

Hazards Associated with Presence of Ground Gases

Methane gas is combustible and potentially explosive. When the concentration of methane in air is between the limits of 5.0%v/v and 15.0%v/v an explosive mixture is formed. The Lower Explosive Limit (LEL) of methane is 5.0%v/v, which is equivalent to 100% LEL. The 15.0%v/v limit is known as the Upper Explosive Limit (UEL), but concentrations above this level cannot be assumed to represent safe concentrations. Further, the LEL and UEL will vary (up and down) depending upon the proportion of other gases (including oxygen). However, the fact that methane is a colourless, odourless gas means that there is no simple indicator of the presence of the gas until such a time as explosive limits are reached, and an incident occurs. Methane is lighter than air and has a low toxicity. However, at high concentrations it can result in asphyxiation due to oxygen displacement.

Carbon dioxide is a colourless, odourless gas, which, although non-flammable, is both toxic and an asphyxiant. As carbon dioxide is denser than air, it will collect in low points and depressions. The UK Health & Safety Executive (HSE) has published information relating to concentrations of carbon dioxide that humans may be exposed to, which uses concentrations contained in the Control of Substances Hazardous to Health Regulations 2002 (as amended). These are the Long-Term Occupational Exposure Limit (LTOEL, 8-hour period) and the Short-Term Occupational Exposure Limit (STOEL, 15-minute period), which are 0.5% and 1.5% carbon dioxide, respectively.

Parameters Influencing the Rate of Ground Gas Production

Figure G2 is taken from EA guidance document LFTGN 03 illustrates typical ground gas generation curves from biodegradable materials:

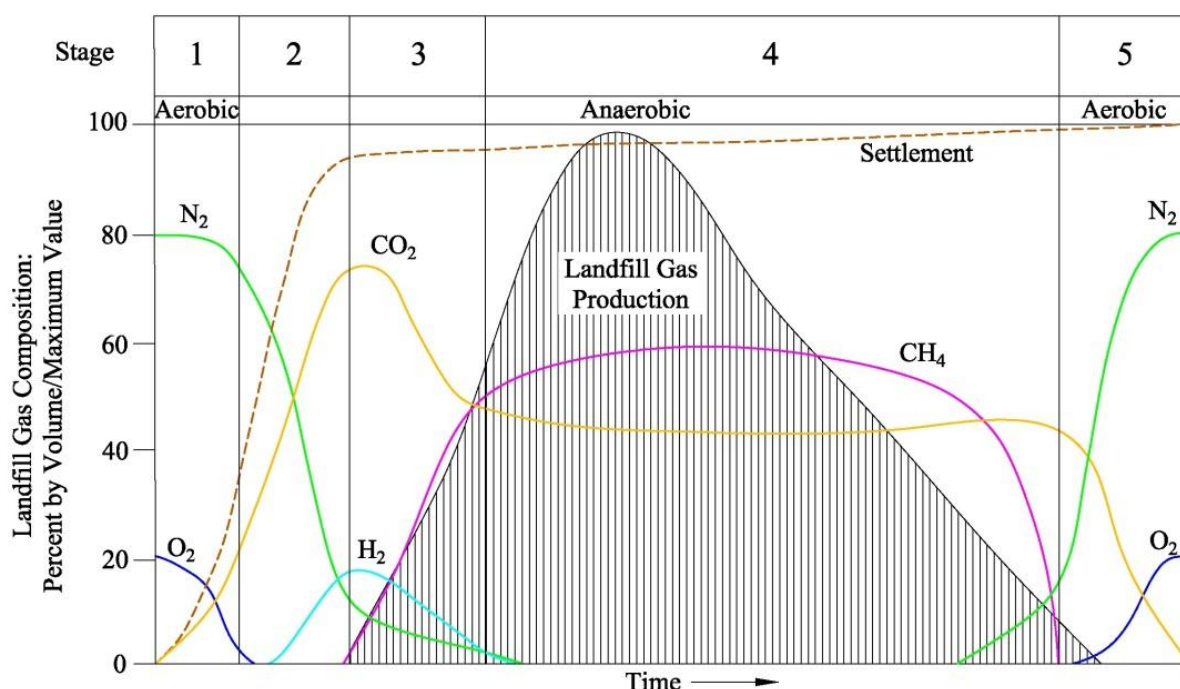


Figure G2. Idealised Representation of Landfill Gas Generation.

The production of methane and carbon dioxide at a landfill site may be expected to be considerable and ongoing. Concentrations of methane will eventually decrease, followed by concentrations of carbon dioxide, but the duration and rate of gas production can vary markedly between sites. Five distinct phases of gas production occur during the process which are, in order of event (as marked on Figure G2), as follows:

1. An aerobic phase involving oxygen depletion and temperature increase through aerobic respiration;
2. The establishment of anaerobic conditions and the evolution of carbon dioxide and hydrogen through acidogenic activity;
3. Commencement of methanogenic activity; the establishment of populations of methanogenic bacteria;
4. A phase of stable methanogenic activity, which may go on for many tens of years;
5. A phase of decreasing methanogenic activity, representing depletion of the organic material and a return to aerobic conditions.

The time scale for the return to the normal ground gas concentrations will be highly variable, depending upon the types and quantities of materials present. In addition, the optimum parameters influencing the rate of decomposition and ground gas production within the ground at a site are as follows:

- High water content with adequate rainfall and water infiltration to provide moisture content between approximately 20 to 26%;
- Conditions that either are or are very close to anaerobic;
- High proportion of biodegradable materials;
- A pH between 6.5 and 8.5, ideally verging slightly on the acidic between pH 6 to 7;
- Temperature between 25°C and 55°C;
- The ratio of the biochemical and chemical oxygen demands (BOD:COD);
- High permeability;
- Small particle size, as finer subsurface materials possess a greater surface area to provide a growing 'face' for the micro-organisms but high fines levels reduces permeability and reduces decomposition rate.

For this reason, it is vital that sources of methane and carbon dioxide are identified prior to the commencement of any work on a construction site, and that the ground gas regime is characterised at the worst temporal conditions a site may experience. From this, a risk assessment is carried out to identify the risk at the site from ground gases so that suitable protection measures can be designed and incorporated into a development to prevent a dangerous build-up of gas occurring.

Factors Influencing the Migration and Behaviour of Ground Gases

There are many factors that influence the migration of ground gases which can affect the risk from a gassing source:

- driving force – pressure differential along a pathway, diffusion and dissolved in solution;
- meteorological conditions – short term and seasonal conditions including atmospheric pressure changes (e.g., rapidly falling pressure causes gas to expand increasing emission rates), rainfall, frozen ground and thawing, temperature;
- geological and groundwater conditions – these can have the over-riding influence on the direction/pathways and quantity of migrating gas;
- anthropogenic influences – man-made pathways include mine shafts, service runs/drains, foundation piles, underground voids/pits/basements, foundation/building design/construction

Guidance Documents

Currently in the UK, there are no statutory threshold limits for hazardous gases in the ground as site specific variables mean that standard threshold values cannot be applied. The published guidance relating to development of sites where methane and carbon dioxide are present has been produced in response to building projects on or close to landfill sites, as both gases are principal constituents of landfill gas. Much of the historic guidance that has been produced on gas risk assessment focused on landfill sites and as a result there has previously been a lack of clarity when relating the process to gas conditions on non-landfill sites.

Statutory guidance regarding methane in the ground has previously taken a limiting concentration of 1.0 % by volume methane (equal to 20% of the lower explosive limit of methane in air) above which necessary actions will be appropriate. For carbon dioxide the limiting recommended trigger was 1.5 % by volume (the Long-Term Exposure Limit for carbon dioxide). Above these concentrations the Building Regulations Approved Document C (1992) stated that consideration should be given to whether actions may be appropriate, whilst more specific solutions would be likely to be necessary at concentrations greater than 5% by volume of carbon dioxide (Building Regulations Approved Document C, 1992). However, the latest fully revised version of Approved Document C (DoE, 2004) no longer endorses this approach and instead requires the use of a risk-based approach in interpreting the findings of a gas monitoring survey. Further, the latest EA documentation on landfill gas (LFTGN 03, 2004) continues to sanction the use of a risk-based approach through a structured approach to the assessment of ground gases and links with the risk assessment process outlined within CLR 11 for soil contaminants.

With the above in mind, recent guidance has been produced in 2006 and 2007 with the aim of providing up to date advice in relation to residential and commercial development. The guidance does not address issues associated with gas derived from landfills, for this refer to “Guidance on the Management of Landfill Gas” (Environment Agency 2004) for an overview.

Recent guidance relevant to gas assessments for residential and commercial development includes;

- **Wilson et al. (CIRIA C665, December 2007) “Assessing Risks Posed by Hazardous Ground Gases for Buildings.”**

This document provides up to date advice on all aspects of ground gas risk assessment such as investigation, monitoring programmes, data collection and interpretation. The guidance presents separate methodologies for the characterisation of:

- **All development types except low rise housing with gardens and for Low Rise Buildings without a 150mm void** (Situation A) (Table 8.5 CIRIA C665)
and;
- **Low rise housing with gardens with a 150mm ventilated sub-floor void** (Situation B) (Table 8.7 CIRIA C665)
(See below for further explanation of the methods of characterisation)

- **Boyle and Witherington (NHBC / RSK Group, Report 10627-R01(04) January 2007) “Guidance on the Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present.”**

This document presents the “Traffic Lights System” detailed below and is relevant only for low rise properties (e.g., bungalows and town houses) that have a ventilated sub-floor void (i.e., Situation B as described in CIRIA C665).

- **Wilson and Card (CIEH, expected 2011) “Ground Gas Handbook for Designers and Regulators”**

This document is expected to provide practical guidance on ground gas assessments and the design and evaluation of protection measures

- **British Standard (BS 8485+A1, January 2019) “Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings”**

This document provides an overview of gas characterisation and assessment. The Standard is intended to be used by designers of gas protection measures and regulators involved in the assessment of design solutions. The Standard provides a framework in line with CLR11 allowing designers to judge the adequacy of ground gas and related site investigation data. The document provides an approach to determine appropriate ground gas parameters that can be used to identify a range of possible construction solutions mitigating against the presence of ground gas on a development site.

Each of these documents continues to highlight the importance of, and give further guidance towards, carrying out a tiered risk-based decision-making process in accord with government policy on dealing with contamination from historic or natural sources and highlight the importance of the Conceptual Model in site characterisation. These documents also stress the importance that the assessor should be confident that the ground gas monitoring results are representative of the likely worse case ground gas regime on a site and that the data collected from the site is sufficient. With this in mind, CIRIA C665 sets out ideal monitoring periods as below.

Idealised Frequency and Period of Monitoring (after Table 5.5a and 5.5b, CIRIA C665)						
		Generation Potential of Source				
		Very Low	Low	Moderate	High	Very High
Sensitivity of Development	Low (Commercial)	4/1	6/2	6/3	12/6	12/12
	Moderate (Flats)	6/2	6/3	9/6	12/12	24/24
	High (Residential with Gardens)	6/3	9/6	12/6	24/12	24/24
Notes 1. First number is the number of readings and the second is the minimum period in months (e.g., 6/2 – six sets of readings over two months). 2. At least two sets of readings must be at low (preferably under 1,000 mb) and falling pressure. 3. High sensitivity end use on high or very high hazard site will not normally be acceptable unless the source is treated to reduce gassing potential.						

Before the latest guidance, good practice for site characterisation had been based upon the method proposed by Wilson and Card (1999). CIRIA C665 (2007) effectively supersedes Wilson and Card (1999) and includes a modified version of the Wilson and Card method (Tables 8.5, 8.6 and Box 8.1). Gas concentrations and flow rates for either methane and/or carbon dioxide measured at a site to 'Characteristic Situations.' Appropriate protection measures are selected from Table 8.6 (if using modified Wilson & Card method) and from Box 8.4 from CIRIA C665 (if using the NHBC traffic lights method). Throughout the risk assessment process, strong regard must be given to the nature of the gassing source, the flow rates and the estimated surface emissions. Note that certain protection measures are stated in CIRIA Report 149 that are now considered wholly inappropriate to certain developments and consequently should not be used without modification. Throughout the process, it is important to remember that these tables are not intended to be used as a definitive design tool and have been prepared to show the typical scope of measures for gas control.

