

**A38 Derby Junctions**  
**TR010022**

**8.57 Technical Note on Controlled  
Waters Quantitative Risk Assessment**

Planning Act 2008

Rule 8 (1)(k)

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Planning Act 2008

**The Infrastructure Planning  
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**A38 Derby Junctions  
Development Consent Order 202[ ]**

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**Technical Note on Controlled Waters Quantitative Risk Assessment**

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<b>Author</b>	A38 Derby Junctions Project Team, Highways England

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20 January 2020

# Technical Note: A38 Derby Junctions Addendum

**Subject: Geology and Soils (Controlled Waters Quantitative Risk Assessment)**

On the 9<sup>th</sup> October 2019 AECOM provided clarification to assist in addressing queries from the Environment Agency regarding groundwater quality in the areas associated with the A38 Derby junctions (referred to as the Scheme herein), namely Kingsway junction, Markeaton junction and Little Eaton junction. This information comprised tables of chemical data and figures presenting borehole locations where exceedances of the Tier 1<sup>1</sup> groundwater generic quantitative risk (GQRA) assessment were recorded. The tables, are not reproduced here, can be found in AECOM Technical Note: A38 Derby Junction 25 November 2019 as can the figures showing the location of the monitoring wells at each of the A38 Derby Junctions.

In November 2019, following the Environment Agency's review of the additional data provided by Highways England, it was clear that the Environment Agency did not agree with the use of UCL95 values within the quantitative risk assessments for controlled waters. As such, the revised Quantitative Risk Assessment (QRA) for Controlled Waters for the Scheme at Kingsway, Markeaton and Little Eaton junctions was undertaken. The revision was undertaken following Environment Agency comments regarding the use of statistical analysis of the datasets in the 2018 Ground Investigation Report which determined a 95<sup>th</sup> percentile upper confidence limit (UCL95) for the groundwater data for each determinand for comparison with the Generic Assessment Criteria. The Environment Agency disagreed with this approach due to the underlying assumptions in the use of UCL95 values. The revised GQRA and DQRA did not use UCL95 values in the assessments. The revised quantitative risk assessment (QRA) was based on groundwater data only. The GQRA and DQRA in the Ground Investigation Report (2018) were based on the maximum concentrations recorded in either soil leachate or groundwater which was a highly conservative approach. The information submitted to the Environment Agency was also submitted to the A38 DCO Examining Authority (ExA) as document reference [REP3-020].

The summary of the revised DQRA, in the AECOM Technical Note: A38 Derby Junctions 25 November 2019, is as follows:

*The Tier 1 screening results revealed elevated concentrations of some metals and organic compounds in groundwater within the Made Ground at Kingsway (former Rowditch Tip) and Natural Ground at Kingsway, Markeaton and Little Eaton junctions.*

*A Detailed Quantitative Risk Assessment (DQRA) was carried out using the Environment Agency's Remedial Targets Worksheet for the contaminants identified in groundwater within the Made Ground at Kingsway junction and Natural Ground at Kingsway, Markeaton and Little Eaton junctions. The results of the DQRA indicates that there is negligible*

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<sup>1</sup> Tier 1 GQRA is terminology from CLR11 (EA, 2004); the terminology has been changed in the Contaminated Land: Risk Management (EA, 2019) guidance which refers to GQRA as Tier 2. For consistency with the earlier reports the GQRA will continue to be referred to as Tier 1.

*risk to identified receptors from organic contaminants. The theoretical risk from dissolved metals is likely to be influenced by naturally occurring low-level concentrations derived from the strata mineralogy. Therefore, it is considered that there is a very low risk to the identified receptors from the presence of cadmium, copper and/or nickel concentrations recorded in a very small number of samples at each of the three junctions.*

*No remedial works are considered necessary regarding the concentrations of potential contaminants encountered within groundwater at the three junctions.*

*Where dewatering of excavations is required during the Scheme construction works, water should be collected, stored, tested and then shall either be:*

- *Discharged to foul sewer under a trade effluent consent agreed with the local sewerage undertaker; and/or*
- *Discharged to surface water under a water discharge activity environmental permit (WDA-EP) from the Environment Agency.*

The revised DQRA was reviewed by the Environment Agency during December 2019 (e-mail dated 18.12.19 with the comments repeated in the Environment Agency submission to the ExA [REP3-034] (refer to comment 74e)). The findings of the DQRA were accepted by the Environment Agency with the exception of the following determinands recorded in Made Ground (former Rowditch Tip) at the Kingsway junction and natural ground at Markeaton junction – see Table 1.

**Table 1. Summary of Exceedances Recorded in Made Ground Groundwater at Kingsway Junction**

Determinand	Units	DWS	EQS	No. of Samples	Recorded Concentrations	No. of Exceedances DWS	No. of Exceedances EQS
>C10-C12 Aliphatics	µg/L	300	-	9	<10 – 331	1	-
>C12-C16 Aliphatics	µg/L	300	-	9	<10 – 324	2	-
>C16-C21 Aliphatics	µg/L	300	-	9	<10 – 542	5	-
>C21-C35 Aliphatics	µg/L	300	-	9	<10 - 5760	6	-
>EC5-EC7 Aromatics	µg/L	1	10	9	<10 – 17	3	2
>EC8-EC10 Aromatics	µg/L	300	-	6	<10 – 391	1	-
>EC10-EC12 Aromatics	µg/L	90	-	9	<10 – 221	3	-
>EC12-EC16 Aromatics	µg/L	90	-	9	<10 – 352	6	-
>EC16-EC21 Aromatics	µg/L	90	-	9	<10 – 484	6	-
>EC21-EC35 Aromatics	µg/L	90	-	9	<10 – 1,850	6	-

The following determinands were recorded in monitoring well BM05 and BM11 at Markeaton junction – see Table 2.

**Table 2. Summary of Exceedances Recorded at Markeaton Junction**

Determinand	Units	DWS	EQS	No. of Samples	Recorded Concentrations	No. of Exceedances DWS	No. of Exceedances EQS
>C21-C35 Aliphatics	µg/L	300	-	16	<10 – 1,250	4	-
>EC21-EC35 Aromatics	µg/L	90	-	16	<10 – 591	4	-

These determinands were recorded as exceedances against Drinking Water Standards (DWS), but not Environmental Quality Standards (EQS). These determinands were not taken further than the Generic Quantitative Risk Assessment as it was noted that the receptors at Kingsway junction and Markeaton junction are surface water bodies and not groundwater bodies. The underlying groundwater is not used for potable water supply. Therefore, no further assessment was considered necessary. However, the Environment Agency consider that the total petroleum hydrocarbon (TPH) concentrations recorded may pose a risk to controlled waters and consider that further comment and/or risk assessment is required.

The following are AECOM comments that relate to the TPH fractions recorded as exceedances of the corresponding DWS at the former Rowditch Tip at Kingsway junction:

- Location of BK12, BK13, BK14 and BK15 is presented in Figure 4 Groundwater Exceedances (Kingsway East) (04/10/2019) (this figure was included in the AECOM Technical Note: A38 Derby Junction 25 November 2019).
- Elevated TPH fractions, in comparison to the corresponding DWS, were recorded in BK12 and BK14 only.
- No elevated TPH fractions were recorded at the two other monitoring wells BK13 and BK15 also located at the site of the former Rowditch Tip. Hydrocarbon odours and/or staining were noted within the Made Ground materials on the borehole logs for BK12 and BK13; none recorded in BK14.
- Monitoring wells BK12, BK13 and BK14 are screened within Made Ground materials at depths between:
  - 1.2m and 9.0m below ground level (bgl) in BK12;
  - 7.1m and 12m bgl in BK13; and
  - 4.0m and 8.0m bgl in BK14.
- Monitoring well BK15 is screened in Natural Ground between 8.0m and 14.0m bgl. A strong hydrocarbon odour was noted in the overlying Made Ground between 1.2m and 2.0m bgl. No hydrocarbon odours were noted in the natural ground.
- Water within the Made Ground is considered to be perched water. Water strikes noted on the borehole logs indicate they occurred where gravel formed the Made Ground materials.
- Water in BK15 in Natural Ground was struck within a Siltstone band between 11.7m and 12.18m bgl.
- The groundwater chemical analysis results indicate that the groundwater within the Made Ground is not in continuity with groundwater within the natural ground.
- It is considered that the risk to surface water (Bramble Brook) from the presence of these TPH fractions in perched groundwater within the landfilled materials at the former Rowditch Tip is minimal. However, earthworks are to be undertaken within this area of the former Rowditch Tip [a link road will cross the site through a cutting] and it is considered prudent to undertake Detailed Quantitative Risk Assessment to assess an assumption that in the event that the earthworks created a plausible new pathway for the migration of groundwater whether it would result in a risk to surface water.

