GEO-ENVIRONMENTAL CONSULTING ENGINEERS

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GROUNDWATER RISK ASSESSMENT

FORMER LAUNDRY/DYE WORKS
ELLISON STREET, GLOSSOP

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Report Prepared for

GOYT CONSTRUCTION LTD

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Groundwater Risk Assessment

Former Laundry/Dye Works, Ellison Street, Glossop

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1. INTRODUCTION

Thomas Consulting has carried out site investigation works at the former laundry/dye works located on Ellison Street, Glossop (hereafter referred to as 'the site,') to quantify the potential risks from contamination. The assessment included a Tier 1 Controlled Waters Risk Assessment.

Following the Tier 1 controlled waters risk assessment it was identified that the concentrations of tetrachloroethene (PCE), trichloroethene (TCE), Aliphatic C8-C10, pyrene, fluoranthene and nickel recorded on site had the potential to affect the quality of Glossop Brook when compared against the appropriate EQS.

A Tier 1 risk assessment is inherently conservative as it does not take into account processes between the source and the receptor such as degradation, retardation, dispersion and dilution. Therefore a detailed quantitative controlled waters risk assessment (CWDQRA) has been undertaken to further evaluate the potential risk to Glossop Brook.

1.1 SITE SETTING

1.1.1 Geology

Published information (1) indicates that the site is underlain by Glacial Till superficial deposits overlying Kinderscout Grit bedrock. The Kinderscout Grit is part of the Millstone Grit formation and described as a medium to coarse grained sandstone with shale pellets, feldspathic, massive or cross-bedded and frequently pebbly sandstone, shales and sandy shales, siltstone and sandstone with shale (2) .

Borehole and trial pit logs from the two recent site investigations (3) proved the presence of made ground across the site ranging from a thickness of 0.3 to 1.9m.

The made ground overlies superficial deposits described as soft to stiff sandy silty clay or slightly sandy clayey silt with clay and sand lenses. It is assumed that these deposits are representative of the Glacial Till.

Bedrock was encountered at one location at a depth of 9.7m bgl (below ground level). Two further boreholes were advanced to 10m bgl but no bedrock was encountered.

(1) Geology of Britain Viewer – http://mapapps.bgs.ac.uk/geologyofbritain/home accessed on the 10th July 2018
(2) www.bgs.ac.uk
(3) P5790 phase 2 addendum report Site Investigation and Assessment Report, Ellison Street, Glossop, Lancashire, Thomas Consulting, June 2018

1.1.2 Hydrogeology

The Glacial Till has been classified by the Environment Agency (EA) as a Secondary Undifferentiated aquifer, whilst the Kinderscout Grit has been classified as a Secondary A aquifer [(1)] . Secondary A aquifers are described as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

During the site investigation water, described as 'slight water ingress' was encountered at two locations, TP5 and TP8 at 0.8 and 1.2m respectively. Following installation of the three wells (CP1, CP2 and CP3) water was recorded and sampled at all three locations. However, due to the slow recharge it was not possible to purge the wells prior to sampling. Instead, grab samples were taken. It is therefore assumed that the water encountered in the trial pits, and sampled in the monitoring wells represents pore water percolating downwards through the made ground and natural strata to the main groundwater body within the underlying bedrock.

There are no potable groundwater abstractions within 1km of the site and the site is not located in a source protection zone, a drinking water protection area, or a drinking water safeguard zone.

1.1.3 Hydrology

The closest surface watercourse to the site is Glossop Brook which is located to the east and south of the site, approximately 300m from the site boundary at its closest point.

1.2 CONCEPTUAL SITE MODEL

1.2.1 Source

Recorded concentrations of the contaminants of concern (CoC) and field observations indicate that the most likely source is the made ground underlying the site.

Water samples collected at the site from CP1, CP2 and CP3 are likely to represent pore or perched water that has percolated through the made ground, potentially mobilising contaminants, and is migrating downwards through the unsaturated zone. It can therefore be assumed that the recovered groundwater samples are representative of the source zone concentrations

(1) www.magic.defra.gov.uk accessed on 18th July 2018

1.2.2 Pathway – Unsaturated Zone

During the investigation water was encountered within the natural strata at one location only (TP8). It is therefore assumed that any groundwater within the superficial Glacial Till is considered to be perched and not considered to represent the permanent water table.