Both the NHBC (2007) and CIRIA (2007) guidance documents and BS 8485+A1 (2019) propose that both ground gas concentrations and flow rates are used to calculate the limiting gas well gas volume flow rates for methane and carbon dioxide, based on the ground gas conditions monitored for during the worse-case temporal conditions. This limiting gas well volume flow rate is termed the Gas Screening Value (GSV, note that this was termed borehole gas volume flow), and is calculated as follows:

$$\text{GSV (l/hr)} = \frac{[\text{gas well gas concentration (\%v/v)}] \times [\text{gas well flow rate (l/hr)}]}{100}$$

These GSVs are then compared to generic ‘Traffic Lights’ contained within the NHBC guidance, which present typical maximum gas concentrations and limiting GSV’s, for ‘Situation B Development’ (Low rise housing with gardens).

Table 8.7 NHBC Traffic light system for 150 mm void

Traffic Light	Methane ¹		Carbon Dioxide ²	
	Typical max concentration ³ (% by volume)	Gas Screening Value ^{2,4} (litres/hour)	Typical max concentration ³ (% by volume)	Gas Screening Value ^{2,4} (litres/hour)
Green	1	0.13	5	0.78
Amber 1	5	0.63	10	1.6
Amber 2	20	1.60	30	3.10
Red				

Notes:

1. The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worst-case temporal conditions that the site may be expected to encounter will be the decider as to what Traffic Light is allocated;
2. Borehole Gas Volume Flow Rate, in litres per hour as defined in Wilson and Card (1999), is the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered;
3. The Typical Maximum Concentrations can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so;
4. The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.

Box 8.4 of CIRIA C665 Gas protection measures for low-rise housing development based upon allocated NHBC Traffic light (Boyle and Witherington, 2007)

Traffic Light Classification	Protection Measures Required
Green	Negligible gas regime identified, and gas protection measures are not considered necessary.
Amber 1	Low to intermediate gas regime identified, which requires low-level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Gas protection measures should be as prescribed in BRE Report 414. Ventilation of the sub-floor void should facilitate a minimum of one complete volume change per 24 hours.
Amber 2	Intermediate to high gas regime identified, which requires high-level gas protection measures, comprising a membrane and ventilated sub-floor void to create a permeability contrast to prevent the ingress of gas into buildings. Gas protection measures should be as prescribed in BRE Report 414. Membranes should always be fitted by a specialist Contractor. As with Amber 1, ventilation of the sub-floor void should facilitate a minimum of one complete volume change per 24 hours. Certification that these passive protection measures have been installed correctly should be provided.
Red	High gas regime identified. It is considered that standard residential housing would not normally be acceptable without a further Gas Risk Assessment and/or possible remedial mitigation measures to reduce and/or remove the source of gas.

For a 'Situation A Development' (All development except low rise housing with gardens), the GSV value is used to derive the appropriate Characteristic Situation from Table 8.5 of CIRIA C665 (below):

Table 8.5 from CIRIA C665 Modified Wilson and Card Classification					
Characteristic Situation (CIRIA R149)	Comparable Partners in Technology gas Regime (see Box 8.2)	Risk Classification	Gas Screening Value (CH₄ or CO₂) (l/hr)¹	Additional Factors	Typical Source of Generation
1	A	Very low risk	<0.07	Typically, methane ≤ 1% and/or carbon dioxide ≤ 5%. Otherwise consider increase to Situation 2	Natural soils with low organic content "Typical" made ground
2	B	Low risk	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to characteristic Situation 3	Natural soil, high peat/organic content. "Typical" made ground

3	C	Moderate risk	<3.5		Old landfill, inert waste, mine working flooded
4	D	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protective measures.	Mine working susceptible to flooding, completed landfill (WMP 26B criteria)
5	E	High risk	<70		Mine working unflooded inactive with shallow workings near surface
6	F	Very high risk	>70		Recent landfill site

It was intended in CIRIA C665 that the characteristic situation allocated to the development from the table above would then be used in Table 8.6 of CIRIA C665 in order to determine the level of gas protection the development requires. However, BS8485:2015 superseded this document and a different set of mitigation standards were put forward.

The recommended minimum gas protection score (points) be selected based on the building type (Table 3 which defines four building types) and the ground gas Characteristic Situation as detailed in Table 4 of BS8485:2015+A1:2019 (see below).

The first step in the decision-making process is to obtain the level of gas protection necessary in the range 0 to 7.5 from Table 4. Then a combination of structural barriers (Table 5) ventilation protection measures (Table 6) and/or gas resistant membranes (Table 8) should be chosen to meet that requirement. The level of gas protection necessary should take into account the characteristic gas situation and a number of other factors. The whole decision-making process should be made transparent, where all parties can see the approach being taken, can understand the various steps and decisions made and be confident that a risk-assessed solution has been designed and installed commensurate with the construction and site constraints.

Where the gas Characteristic Situation is 4 or more (and for NHBC Red situations according to CIRIA C665), the site requires a comprehensive risk assessment to confirm the scope of protection measures. These are higher risk sites and reliance on Table 4 alone is not sufficient.

BS8485:2015+A1:2019 Table 3 Building Types

	Type A	Type B	Type C	Type D
Ownership	Private	Private or commercial/public, possible multiple	Commercial / public	Commercial / industrial
Control (change of use, structural alterations, ventilation)	None	Some but not all	Full	Full

Room sizes	Small	Small / medium	Small to large	Large industrial / retail park style
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BS8485:2015+A1:2019 Table 4 Gas Protection Score by CS and Type of Building

CS	Required Gas Protection			
	High risk	Medium risk		Low risk
	Type A	Type B	Type C	Type D
1	0	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4	3	2.5
4	6.5 ^(A)	5.5 ^(A)	4.5	3.5
5	(B)	6 ^(A)	5.5	4.5
6	(B)	(B)	(B)	6
a) Residential building should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g., high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g., in institutional and/or fully serviced contractual situations. b) The gas hazard is too high for this empirical method to be used to define the gas protection measures NOTE 3 The NHBC has published guidance for use on residential developments, which utilise an alternative classification ("traffic light") system. This guidance typically applies to Type A buildings utilising beam and block floor constructions with clear void ventilation. The design choice variables are limited to decisions relating to the membrane specification and verification recommendations (see Table 7). Designers utilising this system would therefore need to refer to NHBC to assess compliance for specific recommendations [see 8485:2015 for further on this note] NOTE4 The method of selecting the combination of these types of protection is given in section 7.2 of BS8485:2015. Once type of measures has been decided, the detailed design and specification of the measures should be undertaken (section 7.3)				

Section 7.2 defines the order of selecting protective measures. The first choice is provided by structural barriers as defined in Table 5.

BS8485+A1:2019 Table 5 Gas protection scores for structural barriers

PROTECTION ELEMENT/SYSTEM	SCORE	COMMENTS
Floor and substructure design		
Floor slabs	0	<i>General – score conditional that breaches of slab are sealed</i>
Block and beam floor slab		
Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement)	0.5	

Cast in situ monolithic reinforced ground-bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations (with only nominal mesh reinforcement)	1 or 1.5	<i>To achieve 1.5, raft or suspended slab to be well reinforced to prevent cracking and minimal penetrations</i>
Basement floor and walls to BS 8102:2009, Grade 2 waterproofing – See notes in BS8485:2015+A1:2019	2	
Basement floor and walls to BS 8102:2009, Grade 3 waterproofing - See notes in BS8485:2015+A1:2019	2.5	

Ventilation methods are detailed in Table 6, and points can only be gained from using one of the five types:

BS8485:2015+A1:2019 Table 6 Gas Protection Scores for Ventilation Protection Measures			
PROTECTION ELEMENT/SYSTEM		SCORE	COMMENTS
a) Pressure relief pathway (usually formed by low fines gravel or with a thin geocomposite blanket with strips terminating in a gravel trench external to the building)		0.5	<i>Whenever possible, a pressure pathway relief pathway (as a minimum) should be installed in all gas protection measures systems.</i>
b) Passive sub floor dispersal layer			<i>If a layer has a low permeability and/or is not terminating in a venting trench (or similar), then the score is zero.</i>
Very good performance			
Good performance		2.5	<i>Performance criteria shown in Fig B.6 and B.7 of BS 8484:2015.[See Annex B]</i>
Media used to provide the dispersal layer are:		1.5	
• Clear void • Polystyrene void forming blanket • Geocomposite void former blanket • No-fines gravel layer with gas drains • No-fines gravel layer			
c) Active dispersal layer, usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers		1.5 to 2.5	<i>This system relies on continued serviceability of the pumps; therefore, alarm and response systems should be in place. [See Annex B].</i>
d) Active positive pressurisation by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket		1.5 to 2.5	<i>This system relies on continued operation of the pumps; therefore, alarm and response systems should be in place. [See Annex B].</i>

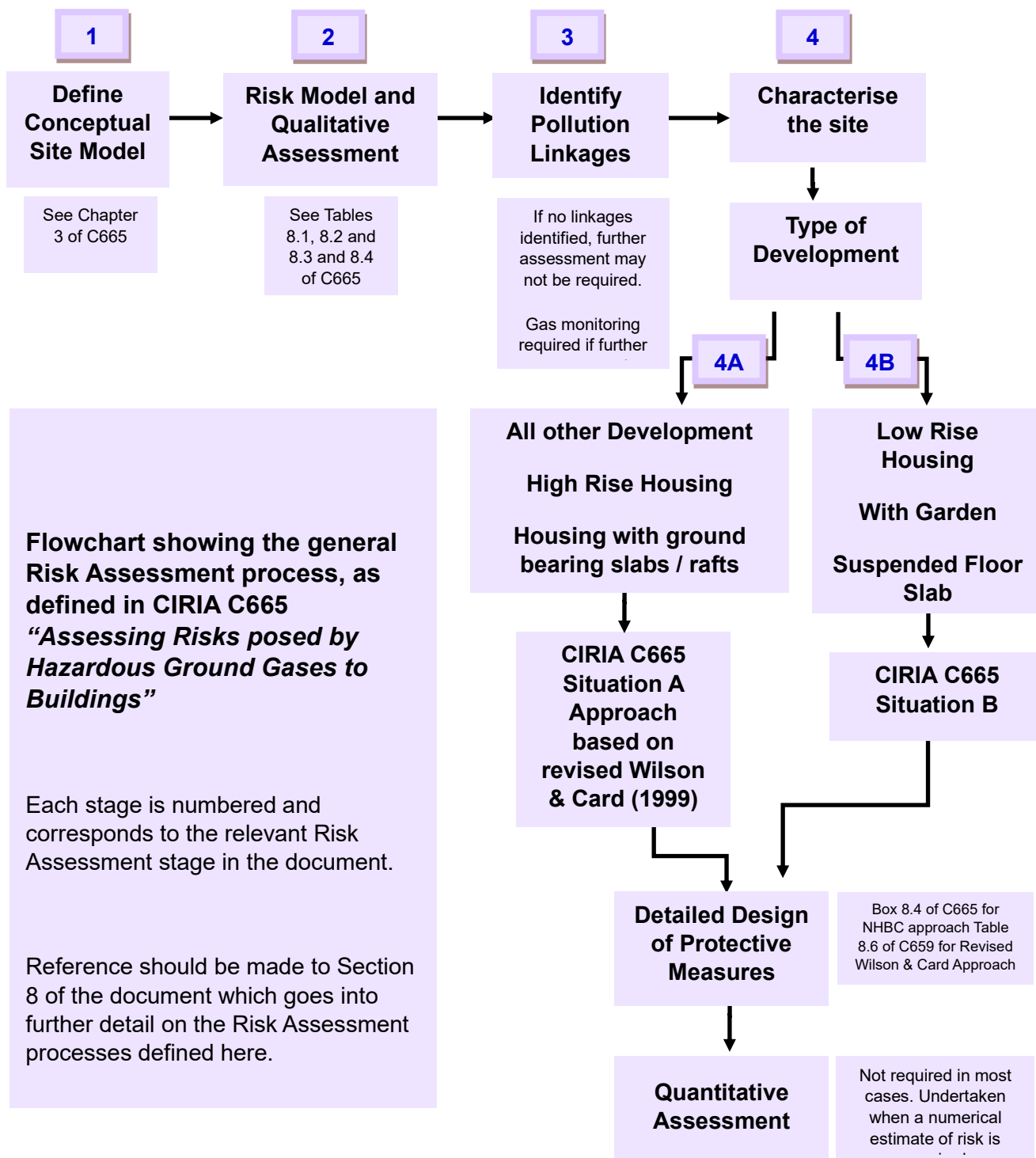
e) Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft)	4	<i>Assumes car park is vented, designed to Building Regulations 2000, Approved Document F.</i>
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Membrane methods are detailed in Table 7.

