Fyrish BESS Hydrogeological Assessment Report

for

Field Fyrish Ltd

ENVIRONMENTAL CONSULTING

Fluid Environmental Consulting Ltd

108/15 Great Junction Street, Edinburgh, EH6 5LD

Tel: 07725 033 725 dsaunders@fluidec.com

Registration No. SC385700

Fyrish BESS Hydrogeological Assessment Report

November 2024

Prepared by :	Fluid Environmental Consulting Ltd
For:	Field Fyrish Ltd
Author:	Tommy Rae
Signature:	
Reviewer:	Duncan Saunders
Signature:	[redacted]

Fluid Environmental Consulting Ltd 108/15 Great Junction Street, Edinburgh, EH6 5LD [redacted]	

Table of Contents

Figures

1 Introduction

Fluid Environmental Consulting (Fluid) has been commissioned by Field Energy to carry out a hydrogeological study in support of the proposed Battery Energy Storage System (BESS) development at Fyrish Field, located near Alness, Scotland. The study aims to assess the potential impacts of the proposed development on a potential Groundwater Dependent Terrestrial Ecosystem (GWDTE) within the Site. This work has included a review of available geological and groundwater data to evaluate the connectivity between the habitat and groundwater, as well as consideration of the potential effects of the BESS infrastructure on groundwater levels, recharge and throughflow. Recommendations for mitigating any adverse effects on the local environment are provided, with particular focus on safeguarding the integrity of the potential GWDTE.

1.1 Background

The Site of the proposed development area for the BESS is located at Fyrish, near Alness, in the Scottish Highlands and is 53.5 hectares in size, currently maintained as unimproved grassland (Figure 1). To the north of the BESS, the land adjoins a forested area, while agricultural fields lie to the east and west. The southern boundary is marked by a rural estate that accommodates various businesses, including housing and timber processing operations.

2 Objectives and Contents of Study

This study has been carried out to support the application for the development of the BESS at Fyrish. The primary objective is to assess the hydrogeological characteristics of the Site to ensure the proposed development will not have adverse impacts on the surrounding groundwater and surface water systems, including possible effects on a nearby potential GWDTE identified within the Preliminary Ecological Appraisal October 2024 (Tetra Tech) as f2c – Upland flushes, fens and swamps in accordance with the UK Habitat Plan. The area identified as 'upland flush' is shown in Figure 1 as a 'potential GWDTE' and is referred to as Area A throughout this report.

The study has focused on:

- Hydrogeological assessment of the Site based on site investigations and groundwater monitoring data.
- Conceptualisation of the hydrogeological regime.
- Understanding the groundwater flow dynamics within and around the proposed BESS development area.
- Investigating potential interactions between the groundwater and surface water systems.
- Evaluating the hydrogeological suitability of the Site for the planned infrastructure, including foundations and drainage systems.

- Assessing the potential risks of reduced groundwater throughflow or decline in groundwater level, particularly in relation to the Area A, and on surrounding land use.
- An evaluation of potential measures to mitigate potential impacts to surface and groundwater flow and water quality.

3 Groundwater Dependent Terrestrial Ecosystems

Groundwater Dependent Terrestrial Ecosystems (GWDTEs) are protected under the Water Framework Directive (WFD) legislation, with assessments regulated by the Scottish Environment Protection Agency (SEPA). These ecosystems rely on sustained groundwater flow to maintain their ecological integrity and are sensitive to changes in the hydrological regime such as could result from development activities.

Assessment of GWDTEs should be made in accordance with SEPA's Land Use Planning System Guidance Note 31 (LUPS-GU31): Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. These guidelines present the National Vegetation Classification (NVC) categories that are potentially groundwater dependent and therefore requiring more detailed assessment.

As a NVC survey has not been completed for the Site a precautionary approach has been applied in this study and the f2c habitat type comprised of upland flushes, fens, and swamps (Area A) has been assumed to represent a potential GWDTE. This approach ensures compliance with regulatory expectations and allows for the potential presence of groundwater-dependent habitats to be appropriately considered.

It should be noted that a GWDTE is typically dependent on a sustained groundwater throughflow from upgradient, and recharge, infiltration of rainfall and surface water to the subsurface. An obstruction or diversion of flow, or modification of surface properties, could lead to changes in these inputs, with potential impacts on groundwater flow or levels which could affect the GWDTE.

4 Hydrogeological Understanding

4.1 Hydrology

The Site is located on the lower south-east facing slopes of Cnoc Fyrish which rises to an elevation of 453 m Above Ordnance Datum (AOD). Most of the land upgradient of the Site is forested while the Site is moorland with some sparsely distributed trees. The Site is bounded on its eastern and southern sides by the Culgraggie Burn which flows towards the north-east from the eastern end of the Site to join the Contullich Burn at the western end of the town of Alness where it then flows south to discharge to Alness Bay and the Cromarty Firth. The elevation of the Site ranges from approximately 50m AOD in the west to about 32m AOD in the east. The land surface has a general slope from north-west to south-east.

4.2 Geology

In terms of bedrock geology, the Site is underlain by the Raddery Sandstone Formation, which dates to the Mid-Devonian period (Figure 3). This formation consists mainly of sandstone and is fluvially derived, being formed through river and estuarine processes. The sedimentary rocks range from coarse- to fine-grained, reflecting the detrital nature of the deposits. These sediments are typically arranged in beds and lenses that indicate the presence of ancient river channels, floodplains, and levees. The Raddery Sandstone Formation is a member of the Black Isle Sandstone Group, itself part of the Old Red Sandstone Supergroup.

Overlying the bedrock is a layer of glaciofluvial deposits, which are primarily composed of gravel, sand, and silt (Figure 2). These deposits are of Quaternary age and result from outwash from melting glaciers during the last ice age. The deposits are detrital in nature and generally coarse-grained, forming beds, channels, plains, and fans associated with the meltwater from glacial retreat.

