST6 No. of exceedances/summer	0	0
RST6 No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.00	0.02
Thresholds RST24	21	32
Thresholds RST6	42	184
Event Statistics Mean	0.02	0.09
90%ile	0.04	0.21
95%ile	0.09	0.38
99%ile	0.28	1.20

Step 2

Velocity: 0.14 m/s — Tier 2 is used for the calculation

DI: -

Minimum % settlement needed: - %

In River (with mitigation)

Step 3

	Copper	Zinc
RST24 Allowable Exceedances/year	1	1
RST24 No. of exceedances/year	0.00	0.00
RST24 No. of exceedances/worst year	0	0
RST24 No. of exceedances/summer	0	0
RST24 No. of exceedances/worst summer	0	0
RST6 Allowable Exceedances/year	0.5	0.5
RST6 No. of exceedances/year	0.00	0.00
RST6 No. of exceedances/worst year	0	0
RST6 No. of exceedances/summer	0	0

DI: -

highways england

View Parameters | Reset Spillage Risk | Go To Interface

		A (main road)	B	C	D	E	F	Totals	Return Period
D1	Water body type	Surface watercourse							
D2	Length of road draining to outfall (m)	3,250							
D3	Road Type (A-road or Motorway)	A							
D4	If A road, is site urban or rural?	Rural							
D5	Junction type	Roundabout							
D6	Location (response time for emergency services)	< 1 hour							
D7	Traffic flow (AADT two way)	149,961							
D8	% HGV	11							
D8	Spillage factor (no/10^2 HGVkm/year)	0.83							
D9	Risk of accidental spillage	0.01624	0.00000	0.00000	0.00000	0.00000	0.00000		
D10	Probability factor	0.60							
D11	Risk of pollution incident	0.00974	0.00000	0.00000	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	No							
D13	Return period without pollution reduction measures	0.00974	0.00000	0.00000	0.00000	0.00000	0.00000	0.0097	103
D14	Existing measures factor	0.6							
D15	Return period with existing pollution reduction	0.00585	0.00000	0.00000	0.00000	0.00000	0.00000	0.0058	171
D16	Proposed measures factor	0.4							
D17	Residual with proposed Pollution reduction measures	0.00234	0.00000	0.00000	0.00000	0.00000	0.00000	0.0023	428

Justification for choice of existing measures factors

Justification for choice of proposed measures factors

Spillage Factor

Location	Serious Accidental Spillages (Billion HGV km/ year)	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Indicative Pollution Risk Reduction Factors for Spillages

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

highways england

Highways England Water Risk Assessment Tool

Version 2.0.4 June 2019

Soluble

EQS - Annual Average Concentration

	Copper	Zinc	
Step 2	0.00	0.01	ug/l
Step 3	0.00	0.01	ug/l

Acute Impact

Copper	Zinc
Pass	Pass

Sediment - Chronic Impact

Alert. Protected Area.

Sediment deposition for this site is judged as:

Accumulating?	No	0.14	Low flow Vel m/s
Extensive?	No	-	Deposition Index

Road number			HE Area / DBFO number		
Assessment type	Non-cumulative assessment (single outfall)				
OS grid reference of assessment point (m)	Easting		Northing		
OS grid reference of outfall structure (m)	Easting		Northing		
Outfall number			List of outfalls in cumulative assessment		
Receiving watercourse					
EA receiving water Detailed River Network ID			Assessor and affiliation		
Date of assessment			Version of assessment		
Notes					

Step 1 Runoff Quality

AADT: >=100,000 | Climatic region: Warm Wet | Rainfall site: Southampton (SAAR 820mm)

Step 2 River Impacts

(Enter zero in Annual Q_{95} river flow box to assess Step 1 runoff quality only)

Annual Q_{95} river flow (m^3/s)	2.6	Freshwater EQS limits:		
Impermeable road area drained (ha)	4.369	Bioavailable dissolved copper (µg/l)	1	D
Permeable area draining to outfall (ha)	0.128	Bioavailable dissolved zinc (µg/l)	10.9	D
Base Flow Index (BFI)	0.89	Is the discharge in or within 1 km upstream of a protected site for conservation?	Yes	
For dissolved zinc only: Water hardness	Medium = 50-200 CaCO3/l	For dissolved copper only: Ambient background concentration (µg/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?			No	D
Tier 1 / Tier 2: Estimated river width (m)	5			
Bed width (m)	17	Manning's n: 0.07 D	Side slope (m/m): 0.5	Long slope (m/m): 0.0001

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for soluble (%)	Attenuation for soluble - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0 D	No restriction D	0 D
Proposed measures		50	No restriction D	50 D

DETAILED RESULTS

Back To Top | Go To Interface

Summary of predictions

Prediction of impact	Soluble - Acute Impact: Copper	Soluble - Acute Impact: Zinc	Sediment - Chronic Impact: Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

In Runoff

Step 1

	Copper RST24	Zinc RST24	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
						Toxicity Threshold				
Allowable Exceedances/year	1	1	1	1	1	1	1	1	1	1
No. of exceedances/year	**111.10**	**115.70**	**113.50**	**124.30**	**6.30**	**17.00**	**56.00**	**17.00**	**14.80**	**31.10**
No. of exceedances/worst year	134	143	147	152	11	25	71	25	22	39
	RST6									
Allowable Exceedances/year	1	1								
No. of exceedances/year	**70.70**	**89.80**								
No. of exceedances/worst year	91	113								
	(ug/l)	(ug/l)	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Thresholds RST24	21	32	Toxicity 191	315	3.5	16170	875	2355	245	515
Thresholds RST6	42	184								
Event Statistics Mean	57.52	264.56	766	2676	1	11065	1314	1837	117	518
90%ile	111.45	539.93	1573	5762	3	28184	4876	4673	299	1319
95%ile	144.76	796.85	1875	7101	3	56234	9729	9335	596	2632
99%ile	239.71	1393.53	2727	10215	5	112202	19411	18626	1189	5251

In River (no mitigation)

Step 2

	Copper RST24	Zinc RST24
Allowable Exceedances/year	1	1
No. of exceedances/year	**0**	**0**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
	RST6	
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	**0**	**0**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.00	0.01
	(ug/l)	(ug/l)
Thresholds RST24	21	32
Thresholds RST6	42	184
Event Statistics Mean	0.01	0.05
90%ile	0.03	0.13
95%ile	0.06	0.23
99%ile	0.18	0.75

