

REMEDIATION STRATEGY

Burdens Motors, Spalding

For

A.F.Blakemore & Son Ltd

17 February 2010

Architects
Consulting Engineers
Project Managers
Surveyors

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FIGURE 1
Site Location Map

FIGURE 2
Site Layout

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Checked by:



Date: 17/2/10

1 INTRODUCTION

1.1 General

We have been instructed by A.F.Blakemore & Son Ltd to produce a Remediation Strategy for the proposed redevelopment of Burdens Motors, Spalding, as a convenience store. The objective is to ensure that there will be no unacceptable risks to human health or the environment from land contamination for the proposed development.

Pick Everard have previously undertaken environmental investigation works at the site, which are detailed in the following reports.

- *'Phase I Environmental Survey, Burdens Motors, Spalding'*, Pick Everard, Report No. 080618/R001, 23 September 2008.
- *'Phase II Environmental Investigation Report, Burdens Motors, Spalding'*, Pick Everard, Report No. 080618/R002, 15 January 2009.

The remedial strategy is based on the findings of the previous works and after discussions with the Environment Agency and Local Planning Authority.

1.2 Site Setting

The site is located immediately north of the A151 Winsover Road and west of Carrington Road, Spalding, approximately 1km west of the town centre. It currently comprises a car showroom and garage surrounded by hardstanding.

The site is underlain by Tidal Flat Deposits comprising clays and silts, which in turn overlie the mudstone of the Oxford Clay Formation. The underlying geology is classed as non-aquifer.

The site location is shown in Figure 1, while the site layout is presented in Figure 2.

2 PREVIOUS INVESTIGATION FINDINGS

2.1 General

The site investigation works undertaken previously on the site comprised the drilling of four window sample boreholes, the retrieval of soil and groundwater samples for chemical analysis and the monitoring of ground gas. The investigation generally recorded Made Ground over a sandy clay to approximately 1.5m.bgl and a silty sand to the base of each hole. These deposits were considered to represent the Tidal Flat Deposits.

2.2 Contamination

The investigation revealed contamination comprising heavy hydrocarbons, particularly PAHs, in the shallow Made Ground and light aromatic hydrocarbons and BTEX compounds in deeper soils and groundwater in the boreholes close to the location of redundant underground tanks. Low levels of methane and carbon dioxide were also detected in the boreholes.

The heavy hydrocarbon and PAH contamination in the shallow Made Ground was not considered to represent a significant risk for the proposed site use, but it was considered that these soils should not be exposed at the surface if any soft landscaping was proposed.

Based on the information from the single gas monitoring visit, it was recommended that basic gas protection measures are incorporated into any new building.

The most significant contamination was considered to be the aromatic hydrocarbons / BTEX compounds, particularly benzene, which were found primarily associated with the groundwater. Although the underlying geology is shown to be a non-aquifer, the presence of shallow groundwater within the drift deposits was proven and this presents the potential for contaminant migration off-site.

It was considered that this contamination source would need mitigating in order to reduce environmental liabilities and satisfy the planning authority.

2.3 Potential Risks

The groundwater itself is not considered to be a sensitive receptor given the designation of the underlying geology as a non-aquifer. The site is not within a groundwater source protection zone and there are no groundwater abstractions recorded within 1km of the site. However, significant shallow groundwater was encountered and future abstraction licences cannot be ruled out.

There are potential risks and liabilities associated with the off-site migration of contamination impacting neighbouring properties and compromising the shallow groundwater quality for potential future use.

Additionally, there are potential risks to human health associated with contaminant vapours, particularly should any new building be located above contaminated soil and/or groundwater.

3 REMEDIATION STRATEGY

3.1 Aromatic Hydrocarbon / BTEX Contamination

It is considered most likely that the observed contamination originated from the, now redundant, underground tanks which are understood to have been unused for well over 30 years and were filled with concrete in 1985. Records indicate that the tanks had a capacity of 6000l, although the number of tanks is unknown.

The likelihood of the tanks still acting as a contamination source is small, assuming the tanks were properly decommissioned. However, this cannot be discounted entirely and there may also be heavily contaminated soil acting as a continuing source in close proximity to the tanks. Contamination appears to have migrated to the groundwater at least in the area close the tanks.

It is considered that the remediation of the site should begin with the suspected original source of contamination, i.e. the tanks, and then address the wider groundwater contamination at the site.

The aim is to reduce concentrations of contaminants at the site to levels which would not represent a continued risk to human health, the environment or site neighbours.

