PARRY'S QUARRY LANDFILL, ALLTAMI, FLINTSHIRE

Environmental Permit Application

Environmental Setting and Installation Design Report

Prepared for: Mold Investments Limited

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1.0 Introduction

1.1 Report Context

SLR Consulting Limited (SLR) has been instructed by Mold Investments Limited (Mold), the Operator, to prepare an application for an Environmental Permit for Parry's Quarry Landfill and Waste Transfer Station (WTS) in Mold, Flintshire under the Environmental Permitting (EP) (England and Wales) Regulations 2016.

This report sets out the details of the conceptual model of the sites environmental setting and installation design (ESID), and it should be read in conjunction with the supporting risk assessments included in this EP application;

- Stability Risk Assessment (SRA) (Ref: 416.07238.00001/SRA) in Section 7;
- Hydrogeological Risk Assessment (HRA) (Ref: 66388R1D1) in Section 8; and
- Landfill Gas Risk Assessment (LFGRA) (Ref: 416.07238.00001/LFGRA) in Section 9.

1.2 Installation Details

The site is currently operated as a brick clay quarry which covers an area of approximately 17 hectares. An area of the wider site holds an EP (Ref: EPR/TB3590HJ) for the transfer and reprocessing of inert waste. This EP application seeks to consolidate this activity within the overall landfill EP for the site.

The proposed landfill operations will comprise the restoration of the quarry void space using non-hazardous non-biodegradable waste, biodegradable wastes (only in Cell 6) and inert waste within fully engineered contained cells. The landfill will be below ground with the base of the cell and engineered containment being above groundwater levels.

The local topography is undulating and formed from a series of ridges and valleys. The site is situated at an elevation of circa 105mAOD on the site of the valley with the land to the south west riding up towards New Brighton at circa 145mAOD and falling away towards the north east towards the Wepre Brook, which is at an elevation of approximately 55mAOD. The wider topography is generally falling towards the River Dee Estuary which is at an elevation of circa 5mAOD approximately 4.5km to the north of site.

1.3 Site Location

The site is situated within the existing Parry's Quarry in Alltami, Flintshire and bounded by the A494 to the south, A55 to the north and Pinfold Road to the west. The National Grid Reference (NGR) for the entrance to the site is SJ 27478 66278.

The remaining land use immediately surrounding the proposed site is predominately agricultural land, with scattered residential and commercial / industrial premises. Access to the site will be via Pinfold lane. The site's location is illustrated on Drawing ESID1, and the site layout on Drawing ESID2.

All surrounding land uses and receptors within 1km are identified on Drawing ESID3 and all cultural and natural heritage is illustrated on Drawing ESID4.

A summary of the site's immediate surrounding land uses is identified in Table 1-1 below.

Table 1-1: Surrounding Land Uses

Boundary	Description
North	Ewloe Wood House and commercial/industrial properties are located adjacent to the northern boundary beyond which lies the A55 and a service station (eastbound on the A55) including a petrol station, hotel and restaurant. Also, to the north of the site beyond the immediate surrounding is the residential conurbation of Northop Hall and the Northop Hall Country House Hotel. The outskirts of Northop Hall are located approximately 600m to the north.
East	To the east of the site is the westbound A55 Service Station, including an unnamed residential property, beyond which lies the A55 and agricultural land. The small town of Ewloe Green and the larger conurbation of Ewloe are located 550m and 1km respectively to the east.
South	Adjacent to the south of the site is an area of small woodland beyond which lies the A494. Beyond the A494 is a large building supply merchant and other commercial/industrial premises. The further surrounding land is predominately agricultural land with scattered residential buildings (farm houses) including Parrys Cottage and the Pottery Cottages. A further large commercial / industrial estate is located within 1km to the south. The south eastern edge of the site encompasses part of multi designated Buckley Claypits and Commons Site of Special Scientific Interest (SSSI) / Deeside and Buckley Newt Site Special Area of Conservation (SAC).
West	Pinfold Lane is located immediately to the west. A disused quarry is located off Pinfold Lane, beyond which lies predominately agricultural land and scattered residential/agricultural buildings, including Pinfold Cottage and Alltami House. The town of Alltami is located approximately 640m to the southwest. Also adjacent to the west and southwest of the site is numerous commercial/industrial premises.

1.4 Residential Properties

The closest residential properties and farms are detailed in Table 1-2 below:

Table 1-2: Residential Properties within 1km of the EP Boundary

Property Reference or Name	Direction from site	Approximate Distance from Boundary
Parrys Cottages	SE	20m
Pottery Cottages	SE	200m
Properties off Smithy Lane	SE	400m
Properties off A494	SE	550m
Unnamed property accessed via the service station	E	55m
The Box	N	80m
Ewloe House	N	120m

Property Reference or Name	Direction from site	Approximate Distance from Boundary
Pinfold House	NW	130m
Old Farm Cottages	N	360m
Penfold Cottage	NW	400m
Gell Farm	N	300m
Oak Farm	S	350m
Ewloe Green Farm	E	750m
Brook Park Farm	N	500m

1.5 Ecology

The following information has been assessed in order to determine the ecological site setting:

- MAGIC Mapping Website[1];
- NRW Designated Sites Tool[2]; and
- Woodland Trust's Ancient Tree Inventory[3].

1.5.1 European/International Sites

Searches on the MAGIC website confirm that there are no Special Protection Areas (SPA) or RAMSAR sites within 2km of the site's proposed EP boundary.

Multi-Designated Site

An area of land located adjacent to the southern boundary of the site is designated as both a SAC and a SSSI. The SAC is known as the Deeside and Buckley Newt Site and the SSSI is known as the Buckley Claypits and Common. The reasons for these designations are detailed below:

- Deeside and Buckley Newt SAC[4] supports a population of over 1000 adult great crested newts in 100 breeding ponds, a protected species under the Wildlife and Countryside Act 1981 and EC Habitats Directive 1994. The mixed mosaic of neutral and acid grasslands, lowland dry and wet heath and mature broad-leaved woodland provide the ideal habitat for various life stages of amphibians and other priority species. The SAC is primarily acidic oak woodland, dominated by Oak *Quercus spp*., Ash *Fraxinus excelsior* and Sycamore *Acer pseudoplatanus*.
- Buckley Claypits and Commons SSSI has been designated for its; assemblage of amphibian species (newts), Great Crested Newt population; and its mixed mosaic of habitats including marshy, acidic and neutral grassland with a variety of wet heath, tall herb and scrub which provides an ideal range of habitats for amphibians to forage, shelter and overwinter at all life stages.

[1] Multi-Agency Information for the Countryside – Available at: http://www.magic.gov.uk, accessed January 2018
[2] NRW Designated Sites Tool , Available at https://naturalresources.wales/guidance-and-advice/environmental-topics/wildlife-and-biodiversity/find-protected-areas-of-land-and-seas/designated-sites/?lang=en, Accessed in June 2017
[3] Woodland Trust Ancient Tree Inventory - http://www.ancient-tree-hunt.org.uk/discoveries/interactivemap/, Accessed in June 2017
[4] This area is separate from the main quarry working area by a metal boundary fence designed to prevent newt migration into the site.

Sites of Special Scientific Interest

There are a further two SSSI's within 2km of the site. The Connahs Quay Ponds and Woodlands SSSI is situated north east of the site at an approximate distance of 760m, whilst Maes y Grug SSSI is located 950m to the west.

- Connahs Quay Ponds and Woodland SSSI has been designated for its assemblage of amphibian species (newts), Great Crested Newt population and semi-natural broadleaved woodland.
- Maes y Grug SSSI has been designated for its populations of Great Crested Newts and mosaic of habitats including broadleaved woodland, mixed grassland, scrub and a range of hedgerows and waterbodies.

1.5.2 Other Ecological Receptors

Searches on the MAGIC website have not identified any of the following ecological receptors within 2km of the permit boundary:

- Area of Outstanding Natural beauty (AONB);
- Registered Parks and Gardens;
- Local Nature Reserves;
- National Nature Reserves;
- Ancient Woodland;
- Biosphere Reserves; and
- National Parks.