Step 2

Velocity: 0.14 m/s — Tier 2 is used for the calculation

DI: -

Minimum % settlement needed: - %

In River (with mitigation)

Step 3

	Copper RST24	Zinc RST24
Allowable Exceedances/year	1	1
No. of exceedances/year	**0.00**	**0.00**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
	RST6	
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	**0.00**	**0.00**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0

DI: -

highways england

Reset GW Assessment | Go To Interface

Groundwater Assessment

Component Number		Weighting Factor	Property or Parameter	Risk Score	Component score	Weighted component score
1	SOURCE	10	Traffic flow	>=100,000 AADT	3	30
2		10	Rainfall depth (annual averages)	>740 to <1060 mm rainfall	2	20
3		10	Drainage area ratio	>50 to <150	2	20
4	PATHWAY	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		20	Flow type (Incorporates flow type an effective grain size)	Flow dominated by fractures/ fissures (e.g. well consolidated sedimentary deposits, igneous and metamorphic rocks or unconsolidated deposits of very coarse sand and coarser)	3	60
7		5	Unsaturated Zone Clay Content	<=1% clay minerals	3	15
8		5	Organic Carbon	<=1% SOM	3	15
9		5	Unsaturated zone soil pH	pH <8 to >5	2	10

TOTAL SCORE	240
RISK SCREENING LEVEL	Medium

highways england

View Parameters | Reset Spillage Risk | Go To Interface

		A (main road)	B	C	D	E	F
D1	Water body type	Surface watercourse					
D2	Length of road draining to outfall *(m)*	1,600					
D3	Road Type *(A-road or Motorway)*	M					
D4	If A road, is site urban or rural?	Rural					
D5	Junction type	Roundabout					
D6	Location (response time for emergency services)	< 1 hour					
D7	Traffic flow (AADT two way)	149,961					
D8	% HGV	10					
D8	Spillage factor *(no/10^3 HGVkm/year)*	0.43					
D9	Risk of accidental spillage	0.00377	0.00000	0.00000	0.00000	0.00000	0.00000
D10	Probability factor	0.60					
D11	Risk of pollution incident	0.00226	0.00000	0.00000	0.00000	0.00000	0.00000
D12	Is risk greater than 0.01?	No					
D13	Return period without pollution reduction measures	0.00226	0.00000	0.00000	0.00000	0.00000	0.00000
D14	Existing measures factor	0.6					
D15	Return period with existing pollution reduction	0.00136	0.00000	0.00000	0.00000	0.00000	0.00000
D16	Proposed measures factor	0.4					
D17	Residual with proposed Pollution reduction measures	0.00054			0.00000	0.00000	0.00000

Totals	Return Period
0.0023	443
0.0014	738
0.0005	1844

Pollution reduction factor

Use the Indicative Pollution Risk Reduction Factor table below to estimate the factor.

Provide justification for the decision in the appropriate comments box below.

A default value of 1 is used if no measures are considered or if no value is entered.

Justification for choice of existing measures factors:

Justification for choice of proposed measures factors:

Spillage Factor

Location	Serious Accidental Spillages (Billion HGV km/ year)	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Indicative Pollution Risk Reduction Factors for Spillages

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

highways england

Reset GW Assessment | Go To Interface

Groundwater Assessment

Component Number		Weighting Factor	Property or Parameter	Risk Score	Component score	Weighted component score
1	SOURCE	10	Traffic flow	>=100,000 AADT	3	30
2		10	Rainfall depth (annual averages)	>740 to <1060 mm rainfall	2	20
3		10	Drainage area ratio	<=50	1	10
4	PATHWAY	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		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		5	Unsaturated Zone Clay Content	<=1% clay minerals	3	15
8		5	Organic Carbon	<=1% SOM	3	15
9		5	Unsaturated zone soil pH	pH <8 to >5	2	10

TOTAL SCORE	210
RISK SCREENING LEVEL	Medium

highways england

View Parameters | Reset Spillage Risk | Go To Interface

		A (main road)	B	C	D	E	F
D1	Water body type	Surface watercourse					
D2	Length of road draining to outfall *(m)*	500					
D3	Road Type *(A-road or Motorway)*	M					
D4	If A road, is site urban or rural?	Rural					
D5	Junction type	Slip road					
D6	Location (response time for emergency services)	< 1 hour					
D7	Traffic flow (AADT two way)	149,961					
D8	% HGV	11					
D8	Spillage factor *(no/10^8 HGVkm/year)*	0.43					
D9	Risk of accidental spillage	0.00129	0.00000	0.00000	0.00000	0.00000	0.00000
D10	Probability factor	0.60					
D11	Risk of pollution incident	0.00078	0.00000	0.00000	0.00000	0.00000	0.00000
D12	Is risk greater than 0.01?	No					
D13	Return period without pollution reduction measures	0.00078	0.00000	0.00000	0.00000	0.00000	0.00000
D14	Existing measures factor	0.6					
D15	Return period with existing pollution reduction	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000
D16	Proposed measures factor	0.6					
D17	Residual with proposed Pollution reduction measures	0.00028	0.00000	0.00000	0.00000	0.00000	0.00000

