McDonnell Cole

May 2020
Ref: 1709-01

Controlled Waters Risk Assessment
for Carlton Colliery, Shaw Lane, Barnsley

Contents

Disclaimer

1. Introduction

AA Environmental Limited (AAe) has been commissioned by Portward Homes Limited (PHL) to develop a Remedial Implementation Plan (RIP) for the former Carlton Colliery. The RIP will be used in the enabling works phase in advance of the site being developed for residential purposes. This Controlled Waters Risk Assessment (CWRA) is prepared in support of the RIP and will develop reuse criteria for the management of materials on site.

The site has been previously investigated in 2006 and in 2008 a remedial plan was approved and planning permission granted for the site's redevelopment. Development did not proceed at this time. AAe carried out further investigations in 2019 to enable a review of the redevelopment proposals. New proposals will be in line with current standards and will aim to allow on site processing of colliery waste and construction waste deposits. This will require a variation of the existing environmental permit, reference EPR/BB3103FE, for the use of waste in a deposit for recovery operation.

Sources of information which have been made available as background information in the preparation of this report include the following:

- AAe: 2019: Former Carlton Colliery, Barnsley, Enabling Works, Remedial Implementation Plan. Report reference 173367/RIP/001;
- Fennell, Green and Bates (FGB): 2008: Remediation Strategy for Former Carlton Colliery, Planning Ref: 2007/1365
- MWP Planning: 2014: Document H, Waste Recovery Plan, submitted on behalf of Portward Homes Ltd. Report reference 10103/CJB/170614.

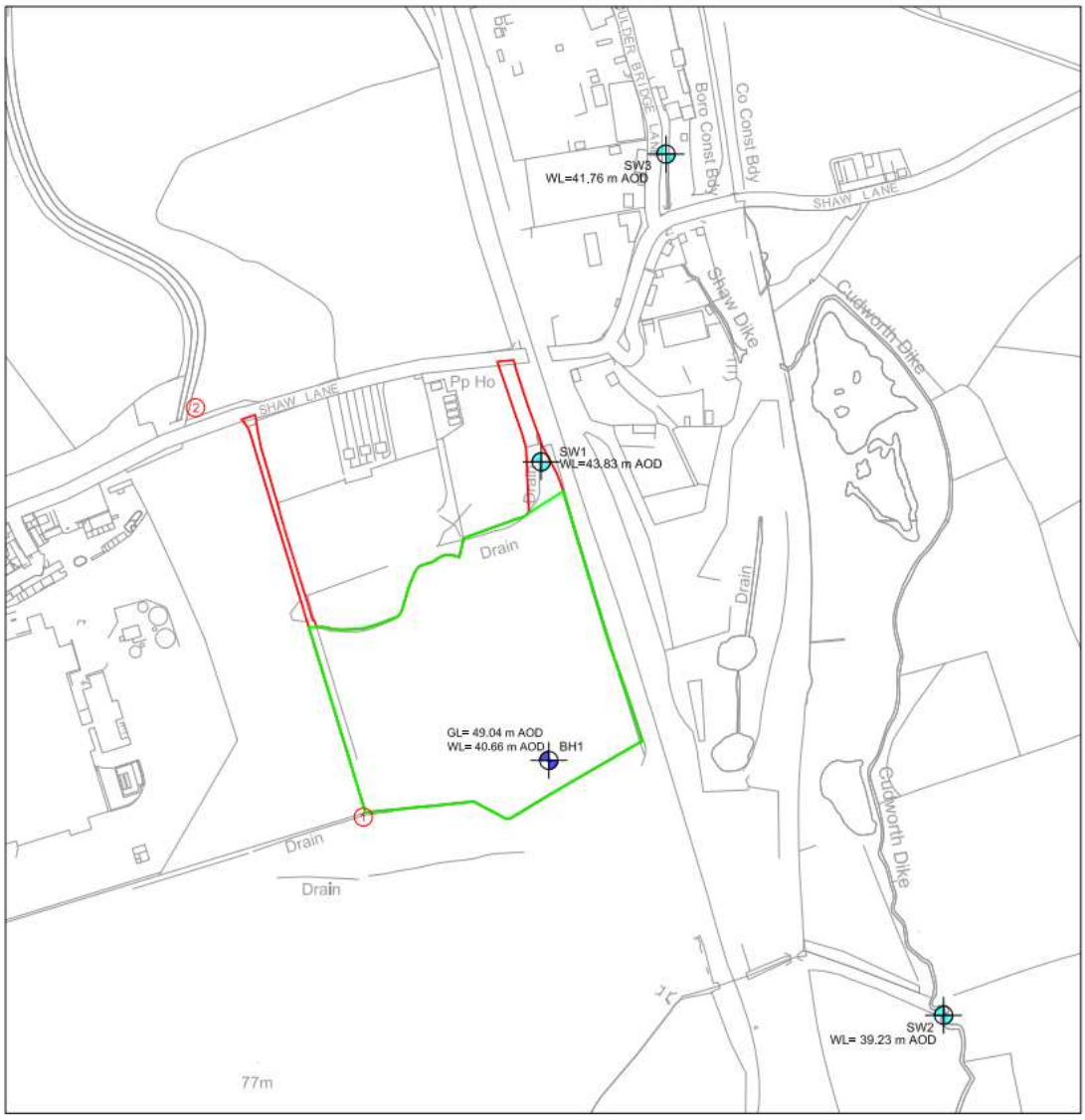
2. The Site

The site is located on Shaw Lane, Carlton, north of Barnsley. The site is centred on National Grid reference SE374 098 and can be located by postcode S71 3HH. The north of the site is formed by open ground south of Shaw Lane. There are a few properties bordering Shaw Lane to the south and a small sewage treatment works. To the west is the Premier Foods (Manor Bakeries) factory. To the south is raised open ground cut by footpaths. To the east is the former Leeds to Sheffield railway line.

The site is approximately 9.4 hectares in area. Ground levels are approximately 48 – 50m AOD and slope from south to north towards Shaw Lane.. There is also a gradual fall from west to east. The previous use of the site includes a colliery, coking plant, spoil heaps, railways, railway sidings and infilled reservoirs. The spoil heaps are reported by AAe to be predominantly mudstone material. MWP report a red shale (burnt colliery shale) tip and a grey colliery shale tip, together with the eastern portion of the site being covered with up to 2m of railway ash, ballast and coal residues. It was

estimated by MWP that a significant amount of coal could be recovered from these locations by washing. AAe investigations have revealed the shale to be smouldering in places and hence, will need to be removed from site. A Site Plan is presented as Figure 1. This also shows an existing groundwater borehole on site and three surface water sampling locations to the north and east.

Figure 1: Site Plan (taken from AAe, 2019)



3. Geology and Hydrogeology

3.1. Geology

The geology of the site is reported by FGB to comprise Quaternary Alluvium (clays, sands, silts and gravels). This is underlain by Middle Coal Measures: the mudstone and shale sequence between the Warmfield Rock and Oaks Rock. Outcrops of the Warmfield Marine Band and the Oaks Rock sandstone occur in the western corner of the site.

The British Geological Survey (BGS) geology of Britain indicates that there are no superficial deposits within the area of the site. Alluvium follows the course of the Cudworth Dike, which flows from north to south past the east of the site. The alluvium is described as clay, silt, sand and gravel. A narrow band of alluvium also follows the southern boundary of the site to join the course of the Cudworth Dike. The BGS viewer confirms, however, that the majority of the site is underlain by the Pennine Middle Coal Measures, listed as mudstone, siltstone and sandstone. The southwest corner is confirmed as being underlain by the Oaks Rock Sandstone. The southeast corner and just beyond the southeastern boundary of the site, are the locations of three former the colliery shafts, which were 300m, or more in depth.

Site investigation trial pit logs from 2001, presented in the FGB report indicate the following sequence in the near surface strata:

Table 1: Summary of shallow geology from FGB Report

Stratum	Typical Thickness (m)	Typical Depth (m)	Description (Environ, 2001)
Made ground	0.3 – 4.3	0 – 4.3	Loose dark brown/black slightly clayey topsoil with occasional brick, glass, rubber, rubble, ash, clinker, sleepers, cables. In places – gravelly sandy red ash. In places dark brown clayey fill with occasional glass.In places – reworked sandstone in slightly clayey sand.
Topsoil	0.2 - 0.4	0 – 0.4m	Loose brown clayey Topsoil
Clay	0.6 – 1.6	0.3 – 1.8	Orange/grey clay, to silty clay becoming grey with depth. Occasional gravel of coal
Clay	0.3 - 0.4	0.9 – 1.5	Black laminated clay
Sandstone	0.1	1.5 – 1.6	Grey medium grained sandstone
Mudstone	1.6 pen.)	1.6 – 3.2	Loose to very stiff grey mudstone
Silt/siltstone	1.9 (pen)	1.1 - 3	Loose grey silt/weathered siltstone (sweet odour recorded in places)
Sandstone	0.6 (pen)	2.4 – 3.8	Very firm brittle to moderately strong fine grained sandstone with clay
Sand and gravel	1.0	1.6 – 2.6	Light brown/yellow sand and gravel

pen. - penetrated

Sandstone, understood to the be the Oak's Rock Sandstone was encountered at depths of approximately 2.8m below ground level (bgl) in the southwest of the site. Sandstone layers were encountered in a small number of locations in the southeast, ranging from 0.1 to 1m in thickness.

The BGS record of the colliery shaft in the most southeasterly corner of the site shows the following sequence:

Made ground/soil	– 5 feet
Clay	- 4 feet
Blue bind	- 4 feet
Grey bind with thin beds of blue rock	- 13 feet
Blue rock (very wet)	- 78 feet
Coal was first encountered at 147 feet.	
Total depth 915 feet	

The term bind was used to mean shale, mudstone, clay, or sandstone overlying the coal seam.

AAe site investigations undertaken in 2019 focussed on gaining soils samples for environmental analysis. However, the factual report, reference 173367, recorded stockpiles on site up to 7m high, of the following materials:

- Imported and site-derived mixed construction and demolition wastes
- Segregated burnt shale and clinker
- Soils and
- Ashes.

3.2. Hydrogeology

3.2.1. General Properties

The Pennine Middle Coal Measures and Oaks Rock Sandstone are designated as secondary A aquifers.. The site is not within a groundwater source protection zone and there are no source protection zones within 5km of the site.

3.2.2. Borehole Records

The 2001 Environ site investigation locations were installed with shallow 19mm monitoring pipes in certain trial pit and window sample locations. It is understood that none of these monitoring installations remain. Investigation records describe the ground as wet in about a fifth of all locations. The depth of wet ground varies between 0.8 and 3m bgl, with dry ground being recorded at lower elevations on the same logs. This indicates that there is some perching of groundwater within the layered horizons on site, but there is no apparent continuity across the site at depths encountered by the investigation: generally up to 4m depth. The presence of perched groundwater is indicative of limited vertical permeability

and this can also limit migration from the site.

The site has an existing borehole towards the southern boundary, as shown in Figure 1. The details of construction are unknown. A recent measurement shows the depth to groundwater to be approximately 8.4m bgl (40.66mAOD). FGB report water strikes in the Carlton Colliery at depths of between 6.83 and 30.7m bgl. Based on the local topography and presence of Cudworth Dike to the east, groundwater flow in a homogeneous aquifer would be likely to be approximately eastwards. The interbedded sequence of the coal measures mudstones, siltstones and sandstones will allow preferential flow along fractures and bedding planes. The coal measures in the vicinity of the site are indicated on geological maps to dip to the northeast. This may create a component of flow to the northeast.

At the time of measuring the groundwater level in the site borehole in April 2020, surface water samples were taken in three locations, as shown in Figure 1. Two of these locations were on Cudworth Dike up and downgradient of the site. The surface water level in the downgradient location was recorded as 39.23mAOD, which is 1.43m below the site groundwater level. If it is assumed that the groundwater below the site could provide some recharge to the Cudworth Dike, relative groundwater and surface water levels can be used to determine an approximate hydraulic gradient. Using the recent groundwater level and the highest groundwater level reported by FGB this would give a hydraulic gradient to the east in the range of 0.005 to 0.009.

A 2018 Envirocheck report lists the closest groundwater abstraction to the site to be 1.4km to the south of the site for Redfearn Brothers. A further licence to Monckton Coke and Chemical Company 1.5km to the north is recorded as revoked. There are no springs recorded on Ordnance Survey maps within 1km of the site.

3.2.3. Groundwater Quality

The water quality of the site borehole was tested in April 2020 and provided the following results summarised in Table 2. The groundwater was also tested for total petroleum hydrocarbons (TPH), polyaromatic hydrocarbons (PAH), volatile and semi-volatile organic hydrocarbons (VOCs and SVOCs)

Table 2: Site Groundwater Quality

Determinand	Units	LOD	Concentration	UKDWS	EQS
pH		N/A	6.9	6.5 – 9.5	6 - 9
Sulphate	mg/l	1.0	730	250	400
Cyanide (Total)	mg/l	0.050	< 0.050	0.05	0.001
Magnesium	mg/l	0.50	92	-	-
Arsenic (Dissolved)	µg/l	1.0	1.2	10	50
Boron (Dissolved)	µg/l	20	200	1000	2000
Cadmium (Dissolved)	µg/l	0.080	< 0.080	5	0.09
Copper (Dissolved)	µg/l	1.0	1.9	2000	1

Determinand	Units	LOD	Concentration	UKDWS	EQS
Mercury (Dissolved)	µg/l	0.50	< 0.50	1	0.07
Nickel (Dissolved)	µg/l	1.0	10	20	4
Lead (Dissolved)	µg/l	1.0	4.0	10	1.2
Selenium (Dissolved)	µg/l	1.0	< 1.0	10	-
Vanadium (Dissolved)	µg/l	1.0	< 1.0	-	20
Zinc (Dissolved)	µg/l	1.0	150	-	9.5
Chromium (Total)	µg/l	1.0	< 1.0	50	3.4
Chromium (Hexavalent)	µg/l	20	< 20	-	4.7

The results show sulphate to be present at concentrations significantly above the UK Drinking Water Standard (UKDWS). Several determinands exceed the freshwater environmental quality standard (EQS) including sulphate, copper, nickel, lead and zinc.

3.3. Hydrology

The site drains towards the northeastern corner, where a drain flows past the sewage treatment works. From the site, drainage is culverted before flowing east into Cudworth Dike, which flows from north to south approximately 250m east of the site at its closest. The area around Cudworth Dike is known as Carlton Marsh, a Local Nature Reserve. The reserve is a wetland that attracts over 110 species of birds.

The site is in Flood Zone 1, which is a low risk of flooding from surface waters.

The closest recorded surface water abstraction to the site, as listed in the 2018 Envirocheck report, is approximately 1km to the northeast, although listed as revoked. An abstraction approximately 1.2km to the northwest, linked to Northern Strip Mining, is also lapsed.

There are seven discharge consents within 1km of the site. Four of these are assigned to Yorkshire Water for the sewage treatment works in the northeast of the site and three other locations downstream to the northeast. The remaining three are south of the site and include PLM Redfearn Glass.

Surface water quality was tested in April 2020 at the three locations shown in Figure 1. The results are summarised in Table 3.

