Intended for
Thorpe Marsh Green Energy Hub Limited

Document type
Report

Date
June 2024

THORPE MARSH LANDFILL (EPR/CP3091SC/V002) ENVIRONMENTAL SETTING AND INSTALLATION DESIGN REPORT

RAMBOLL Bright ideas. Sustainable change.

THORPE MARSH LANDFILL (EPR/CP3091SC/V002) ENVIRONMENTAL SETTING AND INSTALLATION DESIGN REPORT

Project number	**1620016267**
Version	**1.0**
Document type	**Report**
Date	**21st June 2024**
Prepared by	**Nathan Gaasenbeek/Richard Moakes**
Checked by	**Nathan Gaasenbeek**
Approved by	**Jon Eudall**
Description	**Thorpe Marsh Landfill (EPR/CP3091SC/V002) Environmental Setting and Installation Design Report**

Ramboll UK Limited
Registered in England & Wales
Company No: 03659970
Registered office:
240 Blackfriars Road
London
SE1 8NW

CONTENTS

1.	**INTRODUCTION**	**5**
1.0	Report Context	5
1.1	Background	5
1.2	Site Operator	6
1.3	Objectives and Scope of Works	6
1.4	Constraints and Limitations	6
2.	**SITE DETAILS**	**8**
2.1	Location and Access	8
2.2	Site Classification	8
2.3	Site History	8
2.4	Site Boundary and Security	10
2.5	Former Waste Management Actives Boundaries	10
2.6	Site Context	11
3.	**COMPLIANCE POINTS**	**17**
3.1	Groundwater and Surface Water	17
3.2	Landfill Gas	17
4.	**POLLUTION CONTROL MEASURES**	**18**
4.1	General Installation	18
4.2	Basal and Slope Engineering	18
4.3	Capping System	19
4.4	Leachate Infrastructure	19
4.5	Landfill Gas Infrastructure	19
4.6	Amenity	19
4.7	Post Closure Controls (Aftercare)	20
5.	**MONITORING**	**21**
5.1	Weather Monitoring	21
5.2	Leachate Monitoring Infrastructure	21
5.3	Gas Monitoring	21
5.4	Groundwater Monitoring	21
5.5	Surface Water Monitoring	21
5.6	Amenity Monitoring	21

APPENDICES

Appendix 1
Figures

Appendix 2
Stirling Maynard Drawings

Appendix 3
Construction Environmental Management Plan (CEMP)

Appendix 4
Outline Drainage Strategy

1. INTRODUCTION

1.0 Report Context

Ramboll UK Limited ("Ramboll") has produced this Environmental Setting and Installation Design (ESID) report for Thorpe Marsh Landfill (the "site") as part of our ongoing support to Thorpe Marsh Green Energy Hub Limited ("TMGEHL" or herein "the "Client"). The landfill is to be redeveloped into a Battery Energy Storage System (BESS), and the design works are ongoing.

The current permit holder is HJ Banks and Company Ltd. A permit transfer application has been submitted (ref. EPR/CP3091SC/T002) to transfer the permit to Thorpe Marsh Green Energy Hub Limited. This transfer application is to be decided alongside the proposed permit variation application. This report provides information pertaining to environmental setting and installation design to support a permit variation application. The ESID report is part of a collection of reports and documentation required for the permit variation application, most notably the Conceptual Site Model (CSM) report[1] and Hydrological Risk Assessment (HRA) report[2]. As required, this report presents the 'in principle' engineering design based on these risk assessments.

1.1 Background

Pulverised fuel ash (PFA) was originally deposited at the site from the generation activities of Thorpe Marsh Power Station, a 1GWatt coal-fired station, commissioned in 1963 and closed in 1994. It is understood that some of the PFA generated from commissioning in 1963 to 1977 was removed from site and used for construction foundation and fill material during the construction of the local motorway network in the region, prior to waste licensing in the UK. The residual PFA generated to 1977 that was not taken off site was stockpiled on-site in the 'ash fields' (i.e., the development area). Then from 1977 (see below) licensed PFA disposal took place on top of the unlicensed PFA.

Thorpe Marsh Landfill is a regulated waste disposal site covered by an Environmental Permit (WML number WD20D53, originally granted in 1977, now EPR/CP3091SC/V002). The permit allowed the disposal of PFA as well as domestic, commercial, and industrial wastes from the adjacent Thorpe Marsh Power Station. The landfill was operated prior to the implementation of the 2001 Landfill Directive (LfD) and was designed as a 'dilute and disperse' land-raise landfill. The waste disposal cell was formed by the construction of a three sided, 'U' shaped ("horseshoe") bund using PFA. Within the cell, limited or no PFA deposition took place, due to the closure of the Power Station in 1994 when the landfill was also put into closure. In a discrete area at the southern end of the site PFA waste was co-disposed with other permitted waste types. These discrete waste areas are identified in Section 6 and will not be disturbed by the proposed development work.

Despite closure of the Power Station in 1994 the landfill's environmental permit was not surrendered.

The proposed redevelopment of the landfill into a BESS will involve submission of a permit variation application for re-opening of the landfill to facilitate the creation of a development platform by re-profiling PFA from both the eastern and western arms of the 'U' shaped bund.