4.3 Hydrogeology

The hydrogeology of the Site is influenced by the bedrock aquifer of the Middle Old Red Sandstone (Undifferentiated) formation and specifically the Raddery Sandstone Formation. This formation is classified as a moderately productive aquifer, where groundwater flow occurs predominantly through fractures and other discontinuities in the rock. The lithology of this formation consists of sandstones, which are flaggy in places, interspersed with siltstones, mudstones, conglomerates, and occasional interbedded lavas. The groundwater yield from this formation is generally low, with small flows in zones where the rock is sufficiently fractured.

The layer of glaciofluvial deposits that overlie the Raddery Sandstone is in the region of 15m thick at the Site. These are often high permeability materials that will support substantial groundwater flow, particularly through zones of coarse-grained materials. The Raddery Sandstone and glaciofluvial deposits are considered to be in hydraulic continuity.

5 Site Investigations and Monitoring

5.1 Site Investigations

A Ground Investigation (GI) was carried out by GD Drilling in August 2024, comprising 33 trial pits and seven boreholes, four of which were completed as groundwater monitoring wells (BH01, BH04, BH06 and BH07) while the other three were backfilled. Borehole depths varied, with BH01 and BH02 extending to 15m and 18m below ground level (bgl) respectively; the remainder were drilled to depths of 10m bgl. No permeability testing was conducted within the investigation.

5.2 Encountered Ground Conditions

The ground conditions at the Site generally consist of topsoil extending from the surface to depths of between 0.10m bgl and 0.60m bgl. Beneath the topsoil, granular glaciofluvial deposits were observed in all boreholes and trial pits, reaching a maximum observed depth of 15.0m bgl (equivalent to 27.36m AOD). Due to the limitations in the depth of borehole drilling, the full thickness of these deposits could not be determined, other than in exploratory borehole (BH02) where bedrock comprising sandstone and conglomerate and identified as Raddery Sandstone Formation occurred at a depth of 14.70m bgl (25.56m AOD).

In the north-eastern part of the Site, localised clay lenses were observed in trial pits TP24 and TP25, within the glaciofluvial deposits. Additionally, peat to a maximum recorded thickness of 1.00m was found in the south-western corner in several test pits; TPs 03, 04, 05, 06 and 07.

5.3 Groundwater Occurrence

Groundwater occurs at shallow depths across the Site and was encountered during drilling of the exploration boreholes and in those test pits that were completed to sufficient depth to intersect the water table. Water level monitoring carried out in four boreholes indicates levels between 2m and 6m bgl. Additionally, data from groundwater strikes encountered during the GI works have been incorporated into the analysis to enhance the mapping of water table elevations across the Site. Due to the relatively high permeability and the likelihood of an unconfined water table, the water strike depths are likely to be reasonably representative of actual groundwater levels.

5.3.1 Trial Pits (TPs):

- **TP02**: Groundwater was encountered at 35.95m AOD (2.5m below surface), with sands present at the strike depth. The recorded water level is consistent with the surface-level conditions.

- **TP03**: No groundwater was found, indicating that the water level at this Site must be deeper than 34.34m AOD, with 0.3m of peat and sand above the groundwater level.

- **TP04**: No groundwater was recorded in this pit, inferring that the water table elevation at this Site must be below 31.5m AOD, with a peat layer of 0.3m at the surface.

- **TP05**: No groundwater was recorded in this pit, inferring that the water table elevation at this Site must be below 30.74m AOD, with 0.2m of peaty topsoil at the surface.

- **TP06**: No groundwater was recorded in this pit, inferring that the water table elevation at this Site must be below 32.7m AOD, with a 1m peat layer from the surface.

- **TP07**: This test pit was only 0.2m deep, so no usable groundwater data was obtained or inferred for this Site.

- **TP08 - TP10**: These sites show deeper or no clear groundwater data, with TP08 indicating a peat layer with a groundwater strike below 40m AOD.

- **TP28**: Groundwater was found at 2.5m depth (31.74mAOD), consistent with shallow groundwater levels in this section of the Site.

5.3.2 Boreholes (BHs):

- **BH01**: Exhibits significant fluctuations with groundwater levels that appear higher than expected. The static water level (SWL) in BH01 is approximately 4.8m higher than the strike depth, indicating potential confined conditions. The fluctuations here are much more extreme than other boreholes, and further groundwater monitoring is being undertaken at this location to allow a more comprehensive assessment.

- **BH04:** Borehole records indicated sands and silty sands/gravels to a depth of 10m (30.31m AOD), with groundwater levels recorded between 2.1m and 2.5m bgl.

- **BH06**: Borehole records indicated sands and silty sands/gravels to a depth of 10m (33.24m AOD), with groundwater levels recorded between 4.9m and 5.7m bgl.

- **BH07**: Borehole records indicated sands and silty sands/gravels to a depth of 10m (24.06m AOD), with groundwater levels recorded between 1.8m and 2.4m bgl.

- **BH02, BH03, BH05**: These boreholes were either backfilled or provided no useful groundwater data for the assessment.

6 Groundwater Conditions and Hydrogeological Conceptualisation

6.1 Groundwater Elevations and Flow Direction

Groundwater level data collected from the GI trial pit excavations and from the borehole monitoring suggest that groundwater levels fluctuate with time. In general, groundwater levels are found to be at or close to the strike depths at many locations. Measurements collected on the 19th September 2024, 2nd October 2024, and 9th October 2024 indicate variations of up to 2 metres (BH01) while others indicated variations of up to 80cm over the three week period. It should be noted that whilst these short-term datasets are limited, an extended period of monthly monitoring over a year of these boreholes is currently being undertaken and we expect this to further support the conclusions.

