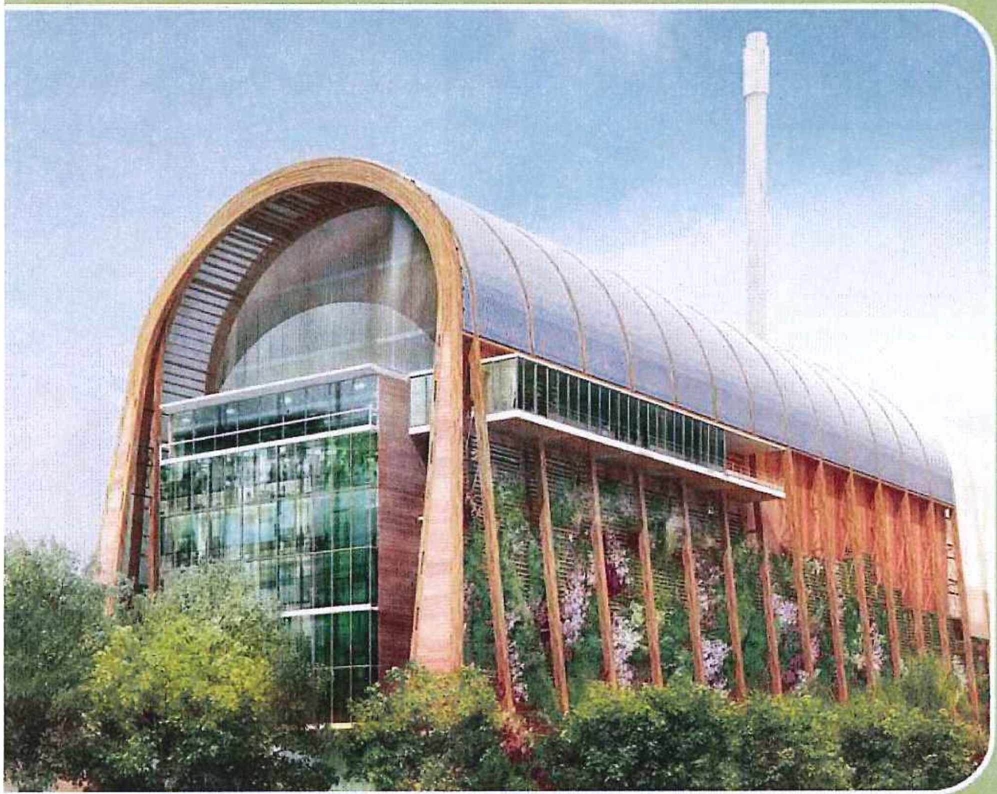
Recycling and Energy Recovery Facility

July 2012

Cross Green Industrial Estate
Leeds



Environmental Permit Application

Volume 4: Annexes B - F

Environmental Management System, Noise, Air Quality, Human Health Risk Assessment, Best Available Technology

ERM

VEOLIA ENVIRONMENTAL SERVICES

Environmental Permit Application

Prepared by: Nicola Crawford, Ioanna Gegisian, Nicola Finlay and Poulomee Basu.

12th July 2012

For and on behalf of
Environmental Resources Management

Approved by: Kirsten Berry

Signed: Kirsten Berry

Position: Partner

Date: 12th July 2012

Annex B

Certificate of Incorporation & Environmental Management Systems Certificates

CERTIFICATE OF INCORPORATION
OF A
PRIVATE LIMITED COMPANY

Company Number. 7876913

The Registrar of Companies for England and Wales, hereby certifies that

VEOLIA ES LEEDS LIMITED

is this day incorporated under the Companies Act 2006 as a private company, that the company is limited by shares, and the situation of its registered office is in England and Wales.

Given at Companies House, Cardiff, on 9th December 2011.

THE OFFICIAL SEAL OF THE REGISTRAR OF COMPANIES

Companies House

— *for the record* —

The above information was communicated by electronic means and authenticated by the Registrar of Companies under section 1115 of the Companies Act 2006

LRQA
Business Assurance

CERTIFICATE OF APPROVAL

This is to certify that the Business Management System of:

Veolia Environmental Services (UK) plc
Veolia ES (UK) Ltd and Subsidiaries
210 Pentonville Road
London N1 9JY
United Kingdom

has been approved by Lloyd's Register Quality Assurance to the following Quality, Environmental and Safety Management System Standards:

ISO 9001:2008
ISO 14001:2004
OHSAS 18001:2007

The scope of this approval is applicable to:

Integrated Resource Management including Waste Collection, Treatment, Disposal and Recycling.

This certificate is valid only in association with the certificate schedule bearing the same number on which the locations applicable to this approval are listed.

Approval
Certificate No: LRQ 4005031

Original QMS Approval: 4 March 2009*

Original EMS Approval: 4 March 2009*

Original SMS Approval: 3 April 2009*

Current Certificate: 19 April 2012

Certificate Expiry: 31 March 2015

Issued by: Lloyd's Register Quality Assurance Limited

*This certificate is a continuation of previous approvals as follows:-
QMS originally registered 11 May 1993, DNV Certificate Number 16206-2007-AQ-NLD-UKAS
EMS originally registered 11 May 1993, DNV Certificate Number 16205-2007-AE-NLD-UKAS
SMS originally registered 23 May 2008, DNV Certificate Number 27871-2008-AHSO-NLD-RvA

UKAS MANAGEMENT SYSTEMS
001

LRQA
Business Assurance

CERTIFICATE SCHEDULE

Veolia Environmental Services (UK) plc
Veolia ES (UK) Ltd and Subsidiaries
210 Pentonville Road
London N1 9JY
United Kingdom

Head Office

210 Pentonville Road,
London, N1 9JY
United Kingdom

Activities

Integrated Resource Management including Waste Collection, Treatment, Disposal and Recycling.

Divisions	Locations
Veolia Environmental Services Limited Central Functions	See Controlled Document LRQ 4005031/A
Veolia Environmental Services Limited Municipal Division	See Controlled Document LRQ 4005031/B
Veolia Environmental Services Limited Commercial & Hazardous Division	See Controlled Document LRQ 4005031/C
Veolia Environmental Services Limited Treatment Division , Energy Recovery Facilities and Integrated Contracts	See Controlled Document LRQ 4005031/D
Veolia Environmental Services Limited Darlaston Recycling	See Certificate LRQ 4005031/E
Veolia ES Field Services Limited	See Certificate LRQA 4005031/F

Approval
Certificate No: LRQ 4005031

Original QMS Approval: 4 March 2009*

Original EMS Approval: 4 March 2009*

Original SMS Approval: 3 April 2009*

Current Certificate: 19 April 2012

Certificate Expiry: 31 March 2015

*This certificate is a continuation of previous approvals as follows:-
QMS originally registered 11 May 1993, DNV Certificate Number 16206-2007-AQ-NLD-UKAS
EMS originally registered 11 May 1993, DNV Certificate Number 16205-2007-AE-NLD-UKAS
SMS originally registered 23 May 2008, DNV Certificate Number 27871-2008-AHSO-NLD-RvA

UKAS MANAGEMENT SYSTEMS
001

Approval Certificate No: LRQ 4005031
This document is subject to the provision on the reverse
71 Fenchurch Street, London EC3M 4BS United Kingdom.

LRQA
Business Assurance

CERTIFICATE OF APPROVAL

This is to certify that the Business Management System of:

Veolia Environmental Services (UK) plc
Veolia ES (UK) Ltd and Subsidiaries
Treatment Division and
Energy Recovery Facilities and Integrated Contracts

has been approved by Lloyd's Register Quality Assurance to the following Quality, Environmental and Safety Management System Standards:

ISO 9001:2008
ISO 14001:2004
OHSAS 18001:2007

The scope of this approval is applicable to:

Integrated Resource Management including Waste Collection, Treatment, Disposal and Recycling.

All approved sites are listed on Controlled Document LRQ 4005031/D

Approval
Certificate No: LRQ 4005031/D

Original QMS Approval:	4 March 2009*
Original EMS Approval:	4 March 2009*
Original SMS Approval:	3 April 2009*
Current Certificate:	19 April 2012
Certificate Expiry:	31 March 2015

Issued by: Lloyd's Register Quality Assurance Limited

*This certificate is a continuation of previous approvals as follows:-
QMS originally registered 11 May 1993, DNV Certificate Number 16206-2007-AQ-NLD-UKAS
EMS originally registered 11 May 1993, DNV Certificate Number 16205-2007-AE-NLD-UKAS
SMS originally registered 23 May 2008, DNV Certificate Number 27871-2008-AHSO-NLD-RvA

UKAS MANAGEMENT SYSTEMS
001

Approval Certificate No: LRQ 4005031
This document is subject to the provision on the reverse
71 Fenchurch Street, London EC3M 4BS United Kingdom.
This approval is carried out in accordance with the LRQA assessment and certification procedures and monitored by LRQA.
The use of the UKAS Accreditation Mark indicates Accreditation in respect of those activities covered by the Accreditation Certificate Number 001
Macro Revision 13

LRQA Business Assurance

Veolia QHSE Certificate Site Schedule
Controlled Document LRQ 4005031/D
Treatment Division

Issue 1.0
Data Version date:19-04-12

IC - BIRMINGHAM

Site	Address
Birmingham Head Office	James Road, Tyseley, Birmingham, B11 2BA
Castle Bromwich CA	Tameside HRC, Chester Road, Birmingham, B35 7AG
Four Ashes MRF	1 Station Road, Four Ashes, Wolverhampton, West Midlands, WV10 7DG
Lifford Lane Transfer Station and CA	Lifford Lane, Edbury Road, Stirchley, Birmingham, B30 3JH
Norris Way CA	Norris Way, Sutton Coldfield, Birmingham, B75 7BB
Perry Barr Transfer Station and CA	Holford Drive, Perry Barr, Birmingham, B42 2TU
Tyseley CA	James Road, Tyseley, Birmingham, B11 2BA
Birmingham ERF	Energy Way, Off Small Heath Highway, Tyseley, Birmingham, B10 0HD

IC - HAMPSHIRE

Alton MRF	Farnham Road, Upper Froyle, Alton, Hants, GU34 4JB
Andover Transfer Station	Harewood Forest Industrial Estate, A303, Longparish, Andover, Hants, SP11 7AQ
Blue Haze Transfer Station	Verwood Road, Ringwood, Hampshire, BH24 3QE
Chilbolton Down Composting	Heath House Estate, Chilbolton, Stockbridge, Hampshire, SO20 6BU
Down End Composting	Down End Road, Fareham, Hants, PO16 8ER
Hampshire Haulage (Marchwood)	Integra South West ERF, Oceanic Way, Marchwood Industrial Park, Normandy Way, Marchwood, Hampshire SO40 4BD
Hampshire Haulage Workshop	Unit 35, Stephenson Road, South Hants Industrial Park, Brunel Road, Totton, S40 3SA.
Licensing and Technical Support	Poles Lane, Otterbourne, Winchester, Hampshire, SO21 2EA
Little Bushywarren Composting	Little Bushy Warren Lane, Herriad, Nr Basingstoke, RG25 2NS
Lymington Transfer Station	Marsh Lane, Lymington, Hampshire, SO41 9BX
Marchwood Transfer Station	Bury Road, Marchwood, Southampton, Hants, SO40 4UD

Site	Address
Netley Transfer Station	Porstmouth Road, Woolston, Netley, Southampton, SO31 8BT
Otterbourne Head Office	Poles Lane, Otterbourne, Winchester, Hampshire, SO21 2EA
Otterbourne Transfer Station & Clinical	Poles Lane, Otterbourne, Hants, SO21 2EA
Portsmouth Clinical Transfer Station	Quartemaine Road, Portsmouth Hants, PO3 5QH
Portsmouth MRF & TS	Quartermaine Road, Portsmouth Hants, PO3 5QH
Rushmoor Transfer Station	Eelmoor Road, Farnborough, Hants, PO17 6AL
Warren Farm Transfer Station	Down End Road, South Boarhunt, Fareham, Hants, PO17 6AL
Chineham ERF	Integra North ERF, Whitmarsh Lane, Reading Road, Basingstoke, Hampshire, RG24 8LL
Marchwood ERF	Area 6 Oceanic Way, Marchwood Industrial Park, Marchwood, Southampton, SO40 4BD
Portsmouth ERF	Integra South East ERF, Quartemaine Road, Portsmouth, PO3 5QH

IC - MERSEYSIDE

Head Office Bidston Recycling Park	Wallasey Bridge Rd, Birkenhead, Merseyside, CH41 1EF
Bidston Recycling Park	Wallasey Bridge Rd, Birkenhead, Merseyside, CH41 1EF
Gillmoss WTS	Bridgehouse Lane, Liverpool, L10 5HA
Huyton WTS & HWRC	Ellis Ashton St, Huyton, Liverpool, L36 6BJ
Southport WTS & HWRC	Foul Lane, Southport PR8 5LA
Clatterbridge HWRC	Mount Rd, Clatterbridge, CH63 6JE
Formby HWRC	Altcar Rd, Formby, L37 8DL
Kirkby HWRC	Depot Rd, Knowsley Industrial Park, Kirkby, L33 3AR
Newton-le-Willows HWRC	Junction Lane, Newton-le-Willows, St. Helens, Merseyside, WA12 8DN
Otterspool HWRC	Jericho Lane, Liverpool, L17 5AR
Rainford HWRC	Southerns Lane, Rainford, Merseyside, WA11 8EY

LRQA Business Assurance

Site	Address
Rainhill HWRC	Tasker Terrace, Rainhill, Merseyside, L35 4NX
Ravenhead HWRC	Burtonhead Rd, St. Helens, WA9 5EA
South Sefton Recycling Park	Irlam Rd, Bootle, L20 4AE
Sefton Meadows HWRC	Sefton Lane, Maghull, L31 8BT
West Kirby HWRC	Greenbank Rd, West Kirby, CH48 5HL
Johnsons Lane RHWC	Johnsons Lane, Widnes, WA8 0SJ
Picow Farm RHWC	Picow Farm Rd, Runcorn, Cheshire, WA7 4UD
Haddocks Wood Composting Facility	Warrington Rd, Astmoor Industrial Estate, Runcorn, Cheshire, WA7 1QH
VES Merseyside & Halton Ltd Transport Operations	Main Transport Office, Ellis Ashton Street, Huyton, Liverpool, L36 6BJ

IC - NOTTINGHAMSHIRE

Beeston HWRC	Lilac Grove, Beeston, Nottinghamshire, NG9 1PF
Bilsthorpe HWRC	Brailwood Road, Bilsthorpe, Nottinghamshire, NG22 8UA
Calverton HWRC	Hollingwood Lane, Calverton, Nottinghamshire, NG14 6NR
Newark HWRC	Brunel Drive, Newark, Nottinghamshire NG24 2DE
Fiskerton HWRC	Fiskerton Road, Southwell, Nottinghamshire, NG25 0TH
Freeth Street TS/Haulage	c/o Trentside Offices, Freeth Street, Nottingham, NG2 3GT
Giltbrook HWRC & Transfer Station	Gilthill Road, Giltbrook, Nottinghamshire, NG16 5LZ
Hucknall HWRC	Wigwam Lane, Hucknall, Nottinghamshire, NG15 7SZ
Kirkby HWRC	Sidings Road, Lowmoor Industrial Estate, Kirkby, Nottinghamshire, NG17 7JZ
Langar HWRC	Coach Gap Lane, Langar, Nottinghamshire, NG13 9HP
Mansfield HWRC	Kestral Park (off Hermitage Lane), Mansfield, Nottinghamshire, NG18 5PT

Site	Address
Mansfield MRF	Warren Way, Mansfield, Nottinghamshire NG19 0FL
Nottinghamshire Head Office	Unit 4, Chase Park, Daleside Road, Nottingham NG2 4GT
Retford HWRC	Hallcroft Road, Retford, Nottinghamshire, DN22 7LB
Warsop HWRC	Oakfield Lane, Warsop, Nottinghamshire, NG20 0JG
West Bridgford HWRC	Rugby Road, West Bridgeford, Nottinghamshire, NG2 7HX
Worksop HWRC	Shireoaks Road, Worksop, Nottinghamshire, S80 3HA

IC - SHEFFIELD

Beighton Road HWRC	Beighton Road, Woodhouse, Sheffield, S13 7PS
Bernard Road Call Centre	Bernard Road Service Centre, Bernard Road, Sheffield, S4 7YX
Blackstock Road HWRC	Blackstock Road, Sheffield, S14 1FY
District Heating	Bernard Road Service Centre, Bernard Road, Sheffield, S4 7YX
Douglas Road HWRC	Longley Avenue West, Sheffield, S5 8WA
High Green HWRC	Greaves Lane, High Green, Sheffield, S35 4GR
Lumley Street Municipal Collections	Lumley Street Service Centre, Lumley Street, Sheffield, S4 7YX
Lumley Street Workshop.	Lumley Street Service Centre, Lumley Street, Sheffield, S4 7YX
Manchester Road HWRC	Manchester Road, Deepcar, Sheffield, S36 2DT
Sheffield CA Management	Lumley Street Service Centre, Lumley Street, Sheffield, S4 7YX
Sheffield Head Office	Bernard Road, Sheffield, S4 7YX
Sheffield MRF	Crown Works, Rotherham Road, Beighton, Sheffield, S20 1AH
Sheffield ERF	Bernard Road Service Centre, Bernard Road, Sheffield, S4 7YX

LRQA Business Assurance

Veolia QHSE Certificate Site Schedule
Controlled Document LRQ 4005031/D
Treatment Division

Issue 1.0
Data Version date:19-04-12

IC - SHROPSHIRE

Site	Address
Battlefield IWMF	Battlefield Enterprise Park, Vanguard Way, Shrewsbury, SY1 3EH
Bridgnorth Municipal	Bridgnorth District Council Depot, Stanley Lane, Shropshire, WV16 4SF
Craven Arms IWMF	Craven Arms Integrated Waste Management Facility, Long Lane Industrial Estate, Long Lane, Craven Arms, Shropshire, SY7 8DU
Ludlow HRC	Coder Road, Ludlow, SY8 1XE
South Shropshire Collections	Coder Road, Ludlow, SY8 1XE
Oswestry IWMF (Service Centre Depot)	Mile Oak Industrial Estate, Oswestry, Shropshire, SY10 8GA
Oswestry IWMF (TS & HRC)	Mile Oak Industrial Estate, Oswestry, Shropshire, SY10 8GA
Shrewsbury Municipal	Weeping Cross Depot, Weeping Cross, Shrewsbury, SY5 6HY
Shropshire Head Office	VES Shropshire Limited, Bolingbroke House, Vanguard Way, Battlefield Enterprise Park, Shrewsbury SY1 3TG
Wem Municipal	(JP Smith & Sons Contract), Aston Road Business Park, Aston Road, wem, SY4 5BA
Whitchurch IWMF	Whitchurch Integrated Waste Management Facility, Waymills Industrial Area, Whitchurch Business Park, Whitchurch, SY1 1TT

IC - SOUTH DOWNS

Brighton (Sheepcote) CA	Sheepcote Valley Site, Wilson Avenue, Opposite junction with Vines Cross Road, Brighton, East Sussex, BN2 5PA
Crowborough CA	Wealdon Industrial Estate, Farningham Road, Crowborough, TN6 2JR
Eastbourne CA	Roselands Depot, St Phillips Avenue, Eastbourne, East Sussex, BN22 8NB
Forest Row CA	Station Road, Forest Row, East Sussex, RH18 5DW
Hailsham CA	Station Road, Hailsham, East Sussex, BN27 2BY
Hastings CA	Freshfield Lane, Bexhill Road, St Leonard's on Sea, East Sussex, TN38 8AY

Site	Address
Heathfield CA	Burwash Road, Heathfield, East Sussex, TN21 8RA
Hollingdean MRF & Transfer Station	Hollingdean Lane, Brighton, East Sussex, BN1 7BB
Hove CA & Transfer Station	Leighton Road Depot, Off Shoreham Road, Hove, East Sussex, BN3 7ES
Lewes CA	Ham Lane, Lewes, East Sussex, BN7 3PS
Mountfield CA	Freeman House, Ellen Street, Portslade, Brighton, East Sussex, BN41 1DU
Newhaven CA	New Road, Newhaven, East Sussex, BN9 0EH
Pebsham Transfer Station	Freshfield Lane, Bexhill Road, St Leonard's on Sea, East Sussex, TN38 8AY
Portslade Head Office	Freeman House, Ellen Street, Portslade, Brighton, East Sussex, BN41 1DU
Seaford CA	Cradle Hill Industrial Estate, Seaford, East Sussex, BN25 3JB
South Downs Haulage	Freshfield Lane, Bexhill Road, St Leonard's on Sea, East Sussex, BN8 6JB
Wadhurst CA	Faircrouch Lane, Wadhurst, East Sussex, TN5 6BX
Maresfield CA	Batts Bridge Road, Maresfield, East Sussex, TN22 2HN
Maresfield Transfer Station	Batts Bridge Road, Maresfield, East Sussex, TN22 2HN

IC - SOUTHWARK

Transfer Station	43 Devon Street, London SE15 1AL
Municipal Collections	43 Devon Street, London SE15 1AL

IC - WEST BERKSHIRE

Municipal Collections	Padworth IWMF, Padworth Lane, Thatcham, West Berkshire RG7 4JF
Newtown Road CA	Newtown Road (A339),Newbury, Berkshire RG20 9AG
West Berks Head Office	Padworth IWMF, Padworth Lane, Thatcham, West Berkshire RG7 4JF

LANDFILL

Albion Landfill	Occupation Road, Albert Village, Swadlincote, DE11 8HD
Blue Haze Landfill	Verwood Road, Ringwood, Hampshire, BH24 3QE

Veolia QHSE Certificate Site Schedule
Controlled Document LRQ 4005031/D
Treatment Division

Issue 1.0
Data Version date:19-04-12

Site	Address
Candles Landfill	Dog in the Lane, Little Wenlock, Telford, Shropshire, TF6 5AR
Croft Farm Landfill	Askern Road, Carcroft, Doncaster, S Yorks, DN6 8DE
Gas Department	Poles Lane, Otterbourne, Winchester, Hampshire, SO21 2EA
Gerrards Cross Landfill	Wapseys Wood, Oxford Road, Gerrards Cross, Bucks, SL9 8TGE
Highmoor Landfill	Doctor Lane, Scouthead, Oldham, Lancashire, OL4 3SA
Leachate Department	Poles Lane, Otterbourne, Winchester, Hampshire, SO21 2EA
Ling Hall Landfill	Ling Hall Quarry, Coalpit Lane, Lawford Heath, Rugby, Warwickshire, CV23 9HH
Norwood - Landfill Monitoring and administration	Norwood Industrial Estate, Ellisons Road, Killamarsh, Sheffield, S21 2DR
Sandy Lane Landfill	Sandy Lane, Wildmoor, Bromsgrove, Worcestshire, B61 0QT
Southern Closed Landfill Management	Medebridge Road, Grays, Essex RM16 5TZ

LANDFILL - CLOSED HAMPSHIRE

Bramshill - Closed Landfill	Plough Lane, Eversley, Hants, RG27
Efford - Closed Landfill	Milford Road, Pennigton, Lymington, Hampshire, SO41 8DF
Hampshire Landfill Management	Poles Lane, Otterbourne, Winchester, Hampshire, SO21 2EA
Paulsgrove - Closed Landfill	Port Solent, Portsmouth, Hampshire
Somerley - Closed Landfill	Verwood Road, Somerley, Ringwood, Hants, BH25 3QE
Southleigh - Closed Landfill	Emsworth Common Road, Emsworth, Hampshire

LANDFILL - CLOSED SOUTH

Springfield Farm Landfill	Broad Lane, Beaconsfield, Bucks, HP9 1XD

Veolia QHSE Certificate Site Schedule
Controlled Document LRQ 4005031/D
Treatment Division

Issue 1.0
Data Version date:19-04-12

LONDON & SE

Site	Address
Greenwich IWF	Nathan Way, Plumstead March, Thamesmead, SE28 0AN
Material Sales	Whitewall Road, Medway City Industrial Estate, Rochester,Kent ME2 4DZ
Northumberland Wharf Transfer Station	Yabsley Street, Poplar, London, E14 9RG
Ockendon Landfill	Medebridge Road, Grays, Essex RM16 5TZ
Pitsea Landfill	Pitsea Hall Lane, Pitsea, Basildon, Essex, SS16 4UH
Rainham Compost	Coldharbour Lane, Off Ferry Lane, Rainham, Essex, RM13 9DA
Rainham Landfill	Coldharbour Lane, Off Ferry Lane, Rainham, Essex, RM13 9DA
Rainham Integrated Waste Facility	Coldharbour Lane, Off Ferry Lane, Rainham, Essex, RM13 9DA
Technical Centre Eastwood	Airbourne Close, Arterial Close, Eastwood, Leigh on Sea, Essex, SS9 4EL
SELCHP	Landmann Way, Off Surrey Canal Road, London SE14 5RS
Southwark Workshop	30-34 Penrose Street, London, SE17 3DW

Annex C

Noise Assessment from Environmental Statement & Baseline Noise Monitoring Report

9 NOISE AND VIBRATION

9.1 Introduction

This Chapter is a summary of Appendix E which contains a Noise and Vibration Impact Assessment (NVIA) prepared in relation to the proposed development.

The aim of the NVIA is to predict the noise levels associated with the construction and operation of the proposed facility and to assess the likely noise levels at the nearest sensitive receptors. The assessment outlines the mitigation measures to be undertaken in order to achieve the noise limits specified by LCC's Environmental Health Officer at the nearest sensitive receptors.

- assess the noise and vibration impacts from the construction of the facility;
- predict the noise levels at the nearest residential receptors from the operation of the proposed facility and from vehicle movements associated with the development on public roads;
- undertake an assessment at the closest residential properties in accordance with the requirements of BS 4142;
- determine the internal noise levels within the closest offices to the facility, and at a proposed Vocational Academy to be located to the north of the facility; and
- recommend noise mitigation measures, if required.

Appendix E describes a summary of relevant national and local policy guidance and details of consultations undertaken. The methodologies used to identify and assess the potential significant effects of the proposed development during the construction and operational phases are then detailed before a description of the baseline conditions is provided. Potential impacts are then presented, before mitigation measures are identified and an assessment of residual effects undertaken. A summary of the assessment is then provided, together with relevant conclusions.

9.2 Assessment Methodology

LCC were consulted with regard to the most appropriate assessment methodology.

9.2.1 *Baseline Noise Measurements*

To quantify the prevailing baseline noise climate, measurement surveys have been carried out at locations representative of surrounding sensitive receptors.

9.2.2 *Site Construction Noise*

Construction noise predictions have been carried out based on the methodology outlined in BS 5228-1: 2009 'Code of practice for noise and vibration control on construction and open sites. Part 1: Noise'. BS 5228 predicts noise as an equivalent continuous noise level averaged over a period such as 1 hour ($L_{Aeq,1h}$).

Details pertaining to construction plant have been sourced from VES for employment in the construction noise assessment.

Noise levels generated by construction activities are regulated by guidelines and subject to Local Authority control. No UK national noise limits exist for construction noise. However, guidance on acceptable noise levels is provided in British Standard BS 5228: 2009. BS 5228 contains a methodology for assessing the significance of impact of construction noise in relation to the ambient noise levels for residential properties. This is known as the ABC method. The criteria for significance is provided in BS 5228-1: 2009.

9.2.3 *Construction Vibration*

Ground vibrations may cause reactions ranging from 'just perceptible' through 'concern' to 'alarm' and 'discomfort'. The subjective response varies widely and is a function of situation, information, time of day and duration.

Buildings are reasonably resilient to ground-borne vibration and vibration-induced damage is rare. Vibration-induced damage can arise in different ways, making it difficult to arrive at universal criteria that will adequately and simply indicate damage risk. Damage can occur directly due to high dynamic stresses, due to accelerated ageing or indirectly, when high quasi-static stresses are induced by, for example, soil compaction.

Vibration due to specific construction work has been estimated at sensitive receptors using example measured source data and the appropriate propagation relationship taken from BS 5228-2: 2009 'Code of practice for noise and vibration control on construction and open sites. Part 2: Vibration'.

The estimated vibration due to construction works on site are compared to the target limits specified in BS 5228-2 Annex C2 to determine the significance of the vibration effects in terms of nuisance. Effects classified as moderate or major are classified as significant; those classified as negligible or minor are not significant.

The estimated vibration due to construction works on site are compared to the target limits specified in BS 7385-2 to determine the significance of the vibration effect in terms of cosmetic building damage.

9.2.4 *Operational Plant Noise*

LCC confirmed that a BS 4142 assessment be undertaken for the operation of the RERF, with the preferred Rating Level from operations to be 5 dB(A) or more below the background noise level at nearest residential receptors (meaning that complaints are unlikely).

A noise propagation model has been developed in the SoundPLAN suite of programs, which implements a range of calculation methods, including the ISO 9613-2 calculation method for industrial noise sources.

The model consists of a three dimensional representation of the proposed facility and the surroundings and has been employed to calculate noise levels at surrounding sensitive receptors due to noise breakout from the facility buildings, noise emission from external plant and activities, and noise emission from HGVs on site.

The assessment of the significance of the noise impacts at residential properties has been based on the guidance in BS 4142: 1997 'Rating industrial noise affecting mixed residential and industrial areas' and LCC's local requirements.

9.2.5 *Operational Plant Vibration*

As the operational RERF will not include any potentially significant sources of vibration, operational vibration effects have been scoped out of the assessment.

9.2.6 *Construction and Operational Traffic Noise*

The magnitude of the impact of noise associated with road traffic generated by the construction and operation of the proposed development has been assessed by calculating the change in the traffic noise levels on the ELLR.

The calculations employ the methodology provided in Calculation of Road Traffic Noise (CRTN), which is the standard methodology adopted in the UK for the calculation of noise levels from road traffic and are based on traffic data included in the Transportation Assessment (Appendix C).

It is generally accepted that changes in road traffic noise levels of 1dB(A) or less are imperceptible; changes of at least 3dB(A) are required for perceptibility. An increase of 10dB(A) is generally perceived as a doubling in loudness.

9.3 Baseline Conditions

9.3.1 *Noise*

Four measurement locations were selected to represent the closest noise sensitive receptors from the proposed site:

- Receptor 1: 225 Cross Green Lane, representative of residential properties to the west of the site.
- Receptor 2: On Halton Moor Road, at a location representative of the nearest residential properties to the site.
- Receptor 3: On Newmarket Lane, at a location representative of the western façade of offices on Felnex Square.
- Receptor 4: Newmarket Approach, to the north of the site at the location of the southern boundary of the proposed Vocational Academy.

These receptors, and the proposed application site boundary, are illustrated in Figure E1 in Appendix E.

Further detail regarding the instrumentation employed, meteorological conditions and the protocol adopted during the noise surveys is provided in Appendix E.

A full set of the monitoring results is provided in Appendix E. As may be expected, measured levels during the daytime period are greater than those measured during the night time period due to the dominant influence of road traffic noise at most locations.

9.3.2 *Vibration*

It is noted that (unlike noise) the assessment of acceptability of new sources of vibration to be introduced to an area does not rely on comparison between existing and future predicted vibration levels. Therefore, no measurements of existing ground borne vibration levels have been undertaken.

9.4 Assessment of Impacts

9.4.1 *Construction Noise*

Receptor Locations

Noise levels resulting from construction activities were predicted at two selected receptors. These receptors were chosen as being representative of the closest noise sensitive properties in different directions from the application site:

- Receptor 1: 225 Cross Green Lane, representative of residential properties to the west of the site.
- Receptor 2: On Halton Moor Road, at a location representative of the nearest residential properties to the site.
- Receptor 3: On Newmarket Lane, at a location representative of the western façade of offices on Felnex Square.
- Receptor 4: Newmarket Approach, to the north of the site at the location of the southern boundary of the proposed Vocational Academy.

The receptor locations are shown in Figure E1 in Appendix E.

Construction Activities

For the purposes of predicting indicative construction noise levels, the likely construction activities have been broken down into various construction scenarios based on the indicative construction programme provide. The scenarios are as follows:

- Demolition/breaking out of hardstanding
- Earthworks
- Excavations and \Foundations
- CFA Piling
- Slab Construction
- Steelwork Construction
- Finishing and Fitting
- Hardstanding
- Access roads on site

The activities and associated plant items employed during each 'phase' are listed within Annex D of Appendix E. Also listed are assumed 'on-times' (the percentage of time that an item of plant is operational per day or hour or other relevant time period) and the reference source noise levels employed within the calculations, sourced from BS 5228-1.

9.4.2 *Predicted Noise Levels*

Construction noise levels to residential receptors are predicted to fall below the threshold levels when assessed using the ABC method given in BS 5228.

During the breaking out of the existing hardstanding there may be significant effects at the closest offices on Felnex Square and at the proposed Vocational Academy. The provision of noise barriers to the construction activities should provide 5 to 10 dB(A) reduction, resulting in negligible effects at these receptors.

The predicted noise levels from the construction activities are based upon information available at the time of writing. Certain assumptions have been made regarding locations and combinations of activities in order to arrive at single figure noise predictions. Should significantly different plant or activities be proposed by the contractor, the construction calculations may require revisiting. Nevertheless, although noise is an inevitable consequence of construction work, it is considered that by employing considerate working practices and best practicable means, resulting noise levels can be reduced to an acceptable level.

9.4.3 *Construction Vibration*

It is anticipated that Continuous Flight Auger (CFA) piling will be employed for the construction works on the application site.

Employing the case history data in Table D6 of BS 5228-2, which provide measured ground vibration levels at set distances from representative piling works, peak particle velocity vibration values at receptors R1 to R4 have been estimated. The results with the criteria for nuisance demonstrates that resultant ground- borne vibration levels at the location of the residential properties (R1 and R2) are unlikely to be perceptible. At the offices on Felnex Square vibration is likely to be perceptible but can be tolerated if prior warning is given. At the proposed Vocational Academy, vibration may just be perceptible.

Comparison of the results with the criteria for building damage in BS 7385-2: 1993 all the predicted vibration levels fall well below the criteria for building damage.

9.4.4 *Operational Noise*

Operational Noise Model

Noise level contours resulting from the operation of the RERF were calculated for daytime operation and night-time operation as described in Appendix E.

In order to best represent the anticipated operations at the RERF the scenarios that have been modelled are shown below in Table 9.1. All scenarios were modelled at each of the receptor locations:

Table 9.1: Operational Scenarios

Scenario	Time period	Tipping Hall	MPT	ERF	Bottom Ash Conveyer	Bottom Ash	HGVs
Daytime	07:00-23:00	✓	✓	✓	✓	✓	✓
Night-time	23:00-07:00	✓	✓	✓	✓	✓	✓

A BS 4142 assessment has been undertaken to predict the impact of the proposed RERF (including vehicle movements) upon the nearest residential receptors for both daytime and night-time periods. The predictions have been based on the measured L_{A90} levels. The predictions are for operations during a worst-case hour during the daytime and a worst-case 5 minutes at night.

The results of the assessment are shown with a correction for stack directivity applied in Table E7.6 of ES Appendix E. The correction for stack directivity is taken from the US Department of Defence document 'Power Plant Acoustics', May 2003 which reduces the sound power level of the stack by 5 dB.

The BS 4142 assessment for the daytime operation of the facility with the correction applied for stack directivity illustrates that at the residential properties (Cross Green Lane and Halton Moor Road) predicted noise levels will fall below the existing background noise levels during the daytime period. The predicted noise levels also fall below the Leeds City Council preferred Rating Level criterion.

The BS 4142 assessment for the night-time operation of the facility illustrates that the predicted noise levels at residential properties on Cross Green Lane will fall below the existing background noise levels and also the Leeds City Council preferred Rating Level criterion at Cross Green Lane at all floor levels. At Halton Moor Road the predicted noise levels fall below the existing background noise level however they marginally exceed the Leeds City Council preferred Rating Level at first floor level when one Tipping Hall door is open.

Internal Noise Levels

Predicted internal noise levels at the closest offices and the proposed Vocational Academy have been estimated and assume double-glazed window units providing a minimum attenuation of 32 dB. The internal noise levels are provided in Table E7.5 of ES Appendix E.

The estimated internal noise level to the offices on Felnex Square without the stack directivity corrected falls within the recommended 'good' internal noise levels of 35-40 dB, both with and without the RERF. At the proposed Vocational Academy the estimated internal noise level falls well below the recommended internal noise levels for classrooms of 35 dB, both with and without the RERF.

As other noise from other elements of the facility are dominant over the stack contribution at the offices and academy, predicted noise levels at the façade of these receptors are negligibly different. Therefore, internal noise levels within the offices and the academy are the same as those estimated for when no stack directivity correction is applied.

The prevailing ambient noise level at the offices on Felnex Square is approximately 65 dB(A). The additional contribution from the RERF will result in a total noise level of 66 dB(A), an increase of 1 dB(A). The significance of this increase is assessed as negligible.

The prevailing ambient noise level at the site of the proposed Academy is approximately 61 dB(A). The additional contribution from the RERF will not result in the total noise level increasing.

Assessment Summary

It can be seen from the assessment that the predicted noise levels at the residential receptors fall below the existing background noise levels. The LCC criterion is also met at all of the residential receptors with the exception of Halton Moor Road where the predicted noise levels marginally exceed the Leeds City Council preferred Rating Level at first floor level when one Tipping Hall door is open. The estimated internal noise level to the offices on Felnex Square falls within the recommended 'good' internal noise levels of 35-40 dB. At the proposed Vocational Academy the estimated internal noise level falls well below the recommended internal noise levels for classrooms of 35 dB.

9.4.5 *Operational Vibration*

As the operational RERF will not include any potentially significant sources of vibration, operational vibration effects have been scoped out of the assessment.

It is considered that HGV traffic on the access and internal routes will not generate high levels of ground-borne vibration, provided the surfaces are maintained in good condition.

9.4.6 *Road Traffic Noise*

The estimated with-development and without-development road traffic flows have been used to calculate the 18 hour weekday flow (06:00-00:00) and the percentage increase in road traffic flows as a result of the operation of the facility. The increase in road traffic flows as a result of the operation of the facility illustrates that an increase of no greater than 1.8 % is estimated. Any resultant increase in noise levels as a consequence of the increased traffic flow will be negligible (<1 dB(A)).

9.5 Mitigation Proposals

9.5.1 *Demolition and Construction Noise Mitigation*

VES will require its contractor to follow Best Practicable Means (BPM) to further reduce the noise impact upon the local community. BPM includes the following:

- all construction plant and equipment should comply with EU noise emission limits;
- proper use of plant with respect to minimising noise emissions and regular maintenance. All vehicles and mechanical plant used for the purpose of the works should be fitted with effective exhaust silencers and should be maintained in good efficient working order;
- selection of inherently quiet plant where appropriate;
- machines in intermittent use should be shut down in the intervening periods between work or throttled down to a minimum;
- plant and equipment such as flat bed lorries should be lined with noise attenuating materials. Materials should be handled with care and be placed, not dropped. Materials should be delivered during normal working hours.
- all ancillary plant such as pumps should be position so as to cause minimum noise disturbance, i.e. furthest from receptors or behind close boarded noise barriers. If necessary, acoustic enclosures should be provided and/or acoustic shielding;
- construction contractors should be obliged to adhere to the codes of practice for construction working given in BS 5228 and the guidance given therein minimising noise emissions from the site; and
- reference should be made to the Building Research Establishment, BRE ‘Pollution Control’ guidelines, Parts 1-5.

Site mobile plant is often fitted with reversing alarms to act as a safety feature where the driver's visibility is restricted. Noise from vehicles with standard "bleeper" reversing alarms may give rise to complaint. To reduce the likelihood of noise complaint due to site mobile plant, alternative reversing alarms and/or alarms fitted with background noise sensing devices should be considered. The use of white noise reversing alarms can considerably reduce their noise impact. Background noise sensing alarms work by adjusting the level of the alarm to be audible above the background noise level, without being unnecessarily loud. Another type of reversing alarm sounds only when the sensors detect persons in the vicinity of the vehicle.

There are potentially short-term significant effects at the offices on Felnex Square and at the proposed Academy for breaking out of concrete hardstanding. Noise levels for this activity can be mitigated by the provision of barriers, which should provide 5 to 10 dB(A) reduction in noise levels, resulting in negligible effects.

9.5.2 *Operational Mitigation*

Further predictions have been undertaken to illustrate the noise reduction that can be achieved if the sound reduction performance of the cladding is upgraded to provide increased noise attenuation. The predictions assume that the additional mitigation will increase the sound reduction of each building cladding material by 5 dB (with the exception of the acoustic louvers, acoustic baffles, acoustic doors, the southern façade of the ERF building and the mesh cladding over the ACC).

Predictions have been made for the worst-case night-time scenario only (one Tipping Hall Door open, MPT doors closed) as it has been demonstrated that predicted daytime noise levels and the night-time scenario with the Tipping Hall doors closed and the MPT door open meet the Leeds City Council preferred Rating Level criterion. The predicted noise levels at the closest receptors assuming the upgraded cladding are shown in Table E8.1 of ES Appendix E.

The worst-case night-time BS4142 assessment shows that the predicted Rating Levels fall below the Leeds City Council requirement (5 dB(A) below background).

In addition to the upgrading of facility cladding, good site practice should also be employed to assist in reducing the noise impact upon residents close to the site. Such good practice could include:

- Keeping doors closed at all times when they are not required to be open to allow ingress and egress to the buildings.
- Machines/plant/HGVs in intermittent use should be shut down in the intervening periods between work or throttled down to a minimum.

9.6 Residual Effects

With the mitigation proposed for the Construction period, noise levels to the majority of surrounding sensitive receptors are assessed as negligible.

With the further mitigation proposed for the RERF the significance of operational noise levels to surrounding sensitive receptors is assessed as negligible.

The significance of noise effects resulting from additional traffic on the surrounding highway network is assessed as negligible.

9.7 Conclusions

Baseline noise monitoring has been undertaken at the location of the nearest sensitive receptors to the site. This monitoring data has been used to specify noise limits from the operation of the proposed facility.

Construction noise levels to residential receptors are predicted to fall below the threshold levels when assessed using the ABC method given in BS 5228.

During the breaking out of the existing hardstanding there may be significant effects at the closest offices on Felnex Square and at the proposed Vocational Academy. The provision of noise barriers to the construction activities should provide 5 to 10 dB(A) reduction, resulting in negligible effects at these receptors.

Vibration levels from piling works have been estimated. The levels fall well below the criteria for building damage and are unlikely to be perceptible at the nearest residential receptors. At the proposed Academy vibration may just be perceptible. At the nearest office location vibration will be perceptible but can be tolerated if prior notification is given.

The BS 4142 assessment for the daytime operation of the facility illustrates that at the residential properties (Cross Green Lane and Halton Moor Road) predicted noise levels will fall well below the existing background noise levels. The Leeds City Council preferred Rating Level criterion is met.

The BS 4142 assessment undertaken prior to the implementation of the upgraded cladding for the night-time operation of the facility illustrates that at the closest residential properties (Cross Green Lane and Halton Moor Road) predicted noise levels will fall well below the existing background noise levels. The Leeds City Council preferred Rating Level criterion is marginally exceeded at Halton Moor Lane, however, with the upgrading of the facility cladding to provide increased sound attenuation, predicted noise levels for the worst-case night-time scenario demonstrate that the Leeds City Council preferred Rating Level criterion can be met.

The estimated internal noise level to the closest offices on Felnex Square falls within the recommended ‘good’ internal noise levels of 35-40 dB. The prevailing ambient noise level at the offices on Felnex Square is approximately 65 dB(A). The additional contribution from the RERF will result in a total noise level of 66 dB(A), an increase of 1 dB(A). The significance of this increase is assessed as negligible.

At the proposed Academy the estimated internal noise level falls well below the recommended internal noise levels for classrooms of 35 dB. The prevailing ambient noise level at the site of the proposed Academy is approximately 61 dB(A). The additional contribution from the RERF will not result in the total noise level increasing.

Increases in road traffic flows resulting from the operation of the RERF are well below 25%, resulting in negligible increases in road traffic noise levels.

The assessment has illustrated that with careful design and selection of appropriate noise attenuating external building materials/cladding, noise levels from the operation of the RERF will meet LCC’s criterion at the nearest residential properties.

1 INTRODUCTION

1.1 General

This Appendix is an assessment of noise and vibration impacts associated with the proposed RERF development. This appendix must be read in conjunction with the main text of the Environmental Statement which contains:

- a detailed description of the proposed development in Section E4 ;
- associated Drawings and Figures; and
- other assessments in this ES which may be relevant (e.g. Appendix C, transportation).

The aim of this report is to predict the noise levels associated with the construction and operation of the proposed facility and to assess the likely noise levels at the nearest sensitive receptors.

The methodology used in this assessment is in accordance with LCC's adopted Scoping Opinion with one exception: LCC requested that the Copperfield College site be considered as a receptor – however, this institution has closed and the buildings have been demolished.

The report will outline the mitigation measures to be undertaken in order to achieve the noise limits specified by LCC's Environmental Health Officer at the nearest sensitive receptors.

The aims of the assessment are to:

- determine the existing ambient noise levels at the location of the nearest sensitive receptors to the site;
- assess the noise and vibration impacts from the construction of the facility;
- predict the noise levels at the nearest residential receptors from the operation of the proposed facility and from vehicle movements associated with the development on public roads;
- undertake an assessment at the closest residential properties in accordance with the requirements of BS 4142[1];
- determine the internal noise levels within the closest offices to the facility, and at a proposed Vocational Academy to be located to the north of the facility;
- recommend noise mitigation measures, if required; and
- report the findings of the noise assessment. Details of noise terminology and theory relevant to this report are given in Annex E1.

1.2 Site Description

The site is the Former Wholesale Market located off the ELLR, at Cross Green Industrial Estate in Leeds.

The area surrounding the site is predominantly industrial in nature, with a number of large manufacturing and distribution premises close to and surrounding the site.

Residential properties are located to the west on Cross Green Lane. These are two storey properties with attic rooms. These are located approximately 600m from the site boundary. The closest existing industrial premises to these receptors are located approximately 350m away.

Residential properties are also located to the north-east on Halton Moor Road and are two storey properties. These are located approximately 300m from the main RERF site boundary (excluding the temporary contractor's compound). The closest existing industrial premises to these receptors are located on the other side of Halton Moor Road, approximately 30m away.

Offices are located to the east of the site on Felnex Square. A Vocational Academy is proposed to the north of the site.

The topography of the site is generally flat in nature. The surrounding area gently falls from north to south.

The location of the site and the nearest receptors are illustrated in Figure E2-1 in Annex E2.

2 FACILITY DETAILS

2.1 Operational Times

The operational elements of the proposed RERF include:

- Tipping Hall
- Mechanical Pre-Treatment (MPT)
- Energy Recovery Facility (ERF)
- Bottom Ash Storage
- Associated Incoming and Outgoing HGV Movements

The two main elements for the purposes of this assessment are the MPT building and the ERF. The former will operate 24 hours a day 6 days a week (Monday to Saturday) while the ERF will operate 24 hours a day 7 days a week.

2.2 HGV Movements

Although the RERF will have the flexibility to accept waste deliveries 24 hours per day it is anticipated that the majority of the HGV movements will occur between the hours of 06:00 and 18:00.

HGV movements included in the noise model are summarised in Table E2.1 below: Figures in bold have been used in the noise model for a worst-case assessment.

Table E2.1: Proposed HGV Movements

Hour Beginning	Tipping Hall		MPT	
	HGV inbound	HGV outbound	HGV inbound	HGV outbound
00:00	1	1	0	0
01:00	**1**	**1**	**0**	**0**
02:00	0	0	0	0
03:00	0	0	0	0
04:00	0	0	0	0
05:00	0	0	0	0
06:00	1	1	0	0
07:00	1	1	3	3
08:00	1	1	3	3
09:00	13	13	3	3
10:00	15	15	4	4
11:00	13	13	3	3
12:00	**25**	**25**	**4**	**4**
13:00	19	19	3	3
14:00	6	6	4	4
15:00	3	3	3	3
16:00	1	1	3	3
17:00	0	0	3	3

Hour Beginning	Tipping Hall		MPT	
	HGV inbound	HGV outbound	HGV inbound	HGV outbound
18:00	1	1	0	0
19:00	1	1	0	0
20:00	1	1	0	0
21:00	1	1	0	0
22:00	1	1	0	0
23:00	1	1	0	0

2.3 Building Construction

It is proposed to construct the RERF using various materials. Full details of the assumed building materials for each element of the facility are given in Annex E4. These building constructions were used in the noise model.

3 CRITERIA

The NPPF has recently replaced PPG24: Planning and Noise (1994)[3]. The potential noise impacts of the proposed development are considered in relation to the following guidance:

- BS 5228 'Control of Noise and Vibration from Construction and Open Sites'
- BS 4142 'Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas'
- BS 8233 'Sound Insulation and Noise Reduction for Buildings – Code of Practice'
- Building Bulletin 93 (BB93) 'Acoustic Design of Schools
- BS 7385: Part 2: 1993 'Evaluation and Measurement for Vibration in Buildings Part 2.

Further details of the guidance/criteria used in this assessment are given below.

3.1 BS 5228 'Noise and Vibration Control on Construction and Open Sites'

3.1.1 *Noise*

Noise levels generated by construction activities are regulated by guidelines and are subject to local authority control. No UK national noise limits exist for construction noise. However, guidance on acceptable noise levels is provided in British Standard BS 5228: 2009[4].

BS 5228 contains a methodology for assessing the significance of impact of construction noise in relation to the ambient noise levels for residential properties. This is known as the ABC method. The criteria for significance provided in BS 5228-1: 2009 are reproduced below in Table E3.1.

Table E3.1: Construction Noise Threshold of Significant Effect

Assessment Category	Threshold Value (dB)		
	Category A	Category B	Category C
Night-time (23:00 – 07:00)	45	50	55
Evenings and Weekends	55	60	65
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
NOTE 1: A significant effect has been deemed to occur if the total L_{Aeq} noise level, including construction, exceeds the threshold value for the category appropriate to the ambient noise level. **NOTE 2:** If the ambient noise level exceeds the threshold values given in the table, then a significant effect is deemed to occur if the total noise level for the period increases by more than 3 dB due to construction activity. **NOTE 3:** Applies to residential receptors only.			
Category A: Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values. **Category B:** Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as Category A values. **Category C:** Threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than Category A values. 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays, 07:00 – 23:00 Sundays.			

For the appropriate period (night, evening/weekend, day), the ambient noise level is determined and rounded to the nearest 5 dB. The appropriate Threshold Value is then determined. The predicted noise level from demolition and construction activities is then compared with this Threshold Value. If the predicted construction noise level exceeds the Threshold Value, then a significant effect is deemed to occur.

A scheme for the assessment of the significance is proposed and presented in Table E3.2. The significance criteria provided in Table E3.2 have been employed for the assessment of the significance of construction noise levels to residential receptors.

Table E3.2: Scheme for Assessment of construction Noise Levels

Construction Noise Level above Threshold Value (dB)	Significance
< 1	Negligible
1 < 3	Low
3 < 5	Medium
> 5	High

For non-residential receptors, it is appropriate to estimate the likely internal noise levels to these spaces resulting from construction works and assess these levels against relevant criteria for internal noise levels. This is discussed further in Sections E3.3 and E3.4.

3.1.2 *Vibration*

There are no accepted formulae for the prediction of the passage of vibration through ground due to the non-uniform effects of different ground conditions, although some empirical formulae have been proposed for known ground conditions based on previously measured data.

The vibration peak particle velocity (ppv) due to driven piling of foundations has been estimated at sensitive receptors using example measured source data and the propagation relationship taken from the BS 5228: 2009.

Due to the large effect local ground conditions have on the transmission of vibration and the lack of detailed information on the method of piling at this outline stage, the predicted vibration ppv values should be treated as estimates.

Construction Vibration Building Damage

Buildings are reasonably resilient to ground-borne vibration and vibration-induced damage is rare; there are less than twelve confirmed instances of vibration-induced damage to buildings in the UK over the last ten years. Vibration-induced damage can arise in different ways, making it difficult to arrive at universal criteria that will adequately and simply indicate damage risk. Damage can occur directly due to high dynamic stresses, resulting in accelerated ageing, or indirectly when high quasi-static stresses are induced by, for example, soil compaction.

British Standard BS 7385: Part 2: 1993 ‘Evaluation and measurement for vibration in buildings Part 2[5]. Guide to damage levels from ground-borne vibration’ gives guidance on the levels of vibration above which the building structures could be damaged. For the purposes of BS 7385, damage is classified as cosmetic (formation of hairline cracks), minor (formation of large cracks) or major (damage to structural elements). Guide values given in the Standard are associated with the threshold of cosmetic damage only, usually in wall and/or ceiling lining materials.

Since case-history data, taken alone, has so far not provided an adequate basis for identifying thresholds for vibration-induced damage, data using controlled vibration sources within buildings has been established to enable definition of vibration thresholds judged to give a minimal risk of vibration-induced damage.

A frequency-based vibration criterion is given in the Standard because the relative displacements associated with cracking will be reached at higher vibration magnitudes with higher frequency vibration. Limits for primarily transient vibration (from a train, for example) above which cosmetic damage could occur are reported in tabular form and graphical form in the Standard and reproduced exactly below in Table E3.3.

Table E3.3: Transient Vibration Guide Values for Cosmetic Damage (from BS 7385: Part 2, 1993)

	Type of Building	Peak Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50mms^{-1} at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mms^{-1} at 4 Hz increasing to 20 mms^{-1} at 15 Hz	20 mms^{-1} at 15 Hz increasing to 50 mms^{-1} at 40 Hz and above

NOTE 1. Values referred to are at the base of the building
NOTE 2. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

The Standard indicates, for example, that for a residential building a ppv of greater than 15 mms^{-1} at 4 Hz or greater than 50 mms^{-1} at 40 Hz or above, measured at the base of the building, may result in cosmetic damage.

The limits contained within Table E3.3 may therefore be used to assess the likelihood of structural damage arising from vibration associated with construction or any permanent new sources of vibration as a consequence of the development.

Construction Vibration Nuisance

The limit of human perception to vibration is of the order of 0.15 mms^{-1} to 0.3 mms^{-1} ppv, in the frequency range 0.1 Hz to 1500 Hz. The human body is not equally sensitive to all frequencies of vibration and weighting curves to reflect the frequency dependency of the body have been developed and are contained within ISO Standards. The weighting gives a good correlation between the measured vibration level and the subjective feeling or impact produced by the vibration.

The weightings can be incorporated into modern vibration meters, thus enabling measurement of vibration levels that correspond to human perception. Those vibrations occurring between 1-80 Hz are of particular interest when measuring exposure to whole-body vibration.

Ground vibrations may cause reactions ranging from ‘just perceptible’ through ‘concern’ to ‘alarm’ and ‘discomfort’. The subjective response varies widely and is a function of situation, information, time of day and duration.

The predicted ppv levels are compared to the guidance levels in Table E2-1 in BS 5228, 2009 (reproduced as Table E3.4), to identify the likelihood of complaint:

Table E3.4: Guidance Effects of Vibration for Human Response (from BS 5228: Part 2: 2009)

PPV Vibration Level mms^{-1}	Effect
0.14	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration
0.3	Vibration might be just perceptible in residential environments
1.0	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10	Vibration is likely to be intolerable for any more than a brief exposure to this level.

3.2 BS 4142 Guidance

British Standard BS 4142: 1997 'Method for rating industrial noise affecting mixed residential and industrial areas'[1] details a method of rating the acceptability of the noise from facilities such as factories and commercial/industrial units.

The basis of the standard is a comparison between the background noise level in the vicinity of residential locations and the specific noise level (adjusted for characteristic features) of the noise source under consideration. The relevant parameters in this instance are as follows:

- Background Noise Level - LA90,T - defined in the Standard as 'the 'A' weighted sound pressure level at the assessment position without the industrial source operating which is exceeded for 90% of the given time interval, T, measured using time weighting F (fast);
- Specific Noise Level - LAeq,Tr - the equivalent continuous 'A' weighted sound pressure level of the source in question over a given time interval; and
- Rating Level - $L_{Ar,Tr}$ - the specific noise level plus any adjustment made for the characteristic features of the noise.

A correction of +5 dB is made to the specific noise level if one or more of the features noted below are present. (Only one +5 dB correction is made regardless of the specific noise level containing one or more of the following characteristics).

- the noise contains a distinguishable, discrete, continuous note (whine, hiss, screech, hum, etc.);
- the noise contains distinct impulses (bangs, clatters or thumps); or
- the noise is irregular enough to attract attention.

Once any adjustments have been made, the Rating Level and the Background Noise Level are compared. The standard states that the greater the difference between the Rating Level and the Background Noise Level, the greater is the likelihood of complaints.

- a difference of around +10 dB or more indicates that complaints are likely;
- a difference of around +5 dB is of marginal significance; and
- if the rating level is more than 10 dB below the measured background level, this is a positive indication that complaints are unlikely.

The standard specifies a one hour assessment period during the day and a five minute period at night.

For non-residential receptors BS 4142 is not applicable and it is appropriate to assess the significance of operational noise impacts in terms of changes in external noise levels and the acceptability of internal noise levels.

3.3 Internal Noise Levels in Offices – BS 8233

BS 8233[6] provides guidance on the recommended indoor ambient noise levels for various types of room when unoccupied, i.e. only noise ingress and noise from building services is considered. Recommended noise levels are quoted as having a design range of 'Good' to 'Reasonable'; the criteria which apply to this development are shown in Table E3.5.

Table E3.5: Indoor Ambient Noise Levels in Spaces When Unoccupied (BS 8233)

Criterion	Typical situations	Design range (dB $L_{Aeq,T}$)	
		Good	Reasonable
Reasonable conditions for study and work requiring concentration	Library, cellular office, museum	40	50
	Staff room	35	45
	Meeting room, executive office	35	40

In addition, for operational noise impacts the potential increase in existing ambient noise levels is also considered.

3.4 Internal Noise Levels in Classrooms– BB93

Building Bulletin 93 (BB93)[7] provides guidance on the recommended indoor ambient noise levels for teaching spaces when unoccupied, i.e. only noise ingress and noise from building services is considered. The criterion which applies to this development, for the assessment of noise levels at the Vocational Academy, is shown in Table E3.6.

Table E3.6: Internal Ambient Noise Levels for Teaching Spaces (BB93)

Criterion	Upper limit for indoor ambient noise level (dB $L_{Aeq,30min}$)
Secondary School classrooms, general teaching areas, seminar rooms, tutorial rooms, language laboratories	35

In addition, for operational noise impacts the potential increase in existing ambient noise levels is also considered.

3.5 Increases in Road Traffic Noise

The Design Manual for Roads and Bridges (DMRB)[8] provides a method of evaluating both the immediate and long term impact of changes in the 18-hour traffic flow (06:00-00:00 hours) in terms of the effects on people and, principally, occupiers of residential properties.

DMRB requires that an assessment is undertaken where the changes in road traffic flow along any road link are 1 dB(A) or greater in the immediate term, or 3 dB(A) or greater in the long term.

Such an assessment employs the methodology outlined in The Calculation of Road Traffic Noise (CRTN)[9].

3.6 Leeds City Council

Contact was made with Simon Clothier, Senior Scientific Officer, Environmental Protection, at Leeds City Council in February 2012 to discuss the assessment methodology[10].

He advised that a BS 4142 assessment should be undertaken for the operation of the RERF, with the preferred Rating Level from operations to be 5 dB(A) or more below the measured background noise level at the nearest residential property.

4 BASELINE NOISE SURVEY

4.1 General

To determine the existing noise environment at the nearest residential properties, ambient noise monitoring was undertaken between Wednesday 30th June and Thursday 1st July 2010. Further monitoring was undertaken on Thursday 24th November 2011 at the location of the closest site boundary of the Vocational Academy to the RERF site.

Unattended 24 hour noise monitoring was undertaken at one location and short-term attended monitoring at three locations. These locations are shown in Figure E2-1 in Annex E2 and are detailed below:

- Location 1: 225 Cross Green Lane, representative of residential properties to the west of the site.
- Location 2: On Halton Moor Road, at a location representative of the nearest residential properties to the site.
- Location 3: On Newmarket Lane, at a location representative of the western façade of offices on Felnex Square.
- Location 4: Newmarket Approach, to the north of the site at the location of the southern boundary of the proposed Vocational Academy.

Full details of the noise monitoring is provided in the report 'Former Wholesale Market Site Cross Green Leeds, Baseline Noise Monitoring Report' August 2010[11].

4.2 Observations

Whilst on site the main sources of noise impacting upon the area were:

- road traffic noise;
- continuous plant noise from William Cook Castings (24 hours);
- distant train movements; and
- birdsong.

4.3 Ambient Noise Monitoring Results

A summary of the daytime noise monitoring results at the residential receptors is presented in Table E4.1.

Table E4.1: measured Daytime Noise levels at residential receptors

Location	Start time	Duration	Average ambient noise level	Average background noise level	Highest $L_{AFmax,1h}$ dB
		Hr:min	$L_{Aeq,1h}$ (dB)*	$L_{A90,1h}$ (dB)†	
225 Cross Green Lane (façade level)	10:23-22:59 and 06:59-09:44	15:21	59.5	48.5	59.7
646 Halton Moor Road (free-field level)	11:00	02:00	63.2	52.3	86.6
	15:08	02:00	61.7	46.2	83.1

* this is the logarithmic energy average over the monitoring period
† this is the arithmetic average over the monitoring period

A summary of the night-time noise monitoring results at the residential receptors is presented in Table E4.2.

Table E4.2: measured night-time Noise levels at residential receptors

Location	Start Time	Duration (hrs:mins)	Ambient noise level	Average background noise level	Highest L_{AFmax} dB
			$L_{Aeq,T}$ (dB)*	$L_{A90,5min}$ (dB) †	
225 Cross Green Lane (façade level)	23:00	08:00	53.4	46.9	77.4
646 Halton Moor Road (free-field level)	00:45	01:00	47.3	39.9	70.4

* this is the logarithmic energy average over the 5 day monitoring period
† this is the arithmetic average over the 5 day monitoring period

As expected, night-time ambient and background noise levels at the monitoring locations are lower than during the daytime period. This will be due to a decrease in road traffic flows.

A summary of the daytime noise monitoring results at the non-residential receptors is presented in Table E4.3.

Table E4.3: measured Daytime Noise levels at non-residential receptors

Location	Start Time	Duration (hrs:mins)	Ambient noise level	Average background noise level	Highest L_{AFmax} dB
			$L_{Aeq,T}$ (dB)	$L_{A90,T}$ (dB)	
Newmarket Lane (representative of offices, free-field)	14:30	00:30*	65.5	52.3	91.4
Newmarket Approach (representative of proposed academy, free-field)	13:00	02:00†	61.2	59.5	77.1

* 30 minute logging period
† 5 minute logging period

5 PROPOSED CRITERIA LEVELS

5.1 Construction Noise Threshold Values

Based on the measured ambient noise levels at the residential receptors, the applicable Threshold Values, as defined in BS 5228, are shown in Table E5.1.

Table E5.1: applicable daytime threshold values

Receptor	Threshold Value L_{Aeq} dB
Cross Green Lane	65
Halton Moor Road	70

The Threshold Values in Table E5.1 have been employed to determine the significance of construction noise impacts to residential receptors.

5.2 BS 4142 Assessment

The Leeds City Council requirement is that the Rating Level at residential receptors should not exceed 5 dB below the background noise level. Based on the measured noise levels, the applicable limits for the Rating Level due to operation of the facility are shown in Table E5.2

Table E5.2: Criterion Levels

Receptor	Measured Background Noise Level	Maximum Rating Level dB $L_{Ar,Tr}$
Daytime		
Cross Green Lane	46*	41
Halton Moor Road	46	41
Night-time		
Cross Green Lane	44*	39
Halton Moor Road	40	35

*These façade levels have been converted to free-field levels through the subtraction of 3 dB.

5.3 Internal Noise Levels

Based on the internal noise levels given in BS 8233 and BB93, the noise level criteria for non-residential receptors shown in Table E5.3 are applicable to this assessment.

Table E5.3: Criterion Levels

Receptor	Internal Noise Level dB L_{Aeq}
Daytime	
Felnex Close (offices)	35 - 50 (office)
Proposed Academy	35

6 DEMOLITION AND CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

6.1 Demolition and Construction Noise Predictions

Noise predictions have been carried out based on experience of similar projects and information provided by the client, including the types and numbers of construction plant.

Estimated distances from construction works to the surrounding receptors are provided in Table E3-1 in Annex E3.

Details of the plant, the associated sound power levels and the percentage on-time per hour employed in the calculations are given in Table E3-2 in Annex E3.

The predicted noise levels for the defined construction activities are given in Table E6.1 below.

Table E6.1: Summary of Noise Prediction Scenarios

Scenario	Receptor 1: 215-239 Cross Green Lane	Receptor 2: 646 Halton Moor Road	Receptor 3: 6 Felnex Square Offices	Receptor 4: Proposed Academy
Demolition/ breaking out of hardstanding	58	64	86	74
Earthworks	44	50	72	60
Excavations and \Foundations	48	53	69	63
CFA Piling	48	52	69	63
Slab Construction	45	50	68	60
Steelwork construction	48	53	70	63
Finishing and fitting	44	49	67	60
Hardstanding	48	53	68	62
Access roads on site	49	59	71	67

An assessment of the significance of the impact of construction noise levels at the residential receptors is given in Table E6.2 below.

The results from the BS 5228 ABC method of assessing the significance of impact of construction noise levels clearly illustrate that, at the closest residential receptors, there will be no significant impact during all construction activities.

Assuming double glazed windows which provide a noise reduction (external to internal) of 32 dB(A), there will be no significant impact at the offices on Felnex Square for all but one construction activity. The exception is during the breakout of the concrete hardstanding when the recommended upper limit for internal noise levels, as defined in Table E5.3, is exceeded by 4 dB(A).

Assuming double glazed windows which provide a noise reduction (external to internal) of 32 dB(A), there will be no significant impact at the proposed Academy for all but one construction activity. The exception is during the breakout of the concrete hardstanding when the recommended upper limit for internal noise levels, as defined in Table E5.3, is exceeded by 7 dB(A).

Table E6.2: significance of construction noise levels to residential

Scenario	Receptor 1: 215-239 Cross Green Lane		Receptor 2: 646 Halton Moor Avenue	
	Difference between predicted noise level and threshold level (dB)	Significance	Difference between predicted noise level and threshold level (dB)	Significance
Demolition/ breaking out of hardstanding	-7	None	-6	None
Earthworks	-21	None	-20	None
Excavations and \Foundations	-17	None	-17	None
CFA Piling	-17	None	-18	None
Slab Construction	-20	None	-20	None
Steelwork construction	-17	None	-17	None
Finishing and fitting	-21	None	-21	None
Hardstanding	-17	None	-17	None
Access roads on site	-16	None	-11	None

6.2 Demolition and Construction Vibration Predictions

It is understood that piled foundations are required. Piling is a potentially significant source of ground borne vibration. Vibration levels have been estimated at the selected receptors R1-R4.

Vibration levels have been predicted at each receptor location, assuming Continuous Flight Auger (CFA) piling. Table E6.3 below shows the predicted vibration levels from the piling at each receptor location.

Table E6.3: Predicted Construction Vibration Levels

Receptor	ppv mms
Receptor 1: 215-239 Cross Green Lane	< 0.1
Receptor 2: 646 Halton Moor Road	< 0.1
Receptor 3: 6 Felnex Square Offices	1.6
Receptor 4: Proposed Vocational Academy	0.6

With reference to Tables E3.3 and E3.4, all the predicted vibration levels fall well below the criteria for building damage. At the location of the residential properties (R1 and R2) it is unlikely that vibration will be perceptible. At the offices on Felnex Square vibration is likely to be perceptible but can be tolerated if prior warning is given. At the proposed Vocational Academy, vibration may just be perceptible.

7 OPERATIONAL NOISE ASSESSMENT

7.1 Prediction Methodology

The noise modelling software SoundPLAN (v7.0) has been used to determine noise levels incident on the nearest sensitive receptors from operational activities to be undertaken at the proposed facility.

The assumptions and settings used in the noise modelling software are given in Annex E4.

7.2 Predicted Operational Scenarios

The following scenarios have been predicted to show the worst-case noise levels during different periods of operation.

Table E7.1: Operational Scenarios

Scenario	Time period	Tipping Hall	MPT	ERF	Bottom Ash Conveyer	Bottom Ash	HGVs
Daytime	07:00-23:00	✓	✓	✓	✓	✓	✓
Night-time	23:00-07:00	✓	✓	✓	✓	✓	✓

7.3 Noise Prediction Results – No Mitigation

The results of the noise predictions for each scenario without additional mitigation are given in Table E7.2 below for the nearest sensitive receptors to the development site. Noise levels at residential properties have been predicted at all floor levels for both daytime and night-time scenarios. At the offices and the proposed Vocational Academy noise levels have been predicted at the worst affected floor level for daytime only.

Table E7.2: Predicted Operational Noise Levels

Receptor	Floor Level	Predicted $L_{Aeq,T}$ dB from Operation of Scheme			
		Scenario 0: Daytime (1 hour)		Scenario 1: Night-time (5 minutes)*	
		All Doors Open	All Doors Closed	One Tipping Hall Door Open, All MPT Doors Closed	One MPT Door Open, All Tipping Hall Doors Closed
Cross Green	Ground	35.1	34.8	31.7	30.6
	First	38.8	38.0	35.0	33.0
	Second	39.9	39.2	35.9	34.3
Halton Moor Road	Ground	34.5	34.4	32.8	32.6
	First	34.5	38.0	35.6	35.2
Felnex Close	Ground	57.2	57.2	-	-
Academy	First	49.5	49.1	-	-

* As given in the Transport Assessment, the scenario of both a Tipping Hall door being open and an MPT door being open is unlikely.

Noise contour plots for the four scenarios given in Table E7.2 are provided in Appendix E5.