The main potential pathway for the migration of mobile soil contamination into the deeper groundwater is the dissolution of contaminants in percolating rainwaters and shallow perched water and subsequent migration of shallow perched water through the Glacial Till and into the permanent water table located at depth beneath the site.

The full thickness of the Glacial Till is therefore considered to represent the unsaturated zone.

Bedrock was only proven at one location at a depth of 10m bgl. Groundwater was not encountered during the investigation. It is therefore likely that the unsaturated zone may continue into the bedrock and be of a thickness greater than 10m bgl. For conservatism it has been assumed that the top of the groundwater table is at 10m bgl.

1.2.3 Pathway – Aquifer

Literature records show that the Kinderscout Grit is over 170m in thickness (1) and that the true groundwater aquifer pathway is likely to be within the sandstone.

As groundwater was not encountered during the site investigation, groundwater contours could not be produced. However, it is assumed that groundwater flow is likely to be towards Glossop Brook.

1.2.4 Receptor

Glossop Brook is considered the main controlled waters receptor, located approximately 300m from the site. EA guidance indicates a distance of 250m from the source for the compliance point of a non-hazardous substance in an aquifer with local resource potential, and a distances of 50m from the source for a hazardous substance. As TCE and fluoranthene are classified as hazardous substances a conservative compliance point of 50m down gradient of the source has been used for all CoCs.

(1) www.bgs.ac.uk

1.3 CONTROLLED WATERS DETAILED QUANTITATIVE RISK ASSESSMENT

1.3.1 Model Software

The CWDQRA has been undertaken using ConSim Ver2.5, a UK regulatory approved model. It is a probabilistic model based around the Environment Agency's 1999 R&D P20 methodology (predecessor to the revised and updated EA RTM) and uses the Monte Carlo simulation technique to select values randomly from each parameter range for use in fate and transport calculations so as to account for parameter uncertainty. Iterating the calculations many times gives a range of output values, the distribution of which reflects the uncertainty inherent in the input values.

1.3.2 Model Inputs

The model inputs for the CWDQRA are detailed in *Tables A1 – A4, Appendix A*.

Source Terms

Of the three monitoring wells installed and sampled, the highest concentrations of the CoCs in water were recorded in CP3, which is in the area where the highest soil concentrations were also recorded.

However, as it is not possible to determine the areal extent of the plume with the available data, the whole site has been assumed to represent the source area, with the concentrations based on the minimum, mean and maximum concentrations recorded across the site.

The thickness of the source term is based on the minimum, mean and maximum thickness of made ground across the site.

Unsaturated Zone

Bedrock has only been encountered at one location, CP2, at a depth of 10m bgl. No groundwater was encountered during the advancement of the three deep boreholes. Therefore it can be assumed that groundwater is greater than 10m bgl. However, for conservatism, it has been assumed that groundwater is at 10m bgl. The unsaturated zone thickness has been calculated as the difference between the base of the monitoring wells (10m) and the thickness of made ground across the site.

Properties for the unsaturated zone, where not site specific, have been based on literature values for sand and clay.

Infiltration

Based on the high levels of hardstanding at the site, infiltration has been assumed to be at 10% of the average annual rainfall.

Receptor

Whilst the nearest surface water course is located approximately 300m from the site, a compliance point 50m down gradient of the site has been used to determine the potential risk to controlled waters. This is in line with EA guidance for a hazardous substance (1) and would be protective of the river.

Time Scale

The EA RTM (2) guidance states that migration times >1,000 years are not of concern therefore the model has been run for 1000 years with additional time slices at 50, 100, 300, 500, 600, 700, 800, 900 and 1000 years.

Retardation

The model has been run assuming retardation in the unsaturated zone and aquifer, which for organic compounds is controlled by the amount of organic carbon present in the matrix of the rock; fraction of organic carbon (*foc*). *Table A4, Annex A* shows the koc values used for each CoC.