Groundwater elevations (mAOD) derived from the borehole monitoring and from the trial pit water strikes have been interpolated to construct an approximate piezometric surface across the Site. This is shown in the form of a piezometric head contour plot in Figure 4. Groundwater level contours were developed using data from the first round of groundwater monitoring in the boreholes, which recorded the highest groundwater levels observed during the monitoring period. Additional data were incorporated from groundwater strikes encountered during the trial pit investigations to provide a comprehensive representation of the groundwater regime across the Site. The contours indicate a generally south to south-easterly groundwater flow direction across the Site. Based on the geological environment and the shallow depth to groundwater this surface is interpreted to represent a water table surface consistent with a shallow unconfined groundwater system which is recharged by rainfall and surface water infiltration at the Site and across the catchment upgradient of the Site.

6.2 Implications on Proposed Construction on Groundwater System

6.2.1 Interaction with Groundwater Throughflow

The interpreted groundwater level across the Site have been compared to the depth of the foundation of the proposed BESS facility. Figure 5 provides a contour plot showing the approximate depth to groundwater from the base of the foundation. The plot indicates that the facility foundation will be below the water table in the north-eastern sector of the Site as shown by the areas shaded yellow, light orange and red. This is commensurate with the substantial area of cut that is proposed for this area. The plot also shows that the water table is not intercepted across the rest of the proposed infrastructure including the area upgradient of Area A.

Analysis of three cross sections (A-A', B-B' and C-C') is presented in Figure 6.

These cross-sections have been constructed using:

- Borehole logs to represent subsurface geology.
- Groundwater monitoring data to define water table elevations.
- Proposed foundation depths and post-construction ground levels.

The cross-sections illustrate the groundwater table, foundation depths, and the proposed new ground levels upgradient of Area A. In the western portion of the Site, the cross-sections confirm that groundwater levels are well below the planned foundation depths and proposed ground levels. As a result, groundwater levels in this area are not anticipated to be affected by construction activities. This analysis supports the conclusion that construction in the west of the Site poses minimal risk to groundwater flow or the GWDTE.

It is possible that a seepage face will develop along the base of the excavation as the excavation extends into the water table. Any such water that reports at surface can be collected and directed past the building within a drain from which it could be discharged or reinfiltrated to the ground downgradient of the BESS. This is considered an issue that can be fully mitigated by correct design and has been fully implemented into the latest layout.

The available groundwater data for the northeast portion of the Site is limited, resulting in some uncertainty regarding the accuracy of groundwater levels in this area. While the groundwater contours in Figure 4 provide an indicative representation, it is possible that actual groundwater levels in this zone may be deeper than currently shown.

Taking a conservative approach, it has been concluded that construction activities in the northeast of the Site are likely to intercept groundwater levels. However, this conclusion is based on limited data and further groundwater monitoring is being undertaken which is expected to support these conclusions. Additional data collection will refine the conceptual hydrogeological model and provide greater confidence in assessing the risks associated with construction in this area.

6.2.2 Impact of BESS on Groundwater Recharge

The proposed development will intercept rainfall as the surface will be impermeable and therefore infiltration over the BESS footprint will be impeded. However, as compared to the volumes of groundwater associated with throughflow this volume is likely to be insignificant; the reduction of recharge to the groundwater system is estimated to be of the order of 2 m^3/day compared to a throughflow across the infrastructure of nearly 4,000 m^3/day (estimated using Darcy's Law). Although likely to contribute less than 0.05% of overall groundwater throughflow, mitigation for this potential reduction is discussed below.

6.3 Overview of Area A

Area A is located downgradient of the proposed development Site and is likely to be dependent on sustained groundwater and surface water flow, with a pond present at the eastern end of

Area A which is an expression of the water table at surface. The downgradient Culcraggie Burn, and its tributaries, bounds the Site to the south, east and west likely also receives baseflow from groundwater discharge, and is likely to be in hydraulic connection to the wetland area. The pond is likely to be a surficial expression of the water table which further highlights the importance of maintaining both groundwater and surface water contributions to sustain the ecological integrity of the area.

Although the north-eastern end of the proposed development will intercept some groundwater this is not considered to have any significant effect on groundwater flow to Area A as flows upgradient will likely remain unaltered. Some mitigation measures to manage any intercepted groundwater are discussed below.

7 Mitigation Measures

Although there is not likely to be any effect on groundwater levels in the vicinity of Area A, a number of mitigation measures will be initiated, some of which would likely be adopted anyway as good management practice.

7.1 Recharge Management

The construction of the BESS will impede direct runoff to the ground over its footprint area. The proportion of recharge area lost is expected to be small however, given that the largest part of groundwater flow through the Site is derived from the larger upgradient catchment areas. An initial estimate is that some 0.05% of recharge which would report as groundwater flow could be intercepted. This loss however will be countered by increased runoff from the building roofs and paved surfaces and will therefore be managed by careful design so that this rainfall component will be channeled directly to Area A, effectively mitigating any impact.

7.2 Monitoring of Groundwater Levels

Regular monitoring of groundwater levels on-site will be continued to establish baseline conditions and record the variations in groundwater levels throughout the year. This long-term monitoring will identify any changes to the system caused by the proposed development during and after construction and provide a basis for any mitigation if it is found to be necessary.

Additional boreholes will be installed in areas with limited data coverage, such as the north-west portion of the Site, to improve spatial understanding of groundwater conditions.

7.3 Drainage during Construction

Temporary drainage systems or barriers should be used where needed to manage water flow and prevent contamination of the natural site waters. Contamination as turbidity may occur and such water should be channelled to settlement ponds to remove any solid materials before discharging to areas for re-infiltration.

7.4 Recharge Management

Surface water from the BESS footprint should be directed to settlement ponds before discharge to the Site drainages. In this way it is expected that there will be no loss of potential water contribution to Area A. Artificial recharge measures in Area A could include infiltration ditches, ponds, etc. to further enhance the Site.

8 Limitations and Assumptions

There are a number of limitations and assumptions associated with the assessment which are discussed below:

The spatial coverage of groundwater monitoring data is limited, particularly in the northwest corner of the Site, where no direct groundwater data exists and in the area under the eastern end of the foundation. In these areas, groundwater contours have been inferred using limited information from adjacent monitoring locations. As a result, there is inherent uncertainty in understanding the groundwater regime and flow dynamics in this portion of the Site.

