Horse Hill Developments Ltd

Title: **Construction Quality Assurance Plan**

Document Number: **HHDL-EPR-HHP-CQA-011**

Revision: **1**

1	Rev	Revised Due To Site Changes	14/12/2020	ZG-SS	ZG-TF	TH
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REVISION DESCRIPTION SHEET

Details to include revision number, a description of the revision indicating paragraphs and pages that have been revised, together with the date and approved signature.

Revision	Description	Date	Approved by
0	Original Issue	30/04/2020	TH
1	Revised following decision to retain existing site footprint.	14/12/2020	TH

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SECTION I INTRODUCTION AND BACKGROUND INFORMATION

1. Introduction

The Construction Quality Assurance (CQA) Plan is applicable to Horse Hill Developments LTD (HHDL), its contractors and subcontractors and is applicable to the design and construction of the Horse Hill Well Site including quality management, quality inspections and data recording.

It can be used in support of applications to the Environment Agency (EA) under the Environmental Permitting (England and Wales) Regulations 2016 (EPR2016) and the Mineral Planning Authority (MPA) where there is a requirement to provide a CQA Plan. The CQA plan sets out the quality assurance arrangements for the installation of the impermeable membrane (High Density Polyethylene (HDPE) Geomembrane) and the additional containment measures that shall be implemented at the Well Site.

2. Definitions

°C:	Degrees Centigrade
°:	Degrees
≥:	Equal to or greater than
“:	Imperial Inch
%:	Percentage
CQA:	Construction Quality Assurance
EPR 2016:	The Environmental Permitting Regulations 2016
g/m^2:	Grams per square metre
g/m^3:	Grams per cubic metre
Ha:	Hectare
HDPE:	High Density Polyethylene
HSE:	Health, Safety and Environmental
kg:	Kilogram
km:	Kilometre
kN/m:	Kilonewton per metre
LFE5:	Environment Agency guidance on using geomembranes in landfill engineering
m:	Metre
m^2:	Square Metre
m^3:	Cubic Metre
mm:	Millimetre
MTN:	Material Transfer Note
N:	Newton
NORM:	Naturally Occurring Radioactive Material
OIT:	Oxidative Induction Time
PAHs:	Polycyclic Aromatic Hydrocarbons
PEDL:	Petroleum Exploration and Development Licence
UKAS:	The United Kingdom Accreditation Service
WRAP:	Registered charity that has developed quality protocols jointly with the Environment Agency

3. ROLES AND RESPONSIBILITIES

Role	Key Responsibilities
Chief Executive	The Chief Executive is overall responsible for all HHDL business activities and has to ensure that suitable and sufficient systems, processes and resources are in place to adhere to quality standards and regulative requirements in relation to quality management. They shall: • Apply quality standards and procedures throughout HHDL; • Provide suitable and sufficient input and resources required to maintain quality standards; and • Define roles and responsibilities to ensure that a proactive and robust system is in place to assist in quality management.
Commercial Director **Or** **Appointed Project Manager**	• The communication and implementation of the CQA Plan; • Providing assistance and guidance in the update and approval of the CQA Plan; • Ensuring that quality compliance is maintained through the provision of adequate competent resources; • Ensuring that defined practices and processes are communicated; • Ensuring that roles and responsibilities are identified and the assessment of individuals is recorded; • Ensuring that competent personnel implement, monitor and assess the requirements of the CQA Plan; • Selecting contractors who can meet HHDL quality standards through a robust tendering and/or selection process and the monitoring of contractors to ensure that these standards are being met; • The development and training of staff or assessing the competence of contractors so that they are competent and capable of carrying out their work to the required standards; • Conducting periodic audits of compliance with the CQA Plan; and • Communicating quality performance, significant findings and non-conformances.
Construction Manager	• Oversee the overall implementation of the CQA Plan; • Ensure designs and quality information is communicated to the Principal Contractor and subcontractors; • Coordinating all project testing, inspections and reporting matters directly with HHDL; • Interceding directly and ceasing unsatisfactory work and control further processing, delivery or installation of non-conforming material; • Providing assistance and guidance in the update and approval of the CQA Plan; • Ensure that defined practices and processes are communicated; • Ensure that roles and responsibilities are identified and the assessment of individuals is recorded; • Conduct periodic audits of compliance with the CQA Plan; and • Communicate quality performance, significant findings and non-conformances.
Principal Contractor	• Ensure works are completed using materials and products identified within the design plans; • Ensure works and materials are compliant with the design and relevant quality standards and guidance; • Ensure materials and products delivered and used within the operations are in compliance with the design; • Ensure compliance with the CQA Plan; and • Ensure subcontractors comply with the CQA Plan and relevant quality standards and guidance.
CQA Engineer	• Develop a suitable CQA method statement which is practical, achievable and ensures the highest standards of environmental protection; • Provide supervision of the lining works in accordance with the CQA Plan to ensure compliance; • Produce a validation report upon completion of the whole or part of the proposed works as required; • Supervise the construction of the site for compliance with all conformance aspects of this document; • Assess the Contractor's documentation for material suitability and arrange CQA testing; • Supervise all surveying or other such procedures involved in the lining system control; • Keep full daily records of all site operations, testing and site conditions; and • Keep records and collect information required for the validation report.
All personnel	All personnel are to follow the requirements of this CQA Plan and cooperate fully with senior management. All personnel must take reasonable care to ensure that their actions do not have an adverse impact on the environment. Personnel must not intentionally or recklessly interfere with, or misuse anything that is provided in the interest of health, safety and the environment.