The following are AECOM comments that relate to the TPH fractions recorded as exceedances of the corresponding DWS at BM05 and BM11 at Markeaton junction:

- BM05 is screened in natural ground between 1.5m and 7.0m bgl. A strong acrid odour was noted at between 3.0m and 5.36m bgl within natural ground.
- BM11 is screened between 1.0m and 25.0m bgl in natural ground. No odours noted in the borehole log.
- Location of BM05 and BM11 is presented in Figure 2 Groundwater Exceedances (Markeaton) (13/11/2019) (this figure was included in the AECOM Technical Note: A38 Derby Junction 25 November 2019). BM05 is located to the south of the existing petrol station adjacent to the northbound carriageway of the A38. BM11 is located to the north west of the existing Markeaton junction adjacent to the northbound A38 carriageway.
- Elevated TPH fractions, in comparison to the corresponding DWS, were recorded in BM05 and BM11 only at Markeaton junction.
- It is considered that there is a potential risk to surface water (Markeaton Lake) from the presence of these TPH fractions in groundwater encountered in natural ground, in the event that the works cause a groundwater migration pathway. Therefore it is considered prudent to undertake Detailed Quantitative Risk Assessment to determine whether the concentrations of the TPH fractions recorded at BM05 and BM11 could impact Markeaton Lake.

## Detailed Quantitative Risk Assessment

Following the Tier 1 risk assessment as detailed in the preceding section, elevated concentrations of TPH fractions which were detected in groundwater samples, at isolated locations at Kingsway junction and Markeaton junction warrant further detailed assessment. The detailed quantitative risk assessment (DQRA) has been undertaken in accordance with current guidance to assess the potential risk posed to the receptors by the elevated contaminants identified in groundwater.

The risk assessment is based on the guidance contained within the Environment Agency (2006) Remedial Target Methodology - Hydrogeological Risk Assessment for Land Contamination' (RTM) and the associated Remedial Targets

Worksheet (Release 3.2). The RTM document provides guidance on the method to derive remedial targets from soil, leachate and groundwater data.

A Level 3 groundwater assessment was undertaken for each of the three junctions. The Level 3 assessment simulates the migration of contaminants that have already reached the underlying groundwater, taking into account the potential attenuation as the contaminated groundwater moves to the receptor(s) as follows:

- Kingsway junction – Bramble Brook
- Markeaton junction – Markeaton Lake/ Pond

The assessment does not take into consideration dilution at the receptor.

## Remedial Target Methodology

The site-specific remedial target concentrations with respect to the elevated contaminants in groundwater were computed in accordance with the Environment Agency's Risk Assessment Methodology (RTM). The Remedial Target Worksheet (Release 3.2) for the hydrogeological risk assessment for land contamination was utilised. The input parameters were derived from data from the ground investigation at the site and the various databases for related soil types and geochemical inputs.

## Risk Assessment Simulation Overview

The risk assessment simulations assume a continuous groundwater body present beneath the site. It is assumed that the underlying groundwater flows towards each of the receptors. There was no on-site measurement of redox potential and dissolved oxygen during the groundwater monitoring at the sites. As such, anaerobic biodegradation rates for the organic contaminants have been used where available. This is a conservative approach.

The specific input parameters for each simulation in RTM worksheet and the physical properties of the various contaminants are included in Appendices A and B.

### Made Ground at Kingsway Junction

Table 3 details the results of the DQRA (full results are included in Appendix A), the simulated remedial target values and the predicted maximum concentrations of the various contaminants at the compliance point (Bramble Brook). The results summarise the predicted concentrations of the contaminant after the contaminant reaches the receptor. A Remedial Target Value (RTV) is given in Red or Green. Red corresponds to an RTV value less than the maximum concentration recorded in groundwater which indicates that mitigation measures may be required, and Green corresponds to an RTV value more than the maximum concentration recorded in groundwater which indicates that mitigation measures are not required.

**Table 3. Results of Detailed Quantitative Risk Assessment in Made Ground at Kingsway Junction**

Determinand	Target Concentration (DWS) (µg/L)	Maximum Concentration in Groundwater (µg/L)	Predicted Concentration at Receptor (µg/L)	Remedial Target Value (µg/L)
>C10-C12 Aliphatics	300	331	<0.00001	>10,000
>C12-C16 Aliphatics	300	324	<0.00001	>10,000
>C16-C21 Aliphatics	300	542	<0.00001	>10,000
>C21-C35 Aliphatics	300	5760	<0.00001	>10,000
>EC5-EC7 Aromatics	1	17	<0.00001	>10,000
>EC8-EC10 Aromatics	300	391	<0.00001	>10,000
>EC10-EC12 Aromatics	90	221	<0.00001	>10,000
>EC12-EC16 Aromatics	90	352	<0.00001	>10,000
>EC16-EC21 Aromatics	90	484	<0.00001	>10,000
>EC21-EC35 Aromatics	90	1,850	<0.00001	>10,000

Determinand	Target Concentration (DWS) (µg/L)	Maximum Concentration in Groundwater (µg/L)	Predicted Concentration at Receptor (µg/L)	Remedial Target Value (µg/L)
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*XX RTV less than maximum concentration in groundwater*

*XX RTV greater than maximum concentration in groundwater*

The results of the DQRA for groundwater sampled from made ground materials at the former Rowditch Tip at Kingsway junction suggest that there will be negligible risks from petroleum hydrocarbon determinands present in groundwater to the identified critical receptor (Bramble Brook).

#### Natural Ground at Markeaton Junction

Table 4 details the results of the DQRA (full results are included in Appendix B), the simulated remedial target values and the predicted maximum concentrations of the various contaminants at the compliance point (Markeaton Lake). The results summarise the predicted concentrations of the contaminant after the contaminant reaches the receptor. A RTV is given in Red or Green. Red corresponds to an RTV value less than the maximum concentration recorded in groundwater which indicates that mitigation measures may be required, and Green corresponds to an RTV value more than the maximum concentration recorded in groundwater which indicates that mitigation measures are not required.

**Table 4. Results of Detailed Quantitative Risk Assessment at in Natural Ground at Markeaton Junction**

Determinand	Target Concentration (DWS) (µg/L)	Maximum Concentration in Groundwater (µg/L)	Predicted Concentration at Receptor (µg/L)	Remedial Target Value (µg/L)
>C21-C35 Aliphatics	300	1,250	<0.00001	>10,000
>EC21-EC35 Aromatics	90	591	<0.00001	>10,000

*XX RTV less than maximum concentration in groundwater*

*XX RTV greater than maximum concentration in groundwater*

The results of the DQRA for groundwater sampled at locations BM05 and BM11 at Markeaton junction suggest that there will be negligible risks from petroleum hydrocarbon determinands present in groundwater to the identified critical receptor (Markeaton Lake/ Pond).

## Conclusion

A Detailed Quantitative Risk Assessment (DQRA) was carried out using the Environment Agency's Remedial Targets Worksheet for the TPH fractions, noted in Table 1, in groundwater within the Made Ground at Kingsway junction and Natural Ground at Markeaton junction. The results of the DQRA indicates that there is negligible risk to identified receptors from the TPH fractions.

No remedial works are considered necessary regarding the concentrations of potential contaminants encountered within groundwater at these junctions.

Where dewatering of excavations is required during the Scheme construction works, water should be collected, stored, tested and then shall either be:

- Discharged to foul sewer under a trade effluent consent agreed with the local sewerage undertaker; and/or
- Discharged to surface water under a water discharge activity environmental permit (WDA-EP) from the Environment Agency.