Table 3: Surface Water Quality

Determinand	Units	LOD	SW1 (on site)	SW2 (down gradient)	SW3 (up gradient)	UKDWS	EQS
pH		N/A	6.8	7.7	7.9	6.5 – 9.5	6 - 9
Sulphate	mg/l	1.0	1500	400	410	250	400
Cyanide (Total)	mg/l	0.050	< 0.050	< 0.050	< 0.050	0.05	0.001
Magnesium	mg/l	0.50	230	70	70	-	-
Arsenic (Dissolved)	µg/l	1.0	3.8	< 1.0	< 1.0	10	50

Determinand	Units	LOD	SW1 (on site)	SW2 (down gradient)	SW3 (up gradient)	UKDWS	EQS
Boron (Dissolved)	µg/l	20	1200	170	170	1000	2000
Cadmium (Dissolved)	µg/l	0.080	2.2	< 0.080	< 0.080	5	0.09
Copper (Dissolved)	µg/l	1.0	10	3.6	3.5	2000	1
Mercury (Dissolved)	µg/l	0.50	0.75	< 0.50	< 0.50	1	0.07
Nickel (Dissolved)	µg/l	1.0	140	4.3	4.2	20	4
Lead (Dissolved)	µg/l	1.0	< 1.0	< 1.0	< 1.0	10	1.2
Selenium (Dissolved)	µg/l	1.0	18	< 1.0	< 1.0	10	-
Vanadium (Dissolved)	µg/l	1.0	< 1.0	< 1.0	< 1.0	-	20
Zinc (Dissolved)	µg/l	1.0	430	30	33	-	9.5
Chromium (Total)	µg/l	1.0	2.9	2.9	2.7	50	3.4
Chromium (Hexavalent)	µg/l	20	< 20	< 20	< 20	-	4.7

Surface waters on site are poorer quality than in the dike, with sulphate, nickel and selenium exceeding the UKDWS. Water quality in the dike is very similar up and downgradient of the site, ie there is no deterioration in quality as the dike passes the site. Exceedances of the EQS were recorded for sulphate, copper, nickel and zinc. All hydrocarbon results were found to be below the limit of detection (LOD) in all samples.

The water quality of the Cudworth Dike is described by the Environment Agency (communication with AAe) to have improved in the last few years. The Envirocheck report lists a large number of pollution incidents. These are associated with the surrounding industrial estate, which includes a number of waste management facilties.

4. Conceptual Hydrogeological Site Model

4.1. Source

The source in this assessment is the Made Ground. The Made Ground has been the subject of several stages of investigation. The 2019 AAe site investigations have tested for total and leachable soil concentrations of materials remaining on site. The full dataset, is presented as Appendix 1.

Soil samples have been tested for a range of metals and organics. The principal determinands, are summarised in Table 4. It is noted that the maximum recorded value for hexavalent chromium is equivalent to the limit of detection (LOD) in use. Total Petroleum Hydrocarbons (TPH) bands are selected for assessment from the table below on the basis that the solubility is greater than the WHO drinking water guideline value, ie aliphatics up to C12 and aromatics up to C21. Polyaromatic Hydrocarbons (PAHs) are selected on the basis that they have an associated UKDWS, or EQS value. Those determinands not taken forwarded for further assessment are shaded grey in the table below.

Table 4: Maximum Contaminant Concentrations in Soil

Determinand	Units	LOD	Max	Number
pH	pH unit	0.1	11.6	66
Boron (Hot Water Soluble)	mg/kg	0.4	1.6	13
Cyanide (Total)	mg/kg	0.5	5	69
Arsenic	mg/kg	1	260	69
Cadmium	mg/kg	0.1	7.5	69
Chromium	mg/kg	1	460	66
Copper	mg/kg	0.5	820	69
Mercury	mg/kg	0.1	0.6	69
Nickel	mg/kg	0.5	180	69
Lead	mg/kg	0.5	1670	69
Selenium	mg/kg	0.2	22	69
Vanadium	mg/kg	5	90	13
Zinc	mg/kg	0.5	850	69
Chromium (Hexavalent)	mg/kg	0.5	0.5	13
Total Organic Carbon	%	0.2	48	10
Aliphatic TPH >C5-C6	mg/kg	0.1	1	12
Aliphatic TPH >C6-C8	mg/kg	0.1	1	12
Aliphatic TPH >C8-C10	mg/kg	0.1	10	12

Determinand	Units	LOD	Max	Number
Aliphatic TPH >C10-C12	mg/kg	1	10	12
Aliphatic TPH >C12-C16	mg/kg	1	27	12
Aliphatic TPH >C16-C21	mg/kg	1	3300	12
Aliphatic TPH >C21-C35	mg/kg	1	23000	12
Aliphatic TPH >C35-C44	mg/kg	1	1700	12
Aromatic TPH >C5-C7	mg/kg	0.1	1	12
Aromatic TPH >C7-C8	mg/kg	0.1	1	12
Aromatic TPH >C8-C10	mg/kg	0.1	20	12
Aromatic TPH >C10-C12	mg/kg	1	35	12
Aromatic TPH >C12-C16	mg/kg	1	700	12
Aromatic TPH >C16-C21	mg/kg	1	2700	12
Aromatic TPH >C21-C35	mg/kg	1	83000	12
Aromatic TPH >C35-C44	mg/kg	1	11000	12
Naphthalene	mg/kg	0.1	8.2	15
Acenaphthylene	mg/kg	0.1	1.3	15
Acenaphthene	mg/kg	0.1	0.67	15
Fluorene	mg/kg	0.1	1.9	15
Phenanthrene	mg/kg	0.1	20	15
Anthracene	mg/kg	0.1	3.7	15
Fluoranthene	mg/kg	0.1	25	15
Pyrene	mg/kg	0.1	23	15
Benzo[a]anthracene	mg/kg	0.1	9	15
Chrysene	mg/kg	0.1	9.4	15
Benzo[b]fluoranthene	mg/kg	0.1	10	15
Benzo[k]fluoranthene	mg/kg	0.1	4	15
Benzo[a]pyrene	mg/kg	0.1	7.4	15
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.1	4.7	15
Dibenz(a,h)Anthracene	mg/kg	0.1	1.3	15
Benzo[g,h,i]perylene	mg/kg	0.1	4.8	15
Total Phenols	mg/kg	0.3	280	66
Benzene	mg/kg	0.1	37	14
Toluene	mg/kg	0.1	110	13
Ethylbenzene	mg/kg	0.1	9.7	13
M-Xylene	mg/kg	0.1	62	13
P-Xylene	mg/kg	0.1	62	13
O-Xylene	mg/kg	0.1	26	13

Results are relatively low in concentration give the history of the site and represent a large

amount of colliery spoil. Leachate data presented in Appendix 1 shows very few exceedances of the EQS for metals and sulphate. It is possible that more concentrated hydrocarbons associated with the coking works may be encountered during stockpile removal and redevelopment of the site. The proposal is to rework the made ground to remove the coal and clinker residues with high calorific values, so any remaining hotspots of historical contamination should be identified during reworking, allowing for their treatment as necessary.

4.2. Pathways

The pathway for migration from site will be leaching of contaminants through the unsaturated zone to the saturated coal measures. The unsaturated zone is principally clay, mudstone and siltstone. Hydraulic conductivities will be low, of the order of 1×10^{-8} to 1×10^{-9} m/s. From there migration will be preferentially, but not solely along fractures and bedding planes. This is most likely to be in a northeasterly direction, as bedding plane weaknesses are shown on geological maps to dip in this direction, together with the topography. However, to introduce conservatism into the assessment it is assumed that migration will be eastwards towards the Cudworth Dike, providing some baseflow at its closest point. The path of the Cudworth Dike is lined with alluvium and it is likely that the basal deposits of the dike are low permeability. This assessment will consider a worst case conservative scenario that a sandstone horizon is in hydraulic continuity with the dyke. Values of hydraulic conductivity for sandstones given by Domenico and Schwarz are of the order of 6×10^{-6} m/s. Coal measures sandstones are likely to be at the lower end of the range given their interbedded occurrence with clays and silts. Values of 6×10^{-7} to 1×10^{-5} m/s are assumed for this assessment.

The thickness of the Coal Measures in this locality, as demonstrated by shaft records, is more than 300m. For conservatism the aquifer is assumed to be 10m thick. The mixing zone is taken to be 5m, based on approximately 2 times the difference in levels between site groundwater and the dike, allowing for seasonal fluctuations.

4.3. Receptors

There are no specific groundwater receptors in the region of the site. The Coal Measures secondary A aquifer below the site has been influenced by coal mining within the site boundary. Sulphate concentrations from the site borehole are almost three times the UKDWS. The most sensitive receptor for this assessment of soils reuse criteria is taken to be the surface waters of the Cudworth Dike, which is 250m to the east of the site at its closest point. Environment Agency guidance on compliance points for land contamination, where there are no identified groundwater receptors, considers a default compliance point for hazardous substances as 50m from the site boundary. For non-hazardous substances a distance up to 250m may be considered. For the Remedial Targets Methodology a distance of 50m is used

for all substances to add conservatism. For further assessment using Consim, which includes assessment of the attenuation in the unsaturated zone, the default receptor 5m downgradient of the site boundary is used, to be conservative.

5. Hydrogeological Risk Assessment

5.1. Derivation of Remedial Targets

Remedial targets are required to determine whether the concentrations of chemical determinands found within the Made Ground are able to remain on site without the risk of contamination to controlled waters off site. The EA's remedial targets worksheet (P20) is used for this purpose in the first instance.

The P20 spreadsheet is over-conservative for inorganic substances, especially in thin aquifers and therefore, calculates unrealistically low target soils concentrations. Inorganic determinands have, therefore, been taken forward for assessment using Consim. This is a more realistic model including allowance for a declining source.

5.2. Modelling – Remedial Targets Worksheet (P20)

5.2.1. Methodology

The maximum concentrations of each chemical determinand recorded within the site soils, from the 2019 investigation are entered as the comparison for the derived remedial targets. The chemical determinands modelled are presented in Table 5. Worst case assumptions for other input parameters are presented in Table 6. The assessment is taken to Level 3 for Soils.

The target concentration is taken to be the lowest of either the UKDWS, EQS, or World Health Organisation (WHO) guideline to add further conservatism into the assessment. Results are assessed at a distance of 50m from the site boundary for all substances. This is conservative as the principal receptor, the Cudworth Dike, is 250m form the site boundary and distances of up to 250m are considered acceptable for the derivation of remediation criteria for non-hazardous substances.

Table 5: Chemical Inputs

	Determinand	Max. in soil (mg/kg)	Max in leachate (ug/l)	Henry's Law constant 25 ° C	Kd – sand / unspecified (l/kg) [1]	Half life (days)	Koc (l/kg)	Max Solubility (mg/l) [1]	EAL (mg/l) UKDWS	EAL (mg/l) EQS
1	Boron	1.6	40	-	4.98 [4]	-	-	1e5 [11]	1	2
2	Cyanide (Total)	5	50	-	9.9 [5]	-	-	9.54e4 [12]	0.05	0.001
3	Arsenic	260	3.3	-	117	-	-	4.41e5	0.01	0.05
4	Cadmium	7.5	0.096	-	240	-	-	6.51e5	0.005	0.00009
5	Chromium	460	20=LOD	-	Logtri (35, 67, 4400)	-	-	1.67e5	0.05	0.0047
6	Copper	820	1	-	295	-	-	2.93e5	2	0.001
7	Mercury	0.6	0.5	-	450	-	-	1e5 [11]	0.001	0.00007
8	Nickel	180	9.5	-	Logtri (20, 400, 8100)	-	-	1.73e5	0.02	0.004
9	Lead	1670	1	-	Logtri (27, 270, 2.7e4)	-	-	1e5 [11]	0.01	0.0012
10	Selenium	22	1	-	150 [5]	-	-	3.14e5	0.01	
11	Vanadium	90	1	-	141	-	-	13100		0.02
12	Zinc	850	38	-	logtri (26, 200, 3.6e4)	-	-	6.06e5		0.0109 (0.0095)
13	Sulphate	n/a	830						250	400
14	Aliphatic TPH >C5-C6	1	-	3.4e+01 [2]	-	730 [6]	794 [2]		15 [9]	
15	Aliphatic TPH >C6-C8	1	-	5.1e+01 [2]	-	730 [6]	3981 [2]		15 [9]	
16	Aliphatic TPH >C8-C10	10	-	80 [2]	-	730 [6]	31600 [2]		0.3 [9]	
17	Aliphatic TPH >C10-C12	10	-	120 [2]	-	1825 [6]	251000 [2]		0.3 [9]	
18	Aromatic TPH >C5-C7	1	-	2.3e-01 [2]	-	300 [1]	79 [2]		0.01 [9]	

	Determinand	Max. in soil (mg/kg)	Max in leachate (ug/l)	Henry's Law constant 25 ° C	Kd – sand / unspecified (l/kg) [1]	Half life (days)	Koc (l/kg)	Max Solubility (mg/l) [1]	EAL (mg/l) UKDWS	EAL (mg/l) EQS
19	Aromatic TPH >C7-C8	1	-	2.7e-01 [2]	-	730 [6]	251 [2]		0.7 [9]	
20	Aromatic TPH >C8-C10	20	-	4.9e-01 [2]	-	730 [6]	1585 [2]		0.3 [9]	
21	Aromatic TPH >C10-C12	35	-	0.14 [2]	-	1825 [6]	2510 [2]		0.09 [9]	
22	Aromatic TPH >C12-C16	700	-	0.053 [2]	-	1825 [6]	5010 [2]		0.09 [9]	
23	Aromatic TPH >C16-C21	2700	-	0.013 [2]	-	3650 [6]	15800 [2]		0.09 [9]	
24	Naphthalene	8.2	-	4.9e-02 [1]	-	258 [7]	1288 [1]			0.002 [8]
25	Anthracene	3.7	-	1.6e-03 [10]	-	460 [10]	29512 [10]			0.0001 [8]
26	Fluoranthene	25	-	3.87e-04 [3]	-	2847 [1]	19800 [1]			0.0063 ug/l [8]
27	Benzo[b]fluoranthene	10	-	2.06E-05 [3]	-	1220 [7]	105000 [3]		0.0001	0.00017ug/l
28	Benzo[k]fluoranthene	4	-	1.74E-05 [3]	-	4280 [7]	148000 [3]		0.0001	0.00017ug/l
29	Benzo[a]pyrene	7.4	-	1.86E-05 [3]	-	1058 [7]	129000 [3]		0.00001	0.00017ug/l
30	Indeno(1,2,3-c,d)Pyrene	4.7	-	1.17E-05 [3]	-	1460 [7]	87100 [3]		0.0001	0.00017ug/l
31	Benzo[g,h,i]perylene	4.8	-	3.03E-05 [3]	-	1300 [7]	417000 [3]		0.0001	0.00017ug/l

1. Consim help file, unless otherwise specified. For P20 assessments the most likely Kd value is used.
2 TPHCWG, 1997. Selection of Representative TPH Fractions Based on Fate and Transport Considerations. Total Petroleum Hydrocarbon Criteria Working Group Series Volume 3.
3 EA : 2008 : Science Report SC050021/SR7, Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values.
4 Daniels : 2007 : Site Specific Distribution Coefficients for Preliminary Modelling Purposes, University of North Carolina
5 EPA : 1996 : Soil Screening Guidance. Technical Background Document EPA/540/R95/128
6 New Zealand Guidelines : 1999 : Modules. Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand. Ministry for the Environment. New Zealand.
7 Howard et al. 1991. Handbook of Environmental Degradation Rates. Lewis Publishers.
8 Freshwater environmental quality standard (EQS)
9 World Health Organisation (WHO), CL:AIRE: 2017: Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies.
10 P5 079-TR1 Review of the Fate and Transport of Selected Contaminants in the Soil Environment
11 In absence of Consim reference, solubility given as 1e5, to be comparable to other metals.
12 Cyanide taken from Risk Assessment Information System: https://rais.ornl.gov/cgi-bin/tools/TOX_search

Table 6: General Input Parameters – P20

Parameter	Unit	Value	Source
Level 1			
Water filled soil porosity	fraction	0.22	Assumed for made ground
Air filled soil porosity	fraction	0.14	Assumed for made ground
Bulk density of soil	g/cm^3	1.8	Assumed for made ground
Fraction of organic carbon	fraction	0.02	Minimum value for TOC
Level 2			
Infiltration	m/d	3.73e-4	Assume 65% buildings / hardstanding = 30mmpa 35% vegetation = 333mmpa effective
Area	m^2	90,000	Site plan
Length of source in direction of groundwater flow	m	300	Length of site, west to east
Saturated aquifer thickness	m	10	Assumed thickness of coal measures sandstone
Hydraulic conductivity of aquifer in which dilution occurs	m/d	0.518	K =6 x 10^{-6} m/s
Hydraulic gradient of water table	-	0.007	Based on site borehole water level and level on dike
Width of contaminant source perpendicular to groundwater flow	m	300	Site Plan
Mixing zone thickness	m	5	Assumed thickness of coal measures sandstone
Level 3			
Bulk density of aquifer	g/cm^3	1.9	Assumed for sandstone
Effective porosity of aquifer	fraction	0.2	Assumed for sandstone
Distance to compliance point	m	50	Downgradient boundary of site / 10% of the distance to the Cudworth Dike
Fraction of organic carbon	fraction	0.01	Conservative for coal measures sandstone

5.2.2. Results of Remedial Targets Assessment - Soils

Table 7 presents the results of the P20 assessment at Level 3 soils. Remedial targets are presented both for comparison with the measured soil concentration (mg/kg) and for comparison with leachate data (mg/l).