The available groundwater data only represents a snapshot of conditions over a few weeks and does not account for potential seasonal variations. Fluctuations in groundwater levels due to changes in precipitation, evapotranspiration, or other seasonal factors could influence the conclusions regarding groundwater levels and flow patterns. Longer-term monitoring is being undertaken to better understand temporal trends and variability in groundwater conditions, particularly in relation to Site construction and its potential impacts on the GWDTE.

In some parts of the Site, particularly where data gaps exist, groundwater conditions have been inferred based on nearby data points and geological interpretation. These inferences introduce a level of uncertainty that may affect the accuracy of prediction of flow patterns and potential impacts identified in the assessment.

The assessment considers groundwater conditions at a site-wide scale. However, localised variations in subsurface conditions, such as perched water tables, soil heterogeneity, or fractures in the bedrock, may not be fully appreciated. These localised factors could influence groundwater flow in ways not accounted for in this assessment.

This assessment assumes that construction and operational activities will follow best practices and mitigation measures of the sort outlined will be adopted. Changes in construction methods or deviations from planned activities could alter the impact on groundwater conditions and flow patterns.

9 Conclusions and Recommendations

Borehole records and groundwater monitoring data has been used to develop a conceptual hydrogeological understanding of the Site and to understand the likely interactions between the proposed development and groundwater levels.

Current groundwater levels are at lower elevations than the facility’s foundations across the majority of the facility with the exception of the north-eastern corner. Although there will be some impedance to groundwater throughflow at this point it is not expected to affect groundwater flow or levels across the rest of the facility or in Area A – the potential GWDTE. It should be noted however that there is substantial uncertainty regarding groundwater levels in the north-eastern corner of the proposed facility and additional monitoring is required.

Mitigation of groundwater throughflow interception can be undertaken through the installation of appropriate drains that will capture any flow and route it for re-infiltration down gradient of the facility.

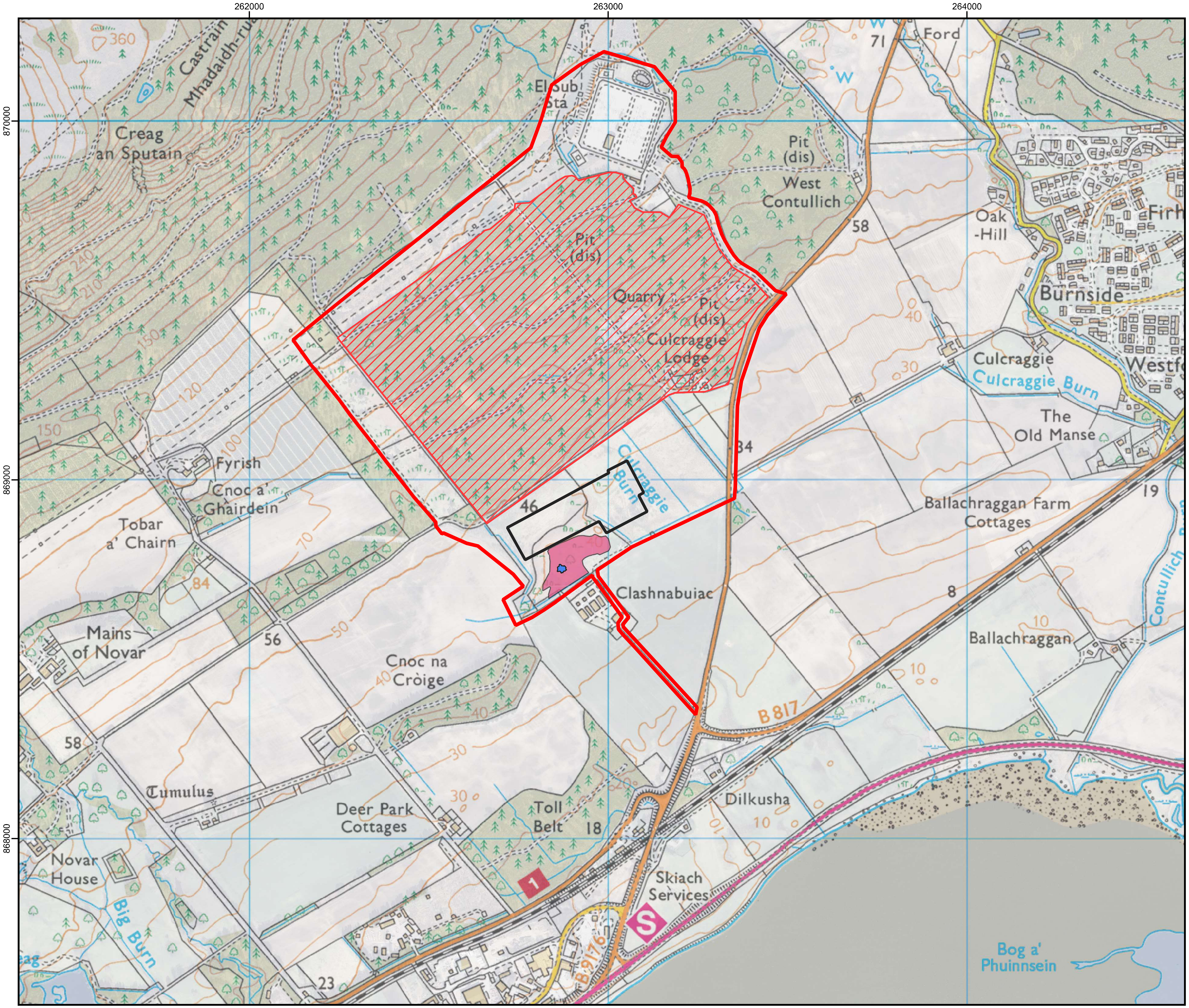
Rainfall recharge to the groundwater will be reduced by the presence of the facility, however this is likely to be only a very small percentage of total recharge and throughflow across the Site. This loss can also be fully mitigated by the collection of the runoff from the buildings and paved areas and its direction directly towards Area A after initial cleaning, if that is found to be necessary.