It is understood that PFA is not considered to be inert (as stated in an email from Helen Culshaw of the Environment Agency (EA) dated 9th October 2023) and therefore the LfD standards for hazardous or non-hazardous wastes[3] would apply. However, it was stated that some standards (including the specification of the lining and leachate collection system) could be reduced or removed based on a risk assessment and this aligns with the EAs landfill guidance[4] that allows sustainability to be considered in the design of landfill cells:

[1] Ramboll UK Ltd. Thorpe Marsh Landfill (EPR/CP3091SC/V002) Conceptual Site Model Report. Dated May 2024. Ref. 1620016237-012-RAM-RP-SS-00001.
[2] Ramboll UK Ltd. Thorpe Marsh Landfill (EPR/CP/3091SC/V002) Hydrogeological Risk Assessment Report. Dated May 2024. Ref. 1620016237-012-RAM-RP-SS-00003.
[3] Landfill operators: environmental permits - Design and build your landfill site - Guidance - GOV.UK (www.gov.uk). Accessed May 2024
[4] LFE4 - Earthworks in landfill engineering, Environment Agency, LFE4_earthworks_on_landfill_sites.pdf (publishing.service.gov.uk). Accessed May 2024

- *"Sustainability: demands that on-site or local materials are used where feasible. The Environment Agency actively encourages the use of low-grade materials, processed to make them acceptable, in appropriate situations within landfills"*

N.B. Directive EC67/584/ECC & Regulation (EC)1272/2008 – substance not classified as hazardous and all COSHH sheets refer to PFA as inert. Also, PFA is still utilised within the construction industry as inert fill and in the manufacturing of cement as an additive and other cement-based materials.

1.2 Site Operator

On completion of the name transfer application ref EPR/CP3091SC/T002, submitted to the Environment Agency in December 2023, Thorpe Marsh Green Energy Hub Ltd will be the site operator.

1.3 Objectives and Scope of Works

Key objectives of this ESID report are to:

- Describe the environmental setting of the proposed landfill cell, including site boundary, topography and local receptors;
- describe the Compliance Points, most notably for groundwater and surface water;
- describe the installation design; including capping structure, drainage management and post-closure controls and drawings (where required); and
- provide monitoring procedures for weather, leachate, landfill gas, groundwater, surface water and amenity.

The ESID report is based on inputs from:

- The landfill design as presented in drawings and documentation prepared by Sterling Maynard (engineer);
- data and interpretation collected through the HRA and CSM reports; and
- Environment Agency Guidance[5]

1.4 Constraints and Limitations

This report has been prepared by Ramboll exclusively for the intended use by the Client in accordance with the agreement between Ramboll and the Client defining, among others, the purpose, the scope and the terms and conditions for the services. No other warranty, expressed or implied, is made as to the professional advice included in this report or in respect of any matters outside the agreed scope of the services or the purpose for which the report and the associated agreed scope were intended, or any other services provided by Ramboll.

In preparation of the report and performance of other services, Ramboll has relied upon publicly available information, information provided by the Client and information provided by third parties. Accordingly, the conclusions in this report are valid only to the extent that the information provided to Ramboll was accurate, complete, and available to Ramboll within the reporting schedule. Ramboll did not undertake full time supervision of the site investigation, and so has had to rely on the Client providing much of the general information on the works.

Ramboll's services are not intended as legal advice, nor an exhaustive review of site conditions and / or compliance. This report and accompanying documents are initial and intended solely for the use and benefit of the Client for this purpose only and may not be used by or disclosed to, in whole or in part, any other person without the express written consent of Ramboll. Ramboll neither owes nor accepts any duty to any third party, unless formally agreed by Ramboll through that party entering into, at Ramboll's sole discretion, a written reliance agreement.

[5] https://www.gov.uk/guidance/landfill-operators-environmental-permits/what-to-include-in-your-environmental-setting-and-installation-design-report accessed May 2024.

Unless otherwise stated in this report, the scope of services, assessment and conclusions made assume that the site will continue to be used for its current purpose and end-use without significant changes either on-site or off-site.

The ground investigation works described were undertaken during a discrete period of time. The findings and conclusions presented in this report are accordingly factually limited by these circumstances. The previous field investigations were restricted to a level of detail necessary to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant period of time has elapsed since the sampling took place. The interpretation of the geological and environmental quality conditions is therefore based on extrapolation from point-source data in a heterogeneous environment (i.e., the site conditions are not fixed; chemical quality will vary over time and also reflecting the variable nature of ground permeability).

Unless stated otherwise, the geological information provided is for general environmental interpretation and should not be used for other geotechnical and / or design purposes.

2. SITE DETAILS

2.1 Location and Access

The site is located to the west of the former Thorpe Marsh Power Station (which was active between 1963 and 1994), approximately 6 km north of Doncaster town centre. The approximate centre of the site is at National Grid Reference 459480, 409490. A site location plan is presented as Figure 1, Appendix 1.

Access to the new landfill cell is through Ash Field Road towards the northeastern edge of the cell (as shown on Figure 2, Appendix 1).

2.2 Site Classification

It is understood that PFA is not considered to be inert (as stated in an email from Helen Culshaw of the Environment Agency (EA) dated 9th October 2023) and therefore the LfD standards for hazardous or non-hazardous wastes[6] would apply. However, it was stated that some standards (including the specification of the lining and leachate collection system) could be reduced or removed based on a risk assessment and this aligns with the EAs landfill guidance[7] that allows sustainability to be considered in the design of landfill cells:

- *"Sustainability: demands that on-site or local materials are used where feasible. The Environment Agency actively encourages the use of low-grade materials, processed to make them acceptable, in appropriate situations within landfills"*

N.B. Directive EC67/584/ECC & Regulation (EC)1272/2008 – substance not classified as hazardous and all COSHH sheets refer to PFA as inert. PFA is continuously utilised within the construction industry as inert fill and in the manufacturing of cement as an additive and other cement-based materials.

No formal records are available detailing the total volume of waste deposited at the site. A conservative estimate of the total volume of PFA waste within the current landfill is 4.4 million m^3. The proposed project is to excavate and redeposit a total of 600,000 m^3 PFA to form a new landfill cell within the confines of the proposed BESS landfill cell current WML boundary.