Table 7: P20 Derived Remedial Targets

	Determinand	EAL (mg/l) EQS unless otherwise specified	Remedial target (mg/kg)	Remedial target (mg/l) Distance to receptor = 50m	Notes
1	Boron	2	12.2	2.38	1
2	Cyanide (Total)	0.001	0.0119	1.19e-3	1
3	Arsenic	0.05	6.98	0.0596	1
4	Cadmium	0.00009	0.0229	9.45e-5	1
5	Chromium	0.0047	0.376	5.6e-3	1
6	Copper	0.001	0.352	1.19e-3	1
7	Mercury	0.00007	0.0376	8.35e-5	1
8	Nickel	0.004	1.91	4.77e-3	1
9	Lead	0.0012	0.386	1.43e-3	1
10	Selenium	0.01 UKDWS	1.79	0.0119	1
11	Vanadium	0.02	10.1	0.0715	1
12	Zinc	0.0109 /0.0095	2.27	0.013	1
13	Aliphatic TPH >C5-C6	15 WHO	>1e6	>1e6	
14	Aliphatic TPH >C6-C8	15 WHO	>1e6	>1e6	
15	Aliphatic TPH >C8-C10	0.3 WHO	>1e6	>1e6	
16	Aliphatic TPH >C10-C12	0.3 WHO	>1e6	>1e6	
17	Aromatic TPH >C5-C7	0.01 WHO	3.13	1.82	
18	Aromatic TPH >C7-C8	0.7 WHO	1360	264	
19	Aromatic TPH >C8-C10	0.3 WHO	>1e6	>1e6	
20	Aromatic TPH >C10-C12	0.09 WHO	>1e6	1.84e5	
21	Aromatic TPH >C12-C16	0.09 WHO	>1e6	>1e6	
22	Aromatic TPH >C16-C21	0.09 WHO	>1e6	>1e6	
23	Naphthalene	0.002 EQS	>1e6	>1e6	
24	Anthracene	0.0001 EQS	>1e6	>1e6	
25	Fluoranthene	0.0063 ug/l EQS	>1e6	>1e6	
26	Benzo[b]fluoranthene	0.00017 ug/l EQS	>1e6	>1e6	
27	Benzo[k]fluoranthene	0.00017 ug/l EQS	>1e6	>1e6	
28	Benzo[a]pyrene	0.00017 ug/l EQS	>1e6	>1e6	
29	Indeno(1,2,3-c,d)Pyrene	0.00017 ug/l EQS	>1e6	>1e6	
30	Benzo[g,h,i]perylene	0.00017 ug/l EQS	>1e6	>1e6	
31	Sulphate	400	58.3	477	1

'1 - further quantitative assessment required – see Consim modelling

The results show very low remedial targets for most inorganics, as predicted and these substances are modelled further using Consim. For organic determinands the results show relatively high remedial targets, indicating that the likelihood of migration from site to a distance of 50m is very low.

The organic determinands are very sensitive to a raising of the value for the fraction of organic carbon (foc) in the Coal Measures sandstone. The value of foc is likely to be higher in a Coal Measures sandstone than a typical sandstone aquifer. The assumed value of 0.01 is considered to be conservative for a Coal Measures sandstone.

5.2.3. Summary

The remedial targets for organic determinands presented in Table 7 can be used as soils remediation/reuse criteria.

The remedial targets spreadsheet methodology is over-conservative for inorganic substances, therefore, inorganic determinands have been taken forward for assessment using Consim.

5.3. Consim

5.3.1. Model Approach

A Consim model is produced for the following substances:

arsenic, boron,
cadmium, chromium, cyanide , copper,
lead, mercury, nickel, selenium,
vanadium and zinc
and sulphate

Initial data is entered as the maximum recorded soil concentration. In the case of sulphate, leachate data is entered as no solid concentrations are available. Cyanide is also entered as a leachate concentration. Leaching tests all indicated cyanide to be less than the limit of detection (LOD), which is 0.05mg/l, the UKDWS. A concentration equal to half the LOD was used, which is higher than the EQS of 0.001mg/l. Consim is used iteratively to determine what increase, if any, in concentration may be acceptable before exceedance of the EAL, taken to be the lower of the UKDWS or EQS. In deriving the final remedial solution reference should also be made to the human health remedial targets to determine the appropriate level of remediation for the designated end use.

General model input parameters are presented in Table 8. Chemical inputs are as given in Table 5. The soil water partition coefficients (Kd) used for the unsaturated zone and aquifer are assumed to be the same for Coal Measures and Coal Measures spoil.

Table 8: Consim Input Parameters

Parameter	Unit	Value	Source
Infiltration	mm/year	136.05	As for P20 averaged over percent cover and open ground
Source			
Dry bulk density	g/cm^3	1.8	Assumed for made ground
Water filled porosity	fraction	0.22	Assumed for made ground
Thickness	m	Tri (0.5, 2, 4.3)	Site data
Air filled porosity	fraction	0.14	Assumed for made ground
Unsaturated zone			
Water filled porosity	fraction	0.2	
Unsaturated conductivity	m/s	Tri (1e-9, 5e-9, 1e-8)	Coal Measures clay
Dry bulk density	g/cm^3	1.9	Assumed for clay
Vertical dispersivity	m	Tri (0.27, 0.5, 0.65)	10% of thickness
Thickness	m	Tri (2.7, 5, 6.5))	Groundwater level assumed as 7m bgl to be conservative
Aquifer			
Thickness	m	10	Conservative for Coal Measures
Mixing zone	m	5	Assumed more permeable zone
Hydraulic conductivity	m/s	LogTri (6e-7, 6e-6, 1e-5)	Domenico & Schwarz sandstone
Hydraulic gradient		Tri (0.005, 0.007, 0.009)	Groundwater and surface water levels
Dry bulk density	g/cm3	1.9	Assumed for sandstone
Effective porosity	fraction	0.2	Assumed for sandstone
Lateral dispersivity	m	0.05	1% of path length
Longitudinal dispersivity	m	0.5	10% of path length
Receptors			
Site boundary			Consim default

5.3.2. Results

The results are summarised in Table 7 for the Consim default receptor on the downgradient boundary of the site. All results are assessed at the 95th percentile. The following scenarios are presented:

Scenario 1 – results at receptor for source at existing soil concentrations;
Scenario 2 – results at receptor for a doubling in source concentrations for most determinands. The concentration of cyanide is reduced to 10% of the LOD (0.005mg/l).
Scenario 3 – results at receptor for a 10-fold increase in concentrations, unless previous scenarios have already shown an exceedance of the EAL at the receptor. Cyanide is reduced to 0.004mg/l.

The results for Scenario 1 show that cyanide would fail the EQS, but not the UKDWS if leachate concentrations were found to be at, or above the LOD. The peak concentration of all other determinands is much lower than the EAL.

Scenario 2, where existing soil concentrations are doubled at source, this shows little change to the receptor concentration. With cyanide at 10% of the LOD the receptor concentration is still above the EQS.

For Scenario 3 the source concentrations for determinands other than cyanide are increased 10 times above the existing concentrations and results show little change to the receptor concentration.

Suggested reuse/remediation criteria are presented in Table 9 based on the results of the Consim iterations. Leachate as well as solid criteria are presented. The leachate criteria are derived from the maximum source concentration, taken as the 95th percentile, at time zero in Consim for the corresponding solid criteria. As discussed above, where derived criteria exceed the human health criteria, the human health criteria should be used in preference.

It is noted that total cyanide has been modelled as available data is for total cyanide. Greater toxicity is related to free cyanide and it is proposed that the reuse criteria apply to free cyanide.

Table 9: Consim Results

Determinand	Units	EAL – EQS unless otherwise denoted	Results Scenario 1 (mg/l)	Results Scenario 2 (mg/l)	Results Scenario 3 (mg/l)	Suggested reuse criteria (mg/kg)	Equivalent leachate criteria (mg/l)
Arsenic	mg/l	0.01 *	<1e-8	<1e-8	<1e-8	2600	21.8
Boron	mg/l	1	0.126	0.24	1.16	16	2
Cadmium	mg/l	0.00009	<1e-8	<1e-8	<1e-8	75	0.3
Chromium	mg/l	0.0047	<1e-8	<1e-8	<1e-8	4600	82
Copper	mg/l	0.001	<1e-8	<1e-8	<1e-8	8200	28
Cyanide	mg/l	0.001 (0.05=UKDWS)	0.0085	0.0017	0.0014		<LOD
Lead	mg/l	0.0012	<1e-8	<1e-8	<1e-8	16700	245
Mercury	mg/l	0.00007	<1e-8	<1e-8	<1e-8	6	0.013
Nickel	mg/l	0.004	<1e-8	<1e-8	<1e-8	1800	31
Selenium	mg/l	0.01 UKDWS	<1e-8	<1e-8	<1e-8	220	1.45
Vanadium	mg/l	0.02	<1e-8	<1e-8	<1e-8	900	6.3
Zinc	mg/l	0.0109 /0.0095	<1e-8	<1e-8	<1e-8	8500	135
Sulphate	mg/l	400	0.001	0.0019	0.01		1660

'* UKDWS is presented as this is a lower EAL than the EQS

5.3.3. Sensitivity Analysis

The sensitivity of two key input parameters to the Consim model are examined by further modelling: thickness of the unsaturated zone and rate of infiltration. The modelled sensitivity scenarios are as follows:

Sensitivity 1 – Reduction in unsaturated zone thickness to Tri (1.7, 4, 5.5)
Sensitivity 2 – Reduction in unsaturated zone thickness to Tri (0.7, 3, 4.5)
Sensitivity 3 – 10% increase in infiltration to 150 mm/yr
Sensitivity 4 – 10% decrease in infiltration to 122 mm/yr

Table 10: Results of Sensitivity Analysis (mg/l)

Determinand	Units	EAL – EQS unless otherwise denoted	Results Sensitivity 1	Results Sensitivity 2	Results Sensitivity 3	Results Sensitivity 4
Arsenic	mg/l	0.01 UKDWS	<1e-8	0 for 2000 yrs	<1e-8	<1e-8
Boron	mg/l	1	0.126	0.126	0.112	0.126
Cadmium	mg/l	0.00009	<1e-8	<1e-8	<1e-8	<1e-8
Chromium	mg/l	0.0047	<1e-8	0 for 2000 yrs	<1e-8	<1e-8
Copper	mg/l	0.001	<1e-8	<1e-8	<1e-8	<1e-8
Cyanide	mg/l	0.001 (UKDWS=0.05)	0.0089	0.011	0.0088	0.0084
Lead	mg/l	0.0012	<1e-8	<1e-8	<1e-8	<1e-8
Mercury	mg/l	0.00007	<1e-8	<1e-8	<1e-8	<1e-8
Nickel	mg/l	0.004	<1e-8	<1e-8	<1e-8	<1e-8
Selenium	mg/l	0.01	<1e-8	<1e-8	<1e-8	<1e-8
Sulphate	mg/l	400	0.00067	0.0006	0.0007	0.003
Vanadium	mg/l	0.06	<1e-8	<1e-8	<1e-8	<1e-8
Zinc	mg/l	0.0109	<1e-8	<1e-8	<1e-8	<1e-8

The results of Sensitivity 1, a reduction in unsaturated zone thickness of 1m, shows very little difference to Scenario 1. For Sensitivity 2, with a reduction in unsaturated zone thickness of 2m breakthrough of arsenic and chromium is observed, but not for 2000 years.

The results of Sensitivity 3 and 4, a 10% increase, or decrease in infiltration, shows very little difference to modelled results for Scenario 1.

6. Summary and Conclusions

The former Carlton Colliery site has been identified for redevelopment for residential purposes. Site investigations to date have demonstrated a limited amount of contamination as a result of former uses of the site. Made ground includes colliery spoil, rubble, clinker and some coal residues. The colliery spoil has been found to be smouldering in places. This material and residues of high calorific value within the made ground will be removed from site prior to redevelopment. It is intended to reuse as much of the remaining material as possible within the new scheme.

Historical records of the site show old coking works. No significant concentrations of contaminants have been found in site investigations to date. It cannot, however, be discounted that hotspots may be identified as the redevelopment begins. This controlled waters risk assessment has determined remedial targets for the reuse of materials to create the final landform. The derived remedial targets indicate that material encountered to date is suitable for reuse on site.

The remedial targets for soils are presented in Table 11.

Table 11: Remedial Targets for Soils

	Determinand	EAL (mg/l) EQS unless otherwise specified	Remedial target (mg/kg)	Remedial target (mg/l)
1	Boron	1	16	2
2	Cyanide (Free)	0.001 (0.05 UKDWS)	n/a	< LOD
3	Arsenic	0.01	260	21.8
4	Cadmium	0.00009	75	0.3
5	Chromium	0.004	4600	82
6	Copper	0.001	8200	28
7	Mercury	0.00007	6	0.013
8	Nickel	0.004	1800	31
9	Lead	0.0012	16700	245
10	Selenium	0.01 UKDWS	2200	1.45
11	Vanadium	0.02	900	6.3
12	Zinc	0.0109 /0.0095	8500	135
13	Aliphatic TPH >C5-C6	15 WHO	>1e6	>1e6
14	Aliphatic TPH >C6-C8	15 WHO	>1e6	>1e6
15	Aliphatic TPH >C8-C10	0.3 WHO	>1e6	>1e6
16	Aliphatic TPH >C10-C12	0.3 WHO	>1e6	>1e6

	Determinand	EAL (mg/l) EQS unless otherwise specified	Remedial target (mg/kg)	Remedial target (mg/l)
17	Aromatic TPH >C5-C7	0.01 WHO	3.13	1.82
18	Aromatic TPH >C7-C8	0.7 WHO	1360	264
19	Aromatic TPH >C8-C10	0.3 WHO	>1e6	>1e6
20	Aromatic TPH >C10-C12	0.09 WHO	>1e6	1.84e5
21	Aromatic TPH >C12-C16	0.09 WHO	>1e6	>1e6
22	Aromatic TPH >C16-C21	0.09 WHO	>1e6	>1e6
23	Naphthalene	0.002 EQS	>1e-6	>1e-6
24	Anthracene	0.0001 EQS	>1e6	>1e6
25	Fluoranthene	0.0063 ug/l EQS	>1e6	>1e6
26	Benzo[b]fluoranthene	0.00017 ug/l EQS	>1e6	>1e6
27	Benzo[k]fluoranthene	0.00017 ug/l EQS	>1e6	>1e6
28	Benzo[a]pyrene	0.00017 ug/l EQS	>1e6	>1e6
29	Indeno(1,2,3-c,d)Pyrene	0.00017 ug/l EQS	>1e6	>1e6
30	Benzo[g,h,i]perylene	0.00017 ug/l EQS	>1e6	>1e6
31	Sulphate		n/a	1660

REFERENCES

1. AAe: 2019: Former Carlton Colliery, Barnsley, Enabling Works, Remedial Implementation Plan. Report reference 173367/RIP/001;
2. CL:AIRE: 2017: Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies.
3. EA: 2003: P5 079-TR1 Review of the Fate and Transport of Selected Contaminants in the Soil Environment.
4. EA : 2008 : Science Report SC050021/SR7, Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values.
5. Daniels : 2007 : Site Specific Distribution Coefficients for Preliminary Modelling Purposes, University of North Carolina
6. EPA : 1996 : Soil Screening Guidance. Technical Background Document EPA/540/R95/128
7. Fennell, Green and Bates (FGB): 2008: Remediation Strategy for Former Carlton Colliery, Planning Ref: 2007/1365
8. MWP Planning: 2014: Document H, Waste Recovery Plan, submitted on behalf of Portward Homes Ltd. Report reference 10103/CJB/170614.
9. New Zealand Guidelines : 1999 : Modules. Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand. Ministry for the Environment. New Zealand.
10. TPHCWG, 1997. Selection of Representative TPH Fractions Based on Fate and Transport Considerations. Total Petroleum Hydrocarbon Criteria Working Group Series Volume 3.