It should be noted that some contamination may already have migrated off-site and that the remedial strategy is designed only to address the remaining on-site contamination source.

3.2 Strategy

The remediation strategy will comprise two stages. The first will target the tanks and any associated contaminated soil, which is the suspected source of the contamination. The second stage will aim to reduce the contamination in the groundwater to acceptable levels.

3.2.1 *Tank and Soil Removal*

The first stage of the remediation strategy will comprise the excavation and removal of the existing underground tanks. Given the nature of the tanks, there are not considered to be any other reasonable alternatives to excavation and off-site recovery or disposal.

Alongside the removal of the tanks, any obviously contaminated soil will also be excavated for off-site disposal. The amount of soil excavated will be kept to a minimum. It is considered that only a small quantity of contaminated soil is likely to be present, given that the ground investigation generally only recorded soil contamination where it was associated with the groundwater. In addition, the types of contaminant recorded (light aromatic hydrocarbons / BTEX compounds, especially benzene) are generally mobile in soil and are more likely to concentrate within the groundwater.

Given the likely small quantities of soil involved (if any), off-site disposal is considered the most practical remedial option.

3.2.2 *Groundwater Treatment*

The removal of the tanks will result in a significant void being temporarily left in the ground. It is considered that this will provide an appropriate opportunity to treat the groundwater by allowing it to be pumped out for treatment and disposal.

The excavation will have to be of sufficient depth to allow groundwater to collect. Groundwater was encountered at approximately 1.9m.bgl in the vicinity of the tanks, which would mean that the excavation should be deepened to approximately 3m to allow sufficient water to collect and be pumped.

3.3 Remedial Targets

Remedial targets have been set for the contaminants of concern in both soil and groundwater that are protective of human health, controlled waters, environmental receptors and site neighbours, and after consultation with the Environment Agency and Local Authority.

3.3.1 Soil Targets

In terms of human health, it is considered that Soil Guideline Values (SGVs) or alternative Generic Site Assessment Criteria (GSAC) calculated using CLEA 1.04 for a commercial / industrial land use are appropriate to be protective of human health from soil contamination. The appropriate remedial targets for the main contaminants of concern are as follows;

Contaminant	Remedial Target (and source) (mg/kg)
Petroleum Hydrocarbons >C6-C8	1300 (GSAC)
Petroleum Hydrocarbons >C8-C10	1400 (GSAC)
Petroleum Hydrocarbons >C10-C12	5500 (GSAC)
Benzene	95 (SGV)

In reality, significantly contaminated soil is not expected to be found and any recorded concentrations are not expected to be as high as the remedial targets. Remediation will aim to reduce concentrations to as low as practical, primarily to aid the groundwater remediation by ensuring the soil is not continuing to act as a significant source of contamination.

3.3.2 Groundwater Targets

Groundwater remedial targets have been developed based on the anticipated risks associated with the identified contamination. The risks to wider controlled waters are considered minimal, given that the site is located on a non-aquifer and there are no surface water features close to the site, while the only potential risks to site users are via vapours, which can be managed by the incorporation of a vapour membrane in the new building.

Therefore, the main driver for the remedial targets is preventing significant contamination migrating off-site and impacting neighbouring properties.

Remedial targets for groundwater have been derived using the Environment Agency's Remedial Targets methodology. Estimations of aquifer properties, published chemical properties and the following assumptions have been used in the derivation of the remedial targets;

- The compliance point is taken as the site boundary, considered to be 30m from the source which is equivalent to the minimum width of the site.

- The target concentration for Benzene at the compliance point is 10µg/l, which is one order of magnitude higher than the UK Drinking Water Standard (DWS) of 1 µg/l. This value is considered appropriate as the DWS is overly conservative in terms of the aims of the remediation.
- The target concentration for Total Petroleum Hydrocarbons at the compliance point is 200µg/l, which is the Surface Water Abstraction threshold for waters which require normal physical/chemical treatment prior to being used for potable supply.
- The remedial target for Total Petroleum Hydrocarbons has been calculated based on published information for aromatic hydrocarbons in the range >C8-C10. This is because the hydrocarbons recorded in the groundwater were concentrated in this range.

Based on the above, the following remedial targets have been calculated. Remedial Targets Worksheets are presented in Appendix 1;

Contaminant	Remedial Target (µg/l)
Total Petroleum Hydrocarbons	462
Benzene	23

Benzene is considered to be the primary contaminant of concern and will be the key indicator of the progress of the remedial works. The aim is to achieve the target concentration outlined above, although a re-assessment of the risks and the remedial target may be appropriate as the works progress.