7.4 BS 4142 Assessment – No Mitigation

A BS 4142 assessment has been undertaken to predict the impact of the proposed RERF (including vehicle movements) upon the nearest residential receptors for both daytime and night-time periods. The predictions have been based on the measured L_{A90} levels. The predictions are for operations during a worst-case hour during the daytime and a worst-case 5 minutes at night.

Source noise data were only available as octave band levels. Using this octave band data to calculate octave band noise levels at surrounding sensitive receptors does not provide a robust method of quantifying tonal components of the resultant noise levels at those receptors.

British Standard BS7445-2: 1991 'Description and Measurement of Environmental Noise. Part 2: Guide to the Acquisition of Data Pertinent to Land Use' describes methods to be used for measuring and describing environmental noise relevant to general land use. Section 4.1.3 deals with tone adjustment and the supplementary note to that section states;-

In some practical cases, a prominent tonal component may be detected in one-third octave spectra if the level of a one-third octave band exceeds the level of the adjacent bands by 5 dB or more, but a narrow-band frequency analysis may be required in order to detect precisely the occurrence of one or more tonal components in a noise signal. If tonal components are clearly audible and their presence can be detected by a one-third octave analysis, the adjustment may be 5 to 6 dB. If the components are only just detectable by the observer and demonstrated by narrow-band analysis, an adjustment of 2 to 3 dB may be appropriate.

This indicates that, if tonal components are clearly audible (e.g. the whine, hiss, screech, hum etc. mentioned above), and their presence can be detected by a one third octave band analysis, the adjustment may be 5 to 6 dB.

Noise measurement data were sourced for a comparable operational facility in Europe. The data as supplied were A-Weighted third octave bands sound pressure levels at two receptor locations. The data were supported by subjective evidence that the noise character did not have any tonal features (e.g. whine, hiss, screech, hum etc.) and that there were no impulsive or irregularity features.

The supplied data were processed to provide Linear third octave band sound pressure levels. For both the A-Weighted and Linear third octave band levels, a simple analysis was carried out to identify any third octave bands where the level was greater than the levels in the adjacent third octave bands. Inspection of the data showed that, whilst there were several bands which meet this criterion, the difference between the band levels was significantly less than 5 dB.

It was concluded that there was no significant tonal component to the noise emitted from the facility. It is considered reasonable that the above analysis can be applied to the facility at Leeds.

As such, and also as tipping of waste will occur within the Tipping Hall and not external to the facility, the 5 dB(A) penalty recognised in BS 4142 for tonal characteristics and bangs and crashes has not been applied.

The results of the BS 4142 assessments for the daytime and night-time periods are given below in Tables E7.3 and E7.4.

Table E7.3: Daytime BS 4142 Assessment – No Mitigation

Location	Floor	Target Noise Level (dB(A))	Calculated Rating Level ($L_{Ar,Tr}$)		Rating Level minus Target Noise Level	
			All Doors Open	All Doors Closed	All Doors Open	All Doors Closed
Cross Green Lane	Ground	41	35.1	34.8	-5.9	-6.2
	First	41	38.8	38.0	-2.2	-3.0
	Second	41	39.9	39.2	-1.1	-1.8
Halton Moor Road	Ground	41	34.5	34.4	-6.5	-6.6
	First	41	38.0	38.0	-3.0	-3.0

Table E7.4: Night-Time BS 4142 Assessment – No Mitigation

Location	Floor	Target Noise Level (dB(A))	Calculated Rating Level ($L_{Ar,Tr}$)		Rating Level minus Target Noise Level	
			One Tipping Hall Door Open, All MPT Doors Closed	One MPT Door Open, All Tipping Hall Doors Closed	One Tipping Hall Door Open, All MPT Doors Closed	One MPT Door Open, All Tipping Hall Doors Closed
Cross Green Lane	Ground	39	31.7	30.6	-7.3	-8.4
	First	39	35.0	33.0	-4.0	-6.0
	Second	39	35.9	34.3	-3.1	-4.7
Halton Moor Road	Ground	35	32.8	32.6	-2.2	-2.4
	First	35	35.6	35.2	0.6	0.2

* As given in the Transport Assessment, the scenario of both a Tipping Hall door being open and an MPT door being open is unlikely.

The BS 4142 assessment for the daytime operation of the facility illustrates that at the residential properties (Cross Green Lane and Halton Moor Road) predicted noise levels will fall below the existing background noise levels during the daytime period. The predicted noise levels also fall below the Leeds City Council preferred Rating Level criterion.

The BS 4142 assessment for the night-time operation of the facility illustrates that the predicted noise levels at residential properties on Cross Green Lane will fall below the existing background noise levels and also the Leeds City Council preferred Rating Level criterion at Cross Green Lane at all floor levels. At Halton Moor Road the predicted noise levels fall below the existing background noise level however they marginally exceed the Leeds City Council preferred Rating Level at first floor level.

7.5 Internal Noise Levels – No Mitigation

Predicted internal noise levels at the closest offices and the proposed Vocational Academy have been estimated and assume double-glazed window units providing a minimum attenuation of 32 dB[3]. The internal noise levels are provided in Table E7.5.

Table E7.5: Predicted Internal Noise Levels – No Mitigation

Receptor	Prevailing Ambient Noise Level $L_{Aeq,T}$ dB (free-field)	Predicted at Façade $L_{Aeq,1h}$ dB (free-field)	Total Ambient with RERF $L_{Aeq,T}$ dB(A)	Calculated Internal Noise Level (No RERF)I $L_{Aeq,1h}$ dB*	Calculated Internal Noise Levels (With RERF) $L_{Aeq,T}$ dB*
3: Felnex Square	65	57	66	36	37
4: Proposed Academy	61	50	61	32	32

* Internal noise levels have been calculated by converting the free-field prevailing and total ambient noise levels to façade levels through the addition of 3 dB

The estimated internal noise level to the offices on Felnex Square falls within the recommended 'good' internal noise levels of 35-40 dB, both with and without the RERF.

At the proposed Vocational Academy the estimated internal noise level falls well below the recommended internal noise levels for classrooms of 35 dB, both with and without the RERF.

7.6 Noise Prediction Results – With Stack Directivity Correction Applied

The results of the noise predictions for each scenario without additional mitigation but applying a correction for stack directivity are given in Table E7.6 below for the nearest sensitive receptors to the development site. The correction for stack directivity is taken from the US Department of Defence document 'Power Plant Acoustics', May 2003[13] which reduces the sound power level of the stack by 5 dB.

Table E7.6: Predicted Operational Noise Levels – With Stack Directivity Correction Applied

Receptor	Floor Level	Predicted $L_{Aeq,T}$ dB from Operation of Scheme			
		Scenario 0: Daytime (1 hour)		Scenario 1: Night-time (5 minutes)*	
		All Doors Open	All Doors Closed	One Tipping Hall Door Open, All MPT Doors Closed	One MPT Door Open, All Tipping Hall Doors Closed
Cross Green	Ground	35.1	34.8	31.6	30.4
	First	38.7	38.0	34.8	32.7
	Second	39.8	39.1	35.7	34.0
Halton Moor Road	Ground	34.3	34.2	32.5	32.3
	First	37.9	37.9	35.4	35.0
Felnex Close	Ground	57.1	57.1	-	-
Academy	First	49.4	49.0	-	-

* As given in the Transport Assessment, the scenario of both a Tipping Hall door being open and an MPT door being open is unlikely.

7.7 BS 4142 Assessment – With Stack Directivity Correction Applied

A BS 4142 assessment has been undertaken to predict the impact of the proposed RERF (including vehicle movements) upon the nearest residential receptors, with the correction applied for stack directivity, for both daytime and night-time periods. The results are given below in Tables E7.7 and E7.8.

Table E7.7: Daytime BS 4142 Assessment –With Stack Directivity Correction Applied

Location	Floor	Target Noise Level (dB(A))	Calculated Rating Level ($L_{Ar,Tr}$)		Rating Level minus Target Noise Level	
			All Doors Open	All Doors Closed	All Doors Open	All Doors Closed
Cross Green Lane	Ground	41	35.1	34.8	-5.9	-6.2
	First	41	38.7	38.0	-2.3	-3.0
	Second	41	39.8	39.1	-1.2	-1.9
Halton Moor Road	Ground	41	34.3	34.2	-6.7	-6.8
	First	41	37.9	37.9	-3.1	-3.1

Table E7.8: Night-Time BS 4142 Assessment – With Stack Directivity Correction Applied

Location	Floor	Target Noise Level (dB(A))	Calculated Rating Level ($L_{Ar,Tr}$)		Rating Level minus Target Noise Level	
			One Tipping Hall Door Open, All MPT Doors Closed	One MPT Door Open, All Tipping Hall Doors Closed	One Tipping Hall Door Open, All MPT Doors Closed	One MPT Door Open, All Tipping Hall Doors Closed
Cross Green Lane	Ground	39	31.6	30.4	-7.4	-8.6
	First	39	34.8	32.7	-4.2	-6.3
	Second	39	35.7	34.0	-3.3	-5.0
Halton Moor Road	Ground	35	32.5	32.3	-2.5	-2.7
	First	35	35.4	35.0	0.4	0.0

* As given in the Transport Assessment, the scenario of both a Tipping Hall door being open and an MPT door being open is unlikely.

The BS 4142 assessment for the daytime operation of the facility with the correction applied for stack directivity illustrates that at the residential properties (Cross Green Lane and Halton Moor Road) predicted noise levels will fall below the existing background noise levels during the daytime period. The predicted noise levels also fall below the Leeds City Council preferred Rating Level criterion.

The BS 4142 assessment for the night-time operation of the facility illustrates that the predicted noise levels at residential properties on Cross Green Lane will fall below the existing background noise levels and also the Leeds City Council preferred Rating Level criterion at Cross Green Lane at all floor levels. At Halton Moor Road the predicted noise levels fall below the existing background noise level however they marginally exceed the Leeds City Council preferred Rating Level at first floor level when one Tipping Hall door is open.

7.8 Internal Noise Levels – With Stack Directivity Correction Applied

As other noise from other elements of the facility are dominant over the stack contribution at the offices and academy, predicted noise levels at the façade of these receptors are negligibly different. Therefore, internal noise levels within the offices and the academy are the same as those estimated for when no stack directivity correction is applied.

7.9 Increase in Road Traffic Noise Levels

Details of the estimated with-development and without-development road traffic flows on the ELLR were provided by the authors of the Transport Assessment[12]. These data have been used to calculate the 18 hour weekday flow (06:00-00:00) and the percentage increase in road traffic flows as a result of the operation of the facility. The calculated increase in road traffic flows is given in Table E7.9 below.

Table E7.9: Change in Road Traffic Flows (Weekday 18hr flows)

Road Link	2016 No Development	2016 With Development	% increase in road traffic flows
ELLR (west of Newmarket Approach)	18,077	18,402	1.8

The increase in road traffic flows as a result of the operation of the facility illustrates that an increase of no greater than 1.6% is estimated. Any resultant increase in noise levels as a consequence of the increased traffic flow will be negligible (<1 dB(A)).

8 MITIGATION

8.1 Demolition and Construction Noise Mitigation

VES will require its contractor to follow Best Practicable Means (BPM) to further reduce the noise impact upon the local community. BPM includes the following:

- all construction plant and equipment should comply with EU noise emission limits;
- proper use of plant with respect to minimising noise emissions and regular maintenance. All vehicles and mechanical plant used for the purpose of the works should be fitted with effective exhaust silencers and should be maintained in good efficient working order;
- selection of inherently quiet plant where appropriate;
- machines in intermittent use should be shut down in the intervening periods between work or throttled down to a minimum;
- plant and equipment such as flat bed lorries should be lined with noise attenuating materials. Materials should be handled with care and be placed, not dropped. Materials should be delivered during normal working hours.
- all ancillary plant such as pumps should be position so as to cause minimum noise disturbance, i.e. furthest from receptors or behind close boarded noise barriers. If necessary, acoustic enclosures should be provided and/or acoustic shielding;
- construction contractors should be obliged to adhere to the codes of practice for construction working given in BS 5228 and the guidance given therein minimising noise emissions from the site; and
- reference should be made to the Building Research Establishment, BRE ‘Pollution Control’ guidelines, Parts 1-5[14].

Site mobile plant is often fitted with reversing alarms to act as a safety feature where the driver’s visibility is restricted. Noise from vehicles with standard “bleeper” reversing alarms may give rise to complaint. To reduce the likelihood of noise complaint due to site mobile plant, alternative reversing alarms and/or alarms fitted with background noise sensing devices should be considered. The use of white noise reversing alarms can considerably reduce their noise impact. Background noise sensing alarms work by adjusting the level of the alarm to be audible above the background noise level, without being unnecessarily loud. Another type of reversing alarm sounds only when the sensors detect persons in the vicinity of the vehicle.

There are potentially short-term significant effects at the offices on Felnex Square and at the proposed Academy for breaking out of concrete hardstanding. Noise levels for this activity can be mitigated by the provision of barriers, which should provide 5 to 10 dB(A) reduction in noise levels, resulting in negligible effects.

8.2 Operational Mitigation

Further predictions have been undertaken to illustrate the noise reduction that can be achieved if the sound reduction performance of the cladding is upgraded to provide increased noise attenuation. The predictions assume that the additional mitigation will increase the sound reduction of each building cladding material by 5 dB (with the exception of the acoustic louvers, acoustic baffles, acoustic doors, the southern façade of the ERF building and the mesh cladding over the ACC).

Predictions have been made for the worst-case night-time scenario only (one Tipping Hall Door open, MPT doors closed) as it has been demonstrated that predicted daytime noise levels and the night-time scenario with the Tipping Hall doors closed and the MPT door open meet the Leeds City Council preferred Rating Level criterion.

Table E8.1 shows the predicted noise levels at the closest receptors assuming the upgraded cladding.

Table E8.1: Night-Time BS 4142 Assessment – With Upgraded Cladding and Stack Directivity Applied

Location	Floor	Target Noise Level (dB(A))	Calculated Rating Level ($L_{Ar,Tr}$)	Rating Level minus Target Noise Level
			One Tipping Hall Door Open, All MPT Doors Closed	
Cross Green Lane	Ground	39	31.0	-8.0
	First	39	34.2	-4.8
	Second	39	35.2	-3.8
Halton Moor Road	Ground	35	31.8	-3.2
	First	35	34.8	-0.2

Inspection of the results in Table E8.1 for the worst-case night-time BS4142 assessment shows that the predicted Rating Levels fall below the Leeds City Council requirement (5 dB(A) below background).

In addition to the upgrading of facility cladding, good site practice should also be employed to assist in reducing the noise impact upon residents close to the site. Such good practice could include:

- Keeping doors closed at all times when they are not required to be open to allow ingress and egress to the buildings.
- Machines/plant/HGVs in intermittent use should be shut down in the intervening periods between work or throttled down to a minimum.

9 CONCLUSIONS

Baseline noise monitoring has been undertaken at the location of the nearest sensitive receptors to the site. This monitoring data has been used to specify noise limits from the operation of the proposed facility.

Construction noise levels to residential receptors are predicted to fall below the threshold levels when assessed using the ABC method given in BS 5228.

During the breaking out of the existing hardstanding there may be significant effects at the closest offices on Felnex Square and at the proposed Vocational Academy. The provision of noise barriers to the construction activities should provide 5 to 10 dB(A) reduction, resulting in negligible effects at these receptors.

Vibration levels from piling works have been estimated. The levels fall well below the criteria for building damage and are unlikely to be perceptible at the nearest residential receptors. At the proposed Academy vibration may just be perceptible.. At the nearest office location vibration will be perceptible but can be tolerated if prior notification is given.

The BS 4142 assessment for the daytime operation of the facility illustrates that at the residential properties (Cross Green Lane and Halton Moor Road) predicted noise levels will fall well below the existing background noise levels. The Leeds City Council preferred Rating Level criterion is met.

The BS 4142 assessment undertaken prior to the implementation of the upgraded cladding for the night-time operation of the facility illustrates that at the closest residential properties (Cross Green Lane and Halton Moor Road) predicted noise levels will fall well below the existing background noise levels. The Leeds City Council preferred Rating Level criterion is marginally exceeded at Halton Moor Lane, however, with the upgrading of the facility cladding to provide increased sound attenuation, predicted noise levels for the worst-case night-time scenario demonstrate that the Leeds City Council preferred Rating Level criterion can be met.

The estimated internal noise level to the closest offices on Felnex Square falls well below the recommended ‘good’ internal noise levels of 35-40 dB. The prevailing ambient noise level at the offices on Felnex Square is approximately 65 dB(A). The additional contribution from the RERF will result in a total noise level of 66 dB(A), an increase of 1 dB(A). The significance of this increase is assessed as negligible.

At the proposed Academy the estimated internal noise level falls well below the recommended internal noise levels for classrooms of 35 dB. The prevailing ambient noise level at the site of the proposed Academy is approximately 61 dB(A). The additional contribution from the RERF will not result in the total noise level increasing.

Increases in road traffic flows resulting from the operation of the RERF are well below 25%, resulting in negligible increases in road traffic noise levels.

The assessment has illustrated that with careful design noise levels from the operation of the RERF will meet Leeds City Council’s criterion at the nearest residential properties.

REFERENCES

1. British Standard BS 4142: 1997 'Rating industrial noise affecting mixed residential and industrial areas', British Standards Institute.
2. Communities and Local Government 'National Planning Policy Guidance'. Department for Communities and Local Government, March 2012.
3. Planning Policy Guidance: Planning and Noise PPG 24, September 2004. Department for the Environment.
4. BS 5228: 2009: 'Control of noise and vibration from construction and open sites' Part 1. British Standards Institute.
5. British Standards Institution (1993) BS 7385: 1993 'Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration'
6. British Standard BS 8233: 1999 'Sound insulation and noise reduction for buildings – Code of practice'. British Standards Institute.
7. Building Bulletin 93- Acoustic Design of Schools. A Design Guide 2005
8. Highways Agency (2011) Design Manual for Roads and Bridges Volume 11 Part 7.
9. Department of Transport and the Welsh Office (1988) Calculation of Road Traffic Noise.
10. Emails between Ruth Dawson (URS) and Simon Clothier (Senior Scientific Officer, Environmental Protection, Leeds City Council), February 2012.
11. Former Wholesale Market Site, Cross green, Leeds, Baseline Noise Monitoring Report' August 2010, Scott Wilson Ltd.
12. Traffic data – provided by URS transport Team
13. US Department for Defence 'Power Plant Acoustics', May 2003. Report number UFC-3-450-02.
14. Building Research Establishment 2003 'Controlling particles, vapour and noise pollution from construction sites Parts 1-5.

ANNEX E1: NOISE PERCEPTION AND TERMINOLOGY

General

Between the quietest audible sound and the loudest tolerable sound there is a million to one ratio in sound pressure (measured in Pascals, Pa). Because of this wide range, a noise level scale based on logarithms is used in noise measurement called the decibel (dB) scale. Audibility of sound covers a range of approximately 0 to 140 dB. The human ear system does not respond uniformly to sound across the detectable frequency range and consequently instrumentation used to measure noise is weighted to represent the performance of the ear. This is known as the 'A weighting' and annotated as dB(A). Table E1-1 lists the sound pressure level in dB(A) for common situations.

Table E1-.1: Noise Levels For Common Situations

Typical noise level, dB(A)	Example
0	Threshold of hearing
30	Rural area at night, still air
40	Public library, refrigerator humming at 2m
50	Quiet office, no machinery
60	Normal conversation
70	Telephone ringing at 2m
80	General factory noise level
90	Heavy goods vehicle from pavement
100	Pneumatic Drill at 5m
120	Discotheque – 1m in front of loud speaker
140	Threshold of pain

The noise level at a measurement point is rarely steady, even in rural areas, and varies over a range dependent upon the effects of local noise sources. Close to a busy motorway, the noise level may vary over a range of 5 dB(A), whereas in a suburban area this variation may be up to 40 dB(A) and more due to the multitude of noise sources in such areas (cars, dogs, aircraft etc.) and their variable operation. Furthermore, the range of night-time noise levels will often be smaller and the levels significantly reduced compared to daytime levels. When considering environmental noise, it is necessary to consider how to quantify the existing noise (the ambient noise) to account for these second to second variations.

Background Noise Levels

A parameter that is widely accepted as reflecting human perception of the ambient noise is the background noise level, $L_{90,}$ this is usually A weighted and can be displaced as L_{90} dB(A) or L_{A90} (dB). This is the noise level exceeded for 90 % of the measurement period and generally reflects the noise level in the lulls between individual noise events. Over a one hour period, the L_{A90} will be the noise level exceeded for 54 minutes.

Ambient or Activity Noise Levels

The equivalent continuous A-weighted sound pressure level, L_{Aeq} (or L_{eq} dB(A)) is the single number that represents the total sound energy measured over that period. LAeq is the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measurement period. It is commonly used to express the energy level from individual sources that vary in level over their operational cycle.

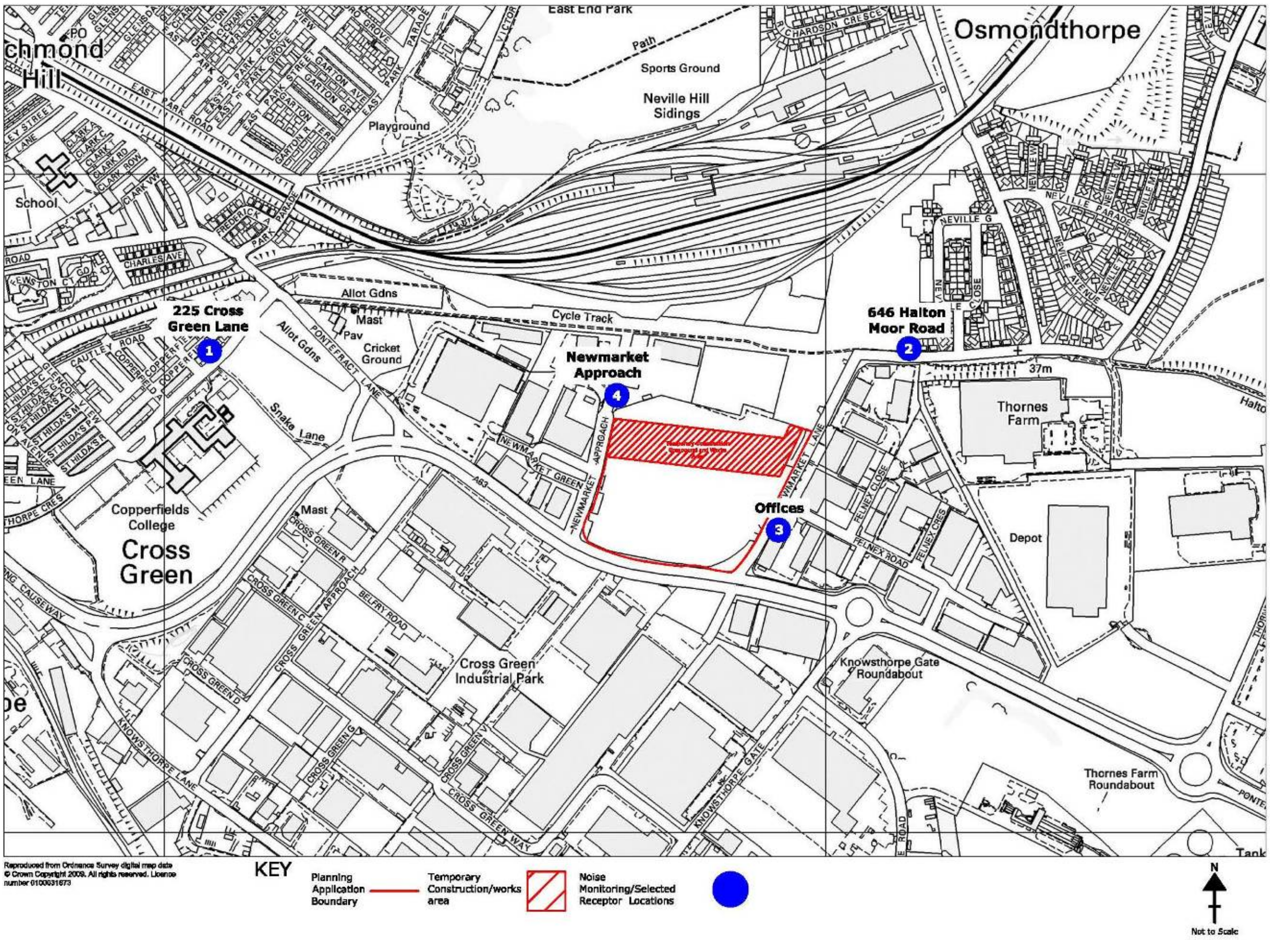
Noise Changes

Human subjects are generally only capable of noticing changes in noise levels of no less than 3 dB(A). It is generally accepted that a change of 10 dB(A) in an overall, steady noise level is perceived to the human ear as a doubling (or halving) of the noise level. (These findings do not necessarily apply to transient or non-steady noise sources such as changes in noise due to changes in road traffic flow, or intermittent noise sources).

ANNEX E2: SITE PLAN/NOISE MONITORING AND SELECTED RECEPTOR LOCATIONS

Noise monitoring was undertaken at three locations on Wednesday 30th June and Thursday 1st July 2010, one location on Thursday 24th November 2012 and. The noise monitoring and selected receptor locations used in this assessment are shown in Figure E2-1.

Figure E2-1: Receptor Locations



ANNEX E3: DEMOLITION AND CONSTRUCTION

Table E3-1: Selected receptors and Distance to Construction Activities

Scenario	Distance to Construction Activities (m)			
	Receptor 1: 215-239 Cross Green Lane	Receptor 2: 646 Halton Moor Avenue	Receptor 3: 6 Felnex Square Offices	Receptor 4: Proposed Academy
Demolition/ breaking out of hardstanding	620	310	15	105
Earthworks	620	310	15	105
Excavations and \Foundations	665	385	50	115
CFA Piling	665	385	50	115
Slab Construction	665	385	50	115
Steelwork construction	665	385	50	115
Finishing and fitting	665	385	50	115
Hardstanding	640	345	55	120
Access roads on site	595	195	40	70

Assumptions
For the prediction of typical construction noise levels, the following has been assumed:

- there is line of sight between the construction activities and the nearest noise sensitive properties;
- earthworks are to be undertaken 10 metres around all construction works;.
- the construction of the off-site site highway improvements, new footpath / cycleroute, grid connection and landscaping will not be significant; and
- clearance is undertaken to the site boundary.

Table E3-2: Assumed Construction Plant

Construction Activity	Plant	Overall L_W dB(A)	On-time (% of shift)
Breaking out of hardstanding	360 degree Excavator	105	50
	360 degree Excavator + hydraulic breaker	120	50
	Tipper wagons (assumed 3)	118	50
Earthworks	360 degree Excavator	105	50
	Articulated dump truck	102	50
	Dozer	103	50
CFA Piling	CFA rig	108	50
	Service crane - 60T crawler	97	50
	Concrete wagons (assumed 2)	110	50
Excavations and foundations	Excavator	102	75
	Loader (tracked)	107	50
	Lorry	105	50
	Cement mixer truck	106	50
	Poker vibrator	100	75
Slab Construction	60 T crawler crane	102	50
	Tower crane (2)	105	50
	Concrete vibration air pokers	104	50
	Concrete pump	103	50
Steelwork Construction /	Crane	97	50
	Generator	94	100
	Electric drills	107	50
	Metal cutter	110	25
	Electric bolter	107	25
	Lorries/hr	113	10
Finishing and Fitting	Generator	94	83
	Welding plant	102	50
	Electric drills	107	50
	Lorry	105	10
Hardstanding	Excavator	102	75
	Dumper	109	50
	Cement mixer truck etc	106	50
	Poker vibrator	100	75
Access Road Construction	Excavator	102	75
	Dumper	109	50
	Asphalt paver	104	75
	Road roller	103	75

ANNEX E4: NOISE MODELLING DETAILS

Assumptions

Assumptions have been made about noise levels within processing buildings and the construction of the building envelop. These assumptions are:

Internal noise level/Noise sources

- reverberant internal noise levels within the facility have been taken from a similar facility; and
- source data for other noise sources, such as the Air Cooled Condensers, the Stack, Transformers etc. have been sourced from similar facilities.

Building fabric

- steel cladding has been assumed to be single-skin trapezoidal cladding;
- polycarbonate cladding has been assumed to be Danpalon polycarbonate 16mm, single or double skin;
- the weatherboard has been assumed to provide no more attenuation than 9mm plywood.
- The concrete walls and roof of the Turbine Hall have been assumed to be 200mm reinforced concrete;
- the doors to the Tipping Hall will be acoustic doors;
- the doors to the MPT will not provide anymore attenuation than weatherboard; and
- any louvers installed will be acoustic louvers.

MPT

North wall –	combination of trapezoidal single-skin steel cladding and Danpalon;
Eastern wall –	single skin Danpalon with 1 door; and
Roof –	Danpalon 16mm.

Tipping Hall

North wall –	combination of trapezoidal single-skin steel cladding and Danpalon and 6 doors;
Western wall –	single skin Danpalon;
Southern wall –	trapezoidal single-skin cladding and single skin Danpalon;
Roof –	single skin Danpalon with 6 acoustic louvres; and
Push walls	conservatively modelled as 5m high 100mm reinforced concrete push walls around the Tipping Hall (push walls will be 250mmm).

Turbine Hall
200mm reinforced concrete walls and roof with acoustic baffles in southern and eastern facades.

Waste bunker

Western façade –	20m high concrete bunker wall with single skin Danpalon above;
Southern façade –	20m high concrete bunker wall with weatherboard above;
Northern façade –	Double skin Danpalon to 29m, single skin Danpalon above;
Roof –	single skin Danpalon and trapezoidal single-skin steel cladding with acoustic louvre.

ERF

Southern façade –	weatherboard and green wall brackets;
Northern façade –	double skin Danpalon to 29m, single skin Danpalon above;
Eastern façade –	mesh (modelled as acoustically transparent) at the upper level and 200mm reinforced concrete wall below;
Eastern façade of filter house	single-skin Danpalon with 200mm reinforced concrete wall below;
Roof –	single skin Danpalon and trapezoidal single-steel steel cladding west of the internal wall, with 6 acoustic louvers above filter house and 1 acoustic louvre above boiler house; and
Louvres –	acoustic louvres.

HGV Assumptions

During the day there will be 25 HGVs to and 25 HGVs from the Tipping Hall per hour. It has been assumed that the HGVs will be evenly distributed to each of the six Tipping Hall Doors. For a worst-case this has been assumed as 5 HGVs to and HGVs from each Tipping Hall door.

During the day there will be 4 HGVs to and 4 HGVs from the MPT.

With regards to the Tipping Hall at night, for a worst-case 5 minute period there will be one HGV to and one HGV from the Tipping Hall, with the HGV access door 3. This door will remain open for the entire 5 minute period for a worst-case assessment.

With regards to the MPT at night, for a worst-case 5 minute period there will be one HGV to and one HGV from the MPT. This door will remain open for the entire 5 minute period for a worst-case assessment.

Other Assumptions

Within this assessment, during the night-time scenarios either one door remains open to the Tipping Hall or one door remains open to the MPT throughout the 5 minute assessment period.

For the stack directivity calculation, the source data for the 'stack with silencer' has been reduced by 5 dB.

The predictions undertaken for upgraded building cladding have been calculated assuming the sound reduction for each type of building material (with the exception of the acoustic louves, acoustic baffles and acoustic doors) is increased by 5 dB.

VES will incorporate such other improvements to the acoustic mitigation as may be necessary to meet the target noise levels as specified by Leeds City Council.

Plant/ Equipment Noise Data

The following sound power data and frequency spectrums were used in the noise model. The levels used have been corrected for on-time and numbers of plant/vehicles. All data has been sourced from similar recent projects.

Modelling assumptions:

- Buildings heights – residential, offices and proposed academy: 2 storeys (6m).
- Ground absorption – surrounding area and wider area 0.0 (urban environment), road surfaces 0.0.
- Receptor heights 1.5m ground floor, 4m first floor.

Table E4-1: Sound Power Data Used in Noise Model

Equipment	Octave Band Frequency Hz									OVERALL dB(A)
	31.5	63	125	250	500	1k	2k	4k	8k	
Internal Reverberant Levels Leq										
Tipping Hall	84.0	84.0	84.0	77.0	74.0	74.0	74.0	65.0	71.0	79.9
MPT	88.8	87.7	83.6	80.8	82.3	82.2	79.8	77.7	72.5	86.9
Waste Bunker	82.5	76.3	74.2	76.7	73.1	76.1	73.9	66.1	63.2	79.9
Boiler House	86.0	86.0	83.0	83.0	82.0	78.0	78.0	77.0	71.0	85.2
Filter House	81.0	81.0	78.0	78.0	77.0	73.0	73.0	72.0	66.0	80.2
Turbine Hall	87.5	84.5	89.5	87.5	89.0	90.0	89.9	84.5	79.0	95.0
Bottom Ash	86.0	85.0	77.0	71.0	71.0	69.0	69.0	68.0	59.0	75.4
External Plant Lw										
Stack with silencer	116.9	112.6	99.5	92.9	78.2	76.8	75.4	76.7	85.1	91.4
Exhaust steam pipe	74.2	77.6	78.6	77.5	80.7	82.3	76.9	69.0	60.7	84.9
ACC fan	92.3	92.3	90.3	87.8	86.1	83.2	78.4	71.7	62.9	88.0
Oil Cooler Fans	84.1	84.1	84.1	79.1	78.1	81.1	72.1	63.1	-	83.0
Transformer	68.6	74.6	76.6	71.6	71.6	65.6	60.6	55.6	48.6	72.0
Bottom Ash Conveyer	-	112.2	96.1	88.6	74.2	71.0	68.8	74.0	82.1	89.0
Electrical room	40.0	53.0	76.0	84.0	77.0	76.0	67.0	65.0	60.0	80.5
Diesel generator room	49.6	62.6	85.6	93.6	86.6	85.6	76.6	74.6	69.6	90.0
Demineralisation water	71.0	71.0	68.0	68.0	67.0	65.0	62.0	60.2	54.0	70.1
Compressor room	87.0	86.0	87.0	84.0	78.0	74.0	72.0	75.0	74.0	82.6

Table E4-2: Sound Power Data Used in Noise Model – HGV Movements

Equipment	No. of HGV pass-bys per hour	Octave Band Frequency Hz									OVERALL Lw dB(A)
		31.5	63	125	250	500	1k	2k	4k	8k	
Daytime HGVs in to Tipping Hall (5 HGVs per door per hour)	5	121.0	121.0	114.0	112.0	109.0	105.0	103.0	97.0	93.0	111.3
Daytime HGVs out from Tipping Hall (5 HGVs per door per hour)	5	121.0	121.0	114.0	112.0	109.0	105.0	103.0	97.0	93.0	111.3
Daytime HGVs in to MPT	4	120.0	120.0	113.0	111.0	108.0	104.0	102.0	96.0	92.0	110.3
Daytime HGVs out from MPT	4	120.0	120.0	113.0	111.0	108.0	104.0	102.0	96.0	92.0	110.3
Night-time HGV in	12*	124.8	124.8	117.8	115.8	112.8	108.8	106.8	100.8	96.8	115.1
Night-time HGV out	12*	124.8	124.8	117.8	115.8	112.8	108.8	106.8	100.8	96.8	115.1

* This is to correspond with 1 HGV movement over a 5 minute period (12 per hour) for the night-time noise assessment.

Table E4-3: Sound Insulation Data

Material	Octave Band Frequency Hz									OVERALL Rw dB
	31.5	63	125	250	500	1k	2k	4k	8k	
Open door/no attenuation	0	0	0	0	0	0	0	0	0	0.0
Trapezoidal single skin steel cladding	6	9	13	17	22	23	27	32	20	25
Danpalon 16mm polycarbonate Single skin	6	9	14	16	20	25	28	24	16	25
Danpalon 16mm polycarbonate Double skin	6	9	17	13	22	32	36	31	16	27
Weatherboard wooden cladding (assumed 9mm plywood on frame)	1	3	7	13	19	25	19	22	15	22
Reinforced Concrete 100mm walls/roof	34	38	38	44	48	52	56	60	64	53
Combined Danpalon 16mm and trapezoidal steel cladding – Tipping Hall	6	9	13	17	22	23	27	30	19	25
Combined Danpalon 16mm and trapezoidal steel cladding – MPT	6	9	13	17	22	23	27	30	19	25
Acoustic Louvres	9	15	6	8	11	17	15	13	12	15
Acoustic door to Tipping Hall	9	15	21	27	32	34	36	36	30	35
Acoustic baffles	2	5	11	25	38	46	47	38	21	35
Blockwork	15	22	28	30	41	47	53	56	50	44
Hollow core steel door	1	7	13	15	16	17	18	20	25	18

ANNEX E5: NOISE CONTOUR PLOTS

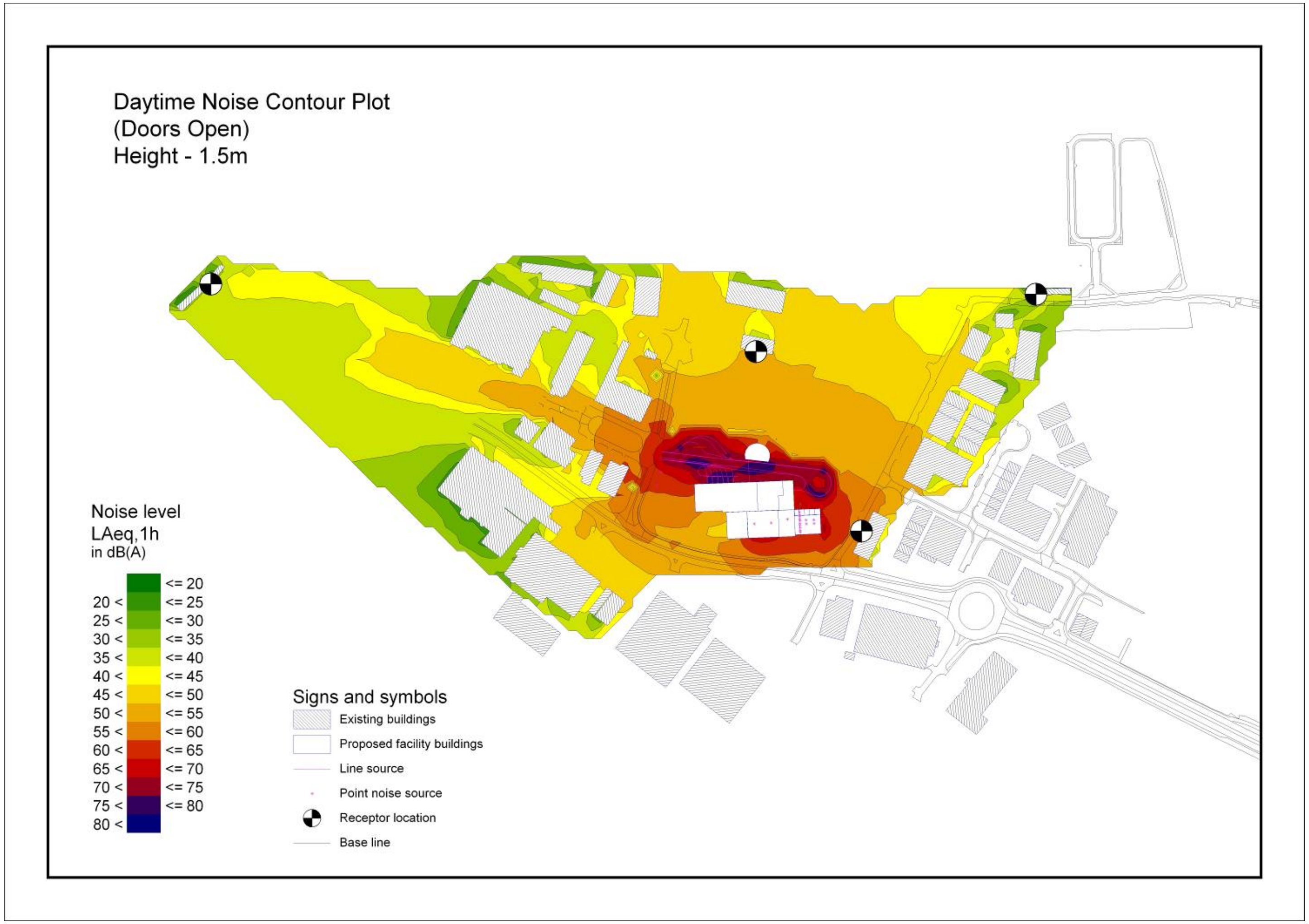


FIGURE E5-1: DAYTIME NOISE CONTOURS (DOORS OPEN)

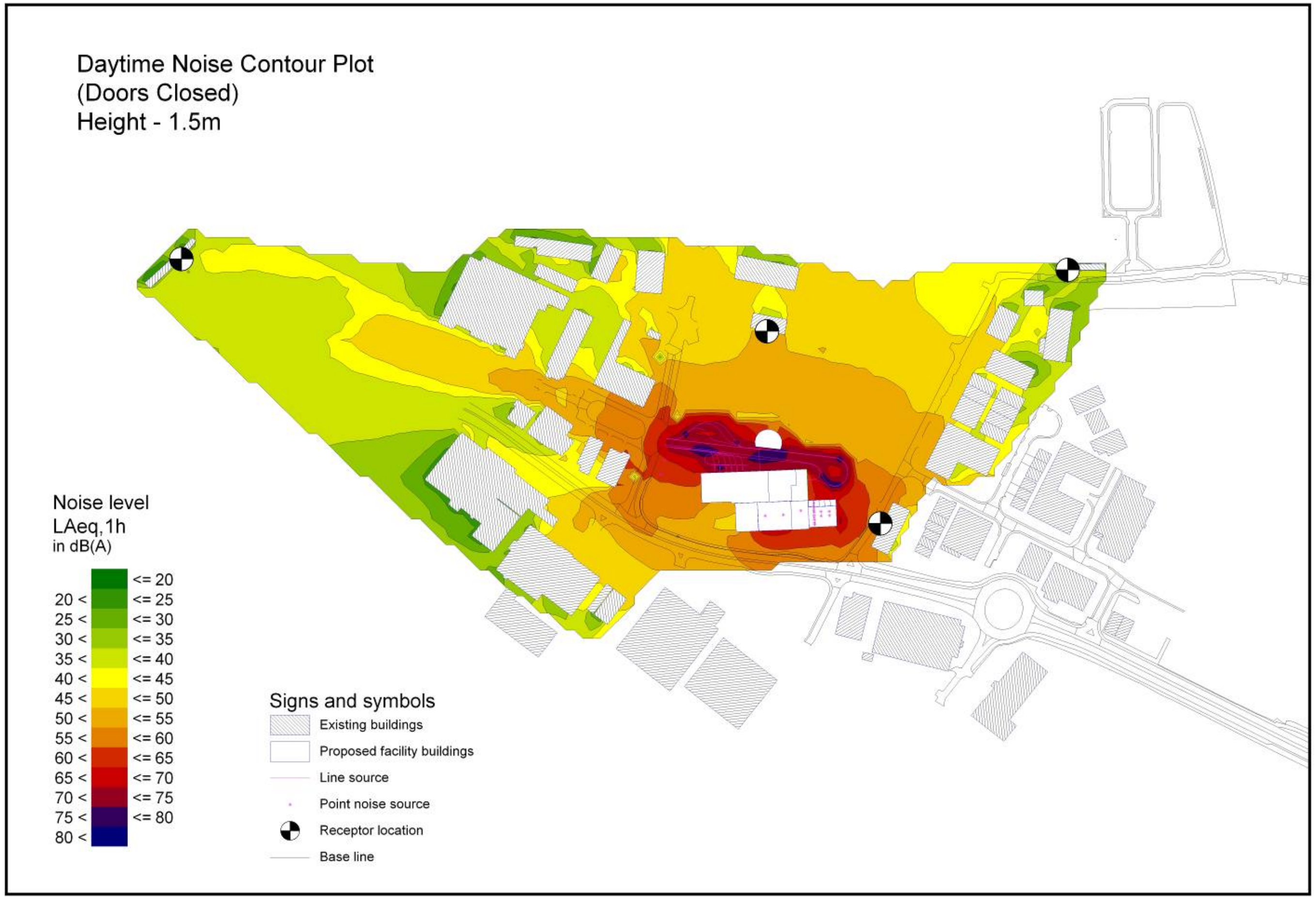


FIGURE E5-2: DAYTIME NOISE CONTOURS (DOORS CLOSED)

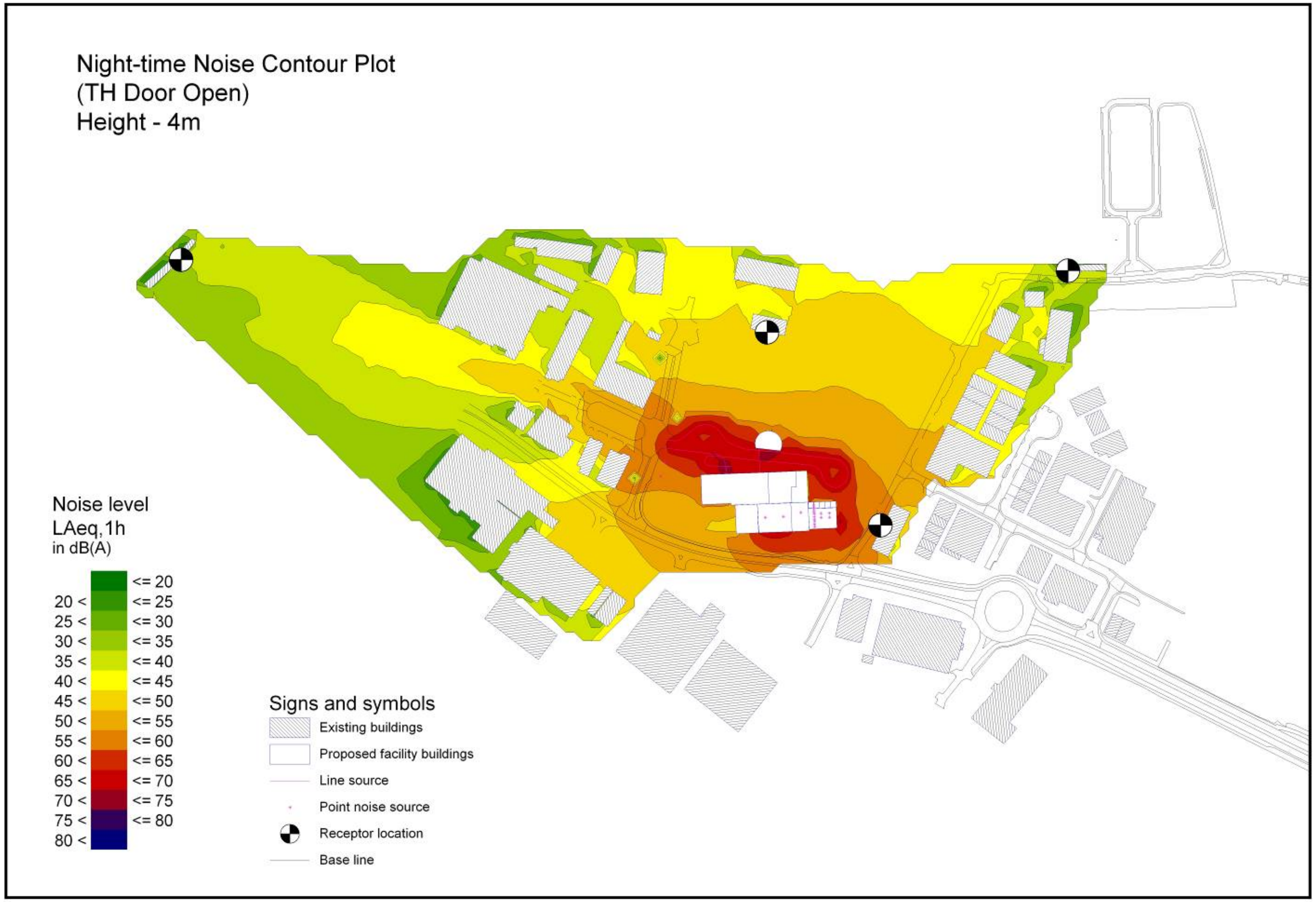


FIGURE E5-3: NIGHT-TIME NOISE CONTOURS (TH DOOR OPEN)

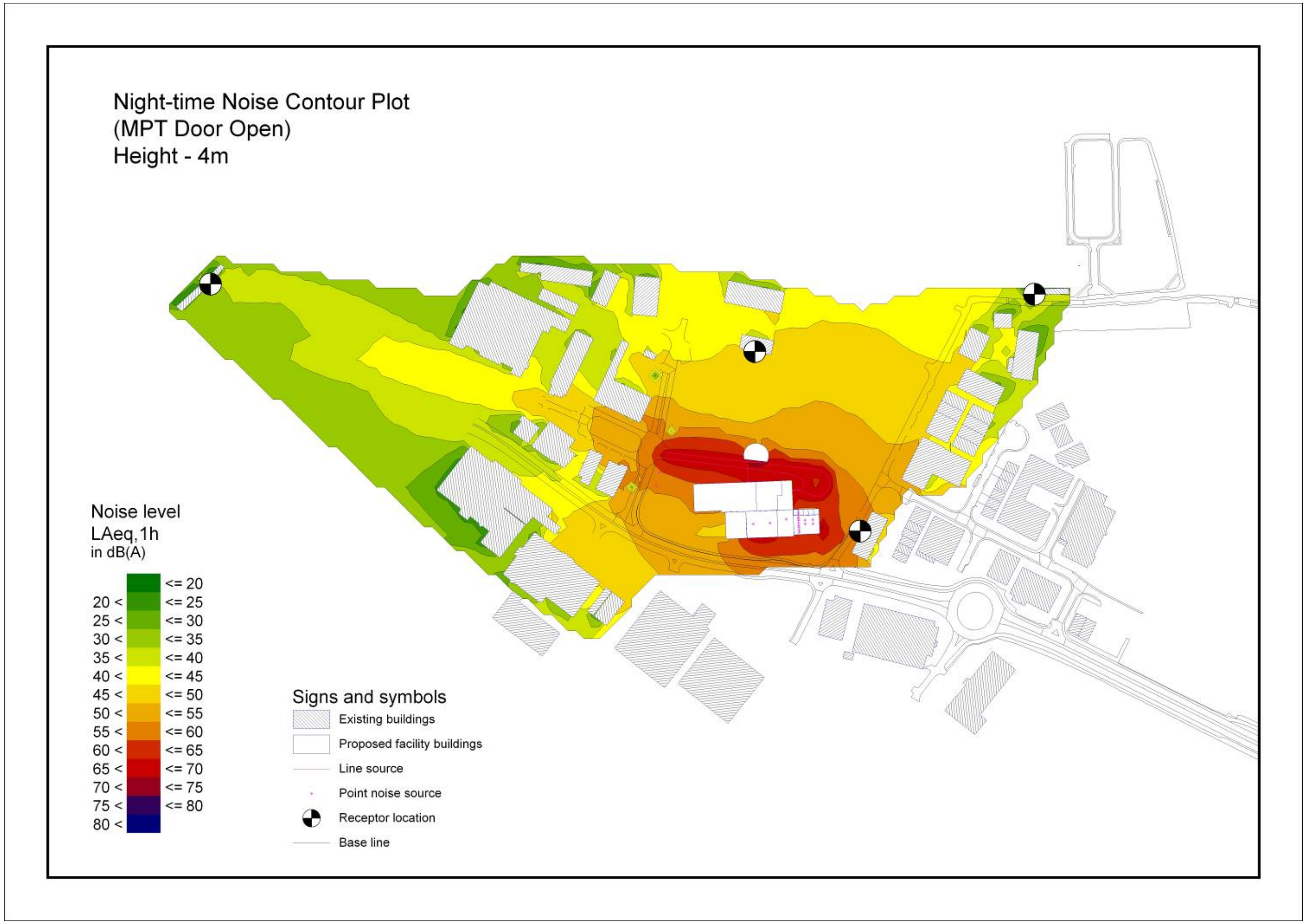


FIGURE E5-4: NIGHT-TIME NOISE CONTOURS (MPT DOOR OPEN)

Scott Wilson

Development of an Integrated Mechanical Pre-treatment and Energy from Waste Facility

Former Wholesale Market Site Cross Green Leeds

Baseline Noise Monitoring Report

August 2010

Prepared for

VEOLIA ENVIRONMENTAL SERVICES

Revision Schedule

Baseline Noise Monitoring Report
August 2010

Rev	Date	Details	Prepared by	Reviewed by	Approved by
02	August 2010	Final	**Ruth Dawson** Senior Assistant Acoustics and Vibration Consultant	**Suzanne Scott** Principal Acoustics Consultant	**Paul Shields** Associate – Acoustics and Vibration Team Leader

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Table of Contents

Executive Summary

Veolia Environmental Services plc (Veolia) is one of two companies remaining in the bid for the residual waste treatment contract being procured by Leeds City Council (LCC) - in its capacity as the Waste Disposal Authority (WDA) for Leeds.

In connection with the above, Veolia is proposing to develop an integrated Mechanical Pre-Treatment (MPT) and Energy from Waste Facility (EWF) at the Former Wholesale Market site in Cross Green, Leeds.

Veolia has commissioned Scott Wilson undertake baseline noise monitoring to determine the existing noise levels experienced by the nearest sensitive receptors to the proposed site.

Noise monitoring was undertaken at two locations representative of the nearest residential properties to proposed site. Noise monitoring was also undertaken at the nearest identified offices to the development site.

At the closest residential properties on Halton Moor Road to the north east of the site, the dominant noise source during the day was the existing nearby premises on the industrial park including constant plant noise, lorries idling and reversing alarms. At night, activities at these adjacent premises ceased, though plant noise from the William Cook Casting site further to the south west on the industrial park was clearly audible. Local road traffic was also a significant noise source at this location.

At the residential properties on Cross Green Lane to the west of the site the William Cook Casting site was the dominant source during the day and night. Local and more distant road traffic was also a significant source.

At the closet identified offices, located immediately to the east of the site, road traffic and noise from existing premises on the industrial park, including the William Cook Casting site, were the dominant sources.

1 Introduction

1.1 Scope

1.1.1 Veolia Environmental Services plc (Veolia) is one of two companies remaining in the bid for the residual waste treatment contract being procured by Leeds City Council (LCC) - in its capacity as the Waste Disposal Authority (WDA) for Leeds.

1.1.2 In connection with the above, Veolia is proposing to develop an integrated Mechanical Pre-Treatment (MPT) and Energy from Waste Facility (EWF) at the Former Wholesale Market site in Cross Green, Leeds.

1.1.3 Veolia has commissioned Scott Wilson undertake baseline noise monitoring to determine the existing noise levels experienced by the nearest sensitive receptors to the proposed site.

1.1.4 This report:

- describes the measurement methodology; and
- reports the findings of the noise survey.

1.1.5 A summary of relevant noise terminology is provided in Appendix A.

1.2 Site Description

1.2.1 The development site is located within the Cross Green Industrial Park, see Figure B.1 in Appendix B. Immediately to the south of the site is the A63 East Leeds Link Road (Pontefract Lane), a busy main road which connects the M1 at junction 45 to Leeds city centre. To the south, beyond the A63, and immediately to the east and west of the site are commercial premises on the industrial park. These are mainly industrial units and warehouses. Immediately to the north of the site is an area of open former industrial land. Further to the north are the Waterloo sidings which are understood to be unused.

1.2.2 The closest identified residential properties are located on Halton Moor Road, approximately 100m to the north east, and Cross Green Lane, approximately 300 m to the west.

1.2.3 The closest identified offices, associated with the commercial premises on the industrial park, are located immediately to the east of the site at EPCO Plastics on New Market Lane.

2 Noise Monitoring

2.1 Methodology

2.1.1 Noise monitoring was undertaken on 30th June -1st July 2010 at two locations representative of the nearest residential receptors to the development site. These locations are

- 225 Cross Green Lane; and
- 646 Halton Moor Road.

2.1.2 Noise monitoring was also undertaken on 30th June 2010 at the location of the nearest identified offices to the development site at EPCO Plastics on New Market Lane.

2.1.3 The noise meters were set to log various parameters including the L_{Aeq}, L_{A10}, L_{A90} and L_{Amax}.

2.1.4 Noise monitoring at the residential properties was undertaken to the requirements of British Standard BS 4142 'Rating mixed industrial and residential areas'[1], which requires a one hour assessment period between the hours of 07:00-23:00 and a five minute assessment period between the hours of 23:00-07:00. Therefore a 1 hour logging period was used during the day and a 5 minute logging period at night.

2.1.5 At the location of the closest identified offices noise monitoring was undertaken for a period of 30 minutes during daytime hours. The meter was set to a 30 minute logging period.

2.1.6 The noise monitoring locations, timing and durations of monitoring were discussed and agreed with Roger Loughton of Leeds City Council (LCC)[2]. Measurements at the closest identified offices within the industrial estate were specifically requested by LCC.

2.1.7 The noise monitoring locations are shown on Figure B.1 in Appendix B.

2.2 Instrumentation

2.2.1 The noise monitoring equipment used during the survey is listed below:

225 Cross Green Lane:

- Brüel and Kjær integrated sound levels meter, type 2238. Serial number: 2541001;
- Brüel and Kjær all weather microphone protection kit; and
- Brüel and Kjær acoustic calibrator, type 4231. Serial number 2656635.

646 Halton Moor Road and offices location

- Norsonic integrated sound level meter, type 118. Serial no. 31441; and
- Brüel and Kjær acoustic calibrator, type 4231. Serial number 2656635.

2.3 Location and Time of Survey

2.3.1 At 225 Cross Green Lane the microphone was positioned 1.5m from the facade of the ground floor level of the property, approximately 1.2 m above ground. At this position a reasonably secure location in which the noise meter could be left unattended was available, therefore continuous measurements were carried out between 10:23 on 30th June and 09:44 on 1st July. In order to ensure a good understanding of the noise climate was obtained personnel were on site at this location between 10:23 – 10:50 and 00:04 – 00:37.

2.3.2 At 646 Halton Moor Road the meter was positioned in a free-field position, with the microphone located at approximately 1.4 m above ground. No secure location in which the noise meter could be left unattended was available therefore attended measurements were carried out for representative periods during the day and night, as agreed with LCC. Measurements were carried out between 11:00 - 13:00 and 15:08 - 17:08 on 30th June, and 00:45 - 01:45 on 1st July.

2.3.3 At the location of the nearest offices the meter was positioned in a free-field position, with the microphone located approximately 1.4 m above ground. Attended measurements were carried out during the daytime between 14:30 - 15:00 on 30th June. It is assumed that offices associated with nearby commercial premises on the industrial estate will not be in use at night.

2.3.4 Photographs of the monitoring locations are provided in Appendix C.

2.4 Weather

2.4.1 A summary of weather conditions observed during the noise monitoring is provided in Appendix D. Weather conditions were good, with no periods of rain. During the day wind speeds were very low (< $1ms^{-1}$) from the south east, at night conditions were calm. These weather conditions are within the acceptable limits given in BS 7445[3].

2.5 Observations

2.5.1 The following observations of local noise sources were made:

225 Cross Green Lane

- constant plant noise from William Cook Castings (day and night) located to the south (see Figure B.1 in Appendix B for location);
- distant road traffic noise;
- occasional road traffic on Cross Green Lane;
- distant train movements; and
- birdsong.

646 Halton Moor Road

- constant plant/machinery noise from industrial units located opposite (daytime only)
- idling lorries and bangs and clatters from activities at the industrial units located opposite;
- plant noise from William Cook Castings (only audible during night-time);
- road traffic on Halton Moor Road;
- reversing alarms from the industrial park;
- vehicles travelling over speed bumps; and
- birdsong.

Offices – New Market Lane

- road traffic on New Market Lane and Pontefract Lane;

- plant noise from William Cook Castings;
- birdsong; and
- activities at nearby industrial units.

2.6 Monitoring Results

2.6.1 A summary of the baseline noise monitoring results at the nearest residential properties are provided in Tables 2.1 and 2.2. Further details are given in Appendix E and F.

Table 2.1: Summary of Noise Monitoring Results, Daytime at residential properties

Location	Start time	Duration Hr:min	Average Ambient Noise Level* $L_{Aeq,1h}$ dB	Average Background Noise Level# $L_{A90,1h}$ dB	Highest $L_{Amax,fast}$ dB
225 Cross Green Lane (façade)	10:23-22:59, and 06:59-09:44	15:21	59.5	48.5	89.7
646 Halton Moor Road (free-field)	11:00	02:00	63.2	52.3	86.6
	15:08	02:00	61.7	46.2	83.1

* Energy average
# Arithmetic average

Table 2.2: Summary of Noise Monitoring Results, Night-time at residential properties

Location	Start time	Duration Hr:min	Average Ambient Noise Level* $L_{Aeq,1h}$ dB	Average Background Noise Level# $L_{A90,1h}$ dB	Highest $L_{Amax,fast}$ dB
225 Cross Green Lane (façade)	23:00	08:00	53.4	46.9	77.4
646 Halton Moor Road (free-field)	00:45	01:00	47.3	39.9	70.4

* Energy average
# Arithmetic average

2.6.2 A summary of the baseline noise monitoring results at the nearest offices are provided in Table 2.3.

Table 2.3: Summary of Noise Monitoring Results, Daytime at closest offices

Location	Start time	Duration Hr:min	Average Ambient Noise Level $L_{Aeq,1h}$ dB	Average Background Noise Level $L_{A90,1h}$ dB	Highest $L_{Amax,fast}$ dB
New Market Lane (free-field)	14:30	00:30	65.5	52.3	91.4

2.7 Discussion of the Results

2.7.1 The dominant noise source at 225 Cross Green Lane was plant noise from the William Cook Castings factory located on Pontefract Lane (see Figure B.1 in Appendix B) and this can be seen in the fairly constant L_{A90} levels at this location (see Table E.1 of full results in Appendix E and time history graph in Appendix F). Average L_{A90} levels during the day are less than 2 dB higher than at night. Local and more distant traffic noise were also significant noise sources at this location.

2.7.2 At 646 Halton Moor Road the dominant noise sources during the daytime was the industrial units located opposite, including constant plant noise, lorries idling and reversing alarms, and road traffic on Halton Moor Road. During the night-time periods plant noise from the William Cook Casting factory located on Pontefract Lane was the dominant noise source, the industrial units opposite the monitoring location did not operate at night.

2.7.3 At the closet identified offices, located immediately to the east of the site, road traffic on both the A63 to the south and within the industrial park, and noise from existing premises on the industrial park, including the William Cook Casting site, were the dominant sources.

2.7.4 It is considered that the noise monitoring data are representative of current existing ambient noise levels at the closest residential properties and offices to the proposed site.

References

1 British Standard BS 4142: 1997 'Rating industrial noise affecting mixed residential and industrial areas', British Standards Institute.

2 Telephone conversation between Suzanne Scott (Scott Wilson Ltd) and Roger Loughton (Leeds City Council) 24.06.2010, and follow up email from Suzanne Scott to Roger Loughton, 24.06.2010.

3 British Standard 7445: 1991 and 2003 'Description and measurement of environmental noise'. British Standards Institute

Appendix A: Noise Terminology and Perception

Between the quietest audible sound and the loudest tolerable sound there is a million to one ratio in sound pressure (measured in Pascals, Pa). Because of this wide range, a noise level scale based on logarithms is used in noise measurement called the decibel (dB) scale. Audibility of sound covers a range of approximately 0 to 140 dB. The human ear system does not respond uniformly to sound across the detectable frequency range and consequently instrumentation used to measure noise is weighted to represent the performance of the ear. This is known as the 'A weighting' and annotated as dB(A). Table A.1 lists the sound pressure level in dB(A) for common situations.

Table A.1: Noise Levels for Common Situations

Approximate Sound Pressure Level dB(A)	Example
0	Threshold of hearing
30	Rural area at night, still air
40	Public library, Refrigerator humming at 2m
50	Quiet office, no machinery, Boiling kettle at 0.5m
60	Normal conversation
70	Telephone ringing at 2m, Vacuum cleaner at 3m
80	General factory noise level
90	Heavy goods vehicle from pavement Powered lawnmower, operator's ear
100	Pneumatic drill at 5m
120	Discotheque - 1m in front of loudspeaker
140	Threshold of pain

The noise level at a measurement point is rarely steady, even in rural areas, and varies over a range dependent upon the effects of local noise sources. Close to a busy motorway, the noise level may vary over a range of 5 dB(A), whereas in a suburban area this variation may be up to 40 dB(A) and more due to the multitude of noise sources in such areas (cars, dogs, aircraft etc.) and their variable operation. Furthermore, the range of night-time noise levels will often be smaller and the levels significantly reduced compared to daytime levels. When considering environmental noise, it is necessary to consider how to quantify the existing noise (the ambient noise) to account for these second to second variations.

A parameter that is widely accepted as reflecting human perception of the ambient noise is the background noise level, L_{A90}. This is the noise level exceeded for 90 % of the measurement period and generally reflects the noise level in the lulls between individual noise events. Over a one hour period, the L_{A90} will be the noise level exceeded for 54 minutes.

The L_{A10} is the noise level exceeded for 10% of the time and is the parameter widely used in the assessment of road traffic noise. Over a one hour period, the L_{A10} will be the noise level exceeded for 6 minutes.

The equivalent continuous A-weighted sound pressure level, L_{Aeq} is the single number that represents the total sound energy measured over that period. L_{Aeq} is the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measurement period. It is commonly used to express the energy level from individual sources that vary in level over their operational cycle.

Human subjects are generally only capable of noticing changes in steady levels of no less than 3 dB(A). It is generally accepted that a change of 10 dB(A) in an overall, steady noise level is perceived to the human ear as a doubling (or halving) of the noise level. (These findings do not necessarily apply to transient or non-steady noise sources such as changes in noise due to changes in road traffic flow, or intermittent noise sources).