McDonnell Cole

36 Dunster Road
West Bridgford
Nottingham
NG2 6JE.

APPENDIX 1

Soil and Leachate Data

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10	WS11	TP35
Sample Location							WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10	WS11	TP35
Sample Ref							E855	E856	E857	E858	E859	E860	E861	E862	E863	E864	E865	E866
Depth (top)							0.2	1.6	2.2	0.2	1	0.5	1.9	0.1	1.2	0.5	0.5	0.5
Depth (bottom)							0.4	1.8	2.4	0.4	1.2	0.7	2.1	0.3	1.9	0.7	0.7	
Lab Report							1152	1152	1152	1152	1152	1152	1152	1152	1152	1152	1152	1152
Sample Date																		
Originator																		
Strata							TS	NAT-CL	NAT	NAT	MG	MG	MG	MG	MG	NAT-CL	MG	
pH	pH unit	0.1	6 to 9	11.6	66	20	6.6	6.2	7.4	6.7	**4.7**	**5.8**	**4.9**	**5.1**	**3.9**	6.3	6.9	6.9
Boron (Hot Water Soluble)	mg/kg	0.4	21000	1.6	13													
Cyanide (Total)	mg/kg	0.5	34	5	69		5	5	5	5	5	5	5	5	5	5	5	5
Sulphide (Easily Liberatable)	mg/kg	0.5		19	10													
Arsenic	mg/kg	1	79	260	69	3	33	64	8	27	68	8	9	19	32	6	28	6
Cadmium	mg/kg	0.1	120	7.5	69		0.9	4.8	4	0.7	0.9	0.5	0.5	0.5	0.5	0.5	0.6	0.5
Chromium	mg/kg	1	1500	460	66		17	49	26	22	7	9	8	8	7	7	2	10
Copper	mg/kg	0.5	12000	820	69		66	180	74	52	61	100	45	84	52	14	71	14
Mercury	mg/kg	0.1	16	0.6	69		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Nickel	mg/kg	0.5	230	180	69		18	180	72	18	25	42	30	36	19	11	20	17
Lead	mg/kg	0.5	630	1670	69	1	90	160	53	64	35	44	28	18	36	21	66	17
Selenium	mg/kg	0.2	1100	22	69		4	22	10	1.9	1.5	2.9	1.6	2.6	2.1	2.2	3.6	1.5
Vanadium	mg/kg	5	2000	90	13													
Zinc	mg/kg	0.5	81000	850	69		180	190	160	71	35	20	91	70	68	68	93	46
Chromium (Hexavalent)	mg/kg	0.5	7.7	0.5	13													
Total Organic Carbon	%	0.2	3	48	10	9												
Aliphatic TPH >C5-C6	mg/kg	1	570000	1	12													
Aliphatic TPH >C6-C8	mg/kg	1	600000	1	12													
Aliphatic TPH >C8-C10	mg/kg	1	13000	10	12													
Aliphatic TPH >C10-C12	mg/kg	1	13000	10	12													
Aliphatic TPH >C12-C16	mg/kg	1	13000	27	12													
Aliphatic TPH >C16-C21	mg/kg	1	250000	3300	12													
Aliphatic TPH >C21-C35	mg/kg	1	250000	23000	12													
Aliphatic TPH >C35-C44	mg/kg	1	250000	1700	12													
Total Aliphatic Hydrocarbons	mg/kg	5		28000	12													
Aromatic TPH >C5-C7	mg/kg	1	72	1	12													
Aromatic TPH >C7-C8	mg/kg	1	56000	1	12													
Aromatic TPH >C8-C10	mg/kg	1	5000	20	12													
Aromatic TPH >C10-C12	mg/kg	1	5000	35	12													
Aromatic TPH >C12-C16	mg/kg	1	5100	700	12													
Aromatic TPH >C16-C21	mg/kg	1	3800	2700	12													
Aromatic TPH >C21-C35	mg/kg	1	3800	83000	12	1												
Aromatic TPH >C35-C44	mg/kg	1	3800	11000	12	1												
Total Aromatic Hydrocarbons	mg/kg	5		98000	12													
TPH C6-C10	mg/kg	1																
TPH C10-C21	mg/kg	1																
TPH C21-C40	mg/kg	1																

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10	WS11	TP35
Sample Location							WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10	WS11	TP35
Sample Ref							E855	E856	E857	E858	E859	E860	E861	E862	E863	E864	E865	E866
Depth (top)							0.2	1.6	2.2	0.2	1	0.5	1.9	0.1	1.2	0.5	0.5	0.5
Depth (bottom)							0.4	1.8	2.4	0.4	1.2	0.7	2.1	0.3	1.9	0.7	0.7	
Lab Report							1152	1152	1152	1152	1152	1152	1152	1152	1152	1152	1152	1152
Sample Date																		
Originator																		
Strata							TS	NAT-CL	NAT	NAT	MG	MG	MG	MG	MG	NAT-CL	MG	
Total Petroleum Hydrocarbons	mg/kg	10		130000	68		20	20	20	20	20	20	20	59	20	20	56	20
Naphthalene	mg/kg	0.1	4900	8.2	15													
Acenaphthylene	mg/kg	0.1	15000	1.3	15													
Acenaphthene	mg/kg	0.1	15000	0.67	15													
Fluorene	mg/kg	0.1	9900	1.9	15													
Phenanthrene	mg/kg	0.1	3100	20	15													
Anthracene	mg/kg	0.1	74000	3.7	15													
Fluoranthene	mg/kg	0.1	3100	25	15													
Pyrene	mg/kg	0.1	7400	23	15													
Benzo[a]anthracene	mg/kg	0.1	29	9	15													
Chrysene	mg/kg	0.1	57	9.4	15													
Benzo[b]fluoranthene	mg/kg	0.1	7.1	10	15	1												
Benzo[k]fluoranthene	mg/kg	0.1	190	4	15													
Benzo[a]pyrene	mg/kg	0.1	5.7	7.4	15	1												
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.1	82	4.7	15													
Dibenz(a,h)Anthracene	mg/kg	0.1	0.57	1.3	15	1												
Benzo[g,h,i]perylene	mg/kg	0.1	640	4.8	15													
Total Of 16 PAH's	mg/kg	2		130	24									20			20	
Total Phenols	mg/kg	0.3	760	280	66		3	3	3	3	3	3	3	3	3	3	3	3
Asbestos	Type	If present	Detected			1	NAD							NAD		NAD	NAD	NAD
Asbestos % (if present)	%	0.001		0.001	1													
Benzene	mg/kg	0.1	72	37	14													
Toluene	mg/kg	0.1	56000	110	13													
Ethylbenzene	mg/kg	0.1	24000	9.7	13													
M-Xylene	mg/kg	0.1	41000	62	13													
P-Xylene	mg/kg	0.1	41000	62	13													
O-Xylene	mg/kg	0.1	41000	26	13													

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	TP36	TP37	TP38	TP39	TP40	TP41	TP42	TP43	TP44	SU1	SU2	TP1
Sample Ref							E867	E868	E869	E870	E871	E872	E873	E874	E875	E876	E877	E534
Depth (top)							1.2	0.5	1.6	0.7	0.3	1.4	0.8	0.5	2.1	GL	GL	2.1
Depth (bottom)																		
Lab Report							1152	1152	1152	1152	1152	1152	1152	1152	1152	1152	1152	1102
Sample Date																		
Originator																		
Strata							NAT-CL	MG	MG	MG	TS	NAT-CL	NAT-CL		NAT			NAT
pH	pH unit	0.1	6 to 9	11.6	66	20	7.4	8.7	7.6	6.2	7.2	**5.7**	6.1	6.8	6.5	**3.4**	**4.1**	**5.6**
Boron (Hot Water Soluble)	mg/kg	0.4	21000	1.6	13													
Cyanide (Total)	mg/kg	0.5	34	5	69		5	5	5	5	5	5	5	5	5	5	5	5
Sulphide (Easily Liberatable)	mg/kg	0.5		19	10													
Arsenic	mg/kg	1	79	260	69	3	9	45	23	39	22	9	56	8	7	**84**	**120**	3
Cadmium	mg/kg	0.1	120	7.5	69		0.5	1.4	0.5	0.6	0.5	0.5	1	0.5	0.5	1.1	1.5	0.5
Chromium	mg/kg	1	1500	460	66		9	10	14	10	9	7	17	13	20	7	21	2
Copper	mg/kg	0.5	12000	820	69		15	820	46	53	61	15	68	12	28	73	18	75
Mercury	mg/kg	0.1	16	0.6	69		0.3	0.3	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Nickel	mg/kg	0.5	230	180	69		9	26	27	15	25	8	31	10	36	32	6	21
Lead	mg/kg	0.5	630	1670	69	1	25	**1670**	140	41	120	30	89	24	20	54	33	14
Selenium	mg/kg	0.2	1100	22	69		1.4	2	1.9	2.3	1.9	1.4	1.9	1.7	1.3	2.6	0.6	1
Vanadium	mg/kg	5	2000	90	13													
Zinc	mg/kg	0.5	81000	850	69		57	850	83	69	51	66	140	43	81	77	12	9
Chromium (Hexavalent)	mg/kg	0.5	7.7	0.5	13													
Total Organic Carbon	%	0.2	3	48	10	9												
Aliphatic TPH >C5-C6	mg/kg	1	570000	1	12													
Aliphatic TPH >C6-C8	mg/kg	1	600000	1	12													
Aliphatic TPH >C8-C10	mg/kg	1	13000	10	12													
Aliphatic TPH >C10-C12	mg/kg	1	13000	10	12													
Aliphatic TPH >C12-C16	mg/kg	1	13000	27	12													
Aliphatic TPH >C16-C21	mg/kg	1	250000	3300	12													
Aliphatic TPH >C21-C35	mg/kg	1	250000	23000	12													
Aliphatic TPH >C35-C44	mg/kg	1	250000	1700	12													
Total Aliphatic Hydrocarbons	mg/kg	5		28000	12													
Aromatic TPH >C5-C7	mg/kg	1	72	1	12													
Aromatic TPH >C7-C8	mg/kg	1	56000	1	12													
Aromatic TPH >C8-C10	mg/kg	1	5000	20	12													
Aromatic TPH >C10-C12	mg/kg	1	5000	35	12													
Aromatic TPH >C12-C16	mg/kg	1	5100	700	12													
Aromatic TPH >C16-C21	mg/kg	1	3800	2700	12													
Aromatic TPH >C21-C35	mg/kg	1	3800	83000	12	1												
Aromatic TPH >C35-C44	mg/kg	1	3800	11000	12	1												
Total Aromatic Hydrocarbons	mg/kg	5		98000	12													
TPH C6-C10	mg/kg	1																
TPH C10-C21	mg/kg	1																
TPH C21-C40	mg/kg	1																

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	TP36	TP37	TP38	TP39	TP40	TP41	TP42	TP43	TP44	SU1	SU2	TP1
Sample Ref							E867	E868	E869	E870	E871	E872	E873	E874	E875	E876	E877	E534
Depth (top)							1.2	0.5	1.6	0.7	0.3	1.4	0.8	0.5	2.1	GL	GL	2.1
Depth (bottom)																		
Lab Report							1152	1152	1152	1152	1152	1152	1152	1152	1152	1152	1152	1102
Sample Date																		
Originator																		
Strata							NAT-CL	MG	MG	MG	TS	NAT-CL	NAT-CL		NAT			NAT
Total Petroleum Hydrocarbons	mg/kg	10		130000	68		20	58	73	20	20	20	20	20	20	20	20	20
Naphthalene	mg/kg	0.1	4900	8.2	15													
Acenaphthylene	mg/kg	0.1	15000	1.3	15													
Acenaphthene	mg/kg	0.1	15000	0.67	15													
Fluorene	mg/kg	0.1	9900	1.9	15													
Phenanthrene	mg/kg	0.1	3100	20	15													
Anthracene	mg/kg	0.1	74000	3.7	15													
Fluoranthene	mg/kg	0.1	3100	25	15													
Pyrene	mg/kg	0.1	7400	23	15													
Benzo[a]anthracene	mg/kg	0.1	29	9	15													
Chrysene	mg/kg	0.1	57	9.4	15													
Benzo[b]fluoranthene	mg/kg	0.1	7.1	10	15	1												
Benzo[k]fluoranthene	mg/kg	0.1	190	4	15													
Benzo[a]pyrene	mg/kg	0.1	5.7	7.4	15	1												
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.1	82	4.7	15													
Dibenz(a,h)Anthracene	mg/kg	0.1	0.57	1.3	15	1												
Benzo[g,h,i]perylene	mg/kg	0.1	640	4.8	15													
Total Of 16 PAH's	mg/kg	2		130	24			20	20									
Total Phenols	mg/kg	0.3	760	280	66		3	3	3	3	3	3	3	3	3	3	3	3
Asbestos	Type	If present	Detected			1		NAD		NAD								
Asbestos % (if present)	%	0.001		0.001	1													
Benzene	mg/kg	0.1	72	37	14													
Toluene	mg/kg	0.1	56000	110	13													
Ethylbenzene	mg/kg	0.1	24000	9.7	13													
M-Xylene	mg/kg	0.1	41000	62	13													
P-Xylene	mg/kg	0.1	41000	62	13													
O-Xylene	mg/kg	0.1	41000	26	13													

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	Sample Location	TP2	TP3	TP4	TP5	TP7	TP8	TP9	TP10	TP11	TP12	TP13	TP14
							Sample Ref	E535	E536	E537	E538	E540	E541	E542	E543	E544	E545	E546	E547
							Depth (top)	0.9	0.4	1	1	0.2	2.9	0.2	2.6	2.1	0.5	1.4	3
							Depth (bottom)												
							Lab Report	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102
							Sample Date												
							Originator												
							Strata	NAT-CL	NAT-CL	NAT-CL	NAT-CL	TS	NAT-CL	MG	NAT	NAT	MG	MG	MG
pH	pH unit	0.1	6 to 9	11.6	66	20		**4.7**	7.1	**5.4**	6.3	7.3	6.5	6.6	6.2	6.6	7.5	7.6	7.6
Boron (Hot Water Soluble)	mg/kg	0.4	21000	1.6	13														
Cyanide (Total)	mg/kg	0.5	34	5	69			5	5	5	5	5	5	5	5	5	5	5	5
Sulphide (Easily Liberatable)	mg/kg	0.5		19	10														
Arsenic	mg/kg	1	79	260	69	3		26	36	22	2	8	8	11	8	6	32	12	17
Cadmium	mg/kg	0.1	120	7.5	69			1.7	1.4	*0.7*	0.5	0.5	0.7	0.5	0.5	0.5	1.3	0.5	0.6
Chromium	mg/kg	1	1500	460	66			10	61	22	14	25	24	12	18	11	13	7	15
Copper	mg/kg	0.5	12000	820	69			25	170	43	42	20	30	21	26	15	100	38	150
Mercury	mg/kg	0.1	16	0.6	69			0.5	0.3	*0.3*	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.6	0.5
Nickel	mg/kg	0.5	230	180	69			32	110	16	18	22	49	16	24	21	34	24	36
Lead	mg/kg	0.5	630	1670	69	1		42	71	40	11	19	52	14	19	16	370	82	180
Selenium	mg/kg	0.2	1100	22	69			1.7	9.3	3.5	0.8	0.7	0.5	1	0.5	0.8	1.8	1	1
Vanadium	mg/kg	5	2000	90	13														
Zinc	mg/kg	0.5	81000	850	69			19	130	32	39	73	130	28	39	38	230	80	170
Chromium (Hexavalent)	mg/kg	0.5	7.7	0.5	13														
Total Organic Carbon	%	0.2	3	48	10	9													
Aliphatic TPH >C5-C6	mg/kg	1	570000	1	12														
Aliphatic TPH >C6-C8	mg/kg	1	600000	1	12														
Aliphatic TPH >C8-C10	mg/kg	1	13000	10	12														
Aliphatic TPH >C10-C12	mg/kg	1	13000	10	12														
Aliphatic TPH >C12-C16	mg/kg	1	13000	27	12														
Aliphatic TPH >C16-C21	mg/kg	1	250000	3300	12														
Aliphatic TPH >C21-C35	mg/kg	1	250000	23000	12														
Aliphatic TPH >C35-C44	mg/kg	1	250000	1700	12														
Total Aliphatic Hydrocarbons	mg/kg	5		28000	12														
Aromatic TPH >C5-C7	mg/kg	1	72	1	12														
Aromatic TPH >C7-C8	mg/kg	1	56000	1	12														
Aromatic TPH >C8-C10	mg/kg	1	5000	20	12														
Aromatic TPH >C10-C12	mg/kg	1	5000	35	12														
Aromatic TPH >C12-C16	mg/kg	1	5100	700	12														
Aromatic TPH >C16-C21	mg/kg	1	3800	2700	12														
Aromatic TPH >C21-C35	mg/kg	1	3800	83000	12	1													
Aromatic TPH >C35-C44	mg/kg	1	3800	11000	12	1													
Total Aromatic Hydrocarbons	mg/kg	5		98000	12														
TPH C6-C10	mg/kg	1																	
TPH C10-C21	mg/kg	1																	
TPH C21-C40	mg/kg	1																	