3.4 Monitoring and Verification

The effectiveness of the remediation works will be monitored and verified by means of soil and groundwater sampling. A verification report, detailing the works undertaken and the verification sampling will be produced on completion of the remediation.

3.4.1 Soil

Should any obviously contaminated soil be encountered during the tank excavations it will be removed and verification samples taken from the base and/or sides of the excavation as appropriate. The results of the verification analysis will be compared with the remedial targets described above. Should contamination still be present at unacceptably high concentrations, then further excavation of the soil will be undertaken.

3.4.2 Groundwater

The quality of the groundwater will be monitored by the taking of samples from groundwater monitoring standpipes. If appropriate, use will be made of the existing monitoring installations that were installed during the original ground investigation. Should these no longer be serviceable, or extra standpipes be considered necessary, new boreholes will be drilled and installed as appropriate.

The samples taken from the monitoring installations will be sent for chemical analysis for the contaminants of concern and the results compared with the remedial targets described above.

Groundwater remediation will continue until it is considered that contaminant concentrations no longer represent a significant risk or liability.

3.5 Material Re-use

The excavation works required to remove the tanks and create a hole large enough to allow groundwater pumping will result in a significant amount of material being taken from the ground. It is preferable, for economic reasons and to avoid unnecessary disposal at landfill, to ensure that where possible, materials are re-used on the site.

Based on the currently available information, it is considered that the soil is generally suitable for re-use in backfilling the excavation on the completion of the remedial works. However, should any obviously contaminated or suspect material be encountered during the works, further assessment will be required to assess its suitability for re-use.

Suspect material will not be re-used unless chemical testing and a subsequent risk assessment determines that the soil is suitable for re-use.

All material movements must be tracked and documented under a Materials Management Plan as part of the CLAIRE Code of Practice, or alternatively under a waste management exemption obtained from the Environment Agency.

3.6 Water Pipes

The local water company will be consulted concerning the laying of any water supply pipes in order to determine their requirements for protective measures and / or resistant pipe materials.

3.7 Contingency Plans

Should any previously unidentified contamination or suspect materials be encountered during earthworks, works must be halted and advice sought from a suitably qualified environmental consultant. Work will not re-commence until it has been demonstrated through a suitable risk assessment that the material does not represent a risk, or a suitable remedial strategy is developed to deal with the additional contamination.

4 OTHER CONSIDERATIONS

4.1 General

In addition to the remedial works described above, the following measures will be undertaken to mitigate the risks from the other minor contamination sources identified during the investigation works.

4.2 Heavy Hydrocarbon / PAH Contamination

Where any soft landscaped areas are proposed on the site, the Made Ground should be covered by approximately 500mm of clean cover to prevent potential exposure to PAH contaminated soils and to provide a suitable growing medium.

The cover layer should be verified by means of chemical testing prior to placement. Any test results and evidence of the placement of the clean material will be included in the verification report.

4.3 Ground Gas

Based the presently available information (i.e. the results of a single monitoring visit) the new building will require basic gas protection measures.

Therefore, in order to mitigate the potential risks from ground gas (and any residual vapours), any new buildings should include a reinforced concrete cast in-situ ground slab with all joints and penetrations sealed, and with a minimum 2000g membrane.

However, further gas monitoring will be undertaken as part of the remediation scheme which will provide more detailed information and may demonstrate that a gas protection measures are unnecessary.