Appendix B: Noise Monitoring Locations

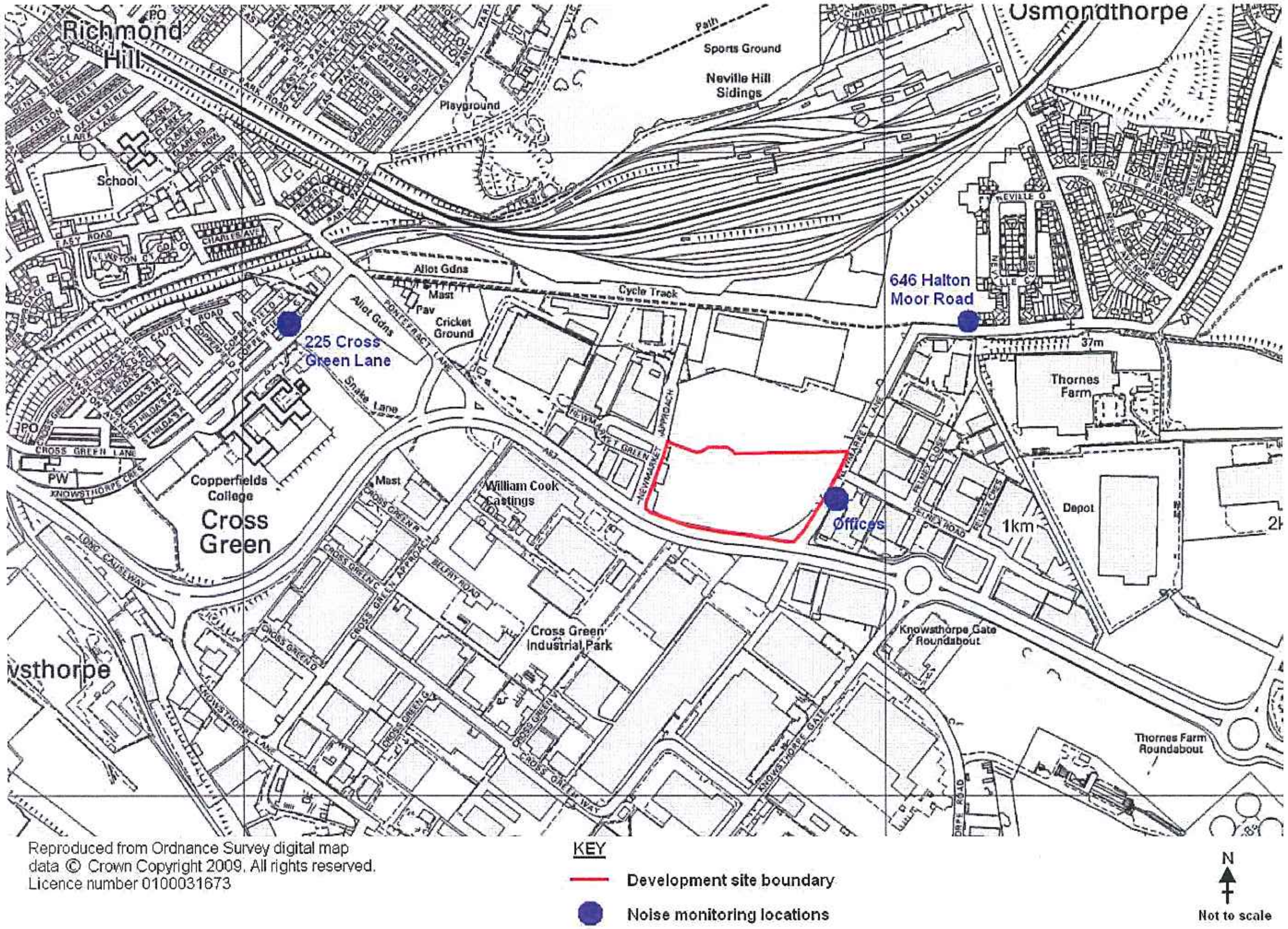


Figure B.1: Location of noise monitoring

Appendix C: Site Photos

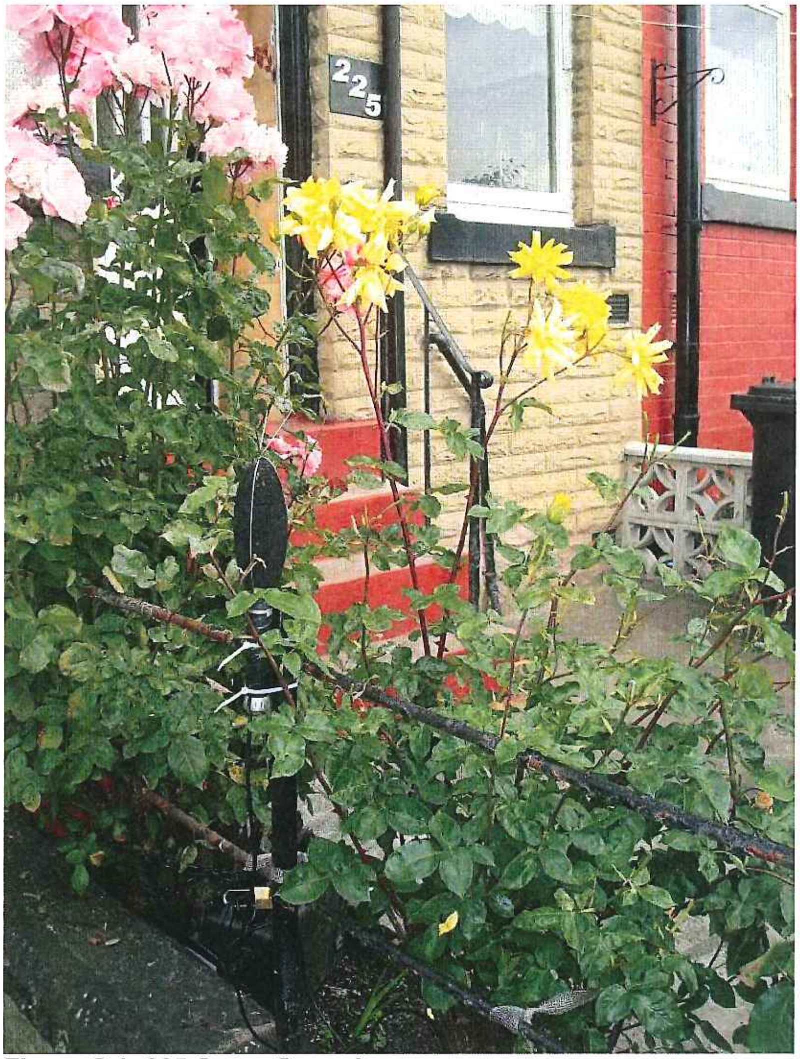


Figure C.1: 225 Cross Green Lane

Figure C.2: 646 Halton Moor Road

Figure C.3: Nearest offices, New Market Lane

Appendix D: Weather Conditions During Monitoring

Table D.1: Summary of weather observations

Day	Time of Observation	Average Temp °C	Average Wind Speed ms^{-1}	Wind Direction	Precipitation
Wednesday 30th June 2010	10:45	24	0.4	SE	None
	15:05	25	0.3	SE	None
Thursday 1st July 2010	00:05	18	Calm	-	None

Appendix E: Noise Monitoring Data

Table E.1: Noise monitoring data – 255 Cross Green Lane

Start Time	$L_{Aeq,1h}$ dB	$L_{A90,1h}$ dB	$L_{A10,1h}$ dB	$L_{Amax,fast}$ dB
10:23	59.7	45.5	62.5	85.9
11:23	61.3	46.0	64.5	83.4
12:23	59	45.5	63.0	78.8
13:23	59.8	49.0	63.0	84.2
14:23	60.2	49.0	63.5	89.7
15:23	60.2	48.0	64.0	78.9
17:24	60.2	48.0	64.0	83.0
18:24	58.9	48.6	62.5	75.7
19:24	58.2	47.8	60.3	81.9
20:24	58.7	46.9	60.4	86.4
21:24	57.2	47.0	58.8	77.9
22.24 (to 22.59)	55.8	48.0	56.3	75.3
06:59	55.0	47.9	53.9	74.0
07:59	60.6	53.0	63.2	87.8
08:59 (to 09:44)	61.4	53.3	64.8	81.3
Start Time	**$L_{Aeq,5min}$ dB**	**$L_{A90,5min}$ dB**	**$L_{A10,5min}$ dB**	**$L_{Amax,fast}$ dB**
22:59	48.8	46.5	50.0	57.3
11:04	53.3	47.0	51.0	69.1
11:09	50.6	47.0	50.0	67.5
11:14	53.7	47.5	53.0	67.9
11:19	55.0	47.5	55.0	69.9
11:24	55.1	48.0	55.0	73.4
11:29	53.9	47.5	53.0	70.3
11:34	54.1	46.5	50.5	72.8
11:39	55.8	46.5	53.0	74.8
11:44	47.3	45.5	48.0	53.9
11:49	50.6	46.5	49.5	68.1

Start Time	$L_{Aeq,5min}$ dB	$L_{A90,5min}$ dB	$L_{A10,5min}$ dB	$L_{Amax,fast}$ dB
11:54	53.7	45.5	55.0	71.3
11:59	51.1	45.0	48.5	68.0
12:04	49.3	45.5	48.5	64.9
12:09	47.1	46.0	47.5	55.1
12:14	52.4	46.0	48.5	72.3
12:19	54.4	46.0	48.5	75.7
12:24	51.9	46.0	48.5	69.6
12:29	47.7	46.5	48.5	60.8
12:34	50.5	45.5	51.0	67.6
12:39	48.3	46.5	50.0	57.3
12:44	51.1	46.5	49.0	72.8
12:49	47.3	46.0	48.0	55.4
12:54	47.8	46.5	48.5	50.8
12:59	51.0	48.0	50.0	68.0
01:04	54.0	47.5	49.0	75.6
01:09	49.2	47.0	50.0	68.6
01:14	47.8	46.0	48.5	53.9
01:19	47.6	46.5	48.5	54.2
01:24	51.9	46.0	50.0	71.2
01:29	47.7	46.0	48.5	52.2
01:34	48.9	46.0	50.5	64.1
01:39	47.3	46.0	48.5	53.3
01:44	54.0	46.0	48.5	72.1
01:49	46.5	45.5	47.5	52.7
01:54	46.8	45.5	48.0	50.8
01:59	46.4	44.5	48.0	62.8
02:04	47.8	44.5	47.5	72.6
02:09	46.5	45.0	48.0	52.6
02:14	47.8	45.5	49.5	61.7
02:19	46.2	44.5	47.0	54.4
02:24	46.2	44.5	47.0	52.7

Start Time	$L_{Aeq,5min}$ dB	$L_{A90,5min}$ dB	$L_{A10,5min}$ dB	$L_{Amax,fast}$ dB
02:29	52.4	45.0	54.0	69.8
02:34	46.2	44.5	47.5	59.0
02:39	45.0	44.0	45.5	49.6
02:44	45.4	44.0	46.0	50.7
02:49	45.2	43.0	46.5	61.6
02:54	44.0	43.0	45.0	51.7
02:59	45.1	43.5	46.5	55.3
03:04	44.7	43.5	45.0	60.4
03:09	46.2	44.5	47.5	59.8
03:14	49.4	43.5	52.0	63.0
03:19	44.5	43.0	45.5	57.3
03:24	43.4	42.0	44.5	48.4
03:29	56.7	43.0	51.0	76.6
03:34	44.9	43.5	46.0	49.8
03:39	49.6	44.5	47.0	67.9
03:44	47.5	45.5	49.5	53.2
03:49	48.2	46.0	50.0	52.2
03:54	47.5	46.5	48.5	51.8
03:59	52.2	45.5	48.0	71.4
04:04	47.4	45.5	48.5	53.3
04:09	47.0	45.5	48.5	54.8
04:14	47.2	45.5	48.5	52.3
04:19	47.3	45.5	48.5	61.1
04:24	47.7	46.0	49.0	51.7
04:29	52.6	46.0	49.5	72.3
04:34	48.1	46.5	49.5	54.6
04:39	49.4	47.0	51.5	60.9
04:44	55.5	47.5	57.5	74.9
04:49	55.5	49.0	58.0	70.1
04:54	56.9	49.0	58.0	72.6
04:59	52.9	48.5	55.5	70.7

Start Time	$L_{Aeq,5min}$ dB	$L_{A90,5min}$ dB	$L_{A10,5min}$ dB	$L_{Amax,fast}$ dB
05:04	55.2	48.0	58.0	71.1
05:09	52.6	48.0	52.0	71.5
05:14	56.4	48.5	54.0	73.4
05:19	55.0	48.0	59.0	68.8
05:24	55.3	48.0	59.5	68.1
05:29	53.0	47.5	55.5	68.8
05:34	54.7	48.5	57.5	68.0
05:39	53.5	48.0	54.0	72.4
05:44	52.3	48.5	52.5	67.2
05:49	57.8	48.5	55.5	76.3
05:54	54.9	48.5	57.0	71.1
05:59	58.7	48.5	53.0	76.3
06:04	57.1	51.0	57.0	77.4
06:09	57.8	53.5	61.5	67.5
06:14	58.1	53.5	61.0	72.0
06:19	56.2	53.0	58.0	67.1
06:24	57.8	53.5	60.5	68.0
06:29	58.3	54.0	60.5	72.4
06:34	56.8	54.0	57.5	72.4
06:39	57.7	53.5	61.0	69.1
06:44	60.7	54.0	63.0	76.3
06:49	59.9	53.5	61.0	75.9
06:54	60.4	53.5	64.0	75.7

Table E.2: Noise monitoring data – 646 Halton Moor Road

Start Time	$L_{Aeq,1h}$ dB	$L_{A90,1h}$ dB	$L_{A10,1h}$ dB	$L_{Amax,fast}$ dB
11:00	63.3	48.2	66.1	82.5
12:00	63.1	56.3	65.8	86.6
15:08	61.2	46.2	65.4	83.1
16:08	62.1	46.1	66.2	82.3
Start Time	**$L_{Aeq,5min}$ dB**	**$L_{A90,5min}$ dB**	**$L_{A10,5min}$ dB**	**$L_{Amax,fast}$ dB**
00:45	45.7	40.8	46.2	68.0
00:50	45.3	40.3	44.6	62.7
00:55	44.8	40.3	43.5	62.4
01:00	51.8	41.1	52.8	70.4
01:05	41.4	40.2	42.4	46.9
01:10	46.0	40.2	42.3	64.6
01:15	45.2	39.1	47.9	61.1
01:20	46.4	39.5	42.4	66.4
01:25	47.3	39.3	46.4	67.5
01:30	47.1	39.4	46.9	65.0
01:35	49.1	39.2	44.8	69.1
01:40	48.9	39.6	49.5	69.9

Appendix F: Noise Monitoring Plots

Figure F.1: Noise plot – Cross Green Lane, daytime

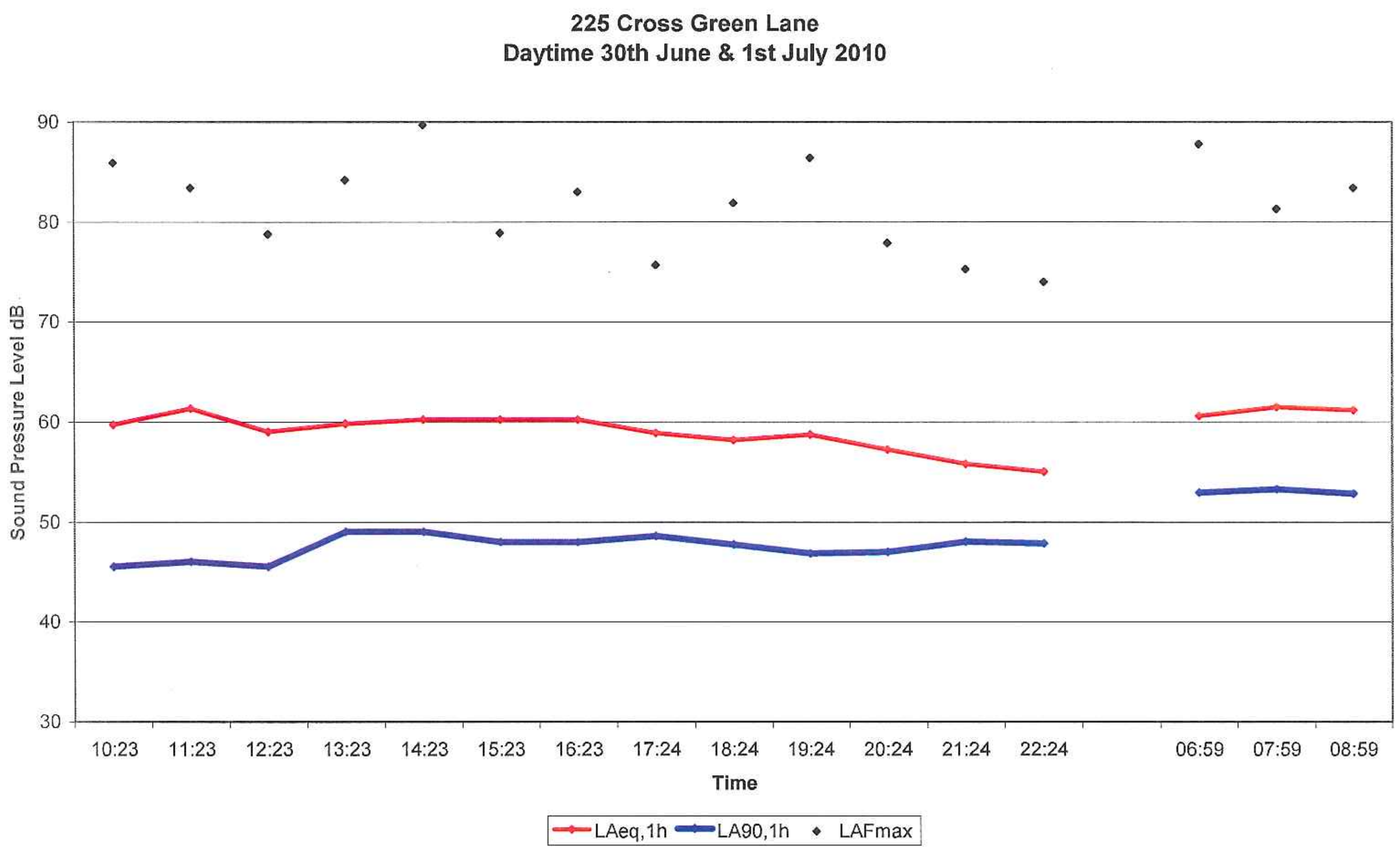
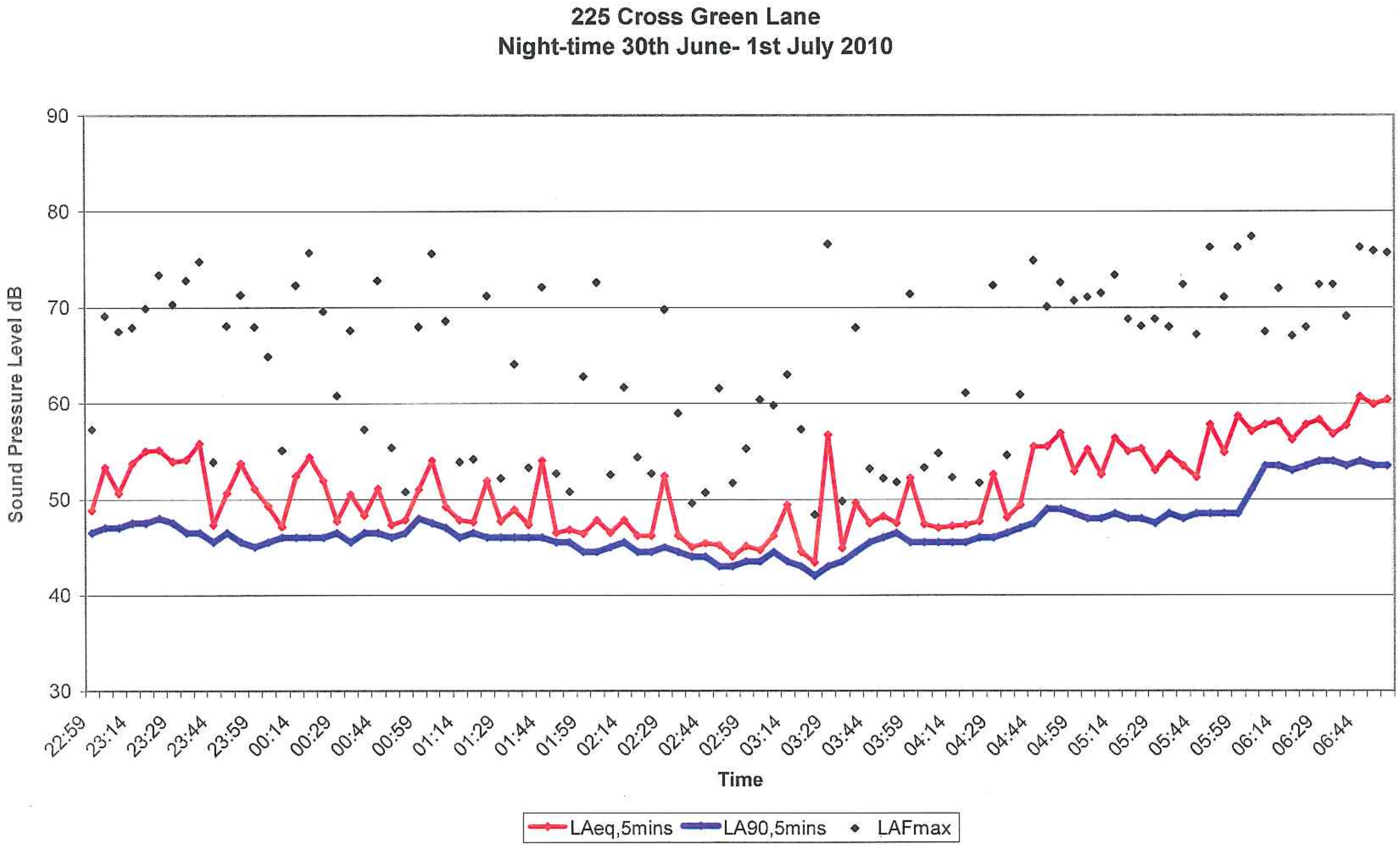


Figure F.2: Noise plot – Cross Green Lane, night-time



Annex D

Air Quality

CONTENTS

D1 INTRODUCTION

D1.1 OVERVIEW

This report sets out the Air Quality Impact Assessment (the Assessment) for the proposed development of a Recycling and Energy Recovery Facility (RERF, or Facility) at Cross Green, Leeds. The Assessment set out supports the Environmental Permit Application required for the Facility.

Impacts to air quality have the potential to arise during the operational phase of the project. This report addresses the emissions arising from the RERF and also presents the in-combination impacts from traffic accessing the site during operation.

The assessment of operational impacts considers effects on both sensitive human and ecological receptors, including:

- the potential for odour emissions to arise during operation;
- the potential impact on air quality during normal operation and the suitability of the stack height to avoid significant impacts to air quality for local sensitive receptors;
- the potential impacts on air quality of start-up and shut down of the Facility, and emissions during abnormal operations;
- the potential for impacts associated with the handling of bottom ash; and
- of the potential for the occurrence of visible plumes.

In addition to these topics, the Assessment is supported by the Human Health Risk Assessment (HHRA) (see *Annex E)* that quantifies the potential long term impacts of emissions from the operation of the process on human health.

D1.2 POLLUTANTS OF INTEREST

In relation to impacts on humans the pollutants of interest are primarily those set out in the *Waste Incineration Directive* (WID) (1) which has since been recast in the *Industrial Emissions Directive* (IED) (2). These are:

- particulate matter (as particulate matter of aerodynamic diameter ≤10µm (PM_{10}));

(1) Directive 2000/76/EC Of The European Parliament And Of The Council of 4 December 2000 on the incineration of waste http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:332:0091:0111:EN:PDF
(2) Directive 2012/75/EC on industrial emissions (integrated pollution prevention and control (recast) of 24 November 2010 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:EN:PDF

- gaseous and vaporous organic substances, expressed as total organic carbon (VOC);
- hydrogen chloride (HCl);
- hydrogen fluoride (HF);
- sulphur dioxide (SO_2);
- oxides of nitrogen (NO_x), the sum of nitric oxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide;
- twelve metals: arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr) (as CrIII and CrVI), copper (Cu), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), antimony (Sb), thallium (Tl) and vanadium(V);
- polychlorinated dibenzo-*para*-dioxins and polychlorinated dibenzo furans (collectively referred to as dioxins); and
- carbon monoxide (CO).

Emissions of ammonia (NH_3), $PM_{2.5}$ (particulate matter of aerodynamic diameter ≤2.5µm) and polycyclic aromatic hydrocarbons (PAH) will also be considered, for the following reasons:

- NH_3 is of interest in relation to impacts on habitats, both directly and as a component of acid and nutrient nitrogen deposition.
- $PM_{2.5}$ has recently become an increasingly prominent air pollutant of interest due to research indicating that $PM_{2.5}$ is associated with impacts to health, and is now subject to a statutory air quality standard in the UK in light of the *European Directive on ambient air quality and cleaner air for Europe* (1) (referred to as the 2008 Directive).
- PAH have recently become an increasingly prominent air pollutant of interest and one of the key PAH species, benzo[a]pyrene, is subject to a statutory air quality standard in the UK in light of the 2008 Directive.

In addition, consideration is made of emissions of dust from handling of bottom ash, and emissions of odour during operation.

In relation to impacts on sensitive ecology, potential impacts associated with emissions of NH_3, NO_X, HF and SO_2 have been assessed both through impacts directly to air quality and through deposition of total chromium, acid and nutrient nitrogen.

(1) Directive 2008/50/EC Of The European Parliament And Of The Council of 21 May 2008 on ambient air quality and cleaner air for Europe

D2 BASELINE RECEPTORS AND METHODOLOGY

D2.1 OVERVIEW

This section sets out the method for the assessment of potential impacts that may arise from the operation of the Facility. In addition, a description of the baseline environment is set out, along with details of human and ecological sensitive receptors and criteria for assigning significance to impacts identified.

D2.2 INITIAL SCOPING AND SCREENING

D2.2.1 Introduction

There are several issues that have been considered and subsequently scoped out of the Air Quality Impact Assessment on the basis of negligible impacts. A summary of these is set out here.

D2.2.2 Dust from On-site Vehicle Movements During the Operational Phase

Dust from on-site vehicle movements during the operational phase will be negligible, as external areas are landscaped and built as hardstanding. The opportunity for surfaces to become soiled due to deposition of waste or from mud tracked in on trucks is negligible, as waste trucks will be sealed or covered, and trucks will not run through soiled areas on their way into or out of the site.

D2.2.3 Flue Gas Treatment Residue

The abatement of the gases generated from the combustion process produces a flue gas treatment (FGT) residue. This material is potentially hazardous, only if allowed to escape to the environment, because of the residual contaminants and the lime it contains. Therefore, the handling of this material is undertaken by a contained system, and the FGT residue is removed by tanker for treatment or disposal off-site. There is no pathway of exposure for members of the public to the FGT residue. On this basis, emissions of FGT residue are considered not to occur and are scoped out of this assessment.

D2.2.4 Bottom Ash

The combustion process produces bottom ash, a non hazardous material that arises from the non-combustible fraction of waste. This material is dry and friable and therefore has the potential to cause nuisance if dust is allowed to escape during processing and handling. The bottom ash systems are designed so that all material handling is undertaken indoors and any dust is therefore contained. In addition, the bottom ash is removed from site in sealed containers and therefore the potential for dust to be released during transport is insignificant. On this basis, emissions of dust arising from processing and handling of bottom ash are considered not to occur and are scoped out of this assessment.

D2.3 BASELINE CONDITIONS

D2.3.1 *Overview*

The baseline conditions in the study area depend upon local and regional sources of emissions to air, both natural and man-made. This section describes the baseline conditions in the study area with regard to existing:

- concentrations of airborne pollutants in the vicinity of the proposed facility and at receptors; and
- deposition of acid and nutrient nitrogen at sensitive habitats.

There are heavily trafficked roads in the vicinity of the proposed development site, including the M1 and M62 to the south, and busy local roads including the A63 and A64. There are also industrial emissions in the vicinity of the proposed development; the associated traffic of these industrial operations all contribute to ambient air quality. As a consequence, concentrations of certain pollutants (notably those related to traffic emissions, ie NO_X and PM_{10}) are variable, with higher concentrations in close proximity to busy roads.

Conversely, concentrations of other pollutants are largely uniform across the study area, as there are no major local sources of emissions (ie PAH, ammonia, HF and HCl). In addition, there are various industries surrounding the site and as a likely consequence of emissions from these processes the concentration of some trace metals, in particular chromium, are elevated in the immediate area around the RERF.

The baseline data are based upon recent monitoring and other currently available information. For the large majority of pollutants where no specific local sources of emissions are present, the future baseline concentrations are likely to be similar to those at present. In the case of some pollutants, in particular PM_{10}, $PM_{2.5}$, NO_2 and NO_x, there are national policies (ie the Air Quality Strategy) in place. The aim of these policies is to decrease their concentrations, particularly in locations where they are elevated (ie adjacent to busy roads), theoretically improving baseline conditions. However, recent research (1) indicates that, in urban environments at least, these policies do not appear to be reducing concentrations of these pollutants as expected. Benefits from technological advances in emission controls are outstripped by the increases in car usage. On this basis, using current baseline pollution concentrations to represent future baseline concentrations represents a pragmatic and reasonable approach and certainly one that is unlikely to underestimate concentrations.

(1) Fuller G. (2009) Source apportionment of PM in the UK using measurements Presented at the Dispersion Modellers Users Group 24th November 2009

D2.3.2 *Summary of Sources*

The baseline air quality data have been derived from consideration of a number of sources, listed here in order of priority.

D2.3.3 *Baseline Monitoring Survey*

A baseline air quality survey was conducted by TRL, commissioned by URS on behalf of VESL, in the vicinity of the proposed development site. The survey includes a continuous air monitoring station (CAMS) located at Newmarket Approach (refer to *Figure D2.1*) and included continuous monitoring of NO_2, NO_x, SO_2, PM_{10} and $PM_{2.5}$. In addition, quarterly monitoring of metals, PAH, PCB, dioxins and furans have been carried out at the same monitoring location. Monitoring at Newmarket Approach was carried out between 30 June 2010 and 15 July 2011.

A diffusion tube monitoring study has also been undertaken by TRL around the location of the proposed RERF. Monitoring has been carried out for a period of twelve months at twelve locations with duplicate samples located at the Newmarket Approach site. The co-location of the diffusion tubes and continuous monitoring site allows the results of the less accurate diffusion tube measurements to be bias corrected. The diffusion tube study included monthly sampling of NO_2.

D2.3.4 *Interpolated Mapping Data*

Interpolated mapping data (1) were interrogated to derive ambient concentrations of benzene and carbon monoxide, as there are no locally available monitoring data for these pollutants. It is anticipated that baseline concentrations of these pollutants will be substantially below the concentrations specified in the relevant AQS.

D2.3.5 *Air Pollution Information Service*

The APIS website provided ambient baseline concentrations for ammonia. In the absence of local monitoring data, this was used to represent baseline concentrations. Given the absence of any significant local sources of emissions, it is anticipated that the concentrations of these substances will be substantially below concentrations specified in the relevant AQS.

D2.3.6 *Expert Panel on Air Quality Standards Review of Halogens*

The EPAQS review of halogens presents ambient baseline concentrations of HCl and HF (2). In light of very limited nationally available monitoring data,

(1) Defra (2011) Interpolated mapping data: Local Air Quality Management Support http://www.defra.gov.uk/environment/quality/air/air-quality/laqm/

(2) Defra (2007) Expert Panel on Air Quality Standards Guidelines for halogens and hydrogen halides in ambient air for protecting human health against acute irritancy effects http://webarchive.nationalarchives.gov.uk/20060715141954/http://www.defra.gov.uk/env

these baseline concentrations have been utilised in the Assessment. Given the absence of any significant local sources of emissions, it is anticipated that the concentrations of these substances will be substantially below concentrations specified in the relevant AQS.

D2.4 SUMMARY OF BASELINE MONITORING SURVEY

D2.4.1 *Monitoring Undertaken in the Vicinity of the Site*

Monitoring has been undertaken at several locations in the vicinity of the site; this programme ran from 30 June 2010 to 15 July 2011. The monitoring included:

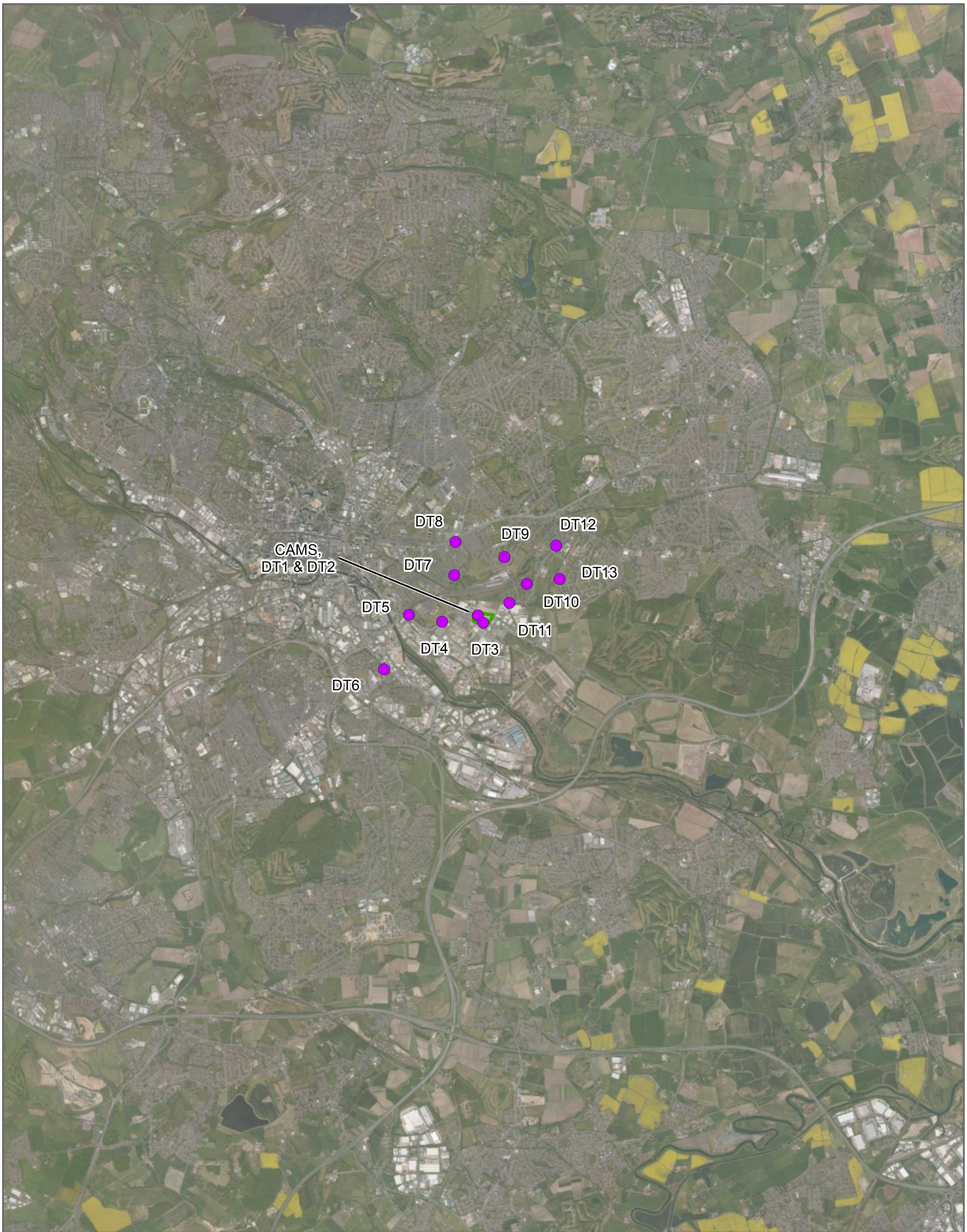
- continuous monitoring of NO_2, NO_X,, SO_2, PM_{10} and $PM_{2.5}$ at one location;
- diffusion tube monitoring of NO_2, at twelve locations; and
- dioxins and furans, polycyclic biphenyls (PCB), polycyclic aromatic hydrocarbons and metals as listed in the Waste Incineration Directive (WID).

D2.4.2 *Monitoring Locations*

Table D2.1 sets out a summary of the monitoring locations in the vicinity of the site. These locations are illustrated in *Figure D2.1*.

Table D2.1 Monitoring Locations

Location ref.	Description of Location	Easting (m)	Northing (m)
Continuous air monitoring station (CAMS)	Newmarket Approach, Former Market Wholesale site, Green Cross	432702	432527
1 and 2 (co-located)	Next to continuous monitoring – Former Market Site, Cross Green	432702	432527
3	East bound side of the dual carriageway next to the market site	432779	432411
4	West bound side of the dual carriageway next to cross green industrial estate	432159	432437
5	Church on Cross Green Lane	431651	432538
6	Whitefield Way	431272	431706
7	Junction of East Park View and East Park Parade	432337	433141
8	Ivy Mount facing the A64	432361	433650
9	Osmondthorpe Avenue	433102	433419
10	Neville View near the bottom of the cul-de-sac	433443	433012
11	Halton Moor Road opposite Neville Close	433178	432720
12	Halton Moor Avenue	433891	433591
13	Junction of Sedburgh Close and Cartmell Drive	433946	433083



Installation Boundary

Monitoring Locations

0 0.5 1 1.5 2 2.5

Kilometres

N

Figure D2.1
Monitoring Locations

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0139262
DATE: 28/06/2012

VERSION: A02
DRAWN: MTC
CHECKED: IG
APPROVED:

ERM

CLIENT:

Veolia ES Leeds

VEOLIA ENVIRONMENTAL SERVICES

PROJECTION: British National Grid

SOURCE: Bing maps (c) 2010 Microsoft Corporation and its data suppliers

Path: T:\GIS Project\0139262VeoliaLeedsGIS_JL_IG\MAPS\0139262_MonitoringLocations_A02.mxd

D2.4.3 *Continuous Monitoring*

A summary of the continuous monitoring results at the Newmarket Approach site is presented in *Table D2.2*. Data capture at the monitoring station is excellent at over 95% and well above the 90% that is considered appropriate for providing a valid annual data set.

Table D2.2 *Summary of Continuous Monitoring*

Pollutant concentration (μg/m³)	Averaging period	AQS (μg/m³)	Average (μg/m³)	Data Capture (%)	Number of Exceedences
PM_{10}	Annual	40	25.7	96.8	n/a
	24hr mean	50	25.6	96.6	23
$PM_{2.5}$	Annual	25	13.5	97.5	n/a
NO_2(a)	Annual	40	31.8	95.5	n/a
SO_2	Annual	20[1]	5.7	97.6	n/a

(a) No exceedences of the 1 hour objective

The continuous monitoring illustrates that baseline concentrations of NO_2, SO_2, PM_{10} and $PM_{2.5}$ are below the annual mean AQS for the protection of human health.

D2.4.4 *Monitoring of NO_2 by Diffusion Tube*

Sample locations 1 and 2 are co-located with the continuous monitoring station, situated at the site within the Cross Green Industrial Park. Although representative of local air quality, this monitoring location will not be representative of public exposure. Similarly, sample locations 3 and 4 are also located within industrial areas and will not be representative of public exposure. The remaining sample locations are within or adjacent to residential areas, some of which are adjacent to busy roads (eg locations 5 and 8). Consequently, the monitoring locations are considered suitable to provide a range of potential public exposure to background concentrations of NO_2.

Table D2.3 sets out a summary of the diffusion tube measurements made at the twelve locations in the vicinity of the site, including the samples co-located with the continuous monitor. The results of the diffusion tube survey for NO_2 have been bias corrected based upon co-location of two sets of tubes with the continuous monitor. The diffusion tubes are less accurate than the continuous monitor and may underestimate or overestimate concentrations depending on a number of factors (eg type of tube used, laboratory carrying out the analysis). By co-locating diffusion tubes with the continuous monitor and comparing continuous results with the diffusion tube results it is possible to determine the degree of variance between the two methods. This is used to determine a bias correction factor (continuous measured concentration divided by the co-located diffusion tube concentration) that can then be applied to all diffusion tube sample results to provide a more accurate determination of NO_2 using the diffusion tubes. For the duration of the monitoring this resulted in the derivation of a bias correction factor of 0.85 which is applied to the diffusion tube results as an annual mean. The annual mean bias corrected NO_2 concentrations are also presented in *Table D2.3*.

Table D2.3 Annual Mean Diffusion Tube Monitoring of NO_2

Diffusion Tube Ref.	**Data Capture (%)**	**Annual Mean Non Bias Corrected (µg m^{-3})**	**Annual Mean Bias Corrected (µg m^{-3})**
DT1/DT2	100%	37.2	31.8
DT3	83%	44.2	37.8
DT4	100%	47.1	**40.3**
DT5	67%	44.8	38.3
DT6	92%	39.3	33.6
DT7	100%	43.7	37.4
DT8	83%	41.2	35.2
DT9	100%	40.4	34.5
DT10	100%	31.3	26.8
DT11	92%	39.0	33.4
DT12	100%	35.2	30.1
DT13	100%	34.6	29.6
Air Quality Standard			*40*

For the bias corrected measurements, NO_2 concentrations vary between 26.8 and 40.3 µg m^{-3} (between 67% and 101% of the AQS). Measured concentrations were below the air quality standard except at monitoring location 4 (DT4) which was slightly above the air quality standard for NO_2. However, it should be noted that DT4 is located adjacent to a busy dual carriageway and in close proximity to the industrial area; it is not representative of public exposure. The average concentration for all twelve diffusion tube locations is 34.0 µg m^{-3} (85%). Taking the more representative residential locations (locations 5 to 13) the average concentration is 33.2 µg m^{-3} (83%).

Installation Boundary

Annual Mean NO_2 Concentrations

0 0.5 1 1.5 2 2.5

Kilometres

N

Figure D2.2
Annual Mean NO_2 Concentrations at Diffusion Tube Monitoring Locations ($\mu g/m^3$)

SCALE: See Scale Bar	VERSION: A03
SIZE: A4	DRAWN: MTC
PROJECT: 0139262	CHECKED: IG
DATE: 28/06/2012	APPROVED:

ERM

CLIENT:

Veolia ES Leeds

VEOLIA ENVIRONMENTAL SERVICES

PROJECTION: British National Grid

SOURCE: Bing maps (c) 2010 Microsoft Corporation and its data suppliers

Path: T:\GIS Project\0139262VeoliaLeedsGIS_JL_IG\MAPS\0139262_NO2_AnnualMean_DT_A03.mxd

As the reference method for measuring NO_2, it is concluded that the continuous monitor would most likely be representative of measured concentrations. Therefore, it is concluded that a baseline annual mean NO_2 concentration of 31.8 µg m^{-3} (79.5%) is adopted for the Assessment. However, it should be recognised that at other locations, including residential areas, measured concentrations are potentially higher.

D2.4.5 *Baseline Air Quality Data Selected for use in this Assessment*

Table D2.4 sets out the baseline values used in the Assessment along with a description of the source of these estimated values. In the immediate vicinity of the Facility and at nearby sensitive receptors, it is anticipated that baseline concentrations will be uniform for the majority of pollutants and therefore there is no requirement to use variable baseline data. The continuous monitoring baseline value for NO_2 has been used rather than the diffusion tube survey results. The diffusion tube survey includes some kerbside locations, which experience consistently high concentrations of NO_2, and a peak in concentrations for all locations occurs over the winter months. Continuous monitoring results are considered representative when compared to non kerbside diffusion tube locations for NO_2. Where variable baseline concentrations have been considered, this is described in detail in the analysis of results.

Table D2.4 Baseline Pollution Data used in the Assessment of Impacts at Sensitive Human Receptors

Pollutant	Averaging period	AQS (µg/m^3)	Baseline concentration (µg/m^3)[(a)]	Source
PM_{10}	Annual	40	25.7	Monitoring commissioned as part of the Leeds RERF work at the former Wholesale Market site
PM_{10}	24 hour (90.4st percentile)	50	30.3	
$PM_{2.5}$	Annual	25	13.5	
VOCs as benzene	Annual	5	0.5	Interpolated mapping for site 2003
HCl	1 hour	750	0.82	EPAQS[(c)]
HF	Annual[(b)]	16	1.5	
HF	1 hour	160	3	
SO_2	24 hour (99.2nd percentile)	125	6.7	Monitoring commissioned as part of the Leeds RERF work at the former Wholesale Market site
SO_2	1 hour (99.7th percentile)	350	13.5	
SO_2	15 minute (99.9th percentile)	266	18.1	
NO_2	Annual	40	31.8	
NO_2	1 hour (99.8th percentile)	200	63.6	
NH_3	Annual	180	1.7	Derived from baseline data available from APIS
NH_3	1 hour	2500	3.4	
Cadmium (Cd)	Annual	0.005	2.0 x 10^{-4}	Monitoring commissioned as part of the Leeds RERF work
Thallium (Tl)	Annual	1	1.8 x 10^{-5}	
Thallium (Tl)	1 hour	30	3.7 x 10^{-5}	

Pollutant	Averaging period	AQS (μg/m³)	Baseline concentration (μg/m³)[(a)]	Source
Mercury (Hg)	Annual	0.25	1.7×10^{-7}	at the former Wholesale Market site
Mercury (Hg)	1 hour	7.5	3.5×10^{-7}	
Antimony (Sb)	Annual	5	2.3×10^{-3}	
Antimony (Sb)	1 hour	150	4.7×10^{-3}	
Arsenic (As)	Annual	0.006	1.1×10^{-3}	
Arsenic (As)	Annual	0.003	1.1×10^{-3}	
Chromium (Cr)	Annual	5	6.3×10^{-3}	
Chromium (Cr)	1 hour	150	1.3×10^{-2}	
Chromium VI	Annual	0.0002	1.3×10^{-3}[(d)]	
Cobalt (Co)	Annual	0.2	2.1×10^{-4}	
Cobalt (Co)	1 hour	6	4.2×10^{-4}	
Copper (Cu)	Annual	10	0.017	
Copper (Cu)	1 hour	200	0.035	
Manganese (Mn)	Annual	0.15	0.10	
Manganese (Mn)	1 hour	1,500	0.20	
Nickel (Ni)	Annual	0.02	0.0066	
Lead (Pb)	Annual	0.25	0.034	
Vanadium (V)	Annual	5	0.0011	
Vanadium (V)	24 hour	1	0.0013	
Dioxins/ furans	Annual	None	0.53 pg I-TEQ/m³	Monitoring commissioned as part of the Leeds RERF work at the former Wholesale Market site
CO	8 hour (maximum daily running)	10,000	425	Interpolated mapping for site 2001
	1 hour	30,000	621	
PAH (as benzo – a –pyrene)	Annual	0.001	4.6×10^{-4}	Monitoring commissioned as part of the Leeds RERF work at the former Wholesale Market site

(a) Short term concentrations are derived from the annual mean by multiplying by 2 to generate an hourly mean and then applying a correction factor to generate other averaging periods (eg 0.59 for 24 hour means and 1.34 for 15 minute means)

(b) EPAQS air quality standard is expressed as a monthly mean but adopted here as the annual mean

(c) Defra/EPAQS (2008) Guidelines for halogens and hydrogen halides in ambient air for protecting human health against acute irritancy effects

(d) The ratio of CrVI to CrIII in ambient air is variable, depending upon local emission sources and local conditions. There are a number of ratios available: EPAQS [(1)] present information suggesting that CrVI may constitute between 3% and 33% of total airborne chromium. The US Department of Health [(2)], suggests that CrVI may constitute between 10% and 20% of total airborne chromium; and the Environment Agency suggest 20% [(3)]. On the basis of the available evidence, a pragmatic ratio of 20% CrVI to 80% CrIII has been used in the assessment to derive the likely background concentration of CrVI from monitored total chromium.

(1) Expert Panel on Air Quality Standards (2009) Metals and Metalloids

(2) U.S. Department Of Health And Human Services Public Health Service Agency For Toxic Substances And Disease Registry (2008) Draft Toxicological Profile For Chromium

(3) Environment Agency (accessed April 2011) Interim Guidance to Applicants on Metals Impact Assessment for Waste Incineration Plant http://www.environment-agency.gov.uk/static/documents/Business/Interim_Metals_Guidance.pdf

The baseline concentrations at sensitive ecological receptors for acidification, ammonia, nutrient nitrogen, NO_x, SO_2 and HF are site specific and are set out in *Table D2.9*.

D2.5 ASSESSMENT CRITERIA

D2.5.1 Overview

The potential impacts of the emissions from the RERF on human health are assessed by comparison to AQS and guidelines. Consideration is made of the contribution from: the plant itself; the traffic accessing the plant during operations in order to assess in-combination impacts; and the existing baseline. The potential impact on sensitive habitats is assessed through comparison with relevant critical loads and critical levels. The criteria used in this Assessment are set out in this section.

D2.5.2 Assessment Criteria for the Protection of Human Health

The criteria for assessment of impacts at sensitive human receptors are derived from three sources, and are set out in *Table D2.5*:

- EU and UK statutory Air Quality Standards (AQS);
- guideline values set out in the Environment Agency's H1 guidance, which are based upon World Health Organization criteria or are derived from occupational health criteria;
- derived from occupational exposures standards (OES) using the methodology provided in H1; and
- based upon recommendations by EPAQS.

Table D2.5 Air Quality Criteria for the Protection of Human Health

Pollutant	Averaging Period and Statistic	Assessment Criterion (µg/m³)	Source
PM_{10}	Annual mean	40	UK/EU AQS
PM_{10}	24 hour mean, not to be exceeded more than 35 times per year	50	UK/EU AQS
$PM_{2.5}$	Annual	25	UK/EU AQS
VOC (as benzene)	Annual	5	UK/EU AQS
HCl	1 hour	750	EPAQS/H1
HF	Annual	16	EPAQS/H1
HF	1 hour	160	EPAQS/H1
SO_2	24 hour mean, not to be exceeded more than 3 times per year	125	UK/EU AQS
SO_2	1 hour mean, not to be exceeded more than 24 times per year	350	UK/EU AQS
SO_2	15 minute mean, not to be exceeded more than 35 times per year	266	UK AQS
NO_2	Annual	40	UK/EU AQS
NO_2	1 hour mean, not to be exceeded more than 18 times per year	200	UK/EU AQS
NH_3	Annual	180	H1
NH_3	1 hour	2500	H1
Cadmium (Cd)	Annual	0.005	H1
Thallium (Tl)	Annual	1	OES/H1
Thallium (Tl)	1 hour	30	OES/H1
Mercury (Hg)	Annual	0.25	H1
Mercury (Hg)	1 hour	7.5	H1
Antimony (Sb)	Annual	5	H1
Antimony (Sb)	1 hour	150	H1
Arsenic (As)	Annual	0.006	UK/EU AQS
Arsenic (As)	Annual	0.003	EPAQS and H1
Chromium (as CrII and CrIII) (Cr)	Annual	5	H1
Chromium (as CrII and CrIII) (Cr)	1 hour	150	H1
Chromium VI	Annual	0.0002	EPAQS and H1
Cobalt (Co)	Annual	0.2	OES/H1
Cobalt (Co)	1 hour	6	OES/H1
Copper (Cu)	Annual	10	H1
Copper (Cu)	1 hour	200	H1
Manganese (Mn)	Annual	0.15	H1
Manganese (Mn)	1 hour	1500	H1
Nickel (Ni)	Annual	0.02	H1
Lead (Pb)	Annual	0.25	UK AQS
Vanadium (V)	Annual	5	H1
Vanadium (V)	24 hour	1	H1
Dioxins/ furans	Annual	none	
CO	8 hour (maximum daily running)	10000	UK/EU AQS
CO	1 hour maximum	30000	H1
PAH (as benzo – a –pyrene)	Annual	0.001	UK/EU AQS

Pollutant	Averaging Period and Statistic	Assessment Criterion (μg/m³)	Source
(1) UK/AQS: Air Quality Standard – these are currently legally binding in the UK and are derived from CAFE, with the exception of the 15 minutes mean SO_2 AQS which is UK specific (2) H1: Derived from version 2.1 and/or version 2.2 of the Environment Agency H1 guidance document (3) EPAQS: Air quality guidelines recommended by the UK Expert Panel on Air Quality Standards (4) Within the Waste Incineration Directive emissions of VOCs are considered as the sum of total VOC emissions. However, no air quality standard exists for total VOCs. Therefore, the UK air quality standard for benzene has been adopted; this represents the worst-case as this is a particularly stringent standard compared to those for other VOCs (5) Within the Waste Incineration Directive emissions of PAHs are considered as the sum of total PAH emissions. However, no air quality standard exists for total PAHs. Therefore, the UK air quality standard for benzo[a]pyrene has been adopted; this represents the worst-case as B[a]P is the most harmful PAH species. (6) Within H1 standards are set separately for chromium II/III and chromium VI. The assumption is made that when assessing against the AQS for Chromium II/III, the total emissions of chromium are assessed inclusive of Chromium VI. (7) Long term air quality standard for HF is given as a monthly, as a worst case this is adopted as the annual mean for HF			

D2.5.3 Assessment Criteria for the Protection of Ecological Habitats

The criteria for the assessment of impacts at sensitive ecological receptors are derived from three sources:

- UK statutory Air Quality Standards (AQS);
- critical loads estimated by CEH and others and set out on the Air Pollution Information System website (APIS) [(1)]; and
- guideline values set out in H1.

Impacts relating directly to air quality (ie NO_x, SO_2, NH_3, HF) are not habitat or species specific and are the same for all sites except for SO_2 and NH_3 where more stringent values may be applied to habitats where lichens may be present. These are set out in *Table D2.6*.

Impacts relating to acid and nutrient nitrogen deposition are habitat and species specific; the site specific critical loads are set out in *Table D2.9* for the sensitive ecological receptors of interest.

(1) Centre for Ecology and Hydrology (2009) Air Pollution Information System http://www.apis.ac.uk/

Table D2.6 Air Quality Critical Loads used for the Assessment of Impacts on Sensitive Ecological Receptors

Pollutant	Averaging Period and Statistic	Assessment Criterion ($\mu g/m^3$)	Source
NO_x	Annual mean	30	H1[1] and AQS[2]
	24 hour maximum	75	H1 and APIS[3]
SO_2	Annual mean	10 (lichens)[4]	H1
	Annual mean	20 (other sites)	UK/EU AQS
	Annual mean (for lichens)	10	H1
	6 month mean (October-March)(1)	20	APIS
Ammonia	Annual mean	1 (lichens)[4]	H1 and APIS
		3 (other sites)	H1 and APIS
HF	1 week mean	0.5	H1 and APIS
	24 hour mean	5	H1 and APIS

(1) H1: Derived from the Environment Agency H1 guidance documents version 2.2
(2) UK/EU AQS: Air Quality Standard – these are currently legally binding in the UK and are derived from CAFE
(3) APIS: Derived from guidelines presented on the APIS website
(4) The lower thresholds are recommended for sites where there are significant population of lichens present. For other sites the upper threshold is recommended.
(5) The dispersion model cannot readily model the one month, three month and six month mean. The annual mean is calculated, and the assumption has been made that if the critical loads for the annual mean are comfortably achieved, then it is reasonable to assume that the one month, three month and six month means will also be achieved

D2.5.4 Significance Criteria

In order to determine the potential significance of the predicted impacts, two parameters have been presented:

- the Process Contribution (PC) which is the concentration of the pollutant which would occur due to the RERF; and

- the Predicted Environmental Concentration (PEC) as a percentage of the relevant Air Quality Standard (AQS). The PEC is the addition of the baseline concentration and the PC.

Based upon the Environment Agency H1 guidance the significance criteria for assessing impacts in the assessment are set out below. (Note that in H1 the air quality standards and guidelines are referred to as Environmental Assessment Levels – EALs):

The PC can be considered insignificant if:

- the long term process contribution is <1% of the long term air quality standards or guidelines;

- the short term process contribution is <10% of the short term air quality standards or guidelines.

The PEC is considered significant if:

- in terms of the long term, the PEC exceeds 70% of the appropriate air quality standard or guideline;
- in terms of the short term the PC is more than 20% of the relevant short term air quality standard or guideline minus twice the long term background concentration.

Where the PEC falls between the two criteria, impacts are not considered 'insignificant', but defined as unlikely to result in air quality standards or guidelines being exceeded ('unlikely exceedances').

In relation to impacts on sensitive ecological receptors, there are specific sensitivity criteria that are used in this assessment derived from H1. These relate to the Critical Loads and Critical Levels set for the protection of habitat sites. Impacts of stack emissions are considered to have insignificant impact (ie no further mitigation or assessment required) upon sensitive ecological receptors if:

- the PC <1% of the Long Term Critical Load or Critical Level; or , if PC> 1%, then
- the PEC <70% of the Critical Load or Critical Level.

This approach is used to give clear definition of what impacts can be disregarded as insignificant, and which need to be considered in more detail or may require specific further mitigation.

D2.6 RECEPTORS

D2.6.1 Overview

This section sets out the sensitive receptors included in this Assessment. Sensitive receptors are areas or locations that may be susceptible to changes in air quality. These will comprise both human receptors (eg residential areas) and ecological receptors (eg designated habitat sites).

The air quality standards and guidelines apply at all off-site locations. Based upon H1, the Assessment considers impacts within 10 km of the proposed Facility. With regard to sensitive ecological receptors, following the H1 guidance document, the following sensitive receptors are considered in the Assessment:

- European designated sites within 10 km of the RERF, these comprising of Special Areas of Conservation (SAC), Special Protection Areas (SPA) and RAMSAR sites;

- Statutory nationally designated Sites of Special Scientific Interest (SSSI), designated for reasons of ecological interest within 2 km of the RERF; and

- National and local non-statutory designated sites including National Nature Reserves (NNR), Local Nature Reserves (LNR), Biodiversity Action Sites (BAS) and Sites of Biological Interest (SBI) etc within 2 km.

D2.6.2 Sensitive Human Receptors

In order to capture the maximum off-site impacts the dispersion model utilises a grid of receptors. Environment Agency guidance suggests that the grid resolution in the model should be no greater than 1.5 times the stack height (in this case 1.5 x 75m = 112.5m). The number of receptor points that can be included in the ADMS dispersion model (as described in *Section D2.7*) is limited. For this assessment, a grid of receptors measuring 10 km by 10 km, centred on this site, with a resolution of 100 m is defined in the model. It is expected that the maximum off-site impacts will occur within 1 – 1.5 km of the Facility. The dispersion model is used to assess the maximum predicted concentration within this grid of receptors. To provide an indication of the likely exposure of local residents to airborne emissions from the RERF, eight specific sensitive human receptors are also defined. Predicted concentrations at these, or any, receptors will be less than or equal to the maximum predicted concentration depending on where the maximum occurs. The specific sensitive receptors that have been defined for this purpose are set out in *Table D2.7* and illustrated in *Figure D2.3*.

Table D2.7 Specific Receptor Locations – Sensitive Human Receptors

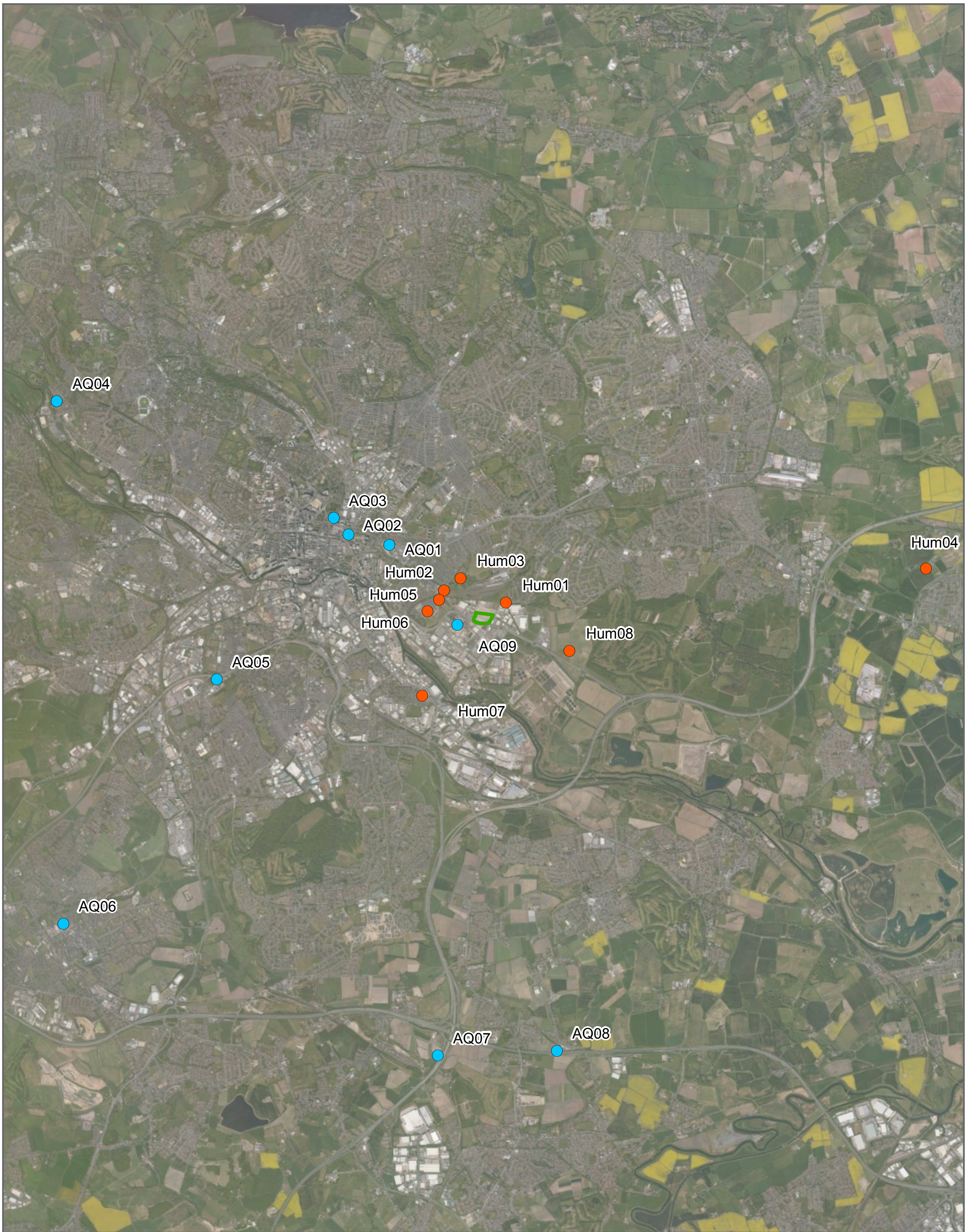
Reference	Name	Easting	Northing	Distance from the Facility (m)	Direction
Hum01	Halton Moor Road	433128	432724	415	NE
Hum02	Park Parade	432187	432910	778	NW
Hum03	Victoria Avenue	432435	433093	747	NNW
Hum04	Richardson Cresent	439529	433237	6760	NNE
Hum05	Cross Green Lane North	432112	432764	770	NW
Hum06	Cross Green Lane South	431930	432590	896	NW
Hum07	Rocheford Gardens/Sussex Gardens	431855	431306	1494	SW
Hum08	Skelton Moor Farm	434095	431990	1360	SE

A number of AQMA have been declared by Leeds and neighbouring authority Wakefield, which fall within 10 km of the proposed Facility, details of which are set out in *Table D2.8* and *Figure D2.3*.

Table D2.8 Details of AQMAs within 10 km [1] of the Facility

Title	Description	Declared for	Easting	Northing	Distance from the facility (km)	Direction
AQ01	Junction of A58(M) and A653	NO_2	431348	433599	1.9	NW
AQ02	Junction of A58(M) and A61	NO_2	430728	433760	2.5	NW
AQ03	Link road from North Street onto the A58(M)	NO_2	430502	434014	2.8	NW
AQ04	Abby Road/ A65	NO_2	426285	435792	7.3	NW
AQ05	M621 and properties on Tilbury Road, Tilbury Mount, Tilbury Terrace	NO_2	428719	431552	4.2	W
AQ06	Junction of Queen street and Queensway	NO_2	426385	427830	7.9	SW
AQ07	M1 between Kirkhamgate and Junction with M62	NO_2	432089	425822	6.7	S
AQ08	M62 and surrounding area from Junction with A655 to Ouzlewell Green	NO_2	433903	425893	6.6	S
AQ09	Majority of the north of Wakefield, reaching as far north as the junction between the M1 and M62	NO_2	432385	432385	6.2	S
Source: Defra (2011) Air Quality Management Areas http://aqma.defra.gov.uk/						

(1) Defra (2011) Air Quality Management Areas http://aqma.defra.gov.uk/



Installation Boundary

Receptors

AQMA Receptors (AQ prefix)

Human Receptors (Hum prefix)

0 0.5 1 1.5 2 2.5

Kilometres

N

Figure D2.3
Location of Human Receptors and AQMA Receptors Considered in the Assessment

SCALE: See Scale Bar	VERSION: A03
SIZE: A4	DRAWN: MTC
PROJECT: 0139262	CHECKED: IG
DATE: 28/06/2012	APPROVED:

ERM

CLIENT:

Veolia ES Leeds

VEOLIA ENVIRONMENTAL SERVICES

PROJECTION: British National Grid

SOURCE: Bing maps (c) 2010 Microsoft Corporation and its data suppliers

Path: T:\GIS Project\0139262VeoliaLeedsGIS_JL_IG\MAPS\0139262_AQReceptorLocations_A03.mxd

Given the distance of the AQMA from the proposed development location, it is anticipated that impacts will not be significant at these AQMA. However, for completeness, consideration is made of the potential impacts at these AQMA on the basis of specific receptors placed at the closest boundary to the proposed site.

D2.6.3 Sensitive Ecological Receptors

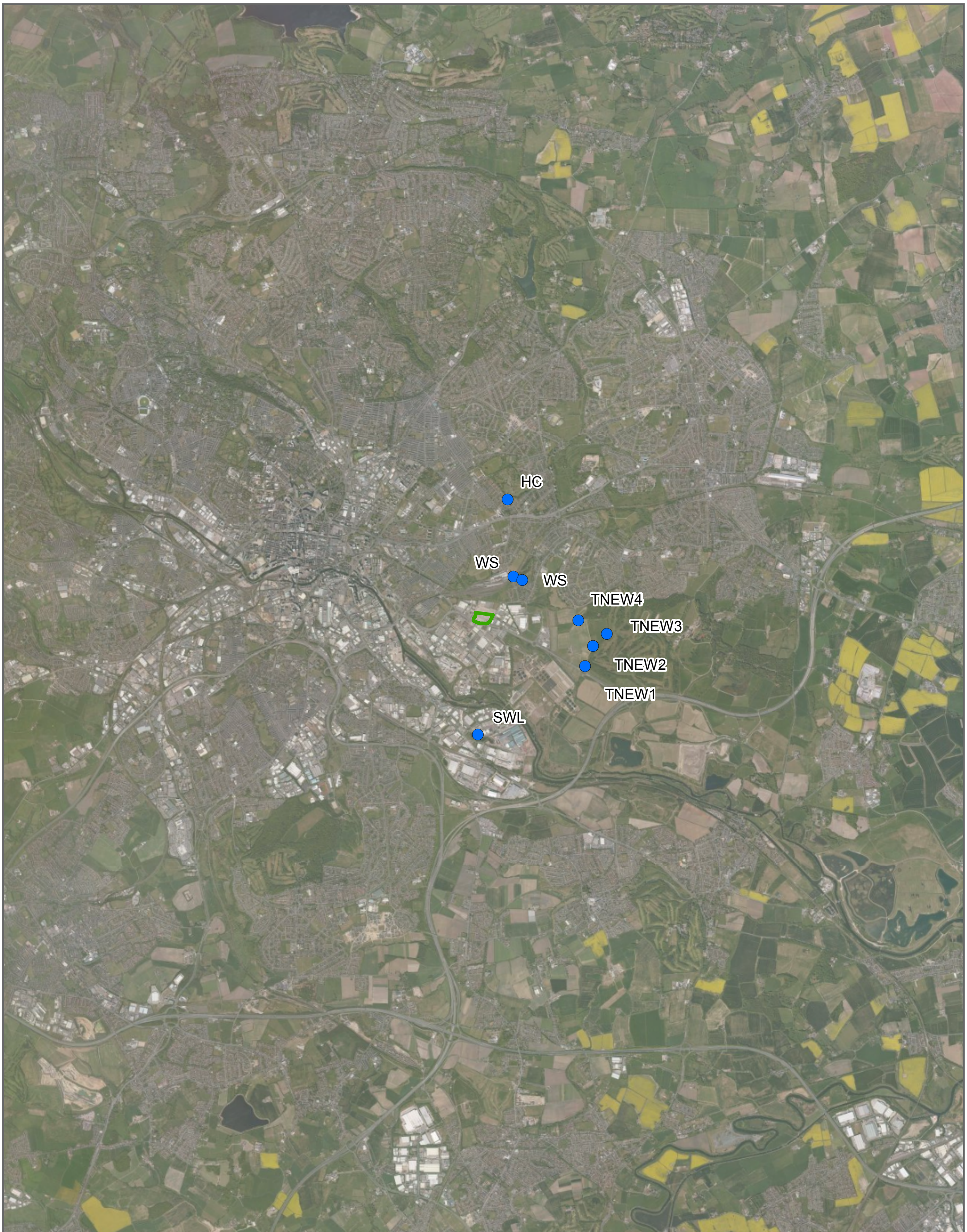
A review of the sensitive habitats has been undertaken using the MAGIC website [(1)] and in discussions with the project ecologist. The review identified that there are no SPA, SAC or Ramsar sites within 10 km of the RERF. Furthermore, there are no SSSI, LNR, NNR or Ancient Woodlands within 2 km of the RERF. The only sensitive habitat sites within 2 km of the RERF comprise four Leeds Nature Areas (LNA), locally designated sites for nature conservation. These are as follows:

- Harehills Cemetery LNA;
- Stourton Works Lagoon LNA;
- Temple Newsam Estate Woods LNA; and
- Waterloo Sidings LNA.

Details of the sensitive ecological receptors considered and associated baseline information are set out in *Table* D2.9 and *Figure D2.4*.

As these are non-statutory habitat sites no information is available from APIS on suitable critical loads for nutrient nitrogen deposition or acidification impacts. There is limited information available on the habitat types present within the Leeds Nature Areas. However, critical loads have been derived from the limited information available and from information provided by APIS. It is assumed that Harehills Cemetery, Waterloo Sidings and Stourton Works Lagoon LNA comprise principally of improved hay meadow and Temple Newsam Estate Woods LNA is broad leaved deciduous woodland.

(1) Multi Agency Geographic Information for the Countryside (MAGIC) (2009) www.magic.gov.uk



Installation Boundary

Habitat Receptors

0 0.5 1 1.5 2 2.5

Kilometres

N

Figure D2.4
Location of Habitat Receptor Points Considered in the Assessment

SCALE: See Scale Bar	VERSION: A02
SIZE: A4	DRAWN: MTC
PROJECT: 0139262	CHECKED: IG
DATE: 28/06/2012	APPROVED:

ERM

CLIENT:

Veolia ES Leeds

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PROJECTION: British National Grid

SOURCE: Bing maps (c) 2010 Microsoft Corporation and its data suppliers

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In many areas of the UK, the baseline conditions are already in excess of the critical loads and critical levels at sensitive ecological receptors. For some of the impacts and sensitive habitat receptors, this is the case here. In particular, the critical level for NO_x is already exceeded at the majority of habitats, and the critical load for nitrogen deposition is exceeded at Temple Newsam Estate Woods LNA. With regard to the habitat descriptions, the most similar habitat type available from APIS has been used to define the site. It is acknowledged that in some cases the characteristics of the habitat site do not exactly match the habitat type on APIS, as there is a limited range of habitat types available and limited information available on the type of habitats present within each of the LNA.

Table D2.9 Summary of Sensitive Ecological Receptors and Baseline Information – Airborne Exposure

Ref.	**Desig-nation**	**Name**	**East (m)**	**North (m)**	**Direction**	**Distance (km)**	**NO_x (µg m^{-3})**		**SO_2 (µg m^{-3})**		**Ammonia (µg m^{-3})**		**HF (µg m^{-3})**	
							CL(1)	**Baseline**	**CL(1)**	**Baseline**	**CL(1)**	**Baseline**	**CL(1)**	**Baseline**
HC	LNA	Harehills Cemetery	433150	434300	North	1.9	30(3) 75(4)	30.8 36.3	20	1.4	3	1.5	0.5(5) 5(6)	0.4 0.5
SWL	LNA	Stourton Works Lagoon	432700	430710	South	1.8	30(3) 75(4)	45.7 53.9	20	1.4	3	1.7	0.5(5) 5(6)	0.4 0.5
TNEW(2)	LNA	Temple Newsam Estate Woods	434333 434454 434666 434227	431757 432060 432242 432455	East	1.5	30(3) 75(4)	25.1 29.6	20	1.4	3	2.1	0.5(5) 5(6)	0.4 0.5
WS(3)	LNA	Waterloo Sidings	433242 433379	433121 433061	North east	0.7	30(3) 75(4)	45.7 53.9	20	1.4	3	1.7	0.5(5) 5(6)	0.4 0.5

(1) Critical level

(2) The site is irregularly shaped or in close proximity to the RERF. In order to ensure that impacts are adequately assessed, four receptor locations have been defined for Temple Newsam Estate Woods LNA and two receptor points for the Waterloo Sidings LNA.

(3) Annual mean

(4) Daily mean critical level. Baseline daily mean concentration is calculated by multiplying the annual mean by 2 to derive the one hour mean and then by 0.59 to derive the 24 hour mean

(5) Weekly mean critical level.

(6) Daily mean critical level.