4. LEGISLATION AND APPLICABILITY

4.1 Compliance with Planning Consent

HHDL operations are to be conducted in accordance with current planning consents and regulated by Surrey County Council (SCC). HHDL submitted a planning application to SCC which was validated on 27th October 2016. SCC approved the planning application for the Horse Hill well site and granted planning permission and subsequently issued a Decision Notice reference RE16/02556/CON dated 1st November 2017.

The Notice of Decision of Planning Authority on Application for Permission to Carry out Development (Decision No. RE18/02667/CON, dated 27th September 2019) details the conditions that the "Applicant" (HHDL) must discharge prior to and during the planned development. Condition 19 of the Decision Notice sets out the requirement for a CQA Plan and states:

Prior to the commencement of the development hereby permitted a Construction Environment Management Plan (CEMP) for the construction works of the process, storage and tanker area shall be submitted to and approved in writing by the County Planning Authority. The CEMP shall apply to the construction of such works that include (but not limited to):

- *Quality Assurance Plan (CQA Plan) for the: perimeter bunding; the earthworks engineering; retaining structures; containment membrane design and its sealing; pavements and floor slabs (including foundation layers); structure foundations; including geotechnical assessment and design methodology;*
- *Monitoring systems, including testing, inspection and maintenance protocol, including the groundwater monitoring wells.*

Personnel conducting operations at the Horse Hill well site are to comply with this CQA Plan and any applicable legislative requirements throughout the lifetime of the development.

4.2 Compliance with Environmental Permissions

The proposed activities at the Horse Hill Well Site are the subject of an application to the EA for approval through the Environmental Permitting (England and Wales) Regulations 2016. As part of the application process the EA has requested, through a Schedule 5 notice, a Construction Quality Assurance Plan, intertwined with a Containment Plan, be produced so as to ensure that the integrity of the site is retained throughout the lifetime of the development. The notice states:

Please provide updated details of a secondary and tertiary containment plan that will be adopted throughout the life span of the site. The plan must include containment infrastructure drawings, and a CQA plan for the installation of the HDPE membrane under the site extension area.

The plan, which should be in accordance with the methodology detailed within CIRIA C736 (2014), should include the condition and extent of secondary and tertiary containment systems where all polluting liquids and solids will be stored, treated, and/or handled. The plan must include containment infrastructure drawings, and a CQA plan for the installation of the HDPE membrane under the site extension area. The plan must contain dates for the implementation of individual improvement measures necessary for the secondary and tertiary containment systems previously designed for exploratory activities to be upgraded to ensure that production activities will adhere to the standards detailed/referenced within CIRIA C736 (2014), or equivalent.

Following the issue of the Schedule 5 notice and the comments provided from the Environment Agency above, a decision has been made by HHDL to retain the exiting site boundary as it is currently and is no longer considering the extension to the well site. However, the comments are still relevant to the proposal insofar as ensuring that the appropriate maintenance regimes and containment strategies are suitable and sufficient during the lifetime of the Horse Hill Well Site.

