Luton Rising
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London Luton Airport Expansion

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5.02 Appendix 20.6 Hydrogeological Risk Assessment - Drainage

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The Planning Act 2008

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

London Luton Airport Expansion Development Consent Order 202x

5.02 ENVIRONMENTAL STATEMENT APPENDIX 20.6 HYDROGEOLOGICAL RISK ASSESSMENT - DRAINAGE

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1 INTRODUCTION

1.1 Report context

1.1.1 This report is part of a suite of documents prepared to support the application for development consent for the expansion of London Luton Airport ('the airport'). Specifically, this Hydrogeological Risk Assessment Report (HRA) is a technical appendix supporting **Chapter 20** Water Resources and Flood Risk of the Environmental Statement (ES) **[TR2000/APP/5.01]**.

1.1.2 This report provides a hydrogeological risk assessment to assess the acceptability of discharge of treated wastewater and surface runoff to ground from the proposed infiltration tanks in terms of the potential impact on groundwater quality.

1.1.3 The proposed drainage infrastructure comprises the construction of a water treatment plant (WTP) and two infiltration tanks for the discharge of surface water runoff, treated surface water runoff and treated effluent to ground.

1.1.4 The proposed drainage infrastructure is to be installed at a future date coinciding with the construction of an additional terminal (Terminal 2) and therefore this risk assessment will need to be revised to account for the final detailed drainage design and to support an application to the Environment Agency for an Environmental Permit to discharge, closer to the time of construction.

1.1.5 This report has been prepared based on hydrogeological data and the drainage strategy at conceptual drainage design stage, as described in the Drainage Design Statement (DDS) provided as **Appendix 20.4** of the ES **[TR2000/APP/5.02]**.

2 PROPOSED DEVELOPMENT

2.1 Summary

2.1.1 An overview of the Proposed Development and the site and surroundings in which it is proposed is provided in **Chapter 2** Site and Surroundings of the ES **[TR02000/APP/5.01]**. A detailed description of the Proposed Development is provided in **Chapter 4** The Proposed Development of the ES **[TR02000/APP/5.01]**. A summary of those elements of the Proposed Development relevant to this assessment is provided below:

a. extension and remodelling of the existing passenger terminal (Terminal 1) to increase the capacity;

b. new passenger terminal building and boarding piers (Terminal 2);

c. earthworks to create an extension to the current airfield platform; the vast majority of material for these earthworks would be generated on site;

d. airside facilities including new taxiways and aprons, together with relocated engine run-up bay and fire training facility;

e. landside facilities, including buildings which support the operational, energy and servicing needs of the airport;

f. enhancement of the existing surface access network, including a new dual carriageway road accessed via a new junction on the existing New Airport Way (A1081) to the new passenger terminal along with the provision of forecourt and car parking facilities;

g. extension of the Luton Direct Air to Rail Transit (Luton DART) with a station serving the new passenger terminal;

h. landscape and ecological improvements, including the replacement of existing open space; and

i. further infrastructure enhancements and initiatives to support the target of achieving zero emission ground operations by 2040[1], with interventions to support carbon neutrality being delivered sooner including facilities for greater public transport usage, improved thermal efficiency, electric vehicle charging, on-site energy generation and storage, new aircraft fuel pipeline connection and storage facilities and sustainable surface and foul water management installations.

2.1.2 The Proposed Development will be delivered incrementally to increase capacity of the existing airport in response to forecast passenger demand. For the purposes of assessment, three assessment Phases 1, 2a and 2b are considered as defined in **Chapter 4** of the ES **[TR02000/APP/5.01].**

[1] This is a Government target, for which the precise definition will be subject to further consultation following the *Jet Zero Strategy*, and which will require further mitigations beyond those secured under the Development Consent Order.

2.2 Proposed Drainage Strategy

2.2.1 As part of the Proposed Development, drainage systems would manage surface water runoff and discharge to ground, via a combination of two infiltration tanks, after treatment as described in the DDS which is provided in **Appendix 20.4** of the ES **[TR020001/APP/5.02]**.

Assessment Phase 1

2.2.2 The existing drainage at the airport discharges into a combination of soakaways and the Thames Water (TW) sewage network. As detailed in the DDS **[TR020001/APP/5.02]**, during the assessment Phase 1 construction works the drainage strategy aims to use the existing airport drainage infrastructure, with flows balanced using rainwater harvesting, attenuation tanks below aprons and landside storage.

2.2.3 Surface runoff from the new aprons will discharge into the existing central soakaway. Live monitoring of contaminants within the drainage system is proposed and any contaminated water will be diverted to the attenuation tanks. Water stored in the tanks will be discharged into the TW foul sewer at an agreed discharge rate.

Assessment Phases 2a and 2b

2.2.4 The main drainage infrastructure for the Proposed Development will be incorporated during assessment Phases 2a and 2b and will include the installation of a new Water Treatment Plant (WTP), attenuation tanks and infiltration tanks.

2.2.5 The construction of the WTP to handle foul effluent has been proposed as TW have indicated that there would not be sufficient capacity at the local water treatment plant to receive effluent from the Proposed Development.

2.2.6 The new drainage system for the Proposed Development would receive part of the existing drainage system, from three existing soakaways to the south of the airport, that would be decommissioned.

2.2.7 Two new infiltration tanks would be constructed, the proposed locations of these are shown in Inset 1**Inset 1**. Both of these tanks would be underground, removing the requirement for open water at surface which is necessary to minimise the risk of bird strikes.

Inset 1: Location of proposed infiltration tanks and WTP

2.2.8 The larger of the two infiltration tanks, from hereon named the 'Southern Infiltration Tank', would be located to the east and down hydraulic gradient of the runway. This tank would be approximately 260m in length by 120m in width. The design of the tank includes 75,000m^3 of storage capacity and is shown in **Inset 2**.

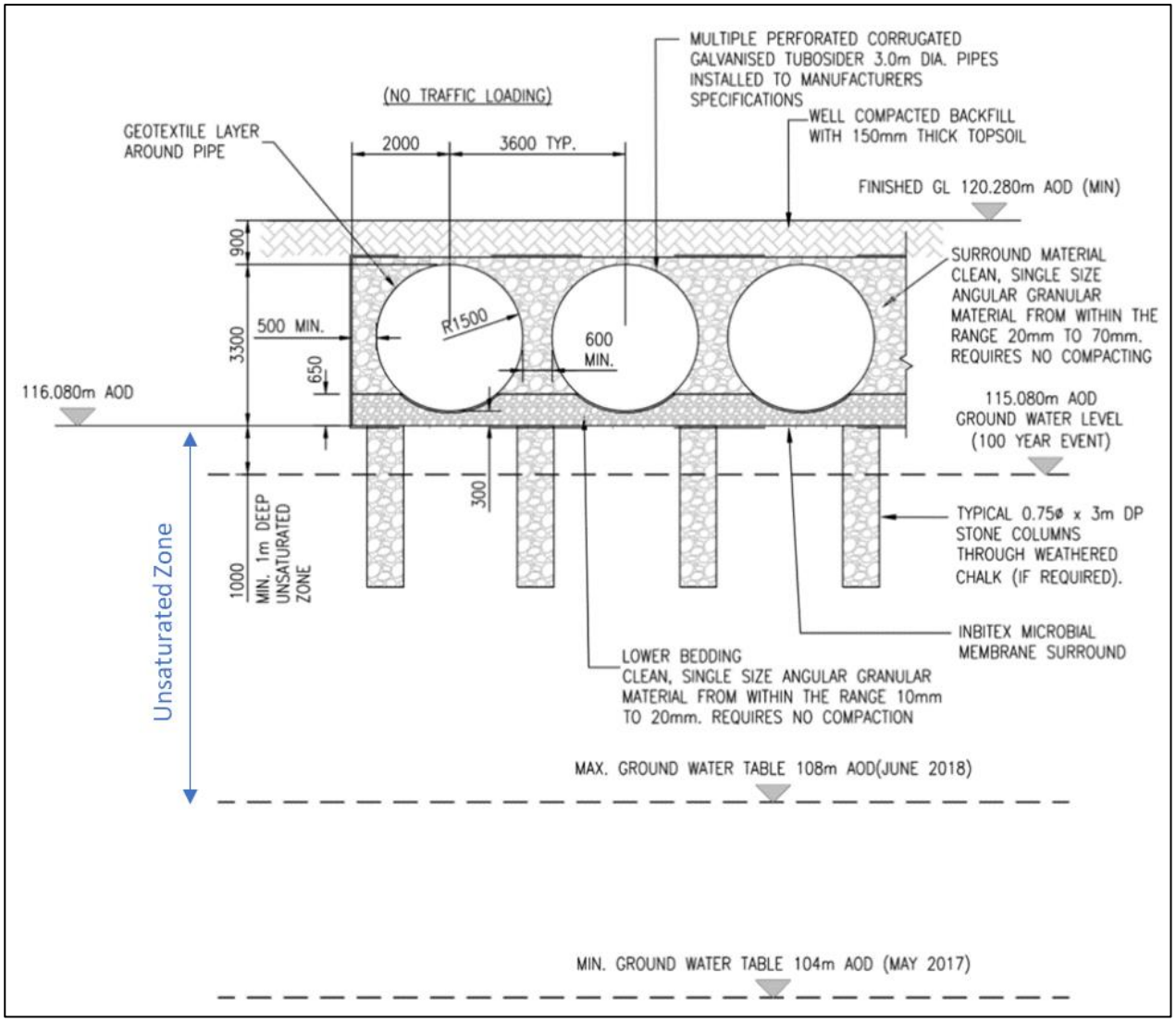
2.2.9 A 300mm granular drainage layer would be provided at the base of the tank which is proposed to be installed directly onto the underlying chalk bedrock. As shown in **Inset 2** stone columns to provide structural support to the tank will be constructed through the weathered chalk if required.

2.2.10 The Southern Infiltration Tank will predominantly be used for discharge of surface water runoff from the whole of the Proposed Development within the Main Application Site as follows:

a. Landside areas – including runoff from the new terminal building and car parks to the north and Green Horizons Park. Water will not be contaminated by airside de-icing agents and oil separators will be provided within the drainage system (the proposed pollution prevention measures are summarised at the end of this Section); and

b. Airside areas – runoff will be directed to the infiltration basin however the water quality will be continuously monitored (including total organic compounds (TOC)) and diverted to the WTP when contaminants including de-icing products are recorded.

Inset 2: Preliminary design of Southern Infiltration Tank (from DDS, **Appendix 20.4** of the ES **[TR020001/APP/5.02]**)

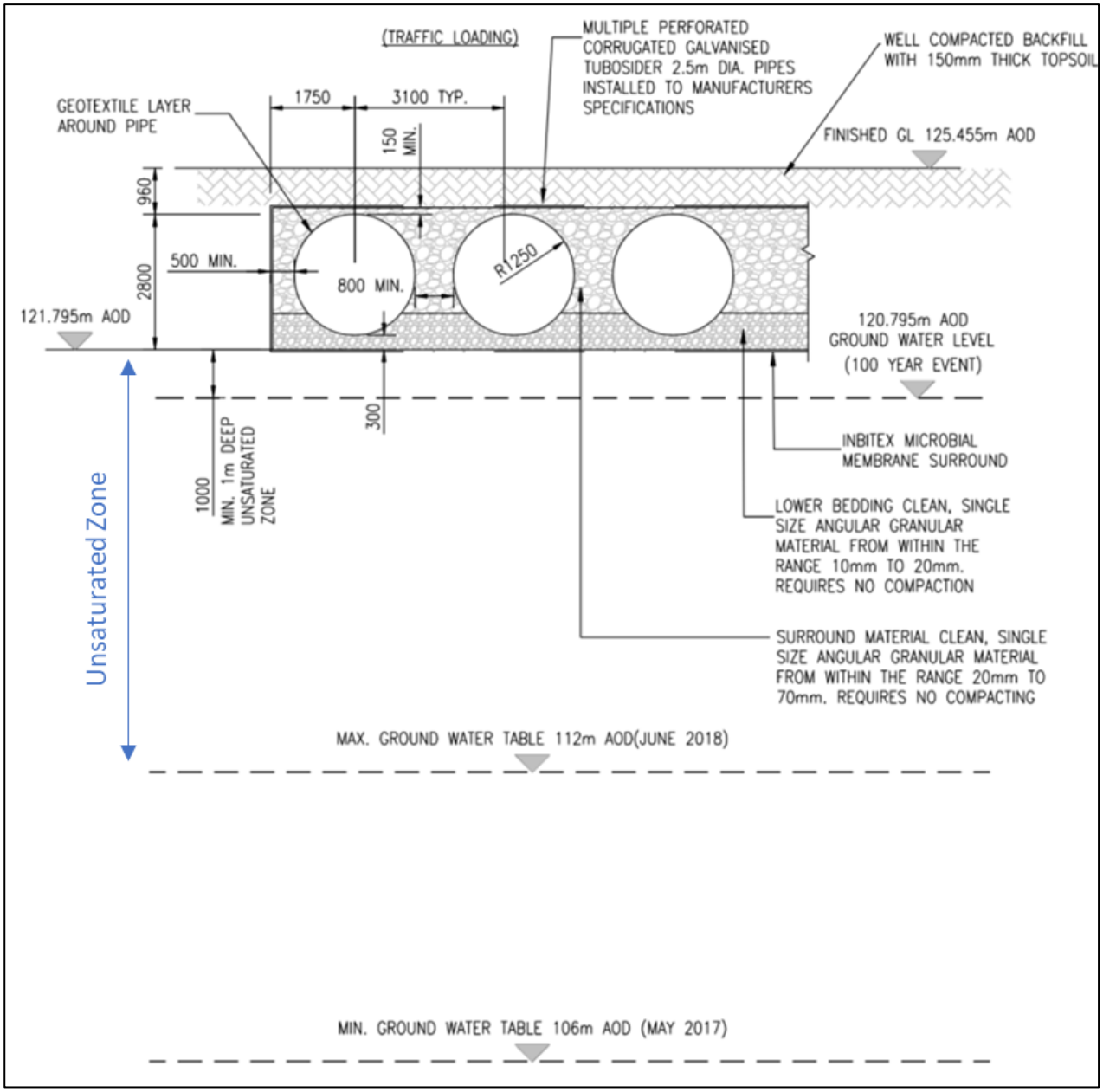


2.2.11 The smaller infiltration tank, from hereon named the ‘Northern Infiltration Tank’, would be located to the east of the proposed new terminal (T2). The tank is approximately 120m in length by 60m in width.

2.2.12 This tank would be used for the discharge of treated sewage effluent and treated surface water run-off from the WTP. The design of the tank includes 7,000m^3 of storage capacity and is shown in **Inset 3**.

2.2.13 A 300mm granular drainage layer would be provided at the base of the tank which is proposed to be installed directly onto the underlying chalk bedrock.

Inset 3: Preliminary design of Northern Infiltration Tank (from DDS, **Appendix 20.4** of the ES **[TR020001/APP/5.02]**)



2.2.14 A WTP would be provided close to the Northern Infiltration Tank to treat both contaminated run-off from the runway activities and all sewage generated at Terminal 2 of the airport. The WTP includes a large underground storage tank system of 70,900m^3 volume, this is designed to contain a two hour 1 in 100-year storm event.