**Appendix A – Kingsway Junction RTM DQRA Made Ground [TPH Fractions]**





## Hydrogeological risk assessment for land contamination

### Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC10 - 12 Aliphatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.3	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	>EC10 - 12 Aliphatics	from Level 1
Target Concentration	3.00E-01	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C <sub>0</sub>	3.31E-01	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	t <sub>1/2</sub>	1.00E+03	days	See Justification Table
Calculated decay rate	λ	6.93E-04	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.60E+02	m	See Justification Table
Plume thickness at source	Sy	2.30E+00	m	See Justification Table
Saturated aquifer thickness	da	2.50E+00	m	See Justification Table
Bulk density of aquifer materials	ρ	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	n	1.00E-01	fraction	See Justification Table
Hydraulic gradient	i	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer	K	1.94E-01	m/d	See Justification Table
Distance to compliance point	x	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	t	9.90E+99	days	time variant options only
<i>Parameters values determined from options</i>				
Partition coefficient	Kd	6.00E+04	l/kg	see options
Longitudinal dispersivity	ax	1.50E+01	m	see options
Transverse dispersivity	az	1.50E+00	m	see options
Vertical dispersivity	ay	1.50E-01	m	see options

Calculated Parameters Variable

Groundwater flow velocity	v	2.72E-01	m/d
Retardation factor	Rf	1.07E+06	fraction
Decay rate used	λ	6.93E-04	d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	2.54E-07	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C <sub>ED</sub>	0.00E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	breakthrough at compliance point	

Select Method for deriving Partition Co-efficient (using pull down menu)

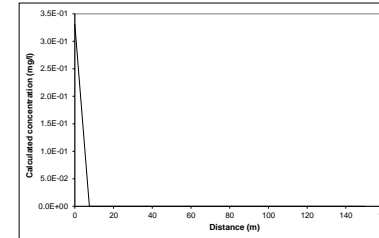
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd	6.00E+04	l/kg
Soil water partition coefficient	K <sub>d</sub>	6.00E+04	l/kg
Entry for non-polar organic chemicals (option)	foc	2.50E-01	fraction
Fraction of organic carbon in aquifer	foc	2.50E-01	fraction
Organic carbon partition coefficient	K <sub>oc</sub>	2.40E+05	l/kg
Soil water partition coefficient	K <sub>d</sub>	6.00E+04	l/kg
Entry for ionic organic chemicals (option)	K <sub>oc,ion</sub>		l/kg
Sorption coefficient for related species	K <sub>oc,ion</sub>		l/kg
Sorption coefficient for ionised species	K <sub>oc,ion</sub>		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction

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

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

Longitudinal dispersivity	ax	1.50E+01	1.50E+01	5.42E+00	m
Transverse dispersivity	az	0.00E+00	1.50E+00	5.42E-01	m
Vertical dispersivity	ay	0.00E+00	1.50E-01	5.42E-02	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log <sub>10</sub> x) <sup>0.14</sup> ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Calculated concentrations for distance-concentration graph

Ogata Banks	
From calculation sheet	
Distance	Concentration
	mg/l
0	3.3E-01
7.5	3.94E-45
15.0	4.42E-89
22.5	5.19E-133
30.0	6.30E-177
37.5	7.80E-221
45.0	9.81E-265
52.5	0.00E+00
60.0	0.00E+00
67.5	0.00E+00
75.0	0.00E+00
82.5	0.00E+00
90.0	0.00E+00
97.5	0.00E+00
105.0	0.00E+00
112.5	0.00E+00
120.0	0.00E+00
127.5	0.00E+00
135.0	0.00E+00
142.5	0.00E+00
150.0	0.00E+00

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks		
Distance to compliance point	150	m
Concentration of contaminant at compliance point after	C <sub>ED</sub> /C <sub>0</sub>	0.00E+00
		9.9E+99
		mg/l
		days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



## Hydrogeological risk assessment for land contamination Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

<u>Details to be completed for each assessment</u>			
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<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC12 - 16 Aliphatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.3	<b>mg/l</b>	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	>EC12 - 16 Aliphatics		from Level 1
Target Concentration	3.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value)

Variable	Value	Unit	Source
Initial contaminant concentration in groundwater at plume core	3.24E-01	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	1.00E+03	days	See Justification Table
Calculated decay rate	6.93E-04	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	3.60E+02	m	See Justification Table
Plume thickness at source	2.30E+00	m	See Justification Table
Saturated aquifer thickness	2.50E+00	m	See Justification Table
Bulk density of aquifer materials	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	1.00E-01	fraction	See Justification Table
Hydraulic gradient	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer	1.94E-01	m/d	See Justification Table
Distance to compliance point	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	9.90E+99	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	1.34E+06	l/kg	see options
Longitudinal dispersivity	1.50E+01	m	see options
Transverse dispersivity	1.50E+00	m	see options
Vertical dispersivity	1.50E-01	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.72E-01	m/d
Retardation factor	2.40E+07	fraction
Decay rate used	6.93E-04	d <sup>-1</sup>
Rate of contaminant flow due to retardation	1.13E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	0.00E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	breakthrough at compliance point

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

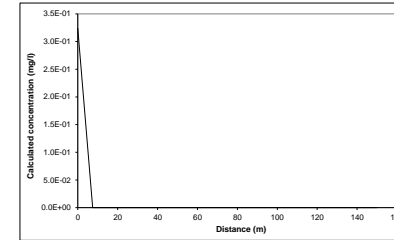
Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	1.34E+06 l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	2.50E-01 fraction
Organic carbon partition coefficient	Koc	5.37E+06 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K <sub>oc,rel</sub>	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	1.34E+06 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	m
Longitudinal dispersivity	ax	0.00E+00	1.50E+01	1.50E+00
Transverse dispersivity	ay	0.00E+00	1.50E+00	1.50E-01
Vertical dispersivity	az	0.00E+00	1.50E-01	1.50E-02

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>ax)<sup>0.14</sup>; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used.

Calculated concentrations for distance-concentration graph

Distance	Concentration
	mg/l
0	3.2E-01
7.5	3.11E-209
15.0	0.00E+00
22.5	0.00E+00
30.0	0.00E+00
37.5	0.00E+00
45.0	0.00E+00
52.5	0.00E+00
60.0	0.00E+00
67.5	0.00E+00
75.0	0.00E+00
82.5	0.00E+00
90.0	0.00E+00
97.5	0.00E+00
105.0	0.00E+00
112.5	0.00E+00
120.0	0.00E+00
127.5	0.00E+00
135.0	0.00E+00
142.5	0.00E+00
150.0	0.00E+00

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks			
Distance to compliance point	150	m	
Concentration of contaminant at compliance point after	C <sub>ED</sub> /C <sub>0</sub>	0.00E+00	mg/l
		9.9E+99	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



## Hydrogeological risk assessment for land contamination

### Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC16 - 21 Aliphatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.3	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	>EC16 - 21 Aliphatics		from Level 1
Target Concentration	3.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction
---

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to pollutants in all phases (e.g. field derived value)
---

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	5.42E-01	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	3.00E+03	days	See Justification Table
Calculated decay rate	2.31E-04	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	3.60E+02	m	See Justification Table
Plume thickness at source	2.30E+00	m	See Justification Table
Saturated aquifer thickness	2.50E+00	m	See Justification Table
Bulk density of aquifer materials	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	1.00E-01	fraction	See Justification Table
Hydraulic gradient	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer	1.94E-01	m/d	See Justification Table
Distance to compliance point	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	9.90E+99	days	time variant options only
Partition coefficient	1.58E+08	l/kg	see options
Longitudinal dispersivity	1.50E+01	m	see options
Transverse dispersivity	1.50E+00	m	see options
Vertical dispersivity	1.50E-01	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.72E-01	m/d
Retardation factor	2.82E+09	fraction
Decay rate used	2.31E-04	d <sup>-1</sup>
Rate of contaminant flow due to retardation	9.64E-11	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	0.00E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	breakthrough at compliance point