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	TP2	TP3	TP4	TP5	TP7	TP8	TP9	TP10	TP11	TP12	TP13	TP14
Sample Location							TP2	TP3	TP4	TP5	TP7	TP8	TP9	TP10	TP11	TP12	TP13	TP14
Sample Ref							E535	E536	E537	E538	E540	E541	E542	E543	E544	E545	E546	E547
Depth (top)							0.9	0.4	1	1	0.2	2.9	0.2	2.6	2.1	0.5	1.4	3
Depth (bottom)																		
Lab Report							1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102
Sample Date																		
Originator																		
Strata							NAT-CL	NAT-CL	NAT-CL	NAT-CL	TS	NAT-CL	MG	NAT	NAT	MG	MG	MG
Total Petroleum Hydrocarbons	mg/kg	10		130000	68		20	20	20	20	20	20	20	20	110	20	20	92
Naphthalene	mg/kg	0.1	4900	8.2	15													1.6
Acenaphthylene	mg/kg	0.1	15000	1.3	15													*0.019*
Acenaphthene	mg/kg	0.1	15000	0.67	15													*0.083*
Fluorene	mg/kg	0.1	9900	1.9	15													0.14
Phenanthrene	mg/kg	0.1	3100	20	15													1.5
Anthracene	mg/kg	0.1	74000	3.7	15													0.13
Fluoranthene	mg/kg	0.1	3100	25	15													0.85
Pyrene	mg/kg	0.1	7400	23	15													0.71
Benzo[a]anthracene	mg/kg	0.1	29	9	15													0.28
Chrysene	mg/kg	0.1	57	9.4	15													0.51
Benzo[b]fluoranthene	mg/kg	0.1	7.1	10	15	1												0.16
Benzo[k]fluoranthene	mg/kg	0.1	190	4	15													*0.097*
Benzo[a]pyrene	mg/kg	0.1	5.7	7.4	15	1												0.14
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.1	82	4.7	15													*0.098*
Dibenz(a,h)Anthracene	mg/kg	0.1	0.57	1.3	15	1												*0.01*
Benzo[g,h,i]perylene	mg/kg	0.1	640	4.8	15													0.16
Total Of 16 PAH's	mg/kg	2		130	24										20			6.487
Total Phenols	mg/kg	0.3	760	280	66		3	3	3	3	3	3	3	3	3	3	3	30
Asbestos	Type	If present	Detected			1		NAD			NAD		NAD			NAD		
Asbestos % (if present)	%	0.001		0.001	1													
Benzene	mg/kg	0.1	72	37	14		2						2		2			2
Toluene	mg/kg	0.1	56000	110	13		2						2		2			2
Ethylbenzene	mg/kg	0.1	24000	9.7	13		9						2		2			4
M-Xylene	mg/kg	0.1	41000	62	13		13						2		2			8
P-Xylene	mg/kg	0.1	41000	62	13		13						2		2			8
O-Xylene	mg/kg	0.1	41000	26	13		6						2		2			5

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	TP15	TP16	TP17	TP18	TP19	TP20	TP21	TP22	TP23	TP24	TP25	TP26
Sample Location							**TP15**	**TP16**	**TP17**	**TP18**	**TP19**	**TP20**	**TP21**	**TP22**	**TP23**	**TP24**	**TP25**	**TP26**
Sample Ref							E548	E549	E550	E551	E552	E553	E554	E555	E557	E558	E559	E560
Depth (top)							1.3	1.9	0.4	1.6	2.6	0.5	1	1	2.6	0.5	1.3	2.8
Depth (bottom)																		
Lab Report							1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102
Sample Date																		
Originator																		
Strata							MG	MG	TS	MG	NAT-GR	TS	MG	MG	MG	TS	MG	NAT-CL
pH	pH unit	0.1	6 to 9	11.6	66	20	7.9	6	7.9	7.9	7.9	7.6	7.1	**5.4**	6.7	6.6	**4**	7
Boron (Hot Water Soluble)	mg/kg	0.4	21000	1.6	13													
Cyanide (Total)	mg/kg	0.5	34	5	69		5	5	5	5	5	5	5	5	5	5	5	5
Sulphide (Easily Liberatable)	mg/kg	0.5		19	10													
Arsenic	mg/kg	1	79	260	69	3	33	20	36	32	35	58	36	22	**260**	38	33	13
Cadmium	mg/kg	0.1	120	7.5	69		7.5	0.6	2.2	0.8	1	2.6	1.4	0.7	7.2	1.2	1	0.7
Chromium	mg/kg	1	1500	460	66		14	5	15	15	17	19	61	22	5	13	11	24
Copper	mg/kg	0.5	12000	820	69		89	43	99	110	59	150	170	43	56	100	63	60
Mercury	mg/kg	0.1	16	0.6	69		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3
Nickel	mg/kg	0.5	230	180	69		34	17	33	30	38	53	110	16	35	40	30	52
Lead	mg/kg	0.5	630	1670	69	1	220	39	45	10	19	67	71	40	74	96	35	66
Selenium	mg/kg	0.2	1100	22	69		1.2	1.6	1.3	0.7	0.5	0.6	9.3	3.5	3.3	1.8	1.3	1.6
Vanadium	mg/kg	5	2000	90	13													
Zinc	mg/kg	0.5	81000	850	69		370	27	170	89	34	240	130	32	55	120	100	200
Chromium (Hexavalent)	mg/kg	0.5	7.7	0.5	13													
Total Organic Carbon	%	0.2	3	48	10	9												
Aliphatic TPH >C5-C6	mg/kg	1	570000	1	12													
Aliphatic TPH >C6-C8	mg/kg	1	600000	1	12													
Aliphatic TPH >C8-C10	mg/kg	1	13000	10	12													
Aliphatic TPH >C10-C12	mg/kg	1	13000	10	12													
Aliphatic TPH >C12-C16	mg/kg	1	13000	27	12													
Aliphatic TPH >C16-C21	mg/kg	1	250000	3300	12													
Aliphatic TPH >C21-C35	mg/kg	1	250000	23000	12													
Aliphatic TPH >C35-C44	mg/kg	1	250000	1700	12													
Total Aliphatic Hydrocarbons	mg/kg	5		28000	12													
Aromatic TPH >C5-C7	mg/kg	1	72	1	12													
Aromatic TPH >C7-C8	mg/kg	1	56000	1	12													
Aromatic TPH >C8-C10	mg/kg	1	5000	20	12													
Aromatic TPH >C10-C12	mg/kg	1	5000	35	12													
Aromatic TPH >C12-C16	mg/kg	1	5100	700	12													
Aromatic TPH >C16-C21	mg/kg	1	3800	2700	12													
Aromatic TPH >C21-C35	mg/kg	1	3800	83000	12	1												
Aromatic TPH >C35-C44	mg/kg	1	3800	11000	12	1												
Total Aromatic Hydrocarbons	mg/kg	5		98000	12													
TPH C6-C10	mg/kg	1																
TPH C10-C21	mg/kg	1																
TPH C21-C40	mg/kg	1																

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	TP15	TP16	TP17	TP18	TP19	TP20	TP21	TP22	TP23	TP24	TP25	TP26
Sample Location							TP15	TP16	TP17	TP18	TP19	TP20	TP21	TP22	TP23	TP24	TP25	TP26
Sample Ref							E548	E549	E550	E551	E552	E553	E554	E555	E557	E558	E559	E560
Depth (top)							1.3	1.9	0.4	1.6	2.6	0.5	1	1	2.6	0.5	1.3	2.8
Depth (bottom)																		
Lab Report							1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102	1102
Sample Date																		
Originator																		
Strata							MG	MG	TS	MG	NAT-GR	TS	MG	MG	MG	TS	MG	NAT-CL
Total Petroleum Hydrocarbons	mg/kg	10		130000	68		150	11900	41	20	20	20	20	20	20	20	20	20
Naphthalene	mg/kg	0.1	4900	8.2	15			1.4										
Acenaphthylene	mg/kg	0.1	15000	1.3	15			*0.01*										
Acenaphthene	mg/kg	0.1	15000	0.67	15			0.11										
Fluorene	mg/kg	0.1	9900	1.9	15			0.35										
Phenanthrene	mg/kg	0.1	3100	20	15			2.2										
Anthracene	mg/kg	0.1	74000	3.7	15			0.57										
Fluoranthene	mg/kg	0.1	3100	25	15			1.4										
Pyrene	mg/kg	0.1	7400	23	15			1.2										
Benzo[a]anthracene	mg/kg	0.1	29	9	15			0.56										
Chrysene	mg/kg	0.1	57	9.4	15			1.3										
Benzo[b]fluoranthene	mg/kg	0.1	7.1	10	15	1		*0.01*										
Benzo[k]fluoranthene	mg/kg	0.1	190	4	15			*0.01*										
Benzo[a]pyrene	mg/kg	0.1	5.7	7.4	15	1		*0.01*										
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.1	82	4.7	15			*0.01*										
Dibenz(a,h)Anthracene	mg/kg	0.1	0.57	1.3	15	1		*0.01*										
Benzo[g,h,i]perylene	mg/kg	0.1	640	4.8	15			*0.01*										
Total Of 16 PAH's	mg/kg	2		130	24		20	9.16										
Total Phenols	mg/kg	0.3	760	280	66		3	280	3	3.9	9.6	3	3	3	3	3	3	3
Asbestos	Type	If present	Detected			1	NAD		NAD			NAD	NAD		NAD			
Asbestos % (if present)	%	0.001		0.001	1													
Benzene	mg/kg	0.1	72	37	14			2				2			2			
Toluene	mg/kg	0.1	56000	110	13			2				2			6			
Ethylbenzene	mg/kg	0.1	24000	9.7	13			7				7			5			
M-Xylene	mg/kg	0.1	41000	62	13			10				15			12			
P-Xylene	mg/kg	0.1	41000	62	13			10				15			12			
O-Xylene	mg/kg	0.1	41000	26	13			6				5			5			

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	TP27	TP28	TP29	TP30	TP31	TP32	TP33	TP34	TP101	TP102	TP102	TP103
Sample Ref							E561	E562	E563	E564	E565	E566	E567	E568	809362	809363	809364	809365
Depth (top)							3.2	0.5	0.4	1.2	0.5	1	3.5	0.4	0.50	0.50	1.00	0.00
Depth (bottom)															1.25	1.00	1.50	0.50
Lab Report							1102	1102	1102	1102	1102	1102	1102	1102	19-12605	19-12605	19-12605	19-12605
Sample Date															9/4/19	9/4/19	9/4/19	9/4/19
Originator																		
Strata							NAT-GR	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG
pH	pH unit	0.1	6 to 9	11.6	66	20	7.3	8	**4.7**	**3.7**	**5.5**	**4.8**	8.4	**3.5**	7.9	**11.6**		**9.5**
Boron (Hot Water Soluble)	mg/kg	0.4	21000	1.6	13										1.3	1.2	1.5	1.6
Cyanide (Total)	mg/kg	0.5	34	5	69		5	5	5	5	5	5	5	5	*0.5*	*0.5*	*0.5*	*0.5*
Sulphide (Easily Liberatable)	mg/kg	0.5		19	10										1.5	19		2.9
Arsenic	mg/kg	1	79	260	69	3	15	30	42	36	51	27	30	40	61	13	40	23
Cadmium	mg/kg	0.1	120	7.5	69		0.7	1.6	1.2	1	1.6	0.8	1	1.1	0.15	0.24	0.23	0.78
Chromium	mg/kg	1	1500	460	66		24	22	14	7	12	10	8	10	8.9	33		45
Copper	mg/kg	0.5	12000	820	69		35	100	330	37	93	63	55	57	46	37	58	32
Mercury	mg/kg	0.1	16	0.6	69		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	*0.1*	*0.1*	0.13
Nickel	mg/kg	0.5	230	180	69		52	43	140	12	38	27	28	28	21	23	28	24
Lead	mg/kg	0.5	630	1670	69	1	84	67	150	29	79	45	140	36	59	98	110	65
Selenium	mg/kg	0.2	1100	22	69		0.5	0.9	2.7	1.7	1.8	1.5	3.5	1.8	1.6	*0.2*	0.84	*0.2*
Vanadium	mg/kg	5	2000	90	13										20	30	33	29
Zinc	mg/kg	0.5	81000	850	69		190	140	93	27	110	85	79	84	48	100	67	86
Chromium (Hexavalent)	mg/kg	0.5	7.7	0.5	13										*0.5*	*0.5*	*0.5*	*0.5*
Total Organic Carbon	%	0.2	3	48	10	9									**48**	**5.1**		**3.2**
Aliphatic TPH >C5-C6	mg/kg	1	570000	1	12										*1*	*1*		*1*
Aliphatic TPH >C6-C8	mg/kg	1	600000	1	12										*1*	*1*		*1*
Aliphatic TPH >C8-C10	mg/kg	1	13000	10	12										4.3	*1*		*1*
Aliphatic TPH >C10-C12	mg/kg	1	13000	10	12										1.7	*1*		*1*
Aliphatic TPH >C12-C16	mg/kg	1	13000	27	12										1.4	*1*		*1*
Aliphatic TPH >C16-C21	mg/kg	1	250000	3300	12										1.5	*1*		*1*
Aliphatic TPH >C21-C35	mg/kg	1	250000	23000	12										*1*	59		*1*
Aliphatic TPH >C35-C44	mg/kg	1	250000	1700	12										*1*	*1*		*1*
Total Aliphatic Hydrocarbons	mg/kg	5		28000	12										8.8	59		*5*
Aromatic TPH >C5-C7	mg/kg	1	72	1	12										*1*	*1*		*1*
Aromatic TPH >C7-C8	mg/kg	1	56000	1	12										*1*	*1*		*1*
Aromatic TPH >C8-C10	mg/kg	1	5000	20	12										3.9	*1*		*1*
Aromatic TPH >C10-C12	mg/kg	1	5000	35	12										1.5	*1*		*1*
Aromatic TPH >C12-C16	mg/kg	1	5100	700	12										2	4.3		*1*
Aromatic TPH >C16-C21	mg/kg	1	3800	2700	12										*1*	110		*1*
Aromatic TPH >C21-C35	mg/kg	1	3800	83000	12	1									*1*	390		*1*
Aromatic TPH >C35-C44	mg/kg	1	3800	11000	12	1									*1*	22		*1*
Total Aromatic Hydrocarbons	mg/kg	5		98000	12										7.4	530		*5*
TPH C6-C10	mg/kg	1																
TPH C10-C21	mg/kg	1																
TPH C21-C40	mg/kg	1																