2.2.15 The drainage arrangements for the Proposed Development have been designed to accommodate the maximum groundwater levels with a 1 in 100 year storm event as outlined in **Appendix 20.4** of the ES **[TR020001/APP/5.02]**.

2.2.16 The infiltration tanks have been designed to an infiltration rate of 0.085m/hr, which corresponds to the hydraulic conductivity in the top 20m of the Chalk,

acquired from on-site permeability testing during ground investigation undertaken across the wider airport area (discussed in **Appendix 20.4** of the ES **[TR020001/APP/5.02]**). Actual infiltration rates would be confirmed following a detailed investigation that includes soakage tests at the infiltration tank base level which will be undertaken as part of the detailed design.

2.2.17 All underground tanks (storage and infiltration) have been designed with the bottom of the tanks at least 1m above the maximum 1 in 100 year storm event groundwater table level (approximately 9m above the seasonal maximum groundwater level).

2.2.18 The Hydrogeological Characterisation Report (**Appendix 20.3** of the ES **[TR020001/APP/5.02]**) presents a detailed discussion on groundwater levels beneath the Main Application Site and provides an assessment of groundwater mounding beneath the proposed infiltration tanks.

2.2.19 The mounding assessment presented in the Hydrogeological Characterisation Report (**Appendix 20.3** of the ES **[TR020001/APP/5.02]**) concludes that the factors required for an effective infiltration tank are present at the site, for all but the most extreme maximum groundwater conditions. In the most extreme condition, the storage in the infiltration tanks would be used to contain storm water before infiltration.

Pollution Prevention Measures

2.2.20 There are a number of activities at the airport where contaminants have the potential to enter the surface water drainage system with the key activities including:

a. de-icing activities during winter months. De-icing chemicals (predominantly ethylene glycol and propylene glycol) are typically applied to the ground and aircraft at central points, taxiways, aprons and at aircraft stands;

b. fuel storage and aircraft refuelling (aviation fuel, petrol, diesel and other hydrocarbon based compounds); and

c. Fire Training Ground (effluent from training activities may contain foam and hydrocarbon compounds).

2.2.21 Surface runoff from all airport areas is also likely to contain traces of heavy metals and hydrocarbons particularly from car park and road areas. Minor amounts of herbicides may also be present from use to control weeds across the airport areas.

2.2.22 Sewage effluent from the proposed terminal will contain nitrogen and biological compounds as well as traces of other contaminants that can typically end up in foul effluent such as solvents from cleaning products.

2.2.23 The DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02])** describes a series of treatment and control measures which are to be incorporated in the airport pollution prevention philosophy and preliminary drainage design to capture and limit pollution within the drainage system reaching the WTP and discharging to ground including:

a. full retention separators for all runoff from airside aprons, taxiways and runway to limit the spread of fuel and oils;
b. bypass separators in areas of short term parking or roadways;
c. reduced use of de-icing and recycling of de-icing products at point of application (e.g. collection using perimeter bunds and vacuum pumps) and continuous monitoring prior to treatment. No de-icing products classed as hazardous will be used;
d. bunding of the fuel storage facility with surface water draining through oil separators with sensors to measure water quality;
e. all refuelling vehicles will carry spill kits to limit the volume of spills reaching the drainage system;
f. emergency isolation valves to use in event of pollutant spillages or where water quality monitoring indicates elevated pollutant concentrations, with access in the WTP storage tank to enable effluent to be tankered away for off-site treatment if required;
g. the new fire training ground will be self-contained and during training operations runoff will be diverted to a holding tank and will not discharge to ground. This effluent will be directed to the existing public sewage network or tankered off-site for treatment.

2.2.24 An automated water quality monitoring system will be installed within the drainage infrastructure upstream of the WTP. The system will allow any water which contains elevated levels of contaminants to be diverted to the WTP rather than being discharged directly to the Southern Infiltration Tank.

2.2.25 The automated monitoring system will include continuous total organic carbon (TOC) monitoring. The DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02])** states that trigger levels for TOC will be defined as part of the detailed drainage design and following a period of background testing as recommended within the Ireland Environmental Protection Agency (EPA) guidance (Ref. 16) in the absence of a UK equivalent guidance.

2.2.26 The WTP will comprise three processes, one for the treatment of sewage load (sewage treatment process (STP)) from the terminal buildings, one for the treatment of polluted surface runoff (effluent treatment process (ETP)) and one for treatment of surface water to enable re-use as greywater in the terminal.

2.2.27 The ETP process is predominantly designed to treat glycol de-icers (during winter months) and small volumes of aviation fuel, diesel, petrol and other hydrocarbon based compounds which escape any upstream separators.

2.2.28 Potential contaminants that could be found in the influent to the WTP include various hydrocarbons compounds, oils, ammonia, metals, de-icers, and disinfection products. The conceptual design of the WTP assumes that the majority of these compounds will be absorbed and broken down in the treatment process.

2.2.29 The detailed design of the WTP will include site specific water quality monitoring to assess background concentrations of contaminants in the airport drainage

system, determine triggers for the automated monitoring system and confirm the final treatment processes for the WTP.

2.2.30 Based on the conceptual drainage design it is assumed that water discharged to the Southern Infiltration Tank is unlikely to contain any significant concentrations of contaminants as a result of the proposed pollution mitigation measures, including diversion of first flush runoff to the WTP.

2.2.31 The proposed concentrations of contaminants in the treated effluent discharge to the Northern Infiltration Tank from the WTP presented in the DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02])** have been compiled based on typical effluent discharge consents in England and are summarised in **Table 2.1**. The effluent parameters and a list of all contaminants including any emerging contaminants will be confirmed during the detailed design and monitoring.

2.2.32 No hazardous substances will be discharged in the final effluent.

Table 2.1: Proposed effluent water quality from WTP (from DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**))

Parameter	Units	Proposed Discharge Concentration
Ammonium as NH4	mg/l	<5
Cadmium	mg/l	0.004
Chromium	mg/l	0.02
Copper	mg/l	0.05
Iron	mg/l	1
Residual Chlorine	mg/l	<2
Residual Bromine	mg/l	<5
Total Suspended Solids	mg/l	<20
BOD	mg/l	<10
COD	mg/l	<20
pH	mg/l	5 to 9.5
TKN (Total Nitrogen)	mg/l	<20
Turbidity	NTU	<10
E.Coli	/100ml	250
Intestinal enterocci	/100ml	100
Total Coliforms	/100ml	1000

3 SITE SETTING

3.1 Location

3.1.1 The Main Application Site of the Proposed Development (as defined in **Chapter 2** of the ES **[TR020001/APP/5.01]** and shown on **Figure 2.2** of the ES **[TR020001/APP/5.03]**) is located approximately 3km south east of Luton town centre and incorporates the area around the airport, with the majority of the undeveloped land required for the Proposed Development to the east of the existing airport.

3.1.2 The proposed WTP and two infiltration tanks will be located in the east of the Main Application site as shown in **Inset 1** on land which is currently undeveloped agricultural land.

3.2 Topography

3.2.1 The airport is located immediately north east of the River Lee on an elevated escarpment area that forms part of a scarp slope of the Chilterns Hills.

3.2.2 The topography of the land within the Order limits, encompassing the whole of the proposed airport expansion, varies between 98 to 164 metres Above Ordnance Datum (mAOD). The highest ground is located in the north west and the land gradually lowers to the south east where the topography includes a dry valley network. The Main Application Site includes two branches of the dry valley network which join approximately 250m south east of the Proposed Development.

3.2.3 Existing ground levels in the locations of the proposed Northern and Southern Infiltration Tanks are approximately 125mAOD and 120mAOD respectively.

3.3 Hydrology

3.3.1 No surface watercourses run through the Main Application Site. The nearest large watercourses are the River Lee situated 450m to the south west of the Main Application Site (as defined in **Chapter 2** of the ES **[TR02000/APP/5.01]**) and the River Mimram situated 3.5km east of the Main Application Site. These are both likely to be in hydraulic continuity with the Chalk aquifer.

3.3.2 The watershed line between the two river catchments divides the airport into two, with the west of the airport within the River Lee catchment and the east within the River Mimram catchment. The WTP and proposed infiltration tanks are within the Mimram catchment. The River Mimram is approximately 4km to the east of the proposed Southern Infiltration Tank and 4.5km to the east of the proposed Northern Infiltration Tank.

3.4 Geology

3.4.1 The understanding of the geology around the airport has been developed through the following resources:

a. the British Geological Survey (BGS) report "The physical properties of major aquifers in England and Wales" (Ref. 4);
b. BGS Geology of Britain webviewer (Ref. 5); and
c. on-site ground investigation as documented in a Contamination Quantitative Risk Assessment (Ref. 6).

Superficial deposits

3.4.2 Superficial deposits that occur within the Order limits include:

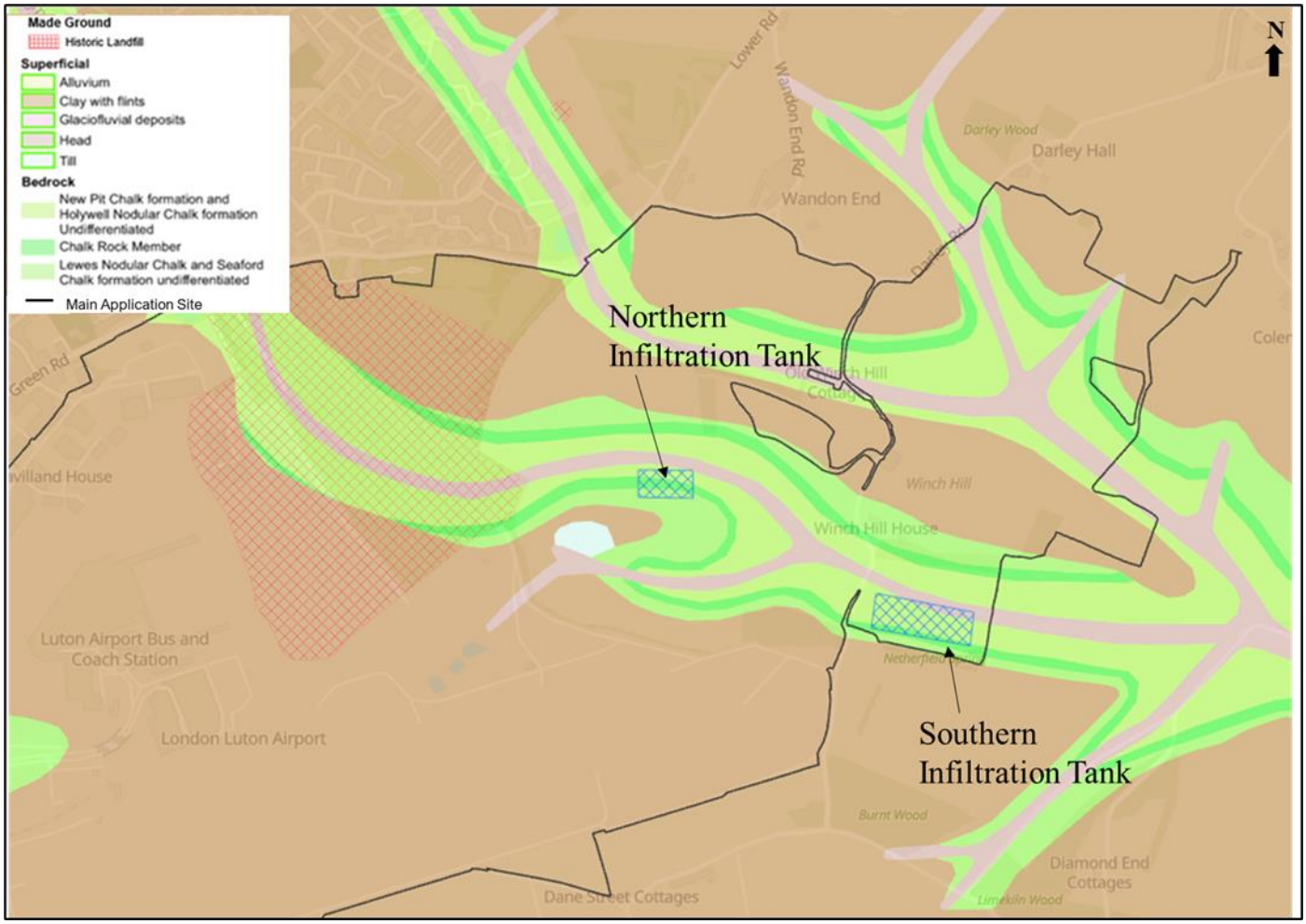
a. Made Ground;
b. Head deposits; and
c. Clay-with-Flints.

3.4.3 Both the Made Ground and Clay-with-Flints underlie the majority of the Main Application Site whereas the Head deposits are found in a thin band within the dry valley bottoms.

3.4.4 A historic landfill is present beneath the east of the current airport and approximately 300m to the west of the proposed Northern Infiltration Tank.

3.4.5 The geological map of the Proposed Development is shown in **Inset 4** which shows where superficial deposits are expected to be absent at the proposed locations of the infiltration tanks.

Inset 4: Geology Map for the Main Application Site



Bedrock

3.4.6 The bedrock beneath the Main Application Site consists of Cretaceous Chalk (undifferentiated Lewes Nodular and Seaford Chalk formations). These are classified as being part of the "White Chalk Subgroup".

3.4.7 These are composed of firm and hard chalk strata with common nodular and tabular flints and hardgrounds.

3.4.8 These in turn are underlain by the older Holywell Nodular and New Pit Chalk formations, also part of the “White Chalk Subgroup”, which outcrop within the dry valleys. These are generally similar in composition to the overlying Chalk formations but are generally flintless.

3.4.1 The condition of the Chalk encountered beneath the Main Application Site is variable. In the upper levels of the Chalk the material has been found to be heavily weathered and was generally recovered as structureless sandy to very silty gravel or sandy gravelly silt. The Chalk material recovered was occasionally recorded as having yellowish brown staining on what are considered to be natural fracture surfaces. Soft grey marl bands were also recovered from within the Chalk.