1.6 Cultural and Heritage

Information provided by NRW indicates numerous Listed Buildings and Scheduled Monuments within 2km of the site. The closest of each to the site is shown below:

- Listed Building: Greenbank Farm Farmhouse, 1.2km west; and
- Scheduled Monument: Site of Pinfold Lane Pottery, 740m south.

1.7 Identified Receptors

Tables 1-2 and 1-3 and Drawings ESID3 and ESID4 identify the receptors which are considered to be potentially sensitive and could reasonably be affected by activities at the site.

Table 1-3: Identified Receptors

Receptor Name	Receptor Type	Direction from Site	Approximate Distance from Site Boundary (in metres)
Environmental Site Setting within 1km of the EP boundary as shown on Drawing ESID3			
A494	Public Transport Network	South	Adjacent
Pinfold Lane	Public Transport Network	West	Adjacent

Receptor Name	Receptor Type	Direction from Site	Approximate Distance from Site Boundary (in metres)
Commercial properties including Deeside Truck Services	Commercial	North	Adjacent
Woodland	Woodland	South	Adjacent
A55 Northop Services including Costa Coffee, UK Diner, McDonalds, Shell and Holiday Inn	Service station	East	20
Disused Quarry	Industrial	West	20
Commercial/Industrial area including AH Plant Hire and Fire Doors	Commercial/Industrial	West	20
Flintshire County Council Offices and Depot	Council	West	20
A55 North Wales Expressway	Road Network	North, East	40
Thorncliffe Building Supplies	Commercial	South	75
Alltami Brook	Surface Water	Southwest, West, Northwest	250
Oaks Farm	Farm/Agricultural	South	260
Northop Services	Service Station	North	450
Werpe Brook	Surface Water	North	700
Northop Hall Bowling Club	Recreational	North	850
Cultural and Natural Heritage identified receptors located within 2km of the EP boundary as shown on Drawing ESID4			
Deeside and Buckley Newt SAC	SAC	South	Adjacent
Buckley Claypits and Commons SSSI	SSSI	South	Adjacent
Site of Pinfold Lane Pottery	Scheduled Monument	South	740
Connahs Quay Ponds and Woodlands SSSI	SSSI	Northeast	760
Maes y Grug SSSI	SSSI	West	950
Greenbank Farm Farmhouse	Listed Building	West	1200

1.8 Landfill Classification

The landfill is listed under the EP (England and Wales) Regulations 2016, in Schedule 1, as detailed in Table 1-4 below.

Table 1-4 Landfill Operations

EPR Schedule 1 Reference	Waste Framework Directive (WFD) Annex I and II Operations	Limits of Specified Activity
Section 5.2 Disposal of waste by landfill, Part A (1), a) ii) the disposal of waste in a landfill with a total capacity of more than 25,000 tonnes.	D5: Specially engineered landfill Landfill for non-hazardous waste and landfill restoration	Receipt, handling, storage and disposal of waste, consisting of types and quantities detailed in Appendix 02-1 of the Operating Techniques and Management Plan (OTMP). TOC content <10%

1.9 Environmental Permit Boundary

The EP Boundary and installation site layout is illustrated on Drawing ESID2.

1.10 Site Security

In order to prevent unauthorised access, a number of site security measures are already in place at the site and complement the operation of a landfill including:

- Fencing along the site boundary;
- Lighting;
- A CCTV system; and
- A gate located at the entrance to the site, which will be locked when the site is closed.

The site will be inspected at the commencement of each working day. Any defects or damage which compromises the integrity of the enclosure will be made secure by temporary repair by the end of the working day. Permanent repairs will be affected as soon as practicable.

All inspections, any defects, damage or repairs will be recorded in the site diary.

1.11 Compliance with NRW/EA Position of Location of Landfills

NRW have adopted the same policy, in respect to the protection of groundwater at landfills, as the Environment Agency (EA) which is detailed in their updated 2018 guidance[5]. This guidance document details situations where NRW would object to an application for a new landfill site if there were specific risks posed to groundwater due to the location. This position is detailed below in Table 1-5 and taken from Section E of the guidance.

Table 1-5 NRW/EA Landfill Location

E1 – Landfill Location
The EA will normally object to any proposed landfill site in groundwater SPZ1. For all other proposed landfill site locations, a risk assessment must be conducted based on the nature and quantity of the wastes and the natural setting and properties of the location.

[5] The EA's approach to groundwater protection, February 2018, Version 1.2

E1 – Landfill Location
Where the risk assessment demonstrates that active long-term site management is essential to prevent long-term groundwater pollution, the EA will object to sites: Below the water table in any strata where the groundwater provides an important contribution to river flow, or other sensitive receptors. Within SPZ2 or 3. On or in a principal aquifer.

Parry's Quarry Landfill is not located with a Source Protection Zone (SPZ), below the water table or within/on a principal aquifer.

The HRA prepared in support of this EP application, concluded that the development of the site will not pose a serious environmental risk. Therefore, it has been assumed that this development complies with NRW's Landfill Position Statement.

2.0 Source Term Characterisation

2.1 The Development of the Installation

The following section details the history of the area of land, and the proposed development.

2.2 Historical Development

2.2.1 1874 to 1964

Historical maps indicate that the southern part of the site was being quarried prior to 1874 and is identified as a brick works with a clay pit, kilns and a railway track shown on the 1874 map. There is also a colliery (later identified as Elm Collieries) present in the south western corner which is now approximately the location of the current site entrance.

Between 1874 and 1912 historic maps show the development and expansion of the brickworks and colliery with a new brickworks identified as Castle Brickworks being developed in the northern half of the site. The quarry development identified above is in the western half of the current site as is visible in historic aerial photographs (Google Earth) from 1945 with the eastern half remaining as agricultural fields.

Historic Maps for the wider area, from 1900 onwards, show a number of brickworks having been developed to the south of the site with a small pit or pond shown immediately to the west of Pinfold Lane near the Castle Brickworks.

2.2.2 1964 to 1982

The original brickworks to the south are identified as disused on the 1964 map and the colliery is no longer shown but disused shafts are identified. By 1970 the former Colliery is identified as a works with industrial buildings having been erected. The Castle Brickworks to the north appears to still be in use in 1964 but over the years the scale of the buildings diminish and eventually it is shown as a workshop which is approximately half the size of the original buildings. The railway is still present on the 1963 map but is shown as dismantled on the 1970 map.

The former brick pits remain shown as disused throughout this period and the brickworks buildings to the south remain until the 1982 map when they are shown as having been removed.

2.2.3 1982 to 2004

The site remains identified as a disused quarry and on the 1988 map the A55 has been developed to the north east of the site. A hotel and filling station are shown on the 1991 Map in the location that is now the A55 services. The situation remains the same on the 2004 map with the exception of Ewloe Barns Industrial Estate being identified to the south.

2.2.4 2004 to Present

The situation as described in 2004 above remains the same with the exception that the small pit identified to the west of Pinfold Lane has now developed into a quarry which is identified as disused on 2015 Ordnance Survey data.

2.3 Proposed Development

2.3.1 Waste Types and Volumes

The proposed landfill operations comprise restoring the quarry void using non-hazardous non-biodegradable waste, biodegradable wastes (only in Cell 6) and inert waste within fully engineered containment cells.

The site will be restored by importing approximately 2,050,133m^3 (2,460,161 tonnes[6]) of non-hazardous and inert waste material over an estimated 8-year period to enable satisfactory restoration.

This will equate to approximately 320,000 tonnes per annum (tpa).