BS8485:2015+A1:2019 Table 7 Gas protection score for gas resistant membrane		
PROTECTION ELEMENT/SYSTEM	SCORE	COMMENTS
Gas resistant membrane meeting all of the following criteria: - Sufficiently impervious to gases with a methane gas transmission rate $<40.0 \text{ ml/day/m}^2/\text{atm}$ (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method) - Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; - Sufficiently strong to withstand in-service stresses (e.g., settlement if placed below a floor slab); - Sufficiently strong to withstand the installation process and following trades until covered (e.g., penetration from steel fibres in fibre reinforced concrete, dropping tools etc); and to withstand in-service stresses (e.g., settlement if placed below a floor slab) - capable, after installation, of providing a complete barrier to the entry of the relevant gas; and - verified in accordance with CIRIA C735 See notes in BS8485:2015+A1:2019 regarding membrane requirements	2	<i>The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation, and the integrity of joints.</i> <i>If a membrane is installed that does not meet the criteria, then the score is zero.</i>

For a site which is impacted by migratory gases from an off source, the development may be protected by imposing pathway intervention methods, which if successfully validated, could also remove the need for further analysis. It is essential that the gas regime in these circumstances has been fully characterised and that the only source impacting the site is located off site and that the pathway is clearly defined and its interception equally proven before construction commences. Pathway intervention methods may include vertical membrane installations, venting trenches, rows of stone columns, activated trenches and various proprietary systems. These systems are particularly relevant to domestic housing where there is limited scope for foundation type solutions.

Following the choice of protection measures, detailed design should be entered into [Section 8 of BS 8485:2015+A1:2019].



Appendix I – Unforeseen Ground Contamination

Unforeseen Ground Contamination

There is the potential for areas of previously unexpected contamination to be present, as is the case with any “brownfield” site. Any significant quantities of asbestos, significant ashy soils, unusual, brightly coloured or significantly oily or odorous material should be considered in this category. If unexpected contamination is found the following procedures should be adhered to:

1. All site works at the position of the suspected contamination will cease.
2. A suitably trained geo-environmental specialist should assess the visual and olfactory observations of the condition of the ground and the extent of contamination, and the Client and the Local Authority should be informed of the discovery. Should the contamination be likely to affect controlled waters the Environment Agency shall also be informed.
3. The suspected contaminated material will be investigated and tested appropriately in accordance with the assessed risks. The investigation works will be carried out in the presence of a suitably qualified geo-environmental engineer. The investigation works shall commence to recover samples for testing and, using visual and olfactory observations of the condition of the ground, delineate the area over which contaminated materials are present.
4. The unexpected, contaminated material will either be left in situ or be stockpiled whilst testing is carried out and suitable assessments completed to determine whether the material can be re-used on site or requires to be disposed as appropriate.
5. Where the material is left in situ awaiting results it will be reburied or covered with plastic sheeting.
6. Where the potentially contaminated material is to be temporarily stockpiled it will either be placed either on a prepared surface of clayey Alluvium, or on 2000-gauge Visqueen sheeting (or other impermeable surface) and covered to prevent dust and odour emissions.
7. Any areas where unexpected visual or olfactory ground contamination will be surveyed, a photographic record kept, and testing results incorporated into the Verification Report.
8. A photographic record will be made of relevant observations.
9. The testing suite will be determined by the independent geo-environmental specialist on the basis of visual and olfactory observations.
10. Test results will be compared against current assessment criteria suitable for the future use of the area of the site affected.
11. The results of the investigation and testing of any suspect unexpected contamination will be used to determine the relevant actions. After consultation with the Local Authority and if necessary the Environment Agency, materials should either be:

- re-used in areas where test results indicate that it meets compliance targets so it can be reused without treatment; or
- treatment of material on site to meet compliance targets so it can be reused; or
- removal from site to a treatment centre or to a suitably licensed landfill or permitted treatment facility.

12. Verification Report will be produced for the work.

Asbestos

Asbestos cement products and asbestos fibres have not been encountered in the soils at the site but based on the age of the Made Ground material containing asbestos could be expected to be encountered. If non-notifiable asbestos (e.g., chrysotile asbestos cement board) is encountered in excavations then it will be dealt with in accordance with the Control of Asbestos Regulations 2012 (CAR 2012) and the HSE's ACoP for asbestos (2013). Finding non-notifiable asbestos is a very common occurrence on brownfield sites and is a relatively low risk activity and can be dealt with as a matter of routine. Therefore, it is not proposed that the Council will be notified but an appropriate record will be kept of confirmatory testing and disposal. This will be included in remediation verification reports.

If suspect notifiable asbestos is encountered then the Council and the HSE will be notified. An appropriate action plan will be agreed with the Council and the HSE in accordance with CAR 2012. The action plan will include the preparation of the Risk Assessment and Plan of Work in accordance with CAR and other statutory requirements including:

- Site mobilisation;
- Excavation methodology;
- Handling, movement and storage on-site of excavation arisings;
- Any processing of excavation arisings containing ACMs;
- Movement and placement of arisings to final destination;
- Placing of cover system over soils with and ACMs remaining on-site;
- Off-site disposal of ACMs;
- Licences;
- PPE & RPE; and,
- Dust and fibre monitoring.

Potential mitigation measures that would be required include:

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- Ensuring works are carried out by suitably trained and experienced personnel with working with asbestos;

- Site investigation and risk assessment;
- Removal or treatment of asbestos hotspots;
- Use of PPE and RPE by construction workers; and,
- Compliance monitoring.

Unexpected Tanks

No buried underground fuel storage tanks have been encountered during the site investigation works; however, there remains a low risk that tanks are present on-site. Should an underground tank be encountered, operations should cease in the area. Additionally, there may be pipework associated with these tanks which could have oily residues. The following procedures are to be adhered to if tanks and pipework are identified:

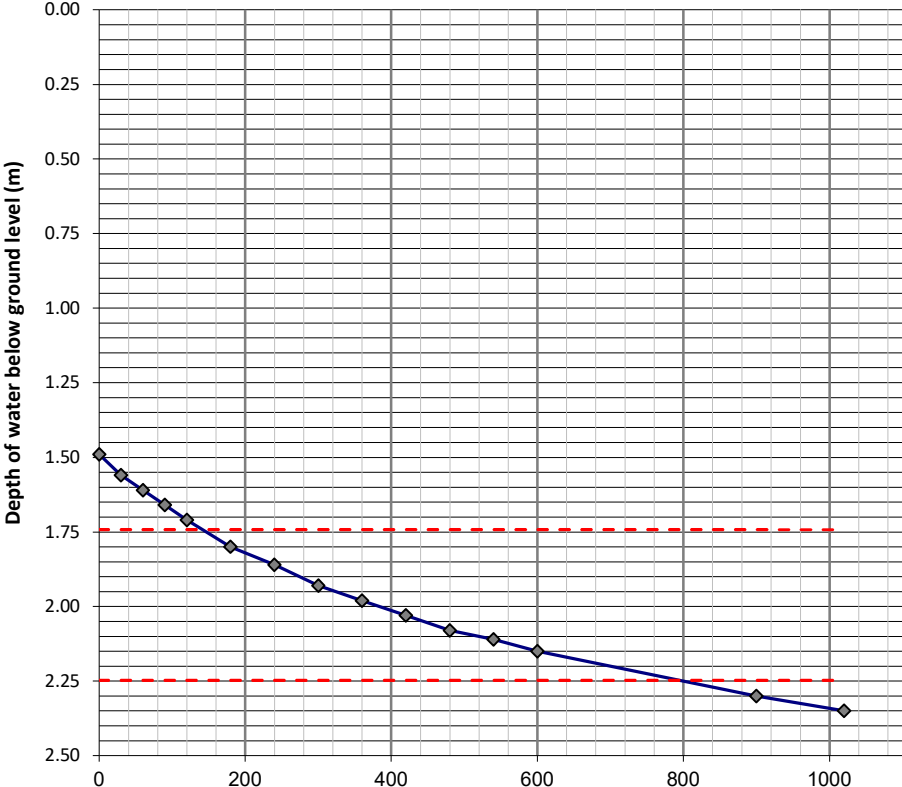
1. All site works at the position of the tanks/pipework should stop.
2. A description of the tank should be made by the geo-environmental engineer including; condition and surround, along with visual and olfactory observations should any contents in the tank be apparent. A photographic record will also be made of relevant observations.
3. The tank's position and depth should be determined and marked on a plan of the site.
4. The independent geo-environmental engineer will inform Client and the Local Authority.
5. During the presence of the independent geo-environmental engineer, investigation works should be undertaken to obtain samples of any liquid or sludge contents and to establish dimensions of the tank.
6. Testing will be determined on the basis of visual and olfactory observations by independent geo-environmental engineer.
7. Test results will be compared against current assessment criteria and proposals for disposal of any contents determined in agreement with the appropriate Regulatory Parties.
8. Emptying the tank and disposal of contents to a suitable licenced disposal facility.
9. Degassing and removal of the tank by a suitably qualified contractor will be required, and a Naked Flame Certificate should be provided.
10. Once the tank has been emptied in accordance with the above proposals, it is to be removed for disposal to a licensed waste management facility. Copies of the relevant waste consignment notes are to be kept and included in the Verification Report.
11. Excavation and remediation of any contaminated soils around the tank will be carried out.

12. Samples of the base and sides of the resultant hole will be sampled and supervised by the independent geo-environmental engineer to confirm whether risks to human health or controlled waters.