3.4.2 As shown in **Inset 4** the proposed infiltration tanks are to be installed directly onto the Chalk.

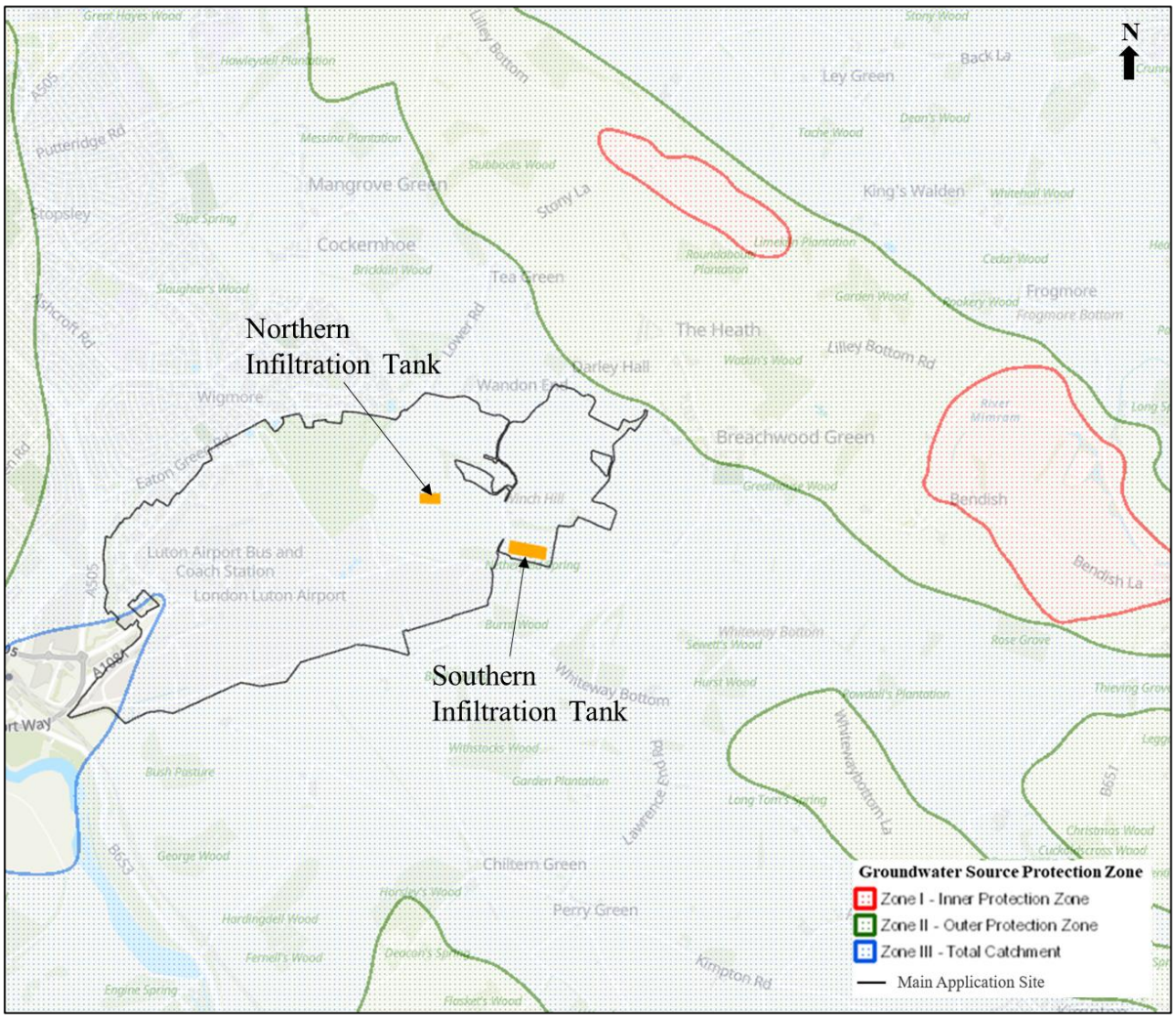
3.5 Hydrogeology

3.5.1 A detailed description of the hydrogeological regime beneath the Main Application Site is described in the Hydrogeological Characterisation Report provided in **Appendix 20.3** of the ES **[TR020001/APP/5.02]** and key characteristics are summarised here.

3.5.2 The Chalk bedrock beneath the Site forms the main water bearing strata in the region and most important aquifer unit within the Thames Basin. It is classed as a Principal aquifer and supplies drinking water for public consumption and supports river flow. The flow through this geology is predominantly through fractures and associated dissolution features.

3.5.1 The Main Application Site is located within a groundwater Source Protection Zone 3 (total catchment) for the public water supply (PWS) abstractions (see **Inset 5**). There are no private groundwater abstractions within 250m of the Main Application Site.

Inset 5: Groundwater Source Protection Zones

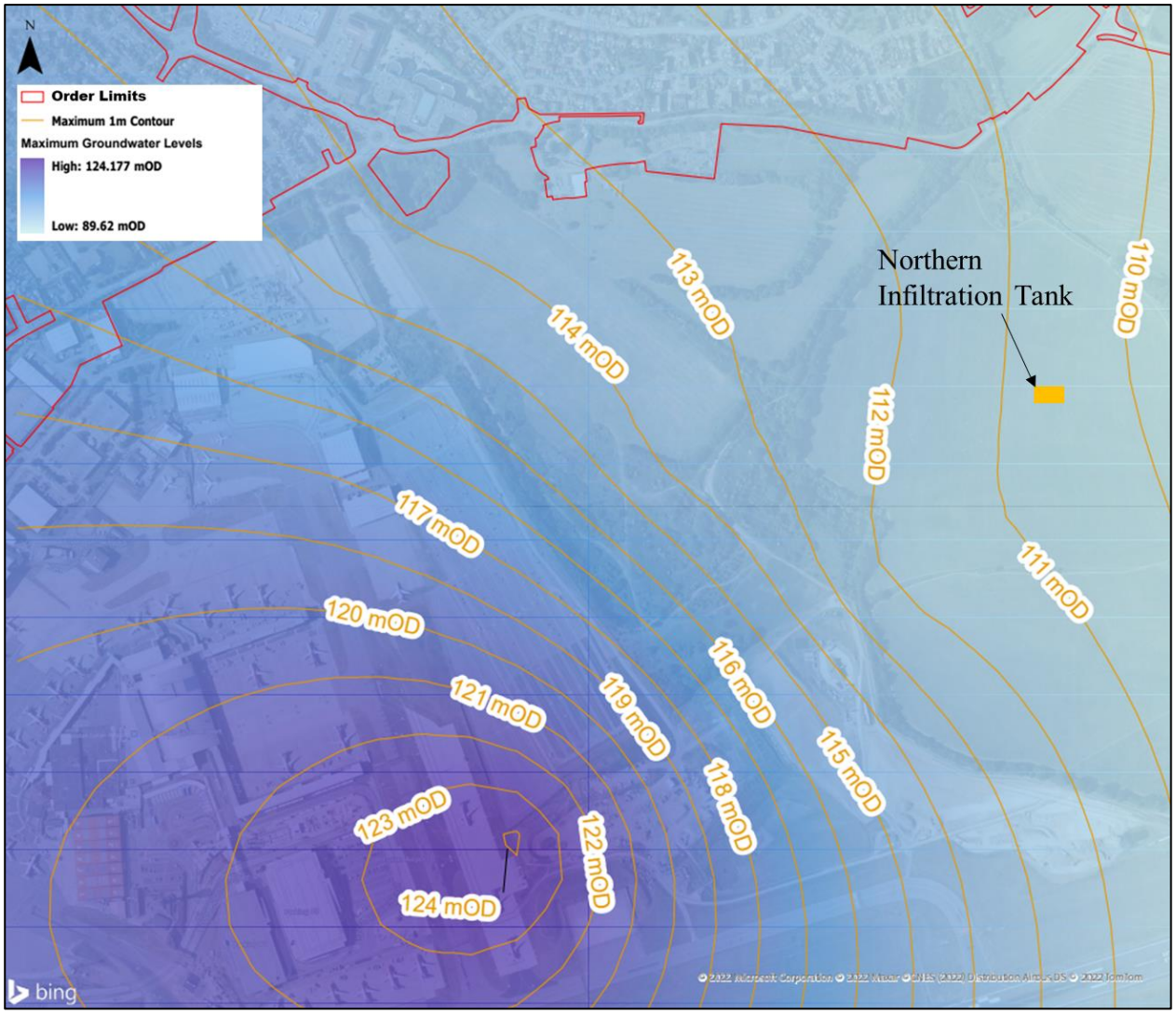


3.5.2 The regional groundwater flow system is modified locally by abstraction and discharge to groundwater. The east of the Main Application site is located within the Mimram catchment and groundwater flow is in a general easterly direction towards the Affinity Water PWS abstractions near Kings Walden, approximately 2.6km to the east.

3.5.3 The Hydrogeological Characterisation Report (**Appendix 20.3** of the ES **[TR020001/APP/5.02]**) presents a detailed discussion on groundwater levels beneath the Main Application Site. Seasonal variation in groundwater levels can be significant within the Chalk in the regional area, with groundwater levels typically showing seasonal ranges from approximately 5m to 10m.

3.5.4 Groundwater contour plans presented in the Hydrogeological Characterisation Report (**Appendix 20.3** of the ES **[TR020001/APP/5.02]**) indicate the maximum typical seasonal groundwater level to be approximately 9.8m beneath the base of the proposed Northern Infiltration Tank as shown in **Inset 6**.

Inset 6: Maximum seasonal groundwater level (from **Appendix 20.3** of the ES **[TR020001/APP/5.02]**)



3.5.1 Hydraulic conductivity within the Chalk shows a variation with depth. On-site packer testing in the Chalk to the west of the proposed infiltration tank locations has indicated that in the top 20m of the Chalk conductivities are shown to be, on average, 2.37 x 10^{-5}m/s. At 40 to 52m from the top of the Chalk, average conductivities are two orders of magnitude lower at 3.36 x 10^{-7}m/s. This is likely due to the presence of more permeable zones associated with fractures and increased dissolution features that occur within the typical range of fluctuation in water table levels at the top of the Chalk.

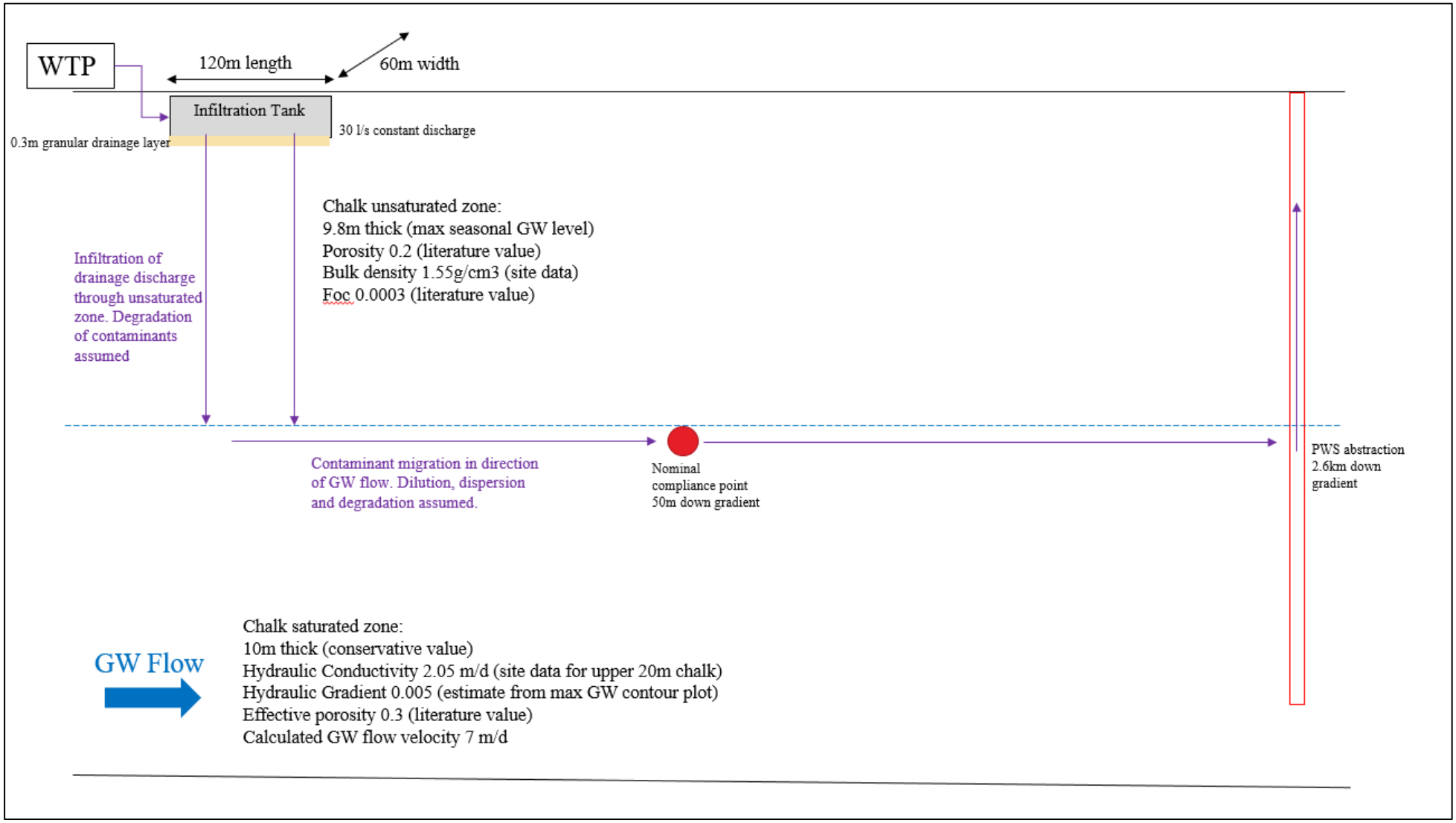
3.5.2 The estimated hydraulic gradient based on maximum seasonal groundwater levels beneath the proposed Northern Infiltration Tank is estimated to be 0.005.

4 CONCEPTUAL SITE MODEL

4.1 Introduction

4.1.1 The following section outlines the conceptual site model and assumptions used to undertake the assessment of impact to groundwater quality from the discharge to ground from the proposed infiltration tanks. The conceptual site model is presented in **Inset 7** and described in the following sections.

Inset 7: Conceptual Site Model



4.2 Source

4.2.1 The drainage infrastructure to be constructed as part of the Proposed Development would manage surface water runoff and discharge to ground, via a combination of two infiltration tanks.

4.2.2 Discharge to the Southern Infiltration Tank will predominantly comprise surface water runoff from the whole of the Proposed Development within the Main Application Site including:

a. Landside areas – including runoff from the new terminal building and car parks to the north and Green Horizons Park . Water will not be contaminated by airside de-icing agents and oil separators will be provided within the drainage system; and

b. Airside areas – runoff will be directed to infiltration basin however the water quality will be continuously monitored (including TOC) and diverted to the WTP when contaminants including de-icing products are recorded.

4.2.3 Surface runoff from these areas may contain traces of metals and hydrocarbons. The first flush of surface water runoff which will be diverted directly to the WTP. Continuous water quality monitoring will also be provided within the drainage system to divert any water containing high levels of contaminants to the WTP (it is noted that the detailed design of this system is to be confirmed).

4.2.4 Based on the conceptual drainage design (see **Section 2.2**) it is assumed that water discharged to the Southern Infiltration Tank is unlikely to contain any significant concentrations of contaminants as a result of the proposed pollution mitigation measures, including diversion of first flush runoff to the WTP. Therefore, this risk assessment primarily considers the risks from discharge to the Northern Infiltration Tank.

4.2.1 The proposed concentrations of contaminants in the treated effluent discharge to the Northern Infiltration tank from the WTP are summarised in **Table 4.1** and have been compared to water quality criteria, with UK drinking water standards (DWS) selected as the most appropriate water quality criteria. Where UK DWS are not available environmental quality standards (EQS) have been selected.