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

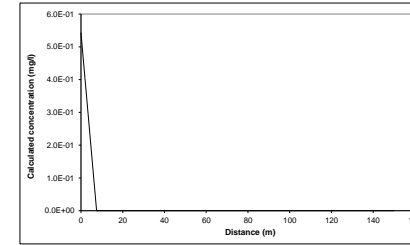
Entry if specify partition coefficient (option)	Kd	1.58E+08	l/kg
Soil water partition coefficient	Kd	1.58E+08	l/kg
Entry for non-polar organic chemicals (option)	Soil water partition coefficient	1.58E+08	l/kg
Fraction of organic carbon in aquifer	foc	2.50E-01	fraction
Organic carbon partition coefficient	Koc	6.31E+08	l/kg
Entry for ionic organic chemicals (option)	K <sub>oc,ion</sub>		l/kg
Sorption coefficient for related species	K <sub>oc,r</sub>		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.58E+08	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	Unit
Longitudinal dispersivity	ax	1.50E+01	1.50E+01	m
Transverse dispersivity	ay	1.50E+00	1.50E+00	m
Vertical dispersivity	az	1.50E-01	1.50E-01	m

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub> x)<sup>0.14</sup>; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks  
From calculation sheet

Distance	Concentration
0	5.4E-01
7.5	0.00E+00
15.0	0.00E+00
22.5	0.00E+00
30.0	0.00E+00
37.5	0.00E+00
45.0	0.00E+00
52.5	0.00E+00
60.0	0.00E+00
67.5	0.00E+00
75.0	0.00E+00
82.5	0.00E+00
90.0	0.00E+00
97.5	0.00E+00
105.0	0.00E+00
112.5	0.00E+00
120.0	0.00E+00
127.5	0.00E+00
135.0	0.00E+00
142.5	0.00E+00
150.0	0.00E+00

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
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Distance to compliance point	150	m	
Concentration of contaminant at compliance point after	0.00E+00	mg/l	Ogata Banks
	9.9E+99	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



## Hydrogeological risk assessment for land contamination Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

### Details to be completed for each assessment

<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC21 - 35 Aliphatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.3	<b>mg/l</b>	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	>EC21 - 35 Aliphatics		from Level 1
Target Concentration	3.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction
---

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to pollutants in all phases (e.g. field derived value)
---

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	5.76E+00	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	1.00E+04	days	See Justification Table
Calculated decay rate	6.93E-05	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	3.60E+02	m	See Justification Table
Plume thickness at source	2.30E+00	m	See Justification Table
Saturated aquifer thickness	2.50E+00	m	See Justification Table
Bulk density of aquifer materials	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	1.00E-01	fraction	See Justification Table
Hydraulic gradient	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer	1.94E-01	m/d	See Justification Table
Distance to compliance point	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	9.90E+99	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	1.90E+09	l/kg	see options
Longitudinal dispersivity	1.50E+01	m	see options
Transverse dispersivity	1.50E+00	m	see options
Vertical dispersivity	1.50E-01	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.72E-01	m/d
Retardation factor	3.40E+10	fraction
Decay rate used	6.93E-05	d <sup>-1</sup>
Rate of contaminant flow due to retardation	8.01E-12	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	0.00E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	breakthrough at compliance point

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Variable	Value	Unit
Soil water partition coefficient		l/kg
Fraction of organic carbon in aquifer	2.50E-01	fraction
Organic carbon partition coefficient	7.59E+09	l/kg
Sorption coefficient for related species		l/kg
Sorption coefficient for ionised species		l/kg
acid dissociation constant		fraction
Fraction of organic carbon in aquifer		fraction
Soil water partition coefficient	1.90E+09	l/kg

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

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

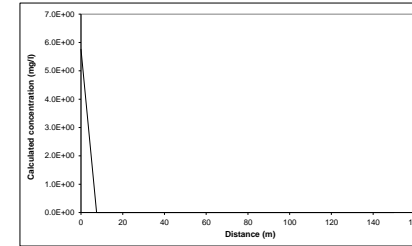
Variable	Enter value	Calc value	Xu & Eckstein	Unit
Longitudinal dispersivity	ax	1.50E+01	5.40E+00	m
Transverse dispersivity	az	1.50E+00	5.40E-01	m
Vertical dispersivity	ay	1.50E-01	5.40E-02	m

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub> x)<sup>0.14</sup>; az = ax/10, ay = ax/100 are assumed

Remedial Targets

Remedial Target	Value	Unit	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	150	m	
Concentration of contaminant at compliance point after	0.00E+00	mg/l	Ogata Banks
	9.9E+99	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Calculated concentrations for distance-concentration graph

Distance	Concentration
	mg/l
0	5.8E+00
7.5	0.00E+00
15.0	0.00E+00
22.5	0.00E+00
30.0	0.00E+00
37.5	0.00E+00
45.0	0.00E+00
52.5	0.00E+00
60.0	0.00E+00
67.5	0.00E+00
75.0	0.00E+00
82.5	0.00E+00
90.0	0.00E+00
97.5	0.00E+00
105.0	0.00E+00
112.5	0.00E+00
120.0	0.00E+00
127.5	0.00E+00
135.0	0.00E+00
142.5	0.00E+00
150.0	0.00E+00





## Hydrogeological risk assessment for land contamination Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC5 - 7 Aromatic		
<b>Target Concentration (C<sub>T</sub>)</b>	0.001	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	>EC5 - 7 Aromatic		from Level 1
Target Concentration C <sub>T</sub>	1.00E-03	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction
---

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to pollutants in all phases (e.g. field derived value)
---

Variable	Value	Unit	Source
Initial contaminant concentration in groundwater at plume core C <sub>0</sub>	1.70E+01	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water t <sub>1/2</sub>	5.00E+01	days	See Justification Table
Calculated decay rate λ	1.39E-02	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow) Sz	3.60E+02	m	See Justification Table
Plume thickness at source Sy	2.30E+00	m	See Justification Table
Saturated aquifer thickness db	2.50E+00	m	See Justification Table
Bulk density of aquifer materials ρ	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer n	1.00E-01	fraction	See Justification Table
Hydraulic gradient i	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer K	1.94E-01	m/d	See Justification Table
Distance to compliance point x	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction y	0.00E+00	m	
Time since pollutant entered groundwater t	9.90E+99	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient Kd	1.69E+01	l/kg	see options
Longitudinal dispersivity ax	1.50E+01	m	see options
Transverse dispersivity az	1.50E+00	m	see options
Vertical dispersivity av	1.50E-01	m	see options

Calculated Parameters Variable

Groundwater flow velocity v	2.72E-01	m/d
Retardation factor Rf	3.04E+02	fraction
Decay rate used λ	1.39E-02	d <sup>-1</sup>
Rate of contaminant flow due to retardation u	8.97E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion C <sub>ED</sub>	4.56E-64	mg/l
Attenuation factor (one way vertical dispersion, CO/CED) AF	3.73E+64	

Remedial Targets

Remedial Target	3.73E+61	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Distance to compliance point	150	m
------------------------------	-----	---

Concentration of contaminant at compliance point after	C <sub>ED</sub> /C <sub>0</sub>	4.56E-64	mg/l	Ogata Banks
		9.9E+99	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

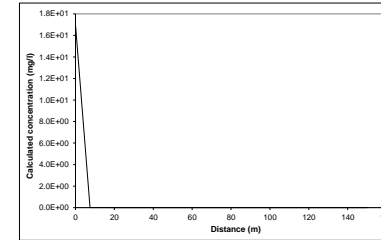
Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	2.50E-01	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	6.76E+01	l/kg
Entry for ionic organic chemicals (option)	K <sub>oc,ion</sub>		l/kg
Sorption coefficient for related species	K <sub>oc,r</sub>		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	1.69E+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	m
Longitudinal dispersivity	ax	0.00E+00	1.50E+01	9.42E+00
Transverse dispersivity	az	0.00E+00	1.50E+00	5.42E-01
Vertical dispersivity	ay	0.00E+00	1.50E-01	5.42E-02

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>0.144</sup>, az = ax/10, ay = ax/100 are assumed