Appendix J – Infiltration Test Results

DATE:		24/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 	
PROJECT No:		C57-2338			
PROJECT NAME:		Sperberry Hill BESS			
CLIENT:		Brockwell Energy			
TRIAL PIT ID:		TP1-NGR			
TEST NUMBER:		1			

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY			VOIDS RATIO OF GRAVEL PACK		30.00 %	
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.	2.20 m		
				PIT WIDTH (W):		
				0.55 m		
				PIT DEPTH (D):		
				2.50 m		
INPUT PARAMETERS:						
0			Total volume of pit (V)		(m ³)	1.22
30			Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio		(m ³)	0.18
60			Maximum depth of water (MDW) = D - Water depth @ time 0		(m)	1.01
90			Surface area of pit up to 50% effective depth (AP ₅₀)		(m ²)	3.99
120			Level of water in pit at 75% effective depth (P ₇₅)		(m)	0.25
180			Level of water in pit at 25% effective depth (P ₂₅)		(m)	0.76
240			Time at 75% effective depth (T ₇₅)		(s)	142
300			Time at 25% effective depth (T ₂₅)		(s)	795
360			Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)		(s)	653
420			SOIL INFILTRATION RATE (f) = PV ₇₅₋₂₅ /(AP ₅₀ x T ₇₅₋₂₅)		(m/s)	7.04E-05
480			WATER INPUT:		300 L	in
540						2 minutes
600			Geology of test section/Test remarks			
900			Topsoil over firm slightly sandy gravelly clay, becoming weathered chalk with gravel at depth to 2.5m.			
1020						
			Compiled by:		GI	Checked by: BF
			After BRE Digest 365, Soakaway Design, 2016			Page 1 of 1



Time (s)	Depth (m)
0	1.50
50	1.60
100	1.65
150	1.70
200	1.75
250	1.80
300	1.85
350	1.90
400	1.95
450	2.00
500	2.05
550	2.10
600	2.15
700	2.20
800	2.25
900	2.30
1000	2.40

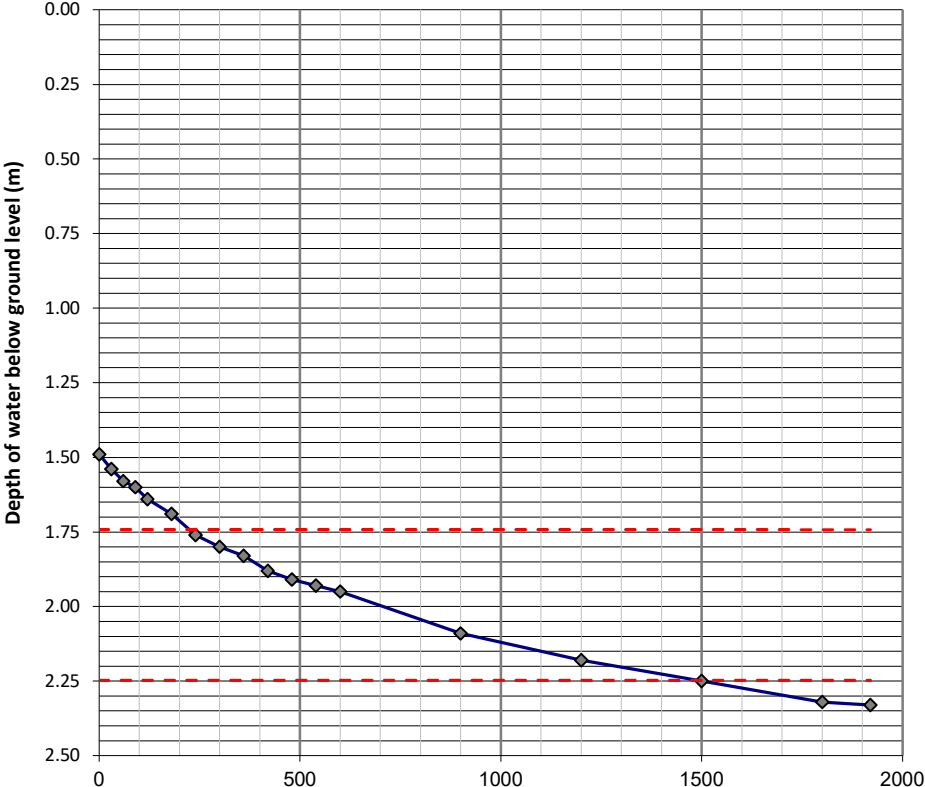
DATE:		25/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600	
PROJECT No:		C57-2338			
PROJECT NAME:		Sperberry Hill BESS			
CLIENT:		Brockwell Energy			
TRIAL PIT ID:		TP1-NGR			
TEST NUMBER:		2			

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %		
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		2.20 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.55 m	
					PIT DEPTH (D):		2.50 m	
INPUT PARAMETERS:								
Total volume of pit (V)				(m ³)	1.27			
Water volume between 75% & 25% depths (PV _{75/75}) = L x W x ½D x Voids Ratio				(m ³)	0.19			
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	1.05			
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)	4.10			
Level of water in pit at 75% effective depth (P ₇₅)				(m)	0.26			
Level of water in pit at 25% effective depth (P ₂₅)				(m)	0.79			
Time at 75% effective depth (T ₇₅)				(s)	183			
Time at 25% effective depth (T ₂₅)				(s)	1057			
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)	874			
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$				(m/s)	5.32E-05			
WATER INPUT:				500 L	in	3 minutes		
Geology of test section/Test remarks								
Topsoil over firm slightly sandy gravelly clay, becoming weathered chalk with gravel at depth to 2.5m.								
Compiled by: GI				Checked by: BF				
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1		

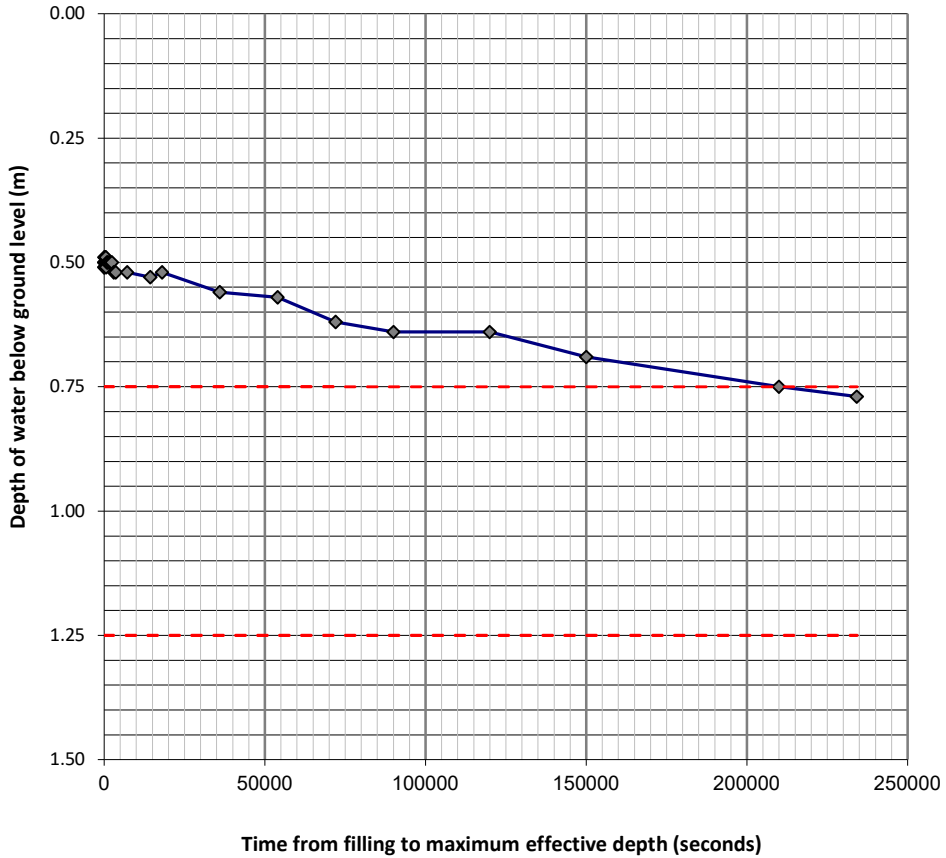
Time (s)	Depth (m)
0	1.45
30	1.49
60	1.54
90	1.60
120	1.62
180	1.71
240	1.77
300	1.83
360	1.87
420	1.92
480	1.95
540	1.99
600	2.03
900	2.18
1200	2.29
1320	2.33

DATE:		26/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 	
PROJECT No:		C57-2338			
PROJECT NAME:		Sperberry Hill BESS			
CLIENT:		Brockwell Energy			
TRIAL PIT ID:		TP1-NGR			
TEST NUMBER:		3			

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY			VOIDS RATIO OF GRAVEL PACK		30.00 %	
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.	2.20 m		
				PIT WIDTH (W):		
					0.55 m	
					PIT DEPTH (D):	
					2.50 m	
INPUT PARAMETERS:						
Total volume of pit (V)				(m ³)	1.22	
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio				(m ³)	0.18	
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	1.01	
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)	3.99	
Level of water in pit at 75% effective depth (P ₇₅)				(m)	0.25	
Level of water in pit at 25% effective depth (P ₂₅)				(m)	0.76	
Time at 75% effective depth (T ₇₅)				(s)	225	
Time at 25% effective depth (T ₂₅)				(s)	1490	
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)	1265	
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$				(m/s)	3.64E-05	
WATER INPUT:			500 L	in	3 minutes	
Geology of test section/Test remarks						
Topsoil over firm slightly sandy gravelly clay, becoming weathered chalk with gravel at depth to 2.5m.						
Compiled by:			GI	Checked by:		BF
After BRE Digest 365, Soakaway Design, 2016					Page 1 of 1	



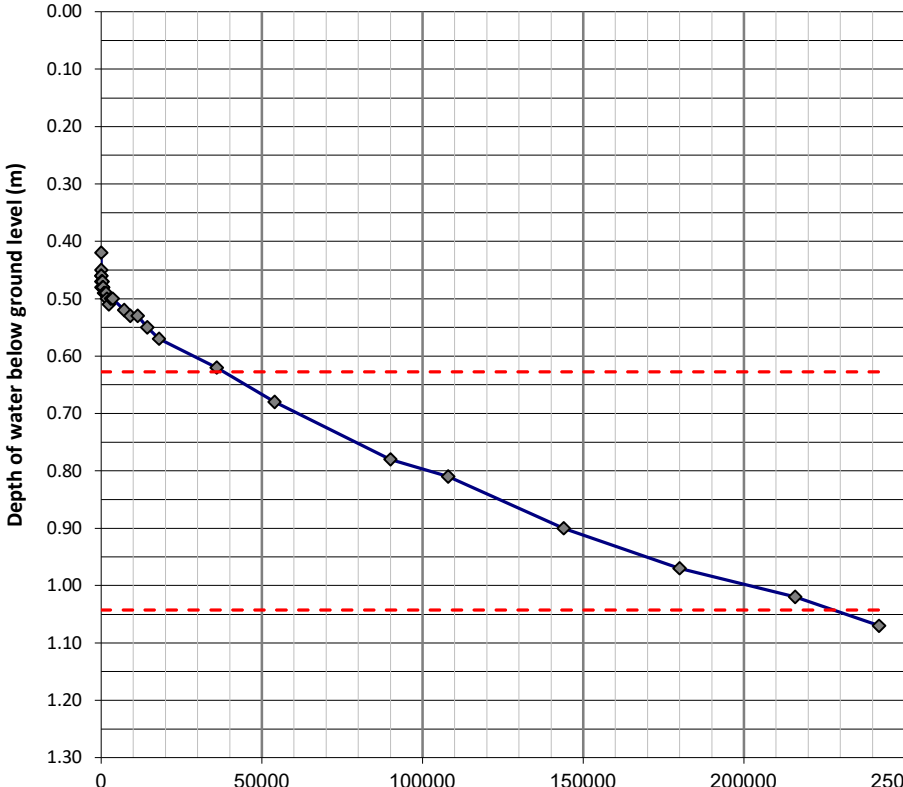
Time (s)	Depth (m)
0	1.50
100	1.60
200	1.65
300	1.70
400	1.75
500	1.80
600	1.85
700	1.90
800	1.95
900	2.00
1000	2.05
1200	2.15
1500	2.25
1800	2.35
1920	2.40