Table 4.1: Comparison of proposed effluent water quality from WTP (from DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**) to water quality criteria

Parameter	Units	Proposed Maximum Discharge Concentration	Water Quality Criteria	
			Concentration	Source
Ammonium as NH4	mg/l	5	0.5	DWS
Cadmium	mg/l	0.004	0.005	DWS
Chromium	mg/l	0.02	0.05	DWS
Copper	mg/l	0.05	2	DWS

Parameter	Units	Proposed Maximum Discharge Concentration	Water Quality Criteria	
			Concentration	Source
Iron	mg/l	1	0.2	DWS
Residual Chlorine	mg/l	2	0.002	EQS (Chlorine)
Residual Bromine	mg/l	5	0.002	EQS (Bromine)
Total Suspended Solids	mg/l	20		
BOD	mg/l	10		
COD	mg/l	20		
pH	mg/l	5 to 9.5		
TKN (Total Nitrogen)	mg/l	20		
Turbidity	NTU	10		
E.Coli	/100ml	250		
Intestinal enterocci	/100ml	100		
Total Coliforms	/100ml	1000		

4.2.2 In accordance with the Water Framework Directive (2000/60/EC) (Ref. 14) (WFD) and Groundwater Daughter Directive (2006/118/EC) (Ref. 15) (GDD), the input of hazardous substances into groundwater should be prevented and the input of non-hazardous pollutants into groundwater should be limited and should not cause pollution (typically assessed by comparison to appropriate water quality standard). No hazardous substances are expected to be discharged to the Northern Infiltration Tank, with the contaminants listed all classed as non-hazardous pollutants.

4.2.3 The proposed discharge concentrations for the metals cadmium, chromium and copper are below the water quality criteria and therefore discharge of these contaminants to ground is not considered to pose a risk.

4.2.4 The proposed concentrations of ammonium, iron, bromine and chlorine are above the water quality criteria and therefore this assessment (**Section 5**) considers if the discharge of these contaminants will pose a risk to the underlying groundwater quality.

4.2.5 A high-level assessment of the potential impacts of the discharge of the biological contaminants, using E.Coli as an indicator, has also been undertaken (**Section 5**).

4.2.6 A constant discharge to ground in the Northern Infiltration Tank has been assumed for this assessment based on an estimated average discharge rate of 30 l/s. This is considered a conservative assumption as seasonal variations in surface runoff and use of Terminal 2 will result in lower discharge at some points during a calendar year, which will reduce the loading of contaminant discharge to ground.

4.3 Pathway

4.3.1 A granular drainage layer approximately 0.3m thick will be provided at the base of the infiltration tank. The tank will be constructed directly onto the chalk bedrock. Discharge from the Northern Infiltration Tank will infiltrate down through the chalk to the underlying groundwater.

4.3.2 The unsaturated zone in the chalk beneath the base of the tank is anticipated to be 9.8m thick based on the estimated maximum seasonal groundwater level. Available site-specific data indicates that the hydraulic conductivity of the upper 20m of the chalk is approximately 2.08 m/d. Use of the maximum seasonal groundwater level is also considered a proportionately conservative assumption.

4.3.3 Attenuation and degradation of contaminants as they migrate through the unsaturated zone has been assumed.

4.3.4 The groundwater in the chalk is estimated to have a flow velocity of approximately 7m/d based on the assumed hydraulic conductivity of 2.08m/d and an estimated hydraulic gradient of 0.005 based on the assumed maximum seasonal groundwater level. Groundwater flow is to the east towards the PWS abstraction 2.6km down hydraulic gradient.

4.3.5 Dilution, dispersion and degradation of contaminants within the aquifer has been assumed. The saturated aquifer thickness has been assumed to be 10m as a conservative assumption.

4.4 Receptor

4.4.1 Groundwater in the chalk principal aquifer is considered to be the primary receptor. Groundwater is abstracted from the chalk for drinking water supply with the nearest PWS abstraction location 2.6km to the east.

4.4.2 Compliance points considered in this assessment include a nominal point located 50m down gradient of the Northern Infiltration Tank and the PWS abstraction 2.6km down gradient.

5 QUANTITATIVE RISK ASSESSMENT

5.1 Approach

5.1.1 The Environment Agency (EA) groundwater risk assessment tool, the Infiltration Worksheet or InfWS (Ref. 13), has been used to assess the potential impact of discharge from the Northern Infiltration Tank to groundwater. Copies of the model worksheets are provided in **Appendix A** of this assessment.

5.1.1 The tool has been used to predict contaminant concentrations at the identified compliance points with the predicted concentrations compared to water quality criteria to assess if there is a potential risk of significant groundwater pollution from the discharge.

5.1.2 For biological contaminants the estimated half-life of E.Coli, which has been selected as an indicator contaminant due to the longest estimated half-life, has been compared to predicted contaminant travel times within the unsaturated zone and saturated zone from the InfWS, to estimate if they are likely to survive and cause potential pollution at the identified receptors.

5.2 Input parameters

5.2.1 The input parameters used for the numerical assessment are summarised in **Tables 5.1** and **5.2**. Degradation of contaminants within the unsaturated and saturated zone has been assumed and the standard model parameter to calculate dispersivity based on 10%, 1% and 0.1% of the pathway length has been selected.

Table 5.1: Hydrogeological model input parameters

Parameter	Value	Unit	Justification/ Notes[A]
Infiltration System			
Type of treatment plant	“Treatment Plant”	-	Most applicable model option
Discharge rate	2,592	m^3/d	Based on average discharge rate of 30l/s
Soakaway area	7,579	m^2	Infiltration tank area from DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**) drawing **[LLADCO-3C-CAP-INF-DRN-DR-CE-5510]** (121.467m x 62.4m)
Drainage layer thickness	0.3	m	Thickness of granular layer beneath tank from DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**) drawing **[LLADCO-3C-CAP-INF-DRN-DR-CE-5510]**
Drainage layer water filled porosity	0.3	-	Estimate based on literature value for fine gravel (Ref. 1)

Parameter	Value	Unit	Justification/ Notes[A]
Drainage layer bulk density	1.36	g/cm^3	Literature value for fine gravel (Ref. 2)
Length of drainage field in direction of groundwater flow	121	m	Length of infiltration tank from DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**) drawing **[LLADCO-3C-CAP-INF-DRN-DR-CE-5510].** Groundwater flow to east.
Width of drainage field in direction of groundwater flow	62.4	m	Length of infiltration tank from DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**) drawing **[LLADCO-3C-CAP-INF-DRN-DR-CE-5510].** Groundwater flow to east.
Unsaturated Zone			
Thickness of unsaturated zone beneath drainage field	9.8	m	Based on maximum seasonal groundwater level contours (**Appendix 20.3** of ES **[TR020001/APP/5.02]** drawing **[LLADCO-3C-ARP-00-00-DR-YE-0230]**)
Unsaturated zone water filled porosity	0.2	-	Estimate based on literature value for chalk (Ref. 3)
Bulk density of unsaturated zone	1.55	g/cm^3	Average value from site data for chalk (Ref. 6)
Fraction of organic carbon	0.003	-	Estimate based on literature value for chalk (Ref. 1)
Saturated Zone			
Saturated aquifer thickness	10	m	Assumed saturated thickness for chalk, considered to be conservative value
Hydraulic conductivity of aquifer	2.08	m/d	Average conductivity value ($2.37x10^{-5}$m/s) of upper 20m of chalk (**Appendix 20.3** of ES **[TR020001/APP/5.02]**)
Hydraulic gradient of water table	0.005	-	Calculated from maximum seasonal groundwater level contour plan (**Appendix 20.3** of ES **[TR020001/APP/5.02]** drawing **[LLADCO-3C-ARP-00-00-DR-YE-0230]**)
Bulk density of aquifer material	1.55	g/cm3	Average value from site data for chalk (Ref. 6)

Parameter	Value	Unit	Justification/ Notes[A]
Effective porosity of aquifer	0.3	-	Estimate based on literature value for chalk (Ref. 3)
Fraction of organic carbon	0.003	-	Estimate based on literature value for chalk (Ref. 1)
Compliance Point			
Distance to compliance point	50	m	Nominal 50m groundwater compliance point down-gradient of infiltration tank
Distance to compliance point	2,600	m	Distance to nearest PWS abstraction down-gradient of infiltration tank

[A] Appropriate literature values have been used where site-specific data is not currently available. Further ground investigation and assessment during detailed design will undertake to provide site specific data for the input parameters where possible.

Table 5.2: Contaminant input parameters

Contaminant	Source concentration (mg/l)	Compliance criteria (mg/l)	K_{oc} (l/kg)	Half Life (days)	K_d (l/kg)
Iron	1	0.2 [A]	-	1E+99	220 [C]
Ammonium as NH4	5	0.5 [A]	-	12 [D]	0.5 [C]
Chlorine	2	0.002 [B]	-	1 [F]	0.8 [E]
Bromine	5	0.002 [B]	120 [D]	1.5 [G]	-
E.Coli	250/100ml	-	-	10 to 12 (32 day survival rate) [H]	-

[A] UK drinking water standard (DWS)
[B] Environmental Quality Standard (EQS) for chloride and bromide used as indicator for chlorine and bromine
[C] ConSim database (Ref. 1)
[D] Literature value (Ref. 8)
[E] Literature value (Ref. 9)
[F] Conservative assumption based on literature value (Ref. 10) indicating chlorine half-life 1.3 to 5 hours
[G] Literature value (Ref. 11)
[H] Literature value (Ref.12)

5.3 Results

5.3.1 The baseline input parameters, summarised in **Section 5.2**, were entered into the EA InfWS. The results based on these parameters are summarised in **Table 6.1.**

Table 6.1: InfWS results for predicted groundwater quality impacts from Northern Infiltration Tank (shaded concentrations exceed the water quality criteria)

Contaminant	Water Quality Criteria (mg/l)	Source concentration (mg/l)	Predicted Concentration (mg/l)		
			Base Unsaturated Zone	50m Compliance Point	Abstraction (2.6km)
Iron	0.2	1	1	0.997	0.005
Ammonium as NH4	0.5	5	1.16	0.57	$1.2x10^{-9}$
Chlorine	0.002	2	$3x10^{-6}$	$1.86x10^{-9}$	$6.1x10^{-42}$
Bromine	0.002	5	0.304	0.056	$1.7x10^{-15}$

5.3.2 Predicted concentrations of all contaminants at the abstraction point are below the water quality criteria indicating significant impact to the abstraction as a result of the discharge from the Northern Infiltration Tank is unlikely to occur.

5.3.3 The results of the InfWS predict that concentrations of chlorine are likely to be below the water quality criteria by the time the discharge reaches the base of the unsaturated zone and at the down-gradient compliance points. Therefore, the discharge of chlorine is not considered to pose a risk of pollution to groundwater.

5.3.4 Predicted concentrations of ammonium are marginally above the water quality criteria at the 50m compliance point (0.57 mg/l compared to a water quality criteria of 0.5 mg/l). On this basis it is considered unlikely that the predicted discharge concentration of ammonium would result in significant pollution of the groundwater underlying the infiltration tank. However, it is recommended that during the detailed design it is considered whether lower concentrations in the discharged effluent could reasonably be achieved.

5.3.5 The concentration of bromine is predicted to exceed the water quality standard at the 50m compliance point. The proposed discharge concentration for bromine stated in the DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02])** is <5mg/l and the InfWS has assumed the worst case discharge concentration of 5mg/l.

5.3.6 The InfWS predicts reducing the bromine discharge concentration to 3mg/l would result in the predicted concentration of bromine at the 50m compliance point being below the water quality criteria. It is recommended that during the detailed design it is considered whether lower concentrations in the discharged effluent could reasonably be achieved.

5.3.7 Predicted concentrations of iron exceed the water quality criteria at the 50m compliance point. The drinking water quality standard for iron is based on aesthetic standards rather than potential health impacts to minimise the occurrence of discoloured (brown/orange) water. Concentrations of iron are not predicted to exceed the DWS at the PWS abstraction point. The EQS for iron is 1mg/l which is equal to the proposed discharge concentration and therefore

environmental impacts as a result of the discharge of iron to ground are not anticipated.

5.3.8 The InfWS predicts unretarded travel times of contaminants within the unsaturated zone to be 11 days with retarded travel times predicted to be 1,810 days. Assuming biological contaminants (based on E.Coli) within the discharge have a half-life of 10 to 12 days and typically will only survive for 32 days (Ref. 12), it is estimated that the number of bacteria in the discharge will have significantly reduced or be close to zero when they reach the base of the unsaturated zone. Allowing for some further degradation to occur within groundwater, biological contaminants in the discharge are unlikely to survive long enough to pose a risk to the down gradient groundwater receptors.

5.4 Discussion

5.4.1 The results of the quantitative risk assessment have predicted that proposed concentrations of some contaminants (ammonium and bromine) discharged from the Northern Infiltration Tank are may result in pollution of groundwater when assessing predicted concentrations to the compliance point 50m down gradient of the infiltration tank.

5.4.2 Marginally elevated concentrations of ammonium have been predicted at the 50m compliance point. On this basis it is considered unlikely that the predicted discharge concentration of ammonium would result in significant pollution of the groundwater underlying the infiltration tank. During the detailed design it will be considered whether lower concentrations in the discharged effluent could reasonably be achieved.

5.4.3 The InfWS predicts that a bromine discharge concentration of <3mg/l would not exceed the water quality criteria at the 50m compliance point. During the detailed design it will be considered whether lower concentrations in the discharged effluent could reasonably be achieved.

5.4.4 The assumptions used in the InfWS are considered to be conservative i.e. a reasonable worst case. The model is particularly sensitive to changes in the discharge rate from the infiltration tank. The model assumes a constant discharge based on the likely peak discharge rates. It is likely that for much of the time discharge rates to the Northern Infiltration tank will be lower which will reduce the loading of contaminant discharge to groundwater.

5.4.5 The thickness of the unsaturated zone will also impact the InfWS predictions with a larger unsaturated zone thickness allowing for more attenuation and degradation as the contaminants migrate down towards the groundwater table. The unsaturated zone thickness assumed is based on the maximum typical seasonal groundwater level, however groundwater levels are likely to be lower than this during parts of the year.

5.4.6 The quantitative risk assessment will need to be revised once the detailed design of the drainage infrastructure has been confirmed in order to support an application for an Environmental Permit to discharge prior to the construction of the infiltration tanks and WTP.

6 CONCLUSIONS

6.1.1 This report has been produced to provide an initial HRA to assess the acceptability of the proposed discharge of treated wastewater and surface runoff to ground from the proposed infiltration tanks in terms of the groundwater quality impact.

6.1.2 The proposed drainage infrastructure comprises the construction of a WTP and two infiltration tanks for the discharge of surface water runoff and treated surface water runoff and treated effluent to ground.

6.1.3 The proposed drainage infrastructure is to be installed during assessment Phases 2a and 2b and therefore this risk assessment will need to be revised to account for the final detailed drainage design and to support an application to the Environment Agency for an Environmental Permit to discharge closer to the time of construction.

6.1.1 The construction of the WTP to handle foul effluent has been proposed as Thames Water has indicated that there would not be sufficient capacity at the local water treatment plant to receive effluent from the Proposed Development. Engagement with TW will continue during the detailed design stage to confirm if this position remains or other feasible drainage solutions could be considered.

6.1.2 This risk assessment is based on the current conceptual drainage design which incorporates a series of pollution mitigation measures to prevent discharge of significant concentrations of contaminants to ground, including an automated monitoring system to divert polluted water to the WTP.