2.3 Site History

Ramboll has undertaken a review of publicly available information, and historical mapping and aerial imagery (where available) obtained from a proprietary environmental database and reported it within the Ramboll 2023 Phase I Geotechnical & Contaminated Land Desk Study[8]. The history of the site and surrounding area are summarised below:

- **1893:** The site is divided into agricultural fields, with drains along some of the east to west running field boundaries (later marked as Applehurst Drain in the north-east, with Stocking's Drain further south, which extends to the eastern site boundary). The Ea Beck is indicated to be present approximately 90 m south of the site on raised embankments, this watercourse was historically raised to prevent ingress to coal mines located in the wider surrounds. Norwood Sluice is noted on the Ea Beck approximately 100 m to the south. A footpath is shown at the southern end of the site, transecting roughly east to west. A railway line (West Riding & Grimsby) is adjacent to the northern site boundary.
- **1955-56:** There are no significant changes to the site until around 1955 to 1956, when Applehurst Lane is labelled in the north of the site area, and Ramsden Bridge is marked to the north-east of the EA Beck. Small ponds are noted in the north-east, centre and south of the site area. Generally,

[6] Landfill operators: environmental permits - Design and build your landfill site - Guidance - GOV.UK (www.gov.uk)
[7] LFE4 - Earthworks in landfill engineering, Environment Agency, LFE4_earthworks_on_landfill_sites.pdf (publishing.service.gov.uk)
[8] Ramboll, 2023. Project Harrier; Thorpe Marsh Battery Energy Storage System (BESS) Phase I Geotechnical & Contaminated Land Desk Study. Ref. 1620016237-RAM-RP-SS-00001_2.0. Dated: October 2023.

ponds and drains line the eastern, southern and western site boundaries during this time. Thorpe Marsh Power Station and associated infrastructure are shown from approximately 450 m east.

- **1966-70:** The late 1960s mapping editions depict the northern portion of the site to be covered in water, with Applehurst Drain feeding into it in the north-west of the site. A Slag Heap is denoted in the north-east corner of the site. The southern portion of the site has remained undeveloped. Elongated ponds are now shown between the perimeter of the site and Ea Beck to the south-east. A drain is shown to connect one of the ponds with the drain located just inside the site boundary.
- **1978-84:** Construction of internal roads within the site; Field Station Road and Ash Fields Road in the north; Plantation Road in the east; and Thorpe Mere Road in the west. Lower Boundary Road is present immediately south and south-east of the site and extends to the west from the south-western boundary. Water and the slag heaps are no longer depicted on site, and an 'Ash Tip' is annotated in the south of the site.
- Stockings and Applehurst Drains are no longer depicted on site. Thorpemere Pond, which is part of the Thorpe Marsh Nature Reserve, is present 70 m west of the site. Numerous drains are shown in the vicinity of the site.
- **Late 1980s:** There are discrete areas of vegetation (trees and similar) along the southern perimeter and in the east of the site. Tracks appear to be present in a roughly crescent shape around the western, southern and eastern boundaries. Thorpemere Pond has been extended northwards to also include a smaller pond.
- **1990s:** In 1996, the U-shaped bund is shown and the railway adjacent to the northern boundary of the site has been labelled as dismantled. Ponds are noted on the southern bank of the Ea Beck to the south of the site, and a water pumping station is now present in close proximity of the south-western site boundary. By 1999, the main buildings associated with the power station have been demolished with only the electrical sub-station and cooling towers remaining. The Google Aerial historical imagery[9] indicate that the cooling towers were demolished between 2009 and 2014.

The site has not undergone any further significant changes in the later mapping editions.

2.3.1 Anecdotal Evidence

Construction of Thorpe Marsh Power Station began in 1959, with operation from between 1963 and 1965, before it was officially opened in 1967. Excavation of land to the west of the power station (assumed to be within the landfill boundary) provided red shale to raise the foundation level. A total of 1 million tons of red shale and ash was used to raise and level the site[10].

A booklet on Thorpe Marsh Power Station from 1967[11] states that the finer fly ash was dampened and discharged into lorries, before it was taken to the station ash fields or sold direct for use on civil engineering projects. Approximately 100 tons of ash per hour was generated by the power station boilers, of which 30 tons was coarse ash, with the remainder fine fly ash.

The 1994 HRA[12] states that the site of the PFA landfill was a borrow pit to provide material for the railway embankments to the north. This then flooded with water naturally (as it was below ground level) and became a wildlife habitat (historical mapping from 1966 to 1980 show water or a lagoon in the north-west of the site).

Initial ash deposition is shown to be in the north-east of the site only on mapping between 1966 and 1980), with deposition in the south shown in mapping from 1982 onwards.

[9] Google Earth Pro, 2024 Version 7.3. Accessed: March 2024.

[10] https://priorieshistoricalsociety.blogspot.com/2012/03/article-history-of-thorpe-marsh-power.html

[11] https://www.flickr.com/photos/robdaniels/albums/72157624390102313/

[12] Geraghty & Miller International Inc, 1994. Hydrogeological Investigation and Waste Disposal Assessment Main Technical Report.

Anecdotal evidence suggests that a 10m high bund was created in the 1970s, although mapping from this time shows the area as fields. It should be noted that the original WML was granted in 1977 and the exact volume of PFA deposited pre and post licensing is not known. However, given the volume generated per hour by the power station it is likely that PFA was placed prior to the WML being in place in at least a proportion of the landfill area.