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	Sample Location	TP27	TP28	TP29	TP30	TP31	TP32	TP33	TP34	TP101	TP102	TP102	TP103
							Sample Ref	E561	E562	E563	E564	E565	E566	E567	E568	809362	809363	809364	809365
							Depth (top)	3.2	0.5	0.4	1.2	0.5	1	3.5	0.4	0.50	0.50	1.00	0.00
							Depth (bottom)									1.25	1.00	1.50	0.50
							Lab Report	1102	1102	1102	1102	1102	1102	1102	1102	19-12605	19-12605	19-12605	19-12605
							Sample Date									9/4/19	9/4/19	9/4/19	9/4/19
							Originator												
							Strata	NAT-GR	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG
Total Petroleum Hydrocarbons	mg/kg	10		130000	68			20	110	170	20	20	55	34	20	16	590		*10*
Naphthalene	mg/kg	0.1	4900	8.2	15			0.13								*0.1*	1.9		*0.1*
Acenaphthylene	mg/kg	0.1	15000	1.3	15			*0.01*								*0.1*	0.59		*0.1*
Acenaphthene	mg/kg	0.1	15000	0.67	15			*0.01*								*0.1*	0.67		*0.1*
Fluorene	mg/kg	0.1	9900	1.9	15			*0.026*								*0.1*	1		*0.1*
Phenanthrene	mg/kg	0.1	3100	20	15			0.11								*0.1*	20		*0.1*
Anthracene	mg/kg	0.1	74000	3.7	15			*0.1*								*0.1*	3.7		*0.1*
Fluoranthene	mg/kg	0.1	3100	25	15			*0.01*								*0.1*	25		*0.1*
Pyrene	mg/kg	0.1	7400	23	15			*0.01*								*0.1*	23		*0.1*
Benzo[a]anthracene	mg/kg	0.1	29	9	15			*0.01*								*0.1*	9		*0.1*
Chrysene	mg/kg	0.1	57	9.4	15			*0.037*								*0.1*	9.4		*0.1*
Benzo[b]fluoranthene	mg/kg	0.1	7.1	10	15	1		*0.01*								*0.1*	10		*0.1*
Benzo[k]fluoranthene	mg/kg	0.1	190	4	15			*0.01*								*0.1*	4		*0.1*
Benzo[a]pyrene	mg/kg	0.1	5.7	7.4	15	1		*0.01*								*0.1*	7.4		*0.1*
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.1	82	4.7	15			*0.01*								*0.1*	4.7		*0.1*
Dibenz(a,h)Anthracene	mg/kg	0.1	0.57	1.3	15	1		*0.01*								*0.1*	1.3		*0.1*
Benzo[g,h,i]perylene	mg/kg	0.1	640	4.8	15			*0.01*								*0.1*	4.8		*0.1*
Total Of 16 PAH's	mg/kg	2		130	24			*0.503*	20	20			20			*2*	130		*2*
Total Phenols	mg/kg	0.3	760	280	66			10	3	3	3	3	3	3	3	*0.3*	*0.3*		*0.3*
Asbestos	Type	If present	Detected			1				NAD		NAD			NAD	NAD	NAD	N/T	NAD
Asbestos % (if present)	%	0.001		0.001	1														
Benzene	mg/kg	0.1	72	37	14			2								1	1		
Toluene	mg/kg	0.1	56000	110	13			2								1	[C] 1.0		
Ethylbenzene	mg/kg	0.1	24000	9.7	13			2								1	[C] 1.0		
M-Xylene	mg/kg	0.1	41000	62	13			5								1	[C] 1.0		
P-Xylene	mg/kg	0.1	41000	62	13			5								1	[C] 1.0		
O-Xylene	mg/kg	0.1	41000	26	13			3								1	[C] 1.0		

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	Sample Location	TP104	TP104	TP105	TP105	TP106	TP106	TP107(Tar)	TP107	TP107	TP108		
							Sample Ref	809366	809367	809368	809369	809370	809371	809372	809373	809374	809375		
							Depth (top)	0.50	1.00	0.00	1.00	0.00	2.00	0.00	0.25	1.20	0.00		
							Depth (bottom)	1.00	1.80	1.00	1.80	2.00	2.20	0.50	0.75	2.00	1.30		
							Lab Report	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605		
							Sample Date	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19		
							Originator												
							Strata	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG		
pH	pH unit	0.1	6 to 9	11.6	66	20		8.2		6	7.6	8.7	6.1		9	8.4			
Boron (Hot Water Soluble)	mg/kg	0.4	21000	1.6	13			1	*0.4*	1.1	0.68	0.94	0.61		0.75	0.82	0.63		
Cyanide (Total)	mg/kg	0.5	34	5	69			*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		0.8	*0.5*	*0.5*		
Sulphide (Easily Liberatable)	mg/kg	0.5		19	10			10		5.6	3.9	15	2.5		6.4	4.4			
Arsenic	mg/kg	1	79	260	69	3		39	9.7	25	22	13	12		27	22	16		
Cadmium	mg/kg	0.1	120	7.5	69			0.53	*0.1*	0.14	*0.1*	0.14	*0.1*		1.1	0.35	0.24		
Chromium	mg/kg	1	1500	460	66			24		24	14	460	28		34	20			
Copper	mg/kg	0.5	12000	820	69			96	27	67	41	34	41		79	49	52		
Mercury	mg/kg	0.1	16	0.6	69			0.12	*0.1*	*0.1*	*0.1*	0.27	*0.1*		0.23	0.12	*0.1*		
Nickel	mg/kg	0.5	230	180	69			48	20	45	25	34	31		40	31	45		
Lead	mg/kg	0.5	630	1670	69	1		61	8.7	56	13	31	18		140	52	32		
Selenium	mg/kg	0.2	1100	22	69			0.62	*0.2*	0.57	0.41	0.54	0.31		0.25	0.49	0.45		
Vanadium	mg/kg	5	2000	90	13			40	22	43	29	90	18		24	21	17		
Zinc	mg/kg	0.5	81000	850	69			160	22	59	60	83	73		230	110	110		
Chromium (Hexavalent)	mg/kg	0.5	7.7	0.5	13			*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*		
Total Organic Carbon	%	0.2	3	48	10	9		**18**		**20**	**3.2**	2	**4.9**		**8**	**8.6**			
Aliphatic TPH >C5-C6	mg/kg	1	570000	1	12			*1*		*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*		
Aliphatic TPH >C6-C8	mg/kg	1	600000	1	12			*1*		*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*		
Aliphatic TPH >C8-C10	mg/kg	1	13000	10	12			*1*		8.6	*1*	*1*	*1*	10	*1*	*1*	*1*		
Aliphatic TPH >C10-C12	mg/kg	1	13000	10	12			*1*		3.8	*1*	*1*	*1*	10	*1*	*1*	*1*		
Aliphatic TPH >C12-C16	mg/kg	1	13000	27	12			*1*		8	*1*	*1*	*1*	27	*1*	*1*	*1*		
Aliphatic TPH >C16-C21	mg/kg	1	250000	3300	12			*1*		16	*1*	*1*	*1*	3300	*1*	*1*	*1*		
Aliphatic TPH >C21-C35	mg/kg	1	250000	23000	12			*1*		170	*1*	*1*	*1*	23000	36	*1*	4.4		
Aliphatic TPH >C35-C44	mg/kg	1	250000	1700	12			*1*		*1*	*1*	*1*	*1*	1700	*1*	*1*	*1*		
Total Aliphatic Hydrocarbons	mg/kg	5		28000	12			*5*		200	*5*	*5*	*5*	28000	36	*5*	*5*		
Aromatic TPH >C5-C7	mg/kg	1	72	1	12			*1*		*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*		
Aromatic TPH >C7-C8	mg/kg	1	56000	1	12			*1*		*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*		
Aromatic TPH >C8-C10	mg/kg	1	5000	20	12			*1*		8	*1*	*1*	*1*	20	*1*	*1*	*1*		
Aromatic TPH >C10-C12	mg/kg	1	5000	35	12			*1*		1.6	*1*	*1*	*1*	35	*1*	*1*	*1*		
Aromatic TPH >C12-C16	mg/kg	1	5100	700	12			*1*		6	*1*	*1*	*1*	700	*1*	*1*	*1*		
Aromatic TPH >C16-C21	mg/kg	1	3800	2700	12			*1*		4.3	*1*	*1*	*1*	2700	*1*	*1*	*1*		
Aromatic TPH >C21-C35	mg/kg	1	3800	83000	12	1		*1*		89	*1*	*1*	*1*	83000	68	*1*	*1*		
Aromatic TPH >C35-C44	mg/kg	1	3800	11000	12	1		*1*		*1*	*1*	*1*	*1*	11000	*1*	*1*	*1*		
Total Aromatic Hydrocarbons	mg/kg	5		98000	12			*5*		110	*5*	*5*	*5*	98000	68	*5*	*5*		
TPH C6-C10	mg/kg	1																	
TPH C10-C21	mg/kg	1																	
TPH C21-C40	mg/kg	1																	

Consolidated Soil Results - Public Open Space (POS) Residential

Site: Carlton Colliery
Project Reference: 173367
Client: Unconfirmed
Strata: ALL Strata
Notes:

KEY
Exceedance of SGV
Below Limit of Detection

Determinant	Units	LOD	SGV	Max	Number	No. Exceedances	Sample Location	TP104	TP104	TP105	TP105	TP106	TP106	TP107(Tar)	TP107	TP107	TP108		
							Sample Ref	809366	809367	809368	809369	809370	809371	809372	809373	809374	809375		
							Depth (top)	0.50	1.00	0.00	1.00	0.00	2.00	0.00	0.25	1.20	0.00		
							Depth (bottom)	1.00	1.80	1.00	1.80	2.00	2.20	0.50	0.75	2.00	1.30		
							Lab Report	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605		
							Sample Date	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19	9/4/19		
							Originator												
							Strata	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG		
Total Petroleum Hydrocarbons	mg/kg	10		130000	68			*10*		310	*10*	*10*	*10*	130000	100	*10*	*10*		
Naphthalene	mg/kg	0.1	4900	8.2	15			8.2		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Acenaphthylene	mg/kg	0.1	15000	1.3	15			1.3		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Acenaphthene	mg/kg	0.1	15000	0.67	15			0.36		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Fluorene	mg/kg	0.1	9900	1.9	15			1.9		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Phenanthrene	mg/kg	0.1	3100	20	15			3		*0.1*	0.54	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Anthracene	mg/kg	0.1	74000	3.7	15			0.32		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Fluoranthene	mg/kg	0.1	3100	25	15			1.3		*0.1*	0.37	0.56	*0.1*	*0.1*	*0.1*	0.53	*0.1*		
Pyrene	mg/kg	0.1	7400	23	15			1.6		*0.1*	0.47	0.64	*0.1*	*0.1*	*0.1*	0.99	*0.1*		
Benzo[a]anthracene	mg/kg	0.1	29	9	15			*0.1*		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Chrysene	mg/kg	0.1	57	9.4	15			*0.1*		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Benzo[b]fluoranthene	mg/kg	0.1	7.1	10	15	1		*0.1*		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Benzo[k]fluoranthene	mg/kg	0.1	190	4	15			*0.1*		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Benzo[a]pyrene	mg/kg	0.1	5.7	7.4	15	1		*0.1*		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Indeno(1,2,3-c,d)Pyrene	mg/kg	0.1	82	4.7	15			*0.1*		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Dibenz(a,h)Anthracene	mg/kg	0.1	0.57	1.3	15	1		*0.1*		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Benzo[g,h,i]perylene	mg/kg	0.1	640	4.8	15			*0.1*		*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		
Total Of 16 PAH's	mg/kg	2		130	24			18		*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*		
Total Phenols	mg/kg	0.3	760	280	66			*0.3*		*0.3*	*0.3*	*0.3*	*0.3*		*0.3*	*0.3*			
Asbestos	Type	If present	Detected			1		**Detected**	N/T	NAD	NAD	NAD	NAD	N/T	NAD	NAD	N/T		
Asbestos % (if present)	%	0.001		0.001	1			0.001											
Benzene	mg/kg	0.1	72	37	14			1		37	1		1						
Toluene	mg/kg	0.1	56000	110	13			1		110	1		1						
Ethylbenzene	mg/kg	0.1	24000	9.7	13			1		9.7	1		1						
M-Xylene	mg/kg	0.1	41000	62	13			1		62	1		1						
P-Xylene	mg/kg	0.1	41000	62	13			1		62	1		1						
O-Xylene	mg/kg	0.1	41000	26	13			1		26	1		1						

Chemtest
The right chemistry to deliver results

Results - Leachate

Project: 173367 - Carlton Colliery, Shaw Lane

Client: AA Environmental Ltd					**Chemtest Job No.:**	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605	19-12605
Quotation No.:					**Chemtest Sample ID.:**	809362	809364	809366	809367	809368	809369	809370	809375
					Client Sample ID.:	TP101	TP102	TP104	TP104	TP105	TP105	TP106	TP108
					Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
					Top Depth (m):	0.50	1.00	0.50	1.00	0.00	1.00	0.00	0.00
					Bottom Depth (m):	1.25	1.50	1.00	1.80	1.00	1.80	2.00	1.30
					Date Sampled:	09-Apr-2019	09-Apr-2019	09-Apr-2019	09-Apr-2019	09-Apr-2019	09-Apr-2019	09-Apr-2019	09-Apr-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**	**Surface Water EQS (µg/l)**								
Sulphate	U	1220	mg/l	1.0	400 (mg/l)	26	43	33	74	170	830	24	310
Cyanide (Total)	U	1300	mg/l	0.050	0.001 (mg/l)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Arsenic (Dissolved)	U	1450	µg/l	1.0	50	1	1.5	3.3	1.4	1	1	1	1
Boron (Dissolved)	U	1450	µg/l	20	2000	20	40	23	20	20	20	20	20
Cadmium (Dissolved)	U	1450	µg/l	0.080	0.08-0.25*	0.08	0.08	0.08	0.08	0.096	0.08	0.08	0.08
Copper (Dissolved)	U	1450	µg/l	1.0	1	1	1	1	1	1	1	1	1
Mercury (Dissolved)	U	1450	µg/l	0.50	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Nickel (Dissolved)	U	1450	µg/l	1.0	4	1	1	1	1	9.5	1	1	4.1
Lead (Dissolved)	U	1450	µg/l	1.0	1.2	1	1	1	1	1	1	1	1
Selenium (Dissolved)	U	1450	µg/l	1.0		1	1	1	1	1	1	1	1
Vanadium (Dissolved)	U	1450	µg/l	1.0	20	1	1	1	1	1	1	1	1
Zinc (Dissolved)	U	1450	µg/l	1.0	10.9	1	1	1	1	38	12	1	5.3
Chromium (Trivalent)	N	1490	µg/l	20	4.7	20	20	20	20	20	20	20	20
Chromium (Hexavalent)	U	1490	µg/l	20		20	20	20	20	20	20	20	20

APPENDIX 2

Remedial Targets Worksheets

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aliphatic C6 - C8		from Level 1
Target Concentration	C_T	15	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		1	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	7.30E+02	days	
Calculated decay rate	λ	9.50E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.98E+01	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	3.79E+02	fraction
Decay rate used	λ	9.50E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	3.43E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	7.17E-15	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.39E+14**	**fraction**
Calculated soil leachate concentration	Co	1.19E-02	mg/l

Remedial Targets

Level 3 Remedial Target		**2.43E+15**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.04E+17	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
				partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**7.17E-15**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	3.98E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	3.98E+01	l/kg