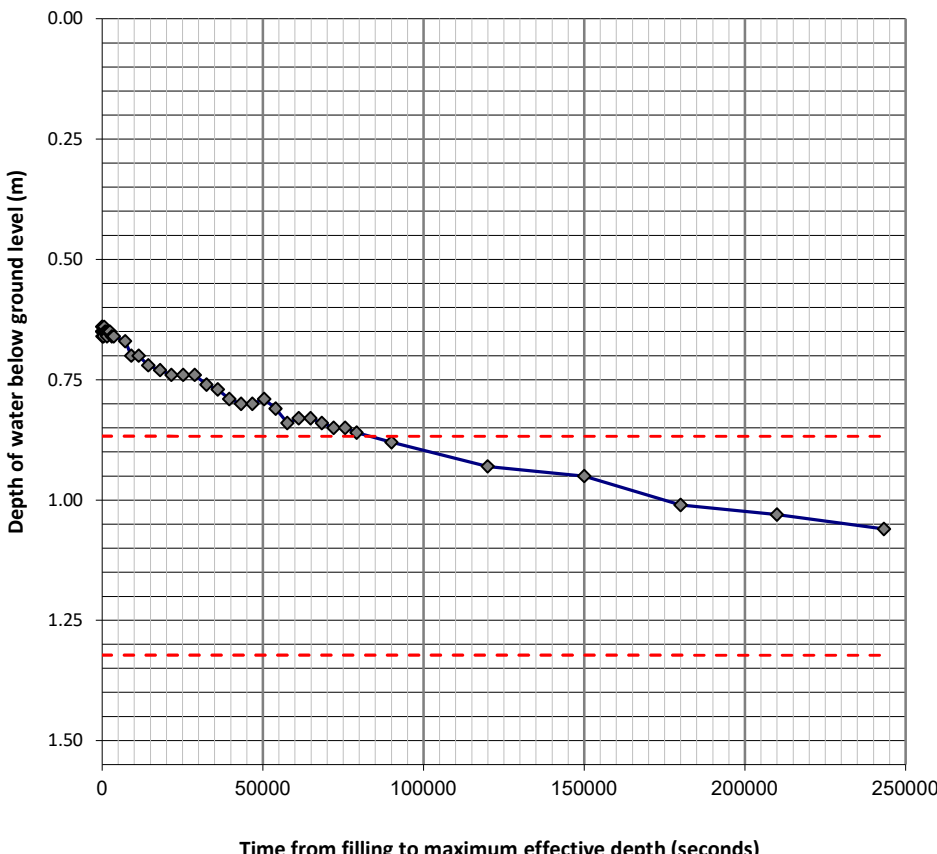
DATE:		24/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 					
PROJECT No:		C57-2338							
PROJECT NAME:		Sperberry Hill BESS							
CLIENT:		Brockwell Energy							
TRIAL PIT ID:		TP2-NGR							
TEST NUMBER:		1							
SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %			
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		2.00 m		
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.60 m		
		PIT DEPTH (D):			1.50 m				
INPUT PARAMETERS:									
Total volume of pit (V)					(m ³)		1.20		
Water volume between 75% & 25% depths (PV _{25/75}) = L x W x ½D x Voids Ratio					(m ³)		0.18		
Maximum depth of water (MDW) = D - Water depth @ time 0					(m)		1.00		
Surface area of pit up to 50% effective depth (AP ₅₀)					(m ²)		3.80		
Level of water in pit at 75% effective depth (P ₇₅)					(m)		0.25		
Level of water in pit at 25% effective depth (P ₂₅)					(m)		0.75		
Time at 75% effective depth (T ₇₅)					(s)		210000		
Time at 25% effective depth (T ₂₅)					(s)		#N/A		
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)					(s)		#N/A		
SOIL INFILTRATION RATE (f) = PV ₇₅₋₂₅ /(AP ₅₀ X T ₇₅₋₂₅)					(m/s)		#N/A		
WATER INPUT:				300 L		in		2 minutes	
Geology of test section/Test remarks									
Topsoil over firm slightly sandy gravelly clay, becoming weathered chalk with gravel at depth to 2.5m.									
Compiled by:				GI		Checked by:		BF	
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1			
									

DATE:		24/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600	
PROJECT No:		C57-2338			
PROJECT NAME:		Sperberry Hill BESS			
CLIENT:		Brockwell Energy			
TRIAL PIT ID:		TP3-NGR			
TEST NUMBER:		1			

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %		
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		2.20 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.50 m	
					PIT DEPTH (D):		1.40 m	
INPUT PARAMETERS:								
Total volume of pit (V)				(m ³)	1.02			
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio				(m ³)	0.15			
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	0.93			
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)	3.61			
Level of water in pit at 75% effective depth (P ₇₅)				(m)	0.23			
Level of water in pit at 25% effective depth (P ₂₅)				(m)	0.70			
Time at 75% effective depth (T ₇₅)				(s)	40857			
Time at 25% effective depth (T ₂₅)				(s)	228322			
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)	187465			
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$				(m/s)	2.27E-07			
WATER INPUT:				300 L	in	2 minutes		
Geology of test section/Test remarks								
Topsoil over clayey gravelly sand (sand and gravel) to 1.5 m.								
Compiled by: GI				Checked by: BF				
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1		

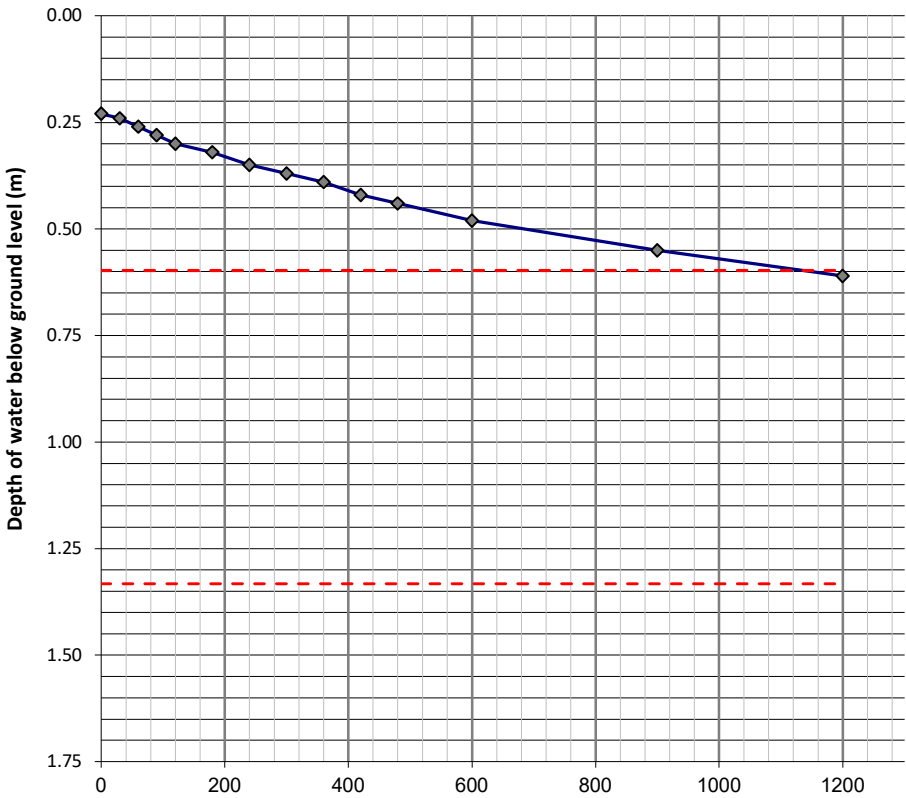
Time (s)	Depth (m)
0	0.50
65000	0.85
150000	1.02
235000	1.15

DATE:		24/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 					
PROJECT No:		C57-2338							
PROJECT NAME:		Sperberry Hill BESS							
CLIENT:		Brockwell Energy							
TRIAL PIT ID:		TP4A-NGR							
TEST NUMBER:		1							
SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %			
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		2.20 m		
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.50 m		
		PIT DEPTH (D):			1.25 m				
INPUT PARAMETERS:									
Total volume of pit (V)					(m ³)		0.91		
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio					(m ³)		0.14		
Maximum depth of water (MDW) = D - Water depth @ time 0					(m)		0.83		
Surface area of pit up to 50% effective depth (AP ₅₀)					(m ²)		3.34		
Level of water in pit at 75% effective depth (P ₇₅)					(m)		0.21		
Level of water in pit at 25% effective depth (P ₂₅)					(m)		0.62		
Time at 75% effective depth (T ₇₅)					(s)		38000		
Time at 25% effective depth (T ₂₅)					(s)		227769		
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)					(s)		189769		
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$					(m/s)		2.16E-07		
WATER INPUT:				300 L		in		3 minutes	
Geology of test section/Test remarks									
Topsoil over very clayey gravelly sand (sand and gravel) to 1.3 m.									
Compiled by: GI				Checked by: BF					
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1			
Depth of water below ground level (m)  Time from filling to maximum effective depth (seconds)									

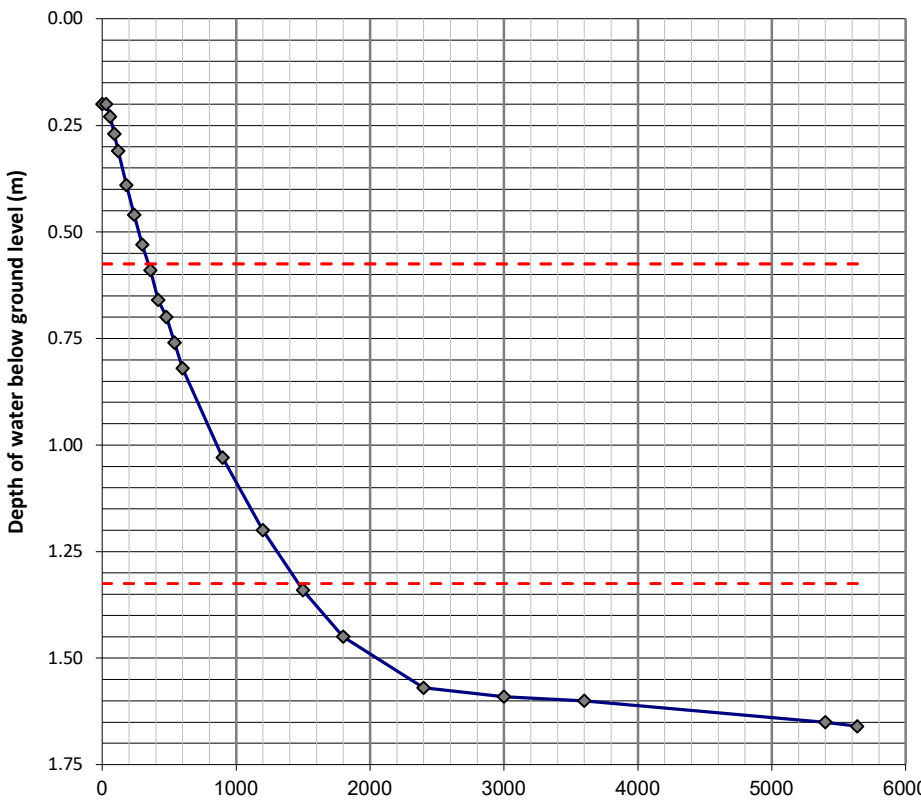
DATE:		24/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 				
PROJECT No:		C57-2338						
PROJECT NAME:		Sperberry Hill BESS						
CLIENT:		Brockwell Energy						
TRIAL PIT ID:		TP5-NGR						
TEST NUMBER:		1						
SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %		
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		2.10 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.50 m	
					PIT DEPTH (D):		1.55 m	
INPUT PARAMETERS:								
Total volume of pit (V)				(m ³)		0.96		
Water volume between 75% & 25% depths (PV _{25/75}) = L x W x ½D x Voids Ratio				(m ³)		0.14		
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)		0.91		
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)		3.42		
Level of water in pit at 75% effective depth (P ₇₅)				(m)		0.23		
Level of water in pit at 25% effective depth (P ₂₅)				(m)		0.68		
Time at 75% effective depth (T ₇₅)				(s)		#N/A		
Time at 25% effective depth (T ₂₅)				(s)		#N/A		
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)		#N/A		
SOIL INFILTRATION RATE (f) = PV ₇₅₋₂₅ /(AP ₅₀ x T ₇₅₋₂₅)				(m/s)		#N/A		
WATER INPUT:				300 L		in 2 minutes		
Geology of test section/Test remarks								
Topsoil over clayey gravelly sand, underlain by stiff slightly sandy clay (glacial till) to 1.55 m.								
Compiled by: GI				Checked by: BF				
After BRE Digest 365, Soakaway Design, 2016				Page 1 of 1				
Depth of water below ground level (m)  Time from filling to maximum effective depth (seconds)								
0	0.00	0.640						
30	0.50	0.650						
60	1.00	0.650						
90	1.50	0.640						
120	2.00	0.650						
180	3.00	0.660						
240	4.00	0.650						
300	5.00	0.650						
360	6.00	0.650						
420	7.00	0.660						
480	8.00	0.650						
540	9.00	0.650						
600	10.00	0.640						
900	15.00	0.650						
1200	20.00	0.650						
1500	25.00	0.660						
1800	30.00	0.650						
2400	40.00	0.650						
3000	50.00	0.660						
3600	60.00	0.660						
7200	120.00	0.670						
9000	150.00	0.700						
11400	190.00	0.700						
14400	240.00	0.720						
18000	300.00	0.730						
21600	360.00	0.740						
25200	420.00	0.740						
28800	480.00	0.740						
32400	540.00	0.760						
36000	600.00	0.770						
39600	660.00	0.790						
43200	720.00	0.800						
46800	780.00	0.800						
50400	840.00	0.790						
54000	900.00	0.810						
57600	960.00	0.840						
61200	1020.00	0.830						
64800	1080.00	0.830						
68400	1140.00	0.840						
72000	1200.00	0.850						
75600	1260.00	0.850						
79200	1320.00	0.860						
90000	1500.00	0.880						
120000	2000.00	0.930						
150000	2500.00	0.950						
180000	3000.00	1.010						
210000	3500.00	1.030						
243300	4055.00	1.060						