Totals	Return Period
0.0008	1287
0.0005	2146
0.0003	3576

Justification for choice of existing measures factors

Justification for choice of proposed measures factors

Spillage Factor

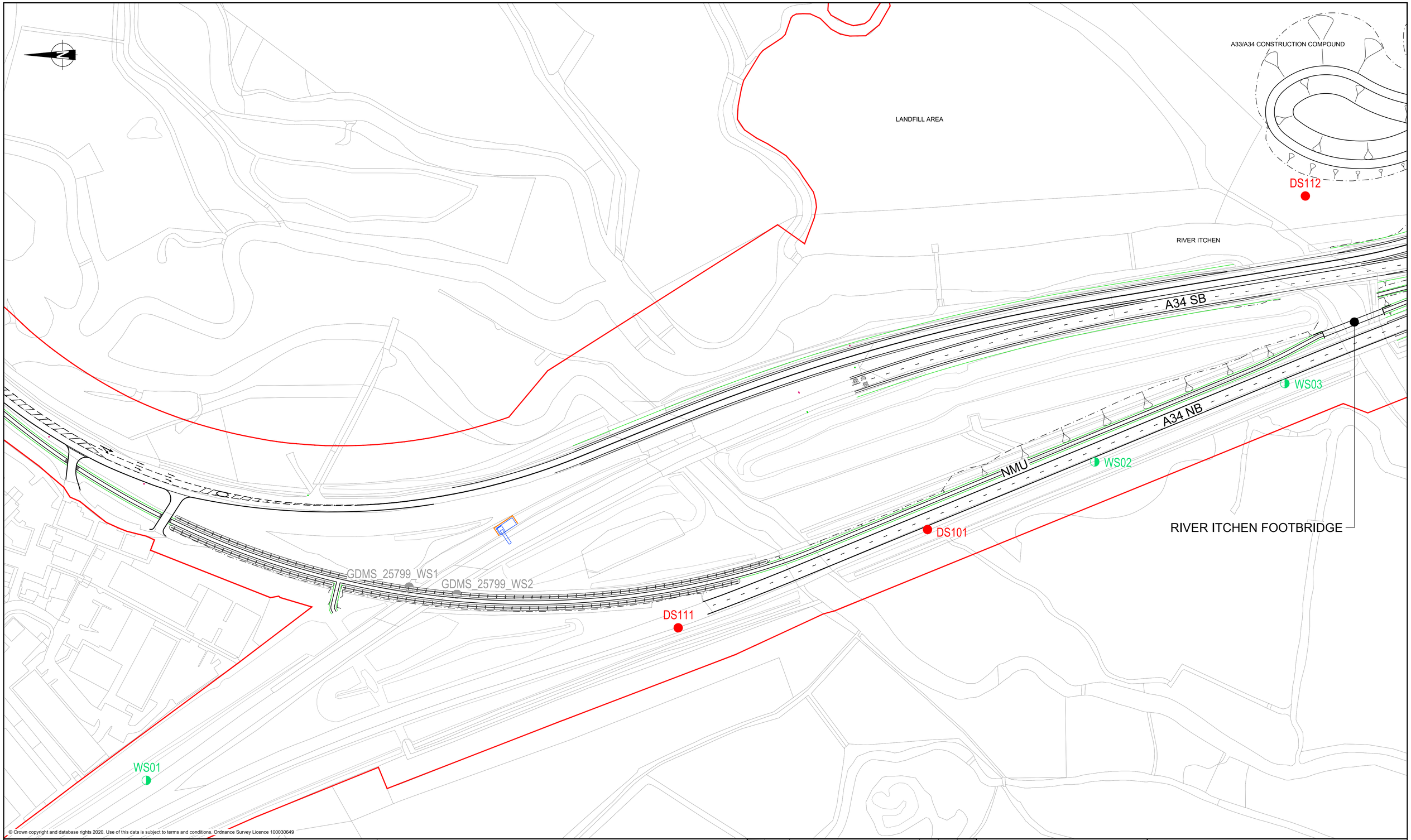
Location	Serious Accidental Spillages *(Billion HGV km/ year)*	Motorways	Rural Trunk	Urban Trunk
	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

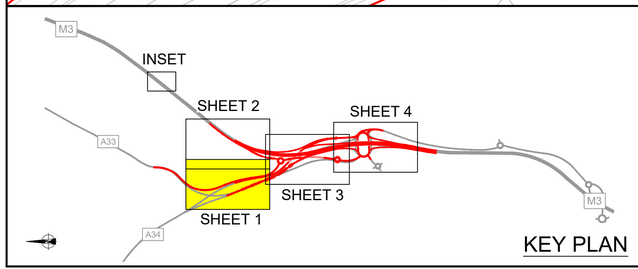
Indicative Pollution Risk Reduction Factors for Spillages

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

Appendix C HE551551-VFK-HGT-X_XXXX_XX-DR-GE-004 Exploratory hole location plan





KEY PLAN

GDMS HISTORICAL EXPLORATORY HOLES

- TRIAL PIT
- CABLE PERCUSSION BOREHOLE
- WINDOWLESS SAMPLING BOREHOLE

SOILS LIMITED 2019 EXPLORATORY HOLES

- TRIAL PIT
- DYNAMIC SAMPLING WITH ROTARY CORE FOLLOW ON
- WINDOWLESS SAMPLING BOREHOLE

Rev.	Date	Description	Drawn	Chk'd	App'd

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

SHEET 1 OF 4

Scale	Designed	Drawn	Checked	Approved
1:1000	AD	davco	AD	RHT
Original Size	**Date**	**Date**	**Date**	**Date**
A1	05.05.21	05.05.21	05.05.21	06.05.21

Drawing Number: HE PIN | Originator | Volume
HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0001
Location | Type | Role | Number