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

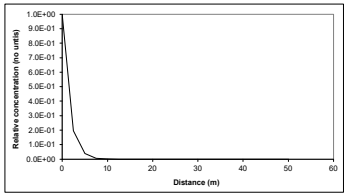
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.03E-02
2.5	1.96E-01	2.02E-03
5.0	3.86E-02	3.97E-04
7.5	7.59E-03	7.80E-05
10.0	1.49E-03	1.53E-05
12.5	2.93E-04	3.01E-06
15.0	5.75E-05	5.92E-07
17.5	1.13E-05	1.16E-07
20.0	2.22E-06	2.28E-08
22.5	4.36E-07	4.48E-09
25.0	8.56E-08	8.80E-10
27.5	1.68E-08	1.73E-10
30.0	3.30E-09	3.39E-11
32.5	6.47E-10	6.65E-12
35.0	1.27E-10	1.30E-12
37.5	2.49E-11	2.56E-13
40.0	4.87E-12	5.01E-14
42.5	9.55E-13	9.82E-15
45.0	1.87E-13	1.92E-15
47.5	3.66E-14	3.77E-16
50.0	7.17E-15	7.37E-17

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aliphatic C5 - C6		from Level 1
Target Concentration	C_T	15	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		1	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	7.30E+02	days	
Calculated decay rate	λ	9.50E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	7.94E+00	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	7.64E+01	fraction
Decay rate used	λ	9.50E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	1.70E-03	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.87E-06	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.59E+05**	**fraction**
Calculated soil leachate concentration	Co	5.36E-02	mg/l

Remedial Targets

Level 3 Remedial Target		**4.51E+06**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		8.40E+07	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**3.87E-06**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	7.94E+02	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	7.94E+00	l/kg

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

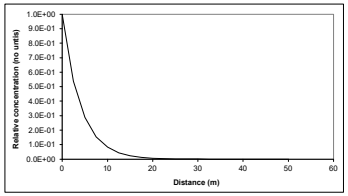
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**4.62E-02**
2.5	**5.37E-01**	**2.48E-02**
5.0	**2.88E-01**	**1.33E-02**
7.5	**1.55E-01**	**7.14E-03**
10.0	**8.31E-02**	**3.84E-03**
12.5	**4.46E-02**	**2.06E-03**
15.0	**2.40E-02**	**1.11E-03**
17.5	**1.29E-02**	**5.94E-04**
20.0	**6.91E-03**	**3.19E-04**
22.5	**3.71E-03**	**1.71E-04**
25.0	**1.99E-03**	**9.18E-05**
27.5	**1.07E-03**	**4.92E-05**
30.0	**5.72E-04**	**2.64E-05**
32.5	**3.07E-04**	**1.42E-05**
35.0	**1.64E-04**	**7.58E-06**
37.5	**8.80E-05**	**4.06E-06**
40.0	**4.71E-05**	**2.18E-06**
42.5	**2.52E-05**	**1.16E-06**
45.0	**1.35E-05**	**6.23E-07**
47.5	**7.23E-06**	**3.34E-07**
50.0	**3.87E-06**	**1.78E-07**

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aliphatic C8 - C10		from Level 1
Target Concentration	C_T	0.3	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		10	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	7.30E+02	days	
Calculated decay rate	λ	9.50E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.16E+02	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	3.00E+03	fraction
Decay rate used	λ	9.50E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	4.33E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.30E-44	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.33E+43**	**fraction**
Calculated soil leachate concentration	Co	1.57E-02	mg/l

Remedial Targets

Level 3 Remedial Target		**8.11E+42**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		5.18E+45	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.30E-44**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	3.16E+04	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction

Soil water partition coefficient — Kd — 3.16E+02 — l/kg

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

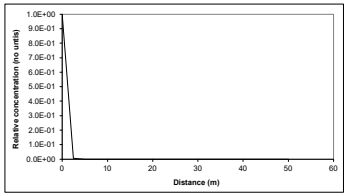
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**1.35E-02**
2.5	**6.80E-03**	**9.16E-05**
5.0	**4.62E-05**	**6.23E-07**
7.5	**3.14E-07**	**4.23E-09**
10.0	**2.13E-09**	**2.87E-11**
12.5	**1.45E-11**	**1.95E-13**
15.0	**9.85E-14**	**1.33E-15**
17.5	**6.69E-16**	**9.02E-18**
20.0	**4.54E-18**	**6.13E-20**
22.5	**3.09E-20**	**4.16E-22**
25.0	**2.10E-22**	**2.83E-24**
27.5	**1.42E-24**	**1.92E-26**
30.0	**9.66E-27**	**1.30E-28**
32.5	**6.55E-29**	**8.83E-31**
35.0	**4.44E-31**	**5.99E-33**
37.5	**3.01E-33**	**4.06E-35**
40.0	**2.04E-35**	**2.75E-37**
42.5	**1.38E-37**	**1.86E-39**
45.0	**9.37E-40**	**1.26E-41**
47.5	**6.35E-42**	**8.56E-44**
50.0	**4.30E-44**	**5.79E-46**

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aliphatic C10 - C12		from Level 1
Target Concentration	C_T	0.3	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		10	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.83E+03	days	
Calculated decay rate	λ	3.80E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	2.51E+03	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	2.38E+04	fraction
Decay rate used	λ	3.80E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	5.45E-06	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	1.21E-79	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**8.24E+78**	**fraction**
Calculated soil leachate concentration	Co	1.99E-03	mg/l

Remedial Targets

Level 3 Remedial Target	**2.87E+78**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.44E+82	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration C_{ED}/C_0	**1.21E-79**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	2.51E+05	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.51E+03	l/kg

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

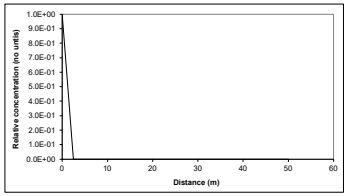
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.71E-03
2.5	1.13E-04	1.94E-07
5.0	1.29E-08	2.20E-11
7.5	1.46E-12	2.50E-15
10.0	1.66E-16	2.83E-19
12.5	1.88E-20	3.21E-23
15.0	2.13E-24	3.65E-27
17.5	2.42E-28	4.14E-31
20.0	2.74E-32	4.69E-35
22.5	3.11E-36	5.32E-39
25.0	3.52E-40	6.03E-43
27.5	3.99E-44	6.83E-47
30.0	4.52E-48	7.74E-51
32.5	5.12E-52	8.77E-55
35.0	5.80E-56	9.93E-59
37.5	6.57E-60	1.12E-62
40.0	7.43E-64	1.27E-66
42.5	8.40E-68	1.44E-70
45.0	9.50E-72	1.63E-74
47.5	1.07E-75	1.84E-78
50.0	1.21E-79	2.08E-82

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	0.0001	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		3.7	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	4.60E+02	days	*Consim - worst*
Calculated decay rate	λ	1.51E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	2.95E+02	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	2.80E+03	fraction
Decay rate used	λ	1.51E-03	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	4.64E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	5.68E-54	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.76E+53**	**fraction**
Calculated soil leachate concentration	Co	6.27E-03	mg/l

Remedial Targets

Level 3 Remedial Target	**2.04E+49**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.21E+52	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**5.68E-54**	**fraction** Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	2.95E+04	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.95E+02	l/kg

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

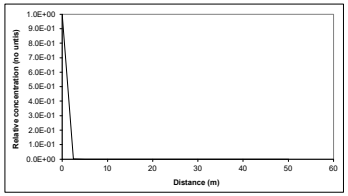
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.39E-03
2.5	2.18E-03	1.18E-05
5.0	4.75E-06	2.56E-08
7.5	1.03E-08	5.58E-11
10.0	2.26E-11	1.22E-13
12.5	4.91E-14	2.65E-16
15.0	1.07E-16	5.78E-19
17.5	2.33E-19	1.26E-21
20.0	5.08E-22	2.74E-24
22.5	1.11E-24	5.97E-27
25.0	2.41E-27	1.30E-29
27.5	5.25E-30	2.83E-32
30.0	1.14E-32	6.16E-35
32.5	2.49E-35	1.34E-37
35.0	5.41E-38	2.92E-40
37.5	1.18E-40	6.34E-43
40.0	2.55E-43	1.38E-45
42.5	5.55E-46	2.99E-48
45.0	1.21E-48	6.50E-51
47.5	2.62E-51	1.41E-53
50.0	5.68E-54	3.07E-56

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aromatic C5 - C6		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		1	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	3.00E+02	days	
Calculated decay rate	λ	2.31E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	7.90E-01	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	8.51E+00	fraction
Decay rate used	λ	2.31E-03	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	1.53E-02	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.39E-03	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.57E+02**	**fraction**
Calculated soil leachate concentration	Co	5.81E-01	mg/l

Remedial Targets

Level 3 Remedial Target	**1.82E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	3.13E+00	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0 **6.39E-03**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	7.90E+01	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	7.90E-01	l/kg

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

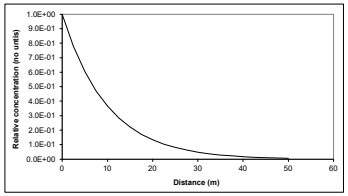
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**5.00E-01**
2.5	**7.78E-01**	**3.89E-01**
5.0	**6.05E-01**	**3.03E-01**
7.5	**4.70E-01**	**2.35E-01**
10.0	**3.66E-01**	**1.83E-01**
12.5	**2.84E-01**	**1.42E-01**
15.0	**2.21E-01**	**1.11E-01**
17.5	**1.72E-01**	**8.61E-02**
20.0	**1.34E-01**	**6.69E-02**
22.5	**1.04E-01**	**5.20E-02**
25.0	**8.08E-02**	**4.04E-02**
27.5	**6.28E-02**	**3.14E-02**
30.0	**4.88E-02**	**2.44E-02**
32.5	**3.79E-02**	**1.89E-02**
35.0	**2.94E-02**	**1.47E-02**
37.5	**2.28E-02**	**1.14E-02**
40.0	**1.77E-02**	**8.85E-03**
42.5	**1.37E-02**	**6.86E-03**
45.0	**1.06E-02**	**5.32E-03**
47.5	**8.24E-03**	**4.12E-03**
50.0	**6.39E-03**	**3.19E-03**

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aromatic C6 - C8		from Level 1
Target Concentration	C_T	0.7	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		1	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	7.30E+02	days	*NZ guidelines*
Calculated decay rate	λ	9.50E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	2.51E+00	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	2.48E+01	fraction
Decay rate used	λ	9.50E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	5.23E-03	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.08E-03	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.25E+02**	**fraction**
Calculated soil leachate concentration	Co	1.94E-01	mg/l

Remedial Targets

Level 3 Remedial Target	**2.64E+02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.36E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**3.08E-03**	**fraction** Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	2.51E+02	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.51E+00	l/kg

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

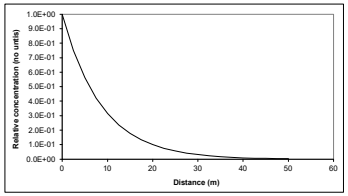
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.67E-01
2.5	7.50E-01	1.25E-01
5.0	5.62E-01	9.37E-02
7.5	4.22E-01	7.03E-02
10.0	3.16E-01	5.27E-02
12.5	2.37E-01	3.95E-02
15.0	1.78E-01	2.96E-02
17.5	1.33E-01	2.22E-02
20.0	9.99E-02	1.67E-02
22.5	7.49E-02	1.25E-02
25.0	5.61E-02	9.36E-03
27.5	4.20E-02	7.01E-03
30.0	3.15E-02	5.25E-03
32.5	2.36E-02	3.93E-03
35.0	1.76E-02	2.94E-03
37.5	1.32E-02	2.20E-03
40.0	9.87E-03	1.65E-03
42.5	7.38E-03	1.23E-03
45.0	5.52E-03	9.20E-04
47.5	4.12E-03	6.87E-04
50.0	3.08E-03	5.13E-04

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aromatic C8-C10		from Level 1
Target Concentration	C_T	0.3	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		20	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	7.30E+02	days	*NZ guidelines*
Calculated decay rate	λ	9.50E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.59E+01	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	1.52E+02	fraction
Decay rate used	λ	9.50E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	8.58E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	5.19E-09	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.93E+08**	**fraction**
Calculated soil leachate concentration	Co	6.28E-01	mg/l

Remedial Targets

Level 3 Remedial Target	**6.71E+07**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	2.14E+09	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**5.19E-09**	**fraction** Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	1.59E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.59E+01	l/kg

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

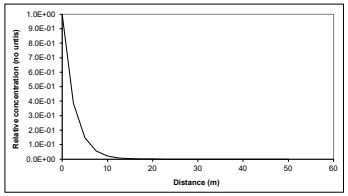
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**5.40E-01**
2.5	**3.86E-01**	**2.08E-01**
5.0	**1.49E-01**	**8.04E-02**
7.5	**5.74E-02**	**3.10E-02**
10.0	**2.21E-02**	**1.20E-02**
12.5	**8.54E-03**	**4.62E-03**
15.0	**3.30E-03**	**1.78E-03**
17.5	**1.27E-03**	**6.87E-04**
20.0	**4.90E-04**	**2.65E-04**
22.5	**1.89E-04**	**1.02E-04**
25.0	**7.29E-05**	**3.94E-05**
27.5	**2.81E-05**	**1.52E-05**
30.0	**1.08E-05**	**5.84E-06**
32.5	**4.17E-06**	**2.25E-06**
35.0	**1.60E-06**	**8.67E-07**
37.5	**6.17E-07**	**3.34E-07**
40.0	**2.38E-07**	**1.28E-07**
42.5	**9.14E-08**	**4.94E-08**
45.0	**3.51E-08**	**1.90E-08**
47.5	**1.35E-08**	**7.30E-09**
50.0	**5.19E-09**	**2.80E-09**

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aromatic C10 - C12		from Level 1
Target Concentration	C_T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		35	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.83E+03	days	
Calculated decay rate	λ	3.80E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	2.51E+01	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	2.39E+02	fraction
Decay rate used	λ	3.80E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	5.43E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	5.67E-07	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.76E+06**	**fraction**
Calculated soil leachate concentration	Co	6.95E-01	mg/l

Remedial Targets

Level 3 Remedial Target		**1.84E+05**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		9.28E+06	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
				partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**5.67E-07**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	2.51E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.51E+01	l/kg

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

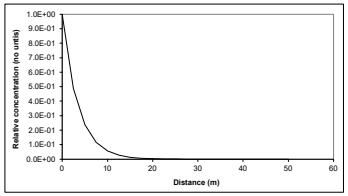
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**5.98E-01**
2.5	**4.88E-01**	**2.92E-01**
5.0	**2.38E-01**	**1.42E-01**
7.5	**1.16E-01**	**6.95E-02**
10.0	**5.66E-02**	**3.39E-02**
12.5	**2.76E-02**	**1.65E-02**
15.0	**1.35E-02**	**8.06E-03**
17.5	**6.57E-03**	**3.93E-03**
20.0	**3.20E-03**	**1.92E-03**
22.5	**1.56E-03**	**9.35E-04**
25.0	**7.61E-04**	**4.56E-04**
27.5	**3.71E-04**	**2.22E-04**
30.0	**1.81E-04**	**1.08E-04**
32.5	**8.80E-05**	**5.27E-05**
35.0	**4.29E-05**	**2.56E-05**
37.5	**2.09E-05**	**1.25E-05**
40.0	**1.01E-05**	**6.07E-06**
42.5	**4.94E-06**	**2.95E-06**
45.0	**2.40E-06**	**1.44E-06**
47.5	**1.17E-06**	**6.98E-07**
50.0	**5.67E-07**	**3.39E-07**

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aromatic C12-C16		from Level 1
Target Concentration	C_T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		700	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.83E+03	days	
Calculated decay rate	λ	3.80E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.01E+01	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	4.77E+02	fraction
Decay rate used	λ	3.80E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	2.73E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.12E-10	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.20E+09**	**fraction**
Calculated soil leachate concentration	Co	6.98E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**3.35E+08**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		3.36E+10	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
				partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.12E-10**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.01E+01	l/kg