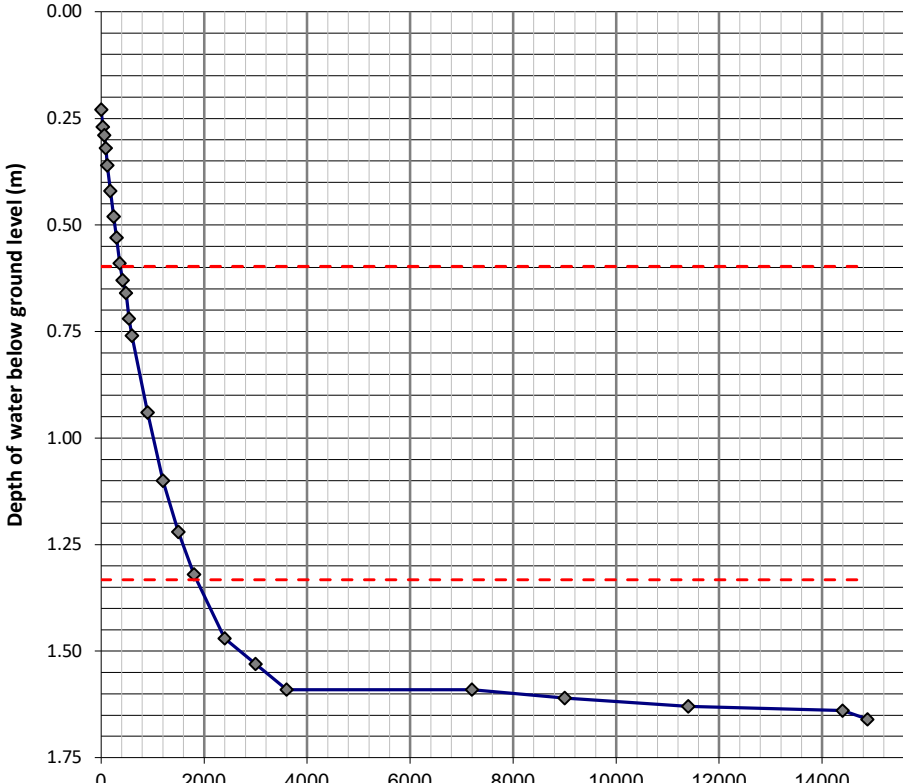
DATE:		24/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 	
PROJECT No:		C57-2338			
PROJECT NAME:		Sperberry Hill BESS			
CLIENT:		Brockwell Energy			
TRIAL PIT ID:		TP6-NGR			
TEST NUMBER:		1			

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %		
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		1.90 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.55 m	
					PIT DEPTH (D):		1.70 m	
INPUT PARAMETERS:								
Total volume of pit (V)				(m ³)	1.54			
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio				(m ³)	0.23			
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	1.47			
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)	4.65			
Level of water in pit at 75% effective depth (P ₇₅)				(m)	0.37			
Level of water in pit at 25% effective depth (P ₂₅)				(m)	1.10			
Time at 75% effective depth (T ₇₅)				(s)	1138			
Time at 25% effective depth (T ₂₅)				(s)	#N/A			
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)	#N/A			
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$				(m/s)	#N/A			
WATER INPUT:				300 L	in	2 minutes		
Geology of test section/Test remarks								
Topsoil over slightly clayey gravelly sand (sand and gravel) to 1.7m. Test run 1 diver malfunction; 20 minutes of manual measurements only.								
Compiled by: GI				Checked by: BF				
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1		



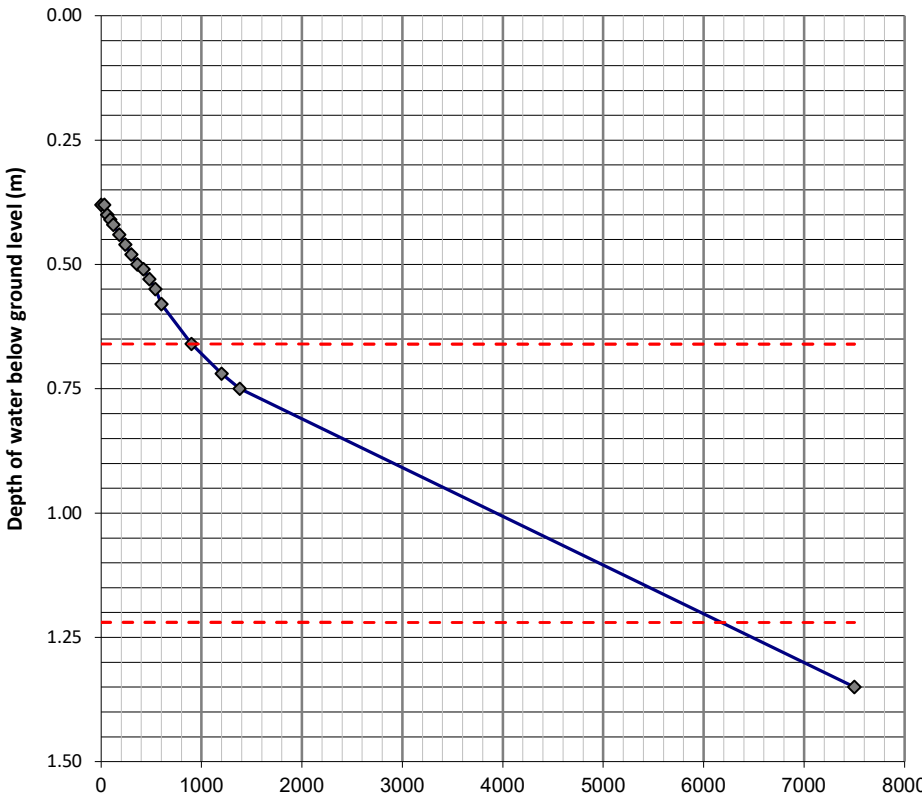
Time (s)	Depth (m)
0	0.25
30	0.24
60	0.23
90	0.22
120	0.21
150	0.20
180	0.19
210	0.18
240	0.17
270	0.16
300	0.15
330	0.14
360	0.13
390	0.12
420	0.11
450	0.10
480	0.09
510	0.08
540	0.07
570	0.06
600	0.05
630	0.04
660	0.03
690	0.02
720	0.01
750	0.00
780	0.00
810	0.00
840	0.00
870	0.00
900	0.00
930	0.00
960	0.00
990	0.00
1020	0.00
1050	0.00
1080	0.00
1110	0.00
1140	0.00
1170	0.00
1200	0.610

DATE:		25/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 		
PROJECT No:		C57-2338				
PROJECT NAME:		Sperberry Hill BESS				
CLIENT:		Brockwell Energy				
TRIAL PIT ID:		TP6-NGR				
TEST NUMBER:		2				
SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY						
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		VOIDS RATIO OF GRAVEL PACK	30.00 %
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT LENGTH (L):	1.90 m
		PIT WIDTH (W):			0.55 m	
				PIT DEPTH (D):	1.70 m	
INPUT PARAMETERS:						
Total volume of pit (V)				(m ³)	1.57	
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio				(m ³)	0.24	
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	1.50	
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)	4.72	
Level of water in pit at 75% effective depth (P ₇₅)				(m)	0.38	
Level of water in pit at 25% effective depth (P ₂₅)				(m)	1.13	
Time at 75% effective depth (T ₇₅)				(s)	345	
Time at 25% effective depth (T ₂₅)				(s)	1468	
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)	1123	
SOIL INFILTRATION RATE (f) = PV ₇₅₋₂₅ /(AP ₅₀ x T ₇₅₋₂₅)				(m/s)	4.44E-05	
WATER INPUT:		500 L		in	5 minutes	
Geology of test section/Test remarks						
Topsoil over slightly clayey gravelly sand (sand and gravel) to 1.7m.						
Compiled by: GI			Checked by: BF			
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Depth of water below ground level (m)  Time from filling to maximum effective depth (seconds)						

DATE:	25/02/2026	Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600			
PROJECT No:	C57-2338				
PROJECT NAME:	Sperberry Hill BESS				
CLIENT:	Brockwell Energy				
TRIAL PIT ID:	TP6-NGR				
TEST NUMBER:	3				
SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY		VOIDS RATIO OF GRAVEL PACK	30.00 %		
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks	PIT LENGTH (L):	1.90 m
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.	PIT WIDTH (W):	0.55 m
				PIT DEPTH (D):	1.70 m
INPUT PARAMETERS:					
Total volume of pit (V)				(m ³)	1.54
Water volume between 75% & 25% depths (PV _{25/75}) = L x W x ½D x Voids Ratio				(m ³)	0.23
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	1.47
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)	4.65
Level of water in pit at 75% effective depth (P ₇₅)				(m)	0.37
Level of water in pit at 25% effective depth (P ₂₅)				(m)	1.10
Time at 75% effective depth (T ₇₅)				(s)	371
Time at 25% effective depth (T ₂₅)				(s)	1850
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)	1479
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$				(m/s)	3.35E-05
WATER INPUT:				500 L	in 5 minutes
Geology of test section/Test remarks					
Topsoil over slightly clayey gravelly sand (sand and gravel) to 1.7m.					
Compiled by: GI			Checked by: BF		
After BRE Digest 365, Soakaway Design, 2016				Page 1 of 1	
Depth of water below ground level (m)  Time from filling to maximum effective depth (seconds)					

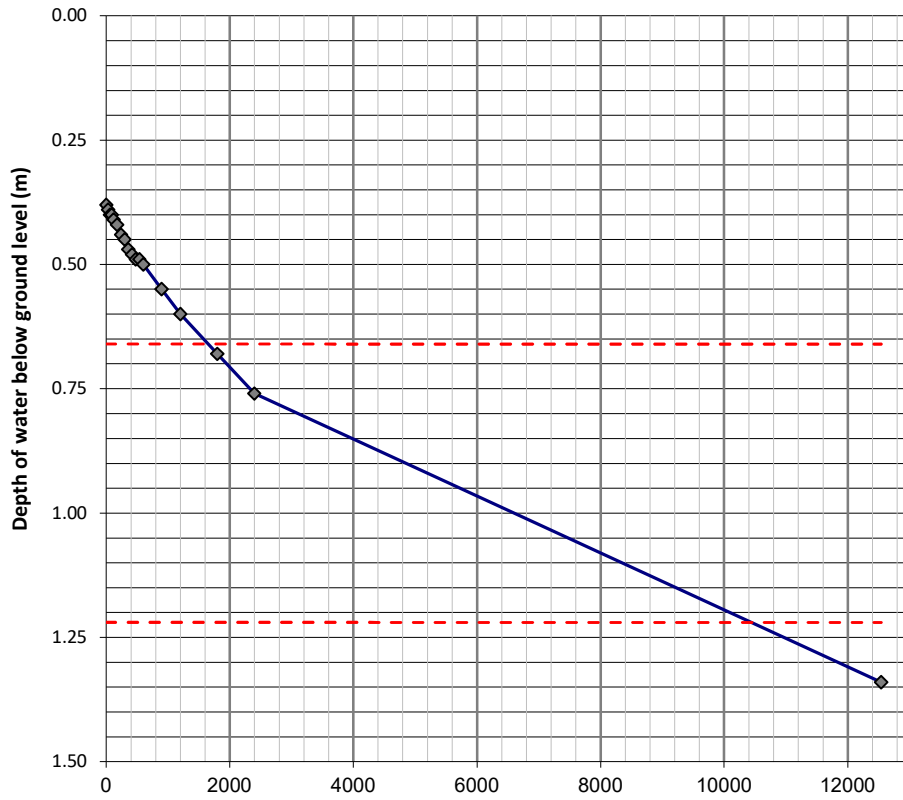
DATE:		24/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600			
PROJECT No:		C57-2338					
PROJECT NAME:		Sperberry Hill BESS					
CLIENT:		Brockwell Energy					
TRIAL PIT ID:		TP7-NGR					
TEST NUMBER:		1					