Calculated concentrations for distance-concentration graph

Distance	Concentration
0	1.7E+01
7.5	9.38E-03
15.0	4.88E-06
22.5	2.66E-09
30.0	1.50E-12
37.5	8.62E-16
45.0	5.03E-19
52.5	2.96E-22
60.0	1.76E-25
67.5	1.05E-28
75.0	6.32E-32
82.5	3.82E-35
90.0	2.31E-38
97.5	1.41E-41
105.0	8.56E-45
112.5	5.28E-48
120.0	3.20E-51
127.5	1.96E-54
135.0	1.20E-57
142.5	7.40E-61
150.0	4.56E-64

Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note  
This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.  
By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.  
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc. than an alternative solution should be used

Site being assessed:	Kingsway Junction
Completed by:	Lucy Full
Date:	#####
Version:	3.2



## Hydrogeological risk assessment for land contamination

### Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination ( Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

#### Details to be completed for each assessment

<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC8 - 10 Aromatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.3	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

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Data carried forward from an earlier worksheet are identified by a light green background

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The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	>EC8 - 10 Aromatics	from Level 1
Target Concentration	3.00E-01	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction
---

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to pollutants in all phases (e.g. field derived value)
---

Source of parameter value			
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub>	3.91E-01	mg/l
Half life for degradation of contaminant in water	t <sub>1/2</sub>	5.00E+02	days
Calculated decay rate	λ	1.39E-03	days <sup>-1</sup>
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.60E+02	m
Plume thickness at source	Sy	2.30E+00	m
Saturated aquifer thickness	da	2.50E+00	m
Bulk density of aquifer materials	ρ	1.79E+00	g/cm <sup>3</sup>
Effective porosity of aquifer	n	1.00E-01	fraction
Hydraulic gradient	i	1.40E-01	fraction
Hydraulic conductivity of aquifer	K	1.94E-01	m/d
Distance to compliance point	x	1.50E+02	m
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m
Time since pollutant entered groundwater	t	9.90E+99	days
<i>Parameters values determined from options</i>			
Partition coefficient	Kd	3.96E+02	l/kg
Longitudinal dispersivity	ax	1.50E+01	m
Transverse dispersivity	az	1.50E+00	m
Vertical dispersivity	ay	1.50E-01	m

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	2.72E-01 m/d
Retardation factor	Rf	7.09E+03
Decay rate used	λ	1.39E-03 d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	3.84E-05 m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C <sub>ED</sub>	1.15E-100 mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	3.39E+99

Remedial Targets

Remedial Target	1.02E+99	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Distance to compliance point	150	m
------------------------------	-----	---

Concentration of contaminant at compliance point after	C <sub>ED</sub> /C <sub>0</sub>	1.15E-100	mg/l
		9.9E+99	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

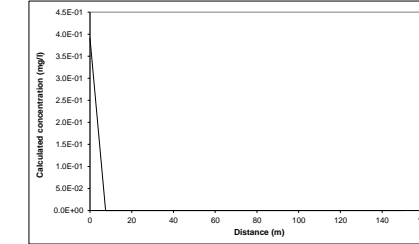
Entry if specify partition coefficient (option)	Kd		l/kg
Entry for ionic organic chemicals (option)	K <sub>oc,ion</sub>		l/kg
Entry for non-polar organic chemicals (option)	K <sub>oc</sub>	1.58E+03	l/kg
Soil water partition coefficient	K <sub>d</sub>	3.96E+02	l/kg
Fraction of organic carbon in aquifer	f <sub>oc</sub>	2.50E-01	fraction
Organic carbon partition coefficient	K <sub>oc</sub>	1.58E+03	l/kg
Sorption coefficient for related species	K <sub>oc,r</sub>		l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	f <sub>oc</sub>		fraction

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

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

	Enter value	Calc value	Xu & Eckstein	Unit
Longitudinal dispersivity	ax	1.50E+01	1.50E+01	m
Transverse dispersivity	az	1.50E+00	1.50E+00	m
Vertical dispersivity	ay	1.50E-01	1.50E-01	m

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub> x)<sup>0.44</sup>; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Calculated concentrations for distance-concentration graph

Distance	Concentration
	mg/l
0	3.9E-01
7.5	3.86E-06
15.0	3.59E-11
22.5	3.50E-16
30.0	3.52E-21
37.5	3.61E-26
45.0	3.76E-31
52.5	3.96E-36
60.0	4.21E-41
67.5	4.49E-46
75.0	4.83E-51
82.5	5.21E-56
90.0	5.63E-61
97.5	6.12E-66
105.0	6.66E-71
112.5	7.27E-76
120.0	7.95E-81
127.5	8.70E-86
135.0	9.55E-91
142.5	1.05E-95
150.0	1.15E-100



## Hydrogeological risk assessment for land contamination

### Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

#### Details to be completed for each assessment

<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC10 - 12 Aromatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.09	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	>EC10 - 12 Aromatics	from Level 1
Target Concentration	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction
---

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to pollutants in all phases (e.g. field derived value)
---

Parameter	Value	Unit	Source
Initial contaminant concentration in groundwater at plume core	2.21E-01	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	1.00E+03	days	See Justification Table
Calculated decay rate	6.93E-04	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	3.60E+02	m	See Justification Table
Plume thickness at source	2.30E+00	m	See Justification Table
Saturated aquifer thickness	2.50E+00	m	See Justification Table
Bulk density of aquifer materials	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	1.00E-01	fraction	See Justification Table
Hydraulic gradient	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer	1.94E-01	m/d	See Justification Table
Distance to compliance point	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	9.90E+99	days	time variant options only
Partition coefficient	6.28E+02	l/kg	see options
Longitudinal dispersivity	1.50E+01	m	see options
Transverse dispersivity	1.50E+00	m	see options
Vertical dispersivity	1.50E-01	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.72E-01	m/d
Retardation factor	1.12E+04	fraction
Decay rate used	6.93E-04	d <sup>-1</sup>
Rate of contaminant flow due to retardation	2.42E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	8.24E-90	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	2.68E+88	

Remedial Targets

Remedial Target	2.41E+87	mg/l	For comparison with measured groundwater concentration.
-----------------	----------	------	---

Distance to compliance point	150	m
------------------------------	-----	---

Concentration of contaminant at compliance point after	8.24E-90	mg/l	Ogata Banks
	9.9E+99	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

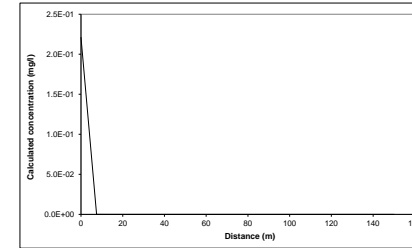
Entry if specify partition coefficient (option)	Kd	6.28E+02	l/kg
Entry for non-polar organic chemicals (option)	Soil water partition coefficient		
Entry for ionic organic chemicals (option)	Soil water partition coefficient		
Fraction of organic carbon in aquifer	foc	2.50E-01	fraction
Organic carbon partition coefficient	Koc	2.51E+03	l/kg
Sorption coefficient for related species	K <sub>oc,rel</sub>		
Sorption coefficient for ionised species	K <sub>oc,i</sub>		
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		
Soil water partition coefficient	Kd	6.28E+02	l/kg

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

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

Dispersivity	ax	ay	az	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	0.00E+00	1.50E+01	1.50E+01	1.50E+01	m
Transverse dispersivity	ay	0.00E+00	1.50E+00	1.50E+00	1.50E+00	m
Vertical dispersivity	az	0.00E+00	1.50E-01	1.50E-01	1.50E-01	m

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>0.414</sup>, az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Calculated concentrations for distance-concentration graph

Distance	Concentration
0	2.2E-01
7.5	7.82E-06
15.0	2.61E-10
22.5	9.14E-15
30.0	3.30E-19
37.5	1.22E-23
45.0	4.55E-28
52.5	1.72E-32
60.0	6.56E-37
67.5	2.51E-41
75.0	9.70E-46
82.5	3.75E-50
90.0	1.46E-54
97.5	5.69E-59
105.0	2.22E-63
112.5	8.70E-68
120.0	3.42E-72
127.5	1.34E-76
135.0	5.29E-81
142.5	2.09E-85
150.0	8.24E-90