The full waste list is included as Appendix 02-1 of the OTMP (Ref; 416.07238.00001/OTMP). Table 2-1 below details the phase by phase quantities:

Table 2-1 Landfill Phase Quantities Summary

Parry's Quarry - Phase by Phase Quantities										
Description	Unit	Phase								Total
		1	2	3	4	5	6	7	8	
Basal Area Lined	m^2	7,144	5,865	5,872	3,975	5,181	4,989	7,416	5,818	46,260
Side Slope Area Lined	m^2	10,763	5,363	4,673	6,700	7,288	5,810	7,212	8,557	56,366
Total Area (Basal + Side Slope)	m^2	17,907	11,228	10,545	10,675	12,469	10,799	14,628	14,375	102,626
Void Space	m^3	139,718	166,522	179,398	131,333	176,234	264,717	374,358	617,853	2,050,133
Temporary Cap Area	m^2	12,156	13,387	12,988	10,779	9,438	13,107	18,160	-	90,015
Permanent Cap Area	m^2	6,079	4,576	5,098	5,762	11,762	14,073	17,265	38,940	103,555
Tonnage Input at 1.2t/m^3	tonnes	167,662	199,826	215,278	157,600	211,481	317,660	449,230	741,424	2,460,161

2.3.2 Phasing

Drawing ESID6 illustrates the design of the landfill and the location of each phase. There are to be eight landfilled cells at the proposed Parry's Quarry landfill site; cells 1, 2, 3, 4, 5, 6, 7 and 8. These cells will ultimately occupy a surface area of 9.8ha.

One of these cells, cell 6, is designated as the cell that will accept 'biodegradable' wastes. It is anticipated that all other cells at the site will essentially accept commercial and industrial wastes that are anticipated to contain significantly lower concentrations of biodegradable material.

The landfill will accept a variety of waste streams, which will be split into the following 3 categories:

- Inert Waste (as defined in the Landfill Directive) – which will be deposited into cells 1, 2, 3, 4, 5, 7 and 8;
- Non-Hazardous Non-Biodegradable Waste – which will be deposited into cells 1, 2, 3, 4, 5, 7 and 8; and
- Non-Hazardous Biodegradable Waste – only deposited into cell 6.

[6] Based on a conversion rate of 1.2tonnes/m^3

2.4 Installation Engineering

The following sections provide further details of the principal components of the landfill development.

2.4.1 Groundwater Management System

The water table design of the landfill necessitates positioning the engineered containment system above the piezometric groundwater surface that has been identified at the site. As described in Section **Error! Reference source not found.** of the HRA, the piezometric surface falls from c. 98 to 100 m AOD in the south-east to c. 87 to 90 m AOD in the west and north-west of the site. Since the base of the existing quarry void is below these levels it will be necessary to place an engineered backfill with a thickness of between 5m and 11m to create a suitable formation level for the containment system.

The formation level for the containment system has been designed to be at an elevation of 91.5 m AOD in the west and north-west of the site rising to 99.5 m AOD in the south-east. This design is detailed in the sections below, but to summarise, the base of the engineered liner will be above the observed maximum groundwater levels that have been measured at the site. This is also to allow for potential longer-term rising trends in groundwater levels that may occur.

Due to the design of the containment system, no groundwater management will be required. If during landfill operations after heavy rainfall events perched water in the cells needs to be removed, pumps will be used to transfer the water to the surface water management lagoon.

2.4.2 Basal Subgrade Model

The basal subgrade will be formed by the base of mineral extraction between approximately 86m – 88mAOD, sloping to the northeast in the deepest area of extraction. The basal subgrade slopes at a shallow gradient following the base of the mineral horizon.

The current base is uneven as a result of stockpiling, access routes and extraction. Groundwater seepage has been recorded at the base of the excavation in the south of the site. As a result, the base of the quarry will be raised with site won material in order to ensure waste remains above groundwater.

2.4.3 Side Slope Subgrade Model

The side slope subgrade will be formed by the cut extraction side slopes and fill comprising site won clay. Overburden comprising glacial till is observed as being up to 2m thick in some locations with underlying mudstone of the Etruria Marl.

Extraction has left the quarry with steep sided slopes. In the main extraction area, the depth of excavation currently reaches 26m below surrounding ground level with slopes at a gradient of 1V:1.4H in the northwest. Prior to installation of the lining system site won clay will be placed against the in-situ side slopes at a maximum gradient of 1V:2.7H.

2.4.4 Basal Lining System Model

The site will benefit from full containment engineering; the lining system will comprise:

- Geological barrier a minimum of 0.5m thick constructed of clay with a permeability of $5x10^{-10}$m/s;
- Geosynthetic Clay Liner (GCL);
- Artificial sealing liner (HDPE);
- Protective geotextile (non-woven); and,
- Leachate drainage layer.

2.4.5 Side Slope Lining System Model

The side slope lining system will be composed of the same material as the basal lining system as outlined in Section 2.4.4.

2.4.6 Waste Mass Model

The site will accept non-hazardous, inert or biodegradable waste for disposal. Waste will be subject to waste acceptance procedures.

The site will be filled in eight cells separated by bunds orientated approximately north to south and east to west.

2.4.7 Capping System Model

The site will be capped following placement of waste. Capping will comprise a minimum of 1m of restoration soils overlying an artificial sealing liner (LLDPE) and underlying regulation layer.

The proposed restoration contours will result in a slightly domed profile with a maximum slope gradient of approximately 1V:5H.

2.4.8 Restoration and Aftercare

The landfill area will be restored in accordance with the approved restoration proposals as detailed in Drawing ESID7.

The ground levels within the site will vary in accordance with the restoration profile approved by the local planning authority. The final restored profile will take account of the likely settlement of the deposited waste. Drawing ESID6 illustrates the predicted pre-settlement and post-settlement contours, with relevant cross-sections.

The final restored site will be utilised for public amenity open space and nature conservation. The current indicative restoration proposals are as follows:

- The majority of the existing tree belts around the perimeter of the site will be retained;
- New extensive woodland planting and the provision of areas of open grassland and wildflower meadow on the landfill area of the site; and
- The final landform of the site after landfilling and restoration will be in the form of a rounded hill, which is sympathetic to the wider undulating landscape.

The restoration scheme is illustrated on Drawing ESID7.

2.5 Leachate Management and Monitoring

2.5.1 Leachate Generation

The potential volumes of leachate that will be generated by Parry's Quarry Landfill have been estimated using water balance methods and the results are presented within Appendix ESID1. These estimations indicate the following:

- During the active phase of landfilling the maximum leachate generation for the whole site is likely to be 9,494m^3/yr (26m^3/day) to 12,569m^3/yr (35m^3/day), the variance being due to whether the effect of adsorption of incident rainfall into fresh waste is zero or at 1.0% of the incoming waste tonnage; and
- During the post closure phase of site management, the maximum leachate generation rate for the whole site is likely to be 3,053m^3/hr (8.5m^3/day).

To assist in the assessment of risk posed by the Parry's Quarry landfill an estimate of the leachate quality likely to be generated by the site has been made.

Leachate quality data from an existing site accepting similar waste streams as those anticipated as being placed in all Cells, with the exception of Cell 6, at the proposed Parry's Quarry landfill has been reviewed. This data has been used as a 'proxy' for the leachate quality expected from Cells 1 to 5 and 7 and 8 (see Table 2-2).

For Cell 6, an amalgamation of leachate qualities from landfill sites accepting putrescible wastes (Municipal Solid Waste landfills) has been used to approximate the leachate quality anticipated as being generated from Cell 6 (see Table 2-2).