Area A which has been considered to be a potential GWDTE due to the lack of current NVC study can be fully protected during and after construction of the proposed BESS using simple mitigation measures as discussed. No impacts on the Culcraggie Burn area are expected given that there should be no overall reduction in groundwater flow.

Long term groundwater monitoring is continuing at Site however the installation of additional boreholes in areas with limited data, such as the north-west part of the Site, is also required in order to provide better spatial coverage.

Results of this monitoring should be reviewed regularly to see that any variations are within expected ranges after taking full account of rainfall episodes and periods of drier weather.

Figures



Key:

- Site Boundary
- Area Excluded from Site Boundary
- Infrastructure
- Potential GWDTE
- Pond

0 200 400 600 m

PROJECT

FYRISH BESS

FIGURE 1

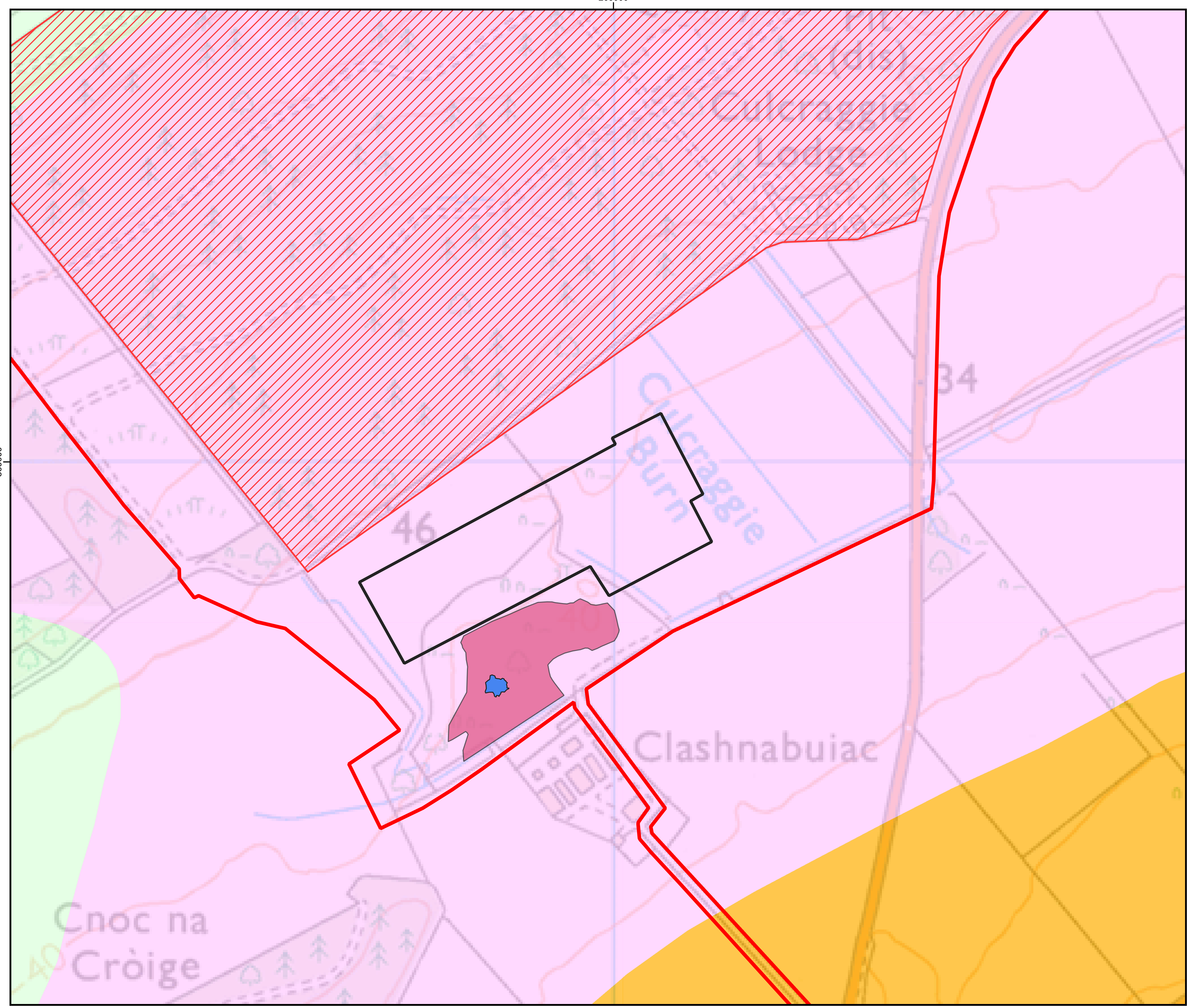
Site Base Map

DRAWN	REVIEWED
JM	
SCALE	DATE
1:10,000 @ A3	11/02/2025

FLUID ENVIRONMENTAL CONSULTING

263000

869000



Key:

- Site Boundary
- Area Excluded from Site Boundary
- Infrastructure
- Potential GWDTE
- Pond