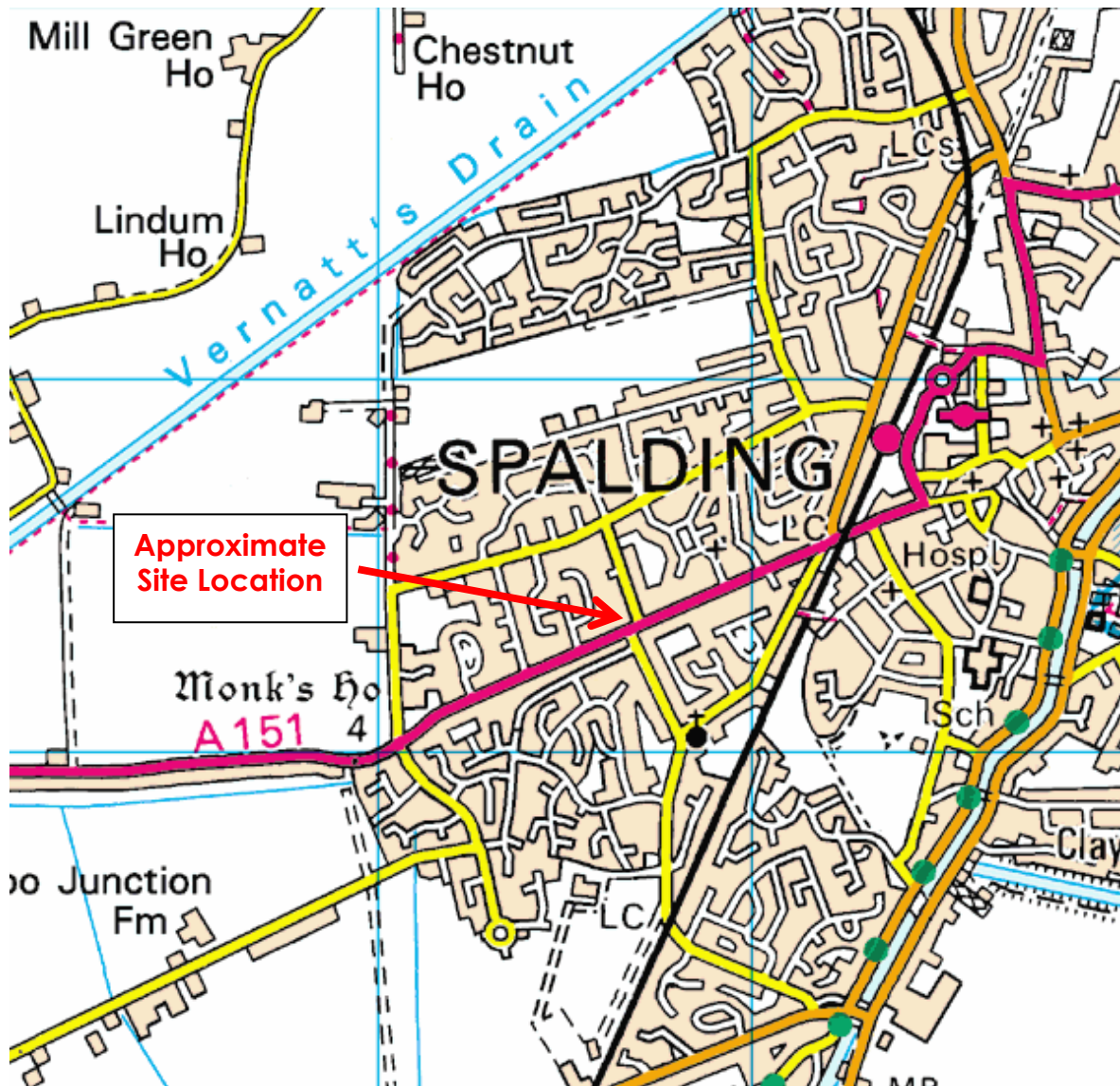
Assuming the soil and groundwater remediation is successful, a 1200g damp-proof membrane will suffice in place of a 2000g membrane.

4.4 Off-site Groundwater Contamination and Liability

The remediation works can only treat the on-site contamination. It is possible that some contamination has already migrated off-site within the groundwater. Although the likelihood is low, there are potential liabilities under common law associated with contamination impacting off-site properties, although the identification of the liable party would be a matter for the lawyers.