Table 2-2: 'Proxy' Leachate Quality for Cell 6 and Cells 1-5 and 7-8

Analyte	Unit	Cell 6	Cell 1-5 and 7-8
Alkalinity as $CaCO_3$	mg/l	7,569	2,543
Ammoniacal Nitrogen as N	mg/l	1,460	41
Arsenic, Total as As	mg/l	0.18	0.05
BOD + ATU (5 day)	mg/l	310	500
Cadmium, Total as Cd	mg/l	0.001	0.001
Calcium, Total as Ca	mg/l	161	78
Chloride as Cl	mg/l	1,793	4,035
Chromium, Total as Cr	mg/l	0.32	0.02
COD	mg/l	3,116	1,000
Conductivity Electrical 20°C	µS/cm	16,300	35,386
Copper, Total as Cu	mg/l	0.17	0.03
Iron, Total as Fe	mg/l	12.2	2.3
Lead, Total as Pb	mg/l	0.007	0.058
Magnesium, Total as Mg	mg/l	128	107
Manganese, Total as Mn	mg/l	1.3	0.258
Nickel, Total as Ni	mg/l	0.148	0.079
pH	pH units	8.1	8.686
Potassium, Total as K	mg/l	575	764
Sodium, Total as Na	mg/l	1,207	2,615
Sulphate as SO_4	mg/l	129	160
TOC (Filtered)	mg/l	1,185	268
Total Suspended Solids	mg/l	92	100
Zinc, Total as Zn	mg/l	0.1	0.3

Analyte	Unit	Cell 6	Cell 1-5 and 7-8
Benzene	mg/l	0.003	0.02
Phenol	mg/l	0.19	0.22
Naphthalene	mg/l	0.002	0.001

These leachate qualities have been combined with the leachate generation volumes from each cell reported in **Error! Reference source not found.** to generate an anticipated 'blend' leachate quality for the whole site using mass balance calculations relating to the analyte concentrations and cell leachate yield volumes for each individual cell and the total volume of leachate and total mass of analyte converted to an instantaneous milligram per litre concentration.

This calculation has been performed on a year by year basis with a summary produced showing the minimum, average and maximum concentrations for the whole site during the active filling phase and as an average concentration for the whole site during the post closure phase in 3. The full details of the calculation are presented in Appendix ESID2.

Table 2-3: Leachate Quality Estimates for Parry's Quarry Landfill

Analyte	Unit	Active Years		Aftercare	
		Maximum	Average	Maximum	Blend
Volume	m^3/yr	12,570	9,764	3,053	3,053
Alkalinity as $CaCO_3$	mg/l	6,028	3,017	6,845	3,137
Ammoniacal Nitrogen as N	mg/l	1,025	175	110	209
Arsenic, Total as As	mg/l	0.14	0.06	0.13	0.07
BOD + ATU (5 day)	mg/l	500	482	1,346	478
Cadmium, Total as Cd	mg/l	0.001	0.001	0.002	0.001
Calcium, Total as Ca	mg/l	136	86	210	88
Chloride as Cl	mg/l	4,035	3,823	10,861	3,770
Chromium, Total as Cr	mg/l	0.23	0.05	0.04	0.05
COD	mg/l	2,467	1,200	2,692	1,250
Conductivity Electrical 20°C	µS/cm	35,386	33,585	95,258	33,129
Copper, Total as Cu	mg/l	0.13	0.04	0.08	0.05
Iron, Total as Fe	mg/l	9.1	3.2	6.1	3.4
Lead, Total as Pb	mg/l	0.058	0.053	0.156	0.052
Magnesium, Total as Mg	mg/l	121	109	287	109
Manganese, Total as Mn	mg/l	0.98	0.36	0.69	0.38
Nickel, Total as Ni	mg/l	0.13	0.09	0.21	0.09

Analyte	Unit	Active Years		Aftercare	
		Maximum	Average	Maximum	Blend
pH	pH units	8.7	8.6	23.4	8.6
Potassium, Total as K	mg/l	764	746	2,056	742
Sodium, Total as Na	mg/l	2,615	2,482	7,040	2,449
Sulphate as SO_4	mg/l	160	157	431	156
TOC (Filtered)	mg/l	904	355	721	376
Total Suspended Solids	mg/l	100	99	269	99
Zinc, Total as Zn	mg/l	1	1	3	1
Benzene	mg/l	0.30	0.28	0.80	0.28
Phenol	mg/l	0.020	0.018	0.054	0.018
Naphthalene	mg/l	0.22	0.22	0.60	0.22

2.5.2 Leachate Management and Monitoring

Details of the proposed leachate collection and abstraction system are provided on Drawing ESID14. The scheme details are as follows:

- A leachate abstraction point (LCP01 – LCP08) will be located at the point of the lowest liner elevation within each cell. Each abstraction point consists of a basal sump at the natural collection point of the basal drainage blanket system.
- The leachate collection system will comprise of a leachate collection blanket with a network of leachate collection pipes installed within it to assist in directing leachate to the leachate extraction sump.
- A geotextile protection layer will be installed below the drainage blanket.
- The drainage blanket will be a clean granular material and will not contain more than 5% fines (silt and clay) or have carbonate content greater than 10%. The blanket will have a permeability of greater than 1×10^{-4}m/s. This material will be a single size granular material and will be siliceous gravel in nature.
- The leachate drainage blanket will only extend 2m vertically up the sideslopes. Above 2m the geotextile protector will be replaced with a combined drainage geocomposite protector.
- The leachate pipework will be 355mm OD primary spine drain and 180mm OD secondary/herringbone drains. All leachate pipework will be laid upon 100mm depth and will be buried beneath 100mm depth of granular material (as described above).
- Unless otherwise agreed with NRW, all pipework will be welded pipework comprised of HDPE smooth bore PE80 SDR 11, rated to 10 bar and made to DIN8074/75 specification.
- Two leachate monitoring wells will be installed to the base of each area in accordance with Drawing ESID14.
- Leachate will be abstracted by a float and trigger pump (set to maintain leachate below the appropriate compliance level). Abstracted leachate will be routed to the holding tank by a continuous, leak free pipework system in accordance with Drawing ESID14 before being tankered off site to a suitably licensed facility.
- The on-site leachate storage systems will be appropriately sized according to the predicted leachate generation on site and designed to comply with current BAT requirements.
- The leachate management system will be constructed under a strict CQA regime.

The proposed monitoring locations are included on Drawing ESID14.

It is proposed that the leachate head compliance level should be set at 2m, as demonstrated by the HRA. In addition, assessment levels will be set at 1.5m. The ability of the leachate abstraction system to maintain heads beneath this proposed compliance level has been established by the leachate generation model presented in Appendix ESID1.

2.6 Landfill Gas Management and Monitoring Infrastructure

2.6.1 Landfill Gas Generation

As part of the LFGRA process, total bulk landfill gas production was simulated by GasSim and is presented within Appendix ESID3.

Parry's Quarry Landfill will be fully restored following installation of the permanent cap to the final phase, anticipated in 2027. Gas generation predictions indicate that peak gas production will occur in 2027 and thereafter, gas generation rates are predicted to decrease such that until 2034 predicted gas generation is above

approximately 160m^3/hr. If all this generated gas is collected this will be sufficient to operate the on-site gas engine. If the engine is not replaced with a lower capacity engine after this time, then the gas will be flared.

Beyond 2050, landfill gas generation rates are predicted to be less than 50m^3/hr which falls below the capacity of current flares on the market. It is likely that it will not be possible to collect all the generated gas and it may be necessary to consider the operation of the flare on a non-continuous basis, or a low calorific flare, in order to optimise gas collection and flaring and minimise release into the environment at this time.

A re-evaluation of this time scale to completion would be undertaken closer to the time and the treatment options engine/flare re-evaluated based on the best available techniques at the time.

2.6.2 Landfill Gas Management

An active gas management system will be constructed at the landfill comprising a network of vertical and side slope gas extraction wells, including temporary and sacrificial wells on temporary capped areas as required, connected to a system of gas mains and spurs. The gas collection system will direct the collected gas to the Landfill Gas Utilisation Plant. The gas extraction system will be progressively expanded as the landfill develops and the completed phases are permanently capped. This will ensure that the quantity of landfill gas collected at any one time is optimised.

The installation of all elements of the gas extraction system will be subject to CQA standards.

Landfill gas will be utilised where possible to generate electricity in a suitable sized Generator set (gen-set) with a back-up landfill gas flare sized to flare the total predicted landfill gas volumes and suitable turn-down ratio. It is anticipated that gas plant would comprise:

- Gas engine gen-set 500kWe output model (capacity 260m3/hour at 50% methane); and
- Enclosed flare 500m3/hour capacity with 10:1 turndown ratio.