Whilst this document itself is not a Secondary and Tertiary Containment Plan (Containment Plan), it does seek to inform the reader of the steps to be taken in order to produce a suitable and sufficient Containment Plan including stock inventory and risk assessment. The Containment Plan shall be issued to the Environment Agency prior to the commencement of future drilling and production operations.

4.3 Industry Quality Standards and Requirements

A review of the design and construction methods to be implemented during the construction works to be undertaken at the Horse Hill well site has identified the following industry quality standards and guidance documents applicable to this CQA:

- Manual of Contract Documents for Highway Works Volume 1 Specification for Highway Works;
- Environment Agency Technical Guidance LFE2 – Cylinder testing geomembranes and their protective materials;
- Environment Agency Technical Guidance LFE5 – Using geomembranes in landfill engineering;
- Environment Agency Technical Guidance LFE7– Using non-woven protector geotextiles in landfill engineering; and
- CIRIA C736 – Containment systems for the prevention of pollution.

4.3.1 Manual of Contract Documents for Highway Works Volume 1 Specification for Highway Works

Volume 1 Specification for Highway Works, developed by the Department for Transport, contains the requirements for the work and materials to be used in constructing and maintaining the UK's trunk road network.

4.3.1.1 600 Series

The 600 Series describes the acceptable materials to be used in earthworks which include recycled and secondary materials and specifies the tests that need to be carried out on them.

The 600 Series details that recycled materials are to contain no more than 1% of contaminants, such as wood, plastic and metal.

Recycled aggregates must be produced in accordance with the WRAP Quality Protocol for the production of aggregates from inert waste.

For clarity, the WRAP Quality Protocol sets out end of waste criteria for the production and use of aggregates from inert waste. If the criteria are met, the aggregates will normally be regarded as having been fully recovered and to have ceased to be waste.

The 600 Series also sets out the requirements for other techniques that can be used to increase resource efficiency in earthworks, such as stabilisation with lime and/or cement, use of geosynthetics, soil reinforcement, ground improvement and foundation drainage.

The 600 Series also provides definitions of the types of recycled material that are allowed to be used. It also provides specifications for each class of fill material and example types of material including recycled and secondary materials.

4.3.2 LFE2 - Cylinder Testing Geomembranes and their Protective Materials

LFE2 is a guidance document developed by the EA and describes a method for determining the effectiveness of a material in protecting a geomembrane against the long-term mechanical effects of static point loads. The cylinder test method tests performance under the actual conditions likely to be encountered.

4.3.3 LFE5 – Using Geomembranes in Landfill Engineering

LFE5 is a document developed by the EA and the British Geomembrane Association and covers the use of geomembranes in landfill engineering.

Although the document covers the use of geomembranes in landfill engineering, it can be utilised to cover the use of geomembranes in other industries including onshore oil and gas exploration.

4.3.4 LFE7 – Using Non-woven Geotextiles in Landfill Engineering

LFE7 is a guidance document developed by the EA and covers the use of non- woven geotextiles in landfill engineering.

4.3.5 CIRIA C736 – Containment Systems for the Prevention of Pollution

CIRIA C736 is a document developed by CIRIA and covers containment systems for the prevention of pollution.

5. SITE LOCATION AND SITE DETAILS

The Horse Hill Well Site is located in Surrey, approximately 3.5km north-west of Horley and approximately 3km north of Gatwick Airport.

The site is situated on the south side of Horse Hill, which is a north-east to south-west ridge of agricultural land.

The site address is:

Land off Horse Hill
Hookwood,
Horley,
Surrey
RH6 0RB

Nation Grid Reference: TQ 25297 43588

5.1 Site and Surroundings

The Site is a worked farm that has been developed to accommodate an operational well site covering 2.08 hectares. A secure boundary fence encloses temporary earth bunding, a flat well pad and an access track of crushed and compacted stone designed consistent with the relevant British Standard[1] and UK guidance "Containment Systems for the Prevention of Pollution" [2]. The dominant tertiary containment mechanism is the high density poly-ethylene (HDPE) impermeable membrane that underlays the well pad directing all surface run off to a continuous 'v' profile perimeter attenuation ditch.