To facilitate ash disposal into the pond created on-site by earlier material excavation, a replacement pond was constructed to the west to retain the wildlife habitat (the current Thorpe Marsh Nature Reserve), which opened in 1980 and is shown on historical mapping from 1982. The material from the new ponds (assumed to be mainly clay and silt), was deposited in a low bund immediately adjacent to the eastern side of the new ponds and parallel with and possibly beneath Thorpe Mere Road. The first PFA was deposited in the old ponds located within the north-west of the earlier bund. In addition, Ramboll notes that as some clay was removed in this area, there will be a slightly reduced thickness of superficial deposit under the current landfill. Specific ground conditions are discussed later in this report.

The height of the bund was subsequently increased again to 20 meters in 1990 to allow additional storage and this represents the U-shaped bund that will be relocated to form the BESS development platform, i.e., the subject of this permit variation application.

The power station closed on 31st March 1994 and no subsequent material was deposited in the landfill.

2.4 Site Boundary and Security

The boundary of the new landfill cell as well as the existing WML boundary are presented in Figure 2, Appendix 1. The landfill cell boundary is defined as the area where excavation and redeposit of PFA will take place. As previously stated by the EA[13], any material not forming part of the new PFA landfill cell will continue to be regulated under the current WML conditions.

Access to the site is restricted and limited by waterways on three sides and a railway to the North. The only access to the new landfill cell will be through a planned gate on Ash Field Road (as shown on Figure 2, Appendix 1).

A security fence will be erected along the perimeter of the new landfill cell with a total length of 2,250 m.

2.5 Former Waste Management Actives Boundaries

The existing WML boundary is shown in Figure 2, Appendix 1.

2.5.1 Pre-Permit Waste Deposition

The original WML was granted in 1977, however, anecdotal evidence and historical mapping indicates that ash deposition occurred within the north-east of landfill from the 1960s when the power station began operation.

The foundation of the U-shaped bund was likely initiated in the late 1970s as a perimeter bund for the landfill using PFA, with further deposition of PFA and other domestic and commercial wastes within the bund occurring after the bund was formed. The U-shaped bund was then raised to ~20m AOD in 1990, with this material proposed for relocation under the Permit variation.

The exact date on which waste deposition ceased and the date the landfill was put in to closure is unknown. However, it is likely that this occurred shortly after the power station closed in 1994.

2.5.2 Waste Types

Waste types that were permitted under the current WML are listed in Table 2.1.

[13] Record of Meeting Minutes: Thorpe Marsh: Meeting with Environment Agency Application Ref: EPR/CP3091SC/V002 CM/NE/4181/PL-04 .Held on Thursday, 10 February 2022 via Microsoft Teams Commencing at 1.00pm.

Table 2-1 - Permitted Waste Types

Waste Type		Permitted Quantity
1	Pulverised Fuel Ash (PFA)	1,250 tonnes / day
2	Untreated Domestic and Commercial Waste. Demolition Waste (plastic packing sections from cooling towers).	50 tonnes / day
Waste in categories 1 and 2 above will not exceed 9,678 tonnes per annum in total.		

Further details on the waste at Thorpe Marsh is presented in the CSM report[14].

2.5.3 Waste Classification

Based on recent ground investigations (see CSM report), it is anticipated the excavated PFA landfill material will not require treatment to enable its use in earthworks. If unsuitable material or gross contamination is observed during the excavations this will become isolated at that point, and appropriately disposed of utilising licensed facilities off-site with waste duty of care in place.

The EWC codes for the landfill material are anticipated to be as set out in Table 2.2.

Table 2-2 - Proposed list of site-derived wastes

EWC Waste Code	EWC Description	Limitations
10 01 01	Bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)	Limited to site-derived material meeting the chemical and physical specifications for the works
10 01 02 c	Coal fly ash	Limited to site-derived material meeting the chemical and physical specifications for the works

2.6 Site Context

2.6.1 Geology

As presented in the CSM, and following the 2024 ground investigation (GI) the site-specific geology is summarised below:

Table 2-3 - Summary of Site-Specific Geology

Strata	Description	Depth / Thickness
Made Ground	Soft, dark grey/grey, gravelly, clayey, fine to medium sand or gravelly, sandy, silty clay i.e., reworked natural deposits.	0.8 m bgl / 6.96 m AOD (RBH146) and 24.5m bgl / 0.13 m AOD (RBH124), due to the raised nature of the PFA landfill.
PFA	Very loose/loose, grey, gravelly, very silty, fine and medium sand.	
Drift (Hemingbrough Glaciolacustrine Formation)	Firm to stiff, orangish brown mottled orange, or light grey, slightly sandy, silty clay with rare occurrences of fine to medium coal and silt partings. With depth, the clayey glaciolacustrine deposits are interbedded with layers of medium dense, greyish, dark brown or orangish brown, silty, fine to medium sand with thin laminae of	0.80 m bgl / 6.96 m AOD (in RBH146, located along the dismantled railway line to the north of the site) and 24.50 m bgl / 0.13 m AOD (in RBH124, located on the southern part of the U-shaped bund).