An indicative landfill gas management plan is illustrated on Drawing ESID13. To summarise, it is proposed that landfill gas management at Parry's Quarry Landfill could comprise the following:

- The landfill gas collection scheme could potentially comprise in excess of 50 individual extraction wells located at 40m to 50m centres and joined to the gas utilisation compound via gas collection pipework.
- The installation of the gas engine gen-set would be phased, as and when required and if commercially and technically practicable, in order to fit with proven landfill gas and limits on the local electricity network.
- Excess gas that cannot be used for power generation will be flared off, as and when required, from an enclosed flare with the appropriate capacity (as detailed above) in order to cover the event of any breakdown.
- In the engine should shutdown, or the engines are unable to cope with an increase in gas flow, gas will be diverted to the flare for combustion. If both the engine and the flare shutdown for any reason, the Site Manager will be notified immediately. A Contingency Plan is included in the Gas Management Plan section of the OTMP.

2.6.3 Landfill Gas Monitoring Infrastructure

More details of the proposed landfill gas monitoring regime are presented within the LFGRA. However, in summary, it is proposed that landfill gas monitoring would comprise the following:

- The installed extraction wells will be used for landfill gas monitoring within the main body of the fill. This will be carried out in order to assess methane generation and the quality of the gas, to evaluate landfill gas management requirements. The gas extraction wells will be monitored for methane, carbon dioxide, oxygen and suction.

- The emissions from the flare and gas engine gen-set will also be monitored for nitrogen dioxide, carbon and total VOC's. The details of the emissions monitoring frequency and levels are detailed in Tables 5-4 and 5-5 of the LFGRA.
- A total of 14 (G1 – G14) perimeter gas management boreholes have already been installed onsite, the locations of which are illustrated on Drawing ESID9. The external boreholes will continue to be monitored for methane, carbon dioxide and oxygen. Weather conditions and atmospheric pressure will also be recorded. Further details relating to the perimeter gas monitoring boreholes are detailed in Section 5.3.2 of the LFGRA.
- As discussed in Section 5.3.1 of the LFGRA, the monitoring of gas emissions from the surface of the landfill will be carried out in accordance with LFTGN07. The emission standards are detailed in Table 5-1 of the LFGRA.

2.7 Surface Water Management System

Surface water will be managed throughout both the operational and post closure phases.

2.7.1 Operational Phase

During the operational phase, clean surface water which accumulates in the base of the quarry will be pumped to the surface water discharge point located along the north west boundary at NGR SJ 2746 6669. The discharge consent is regulated by NRW (EPR/CG0392101). The location of this discharge point, to Alltami Brook, is illustrated on Drawing ESID9.

Any water which comes into contact with waste will be collected within the engineered cells and treated as leachate.

2.7.2 Post Closure Phase

Once completed and capped, surface water will be directed to surface water ditches that will be present at the boundaries of the site, with all surface water ultimately falling to the lagoon, the location of which is illustrated on Drawing ESID2.

2.7.3 Surface Water Monitoring

Locations of the surface water monitoring points are illustrated on Drawing ESID9. Further details on surface water monitoring are contained in the HRA.

2.8 Environmental Monitoring

The site has a network of boreholes which are and will continue to be monitored on a regular basis. Further details on environmental monitoring, monitoring schedules and limits for landfill gas, groundwater, surface water and leachate are contained in the LFGRA and HRA included within this EP application.

2.9 Post Closure Controls

The active management measures that are critical to the operation of the landfill are leachate and landfill gas management. In addition, passive management measures include the containment system and the landfill cap. The conceptualisation of how these systems will operate throughout the life cycle of the landfill is presented in Table 2-4. In summary:

- Leachate and landfill gas management would be ongoing throughout the operational and post-closure, aftercare phases in the life of the landfill. These systems would not operate during the site completion/post completion stages, although monitoring would be ongoing during site completion.

- Some degradation of the active management systems is expected, which would reduce their efficiency. The extent of the degradation would increase with time and it has been assumed that all management systems become non-functional during the post-site completion phase.

With regards to the conditions when EP completion will be obtained, these would be satisfied when the site no longer has the potential to cause damage to or deterioration of the environment and risk to human health i.e. it no longer poses a potential risk to the environment or human health. More specifically:

- With regards to **potential impact on ground and surface water**, this means that the site needs to comply with the requirements of the Groundwater (England and Wales) Regulations 2009, following the cessation of active leachate management; and
- **Landfill gas** completion criteria would be related to when the site no longer poses a potential risk to either humans or the environment following the cessation of active landfill gas management.

Table 2-4 The Conceptualisation of Management Measures and Technical Controls throughout the Landfill Life Cycle

Landfill Phases	Leachate Management	Landfill Gas Management	Containment System – Engineered Clay	Landfill Cap
Operational	Ongoing management of leachate heads to ensure compliance with specified limits	Ongoing management of landfill gas	Operates as designed	Not applicable
Post Closure and Aftercare Period	Ongoing management of leachate heads to ensure compliance with specified limit Some degradation (i.e. clogging) of the drainage system	Ongoing management of landfill gas Some degradation (i.e. well clogging) of the abstraction system	Operates as designed	Operates as designed
Site Completion	Passive management (monitoring only) Further degradation of the drainage system	Passive management (monitoring only) Further degradation (i.e. well clogging) of the abstraction system	Operates as designed	Operates as designed
Post-site Completion	None	None	Operates as designed	Operates as designed

3.0 Pathway and Receptor Term Characterisation

3.1 Climate

The site is located to the south of Meteorological Office Rainfall and Evaporation Calculation System (MORECS) square 104. The Meteorological Office has supplied long-term monthly averages for rainfall and hydrologically effective rainfall (HER) for the period 1971 to 2000. This is presented in Table 3-1 for a grassed surface for a median available water capacity soil type.

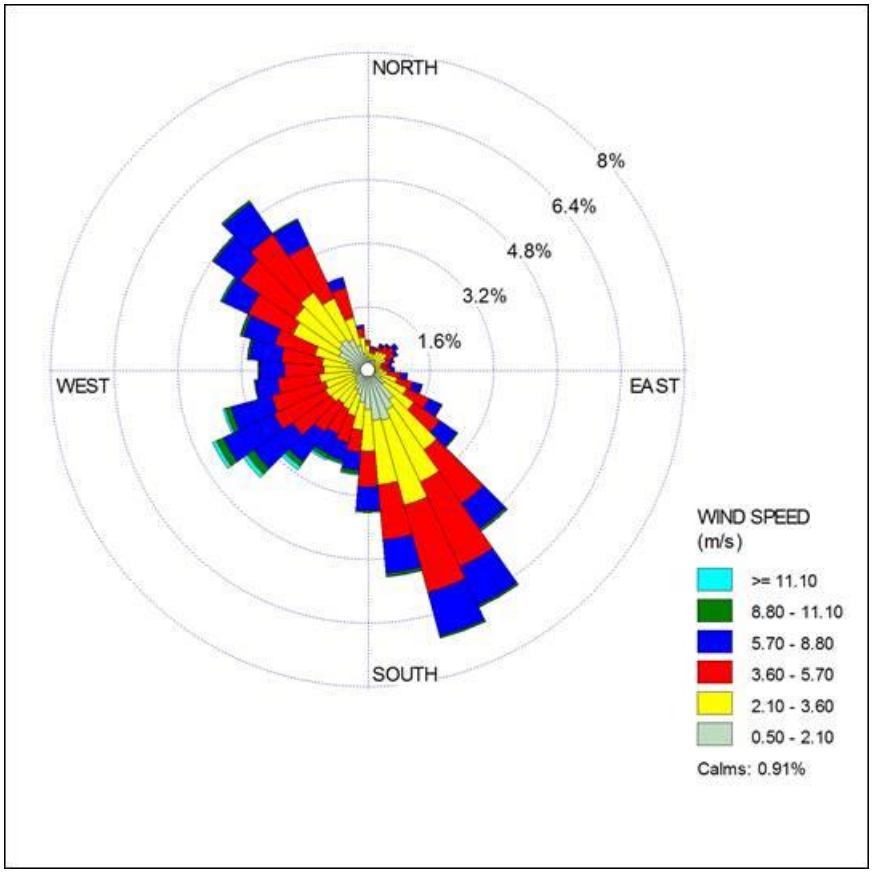
Table 3-1 MORECS data for square 104 – Long-term average 1971 to 2000 for grass land use with median available water capacity (AWC) soil type

Month	Rainfall (mm)	HER (mm)
January	69.6	53.1
February	51.5	32.8
March	62.9	32.5
April	51.2	15.9
May	50.5	2.0
June	60.4	1.1
July	55.9	0.0
August	69.0	0.4
September	73.9	2.2
October	86.5	20.9
November	85.3	37.0
December	83.0	63.9
Annual	**799.7**	**261.8**

Long-term average rainfall is c. 800mm per year. The highest monthly rainfall occurs in October and reduces to a minimum in May. The HER is 262mm per year. This is defined as the sum of rainfall less actual evapotranspiration.