Table D2.10 Summary of Sensitive Ecological Receptors and Baseline Information – Acidification and Nitrogen Deposition

Ref.	**Designation**	**Name**	**East (m)**	**North (m)**	**Direction**	**Distance (km)**	**Acid Deposition (keq ha^{-1} yr^{-1})[(3)]**		**Nutrient Nitrogen Deposition (kg N ha^{-1} yr^{-1}) [(4)]**	
							CL[(1)]	**Baseline**	**CL[(1)]**	**Baseline**
HC	LNA	Harehills Cemetery	433150	434300	North	1.9	3.82 (for S) 4.68 (for N)	0.35 (for S) 1.44 (for N)	20 to 30	20.2
SWL	LNA	Stourton Works Lagoon	432700	430710	South	1.8	3.83 (for S) 4.69 (for N)	0.35 (for S) 1.44 (for N)	20 to 30	20.2
TNEW[(2)]	LNA	Temple Newsam Estate Woods	434333 434454 434666 434227	431757 432060 432242 432455	East	1.5	2.56 (for S) 2.92 (for N)	0.39 (for S) 2.49 (for N)	10 to 20	34.9
WS[(2)]	LNA	Waterloo Sidings	433242 433379	433121 433061	North east	0.7	3.82 (for S) 4.68 (for N)	0.35 (for S) 1.44 (for N)	20 to 30	20.2

(1) Critical load (as obtained from APIS, January 2012)
(2) The site is irregularly shaped or in close proximity to the RERF. In order to ensure that impacts are adequately assessed, four receptor locations have been defined for Temple Newsam Estate Woods LNA and two receptor points for the Waterloo Sidings LNA.
(3) Acid Deposition Critical Loads are presented in terms of N and S components where CL function information is available. Where it is not, the total critical load for acid deposition has been listed. All baseline and critical load values are from the APIS database (as of 16 January 2012).
(4) Nutrient Nitrogen Critical Loads are presented in terms of a range. The assessment is undertaken against both the upper and lower critical load. The baseline and critical load values are from the APIS database as of 16 January 2012.

D2.7 *POINT SOURCE DISPERSION MODELLING INPUTS AND METHODOLOGY*

D2.7.1 *Overview*

When assessing the emissions from the proposed RERF the production of effluent gases, due to combustion of waste are considered. These emissions are exhausted to atmosphere via the main stack.

The potential for impacts to air quality due to emissions arising from the project are assessed by comparing the predicted impacts against standards and guidelines for the protection of human health, and critical loads and levels for the protection of sensitive ecology as described above. The Assessment uses dispersion modelling to predict the ground level increases in pollution concentrations attributable to the plant emissions, and combines this with the baseline pollution concentration to establish whether there is the potential for significant impacts to occur (see *Section D2.5.4*).

The detailed dispersion modelling is used to predict concentrations of pollutants at ground level locations outside the plant boundary, at sensitive human receptors and sensitive ecological receptors. Five years of hourly meteorological data are used, so that inter annual variability is incorporated in the model. The results of the Assessment are based upon the worst case result for any of the five meteorological years used for each of the receptors considered.

The potential impacts from the plant are assessed in terms of:

- Process Contribution (PC) – this is the impact associated with emissions from the plant only; and

- Predicted Environmental Concentration (PEC) – this is the impact associated with emissions from the plant added to the existing background conditions.

The dispersion model has been used for several aspects of the impact assessment:

- determination of stack height;
- determination of impacts associated with the operation of the plant; and
- determination of the occurrence of visible plumes.

Dispersion Model

The operational impacts from the combustion process were assessed using the ADMS (Atmospheric Dispersion Modelling System version 4.2) model. ADMS is one of a 'new generation' of dispersion models which describe the atmospheric boundary layer properties. ADMS allows for the modelling of dispersion under convective meteorological conditions using a skewed Gaussian concentration distribution. It is able to simulate the effects of terrain and building downwash simultaneously. It can also calculate concentrations for direct comparison with AQS or guidelines, and is used to predict the occurrence of visible plumes.

D2.7.2 *Modelling Approach*

Waste Combustion Process

The modelling approach for the detailed impact assessment, for assessing stack height sensitivity and plume visibility, is based on the same set of model inputs and utilises the same assumptions, unless highlighted specifically as being different.

The Facility has been modelled at nominal operating capacity (ie operating to its design capacity in terms of waste throughput). Furthermore, it is assumed that the RERF operates continuously 24 hours per day, 365 days per year, without any downtime for maintenance etc. For normal operation, emissions for the majority of pollutants have been modelled at the emission limits specified in the WID. This represents a worst-case assumption as actual emissions will be below the WID limits and in some cases will be substantially lower. For most of the pollutants of interest, this approach is appropriate; however there is an exception when considering metals.

The Environment Agency recognises that this approach, when applied to emissions of metals, produces excessively conservative impacts. Instead, the guidance note produced by the Environment Agency relating to the assessment of emissions of metals is utilised (1). This approach considers emissions of metals at actual emission concentrations, as based upon monitoring undertaken at a number of UK energy from waste (EfW) facilities.

In some cases, substances included in the model are not covered by WID and therefore do not have WID emission limits, or require a different approach. These are as follows:

- NH_3 – in this case emissions based upon Best Available Technique (BAT) (2) are used in the Assessment.
- PAH – in this case emissions are based upon monitored concentrations at the Veolia Sheffield Energy Recovery Facility (ERF).
- PM_{10} and $PM_{2.5}$ – there are no specific emission limits for PM_{10} and $PM_{2.5}$; instead WID stipulates emissions relating to emissions of total particulate matter. However, due to the emissions abatement proposed at the Facility

(1) Environment Agency (accessed April 2011) Interim Guidance to Applicants on Metals Impact Assessment for Waste Incineration Plant http://www.environment-agency.gov.uk/static/documents/Business/Interim_Metals_Guidance.pdf
(2) European Commission (2006) Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration ftp://ftp.jrc.es/pub/eippcb/doc/wi_bref_0806.pdf

the assumption is made that all emissions of particulate matter occur in the PM_{10} and $PM_{2.5}$ size fractions, depending on which is being assessed. This represents a reasonable approach, as in reality the very large majority of emissions are likely to be within the $PM_{2.5}$ size range.

- Chromium VI – there is no specific WID limit for CrVI (as opposed to total Cr), and therefore emissions are based upon guidance provided by the Environment Agency [(1)]. The need to assess total chromium and chromium VI separately arises out of the fact that there is an air quality guideline recommended for chromium, by the Expert Panel on Air Quality Standards (EPAQS) which relates specifically to the carcinogenic potential of chromium VI (chromium III is non-carcinogenic).

- VOC – there are no AQS or guidelines applicable to emissions of total VOC. Taking a worst case approach, the assumption is made that all VOC occur as benzene. In practice there will be numerous VOC species emitted, but benzene has the most stringent air quality standard and therefore this represents a worst case approach.

The stack parameters for the RERF are set out in *Table D2.11*.

Table D2.11 Summary of Stack Parameters for the RERF

Parameter	Units	Values
Number of stacks		1
Number of flues per stack		1
Stack height actual	m	75
Flue diameter	m	1.6
Emission velocity	m/s	22.2
Volume flow rate (nominal) [(1), (2)]	Am^3/s	44.3
Volume flow rate (nominal) [(1), (3)]	Nm^3/s (normalised to temperature, moisture, and oxygen)	28.4
Emission temperature (actual)	Celsius	140
Oxygen (actual)	% v/v	9.3 (dry)
Moisture (actual)	% v/v	17.4
Moisture (actual)	% w/w	11.4
Flue N Easting		432815
Flue N Northing		432451

(1) Normalised/Actual Emissions are described in terms of the Actual conditions at emission from the stack or in terms of Normalised conditions. The use of Normalised conditions allows different sources of emissions to be compared on the same basis (for example when setting emission limits).
(2) The volume flow rate is calculated from the normalised flow rate value by correcting emission temperature, plume moisture and plume oxygen (dry).
(3) Flow rate is normalised to 273K, dry and 11% O_2.

(1) Environment Agency (accessed April 2011) Interim Guidance to Applicants on Metals Impact Assessment for Waste Incineration Plant http://www.environment-agency.gov.uk/static/documents/Business/Interim_Metals_Guidance.pdf

The pollutant emissions data used in the assessment are set out in *Table D2.12*. Where further assessment has been undertaken using actual emissions rather than at WID limits, these are also set out; the exception to this is metals, which instead are considered in detail and presented in *Table D3.7* (refer *to Section D3.3.6*)

Table D2.12 Summary of Waste Combustion Process Pollutant Emissions Data

Pollutant	Units	Emissions	Basis of emission rate used in modelling
HCl	mg/Nm3	10	WID limit
SO_2	mg/Nm3	50	WID limit
NO_x	mg/Nm3	200	WID limit
CO	mg/Nm3	50	WID limit
VOC	mg/Nm3	10	WID limit
Total PM	mg/Nm3	10	WID limit
Ammonia	mg/Nm3	10	Based on BAT
HF	mg/Nm3	1	WID limit
Dioxins	mg/Nm3	$1.00x10^{-7}$	WID limit
Group 1 metals (Cd and Tl)	mg/Nm3	0.05	WID limit
Group 2 metals (Hg)	mg/Nm3	0.05	WID limit
Group 3 metals [a]	mg/Nm3	0.5	WID limit
PAH (as Benzo[a]pyrene)	mg/Nm3	$8.80x10^{-5}$	Actual emissions at Sheffield ERF

Pollutant	Units	Emission Rate
HCl	g/s	0.28
SO_2	g/s	1.42
NO_x	g/s	5.68
CO	g/s	1.42
VOC	g/s	0.28
PM (dust)	g/s	0.28
Ammonia	g/s	0.28
HF	g/s	0.03
Dioxins	g/s	2.84×10^{-9}
Group 1 metals (Hg)	g/s	0.0014
Group 2 metals (Cd and Tl)	g/s	0.0014
Group 3 metals	g/s	0.01
PAH	g/s	2.50×10^{-6}

(a) Group 3 metals include chromium which may be emitted as trivalent or hexavalent chromium. It is assumed that the emission concentration for hexavalent chromium is 0.7% of the total chromium in accordance with Environment Agency guidance

In addition to the proposed ERF, there are diesel generators for providing emergency power. However, these will operate only for emergency or start up purposes and for up to 100 hours per year (1% of the time). Compared to the ERF, which is assumed to operate continuously, emissions from the diesel generators will have an insignificant impact on local air quality.

In addition to normal operation, an assessment of impacts under abnormal operating conditions is provided. Details of the emissions and assumptions made relating to this assessment are provided in *Section D3.4*.

D2.7.3 Determination of Stack Height

There are two matters to be considered when determining an appropriate stack height:

1. There is proportionately less benefit in terms of reduced impacts on air quality with increasing stack height. On the curve which results from plotting stack height versus ground level concentration, there is a point at which benefit begins to flatten. This represents the optimum stack height (See *Figure D3.1*).

2. It is necessary to identify the stack height at which the impacts associated with the emissions from the proposed plant are acceptable. This is dependent upon many factors including the nature of sensitive receptors, the existing baseline, the plant design and the local meteorology.

Consideration of these two points is required to determine the optimum stack height for the Facility.

D2.7.4 Determination of the Occurrence of Visible Plumes

In order to predict visible plumes, the dispersion model is run as described previously, with one additional parameter, the exhaust gas moisture content in mass terms. This is estimated to be 0.11 kg of water per kg of exhaust gas. All other emission parameters remain the same.

D2.7.5 Use of WID Limits

Within the WID, emission limits are set for two averaging periods: daily and half-hourly. The half hourly average recognises that short term elevated emissions may occur due to routine process variables; however, over the longer term the daily average values must be achieved. The AQS and guidelines used in this Assessment largely refer to averaging periods of one hour or greater; in addition, the UK Air Quality Standards for several pollutants have a number of 'allowable' occasions in which the limit value may be exceeded within any one calendar year before the standard is deemed to have been breached. Therefore, short term emissions occurring for less than 30 minutes are unlikely to have a significant impact on short term air quality, particularly as the number of excursions of the emission concentrations to the 30 minute value is effectively limited by the WID. On this basis, the Assessment of normal emissions is based upon daily average values for emissions from the plant. An assessment of short term emissions at the half-hourly emission limits is provided in *Section D3.4*.

D2.7.6 Assessment of Metal Emissions

Within the WID, emissions of metals are divided into three groups. The total emissions of metals within each group is not permitted to exceed the prescribed emission limit set for the group. For the purposes of the modelling, initially the assumption is made that each metal is emitted as 100% of the total emission for the group. This allows the initial screening out of metals that do not pose a significant risk even based on very worst-case assumptions. In reality, this assumption is highly conservative and is likely to greatly overestimate the actual impacts associated with emissions of metals.

In accordance with Environment Agency guidance (1), the next step is to assume that each metal comprises an equal proportion of the group emission (eg 50% for Group 2 and 1/9th for Group 3 metals). Where metals cannot be considered insignificant a further step, using a less conservative assumption, is applied. At this point metals are assessed assuming typical emissions of these metals, based on data from other operational facilities, as provided by the Environment Agency. The emissions data used are set out in *Table D3.5* (refer to *Section D3.3.6*).

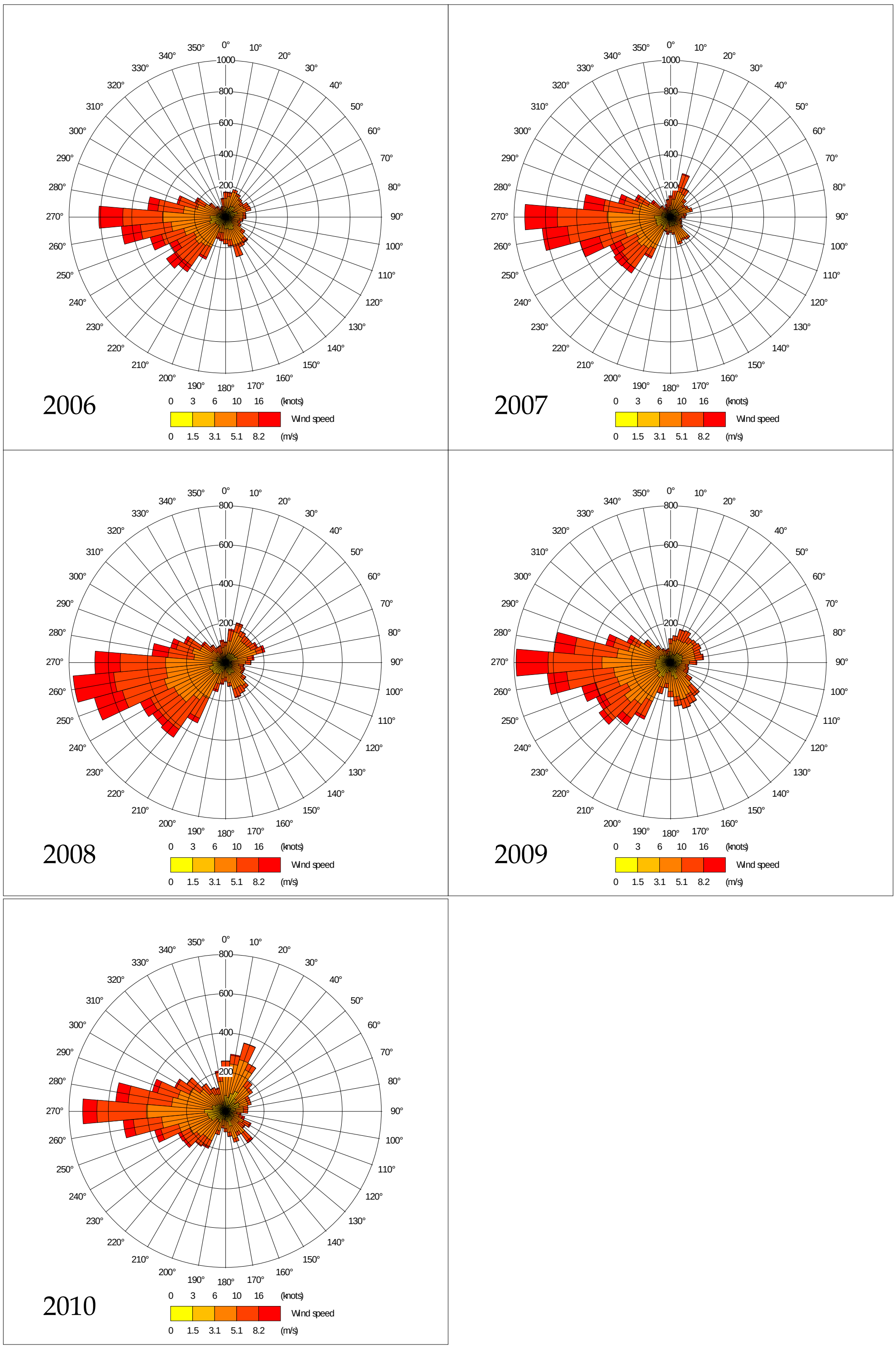
The Expert Panel on Air Quality Standards (EPAQS) has published a recommended air quality guideline for chromium, which has been adopted in this assessment. This guideline value is based upon the carcinogenic risk of exposure to Cr(VI), whereas the majority of chromium emissions from waste incineration occur as Cr(III) (which is a non-carcinogen), rather than Cr(VI). Therefore, it is not appropriate to assume that all the total chromium emissions occur as Cr(VI). The Environment Agency suggests that typically 0.7% of the total chromium emissions from EfW facilities occur as Cr(VI) (2) . In addition, a report by the EPAQS (3) suggests that Cr(VI) may constitute between 10% and 20% of total airborne chromium. These factors have been used in the Assessment to estimate the maximum emissions of Cr(VI) and therefore allow meaningful comparison with the EPAQS guideline.

D2.7.7 *Meteorological Data Selection*

The meteorological data used in the model must be reflective of the local conditions. There are only a limited number of meteorological stations in the UK which measure all of the parameters required by the model and there are no stations which are particularly close to the proposed development location. A review of available meteorological sites was undertaken, which focussed on the surrounding land use, the surrounding terrain and relative proximity to the coast. On the basis of these criteria, the nearest meteorological station considered representative of conditions is at Leeds Airport, which is approximately 14 km north west of the site. Data for Leeds for 2006-2010 inclusive were used in the assessment. The wind roses for these data are illustrated in *Figure D2.5*.

(1) Environment Agency (2011) Guidance to Applicants on Impact Assessment for Group 3 Metals Stack Releases http://www.environment-agency.gov.uk/static/documents/Business/Interim_Metals_Guidance.pdf
(2) Environment Agency (accessed April 2011) Interim Guidance to Applicants on Metals Impact Assessment for Waste Incineration Plant http://www.environment-agency.co.uk/static/documents/Business/Interim_Metals_Guidance.pdf
(3) Expert Panel on Air Quality Standards (2009) Metals and Metalloids

Figure D2.5 Wind Roses for Leeds (2006 - 2010)



D2.7.8 Consideration of Terrain Effects

Changes in terrain elevations (ie hills or mountains) can have a significant impact on dispersion of emissions, in terms of funnelling of plumes and changing local wind flows. Terrain effects are typically considered important where there are sustained gradients of 1:10 or greater. There are no such sustained gradients in the vicinity of the proposed Facility and therefore terrain was not included in the model.

D2.7.9 Consideration of Surface Roughness Effects

The surface roughness length is a representation of the disruption of airflow close to the ground due to obstructions and protuberances, such as buildings, trees and hedges. In this case a surface roughness of 1.0 m has been used. This surface roughness was used as it is considered representative of cities, woodlands and suburban areas, and therefore the proposed RERF site in Leeds.

D2.7.10 Consideration of Building Downwash

When air flow passes over buildings, a phenomenon known as building downwash occurs where the airflow is entrained in the lee of the building and drawn down to ground level. This effect can bring the plume from the stack down to ground level more quickly than would otherwise be the case, and therefore increase the ground level concentration relative to a case where there are no buildings. All buildings that are greater than one third of the stack height, within five stack heights of the stack, need to be included. On this basis, the two main RERF buildings have been included in the model. Within the model, buildings are conceptually considered as a block shape, as the model cannot take into account downwash effects around a complex building shape. The dimensions used in this assessment are presented in *Table D2.13*.

Table D2.13 Dimensions of Conceptual RERF Building, as Modelled

Parameter	**Units**	**Value**
Building one –main building		
Easting	M	432796
Northing	M	432445
Height	M	42
Length	M	35
Width	M	130
Angle to north	Degrees	358
Building two		
Easting	m	432762
Northing	m	432481
Height	m	18
Length	m	37.5
Width	m	125
Angle to north	Degrees	358

D2.7.11 Conversion of NO_x to NO_2

The combustion process generates oxides of nitrogen (NO_x). In the exhaust gases from the stack, these are in the ratio of approximately 95% nitric oxide (NO) to 5% nitrogen dioxide (NO_2). With regard to the assessment of the impact on human health NO_2 is the pollutant of interest as NO is largely inert in the human body. Within the atmosphere various processes oxidise NO to create NO_2 but this process will not occur quickly or completely before the plume reaches ground level. Therefore it is overly pessimistic to assume 100% conversion from NO to NO_2, and it is necessary to use a factor to estimate ground level concentrations of NO_2 based upon total NO_x emitted.

Based upon Environment Agency guidance (1) for worst case conditions, the assumption is made that when assessing short term average concentrations, 35% of NO_x occurs as NO_2, and for long term average concentrations, 70% of NO_x occurs as NO_2. An initial, screening/worst case step is also outlined within this guidance where 100% and 50% oxidation is assumed for long and short term assessments, respectively. However, as detailed modelling of NO_x emissions is provided for this assessment, this step has not been adopted as it is considered overly pessimistic. However, a sensitivity analysis is provided in *Section D3.3.2* that assesses what the impact of NO_x emissions would be on local air quality and predicted NO_2 concentrations for this very worst case scenario.

The conversion of NO to NO_2 applies only to the assessment of impacts on sensitive human receptors, as when assessing impacts on sensitive ecological receptors total NO_x is assessed and therefore no conversion is required.

D2.7.12 Derivation of Acid and Nutrient Nitrogen Deposition

The deposition of acid and nutrient nitrogen is not directly modelled but is derived from the concentration predicted at each sensitive ecological receptor for each pollutant of interest. The derivation is based upon Environment Agency guidance (2) and uses the conversion factors set out in *Table D2.13* and *Table D2.15*. The factors take into account the difference in deposition velocity and mechanisms experienced in forests, and grasslands and other non-arboreal areas.

Table D2.14 Factors for Conversion of Annual Mean Concentrations to Acid Deposition

Pollutant	**Deposition Velocity – Grasslands ($m\ s^{-1}$)**	**Deposition Velocity – Forests ($m\ s^{-1}$)**	**Conversion Factor ($\mu g\ m^{-2}\ s^{-1}$ to $kg\ ha^{-1}\ year^{-1}$)**	**Conversion Factor ($kg\ ha^{-1}\ year^{-1}$ to $keq\ ha^{-1}\ year^{-1}$)**
SO_2	0.012	0.024	158	0.0625
NO_x as NO_2	0.0015	0.003	96	0.0714
NH_3	0.02	0.02	260	0.0714
HCl	0.025	0.06	307	0.0282

(1) Environment Agency, Conversion ratios for NOX and NO_2, as provided on the Agency website (3 May 2012)- agency.gov.uk/static/documents/Business/noxno2conv2005_1233043.pdf

(2) AQTAG06 – Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air, Environment Agency, produced 06/02/04, Version 8

Table D2.15 Factors for Conversion of Annual Mean Concentrations to Nutrient Nitrogen Deposition

Pollutant	Deposition Velocity - Grasslands (m s^{-1})	Deposition Velocity - Forests (m s^{-1})	Conversion Factor (µg m^{-2} s^{-1} to kg ha^{-1} $year^{-1}$)
NO_x as NO_2	0.0015	0.003	96
NH_3	0.02	0.03	260

D2.7.13 Traffic Assessment

D2.7.14 Overview

The proposed development will generate additional traffic on the local road network during operation, as a result of vehicles delivering waste to the site and removing residual products.

The potential impact on local air quality of the increased traffic flows has been assessed using the Highways Agency Design Manual for Roads and Bridges (DMRB) (1), a screening tool, which can be used to predict ground level concentrations of pollutants in the vicinity of roads. The methodology is widely used in support of planning applications for new residential/commercial developments and road building projects.

The screening method predicts annual average ground level concentrations at sensitive receptors by applying average roadside emission dispersion curves and correcting for vehicle type and speed.

The most recent version of the DMRB (version 1.03c) was issued in July 2007and requires the following information to assess the impact at sensitive receptor locations:

- distance from road link to sensitive receptor location;
- annual average daily traffic (AADT) flows;
- annual average speed;
- fleet composition; and
- ambient background concentrations.

The proposed RERF site is accessed via Newmarket Approach from the eastbound carriageway of the A63, Pontefract Lane. The Facility is expected to result in 307 additional vehicle movements on Pontefract Lane, 240 of which will be Heavy Goods Vehicles (HGV).

This additional traffic represents an increase of less than 2% of the baseline flow on the A63, which would not normally be considered significant in terms

(1) DMRB (HA 207/07), Volume 11, Section 3

of air quality. However, DMRB suggests that impacts on air quality may be significant for schemes that generate more than an additional 200 HGV movements per day; therefore an assessment of the potential impact on air quality of these additional vehicles has been undertaken.

The impact of traffic related emissions is used to assess the in-combination effects of vehicle movements associated with the development along with emissions from the operation of the RERF.

D2.7.15 Traffic data

A summary of the baseline and development flows for the A63 and Newmarket Approach are presented in *Table D2.16*. There are two scenarios for which traffic data are generated:

- 2016 Do Nothing – a future baseline without the proposed development; and
- 2016 Do Something - a future baseline plus operational traffic associated with the development

The 2016 flows are derived from data measured during a traffic survey carried out from 2nd to 8th July 2010. The average speed of vehicles on the A63 during this period was 38.5 mph (62 kph).

Table D2.16 Summary of Baseline and Development Traffic Flows

Road link	**2016 Do Nothing (AADT)**			**2016 Do Something (AADT)**		
	LGV	HGV	Total	LGV	HGV	Total
A63 Pontefract Lane (West of Newmarket Approach)	13,768	1,754	15,522	13,835	1,994	15,829
A63 Pontefract Lane Eastbound (Left Turn to Newmarket Approach)	453	89	542	487	232	719
Newmarket Approach (Left Turn onto A63 Pontefract Lane)	534	83	617	568	226	794

D3 RESULTS

D3.1 OVERVIEW

The assessment of results covers the following aspects:

- a stack height sensitivity assessment to identify an appropriate stack height to minimise potential air quality impacts for local sensitive receptors;
- detailed assessment of the potential impacts on human health and sensitive ecology from the plant during normal operation;
- detailed assessment of the potential impacts on human health from the plant during abnormal operation;
- assessment of the potential for adverse impacts on human health due to in-combination effects of operational plant emissions and traffic related emissions; and
- assessment of the potential for the occurrence of visible plumes.

In addition, consideration is made of the potential for odour and dust annoyance to occur.

D3.2 STACK HEIGHT SENSITIVITY

The appropriate stack height for the Facility is dependent upon a number of factors, critically ensuring adequate dispersion of emissions. *Figure D3.1* presents the results of the modelling of incremental annual maximum ground level NO_x concentrations, modelled at WID emission limits, at a range of stack heights between 55m and 85m using 2008 meteorological data. Predicted concentrations are presented for NO_x as, based on previous experience, predicted concentrations of NO_2 are likely to be the most significant with respect to background concentrations and the air quality standard.

The purpose of this graph is to determine an 'optimum' stack height, by identifying the required mitigation of impacts from air quality. The change in concentration as a percentage from increasing the stack height by incrementally is presented in *Figure D3.2*.

Figure D3.1 Stack Height Sensitivity Modelled at WID Emission Limits

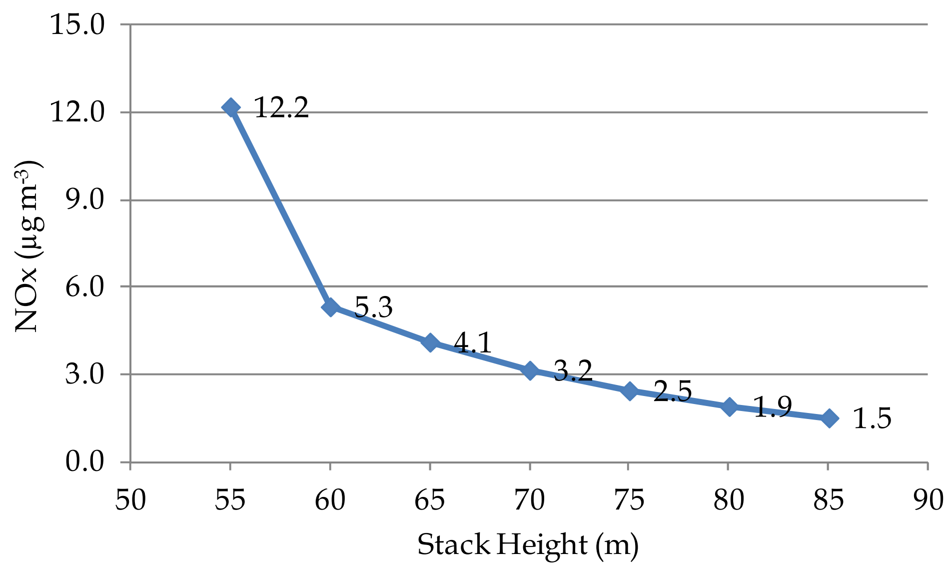
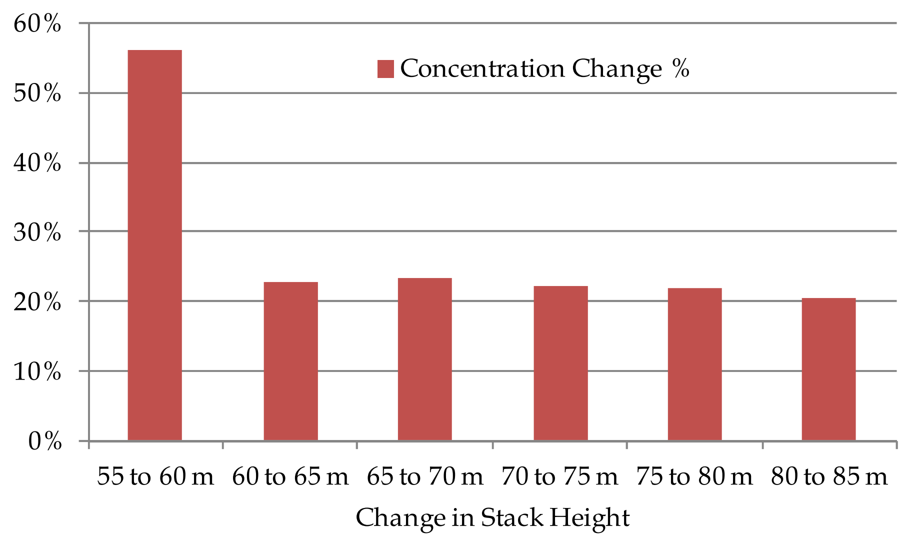


Figure D3.2 Percentage Change in Concentration with Increasing Stack Height



The results set out in *Figure D3.1* and *Figure D3.2*, illustrate that the optimum stack height is likely to be around 60-70m.

In addition to the 'optimum' stack height, there is a need to identify a stack height at which impacts are acceptable. The dispersion modelling results show that a stack height of 75m, modelled at WID, would give rise to a predicted NO_x annual mean concentration of 2.5 µg m^{-3} (equivalent to an annual mean of 1.7 µg m^{-3} for NO_2 assuming a 70% conversion rate). This represents approximately 4% of the air quality objective for NO_2 and based upon the criteria provided by Environmental Protection UK [1] is assessed as a 'Small' change in magnitude. However, at 70 m, the predicted concentration (2.2 µg m^{-3} NO_2) exceeds 5% of the air quality objective and is assessed as a 'medium' change in magnitude. It should be noted that the EPUK criteria is used as to achieve NO_2 concentrations below the Environment Agency's insignificance criteria of 1% of the AQS would result in an inappropriately tall stack.

On this basis, a stack height of 75m was selected for the proposed RERF.

D3.3 *ASSESSMENT OF PLANT EMISSIONS AT 75M STACK HEIGHT*

D3.3.1 *Summary of Predicted Impacts at Sensitive Human Receptors*

The results of the modelling assessment for sensitive human receptors are set out in *Table D3.1*. The Table sets out the:

- pollutant of interest;
- averaging period;
- air quality standard or guideline;
- existing baseline;
- PC;
- PEC; and
- the significance of the predicted impacts.

The predicted impacts are described using the criteria set out in *Section D2.5.4*. The PC presented are the highest impact predicted anywhere off-site, and are based upon the maximum predicted impact for any of the five years of meteorological data. The PC presented are based upon modelling of emissions at WID limits, and for those substances not subject to WID limits, in line with the emissions set out in *Table D2.12*.

Emissions for the metals are assumed to be at the WID limits and for the Group 1 and Group 3 metals it is assumed as an extreme worst-case that each metal within the group emits at the emission limit for the group. This is used to screen out those metals that do not have a significant impact even under these worst case conditions. Those metals that are not screened out are assessed in more detail with the application of more appropriate emission concentrations.

(1) Development Control: Planning for Air Quality (2010 Update), Environmental Protection UK

Table D3.1 Summary of Maximum Predicted Impacts at Off-site Locations, for any Meteorological Year with a 75m stack, Modelled at WID Limits

Pollutant	**Averaging Period**	**AQS** ($\mu g\ m^{-3}$)	**Baseline** ($\mu g\ m^{-3}$)	**PC** ($\mu g\ m^{-3}$)	**PC/ AQS** (%)	**PEC** ($\mu g\ m^{-3}$)	**PEC/ AQS** (%)	**Significance**
PM_{10}	Annual	40	25.7	0.12	0.31%	25.8	64.5%	Not significant
PM_{10}	24 hour (90.41st percentile)	50	30.3	0.38	0.76%	30.7	61.3%	Not significant
$PM_{2.5}$	Annual	25	13.5	0.12	0.50%	13.7	54.6%	Not significant
VOCs as benzene	Annual	5	0.5	0.12	2.48%	0.62	12.5%	AQS likely to be met
HCl	1 hour	750	0.82	3.0	0.40%	3.8	0.5%	Not significant
HF	Annual	16	1.5	0.012	0.08%	1.51	9.5%	Not significant
HF	1 hour	160	3	0.30	0.19%	3.3	2.1%	Not significant
SO_2	24 hour (99.18th percentile)	125	6.7	3.2	2.6%	10.0	8.0%	Not significant
SO_2	1 hour (99.73rd percentile)	350	13.5	5.0	1.4%	18.5	5.3%	Not significant
SO_2	15 minute (99.90th percentile)	266	18.1	5.8	2.2%	23.9	9.0%	Not significant
NO_2	Annual	40	31.8	1.7	4.3%	33.5	83.8%	Potentially significant
NO_2	1 hour (99.79th percentile)	200	63.6	7.0	3.5%	70.6	35.3%	Not significant
NH_3	Annual	180	1.7	0.12	0.1%	1.8	1.0%	Not significant
NH_3	1 hour	2500	3.4	3.0	0.1%	6.4	0.3%	Not significant
Cadmium (Cd)	Annual	0.005	2.0×10^{-4}	6.2×10^{-4}	12.4%	8.2×10^{-4}	16.5%	AQS likely to be met
Thallium (Tl)	Annual	1	1.8×10^{-5}	6.2×10^{-4}	0.1%	6.4×10^{-4}	0.1%	Not significant
Thallium (Tl)	1 hour	30	3.7×10^{-5}	0.015	0.0%	0.015	0.0%	Not significant
Mercury (Hg)	Annual	0.25	1.7×10^{-7}	6.2×10^{-4}	0.2%	6.2×10^{-4}	0.2%	Not significant
Mercury (Hg)	1 hour	7.5	3.5×10^{-7}	0.015	0.2%	0.015	0.2%	Not significant
Antimony (Sb)	Annual	5	0.0023	0.0062	0.1%	0.0085	0.2%	Not significant
Antimony (Sb)	1 hour	150	0.0047	0.15	0.1%	0.15	0.1%	Not significant
Arsenic (As)	Annual	0.006	0.0011	0.0062	103%	0.0073	121%	Potentially significant
Arsenic (As)	Annual	0.003	0.0011	0.0062	206%	0.0073	243%	Potentially significant
Chromium (Cr)	Annual	5	0.0063	0.0062	0.1%	0.012	0.2%	Not significant
Chromium (Cr)	1 hour	150	0.013	0.15	0.1%	0.16	0.1%	Not significant
Chromium VI	Annual	0.0002	0.0013[(a)]	4.3×10^{-5}	21.7%	0.0013	648%	Potentially significant
Cobalt (Co)	Annual	0.2	2.1×10^{-4}	0.0062	3.1%	0.0064	3.2%	AQS likely to be met
Cobalt (Co)	1 hour	6	4.2×10^{-4}	0.15	2.5%	0.15	2.5%	Not significant
Copper (Cu)	Annual	10	0.017	0.0062	0.1%	0.023	0.2%	Not significant

Pollutant	Averaging Period	AQS ($\mu g\ m^{-3}$)	Baseline ($\mu g\ m^{-3}$)	PC ($\mu g\ m^{-3}$)	PC/ AQS (%)	PEC ($\mu g\ m^{-3}$)	PEC/ AQS (%)	Significance
Copper (Cu)	1 hour	200	0.035	0.15	0.1%	0.27	0.1%	Not significant
Manganese (Mn)	Annual	0.15	0.10	0.0062	4.1%	0.21	139%	Potentially Significant
Manganese (Mn)	1 hour	1500	0.20	0.15	0.0%	0.35	0.0%	Not significant
Nickel (Ni)	Annual	0.02	0.0066	0.0062	31.0%	0.013	63.8%	AQS likely to be met
Lead (Pb)	Annual	0.25	0.034	0.0062	2.5%	0.040	16.0%	AQS likely to be met
Vanadium (V)	Annual	5	0.0011	0.0062	0.1%	0.0073	0.1%	Not significant
Vanadium (V)	24 hour	1	0.0012	0.038	3.8%	0.039	3.9%	Not significant
Dioxins/ furans	Annual	none	5.3×10^{-7}	1.2×10^{-9}	n/a	5.3×10^{-7}	n/a	n/a
CO	8 hour (maximum daily running)	10000	435	5.1	0.05%	441	4.4%	Not significant
CO	1 hour	30000	621	15.0	0.1%	636	2.1%	Not significant
PAH (as benzo – a –pyrene)	Annual	0.001	4.6×10^{-4}	1.1×10^{-6}	0.11%	4.6×10^{-4}	46.0%	Not significant

(a) Baseline CrVI is assumed to be 20% of the measured total chromium

The results of the dispersion modelling, presented in *Table D3.1*, demonstrate that impacts are not significant for the large majority of pollutants.

Except for NO_2, the impact for all non metals is assessed as not significant or that the AQS is likely to be met. For NO_2, the annual mean PC is greater than 1% of the AQS and background concentration at 79.7% of the AQS is already in excess of 70% of the AQS. Therefore, using the Environment Agency's significance criteria the impact is assessed as Potentially Significant. However, the PEC is less than the AQS and predicted concentrations represent worst-case conditions with the worst case meteorological year, the plant operating at full load operating continuously and with emissions at the maximum limit. Therefore, it is unlikely that the additional contribution of the Facility would result in an exceedance of the AQS.

With regards to impacts associated with emissions of metals, the results set out in *Table D3.1* are based upon impacts arising from emissions at WID limits with all metals assumed to be individually emitting at the emission limit for the group as a whole. Following Environment Agency guidance, further analysis of the impacts due to metals has been undertaken, based upon emissions as a proportion of the group and at expected actual emission concentrations. These are presented in *Section D3.3.6*.

D3.3.2 Predicted NO_2 Concentrations for Screening/Worst-case Oxidation Ratios

Maximum predicted concentrations presented in *Table D3.1* for NO_2 assume NO to NO_2 70% conversion ratios for annual mean concentrations and 35% for hourly mean concentrations. Adopting the Environment Agency's screening ratios of 100% and 50% predicted annual mean concentrations (as the PC) would be 2.4 $\mu g\ m^{-3}$ (6% of the AQS) and the PEC would be 34.2 $\mu g\ m^{-3}$ (85.5% of the AQS).

Similarly, maximum predicted short term concentrations of NO_2 would be 10.0 $\mu g\ m^{-3}$ as the PC (5.0%) and the PEC would be 73.6 $\mu g\ m^{-3}$ (36.8% of the AQS). Therefore, even under very worst-case conditions there is unlikely to be an exceedence of the AQS as a result of the additional emissions from the RERF.

D3.3.3 Distribution of Predicted Concentrations

Contour plots have been generated to show the dispersion of emissions from the Facility. These are set out in *Figure D3.3* to *Figure D3.6*.

The contour plots for the annual mean period show that the highest impacts are towards to northeast of the proposed Facility, which is to be expected given the prevailing southwesterly winds. Results for the short term periods (ie 1hour and 24 hour means) indicate that the highest impacts over the short term occur in close proximity to the RERF. The contour plots have been generated for NO_2 and PM_{10} as these pollutants are of the most interest on a national basis. However, other pollutants would show similar patterns of dispersion, albeit at different concentrations based on their emissions.

Installation Boundary

Predicted Annual Mean NO_2 Concentrations

0 0.5 1 1.5 2 2.5

Kilometres

N

Figure D3.3
Predicted Annual Mean NO_2 Concentrations

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0139262
DATE: 28/06/2012

VERSION: A02
DRAWN: MTC
CHECKED: IG
APPROVED:

ERM

CLIENT:

Veolia ES Leeds

VEOLIA ENVIRONMENTAL SERVICES

PROJECTION: British National Grid

SOURCE: Bing maps (c) 2010 Microsoft Corporation and its data suppliers

Path: T:\GIS Project\0139262VeoliaLeedsGIS_JL_IG\MAPS\0139262_Pred_NO2_AnnualMean_A02.mxd

Installation Boundary

Predicted 99.8th Percentile of Hourly Mean NO2 Concentrations (µg/m³)

0 0.5 1 1.5 2 2.5
Kilometres

N

Figure D3.4
Predicted 99.8th Percentile of Hourly Mean NO_2 Concentrations (µg/m³)

SCALE: See Scale Bar	VERSION: A02
SIZE: A4	DRAWN: MTC
PROJECT: 0139262	CHECKED: IG
DATE: 28/06/2012	APPROVED:

ERM

CLIENT:

Veolia ES Leeds

VEOLIA ENVIRONMENTAL SERVICES

PROJECTION: British National Grid

SOURCE: Bing maps (c) 2010 Microsoft Corporation and its data suppliers

Path: T:\GIS Project\0139262VeoliaLeedsGIS_JL_IG\MAPS\0139262_Pred_NO2_HourlyMean_A02.mxd

Installation Boundary

Predicted Annual Mean PM_{10} Concentrations (µg/m^3)

0 0.5 1 1.5 2 2.5
Kilometres

N

Figure D3.5
Predicted Annual Mean PM_{10} Concentrations (µg/m^3)

SCALE: See Scale Bar	VERSION: A01
SIZE: A4	DRAWN: MTC
PROJECT: 0139262	CHECKED: IG
DATE: 28/06/2012	APPROVED:

ERM

CLIENT:

Veolia ES Leeds

VEOLIA ENVIRONMENTAL SERVICES

PROJECTION: British National Grid

Path: T:\GIS Project\0139262VeoliaLeedsGIS_JL_IG\MAPS\0139262_Pred_PM10_AnnualMean_A02.mxd

Installation Boundary

Predicted 90.4th Percentile of 24-hour Mean PM10 Concentrations (µg/m3)

0 0.5 1 1.5 2 2.5
Kilometres

N

Figure D3.6
Predicted 90.4th Percentile of 24-hour Mean PM_{10} Concentrations (µg/m^3)

SCALE: See Scale Bar	VERSION: A02
SIZE: A4	DRAWN: MTC
PROJECT: 0139262	CHECKED: IG
DATE: 28/06/2012	APPROVED:

ERM

CLIENT:
Veolia ES Leeds

VEOLIA ENVIRONMENTAL SERVICES

PROJECTION: British National Grid

Path: T:\GIS Project\0139262VeoliaLeedsGIS_JL_IG\MAPS\0139262_Pred_PM10_24hrMean_A02.mxd

D3.3.4 *Analysis of Concentrations at AQMA*

As discussed in *Section D2.6*, there are a number of AQMA that have been declared for NO_2 within 10 km of the proposed RERF site. The predicted contribution of the RERF to annual mean NO_2 concentrations at these locations is provided in *Table D3.2*.

The contribution of the RERF to annual mean concentrations of NO_2 at the AQMA is less than 1% of the AQS. Therefore, it is concluded that there are no significant impacts on AQMA as a result of emissions from the RERF.

Table D3.2 Predicted Contribution of the RERF to Annual Mean NO_2 Concentrations at the AQMA within 10 km of the Facility

Title	Description	Declared for	Predicted Annual Mean NO_2 ($\mu g\ m^{-3}$)	Percentage of the AQS
AQ01	Junction of A58(M) and A653	NO_2	0.086	0.21%
AQ02	Junction of A58(M) and A61	NO_2	0.053	0.13%
AQ03	Link road from North Street onto the A58(M)	NO_2	0.047	0.12%
AQ04	Abby Road/ A65	NO_2	0.012	0.03%
AQ05	M621 and properties on Tilbury Road, Tilbury Mount, Tilbury Terrace	NO_2	0.033	0.08%
AQ06	Junction of Queen street and Queensway	NO_2	0.015	0.04%
AQ07	M1 between Kirkhamgate and Junction with M62	NO_2	0.032	0.08%
AQ08	M62 and surrounding area from Junction with A655 to Ouzlewell Green	NO_2	0.022	0.05%
AQ09	Majority of the north of Wakefield, reaching as far north as the junction between the M1 and M62	NO_2	0.37	0.92%

D3.3.5 *Analysis of Concentrations at Sensitive Human Receptors*

Predicted concentrations presented in *Table D3.1* are the maximum predicted concentration at any location. These locations may not be representative of public exposure. For the sensitive human receptors identified, predicted concentrations of NO_2 (long-term and short-term) are presented in *Table D3.3*.

For the annual mean, highest concentrations are predicted for Halton Moor Road (Hum01) and are 3.8% of the air quality standard. For the majority of the sensitive receptors, the PC is less than 1% of the air quality standard and would be assessed as insignificant in accordance with the Environment Agency's insignificance criteria.

Table D3.3 Predicted Contribution of the RERF to NO_2 Concentrations at the Sensitive Human Receptors

Reference	Name	Annual Mean PC (µg m^{-3})	Annual Mean PEC (µg m^{-3})	99.8th %ile of Hourly Means PC (µg m^{-3})	99.8th %ile of Hourly Means PEC (µg m^{-3})
Hum01	Halton Moor Road	1.5	33.3	6.8	70.4
Hum02	Eastside properties on Park Parade	0.26	32.1	4.1	67.7
Hum03	Victoria Avenue	0.42	32.2	4.4	68.0
Hum04	Richardson Cresent	0.07	31.9	0.57	64.2
Hum05	Cross Green Lane North	0.20	32.0	3.9	67.5
Hum06	Cross Green Lane South	0.17	32.0	3.2	66.8
Hum07	Rocheford Gardens/ Sussex Gardens	0.17	32.0	2.2	65.8
Hum08	Skelton Moor Farm	0.37	32.2	2.4	66.0

D3.3.6 Further Analysis of Metals

Emission rates of individual metals entered into the model assume that each metal is emitted at 100% of the WID limit for each metal. In the case of Group 1 metals (cadmium and thallium) and Group 3 metals (antimony, arsenic, chromium, cobalt, copper, lead, manganese, nickel and vanadium) in particular, this is a highly pessimistic assumption. In addition, this approach does not reflect the fact that modern EfW plants emit metals at concentrations that are substantially below the WID limits. Consequently, the results set out in *Table D3.1* are highly conservative and additional analysis has been undertaken to quantify the potential impacts of metals based upon guidance provided by the Environment Agency [(1)].

Step 1 of the guidance indicates that metals can be screened out where they are emitted at the maximum permissible emission limit and where the annual mean PEC < 70% of the AQS (< 20% of the headroom for short term PEC).

Step 2 of the guidance requires emissions to be assessed on the basis that each metal emits at an equal proportion of the group for the Group 3 metals (eg 1/9th of the WID emission limit). The guidance relates to Group 3 metals only, however, a similar approach has been adopted for Group 1 metals cadmium and thallium, with each assumed to emit at 50% of the WID limit. A summary of the emission concentrations assumed for Step 1 and Step 2 is provided in *Table D3.4*.

(1) Environment Agency Guidance to Applicants on Impact Assessment for Group 3 Metals Stack Releases – V.2 June 2011 http://www.environment-agency.gov.uk/static/documents/Business/Interim_Metals_Guidance.pdf

Table D3.4 Summary of Assumed Metal Emissions for Step 1 and Step 2 using the Environment Agency Guidance

Metal Species	WID limit (mgNm-3)	Assumed Concentration for Step 1 (mg Nm-3)	Assumed Concentration for Step 2 (mg Nm-3)
Antimony	0.5	0.5	0.056 (a)
Arsenic	0.5	0.5	0.056 (a)
Cadmium	0.05	0.05	0.025 (b)
Chromium	0.5	0.5	0.056 (a)
Cobalt	0.5	0.5	0.056 (a)
Copper	0.5	0.5	0.056 (a)
Lead	0.5	0.5	0.056 (a)
Manganese	0.5	0.5	0.056 (a)
Mercury	0.05	0.05	0.05
Nickel	0.5	0.5	0.056 (a)
Thallium	0.05	0.05	0.025 (b)
Vanadium	0.5	0.5	0.056 (a)

(a) Assumed to be an equal proportion of the group (ie 1/9th of the WID limit)

(b) As for Group 3 metals, a similar approach is taken for Group 1 metals, (ie ½ of the WID limit

Where metals cannot be screened out using the same criteria as for Step 1 (annual mean PEC < 70%, short term PEC< 20% of the headroom), Step 3 requires further analysis using typical emissions data for each metal.

Where required, the typical emissions data used for this assessment are based upon the following:

- Emissions of the nine Group 3 metals are derived from the mean emission concentrations set out in the interim metals guidance note produced by the Environment Agency (1).

- Emissions of cadmium and mercury are based upon data collated from the Defra report on emissions from waste management facilities (2).

- Emissions of thallium are not reported directly. However, the European Commission (3) report that 'thallium is virtually non-existent in municipal waste'. Within this source, data is provided stating that thallium content of municipal waste is <0.1 mg kg^{-1} dry solids, and that cadmium is present in the range of 1-15 mg kg^{-1} dry solids. On the basis of these data, a ratio of the likely emissions of thallium and cadmium has been estimated, with thallium being emitted at a rate of, at most, 10% of the rate of cadmium emissions (and at least 0.66%). On the basis that reported emissions of cadmium are 1.53% of the WID limit for cadmium and thallium (Defra

(1) Environment Agency Guidance to Applicants on Impact Assessment for Group 3 Metals Stack Releases – V.2 June 2011 http://www.environment-agency.gov.uk/static/documents/Business/Interim_Metals_Guidance.pdf
(2) Defra (2012) WR 0608 Emissions from Waste Management Facilities http://randd.defra.gov.uk/Document.aspx?Document=WR0608FinalReport.pdf
(3) European Commission (2006) Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

data), it can therefore be deduced that thallium emissions are, at most, 0.153% of the WID limit. Additional information on thallium emissions have been obtained from VES's RERF facility at Sheffield where quarterly monitoring indicates that thallium emissions are generally below the detection limit of the analysis. For 2010, the emission concentration for thallium was reported as 0.000464 mg Nm^{-3} (0.93% of the Group 1 limit). Therefore, this value is adopted as being representative of typical emissions of thallium from the proposed RERF.

For the Step 3 analysis, where required, metal emissions data have been collated and are provided in *Table D3.5*. These derived emissions data have been used as the basis for the subsequent assessment of the potential impacts of metals emissions at assumed actual emission concentrations.

Table D3.5 Summary of Metals Emissions from UK Energy from Waste Facilities (mg Nm^{-3})

Metal Species	WID limit (mg Nm^{-3})	Actual metals emissions as a percentage of the WID limit
Antimony	0.5	0.66% (a)
Arsenic	0.5	0.14% (a)
Cadmium	0.05	1.53% (b)
Chromium	0.5	2.18% (a)
Cobalt	0.5	0.060% (a)
Copper	0.5	1.54% (a)
Lead	0.5	3.16% (a)
Manganese	0.5	3.44% (a)
Mercury	0.05	22.6% (c)
Nickel	0.5	4.4% (a)
Thallium	0.05	0.93% (d)
Vanadium	0.5	0.040% (a)

(a) Environment Agency guidance for Group 3 metals

(b) Derived from information provided by the European Commission's Best Available Techniques for Waste Incineration

(c) ERM report for Defra on emissions from waste management facilities

(d) From monitoring data from VES's Energy Recovery Facility at Sheffield

Further analysis is only required for arsenic, chromium VI and manganese as all other metals were assessed as insignificant even when they are assumed to be emitted at the emission limit for the group. For arsenic, chromium VI and manganese, predicted annual mean concentrations for emissions at equal proportions of the WID limits are presented inTable *D3.6*.

Table D3.6 *Assessment of Emissions of Metals at an Equal Proportion of the WID Limit ($\mu g\ m^{-3}$)*

Metal Species	AQS	PC	PEC	PC/AQS	PEC/AQS
Arsenic	0.006	0.00068	0.0018	11.4%	29.7%
Arsenic	0.003	0.00068	0.0018	22.7%	59.4%
Chromium VI	0.0002	0.0000048	0.0013	2.4%	630%
Manganese	0.15	0.00068	0.10	0.45%	68.3%

On the basis of emissions at an equal proportion of the group, arsenic and manganese can be screened out as being insignificant. However, the principal issue regarding chromium VI is the elevated background concentration of chromium measured close to the RERF site. Total background concentrations of chromium were measured at 0.0063 $\mu g\ m^{-3}$. Assuming that 20% of total chromium is hexavalent then 0.0013 $\mu g\ m^{-3}$ would comprise chromium VI, this is a factor of more than six higher than the air quality standard for chromium VI of 0.0002 $\mu g\ m^{-3}$. Therefore, even if chromium VI is considered at actual emissions in accordance with Step 3 of the guidance, the PEC is still in excess of the Air Quality Standard as indicated in *Table D3.7*.

Table D3.7 *Assessment of Emissions of Metals at Typical Emissions ($\mu g\ m^{-3}$)*

Metal Species	AQS	PC	PEC	PC/AQS	PEC/AQS
Chromium VI	0.0002	9.5×10^{-7}	0.0013	0.47%	628%

However, the PC is less than 1% which, in accordance with the Environment Agency H1 assessment criteria, is assessed as insignificant. Furthermore, the elevated background concentrations of chromium were measured at a location close to the RERF site, where there is a likely local source of chromium within the industrial area. There is indeed a foundry located approximately 500 m to the west of the RERF site and this could be a potential source of chromium emissions. Measured concentrations at sensitive human receptors at further distances from the RERF site and the local source are likely to be lower than those measured.

Therefore, the alternative assessment of metals at equal proportion of the group limit and at assumed actual emissions illustrates that the original modelling at the WID limit for individual metals was highly conservative, and that the emissions of metals from the RERF are predicted to result in no significant impacts to air quality.

D3.3.7 *Sensitive Ecological Receptors*

Table D3.8 to *Table D3.16* set out the results of the dispersion modelling for the sensitive ecological receptors due to acid deposition, nutrient nitrogen deposition, deposition of total chromium and airborne concentrations of NO_x,

SO_2, NH_3 and HF. These results are based upon modelling of emissions at WID limits unless otherwise stated.

Table D3.8 Predicted Acid Deposition at Ecological Receptors Modelled at WID (Annual Mean)

Site	Assumed Habitat Type	Critical Load for Acid Deposition (keq ha^{-1} yr^{-1})	Background Acid Deposition (keq ha^{-1} yr^{-1})	PC (keq ha^{-1} yr^{-1})	PC/CL	PEC (keq ha^{-1} yr^{-1})	PEC/CL	Significance
Harehills Cemetery LNA	Improved hay meadow	8.50	1.77	0.0091	0.1%	1.78	20.9%	Not significant
Stourton Works Lagoon LNA	Improved hay meadow	8.50	1.79	0.018	0.2%	1.81	21.3%	Not significant
Temple Newsam Estate Woods LNA	Broadleaved deciduous woodland	5.48	2.88	0.10	1.9%	2.98	54.4%	Not significant
Waterloo Sidings LNA	Improved hay meadow	8.50	1.79	0.070	0.8%	1.86	21.9%	Not significant

Table D3.9 Predicted Nutrient Nitrogen Deposition at Ecological Receptors Modelled at WID (Annual Mean)

Sites	Habitat Type	Critical Load for Nutrient Nitrogen Deposition (kgN ha^{-1} yr^{-1})	Background Nutrient Nitrogen Deposition (kgN ha^{-1} yr^{-1})	PC (kgN ha^{-1} yr^{-1})	PC/CL	PEC (kgN ha^{-1} yr^{-1})	PEC/CL	Significance
Harehills Cemetery LNA	Improved hay meadow	25	19.9	0.053	0.2%	20.0	79.8%	Not significant
Stourton Works Lagoon LNA	Improved hay meadow	25	20.2	0.10	0.4%	20.3	81.2%	Not significant
Temple Newsam Estate Woods LNA	Broadleaved deciduous woodland	15	38.8	0.45	3.0%	39.2	261.6%	Potentially significant
Waterloo Sidings LNA	Improved hay meadow	25	20.2	0.40	1.6%	20.6	82.4%	Potentially significant

Table D3.10 Predicted NO_X at Ecological Receptors Modelled at WID (Annual Mean)

Sites	**Critical Level (µg m^{-3})**	**Background Conditions (µg m^{-3})**	**PC (µg m^{-3})**	**PC/AQS**	**PEC (µg m^{-3})**	**PEC/AQS**	**Significance**
Harehills Cemetery LNA	30	30.8	0.13	0.4%	30.9	103%	Not significant
Stourton Works Lagoon LNA	30	45.7	0.26	0.9%	46.0	153%	Not significant
Temple Newsam Estate Woods LNA	30	25.1	0.82	2.7%	25.9	86%	Potentially significant
Waterloo Sidings LNA	30	45.7	1.0	3.3%	46.7	156%	Potentially significant

Table D3.11 Predicted NO_X at Ecological Receptors Modelled at WID (24 hour Mean)

Sites	**Critical Level (µg m^{-3})**	**Background Conditions (µg m^{-3})**	**PC (µg m^{-3})**	**PC/AQS**	**PEC (µg m^{-3})**	**PEC/AQS**	**Significance**
Harehills Cemetery LNA	75	36.3	1.9	2.6%	38.3	51%	Not significant
Stourton Works Lagoon LNA	75	53.9	2.9	3.9%	56.9	76%	Not significant
Temple Newsam Estate Woods LNA	75	29.6	3.9	5.2%	33.5	45%	Not significant
Waterloo Sidings LNA	75	53.9	7.6	10.1%	61.5	82%	Potentially significant

Table D3.12 Predicted SO_2 at Ecological Receptors Modelled at WID (Annual Mean)

Sites	Critical Level (µg m^{-3})	Background Conditions (µg m^{-3})	PC (µg m^{-3})	PC/AQS	PEC (µg m^{-3})	PEC/AQS	Significance
Harehills Cemetery LNA	20	1.4	0.033	0.2%	1.4	7%	Not significant
Stourton Works Lagoon LNA	20	1.4	0.065	0.3%	1.5	7%	Not significant
Temple Newsam Estate Woods LNA	20	1.4	0.20	1.0%	1.6	8%	Not significant
Waterloo Sidings LNA	20	1.4	0.25	1.3%	1.7	8%	Not significant

Table D3.13 Predicted Ammonia at Ecological Receptors Modelled at Expected Emissions (Annual Mean)

Sites	Critical Level (µg m^{-3})	Background Conditions (µg m^{-3})	PC (µg m^{-3})	PC/ASQ	PEC (µg m^{-3})	PEC/AQS	Significance
Harehills Cemetery LNA	3	1.5	0.007	0.2%	1.5	50%	Not significant
Stourton Works Lagoon LNA	3	1.7	0.013	0.4%	1.7	57%	Not significant
Temple Newsam Estate Woods LNA	3	2.1	0.041	1.4%	2.1	71%	Potentially significant
Waterloo Sidings LNA	3	1.7	0.050	1.7%	1.8	58%	Not significant

Table D3.14 Predicted Hydrogen Fluoride at Ecological Receptors Modelled at WID (Weekly Mean)

Sites	Critical Level (µg m-3)	Background Conditions (µg m-3)	PC (µg m-3)	PC/ASQ	PEC (µg m-3)	PEC/AQS	Significance
Harehills Cemetery LNA	0.5	0.5	0.0030	0.6%	0.50	101%	Not significant
Stourton Works Lagoon LNA	0.5	0.5	0.0054	1.1%	0.51	101%	Potentially significant
Temple Newsam Estate Woods LNA	0.5	0.5	0.011	2.2%	0.51	102%	Potentially significant
Waterloo Sidings LNA	0.5	0.5	0.016	3.2%	0.52	103%	Potentially significant

Table D3.15 Predicted Hydrogen Fluoride at Ecological Receptors Modelled at WID (24 hour Mean)

Sites	Critical Level (µg m-3)	Background Conditions (µg m-3)	PC (µg m-3)	PC/ASQ	PEC (µg m-3)	PEC/AQS	Significance
Harehills Cemetery LNA	5	0.5	0.0096	0.2%	0.51	10%	Not significant
Stourton Works Lagoon LNA	5	0.5	0.015	0.3%	0.51	10%	Not significant
Temple Newsam Estate Woods LNA	5	0.5	0.019	0.4%	0.52	10%	Not significant
Waterloo Sidings LNA	5	0.5	0.038	0.8%	0.54	11%	Not significant

Table D3.16 Predicted Total Chromium (Cr) Deposition at Ecological Receptors Modelled at Typical Emissions (Annual Mean)

Sites	Critical Load (µg m-2 d-1)	PC Load (µg m-2 d-1)	PC/CL	Significance
Harehills Cemetery LNA	1,500	0.030	0.002%	Not significant
Stourton Works Lagoon LNA	1,500	0.058	0.004%	Not significant
Temple Newsam Estate Woods LNA	1,500	0.18	0.01%	Not significant
Waterloo Sidings LNA	1,500	0.23	0.02%	Not significant

The results of the Assessment indicate that impacts associated with acidification, airborne SO_2 and deposition of total chromium are not significant for the four LNA considered. For some habitats, the impact is described as Potentially Significant as follows:

- For nutrient nitrogen deposition, impacts are Potentially significant for Temple Newsam Estate Woods and Waterloo Sidings but this is principally due to the high background nutrient nitrogen deposition rates.

- Predicted annual mean NO_x concentrations are also high relative to the critical level at Temple Newsam Estate Woods and Waterloo Sidings but again this is due to elevated background concentrations of NO_x.

- Predicted annual mean NH_3 concentrations are high relative to the critical level at Temple Newsam Estate Woods due to relatively high background concentrations. However, concentrations are below the critical level.

- Predicted long term concentrations of HF are assessed as Potentially Significant but this is due to limited data on baseline concentrations and it has been assumed that the baseline is equivalent to the critical level.

A summary of the results of the assessment of sensitive habitats is set out in *Table D3.17*.

Table D3.17 Summary of Impacts on Sensitive Ecological Receptors

Site	Acid Deposition	Nutrient Nitrogen Deposition	NO_x Annual Mean	NO_x 24 hour mean	SO_2 Annual Mean	NH_3 Annual Mean	HF 1 Week Mean	HF 24 Hour Mean	Total Chromium Deposition
Harehills Cemetery LNA	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant
Stourton Works Lagoon LNA	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Potentially significant	Not significant	Not significant
Temple Newsam Estate Woods LNA	Not significant	Potentially significant	Potentially significant	Not significant	Not significant	Potentially significant	Potentially significant	Not significant	Not significant
Waterloo Sidings LNA	Not significant	Potentially significant	Potentially significant	Potentially significant	Not significant	Not significant	Potentially significant	Not significant	Not significant

Key:

Potentially significant (PC>1%; PEC>70%)

Not significant (PC<1%, or PC>1%; PEC<70%)

The assessment undertaken has been carried out under worst-case conditions in particular with regard to the following:

- emissions assumed to be at the WID limit;
- RERF plant assumed to operate continuously;
- worst-case critical levels and critical loads adopted for the habitat sites identified; and
- worst-case baseline concentrations and deposition rates assumed.

In conclusion, whilst there are predicted to be Potentially Significant impacts from the RERF as a result of airborne emissions, the low sensitivity and ecological value of the LNA is such that these impacts are considered to be of low importance.

D3.4 ASSESSMENT OF POTENTIAL IMPACTS DURING ABNORMAL OPERATIONS

D3.4.1 Introduction

Results presented in *Section D3.3*, are based on normal operating conditions and using daily emission limits where daily and half hourly values are provided. Article 13 of the Waste Incineration Directive (WID) allows abnormal operation, where emission limit values can be exceeded for certain periods, without being in contravention of the Environmental Permit for the plant. This assessment identifies foreseeable events at the plant which constitute abnormal operations, which may have an impact on the subsequent emissions to air. The assessment then goes on to quantify the impacts to air quality in the vicinity of the plant as a result of these changes in emissions. The assessment focuses on the potential changes in emissions arising from failure of abatement plant, and mechanical failure.

In addition to the ERF plant, there are diesel generators. These are used to provide emergency power in the event of off-site power failure to allow the plant to remain operational or shut down in a controlled manner. However, the assessment of abnormal emissions focuses specifically on the ERF plant and no consideration of the generator emissions has been undertaken within this Assessment.

D3.4.2 Overview of Abnormal Operations

In the event of any process upset or mechanical failure the immediate action is to rapidly assess the situation and implement process control actions, which ensure that standby equipment, where available and associated abatement systems are operational.

In addition, various actions and monitoring procedures will be initiated by the Operator to ensure that the ERF combustion parameters and emissions remain within the Environmental Permit, thereby avoiding an abnormal operation where possible.

If any process upset or mechanical failure results in a significant change to the emission conditions or process that cannot be easily and quickly remedied, the primary response from the ERF plant operator will be to reduce load or initiate a controlled shutdown. This is a responsible precautionary measure and proactive action to minimise any potential environmental impact.

Abnormal operation is not applicable to high CO or total organic carbon (TOC) emissions; in the event of emissions levels of either being above the Emission Limit Value (ELV) the plant load would be reduced and a controlled shutdown initiated. The proposed Facility will have a fully operational and certified standby CEMS system that will be capable of monitoring the one stream. This will minimise the risk of abnormal operation occurring due to failure of the CEMS system such that CO and / or TOC could not be monitored.

Furthermore, it has been shown that high emissions of CO and TOC generally occur concurrently; under a CEMS system failure each can be used as a surrogate for the other to give confidence that there are no excessive emissions.

VES does not therefore foresee periods where the plant continues to operate for extended periods with CO or TOC above the ELV.

The list below identifies some typical failures and the Operator initiated actions and control measures.

Failure of the export/import electrical supply: While this would not be classified as an abnormal operation, if the export/import supply fails then the plant continues to operate but in island mode ie generating its own power. If the turbine then trips, the standby emergency generator starts up to produce sufficient power for a controlled shutdown. If the standby supply fails, then the Operator initiates an Emergency Shutdown, using the Uninterruptable Power Supply (UPS) to supply power to the CEMS equipment and other key control systems.

Failure of the FGT equipment: There are various standby items and storage capacities within the FGT system eg a standby water injection nozzle that can be readily installed and both duty and standby lime injection systems. If a total lime system failure occurs, such that a repair cannot be effected immediately, then load would be reduced in preparation for a Controlled Shutdown. Unspent lime on the filter bags will minimise the risk of emissions being above the ELV set in the Permit while the plant is being shut down.

Failure of the filtration system: Online maintenance is achieved through isolation of filter sections. In the unlikely occurrence of multiple bag failures the Operator will need to isolate failed bags, if the isolation proves ineffective then a Controlled Shutdown will be initiated to minimise the risk of emissions being above the ELV set in the Permit.

Failure of equipment: While these would not be classified as an abnormal operation, in the event of a failure of bottom ash and FGT residue conveyors, then diverter chutes and bypasses are utilised to avoid shutdowns. In the event of a failure of grate rams and fans, the Operator initiates a Controlled Shutdown. The combustion conditions and emissions will comply with the Permit.

D3.4.3 Approach

The air quality impact assessment provided in *Section D2.7* utilised dispersion modelling. The modelling approach has been amended to look at the short term impacts during periods of WID abnormal operation, assuming worst case of complete abatement failure. A series of factors have been derived in order to ascertain the likely increases in emissions that may occur in each pollutant due to various foreseeable abnormal operations.

For particulate matter, CO, and TOC the limits in Article 13(4) were used for this assessment.

The dispersion modelling approach used to assess impacts under normal operating conditions (refer *Section D2.7*) shows the short term incremental ground level concentrations based on daily emission limits. These predictions are then compared to AQSs. For the assessment of abnormal emissions, the impact on short term concentrations is of more importance since occasional excursion above the ELV would have negligible impact on long term air quality impacts.

In order to assess the short-term ground level conditions that would result from the RERF operating at a plausible abnormal operational emission level for the full 4 hours, the assessment has considered the short term ground level concentrations where emissions occur at above half-hourly emission limits. A period of 4 hours has been selected, as shut-down would be initiated should an abnormal event last longer than that.