6.1.3 During the detailed design, site specific water quality monitoring will be undertaken to assess fully the likely contaminant concentrations which will be present in the influent to the WTP and to determine appropriate monitoring systems and trigger levels.

6.1.1 Based on the conceptual drainage design it is assumed that water discharged to the Southern Infiltration Tank is unlikely to contain any significant concentrations of contaminants as a result of the proposed pollution mitigation measures, including diversion of first flush runoff to the WTP. Therefore, this risk assessment primarily considers the risks from discharge to the Northern Infiltration Tank.

6.1.1 The key contaminants that are likely to be found in the influent to the WTP include various hydrocarbon compounds, fuel oils, ammonia, metals, de-icers, pesticides and disinfection products. The conceptual design of the WTP states that the majority of these compounds will be absorbed and broken down in the treatment process.

6.1.2 Potential contaminants in the proposed WTP discharge to the Northern Infiltration Tank comprise metals (cadmium, chromium, copper and iron), ammonium, chlorine, bromine and biological contaminants including E.Coli.

6.1.1 The proposed discharge concentrations of cadmium, chromium, copper and chlorine are considered to be acceptable and are unlikely to result in significant pollution of groundwater. Biological contaminants in the discharge are also

considered unlikely to survive long enough to pose a potential risk to the down gradient groundwater receptors when considering predicted travel times through the unsaturated and saturated zones.

6.1.2 Elevated concentrations of ammonium and bromine have been predicted within 50m down gradient of the Northern Infiltration Tank. Allowing for the conservatism in the model and marginal elevated concentrations, significant pollution of the groundwater is not predicted. However, during the detailed design it will be considered whether lower concentrations in the discharge effluent could reasonably be achieved and whether any other mitigation measures are required. This will be considered in further detail as part of the application for an Environmental Permit to discharge nearer the time of construction.

6.1.1 Predicted concentrations of iron exceed the water quality criteria at both the 50m compliance point. The drinking water quality standard for iron is based on aesthetic standards rather than potential health impacts. The EQS for iron is 1mg/l which is equal to the proposed discharge concentration and therefore environmental impacts as a result of the discharge of iron to ground are not anticipated. Predicted concentration of iron at the abstraction point are below the drinking water standard. Therefore, it is considered unlikely that significant pollution to groundwater will occur as a result of the discharge of iron to ground.

6.1.1 The assumptions used in the model are considered to be conservative. The model is particularly sensitive to changes in the discharge rate and unsaturated zone thickness. Worst case assumptions for the discharge rate have been used and it is considered likely that discharge rates to ground could be lower at certain periods during a calendar year which would reduce the loading of contaminant discharge to groundwater.

6.2 Recommendations

6.2.1 This risk assessment is based on the conceptual drainage design for the Proposed Development. The risk assessment will need to be revised once the detailed design of the drainage infrastructure has been confirmed in order to support an application for an Environmental Permit to discharge prior to the future construction of the infiltration tanks and WTP. It is acknowledged that regulatory requirements for discharge to groundwater (including changes to water quality standards and emerging contaminants) may have changed by the time the permit application is made and water treatment technology may have improved.

6.2.1 During the detailed drainage design stage, site specific water quality monitoring will be undertaken to assess fully the likely contaminant concentrations which will be present in the surface water drainage influent to the WTP and discharge effluent to the infiltration tanks and to determine appropriate monitoring systems and trigger levels.

6.2.2 The ground conditions parameters used in this risk assessment are based on available ground investigation information from the wider airport site. Site

specific infiltration testing will be undertaken at the proposed infiltration tank locations to confirm the infiltration rates and detailed design of the tanks.

6.2.3 Groundwater quality monitoring boreholes are likely to be required by the Permit down gradient of the proposed infiltration tanks for compliance monitoring of groundwater during operation.

GLOSSARY AND ABBREVIATIONS

Term	Definition
Aquifer	An aquifer is a body of rock and/or sediment that holds groundwater.
BGS	British Geological Survey
Chalk	Chalk is a soft, white, porous, sedimentary carbonate rock. It is a form of limestone composed of the mineral calcite and originally formed deep under the sea by the compression of microscopic plankton that had settled to the sea floor.
Clay with Flints	Superficial deposits of stiff red, brown or yellow clay containing unworn whole flints as well as angular shattered fragments, also with a variable admixture of rounded flint, quartz, quartzite and other pebbles
DCO	Development Consent Order
DDS	Drainage Design Statement
EA	Environment Agency
ES	Environmental Statement
Groundwater	Groundwater is any water found beneath the surface that fills pores or cracks in the underlying soil and rocks.
Groundwater mounding	A localised increased in groundwater level.
HCR	Hydrogeological characterisation report
Hydraulic conductivity	Hydraulic conductivity is a physical property which measures the ability of the material to transmit fluid through pore spaces and fractures in the presence of an applied hydraulic gradient.
LBC	Luton Borough Council
mAOD	Metres above ordnance survey
mBGL	Metres below ground level
Permeability	A measure of the ability of a material (such as rocks) to transmit fluids
PWS	Public Water Supply
River Lee	Main river located 450m to the west of the Proposed Development. A tributary of the River Thames. Upper reaches are groundwater fed.
River Mimram	Main river located 3.5km to the south-east of the Proposed Development. A tributary of the River Thames. Upper reaches are groundwater fed.
WFD	Water Framework Directive
WTP	Water Treatment Plant

REFERENCES

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Ref. 13. Environment Agency (2014) Annex J 5, Infiltration Worksheet User Manual v2.0
Ref. 14. Secretary of State (2015) Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
Ref 15. Directive 2006/118/EC on the protection of groundwater against pollution and deterioration (the Groundwater Daughter Directive)
Ref 16 EPA Office of Environmental (2012). Guidance on the setting of trigger values for storm water discharges to off-site surface waters at epa ippc and waste licensed facilities. Issue No. 1. Ireland. (Accessed 10 October 2022). Available at: [redacted]

APPENDIX A INFILTRATION WORKSHEETS

Groundwater risk assessment for treated effluent discharges to infiltration systems

Infiltration Worksheet , Release v3.0

Date of Workbook Issue: March 2022

This worksheet has been produced in combination with the document: H1 Annex J5 User Manual version 2.0 (Environment Agency, 2014).

IMPORTANT: To enable MS Excel worksheet, click the Microsoft Office Button  c… Excel Options, click Add-Ins. In the Manage box, select Excel Add-ins. Click Go. Select **Analysis ToolPak** and **Analysis ToolPak-VBA** (to calculate error functions)

Details to be completed for each assessment				
Site Name:	**Luton Airport**			
Site Address:	**Luton**			
Completed by:	**JW**			
Date:	**27-Oct-22**	**Version:**	**1**	
Substance	**Ammonium as NH4**			
Environmental Standard (C_T)	**0.5**	**mg/l**	**Origin of C_T:**	**DWS**

This spreadsheet has been developed as a tool to assist groundwater risk assessment for effluent discharges to infiltration systems. The following worksheets are available:

Site details entered on this page are automatically copied to each worksheet.
The worksheet uses the following colour coding:

	Worksheet option with pull down menu
	Data entry
	Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
	Data carried forward from an earlier worksheet
	Calculation

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

Infiltration Worksheet

Infiltration System

This sheet allows user to enter effluent concentration and details of infiltration system

Substance		**Ammonium as NH4**		From introduction sheet
Compliance value or environmental standard	C_T	**5.00E-01**	**mg/l**	From introduction sheet

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Concentration of substance in discharge (entering infiltration system)	C_e	5.00E+00	mg/l	Proposed Discharge Concentration (DDS)	
Type of treatment plant		**Treatment plant**			
Water use and percolation rate (for use only with septic tanls and package treatment plants)					
Number of persons	p				*Not valid for this treatment plant option*
Water use		1.80E+02	litres/person/day		*Not valid for this treatment plant option*
Percolation rate	Vp		s/mm		*Not valid for this treatment plant option*
Specify discharge (Q1) or calculate based on use (Q2)		**Specified discharge Q1**			
Discharge rate	Q1	2.59E+03	m^3/d	Based on peak discharge rate of 30l/s	
Calculated discharge	Q2	0.00E+00	m^3/d		*Value specifed by user and not calculated*
Area of drainage fied and hydraulic loading					
Specify area of drainage field or calculate based on percolation rate		**Specify**			
Enter area of drainage field	A	7.58E+03	m^2	filtration tank dimentions from DDS (121.467m x 62.4	
Calculated area of drainage field	A	0.00E+00	m^2		*Value specifed by user and not calculated*
Calculated infiltration rate	Inf	3.42E-01	m/d		

Site being assessed:	Luton Airport
Completed by:	JW
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Infiltration Worksheet

Attenuation unsaturated zone

This sheet calculates attenuation factor for the unsaturated zone; concentration at base of unsaturated zone and discharge consent limit

Contaminant		**Ammonium as NH4**		From introduction sheet
Compliance value or environmental standard	C_T	**5.00E-01**	mg/l	From introduction sheet
Concentration of substance in substance in discharge (entering infiltration system)	C_e	**5.00E+00**	mg/l	From infiltration sheet

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Drainage Layer					
Infiltraton rate	**Inf**	**3.42E-01**	**m/d**	From infiltration sheet	
Thickness of drainage layer	S_1	3.00E-01	m	Thickness of granular layer beneath tank from drawings in DDS	
Water filled porosity	θ_1	3.00E-01	fraction	Estiamte literature value for fine gravel (ConSim manual)	
Bulk density	ρ_1	1.36E+00	g/cm^3	Literature value for fine gravel (CLEA Report SR3)	
Calculated dispersivity	D_1	3.00E-02	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation of substance	$t_{1/2}$	1.20E+01	days		
Calculated decay rate	λ_1	5.78E-02	days^{-1}	calculated (very low value set if no degradation)	*Calculated from half life (above)*
Enter method of defining partition co-efficient (using pull down list)		**User specified value for partition coefficient**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_1	5.00E-01	l/kg	Literature Value	
Entry for organic chemicals (option)					
Fraction of organic carbon in soil	foc_1	1.00E-02	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_1	1.00E+01	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_1**	**5.00E-01**	**l/kg**	*Specified value*	
Retardation factor	Rfu_1	3.27E+00			
Unretarded travel time (no dispersion)	tu_1	2.63E-01	d		
Unretarded travel time (with dispersion)	tu_1	2.37E-01	d		
Retarded travel time (with dispersion)	tr_1	7.74E-01	d		
Attenuation factor	AFu_1	1.05E+00			
Unsaturated Zone					
Thickness of unsaturated zone below drainage field	S_2	9.80E+00	m	Based on max seasonal groundwater level contours	
Water filled porosity	θ_2	2.00E-01	fraction	Estimate based on CIRIA C574, 2002, Engineering Properties of Chalk	
Bulk density of unsaturated zone	ρ_2	1.55E+00	g/cm^3	Average site data for Chalk (range of 1.23 to 2.23 mg/m3, in DQRA)	
Calculated dispersivity	D_2	9.80E-01	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation of substance	$t_{1/2}$	1.20E+01	days	Literature value	
Calculated decay rate	λ_2	5.78E-02	days^{-1}	calculated (very low value set if no degradation)	*Default value of 1/10^99 used*
Fraction of rapid flow through unsaturated zone	B	0.00E+00	fraction	*Assumed no by-pass*	
Enter method of defining partition co-efficient (using pull down list)		**User specified value for partition coefficient**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_2	5.00E-01	l/kg	Literature Value	
Entry for organic chemicals (option)					
Fraction of organic carbon in soil	foc_2	1.00E-02	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_2	1.00E+01	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_2**	**5.00E-01**	**l/kg**	*Specified value*	
Retardation factor	Rfu_2	4.88E+00			
Unretarded travel time (no dispersion)	tu_2	5.73E+00	d		
Unretarded travel time (with dispersion)	tu_2	5.16E+00	d		
Retarded travel time (with dispersion)	tr_2	2.51E+01	d		
Attenuation factor	AFu_2	4.11E+00			
Total unretarded travel time	$tu_1 + tu_2$	5.99E+00	d		
Total retarded travel time	$tr_1 + tr_2$	2.88E+01	d		

Attenuation factor and discharge consent limit

Drainage layer attenuation factor	**AFu_1**	**1.05E+00**	
Unsaturated zone attenuation factor	**AFu_2**	**4.11E+00**	
Concentration at base of drainage layer	**C_{dl}**	**4.76E+00**	**mg/l**
Concentration at base of unsaturated zone	**C_{wt}**	**1.16E+00**	**mg/l**
		and	

Site being assessed:	Luton Airport
Completed by:	JW
Date:	27-Oct-22
Version:	1

Infiltration Worksheet

Dilution

This sheet calculates the dilution factor for groundwater dilution below the drainage field.
Substance concentration in groundwater and discharge consent limit

Substance		**Ammonium as NH4**		From introduction sheet
Compliance value or environmental standard	**C_T**	**5.00E-01**	**mg/l**	From introduction sheet
Source concentration	**C_e**	**5.00E+00**	**mg/l**	From infiltration sheet
Concentration at base of drainage layer	**C_{wt}**	**1.16E+00**	**mg/l**	From atten_unsatzone sheet

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Infiltration	Inf	3.42E-01	m/d	From infiltration sheet
Area of drainage field	A	7.58E+03	m^2	From infiltration sheet
Entry for groundwater flow below site				
Length of drainage field in direction of groundwater flow	L	1.21E+02	m	**Length of infiltration tank from DDS**
Saturated aquifer thickness	da	1.00E+01	m	**aturated thickness for chalk, considered to be conser**
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.08E+00	m/d	**20m of chalk average conductivity value 2.37x10-5m/s**
Hydraulic gradient of water table	i	5.00E-03	fraction	**ated from maximum groundwater level contour plan i**
Width of drainage field perpendicular to groundwater flow	w	6.24E+01	m	**Width of infiltration tank from DDS**
Background concentration of substance in groundwater up-gradient of site	Cu	0.00E+00	mg/l	**Assumed no background concentration**
		Calculate		
Enter mixing zone thickness	Mz	5.00E+00	m	*Not valid - Value calculated*
Calculated mixing zone thickness	Mz	1.00E+01	m	
Groundwater flow (mixing zone) below drainage field	Gw	6.48	m^3/d	

Dilution factor and discharge consent limit

Dilution Factor	**DF**	**1.002500911**		
Headroom Factor	**HF**	**1.002500911**		
Unsaturated zone attenuation factor	**AFu**	**4.11E+00**		From infiltration sheet
Concentration in groundwater below drainage field	**C_{gw}**	**1.15E+00**	**mg/l**	
		or		
Environmental Permit limit value	**EPL_2**	**2.165718751**	**mg/l**	

Site being assessed:	Luton Airport
Completed by:	JW
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Version:	1

Concentration immediately downgradient of drainage field exceeds target concentration

Infiltration Worksheet

Attenuation in saturated zone

This sheet calculates attenuation factor for the saturated zone; substance concentration at downgradient compliance point and discharge consent limit

Input Parameters	Variable	Value	Unit	Source
Substance		**Ammonium as NH4**		From introduction sheet
Compliance value or environmental standard	**C_T**	**5.00E-01**	mg/l	From introduction sheet
Source concentration	**C_e**	**5.00E+00**	mg/l	From infiltration sheet
Dilution Factor	**DF**	**1.00E+00**		from dilution sheet
Unsaturated zone attenuation factor	**AFu**	**4.11E+00**		From atten_unsatzone sheet