Degradation

PCE and TCE were used historically on site in the laundry. The presence of cis-dichloroethene (cis-DCE) and vinyl chloride indicates that some degradation of the CoC is occurring as they are breakdown productions from the degradation of PCE and TCE. However the level of degradation is not known and therefore, for a conservative assessment, degradation has not been used during the model.

1.3.3 Results

As ConSim is a probabilistic model it provides a range of outputs as different percentiles. The model has been set to perform with 1001 iterations thus enabling a 90th percentile result to be calculated. This value indicates that there is a 90% probability that the predicted result will exist below this value i.e. there is only a 1 in 10 chance that it will be above. It can be considered a conservative value and indicative of a scenario whereby nearly all the worst case values from the inputs were realised and therefore a reasonable worst case scenario. The 50th percentile can be considered a 'more likely than not' scenario.

None of the CoCs are predicted to have a detectable concentration 50m down gradient of the source zone within 1,000 years.

(1) https://www.gov.uk/guidance/land-contamination-groundwater-compliance-points-quantitative-risk-assessments#hazardous-substances-compliance-points
(2) Remedial Targets Methodology, Hydrogeological Risk Assessment for Land Contamination; Environment Agency; 2006

1.3.4 Sensitivity Analysis

Within ConSim, there is an inbuilt sensitivity analysis that is calculated each run indicating the influence that each of the input parameters has on the model results. It includes all input parameters except single value inputs.

The sensitivity analysis results vary between 1 and –1. A value of 1 indicates a perfect positive linear correlation between the input value and the result. A result of –1 indicates a perfect negative linear correlation between the input and the result. A value of 0 indicates no correlation between the input and the result.

Table 1 shows the sensitivity analysis results for each CoC for the travel time to the 50m receptor for any input parameters that have a result greater than 0.1, or less than -0.1.

Table 1 ***Sensitivity Analysis Results for Travel Time to the Receptor***

Contaminant	Input parameter	Sensitivity analysis result
PCE	Infiltration	-0.41
	Koc	0.24
	Aquifer hydraulic conductivity	-0.17
	Unsaturated zone hydraulic conductivity	-0.11
TCE	Infiltration	-0.41
	Koc	0.23
	Aquifer hydraulic conductivity	-0.17
	Unsaturated zone hydraulic conductivity	-0.13
Aliphatic C8-C10	Infiltration	-0.49
	Aquifer hydraulic conductivity	-0.21
	Unsaturated zone hydraulic conductivity	-0.14
Pyrene	Infiltration	-0.47
	Aquifer hydraulic conductivity	-0.21
	Unsaturated zone hydraulic conductivity	-0.14
	Koc	0.16
Fluoranthene	Infiltration	-0.51
	Aquifer hydraulic conductivity	-0.22
	Unsaturated zone hydraulic conductivity	-0.15
	koc	0.15
Nickel	Infiltration	-0.58
	Aquifer hydraulic conductivity	-0.17
	Unsaturated zone hydraulic conductivity	-0.16

In all cases, the most sensitive parameter is infiltration, where increasing the infiltration would decrease the travel time to, and therefore increasing the concentration at the 50m receptor. The rate of infiltration has been calculated assuming that the majority of the site was covered by hardstanding, and that only 10% of the annual rainfall would infiltrate. However, if the site was redeveloped for a residential end use, with soft landscaping and gardens, then infiltration may be as much as 30%.

The model has therefore been re-run assuming a 30% infiltration rate.

The results of this second model run again show that concentrations of all CoC are predicted to be below detection at the 50m compliance point after 1000 years.

1.4 CONCLUSIONS

Based on the predicted concentrations at both the 90th and 50th percentiles, the model shows that the current recorded perched water concentrations of PCE, TCE, aliphatic C8-C10, pyrene, fluoranthene and nickel on site are unlikely to present a significant risk to Glossop Brook within 1000 years.