The short term ground level concentration has been calculated by multiplying the maximum short-term average modelling result (based on daily limit values shown in the Application) by the ratio of the maximum abnormal half-hour emission concentration to the normal daily emission concentration. This calculation is based on the assumption that other operating conditions, such as volumetric flow, remain the same. The assessment of the ERF operating at a plausible abnormal operational emission level is presented in *Table D3.18.*

Table D3.18 Short-term Ground Level Concentrations with ERF Operating for 4 Hours at Abnormal Emissions

Pollutant	Half hour average emission limit (mg/Nm³) (a)	Daily average emission concentrations (mg/Nm³) (b)	Increase above half hour average emission concentration (%) during abnormal event	Emission during abnormal event (mg/Nm³)(d)	Short Term Maximum PC based on plausible abnormal operation emission levels (µg/m³)	AQS (µg/m³)	PC as % of AQS
NO_2 (a)	400	200	7%	428	44.6	200 (1 hour)	22.3%
SO_2	200	50	5%	210	62.5	350 (1 hour)	17.9%
				210	63.9	266 (15 minute)	24.0%
				210	5.8	125 (24 hour)	4.6%
Total Dust (assumed to be all PM_{10})(	30	10	400% (b)	33.3 (e)	2.5	50 (24 hour)	5.0%
HCl	60	10	25%	75	22.3	750(1 hour)	3.0%
HF	4	1	0%	4	1.2	160 (1 hour)	0.74
CO	100	50	0%	75 (f)	7.7	10000 (8 hour)	0.08%
	100	50	0% ©	100	29.8	30000 (1 hour)	0.09%

(a) Nitrogen monoxide and NO_2, expressed as NO_2. The assessment assumes 35% NO to NO_2 conversion ratio
(b) The maximum total dust emission is restricted to 150 mg Nm^{-3} (Article 13(4) of the WID) and this is adopted as the upper emission level
(c) No exceedences above the half hourly emission limit is allowed for CO (Article 13(4) of the WID)
(d) Abnormal emissions assumed to occur for 4 hours, for the remainder of the averaging period (eg for emissions with 24-hour or 8 hour AQS) emissions are assumed to be at the daily average emission limit
(e) Calculated as 4 hours at 150 mg Nm^{-3} and 20 hours at 10 mg Nm^{-3}
(f) Calculated as 4 hours at 100 mg Nm^{-3} and 4 hours at 50 mg Nm^{-3}

In the event that such an increased emission was coincident with the very worst hour in the year for dispersion, then the short term air quality criteria would not be exceeded during periods where emissions are at the half hourly emission levels indicated. With the exception of NO_2 and SO_2 (1 hour and 15 minute concentrations), predicted short term concentrations under abnormal operation are less than 10% of the air quality standard and considered to be Not significant. For NO_2 and SO_2, the PEC for these short term predictions would be as follows:

- The PEC for the maximum hourly NO_2 concentration would be 108.2 $\mu g\ m^{-3}$ (for a baseline of 63.6 $\mu g\ m^{-3}$) and is 54% of the AQS.

- The PEC for the maximum hourly SO_2 concentration would be 76.0 $\mu g\ m^{-3}$ (for a baseline of 13.5 $\mu g\ m^{-3}$) and is 22% of the AQS.

- The PEC for the maximum 15 minute SO_2 concentration would be 82.0 $\mu g\ m^{-3}$ (for a baseline of 18.1 $\mu g\ m^{-3}$) and is 31% of the AQS.

Therefore, it is unlikely that there would be an exceedence of the AQS for NO_2 or SO_2 as a result of emissions during abnormal operation.

In the specific case of particulate matter and carbon monoxide, the predicted impact during abnormal operations has been calculated based on the ERF running at maximum concentration allowable by WID. As a responsible operator, VES would be unlikely to allow the ERF to operate for four hours under such abnormal conditions, therefore the calculations presented in *Table D3.18* should be considered to be pessimistic.

D3.5 TRAFFIC ASSESSMENT

D3.5.1 DMRB Assessment

The impact of traffic emissions on local air quality is used to assess the in-combination effects of traffic related air quality and operational emissions from the RERF.

For the purposes of the assessment, a theoretical residential property located five metres from the kerbside of the A63 has been assumed. The A63 Pontefract Lane is a dual carriageway and the total distance from the centre of the road to the kerbside is approximately 8 m, therefore the theoretical sensitive receptor is 13 m from the centre of the road.

The maximum annual average daily 2016 baseline traffic flow on the A63 is 15,522 rising to 15,829 when the development is operational. This corresponds to a 1.9% increase in total vehicle movements and an increase in HGV movements of 13%.

D3.5.2 *Method for converting NO_x to NO_2*

The method to convert roadside NO_x to NO_2 within the DMRB model was based on measurements made between 1999 and 2001. Recent evidence shows that the proportion of primary NO_2 in vehicle exhaust has increased (1). This means that the relationship between NO_x and NO_2 at the roadside has changed from that currently used in the DMRB model. A NO_x to NO_2 calculator (2) has therefore been developed and is used in conjunction with the DMRB model to obtain a more accurate assessment of NO_2 concentrations.

The NO_2 road contribution is then added to the annual mean NO_2 background concentration (31. 5 $\mu g\ m^{-3}$) to produce the total environmental concentration for comparison with the air quality objectives.

D3.5.3 *Results for NO_2*

Predicted ground level concentrations of NO_2 arising from vehicle emissions for the Do Nothing and Do Something Scenarios are presented in *Table D3.19*.

The difference between the two sets of predictions is the impact of the traffic associated with the proposed RERF.

Table D3.19 Predicted Annual Mean NO_2 Concentrations 5 m from the Kerbside of the A63

Predicted Concentration	**2016 Do Nothing ($\mu g\ m^{-3}$)**	**2016 Do Something ($\mu g\ m^{-3}$)**
DMRB NO_x	16.0	17.3
Corresponding Road NO_2	7.8	8.4
Background NO_2	31.8	31.8
Total NO_2	39.6	40.2
Project related increase in NO_2	0.6	
Air Quality Objective	*40*	

It is widely recognised that the DMRB model can significantly under or over-estimate pollutant concentrations and it is therefore desirable to verify the predicted concentrations against local monitoring data, if these are available.

Ambient NO_2 concentrations have been measured by diffusion tube close to the kerbside of the A63 carriageway (see *Table D2.3*) and indicate that the annual mean air quality objective is currently being exceeded slightly at this location.

The DMRB model predicts a slight exceedence of the objective 5m from the kerbside, which is consistent with the monitoring data. However, as

(1) http://www.defra.gov.uk/environment/airquality/publications/primaryno2-trends/pdf/primary-no-trends.pdf
(2) http://laqm.defra.gov.uk/tools-monitoring-data/no-calculator.html

mentioned, there is no relevant public exposure at this distance from the carriageway and the nearest sensitive receptors are over 15m from the road. The predicted impact at 15m from the road is presented in *Table D3.20.*

Table D3.20 Predicted Annual Mean NO_2 Concentrations 15 m from the Kerbside of the A63

Predicted Concentration	**2016 Do Nothing (µg m^{-3})**	**2016 Do Something (µg m^{-3})**
DMRB NOx	12.2	13.1
Corresponding Road NO_2	6.0	6.4
Background NO_2	31.8	31.8
Total NO_2	37.8	38.2
Project related increase in NO_2	0.4	
Air Quality Objective	*40*	

Predicted concentrations at a sensitive receptor 15m from the kerbside are within the annual mean air quality objective for NO_2. The traffic associated with the proposed RERF increases the NO_2 concentration by 0.4 µg m^{-3}.

The DMRB model is unable to predict short-term (1-hour mean) NO_2 concentrations for comparison with the objective. However, research (2) has shown that exceedances of the 1-hour mean objective are generally unlikely to occur where annual mean concentrations are below 60 µg m^{-3}. The maximum predicted concentration is well within this concentration.

D3.5.4 Results for PM_{10}

Predicted PM_{10} concentrations for the Do Nothing and Do Something scenarios are presented in *Table D3.21***.**

Table D3.21 Predicted Annual Mean PM_{10} Concentrations 5 m from the Kerbside of the A63

Predicted Concentration	**2016 Do Nothing (µg m^{-3})**	**2016 (Do Something (µg m^{-3})**
DMRB PM_{10}	1.2	1.3
Background PM_{10}	25.7	25.7
Total PM_{10}	26.9	27.0
Project related increase in PM_{10}	0.1	
Air Quality Objective	*40*	

The predicted PM_{10} concentrations are well within the annual mean air quality objectives for both scenarios. The increase due to traffic associated with the proposed RERF is 0.10 µg m^{-3}.

DMRB predicts that there will be 17 exceedences of the 24-mean PM_{10} objective for the future baseline traffic (35 exceedences are allowable within the objective). Traffic associated with the development does not result in any predicted additional exceedences.

D3.5.5 *Predicted $PM_{2.5}$ Concentrations*

Assuming all of the particles emitted from vehicles comprise the finer $PM_{2.5}$ fraction, predicted concentrations of $PM_{2.5}$ are compared with background levels in the vicinity of the proposed plant.

Table D3.22 Predicted Annual Mean $PM_{2.5}$ Concentrations 5 m from the Kerbside of the A63

Predicted Concentration	2016 Do Nothing (µg m^{-3})	2016 (Do Something (µg m^{-3})
DMRB $PM_{2.5}$	1.2	1.3
Background $PM_{2.5}$	13.5	13.5
Total $PM_{2.5}$	14.7	14.8
Project related increase in $PM_{2.5}$	0.1	
Air Quality Objective	*25*	

The predicted $PM_{2.5}$ concentrations are well within the annual mean air quality objectives for both scenarios. The increase due to traffic associated with the proposed RERF is 0.10 µg m^{-3}.

D3.6 CUMULATIVE AND IN-COMBINATION IMPACTS

D3.6.1 *Cumulative Impacts*

Development specific baseline monitoring has been carried out within the immediate vicinity of the RERF and at sensitive receptors locations. The purpose of the monitoring is to determine the influence of background sources on local air quality. Therefore, the background monitoring results will include the contribution of other significant sources of emissions. However, background monitoring will not include the contribution of proposed emissions sources (ie those that are planned but not yet built or operational). Where there is a high degree of certainty that a planned development will take place (eg it has received planning permission) then cumulative modelling would be carried out to determine the combined impact of all future emissions on local air quality.

Biffa has submitted a planning application to Leeds City Council for the Skelton Grange Energy Recovery Facility proposed to be located to the southwest of the Knostrop Sewage Treatment Works, to the southeast of the proposed Veolia RERF. To date, the Biffa development has not received planning permission and therefore detailed cumulative modelling of emission has not been provided. However, it is recognised that should the Biffa development proceed there may be local concerns relating to the combined impact of the two developments. Consequently, an assessment of the likely cumulative effects has been carried out for NO_2, the pollutant of most interest with respect to elevated background concentrations and the additional contribution from the RERF.

The contribution of the Biffa and Veolia developments to annual mean NO_2 concentrations is as follows:

- maximum concentrations from the Biffa development are predicted as 0.96 µg m^{-3} and occur to the east of the sewage works. At this location the contribution from the Veolia development is 0.1 µg m^{-3}; and
- maximum concentrations from the Veolia development are predicted as 1.7 µg m^{-3} and occur to the north of the sewage works. At this location the contribution from the Biffa development is around 0.2 µg m^{-3}.

Therefore, at worst, the maximum predicted annual mean NO_2 concentration is 1.9 µg m^{-3} (4.8% of the air quality standard). Combined with a background concentration of 31.8 µg m^{-3} the total predicted concentration, including the contribution from the two proposed developments, is 33.7 µg m^{-3}, well below the air quality standard of 40 µg m^{-3}.

D3.6.2 In-combination Impacts of Plant Emissions and Road Traffic Emissions

This section considers impacts of the proposed RERF in terms of in-combination impacts of plant emissions and road traffic related emissions. Maximum predicted annual mean concentrations arising from the ERF stack emissions occur to the north east of the RERF. However, the biggest impact from vehicle movements occurs to the south of the proposed RERF site along the A63. Therefore adding the maximum impacts arising from the RERF and road traffic sources is conservative. The predicted contribution of the RERF to annual mean NO_2 and PM_{10} is presented in *Figure D3.3* and *Figure D3.5*, respectively. At the A63, maximum predicted NO_2 concentrations are 0.6 µg m^{-3} and maximum PM_{10} concentrations are 0.1 µg m^{-3}. The combined impact of vehicle emissions and the ERF emissions on NO_2 and PM_{10} are presented in *Table D3.23* and *Table D3.24*.

Table D3.23 Predicted In-combination Annual Mean NO_2 Concentrations

Predicted Concentration	2016 Do Nothing (µg m^{-3})	2016 Do Something (µg m^{-3})
Road NO_2 at nearest sensitive receptor to the roadside (15m)	6.0	6.4
Background NO_2	31.8	31.8
ERF contribution to NO_2	0.0	0.8
Theoretical maximum total NO_2	37.8	39.0
Theoretical maximum project related increase in NO_2	1.2	
Air Quality Objective	*40*	

The predicted total increase in NO_2 from traffic and the ERF for the Do Something scenario is 1.2 µg m^{-3} and is 3% of the annual mean air quality standard.

Table D3.24 ***Predicted In-combination Annual Mean PM_{10} Concentrations***

Predicted Concentration	2016 Do Nothing (µg m^{-3})	2016 (Do Something (µg m^{-3})
Road PM_{10}	1.2	1.3
Background PM_{10}	25.7	25.7
ERF contribution to PM_{10}	0.0	0.4
Theoretical maximum total PM_{10}	26.9	27.4
Theoretical maximum project related increase in NO_2	0.5	
Air Quality Objective	*40*	

The predicted total increase in PM_{10} from traffic and the ERF for the Do Something scenario is 0.5 µg m^{-3} and is 1% of the annual mean air quality standard.

Therefore, it is concluded that the in-combination impact of vehicle emissions with the ERF emissions is Not Significant.

D3.7 VISIBLE PLUMES

Visible plumes from ERFs arise as a result of the condensation of water vapour in the exhaust gas into droplets as the exhaust gases cool when emitted. The occurrence of visible plumes depends upon the following:

- Visible plumes are sometimes generated when hot exhaust gas meets cooler ambient air upon exit from a stack. The exhaust gas is rapidly cooled, resulting in a supersaturated air mass (relative humidity > 100%). Under these conditions, water vapour within the exhaust gas condenses onto available hygroscopic particles (condensation nuclei) forming water droplets.

- As the exhaust gas rises (it is positively buoyant due to its higher temperature relative to the ambient air), atmospheric turbulence results in entrainment (mixing) of cooler ambient air into the plume, introducing new condensation nuclei and enabling further droplets to form; the plume spreads. However, at the same time, the entrainment of drier ambient air into the plume also reduces the humidity of the plume, leading to evaporation of the water droplets and thereby reducing visibility of the plume. Therefore, eventually the visible plume will dissipate.

- The frequency of occurrence of a visible plume and distance downwind of the stack before it dissipates will depend principally on the temperature difference between the exhaust gas and ambient air, the moisture content of the exhaust gases and a combination of the relative humidity and temperature of the ambient air into which the plume is dispersed.

The ADMS model takes into consideration the ambient air temperature and relative humidity for each hour of the year (this data is contained within the meteorological data file), and takes into account the exhaust gas characteristics. The model predicts how often plumes will occur and how far downwind they will extend until they break up and disperse becoming no longer visible.

The results of the plume visibility assessment are set out in *Table D3.25*. This provides the percentage of the year when there would be a visible plume and includes the frequency for both day and night time. Plume visibility has been predicted assuming the water content is 0.11 kg/kg (kg of water per kg of exhaust gas).

Table D3.25 Summary of Plume Visibility Study Results

Parameter	Percentage of year visible plumes would have occurred				
	2006	**2007**	**2008**	**2009**	**2010**
No plume	62.0%	60.6%	58.0%	60.8%	58.5%
0-50m	22.9%	26.5%	26.9%	24.4%	20.3%
50-100m	12.2%	11.1%	13.3%	12.1%	13.8%
100-200m	2.9%	1.8%	1.7%	2.7%	7.4%
200-400m	0.0%	0.0%	0.0%	0.0%	0.0%
>400 m	0.0%	0.0%	0.0%	0.0%	0.0%
Average length (m)	48.0	43.3	44.6	46.4	59.6
Maximum length (m)	204	193	183	204	216

The Assessment predicts that visible plumes are likely to be present for around 40% of the time. The approximate dimensions of the site are 270 m by 130 m and plumes in excess of 100 m are likely to extend beyond the site boundary. The plume length is predicted to be greater than 100m for approximately 2% of the year. The plume will be white or grey depending on lighting conditions during the day, and may be lit to some extent from beneath by streetlights during the night, and will be somewhat broken and diffuse as the plume disperses.

On this basis, following the guidance set out in the Environment Agency H1 document (version 6, July 2003) the impacts are considered to be low for the following reasons:

- regular small impact from operation of the process;
- plume length exceeds boundary <5% of daylight hours per year; and
- there are sensitive local receptors.

D3.8 *ODOUR AND DUST IMPACT ASSESSMENT*

D3.8.1 *Introduction*

The RERF is designed so that, when operational, the air required for the combustion process is drawn from within the building. This process produces a slight negative pressure in the building and ensures that all potentially odorous air from the MPT and bunker is drawn into the furnace where odours are destroyed by combustion. On this basis, during normal operations the RERF would not be associated with potentially significant releases of odour. In addition, the RERF will be equipped with activated carbon filters, with one filter in continuous operation. The remaining filters will come into operation in the event of plant shutdown.

D3.8.2 *Fugitive Sources of Odour and Dust*

During breakdown or planned maintenance, the combustion plant will not operate and the additional activated carbon filters will be required. In the event of maintenance, this will be planned so that the Facility will be able to deplete waste in the storage bunker prior to shutdown, thus minimising the potential for odours. Where shut down occurs (planned or unplanned) there is the potential for odours to be released from the Mechanical Pre Treatment (MPT) and waste stored on site.

The potential for odour events to occur at energy from waste facilities was investigated in a Defra report on emissions from waste management facilities [(1)]; this report was prepared by ERM in collaboration with Defra and the Environment Agency, from whom information was obtained. Within this report evidence is provided that these types of events are rare at this type of plant, with only two odour events recorded by the Environment Agency at operational energy from waste facilities between 2005 and 2009.

Furthermore, any odorous air arising from within the RERF will be passed through the activated carbon filters . Therefore, the potential for odour annoyance to occur is considered minimal.

The activated carbon filters will vent directly to air from the roof of the MPT building and has the potential for residual odour. Therefore, a quantitative assessment of odour annoyance arising from these is provided in *Section D3.8.3*.

Incoming waste will be delivered in covered vehicles or containers. From the weighbridge the vehicles will proceed to the reception hall to discharge their load.

There will be no large scale storage of fuels or stockpiles of raw materials, other than of waste: this will be done in the MPT reception hall and in the ERF

(1) Defra (2012) WR 0608 Emissions from Waste Management Facilities
http://randd.defra.gov.uk/Document.aspx?Document=WR0608FinalReport.pdf

bunkers, in normal conditions, waste should not remain in the main bunker for longer than 3 days.

The reception hall will be fitted with fast shutting doors to minimise fugitive emissions of odour. This door will remain closed when there are no waste deliveries occurring.

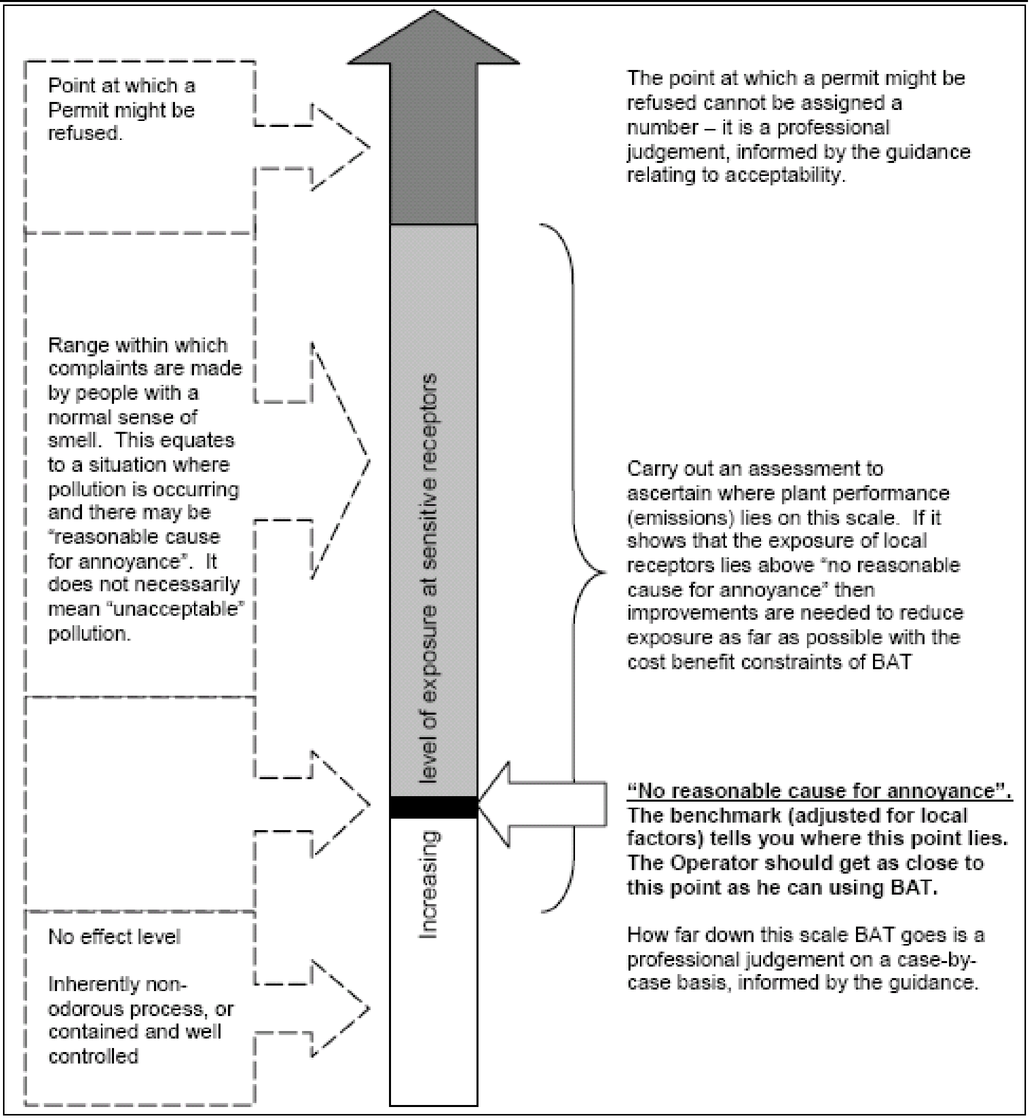
Within the waste bunker, regular mixing of the waste will prevent anaerobic conditions that may otherwise give rise to odours and to ensure that the waste fed to the furnace is of an even consistency. Mixing will be achieved by the operation of a grab crane.

Containment of dust and odour within the waste reception hall and the waste bunker will also be achieved through the maintenance of negative pressure. The combustion air fans will draw air from these areas into the furnace to feed the combustion process; in this way odours and airborne dust are drawn into the incineration line. Odorous substances will thus be destroyed by incineration. As a result, any dust or odour from the tipping, mixing and furnace loading operations will be retained within the waste reception hall or carried into the furnace rather than escaping to the outside.

There will be some unavoidable and trivial emissions of solvent vapours from paints and solvents during maintenance (painting). These will be minimised by selecting painting solvent systems (paint and thinners) with the lowest possible volatile organic compound (VOC) content compatible with satisfactory performance in surface protection.

There are thus no significant fugitive emissions to air of gases, vapours, odours or particulate matter. The plant is well within the point on the sliding scale at which 'no reasonable cause for annoyance' occurs, as defined in *Figure D3.7*.

Figure D3.7 *The Concept of the Sliding Scale Towards 'No Reasonable Cause for Annoyance' as Detailed in the Guidance (H4 Part 1)*



Source of image: Technical Guidance Note IPPC H4. Integrated Pollution Prevention and Control (IPPC). DRAFT. Horizontal Guidance for Odour. Part 1 - Regulation and Permitting. Draft for Consultation. October 2002. pp 4. Environment Agency, Bristol.

D3.8.3 *Point Source Emissions of Odour*

The activated carbon filters will vent directly to atmosphere and have the potential for residual odour. Therefore, there is the potential for odour annoyance during poor dispersion conditions. Dispersion modelling has been used to assess the potential impact of this emission source on local residents. Details of the emission are as follows:

- vent height of 18 m (top of the MPT building);
- vent dimensions of 1.5 m by 2.0 m (giving rise to an effective stack diameter of (1.95 m);
- vent location is assumed to be 432760, 432490;

- during normal operation the flow rate through the vent will be 60,000 $m^3 h^{-1}$ (16.7 $m^3 s^{-1}$);

- emission velocity through the vent is assumed to be 5.6 m s^{-1};

- during normal operation the temperature of the emission will vary between 15 to 20 °C (a value of 17.5 °C has been assumed for the modelling);

- odour concentration is assumed to be 500 OU m^{-3} (29.9 OU s^{-1}).

Predicted odour concentrations arising from emissions from the vent are provided for the five years of meteorological data (2006 to 2010). Predicted concentrations are expressed as the 98th percentile of hourly mean values and compared to benchmark levels provided by the Environment Agency[1]. The Environment Agency has provided three benchmark levels depending on the perceived offensiveness of the odour source. For the purposes of this assessment, the most stringent criterion has been adopted (1.5 OU m^{-3}).

The maximum predicted concentration at sensitive receptors is presented in *Table D3.26*. For the five years of meteorological data, maximum concentrations are presented for each receptor.

Table D3.26 Predicted Odour Concentrations from Emissions from the Activated Carbon Filters

Reference	Receptor	Odour Concentration as 98th Percentile of Hourly Means (OU m^{-3})
Maximum predicted		0.0092
Hum01	Halton Moor Road	0.00034
Hum02	Park Parade	0.00010
Hum03	Victoria Avenue	0.00014
Hum04	Richardson Cresent	0.0000070
Hum05	Cross Green Lane North	0.000086
Hum06	Cross Green Lane South	0.000085
Hum07	Rocheford Gardens/Sussex Gardens	0.000044
Hum08	Skelton Moor Farm	0.000050
Assessment criterion		*1.5*

Maximum predicted odour concentrations as the 98th percentile of hourly means are less than 1% of the benchmark level of 1.5 OU m^{-3}. At sensitive receptors, predicted concentrations are substantially less than the maximum. Therefore, odour emissions from the activated carbon filters are assessed as not significant.

[1] H4 Odour Management, Environment Agency (March 2011)

D3.8.4 Management and Control of Odours

On the basis of the evidence provided, the potential for odour nuisance to occur is considered minimal. However, in order to ensure that the risk of odour issues arising at the facility is negligible, the odour management control measures provided in *Table D3.27* will be implemented.

Table D3.27 Odour Risk Assessment and Management Plan

What do you do that can harm and what can be harmed			Managing the Risk	Assessing the Risk		
Hazard What has the potential to cause harm?	**Receptor** What is at risk? What do I wish to protect?	**Pathway** How can the hazard get to the receptor?	**Risk Management** What measures will you take to reduce the risk? If it occurs – who is responsible for what?	**Probability of Exposure** How likely is this contact?	**Consequence** What is the harm that can be caused?	**What is the overall risk** What is the risk that still remains? The balance and probability of consequence
Odour from incoming waste vehicles	Residential receptors (residents in Osmonthorpe to the northeast of the site, and in Cross Green to the west of the site).	Air	Waste will be delivered in covered vehicles and containers. Queuing times will be minimised using traffic management to reduce the potential for odour emissions to arise from waste in vehicles.	Unlikely.	Odour nuisance especially in summer.	Evidence provided by the Environment Agency suggests that odour nuisance events at EfW plants are very rare. In the highly unlikely event of an occurrence, the impact will be of a temporary nature. On this basis, impacts are considered to be insignificant.
Waste reception, MPT and waste bunker.	As above	Air	Waste will be stored in the MPT reception hall and the ERF bunkers in normal conditions. Waste should not remain in the bunker for longer than 3 days. The reception hall will be fitted with fast shutting doors to minimise fugitive emissions of odour. These doors will remain closed when there are no waste deliveries occurring.	Highly unlikely	Odour nuisance	Highly unlikely to be a risk as evidence from other ERFs have shown that the mechanisms in place are adequate to prevent odour emissions. The plant design is such that even in the event of maintenance or

What do you do that can harm and what can be harmed			Managing the Risk	Assessing the Risk		
Hazard What has the potential to cause harm?	**Receptor** What is at risk? What do I wish to protect?	**Pathway** How can the hazard get to the receptor?	**Risk Management** What measures will you take to reduce the risk? If it occurs – who is responsible for what?	**Probability of Exposure** How likely is this contact?	**Consequence** What is the harm that can be caused?	**What is the overall risk** What is the risk that still remains? The balance and probability of consequence
			The MPT reception hall and ERF bunkers will be maintained at a negative pressure in order to further minimise the potential for emissions of odour. Odours arising from wastes will be drawn into the combustion process and destroyed. The plant is equipped with activated carbon filters for the treatment of air from MPT building. In the event of a total plant shut down, additional filters will operate. Periodic washing will be utilised to maintain a clear and clean area.			unplanned events, the potential for odour emissions is minimised. If this occurs, it will be of a temporary nature and can therefore, be deemed insignificant
Solvent emissions from paints and solvents during maintenance	As above	Air	Emissions will be minimised by selecting painting solvent systems (paint and thinners) with the lowest possible volatile organic compound (VOC) content compatible with satisfactory performance in surface protection.	Unlikely due to small quantity of trivial emissions	Odour nuisance	Due to temporary nature, can be deemed insignificant.

D4 CONCLUSION

The key findings of the Assessment are that there will be no significant impacts on sensitive human receptors from the proposed Facility with a stack height of 75 m.

There are no statutorily designated habitat sites that would be affected by emissions from proposed RERF. The nearest habitat sites are locally designated sites of nature conservation interest and include four Leeds Nature Areas (LNA). Whilst there are predicted to be Potentially significant impacts from the RERF, as a result of airborne emissions to these sites, the low sensitivity and ecological value of the LNA is such that these impacts are considered to be of low importance.

With regard to impacts associated with road traffic, the in-combination effects on air quality of traffic related emissions, plant emissions and the existing baseline are considered to be Not Significant.

The Facility is predicted to produce visible plumes from the main stack during particular meteorological conditions. On occasions, these plumes are predicted to be greater than 100m in length and extend beyond the site boundary for approximately 2% of the year. The plume will be white or grey depending on lighting conditions, and will be somewhat broken as the plume disperses. On this basis, impacts are considered to be low.

Annex E

Human Health Risk Assessment

CONTENTS

E1 INTRODUCTION

E1.1 SCOPE OF THE ASSESSMENT

Human exposure to any harmful pollutants discharged directly to the aquatic environment and from solid waste disposal is considered to be negligible. Consequently, the Human Health Risk Assessment (HHRA or the Assessment) considers the effects of human exposure from emissions to air from the proposed Recycling and Energy Recovery Facility (RERF, or the Facility) at Cross Green, Leeds.

Emissions from the stack associated with the proposed RERF would contain a number of substances that cannot be evaluated in terms of their effects on human health simply by reference to ambient air quality standards. Health effects could occur through exposure routes other than purely inhalation. As such, an assessment needs to be made of the overall human *exposure* to the substances by the local population and then the *risk* that this exposure causes.

The Assessment presented here considers the impact of certain substances released by the stack on the health of the local population at the point of maximum exposure. These substances are those that are 'persistent' in the environment and have several pathways from the point of release to the human receptor. Essentially they can be described as dioxins/furans and metals. They are present in extremely small quantities and are typically measured in mass units of nanograms (ng = 10^{-9} g), picograms (pg = 10^{-12} g) and femtograms (fg = 10^{-15} g).

Unlike substances such as nitrogen dioxide (which have short term, acute effects on the respiratory system) dioxins/furans and metals have the potential to cause effects through long term, cumulative exposure. A lifetime is the conventional period over which such effects are evaluated. As the United States Environmental Protection Agency (US EPA) Human Health Risk Assessment Protocol (HHRAP) default, a lifetime is taken to be 70 years.

The exposure scenarios used here represent a highly unrealistic situation in which all exposure assumptions are chosen to represent a worst case, consequently they should be treated as an extreme view of the risks to health. While individual high-end exposure estimates may represent actual exposure possibilities (albeit at very low frequency), the possibility of all high end exposure assumptions accumulating in one individual is, for practical purposes, never realised. Therefore, intakes presented here should be regarded as an extreme upper estimate of the actual exposure that would be experienced by the real population in the locality.

E1.2 *APPROACH TO THE ASSESSMENT*

In the absence of a formal UK methodology, the risk assessment process is principally based on the application of the US EPA Human Health Risk Assessment Protocol (HHRAP) (1). The HHRAP has been rigorously peer reviewed with input data obtained from internationally reputable sources. This protocol has been assembled into a commercially available model, Industrial Risk Assessment Program (IRAP, Version 4.0) and marketed by Lakes Environmental of Ontario. ERM holds a user licence for this model, which has been used here.

The approach seeks to quantify the *hazard* faced by the receptor, the *exposure* of the receptor to the substances identified as being a potential hazard and then to assess the *risk* of the exposure, as follows:

- *Quantification of the exposure*: an exposure evaluation determines the dose and intake of key indicator chemicals for an exposed person. The dose is defined as the amount of a substance contacting body boundaries (in the case of inhalation, the lungs) and intake is the amount of the substance absorbed into the body. The evaluation is based upon worst-case, conservative scenarios, with respect to the following:

    - Location of the exposed individual and duration of exposure;
    - Exposure rate;
    - Emission rate from the source.

- *Risk characterisation*: following the above steps, the risk is characterised by examining the toxicity of the chemicals to which the individual has been exposed, and evaluating the significance of the calculated dose in the context of probabilistic risk.

US health guideline values (HGV) have been used for this HHRA as these are the default values included within the HHRAP and are expressed in the format required by the HHRAP. It is recognised that there are UK HGV that could be used, or could be adapted for use, within the model. Often UK HGVs are derived using the same toxicological data and in some instances (eg antimony) use US based HGV. An alternative assessment is also provided that utilises UK derived HGV.

Local monitoring of trace metals has identified that concentrations of total chromium in the local area are relatively high (refer to *Annex D*). Therefore, the impact of elevated background concentrations of chromium, in particular chromium VI, is also assessed.

(1) US EPA Office of Solid Waste (September 2005) Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities

E2 METHODOLOGY FOR ESTIMATING EXPOSURE TO EMISSIONS

E2.1 INTRODUCTION

An exposure assessment for the purposes of characterising the health impact of the proposed RERF emissions requires the following steps:

(1) Measurement or estimation of emissions from the source.

(2) Modelling the fate and transport of the emitted substances through the atmosphere and through soil, water and biota following deposition onto land. Concentrations of the emitted chemicals in the environmental media are estimated at the point of exposure, which may be through inhalation or ingestion.

(3) Calculation of the uptake of the emitted chemicals into humans coming into contact with the affected media and the subsequent distribution in the body.

With regard to Step (3), the exposure assessment considers the uptake of polychlorinated dibenzo-para-dioxins and polychlorinated dibenzofurans (PCDD/F, often abbreviated to 'dioxins/furans') and metals by various categories of human receptors. In addition, emissions of polycyclic aromatic hydrocarbons (PAH) are considered, assuming as a worst-case that emissions comprise entirely of one of the more toxic PAH, that of benzo(a)pyrene (B[a]P).

E2.2 POTENTIAL EXPOSURE PATHWAYS

There are two primary exposure 'routes' where humans may come into contact with chemicals that may be of concern:

- direct, via inhalation; or
- indirect, via ingestion of water, soil, vegetation and animals and animal products that become contaminated through the food chain.

There are four other potential exposure pathways of concern following the introduction of substances into the atmosphere:

- dermal (skin) contact with soil;
- dermal (skin) contact with water;
- ingestion of drinking water; and
- incidental ingestion of soil.

E2.3 *EXPOSURE PATHWAYS CONSIDERED IN THE ASSESSMENT*

The possible exposure pathways included in the IRAP model are shown in *Figure E2.1*. Dermal contact with soil is an insignificant exposure pathway on the basis of the infrequent and sporadic nature of the events and the very low dermal absorption factors for this exposure route, coupled with the low plausible total dose that may be experienced (when considered over the lifetime of an individual). Health risk assessments of similar emissions (Pasternach (1989) *The Risk Assessment of Environmental and Human Health Hazards*, John Wiley, New York) have concluded that dermal absorption of soil is at least one order of magnitude less efficient than lung absorption.

Similar arguments are relevant with respect to the elimination of aquatic pathways from consideration; swimming, fishing and other recreational activities are also sporadic and unlikely to lead to significant exposures or uptake of any contamination into the human body via dermal contact with water.

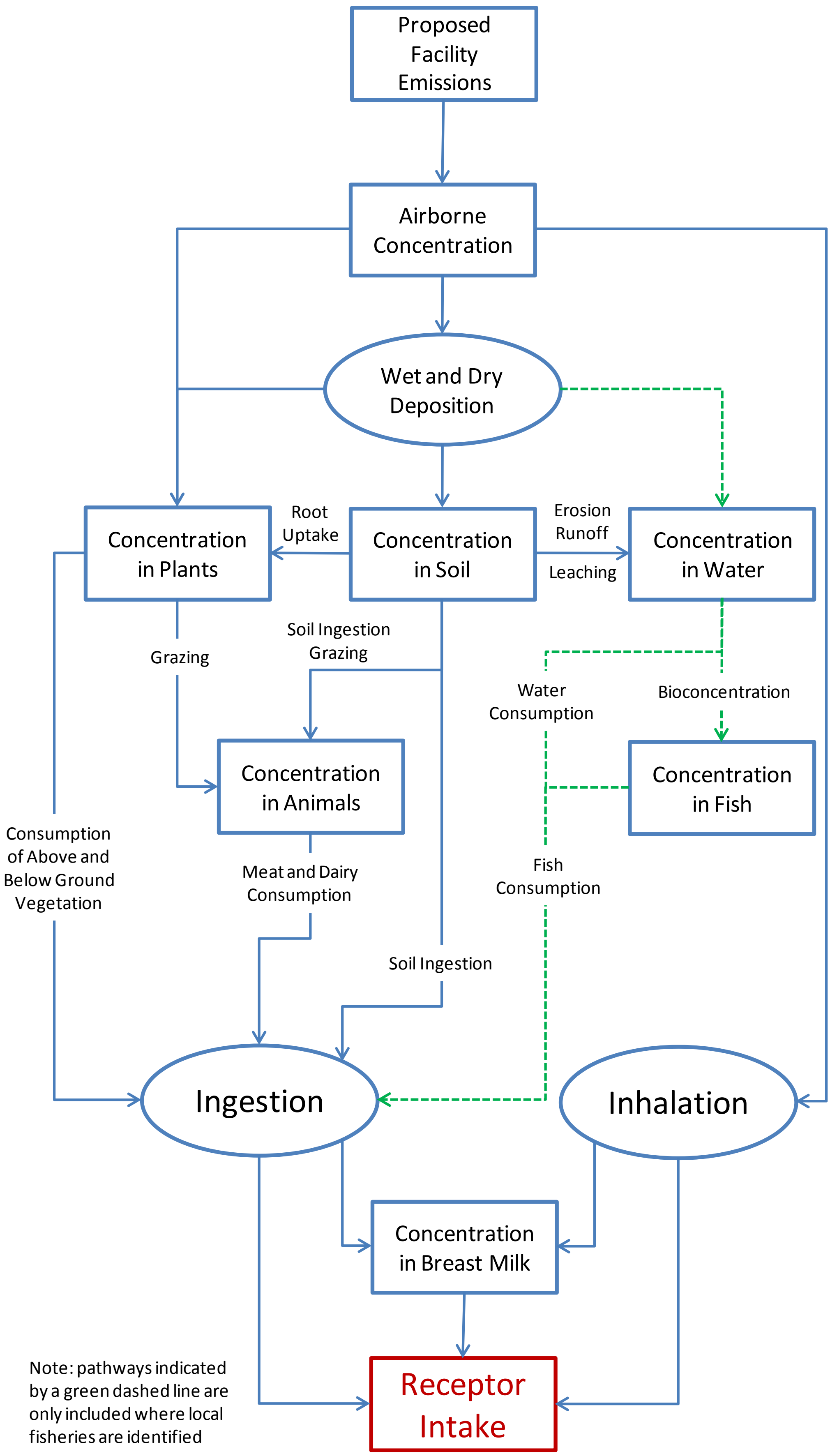
Exposure via drinking water requires contamination of drinking water sources local to the point of consumption. The likelihood of contamination reaching a level of concern in the local water sources and ground water supplies is extremely low, particularly where there is no large scale storage (eg reservoirs) or catchment areas for local water supplies. However, the US EPA's HHRAP does include the ingestion of drinking water from surface water sources as a potential exposure pathway where water bodies and water sheds have been defined within the exposure scenario. The ingestion of groundwater as a source of local drinking water is not included within the HHRAP, as it is considered to be an insignificant exposure pathway for combustion emissions.

On the basis of the assessment of the potential significance of the exposure pathways the key exposure pathways which are relevant to this assessment and, hence, subject to examination in detail are as follows:

- inhalation;
- ingestion of food; and
- ingestion of soil.

With respect to the ingestion of food, local foods consumed will depend on the receptor and may include the vegetables, dairy products and meat products. The likelihood of locally caught edible fish (eg non-coarse fish) within 5 km of the proposed RERF being consumed regularly has been considered. There are a number of potential areas for coarse fishing within 5 km of the proposed facility. These include the Aire and Calder Canal, a portion of which has been identified for coarse fishing. This runs from just north of the lock at Old Mill Lane (north of the proposed RERF) to Woodlesford Lock to the south. There is an additional fishing venue at Swillington Park, again used for coarse fishing (carp, tench, bream, rudd, barbell, perch, roach) but this is in excess of 5 km of the proposed RERF.

Figure E2.1   Exposure Pathways for Receptors



The fisheries identified are a potential source of fish and may be consumed by Eastern Europeans, who are regular consumers of some types of coarse fish. However, in the UK coarse fisheries are a source of recreational fishing; fish which are caught are returned to the water rather than being retained for human consumption. Consequently, coarse fisheries do not generally allow fish to be taken. A review of local fisheries indicates that there are no fisheries within 5 km where edible fish (eg trout or salmon) may be taken. Therefore, the ingestion of locally caught fish has not been considered, as consumption rates are likely to be very small.

The ingestion of drinking water from surface water sources is only considered a potential exposure pathway where consideration is given to a local surface water body for the consumption of locally caught fish. Local drinking water will be provided predominantly by Yorkshire Water.

The exposures arising from ingestion are assessed with reference to the following:

- milk from home-reared cows;
- eggs from home-reared chickens;
- home-reared beef;
- home-reared pork;
- home-reared chicken;
- home-grown vegetable and fruit produce;
- breastmilk; and
- soil (incidental).

The inclusion of all food groups in the HHRA conservatively assumes that both arable and pasture land are present in the vicinity of the predicted maximum annual average ground level concentration. This is, in reality, a highly unlikely scenario, but it has been included as a means of building a high degree of conservatism into the assessment and, hence, reducing the risk of exposures being underestimated. However, it should be noted that not all exposure scenarios will result in the ingestion of home-reared meat and animal products and these food products are only considered by the HHRAP for Farmers and the families of Farmers. Similarly, the ingestion of fish is only considered where there is a local water body that is used for fishing and where the diet of the Fisher (and family) may be regularly supplemented by fish caught from these local water sources.

E3 EMISSIONS AND DISPERSION MODELLING INPUT DATA

E3.1 COMPOUNDS OF POTENTIAL CONCERN (COPC)

The substances that have been considered in the assessment are referred to as the Compounds of Potential Concern (COPC). The substances that have been included for this Assessment are those that are authorised emissions and which are included in the EPA HHRAP COPC database for the assessment of long term health effects. Although emission limits for PAH are not currently set, monitoring of PAH is required by the Waste Incineration Directive (WID). Therefore, benzo(a)pyrene has been included in the assessment to represent PAH emissions. Consequently, the following have been considered as COPC for the proposed RERF:

- PCDD/F (individual congeners);
- Benzo(a)pyrene;
- Antimony (Sb);
- Arsenic (As);
- Cadmium (Cd);
- Chromium (Cr), trivalent and hexavalent;
- Mercury (Hg);
- Lead (Pb); and
- Nickel (Ni).

The 2005 protocol excludes thallium (Tl) by virtue of there being no reference dose, reference concentration or cancer slope factors for thallium. This is at variance with the draft 1998 protocol which did include thallium in the assessment of hazards. The toxic properties of thallium are well known and it is ERM's opinion that thallium should be included in the assessment of hazards. Therefore, the 1998 US EPA reference data has been used to assess the hazards associated with exposure to thallium.

E3.2 EMISSION CONCENTRATIONS FOR THE COPC

E3.2.1 Introduction

The emission concentrations for the COPC considered are reported in the *Air Quality Chapter* of the Environmental Statement (ES) and for short term emissions are governed by the Waste Incineration Directive (WID). For long term emissions, information on Group 3 metal emissions and the proportion of chromium emitted as hexavalent chromium (CrVI) have been obtained from Environment Agency guidance (1). Emissions of PCDD/F are assumed to be at the WID limit and emissions for benzo(a)pyrene, which does not have a WID limit, is based on actual emissions data for a similar plant. Emissions of cadmium, thallium and mercury are also based on actual monitoring data

(1) Guidance to Applicants on Impact Assessment for Group 3 Metals Stack Releases – V.2, June 2011 (Environment Agency)

as information on typical emission concentrations for these are not provided by the Environment Agency guidance. Details of adopted emission concentrations for the assessment are provided in *Annex D*.

E3.2.2 Metals

For the metals considered for the health risk assessment, the individual emission concentrations are presented in *Table E3.1*. Some of the metals listed in the WID are excluded from this assessment, on the grounds that they pose little or no hazard in the context of long term health impacts, and as such are not included in the EPA HHRAP COPC database; these are cobalt, copper, manganese and vanadium.

Table E3.1 Metal Emission Rates Used in the IRAP Model

Pollutant	Emission Concentration (b) (mg Sm^{-3})	Emission Rate (g s^{-1})
Antimony	0.0033	0.000094
Arsenic	0.00070	0.000020
Cadmium	0.00077 (c)	0.000022
Chromium III (a)	0.011	0.00031
Chromium VI (a)	0.000076	0.0000022
Lead	0.016	0.00045
Mercury	0.011 (c)	0.00032
Nickel)	0.022	0.00062
Thallium	0.00046 (c)	0.000013

(a) Chromium is assumed to be 99.3% trivalent chromium and 0.7% hexavalent chromium

(b) As discussed in Section D.3.3 of the air quality assessment, emissions of metals are based on guidance provided by the Environment Agency for Group 3 metals

(c) For cadmium, thallium and mercury, emissions are derived from alternative sources (refer to Section D.3.3 of the air quality assessment)

In accordance with the methodology it is important that loss of mercury to the global cycle is accounted for. For this purpose, the IRAP default values have been used and it is assumed that of the total mercury emitted, 51.8% is lost to the global cycle, 48.0% is deposited as divalent mercury and 0.2% is emitted as elemental mercury. The model assumes that human exposure to elemental mercury occurs only through direct inhalation of the vapour phase elemental form. Human exposure to divalent mercury occurs through both indirect and direct inhalation pathways in the form of vapour and particle-bound mercuric chloride. Therefore, the following emission rates for mercury have been assumed:

- elemental mercury at 6.4×10^{-7} g s^{-1};
- mercuric chloride at 1.5×10^{-4} g s^{-1}.

E3.2.3 Polycyclic Aromatic Hydrocarbons (PAH)

As a worst-case it is assumed that emissions of PAH are as benzo(a)pyrene, one of the more toxic of the PAH. PAH emissions are assumed to be 8.8×10^{-5} mg Nm^{-3} (2.5×10^{-6} g s^{-1}).

E3.2.4 *Polychlorinated dibenzo-p- dioxins and polychlorinated dibenzo furans (PCDD/F)*

The general term dioxins denotes a family of compounds, with each compound composed of two benzene rings interconnected with two oxygen atoms. There are 75 individual dioxins, with each distinguished by the position of chlorine or other halogen atoms positioned on the benzene rings. Furans are similar in structure to dioxins, but have a carbon bond instead of one of the two oxygen atoms connecting the two benzene rings. There are 135 individual furan compounds. Each individual furan or dioxin compound is referred to as a congener and each has a different toxicity and physical properties with regard to its atmospheric behaviour. It is important, therefore, that the exposure methodology determines the fate and transport of PCDD/F on a congener specific basis. It does this by accounting for the varying volatility of the congeners and their different toxicities. Consequently, information regarding the PCDD/F annual mean ground level concentrations on a congener specific basis is required. For the purposes of the exposure assessment, the congener profile for the proposed RERF is presented in *Table E3.2*, which is a standard profile for municipal waste incinerators derived by Her Majesty's Inspectorate of Pollution (HMIP), one of the predecessors of the Environment Agency. The international toxic equivalency factors are given and used to derive the toxic equivalent emission (I-TEQ). As a worst-case, it is assumed that PCDD/F emissions are at the maximum WID limit of 0.1 ng I-TEQ Nm^{-3}. The emission rates for each substance as input to the IRAP model are provided in *Table E3.3.*

Table E3.2 ***PCDD/F Congener Profile for the Proposed RERF [(a)]***

Congener	Annual Mean Emission Concentration (ng Sm^{-3})	I-TEF (toxic equivalent factors)	Annual Mean Emission (ng I-TEQ Sm^{-3})
2,3,7,8-TCDD	0.0031	1.0	0.0031
1,2,3,7,8-PeCDD	0.025	0.5	0.012
1,2,3,4,7,8-HxCDD	0.029	0.1	0.0029
1,2,3,7,8,9-HxCDD	0.021	0.1	0.0021
1,2,3,6,7,8-HxCDD	0.026	0.1	0.0026
1,2,3,4,6,7,8-HpCDD	0.17	0.01	0.0017
OCDD	0.40	0.001	0.00040
2,3,7,8-TCDF	0.028	0.1	0.0028
2,3,4,7,8-PeCDF	0.054	0.5	0.027
1,2,3,7,8-PeCDF	0.028	0.05	0.0014
1,2,3,4,7,8-HxCDF	0.22	0.1	0.022
1,2,3,7,8,9-HxCDF	0.0040	0.1	0.00040
1,2,3,6,7,8-HxCDF	0.081	0.1	0.0081
2,3,4,6,7,8-HxCDF	0.087	0.1	0.0087
1,2,3,4,6,7,8-HpCDF	0.44	0.01	0.0044
1,2,3,4,7,8,9-HpCDF	0.040	0.01	0.00040
OCDF	0.40	0.001	0.00040
Total (ng I-TEQ m^{-3})			**0.1**

(a) Congener profile from *Table 7.2a* DOE (1996) Risk Assessment of Dioxin Releases from Municipal Waste Incineration Processes Contract No. HMIP/CPR2/41/1/181

Table E3.3 PCDD/F Emission Rates Used in the IRAP Model

Congener	Emission Rate ($g\ s^{-1}$)
2,3,7,8-TCDD	8.8×10^{-11}
1,2,3,7,8-PeCDD	7.0×10^{-10}
1,2,3,4,7,8-HxCDD	8.2×10^{-10}
1,2,3,7,8,9-HxCDD	6.0×10^{-10}
1,2,3,6,7,8-HxCDD	7.4×10^{-10}
1,2,3,4,6,7,8-HpCDD	4.8×10^{-9}
OCDD	1.1×10^{-8}
2,3,7,8-TCDF	8.0×10^{-10}
2,3,4,7,8-PeCDF	1.5×10^{-9}
1,2,3,7,8-PeCDF	8.0×10^{-10}
1,2,3,4,7,8-HxCDF	6.2×10^{-9}
1,2,3,7,8,9-HxCDF	1.1×10^{-10}
1,2,3,6,7,8-HxCDF	2.3×10^{-9}
2,3,4,6,7,8-HxCDF	2.5×10^{-9}
1,2,3,4,6,7,8-HpCDF	1.3×10^{-8}
1,2,3,4,7,8,9-HpCDF	1.1×10^{-9}
OCDF	1.1×10^{-8}

E3.3 DISPERSION MODELLING ASSUMPTIONS

The air quality assessment has relied upon the use of ADMS to estimate ground level concentrations of pollutants. The IRAP model, however, has been designed to accept only output files from the US EPA ISC or AERMOD dispersion models, reflecting its North American origins and its need to follow the US EPA risk assessment protocol. To maintain consistency with the air quality assessment it has been possible to use output from the ADMS model with IRAP using the following procedure;

- generation of ISC input files and output files for the study area;
- generation of ADMS output data using the approach outlined in the US EPA risk assessment protocol;
- inserting the ADMS results into the ISC output files.

Therefore, the HHRA has been carried out using the ADMS dispersion modelling results. For the modelling, all emission properties, building heights, and other relevant factors were retained from the air quality assessment described in the *Annex D*. As the health risk assessment requires information on the deposition of substances to surfaces as well as airborne concentrations of substances, the ADMS dispersion model has also been used to predict the following:

- the airborne concentration of vapour, particle and particle bound substances emitted;
- the wet deposition rate of vapour, particle and particle bound substances; and
- the dry deposition rate of vapour, particle and particle bound substances.

For dry deposition of particles and particle bound contaminants a fixed deposition velocity of 0.01 m s^{-1} has been used. The proposed RERF will be equipped with fabric filters and the emitted particles are likely to be predominantly in the size range 1 -2 µm in diameter. For particles of this size, deposition velocities are likely to be of the order of 0.001 to 0.01 m s^{-1}. Therefore, as a worst-case, for the ADMS modelling a value of 0.01 m s^{-1} has been adopted.

E3.4 DISPERSION MODELLING RESULTS

A summary of the key results from the ADMS dispersion model is presented in *Table E3.4*. These have been predicted using the 2008 Leeds meteorological data set as this year provided the highest predicted annual mean concentration.

Table E3.4 Maximum Annual Average Particle Phase Concentrations and Particle Phase Deposition Rates Estimated by ADMS for Leeds 2008

Pollutant	**ADMS**	
	Max Annual Average Concentration (a)	**Max Annual Average Deposition Rate (b)**
Metals	**(ng m^{-3})**	**(mg m^{-2} $year^{-1}$)**
Antimony	0.039	0.050
Arsenic	0.0083	0.011
Cadmium	0.0091	0.012
Chromium III	0.13	0.17
Chromium VI	0.00091	0.0012
Lead	0.19	0.24
Nickel	0.26	0.33
Thallium	0.0055	0.0070
Elemental mercury	0.00027	0.00034
Mercuric chloride	0.065	0.082
PAH		
Benzo(a)pyrene	0.0010	0.0013
PCDD/F	**(fg m^{-3})**	**(ng m^{-2} $year^{-1}$)**
2,3,7,8-TCDD	0.037	0.047
1,2,3,7,8-PeCDD	0.29	0.37
1,2,3,4,7,8-HxCDD	0.34	0.44
1,2,3,7,8,9-HxCDD	0.25	0.32
1,2,3,6,7,8-HxCDD	0.31	0.39
1,2,3,4,6,7,8-HpCDD	2.0	2.6
OCDD	4.8	6.1
2,3,7,8-TCDF	0.33	0.42
2,3,4,7,8-PeCDF	0.64	0.81
1,2,3,7,8-PeCDF	0.33	0.42
1,2,3,4,7,8-HxCDF	2.6	3.3
1,2,3,7,8,9-HxCDF	0.048	0.061
1,2,3,6,7,8-HxCDF	0.96	1.2
2,3,4,6,7,8-HxCDF	1.0	1.3
1,2,3,4,6,7,8-HpCDF	5.2	6.7
1,2,3,4,7,8,9-HpCDF	0.48	0.61
OCDF	4.8	6.1

(a) Where 1 ng m^{-3} is equal to 1 x 10^{-9} g m^{-3} and 1 fg m^{-3} is equal to 1 x 10^{-15} g m^{-3}

(b) Where 1 mg m^{-2} $year^{-1}$ is equal to 1 x 10^{-3} g m^{-2} $year^{-1}$ and 1 ng m^{-2} $year^{-1}$ is equal to 1 x 10^{-9} g m^{-2} $year^{-1}$

E4 INPUT PARAMETERS FOR THE IRAP MODEL

E4.1 INTRODUCTION

Exposure of an individual to a chemical may occur either by inhalation or ingestion (including food, water and soil). Of interest is the total dose of the chemical received by the individual through the combination of possible routes, and the IRAP model has been developed to estimate the dose received by the human body, often referred to as the external dose.

Exposure to COPC is a function of the estimated concentration of the substance in the environmental media with which individuals may come into contact (ie exposure point concentrations) and the duration of contact. The concentration at the point of contact is itself a function of the transfer through air, soil, water, plants and animals that form part of the overall pathway. Exposure equations have been developed which combine exposure factors (e.g. exposure duration, frequency and medium intake rate) and exposure point concentrations. The dose equations therefore facilitate estimation of the received dose and account for the properties of the route of exposure, i.e. ingestion and inhalation.

For those substances that bio-accumulate, ie become more concentrated higher up the food chain, especially in body fats, the exposure to meats and milk is of particular significance.

The IRAP model user has the facility to adjust some of the key exposure factors. An example is the diet of the receptor and the proportion of which is local produce, which may be contaminated. Obviously, if a nearby resident eats no food grown locally, then that person's diet cannot be contaminated by the emissions from the source, in this case the proposed RERF. It is conventional to investigate two types of receptor, a Farmer and a Resident. It is assumed that a Farmer eats proportionately more locally grown food than a Resident. Where the potential exists for the consumption of locally caught fish a Fisher receptor may also be considered. However, as discussed in *Section E2.3*, consumption rates for locally caught fish are likely to be very small and the ingestion of fish has been excluded from the assessment.

The receptor types can also be divided into adults and children. Children are important receptors because they tend to ingest soil and dusts directly and have lower body weights, so that the effect of the same dose is greater in the child than in the adult.

The IRAP model is designed to accept output files of airborne concentrations and deposition rates. From these, it proceeds to calculate the concentrations of the pollutants of concern in the environmental media, foodstuffs and the human receptor. In order to do this, the model requires a wide range of input parameters to be defined; these include:

- physical and chemical properties of the COPC;
- site information, including site specific data; and
- receptor information – for each receptor type (eg adult or child, Resident or Farmer or Fisher).

The HHRAP default values, which are incorporated into the IRAP model, have been used for the majority of these input values. These data are provided in the following sections.

E4.2 INPUT PARAMETERS FOR THE COPC

The IRAP model contains a database of physical and chemical parameters for each of 206 COPC. This database is based on default values provided by the HHRAP and all default values have been used for this assessment.

These parameters are used to determine how each of the COPC behaves in the environment and their presence and accumulation in various food products (meat, fish, animal products, vegetation, soil and water). For cadmium and 2,3,7,8-TCDD (the most toxic of the PCDD/F), the default parameters are provided in *Table E4.1.*

Table E4.1 IRAP Input Parameters for Cadmium and 2, 3, 7, 8-TCDD

Parameter Description	Symbol	Units	Cadmium	2,3,7,8-TCDD
Chemical abstract service number	CAS No.	-	7440-43-9	1746-01-6
Molecular weight	MW	g $mole^{-1}$	112.4	322.0
Melting point of chemical	T_m	K	593.2	578.7
Vapour pressure	V_p	atm	5.5×10^{-12}	1.97×10^{-12}
Aqueous solubility	S	mg L^{-1}	123000	1.93×10^{-5}
Henry's Law constant	H	atm-m^3 mol^{-1}	0.031	3.29×10^{-5}
Diffusivity of COPC in air	D_a	cm^2 s^{-1}	0.0772	0.104
Diffusivity of COPC in water	Dw	cm^2 s^{-1}	9.6×10^{-6}	5.6×10^{-6}
Octanol-water partition coefficient	K_ow	-	0.85	6,309,573
Organic carbon-water partition coefficient	K_oc	mL g^{-1}	0	3,890,451
Soil-water partition coefficient	Kd_s	mL g^{-1}	75	38,904
Suspended sediments/surface water partition coefficient	Kd_sw	L kg^{-1}	75	291,784
Bed sediment/sediment pore water partition coefficient	Kd_bs	mL g^{-1}	75	155,618
COPC loss constant due to biotic and abiotic degradation	K_sg	a^{-1}	0	0.03
Fraction of COPC air concentration in vapour phase	f_v		0.009	0.664
Root concentration factor	RCF	mL g^{-1}	0	39,999
Plant-soil bioconcentration factor for below ground produce	br_root_veg	-	0.064	1.03
Plant-soil bioconcentration factor for leafy vegetables	br_leafy_veg	-	0.125	0.00455
Plant-soil bioconcentration factor for forage	br_forage	-	0.364	0.00455
COPC air-to-plant biotransfer factor for leafy vegetables	bv_leafy_veg	-	0	65,500
COPC air-to-plant biotransfer factor for forage	bv_forage	-	0	65,500
COPC biotransfer factor for milk	ba_milk	day kg^{-1}	6.5×10^{-6}	0.0055
COPC biotransfer factor for beef	ba_beef	day kg^{-1}	1.2×10^{-4}	0.026
COPC biotransfer factor for pork	ba_pork	day kg^{-1}	1.9×10^{-4}	0.032
Bioconcentration factor for COPC in eggs	Bcf_egg	-	0.0025	0.060
Bioconcentration factor for COPC in chicken	Bcf_chicken	-	0	3.32
Fish bioconcentration factor	BCF_fish	L kg^{-1}	907	34,400
Fish bioaccumulation factor	BAF_fish	L kg^{-1}	0	0
Biota-sediment accumulation factor	BSAF_fish	-	0	0.09
Plant-soil bioconcentration factor for grain	br_grain	-	0.062	0.00455
Plant-soil bioconcentration factor for eggs	br_egg	-	0.0025	0.011
COPC biotransfer factor for chicken	ba_chicken	day kg^{-1}	0.11	0.019

Toxicity factors (eg reference doses, unit risk factors) are provided in *Table E4.2* for all of the COPC. These are used to determine the carcinogenic risk or hazard associated with exposure to each COPC via inhalation or ingestion exposure pathways.

Table E4.2 *Toxicity Factors for the COPC Considered for the Assessment*

COPC	Ingestion Reference Dose	Inhalation Reference Concentration	Ingestion Carcinogenic Slope Factor [b]	Inhalation Unit Risk Factor [b]
Symbol	**RfD**	**RfC**	**Ing_csf**	**Inh_URF**
Units	**(mg kg^{-1} d^{-1})**	**(mg m^{-3})**	**(mg kg^{-1} d^{-1})$^{-1}$**	**(µg m^{-3})$^{-1}$**
Metals				
Antimony	0.0004	0.0014	0	0
Arsenic	0.0003	3.0×10^{-5}	1.5	0.0043
Cadmium	0.0004	0.0002	0.38	0.0018
Chromium III	1.5	5.3	0	0
Chromium VI	0.0030	8.0×10^{-6}	0	0.012
Lead	0.000429	0.0015	0.0085	1.2×10^{-5}
Nickel	0.02	0.0002	0	0.00024
Thallium [a]	0.00008	0.00028	0	0
Elemental mercury	8.57×10^{-5}	0.0003	0	0
Mercuric chloride	0.0003	0.0011	0	0
Methyl mercury	0.0001	0.00035	0	0
PAH				
Benzo(a)pyrene	0	0	7.3	0.0011
PCDD/F				
2,3,7,8-TCDD	1×10^{-9}	0	150000	38
1,2,3,7,8-PeCDD	0	0	150000	38
1,2,3,4,7,8-HxCDD	0	0	15000	3.8
1,2,3,7,8,9-HxCDD	0	0	6200	3.8
1,2,3,6,7,8-HxCDD	0	0	6200	3.8
1,2,3,4,6,7,8-HpCDD	0	0	1500	0.38
OCDD	0	0	15	0.011
2,3,7,8-TCDF	0	0	15000	3.8
2,3,4,7,8-PeCDF	0	0	75000	11.4
1,2,3,7,8-PeCDF	0	0	7500	1.14
1,2,3,4,7,8-HxCDF	0	0	15000	3.8
1,2,3,7,8,9-HxCDF	0	0	15000	3.8
1,2,3,6,7,8-HxCDF	0	0	15000	3.8
2,3,4,6,7,8-HxCDF	0	0	15000	3.8
1,2,3,4,6,7,8-HpCDF	0	0	1500	0.38
1,2,3,4,7,8,9-HpCDF	0	0	1500	0.38
OCDF	0	0	15	0.011

(a) Reference data for thallium have been taken from the 1998 US EPA HHRA protocol

(b) For PCDD/Fs, values derived as advised by Lakes Environmental

The Reference Dose (ingestion) and Reference Concentration (inhalation) for each COPC is used to determine the non-carcinogenic risk associated with exposure. The Carcinogenic Slope Factors (ingestion) are used to determine the carcinogenic risk from ingestion. The Unit Risk Factors are used to determine the carcinogenic risk from inhalation. The methodology used for calculating total non-carcinogenic and carcinogenic risk is provided in *Section E5.2*.

E4.3 SITE AND SITE SPECIFIC PARAMETERS

The IRAP health risk assessment model requires information relating to the industrial location and its surroundings. The parameters required include the following.

- The fraction of animal feed (grain, silage and forage) grown on contaminated soils and quantity of animal feed and soil consumed by the various animal species considered.

- The interception fraction for above ground vegetation, forage and silage and length of vegetation exposure to deposition. The yield/standing crop biomass is also required.

- Input data for assessing the risks associated with exposure to breast milk, including:

    - body weight of infant;
    - exposure duration;
    - proportion of ingested COPC stored in fat;
    - proportion of mother's weight that is fat;
    - fraction of fat in breast milk;
    - fraction of ingested contaminant that is absorbed; and
    - half-life of dioxins in adults and ingestion rate of breast milk.

- Other physical parameters (e.g. soil dry bulk density, density of air, soil mixing zone depth).

For all of these parameters the IRAP/EPA HHRAP default values have been used and these are presented in *Appendix E.1*. Other site specific parameters are also required which are not provided by the IRAP model. These parameters were specified for the proposed RERF location as follows:

- annual average evapotranspiration rate of 82.6 cm a^{-1} (assumed to be 70% of total precipitation);

- annual average precipitation of 118 cm a^{-1} (based on 2008 meteorological data);

- annual average irrigation of 0 cm a^{-1};

- annual average runoff of 11.8 cm a^{-1} (assumed to be 10% of total precipitation);

- an annual average wind velocity of 5.0 m s^{-1} (based on 2008 meteorological data); and

- a time period over which deposition occurs of 30 years.

E4.4 RECEPTOR INFORMATION

Within the IRAP model there are three receptor types; Resident, Farmer and Fisher. Information relating to each receptor type (adult and/or child) is required by the model where these receptor types are used. The information required includes the following:

- Food (meat, dairy products, fish and vegetables), water and soil consumption rates for each receptor type. However, only Fishers are assumed to consume fish and only Farmers are assumed to consume locally reared animals and animal products.

- Fraction of contaminated food, water and soil which is consumed by each receptor type.

- Input data for the inhalation exposure including: inhalation exposure duration, inhalation exposure frequency, inhalation exposure time; and inhalation rate.

- Input data for the ingestion exposure including: exposure duration, exposure frequency, exposure time; and body weight of receptor.

For the purposes of this assessment the default IRAP/HHRAP parameters have been used to define the characteristics of the receptors. The input data used are presented in *Appendix E.2*.

E5 EXPOSURE ASSESSMENT

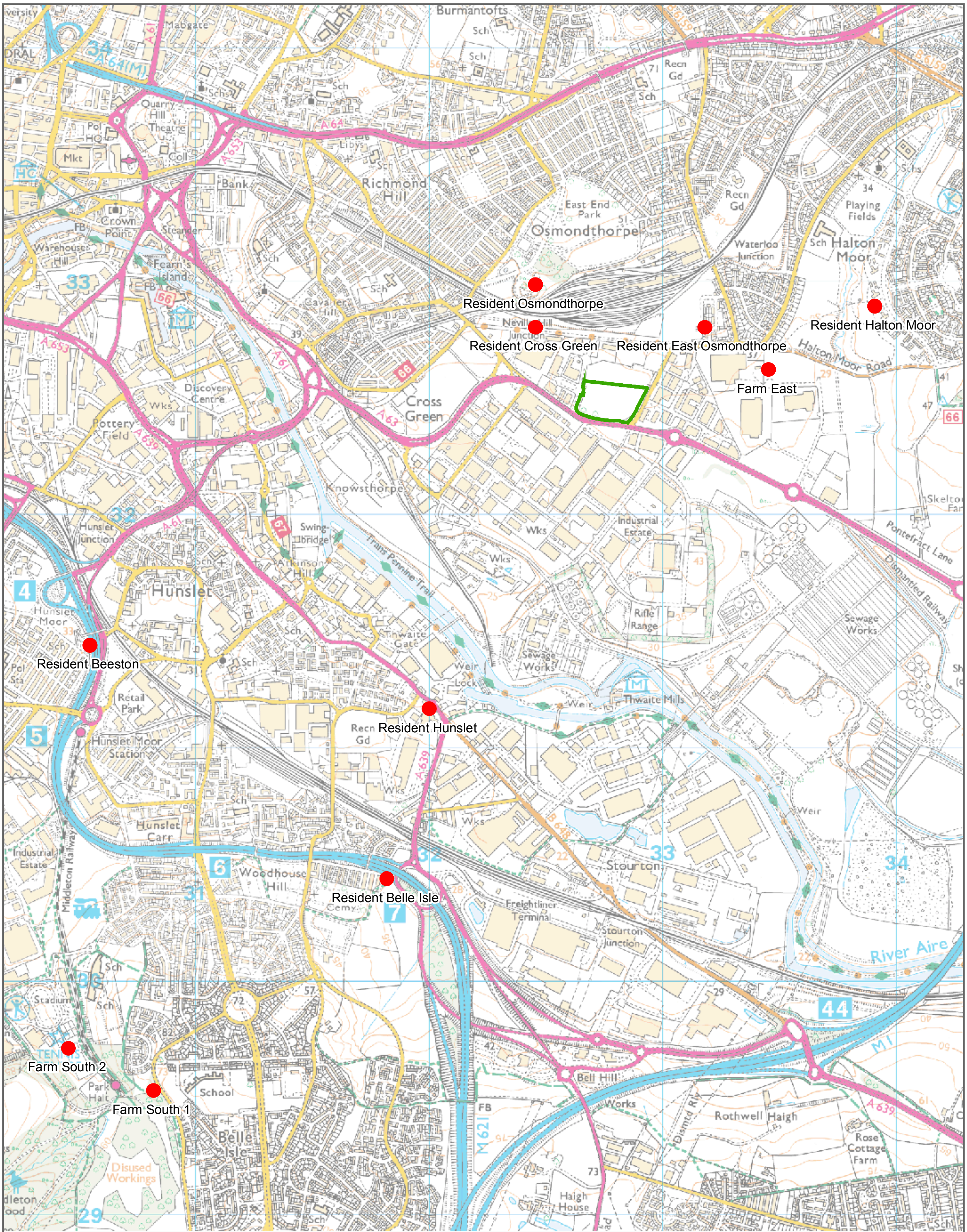
E5.1 SELECTION OF RECEPTORS

In addition to defining specific locations for assessment, IRAP can be used to determine the location of maximum impact over an area based on the results of the dispersion model. For each defined land-use area, IRAP selects the locations which represent the maximum predicted concentrations or deposition rates for the area selected. The locations of these various maxima are often co-located resulting in the selection of one to three receptor locations per defined area. This approach is adopted by IRAP since the maximum receptor impact may occur at any one of the maximum concentration or deposition locations identified.