Meteorological data for the site is available from Hawarden observation station located approximately 7km east-southeast of the site. Five consecutive years of hourly-sequential observation data from this location, covering the period 2012 – 2016, inclusive, have been obtained and presented as a windrose in Figure 1.

Figure 1 Harwenden Meteorological Station; 2012 -2016



3.2 Geology

The site is situated within an outcrop of Carboniferous aged Coal Measures strata (predominately comprising mudstones with sub-ordinate sandstones, siltstones and coal beds). The geological succession is complicated by local structural controls; which has created a series of fault bounded blocks in the area and caused the various types of bedrock to locally become juxtaposed against each other.

The geological sequence at the site has previously been described as very complex (TerraConsult[7], 2015); which is considered to reflect the rapid lateral and vertical changes in lithology due to the depositional nature of the sequence and post-depositional structural controls (i.e. dipping bedding and faulting). Attempts were made by TerraConsult to laterally correlate units observed at the site; evidently this was difficult due to the limitations of the available data (including that boreholes only provide a one-dimensional (vertical) record of the geological succession) and the complicated nature of the geology as outlined above. Nevertheless, based on published geological mapping, the following simplified geological sequence for local area has been identified:

- Etruria Formation[8] – comprising red, purple, brown, ochreous, green, grey and commonly mottled mudstone, with lenticular sandstones and conglomerates. The Etruria Formation includes the 'Buckley Blue' unit (a local and now obsolete name), which comprises a purple, black and grey mudstone, and was principally the clay that was excavated from the quarry void;

[7] **Terraconsult, 2015.** Parrys Quarry Landfill Site. Hydrogeological Risk Assessment. December 2015. Report: 2434-R05

[8] Note that the Etruria Formation is used here in preference to the term Etruria Marl as was adopted by TerraConsult (2015) since this is the current name for this unit given by the BGS (2018).

- Pennine Middle Coal Measures Formation – comprising inter-bedded grey mudstone, siltstone, pale grey sandstone and coal seams. The upper part of the Coal Measures includes a sandstone unit referred to as the 'Hollin Rock' which immediately underlies the Etruria Formation; and
- Pennie Lower Coal Measures Formation – comprising inter-bedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part.

Available geological mapping (British Geological Survey (BGS) (2018), as shown on Drawing ESID11, indicates that sandstones of the Etruria Formation are present across the eastern two thirds of the Site (and extend to the area immediately to the east); mudstones, sandstones and conglomerates of the Etruria Formation are present across the western third of the Site. The Middle Coal Measures are then present further to the west. This includes the Hollin Rock Member which is identified beyond a north-south faulted boundary (with an apparent 50m downthrow) present along the western boundary of the Site. The Lower Coal Measures Formation are present c. 50m to the east of the Site beyond another approximately north-south faulted boundary.

Mapping of the superficial geology, as shown on Drawing ESID10, also shows that glacial till is present above bedrock across much of the area surrounding the site. The TerraConsult report shows that it is c. 2m in thickness and comprises a sandy clay with sandstone fragments. Superficial deposits are absent along the route of Alltami Brook where it is closets to the site (i.e. 250m to the northeast). Elsewhere however, alluvium is present along the course of the brook to the south (i.e. up-stream); and alluvium and glacio-fluvial (sand and gravel) deposits are present on both Alltami and Wepre brooks to the north (i.e. down-stream).

The mapping shows that superficial deposits are absent from across much of the site; this is due to the development that has taken place (i.e. initially a brickworks, followed by quarry extraction). Furthermore, the southern quarter of the site; the areas immediately to the north and to the south of the site; and several other areas in the vicinity are identified as artificial ground. Again, this relates to the former uses of these areas.

3.2.1 Man-Made Subsurface Pathways

The Coal Measures in the local area are known to have been worked historically; and Coal Authority (2018) records indicate that this includes workings associated with the former Elm Colliery which was located immediately to the south-west of the site (on the area now occupied by the FCC depot). Former workings may have become preferential groundwater flow pathways.

Three former shafts are identified in this area; which were worked until the colliery was closed in 1934. However, the shafts and workings are understood to have been between 150m and 31m below ground level. Coal Authority (2018) records indicates that worked seams present beneath the site were all below -63m AOD. Coal Authority records also indicates that the closest dewatering works are at Harwarden (which is located c. 4km to the south-east). The depth and distances to the seams suggest that they are unlikely to affect groundwater at the site.

3.3 Hydrology

The site lies within the catchment area of the River Dee. The nearest water course to the site is Alltami Brook which is situated to the west of the site; flowing from southwest to northeast. At its closest point it is 250m to the northwest of the site; it flows onwards and converges with Wepre Brook 700m to the north of the site. Wepre Brook flows from west to the east and is a tributary to the River Dee c. 4km to the northeast of the site. New Inn Brook, another tributary to Wepre Brook, is present 900m to the east of the site.

Identified flood risk zones associated with Wepre Brook and Alltami Brook are confined to their respective river channels and, as such, at their closest they are approximately 250m to the northeast of the site.

The area immediately to the south of the site includes several ponds and is part of the Deeside and Buckley Newt Sites designated SSSI and SAC. This relates to the presence of four protected amphibian species which were identified on the site mid-1990s. The owner of the site at that time (Hanson Brick Ltd) relocated these species

from an area of planned mineral extraction and established a dedicated conservation area (which were subsequently designated as part of the SSSI and SAC).

3.4 Discharge Consents

There is an active discharge consent for the site held by Mold. This allows trade discharges (e.g. surface water) from a point on the north-western boundary of the site to Alltami Brook. It is understood that the discharge is limited to a maximum of 14 l/s. There is a similar discharge consent for trade discharges from the adjacent quarry between Pinfold Lane and Alltami Brook.

There are two discharge consents for treated sewage effluent into a tributary of the Alltami Brook, c. 350 m southwest (and upstream) of the Site associated with the FCC depot. There are also a group of discharge consents for treated sewage effluent from domestic properties to the same tributary immediately upstream of this point. There is another group of discharge consents, primarily relating to sewage discharges from a water company to Wepre Brook c. 700 m to the north of the Site.

3.5 Pollution incidents

NRW hold records of four substantiated pollution incidents to Alltami Brook; c. 250m to the north and north-west of the Site. All are classified as 'Category 2 – significant incident'. Three relate to suspended soils or clay and stones; the fourth relates to agricultural slurry. A minor incident also involving similar materials (i.e. mud/clay/soil) is also record to Alltami Brook; c. 250m to the west of the Site.

There are of two minor incidents that are reported to have occurred on the Site (although it is noted that their positional accuracy is reported as being within 100m so they may not actually have occurred on the Site itself). Both occurred in 1991; and no further details are provided.

Two incidents associated with farming activities are recorded at Gell Farm c. 400m to the north-west of the Site. The incidents were classified as significant (agricultural carcasses) and minor (effluent discharge).

Nineteen other pollution incidents have been recorded within 1km of the Site; they are associated with a variety of causes (e.g. hydrocarbon spillages from road traffic accidents; sewage overflows from pumping stations; accidental agricultural slurry discharges). Whilst most incidents were classified as minor, they may have caused some residual impact on surface water and groundwater quality in the local area.