[14] Ramboll UK Ltd. Thorpe Marsh Landfill (EPR/CP3091SC/V002) Conceptual Site Model Report. Dated May 2024. Ref. 1620016237-012-RAM-RP-SS-00001.

	dark grey silt or partings of brown clay and occasional fine to coarse siltstone, sandstone or quartzite gravel. Occasionally, layers of very dense, grey or brown, sandy, angular to well-rounded fine to coarse sandstone and quartzite gravel have also been recorded interbedding with the above.	The thickness of the glaciolacustrine deposits ranged between 4.50 m (in RBH119 in the east of the site, off the bund) and to >27.10 m (in RBH141A, in the south-east of the site). Although the base of the unit was not proven in this location, an historic borehole log (MW4S) indicates a drift thickness of 67.50 m in the area.
Bedrock (Chester Formation)	Very dense, reddish brown, slightly silty, fine and medium sand, and occasionally with clay and fine to coarse siltstone, sandstone or coal gravel.	Probable weathered sandstone was encountered beneath the drift deposits, from the depths of between 10.50 m bgl / -2.06 m AOD (in RBH113 in the north-east of the site) and 33.0 m bgl / -10.16 m AOD (in RBH129 in the west of the site). The 2021 boreholes indicated that the bedrock unit was encountered at even greater depths of 40.70 m bgl (MW7S) in the north-west of the site and of 71.50 m bgl / -60.1 m AOD (MW4S) in the south-east. The depth to bedrock varies due to the presence of an infilled glacial channel that runs NW-SE through this area.

2.6.2 Hydrogeology

The underlying Hemingbrough Glaciolacustrine Formation is designated as an Unproductive Strata which is 'rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow'.

The Alluvium (located immediately east of the site) is designated as a Secondary A Aquifer which comprises permeable layers that can support local water supplies and may form an important source of base flow to rivers. However, this is likely to be of limited thickness and extent. The Secondary A Aquifer is unlikely to be used for potable or commercial water supply due to limited lateral extent and thickness.

The bedrock geology comprising the Chester Formation is designated as a Principal Aquifer which has a high intergranular and / or fracture permeability meaning it is highly likely to provide a high level of water storage and may also support water supply and / or river base flow on a strategic scale.

The site is located within Zone III (Total Catchment) of an EA designated groundwater Source Protection Zone (Figure 7-A, below). This is the total catchment area around the source (point of abstraction), where pollutant travel times are greater than 400 days. The SPZ is associated with nine abstraction wells to the south-east and south of the site all of which are greater than 2km from the site.

The CSM and HRA identified groundwater to be present within the PFA, drift deposits and the underlying sandstones (the latter under semi-artesian pressure) at similar resting levels in boreholes, and it was considered there was a potential for hydraulic connectivity to exist between all three water

bodies, although the potential for the sandstone to be in direct hydraulic connection to the upper water bodies was concerned likely to be limited by the depth to bedrock (and groundwater in the rock) and the semi-artesian nature of the groundwater limiting the potential for mixing across much of the site. It was acknowledged that the depth to rockhead was shallower in the east of the site although the existing groundwater chemical data demonstrated much lower concentrations of potential PFA derived contaminants in the sandstone compared to groundwater in the PFA and drift as further evidence of the limited connection to deeper groundwater. Further description is provided in the CSM and HRA reports on groundwater levels and baseline conditions.

2.6.3 Topography & Surrounds

The site topography is dominated by the deposited waste (PFA) that rises above the surrounding ground. The site levels vary between approximately 0m AOD in the south of the site (i.e., similar to surrounding ground level) to 24 m AOD at the top of the bund. A topographical survey was undertaken in February 2024 and is presented as Figure 3, Appendix 1.

The surrounding land use comprises predominantly agricultural land including the following:

- To the north, the existing Network Rail freight line with agricultural fields and minor roads beyond. Approximately 0.9 km from the northern boundary is the village of Thorpe-in-Balne.
- To the east, the former Thorpe Marsh (coal-fired) Power Station site (now demolished) and the existing National Grid 400 kV Thorpe Marsh Substation. Further to the east, Thorpe Bank (road), the River Don (approx. 1km), agricultural fields, and the River Dun Navigation. Approximately 1.5 km from the eastern boundary is the village of Barnaby Dun.
- To the south, the EA Beck (also referred to in documentation as the Thorpe Marsh Drain), agricultural fields and Fordstead Lane (road). Approximately 2 km from the southern boundary is the village of Arksey.
- To the west, the (Yorkshire Wildlife Trust managed) Thorpe Marsh Nature Reserve (with Thorpemere Pond present) followed by agricultural fields and another Network Rail line beyond. Approximately 4.75 km from the western boundary are the towns or Adwick-le-Street and Carcroft.

The raised Ea Beck is present approximately 90 m south and it is flanked by levees. Beyond the Ea Beck there is a further ground level drain located from approximately 20m with a network of drains in the wider agricultural land.

2.6.4 Local Receptors

As detailed in the CSM report, the sensitive receptors at this site include:

- Human health:
    - Future site users, such as the maintenance and security workers;
    - The nearest residential properties are small farmhouses located 175m north and 830m south respectively. These locations also include commercial buildings associated with the respective farm operations. A National Grid compound is located 540m to the east but is not understood to be permanently occupied (i.e., other than working hours). These potential off-site receptors are therefore not considered to be a potential receptor of significance.
    - Members of the public, walking on nearby footpaths or at Thorpe Marsh Nature Reserve.
- Surface waters:
    - The two inner surface water toe drains for the existing landfill are not considered to be sensitive surface water receptors.

- Thorpe Marsh Drain (Ea Beck) (surface water to south and east of the site). Although the drain is not in hydraulic connectivity with groundwater beneath the site as it is topographically higher, albeit there is no clear pathway to the EA Beck as the toe drains appear silted up. This is located approximately 30m to the south-west of the WML permit boundary and c.250m south-west from the new landfill cell The land drain beyond the EA Beck.
- The adjacent Thorpe Marsh Nature Reserve is located within the wider WML permit boundary.