## Hydrogeological risk assessment for land contamination Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC12 - 16 Aromatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.09	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	>EC12 - 16 Aromatics		from Level 1
Target Concentration	9.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction
---

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to pollutants in all phases (e.g. field derived value)
---

Variable	Value	Unit	Source
Initial contaminant concentration in groundwater at plume core	3.52E-01	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	1.00E+03	days	See Justification Table
Calculated decay rate	6.93E-04	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	3.60E+02	m	See Justification Table
Plume thickness at source	2.30E+00	m	See Justification Table
Saturated aquifer thickness	2.50E+00	m	See Justification Table
Bulk density of aquifer materials	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	1.00E-01	fraction	See Justification Table
Hydraulic gradient	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer	1.94E-01	m/d	See Justification Table
Distance to compliance point	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	9.90E+99	days	time variant options only
Partition coefficient	1.25E+03	l/kg	see options
Longitudinal dispersivity	1.50E+01	m	see options
Transverse dispersivity	1.50E+00	m	see options
Vertical dispersivity	1.50E-01	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.72E-01	m/d
Retardation factor	2.24E+04	fraction
Decay rate used	6.93E-04	d <sup>-1</sup>
Rate of contaminant flow due to retardation	1.21E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	9.98E-127	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	3.53E+125	

Remedial Targets

Remedial Target	3.18E+124	mg/l	For comparison with measured groundwater concentration.
-----------------	-----------	------	---

Distance to compliance point	150	m
------------------------------	-----	---

Concentration of contaminant at compliance point after	9.98E-127	mg/l	Ogata Banks
	9.9E+99	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

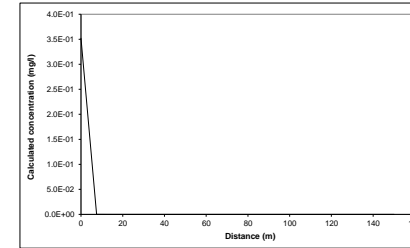
Entry if specify partition coefficient (option)	Kd	l/kg
Entry for ionic organic chemicals (option)	Soil water partition coefficient	
Entry for non-polar organic chemicals (option)	Soil water partition coefficient	2.50E-01
Fraction of organic carbon in aquifer	foc	fraction
Organic carbon partition coefficient	Koc	5.01E+03
Sorption coefficient for related species	K <sub>oc,rel</sub>	l/kg
Sorption coefficient for ionised species	K <sub>oc,ion</sub>	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	1.25E+03
		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	m
Longitudinal dispersivity	ax	0.90E+00	1.50E+01	5.40E+00
Transverse dispersivity	ay	0.00E+00	1.50E+00	5.40E-01
Vertical dispersivity	az	0.00E+00	1.50E-01	5.40E-02

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>ax)<sup>0.144</sup>; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Calculated concentrations for distance-concentration graph

Distance	Concentration
	mg/l
0	3.5E-01
7.5	1.74E-07
15.0	8.08E-14
22.5	3.94E-20
30.0	1.98E-26
37.5	1.02E-32
45.0	5.30E-39
52.5	2.79E-45
60.0	1.48E-51
67.5	7.93E-58
75.0	4.26E-64
82.5	2.30E-70
90.0	1.24E-76
97.5	6.76E-83
105.0	3.68E-89
112.5	2.01E-95
120.0	1.10E-101
127.5	6.01E-108
135.0	3.30E-114
142.5	1.81E-120
150.0	9.98E-127





## Hydrogeological risk assessment for land contamination

### Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

#### Details to be completed for each assessment

<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC16 - 21 Aromatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.09	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	>EC16 - 21 Aromatics		from Level 1
Target Concentration	9.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value)

Variable	Value	Unit	Source
Initial contaminant concentration in groundwater at plume core	4.84E-01	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	3.00E+03	days	See Justification Table
Calculated decay rate	2.31E-04	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	3.60E+02	m	See Justification Table
Plume thickness at source	2.30E+00	m	See Justification Table
Saturated aquifer thickness	2.50E+00	m	See Justification Table
Bulk density of aquifer materials	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	1.00E-01	fraction	See Justification Table
Hydraulic gradient	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer	1.94E-01	m/d	See Justification Table
Distance to compliance point	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	9.90E+99	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	3.53E+03	l/kg	see options
Longitudinal dispersivity	1.50E+01	m	see options
Transverse dispersivity	1.50E+00	m	see options
Vertical dispersivity	1.50E-01	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.72E-01	m/d
Retardation factor	6.32E+04	fraction
Decay rate used	2.31E-04	d <sup>-1</sup>
Rate of contaminant flow due to retardation	4.31E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	1.11E-122	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	4.35E+121	

Remedial Targets

Remedial Target	3.91E+120	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks

Distance to compliance point	150	m
Concentration of contaminant at compliance point after	1.11E-122	mg/l
	9.9E+99	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

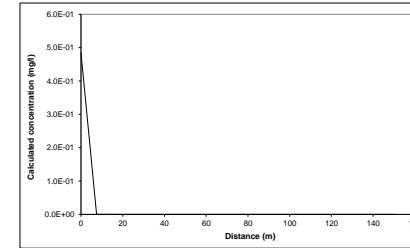
Variable	Value	Unit
Soil water partition coefficient		l/kg
Fraction of organic carbon in aquifer	2.50E-01	fraction
Organic carbon partition coefficient	1.41E+04	l/kg
Sorption coefficient for related species		l/kg
Sorption coefficient for ionised species		l/kg
pH value		
acid dissociation constant		
Fraction of organic carbon in aquifer		fraction
Soil water partition coefficient	3.53E+03	l/kg

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

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

Variable	Enter value	Calc value	Xu & Eckstein	Unit
Longitudinal dispersivity	ax	1.50E+01	1.50E+01	m
Transverse dispersivity	ay	1.50E+00	1.50E+00	m
Vertical dispersivity	az	1.50E-01	1.50E-01	m

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub> x)<sup>0.14</sup>; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Calculated concentrations for distance-concentration graph

Distance	Concentration
	mg/l
0	4.8E-01
7.5	3.74E-07
15.0	2.73E-13
22.5	2.09E-19
30.0	1.65E-25
37.5	1.33E-31
45.0	1.09E-37
52.5	8.97E-44
60.0	7.47E-50
67.5	6.26E-56
75.0	5.28E-62
82.5	4.46E-68
90.0	3.79E-74
97.5	3.23E-80
105.0	2.76E-86
112.5	2.36E-92
120.0	2.02E-98
127.5	1.74E-104
135.0	1.50E-110
142.5	1.29E-116
150.0	1.11E-122



## Hydrogeological risk assessment for land contamination

### Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC21 - 35 Aromatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.09	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	>EC21 - 35 Aromatics		from Level 1
Target Concentration	9.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction
---

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to pollutants in all phases (e.g. field derived value)
---

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	1.85E+00	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	1.00E+04	days	See Justification Table
Calculated decay rate	6.93E-05	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	3.60E+02	m	See Justification Table
Plume thickness at source	2.30E+00	m	See Justification Table
Saturated aquifer thickness	2.50E+00	m	See Justification Table
Bulk density of aquifer materials	1.79E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	1.00E-01	fraction	See Justification Table
Hydraulic gradient	1.40E-01	fraction	See Justification Table
Hydraulic conductivity of aquifer	1.94E-01	m/d	See Justification Table
Distance to compliance point	1.50E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	9.90E+99	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	3.15E+04	l/kg see options
Longitudinal dispersivity	ax	1.50E+01	m see options
Transverse dispersivity	ay	1.50E+00	m see options
Vertical dispersivity	az	1.50E-01	m see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	2.72E-01 m/d
Retardation factor	Rf	5.63E+05 fraction
Decay rate used	λ	6.93E-05 d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	4.83E-07 m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C <sub>1D</sub>	2.36E-200 mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	7.82E+199