3.6 Hydrogeology

3.6.1 Aquifer Characteristics

The Coal Measures and surrounding bedrock are classified as a Secondary A Aquifer. Jones *et al.* (2000) describe how these strata are expected to behave as a multi-layered aquifer system in which lower permeability mudstones act as aquicludes between sandstone aquifer horizons. Both the mudstones and sandstones (which are well cemented) possess minimal primary porosity. Groundwater flows predominately occur within joints and fractures within the sandstone strata to depths of up to 250m; transmission of groundwater will depend on how locally well connected these hydrogeological units are. Lateral recharge is considered likely to be limited as the hydraulic continuity of the aquifer is disrupted by the faulting which effectively splits the aquifer units into isolated blocks. Locally, the hydrogeology can be modified by the presence of mine shafts and inter-connecting mine workings.

The superficial deposits (alluvium and glacio-fluvial) locally present along Alltami Brook and Wepre Brook are classified as Secondary A Aquifer. The Glacial Till is classified as unproductive strata.

3.6.2 Aquifer Properties

Jones *et al.* (2000) describe the properties of the Coal Measures (Westphalian aged) strata within North Wales region.

Laboratory testing of sandstone core from an outcrop of the Hollin Rock (at Wepre Dingle, about 2 km to the north-east of the Site) gave porosities of about 11% and hydraulic conductivities of less than $6x10^{-4}$ m/d (~$7x10^{-9}$ m/s). It was noted that as these samples were taken from outcrop they will have been affected by weathering to some degree. Hence, un-weathered strata at depth are likely to have lower porosities and hydraulic conductivities.

Aquifer test data are available from seven boreholes penetrating the Coal Measures strata in North Wales (Jones et al., 2000). Discharge rates from five of the boreholes which were between 30 and 70 m deep ranged between 15 and 170m^3/d which gives specific capacities of between 2.5 and 28 m^3/d/m. The two remaining boreholes were deeper and were pumped at much higher rates which gave much higher specific capacities. Jones et al., (2000) conclude that, while there is no indication that these boreholes encountered mine workings, the lower values recorded in the five other boreholes are probably more representative of the Coal Measures strata.

TerraConsult (2015) presented a summary of the results from various aquifer tests that have been performed at the Site. Two ranges of hydraulic conductivity values were identified which were considered to be indicative of two types of flow within the strata present at the Site: relatively low values of $<10^{-6}$ m/s were deemed to be consistent with primary permeabilities (i.e. rock matrix); with higher values in the order of $6x10^{-5}$ m/s considered to represent the secondary permeability of the local rock types (i.e. bulk flow via the fracture network).

3.6.3 Groundwater Flow

In general, the groundwater flow direction within the Coal Measures is expected to follow the overall topography towards the north; however local variations in flow directions (and hence piezometric head differences between separate or poorly connected hydrogeological units present within the Coal Measures) are also likely to be apparent.

TerraConsult (2015) previously undertook a detailed review of available groundwater level data at the site. However, limitations were recognised with the available data set including borehole records were not available for all monitoring points (i.e. so there was no knowledge of which hydrogeological units were being monitored); and rather than targeting discrete water bearing units, the groundwater monitoring points tended to have been installed with long response zones that intersect multiple, higher and lower, permeability units. As a result, the water levels may provide an 'average' water level for all the units; including some at higher elevations where groundwater flows may actually be negligible. Other limitations included the frequency and duration of available groundwater level monitoring data; and identifying the influence of groundwater dewatering that had been undertaken historically at the Site and in a neighbouring quarry.

For these reasons, it was decided that a new network of groundwater monitoring points was required at the site. This resulted in borehole drilling and the installation of 14 dedicated groundwater monitoring locations around the perimeter of the site in early 2017 (TerraConsult, 2017).

A programme of a groundwater level monitoring has been undertaken since these new groundwater monitoring points have been installed. The results are discussed in further detail in the HRA and are summarised below:

- The groundwater level monitoring that has been undertaken between January 2017 and November 2018 suggests that a relatively consistent piezometric surface is present which falls from c. 98 to 100mAOD in the south-east to c. 87 to 90mAOD in the west and north-west of the site.
- With the exception of one monitoring location (2016-C) the variation in groundwater levels that has been observed over this period is on average c. 2m but variations of up to a maximum of c. 4m have been identified.

- The recent groundwater monitoring data suggests that despite the identified small scale geological complexity, individual water bearing units appear to be relatively well connected at the scale of the site and so appear to combine to act as a single aquifer unit with a broadly consistent and identifiable piezometric surface across the site.

As described above, Alltami Brook, is located c. 250m to the north-west of the site. It is down topography from the site (where it is situated in a valley at an elevation of between c. 80 and 90mAOD; compared to the elevation of the site at around 110mAOD). Given that groundwater levels within the Coal Measures are typically between 87 and 90mAOD on the north-western boundary of the Site it is considered likely that there is hydraulic connection between groundwater and the brook down hydraulic gradient of the site (TerraConsult, 2015).

3.6.4 Groundwater Quality

A review of available groundwater quality at the site was undertaken as part of the previous permit application. As with the groundwater level data set identified above, issues and uncertainties were identified with this groundwater quality data set.

Following the installation of the new groundwater monitoring points in early 2017 groundwater quality monitoring has also been undertaken between early 2017 and March 2018. The result from this monitoring are discussed below with, where relevant, reference and commentary on the observations regarding groundwater level that were made by TerraConsult (2015):

- TerraConsult (2015) identified that chloride concentrations in groundwater generally remained below <90 mg/l with the exception of those monitoring points positioned along the western perimeter of the Site. Here, TerraConsult (2015) identified chloride concentrations up to 1,250mg/l and concluded that groundwater quality was influenced by the leaching of road salt which is stored at the Flintshire County Council depot.
    - In general, the results from the recent monitoring programme support these observations with mean chloride concentrations <90mg/l in nine of the 14 monitoring points. Four of the five remaining monitoring points (BHH, BHI, BHJ and BHK) are located along the western perimeter of the site (the mean concentrations observed in these points were between 147 and 395mg/l). The final monitoring point (BHC) (where the mean concentration was 168mg/l) is, in contrast, located to the south-east of the Site. For comparison the UK Drinking Water Standard (DWS) for chloride in 250mg/l.
    - It is notable that chloride concentrations in BHC were consistently less than 100mg/l throughout 2017; after which they rose to almost 400mg/l. The cause of this rise and the origin of the chloride in this location is not known (however, as described below, elevated sodium and sulphate concentrations are also observed in BHC so it is considered that they may also originate from road salt).
    - It is also notable that the chloride concentrations in BHK1 were appreciably lower than in BHK (mean concentrations of 61mg/l and 327mg/l respectively). Whilst these monitoring points are both located to the south-west of the Site they monitor vertically separate sandstone units; with the screened section of BHK1 monitoring at the higher elevation of 74.7 to 76.1mAOD compared to BHK which monitors at 63.9 to 70.0mAOD.
    - As TerraConsult (2015) note, the presence of chloride in groundwater that likely originates from nearby anthropogenic source(s), means that due consideration should be given to the use of chloride to assess the long-term performance of a non-hazardous landfill.
- The observations made by TerraConsult (2015) regarding the likely origin of the chloride from road salt are supported by the sodium concentrations observed during the recent monitoring programme. Sodium

concentrations show a very similar pattern to chloride; with elevated concentrations (i.e. typically above 50mg/l) only observed in BHC, BHH, BHI, BHJ and BHK.

- TerraConsult (2015) reported that outside the salt influenced area that sulphate concentrations were typically in the range 100 to 400mg/l (compared to concentrations of over 500mg/l within this area). As with the sodium concentrations, elevated sulphate concentrations (i.e. in excess of the UK DWS of 250mg/l) were only observed in those monitoring points where elevated chloride concentrations were also observed (i.e. BHC, BHH, BHI, BHJ and BHK).
- The pattern of ammoniacal nitrogen concentrations observed from the recent monitoring programme contrast to chloride, sulphate and sodium. Apart from BHH, ammoniacal nitrogen concentrations have largely remained below the UK DWS of 0.39mg/l as N and no trends or patterns are readily identifiable. Concentrations in excess of 1mg/l as N were detected in BHH at the start of 2017 and increased to 2mg/l as N in May 2017; however, since that time they have fallen appreciably. Since early 2018 they have remained around 0.1 mg/l as N.
- A summary of metal and minor ion concentrations from the recent monitoring programme is presented in Table 3-2. The table includes current UK DWS and shows that only the observed concentrations of iron, manganese, nickel and cyanide exceed these standards (as marked in bold).