The Site is within a rural area of the County of Surrey and the Borough of Reigate and Banstead approximately 3.1km west of Horley town centre, 2.3km northeast of the village of Charlwood and 1.6km northwest of the village of Hookwood. The centre of Gatwick Airport's main runway is 3.5km southeast of the Site. The nearest residential properties to the well pad are High Trees Court approximately 320m to the north, Wray's Farm House approximately 370m to the east and Five Acres approximately 410m southeast. The access road is in closer proximity to residential properties with the highway entrance being located near to Wray's Farm House.

The Site is bounded by farmland with woodland to the east, northwest and southwest in a landscape of agricultural, forestry and equestrian land uses. The Site is within the Metropolitan Green Belt but is not within or adjacent to an area of local, national or higher-level heritage designation. The Site is not open to the public and there are no Public Rights of Way (PRoW) on the Site although there is a PRoW which runs along the southern boundary of the Site[3] and a Surrey Cycleway along Horse Hill.

The Site is situated within the Low Weald which is known as a "broad, low-lying clay vale" and the topography is generally flat. The land gently rises to a ridgeline approximately 1km north and west from the Site which then continues southwest for a distance of 5km. There are no natural water features within the Site, dispersed ponds exist within the surrounding woodland and the nearest watercourse is Spencer's Gill, a tributary of the River Mole approximately 590m to the south.

[1] BS EN 1997-2:2007 Eurocode 7. Geotechnical Design. Ground Investigations and Testing.

[2] CIRIA C736: Containment Systems for the Prevention of Pollution – Secondary, Tertiary and other measures for industrial and commercial premises, I L W Walton (SLR Consulting) CIRIA 2014.

[3] Surrey County Council Interactive Map: Roads and Transport – Footpath FP414

6. CONSTRUCTION QUALITY ASSURANCE PLAN

6.1 Distribution of the Construction Quality Assurance Plan

HHDL will communicate the CQA Plan to the Principal Contractor and to the Horse Hill Well Site Supervisor. The CQA Plan may be issued as an electronic version or paper copy. A copy of receipt or transmittal will be recorded by HHDL.

A copy of the CQA Plan is to be held within the Horse Hill Well Site Supervisor's office and be available for review by regulatory bodies.

The CQA Plan will be communicated to site personnel and a copy of the CQAP will be made available on site to all personnel during operations.

6.2 Alterations to the Construction Quality Assurance Plan

Any required changes or deviations from this CQA Plan are to be referred to HHDL or to the Horse Hill Well Site Supervisor in the first instance. No changes to, or deviations from, this CQA Plan are to be implemented until the required changes or deviations have been reviewed by HHDL and the relevant approvals obtained in writing from the Planning Authority.

Alterations to the CQA Plan will be captured in an amended CQA Plan and communicated to site personnel by the Horse Hill Well Site Supervisor.

However, alterations may be implemented as an immediate control measure to resolve an identified problem. These alterations shall be notified to the Planning Authority as soon as reasonably practicable by HHDL.

6.3 Reviewing and Revising the Construction Quality Assurance Plan

HHDL will periodically review the CQA Plan or when significant changes to operations or site equipment have occurred and amend where necessary in accordance with the HHDL Document Control Procedure.

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SECTION II ORIGINAL WELL SITE - CURRENT CONSTRUCTION

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7. CURRENT WELLSITE STATUS

The Horse Hill Well Site was designed, following standard industry practices, as a stable, level working platform to support a drilling rig and all associated equipment. The surface has been formed with a minimum of 300mm of granular material, compacted in accordance with the Specification for Highway Works on top of an appropriate geogrid for added strength.

The site is fully lined underneath the stone with a 1mm thick impermeable membrane made from Junifol High Density Polyethylene (HDPE) material, which is continuous through to a perimeter ditch. This impermeable membrane protects the surface water and groundwater from any site leakages, or potential spills. The membrane is further protected above and below using a 300g/m^2 non-woven geotextile. The use of crushed stone on top of an impermeable geomembrane layer is a standard and accepted method of site construction for onshore exploration well sites. The site was built by a competent contractor to industry standards, which included regular QA/QC checks on the site construction, as well as on the impermeable membrane, as outlined below.