Superficial Geology

- TILL AND MORAINIC DEPOSITS
- GLACIOFLUVIAL DEPOSITS
- RAISED MARINE DEPOSITS, DEVENSIAN

0 50 100 150 200 m

PROJECT

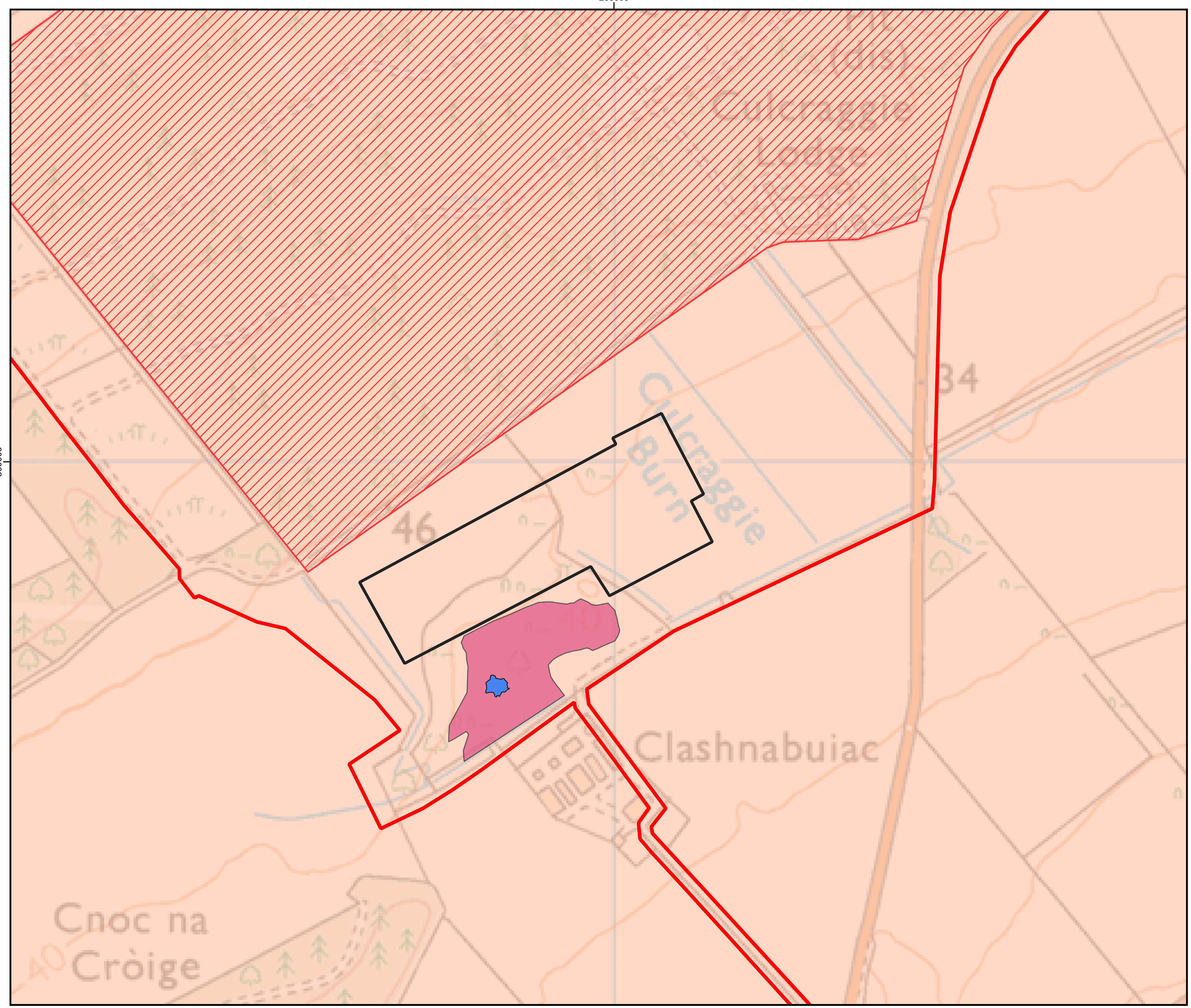
FYRISH BESS

FIGURE 2

Superficial Geology

DRAWN	REVIEWED
JM	
SCALE	DATE
1:4,000 @ A3	11/02/2025

FLUID ENVIRONMENTAL CONSULTING



Key:

- Site Boundary
- Area Excluded from Site Boundary
- Infrastructure
- Potential GWDTE
- Pond