Project Ref. No.: 48176

Revision: P01

BH543

GDMS_3212_BH541

DS218

DS220

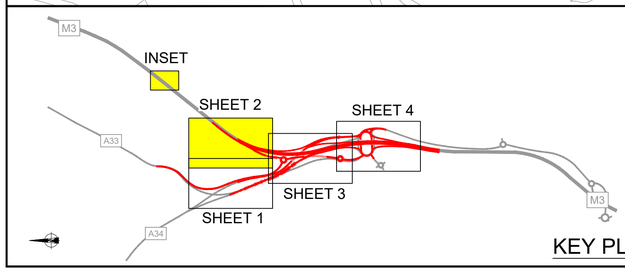
DS203

M3

M3

A33/A34 CONSTRUCTION COMPOUND

LANDFILL AREA



KEY PLAN

GDMS HISTORICAL EXPLORATORY HOLES

- TRIAL PIT
- CABLE PERCUSSION BOREHOLE
- WINDOWLESS SAMPLING BOREHOLE

SOILS LIMITED 2019 EXPLORATORY HOLES

- TRIAL PIT
- DYNAMIC SAMPLING WITH ROTARY CORE FOLLOW ON
- WINDOWLESS SAMPLING BOREHOLE

Rev.	Date	Description	Drawn	Chk'd	App'd

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

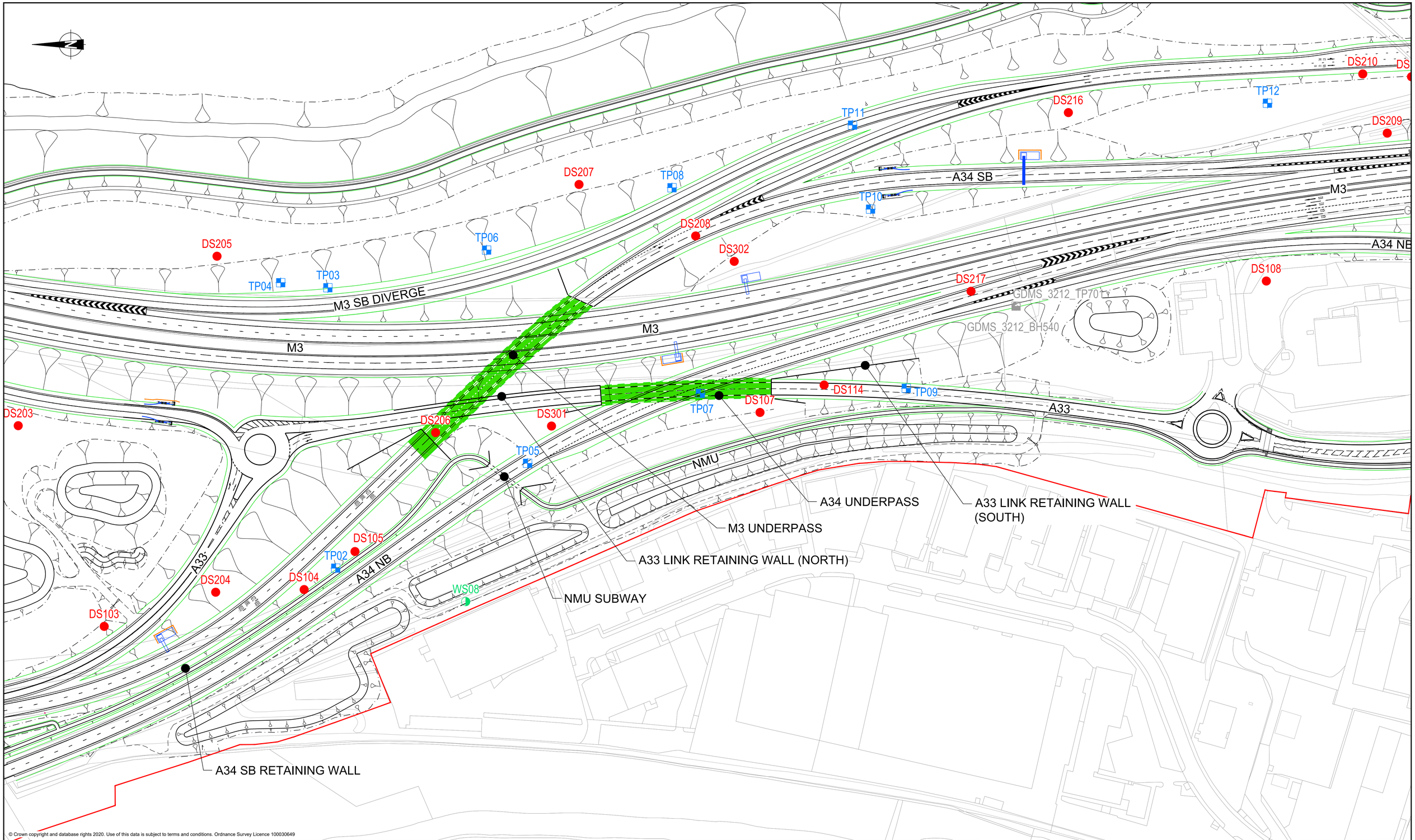
SHEET 2 OF 4

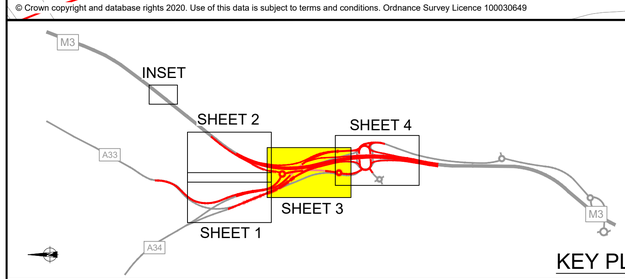
Scale	Designed	Drawn	Checked	Approved
1:1000	AD	davco	AD	RHT
Original Size	**Date**	**Date**	**Date**	**Date**
A1	05.05.21	05.05.21	05.05.21	06.05.21

Drawing Number: HE PIN | Originator | Volume
HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0002
Location | Type | Role | Number

Project Ref. No.: 48176

Revision: P01





KEY PLAN

GDMS HISTORICAL EXPLORATORY HOLES

- TRIAL PIT
- CABLE PERCUSSION BOREHOLE
- WINDOWLESS SAMPLING BOREHOLE

SOILS LIMITED 2019 EXPLORATORY HOLES

- TRIAL PIT
- DYNAMIC SAMPLING WITH ROTARY CORE FOLLOW ON
- WINDOWLESS SAMPLING BOREHOLE

Rev.	Date	Description	Drawn	Chk'd	App'd

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

SHEET 3 OF 4

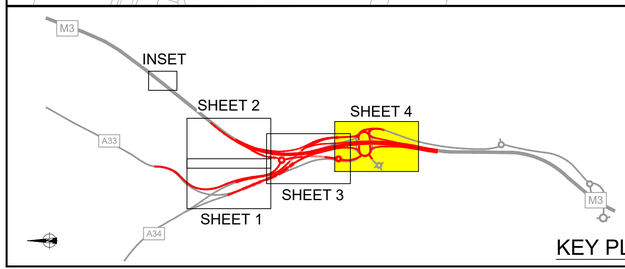
Scale	Designed	Drawn	Checked	Approved
1:1000	AD	davco	AD	RHT
Original Size	**Date**	**Date**	**Date**	**Date**
A1	05.05.21	05.05.21	05.05.21	06.05.21

Drawing Number: HE PIN | Originator | Volume | Location | Type | Role | Number
HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0003