	Variable	Value	Unit	Source of parameter value
Concentration in groundwater below drainage field	Cgw	1.15E+00	mg/l	from dilution sheet
Option to select degradation		Degradation occurs - sorbed and dissolved phases		
Half life for degradation of substance	$t_{1/2}$	1.20E+01	days	Literature value
Calculated decay rate	λ	5.78E-02	$days^{-1}$	calculated (very low value set if no degradation)
Width of drainage field	w	6.24E+01	m	from dilution sheet
Mixing zone thickness	Mz	1.00E+01	m	from dilution sheet
Bulk density of aquifer materials	ρ	1.55E+00	g/cm^3	*Average site data for Chalk (1.23-2.26mg/m3 fror*
Effective porosity of aquifer	n	3.00E-01	fraction	*Table 4.7 of CIRIA C574, 2002, Engineering prop*
Hydraulic gradient	i_{corr}	2.00E+00	fraction	from dilution sheet (adjusted)
Hydraulic conductivity of saturated aquifer	K	2.08E+00	m/d	from dilution sheet
Distance to compliance point	x	5.00E+01	m	*Nominal Compliance Point*
Option to select time		Use steady state (recommended)		
Enter time	T	1.00E+01	days	time variant options only
Time since pollutant entered groundwater	t	1.00E+99		
Parameters values determined from options				
Partition coefficient	Kd	5.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	5.00E+00	m	*see options*
Transverse dispersivity	az	5.00E-01	m	*see options*
Vertical dispersivity	ay	5.00E-02	m	*see options*

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	1.39E+01	m/d
Retardation factor	Rf	3.58E+00	fraction
Decay rate used	λ	5.78E-02	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i_{corr}	2.00E+00	fraction
Rate of contaminant flow due to retardation	u	3.87E+00	m/d
Attenuation factor	**AFs**	**2.01E+00**	**fraction**

Attenuation and Dilution factors and discharge consent limit

Dilution Factor	**DF**	**1.00E+00**	
Unsaturated zone attenuation factor	**AFu**	**4.11E+00**	
Saturated zone attenuation factor	**AFs**	**2.01E+00**	
Concentration in groundwater at compliance point	**C_{dcp}**	**0.574952183**	**mg/l**
		or	
Environmental Permit limit value	**EPL_3**	**4.35E+00**	**mg/l**
Distance to compliance point		**50**	**m**

Concentration at compliance point exceeds target concentration

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	5.00E-01	l/kg

Entry for organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Soil water partition coefficient	Kd	5.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

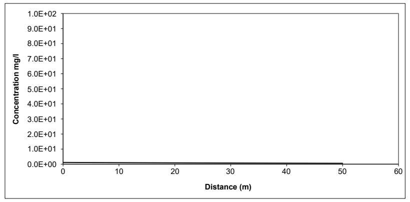
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity (m)	**ax**	1.00E-12	5.00E+00	2.98E+00
Transverse dispersivity (m)	**az**	1.00E-12	5.00E-01	2.98E-01
Vertical dispersivity (m)	**ay**	1.00E-12	5.00E-02	2.98E-02

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x



Calculated concentrations for distance-concentration graph

From calculation sheet

Distance m	**Concentration mg/l**
0	**1.2E+00**
2.5	**1.11E+00**
5.0	**1.08E+00**
7.5	**1.04E+00**
10.0	**1.00E+00**
12.5	**9.70E-01**
15.0	**9.37E-01**
17.5	**9.04E-01**
20.0	**8.73E-01**
22.5	**8.44E-01**
25.0	**8.15E-01**
27.5	**7.87E-01**
30.0	**7.60E-01**
32.5	**7.34E-01**
35.0	**7.09E-01**
37.5	**6.84E-01**
40.0	**6.61E-01**
42.5	**6.38E-01**
45.0	**6.16E-01**
47.5	**5.95E-01**
50.0	**5.75E-01**

Site being assessed:	Luton Airport
Completed by:	0
Date:	00-Jan-00
Version:	0

Groundwater risk assessment for treated effluent discharges to infiltration systems

Infiltration Worksheet , Release v3.0

Date of Workbook Issue: March 2022

This worksheet has been produced in combination with the document: H1 Annex J5 User Manual version 2.0 (Environment Agency, 2014).

IMPORTANT: To enable MS Excel worksheet, click the Microsoft Office Button  c… Excel Options, click Add-Ins. In the Manage box, select Excel Add-ins. Click Go. Select **Analysis ToolPak** and **Analysis ToolPak-VBA** (to calculate error functions)

Details to be completed for each assessment				
Site Name:	**Luton Airport**			
Site Address:	**Luton**			
Completed by:	**JW**			
Date:	**27-Oct-22**	**Version:**	**1**	
Substance	**Bromine**			
Environmental Standard (C_T)	**0.002**	**mg/l**	**Origin of C_T:**	**EQS**

This spreadsheet has been developed as a tool to assist groundwater risk assessment for effluent discharges to infiltration systems. The following worksheets are available:

Site details entered on this page are automatically copied to each worksheet.
The worksheet uses the following colour coding:

	Worksheet option with pull down menu
	Data entry
	Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
	Data carried forward from an earlier worksheet
	Calculation

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

Infiltration Worksheet

Infiltration System

This sheet allows user to enter effluent concentration and details of infiltration system

Substance		**Bromine**		From introduction sheet
Compliance value or environmental standard	C_T	**2.00E-03**	**mg/l**	From introduction sheet

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Concentration of substance in discharge (entering infiltration system)	C_e	5.00E+00	mg/l	Proposed Dischrgae Concentration (DDS)	
Type of treatment plant		**Treatment plant**			
Water use and percolation rate (for use only with septic tanls and package treatment plants)					
Number of persons	p				*Not valid for this treatment plant option*
Water use		1.80E+02	litres/person/day		*Not valid for this treatment plant option*
Percolation rate	Vp		s/mm		*Not valid for this treatment plant option*
Specify discharge (Q1) or calculate based on use (Q2)		**Specified discharge Q1**			
Discharge rate	Q1	2.59E+03	m^3/d	Based on peak discharge rate of 30l/s	
Calculated discharge	Q2	0.00E+00	m^3/d		*Value specifed by user and not calculated*
Area of drainage fied and hydraulic loading					
Specify area of drainage field or calculate based on percolation rate		**Specify**			
Enter area of drainage field	A	7.58E+03	m^2	filtration tank dimentions from DDS (121.467m x 62.4	
Calculated area of drainage field	A	0.00E+00	m^2		*Value specifed by user and not calculated*
Calculated infiltration rate	Inf	3.42E-01	m/d		

Site being assessed:	Luton Airport
Completed by:	JW
Date:	27-Oct-22
Version:	1

Infiltration Worksheet

Attenuation unsaturated zone

This sheet calculates attenuation factor for the unsaturated zone; concentration at base of unsaturated zone and discharge consent limit

Contaminant		**Bromine**		From introduction sheet
Compliance value or environmental standard	C_T	**2.00E-03**	mg/l	From introduction sheet
Concentration of substance in substance in discharge (entering infiltration system)	C_e	**5.00E+00**	mg/l	From infiltration sheet

Input Parameters	Variable	Value	Unit	Source of parameter value	
Standard entry					
Drainage Layer					
Infiltraton rate	**Inf**	**3.42E-01**	**m/d**	From infiltration sheet	
Thickness of drainage layer	S_1	3.00E-01	m	Thickness of granular layer beneath tank from drawings in DDS	
Water filled porosity	θ_1	3.00E-01	fraction	Estimate literature value for fine gravel (ConSim manual)	
Bulk density	ρ_1	1.36E+00	g/cm^3	Literature value for fine gravel (CLEA Report SR3)	
Calculated dispersivity	D_1	3.00E-02	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation of substance	$t_{1/2}$	1.50E+00	days	Literature value for fine gravel (CLEA Report SR3)	
Calculated decay rate	λ_1	4.62E-01	days^{-1}	calculated (very low value set if no degradation)	*Calculated from half life (above)*
Enter method of defining partition co-efficient (using pull down list)		**Calculate for non-polar organic chemicals**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_1	2.0E+02	l/kg	Literature value	*Not valid - Calculated value used*
Entry for organic chemicals (option)					
Fraction of organic carbon (in soil)	foc_1	1.00E-04	fraction		
Organic carbon partition coefficient	Koc_1	1.20E+02	l/kg		
Soil water partition coefficient used in assessment	**Kd_1**	**1.20E-02**	**l/kg**	*Calculated value*	
Retardation factor	Rfu_1	1.05E+00			
Unretarded travel time (no dispersion)	tu_1	2.63E-01	d		
Unretarded travel time (with dispersion)	tu_1	2.37E-01	d		
Retarded travel time (with dispersion)	tr_1	2.50E-01	d		
Attenuation factor	AFu_1	1.13E+00			

Unsaturated Zone					
Thickness of unsaturated zone below drainage field	S_2	9.80E+00	m	Based on max seasonal groundwater level contours	
Water filled porosity	θ_2	2.00E-01	fraction	Estimate based on CIRIA C574, 2002, Engineering Properties of Chalk	
Bulk density of unsaturated zone	ρ_2	1.55E+00	g/cm^3	Average site data for Chalk (range of 1.23 to 2.23 mg/m3, in DQRA)	
Calculated dispersivity	D_2	9.80E-01	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation of substance	$t_{1/2}$	1.50E+00	days	Literature value	
Calculated decay rate	λ_2	4.62E-01	days^{-1}	calculated (very low value set if no degradation)	*Default value of 1/10^99 used*
Fraction of rapid flow through unsaturated zone	B	0.00E+00	fraction	*Assumed no by-pass*	
Enter method of defining partition co-efficient (using pull down list)		**Calculate for non-polar organic chemicals**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_2	2.0E+02	l/kg	Literature value	*Not valid - Calculated value used*
Entry for organic chemicals (option)					
Fraction of organic carbon (in soil)	foc_2	3.00E-04	fraction		
Organic carbon partition coefficient	Koc_2	1.20E+02	l/kg		
Soil water partition coefficient used in assessment	**Kd_2**	**3.60E-02**	**l/kg**	*Calculated value*	
Retardation factor	Rfu_2	1.28E+00			
Unretarded travel time (no dispersion)	tu_2	5.73E+00	d		
Unretarded travel time (with dispersion)	tu_2	5.16E+00	d		
Retarded travel time (with dispersion)	tr_2	6.60E+00	d		
Attenuation factor	AFu_2	1.45E+01			
Total unretarded travel time	$tu_1 + tu_2$	5.99E+00	d		
Total retarded travel time	$tr_1 + tr_2$	7.61E+00	d		

Attenuation factor and discharge consent limit

Drainage layer attenuation factor	**AFu_1**	**1.13E+00**	
Unsaturated zone attenuation factor	**AFu_2**	**1.45E+01**	
Concentration at base of drainage layer	**C_{dl}**	**4.41E+00**	**mg/l**
Concentration at base of unsaturated zone	**C_{wt}**	**3.04E-01**	**mg/l**
		and	

Site being assessed:	Luton Airport
Completed by:	JW
Date:	27-Oct-22
Version:	1

Infiltration Worksheet

Dilution

Substance		**Bromine**		From introduction sheet
Compliance value or environmental standard	**C_T**	**2.00E-03**	**mg/l**	From introduction sheet
Source concentration	**C_e**	**5.00E+00**	**mg/l**	From infiltration sheet
Concentration at base of drainage layer	**C_{wt}**	**3.04E-01**	**mg/l**	From atten_unsatzone sheet

This sheet calculates the dilution factor for groundwater dilution below the drainage field.
Substance concentration in groundwater and discharge consent limit

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Infiltration	Inf	3.42E-01	m/d	From infiltration sheet
Area of drainage field	A	7.58E+03	m^2	From infiltration sheet
Entry for groundwater flow below site				
Length of drainage field in direction of groundwater flow	L	1.21E+02	m	**Length of infiltration tank from DDS**
Saturated aquifer thickness	da	1.00E+01	m	**aturated thickness for chalk, considered to be conser**
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.08E+00	m/d	**20m of chalk average conductivity value 2.37x10-5m/s**
Hydraulic gradient of water table	i	5.00E-03	fraction	**lculated from maximum groundwater level contour pl**
Width of drainage field perpendicular to groundwater flow	w	6.24E+01	m	**Width of infiltration tank from DDS**
Background concentration of substance in groundwater up-gradient of site	Cu	0.00E+00	mg/l	**Assumed no background concentration**
		Calculate		
Enter mixing zone thickness	Mz	5.00E+00	m	*Not valid - Value calculated*
Calculated mixing zone thickness	Mz	1.00E+01	m	
Groundwater flow (mixing zone) below drainage field	Gw	6.48	m^3/d	

Dilution factor and discharge consent limit

Dilution Factor	**DF**	**1.002500911**		
Headroom Factor	**HF**	**1.002500911**		
Unsaturated zone attenuation factor	**AFu**	**1.45E+01**		From infiltration sheet
Concentration in groundwater below drainage field	**C_{gw}**	**3.03E-01**	**mg/l**	
		or		
Environmental Permit limit value	**EPL_2**	**0.032957599**	**mg/l**	

Site being assessed:	Luton Airport
Completed by:	JW
Date:	27-Oct-22
Version:	1

Concentration immediately downgradient of drainage field exceeds target concentration

Infiltration Worksheet

Attenuation in saturated zone

This sheet calculates attenuation factor for the saturated zone; substance concentration at downgradient compliance point and discharge consent limit

Input Parameters	Variable	Value	Unit	Source
Substance		Bromine		From introduction sheet
Compliance value or environmental standard	C_T	2.00E-03	mg/l	From introduction sheet
Source concentration	C_o	5.00E+00	mg/l	From infiltration sheet
Dilution Factor	DF	1.00E+00		from dilution sheet
Unsaturated zone attenuation factor	AFu	1.45E+01		From atten_unsatzone sheet

	Variable	Value	Unit	Source of parameter value
Concentration in groundwater below drainage field	Cgw	3.03E-01	mg/l	from dilution sheet
Option to select degradation	Degradation occurs - sorbed and dissolved phases			
Half life for degradation of substance	$t_{1/2}$	1.50E+00	days	Literature Value
Calculated decay rate	λ	4.62E-01	$days^{-1}$	calculated (very low value set if no degradation)
Width of drainage field	w	6.24E+01	m	from dilution sheet
Mixing zone thickness	Mz	1.00E+01	m	from dilution sheet
Bulk density of aquifer materials	ρ	1.55E+00	g/cm^3	*Average site data for Chalk (1.23-2.26mg/m3 from*
Effective porosity of aquifer	n	3.00E-01	fraction	*Table 4.7 of CIRIA C574, 2002, Engineering prop*
Hydraulic gradient	i_{corr}	2.00E+00	fraction	from dilution sheet (adjusted)
Hydraulic conductivity of saturated aquifer	K	2.08E+00	m/d	from dilution sheet
Distance to compliance point	x	5.00E+01	m	*Nominal Compliance Point*
Option to select time	Use steady state (recommended)			
Calculation time	t	2.50E+01	days	Use steady state (recommended)
Time since pollutant entered groundwater	t	1.00E+99		
Parameters values determined from options				
Partition coefficient	Kd	3.60E-02	l/kg	*see options*
Longitudinal dispersivity	ax	5.00E+00	m	*see options*
Transverse dispersivity	az	5.00E-01	m	*see options*
Vertical dispersivity	ay	5.00E-02	m	*see options*