- Groundwater:
  - Off-site Secondary A Aquifer associated with the alluvium. This is unlikely to be used for potable or commercial water supply due to its limited lateral and vertical extent, so is considered a limited receptor and as a pathway to surface waters only.
  - Principal Aquifer associated with the sandstone of the Chester Formation. The site is located within a SPZ Zone III (Total Catchment) relating to groundwater at significant depth in the bedrock. There are five (5) licensed groundwater abstractions listed within 2km of the site (closest 370m east) for a variety of uses including general industrial and general farming and domestic. The SPZ is associated with nine abstraction wells to the south-east and south of the site all of which are greater than 2km from the site. The nearest is located 4.6km to the south-east.
- Ecology:
  - Thorpe Marsh Nature Reserve is located within the wider WML permit boundary. Vegetation is present on-site over the PFA, but is generally of limited ecological value. The vegetation will need to be cleared prior to the works commencing and will be managed through the planning system, including achieving Biological Net Gain (BNG) targets. Ecology receptors on-site (notably badgers and newts) that require translocation will be identified and relocated.
- Buildings / Infrastructure
  - A National Grid compound is located 540m to the east but is not understood to be permanently occupied (i.e., other than working hours).
  - The nearest residential properties are two farmhouses located 200m north and 830m south respectively. These locations also include commercial buildings associated with the respective farm operations.

However, the CSM concluded that the above receptors, and the associated source/pathway connections were considered to have either a negligible impact or no potential hazard. It is therefore considered specific mitigation measures are not required above those associated with the management controls to be implemented through the Environmental Management System and Construction Environmental Management Plans (CEMP) for the development project (Appendix 3).

2.6.5 Climate and Climate Adaptation

The UK Government and devolved administrations have produced climate change adaptation programmes, including plans for both mitigating and adapting to climate change. SDGs support the development of Sustainable Cities and Communities (SDG No. 11), Clean Water and Sanitation (SDG No.6), sustainable ecosystems (SDG No.14. Life below Water and SDC No. 15 Life on Land). It is therefore important to recognise how changes in weather/season/climate could affect the ground conditions that were encountered during the investigation.

Climate change projections[15] demonstrate that in the UK the following conditions are expected to result from future climate change: drier and hotter summers, wetter and milder winters, a higher frequency of intense rainfall periods and sea level rise. The following are considered relevant to the assessment:

- **Increase in precipitation** – this may cause increased infiltration and a rise in groundwater levels leading to groundwater flooding, increased leaching, runoff and contaminant mobilisation and a potential change in locations of surface water receptors.
- **Drier, hotter weather** – this may increase potential for low permeability horizons to desiccate and permit a higher rate of infiltration, migration of contaminants from surface into subsurface, increase in groundwater abstractions causing change in flow paths or introducing new receptors.

The key parameters which require consideration under conditions of climate change are recharge, groundwater elevations (unsaturated and saturated zone thickness) and hydraulic gradient. As the effects of climate change in the UK are projected to be spatially variable it is necessary to seek an understanding of the changes in recharge and groundwater elevation as close as possible to the site being assessed.

The impacts of climate change have been considered within the HRA modelling in the sensitivity analysis section by incorporating the following:

1. Recharge, potential increase in rainfall and increase in recharge is considered by varying the infiltration rates from 25mm to 100mm effective recharge / year. This range is representative of the higher range of infiltration that may occur due to increased storms events/wetter weather as a consequence of climate change.
2. Change in groundwater elevations due to extreme weather events considered via variations in the unsaturated and saturated zone thicknesses.
3. Potential increase/decrease in hydraulic gradient due to variations in the groundwater elevations across the site.

Within the outline drainage strategy (see Appendix 4) for the new landfill cell, the attenuation storage volume required has been calculated using the HR Wallingford Surface Water Storage Estimation tool and the IH124 estimation methodology. Rainfall values for the 6hr and 12 hr 1 in 100-year storm events have been manually edited to the FEH13 values. A 40% climate change to rainfall has been applied as per Environment Agency guidance for the area.

The nearest climate station at Robin Hood Doncaster Sheffield Airport indicates that between 1991 and 2020 annual rainfall was 582 mm. According to the EA's fluvial and tidal flood map for planning:

- The west of the site (the area of the PFA mound) is Flood Zone 2 (Medium Probability). This zone comprises land assessed as having between a 1 in 100 (1%) and a 1 in 1000 (0.1%) annual probability of river flooding and / or a 1 in 200 (0.5%) and a 1 in 1000 (0.1%) annual probability of sea flooding.
- The remainder of the site is located in Flood Zone 3 (High Probability). This zone comprises land assessed as having a 1 in 100 (1%) or greater annual probability of river flooding and / or a 1 in 200 (0.5%) or greater annual probability of sea flooding.

However, the Environment Agency mapping is based on historic flood extent through this area prior to the placement of the mound that occurred in 1947 as a result of a flood defenses failure and the development platform/PFA mound at a post construction level of ~10-11m AOD sits well above the climate change (20%) adjusted 1 in 1000-year flood extent of 7.37m AOD.

According to the EA Flood Map for Surface Water which presents the theoretical potential for flooding from pluvial sources (i.e., flooding caused by rainwater exceeding capacity of drainage systems), the

[15] Meteorological Office UK (2018). UKCP18 Land Projections: Science Report. Updated March 2019.

site is generally located in an area of Very Low flooding probability. This zone comprises land assessed as having a less than 1 in 1,000 annual probability of pluvial flooding (<0.1% in any year).

There are sporadic areas on the map where surface water flooding is between a Low (0.1% and 1% of annual probability) and High risk (greater than 3.3% of annual probability). This is at generally low points in the topography in the vicinity of surface water features such as Thorpe Marsh Drain.

As noted above an engineered surface water drainage system will be provided for the BESS with the concept engineering design provided in Appendix 2 including a Planned Preventative Maintenance (PPM) schedule for the individual elements of the drainage system.