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

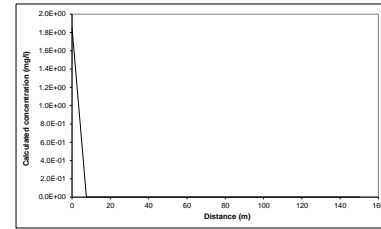
Soil water partition coefficient	Kd	3.15E+04	l/kg
Soil organic carbon in aquifer	foc	2.50E-01	fraction
Organic carbon partition coefficient	Koc	1.28E+05	l/kg
Organic carbon partition coefficient	K <sub>oc,1</sub>		l/kg
Sorption coefficient for related species	K <sub>oc,1</sub>		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	3.15E+04	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	m
ax	1.50E+01	1.50E+01	m
ay	1.50E+00	1.50E+00	m
az	1.50E-01	1.50E-01	m

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>0.411</sup>; az = ax/10, ay = ax/100 are assumed



Calculated concentrations for distance-concentration graph

Distance	Concentration	mg/l
0	1.85E-00	
7.5	1.75E-10	
15.0	1.56E-20	
22.5	1.46E-30	
30.0	1.41E-40	
37.5	1.38E-50	
45.0	1.38E-60	
52.5	1.40E-70	
60.0	1.42E-80	
67.5	1.46E-90	
75.0	1.50E-100	
82.5	1.55E-110	
90.0	1.61E-120	
97.5	1.68E-130	
105.0	1.75E-140	
112.5	1.84E-150	
120.0	1.93E-160	
127.5	2.02E-170	
135.0	2.13E-180	
142.5	2.24E-190	
150.0	2.36E-200	

Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.  
By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.  
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Kingway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Remedial Targets

Remedial Target	Value	Unit	Notes
Ogata Banks	7.04E+198	mg/l	For comparison with measured groundwater concentration.
Distance to compliance point	150	m	
Concentration of contaminant at compliance point after	C <sub>1D</sub> /C <sub>0</sub>	2.36E-200 mg/l	Ogata Banks
		9.9E+99 days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.

**Appendix B – Markeaton Junction RTM DQRA [TPH Fractions]**



## Hydrogeological risk assessment for land contamination Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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**IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).**

### Details to be completed for each assessment

<b>Site Name:</b>	Markeaton Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC21 - 35 Aliphatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.3	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

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Data carried forward from an earlier worksheet are identified by a light green background

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

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	>EC21 - 35 Aliphatics	from Level 1
Target Concentration	3.00E-01	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value)

Source of parameter value			
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub>	5.76E+00	mg/l
Half life for degradation of contaminant in water	t <sub>1/2</sub>	1.00E+04	days
Calculated decay rate	λ	6.93E-05	days <sup>-1</sup>
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+02	m
Plume thickness at source	Sy	2.50E+01	m
Saturated aquifer thickness	da	3.00E+01	m
Bulk density of aquifer materials	ρ	2.30E+00	g/cm <sup>3</sup>
Effective porosity of aquifer	n	1.00E-01	fraction
Hydraulic gradient	i	4.00E-02	fraction
Hydraulic conductivity of aquifer	K	6.48E-02	m/d
Distance to compliance point	x	2.90E+02	m
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m
Time since pollutant entered groundwater	t	9.90E+99	days
<i>Parameters values determined from options</i>			
Partition coefficient	Kd	1.90E+09	l/kg
Longitudinal dispersivity	ax	2.90E+01	m
Transverse dispersivity	az	2.90E+00	m
Vertical dispersivity	ay	2.90E-01	m

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	2.59E-02 m/d
Retardation factor	Rf	4.36E+10
Decay rate used	λ	6.93E-05 d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	5.94E-13 m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C <sub>ED</sub>	0.00E+00 mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	breakthrough at compliance point

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

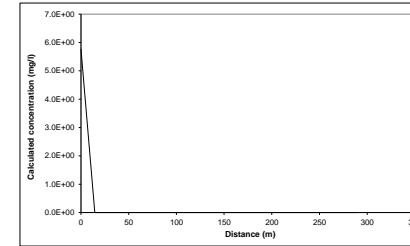
Entry if specify partition coefficient (option)	Kd	1.90E+09	l/kg
Entry for ionic organic chemicals (option)	K <sub>oc,ion</sub>	7.59E+09	l/kg
Entry for non-polar organic chemicals (option)	K <sub>oc</sub>	7.59E+09	l/kg
Fraction of organic carbon in aquifer	f <sub>oc</sub>	2.50E-01	fraction
Soil water partition coefficient	K <sub>d</sub>	1.90E+09	l/kg
Sorption coefficient for related species	K <sub>oc,r</sub>		l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	f <sub>oc</sub>		fraction

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

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

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	ax	0.90E+00	2.90E+01	7.31E+00
Transverse dispersivity	az	0.90E+00	2.90E+00	7.31E-01
Vertical dispersivity	ay	0.90E+00	2.90E-01	7.31E-02

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub> x)<sup>0.14</sup>; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks  
From calculation sheet

Distance	Concentration
0	5.8E+00
14.5	0.00E+00
29.0	0.00E+00
43.5	0.00E+00
58.0	0.00E+00
72.5	0.00E+00
87.0	0.00E+00
101.5	0.00E+00
116.0	0.00E+00
130.5	0.00E+00
145.0	0.00E+00
159.5	0.00E+00
174.0	0.00E+00
188.5	0.00E+00
203.0	0.00E+00
217.5	0.00E+00
232.0	0.00E+00
246.5	0.00E+00
261.0	0.00E+00
275.5	0.00E+00
290.0	0.00E+00

Site being assessed:	Markisaton Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks		
Distance to compliance point	290	m
Concentration of contaminant at compliance point after	C <sub>ED</sub> /C <sub>0</sub>	0.00E+00 mg/l
		9.9E+99 days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



## Hydrogeological risk assessment for land contamination Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

**Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.**

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### Details to be completed for each assessment

<b>Site Name:</b>	Kingsway Junction		
<b>Site Address:</b>	A38, Derbyshire		
<b>Completed by:</b>	Gabiella Barnes		
<b>Date:</b>	10-Jan-20	<b>Version:</b>	3.2
<b>Contaminant</b>	>EC21 - 35 Aromatics		
<b>Target Concentration (C<sub>T</sub>)</b>	0.09	mg/l	<b>Origin of C<sub>T</sub>:</b> DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

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The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.



R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	>EC21 - 35 Aromatics	from Level 1
Target Concentration	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value)

Parameter	Value	Unit	Source
Initial contaminant concentration in groundwater at plume core	1.85E+00	mg/l	Maximum concentration in GW
Half life for degradation of contaminant in water	1.00E+04	days	See Justification Table
Calculated decay rate	6.93E-05	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	2.00E+02	m	See Justification Table
Plume thickness at source	2.50E+01	m	See Justification Table
Saturated aquifer thickness	3.00E+01	m	See Justification Table
Bulk density of aquifer materials	2.30E+00	g/cm <sup>3</sup>	See Justification Table
Effective porosity of aquifer	1.00E-01	fraction	See Justification Table
Hydraulic gradient	4.00E-02	fraction	See Justification Table
Hydraulic conductivity of aquifer	6.48E-02	m/d	See Justification Table
Distance to compliance point	2.90E+02	m	See Justification Table
Distance (lateral) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Distance (depth) to compliance point perpendicular to flow direction	0.00E+00	m	See Justification Table
Time since pollutant entered groundwater	9.90E+99	days	time variant options only
Partition coefficient	3.15E+04	l/kg	see options
Longitudinal dispersivity	2.90E+01	m	see options
Transverse dispersivity	2.90E+00	m	see options
Vertical dispersivity	2.90E-01	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.59E-02	m/d
Retardation factor	7.24E+05	fraction
Decay rate used	6.93E-05	d <sup>-1</sup>
Rate of contaminant flow due to retardation	3.58E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	0.00E+00	mg/l

Attenuation factor (one way vertical dispersion, CO/CED) AF **breakthrough at compliance point**