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %		
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		2.05 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.60 m	
					PIT DEPTH (D):		1.50 m	
INPUT PARAMETERS:								
Total volume of pit (V)				(m ³)	1.38			
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio				(m ³)	0.21			
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	1.12			
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)	4.20			
Level of water in pit at 75% effective depth (P ₇₅)				(m)	0.28			
Level of water in pit at 25% effective depth (P ₂₅)				(m)	0.84			
Time at 75% effective depth (T ₇₅)				(s)	900			
Time at 25% effective depth (T ₂₅)				(s)	6175			
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)	5274			
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$				(m/s)	9.33E-06			
WATER INPUT:				300 L	in	2 minutes		
Geology of test section/Test remarks								
Topsoil over clayey gravelly sand (sand and gravel) to 1.5m.								
Compiled by: GI				Checked by: BF				
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1		



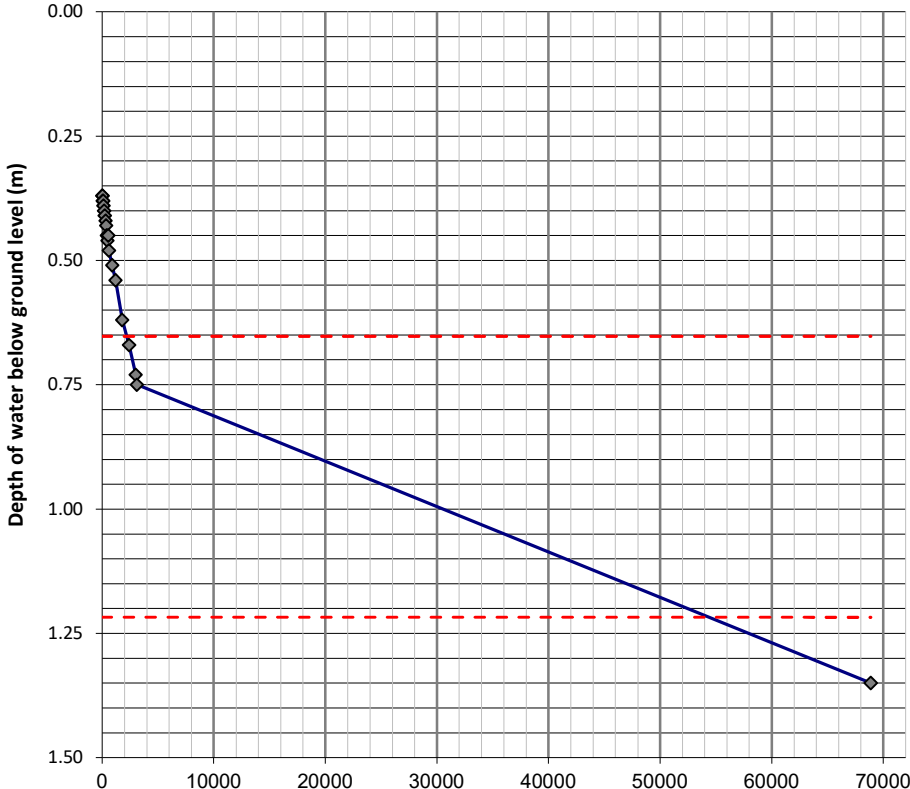
Depth of water below ground level (m)

Time from filling to maximum effective depth (seconds)

DATE:		25/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 					
PROJECT No:		C57-2338							
PROJECT NAME:		Sperberry Hill BESS							
CLIENT:		Brockwell Energy							
TRIAL PIT ID:		TP7-NGR							
TEST NUMBER:		2							
SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %			
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		2.05 m		
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.60 m		
					PIT DEPTH (D):		1.50 m		
INPUT PARAMETERS:									
Total volume of pit (V)					(m ³)		1.38		
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio					(m ³)		0.21		
Maximum depth of water (MDW) = D - Water depth @ time 0					(m)		1.12		
Surface area of pit up to 50% effective depth (AP ₅₀)					(m ²)		4.20		
Level of water in pit at 75% effective depth (P ₇₅)					(m)		0.28		
Level of water in pit at 25% effective depth (P ₂₅)					(m)		0.84		
Time at 75% effective depth (T ₇₅)					(s)		1651		
Time at 25% effective depth (T ₂₅)					(s)		10443		
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)					(s)		8793		
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$					(m/s)		5.60E-06		
WATER INPUT:				400 L		in		3 minutes	
Geology of test section/Test remarks									
Topsoil over clayey gravelly sand (sand and gravel) to 1.5m.									
Compiled by: GI				Checked by: BF					
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1			
Depth of water below ground level (m)  Time from filling to maximum effective depth (seconds)									

DATE:	25/02/2026	Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 
PROJECT No:	C57-2338	
PROJECT NAME:	Sperberry Hill BESS	
CLIENT:	Brockwell Energy	
TRIAL PIT ID:	TP7-NGR	
TEST NUMBER:	3	

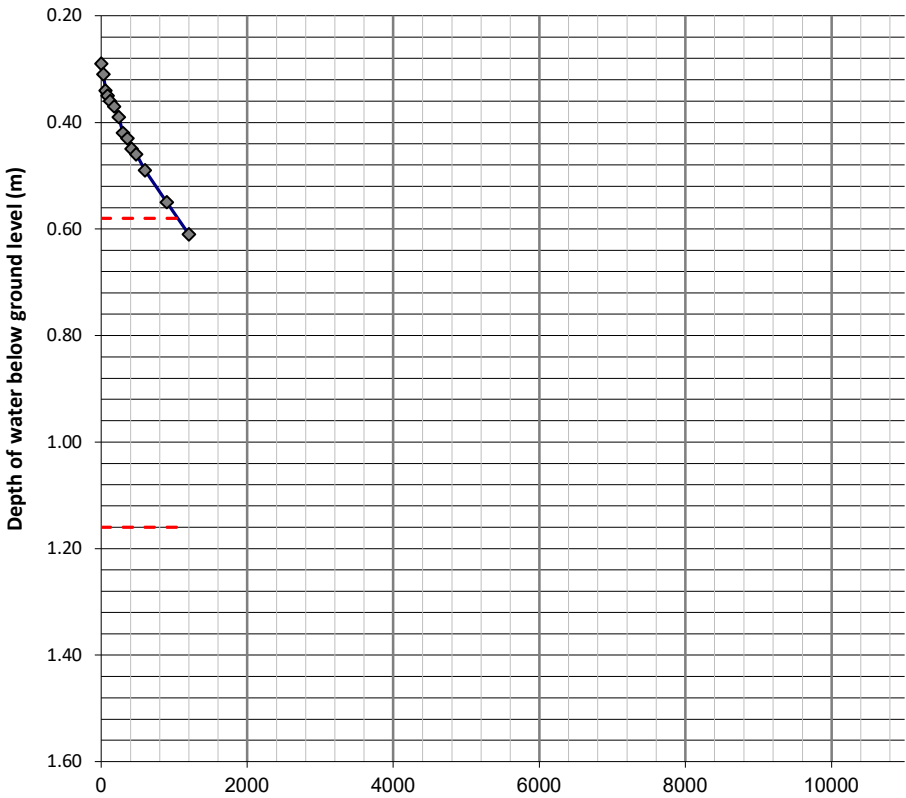
SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY			VOIDS RATIO OF GRAVEL PACK		30.00 %
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		
			PIT LENGTH (L):		2.05 m
			PIT WIDTH (W):		0.60 m
			PIT DEPTH (D):		1.50 m
INPUT PARAMETERS:					
0	0.00	0.370	Total volume of pit (V)		(m ³) 1.39
30	0.50	0.370	Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio		(m ³) 0.21
60	1.00	0.380	Maximum depth of water (MDW) = D - Water depth @ time 0		(m) 1.13
90	1.50	0.380	Surface area of pit up to 50% effective depth (AP ₅₀)		(m ²) 4.22
120	2.00	0.390	Level of water in pit at 75% effective depth (P ₇₅)		(m) 0.28
180	3.00	0.400	Level of water in pit at 25% effective depth (P ₂₅)		(m) 0.85
240	4.00	0.410	Time at 75% effective depth (T ₇₅)		(s) 2191
300	5.00	0.420	Time at 25% effective depth (T ₂₅)		(s) 54367
360	6.00	0.430	Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)		(s) 52176
420	7.00	0.450	SOIL INFILTRATION RATE (f) = $P_{V_{75-25}}/(AP_{50} \times T_{75-25})$		(m/s) 9.46E-07
480	8.00	0.460	WATER INPUT:		400 L in 3 minutes
540	9.00	0.450	Geology of test section/Test remarks		
600	10.00	0.480	Topsoil over clayey gravelly sand (sand and gravel) to 1.5m.		
900	15.00	0.510	Compiled by: GI		Checked by: BF
1200	20.00	0.540	After BRE Digest 365, Soakaway Design, 2016		Page 1 of 1
1800	30.00	0.620			
2400	40.00	0.670			
3000	50.00	0.730			
3120	52.00	0.750			
68880	1148.00	1.350			



The graph plots the depth of water below ground level (m) on the y-axis (0.00 to 1.50) against time from filling to maximum effective depth (seconds) on the x-axis (0 to 70000). The data points show a rapid initial drop in water depth, reaching approximately 0.625m at around 2000 seconds, followed by a steady linear decrease. A red dashed horizontal line is drawn at 0.625m depth, indicating the maximum effective depth.

DATE:		24/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600			
PROJECT No:		C57-2338					
PROJECT NAME:		Sperberry Hill BESS					
CLIENT:		Brockwell Energy					
TRIAL PIT ID:		TP8-NGR					
TEST NUMBER:		1					

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %		
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		1.90 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.55 m	
					PIT DEPTH (D):		1.45 m	
INPUT PARAMETERS:								
Total volume of pit (V)				(m ³)	1.21			
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio				(m ³)	0.18			
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	1.16			
Surface area of pit up to 50% effective depth (AP ₅₀)				(m ²)	3.89			
Level of water in pit at 75% effective depth (P ₇₅)				(m)	0.29			
Level of water in pit at 25% effective depth (P ₂₅)				(m)	0.87			
Time at 75% effective depth (T ₇₅)				(s)	1050			
Time at 25% effective depth (T ₂₅)				(s)	#N/A			
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)				(s)	#N/A			
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$				(m/s)	#N/A			
WATER INPUT:				300 L	in	2 minutes		
Geology of test section/Test remarks								
Topsoil over very clayey gravelly sand (sand and gravel) to 1.5m. Diver malfunction - manual measurements only.								
Compiled by: GI				Checked by: BF				
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1		