3. COMPLIANCE POINTS

3.1 Groundwater and Surface Water

As described within the HRA, initial modelling assumes the receptor is the groundwater below the site. WFD requirements states that for hazardous substances the compliance point must be the point at which substances reach the groundwater. Substances listed as non-hazardous to groundwater can be considered both in terms of risk to groundwater below the site and to an off-site receptor (i.e., the wider aquifer or wider land drainage network). In this scenario, an off-site compliance point has been set at a distance of 50m from the source area, this is also suitably protective of wider surface watercourses.

Further details regarding groundwater/surface water monitoring are discussed in Section 5, below.

3.2 Landfill Gas

PFA is not biodegradable so cannot produce landfill gases. There is untreated domestic waste within the historical landfill, but this waste will not be excavated as part of these works.

Ground gas monitoring has not identified concentrations of methane above the 1% v/v compliance limit set for the current WML. Within the in-waste wells, carbon dioxide concentrations ranged between ≤0.1 % v/v to the maximum of 3.0 % v/v (BH03, October 2021).

Within the perimeter wells, carbon dioxide was recorded between 0.1 % v/v to the maximum concentration of 6.3 % v/v (MW4D, November 2023). Carbon dioxide has been found typically above the compliance limits throughout the monitoring period in MW4D (ten rounds) and MW7D (five rounds). It was also above the compliance limit twice in MW1D, MW2 and MW5S and once in MW7S (in July 2021 only). It should be noted that the compliance limited of 1.5%v/v is conservative, especially given the control limit for new residential properties requiring gas protection considerations is 5%v/v. The concentrations are within the range of what could be expected from natural drift deposits (i.e., alluvium) as recorded on site.

4. POLLUTION CONTROL MEASURES

4.1 General Installation

The existing landfill was operated under a WML granted in 1977 and is of a dilute and disperse construction.

The proposed installation and movement of PFA will create a new landfill cell within the area of the existing landfill. This is to allow for the construction of the BESS. It is estimated that approximately 600,000 m^3 of PFA will be excavated and used to form the new landfill cell which will form the development platform for the planned BESS scheme. A key consideration for design and construction of the new landfill cell is minimising the import of off-site material. This will greatly reduce the potential impact of increased traffic on nearby receptors.

After removal of vegetation and limited topsoil in the proposed new landfill area, PFA from the eastern and western U-shaped bund will be deposited in 225 mm thick layers and compacted to reduce future settlement/infiltration. Stability and settlement risk assessments indicate that the design of the landfill is sufficient to form the development platform for the BESS and PFA slopes will be stable. Final landfill elevations will vary between approximately 7.0 metres Above Ordnance Datum (m AOD) and 15.1 m AOD, with the development platform having a general sloping surface towards the south-west to aid surface water run-off.

The compacted cut and fill thickness will range from 0.00m to maximum of approximately 9.9m. This will create a low-permeability material throughout the thickness of the new landfill cell. A surface drainage system consisting of rock-filled trenches, ditches, piping and attenuation basins will collect rainfall towards the discharge point. Primary drains with a length of approximately 2,200m and secondary drains with a length of approximately 13,000m total will be installed to transport rainwater to the attenuation basins.

Infrastructure related to the BESS development will be installed inside and on top of the engineering layer such as roads, cable conduits, BESS battery unit foundations and other infrastructure elements. A switchyard / substation and welfare area are constructed on top of the landfill. Given the likely loadings of the switchyard / substation, the foundations may need to be piled. A piling risk assessment will form part of the detailed design and construction quality assurance (CQA) works following permit issue and prior to any works commencing. Management of pile arisings (as required) will also be address in the detailed design works.

As stated in the Stability Risk Assessment[16] (SRA), settlement magnitudes are not considered excessive given the scale of the works. Given the generally uniform increase in stress across the site, differential settlements should not significantly affect the falls or drainage. Where fill depth is maximum to the south of the site, it may be necessary to over-fill to ensure long-term settlements do not cause failure of the drainage system, however this will be addressed during detailed design.

Access to the site is restricted and limited by waterways on three sides (West, South and East) and a railway to the North. Single access to the site is through a planned gate on Ash Field Road.

A security fence will be erected along the permit boundary.

4.2 Basal and Slope Engineering

Based on the CSM and HRA, a geological barrier and basal liner are not required given the negligible impact of potential substance release and impact on receptors and the expected limited infiltration through the low permeability engineered PFA (see Section 4.3).

[16] Ramboll UK Ltd. Thorpe Marsh Landfill Stability Risk Assessment. Date June 2024. Ref. 1620016237-012-RAM-RP-SS-00006.

The SRA provides verification that the proposed works will not result in environmental risks due to slope failure. N.B. Settlement of the waste mass is not considered to pose a risk as there is no formal capping system and/or leachate management infrastructure within the landfill.

The design geometry of the reprofiled waste mass includes cut slopes in the existing material, and new embankment slopes, both proposed at gradients of 1V:3H. It should be noted, however that existing slopes within the site are observed to be stable at 1V:2.5H.

Based on the results of slope stability analysis it is concluded that the proposed geometry of cut slopes and embankment faces will remain stable in the long term.

Establishment of vegetation will serve to improve stability by binding the soils together and mitigating the effects of erosion.

4.3 Capping System

Although the new landfill cell will not have an engineered cap, the compacted PFA will act as a low permeability layer (to c.10^{-7} m/s) which will inhibit infiltration and provide improvement compared to the current free draining situation (10^{-5} m/s recorded in PFA groundwater monitoring wells).

The earthworks design for the new PFA landfill cell consists of the following elements (bottom-up):

1. Engineered / Low permeability material.
2. Surface drainage system.
3. Vegetation layer / gravel cover and/or BESS infrastructure.