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

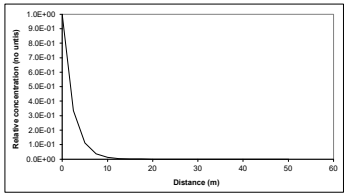
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	6.00E+00
2.5	3.35E-01	2.01E+00
5.0	1.12E-01	6.75E-01
7.5	3.77E-02	2.26E-01
10.0	1.26E-02	7.58E-02
12.5	4.23E-03	2.54E-02
15.0	1.42E-03	8.51E-03
17.5	4.75E-04	2.85E-03
20.0	1.59E-04	9.56E-04
22.5	5.33E-05	3.20E-04
25.0	1.79E-05	1.07E-04
27.5	5.98E-06	3.59E-05
30.0	2.00E-06	1.20E-05
32.5	6.70E-07	4.02E-06
35.0	2.24E-07	1.35E-06
37.5	7.50E-08	4.50E-07
40.0	2.51E-08	1.50E-07
42.5	8.37E-09	5.03E-08
45.0	2.80E-09	1.68E-08
47.5	9.35E-10	5.61E-09
50.0	3.12E-10	1.87E-09

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH aromatic C16-21		from Level 1
Target Concentration	C_T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		2700	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	3.65E+03	days	
Calculated decay rate	λ	1.90E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.58E+02	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	1.50E+03	fraction
Decay rate used	λ	1.90E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	8.66E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.11E-13	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.43E+12**	**fraction**
Calculated soil leachate concentration	Co	8.54E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**2.54E+11**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		8.03E+13	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
				partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.11E-13**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	1.58E+04	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.58E+02	l/kg

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

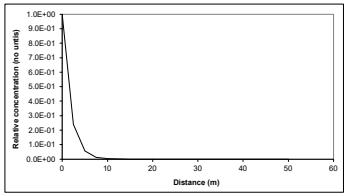
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	7.35E+00
2.5	2.41E-01	1.77E+00
5.0	5.79E-02	4.25E-01
7.5	1.39E-02	1.02E-01
10.0	3.35E-03	2.46E-02
12.5	8.06E-04	5.92E-03
15.0	1.94E-04	1.43E-03
17.5	4.67E-05	3.43E-04
20.0	1.12E-05	8.25E-05
22.5	2.70E-06	1.98E-05
25.0	6.49E-07	4.77E-06
27.5	1.56E-07	1.15E-06
30.0	3.75E-08	2.75E-07
32.5	9.00E-09	6.61E-08
35.0	2.16E-09	1.59E-08
37.5	5.19E-10	3.81E-09
40.0	1.24E-10	9.15E-10
42.5	2.99E-11	2.19E-10
45.0	7.16E-12	5.26E-11
47.5	1.72E-12	1.26E-11
50.0	4.11E-13	3.02E-12

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		BaP		from Level 1
Target Concentration	C_T	0.00000017	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		7.4	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.06E+03	days	
Calculated decay rate	λ	6.55E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.29E+03	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	1.23E+04	fraction
Decay rate used	λ	6.55E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	1.06E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.57E-75	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.52E+74**	**fraction**
Calculated soil leachate concentration	Co	2.87E-03	mg/l

Remedial Targets

Level 3 Remedial Target		**3.01E+67**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		7.76E+70	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
				partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**6.57E-75**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	1.29E+05	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.29E+03	l/kg

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

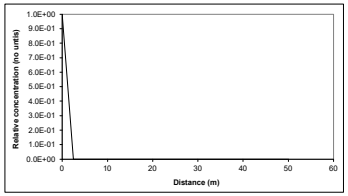
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**2.47E-03**
2.5	**1.96E-04**	**4.83E-07**
5.0	**3.83E-08**	**9.45E-11**
7.5	**7.49E-12**	**1.85E-14**
10.0	**1.46E-15**	**3.62E-18**
12.5	**2.87E-19**	**7.07E-22**
15.0	**5.61E-23**	**1.38E-25**
17.5	**1.10E-26**	**2.71E-29**
20.0	**2.14E-30**	**5.29E-33**
22.5	**4.19E-34**	**1.04E-36**
25.0	**8.20E-38**	**2.02E-40**
27.5	**1.60E-41**	**3.95E-44**
30.0	**3.13E-45**	**7.73E-48**
32.5	**6.11E-49**	**1.51E-51**
35.0	**1.19E-52**	**2.95E-55**
37.5	**2.33E-56**	**5.75E-59**
40.0	**4.55E-60**	**1.12E-62**
42.5	**8.87E-64**	**2.19E-66**
45.0	**1.73E-67**	**4.27E-70**
47.5	**3.37E-71**	**8.32E-74**
50.0	**6.57E-75**	**1.62E-77**

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Benzo-b-fluoranthene		from Level 1
Target Concentration	C_T	0.00000017	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		10	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.22E+03	days	
Calculated decay rate	λ	5.68E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.05E+03	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	9.98E+03	fraction
Decay rate used	λ	5.68E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	1.30E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	1.02E-62	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**9.80E+61**	**fraction**
Calculated soil leachate concentration	Co	4.76E-03	mg/l

Remedial Targets

Level 3 Remedial Target		**1.94E+55**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		4.07E+58	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
				partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**1.02E-62**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	1.05E+05	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.05E+03	l/kg

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

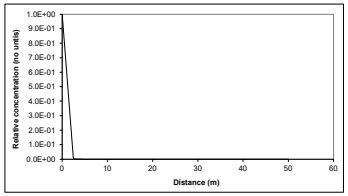
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	4.10E-03
2.5	7.96E-04	3.26E-06
5.0	6.34E-07	2.60E-09
7.5	5.05E-10	2.07E-12
10.0	4.02E-13	1.65E-15
12.5	3.20E-16	1.31E-18
15.0	2.55E-19	1.04E-21
17.5	2.03E-22	8.31E-25
20.0	1.61E-25	6.61E-28
22.5	1.28E-28	5.26E-31
25.0	1.02E-31	4.19E-34
27.5	8.12E-35	3.33E-37
30.0	6.46E-38	2.65E-40
32.5	5.13E-41	2.10E-43
35.0	4.08E-44	1.67E-46
37.5	3.24E-47	1.33E-49
40.0	2.57E-50	1.05E-52
42.5	2.04E-53	8.37E-56
45.0	1.62E-56	6.64E-59
47.5	1.29E-59	5.27E-62
50.0	1.02E-62	4.18E-65

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Benzo(ghi)perylene		from Level 1
Target Concentration	C_T	0.00000017	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		4.8	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.30E+03	days	
Calculated decay rate	λ	5.33E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.17E+03	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	3.96E+04	fraction
Decay rate used	λ	5.33E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	3.28E-06	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.34E-122	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**4.28E+121**	**fraction**
Calculated soil leachate concentration	Co	5.76E-04	mg/l

Remedial Targets

Level 3 Remedial Target		**8.45E+114**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		7.05E+118	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**2.34E-122**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	4.17E+05	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction

Soil water partition coefficient — Kd — 4.17E+03 — l/kg

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

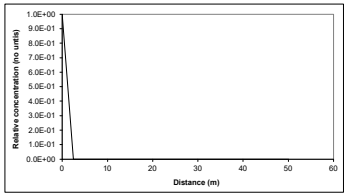
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	4.95E-04
2.5	8.30E-07	4.11E-10
5.0	6.89E-13	3.41E-16
7.5	5.71E-19	2.83E-22
10.0	4.74E-25	2.35E-28
12.5	3.94E-31	1.95E-34
15.0	3.27E-37	1.62E-40
17.5	2.71E-43	1.34E-46
20.0	2.25E-49	1.11E-52
22.5	1.86E-55	9.24E-59
25.0	1.55E-61	7.66E-65
27.5	1.28E-67	6.35E-71
30.0	1.06E-73	5.26E-77
32.5	8.80E-80	4.36E-83
35.0	7.29E-86	3.61E-89
37.5	6.04E-92	2.99E-95
40.0	5.00E-98	2.47E-101
42.5	4.13E-104	2.05E-107
45.0	3.42E-110	1.69E-113
47.5	2.83E-116	1.40E-119
50.0	2.34E-122	1.16E-125

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Benzo-k-fluoranthene		from Level 1
Target Concentration	C_T	0.00000017	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		4	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	4.28E+03	days	
Calculated decay rate	λ	1.62E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.48E+03	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	1.41E+04	fraction
Decay rate used	λ	1.62E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	9.25E-06	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.90E-39	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.44E+38**	**fraction**
Calculated soil leachate concentration	Co	1.35E-03	mg/l

Remedial Targets

Level 3 Remedial Target	**6.80E+31**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	2.01E+35	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**2.90E-39**	**fraction** Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	1.48E+05	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.48E+03	l/kg

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

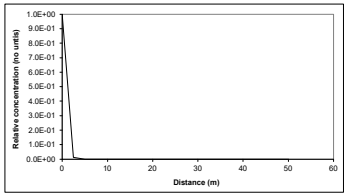
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.16E-03
2.5	1.18E-02	1.38E-05
5.0	1.40E-04	1.63E-07
7.5	1.66E-06	1.93E-09
10.0	1.97E-08	2.29E-11
12.5	2.34E-10	2.72E-13
15.0	2.77E-12	3.22E-15
17.5	3.28E-14	3.81E-17
20.0	3.89E-16	4.52E-19
22.5	4.60E-18	5.35E-21
25.0	5.45E-20	6.34E-23
27.5	6.45E-22	7.50E-25
30.0	7.64E-24	8.88E-27
32.5	9.03E-26	1.05E-28
35.0	1.07E-27	1.24E-30
37.5	1.26E-29	1.47E-32
40.0	1.49E-31	1.74E-34
42.5	1.76E-33	2.05E-36
45.0	2.08E-35	2.42E-38
47.5	2.46E-37	2.86E-40
50.0	2.90E-39	3.38E-42

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Fluoranthene		from Level 1
Target Concentration	C_T	0.0063	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		25	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.85E+03	days	
Calculated decay rate	λ	2.43E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.98E+02	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	1.88E+03	fraction
Decay rate used	λ	2.43E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	6.91E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.34E-17	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.58E+16**	**fraction**
Calculated soil leachate concentration	Co	6.31E-02	mg/l

Remedial Targets

Level 3 Remedial Target	**1.16E+14**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	4.58E+16	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**6.34E-17**	**fraction** Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	1.98E+04	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction

Soil water partition coefficient	Kd	1.98E+02	l/kg

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

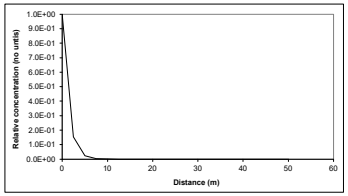
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**5.43E-02**
2.5	**1.55E-01**	**8.42E-03**
5.0	**2.41E-02**	**1.31E-03**
7.5	**3.73E-03**	**2.03E-04**
10.0	**5.79E-04**	**3.14E-05**
12.5	**8.98E-05**	**4.88E-06**
15.0	**1.39E-05**	**7.56E-07**
17.5	**2.16E-06**	**1.17E-07**
20.0	**3.35E-07**	**1.82E-08**
22.5	**5.19E-08**	**2.82E-09**
25.0	**8.05E-09**	**4.37E-10**
27.5	**1.25E-09**	**6.78E-11**
30.0	**1.93E-10**	**1.05E-11**
32.5	**2.99E-11**	**1.63E-12**
35.0	**4.63E-12**	**2.52E-13**
37.5	**7.17E-13**	**3.89E-14**
40.0	**1.11E-13**	**6.02E-15**
42.5	**1.72E-14**	**9.32E-16**
45.0	**2.65E-15**	**1.44E-16**
47.5	**4.10E-16**	**2.23E-17**
50.0	**6.34E-17**	**3.44E-18**

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Indeno(1,2,3 cd) pyrene		from Level 1
Target Concentration	C_T	0.00000017	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		4.7	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.46E+03	days	
Calculated decay rate	λ	4.75E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	8.71E+02	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	8.28E+03	fraction
Decay rate used	λ	4.75E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	1.57E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	5.44E-52	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.84E+51**	**fraction**
Calculated soil leachate concentration	Co	4.33E-04	mg/l

Remedial Targets

Level 3 Remedial Target	**3.63E+44**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	3.93E+48	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**5.44E-52**	**fraction** Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	8.71E+04	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	8.71E+02	l/kg

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

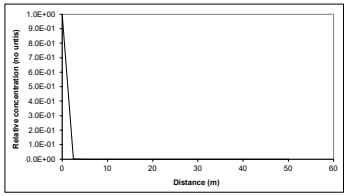
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.73E-04
2.5	2.74E-03	1.02E-06
5.0	7.49E-06	2.80E-09
7.5	2.05E-08	7.65E-12
10.0	5.62E-11	2.09E-14
12.5	1.54E-13	5.73E-17
15.0	4.21E-16	1.57E-19
17.5	1.15E-18	4.30E-22
20.0	3.15E-21	1.18E-24
22.5	8.63E-24	3.22E-27
25.0	2.36E-26	8.80E-30
27.5	6.45E-29	2.41E-32
30.0	1.76E-31	6.58E-35
32.5	4.82E-34	1.80E-37
35.0	1.32E-36	4.91E-40
37.5	3.60E-39	1.34E-42
40.0	9.82E-42	3.66E-45
42.5	2.68E-44	1.00E-47
45.0	7.32E-47	2.73E-50
47.5	2.00E-49	7.45E-53
50.0	5.44E-52	2.03E-55

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Naphthalene		from Level 1
Target Concentration	C_T	0.002	mg/l	from Level 1
Dilution Factor	DF	1.16E+00		from Level 2

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

Ogata Banks — Equations in HRA publication

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, l

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		8.2	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.58E+02	days	*Howard*
Calculated decay rate	λ	2.69E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	3.00E+02	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	2.00E-01	fraction	
Hydraulic gradient	i	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	5.18E-01	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.29E+01	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.30E-01	m/d
Retardation factor	Rf	1.23E+02	fraction
Decay rate used	λ	2.69E-03	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	5.02E-02	fraction
Rate of contaminant flow due to retardation	u	1.05E-03	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.20E-14	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.12E+13**	**fraction**
Calculated soil leachate concentration	Co	3.17E-01	mg/l

Remedial Targets

Level 3 Remedial Target	**7.26E+10**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.88E+12	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water
			partitioning equation.
Ratio of Compliance Point to Source Concentration C_{ED}/C_0	**3.20E-14**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	1.00E-02	fraction
Organic carbon partition coefficient	Koc	1.29E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.29E+01	l/kg

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

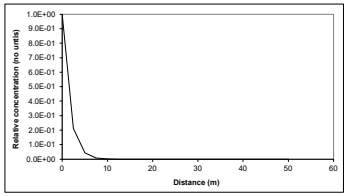
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

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

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), 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 (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water 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 9.9E+99.

Site being assessed:	Carlton Colliery
Completed by:	Helen McDonnell
Date:	#######
Version:	x.xx

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.73E-01
2.5	2.12E-01	5.77E-02
5.0	4.48E-02	1.22E-02
7.5	9.49E-03	2.59E-03
10.0	2.01E-03	5.48E-04
12.5	4.26E-04	1.16E-04
15.0	9.01E-05	2.46E-05
17.5	1.91E-05	5.20E-06
20.0	4.04E-06	1.10E-06
22.5	8.55E-07	2.33E-07
25.0	1.81E-07	4.93E-08
27.5	3.83E-08	1.04E-08
30.0	8.09E-09	2.21E-09
32.5	1.71E-09	4.66E-10
35.0	3.62E-10	9.86E-11
37.5	7.64E-11	2.08E-11
40.0	1.61E-11	4.40E-12
42.5	3.41E-12	9.28E-13
45.0	7.19E-13	1.96E-13
47.5	1.52E-13	4.14E-14
50.0	3.20E-14	8.72E-15

APPENDIX 3

Consim Files

(Electronic files supplied separately)