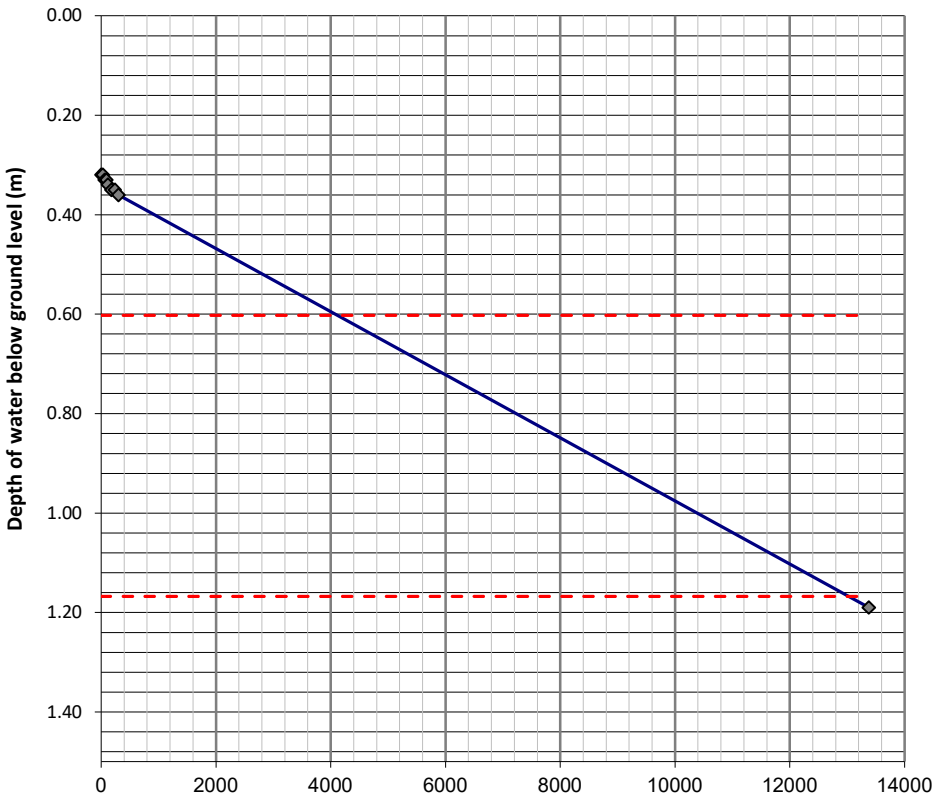


Depth of water below ground level (m)

Time from filling to maximum effective depth (seconds)

DATE:		25/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 	
PROJECT No:		C57-2338			
PROJECT NAME:		Sperberry Hill BESS			
CLIENT:		Brockwell Energy			
TRIAL PIT ID:		TP8-NGR			
TEST NUMBER:		2			

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY			VOIDS RATIO OF GRAVEL PACK		30.00 %	
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):	
					PIT DEPTH (D):	
			1.90 m			
			0.55 m			
			1.45 m			
INPUT PARAMETERS:						
0	0.00	0.320	Total volume of pit (V)		(m ³)	1.18
30	0.50	0.320	Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio		(m ³)	0.18
60	1.00	0.330	Maximum depth of water (MDW) = D - Water depth @ time 0		(m)	1.13
90	1.50	0.330	Surface area of pit up to 50% effective depth (AP ₅₀)		(m ²)	3.81
120	2.00	0.340	Level of water in pit at 75% effective depth (P ₇₅)		(m)	0.28
180	3.00	0.350	Level of water in pit at 25% effective depth (P ₂₅)		(m)	0.85
240	4.00	0.350	Time at 75% effective depth (T ₇₅)		(s)	4122
300	5.00	0.360	Time at 25% effective depth (T ₂₅)		(s)	13027
13380	223.00	1.190	Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)		(s)	8905
			SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$		(m/s)	5.22E-06
			WATER INPUT:		400	in
						3 minutes
Geology of test section/Test remarks						
Topsoil over very clayey gravelly sand (sand and gravel) to 1.5m.						
Compiled by:			GI		Checked by: BF	
			After BRE Digest 365, Soakaway Design, 2016		Page 1 of 1	

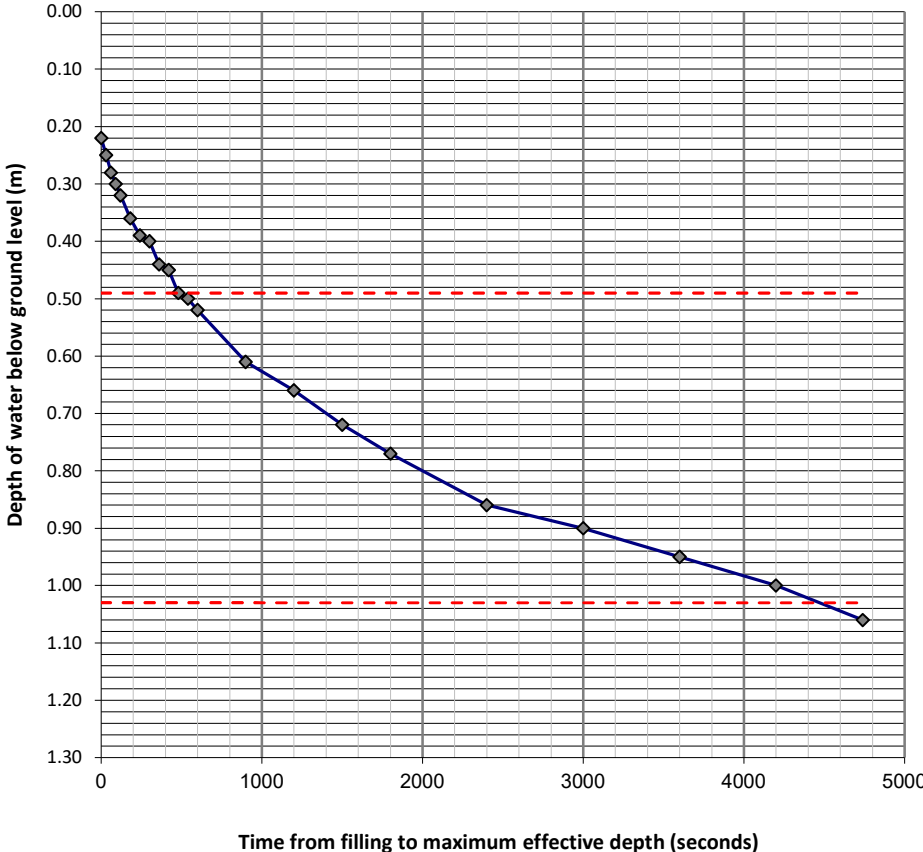


Time from filling to maximum effective depth (seconds)

DATE:		25/02/2026		Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600	
PROJECT No:		C57-2338			
PROJECT NAME:		Sperberry Hill BESS			
CLIENT:		Brockwell Energy			
TRIAL PIT ID:		TP8-NGR			
TEST NUMBER:		3			

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %		
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks		PIT LENGTH (L):		1.90 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.		PIT WIDTH (W):		0.55 m	
					PIT DEPTH (D):		1.45 m	
INPUT PARAMETERS:								
Total volume of pit (V)			(m ³)		1.22			
Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio			(m ³)		0.18			
Maximum depth of water (MDW) = D - Water depth @ time 0			(m)		1.17			
Surface area of pit up to 50% effective depth (AP ₅₀)			(m ²)		3.91			
Level of water in pit at 75% effective depth (P ₇₅)			(m)		0.29			
Level of water in pit at 25% effective depth (P ₂₅)			(m)		0.88			
Time at 75% effective depth (T ₇₅)			(s)		17207			
Time at 25% effective depth (T ₂₅)			(s)		56377			
Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)			(s)		39170			
SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$			(m/s)		1.20E-06			
WATER INPUT:			400 L		in		3 minutes	
Geology of test section/Test remarks								
Topsoil over very clayey gravelly sand (sand and gravel) to 1.5m.								
Compiled by: GI				Checked by: BF				
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1		

Time from filling to maximum effective depth (seconds)

DATE:	24/02/2026	Ayesa 9 The Courtyard Phoenix Square Wyncolls Road Colchester, CO4 9PE Tel: 01206 585600 				
PROJECT No:	C57-2338					
PROJECT NAME:	Sperberry Hill BESS					
CLIENT:	Brockwell Energy					
TRIAL PIT ID:	TP9A-NGR					
TEST NUMBER:	1					
SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY		VOIDS RATIO OF GRAVEL PACK	30.00 %			
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks	PIT LENGTH (L):	2.20 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.	PIT WIDTH (W):	0.60 m	
				PIT DEPTH (D):	1.30 m	
INPUT PARAMETERS:						
0	0.00	0.220	Total volume of pit (V)	(m ³)	1.43	
30	0.50	0.250	Water volume between 75% & 25% depths (PV25/75) = L x W x ½D x Voids Ratio	(m ³)	0.21	
60	1.00	0.280	Maximum depth of water (MDW) = D - Water depth @ time 0	(m)	1.08	
90	1.50	0.300	Surface area of pit up to 50% effective depth (AP ₅₀)	(m ²)	4.34	
120	2.00	0.320	Level of water in pit at 75% effective depth (P ₇₅)	(m)	0.27	
180	3.00	0.360	Level of water in pit at 25% effective depth (P ₂₅)	(m)	0.81	
240	4.00	0.390	Time at 75% effective depth (T ₇₅)	(s)	480	
300	5.00	0.400	Time at 25% effective depth (T ₂₅)	(s)	4470	
360	6.00	0.440	Time for outflow for 75% and 25% effective depth (T ₇₅ -T ₂₅)	(s)	3990	
420	7.00	0.450	SOIL INFILTRATION RATE (f) = $PV_{75-25}/(AP_{50} \times T_{75-25})$	(m/s)	1.23E-05	
480	8.00	0.490	WATER INPUT:	300 L	in	2 minutes
540	9.00	0.500	Geology of test section/Test remarks			
600	10.00	0.520	Topsoil over very gravelly clayey sand (sand and gravel) to 1.3m.			
660	11.00	0.560	Compiled by:	GI	Checked by:	BF
720	12.00	0.600	After BRE Digest 365, Soakaway Design, 2016			Page 1 of 1
780	13.00	0.640				
840	14.00	0.680				
900	15.00	0.720				
960	16.00	0.760				
1020	17.00	0.800				
1080	18.00	0.840				
1140	19.00	0.880				
1200	20.00	0.920				
1260	21.00	0.960				
1320	22.00	1.000				
1380	23.00	1.040				
1440	24.00	1.080				
1500	25.00	1.120				
1560	26.00	1.160				
1620	27.00	1.200				
1680	28.00	1.240				

[illegible]

DATE:		25/02/2026	
PROJECT No:		C57-2338	
PROJECT NAME:		Sperberry Hill BESS	
CLIENT:		Brockwell Energy	
TRIAL PIT ID:		TP9A-NGR	
TEST NUMBER:		3	

Ayesa
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Tel: 01206 585600

SOAKAWAY TEST - SOIL INFILTRATION RATE/PERMEABILITY				VOIDS RATIO OF GRAVEL PACK		30.00 %	
Time Elapsed (s)	Time Elapsed (mins)	Distance to water surface from ground level (m)	Pit Construction Remarks	PIT LENGTH (L):		2.20 m	
			Gravel backfilled in tested zone. Voids ratio allowed for in calculations.	PIT WIDTH (W):		0.60 m	
				PIT DEPTH (D):		1.30 m	
INPUT PARAMETERS:							
Total volume of pit (V)				(m^3)	1.44		
Water volume between 75% & 25% depths ($P_{V25/75}$) = L x W x ½ D x Voids Ratio				(m^3)	0.22		
Maximum depth of water (MDW) = D - Water depth @ time 0				(m)	1.09		
Surface area of pit up to 50% effective depth (AP_{50})				(m^2)	4.37		
Level of water in pit at 75% effective depth (P_{75})				(m)	0.27		
Level of water in pit at 25% effective depth (P_{25})				(m)	0.82		
Time at 75% effective depth (T_{75})				(s)	1095		
Time at 25% effective depth (T_{25})				(s)	8582		
Time for outflow for 75% and 25% effective depth ($T_{75}-T_{25}$)				(s)	7487		
SOIL INFILTRATION RATE (f) = $\frac{PV_{75-25}}{(AP_{50} \times T_{75-25})}$				(m/s)	6.59E-06		
WATER INPUT:				400 L	in	3 minutes	
Geology of test section/Test remarks							
Topsoil over very gravelly clayey sand (sand and gravel) to 1.3m.							
Compiled by: GI				Checked by: BF			
After BRE Digest 365, Soakaway Design, 2016						Page 1 of 1	

Depth of water below ground level (m)

Time (s)	Depth (m)
0	0.20
100	0.25
200	0.28
300	0.30
400	0.32
500	0.34
600	0.36
700	0.38
800	0.40
1000	0.42
1500	0.48
2000	0.55
2500	0.62
3000	0.68
3500	0.75
4000	0.82
7200	0.97
9000	1.05

Time from filling to maximum effective depth (seconds)