Project Ref. No.: 48176

Revision: P01

NMU SUBWAY
NMU
A272 SPITFIRE LINK
SPITFIRE LINK
RETAINING WALL
DS109A
DS109
DS110
DS210
DS115
WS05
TP12
DS211
GDMS_3212_BH536
GDMS_3212_BH535
DS209
GDMS_3212_BH539
GDMS_3212_BH630
DS219
M3
GDMS_3212_TP629
M3
M3
GDMS_3212_BH805
GDMS_3212_TP628
GDMS_3212_BH538
GDMS_3212_BH534
DS212
WS04
A34 NB
GDMS_3212_BH537
DS213
DS214
DS214A
DS108
WS06
DS215
M3 J9 SOUTHERN BRIDGE
WS07
NMU SUBWAY
NMU
EASTON LANE
NMU SUBWAY
M3 J9 NORTHERN BRIDGE



KEY PLAN

GDMS HISTORICAL EXPLORATORY HOLES

- TRIAL PIT
- CABLE PERCUSSION BOREHOLE
- WINDOWLESS SAMPLING BOREHOLE

SOILS LIMITED 2019 EXPLORATORY HOLES

- TRIAL PIT
- DYNAMIC SAMPLING WITH ROTARY CORE FOLLOW ON
- WINDOWLESS SAMPLING BOREHOLE

Rev.	Date	Description	Drawn	Chk'd	App'd

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

SHEET 4 OF 4

Scale	Designed	Drawn	Checked	Approved
1:1000	AD	davco	AD	RHT
Original Size: A1	Date: 05.05.21	Date: 05.05.21	Date: 05.05.21	Date: 06.05.21

Drawing Number: HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0004
(Originator | Volume | Location | Type | Role | Number)

Project Ref. No.: 48176

Revision: P01

Appendix D HE551551-VFK-HGT-X_XXXX_XX-DR-GE-0020 Geological plan

Key

- Made Ground
- Peat
- Alluvium
- Head
- Structureless Chalk (Grade Dm and Dc)
- Structured Chalk (Grade A to C)

Rev.	Date	Description	Drawn	Chk'd	App'd
P02	05.05.21	INCORPORATING HE COMMENTS	davco	AD	RHT

Drawing Status: FOR SGAR 3B

VolkerFitzpatrick

Client: highways england

Project Title: M3 JUNCTION 9 IMPROVEMENTS

Drawing Title: GEOLOGICAL PLAN

Scale	Designed	Drawn	Checked	Approved
1:2500	AD	davco	AD	RHT
Original Size	**Date**	**Date**	**Date**	**Date**
A1	01.12.20	01.12.20	04.12.20	08.12.20

Drawing Number: HE551511 - VFK - HGT - X_XXXX_XX - DR - GE - 0020 (HE PIN | Originator | Volume | Location | Type | Role | Number)

Project Ref. No.: 48176

Revision: P02

Appendix E RAM model files

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

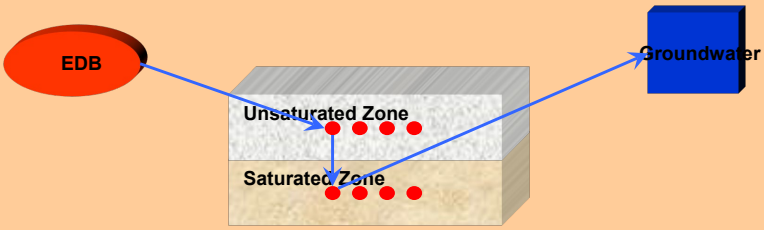
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



SOURCE CONCENTRATIONS: EDB

SOIL SOURCE

Source Data Options

- (●) Pore water concentrations
- ( ) Leaching test
- ( ) Soil contaminant concentrations

Source Type

- (●) Constant source
- ( ) Declining source

Source Geometry

EDB_Source_length	28.03333	**m**
EDB_Source_width	150	**m**
EDB_Source_area	4205	**m2**
EDB_Source_thickness	1	**m**
EDB_Source_volume	4205	**m3**

Source Contaminant Information

Source determinand names		Copper	Zinc
EDB_Pore_water_concentration	**mg/L**	0.145	0.797
EDB_Input_concentration	**mg/L**	0.145	0.797

CONTAMINANT INFORMATION

		Species1	Species2
Source determinand names	2	Copper	Zinc

Receptor Target Concentrations

	Name	Values in mg/L	
Quality Standard 1	EAL	2	5
Quality Standard 2			
Quality Standard 3			
Quality Standard 4			

Generic Contaminant Properties

Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**	
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**	

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	3.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-05	1.00E-05
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-05	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate	Saturated Zone
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.001	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	157680	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	157680	**mm/year**
Infiltration_Area	4205	**m2**
Q_Infiltration	0.021010609	**m3/s**
Infiltration rate check	5.0E-06	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-05				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	0.4				
Path 1 Parameter3	**Q_path [m3/s]**	2.101E-02	**Travel Distance [m]**	3.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**	5.0		
Path 1 Parameter5					**Mixing Width [m]**	150.0		
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	5.700E-05	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

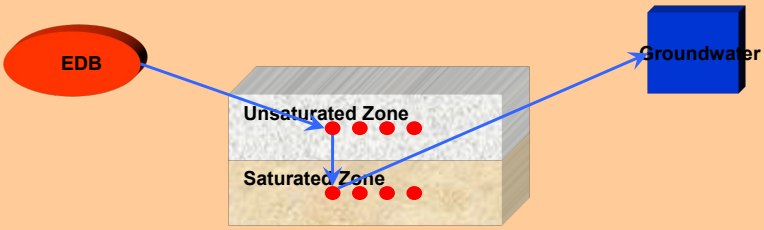
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	13.1	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	5.0E-07	1.00E-05
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate Saturated Zone	
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	1925	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	4.17E-09	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	462	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	1.74E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	365	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	2.2E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	730	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	1.1E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	1351	**m2**
Q_Infiltration	0.000675038	**m3/s**
Infiltration rate	5.0E-07	

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	1.3				
Path 1 Parameter3	**Q_path [m3/s]**	6.750E-04	**Travel Distance [m]**	13.1				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**			
Path 1 Parameter5					**Mixing Width [m]**			
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	0.000E+00	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