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	1.39E+01	m/d
Retardation factor	Rf	1.19E+00	fraction
Decay rate used	λ	4.62E-01	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i_{corr}	2.00E+00	fraction
Rate of contaminant flow due to retardation	u	1.17E+01	m/d
Attenuation factor	**AFs**	**5.41E+00**	**fraction**

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for organic chemicals (option)

Fraction of organic carbon in aquifer	foc	3.00E-04	fraction
Organic carbon partition coefficient	Koc	1.20E+02	l/kg
Soil water partition coefficient	Kd	3.60E-02	l/kg

Define dispersivity (click brown cell and use pull down list)

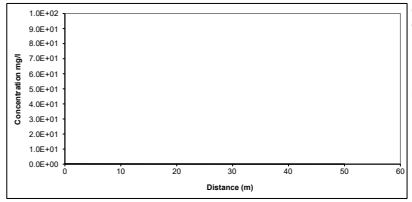
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity (m)	ax	1.00E-12	5.00E+00	2.98E+00
Transverse dispersivity (m)	az	1.00E-12	5.00E-01	2.98E-01
Vertical dispersivity (m)	ay	1.00E-12	5.00E-02	2.98E-02

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x



Calculated concentrations for distance-concentration graph

From calculation sheet

Distance m	Concentration mg/l
0	3.0E-01
2.5	2.79E-01
5.0	2.56E-01
7.5	2.36E-01
10.0	2.16E-01
12.5	1.99E-01
15.0	1.83E-01
17.5	1.68E-01
20.0	1.54E-01
22.5	1.42E-01
25.0	1.30E-01
27.5	1.20E-01
30.0	1.10E-01
32.5	1.01E-01
35.0	9.30E-02
37.5	8.55E-02
40.0	7.86E-02
42.5	7.22E-02
45.0	6.64E-02
47.5	6.10E-02
50.0	5.60E-02

Site being assessed:	Luton Airport
Completed by:	0
Date:	00-Jan-00
Version:	0

Attenuation and Dilution factors and discharge consent limit

Dilution Factor	DF	1.00E+00	
Unsaturated zone attenuation factor	AFu	1.45E+01	
Saturated zone attenuation factor	AFs	5.41E+00	
Concentration in groundwater at compliance point	C_{dcp}	0.056048076 or	mg/l
Environmental Permit limit value	EPL_3	1.78E-01	mg/l
Distance to compliance point		50	m

Concentration at compliance point exceeds target concentration

Groundwater risk assessment for treated effluent discharges to infiltration systems

Infiltration Worksheet , Release v3.0

Date of Workbook Issue: March 2022

This worksheet has been produced in combination with the document: H1 Annex J5 User Manual version 2.0 (Environment Agency, 2014).

IMPORTANT: To enable MS Excel worksheet, click the Microsoft Office Button  c… Excel Options, click Add-Ins. In the Manage box, select Excel Add-ins. Click Go. Select **Analysis ToolPak** and **Analysis ToolPak-VBA** (to calculate error functions)

Details to be completed for each assessment

Site Name:	**Luton Airport**			
Site Address:	**Luton**			
Completed by:	**JW**			
Date:	**27-Oct-22**	**Version:**	**1**	
Substance	**Chlorine**			
Environmental Standard (C_T)	**0.002**	**mg/l**	**Origin of C_T:**	**EQS**

This spreadsheet has been developed as a tool to assist groundwater risk assessment for effluent discharges to infiltration systems. The following worksheets are available:

Site details entered on this page are automatically copied to each worksheet.
The worksheet uses the following colour coding:

	Worksheet option with pull down menu
	Data entry
	Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
	Data carried forward from an earlier worksheet
	Calculation

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

Infiltration Worksheet

Infiltration System

This sheet allows user to enter effluent concentration and details of infiltration system

Substance		Chlorine		From introduction sheet
Compliance value or environmental standard	C_T	2.00E-03	mg/l	From introduction sheet

Input Parameters	Variable	Value	Unit	Source of parameter value	
Standard entry					
Concentration of substance in discharge (entering infiltration system)	C_e	2.00E+00	mg/l	Proposed Dischrgae Concentration (DDS)	
Type of treatment plant		**Treatment plant**			
Water use and percolation rate (for use only with septic tanls and package treatment plants)					
Number of persons	p				*Not valid for this treatment plant option*
Water use		1.80E+02	litres/person/day		*Not valid for this treatment plant option*
Percolation rate	Vp		s/mm		*Not valid for this treatment plant option*
Specify discharge (Q1) or calculate based on use (Q2)		**Specified discharge Q1**			
Discharge rate	Q1	2.59E+03	m^3/d	Based on peak dischareg rate of 30l/s	
Calculated discharge	Q2	0.00E+00	m^3/d		*Value specifed by user and not calculated*
Area of drainage fied and hydraulic loading					
Specify area of drainage field or calculate based on percolation rate		**Specify**			
Enter area of drainage field	A	7.58E+03	m^2	filtration tank dimentions from DDS (121.467m x 62.4	
Calculated area of drainage field	A	0.00E+00	m^2		*Value specifed by user and not calculated*
Calculated infiltration rate	Inf	3.42E-01	m/d		

Site being assessed:	Luton Airport
Completed by:	JW
Date:	27-Oct-22
Version:	1

Infiltration Worksheet

Attenuation unsaturated zone

This sheet calculates attenuation factor for the unsaturated zone; concentration at base of unsaturated zone and discharge consent limit

Contaminant		**Chlorine**		From introduction sheet
Compliance value or environmental standard	C_T	**2.00E-03**	mg/l	From introduction sheet
Concentration of substance in substance in discharge (entering infiltration system)	C_e	**2.00E+00**	mg/l	From infiltration sheet

Input Parameters	Variable	Value	Unit	Source of parameter value	
Standard entry					
Drainage Layer					
Infiltraton rate	**Inf**	**3.42E-01**	**m/d**	From infiltration sheet	
Thickness of drainage layer	S_1	3.00E-01	m	Thickness of granular layer beneath tank from drawings in DDS	
Water filled porosity	θ_1	3.00E-01	fraction	Estiamte literatur value for fine gravel (ConSim manual)	
Bulk density	ρ_1	1.36E+00	g/cm^3	Literature value for fine gravel (CLEA Report SR3)	
Calculated dispersivity	D_1	3.00E-02	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation of substance	$t_{1/2}$	1.00E+00	days	Literature value	
Calculated decay rate	λ_1	6.93E-01	days^{-1}	calculated (very low value set if no degradation)	*Calculated from half life (above)*
Enter method of defining partition co-efficient (using pull down list)		**User specified value for partition coefficient**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_1	8.00E-01	l/kg	Literature Value	
Entry for organic chemicals (option)					
Fraction of organic carbon in soil	foc_1	1.00E-03	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_1	3.20E+02	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_1**	**8.00E-01**	**l/kg**	*Specified value*	
Retardation factor	Rfu_1	4.63E+00			
Unretarded travel time (no dispersion)	tu_1	2.63E-01	d		
Unretarded travel time (with dispersion)	tu_1	2.37E-01	d		
Retarded travel time (with dispersion)	tr_1	1.10E+00	d		
Attenuation factor	AFu_1	2.19E+00			
Unsaturated Zone					
Thickness of unsaturated zone below drainage field	S_2	9.80E+00	m	Based on maximum groundwater level contours (June 2018)	
Water filled porosity	θ_2	2.00E-01	fraction	Estimate based on CIRIA C574, 2002, Engineering Properties of Chalk	
Bulk density of unsaturated zone	ρ_2	1.55E+00	g/cm^3	Average site data for Chalk (range of 1.23 to 2.23 mg/m3, in DQRA)	
Calculated dispersivity	D_2	9.80E-01	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation of substance	$t_{1/2}$	1.00E+00	days	Literature value	
Calculated decay rate	λ_2	6.93E-01	days^{-1}	calculated (very low value set if no degradation)	*Default value of 1/10^99 used*
Fraction of rapid flow through unsaturated zone	B	0.00E+00	fraction	*Assumed no by-pass*	
Enter method of defining partition co-efficient (using pull down list)		**User specified value for partition coefficient**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_2	8.00E-01	l/kg	Literature Value	
Entry for organic chemicals (option)					
Fraction of organic carbon in soil	foc_2	1.00E-03	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_2	3.20E+02	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_2**	**8.00E-01**	**l/kg**	*Specified value*	
Retardation factor	Rfu_2	7.20E+00			
Unretarded travel time (no dispersion)	tu_2	5.73E+00	d		
Unretarded travel time (with dispersion)	tu_2	5.16E+00	d		
Retarded travel time (with dispersion)	tr_2	3.71E+01	d		
Attenuation factor	AFu_2	3.08E+05			
Total unretarded travel time	$tu_1 + tu_2$	5.99E+00	d		
Total retarded travel time	$tr_1 + tr_2$	4.25E+01	d		

Attenuation factor and discharge consent limit

Drainage layer attenuation factor	**AFu_1**	**2.19E+00**	
Unsaturated zone attenuation factor	**AFu_2**	**3.08E+05**	
Concentration at base of drainage layer	**C_{dl}**	**9.14E-01**	**mg/l**
Concentration at base of unsaturated zone	**C_{wt}**	**2.97E-06**	**mg/l**
		and	

Site being assessed:	Luton Airport
Completed by:	JW
Date:	27-Oct-22
Version:	1

Infiltration Worksheet

Dilution

This sheet calculates the dilution factor for groundwater dilution below the drainage field.
Substance concentration in groundwater and discharge consent limit

Substance		**Chlorine**		From introduction sheet
Compliance value or environmental standard	C_T	**2.00E-03**	**mg/l**	From introduction sheet
Source concentration	C_e	**2.00E+00**	**mg/l**	From infiltration sheet
Concentration at base of drainage layer	C_{wt}	**2.97E-06**	**mg/l**	From atten_unsatzone sheet

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Infiltration	Inf	3.42E-01	m/d	From infiltration sheet
Area of drainage field	A	7.58E+03	m^2	From infiltration sheet
Entry for groundwater flow below site				
Length of drainage field in direction of groundwater flow	L	1.21E+02	m	**Length of infiltration tank from DDS**
Saturated aquifer thickness	da	1.00E+01	m	**aturated thickness for chalk, considered to be conser**
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.08E+00	m/d	**20m of chalk average conductivity value 2.37x10-5m/s**
Hydraulic gradient of water table	i	5.00E-03	fraction	**ated from maximum groundwater level contour plan i**
Width of drainage field perpendicular to groundwater flow	w	6.24E+01	m	**Width of infiltration tank from DDS**
Background concentration of substance in groundwater up-gradient of site	Cu	0.00E+00	mg/l	**Assumed no background concentration**
		Calculate		
Enter mixing zone thickness	Mz	5.00E+00	m	*Not valid - Value calculated*
Calculated mixing zone thickness	Mz	1.00E+01	m	
Groundwater flow (mixing zone) below drainage field	Gw	6.48	m^3/d	

Dilution factor and discharge consent limit

Dilution Factor	**DF**	**1.002500911**		
Headroom Factor	**HF**	**1.002500911**		
Unsaturated zone attenuation factor	**AFu**	**3.08E+05**		From infiltration sheet
Concentration in groundwater below drainage field	C_{gw}	**2.97E-06**	**mg/l**	**below compliance value**
		or		
Environmental Permit limit value	EPL_2	**1348.649194**	**mg/l**	**discussion with**

Site being assessed:	Luton Airport
Completed by:	JW
Date:	27-Oct-22
Version:	1

Concentration immediately downgradient of drainage field below target concentration

Infiltration Worksheet

Attenuation in saturated zone

This sheet calculates attenuation factor for the saturated zone; substance concentration at downgradient compliance point and discharge consent limit

Input Parameters	Variable	Value	Unit	Source
Substance		Chlorine		From introduction sheet
Compliance value or environmental standard	C_T	2.00E-03	mg/l	From introduction sheet
Source concentration	C_o	2.00E+00	mg/l	From infiltration sheet
Dilution Factor	DF	1.00E+00		from dilution sheet
Unsaturated zone attenuation factor	AFu	3.08E+05		From atten_unsatzone sheet

	Variable	Value	Unit	Source of parameter value
Concentration in groundwater below drainage field	Cgw	2.97E-06	mg/l	from dilution sheet
Option to select degradation	Degradation occurs - sorbed and dissolved phases			
Half life for degradation of substance	$t_{1/2}$	1.00E+00	days	Literature value
Calculated decay rate	λ	6.93E-01	$days^{-1}$	calculated (very low value set if no degradation)
Width of drainage field	w	6.24E+01	m	from dilution sheet
Mixing zone thickness	Mz	1.00E+01	m	from dilution sheet
Bulk density of aquifer materials	ρ	1.55E+00	g/cm^3	*Average site data for Chalk (1.23-2.26mg/m3 from*
Effective porosity of aquifer	n	3.00E-01	fraction	*Table 4.7 of CIRIA C574, 2002, Engineering prop*
Hydraulic gradient	i_{corr}	2.00E+00	fraction	from dilution sheet (adjusted)
Hydraulic conductivity of saturated aquifer	K	2.08E+00	m/d	from dilution sheet
Distance to compliance point	x	5.00E+01	m	*Nominal Compliance Point*
Option to select time	Use steady state (recommended)			
Calculation time	t	1.00E+02	days	Use steady state (recommended)
Time since pollutant entered groundwater	t	1.00E+99		
Parameters values determined from options				
Partition coefficient	Kd	8.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	5.00E+00	m	*see options*
Transverse dispersivity	az	5.00E-01	m	*see options*
Vertical dispersivity	ay	5.00E-02	m	*see options*

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	1.39E+01	m/d
Retardation factor	Rf	5.13E+00	fraction
Decay rate used	λ	6.93E-01	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i_{corr}	2.00E+00	fraction
Rate of contaminant flow due to retardation	u	2.70E+00	m/d
Attenuation factor	**AFs**	**1.60E+03**	**fraction**

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 8.00E-01 — l/kg

Entry for organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction

Organic carbon partition coefficient — Koc — l/kg

Soil water partition coefficient — Kd — 8.00E-01 — l/kg

Define dispersivity (click brown cell and use pull down list)

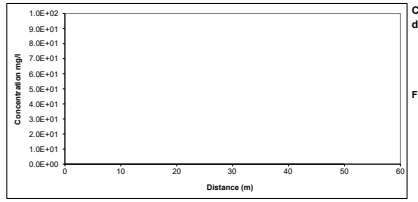
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity (m)	ax	1.00E-12	5.00E+00	2.98E+00
Transverse dispersivity (m)	az	1.00E-12	5.00E-01	2.98E-01
Vertical dispersivity (m)	ay	1.00E-12	5.00E-02	2.98E-02

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x



Calculated concentrations for distance-concentration graph

From calculation sheet

Distance m	Concentration mg/l
0	3.0E-06
2.5	2.05E-06
5.0	1.42E-06
7.5	9.81E-07
10.0	6.78E-07
12.5	4.69E-07
15.0	3.24E-07
17.5	2.24E-07
20.0	1.55E-07
22.5	1.07E-07
25.0	7.42E-08
27.5	5.13E-08
30.0	3.55E-08
32.5	2.45E-08
35.0	1.70E-08
37.5	1.17E-08
40.0	8.12E-09
42.5	5.61E-09
45.0	3.88E-09
47.5	2.68E-09
50.0	1.86E-09

Site being assessed:	Luton Airport
Completed by:	0
Date:	00-Jan-00
Version:	0

Attenuation and Dilution factors and discharge consent limit

Dilution Factor	DF	1.00E+00		
Unsaturated zone attenuation factor	AFu	3.08E+05		
Saturated zone attenuation factor	AFs	1.60E+03		
Concentration in groundwater at compliance point	C_{dcp}	1.85671E-09 or	mg/l	below compliance value
Environmental Permit limit value	EPL_3	2.15E+06	mg/l	Discharge limit for discussion with Environment Agency
Distance to compliance point		50	m	

Concentration at compliance point below target concentration

Groundwater risk assessment for treated effluent discharges to infiltration systems

Infiltration Worksheet , Release v3.0

Date of Workbook Issue: March 2022

This worksheet has been produced in combination with the document: H1 Annex J5 User Manual version 2.0 (Environment Agency, 2014).