For the RERF, residential exposure within the immediate vicinity of the Facility is limited. The immediate locality is mixed industrial and commercial. The nearest residential areas are to the north (East Osmondthorpe) and Cross Green to the west. The area to the north is densely populated and includes Osmonthorpe and Halton Moor. To the south there are also small residential areas (e.g. Hunslet). The area to the east, beyond the Knostrop Sewage Treatment Works (STW), is predominantly rural. Therefore, seven areas where residential exposure may occur have been defined based on residential areas around the proposed RERF site. These include: Beeston, Belle Isle, Cross Green, Halton Moor, Hunslet, Osmonthorpe and East Osmondthorpe. These are the nearest residential settlements. The defined Cross Green residential area includes the allotments that are located between the site and Cross Green. As Resident receptors are assumed to consume locally grown vegetables, the inclusion of the allotments within the residential area enables the assessment to consider the consumption of vegetables grown at this specific location even if the location is not occupied for residential use.

The area surrounding the RERF is not generally characterised by farming. There are rural areas to the east but this partly comprises a golf course and woodlands. Therefore, farming activities are limited. Two areas where the potential for farming exists have been defined. This includes an area to the east of the RERF site that includes rural areas and green space up to the industrial area, including to the north and south of the Knostrop STW and rural areas to the north and west of Rothwell. A second area to the south west has also been defined which includes the rural areas around Middleton Park.

For each type of receptor up to three locations are selected based on the maximum predicted airborne concentration, maximum predicted wet deposition rate and maximum dry deposition rate. However, often these maxima are co-located and, therefore, each receptor type will have between one and three identified receptors per defined area. For the assessment, seven Residential receptors and three Farmer receptors have been assessed. It is considered that the likelihood of local caught fish being consumed is low and fisher receptors have not been included in the assessment. For all of the receptor types, adult and child receptors have been considered. The locations of the Resident and Farmer receptors are presented in *Figure E5.1*. For each identified area there is a single receptor except for Farmer South where two receptors are defined based on maximum predicted airborne concentrations and wet and dry deposition rates. At other locations not specifically considered in the assessment, the predicted hazards and risks will be lower than predicted for the discrete receptors considered.



Application Boundary

Receptor Locations

0 100 200 300 400 500
Metres

N

Figure E5.1
Location of the Resident and Farmer Receptors
Proposed Leeds RERF

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0139262
DATE: 24/05/2012

VERSION: A01
DRAWN: MTC
CHECKED: IG
APPROVED:

ERM

CLIENT:
Veolia ES Leeds

VEOLIA ENVIRONMENTAL SERVICES

PROJECTION: British National Grid

Path: T:\GIS Project\0139262VeoliaLeedsGIS_MTC_NC\MAPS\0139262_ReceptorLocations_A01.mxd

E5.2 ASSESSMENT OF NON-CARCINOGENIC AND CARCINOGENIC RISK

E5.2.1 Non-carcinogenic Risk

The non-carcinogenic effect of the emissions on human health can be assessed in terms of the *Hazard Quotient* (HQ). For ingestion, the HQ is calculated as the Average Daily Dose (ADD) divided by the reference dose (RfD). For example, the HQ for ingestion exposure for cadmium (Cd) is calculated as follows:

$$HQ_{Ing,\,Cd} = \frac{ADD_{Ing,\,Cd}}{RfD_{Ing,\,Cd}}$$

Where:

$$ADD_{Ing,\,Cd} = \frac{I_{Ing,\,Cd} \bullet ED \bullet EF}{AT \bullet 365}$$

Where: $ADD_{Ing,\,Cd}$ = ingestion dose for cadmium; ED is the exposure duration (dependent on the receptor type); EF is the exposure frequency (350 days per year); and AT is the averaging time (equal to ED for non-carcinogenic effects and 70 years for carcinogenic risks).

For inhalation, the HQ is calculated as the exposure concentration divided by the reference concentration (RfC). For example, the HQ for inhalation exposure for cadmium (Cd) is calculated as follows:

$$HQ_{Inh,\,Cd} = \frac{EC_{Cd} * 0.001}{RfC_{Inh,\,Cd}}$$

Where:

$$EC_{Cd} = \frac{C_a \bullet ED \bullet EF}{AT \bullet 365}$$

Where: EC_{Cd} is the exposure concentration (µg m^{-3}), $RfC_{Inh,\,Cd}$ is the reference concentration for cadmium (mg m^{-3}) and C_a is the concentration of cadmium in air.

The Reference Dose and Reference Concentration for each COPC and exposure pathway is provided in *Section E4.2*. The RfD and RfC are set conservatively; they are protective of health and doses at, or greater than, the RfD or RfC indicate the *potential* for effect, rather than clear and certain indication of an effect. For example, should the maximum daily intake for the new source, in this case the proposed RERF, be equal to the RfD, then the HQ would be equal to 1.0 and this would indicate the *potential* for a health effect.

On the other hand a hazard quotient of less than unity (1.0) implies that such an exposure would not create an adverse non-carcinogenic health effect.

The *Hazard Index* (HI) is the sum of the individual COPC/pathway HQ and assumes that there are no synergistic or antagonist health effects arising from the release. The smaller the HI, the less risk to human health is implied.

E5.2.2 Carcinogenic Risk

The risk of interest in this context is the extra lifetime risk associated with the total dose resulting from exposure to the proposed RERF emissions. For each COPC, the US EPA has calculated a carcinogenic slope factor (CSF). These are calculated for ingestion exposure whereas for inhalation exposure, a unit risk factor (URF) has been adopted. A summary of the factors used for this assessment is provided in *Section E4.2*. Where the CSF or URF is zero, this indicates that the COPC is non-carcinogenic via that exposure route. The IRAP model uses these values to calculate a cancer risk for each pollutant and for each pathway for exposure, so that the results can be expressed in a high degree of detail.

The risk associated with the ingestion exposure (food, water and soil) of cadmium is calculated as follows:

$$Risk_{Ing,\,Cd} = ADD_{Ing,\,Cd} \bullet CSF_{Ing,\,Cd}$$

Where $ADD_{Ing,\,Cd}$ is the sum of the average daily dose from all ingestion exposure routes.

The risk associated with the inhalation of cadmium is calculated as follows:

$$Risk_{Inh,\,Cd} = EC_{Cd} \bullet URF_{Inh,\,Cd}$$

E6.1 SUMMARY OF NON-CARCINOGENIC EFFECTS

The Hazard Index (HI) calculated by IRAP for emissions from the RERF for each of the receptors (adult and child) is presented in *Table E6.1*. (Highest values for Farmer and Resident are picked out in bold type).

Table E6.1 Hazard Index for Resident and Farmer Receptors

Receptor Name	Receptor Type	Hazard Index (HI)
Farmer East	Adult Farmer	0.0079
Farmer East	Child Farmer	**0.011**
Farmer South 1	Adult Farmer	0.00026
Farmer South 1	Child Farmer	0.00038
Farmer South 2	Adult Farmer	0.00025
Farmer South 2	Child Farmer	0.00037
Resident Beeston	Adult Resident	0.00012
Resident Beeston	Child Resident	0.00018
Resident Belle Isle	Adult Resident	0.00014
Resident Belle Isle	Child Resident	0.00022
Resident Cross Green	Adult Resident	0.00071
Resident Cross Green	Child Resident	0.0012
Resident Halton Moor	Adult Resident	0.0010
Resident Halton Moor	Child Resident	0.0016
Resident Hunslet	Adult Resident	0.00022
Resident Hunslet	Child Resident	0.00036
Resident Osmonthorpe	Adult Resident	0.00063
Resident Osmonthorpe	Child Resident	0.0010
Resident East Osmondthorpe	Adult Resident	0.0022
Resident East Osmondthorpe	Child Resident	**0.0036**
Criterion		*1.0*

The HI are significantly below unity (1.0) and so it is highly unlikely that emissions of COPC from the RERF would cause an adverse non-carcinogenic health risk. The highest HI is predicted for the Farmer East Child and is a factor of around 9 less than unity. For Resident receptors the highest predicted HI is for the Resident East Osmondthorpe Child and is a factor of 275 less than unity.

Predicted HI for Farmers are higher than for Resident receptors, because of the consumption of animal products.

For the farmer and resident with the highest HI (Farmer East Child and Resident East Osmondthorpe Child), a more detailed analysis (e.g. breakdown of the risk by COPC and exposure pathway) is provided in *Sections E6.2* and *E6.3*. This provides an indication of the most significant pathway for exposure and the most significant COPC that contributes to the total exposure.

E6.2 NON-CARCINOGENIC EFFECTS BY COPC

The Exposure Concentrations (EC), Average Daily Doses (ADD) and HQ for each COPC for the Farmer East Child and Resident East Osmondthorpe Child are presented in *Table E6.2* and *Table E6.3* respectively.

Table E6.2 Summary of EC, ADD and HQ for Each COPC for the Farmer East Child

COPC	EC ($\mu g\ m^{-3}$) Inhalation	ADD ($mg\ kg^{-1} day^{-1}$) Ingestion	Hazard Quotient (HQ) Inhalation	Hazard Quotient (HQ) Ingestion
Antimony	3.0×10^{-5}	1.1×10^{-11}	2.1×10^{-5}	2.6×10^{-8}
Arsenic	6.2×10^{-6}	3.2×10^{-8}	2.0×10^{-4}	1.0×10^{-4}
Cadmium	6.8×10^{-6}	2.7×10^{-8}	3.3×10^{-5}	6.5×10^{-5}
Chromium III	9.7×10^{-5}	2.5×10^{-6}	1.7×10^{-8}	1.6×10^{-6}
Chromium VI	6.8×10^{-7}	1.8×10^{-8}	8.1×10^{-5}	5.6×10^{-5}
Lead	1.4×10^{-4}	9.9×10^{-7}	9.0×10^{-5}	2.2×10^{-3}
Mercuric chloride	7.2×10^{-6}	4.6×10^{-7}	6.3×10^{-6}	1.5×10^{-3}
Methyl mercury	-	2.1×10^{-8}	-	2.0×10^{-4}
Nickel	2.0×10^{-4}	3.5×10^{-6}	**9.4×10^{-4}**	1.7×10^{-4}
Thallium	4.1×10^{-6}	1.9×10^{-7}	1.4×10^{-5}	2.3×10^{-3}
2,3,7,8-TCDD	-	3.5×10^{-12}	-	**3.3×10^{-3}**
Total HQ for Exposure Route			*0.0014*	*0.0098*
Hazard Index (HI)			*0.011*	

Table E6.3 Summary of EC, ADD and HQ for Each COPC for the Resident East Osmondthorpe Child

COPC	EC ($\mu g\ m^{-3}$) Inhalation	ADD ($mg\ kg^{-1} day^{-1}$) Ingestion	Hazard Quotient (HQ) Inhalation	Hazard Quotient (HQ) Ingestion
Antimony	3.1×10^{-5}	1.0×10^{-11}	2.1×10^{-5}	2.5×10^{-8}
Arsenic	6.4×10^{-6}	1.7×10^{-8}	2.0×10^{-4}	5.6×10^{-5}
Cadmium	6.9×10^{-6}	1.9×10^{-8}	3.3×10^{-5}	4.6×10^{-5}
Chromium III	9.9×10^{-5}	3.6×10^{-7}	1.8×10^{-8}	2.3×10^{-7}
Chromium VI	6.9×10^{-7}	2.6×10^{-9}	8.3×10^{-5}	8.3×10^{-7}
Lead	1.4×10^{-4}	3.9×10^{-7}	9.2×10^{-5}	**8.8×10^{-4}**
Mercuric chloride	7.4×10^{-6}	1.9×10^{-7}	6.4×10^{-6}	6.2×10^{-4}
Methyl mercury	-	1.1×10^{-8}	-	1.1×10^{-4}
Nickel	2.0×10^{-4}	5.5×10^{-7}	**9.6×10^{-4}**	2.6×10^{-5}
Thallium	4.2×10^{-6}	2.1×10^{-8}	1.4×10^{-5}	2.5×10^{-4}
2,3,7,8-TCDD	-	1.8×10^{-13}	-	1.7×10^{-4}
Total HQ for Exposure Route			*0.0014*	*0.0022*
Hazard Index (HI)			*0.0036*	

For the Farmer and Resident, the highest inhalation HQ were predicted for arsenic; the highest ingestion HQ was predicted for 2,3,7,8-TCDD for the Farmer, and lead for the Resident.

E6.3 NON-CARCINOGENIC EFFECTS BY PATHWAY

The ADD and HQ for each exposure pathway for the Farmer East Child and Resident East Osmondthorpe Child are presented in *Table E6.4.*

Table E6.4 Summary of HQ for Each Exposure Pathway for the Farmer East Child and Resident East Osmondthorpe Child

Pathway	**HQ for Farmer East Child**	**HQ for Resident East Osmondthorpe Child**
Inhalation	0.0014	0.0014
Ingestion of above ground vegetation	0.0024	0.0018
Ingestion of beef	0.0011	0
Ingestion of chicken	0.0000034	0
Ingestion of drinking water	0	0
Ingestion of eggs	0.0000036	0
Ingestion of fish	0	0
Ingestion of milk	0.0061	0
Ingestion of pork	0.000035	0
Ingestion of soil	0.00028	0.00031
Hazard Index (HI)	*0.011*	*0.0036*

The HI for the Farmer Adult is a factor of three higher than for the Resident Child. For the Farmer Child, highest exposures occur as a result of the ingestion of food produce, in particular beef, milk and above ground vegetables. For the Resident Child, highest exposures occur via the ingestion of above ground vegetation and inhalation.

E7 ASSESSMENT OF CARCINOGENIC EFFECTS USING IRAP

E7.1 SUMMARY OF CANCER RISKS

The total lifetime risk calculated by IRAP resulting from exposure to emissions from the RERF for each of the ten receptors (adult and child) is presented in *Table E7.1.*

Table E7.1 ***Total Lifetime Risk for Resident and Farmer Receptors***

Receptor Name	Receptor Type	Total Lifetime Risk
Farmer East	Adult Farmer	**7.1×10^{-6}**
Farmer East	Child Farmer	1.5×10^{-6}
Farmer South 1	Adult Farmer	2.4×10^{-7}
Farmer South 1	Child Farmer	5.2×10^{-8}
Farmer South 2	Adult Farmer	2.3×10^{-7}
Farmer South 2	Child Farmer	5.0×10^{-8}
Resident Beeston	Adult Resident	1.0×10^{-8}
Resident Beeston	Child Resident	5.1×10^{-9}
Resident Belle Isle	Adult Resident	1.3×10^{-8}
Resident Belle Isle	Child Resident	6.2×10^{-9}
Resident Cross Green	Adult Resident	6.7×10^{-8}
Resident Cross Green	Child Resident	3.4×10^{-8}
Resident Halton Moor	Adult Resident	9.1×10^{-8}
Resident Halton Moor	Child Resident	4.4×10^{-8}
Resident Hunslet	Adult Resident	2.0×10^{-8}
Resident Hunslet	Child Resident	9.9×10^{-9}
Resident Osmonthorpe	Adult Resident	5.9×10^{-8}
Resident Osmonthorpe	Child Resident	3.0×10^{-8}
Resident East Osmondthorpe	Adult Resident	**2.0×10^{-7}**
Resident East Osmondthorpe	Child Resident	9.8×10^{-8}
Criterion		*7×10^{-5}*

The highest carcinogenic risk is predicted for the Farmer East Adult and Resident East Osmondthorpe Adult. The additional, total, **lifetime** risks to these receptors are 7.1×10^{-6} (1 in 140,850) for the Farmer and 2.0×10^{-7} (1 in 5,000,000) for the Resident. Expressed as an **annual** risk of exposure to emissions from the RERF, these risk estimates become 1 in 9,859,500 for the Farmer East Adult and 1 in 350,000,000 (1) for the Resident East Osmondthorpe Adult, assuming a lifetime of 70 years. Such risks are well within an annual risk of 1×10^{-6} (1 in 1 million), conventionally considered to be acceptable for industrial regulation in the UK (2).

A more detailed analysis (e.g. breakdown of the risk by COPC and exposure pathway) for the Farmer East Adult and Resident East Osmondthorpe Adult is provided in *Sections E7.2* and *E7.3*.

(1) For example, 2.0 x 10-7 as a lifetime risk over 70 years is equivalent to an annual risk equal to 2.0 x 10-7 divided by 70, equivalent to 2.86 x 10-9 or 1 in 350,000,00
(2) Risk Assessment for Environmental Professionals, CIWEM Publication (December 2001)

E7.2 CARCINOGENIC RISK BY COPC

The ADD and lifetime risks for each COPC for the Farmer East Adult and Resident East Osmondthorpe Adult are presented in *Table E7.2* and *Table E7.3* respectively.

Table E7.2 Summary of ADD and Lifetime Risk for Each COPC for the Farmer East Adult

COPC	**EC Inhalation ($\mu g\ m^{-3}$)**	**ADD Ingestion ($mg\ kg^{-1}\ day^{-1}$)**	**Lifetime Risk Inhalation**	**Lifetime Risk Ingestion**
Arsenic	6.2×10^{-6}	1.8×10^{-8}	1.5×10^{-8}	1.5×10^{-8}
Benzo(a)pyrene	7.9×10^{-7}	9.9×10^{-8}	4.8×10^{-10}	4.0×10^{-7}
Cadmium	6.8×10^{-6}	1.2×10^{-8}	6.7×10^{-9}	2.4×10^{-9}
Chromium VI	6.8×10^{-7}	-	4.5×10^{-9}	-
Lead	1.4×10^{-4}	5.1×10^{-7}	9.2×10^{-10}	2.4×10^{-9}
Nickel	2.0×10^{-4}	-	**2.6×10^{-8}**	-
Total PCDD/Fs	1.8×10^{-8}	8.1×10^{-10}	1.9×10^{-8}	**6.6×10^{-6}**
Total Lifetime Risk for Exposure Route			*0.072×10^{-6}*	*7.0×10^{-6}*
Total Lifetime Risk			*7.1×10^{-6}*	

Table E7.3 Summary of ADD and Lifetime Risk for Each COPC for the Resident East Osmondthorpe Adult

COPC	**EC Inhalation ($\mu g\ m^{-3}$)**	**ADD Ingestion ($mg\ kg^{-1}\ day^{-1}$)**	**Lifetime Risk Inhalation**	**Lifetime Risk Ingestion**
Arsenic	6.4×10^{-6}	7.3×10^{-8}	1.1×10^{-8}	4.5×10^{-9}
Benzo(a)pyrene	8.1×10^{-7}	1.0×10^{-9}	3.7×10^{-10}	3.1×10^{-9}
Cadmium	6.9×10^{-6}	7.9×10^{-9}	5.1×10^{-9}	1.2×10^{-9}
Chromium VI	6.9×10^{-7}	-	3.4×10^{-9}	-
Lead	1.4×10^{-4}	1.6×10^{-7}	7.1×10^{-10}	5.7×10^{-10}
Nickel	2.0×10^{-4}	-	**2.0×10^{-8}**	-
Total PCDD/Fs	1.9×10^{-8}	3.5×10^{-11}	1.4×10^{-8}	**1.3×10^{-7}**
Total Lifetime Risk for Exposure Route			*0.055* $\times 10^{-6}$	*0.14* $\times 10^{-6}$
Total Lifetime Risk			*0.20×10^{-6}*	

For both receptors, the highest risk via inhalation exposure is for nickel which represents 0.4% and 10% of the total exposure for the Farmer and Resident, respectively. For both receptors, the highest risk via ingestion exposure is for total PCDD/F and represents 93% and 65% of the total risk for the Farmer and Resident, respectively.

E7.3 CARCINOGENIC RISK BY PATHWAY

The lifetime risks for each exposure pathway for the Farmer East Adult and Resident East Osmondthorpe Adult are presented in *Table E7.4.*

Table E7.4 Summary of Lifetime Risk for Each Exposure Pathway for the Farmer East Adult and Resident East Osmondthorpe Adult

Pathway	**Lifetime Risk for Farmer East Adult**	**Lifetime Risk for Resident East Osmondthorpe Adult**
Inhalation	7.2×10^{-8}	5.5×10^{-8}
Ingestion of above ground vegetation	2.3×10^{-7}	1.3×10^{-7}
Ingestion of beef	1.5×10^{-6}	0
Ingestion of chicken	3.8×10^{-9}	0
Ingestion of drinking water	0	0
Ingestion of eggs	2.5×10^{-9}	0
Ingestion of fish	0	0
Ingestion of milk	5.1×10^{-6}	0
Ingestion of pork	1.3×10^{-7}	0
Ingestion of soil	1.9×10^{-8}	1.4×10^{-8}
Total Lifetime Risk	*7.1×10^{-6}*	*0.20×10^{-6}*

Residents are assumed only to be exposed via inhalation and the ingestion of above ground vegetation and soil. For the Farmer receptor, the highest risk is calculated for exposure via the ingestion of milk and represents 72%, of the total risk for the Farmer. For the Resident receptor, the highest risk is calculated for the ingestion of above ground vegetation and represents 65% of the total risk for this receptor.

E8 UK BASED APPROACH TO ASSESSING NON-CARCINOGENIC AND CARCINOGENIC IMPACTS

E8.1 INTRODUCTION

Using the results generated by the IRAP model, an alternative approach to assessing the impacts of the RERF on human health has been provided. This considers the following:

- An assessment of non-carcinogenic impacts with comparison of predicted impact from the RERF with background intakes and UK health criteria values (HCV).
- A comparison of predicted concentrations of metal and PCDD/F in soil with soil guideline values (SGV).
- A comparison of predicted concentrations of PCDD/F in eggs and milk compared to maximum levels set by the European Commission.
- Concentrations of PCDD/F in breast milk and a comparison of the daily intake for breast fed infants with TDI set by the WHO and UK COT.
- An assessment of carcinogenic risks using the Margin of Exposure (MoE) approach.

In addition to assessing the contribution of the RERF to non-carcinogenic and carcinogenic impacts, the exposure of the local population to potentially elevated background concentrations of chromium VI from local pollution sources is also considered.

E8.2 NON-CARCINOGENIC IMPACTS

E8.2.1 Introduction

For PCDD/F and trace metals a comparison of the incremental intake as a result of emissions from the RERF are provided as follows:

- predicted incremental intake due to emissions from the RERF;
- average daily background intake (i.e. that arising from other sources), referred to as the mean daily intake (MDI);
- the total intake (i.e. the sum of the predicted incremental intake and the MDI);
- a comparison of the total intake with the HCV for each substance.

For the four key receptors (i.e. those which represent the predicted highest exposure for the receptor types considered) the results are presented in *Appendix E.3*. Results are presented for both adult and child receptors. For each COPC, the HCV and the MDI used for this comparison are summarised in *Appendix E.3*. In deriving the MDI for the child receptors, a bodyweight of 15 kg has been used in order to be consistent with the IRAP predictions which assume a bodyweight of 15 kg. As a consequence the MDI are higher than they would be for a 20 kg child and also represent a worst case. It should be noted that for some substances the MDI already exceeds the HCV without the contribution of the RERF (e.g. cadmium and PCDD/F).

E8.2.2 Inhalation of Trace Metals

The results of the assessment for inhalation exposure to trace metals are provided in *Appendix E.3* and summarised in *Table E8.1* and *Table E8.2*. This provides the RERF contribution to inhalation intake and the total inhalation as a percentage of the relevant inhalation HCV.

Table E8.1 Summary of Non-carcinogenic Inhalation Exposure for the Farmer East Adult and Child

Substance	RERF Contribution as %age of the HCV		Total Intake as %age of the HCV	
	Child	Adult	Child	Adult
Antimony	0.03%	0.02%	34.9%	11.5%
Cadmium	0.23%	0.14%	62.1%	20.5%
Chromium III	0.15%	0.09%	39.2%	12.9%
Lead	0.02%	0.01%	20.2%	6.7%
Mercuric chloride	0.01%	0.00%	0.0%	0.0%
Nickel	1.56%	0.93%	44.9%	15.2%
Thallium	0.00%	0.00%	0.5%	0.2%
Elemental mercury	0.00%	0.00%	3.6%	1.2%

Table E8.2 Summary of Non-carcinogenic Inhalation Exposure for the Resident East Osmondthorpe Adult and Child

Substance	RERF Contribution as %age of the HCV		Total Intake as %age of the HCV	
	Child	Adult	Child	Adult
Antimony	0.03%	0.02%	34.9%	11.5%
Cadmium	0.24%	0.14%	62.1%	20.5%
Chromium III	0.16%	0.09%	39.2%	13.0%
Lead	0.02%	0.01%	20.2%	6.7%
Mercuric chloride	0.01%	0.00%	0.0%	0.0%
Nickel	1.60%	0.95%	44.9%	15.2%
Thallium	0.00%	0.00%	0.5%	0.2%
Elemental mercury	0.00%	0.00%	3.6%	1.2%

For inhalation exposure, the highest contribution from the RERF relative to the HCV was from nickel, for all four receptors. However, relative to the HCV the contribution from the RERF was relatively small (1.6% of the HCV at worst).

With the addition of background exposure total intakes were well below the HCV for nickel.

For inhalation exposure, the total intake (background + RERF contribution) are all well below the respective HCV for all receptors.

E8.2.3 Ingestion of Trace Metals

The results of the assessment for ingestion exposure to trace metals are provided in *Appendix E.3* and summarised in *Table E8.3* and *Table E8.4*. This provides the RERF contribution to ingestion intake and the total ingestion as a percentage of the relevant ingestion HCV.

Table E8.3 Summary of Non-carcinogenic Ingestion Exposure for the Farmer East Adult and Child

Substance	**RERF Contribution as %age of the HCV**		**Total Intake as %age of the HCV**	
	Child	**Adult**	**Child**	**Adult**
Antimony	0.00%	0.00%	27.1%	8.9%
Cadmium	0.01%	0.00%	161.3%	53.2%
Chromium III	0.00%	0.00%	1.7%	0.6%
Chromium VI	0.00%	0.00%	29.0%	9.6%
Lead	0.01%	0.01%	13.9%	4.6%
Mercuric chloride	0.15%	0.08%	14.6%	4.8%
Methyl mercury	0.02%	0.01%	21.7%	7.2%
Nickel	0.03%	0.02%	47.0%	15.5%
Thallium	0.24%	0.21%	45.7%	15.2%

Table E8.4 Summary of Non-carcinogenic Ingestion Exposure for the Resident East Osmondthorpe Adult and Child

Substance	**RERF Contribution as %age of the HCV**		**Total Intake as %age of the HCV**	
	Child	**Adult**	**Child**	**Adult**
Antimony	0.00%	0.00%	27.1%	8.9%
Cadmium	0.01%	0.00%	161.3%	53.2%
Chromium III	0.00%	0.00%	1.7%	0.6%
Chromium VI	0.00%	0.00%	29.0%	9.6%
Lead	0.00%	0.00%	13.9%	4.6%
Mercuric chloride	0.06%	0.02%	14.5%	4.8%
Methyl mercury	0.01%	0.00%	21.7%	7.1%
Nickel	0.00%	0.00%	46.9%	15.5%
Thallium	0.03%	0.01%	45.5%	15.0%

For oral exposure, the highest contribution from the RERF relative to the HCV is very small and is predicted for thallium (farmer) or mercuric chloride (resident).

The total intake (background + RERF) exceeds the cadmium HCV for both child receptors. However, these exceedences are due to background intake rather than the RERF contribution. The MDI for cadmium is provided by the

Environment Agency's Contaminated Land Exposure Assessment (CLEA) Tox reports (converted to an MDI for a child) and is higher than the HCV for the child. When setting Soil Guideline Values using the CLEA method, the MDI in this case (where the MDI exceeds the HCV) would effectively be assumed to be half the HCV (the Average Daily Exposure is assumed to be 50% of the TDI). Therefore, with the negligible contribution from the RERF, total intakes would be well below the oral HCV for cadmium.

E8.2.4 Ingestion of Chromium VI

The impact of locally generated chromium VI from existing sources has been assessed. Average background airborne concentrations of total chromium were measured at 0.0063 µg/m^3 at the Cross Green site. A report by the Expert Panel on Air Quality Standards (EPAQS) (1) suggests that Cr(VI) may constitute between 10% and 20% of total chromium in the atmosphere. Therefore, assuming that 20% of total chromium comprises chromium VI, the concentration of chromium VI would be 0.0013 µg/m^3 and would exceed the EPAQS guideline for chromium VI of 0.0002 µg/m^3. For the Farmer East, the contribution of the RERF to chromium VI concentrations is substantially less than this at 6.8 x 10^{-7} µg/m^3 (0.05% of the local background).

The predicted exposure to chromium VI is presented in *Table E8.5* for exposure to the elevated background concentration and for the RERF contribution. This assumes that the Farmer receptor is exposed to the same background concentration as was measured at the Cross Green monitoring site.

Table E8.5 Summary of Non-carcinogenic Ingestion of Chromium VI Exposure for the Farmer East Adult and Child

Substance	**Local Source Contribution as %age of the HCV**		**Total Intake as %age of the HCV (a)**	
	Child	**Adult**	**Child**	**Adult**
Chromium VI from background	3.4%	2.1%	32.4%	11.7%
Chromium VI from RERF	0.00%	0.00%	29.0%	9.6%
Total	3.4%	2.1%	32.4%	11.7%

(a) Total intake includes the average UK background intake plus the contribution from the local background and/or the RERF

Even at the elevated background concentrations measured, the predicted impact on the Farmer receptor is relatively small at 3.4% of the HCV for the child and 2.1% of the HCV for the adult. The contribution from the RERF is negligible in comparison to the local background. The total intake taking into account additional background exposure (e.g. from the ingestion of food) is well below the HCV.

(1) Expert Panel on Air Quality Standards (2009) Metals and Metalloids

E8.2.5 Inhalation and Ingestion of PCDD/F

E8.2.6 RERF Contribution to Intake

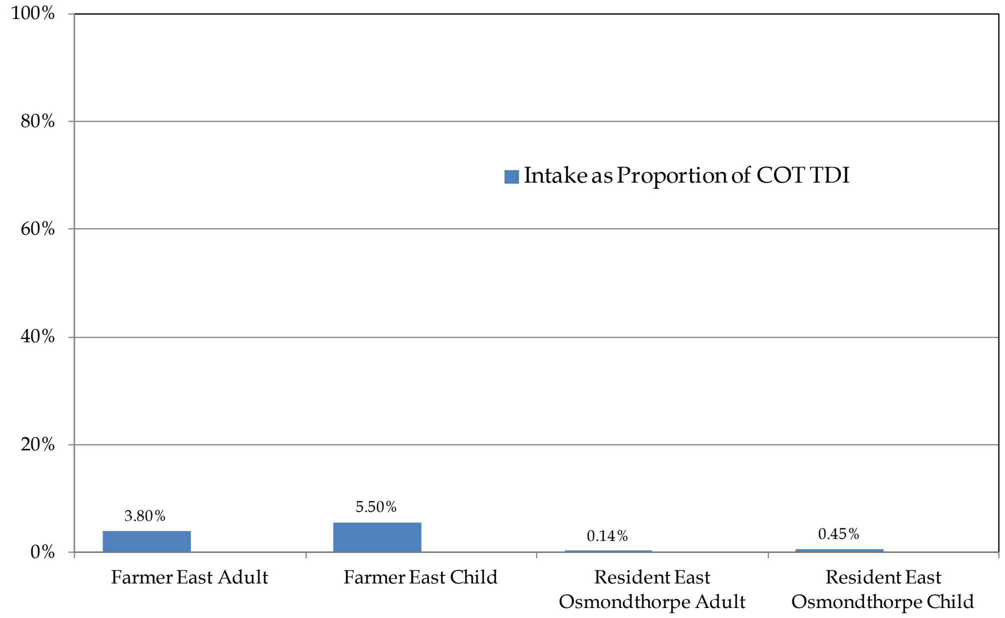
The World Health Organization (WHO) recommends a tolerable daily intake for dioxins/furans of 1 to 4 pg I-TEQ kg-BW^{-1} d^{-1} (picogrammes as the International Toxic Equivalent per kilogram bodyweight per day) [(1)]. The TDI represents the tolerable daily intake for lifetime exposure and short-term excursions above the TDI would have no consequence provided that the average intake over long periods is not exceeded. The contribution of the RERF to the average (lifetime) daily intake of dioxins/furans for the receptors considered is presented in *Table E8.6*. These are also compared to the Committee on Toxicity (COT) TDI of 2 pg I-TEQ kg-BW^{-1} d^{-1}. These are also presented as a percentage of the COT TDI in *Figure E8.1* for the Farmer East and Resident East Osmondthorpe receptors.

Table E8.6 Contribution of the RERF to Average Daily Intakes of Dioxins/Furans for Receptors (pg I-TEQ kg-BW^{-1} d^{-1})

Receptor Name	**Adult**	**Child**
Farmer East	0.076	0.11
Farmer South 1	0.0026	0.0038
Farmer South 2	0.0025	0.0037
Resident Beeston	0.00015	0.00046
Resident Belle Isle	0.00018	0.00057
Resident Cross Green	0.00099	0.0031
Resident Halton Moor	0.0013	0.0040
Resident Hunslet	0.00028	0.00090
Resident Osmonthorpe	0.00087	0.0028
Resident East Osmondthorpe	0.0028	0.0089
WHO TDI	*1 to 4 pg I-TEQ kg-BW^{-1} d^{-1}*	
Committee on Toxicity (COT) TDI	*2 pg I-TEQ kg-BW^{-1} d^{-1}*	

(1) Assessment of the Health Risk of Dioxins: Re-evaluation of the Tolerable Daily Intake (TD), WHO Consultation, May 25-29 1998, Geneva, Switzerland

Figure E8.1 ***Contribution of the RERF to Predicted Dietary Intake of Dioxins and Furans for the Farmer East and Resident East Osmondthorpe as a Percentage of the Committee on Toxicity's Tolerable Daily Intake***



The contribution of the RERF to the COT TDI is less than 5.5% for the Farmer receptors and less than 0.5% for the Resident receptors. The predicted average daily intake of PCDD/Fs is at least a factor of nine smaller than the lower end of the WHO TDI range for the Farmer receptors and less than 0.9% of the WHO TDI lower range for the Resident.

E8.2.7 *Total Intake*

The results of the assessment for inhalation and ingestion of PCDD/F are provided in *Appendix E.3* and summarised in *Table E8.7*. This provides the RERF contribution to ingestion intake and the total ingestion as a percentage of the relevant ingestion HCV.

Table E8.7 ***Summary of Non-carcinogenic Inhalation and Ingestion Exposure to PCDD/F Emissions***

Receptor	**RERF Contribution as %age of the HCV**	**Total Intake as %age of the HCV**
Farmer East Child	5.5%	111.7%
Farmer East Adult	3.8%	38.8%
Resident East Osmondthorpe Child	0.4%	106.6%
Resident East Osmondthorpe Adult	0.1%	35.1%

For inhalation and oral intake of PCDD/F for adults, total intake is well below the HCV. Background exposure represents approximately 35% of total exposure. At worst, the RERF contributes 3.8% to the HCV for adults.

For inhalation and oral intake of PCDD/F for children, the background intake is in excess of the HCV. This is partly due to the use of 15 kg child. For a 20 kg child, the MDI would be 1.8 pg TEQ kg^{-1} d^{-1} which is below (90%) the HCV of 2 pg TEQ kg^{-1} d^{-1}. At worst the additional contribution from the RERF for a child is 0.11 pg TEQ kg^{-1} d^{-1} (5.5% of the HCV). Combined with the background exposure for a 20 kg child the total intake would be less than the HCV. Furthermore, it should be noted that the HCV for PCCD/F is set for the purposes of assessing lifetime exposure and these elevated exposures are therefore not representative of long term exposure.

As discussed in *Section E1.1*, the exposure scenarios represent a highly unrealistic situation in which all exposure assumptions are chosen to represent a worst case and should be treated as an extreme view of the risks to health. Therefore, intakes presented here should be regarded as an extreme upper estimate of the actual exposure that would be experienced by the real population in the locality.

E8.3 SOIL CONCENTRATIONS AND CONCENTRATIONS IN MILK AND EGGS

E8.3.1 Comparison of Concentrations in Soil with Soil Guideline Values

Defra has developed Soil Guideline Values (SGV) for a range of trace metals including arsenic, nickel, mercury, selenium and cadmium (1). These have been derived using the Contaminated Land Exposure Assessment (CLEA) model, which takes account of the following exposure pathways:

- ingestion of soil and household dust;
- ingestion of contaminated vegetables and soil attached to vegetables;
- dermal contact with soil and household dust;
- inhalation of fugitive soil and household dust; and
- inhalation of vapours inside and outside.

A comparison of metal (arsenic, nickel, mercury and cadmium) concentrations in soil with appropriate SGV is presented in *Table E8.8* for the Farmer East and Resident East Osmondthorpe receptors.

(1) Environment Agency, environment-agency.gov.uk/subjects/landquality/113813/672771/675257/?version=1&lang=_e

Table E8.8 *Maximum Metal Concentrations in Soil for the Farmer East and Resident East Osmondthorpe Receptors*

Metal	**Farmer East (mg kg-1) (b)**	**Resident East Osmondthorpe (mg kg-1)**	**SGV (mg kg-1) (a)**
Arsenic	1.2×10^{-9} (0.00%)	1.4×10^{-9} (0.00%)	32
Cadmium	8.4×10^{-8} (0.00%)	9.6×10^{-8} (0.00%)	1.8
Inorganic mercury	3.0×10^{-3} (0.04%)	3.3×10^{-3} (0.04%)	80
Methyl mercury	6.0×10^{-5} (0.00%)	6.5×10^{-5} (0.00%)	8
Nickel	2.6×10^{-6} (0.00%)	3.0×10^{-6} (0.00%)	130

(a) For each metal, the most stringent SGV is adopted
(b) Figures in parentheses are the soil concentration as a percentage of the SGV

Relative to the SGV, highest concentrations are predicted for inorganic mercury at 0.04% of the SGV for the Farmer and Resident receptors. For arsenic, nickel, methyl mercury and cadmium, concentrations are less than 0.01% of the respective SGV.

Defra has also developed a Soil Guideline Value (SGV) for dioxins, furan and dioxin-like PCB (1). As for the trace metals, these have been derived using the CLEA model. A comparison of predicted soil concentrations for the Farmer East and Resident East Osmondthorpe receptors with the SGV for residential and allotment land uses is presented in *Table E8.9*.

Table E8.9 *Maximum Dioxin and Furan Concentrations in Soil for the Farmer East and Resident East Osmondthorpe Receptors*

Metal	**Farmer East (µg kg-1)**	**Resident East Osmondthorpe (µg kg-1)**	**SGV (µg kg-1)**
Total PCDD/PCDF (a)	0.0050	0.0055	8

(a) Concentrations not adjusted for toxic equivalence

Relative to the SGV, soil concentrations of dioxins and furans are predicted as follows:

- Farmer East receptor at 0.06% of the SGV; and
- Resident East Osmondthorpe at 0.07% of the SGV.

E8.3.2 Concentrations of PCDD/Fs in Milk and Eggs

Maximum levels of dioxins and furans in various foodstuffs have been set by the European Commission (2). Food products include meat and meat products, fish, milk, eggs and oils and fats. The contribution of the RERF to dioxin and furan concentrations in milk and eggs for the farmer receptors is

(1) Soil Guideline Values for dioxins, furans and dioxin-like PCBs in soil, Environment Agency Science Report SC050021/Dioxins SGV (September 2009)
(2) Commission Regulation 1881/2006, Setting of Maximum Levels for Certain Contaminants in Foodstuffs (19 December 2006)

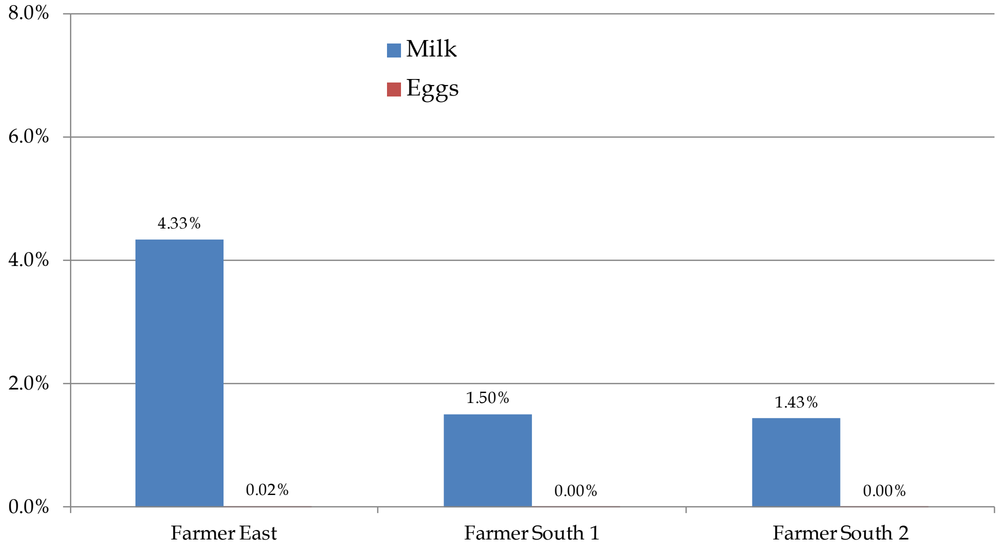
presented in *Table E8.10*. These are presented as a percentage of the maximum levels in *Figure E8.2*.

Table E8.10 ***Predicted Contribution of the Facility to the Concentration of Dioxins and Furans in Milk and Eggs***

Farmer Receptor	Concentration in Milk (a) (pg I-TEQ g^{-1} fat)	Concentration in Eggs (b) (pg I-TEQ g^{-1} fat)
Farmer East	0.13	0.00046
Farmer South 1	0.045	0.000017
Farmer South 2	0.043	0.000016
Maximum level	*3*	*3*

(a) Assuming the fat content of milk is 3%
(b) Assuming the fat content of eggs is 12%

Figure E8.2 ***Predicted Concentration of Dioxins and Furans in Milk and Eggs as a Percentage of the Maximum Levels***



The contribution of the RERF to the concentration of dioxins and furans in eggs is less than 0.02% of the maximum level. For milk, the RERF contributes at most 4.3% of the maximum level (Farmer East).

E8.3.3 *Concentrations of PCDD/F in Breast Milk*

Another exposure pathway of interest, is infant exposure to PCDD (polychlorinated di benzo(p)dioxins) and PCDF (polychlorinated dibenzofurans) via the ingestion of its mother's breast milk. This is because the potential for contamination of breast milk is particularly high for dioxin-like compounds such as these, as they are extremely lipophilic (fat soluble) and hence likely to accumulate in breast milk. Further, the infant body weight is smaller and it could be argued that the effect is therefore proportionately greater than in an adult.

This exposure is measured by the Average Daily Dose (ADD) on the basis of an averaging time of 1 year. In the US, a threshold value of 50 pg kg^{-1} d^{-1} of 2,3,7,8-TCDD TEQ is cited as being potentially harmful. The IRAP model calculates the ADD that would result from an adult receptor breast feeding an infant. A summary of the ADD for each of the infants of key adult receptors considered for the assessment is presented in *Table E8.11.*

Table E8.11 Assessment of the Average Daily Dose for a Breast-fed Infant of an Adult Receptor

Receptor Name	**Average Daily Dose from Breast Feeding (pg I-TEQ kg^{-1} d^{-1})**
Farmer East	0.90
Farmer South 1	0.031
Farmer South 2	0.030
Resident Beeston	0.0015
Resident Belle Isle	0.0019
Resident Cross Green	0.011
Resident Halton Moor	0.013
Resident Hunslet	0.0030
Resident Osmonthorpe	0.0093
Resident East Osmondthorpe	0.030
US EPA Criterion	*50*
WHO criterion	*1 to 4*
UK criterion (COT)	*2*

The highest ADD are calculated for the infants of Farmer receptors and represent at worst less than 1.8% of the US EPA criterion of 50 pg kg^{-1} d^{-1} of 2,3,7,8-TCDD. The calculated ADD for Resident receptors are substantially lower (0.06% at worst) compared to the Farmers since the most significant exposure to dioxins/furans is via the food chain, particularly animals and animal products. The Farmer receptors are assumed to consume contaminated meat and dairy products. However, Resident receptors are only assumed to consume vegetable products which are less significant with regard to exposure to dioxins/furans.

The ADD for the infants of Farmers and Residents are less than the lower WHO TDI and the COT criterion but contribute a significant proportion to these. However, the duration of exposure is short and the average daily intake over the lifetime of the individual would be substantially less. For example, taking the worst case of the Farmer East at maximum emissions, lifetime exposure to emissions from the RERF would consist of the following components:

- One year as a breast fed infant at 0.90 pg I-TEQ kg-BW^{-1} d^{-1};
- Five years as a child farmer at 0.11 pg I-TEQ kg-BW^{-1} d^{-1};
- 40 years as an adult farmer at 0.076 pg I-TEQ kg-BW^{-1} d^{-1}; and
- 24 years as an adult resident (farmer exposure assumed 40 years only) at 0.0028 pg I-TEQ kg-BW^{-1} d^{-1}.

This would result in a total average (lifetime) daily intake of 0.065 pg I-TEQ kg-BW^{-1} d^{-1}.

The WHO recognises that breast-fed infants will be exposed to higher intakes for a short duration, but also that breast feeding itself provides associated benefits.

E8.4 *CARCINOGENIC IMPACTS*

E8.4.1 *Introduction*

ERM considers that the HHRAP used for assessing human health risks is appropriate to the UK situation and that the methods and assumptions used have been rigorously peer reviewed. However, recognising that there are other approaches to assessing health risks, the Margin of Exposure (MoE) method has been utilised as an alternative. It should be noted that currently the general UK approach for assessing non-threshold risks utilises the Index Dose (ID) approach as outlined in the Environment Agency's Science Report (SC050021/SR2). Therefore, an assessment utilising the ID derived from the relevant Environment Agency Tox reports is also presented.

This assessment has been provided for those substances that are known or suspected genotoxic carcinogens (non-threshold effects) and include the following:

- inhalation of arsenic;
- ingestion of arsenic; and
- inhalation of hexavalent chromium.

Index Doses for Arsenic and CrVI have been obtained from the Environment Agency CLEA Tox reports.

The MoE is defined as the ratio of the no observed adverse effects level (NOAEL), obtained from epidemiological studies on animals, to the predicted exposure. The NOAEL is generally based on the benchmark dose lower confidence limit (BMDL). However, it is not appropriate to identify a NOAEL for COPC that are genotoxic or carcinogenic (i.e. that have a threshold below which there are no effects). Therefore, the MoE is calculated from a Point of Departure (PoD) on the dose-response relationship and is the dose that causes a low but measurable response, a 10% extra risk of cancer is generally used as the PoD. This is the Bench Mark Dose (BMD) and the BMDL is the lower 95% confidence limit and therefore takes into account uncertainty in the data. Therefore, the lower confidence limit for an extra 10% risk of cancers is referred to as the $BMDL_{10}$.

The ratio of the BMDL to the predicted exposure is the Margin of Exposure and typical descriptors for these are as follows:

- MoE is < 10,000 – may be a risk to health;

- MoE is 10,000 to 1,000,000 – very little risk to health; and
- MoE is > 1,000,000 – negligible risk to health.

For As and CrVI, BMDL have been obtained from the following sources:

- For CrVI, the US EPA (draft Toxicological Review of Hexavalent Chromium, September 2010) provides a range of $BMDL_{10}$ depending on the species and toxicological endpoint. These ranged from 0.09 to 0.52 mg kg d^{-1}. For the purposes of this assessment the lower $BMDL_{10}$ of 0.09 mg kg d^{-1} has been used to determine the MoE.

- For As, the European Food Safety Authority (EFSA) has published a Scientific Opinion on Arsenic in Food (EFSA Journal 2009: 7(10):1351). However, dose-response modelling indicated that a benchmark response of 1% extra risk was within the range of the observed data and was therefore selected for the benchmark dose. The EFSA identified a range of values for the 95% confidence limit for each endpoint. The $BMDL_{01}$ identified by EFSA was based on human exposure to arsenic rather than animal studies as animals metabolise arsenic differently than humans. The EFSA proposed a range for the $BMDL_{01}$ of 0.3 to 8 µg kg d^{-1} rather than a single reference point due to the variability of different population exposure data available. The EFSA also identified that estimated dietary exposure to arsenic varied between 0.13 to 0.56 µg kg d^{-1} (average exposure) and between 0.37 to 1.22 µg kg d^{-1} (95^{th} percentile consumers). Consequently, background exposures are close to the range of the $BMDL_{01}$ and provide very little or no MoE.

E8.4.2 Carcinogenic Risk using the ID Approach

For the two receptor types (Farmer and Resident), an assessment of carcinogenic risk using the ID approach is presented in *Table E8.12*. Detailed calculations and assumptions are provided in *Appendix E.4*.

Table E8.12 Assessment of the Carcinogenic Risk using the Index Dose Approach

Receptor	Substance/ Route	Dose (mg $kg^{-1}d^{-1}$)	Dose as a %age of the ID
Farmer East Child	Arsenic – inhalation	3.0×10^{-9}	0.15%
	Arsenic – ingestion	3.2×10^{-8}	0.01%
	Chromium VI - inhalation	3.3×10^{-10}	0.33%
Farmer East Adult	Arsenic – inhalation	1.8×10^{-9}	0.09%
	Arsenic – ingestion	1.8×10^{-8}	0.01%
	Chromium VI - inhalation	1.9×10^{-10}	0.19%
Resident East Osmondthorpe Child	Arsenic – inhalation	3.1×10^{-9}	0.15%
	Arsenic – ingestion	1.7×10^{-8}	0.01%
	Chromium VI - inhalation	3.3×10^{-10}	0.33%
Resident East Osmondthorpe Adult	Arsenic – inhalation	1.8×10^{-9}	0.09%
	Arsenic – ingestion	7.3×10^{-9}	0.00%
	Chromium VI - inhalation	2.0×10^{-10}	0.20%
Index Dose (mg kg^{-1} d^{-1})	*Arsenic – inhalation*	*2.0×10^{-6}*	-
	Arsenic – ingestion	*3.0×10^{-4}*	-
	Chromium VI - inhalation	*1.0×10^{-7}*	-

Relative to their respective ID, highest intakes are predicted for the inhalation of chromium VI and represent 0.19% to 0.33% of the ID for the Farmer and 0.20% to 0.33% for the Resident. The inhalation of arsenic is less than 0.2% of the ID for all receptors and the ingestion of arsenic is substantially less, at worst being 0.01% of the ingestion ID.

E8.4.3 Carcinogenic Risk using the MoE Approach

For the two receptor types (Farmer and Resident), an assessment of carcinogenic risk using the MoE approach is presented in *Table E8.13*. Detailed calculations and assumptions are provided in *Appendix E.4*.

Table E8.13 Assessment of the Carcinogenic Risk using the Margin of Exposure Approach

Receptor	**Substance/ Route**	**Dose (mg kg^{-1} d^{-1})**	**MoE**
Farmer East Child	Arsenic – total	3.5×10^{-8}	8,575 to 228,666
	Chromium VI - inhalation	3.3×10^{-10}	276,141,384
Farmer East Adult	Arsenic – total	2.0×10^{-8}	15,169 to 404,507
	Chromium VI - inhalation	1.9×10^{-10}	463,917,526
Resident East Osmondthorpe Child	Arsenic – total	5.3×10^{-8}	14,957 to 398,851
	Chromium VI - inhalation	9.4×10^{-10}	269,784,173
Resident East Osmondthorpe Adult	Arsenic – total	2.4×10^{-9}	32,895 to 877,193
	Chromium VI - inhalation	5.6×10^{-10}	453,237,410
BMDL (mg kg^{-1} d^{-1})	*Arsenic – inhalation*	*0.0003 to 0.008*	-
	Chromium VI - inhalation	*0.09*	-

For chromium VI the predicted MoE are all in excess of 1,000,000 and indicate a negligible risk to health. For arsenic a range of BMDL values are provided and this range varies by a factor of more than 25. Using the lower BMDL, the predicted intake for the Farmer East Child has a MoE of less than 10,000 and 'may be a risk to health'. Using the upper BMDL, the MoE are substantially higher and fall within the 'very little risk to health' category. However, emissions from the RERF have been assessed under the worst-case (i.e. an individual exposed for a lifetime to highest airborne concentrations and consuming predominantly locally grown produce). In reality, actual exposures will be less than those identified. In addition, the Farmer receptor considered for the assessment is assumed to be located immediately adjacent to industrial areas on land that is unlikely to be used for a full range of agricultural activities. Therefore, the assessment for the Farmer represents a very worst case scenario.

Furthermore, exposure to arsenic from the ERF should be compared with background exposure to determine the increase in risk. It should be noted that the average background dietary intake to arsenic is estimated to be between 0.13 to 0.56 µg kg d^{-1} (1.3×10^{-4} to 5.6×10^{-4} mg kg^{-1} d^{-1}). The contribution of the RERF to dietary intake at most is 0.04% of the background dietary intake. Therefore, the increased risk from exposure to the ERF emissions is negligible.

E8.4.4 Carcinogenic Risk of Exposure to Background Chromium VI

The carcinogenic risk of exposure to locally generated chromium VI from existing sources has been assessed. The predicted exposure to chromium VI is presented in *Table E8.14* for exposure to the elevated background concentration and for the RERF contribution. The assessment is provided for the Index Dose approach and the MoE approach. This assessment assumes that the Farmer receptor is exposed to the same background concentration as was measured at the Cross Green monitoring site.

Table E8.14 Summary of Carcinogenic Risk from the Inhalation of Chromium VI for the Farmer East Adult and Child

	Child	**Adult**
Background Exposure		
Dose (mg kg d^{-1})	6.3×10^{-7}	3.6×10^{-7}
Dose as percentage of ID	630%	360%
Margin of exposure	142,857	250,000
RERF Exposure		
Dose (mg kg d^{-1})	3.3×10^{-10}	1.9×10^{-10}
Dose as percentage of ID	0.33%	0.19%
Margin of exposure	276,141,384	463,917,526

For the background exposure, the predicted dose exceeds the Index Dose by a factor of more than six for the child receptor. However, this assumes that the receptor is exposed to the same background concentration as measured at Cross Green. As the monitoring location was sited within the industrial area and is likely influenced by a local pollution source, this is a highly pessimistic assumption.

For the MoE approach, exposure to background concentrations would fall within the 'very little risk to health' category. The contribution from the RERF would fall within the 'negligible risk to health' category.

In comparison to the local background intake, the contribution of the RERF to the carcinogenic risk is negligible (0.05% of the background intake).

E9 SUMMARY AND CONCLUSIONS

E9.1 SUMMARY

E9.1.1 Approach to the Assessment

The possible impacts on human health arising from dioxins and furans (PCDD/F), polycyclic aromatic hydrocarbons (PAH) and trace metals emitted from the proposed RERF have been assessed under the very worst-case scenario, namely that of an individual exposed for a lifetime to the effects of the highest airborne concentrations and consuming mostly locally grown food. This equates to a hypothetical farmer consuming food grown on the farm, situated in close proximity to the RERF. The assessment has identified and considered the most plausible pathways of exposure for the individuals considered (Farmer and Resident). Deposition and subsequent uptake of the compounds of potential concern (COPCs) into the food chain is likely to be the more numerically significant pathway over direct inhalation.

The Assessment has utilised the US EPA Human Health Risk Assessment Protocol (HHRAP) via a commercially available version of the model (IRAP version 4.0) developed by Lakes Environmental. Consequently, the US EPA approach to assessing hazards and risks has been used in the first instance. However, it is recognised that in the UK different methods of assessing health impacts and different health criteria values (HCV) are available. Therefore, using the output from the IRAP model, an alternative UK based approach to assessing health risks is also provided.

E9.1.2 Assessment Based on HHRAP

The predicted Hazard Indices for each of the receptors considered were well below the assessment criterion. Highest values were predicted for the Farmer due to the consumption of animal products. These were a factor of nine lower than the assessment criterion. For Residents, predicted impacts were lower and at worst were a factor of 275 less than the assessment criterion.

The additional, **lifetime** carcinogenic risk arising from inhalation and ingestion of COPC was assessed using US EPA cancer potency factors and unit risk factors, resulting in worst case estimates as follows:

- 7.1×10^{-6} (1 in 140,850) for the Farmer; and
- 2.0×10^{-7} (1 in 5,000,000) for the Resident.

The assessment of health effects arising from exposure to COPC indicates that emissions from the RERF do not pose a significant risk to health, given what is considered to be an acceptable level of lifetime risk in the UK, ie 1 in 14,300 (ie equivalent to an annual risk of 1 in 1,000,000 over a lifetime of 70 years).

E9.1.3 UK Based Assessment

E9.1.4 Non-carcinogenic Impacts

For the assessment of non-carcinogenic impacts, the predicted contribution of the RERF to trace metal and PCDD/F intake has been assessed relative to mean daily intakes (MDI) and relevant UK HCV. The results are summarised as follows:

- For inhalation exposure to metals, the highest contribution from the RERF relative to the HCV was for nickel. However, relative to the HCV the contribution from the RERF was relatively small (1.6% of the HCV at worst). The total intake for all metals (background + RERF contribution) are all well below the respective HCVs for all receptors.

- For oral exposure to metals, the highest contribution from the RERF relative to the HCV was for thallium or mercuric chloride depending on the receptor. With the addition of background exposure total intakes were well below the HCV for thallium and mercuric chloride.

- The total intake (background + RERF) exceeds the cadmium HCV for child receptors. However, these exceedences are due to background intake rather than the RERF contribution which is relatively small (less than 0.01%).

- For PCDD/F, the contribution of the RERF to the COT TDI is less than 5.5% for the Farmer receptors and less than 0.5% for the Resident receptors.

- For inhalation and oral intake of PCDD/F for adults, total intake is well below the HCV. Background exposure represents approximately 35% of total exposure. At worst, the RERF contributes 3.8% to the HCV for adults.

- For inhalation and oral intake of PCDD/F for children, the background intake is in excess of the HCV due to assumptions relating to the bodyweight of the child. At worst the additional contribution from the RERF for a child is 5.5% of the HCV. Furthermore, it should be noted that the HCV for PCCD/F is set for the purposes of assessing lifetime exposure and these elevated exposures are therefore not representative of long term exposure.

E9.1.5 Carcinogenic Risks

For the assessment of carcinogenic risks, two methods have been used; the Index Dose (ID) approach and the Margin of Exposure (MoE) approach. An assessment of carcinogenic risk has been provided for the inhalation and ingestion of arsenic and the inhalation of hexavalent chromium.

The results are summarised as follows:

- Relative to their respective ID, highest intakes are predicted for the inhalation of chromium VI and represent 0.19% to 0.33% of the ID for the Farmer and 0.20% to 0.33% for the Resident. The inhalation of arsenic is less than 0.2% of the ID for all receptors and the ingestion of arsenic is substantially less, at worst being 0.01% of the ingestion ID.

- For chromium VI the predicted MoE are all in excess of 1,000,000 and indicate a negligible risk to health.

- For arsenic, the MoE varies between 'may be a risk to health' to 'very little risk to health' depending on the BMDL used.

For arsenic, the MoE approach indicates that emissions have the potential to pose a risk to health when the most stringent BMDL is used. However, emissions from the RERF have been assessed under the worst-case (i.e. an individual exposed for a lifetime to highest airborne concentrations and consuming predominantly locally grown produce). Furthermore, exposure to arsenic from the ERF should be compared with background exposure to determine the increase in risk. The contribution of the RERF to the background dietary intake of arsenic is very small at less than 0.04%, therefore, the increased risk from exposure to the ERF emissions is negligible.

E9.1.6 Carcinogenic Risk to Background Concentrations of Chromium VI

Elevated concentrations of chromium VI have been measured within the locality and are thought to arise from a local emission source. The impact on human health of this background exposure has been assessed. The predicted dose from this background exposure exceeds the Index Dose by a factor of more than six for the child receptor. However, this assumes that the receptor is exposed to the same background concentration as measured at Cross Green. As the monitoring location was sited within the industrial area and is likely influenced by a local pollution source, this is a highly pessimistic assumption.

For the MoE approach, exposure to local background concentrations would fall within the 'very little risk to health' category. The contribution from the RERF would fall within the 'negligible risk to health' category.

In comparison to the local background intake, the contribution of the RERF to the carcinogenic risk is negligible (0.05% of the background intake).

E9.2 CONCLUSIONS

The risk assessment methodology used in this assessment has been structured so as to create 'realistic' worst case estimates of risk. A number of features in the methodology give rise to this degree of conservatism, most obviously through the assumption that the exposed individual lives in the area of maximum impact and consumes most of his/her animal, dairy, vegetable and cereal products derived from this area where deposition will occur (in the case of a Farmer).

Given the conservative nature of the assessment, it can be demonstrated that the maximally exposed individual is not subject to a significant carcinogenic risk or non-carcinogenic hazard, arising from exposures via both inhalation and the ingestion of foods.