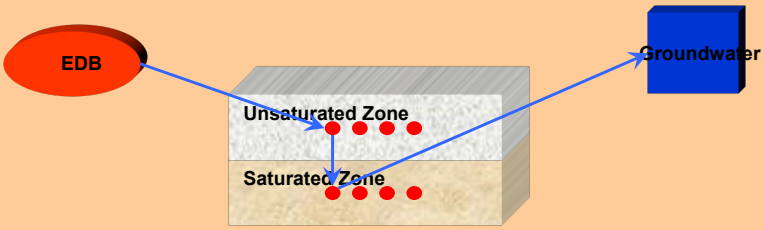
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	13.1	20
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate	Saturated Zone
General properties			
Attenuation_Dry_bulk_density	kg/m3	1800	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	247861	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	5419	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	13519	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	12241	1
Attenuation_Half_Life_Species_4	days	60	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	1.34E-07	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	8839	1
Attenuation_Half_Life_Species_5	days	182	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	4.41E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	4231	1
Attenuation_Half_Life_Species_6	days	210	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	3.82E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	3763	1
Attenuation_Half_Life_Species_7	days	90	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	8.91E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	1351	**m2**
Q_Infiltration	0.000675038	**m3/s**
Infiltration rate check	5.00E-07	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	1.3				
Path 1 Parameter3	**Q_path [m3/s]**	6.750E-04	**Travel Distance [m]**	13.1				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**	5.0		
Path 1 Parameter5					**Mixing Width [m]**	55.0		
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	2.090E-05	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

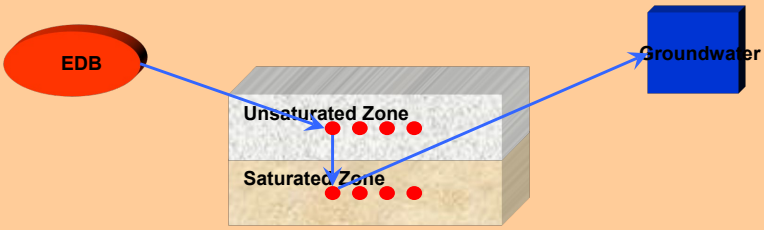
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	5.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate	Saturated Zone
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.001	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	68	0
Attenuation_Retardation_Species_4	[-]	1622.8	1
Attenuation_Half_Life_Species_4	days	1925	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	4.17E-09	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	49.1	0
Attenuation_Retardation_Species_5	[-]	1172.035	1
Attenuation_Half_Life_Species_5	days	462	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	1.74E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	23.5	0
Attenuation_Retardation_Species_6	[-]	561.475	1
Attenuation_Half_Life_Species_6	days	365	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	2.2E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	20.9	0
Attenuation_Retardation_Species_7	[-]	499.465	1
Attenuation_Half_Life_Species_7	days	730	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	1.1E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	2046	**m2**
Q_Infiltration	0.0010223	**m3/s**
Infiltration rate check	5.0E-07	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	0.6				
Path 1 Parameter3	**Q_path [m3/s]**	1.022E-03	**Travel Distance [m]**	5.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**			
Path 1 Parameter5					**Mixing Width [m]**			
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	0.000E+00	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

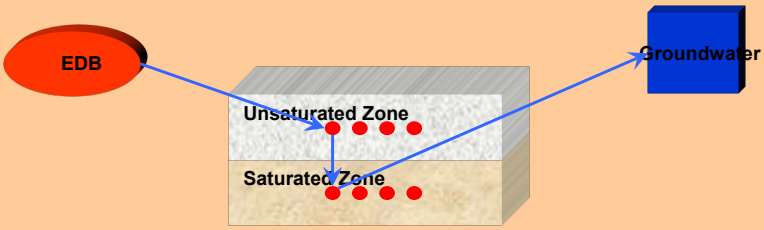
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	5.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	9.99E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate Saturated Zone	
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	1925	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	4.17E-09	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	462	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	1.74E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	365	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	2.2E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	730	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	1.1E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	31536	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	31536	**mm/year**
Infiltration_Area	2046	**m2**
Q_Infiltration	0.0020446	**m3/s**
Infiltration rate check	1.0E-06	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	9.993E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	0.6				
Path 1 Parameter3	**Q_path [m3/s]**	2.045E-03	**Travel Distance [m]**	5.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**			
Path 1 Parameter5					**Mixing Width [m]**			
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	0.000E+00	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

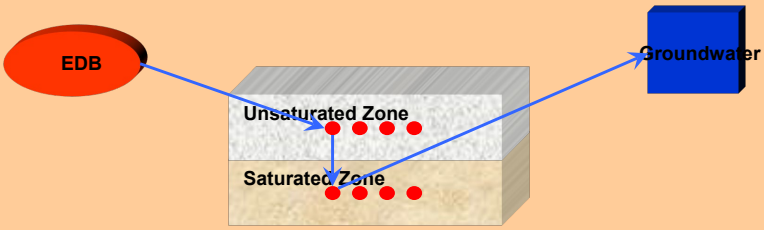
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	10.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate Saturated Zone	
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	1925	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	4.17E-09	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	462	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	1.74E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	365	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	2.2E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	730	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	1.1E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	2046	**m2**
Q_Infiltration	0.0010223	**m3/s**
Infiltration rate check	5.0E-07	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	1.1				
Path 1 Parameter3	**Q_path [m3/s]**	1.022E-03	**Travel Distance [m]**	10.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**			
Path 1 Parameter5					**Mixing Width [m]**			
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	0.000E+00	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

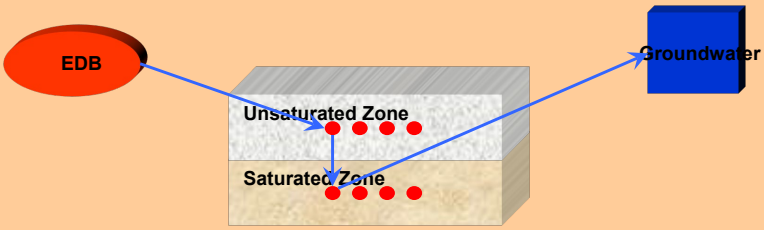
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	5.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate Saturated Zone	
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	1925	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	4.17E-09	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	462	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	1.74E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	365	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	2.2E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	730	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	1.1E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	2046	**m2**
Q_Infiltration	0.0010223	**m3/s**
Infiltration rate check	5.0E-07	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	0.6				
Path 1 Parameter3	**Q_path [m3/s]**	1.022E-03	**Travel Distance [m]**	5.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**			
Path 1 Parameter5					**Mixing Width [m]**			
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	0.000E+00	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