The surface water drainage system will be designed to collect 100% of the rainfall (minus the 5mm interception loses) using trenches, ditches, swails, piping and attenuation basins. All surface water will be attenuated in open attenuation basins formed within WML site boundary. These basins will be lined (with HDPE or similar liner) to prevent uncontrolled seepage.

Outside areas covered by BESS infrastructure such as service roads, battery units and surface water infrastructure, a vegetation layer will be installed with a thickness of 50-100 mm.

4.4 Leachate Infrastructure

As reported in the CSM, all soil leachate of the cut PFA GAC exceedances are of the same order of magnitude, and with the exception of sulphate, only recorded in isolated locations. The sulphate exceedances are also quite marginal and not an order of magnitude difference. These are therefore not considered to be significant. The HRA has confirmed this is not a significant risk to underlying groundwater.

This is in contrast with the exceedances against GAC recorded within groundwater beneath the site, which would suggest that the water body has been previously impacted from the existing landfill.

Therefore, the cut and relocated PFA (i.e., new landfill cell) will have a negligible impact to the underlying groundwater bodies and no leachate infrastructure will be installed.

4.5 Landfill Gas Infrastructure

The materials proposed to be deposited (PFA) will not generate landfill gas. Therefore, no proposals for gas management systems or offsite gas monitoring.

4.6 Amenity

Aspects of noise, odour, dust will be closely monitored throughout the development phase in line with the CEMP (Appendix 3).

A construction noise management plan will be developed which will incorporate mitigation measures, which may include speed restrictions for vehicles entering and exiting the site; operational hours restricted to daylight hours only and screening bunds incorporated, if required.

Odour is not anticipated to be an issue due to the nature of materials that will be excavated and redeposited (PFA).

Dust generation will be monitored throughout and mitigation such as damping down/spraying of materials will be undertaken; a dust management plan will be developed.

The site operations will be appropriately managed to identify environmental risks and put in place appropriate mitigation measures where required.

4.7 Post Closure Controls (Aftercare)

4.7.1 Restoration / Aftercare

The waste activity will ultimately lead to the creation of a development platform for the planned BESS scheme. Landfill restoration is not included as part of this variation but is likely to include placement of gravel on the landfill surface (BESS development platform), with seeded topsoil on PFA slopes to allow for landfill restoration activities to occur in future (detail not included in this application, but that will form part of a wider scheme include meeting the Client's ambitious biodiversity net gain targets).

4.7.2 Closure

It is a requirement of the Landfill Directive that a closure and aftercare management plan is maintained throughout the life of the landfill.

Closure is an ongoing process between the time when the Site is 'closed', i.e., has ceased accepting waste for disposal and 'definite closure', i.e., when the EA agree that the Site may enter the aftercare phase.

Monitoring plays a vital part in determining the performance of the landfill against any assumptions made. It is necessary to consider the following factors:

- Generation of landfill gas;
- Potential for leachate or gas to be generated in future;
- Physical stability of the waste and associated structures; and
- Surface water and groundwater monitoring.

The non-hazardous waste (i.e., PFA) permitted to be landfilled at the Site will not generate landfill gas or leachate and management infrastructure will not be required.

The Site will be monitored for evidence of instability when topographical surveys are carried out to assess the settlement of the waste mass. The landfill surface and waste slopes will be assessed during each monitoring round.

Monitoring of the post closure surface will be carried out on regular occasions (at least quarterly). On these occasions observations will be made and the results will be recorded on a Site check sheet. Should it be identified that settlement of the waste has occurred to affect the surface, the details of any rectification works necessary will be passed to the Site operator.

Once landfilling is complete a notification that the Site has ceased accepting waste will be sent to the EA. Following this notification, the operator shall submit an application for Definite Closure.

A post closure monitoring schedule for landfill gas and groundwater will be proposed based on the results of monitoring during the operational phase. Monitoring will be carried out for at least two years after the Site has ceased to accept wastes for landfill. The Site closure requirements will be reviewed periodically during the operational phase. Closure requirements will be in accordance with the guidance that is current at the time.

5. MONITORING

5.1 Weather Monitoring

The nearest weather station to the site is at Robin Hood Doncaster Sheffield Airport, some 11km south-west of the site.

The average rainfall (as per the period 1991 to 2020) is around 582mm per year, the drier months generally being Spring (February and March)[17]. Average Temperatures range from a minimum of 1.43°C to 22.3°C[17]. The monthly mean wind speed at 10 m range from 6.94 knots to 9.03 knots[17].

As part of the monitoring works a site weather station will be installed to monitor site-specific weather details throughout the operation of the landfill.

5.2 Leachate Monitoring Infrastructure

Leachate monitoring is not required.

5.3 Gas Monitoring

No new gas monitoring locations are proposed Reference should be made to the existing Environmental Monitoring Plan[18].

5.4 Groundwater Monitoring

Reference should be made to the Environmental Monitoring Plan.

5.5 Surface Water Monitoring

Reference should be made to the Environmental Monitoring Plan.

5.6 Amenity Monitoring

Aspects of noise, odour, dust will be closely monitored throughout the development phase in line with the CEMP (Appendix 3)

[17] https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcx21p9fr accessed 03/06/2024

[18] Environmental Monitoring Plan, Thorpe Marsh Tip, prepared by Egniol, dated December 2020, ref. ECL.7991.R02.001

APPENDIX 1
FIGURES

APPENDIX 2
STIRLING MAYNARD DRAWINGS

APPENDIX 3
CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN (CEMP)

APPENDIX 4
OUTLINE DRAINAGE STRATEGY