Appendix E1

Site Parameters Defined for the Human Health Risk Assessment

Site Parameters Defined for the Health Risk Assessment

Parameter	Parameter Value	IRAP Symbol	Units
Soil dry bulk density	1.5	bd	g cm^{-3}
Forage fraction grown on contam. soil eaten by CATTLE	1.0	beef_fi_forage	--
Grain fraction grown on contam. soil eaten by CATTLE	1.0	beef_fi_grain	--
Silage fraction grown on contam. eaten by CATTLE	1.0	beef_fi_silage	--
Qty of forage eaten by CATTLE each day	8.8	beef_qp_forage	kg DW d^{-1}
Qty of grain eaten by CATTLE each day	0.47	beef_qp_grain	kg DW d^{-1}
Qty of silage eaten by CATTLE each day	2.5	beef_qp_silage	kg DW d^{-1}
Grain fraction grown on contam. soil eaten by CHICKEN	1.0	chick_fi_grain	--
Qty of grain eaten by CHICKEN each day	0.2	chick_qp_grain	kg DW d^{-1}
Fish lipid content	0.07	f_lipid	--
Fraction of CHICKEN's diet that is soil	0.1	fd_chicken	--
Universal gas constant	8.205e-5	gas_r	atm-m^3 mol^{-1} K^{-1}
Plant surface loss coefficient	18	kp	a^{-1}
Fraction of mercury emissions NOT lost to the global cycle	0.48	merc_q_corr	--
Fraction of mercury speciated into methyl mercury in produce	0.22	mercmethyl_ag	--
Fraction of mercury speciated into methyl mercury in soil	0.02	mercmethyl_sc	--
Forage fraction grown contam. soil, eaten by MILK CATTLE	1.0	milk_fi_forage	--
Grain fraction grown contam. soil, eaten by MILK CATTLE	1.0	milk_fi_grain	--
Silage fraction grown contam. soil, eaten by MILK CATTLE	1.0	milk_fi_silage	--
Qty of forage eaten by MILK CATTLE each day	13.2	milk_qp_forage	kg DW d^{-1}
Qty of grain eaten by MILK CATTLE each day	3.0	milk_qp_grain	kg DW d^{-1}
Qty of silage eaten by MILK CATTLE each day	4.1	milk_qp_silage	kg DW d^{-1}
Averaging time	1	milkfat_at	a
Body weight of infant	9.4	milfat_bw_infant	kg
Exposure duration of infant to breast milk	1	milkfat_ed	a
Proportion of ingested dioxin that is stored in fat	0.9	milkfat_f1	--
Proportion of mothers weight that is fat	0.3	milkfat_f2	--
Fraction of fat in breast milk	0.04	milkfat_f3	--
Fraction of ingested contaminant that is absorbed	0.9	milkfat_f4	--
Half-life of dioxin in adults	2555	milkfat_h	d
Ingestion rate of breast milk	0.688	milkfat_ir_milk	kg d^{-1}
Viscosity of air corresponding to air temp.	1.81e-04	mu_a	g cm^{-1} s^{-1}
Fraction of grain grown on contam. soil eaten by PIGS	1.0	pork_fi_grain	--
Fraction of silage grown on contam. soil and eaten by PIGS	1.0	pork_fi_silage	--
Qty of grain eaten by PIGS each day	3.3	pork_qp_grain	kg DW d^{-1}
Qty of silage eaten by PIGS each day	1.4	pork_qp_silage	kg DW d^{-1}
Qty of soil eaten by CATTLE	0.5	qs_beef	kg d^{-1}
Qty of soil eaten by CHICKEN	0.022	qs_chick	kg d^{-1}
Qty of soil eaten by DAIRY CATTLE	0.4	qs_milk	kg d^{-1}
Qty of soil eaten by PIGS	0.37	qs_pork	kg d^{-1}
Density of air	1.2e-3	rho_a	g cm^{-3}
Solids particle density	2.7	rho_s	g cm^{-3}
Interception fraction - edible portion ABOVEGROUND	0.39	rp	--
Interception fraction - edible portion FORAGE	0.5	rp_forage	--
Interception fraction - edible portion SILAGE	0.46	rp_silage	--
Ambient air temperature	298	t	K
Temperature correction factor	1.026	theta	--
Soil volumetric water content	0.2	theta_s	mL cm^{-3}
Length of plant expos. to depos. - ABOVEGROUND	0.16	tp	a
Length of plant expos. to depos. - FORAGE	0.12	tp_forage	a
Length of plant expos. to depos. - SILAGE	0.16	tp_silage	a
Average annual wind speed	3.9	u	m s^{-1}
Dry deposition velocity	0.5	vdv	cm s^{-1}
Dry deposition velocity for mercury	2.9	vdv_hg	cm s^{-1}
Wind velocity	3.9	w	m s^{-1}
Yield/standing crop biomass - edible portion ABOVEGROUND	2.24	yp	kg DW m^{-2}
Yield/standing crop biomass - edible portion FORAGE	0.24	yp_forage	kg DW m^{-2}
Yield/standing crop biomass - edible portion SILAGE	0.8	yp_silage	kg DW m^{-2}
Soil mixing zone depth	2.0	z	cm

Appendix E2

Exposure Scenario Parameters for the Human Health Risk Assessment

Exposure Scenario Parameters

Parameter Description	Adult Resident	Child Resident	Adult Farmer	Child Farmer	Adult Fisher	Child Fisher	Units
Averaging time for carcinogens	70	70	70	70	70	70	a
Averaging time for noncarcinogens	30	6	40	6	30	6	a
Consumption rate of BEEF	0.0	0.0	0.00122	0.00075	0.0	0.0	kg kg^{-1} FW d^{-1}
Body weight	70	15	70	15	70	15	kg
Consumption rate of POULTRY	0.0	0.0	0.00066	0.00045	0.0	0.0	kg kg^{-1} FW d^{-1}
Consumption rate of ABOVEGROUND PRODUCE	0.00032	0.00077	0.00047	0.00113	0.00032	0.00077	kg kg^{-1} DW d^{-1}
Consumption rate of BELOWGROUND PRODUCE	0.00014	0.00023	0.00017	0.00028	0.00014	0.00023	kg kg^{-1} DW d^{-1}
Consumption rate of DRINKING WATER	1.4	0.67	1.4	0.67	1.4	0.67	L d^{-1}
Consumption rate of PROTECTED ABOVEGROUND PRODUCE	0.00061	0.0015	0.00064	0.00157	0.00061	0.0015	kg kg^{-1} DW d^{-1}
Consumption rate of SOIL	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002	kg d^{-1}
Exposure duration	30	6	40	6	30	6	yr
Exposure frequency	350	350	350	350	350	350	d a^{-1}
Consumption rate of EGGS	0.0	0.0	0.00075	0.00054	0.0	0.0	kg kg^{-1} FW d^{-1}
Fraction of contaminated ABOVEGROUND PRODUCE	1.0	1.0	1.0	1.0	1.0	1.0	--
Fraction of contaminated DRINKING WATER	1.0	1.0	1.0	1.0	1.0	1.0	--
Fraction contaminated SOIL	1.0	1.0	1.0	1.0	1.0	1.0	--
Consumption rate of FISH	0.0	0.0	0.0	0.0	0.00125	0.00088	kg kg^{-1} FW d^{-1}
Fraction of contaminated FISH	1.0	1.0	1.0	1.0	1.0	1.0	--
Inhalation exposure duration	30	6	40	6	30	6	a
Inhalation exposure frequency	350	350	350	350	350	350	d a^{-1}
Inhalation exposure time	24	24	24	24	24	24	h d^{-1}
Fraction of contaminated BEEF	1	1	1	1	1	1	--
Fraction of contaminated POULTRY	1	1	1	1	1	1	--
Fraction of contaminated EGGS	1	1	1	1	1	1	--
Fraction of contaminated MILK	1	1	1	1	1	1	--
Fraction of contaminated PORK	1	1	1	1	1	1	--
Inhalation rate	0.83	0.30	0.83	0.30	0.83	0.30	m^3 h^{-1}
Consumption rate of MILK	0.0	0.0	0.01367	0.02268	0.0	0.0	kg kg^{-1} FW d^{-1}
Consumption rate of PORK	0.0	0.0	0.00055	0.00042	0.0	0.0	kg kg^{-1} FW d^{-1}
Time period at the beginning of combustion	0	0	0	0	0	0	a
Length of exposure duration	30	6	40	6	30	6	a

Appendix E3

Summary of Non-carcinogenic Risk

Source of Assessment Criteria and Background Intakes

Inhalation

	UK TDI (mg/kg/d)	MDI Child (mg/kg/d	MDI Adult (mg/kg/d)	Source	Child MDI as %age of TDI	Adult MDI as %age of TDI
Antimony	5.71E-05	1.99E-05	6.57E-06	TDI and MDI from The Soil Generic Assessment Criteria for Human Health Risk Assessment, CL: AIRE (Dec 2009)	34.9%	11.5%
Cadmium	1.40E-06	8.67E-07	2.86E-07	TDI and MDI from Environment Agency Science Report SC050021/Cadmium SGV (June 2009)	61.9%	20.4%
Chromium III	3.00E-05	1.17E-05	3.86E-06	TDI and MDI from LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment, 2nd Edition (July 2009), including erratum of 28/03/11	39.0%	12.9%
Lead	5.71E-04	8.67E-05	2.86E-05	TDI derived from concentration in blood. TDI and MDI from previous version of Environment Agency Science Report on Lead	15.2%	5.0%
Elemental mercury	6.00E-05	2.17E-06	7.14E-07	TDI and MDI from Environment Agency Science Report SC050021/Mercury SGV (March 2009)	3.6%	1.2%
Inorganic mercury	6.00E-05	0	0	TDI and MDI from Environment Agency Science Report SC050021/Mercury SGV (March 2009)	0.0%	0.0%
Methyl mercury	2.30E-04	0	0	TDI and MDI from Environment Agency Science Report SC050021/Mercury SGV (March 2009)	0.0%	0.0%
Nickel	6.00E-06	2.60E-06	8.57E-07	TDI and MDI from Environment Agency Science Report SC050021/Nickel SGV (March 2009)	43.3%	14.3%
Thallium	8.00E-05	4.33E-07	1.43E-07	TDI derived from HHRAP RfC, MDI derived from airborne concentration of 0.5 ng/m3 and 20 m3/day respiration rate	0.5%	0.2%

Ingestion

	UK TDI (mg/kg/d)	MDI Child (mg/kg/d	MDI Adult (mg/kg/d)	Source	Child MDI as %age of TDI	Adult MDI as %age of TDI
Antimony	6.00E-03	1.08E-04	3.57E-05	TDI and MDI from The Soil Generic Assessment Criteria for Human Health Risk Assessment, CL: AIRE (Dec 2009)	1.8%	0.6%
Cadmium	3.60E-04	5.81E-04	1.91E-04	TDI and MDI from Environment Agency Science Report SC050021/Cadmium SGV (June 2009)	161.4%	53.1%
Chromium III	1.50E-01	2.61E-03	8.60E-04	TDI and MDI from LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment, 2nd Edition (July 2009), including erratum of 28/03/11	1.7%	0.6%
Chromium VI	1.00E-03	2.90E-04	9.57E-05	TDI and MDI from LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment, 2nd Edition (July 2009), including erratum of 28/03/11	29.0%	9.6%
Lead	1.00E-02	1.39E-03	4.57E-04	TDI derived from concentration in blood. TDI and MDI from previous version of Environment Agency Science Report on Lead	13.9%	4.6%
Mercuric chloride	2.00E-03	4.33E-05	1.43E-05	TDI and MDI from Environment Agency Science Report SC050021/Mercury SGV (March 2009)	2.2%	0.7%
Methyl mercury	2.30E-04	2.17E-05	7.14E-06	TDI and MDI from Environment Agency Science Report SC050021/Mercury SGV (March 2009)	9.4%	3.1%
Nickel	1.20E-02	5.63E-03	1.86E-03	TDI and MDI from Environment Agency Science Report SC050021/Nickel SGV (March 2009)	46.9%	15.5%
Thallium	8.00E-05	3.64E-05	1.20E-05	TDI derived from HHRAP RfC, MDI derived from FSA TDS 2006	45.5%	15.0%

Non-carcinogenic Impacts

Farmer East Child

IR	7.2	m3/h
BW	15	kg

Inhalation of Metals

Substance	ABSinh	PC Air Concentration (ug/m3)	PC Air Concentration (mg/m3)	PC Intake Inhalation (mg/kg/d)	MDI Inh Child (mg/kg/d)	Total Inh (mg/kg/d)	HCV Inh (mg/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
Antimony	1.0	3.0E-05	3.0E-08	1.5E-08	2.0E-05	2.0E-05	5.71E-05	0.03%	34.9%
Cadmium	1.0	6.8E-06	6.8E-09	3.3E-09	8.7E-07	8.7E-07	1.4E-06	0.23%	62.1%
Chromium III	1.0	9.7E-05	9.7E-08	4.6E-08	1.2E-05	1.2E-05	3.0E-05	0.15%	39.2%
Lead	1.0	1.4E-04	1.4E-07	6.7E-08	8.7E-05	8.7E-05	4.3E-04	0.02%	20.2%
Mercuric chloride	1.0	7.2E-06	7.2E-09	3.5E-09	0.0E+00	3.5E-09	6.0E-05	0.01%	0.0%
Nickel	1.0	2.0E-04	2.0E-07	9.4E-08	2.6E-06	2.7E-06	6.0E-06	1.56%	44.9%
Thallium	1.0	4.1E-06	4.1E-09	2.0E-09	4.3E-07	4.4E-07	8.0E-05	0.00%	0.5%
Elemental mercury	1.0	3.0E-08	3.0E-11	1.4E-11	2.2E-06	2.2E-06	6.0E-05	0.00%	3.6%

Ingestion of Metals

Substance	Ing Intake PC (mg/kg/d)	MDI Ing Child (mg/kg/d)	Total Ingestion (mg/kg/d)	HCV Ingestion (mg/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
Antimony	1.1E-11	1.1E-04	1.1E-04	4.0E-04	0.00%	27.1%
Cadmium	2.7E-08	5.8E-04	5.8E-04	3.6E-04	0.01%	161.3%
Chromium III	2.5E-06	2.6E-03	2.6E-03	1.5E-01	0.00%	1.7%
Chromium VI	1.8E-08	2.9E-04	2.9E-04	1.0E-03	0.00%	29.0%
Lead	9.9E-07	1.4E-03	1.4E-03	1.0E-02	0.01%	13.9%
Mercuric chloride	4.6E-07	4.3E-05	4.4E-05	3.0E-04	0.15%	14.6%
Methyl mercury	2.1E-08	2.2E-05	2.2E-05	1.0E-04	0.02%	21.7%
Nickel	3.5E-06	5.6E-03	5.6E-03	1.2E-02	0.03%	47.0%
Thallium	1.9E-07	3.6E-05	3.7E-05	8.0E-05	0.24%	45.7%

Ingestion and Inhalation of PCDD/Fs

Substance	Inhalation Intake PC (pg TEQ/kg/d)	Ingestion Intake PC (pg TEQ/kg/d)	Total Intake PC (pg TEQ/kg/d)	MDI Inh + Ing (pg TEQ/kg/d)	Total Intake (pg TEQ/kg/d)	HCV Inhalation + Ingestion (pg TEQ/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
PCCD/Fs	3.53E-05	1.10E-01	1.10E-01	2.12	2.23	2	5.5%	111.7%

Non-carcinogenic Impacts

Farmer East Adult

IR	20	m3/h
BW	70	kg

Inhalation of Metals

Substance	ABSinh	PC Air Concentration (ug/m3)	PC Air Concentration (mg/m3)	PC Intake Inhalation (mg/kg/d)	MDI Inh Adult (mg/kg/d)	Total Inh (mg/kg/d)	HCV Inh (mg/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
Antimony	1.0	3.0E-05	3.0E-08	8.6E-09	6.6E-06	6.6E-06	5.71E-05	0.02%	11.5%
Cadmium	1.0	6.8E-06	6.8E-09	1.9E-09	2.9E-07	2.9E-07	1.4E-06	0.14%	20.5%
Chromium III	1.0	9.7E-05	9.7E-08	2.8E-08	3.9E-06	3.9E-06	3.0E-05	0.09%	12.9%
Lead	1.0	1.4E-04	1.4E-07	4.0E-08	2.9E-05	2.9E-05	4.3E-04	0.01%	6.7%
Mercuric chloride	1.0	7.2E-06	7.2E-09	2.1E-09	0.0E+00	2.1E-09	6.0E-05	0.00%	0.0%
Nickel	1.0	2.0E-04	2.0E-07	5.6E-08	8.6E-07	9.1E-07	6.0E-06	0.93%	15.2%
Thallium	1.0	4.1E-06	4.1E-09	1.2E-09	1.4E-07	1.4E-07	8.0E-05	0.00%	0.2%
Elemental mercury	1.0	3.0E-08	3.0E-11	8.6E-12	7.1E-07	7.1E-07	6.0E-05	0.00%	1.2%

Ingestion of Metals

Substance	Ing Intake PC (mg/kg/d)	MDI Ing Adult (mg/kg/d)	Total Ingestion (mg/kg/d)	HCV Ingestion (mg/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
Antimony	4.7E-12	3.6E-05	3.6E-05	4.0E-04	0.00%	8.9%
Cadmium	1.2E-08	1.9E-04	1.9E-04	3.6E-04	0.00%	53.2%
Chromium III	1.6E-06	8.6E-04	8.6E-04	1.5E-01	0.00%	0.6%
Chromium VI	1.1E-08	9.6E-05	9.6E-05	1.0E-03	0.00%	9.6%
Lead	5.1E-07	4.6E-04	4.6E-04	1.0E-02	0.01%	4.6%
Mercuric chloride	2.4E-07	1.4E-05	1.5E-05	3.0E-04	0.08%	4.8%
Methyl mercury	1.1E-08	7.1E-06	7.2E-06	1.0E-04	0.01%	7.2%
Nickel	2.3E-06	1.9E-03	1.9E-03	1.2E-02	0.02%	15.5%
Thallium	1.6E-07	1.2E-05	1.2E-05	8.0E-05	0.21%	15.2%

Ingestion and Inhalation of PCDD/Fs

Substance	Inhalation Intake PC (pg TEQ/kg/d)	Ingestion Intake PC (pg TEQ/kg/d)	Total Intake PC (pg TEQ/kg/d)	MDI Inh + Ing (pg TEQ/kg/d)	Total Intake (pg TEQ/kg/d)	HCV Inhalation + Ingestion (pg TEQ/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
PCCD/Fs	1.06E-04	7.54E-02	7.55E-02	0.70	0.78	2	3.8%	38.8%

Non-carcinogenic Impacts

Resident Waterloo Junction Child

IR	7.2	m3/h
BW	15	kg

Inhalation of Metals

Substance	ABSinh	PC Air Concentration (ug/m3)	PC Air Concentration (mg/m3)	PC Intake Inhalation (mg/kg/d)	MDI Inh Child (mg/kg/d)	Total Inh (mg/kg/d)	HCV Inh (mg/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
Antimony	1.0	3.1E-05	3.1E-08	1.5E-08	2.0E-05	2.0E-05	5.71E-05	0.03%	34.9%
Cadmium	1.0	6.9E-06	6.9E-09	3.3E-09	8.7E-07	8.7E-07	1.4E-06	0.24%	62.1%
Chromium III	1.0	9.9E-05	9.9E-08	4.7E-08	1.2E-05	1.2E-05	3.0E-05	0.16%	39.2%
Lead	1.0	1.4E-04	1.4E-07	6.9E-08	8.7E-05	8.7E-05	4.3E-04	0.02%	20.2%
Mercuric chloride	1.0	7.4E-06	7.4E-09	3.5E-09	0.0E+00	3.5E-09	6.0E-05	0.01%	0.0%
Nickel	1.0	2.0E-04	2.0E-07	9.6E-08	2.6E-06	2.7E-06	6.0E-06	1.60%	44.9%
Thallium	1.0	4.2E-06	4.2E-09	2.0E-09	4.3E-07	4.4E-07	8.0E-05	0.00%	0.5%
Elemental mercury	1.0	3.1E-08	3.1E-11	1.5E-11	2.2E-06	2.2E-06	6.0E-05	0.00%	3.6%

Ingestion of Metals

Substance	Ing Intake PC (mg/kg/d)	MDI Ing Child (mg/kg/d)	Total Ingestion (mg/kg/d)	HCV Ingestion (mg/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
Antimony	1.0E-11	1.1E-04	1.1E-04	4.0E-04	0.00%	27.1%
Cadmium	1.9E-08	5.8E-04	5.8E-04	3.6E-04	0.01%	161.3%
Chromium III	3.6E-07	2.6E-03	2.6E-03	1.5E-01	0.00%	1.7%
Chromium VI	2.6E-09	2.9E-04	2.9E-04	1.0E-03	0.00%	29.0%
Lead	3.9E-07	1.4E-03	1.4E-03	1.0E-02	0.00%	13.9%
Mercuric chloride	1.9E-07	4.3E-05	4.4E-05	3.0E-04	0.06%	14.5%
Methyl mercury	1.1E-08	2.2E-05	2.2E-05	1.0E-04	0.01%	21.7%
Nickel	5.5E-07	5.6E-03	5.6E-03	1.2E-02	0.00%	46.9%
Thallium	2.1E-08	3.6E-05	3.6E-05	8.0E-05	0.03%	45.5%

Ingestion and Inhalation of PCDD/Fs

Substance	Inhalation Intake PC (pg TEQ/kg/d)	Ingestion Intake PC (pg TEQ/kg/d)	Total Intake PC (pg TEQ/kg/d)	MDI Inh + Ing (pg TEQ/kg/d)	Total Intake (pg TEQ/kg/d)	HCV Inhalation + Ingestion (pg TEQ/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
PCCD/Fs	3.61E-05	8.83E-03	8.87E-03	2.12	2.13	2	0.4%	106.6%

Non-carcinogenic Impacts

Resident Waterloo Junction Adult

IR	20	m3/h
BW	70	kg

Inhalation of Metals

Substance	ABSinh	PC Air Concentration (ug/m3)	PC Air Concentration (mg/m3)	PC Intake Inhalation (mg/kg/d)	MDI Inh Adult (mg/kg/d)	Total Inh (mg/kg/d)	HCV Inh (mg/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
Antimony	1.0	3.1E-05	3.1E-08	8.9E-09	6.6E-06	6.6E-06	5.71E-05	0.02%	11.5%
Cadmium	1.0	6.9E-06	6.9E-09	2.0E-09	2.9E-07	2.9E-07	1.4E-06	0.14%	20.5%
Chromium III	1.0	9.9E-05	9.9E-08	2.8E-08	3.9E-06	3.9E-06	3.0E-05	0.09%	13.0%
Lead	1.0	1.4E-04	1.4E-07	4.1E-08	2.9E-05	2.9E-05	4.3E-04	0.01%	6.7%
Mercuric chloride	1.0	7.4E-06	7.4E-09	2.1E-09	0.0E+00	2.1E-09	6.0E-05	0.00%	0.0%
Nickel	1.0	2.0E-04	2.0E-07	5.7E-08	8.6E-07	9.1E-07	6.0E-06	0.95%	15.2%
Thallium	1.0	4.2E-06	4.2E-09	1.2E-09	1.4E-07	1.4E-07	8.0E-05	0.00%	0.2%
Elemental mercury	1.0	3.1E-08	3.1E-11	8.8E-12	7.1E-07	7.1E-07	6.0E-05	0.00%	1.2%

Ingestion of Metals

Substance	Ing Intake PC (mg/kg/d)	MDI Ing Adult (mg/kg/d)	Total Ingestion (mg/kg/d)	HCV Ingestion (mg/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
Antimony	4.0E-12	3.6E-05	3.6E-05	4.0E-04	0.00%	8.9%
Cadmium	7.9E-09	1.9E-04	1.9E-04	3.6E-04	0.00%	53.2%
Chromium III	1.4E-07	8.6E-04	8.6E-04	1.5E-01	0.00%	0.6%
Chromium VI	9.7E-10	9.6E-05	9.6E-05	1.0E-03	0.00%	9.6%
Lead	1.6E-07	4.6E-04	4.6E-04	1.0E-02	0.00%	4.6%
Mercuric chloride	7.2E-08	1.4E-05	1.4E-05	3.0E-04	0.02%	4.8%
Methyl mercury	4.7E-09	7.1E-06	7.1E-06	1.0E-04	0.00%	7.1%
Nickel	2.3E-07	1.9E-03	1.9E-03	1.2E-02	0.00%	15.5%
Thallium	6.1E-09	1.2E-05	1.2E-05	8.0E-05	0.01%	15.0%

Ingestion and Inhalation of PCDD/Fs

Substance	Inhalation Intake PC (pg TEQ/kg/d)	Ingestion Intake PC (pg TEQ/kg/d)	Total Intake PC (pg TEQ/kg/d)	MDI Inh + Ing (pg TEQ/kg/d)	Total Intake (pg TEQ/kg/d)	HCV Inhalation + Ingestion (pg TEQ/kg/d)	PC Intake as %age of HCV	Total Intake as %age of HCV
PCCD/Fs	8.13E-05	2.73E-03	2.81E-03	0.70	0.70	2	0.1%	35.1%

Appendix E4

Summary of Carcinogenic Risk

Carcinogenic (Non-threshold) Effects

Farmer East Child

		IR	7.2	m3/d
Ingestion Dose		BW	15	kg

COPC	**Route**	**Abs Inh**	**Predicted concentration (ug/m3)**	**Predicted concentration (mg/m3)**	**Dose PC (mg/kg/d)**	**ID (mg/kg/d)**	**Dose/ID**	**ID Comment**
Arsenic	inhalation	1	6.22E-06	6.22E-09	3.0E-09	2.0E-06	0.15%	EA Tox
Arsenic	ingestion	-	-	-	3.2E-08	3.0E-04	0.01%	EA Tox
Chromium VI	inhalation	1	6.79E-07	6.79E-10	3.3E-10	1.0E-07	0.33%	Based on 0.25 ng/m3 WHO, 70 kg, 20 m3/d rounded up

Margin of Exposure

COPC	**Route**	**Dose PC (mg/kg/d)**	**BMDL Lower (mg/kg/d)**	**BMDL Upper (mg/kg/d)**	**MoE Lower**	**MoE Upper**	**BMDL Comment**
Arsenic	total	3.5E-08	0.0003	0.008	8,575	228,666	Based on BMDL 01, according to EFSA report, 2009
Chromium VI	inhalation	3.3E-10	0.09		276,141,384		BMDL 10, US EPA tox review, September 2010

Farmer East Adult

		IR	20	m3/d
Ingestion Dose		BW	70	kg

COPC	**Route**	**Abs Inh**	**Predicted concentration (ug/m3)**	**Predicted concentration (mg/m3)**	**Dose PC (mg/kg/d)**	**ID (mg/kg/d)**	**Dose/ID**
Arsenic	inhalation	1	6.22E-06	6.22E-09	1.8E-09	2.0E-06	0.09%
Arsenic	ingestion	-	-	-	1.8E-08	3.0E-04	0.01%
Chromium VI	inhalation	1	6.79E-07	6.79E-10	1.9E-10	1.0E-07	0.19%

Margin of Exposure

COPC	**Route**	**Dose PC (mg/kg/d)**	**BMDL Lower (mg/kg/d)**	**BMDL Upper (mg/kg/d)**	**BMDL Lower/ Dose**	**BMDL Upper/ Dose**
Arsenic	total	2.0E-08	0.0003	0.008	15,169	404,507
Chromium VI	inhalation	1.9E-10	0.09		463,917,526	

Carcinogenic (Non-threshold) Effects

Resident Waterloo Junction Child

		IR		7.2	m3/d				
Ingestion Dose		BW		15	kg				
COPC	**Route**	**Abs Inh**	**Predicted concentration (ug/m3)**	**Predicted concentration (mg/m3)**	**Dose PC (mg/kg/d)**	**ID (mg/kg/d)**	**Dose/ID**	**ID Comment**
Arsenic	inhalation	1	6.37E-06	6.37E-09	3.1E-09	2.0E-06	0.15%	EA Tox
Arsenic	ingestion	-	-	-	1.7E-08	3.0E-04	0.01%	EA Tox
Chromium VI	inhalation	1	6.95E-07	6.95E-10	3.3E-10	1.0E-07	0.33%	Based on 0.25 ng/m3 WHO, 70 kg, 20 m3/d rounded up

Margin of Exposure

COPC	**Route**	**Dose PC (mg/kg/d)**	**BMDL Lower (mg/kg/d)**	**BMDL Upper (mg/kg/d)**	**MoE Lower**	**MoE Upper**	**BMDL Comment**
Arsenic	total	2.0E-08	0.0003	0.008	14,957	398,851	Based on BMDL 01, according to EFSA report, 2009
Chromium VI	inhalation	3.3E-10	0.09		269,784,173		BMDL 10, US EPA tox review, September 2010

Resident Waterloo Junction Adult

		IR		20	m3/d		
Ingestion Dose		BW		70	kg		
COPC	**Route**	**Abs Inh**	**Predicted concentration (ug/m3)**	**Predicted concentration (mg/m3)**	**Dose PC (mg/kg/d)**	**ID (mg/kg/d)**	**Dose/ID**
Arsenic	inhalation	1	6.37E-06	6.37E-09	1.8E-09	2.0E-06	0.09%
Arsenic	ingestion	-	-	-	7.3E-09	3.0E-04	0.00%
Chromium VI	inhalation	1	6.95E-07	6.95E-10	2.0E-10	1.0E-07	0.20%

Margin of Exposure

COPC	**Route**	**Dose PC (mg/kg/d)**	**BMDL Lower (mg/kg/d)**	**BMDL Upper (mg/kg/d)**	**BMDL Lower/ Dose**	**BMDL Upper/**
Arsenic	total	9.1E-09	0.0003	0.008	32,895	877,193
Chromium VI	inhalation	2.0E-10	0.09		453,237,410	

Annex F

Best Available Technology

CONTENTS

F1 INTRODUCTION

This Annex contains an assessment of the Best Available Technology (BAT) for the Facility. This is based on H1 Software supplied by the Environment Agency.

The BAT Assessment methodology is an objective means of establishing the most appropriate design for the process, taking into account both the consequences for the environment and the costs associated with the various possible design options. By applying the methodology, the Environment Agency and the public can see this evaluation process in as transparent a manner as possible.

The BAT Assessment consists of 6 basic modules:

1. Definition of the objective of the assessment and options to be considered.

2. Quantification of the emissions for each option.

3. Quantification of the environmental impacts resulting from the emissions.

4. Comparison of the options and ranking in order of best overall environmental performance.

5. Evaluation of the costs to implement each option.

6. Identification of the option that represents the Best Available Technique, by balancing the environmental benefits against costs.

F1.1 DEFINITION OF TERMS

Article 2 of the IPPC Directive defines 'Best Available Techniques (BAT)' as:

> *'the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular Techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole'.*

This description uses the following definitions:

- 'Best' means '*the most effective in achieving a high general level of protection of the environment as a whole*'.

- 'Available' are *'those techniques developed on a scale which allows them to be used in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the cost and advantages'*.

- 'Techniques' includes *'both the technology and the way the installation is designed, built, maintained, operated and decommissioned.'*

F2 OVERVIEW OF TECHNOLOGIES

F2.1 INTRODUCTION

F2.1.1 Thermal treatment

Waste can be treated thermally using a variety of technologies: moving grate incineration, fluidised bed and some more novel technologies such as pyrolysis and gasification.

Moving grate incineration plants have been operating world-wide for many years and the technology is well proven as an effective method of treating municipal waste.

Incineration plants with fluidised bed plants are also found world-wide. They have, however, generally been operating on homogenous wastes. Few fluidised bed plants have been built for operation on municipal waste and these are mainly in Japan. These are small plants however. It is only in recent years that larger plants have been constructed specifically for municipal waste, and in many of these cases, problems have still been encountered with feedstock preparation and meeting the high availabilities envisaged (see *Section 10.2.6* of the BREF note (1)). Other plants have encountered problems meeting anticipated performance due to lack of experience and feedback.

Pyrolysis and gasification thermally degrade the waste to produce a gas, which can then be burnt. This has theoretical advantages, opportunities to burn the gas in gas turbines, along with drawbacks. The principal drawbacks of gasification and pyrolysis are the technical difficulties in treating residual municipal waste, the need to prepare feedstocks, high energy consumption of the system, and for some processes the char remaining which must be further treated. In the opinion of VES some of these processes are not suited to municipal waste, particularly given the lack of commercial operating facilities using these technologies.

F2.1.2 Flue Gas Treatment

There are several abatement techniques available to reduce the emissions to atmosphere. In terms of NO_x abatement, in addition to primary measures to reduce NO_x emissions, there are other secondary technologies such as Selective Non-Catalytic Reduction (SNCR) and Selective Catalytic Reduction (SCR). Techniques for reducing acid gas emissions include dry, semi-dry and wet scrubbing systems.

The choice of BAT has therefore been based upon commercially proven technologies which are readily available.

(1) Reference Document on the Best Available Techniques for Waste Incineration, May 2005.

F2.1.3 Furnace

Moving Grate

Moving grate technology (often reciprocating or rolling) aids combustion in the furnace by mixing burning waste with freshly fed waste. Primary air is fed into the furnace from underneath, while secondary air is fed in from above.

There are several different designs for moving grate furnaces, with various configurations. For example, the Von Roll System consists of a *forward action reciprocating grate* in an alternative fixed and moving configuration which is driven by a hydraulic system. The Martin reverse action moving grate is described as *reciprocating counter-flow design* and moves the burning waste underneath the fresh waste, while feeding primary air through the high temperature alloy steel bars. In the Volund system, the grate consists of a series of cast iron bars, alternatively fixed and moving in a vertical action, the waste is therefore agitated by the reciprocating and vertical movements. The grate is described as a *double motion transvection grate* and comprises of a series of horizontal modules, each consisting of superimposed grate bars driven in opposite directions with rocker arms. The Martin design, selected for the RERF in Leeds, will be made up of alternate steps of fixed and moving grate bar rows which perform slow mixing stokes in an upward direction, opposite to the downward movement of the waste due to the inclination of the grate at approximately 26°. These various designs have implications on maintenance and operational procedures but are similar in terms of performance.

Energy from waste (EfW) facilities with moving grate technology have been operating world-wide for many years and the technology is well proven as an effective method of treating municipal waste.

Fluidised Bed

Fluidised bed technology blows air or other gas through the bottom of the furnace. The waste lies on a distribution plate covered with sand or limestone and is mobilised by air being blown up from beneath.

It was originally used for homogeneous wastes, such as sewage sludge, but has recently been adapted for more heterogeneous wastes, such as municipal waste. However, there is still very little experience of using fluidised bed technology in EfW facilities of the size proposed in this Application.

Fluidised beds theoretically have higher combustion efficiencies than other grate systems. However, the use of a fluidised bed can lead to higher emissions of fine particulate matter, and consequently to larger amounts of flue gas treatment (FGT) residues.

The system is simple, with no moving parts, decreasing the maintenance costs, although there are increased pre-treatment costs, as the waste has to be prepared prior to input. Fluidised bed technology can produce a substantial amount of reject material and ash (which consists of 5% by weight of incoming waste during waste preparation, 20% as the mineral fraction in the combustion phase and 5% as flue gas residue). There is little known about composition and characterisation of the flue gas treatment residues and other by-products and their possible recovery. There is also a concern for commercial reliability as there has only been limited experience of the use of fluidised bed technology for a facility of this size.

Rotary Kiln

Incineration in a rotary kiln is a two stage process consisting of a kiln and a separate secondary combustion chamber. The rotation of the kiln moves the waste with a tumbling action which exposes fresh waste to heat and oxygen.

Rotary kilns can operate at higher temperatures than other systems due to the absence of exposed metal surfaces, and can therefore be used to incinerate hazardous, clinical and industrial wastes. The use of rotary kilns can lead to increased numbers of fine particles emitted due to the disturbance caused by the tumbling action on the waste.

In addition, the rotary kiln experiences poor unburnt residue performance in the bottom ash (typically in excess of 5%). They also do not generally allow for a throughput capacity above 5 tonnes/hour. Consequently this technology has been rejected as a treatment option in this Assessment.

Pyrolysis and Gasification

Gasification is a process whereby the municipal waste is partially combusted in a limited supply of air. The heat generated by this process is then used to decompose the remaining waste into hydrocarbon gases (and some inert gas). This gas is cleaned and can then be used to generate heat and electricity.

Pyrolysis is similar to gasification but is carried out in the absence of oxygen which creates a gas and a tar.

VES has investigated the full range of thermal treatment technologies (from pilot scale developments to full scale commercial operations), including the Type 2 gasification/pyrolysis options (production of a syngas which is cleaned and burnt directly in a gas turbine or reciprocating gas engine which runs generator). For example, VES NE (North America) and VES UK both have had regular contact with Inetec Chemical (also known as IET). Inetec Chemical is a technology development company and has developed this technology solution for a highly chlorinated liquid hazardous waste stream (trichlorosilane) from a specific production process in the US. The facility in Midland Michigan is specific to this hazardous waste stream, which cannot be easily treated in any other way. However, the opinion remains that this technology is not currently suited to treat residual municipal waste.

Neither pyrolysis nor gasification technology present any particular environmental benefit over high efficiency incineration with modern flue gas treatment, and often result in less energy recovered per tonne processed.

There are some commercially operating technologies but they do not demonstrate environmental nor energy based benefits. Operating facilities do not present a viable option for the scale of the Leeds project.

F2.1.4 NO_x Reduction System

Introduction

Oxides of nitrogen are formed from the input constituent during the incineration process. The majority of this occurs initially as nitric oxide, NO. Once released into the atmosphere this is oxidised over a period of time to nitrogen dioxide, NO_2. This substance can have significant adverse health effects at sufficiently high concentrations.

Primary NO_x Control

The nature of the waste incineration sector means that there is little room for fuel selection; as such this is discounted as a feasible primary NO_x control measure.

Conditions in the furnace (as described *Volume 2, Section 4* of the EP Application) are carefully controlled to ensure the efficient combustion of waste. An optimum supply of oxygen is maintained to avoid unnecessary production of NO_x.

The auxiliary burner fitted to the combustion chamber (see *Volume 2, Section 4* of the EP Application) is a low-NO_x burner, that will be oil-fired.

Although fluidised bed incinerators tend to produce less NO_x than moving grate incinerators, as discussed earlier on in this section, this type of furnace is not suitable for municipal waste as it is not homogeneous in nature.

Computation fluid dynamics (CFD) is used by the contractor to validate combustion conditions including the primary and secondary air inputs and temperature control. CFD also confirms that the temperature and flow profile within the furnace is even and optimised. In order to comply with the Waste Incineration Directive, the temperature within the furnace will be maintained at a minimum of 850 °C, and the residence time of the waste within the chamber will be at least 2 seconds.

Flue Gas Recirculation (FGR), which prevents NO_X formation by replacing 10 – 20% of secondary air with recirculated flue gases, has been considered alongside the secondary NO_X control measures in this Assessment.

Selective Non Catalytic Reduction (SNCR)

Selective Non Catalytic Reduction (SNCR) uses urea (or ammonia) as a reagent, which is injected into the system and reacts with NO and NO_2 to reduce them to N_2 as follows:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$
$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

Selective Non Catalytic Reduction, which has been selected here, is an established technique currently practised at numerous energy-from-waste plants in the UK. Nevertheless it requires high temperatures and requires reagents in excess of the stoichiometry of the reaction.

Selective Catalytic Reduction (SCR)

Selective Catalytic Reduction adds a catalyst to the reaction thereby reducing the temperature required for the reaction to take place. It also reduces the amount of reagent used in the process. However, the capital and operating costs of the process are high since the expensive catalyst needs to be periodically changed.

F2.1.5 Acid Gas Removal Treatment

Introduction

Acid gases (hydrogen chloride, hydrogen fluoride (HCl and HF)) and sulphur oxides (SO_2 and SO_3) are formed from the input constituent during the incineration process. The treatment of these gases consists of neutralising them by the addition of a base reagent.

The most commonly used are the alkaline earth reagents. There are different options for reagents: hydrated lime ($CaOH_2$); sodium hydroxide (NaOH); sodium bicarbonate ($NaHCO_3$); and sodium carbonate (Na_2CO_3). Lime has been selected as the reagent here as it presents the best overall cost benefit ratio.

Wet Scrubbing

Pre-formed spray towers are chambers in which a liquid is atomised by high pressure spray nozzles. The gas stream usually enters the bottom of the chamber and flows concurrent to the liquid, although both concurrent and crosscurrent modes have been used. The gas may travel in a single part or may be directed by a series of baffles. The atomised liquid forms droplets and mass transfer occurs at the droplet surface. The finer the droplets the more gas adsorption is enhanced. Impurities which are soluble in the scrubbing liquid are removed by the gas adsorption process. The scrubbing medium can be water, or an aqueous suspension of lime or limestone.

Wet scrubbing has a high performance and reliability. It is currently in use in many similar situations. However, it produces significant amount of waste water, contaminated with a range of pollutants and must be dealt with carefully. It can also produce a visible plume at the stack, and has high capital costs and water consumption.

Figure F2.1 shows a schematic diagram of a wet FGT system.

Dry/Semi-dry Scrubbing

For dry and semi-dry treatment methods, the neutralisation reactions employed are heterogeneous phase reactions of the gas/solid type. Whether they are injected in pulverulent form or in suspension (lime slurry), the particles constituting the reagent must provide as high a surface/volume ratio as possible.

Both systems induce broadly the same consumption of reagents and therefore produce the same quantity of residue.

Dry treatment involves treating the flue gases by pneumatic injection of the pulverulent base (hydrated lime and activated carbon). It is a relatively simple system, which unlike other systems does not produce a plume or liquid releases. It has relatively low capital costs for a high performance.

Due to its relative simplicity, a well-designed dry FGT system is very reliable. This is the option selected for the RERF.

This system is more energy efficient than a semi-dry system since a greater proportion of the energy in the flue gas can be recovered, as it is not required to evaporate large amounts of water associated with a semi-dry system.

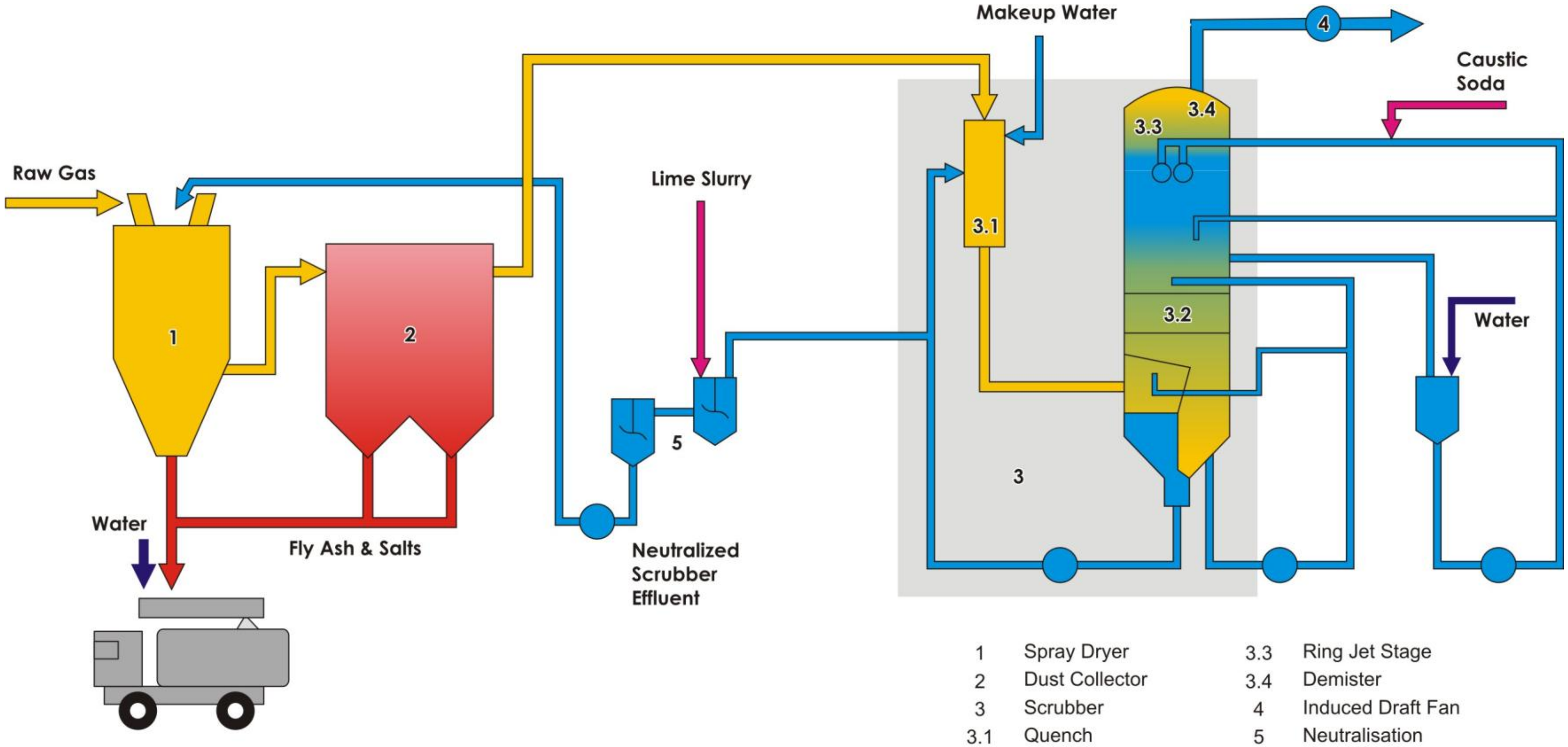
Figure F2.2 shows the schematic diagram of a dry FGT system.

Semi-dry treatment consists of the injection into the flue gases of the base reagent (lime and activated carbon) with water to condition the gas temperature. The flue gases are therefore both cooled and treated.

This system has also a high performance and reliability.

Figure F2.3 shows the schematic diagram of a semi-dry FGT system.

Figure F2.1 Schematic Diagram of Wet Flue Gas Treatment (FGT) System



1	Spray Dryer	3.3	Ring Jet Stage
2	Dust Collector	3.4	Demister
3	Scrubber	4	Induced Draft Fan
3.1	Quench	5	Neutralisation
3.2	Packed Bed Stage		

Figure F2.2 Schematic Diagram of Dry Flue Gas Treatment (FGT) System

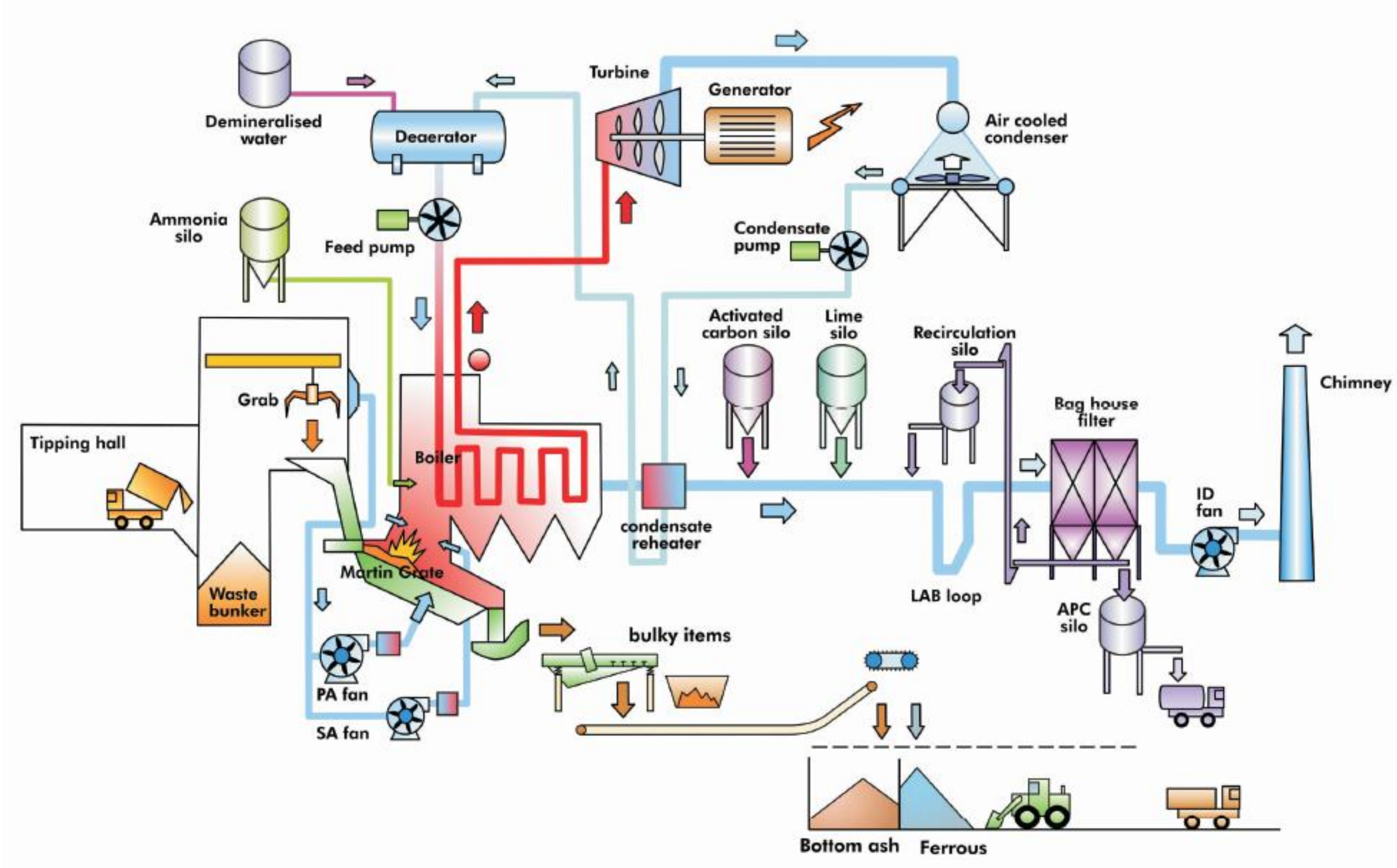
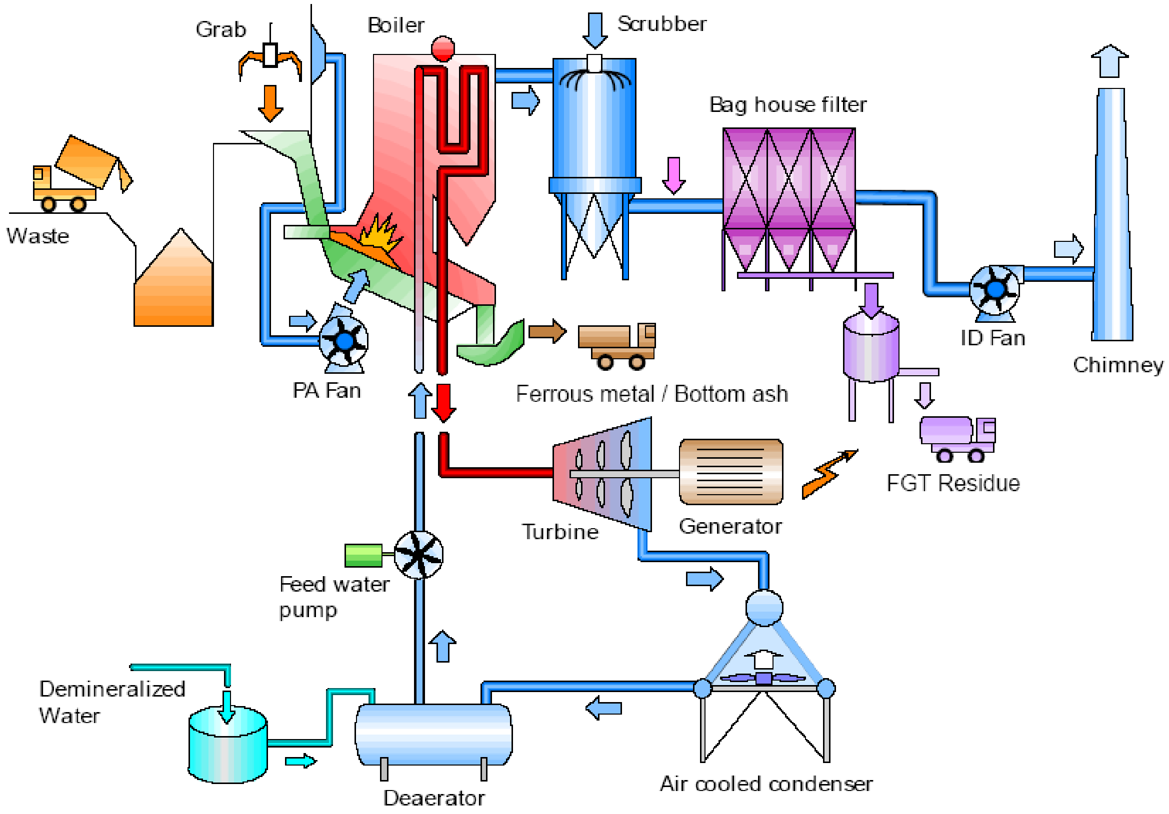


Figure F2.3 *Schematic Diagram of Semi-Dry Flue Gas Treatment (FGT) System*



F2.1.6 *Steam Condensers*

Both air and water cooled steam condensers are environmentally acceptable. *Table F2.1* summarises the advantages and disadvantages of air and water cooled condensers.

Table F2.1 Advantages and Disadvantages of Air and Water Cooled Condensers

Condenser type	Advantages	Disadvantages
Air cooled condenser	• Technically reliable • Best solution where water for cooling not available or is in short supply	• Visual impact • Noise impact • Lower efficiency
Water cooled condenser	• Technically reliable • Higher steam cycle efficiency	• Thermal plume • Inlet and discharge pipes • Higher capital cost • Fouling control (biocide)

For this site, air cooled condensers have been selected. The air cooled condensers have been specifically designed to meet the low noise condition suggested in the planning application and have been architecturally integrated into the overall plant design. A water cooled condenser design cannot be proposed as there is no industrial water supply or suitable discharge point.

In this case, the air cooled condensers are BAT compared to the water cooled condensers. Water cooled condensers are not considered further here.

F2.1.7 *District Heating*

The Facility has been designed so that at any stage in its life, there is the potential to connect to a turbine take off that could be used for district heating purposes. The development of district heating does not generally depend on the heat source but much more on the user. VESL is investigating potential local users and will consider the various opportunities to develop heat or steam sales on a commercial basis.

F2.1.8 *Fuel Selection for Emergency Generator*

Diesel has been selected for the fuel for the emergency generator over other fuels, such as natural gas. This is for operational reasons. It is vital that sufficient fuel is stored onsite to enable the safe shut-down of the Facility in the event of an emergency or abnormal event requiring shut-down. Establishing a permanent connection to the natural gas grid is very expensive for intermittent usage of gas and is not considered economically viable. Additionally, diesel is also needed for refuelling of on-site vehicles.

F2.1.9 Selection of Odour Control for MPT

An activated carbon filter will present on the MPT. This will complement the extraction of air via the combustion air fans of the ERF which creates a negative pressure in the ERF and MPT buildings preventing the fugitive emissions of odour. During ERF shutdown additional units of the activated carbon filter will be brought online to compensate for the lack of negative pressure being drawn from the ERF.

Based on VES' recent operational experience with biofilters installed in other waste treatment facilities it is considered that activated carbon filters represent BAT for this facility. Biofilters need to operate at consistently high load to produce the best established conditions and as the RERF will only require intermittent operation of the filtration system, a biofilter is not considered the most appropriate solution.

Activated carbon filters are suitable for intermittent operation and are therefore our possible proposed alternative and this is BAT for air treatment based on the BREF documentation.

F3 BAT OPTIONS SELECTION

F3.1 OBJECTIVE OF BAT

The objective of this exercise is to compare the environmental consequences of the proposed technologies selected for this project (the base case) with several alternative options for the process. This comparison is done on a relative basis, for instance by generating numerical values for the *Process Contribution (PC)* and the *Predicted Environmental Contribution (PEC)* and comparing these with the *Environmental Assessment Levels (EAL)*, *Photochemical Ozone Creation Potential* (POCP) and *Global Warming Potential* (GWP) values.

F3.1.1 Generating Options to Meet the Objective - Stage 1 (Furnace and NO_X Reduction Options)

The principal feature of a quantitative BAT assessment is the comparison of a base case with alternative options. These options should be 'practicable' and use the 'cleanest', feasible technique for each step of the process. This approach can, in theory, generate a large number of permutations. To avoid unnecessary evaluation of a large number of process options, the number of techniques can be reduced by the 'application of technical assessment and professional judgement'. Examples of this are given as being 'technical viability', 'excessive cost' and 'availability of particular techniques'.

The Assessment is carried out as an iterative process, ie split into two stages. In Stage 1, different furnace designs and NO_x reduction techniques are assessed. The NO_X reduction techniques include one primary measure, Flue Gas Recirculation (FGR), and two secondary measures, SNCR and SCR. The top two options in Stage 1 will be taken forward into Stage 2, which incorporates options for acid gas treatment. The options in Stage 1 are summarised in *Table F3.1* with full details of each option considered shown in *Section F2*.

In this study, the base case is the preferred option, with moving grate technology in the furnace and SNCR for NO_x control considered in Stage 1. This option is felt to give the best performance (in terms of both the environment and in general operation) available in this situation. The BAT Assessment will examine this supposition.

The alternative options have been selected to represent a realistic range of plausible alternatives to the base case. The range of options cannot include all possible alternatives and permutations because these would be too numerous to assess, but it does include enough alternatives to enable a comprehensive assessment of the plausible best available techniques.

Table F3.1 ***Base Case and Alternative Design Options – Stage 1 (Furnace and NO_x Control)***

	Options				
	Base Case Option 1	**2**	**3**	**4**	**5**
Furnace					
Moving Grate	✓	✓	✓		
Fluidised Bed				✓	✓
Additional NO_x Reduction					
FGR			✓		
SNCR	✓		✓	✓	
SCR		✓			✓

Pollutant release rates used in the BAT Assessment for the Base Case are those used in the Air Quality Assessment presented in *Annex D.* These are derived from the emission concentration limits in the Waste Incineration Directive (WID). Consequently they are guaranteed maximum emissions and it is likely that, during normal operating procedures, emissions would be lower.

Selection of the NO_x Control Reagent

The BAT Assessment presented in this Annex considers both urea and ammonia used as reagents for NO_x control. Ammonia is considered for Options 2 and 5 (which employ SCR) and urea is considered for the SNCR options (Base Case, Option 3 and Option 4).

F3.1.2 *Generating Options to Meet the Objective - Stage 2 (Acid Gas Treatment Options)*

The Stage 2 assessment will take the best two options arising from Stage 1 and subject them to a BAT analysis for acid gas (ie SO_2) treatment options.

The acid gas treatment options will include dry, semi-dry and wet treatment systems.

F4 DETAILS OF THE BAT ANALYSIS - STAGE 1

F4.1 INTRODUCTION

This section presents details of the input data used in the H1 Software Tool to generate the results of the BAT Assessment. In Stage 1, each of the candidate options detailed in *Table F3.1* was evaluated and compared for the following variables:

- emissions to air;
- energy consumption;
- raw materials; and
- waste streams.

H1 also considers:

- noise and vibration;
- accidental emissions;
- odour;
- visual impacts; and
- deposition from land to air.

However, these 5 issues are not included in this Assessment as there are no appreciable differences between the various options.

All of the data, for all of the options presented in this Annex are based on 8,000 hours of operation per year.

F4.1.1 Emissions to Air

The unabated concentrations of the pollutants emitted to atmosphere for the different options included in the BAT Assessment are presented in *Table F4.1* below. It has been assumed that all NO_x is in the form of NO_2.

Table F4.1 Unabated Pollutant Concentrations (mg Nm^{-3})

Options	Unabated NO_2 Concentration[(a)]
Base Case (Option 1)	400
Option 2	400
Option 3	390
Option 4	385
Option 5	385

(a) Corrected for: Temperature; 273 K; Pressure; 101.3 kPa; dry; 11% v/v O_2.

Table F4.2 below shows the long-term atmospheric emission rates from each option, with the percentage emission reductions shown in parentheses, when compared to the unabated case. *Table F4.3* shows the abated NO_X emissions.

Table F4.2 Concentrations (mg Nm^{-3}) and Emissions (g s^{-1}) for the Different Options Considered

Options	NO_2 [(a)] Concentration (Long term) after Abatement mg Nm^{-3} [(b) (c)]	NO_2 Emissions (Long term) after Abatement g s^{-1}
Base Case (Option 1)	200 (50%)	5.68
Option 2	80 (80%)	2.27
Option 3	200 (49%)	5.68
Option 4	200 (48%)	5.68
Option 5	80 (79%)	2.27

(a) These values are presented as NO_2 in the H1 spreadsheet which represents a worst case
(b) Percentage reductions shown in parentheses, eg NO_2 emissions reduced 50% in Base Case compared to an unabated Base Case.
(c) Short-term concentrations and emission rates included in H1 are double the long-term.

Table F4.3 NO_2 Emissions Abated (tonnes $year^{-1}$)

Options	NO_2 Emissions Abated
Base Case (Option 1)	164
Option 2	262
Option 3	155
Option 4	151
Option 5	249

The impact of the atmospheric emissions in the Base Case has been taken from the detailed air quality modelling carried out as part of this application. The impacts from the alternative options have been calculated by pro-rating the ground level concentrations by the emission rates for each alternative. The process contributions to impacts are shown in *Table F4.4* below.

Table F4.4 Maximum Process Contributions (μg m^{-3})

Options	Long Term NO_2[(a)]	Short Term NO_2[(a)]
Base Case (Option 1)	1.70	7.0
Option 2	0.68	2.8
Option 3	1.70	7.0
Option 4	1.70	7.0
Option 5	0.68	2.8

(d) If the process contributions are less than 1% of the EAL they are automatically screened out of the H1 assessment, however no values were below this screening threshold for the Stage 1 assessment.

F4.1.2 Emissions to Water

Emissions to water have not been included in the BAT Assessment as there are no discharges during normal operations in any of these options.

F4.1.3 *Energy Consumption*

Table F4.5 illustrates the power requirements of the alternative design options relative to the Base Case. *Table F4.6* shows the breakdown of annual delivered energy consumption.

Table F4.5 ***Power Requirements of the Alternative Design Options (kWh t_{MSW}^{-1})***

	Base Case (Option 1)	Option 2	Option 3	Option 4	Option 5
Furnace					
Moving Grate	47	47	47		
Fluidised Bed (including preparation)				105	105
NO_x Reduction					
SNCR	1		0.95	0.93	
SCR		25			25
FGR			5		
Total (kWh/t_{MSW})	**48**	**72**	**53**	**106**	**130**

Table F4.6 ***Breakdown of Annual Delivered Energy Consumption (MWh $year^{-1}$)***

Options	Imported Electricity [(a) (c)]	Parasitic Self-Generated Electricity [(b)]	Net Exported Electricity [(d)] [(e)]
Base Case (Option 1)	120	7,752	98,400
Option 2	179	11,629	92,250
Option 3	132	8,552	98,408
Option 4	264	17,108	88,900
Option 5	324	20,996	82,738

(a) Assumes 1.5% of the parasitic energy requirements are met through imported electricity
(b) Assumes 98.5% of the parasitic energy requirements are met through generation from waste combustion
(c) In an emergency scenario, electricity could be imported either from the grid or generated by the standby generator. This assessment assumes that it will be imported from the grid but, in addition, this will also account for the fuel used by the standby generator. This is the worst case scenario on each side.
(d) Note the MPT is not included in this breakdown for any of the options
(e) Note that all options have been considered with a dry FGT

F4.1.4 *Assessment of Greenhouse Gas Emissions*

The emissions data for use in the assessment of greenhouse gases is detailed in *Table F4.7* below.

Table F4.7 Greenhouse Gas Emissions (tonnes year[-1])

Options	N_2O from process/ de-NO_X process	CO_2 from de-NO_x process	CO_2 from imported energy [(a)]	CO_2 from exported energy[(a)]	CO_2 from waste combustion [(b)]
Base Case (Option 1)	13.8	331	53	- 43,493	517,174
Option 2	1.63	0	79	- 40,775	517,174
Option 3	13.8	314	58	- 43,497	517,174
Option 4	24.52	306	117	- 39,294	517,174
Option 5	13.08	0	143	- 36,570	517,174

(a) CO_2 emissions associated with the generation of the power imported by the ERF from the National Grid and the energy exported back to the grid, based on a conversion factor of 2.6 and a CO_2 factor of 0.17

(b) CO_2 emissions associated with waste combustion and based on a CO_2 factor of 0.34 for waste fuel

F4.1.5 *Assessment of Raw Materials*

The use of raw materials in the Base Case has been taken from *Section 7 Raw and Auxiliary Materials*. The predicted usage of raw materials in the alternative options has been estimated and is show in *Table F4.8* below.

Table F4.8 Raw Materials Usage (tonnes year[-1])

Options	Water	Urea	Ammonia	Sand
Base Case (Option 1)	41,000	451	0	0
Option 2	41,000	0	532	0
Option 3	41,000	428	0	0
Option 4	37,720	417	0	1,640
Option 5	37,720	0	512	1,640

SCR catalyst, which is used in Options 2 and 5, is not included in the assessment as it is not technically consumed, but rather it is regenerated and then reused.

F4.1.6 *Assessment of Waste Streams*

The quantities of materials in the waste streams of the Base Case have been taken from the mass balance in *Figure 7.1* of *Volume 2* of the Application. *Table F4.9* below shows the waste streams that are predicted for the alternative options.

Table F4.9 ***Waste Streams (tonnes $year^{-1}$)[a]***

Options	Bottom Ash	Ferrous Metals
Base Case (Option 1)	37,720	820
Option 2	37,720	820
Option 3	37,720	820
Option 4	41,820	820
Option 5	41,820	820
Hazard Category	Non-Hazardous	Inert
Disposal Method	Recycling	Recycling
Distance in km	50-100	0-50

(a) FGT residues are not considered in Stage 1 but are considered in Stage 2 which investigates different FGT options

This is a conservative assessment as it is likely that the bottom ash will be recycled for use as aggregate.

F4.1.7 Comparison of Impacts

The results of this BAT Assessment are presented in the form of the tables and graphs produced by the H1 Software. These are presented in the *Stage 1 Appendix* at the rear of this document.

The options are compared for each environmental topic. For Stage 1 BAT analysis, the costs of the options have also been included; the best options arising from Stage 1 and to be evaluated further in Stage 2 will, therefore, be selected based on environmental merit and cost.

Air Quality

The Environmental Quotients (EQs) for each of the options is ranked in *Table F4.10* below. Options 4 and 5 have the lowest (best) EQs whilst the Base Case, Option 2 and Option 3 have a slightly higher (worst) EQ.

Table F4.10 ***Air Quality Environmental Quotients (EQs)***

Options	Long Term Air Quality EQ	Short Term Air Quality EQ
Option 4	0.02	0.01
Option 5	0.02	0.01
Base Case (Option 1)	0.04	0.04
Option 2	0.04	0.04
Option 3	0.04	0.04

Waste

The Waste Scores for each of the Options is ranked in *Table F4.11* below. The Base Case, Option 2 and Option 3 perform the same in terms of waste, whilst Options 4 and 5 perform slightly worse.

Table F4.11 Waste

Options	**Waste Score**
Base Case (Option 1)	907,740
Option 2	907,740
Option 3	907,740
Option 4	1,006,140
Option 5	1,006,140

Photochemical Ozone Creation Potential (POCP)

The POCP for each substance assessed for each of the Options is ranked in *Table F4.12* below. It can be seen that the POCP is lower for Options 2 and 5 as these options have the lowest NO_2 emissions. The remainder of the options show no significant differences in the POCPs as the emission rates of NO_2 are similar for these options.

Table F4.12 Photochemical Ozone Creation Potential (POCP)

Options	**Substance**	**POCP**
Option 2	NO_2	183
Option 5	NO_2	183
Base Case (Option 1)	NO_2	458
Option 3	NO_2	458
Option 4	NO_2	458

Global Warming Potential (GWP)

The GWP for each substance assessed for each of the Options is ranked in ascending order in

Table ***F4.13*** below. Option 2 has the lowest (best) GWP, Option 3 and Base Case (Option 1) are the next best.

The CO_2 from indirect energy differs due to the different parasitic energy requirements (generated by the RERF) for each option and the difference in the net exported electricity.

Table F4.13 Global Warming Potential (GWP)

Options	Substance	Global Warming Potential
Option 2	CO_2 Direct Energy [a]	517,174
	CO_2 Indirect Energy [b]	-40,695
	CO_2 Process Direct [c]	0
	N_2O Process Direct [d]	505
	TOTAL	**476,984**
Option 3	CO_2 Direct Energy [a]	517,174
	CO_2 Indirect Energy [b]	-43,438
	CO_2 Process Direct [c]	314
	N_2O Process Direct [d]	4,055
	TOTAL	**478,105**
Base Case (Option 1)	CO_2 Direct Energy [a]	517,174
	CO_2 Indirect Energy [b]	-43,440
	CO_2 Process Direct [c]	331
	N_2O Process Direct [d]	4,055
	TOTAL	**478,120**
Option 5	CO_2 Direct Energy [a]	517,174
	CO_2 Indirect Energy [b]	-36,427
	CO_2 Process Direct [c]	0
	N_2O Process Direct [d]	4,055
	TOTAL	**484,802**
Option 4	CO_2 Direct Energy [a]	517,174
	CO_2 Indirect Energy [b]	-39,177
	CO_2 Process Direct [c]	306
	N_2O Process Direct [d]	7,601
	TOTAL	**485,904**

(a) CO_2 from waste combustion
(b) CO_2 from the net exported or imported electricity
(c) CO_2 emitted from the de-NO_x process
(d) N_2O from de-NO_x and waste combustion

F4.1.8 Assessment of Costs

The different technologies discussed in the chapter carry with them various associated costs. The costs can be considered in terms of annualised costs, which include initial capital costs and financing costs (which are theoretically spread over the estimated life of the technology) and the maintenance and supply costs taking into account the revenue gained from energy recovery. For each technology, the costs vary between manufacturers but an estimate can be made. Capital and financing costs, as well as operating costs have been considered for waste preparation in the fluidised bed option.

The estimated annualised costs of each technology and consequently each option relative to the base case are shown in *Table F4.14*.

Table F4.14 Relative Annualised Costs for Each NO_x Abatement Technology and the Various Options

	Options				
	1 (Base Case)	**2**	**3**	**4**	**5**
Furnace					
Moving Grate	✓	✓	✓		
Fluidised Bed				✓	✓
Additional NO_x Reduction					
FGR			✓		
SNCR	✓		✓	✓	
SCR		✓			✓
Relative Annualised Costs to the Base Case in £k, for NO_x Abatement	**0**	**1,049**	**207**	**1,003**	**1,957**

The figures below show the relationship between the costs if implementing each option and the applicable assessment parameters from the H1 Software.

Figure F4.1 shows the relationship between the Long-term Air Quality EQ and the costs of implementing each Option.

Figure F4.1 Graph of Relative Annualised Costs versus Long-term Air Quality EQ

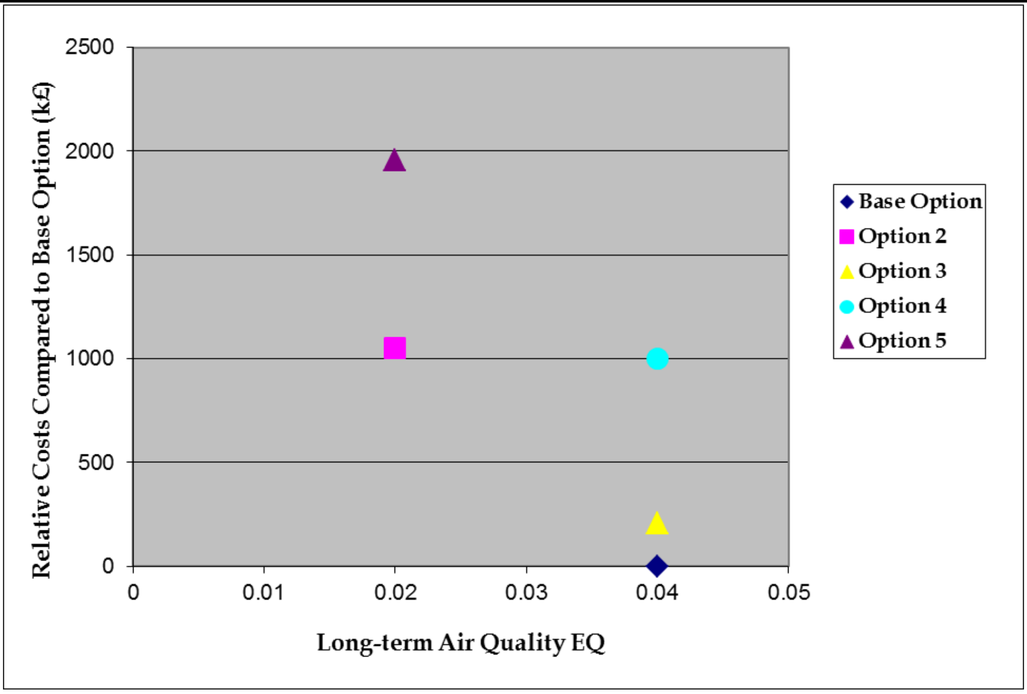


Figure F4.2 shows the relationship between the Short-term Air Quality EQ and the costs of implementing each Option.

Figure F4.2 ***Graph of Relative Annualised Costs versus Short-term Air Quality EQ***

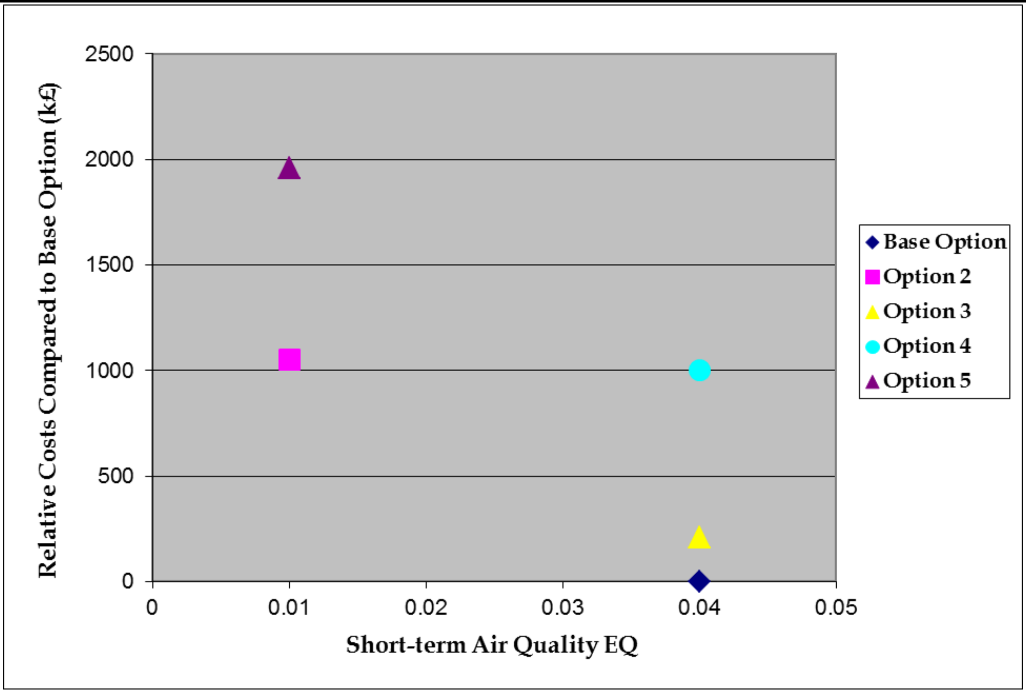


Figure F4.3 shows the relationship between the tonnes of pollutant (NO_2) abated and the costs of implementing each Option.