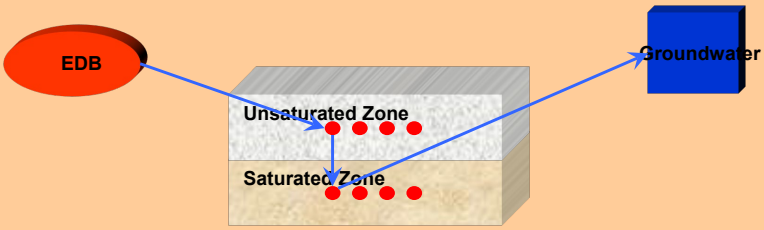
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	5.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	9.99E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate	Saturated Zone
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	60	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	1.34E-07	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	182	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	4.41E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	210	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	3.82E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	90	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	8.91E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	31536	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	31536	**mm/year**
Infiltration_Area	2046	**m2**
Q_Infiltration	0.0020446	**m3/s**
Infiltration rate check	1.0E-06	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	9.993E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	0.6				
Path 1 Parameter3	**Q_path [m3/s]**	2.045E-03	**Travel Distance [m]**	5.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**	5.0		
Path 1 Parameter5					**Mixing Width [m]**	22.0		
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	8.360E-06	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

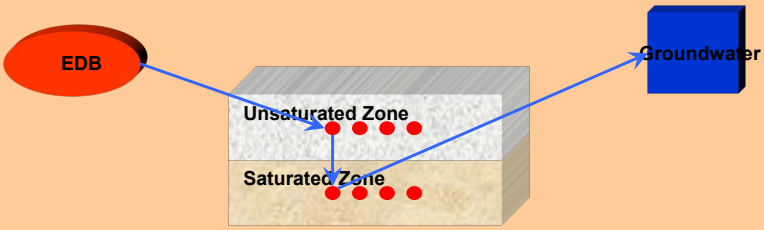
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	10.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate	Saturated Zone
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	60	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	1.34E-07	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	182	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	4.41E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	210	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	3.82E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	90	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	8.91E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	2046	**m2**
Q_Infiltration	0.0010223	**m3/s**
Infiltration rate check	5.0E-07	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	1.1				
Path 1 Parameter3	**Q_path [m3/s]**	1.022E-03	**Travel Distance [m]**	10.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**	5.0		
Path 1 Parameter5					**Mixing Width [m]**	22.0		
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	8.360E-06	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

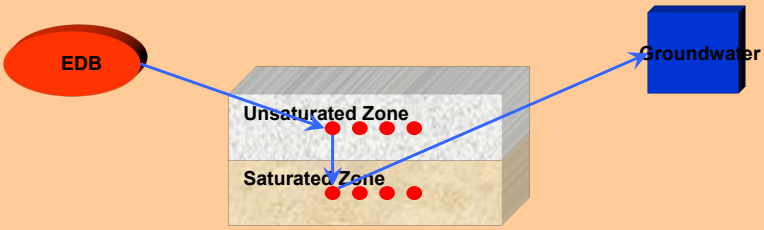
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	5.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate	Saturated Zone
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	60	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	1.34E-07	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	182	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	4.41E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	210	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	3.82E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	90	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	8.91E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	2046	**m2**
Q_Infiltration	0.0010223	**m3/s**
Infiltration rate check	5.0E-07	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	0.6				
Path 1 Parameter3	**Q_path [m3/s]**	1.022E-03	**Travel Distance [m]**	5.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**	5.0		
Path 1 Parameter5					**Mixing Width [m]**	22.0		
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	8.360E-06	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

◉ Level One

○ Level Two

○ Level Three

○ Level Four

○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited

CONTAMINANT INFORMATION

		Species1	Species2
Source determinand names	2	Copper	Zinc

Receptor Target Concentrations

	Name	Values in mg/L	
Quality Standard 1	EAL	2	5
Quality Standard 2			
Quality Standard 3			
Quality Standard 4			

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 5

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
10
20
30
40
50

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

◉ Level One

○ Level Two

○ Level Three

○ Level Four

○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited

CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 5

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
10
20
30
40
50

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

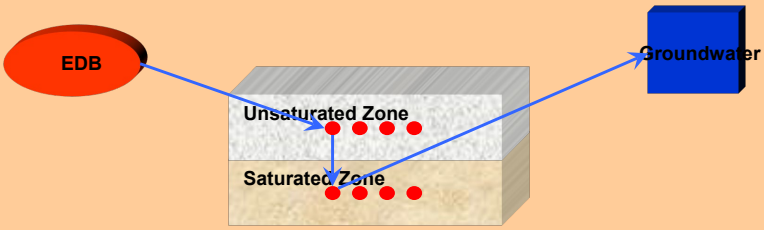
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	3.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate Saturated Zone	
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	1925	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	4.17E-09	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	462	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	1.74E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	365	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	2.2E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	730	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	1.1E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	4205	**m2**
Q_Infiltration	0.002101061	**m3/s**
Infiltration rate check	5.00E-07	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	0.4				
Path 1 Parameter3	**Q_path [m3/s]**	2.101E-03	**Travel Distance [m]**	3.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**			
Path 1 Parameter5					**Mixing Width [m]**			
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	0.000E+00	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100