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

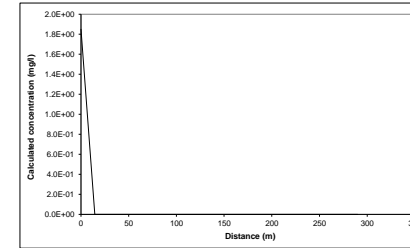
Entry if specify partition coefficient (option)	Kd	3.15E+04	l/kg
Entry for ionic organic chemicals (option)	Soil water partition coefficient		
Entry for non-polar organic chemicals (option)	Fraction of organic carbon in aquifer	2.50E-01	fraction
	Organic carbon partition coefficient	1.26E+05	l/kg
	Sorption coefficient for related species		
	Sorption coefficient for ionised species		
	pH value		
	acid dissociation constant		
	Fraction of organic carbon in aquifer		
	Soil water partition coefficient	3.15E+04	l/kg

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

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

Dispersivity	Enter value	Calc value	Xu & Eckstein	Unit
Longitudinal dispersivity	ax	2.90E+01	7.31E+01	m
Transverse dispersivity	az	2.90E+00	7.31E-01	m
Vertical dispersivity	ay	2.90E-01	7.31E-02	m

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>ax)<sup>0.14</sup>; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

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Calculated concentrations for distance-concentration graph

Ogata Banks  
From calculation sheet

Distance	Concentration
0	1.9E+00
14.5	8.41E-52
29.0	3.83E-103
43.5	1.74E-154
58.0	7.91E-206
72.5	3.60E-257
87.0	0.00E+00
101.5	0.00E+00
116.0	0.00E+00
130.5	0.00E+00
145.0	0.00E+00
159.5	0.00E+00
174.0	0.00E+00
188.5	0.00E+00
203.0	0.00E+00
217.5	0.00E+00
232.0	0.00E+00
246.5	0.00E+00
261.0	0.00E+00
275.5	0.00E+00
290.0	0.00E+00

Site being assessed:	Kingsway Junction
Completed by:	Gabriella Barnes
Date:	10/01/2020
Version:	3.2

Remedial Targets

Remedial Target	No impact	mg/l	For comparison with measured groundwater concentration.
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Ogata Banks			
Distance to compliance point	290	m	
Concentration of contaminant at compliance point after	0.00E+00	mg/l	Ogata Banks
	9.9E+99	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



BM05	
Date	23/03/2017
C21_C35_ALI	1250
EC21_EC35_ARO	591
Cr	76.4
Cu	1.68
Fe	70400
Fluoranthene	0.839
B(a)P	1.05
Dibenz(a,h)anthracen	0.12
Benzo(g,h,i)perylene	0.73
Benzo(b)fluoranthene	1.26
Benzo(k)fluoranthene	0.532

BM11				
Date	18/01/2018 14/02/2018 14/03/2018 19/04/2018			
C21_C35_ALI	923	604	314	
EC21_EC35_ARO	234	231	125	
Cr	255	186	180	212
Fe	211000	190000	107000	128000
Anthracene	0.196	0.215	0.147	
Fluoranthene	3.05	3.37	1.34	0.0172
B(a)P	2.16	2.27	1.15	
Dibenz(a,h)anthracen	0.213	0.238	0.161	
Benzo(g,h,i)perylene	2.04	1.71	1.18	
Benzo(b)fluoranthene	2.69	2.99	1.56	
Benzo(k)fluoranthene	1.24	1.29	0.813	
Cu			1.19	

BM10				
Date	18/01/2018 14/02/2018 14/03/2018 19/04/2018			
Fe	16100	10600	16400	4890
Fluoranthene	0.0114	0.0145	0.0128	0.139
Phenol	15.3			
B(a)P		0.0138	0.0057	0.0589
Benzo(g,h,i)perylene		0.0122		0.0503
Benzo(b)fluoranthene				0.08
Benzo(k)fluoranthene				0.0477

BM06A							
Date	14/12/2016 21/03/2017 04/07/2017 18/01/2018 14/02/2018 14/03/2018 19/04/2018						
Cr	60.7						
Fe	27800	13100	9280	8440	15800	12000	6070
Fluoranthene	0.0302		0.0533	0.0102		0.00813	0.00797
B(a)P			0.0869				
Benzo(g,h,i)perylene			0.0703			0.0219	
Benzo(b)fluoranthene			0.103				
Benzo(k)fluoranthene			0.0961				
Zn							11.2

**Key**

37.9 = Exceedance of DWS

1.62 = Exceedance of EQS

All concentrations are in µg/l

**Figure 2 : Groundwater Exceedances (Markeaton)**

Project : A38 Derby Junctions

Project Number : 60533462

Date : 13/11/2019







BK12			
Date	15/12/2016	23/03/2017	05/07/2017
C10 C12 ALI	331		
C16 C21 ALI	485		476
C21 C35 ALI	3680	2610	3850
EC5 EC7 ARO	17	10	16
EC10 EC12 ARO	221	115	124
EC12 EC16 ARO	112	99	230
EC16 EC21 ARO	464	258	446
EC21 EC35 ARO	1380	994	1180
B	3030	1240	2850
Cr	791	192	411
Fe	23700	92400	428000
Ni	50.3	39.6	30.5
Naphthalene	9.97	3.9	7.44
Phenanthrene	19.7	9.47	25.5
Anthracene	3.9	2.48	3.52
Fluoranthene	17.9	3.16	33.5
Pyrene	13.3		25.2
Benz(a)anthracene	6.75		5.52
B(a)P	7.12	2.25	5.65
Dibenz(a,h)anthracen	1.03	0.153	0.619
Benzo(g,h,i)perylene	4.57	1.28	2.42
Benzo(b)fluoranthene	7.81	2.92	6.8
Benzo(k)fluoranthene	2.95	1.08	2.6
PAHs (sum of 4)	19.14		
E	34		26.4
X	380	130	271
1,2,4-trimethylbenze	71.8		57.4
Bis(2-ethylhexyl) ph		18.1	22.2
EC8 EC10 ARO			391
Zn			11.2
Phenol			30

BK13			
Date	15/12/2016	23/03/2017	05/07/2017
Fe	5580	10700	6750
Ni	10.8	16.7	
Fluoranthene	0.124	0.0662	0.0254
B(a)P	0.0496		
Benzo(g,h,i)perylene	0.0643		
Benzo(b)fluoranthene	0.0884		
Benzo(k)fluoranthene	0.038		
PAHs (sum of 4)	0.2284		

BK14			
Date	15/12/2016	21/03/2017	05/07/2017
C16 C21 ALI	542	514	525
C21 C35 ALI	5760	5360	5370
EC12 EC16 ARO	183	258	352
EC16 EC21 ARO	440	484	448
EC21 EC35 ARO	1850	1790	1160
As	35.3		13.1
Cr	872	377	278
Fe	429000	300000	169000
Ni	5.46	8.1	8.62
Naphthalene	15.3	12.8	2.35
Acenaphthene	28.3	20.6	
Fluorene	20.3	16.8	
Phenanthrene	74.1	61.4	22.8
Anthracene	21.8	19.8	6.22
Fluoranthene	65.2	52.4	21.7
Pyrene	55.3	43.3	18.3
Benz(a)anthracene	39.7	19.2	7.62
Chrysene	35.4	17.4	7.39
B(a)P	78.9	31.2	14.3
Dibenz(a,h)anthracen	11.2	3.63	1.73
Benzo(g,h,i)perylene	45.8	16.7	8.45
Benzo(b)fluoranthene	89.3	19.5	16.9
Benzo(k)fluoranthene	35.4	11.5	7.13
PAHs (sum of 4)	214		
B	2.57	2.2	1190
Bis(2-ethylhexyl) ph	27.6	37.4	17.2
Dibenzofuran	13.8	11.5	
C12 C16 ALI		324	323
2,4-dichlorophenol		4.76	

BK15			
Date	15/12/2016	21/03/2017	05/07/2017
Fe	8080	5230	6780
B(a)P		0.0102	

**Key**

37.9 = Exceedance of DWS

1.62 = Exceedance of EQS

All concentrations are in µg/l

**Figure 4 : Groundwater Exceedances (Kingsway East)**

Project : A38 Derby Junctions

Project Number : 60533462

Date : 04/10/2019