Figure F4.3 ***Graph of Relative Annualised Costs versus Tonnes of Pollutant Abated***

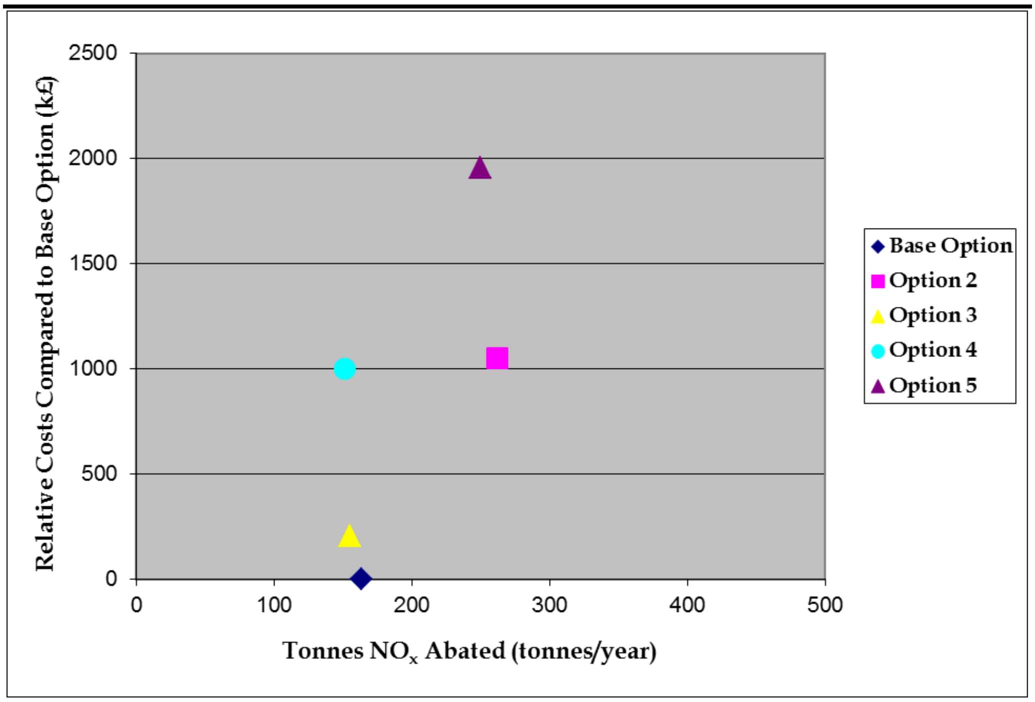


Figure F4.4 shows the relationship between the global warming potential and the costs of implementing each Option.

Figure F4.4 ***Graph of Relative Annualised Costs versus Global Warming Potential***

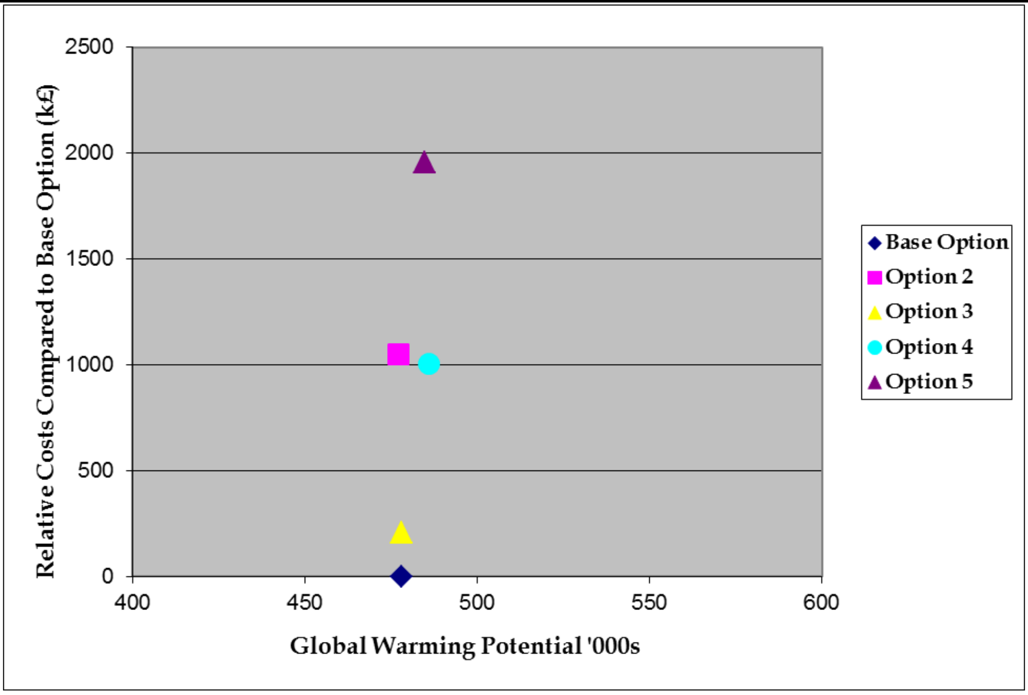


Figure F4.5 shows the relationship between the POCP and the costs of implementing each Option.

Figure F4.5 ***Graph of Relative Annualised Cost versus Photochemical Ozone Creation Potential (POCP)***

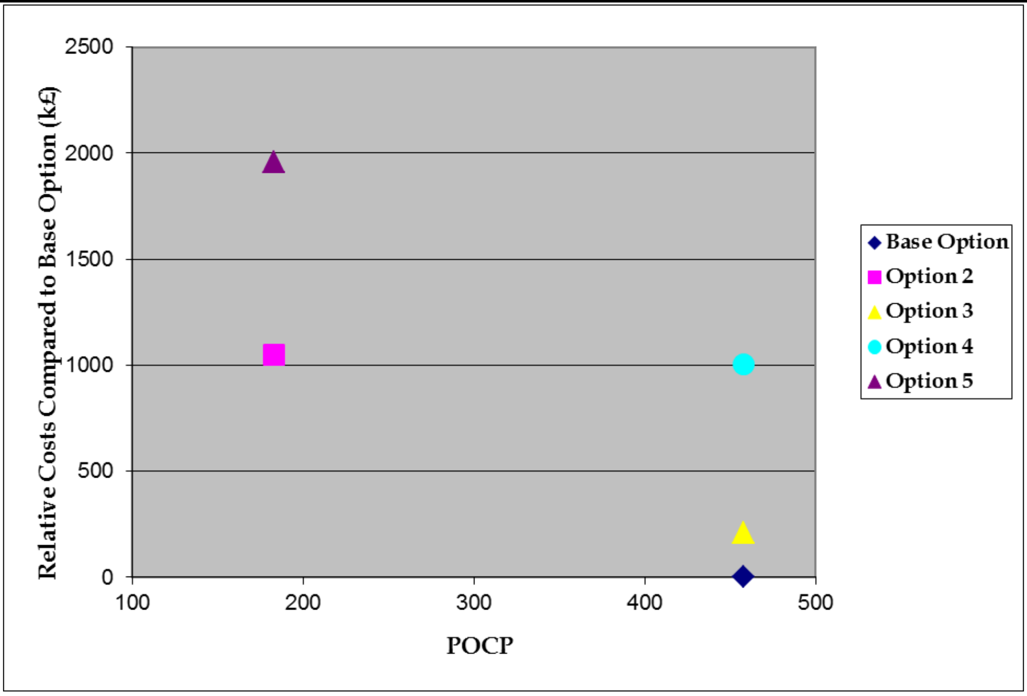


Figure F4.6 shows a graph of tonnes of NO_2 abated versus POCP.

Figure F4.6 Tonnes of NO_2 Abated versus POCP

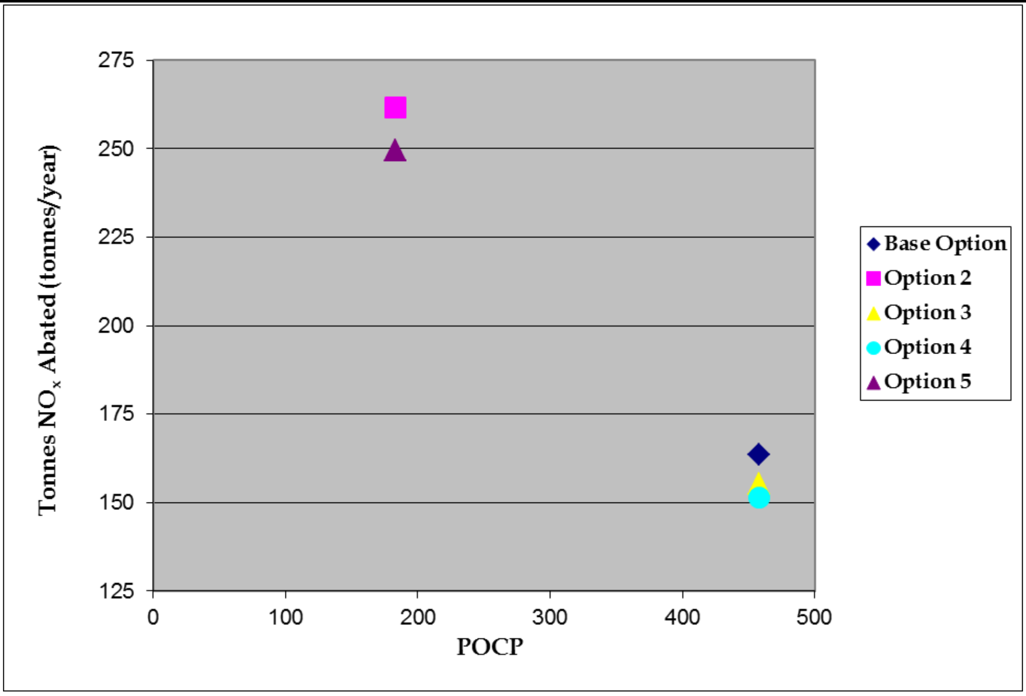
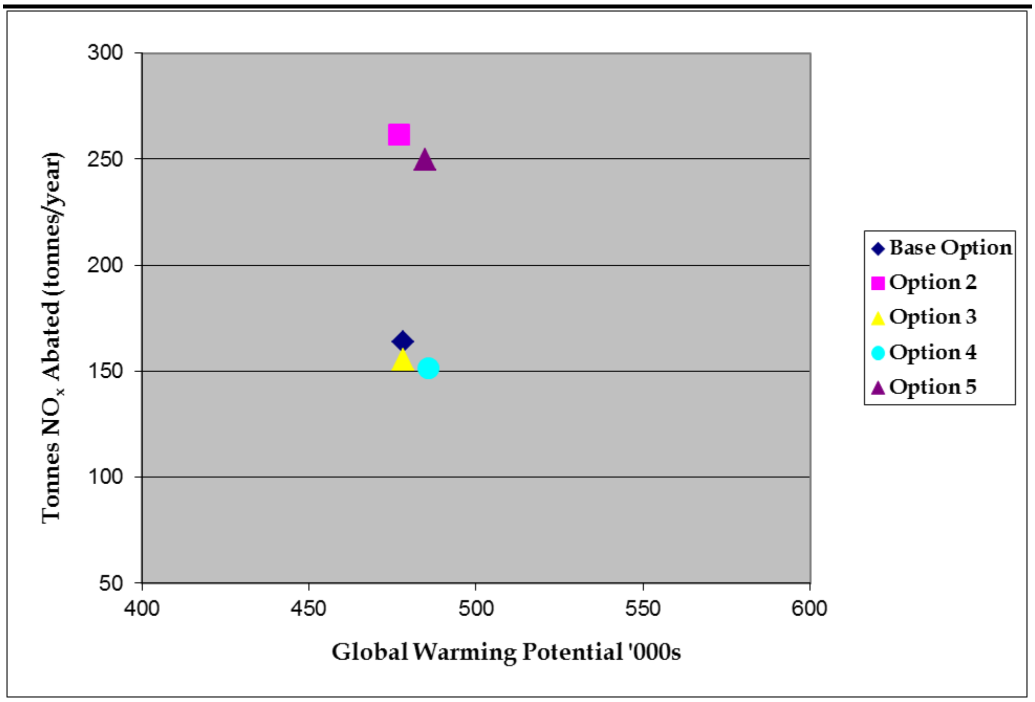


Figure F4.7 shows a graph of tonnes of NO_2 abated versus GWP.

Figure F4.7 Tonnes of NO_2 Abated versus GWP



F4.1.9 Identifying the Best Available Technique from Stage 1 Analysis

An overall comparison of the different options to ascertain the BAT in Stage 1 is now possible.

The Base Case, Option 2 and Option 3 perform better than Options 4 and 5 in terms of Waste Score.

Long-term Air Quality Environmental Quotients (*Figure F4.1)* vary only slightly, with Options 2 and 5 performing better than the Base Case and Option 3 and 4. There is a similar relative performance in terms of short-term Air Quality Environmental Quotients (*Figure F4.2)*.

Figure F4.3 illustrates that Options 2 and 5 deliver the greatest reduction in NO_x emissions. The Base Case performs marginally better than Options 4 and 3. With regards to GWP (see *Figure F4.4*) Option 2 performs marginally better than the Base Case (Option 1) and Option 3. Options 5 and 4 have the largest (worst) GWP.

Regarding POCP (*Figure F4.5)* the Base Case performs similarly to Options 3 and 4, whilst Options 2 and 5 deliver a marginally better performance in terms of POCP.

Option 5 is the most expensive, yet it does not deliver a substantial additional benefit in terms of NO_x abatement. In addition it has the highest GWP, emitting 6,682 tonnes/year of CO_2 more that the Base Case (Option 1). Consequently, Option 5 has been removed from further consideration.

Option 4 is more expensive than the Base Case, yet it delivers no added benefit in terms of tonnes of NO_x abated and performs worse in terms of GWP. It is also, therefore, removed from further consideration.

Option 2 and 3 performance in regards to GWP is very similar with little to distinguish between these two options. Option 2 has a lower short-term and long-term EQs, abates slightly more NO_2 and has a lower POCP compared to the Base Case (Option 1). The difference in the GWP performance between the options is insignificant (less than 1%).
Option 2 comes at an additional cost of £1,049,000 per year. This high additional annual cost is not considered commensurate with the additional benefit it provides and therefore it is excluded from the remainder of the assessment.

The two remaining options that perform the best are, therefore, the Base Case (Option 1) and Option 3. Option 3 is retained for further assessment against the Base Case in the Stage 2 BAT analysis. This is based on performance of NO_x abatement and GWP, which are the environmental priorities for this project, and cost.

F5 DETAILS OF THE BAT ANALYSIS – STAGE 2

F5.1 INTRODUCTION

The Stage 2 BAT analysis will subject the best two Options arising from the Stage 1 analysis (ie Option 1 and Option 3) to flue gas treatment (FGT) options, ie acid gas (SO_2) removal. The Stage 2 evaluated options are presented in *Table F5.1*.

Table F5.1 Base Case and Alternative Design Options with Annualised Costs– Stage 2 (Acid Gas Treatment)

	Option 1a (Base Case)	**Option 1b**	**Option 1c**	**Option 3a**	**Option 3b**	**Option 3c**
Furnace						
Moving Grate	✓	✓	✓	✓	✓	✓
Fluidised Bed						
Additional NOx Reduction						
FGR				✓	✓	✓
SNCR	✓	✓	✓	✓	✓	✓
FGT						
Acid Gas Removal						
Dry System	✓			✓		
Semi-dry System			✓			✓
Wet System		✓			✓	
Relative Annualised Costs to the Base Case in (k£)	**0**	**847**	**93**	**207**	**1,054**	**299**

Note: All options incorporate Fabric Filters and Activated Carbon Injection.

In Stage 2, the Base Case (Option 1a) has the dry system as the preferred acid gas removal option. This option is felt to give the best performance and the BAT analysis will examine this supposition.

Each of the candidate options detailed in *Table F5.1* was evaluated and compared for the following variables:

- emissions to air;
- energy consumption;
- raw materials; and
- waste streams.

F5.1.1 Emissions to Air

The unabated concentrations of the pollutants emitted to atmosphere for the different options included in the BAT Assessment are presented in *Table F5.2* below. NO_X has been evaluated as NO_2.

Table F5.2 Unabated Pollutant Concentrations from Stack (mg Nm^{-3})

Options	Unabated NO_2 Concentration[(a)]	Unabated SO_2 Concentration[(a)]
Option 1a (Base Case)	400	150
Option 1b	400	150
Option 1c	400	150
Option 3a	390	150
Option 3b	390	150
Option 3c	390	150

(a) Corrected for: Temperature; 273 K; Pressure; 101.3 kPa (1 atmosphere); dry; 11% v/v O_2.

Table F5.3 below shows the atmospheric emissions from each Option, with the percentage emission reductions shown in parentheses, when compared to the unabated case. *Table F5.4* shows the abated NO_X and SO_2 emissions.

Table F5.3 Concentrations (mg Nm^{-3}) and Emissions (g s^{-1}) for the Different Options Considered After Abatement

Options	NO_2 Long-term Concentration After Abatement mg Nm^{-3} (a)	NO_2 Emissions After Abatement g s^{-1}	SO_2 Concentration After Abatement mg Nm^{-3} (a) (b)	SO_2 Emissions After Abatement g s^{-1}
Option 1a (Base Case)	200 (50%)	5.68	50 (67%)	1.42
Option 1b	200 (50%)	5.68	19 (87%)	0.54
Option 1c	200 (50%)	5.68	50 (67%)	1.42
Option 3a	200 (49%)	5.68	50 (67%)	1.42
Option 3b	200 (49%)	5.68	19 (87%)	0.54
Option 3c	200 (49%)	5.68	50 (67%)	1.42

(a) Percentage reductions shown in parentheses, eg SO_2 emissions reduced 55% in Base Case compared to an unabated Base Case.

(b) Note that the short-term concentration for the Base case is 200 mg Nm^{-3} and the short-term concentrations for the other options are pro-rated accordingly

Table F5.4 NO_2 and SO_2 Emissions Abated (tonnes year^{-1})

Options	NO_2 Emissions Abated	SO_2 Emissions Abated
Option 1a (Base Case)	164	82
Option 1b	164	107
Option 1c	164	82
Option 3a	155	82
Option 3b	155	107
Option 3c	155	82

The impact of the atmospheric emissions in the Base Case has been taken from the detailed air quality modelling carried out as part of this Application. The impacts from the alternative options have been calculated by pro-rating the ground level concentrations by the emission rates for each alternative. The input data for the assessment is shown in *Table F5.5* below.

Table F5.5 ***Process Contributions ($\mu g\ m^{-3}$)[(a)]***

Options	Long Term NO_2	Short Term NO_2	Short Term SO_2
Option 1a (Base Case)	1.7	7.0	13.5
Option 1b	1.7	7.0	5.13
Option 1c	1.7	7.0	13.5
Option 3a	1.7	7.0	13.5
Option 3b	1.7	7.0	5.13
Option 3c	1.7	7.0	13.5

(a) If the process contributions are less than 1% of the EAL they are automatically screened out of the H1 assessment, however these are manually included to illustrate the difference between the options.

F5.1.2 Emissions to Water

Emissions to water have not been included in the BAT Assessment; these contributions are negligible.

F5.1.3 Energy Consumption

Table F5.6 illustrates the power requirements of the alternative design options relative to the Base Case.

Table F5.6 ***Power Requirements of the Alternative Design Options (kWh t_{MSW}^{-1}) [(a)]***

	Option 1a (Base Case)	Option 1b	Option 1c	Option 3a	Option 3b	Option 3c
Furnace						
Moving Grate Fluidised Bed (including preparation)	47	47	47	47	47	47
NO_x Reduction						
SNCR	1	1	1	0.95	0.95	0.95
SCR						
FGR				5	5	5
Acid Gas Removal						
Dry System	27			27		
Semi-dry System			29			29
Wet System		46			46	
Total (kWh/t_{MSW})	75	94	77	80	99	82

(a) The Base Case and all options incorporate Bag Filters and Activated Carbon Injection. All options exclude the MPT

Table F5.7 shows the figures for the energy consumption for the different options.

Table F5.7 Breakdown of Annual Delivered Energy Consumption (MWh year^{-1})

Options	Imported Electricity	Parasitic Self-Generated Electricity	Exported Electricity	Diesel	Waste
Option 1a (Base Case)	187	12,113	98,400	1,492	410,000
Option 1b	234	15,182	92,906	1,492	410,000
Option 1c	192	12,436	94,956	1,492	410,000
Option 3a	199	12,913	98,408	1,492	410,000
Option 3b	247	15,981	92,914	1,492	410,000
Option 3c	204	13,236	94,964	1,492	410,000

F5.1.4 Assessment of Greenhouse Gas Emissions

The emissions data for use in the assessment of greenhouse gases is detailed in *Table F5.8* below.

Table F5.8 Greenhouse Gas Emissions (tonnes year^{-1})

Options	N_2O from de-NO_x process/ flue gases	CO_2 from de-NO_x process	CO_2 from imported energy [a]	CO_2 from exported energy [a]	CO_2 from waste combustion	CO_2 from diesel
Option 1a (Base Case)	13.08	331	83	-43,493	517,174	388
Option 1b	13.08	331	104	-41,065	517,174	388
Option 1c	13.08	331	85	-41,971	517,174	388
Option 3a	13.08	314	88	-43,497	517,174	388
Option 3b	13.08	314	109	-41,068	517,174	388
Option 3c	13.08	314	90	-41,974	517,174	388

(a) CO_2 emissions associated with the generation of the power imported by the RERF and the CO_2 emissions offset by the export of energy to the National Grid.

F5.1.5 Assessment of Raw Materials

The use of raw materials in the Base Case has been taken from *Section 7 Raw and Auxiliary Materials*. The predicted usage of raw materials in the alternative options has been estimated and is show in *Table F5.9* below.

Table F5.9 Raw Materials Usage (tonnes year-1)

Options	Water	Caustic Soda, NaOH	Hydrated Lime, $Ca(OH)_2$	Quick Lime, CaO	Activated Coke	Activated Carbon
Option 1a (Base Case)	41,000	0	1,912	0	0	54
Option 1b	149,240	512	0	158	40	0
Option 1c	68,060	0	0	5,000	0	54
Option 3a	41,000	0	1,912	0	0	54
Option 3b	149,240	512	0	158	40	0
Option 3c	68,060	0	0	5,000	0	54

F5.1.6 *Assessment of Waste Streams*

The quantities of materials in the waste streams of the Base Case have been taken from the mass balance in the EP Application. *Table F5.10* below shows the waste streams that are predicted for the alternative options.

Table F5.10 Waste Streams (tonnes year-1)

Options	Bottom Ash	Ferrous Metals	FGT Residue	FGT Sludge
Option 1a (Base Case)	37,720	820	6,560	0
Option 1b	37,720	820	3,509	41,590
Option 1c	37,720	820	6,560	0
Option 3a	37,720	820	6,560	0
Option 3b	37,720	820	3,509	41,590
Option 3c	37,720	820	6,560	0
Hazard Category	Non-Hazardous	Inert	Hazardous	Hazardous
Disposal Method	Recycling	Recycling	Landfill	Landfill
Distance in km	50 - 100	50 - 100	200-300	200-300

This is a conservative assessment as it is likely that the FGT residue will be pre-treated into a non-hazardous form, prior to landfill.

F5.1.7 *Comparison of Impacts*

The results of this BAT Assessment are presented in the form of the tables and graphs produced by the H1 Software. These are presented in the *Stage 2 Appendix* at the rear of this document.

The Options are compared for each environmental topic. For Stage 2 BAT analysis, the costs of the options relative to the Base Case are included, in addition to environmental performance.

Air Quality

The Environmental Quotients (EQs) for each of the options are ranked in *Table F5.11* below. Both the long term and short term EQs are very similar, with the small change in SO_2 EQs making the difference across all Options.

Table F5.11 Air Quality Environmental Quotients (EQs)

Options	Long Term Air Quality EQ	Short Term Air Quality EQ[a]
Option 1b	0.04	0.05
Option 3b	0.04	0.05
Option 1a (Base Case)	0.04	0.07
Option 1c	0.04	0.07
Option 3a	0.04	0.07
Option 3c	0.04	0.07

[a] Sum of EQs for NO_X and SO_2

Waste

The Waste Scores for each of the Options is ranked in ascending order in *Table F5.12* below.

Table F5.12 Waste Hazard and Disposal

Options	Waste Score
Option 1a (Base Case)	2,875,740
Option 1b	2,875,740
Option 1c	2,875,740
Option 3c	2,875,740
Option 1b	14,437,440
Option 3b	14,437,440

Photochemical Ozone Creation Potential (POCP)

The POCP for Options 1a, 1c, 3a and 3c is 654. For Options 1a and 1b the POCP is 533.

Global Warming Potential (GWP)

The GWP for each substance assessed for each of the Options is ranked in ascending order in *Table F4.13* below.

Table F5.13 Global Warming Potential (GWP)

Options	Substance	Global Warming Potential
Option 3a	CO_2 Direct Energy (a)	517,562
	CO_2 Indirect Energy (b)	-43,408
	CO_2 Process Direct (c)	314
	N_2O Process Direct (d)	4,055
	TOTAL	**478,522**
Base Case (Option 1a)	CO_2 Direct Energy (a)	517,562
	CO_2 Indirect Energy (b)	-43,410
	CO_2 Process Direct (c)	331
	N_2O Process Direct (d)	4,055
	TOTAL	**478,538**
Option 3c	CO_2 Direct Energy (a)	517,562
	CO_2 Indirect Energy (b)	-41,884
	CO_2 Process Direct (c)	314
	N_2O Process Direct (d)	4,055
	TOTAL	**480,047**
Option 1c	CO_2 Direct Energy (a)	517,562
	CO_2 Indirect Energy (b)	-41,886
	CO_2 Process Direct (c)	331
	N_2O Process Direct (d)	4,055
	TOTAL	**480,062**
Option 3b	CO_2 Direct Energy (a)	517,562
	CO_2 Indirect Energy (b)	-40,959
	CO_2 Process Direct (c)	314
	N_2O Process Direct (d)	4,055
	TOTAL	**480,972**
Option 1b	CO_2 Direct Energy (a)	517,562
	CO_2 Indirect Energy (b)	-40,961
	CO_2 Process Direct (c)	331
	N_2O Process Direct (d)	4,055
	TOTAL	**480,987**

(a) CO_2 emissions from the combustion of waste and oil
(b) CO_2 emissions from the net export and import of electricity
(c) CO_2 emissions from the de-NO_x process
(d) N_2O emissions from the combustion and de-NO_x process

F5.1.8 Assessment of Costs

This section presents the assessment of the options based on their associated costs relative to the base case. As in *Section F4.1.8*, this is based on the annualised costs of the technologies.

The annualised costs for the different options are presented below.

Table F5.14 ***Relative Annualised Costs (k£ year-1)***

Options	Relative Annualised Costs to the Base Case (k£)
Option 1a (Base Case)	0
Option 1b	838
Option 1c	98
Option 3a	199
Option 3b	1037
Option 3c	297

Figure F5.1 and *Figure F5.2* show the long-term and short-term air quality EQs, respectively, against the annualised costs.

Figure F5.1 ***Graph of Long-term Air Quality Environmental Quotient versus Relative Annualised Costs***

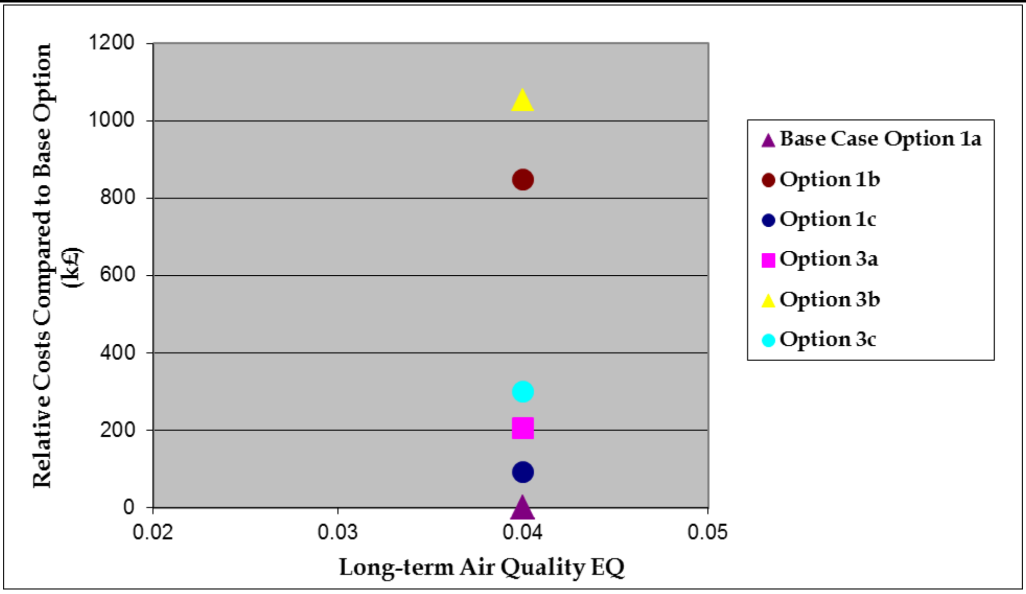


Figure F5.2 *Graph of Short-term Air Quality Environmental Quotient versus Relative Annualised Costs*

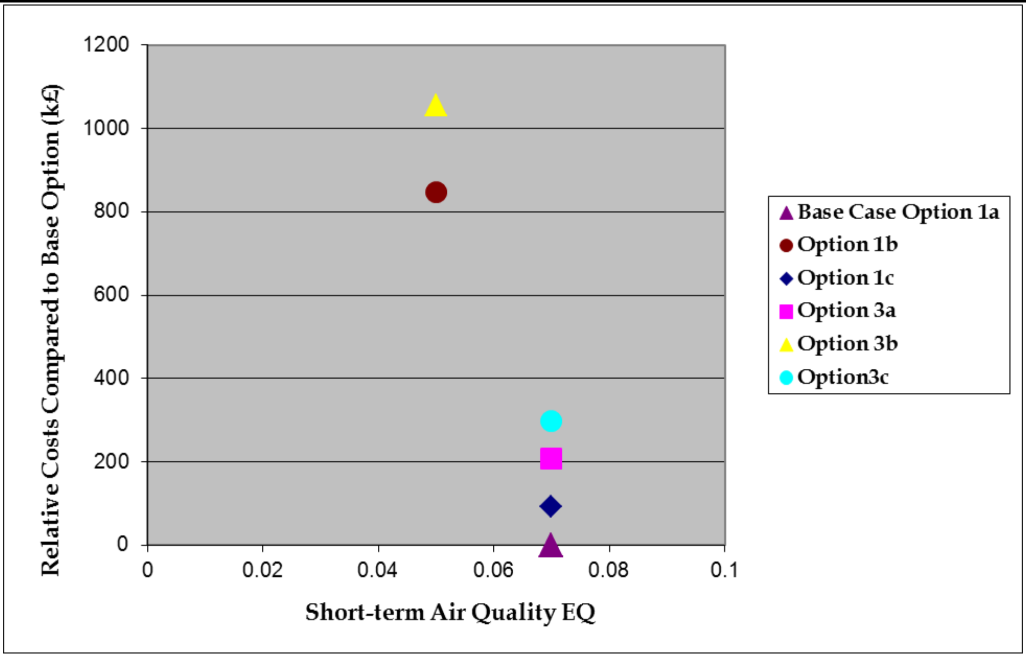


Figure F5.3 and *Figure F5.4* shows the tonnes of NO_2 and SO_2 abated and the GWP against the annualised costs respectively.

Figure F5.3 *Graph of NO_2 and SO_2 Abated versus Relative Annualised Costs*

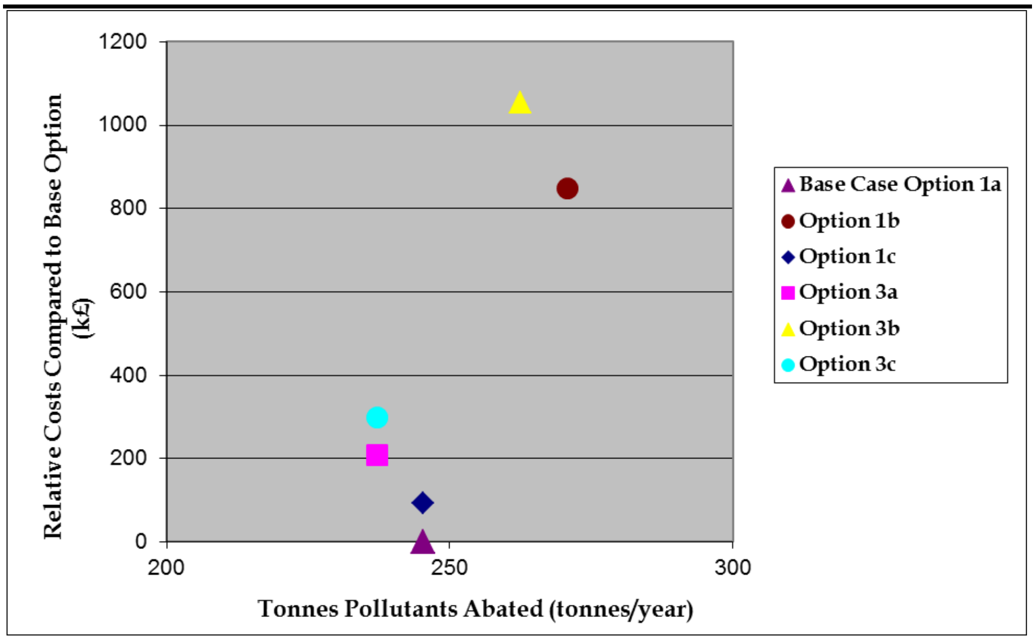


Figure F5.4 *Graph of Global Warming Potential versus Relative Annualised Costs*

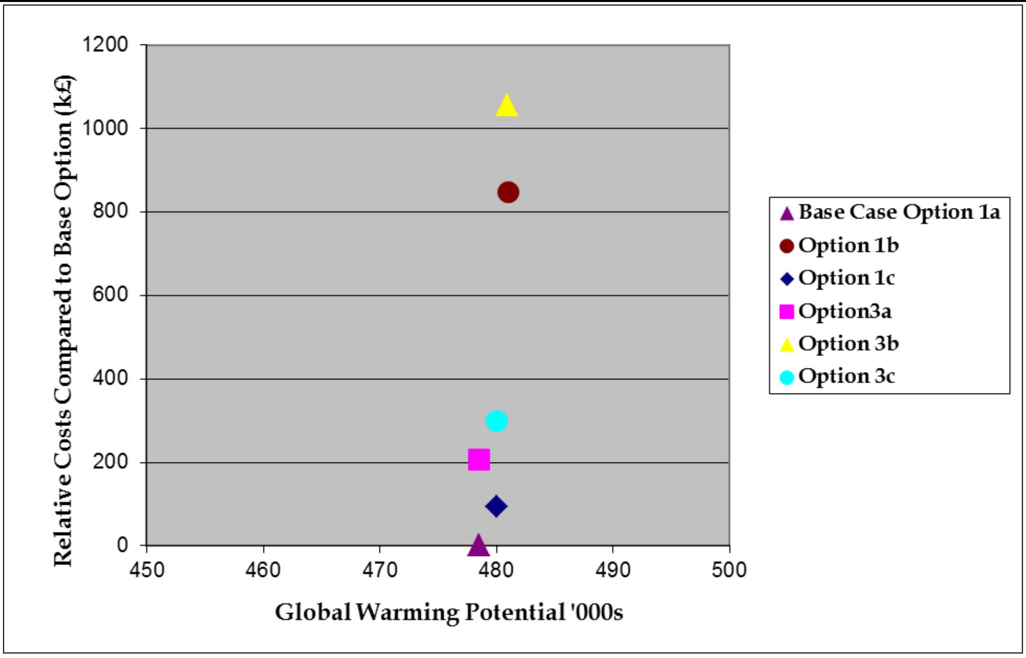
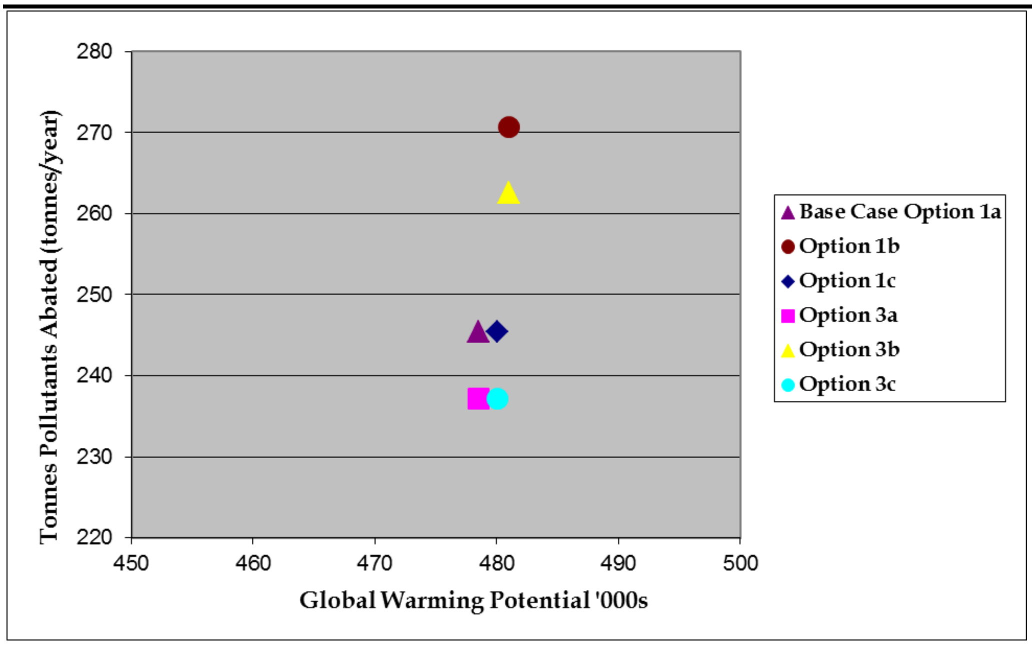


Figure F5.5 shows the tonnes of NO_2 and SO_2 abated against the GWP.

Figure F5.5 *Graph of NO_2 and SO_2 Abated versus Global Warming Potential*



Options 1b and 3b (wet scrubbing options for SO_2 removal) have the largest waste score due to the large volumes of FGT sludge requiring disposal. Although these Options have lower POCP, they have the highest (worst) GWP of the options and cost significantly more than the other four options. Based on these criteria, Options 1b and 3b are not considered to be BAT, and are not considered further in this Assessment.

Of the remaining options, there is no difference for long-term EQs (as this is based solely on NO_x performance), only a small difference in short- term EQs (that include both NOx and SO_2) and no difference in the waste score and POCP. The two key parameters for this Assessment are therefore considered to be GWP and tonnes of pollutant abated.

Figure F5.5 shows the relationship between tonnes of pollutant abated and GWP. The Base Case and Option 3a have similar GWP, but the Base Case abates more tonnes of pollutants, so Option 3a can be disregarded. Option 3c delivers a lower performance in terms of tonnes of pollutant abated and has a higher GWP so is also excluded from further assessment. Options 1b and 3b perform marginally better than the Base Case and Option 1c in terms of abatement, however there is a consequential burden in GWP. In order to maximise pollutant abatement, while minimising GWP, the two remaining Options to consider are therefore the Base Case and Option 1c.

The GWP for the Base Case and Option 1c are 478,536 and 480,062 respectively, and the tonnes of pollutant abated is 246 tonnes/year for both options. The annualised costs are also very similar. With no difference in the tonnes of pollutants abated, and only a small difference in GWP (Option 1c performing marginally worse than Base Case by 1,524), Option 1c is removed from further consideration for BAT.

The minimisation of local air quality pollutants, the reduction of local air quality burden and the minimisation of global warming potential are environmental priorities for this project. The Base Case is considered BAT for this installation as it delivers sufficient minimisation of emissions of local air quality pollutants whilst not leading to excessive dis-benefit to global warming.

F7 CONCLUDING REMARKS AND SUMMARY

A BAT analysis of the relative merits of the Base Case Option for the operation of the Leeds ERF in comparison with alternative options has been carried out using H1. This analysis has been carried as an iterative process, and has focused mainly on the possible options to control releases to atmosphere of NO_x (as NO_2) and SO_2.

This Assessment concludes that the Base Case is BAT for this project, as it is the most cost-effective while maintaining the environmental performance in terms of achieving WID without excessive dis-benefit to global warming.

Nevertheless, it should be borne in mind that all of these technologies are very similar in terms of the environmental performance. The actual separation expressed in terms of environmental performance is fairly marginal. Therefore, cost provides a greater degree of separation between the Options than does their impact on the environment.

Appendix F1

Stage 1 Graphs & Tables

Air Summary Tables

(Substances screened as insignificant are not shown)

Option 1 - Base-Case (Option 1)

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
						Total:	**0.04**

Option 2 - Option 2

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	0.68	32.48	1.70	81.20	0.02
						Total:	**0.02**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	2.8	66.40	1.40	33.20	0.01
						Total:	**0.01**

Option 3 - Option 3

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
						Total:	**0.04**

Option 4 - Option 4

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
						Total:	**0.04**

Option 5 - Option 5

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	0.68	32.48	1.70	81.20	0.02
						Total:	**0.02**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	2.8	66.40	1.40	33.20	0.01
						Total:	**0.01**

Option Summary

Long Term Option Summary

Substance Assessed	Option	% PC of EAL	% PEC of EAL	EQ
Nitrogen Dioxide	1	4.25	83.75	0.04
	2	1.70	81.20	0.02
	3	4.25	83.75	0.04
	4	4.25	83.75	0.04
	5	1.70	81.20	0.02

Global Warming Potential Summary Tables

(Substances screened as insignificant are not shown)

Option	Substance	GWP
Option 1 - Base-Case (Option 1)	C02 Energy: direct	517174
	C02 Energy: indirect	-43439.76
	Carbon dioxide Process: direct	331
	Nitrous oxide Process: direct	4054.8
Option 2 - Option 2	C02 Energy: direct	517174
	C02 Energy: indirect	-40695.382
	Carbon dioxide Process: direct	0
	Nitrous oxide Process: direct	505.3
Option 3 - Option 3	C02 Energy: direct	517174
	C02 Energy: indirect	-43437.992
	Carbon dioxide Process: direct	314
	Nitrous oxide Process: direct	4054.8
Option 4 - Option 4	C02 Energy: direct	517174
	C02 Energy: indirect	-39177.112
	Carbon dioxide Process: direct	306
	Nitrous oxide Process: direct	7601.2
Option 5 - Option 5	C02 Energy: direct	517174
	C02 Energy: indirect	-36426.988
	Carbon dioxide Process: direct	0
	Nitrous oxide Process: direct	4054.8

Photochemical Ozone Creation Potential Summary Tables

(Substances screened as insignificant are not shown)

Option	Substance	POCP
Option 1 - Base-Case (Option 1)	Nitrogen Dioxide	458.024
Option 2 - Option 2	Nitrogen Dioxide	183.204
Option 3 - Option 3	Nitrogen Dioxide	458.024
Option 4 - Option 4	Nitrogen Dioxide	458.024
Option 5 - Option 5	Nitrogen Dioxide	183.204

Waste Stream Summary Tables

Option	Impact Score	Normalised Impact
Option 1 - Base-Case (Option 1)	907740	1

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	Bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	Ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460

Option 2 - Option 2	907740	1

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	Bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	Ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460

Option 3 - Option 3	907740	1

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	Bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	Ferous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460

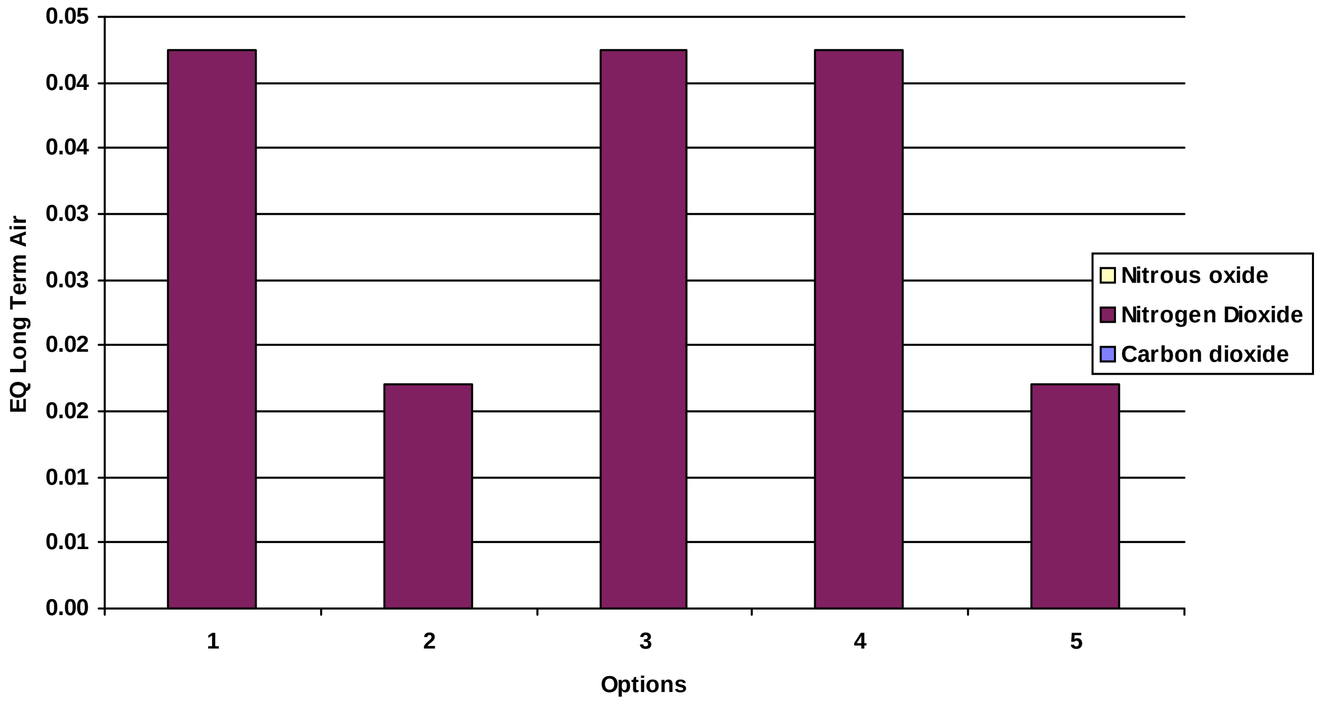
Option 4 - Option 4	1006140	1.1084010840108

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	Bottom ash	41820	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	1003680
2	Ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460

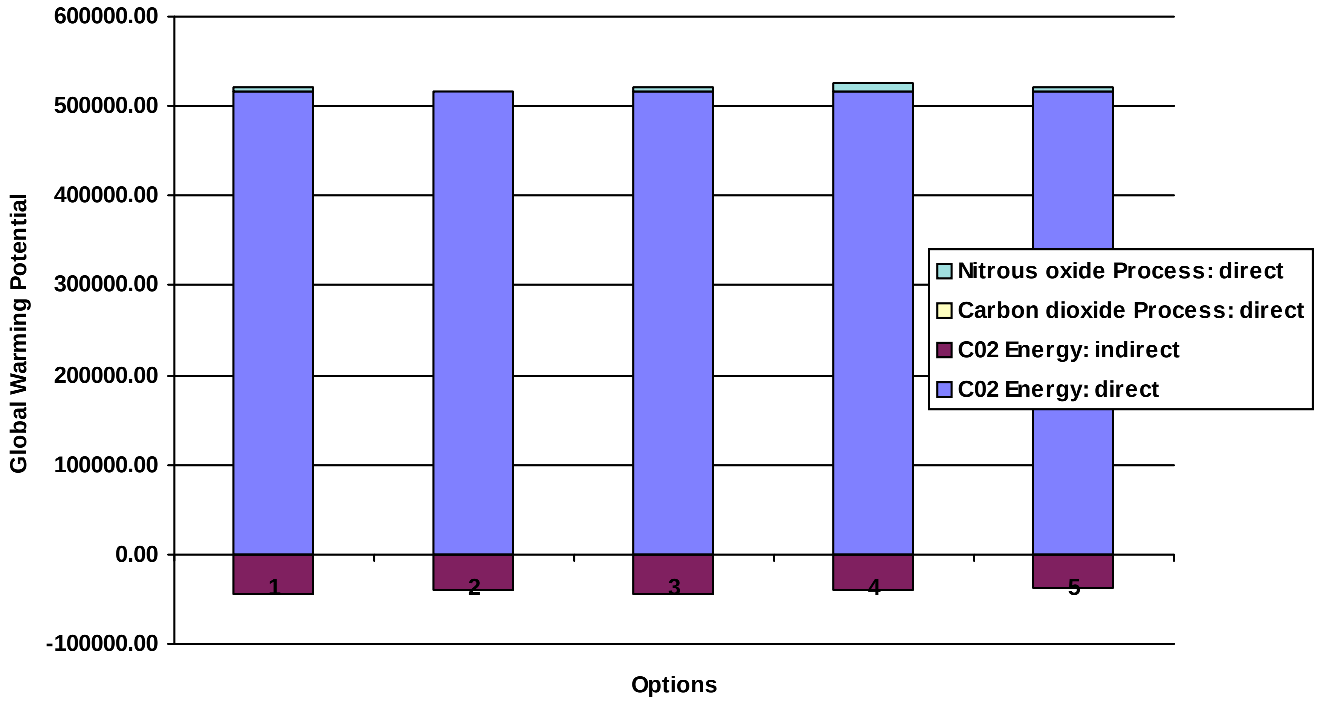
Option 5 - Option 5	1006140	1.1084010840108

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	Bottom ash	41820	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	1003680
2	Ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460

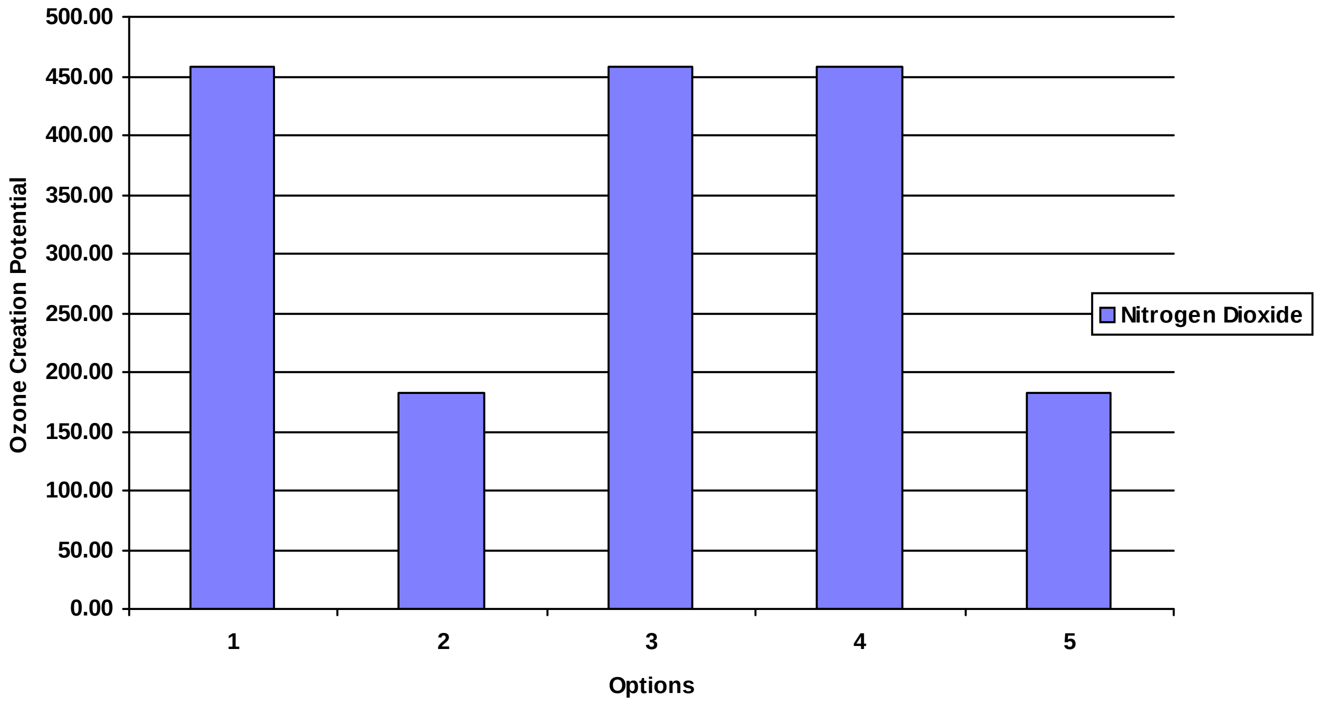
Air Long Term Effects - Total EQ by Option



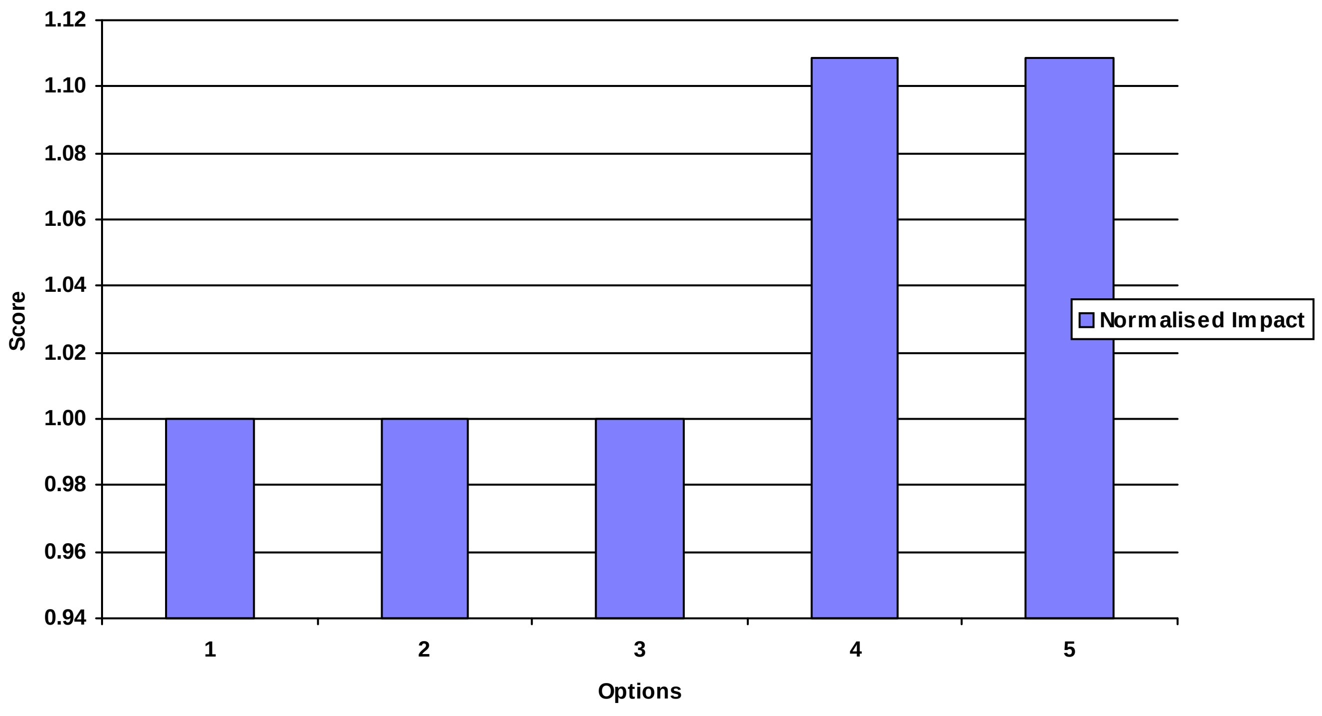
Global Warming - Substance Comparison



Ozone Creation - Substance Comparison



Waste - Option Comparison



Appendix F2

Stage 2 Graphs & Tables

Air Summary Tables

(Substances screened as insignificant are not shown)

Option 1 - Base-Case (Option 1) A

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
Sulphur Dioxide (1 Hour Mean)		350	13.5		3.86		0.04
						Total:	**0.07**

Option 2 - Option 1B

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
Sulphur Dioxide (1 Hour Mean)		350	5.13		1.47		0.01
						Total:	**0.05**

Option 3 - Option 1C

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
Sulphur Dioxide (1 Hour Mean)		350	13.5		3.86		0.04
						Total:	**0.07**

Option 4 - Option 3A

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
Sulphur Dioxide (1 Hour Mean)		350	13.5		3.86		0.04
						Total:	**0.07**

Option 5 - Option 3B

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
Sulphur Dioxide (1 Hour Mean)		350	5.13		1.47		0.01
						Total:	**0.05**

Option 6 - Option 3C

Release Points

Number	Description	Location	Effective Height	Efflux Velocity	Total Flow
			metres	m/s	m3/hr
1	1	Stack 1	75	22.2	102240

Long Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	31.8	40	1.7	33.50	4.25	83.75	0.04
						Total:	**0.04**

Short Term Impact

Substance Assessed	Background Contribution	EAL	PC	PEC	% PC of EAL	% PEC of EAL	EQ
	µg/l	µg/m3	µg/m3	µg/m3			
Nitrogen Dioxide	63.6	200	7	70.60	3.50	35.30	0.04
Sulphur Dioxide (1 Hour Mean)		350	13.5		3.86		0.04
						Total:	**0.07**

Option Summary

Long Term Option Summary

Substance Assessed	Option	% PC of EAL	% PEC of EAL	EQ
Nitrogen Dioxide	1	4.25	83.75	0.04
	2	4.25	83.75	0.04
	3	4.25	83.75	0.04
	4	4.25	83.75	0.04
	5	4.25	83.75	0.04
	6	4.25	83.75	0.04

Global Warming Potential Summary Tables

(Substances screened as insignificant are not shown)

Option	Substance	GWP
Option 1 - Base-Case (Option 1) A	C02 Energy: direct	517561.92
	C02 Energy: indirect	-43410.146
	Carbon dioxide Process: direct	331
	Nitrous oxide Process: direct	4054.8
Option 2 - Option 1B	C02 Energy: direct	517561.92
	C02 Energy: indirect	-40961.024
	Carbon dioxide Process: direct	331
	Nitrous oxide Process: direct	4054.8
Option 3 - Option 1C	C02 Energy: direct	517561.92
	C02 Energy: indirect	-41885.688
	Carbon dioxide Process: direct	331
	Nitrous oxide Process: direct	4054.8
Option 4 - Option 3A	C02 Energy: direct	517561.92
	C02 Energy: indirect	-43408.378
	Carbon dioxide Process: direct	314
	Nitrous oxide Process: direct	4054.8
Option 5 - Option 3B	C02 Energy: direct	517561.92
	C02 Energy: indirect	-40958.814
	Carbon dioxide Process: direct	314
	Nitrous oxide Process: direct	4054.8
Option 6 - Option 3C	C02 Energy: direct	517561.92
	C02 Energy: indirect	-41883.92
	Carbon dioxide Process: direct	314
	Nitrous oxide Process: direct	4054.8

Waste Stream Summary Tables

Option	Impact Score	Normalised Impact
Option 1 - Base-Case (Option 1) A	2875740	1

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	Bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	Ferous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460
3	FGT residue	6560	Landfill (D5)	30	hazardous	10	1968000
4	FGT sludge	0	Landfill (D5)	30	hazardous	10	0

Option	Impact Score	Normalised Impact
Option 2 - Option 1B	14437440	5.020426046861

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460
3	FGT residue	3509	Landfill (D5)	30	hazardous	10	1052700
4	FGT sludge	41590	Landfill (D5)	30	hazardous	10	12477000

Option	Impact Score	Normalised Impact
Option 3 - Option 1C	2875740	1

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460
3	FGT residue	6560	Landfill (D5)	30	hazardous	10	1968000
4	FGT sludge	0	Landfill (D5)	30	hazardous	10	0

Option	Impact Score	Normalised Impact
Option 4 - Option 3A	2875740	1

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460
3	FGT residue	6560	Landfill (D5)	30	hazardous	10	1968000
4	FGT sludge	0	Landfill (D5)	30	hazardous	10	0

Option	Impact Score	Normalised Impact
Option 5 - Option 3B	14437440	5.020426046861

Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	Bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460
3	FGT residue	3509	Landfill (D5)	30	hazardous	10	1052700
4	FGT sludge	41590	Landfill (D5)	30	hazardous	10	12477000

Option	Impact Score	Normalised Impact
Option 6 - Option 3C	2875740	1

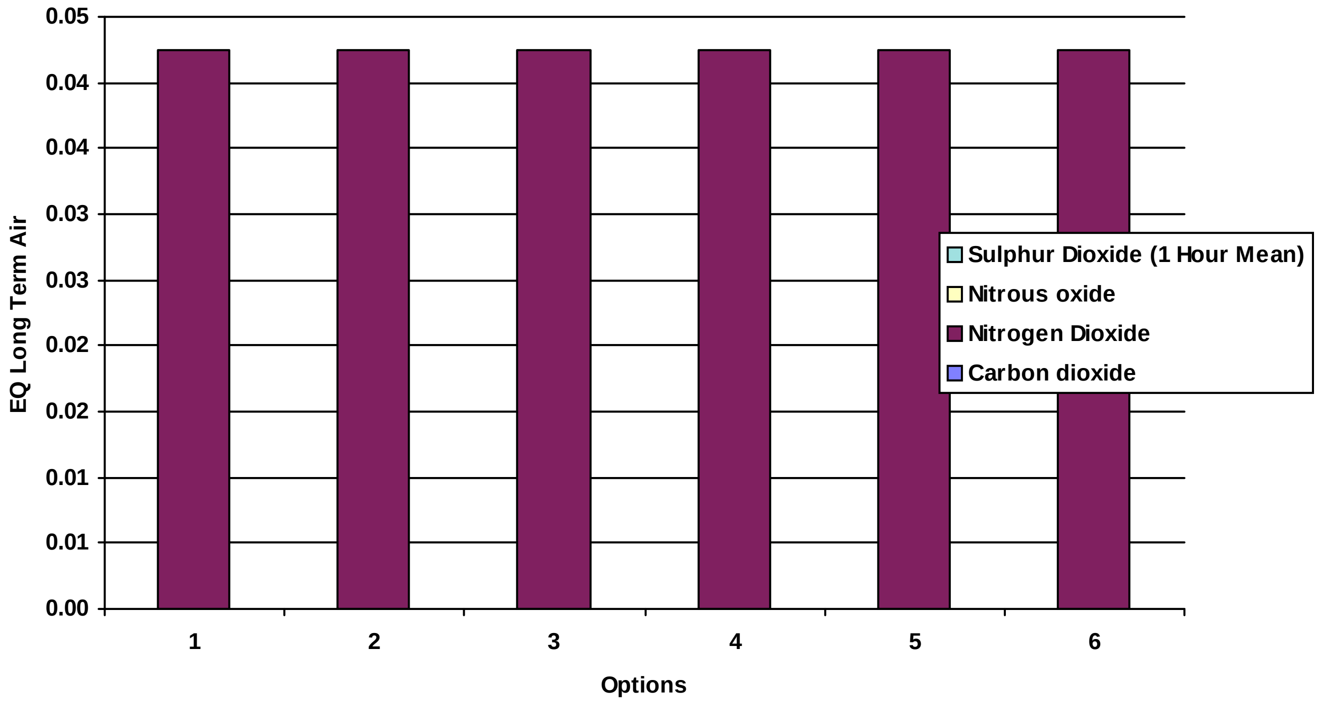
Number	Waste Stream:	Quantity:	Method	Score:	Waste Category:	Score:	Impact Score:
1	bottom ash	37720	Other Recycling (R3:R4:R5:R11	3	stable non-reactive hazardo	8	905280
2	ferrous metals	820	Other Recycling (R3:R4:R5:R11	3	inert	1	2460
3	FGT residue	6560	Landfill (D5)	30	hazardous	10	1968000
4	FGT sludge	0	Landfill (D5)	30	hazardous	10	0

Photochemical Ozone Creation Potential Summary Tables

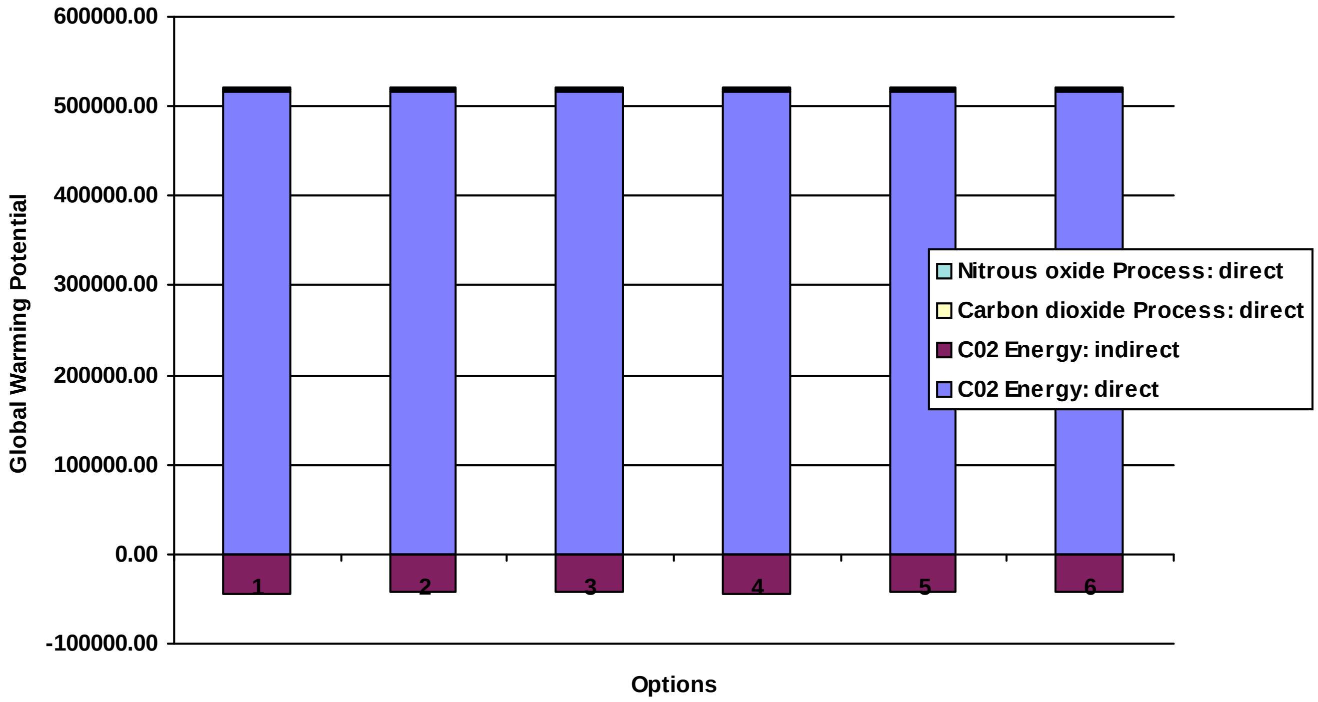
(Substances screened as insignificant are not shown)

Option	Substance	POCP
Option 1 - Base-Case (Option 1) A	Nitrogen Dioxide	458.024
	Sulphur Dioxide (1 Hour Mean)	196.32
Option 2 - Option 1B	Nitrogen Dioxide	458.024
	Sulphur Dioxide (1 Hour Mean)	74.592
Option 3 - Option 1C	Nitrogen Dioxide	458.024
	Sulphur Dioxide (1 Hour Mean)	196.32
Option 4 - Option 3A	Nitrogen Dioxide	458.024
	Sulphur Dioxide (1 Hour Mean)	196.32
Option 5 - Option 3B	Nitrogen Dioxide	458.024
	Sulphur Dioxide (1 Hour Mean)	74.592
Option 6 - Option 3C	Nitrogen Dioxide	458.024
	Sulphur Dioxide (1 Hour Mean)	196.32

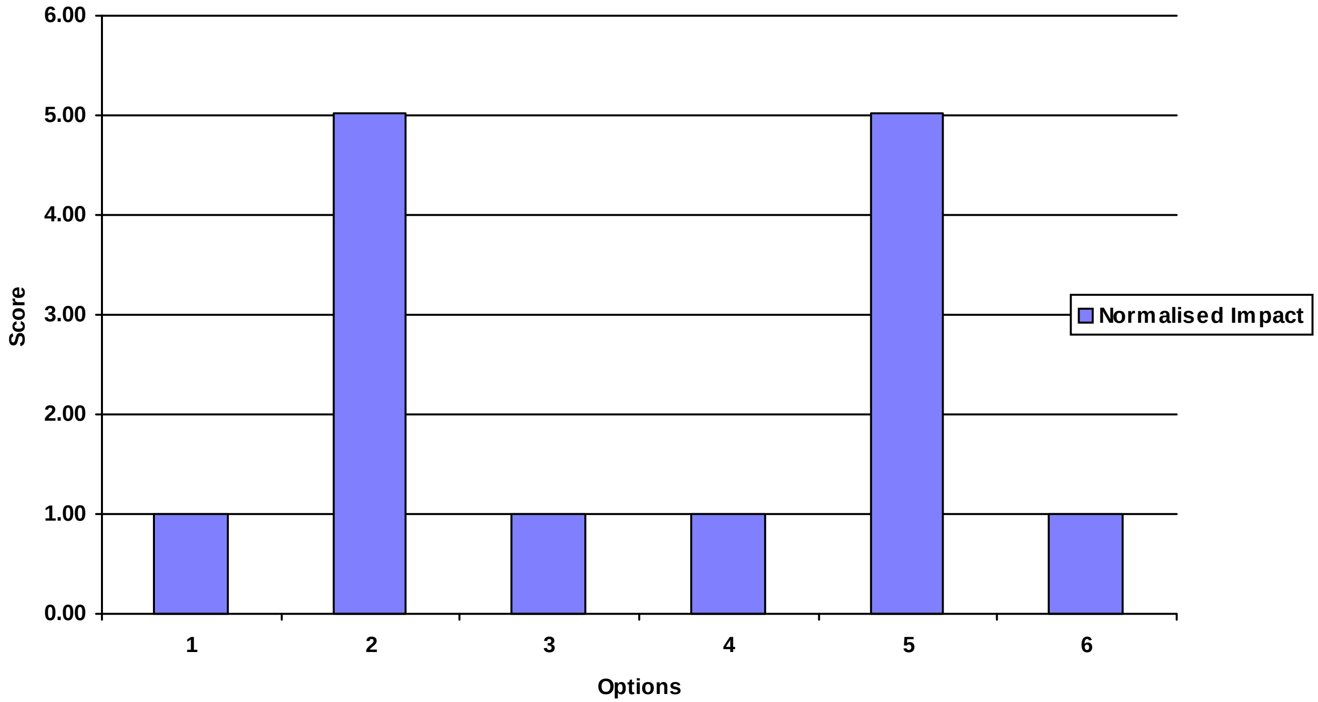
Air Long Term Effects - Total EQ by Option



Global Warming - Substance Comparison



Waste - Option Comparison



Ozone Creation - Substance Comparison