Source Type

☑ Soil Source ☐ Groundwater Source

Level Number

- ○ Level One
- ◉ Level Two
- ○ Level Three
- ○ Level Four
- ○ Advanced

Parameter Values

◉ Deterministic ○ Probabilistic

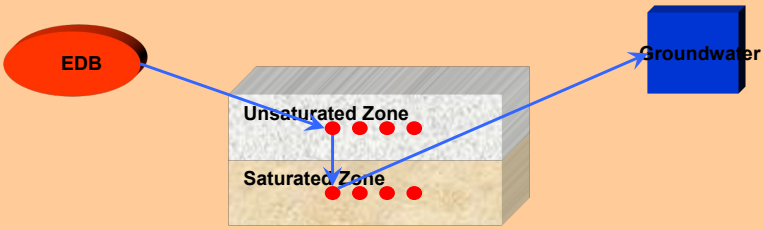
Created: 27/07/2021 09:36:16

by: Holtham, Richard

Version: 3.06.01x Adv

Site: EDBs

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



CONTAMINANT INFORMATION

			Species1	Species2	Species3	Species4	Species5	Species6	Species7
Source determinand names		7	Copper	Zinc	Cadmium	Pyrene	Fluoranthe	Anthracene	Phenanthrene

Receptor Target Concentrations

	Name	Values in mg/L						
Quality Standard 1	EAL	2	5	5.00E-03	5.00E-06	5.00E-05	5.00E-05	5.00E-06
Quality Standard 2								
Quality Standard 3								
Quality Standard 4								

Generic Contaminant Properties

Contaminants_Solubility	**mg/L**	2.93E+05	6.06E+05	6.51E+05	0.137	2.32E-01	5.37E-02	1.28
Contaminants_Henrys_Law_Constant	**[-]**							
Contaminants_Organic_Carbon_Water_Partition_Coefficient_Koc	**L/kg**				6.80E+04	4.91E+04	2.35E+04	2.09E+04
Contaminants_Free_Water_Diffusion_Coefficient	**m2/s**							

HYDROGEOLOGICAL UNITS

Hydrogeological Units		Unsaturate	Saturated Zone
Hydrogeology_Unit_Thickness	m	3.8	5
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)		
Hydrogeology_Hydraulic_Conductivity	m/s	1.00E-06	0.00001
Hydrogeology_Hydraulic_Gradient	[-]	1	0.0076
Hydrogeology_Porosity	[-]	0.1	0.01
Hydrogeology_Velocity	m/s	5E-06	7.6E-06
Hydrogeology_Tortuosity	[-]		

ATTENUATION PARAMETERS

Hydrogeological Units		Unsaturate	Saturated Zone
General properties			
Attenuation_Dry_bulk_density	kg/m3	2385	
Attenuation_Fraction_organic_carbon	[-]	0.01	
Contaminant specific parameters			
Copper			
Attenuation_Partition_Coefficient_Kd_Species_1	L/kg	13770	0
Attenuation_Retardation_Species_1	[-]	328415.5	1
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0
Zinc			
Attenuation_Partition_Coefficient_Kd_Species_2	L/kg	301	0
Attenuation_Retardation_Species_2	[-]	7179.85	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0
Cadmium			
Attenuation_Partition_Coefficient_Kd_Species_3	L/kg	751	0
Attenuation_Retardation_Species_3	[-]	17912.35	1
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0
Pyrene			
Attenuation_Partition_Coefficient_Kd_Species_4	L/kg	680	0
Attenuation_Retardation_Species_4	[-]	16219	1
Attenuation_Half_Life_Species_4	days	60	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	1.34E-07	0
Fluoranthene			
Attenuation_Partition_Coefficient_Kd_Species_5	L/kg	491	0
Attenuation_Retardation_Species_5	[-]	11711.35	1
Attenuation_Half_Life_Species_5	days	182	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	4.41E-08	0
Anthracene			
Attenuation_Partition_Coefficient_Kd_Species_6	L/kg	235	0
Attenuation_Retardation_Species_6	[-]	5605.75	1
Attenuation_Half_Life_Species_6	days	210	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	3.82E-08	0
Phenanthrene			
Attenuation_Partition_Coefficient_Kd_Species_7	L/kg	209	0
Attenuation_Retardation_Species_7	[-]	4985.65	1
Attenuation_Half_Life_Species_7	days	90	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	8.91E-08	0

WATER BALANCE

Infiltration through the soil zone source

Source Name: EDB

Effective_Rainfall	15768	**mm/year**
Infiltration_Factor	1	**[-]**
Infiltration_Rate	15768	**mm/year**
Infiltration_Area	4205	**m2**
Q_Infiltration	0.002101061	**m3/s**
Infiltration rate check	5.0E-07	**m/s**

PATHWAY SUMMARY

Path 1	Section 1		Section 2		Section 3		Section 4	
Path 1 Type	Source		Unit		Unit		Receptor	
Path 1 Name	**EDB**		**Unsaturated Zone: Node 1**		**Saturated Zone: Node 1**		**Groundwater**	
Path 1 Process	Constant source		ADRD (1D)		Aquifer Dilution Only		Monitoring Borehole	
Path 1 Standards							Target Standard	EAL
Path 1 Parameter1	**Q_managed [m3/s]**	0.000E+00	**Velocity [m/s]**	4.997E-06				
Path 1 Parameter2	**Managed time [years]**	0.000E+00	**Dispersivity [m]**	0.4				
Path 1 Parameter3	**Q_path [m3/s]**	2.101E-03	**Travel Distance [m]**	3.8				
Path 1 Parameter4	**Q_decline [m3/s]**	0.000E+00			**Mixing Depth [m]**	5.0		
Path 1 Parameter5					**Mixing Width [m]**	150.0		
Path 1 Parameter6			**Q_Dilute [m3/s]**	0	**Q_Dilute [m3/s]**	5.700E-05	**Q_dilute [m3/s]**	0.000E+00

SIMULATION PARAMETERS

Monte Carlo Analysis with Crystal Ball

Reported Percentile	95
Number of simulations	10000

☐ Stop on calculation error

☐ Use same sequence of random numbers

Minimise while running:

◉ Nothing

○ All Spreadsheets (faster)

○ Microsoft Excel (fastest)

Named Constants

s_per_year	31557600
s_per_day	86400

Laplace Transform Solution Parameters

sigma	0
nu	1
nsum	16
omega	11

Reporting Options

☐ Include Remedial Targets and Attenuation Factors on the results sheets in Advanced level

☐ Use the array form of the RAM function

☐ Include a set of timeslices for each contaminant in each pathway

Number of timeslices for breakthrough curves: 4

The timeslices specified on the results sheets are saved below.

Path1 timeslices in years

TS_Path1
0.1
1
10
100