Table 3-2 Summary of metal concentrations in groundwater (2017 to 2018)

Analyte	Units	Nr	Nr>LOD	Minimum	Maximum	Mean	UK DWS
Cadmium	mg/l	98	36	<0.0001	0.0008	0.00025	0.005
Calcium	mg/l	138	138	16	289	118.2	-
Chromium	mg/l	98	27	<0.002	0.013	0.0053	0.05
Copper	mg/l	98	86	<0.001	0.038	0.0063	2
Iron	mg/l	138	138	0.04	**7.96**	**0.38**	0.2
Lead	mg/l	98	1	<0.001	0.002	-	0.01
Magnesium	mg/l	138	138	3	166	45.1	-
Manganese	mg/l	138	132	<0.003	**10.5**	**2.0**	0.05
Mercury	mg/l	98	0	<0.001	<0.001	-	0.001
Nickel	mg/l	98	90	0.001	**0.032**	0.010	0.02
Potassium	mg/l	138	138	1	21	8.6	-
Zinc	mg/l	98	98	0.002	0.279	0.027	-
Cyanide (total)	mg/l	98	12	<0.03	**1.38**	**0.27**	0.05

- As TerraConsult (2015) identified, the Coal Measures and Etruria Marl are a readily available source of iron and manganese, hence their presence in groundwater at elevated concentrations at the site is not unsurprising. Furthermore, they will therefore be less useful as a means of assessing the long-term performance of the landfill.
- Detailed inspection of the data from nickel shows that the UK DWS is only exceeded in four monitoring points (in all 7 times nickel was analysed in BHF1; in 5 of the 7 times in BHJ; twice in BHK; and once in BHI).

- Inspection of the cyanide data shows that seven results exceed the UK DWS; however, all of these results occurred during a single monitoring round (on 23 June 2017). On all the other six monitoring rounds where cyanide was analysed, it was below the laboratory limit of detection (<0.02mg/l) in all monitoring points. It is therefore considered likely that these positive results are erroneous.
- Phenols and phenolic compounds are the only organic compounds that have been analysed in groundwater during the most recent monitoring programme. They have however been very few instances when they have been detected.
- The exceptions relate to groundwater monitoring points BHA and BHB (which are both located to the south of the site i.e. on the up-hydraulic gradient boundary). The compounds detected were methylphenols and dimethylphenols in BHA at concentrations of 130µg/l and 260µg/l in January and March 2018 respectively; and cresols in BHB at a concentration of 1.2µg/l. There are no UK DWS's for these substances; as a guide however, the UK DWS for phenol is 0.5 µg/l.

It is noted that several historical landfills are present within the vicinity of the site including two to the south: Ewole Barn Clayhole c. 200m away (which received inert and commercial waste through the 1980s); and Brookhill Landfill site which is c. 500m from the site which received household, commercial and industrial wastes (and closed in 2007). There is also a landfill known as New Bridge Farm c. 150m to the north of the site which accepted inert and commercial wastes between 1983 and 1985. It is possible that leachate originating from these landfills may influence background groundwater quality in the area; and they may be the source of the phenolic compounds observed on the up-hydraulic boundary of the site. Furthermore, as outlined in Section 3.5, a number of pollution incidents have been recorded in the vicinity of the site which may also have influenced background water quality.

3.7 Receptors and Compliance Points

3.7.1 Hydrogeological Risk Assessment

For the purposes of the HRA, the primary receptors have been taken to be the compliance points as required by the Groundwater Regulations 1998. These are as follows:

- For **hazardous substances**, the potential receptor has been assumed to be the groundwater directly beneath the landfill (prior to any dilution occurring); and
- For **non-hazardous pollutants**, the potential receptor has been assumed to be the groundwater in the Coal Measures at the down hydraulic gradient boundary of the landfill and in Alltami Brook (which is assumed to receive baseflow from groundwater from the Coal Measures and is the closest surface water course to the landfill).

3.7.2 Landfill Gas Risk Assessment

For the purposes of the LFGRA, the compliance points have been taken as the following:

- The off-site gas monitoring boreholes as presented within Drawing ESID9; and
- The off-site receptors that have been indicated as being at potential risk from the development (see LFGRA for more details).

3.7.3 Environmental Risk Assessment

For the purposes of the Environmental Risk Assessment, the potential receptors that need to be considered are presented within Drawings ESID3 and ESID4 and have been set out within Tables 1-2 and 1-3 of this ESID. However, with regards to the potential compliance points, it is proposed that the landfill site boundary would be used.

4.0 Site Condition Report

4.1 Introduction and Background Information

A Site Condition Report (SCR) has been prepared in accordance with the NRW H5 Guidance Note on Site Condition Reports[9] and is included in Section 12 of this EP application, as Appendix 03 to the OTMP.

4.1.1 Site Details

All details relating to the site are included in Section 1.0 of this ESID report.

4.1.2 Outline of Proposed Development

All details relating to the proposed development of the site are included in Section 1.0 of this ESID report.

4.1.3 Former Land Uses

All details relating to former land uses are included in Section 2.2 of this ESID report and the SCR included in Section 12 of this EP application.

4.1.4 Geology and Hydrogeology

All details relating to the geology, hydrology and hydrogeology of the site are included in Section 3.2, 3.3 and 3.6 respectively of this ESID report and the SCR included in Section 12 of this EP application.

4.1.5 Potential Contaminants and History of Incidents

All details relating to potential contaminants are included in Section 2.2 of this ESID report and a history of pollution incidents in Section 3.5

4.2 Objectives of this Assessment

The objective of the SCR is to record and describe the condition of the land at the time of the permit application and prior to work beginning. This provides baseline environmental data and a point of reference so that upon surrender of the permit it can be demonstrated that there is no deterioration of the land as a consequence of the proposed operations and ensure that the condition of the land is in a 'satisfactory state' on surrender of the permit.

An SCR is not a requirement for the permanent deposit of waste (the proposed landfill) therefore the SCR only focuses on the areas of land contained within the EP boundary not subject to the infilling of waste. The installation site layout is detailed on Drawing ESID2, which illustrates the areas that this SCR relates to.

Sections 1 to 3 of NRW's SCR template have been completed in the preparation of this document, which comprises the following:

- Site details;
- Condition of the land at permit issue;
    - Geology;
    - Hydrology;

[9] Natural Resources Wales – Environmental Permitting Regulations, Guidance for applicants; H5 Site Condition Report – guidance and templates, October 2014, Version 5.0.

  - Hydrogeology;
- Pollution history;
- Evidence of historic contamination; and
- Permitted activities.

Sections 4 to 7 of the SCR template will be maintained during the life of the permit and Sections 8 to 10 will be completed and submitted in support of the application to surrender the permit.

4.2.1 Areas of the Site Considered

Those areas of the Site which will not be subject to the permanent deposit of waste are as follows:

- Access roads;
- Wheel wash area;
- Waste reception area and weighbridge;
- Fuel storage area;
- Surface water attenuation lagoon;
- Landfill gas control compound;
- Leachate control compound; and
- WTS.

4.3 Conclusions

The information presented within Sections 1.0, 2.0 and 3.0 of this ESID report and the SCR establishes the landfill source, pathway and receptor term characterisation for the installation, and defines the baseline site conditions, in terms of the geology, surface water and groundwater conditions and their sensitivity.

This section of the ESID report is considered to have provided the necessary information on the potential source term characterisation for the non-landfill areas of the installation and should be read in conjunction with the remaining sections of the ESID report.

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