Bedrock Geology

- RADDERY SANDSTONE FORMATION - SANDSTONE

0 50 100 150 200 m

PROJECT

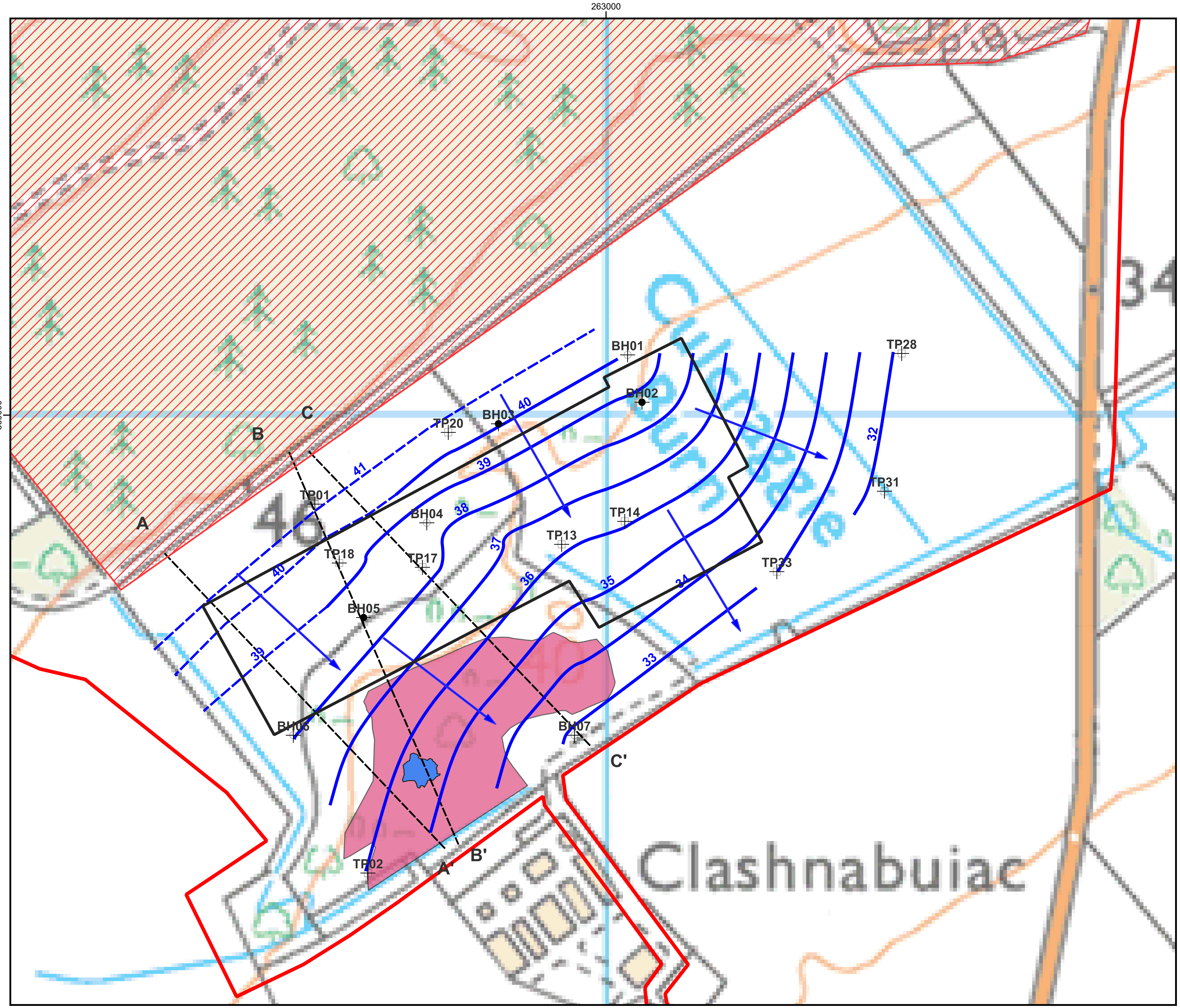
FYRISH BESS

FIGURE 3

Bedrock Geology

DRAWN	REVIEWED
JM	
SCALE	DATE
1:4,000 @ A3	11/02/2025

FLUID ENVIRONMENTAL CONSULTING



Key:
- Site Boundary
- Area Excluded from Site Boundary
- Infrastructure
- Potential GWDTE
- Pond
- Cross Section Locations
- Groundwater Contours (m AOD)
- Grownwater Inferred Contours (m AOD)
- Groundwater Flow
- Borehole Locations (GW Monitoring)
- Borehole Locations (Backfilled)
- Trial Pit Locations

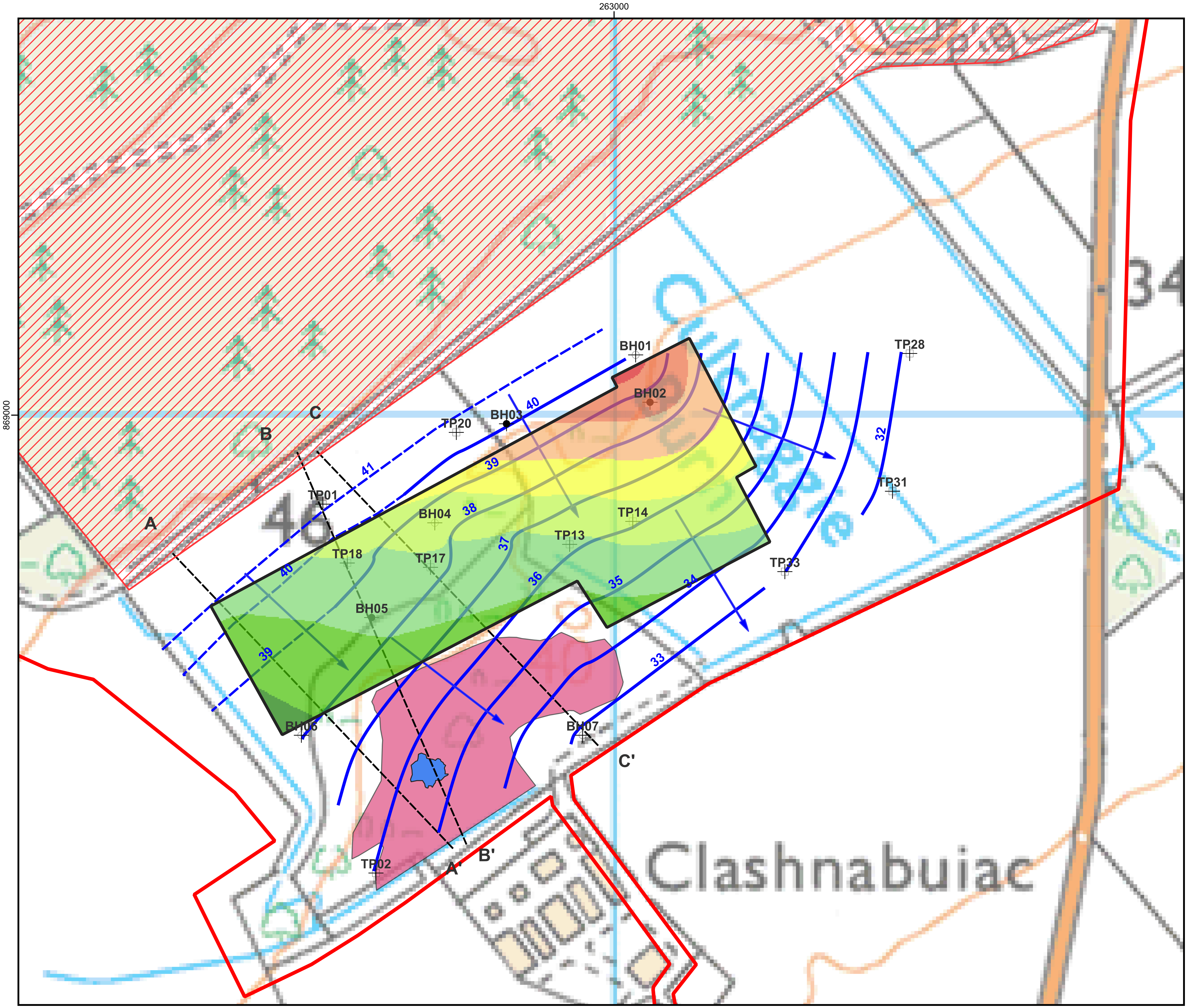
0 25 50 75 100 m

PROJECT
FYRISH BESS

FIGURE 4
Groundwater Contours Map

DRAWN	REVIEWED
JM	
SCALE	DATE
1:2,500 @ A3	11/02/2025

FLUID ENVIRONMENTAL CONSULTING



Key:

- Site Boundary
- Area Excluded from Site Boundary
- Infrastructure
- Potential GWDTE
- Pond
- Cross Section Locations
- Groundwater Contours (m AOD)
- Grownwater Inferred Contours (m AOD)
- Groundwater Flow
- Borehole Locations (GW Monitoring)
- Borehole Locations (Backfilled)
- Trial Pit Locations

Depth to Groundwater from Base of Foundation

- <= -3.0 m
- -3.0 - -2.0 m
- -2.0 - -1.0 m
- -1.0 - 0.0 m
- 0.0 - 1.0 m
- 1.0 - 2.0 m
- 2.0 - 3.0 m
- > 3.0 m

0 25 50 75 100 m

PROJECT

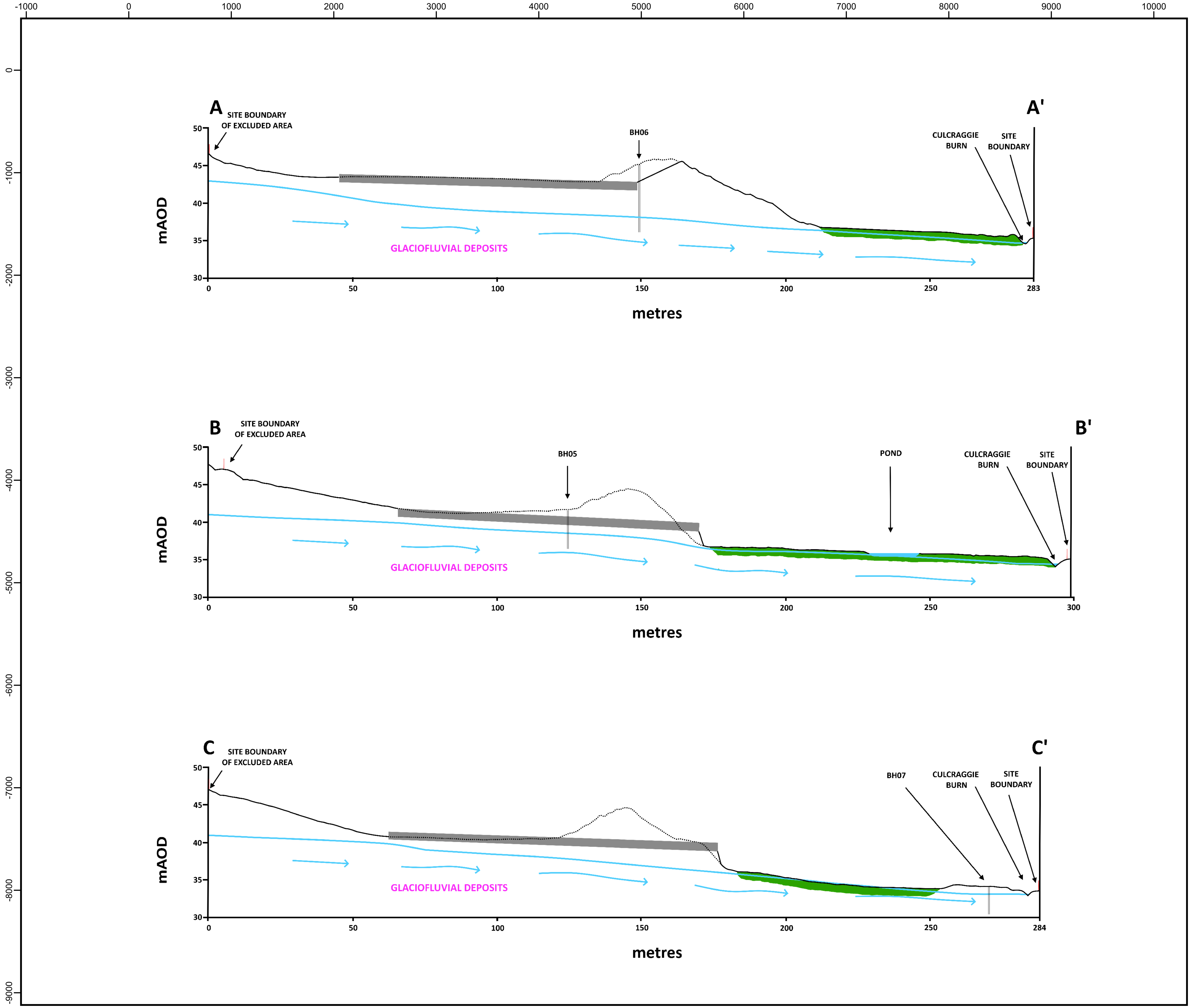
FYRISH BESS

FIGURE 5

Depth to Groundwater from Base of Foundation

DRAWN	REVIEWED
JM	
SCALE	DATE
1:2,500 @ A3	11/02/2025

FLUID ENVIRONMENTAL CONSULTING



Key:

- Foundation
- Upland Flush (Potential GWDTE)

PROJECT

FYRISH BESS

FIGURE 6

Hydrogeological Cross Sections

DRAWN	REVIEWED
JM	
SCALE	DATE
	11/02/2025

FLUID ENVIRONMENTAL CONSULTING