FIGURE 1

Site Location Map



Client A.F.Blakemore

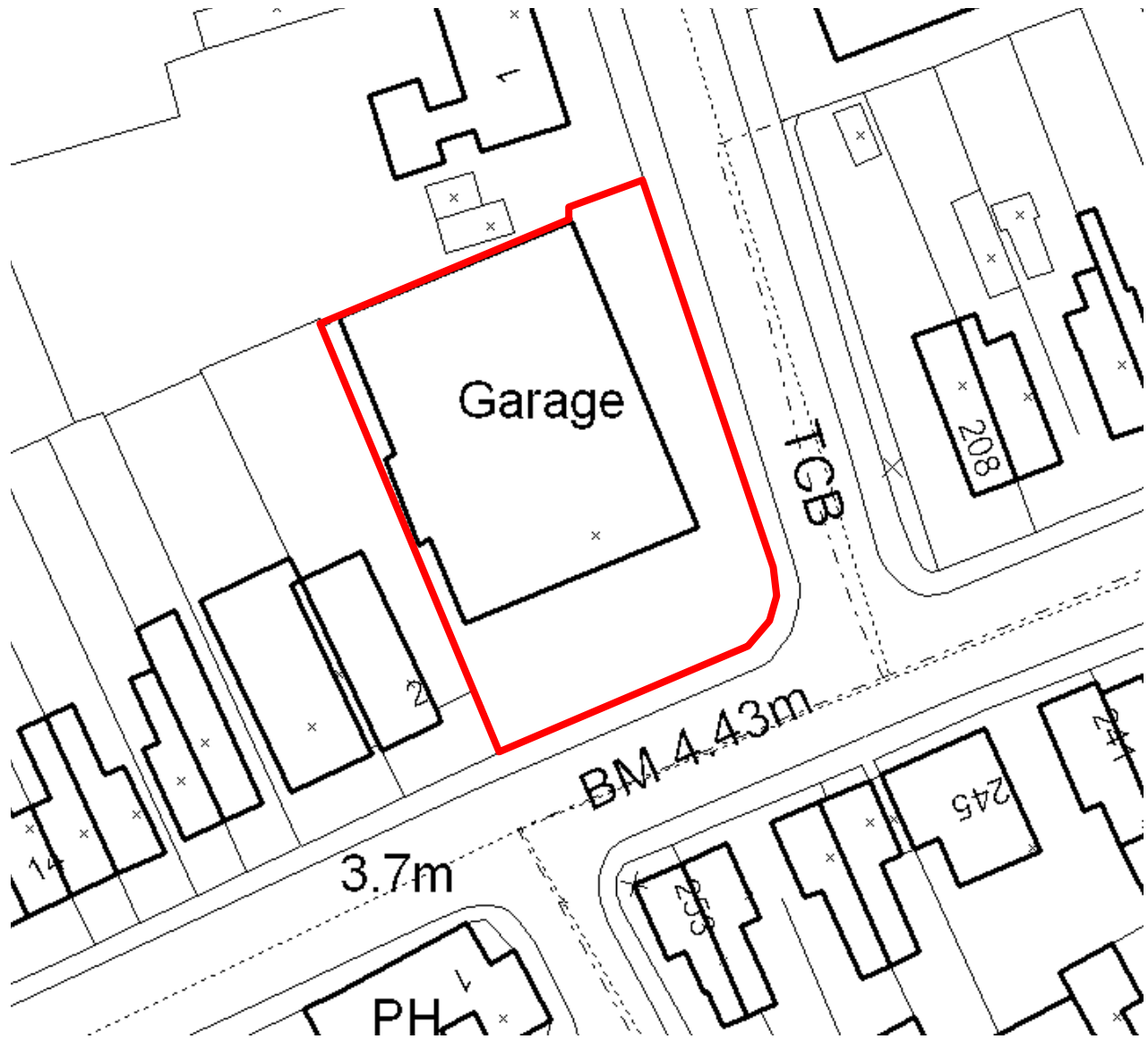
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Drawing Title Site Location Map.	Status Final	
	Scale - unless otherwise stated NTS	
	Drawing Number	Rev
	D001CMH- 080618	

FIGURE 2

Site Layout



Client A.F.Blakemore

Project Burdens Motors,
Spalding

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	Drawing Number	Rev
	D002CMH- 080618	

APPENDIX 1

Remedial Targets Worksheets

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Benzene	from Level 1
Target Concentration	C _T 1.00E-02	mg/l from Level 1

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

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

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

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

Initial contaminant concentration in groundwater at plume core	C ₀	9.00E+00	mg/l	Site measurement
Half life for degradation of contaminant in water	t _{1/2}	1.00E+100	days	
Calculated decay rate	λ	6.93E-101	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	5.00E+00	m	Site estimate
Plume thickness at source	Sy	3.00E+00	m	Site estimate
Saturated aquifer thickness	da	5.00E+00	m	Site estimate
Bulk density of aquifer materials	ρ	1.09E+00	g/cm ³	SC050021/SR3 for silt loam
Effective porosity of aquifer	n	4.00E-01	fraction	Estimate based on CLEA rep. values
Hydraulic gradient	i	1.00E-02	fraction	Estimate
Hydraulic conductivity of aquifer	K	1.58E-03	m/d	SC050021/SR3 for silt loam
Distance to compliance point	x	3.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only

Parameters values determined from options				
Partition coefficient	Kd	8.11E-01	l/kg	see options
Longitudinal dispersivity	ax	3.00E+00	m	see options
Transverse dispersivity	az	3.00E-01	m	see options
Vertical dispersivity	ay	3.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.95E-05	m/d	
Retardation factor	Rf	3.21E+00	fraction	
Decay rate used	λ	6.93E-101	d ⁻¹	
Rate of contaminant flow due to retardation	u	1.23E-05	m/d	
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	3.90E+00	mg/l	
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.31E+00		