Whilst there is limited site specific data used in the model, the CWDQRA is inherently conservative as it has assumed an ongoing source, no biodegradation, and does not allow for dilution at Glossop Brook.

The compliance point used was located 50m down gradient of the source and not at Glossop Brook. In addition, groundwater elevation has been assumed to be at approximately 10m bgl, whereas during the site investigation, groundwater was not encountered.

As the site is no longer an active laundry, there is onsite evidence of degradation due to the presence of cis-DCE and vinyl chloride, and dilution will occur in Glossop Brook, it can be concluded that the current concentrations of all CoC do not present a significant risk to controlled waters.

APPENDIX A

Model inputs

Table A1 Source Concentrations

Parameter	Distribution	Units
TPH Aliphatic C8-C10	LogTriangular(0.01,0.22,16.734)	mg/l
Tetrachloroethene	LogTriangular(0.003,0.201,9.425)	mg/l
Trichloroethene	LogTriangular(0.032,0.037,0.777)	mg/l
Fluoranthene	Uniform(0.012,0.04)	mg/l
Pyrene	Triangular(1.3E-5,2.3E-5,6.9E-5)	mg/l
Nickel	LogTriangular(0.005,0.062,0.154)	Mg/l

Table A2 Unsaturated Zone Properties

Parameter	Distribution	Units	Source
Thickness	Triangular(8.7,9,9.2)	m	Site specific
Water filled porosity	Uniform(0.152,0.3)		50% porosity for clay and sand from the ConSim help file
Dry Bulk Density	Uniform(1,2.4)	g/cm3	ConSim help file for clay and sand.
Unsaturated conductivity	LogUniform(1E-11,2E-5)	m/s	ConSim help file for clay and fine sand.
Vertical dispersivity	Triangular(0.87,0.9,0.92)	m	10% of the pathway
TOC (input as foc in the model)	Uniform(0.17,0.18)		ConSim help file for Glacial Till
Infiltration	LogUniform(132.94,13.294)	mm/year	10% of the annual average rainfall at Buxton from 1981-2010, taken from the Met Office.

Note: Met Office: https://www.metoffice.gov.uk/public/weather/climate/gcqwurqwy

Table A3 Aquifer Properties

Parameter	Distribution	Units	Source
Aquifer Properties			
Thickness	LogNormal(170,17)	m	BGS (1) thickness of Kinderscout Grit
Hydraulic Conductivity	LogTriangular(3.47E-9,5.79E-8,8.10E-6)	m/s	BGS – value for Millstone Grit
Effective Porosity	Triangular(0.21,0.41)	Unitless	
Dry Bulk Density	Uniform(1.6,2.68)	g/cm^3	ConSim help file for sandstone
Total Organic Carbon	Uniform(0.7,0.8)	%	ConSim help file for sandstone
Hydraulic Gradient	0.005	unitless	EA Guidance where site specific data not available (2)
Longitudinal Dispersivity	Single(17)	m	10% of pathway range

(1) BGS: The physical properties of minor aquifers in England and Wales Environment Agency R&D Publication 68, 1997
(2) Annex J5: Infiltration worksheet user manual ver2.0

Parameter	Distribution	Units	Source
Latitudinal Dispersivity	Single(6)	m	30% of longitudinal dispersivity

Table A4 KOC values

CoC	Koc value	Source
Fluoranthene	Triangular(5248,18197,25119)	Mackay and SR7 estimated by linear regression from log Kow
Pyrene	Triangular(5129,16218,37153)	Mackay and SR7 estimated by linear regression from log Kow
Ali C8-C16	LogUniform(31623,5011872)	TPH CWG
Tetrachloroethene	Triangular(87,269,1445)	Mackay and SR7 estimated by linear regression from log Kow
Trichloroethene	Triangular(87,141,977)	Mackay and SR7 estimated by linear regression from log Kow
Nickel (kd value)	Single(85.7)	ConSim help file for Glacial Till

Mackay: Mackay et al, 2006. *Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. Second Edition.*
SR7: Environment Agency, 2008. *Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values. Science Report SC050021/SR7*
Estimate: estimated by linear regression from log Kow

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