IMPORTANT: To enable MS Excel worksheet, click the Microsoft Office Button  c… Excel Options, click Add-Ins. In the Manage box, select Excel Add-ins. Click Go. Select **Analysis ToolPak** and **Analysis ToolPak-VBA** (to calculate error functions)

Details to be completed for each assessment				
Site Name:	**Luton Airport**			
Site Address:	**Luton**			
Completed by:	**JW**			
Date:	**27-Oct-22**	**Version:**	**1**	
Substance	**Iron**			
Environmental Standard (C_T)	**0.2**	**mg/l**	**Origin of C_T:**	**DWS**

This spreadsheet has been developed as a tool to assist groundwater risk assessment for effluent discharges to infiltration systems. The following worksheets are available:

Site details entered on this page are automatically copied to each worksheet.
The worksheet uses the following colour coding:

	Worksheet option with pull down menu
	Data entry
	Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
	Data carried forward from an earlier worksheet
	Calculation

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

Infiltration Worksheet

Infiltration System

This sheet allows user to enter effluent concentration and details of infiltration system

Substance		Iron		From introduction sheet
Compliance value or environmental standard	C_T	2.00E-01	mg/l	From introduction sheet

Input Parameters	Variable	Value	Unit	Source of parameter value	
Standard entry					
Concentration of substance in discharge (entering infiltration system)	C_e	1.00E+00	mg/l	Proposed Dischrgae Concentration (DDS)	
Type of treatment plant		**Treatment plant**			
Water use and percolation rate (for use only with septic tanls and package treatment plants)					
Number of persons	p				*Not valid for this treatment plant option*
Water use		1.80E+02	litres/person/day		*Not valid for this treatment plant option*
Percolation rate	Vp		s/mm		*Not valid for this treatment plant option*
Specify discharge (Q1) or calculate based on use (Q2)		**Specified discharge Q1**			
Discharge rate	Q1	2.59E+03	m^3/d	Based on peak discharge of 30 l/s	
Calculated discharge	Q2	0.00E+00	m^3/d		*Value specifed by user and not calculated*
Area of drainage fied and hydraulic loading					
Specify area of drainage field or calculate based on percolation rate		**Specify**			
Enter area of drainage field	A	7.58E+03	m^2	iltration tank dimentions from DDS (121.467m x 62.4	
Calculated area of drainage field	A	0.00E+00	m^2		*Value specifed by user and not calculated*
Calculated infiltration rate	Inf	3.42E-01	m/d		

Site being assessed:	Luton Airport
Completed by:	JW
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Infiltration Worksheet

Attenuation unsaturated zone

This sheet calculates attenuation factor for the unsaturated zone; concentration at base of unsaturated zone and discharge consent limit

Contaminant		**Iron**		From introduction sheet
Compliance value or environmental standard	C_T	**2.00E-01**	mg/l	From introduction sheet
Concentration of substance in substance in discharge (entering infiltration system)	C_e	**1.00E+00**	mg/l	From infiltration sheet

Input Parameters	Variable	Value	Unit	Source of parameter value	
Standard entry					
Drainage Layer					
Infiltraton rate	**Inf**	**3.42E-01**	**m/d**	From infiltration sheet	
Thickness of drainage layer	S_1	3.00E-01	m	Thickness of granular layer beneath tank from drawings in DDS	
Water filled porosity	θ_1	3.00E-01	fraction	Estiamte literature value for fine gravel (ConSim manual)	
Bulk density	ρ_1	1.36E+00	g/cm^3	Literature value for fine gravel (CLEA Report SR3)	
Calculated dispersivity	D_1	3.00E-02	m	calculated	
Option to select degradation		**No degradation occurs**			
Half life for degradation in substance	$t_{1/2}$	1.00E+100	days		*Half life not required - No degradation occuring*
Calculated decay rate	λ_1	1.00E-99	days^{-1}	calculated (very low value set if no degradation)	*Default value of 1/10^99 used*
Enter method of defining partition co-efficient (using pull down list)		**User specified value for partition coefficient**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_1	2.20E+02	l/kg	Literature Value	
Entry for organic chemicals (option)					
Fraction of organic carbon in soil	foc_1	1.00E-02	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_1	1.00E+01	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_1**	**2.20E+02**	**l/kg**	*Specified value*	
Retardation factor	Rfu_1	9.98E+02			
Unretarded travel time (no dispersion)	tu_1	2.63E-01	d		
Unretarded travel time (with dispersion)	tu_1	2.37E-01	d		
Retarded travel time (with dispersion)	tr_1	2.36E+02	d		
Attenuation factor	AFu_1	1.00E+00			
Unsaturated Zone					
Thickness of unsaturated zone below drainage field	S_2	9.80E+00	m	Based on maximum groundwater level contours (June 2018)	
Water filled porosity	θ_2	2.00E-01	fraction	Estimate based on CIRIA C574, 2002, Engineering Properties of Chalk	
Bulk density of unsaturated zone	ρ_2	1.55E+00	g/cm^3	Average site data for Chalk (range of 1.23 to 2.23 mg/m3, in DQRA)	
Calculated dispersivity	D_2	9.80E-01	m	calculated	
Option to select degradation		**Degradation occurs - sorbed and dissolved phases**			
Half life for degradation in substance	$t_{1/2}$	1.00E+100	days		*Half life not required - No degradation occuring*
Calculated decay rate	λ_2	6.93E-101	days^{-1}	calculated (very low value set if no degradation)	*Default value of 1/10^99 used*
Fraction of rapid flow through unsaturated zone	B	0.00E+00	fraction	*Assumed no by-pass*	
Enter method of defining partition co-efficient (using pull down list)		**User specified value for partition coefficient**			
Entry if specify partition coefficient (option)					
Soil water partition coefficient	Kd_2	2.20E+02	l/kg	Literature Value	
Entry for organic chemicals (option)					
Fraction of organic carbon in soil	foc_2	1.00E-02	fraction		*Not valid - User specified value used*
Organic carbon partition coefficient	Koc_2	1.00E+01	l/kg		*Not valid - User specified value used*
Soil water partition coefficient used in assessment	**Kd_2**	**2.20E+02**	**l/kg**	*Specified value*	
Retardation factor	Rfu_2	1.71E+03			
Unretarded travel time (no dispersion)	tu_2	5.73E+00	d		
Unretarded travel time (with dispersion)	tu_2	5.16E+00	d		
Retarded travel time (with dispersion)	tr_2	8.80E+03	d		
Attenuation factor	AFu_2	1.00E+00			
Total unretarded travel time	$tu_1 + tu_2$	5.99E+00	d		
Total retarded travel time	$tr_1 + tr_2$	1.00E+04	d		

Attenuation factor and discharge consent limit

Drainage layer attenuation factor	**AFu_1**	**1.00E+00**	
Unsaturated zone attenuation factor	**AFu_2**	**1.00E+00**	
Concentration at base of drainage layer	**C_{dl}**	**1.00E+00**	**mg/l**
Concentration at base of unsaturated zone	**C_{wt}**	**1.00E+00**	**mg/l**
		and	

Site being assessed:	Luton Airport
Completed by:	JW
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Infiltration Worksheet

Dilution

This sheet calculates the dilution factor for groundwater dilution below the drainage field.
Substance concentration in groundwater and discharge consent limit

Substance		**Iron**		From introduction sheet
Compliance value or environmental standard	C_T	**2.00E-01**	**mg/l**	From introduction sheet
Source concentration	C_e	**1.00E+00**	**mg/l**	From infiltration sheet
Concentration at base of drainage layer	C_{wt}	**1.00E+00**	**mg/l**	From atten_unsatzone sheet

Input Parameters	Variable	Value	Unit	Source of parameter value
Standard entry				
Infiltration	Inf	3.42E-01	m/d	From infiltration sheet
Area of drainage field	A	7.58E+03	m^2	From infiltration sheet
Entry for groundwater flow below site				
Length of drainage field in direction of groundwater flow	L	1.21E+02	m	**Length of infiltration tank from DDS**
Saturated aquifer thickness	da	1.00E+01	m	**aturated thickness for chalk, consiered to be conserv**
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.08E+00	m/d	**20m of chalk average conductivity value 2.37x10-5m/s**
Hydraulic gradient of water table	i	5.00E-03	fraction	**ated from maximum groundwater level contour plan i**
Width of drainage field perpendicular to groundwater flow	w	6.24E+01	m	**Width of infiltration tank from DDS**
Background concentration of substance in groundwater up-gradient of site	Cu	0.00E+00	mg/l	**Assumed no background concentration**
		Calculate		
Enter mixing zone thickness	Mz	5.00E+00	m	*Not valid - Value calculated*
Calculated mixing zone thickness	Mz	1.00E+01	m	
Groundwater flow (mixing zone) below drainage field	Gw	6.48	m^3/d	

Dilution factor and discharge consent limit

Dilution Factor	**DF**	**1.002500911**		
Headroom Factor	**HF**	**1.002500911**		
Unsaturated zone attenuation factor	**AFu**	**1.00E+00**		From infiltration sheet
Concentration in groundwater below drainage field	C_{gw}	**9.98E-01**	**mg/l**	
		or		
Environmental Permit limit value	EPL_2	**0.200500182**	**mg/l**	

Site being assessed:	Luton Airport
Completed by:	JW
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Version:	1

Concentration immediately downgradient of drainage field exceeds target concentration

Infiltration Worksheet

Attenuation in saturated zone

This sheet calculates attenuation factor for the saturated zone; substance concentration at downgradient compliance point and discharge consent limit

Input Parameters	Variable	Value	Unit	Source
Substance		Iron		From introduction sheet
Compliance value or environmental standard	**C_T**	**2.00E-01**	mg/l	From introduction sheet
Source concentration	**C_e**	**1.00E+00**	mg/l	From infiltration sheet
Dilution Factor	**DF**	**1.00E+00**		from dilution sheet
Unsaturated zone attenuation factor	**AFu**	**1.00E+00**		From atten_unsatzone sheet

	Variable	Value	Unit	Source of parameter value
Concentration in groundwater below drainage field	Cgw	9.98E-01	mg/l	from dilution sheet
Option to select degradation	No degradation occurs			
Half life for degradation of substance	$t_{1/2}$	1.00E+100	days	
Calculated decay rate	λ	1.00E-99	days^{-1}	calculated (very low value set if no degradation)
Width of drainage field	w	6.24E+01	m	from dilution sheet
Mixing zone thickness	Mz	1.00E+01	m	from dilution sheet
Bulk density of aquifer materials	ρ	1.55E+00	g/cm^3	*Average site data for Chalk (1.23-2.26mg/m3 fror*
Effective porosity of aquifer	n	3.00E-01	fraction	*Table 4.7 of CIRIA C574, 2002, Engineering prop*
Hydraulic gradient	i_{corr}	2.00E+00	fraction	from dilution sheet (adjusted)
Hydraulic conductivity of saturated aquifer	K	2.08E+00	m/d	from dilution sheet
Distance to compliance point	x	5.00E+01	m	*Nominal Compliance Point*
Option to select time	Use steady state (recommended)			
Enter time	t	5.10E+03	days	time variant options only
Time since pollutant entered groundwater	t	1.00E+99		
Parameters values determined from options				
Partition coefficient	Kd	2.20E+02	l/kg	*see options*
Longitudinal dispersivity	ax	5.00E+00	m	*see options*
Transverse dispersivity	az	5.00E-01	m	*see options*
Vertical dispersivity	ay	5.00E-02	m	*see options*

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	1.39E+01	m/d
Retardation factor	Rf	1.14E+03	fraction
Decay rate used	λ	1.00E-99	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i_{corr}	2.00E+00	fraction
Rate of contaminant flow due to retardation	u	1.22E-02	m/d
Attenuation factor	**AFs**	**1.00E+00**	**fraction**

Attenuation and Dilution factors and discharge consent limit

Dilution Factor	**DF**	**1.00E+00**	
Unsaturated zone attenuation factor	**AFu**	**1.00E+00**	
Saturated zone attenuation factor	**AFs**	**1.00E+00**	
Concentration in groundwater at compliance point	**C_{dcp}**	**0.997487403**	**mg/l**
		or	
Environmental Permit limit value	**EPL_3**	**2.01E-01**	**mg/l**
Distance to compliance point		**50**	**m**

Concentration at compliance point exceeds target concentration

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	2.20E+02	l/kg
Entry for organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Soil water partition coefficient	Kd	2.20E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

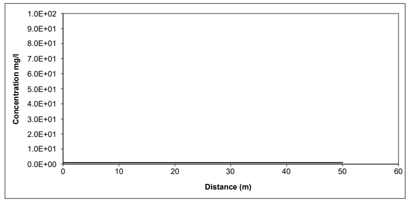
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity (m)	**ax**	1.00E-12	5.00E+00	2.98E+00
Transverse dispersivity (m)	**az**	1.00E-12	5.00E-01	2.98E-01
Vertical dispersivity (m)	**ay**	1.00E-12	5.00E-02	2.98E-02

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x



Calculated concentrations for distance-concentration graph

From calculation sheet

Distance m	Concentration mg/l
0	1.0E+00
2.5	9.98E-01
5.0	9.98E-01
7.5	9.98E-01
10.0	9.98E-01
12.5	9.98E-01
15.0	9.98E-01
17.5	9.98E-01
20.0	9.98E-01
22.5	9.98E-01
25.0	9.98E-01
27.5	9.98E-01
30.0	9.98E-01
32.5	9.98E-01
35.0	9.98E-01
37.5	9.98E-01
40.0	9.98E-01
42.5	9.98E-01
45.0	9.97E-01
47.5	9.97E-01
50.0	9.97E-01

Site being assessed:	Luton Airport
Completed by:	0
Date:	00-Jan-00
Version:	0