Remedial Targets

Remedial Target	2.31E-02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			

Distance to compliance point 30 m

Concentration of contaminant at compliance point after C_{ED}/C_T 3.90E+00 mg/l Ogata Banks
1.0E+100 days

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

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

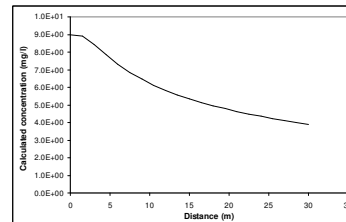
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	f _{oc}	1.20E-02	fraction
Organic carbon partition coefficient	K _{oc}	6.76E+01	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,i}		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	f _{oc}		fraction
Soil water partition coefficient	Kd	8.11E-01	l/kg

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

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

Longitudinal dispersivity	ax	Enter value	Calc value Xu & Eckstein	m
Transverse dispersivity	az	1.50E+00	3.00E-01	2.13E-01 m
Vertical dispersivity	ay	1.00E-04	3.00E-02	3.10E-02 m
Note values of dispersivity must be > 0				
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x				
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ X) ^{1.411} ; az = ax/10, ay = ax/100 are assumed				



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

Note

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

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

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

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Burdons Motors
Completed by: CMH
Date: 09/09/2010
Version: 1.0

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	TPH Aromatic C8-10		from Level 1
Target Concentration	C _T 2.00E-01	mg/l	from Level 1

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

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

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

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

Initial contaminant concentration in groundwater at plume core	C ₀	1.90E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.00E+100	days	
Calculated decay rate	λ	6.93E-101	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	5.00E+00	m	
Plume thickness at source	Sy	3.00E+00	m	
Saturated aquifer thickness	da	5.00E+00	m	
Bulk density of aquifer materials	ρ	1.09E+00	g/cm ³	
Effective porosity of aquifer	n	4.00E-01	fraction	
Hydraulic gradient	i	1.00E-02	fraction	
Hydraulic conductivity of aquifer	K	1.58E-03	m/d	
Distance to compliance point	x	3.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only

Parameters values determined from options				
Partition coefficient	Kd	1.90E+01	l/kg	see options
Longitudinal dispersivity	ax	3.00E+00	m	see options
Transverse dispersivity	az	3.00E-01	m	see options
Vertical dispersivity	ay	3.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	3.95E-05	m/d	
Retardation factor	Rf	5.28E+01	fraction	
Decay rate used	λ	6.93E-101	d ⁻¹	
Rate of contaminant flow due to retardation	u	7.48E-07	m/d	
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	8.23E+00	mg/l	
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.31E+00		

Remedial Targets

Remedial Target	4.62E-01	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	30	m	
Concentration of contaminant at compliance point after	C _{ED} /C _T 8.23E+00	mg/l	Ogata Banks
	1.0E+100	days	

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

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

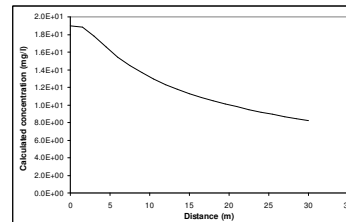
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	1.20E-02	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	1.59E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,i}		l/kg
Sorption coefficient for ionised species	K _{ow,i}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.90E+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	m
ax	1.50E+01	3.00E+00	3.35E+00
az	1.50E+00	3.00E-01	2.13E-01
ay	1.00E-04	3.00E-02	5.19E-05
Longitudinal dispersivity			
Transverse dispersivity			
Vertical dispersivity			
Note values of dispersivity must be > 0			
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x			
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ X) ^{1.411} ; az = ax/10, ay = ax/100 are assumed			



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

Note

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

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

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

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Burdons Motors
Completed by: CMH
Date: #####
Version: x.xx

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.9E+01
1.5	1.88E+01
3.0	1.78E+01
4.5	1.66E+01
6.0	1.54E+01
7.5	1.45E+01
9.0	1.36E+01
10.5	1.29E+01
12.0	1.23E+01
13.5	1.18E+01
15.0	1.13E+01
16.5	1.09E+01
18.0	1.05E+01
19.5	1.01E+01
21.0	9.78E+00
22.5	9.48E+00
24.0	9.19E+00
25.5	8.93E+00
27.0	8.68E+00
28.5	8.45E+00
30.0	8.23E+00