7.1 Impermeable Membrane

All membranes delivered to site were accompanied by manufacturer's test data. The rolls of membrane were attached to a roll out frame, which in turn was attached to an excavator, the excavator tracked along unrolling the membrane, the membrane unrolled to the correct length, and once the correct length reached, the membrane was cut from the roll. The excavator then tracked adjacent to the panel of membrane laid and unrolled a further panel so that it overlapped the previous panel. This operation continued until the area was covered.

The membrane was placed with seam overlaps and prior to forming the joints, these overlaps were checked to ensure the weld area was clean, dry and free from imperfections. Welding (either hot wedge or extrusion welding) was carried out by certified welding technicians. When extrusion-welding methods were to be employed, the surface oxidation was removed from the membrane by sanding. Prior to commencing welding, a test weld was completed using off cuts of membrane and tested to destruction using field clamps in both the peel and shear modes. Failure must occur in the parent material and not enter the seam. The installation supervisor recorded all materials placed, roll numbers, panel numbers, seams welded and tested, and weather conditions.

All welds were tested as follows: site fusion welds were tested using air; twin fusion welds (hot wedge) were tested by sealing the ends of the air channel then inducing air pressure into the channel; extrusion welds were tested using spark testing methods. Welds which failed to conform to these non-destructive tests were repaired.

The installation of membranes is sensitive to ambient temperature, moisture and high winds and no material installation or seam welding took place while adverse weather conditions existed.

A concrete slab on site is formed around two well cellars. Each cellar is sealed and the slab is set on top of the impermeable membrane layer, which is also sealed to the cellar so it is part of the overall larger impermeable site area. Surface run-off water directed into the cellar from the concrete slab can be disposed of off-site via a suction tanker to an authorised waste disposal facility.

The sealing of each cellar was tested by carrying out a 24-hour hydrotest: the cellar is filled with water and checks are made that this volume is retained over the 24-hour period.

The location of the impermeable membrane, covering all the internal well site area, is shown by the blue line in detailed within Site Plans located within Appendix 1.

7.2 Perimeter Drainage Ditch

This includes the perimeter ditch encircling the site and where the lining extends up, and on to, the bund beyond the ditch. At the entrance to the site the lining is raised to the overall compound level (with the surface ramped up to this point on both sides to provide containment whilst allowing traffic to practically enter or leave the site). A cross sectional view across the well site showing the impermeable membrane and perimeter ditch is shown in Site Plans located within Appendix 1.

The perimeter ditch serves the purpose of collecting all surface drainage from the lined well site footprint. An earth bund has been constructed on the outside of the ditch. The ditch design plan and cross-section are presented in Site

Plans located within Appendix 1. It has a cross-sectional area of around 1.7m^2 and a length of approximately 290m, which gives a containment volume of around 500m^3 (500,000 litres) of fluid.

Rainfall onto the compound and bunded area, as well as any potential contaminants such as diesel fuel, oil and chemicals used in operating the site, are directed into the perimeter ditch and then under gravity, via an outfall pipe and Class 1 SPEL oil bypass separator, into a 150mm pipe buried in a gravel swale beyond the lined bunded compound area, as shown in Site Plans located within Appendix 1.

Isolation valves are installed both upstream and downstream of the separator (to allow full isolation of the site as well as isolation of the separator for maintenance works should they be required). The system is designed and operated to separate oil and water and fully conforms to both the Environment Agency PPG3 guidelines and European Standard BSEN-858-1-2 (less than 5mg of hydrocarbons/litre of water). The use of the separator has previously been approved by the EA and is in use during periods of inactivity.

When any workover or drilling rig is on site, the separator isolation valves remain closed. After operations have been completed, the excess water is released to the environment, pending the testing of the ditch fluid and the results being sent to the EA as per the Water Discharge Permit, EPR/BB3691NN. Any oil contamination from the test equipment or site traffic will be retained in the separator and removed by road tanker off site at the end of the well work.

The separator is designed to address the risk of infrequent light contamination and small-scale spills and is sized as appropriate for the size of the site. It is not designed to manage a major spill of hazardous materials (considered extremely unlikely). In such circumstances, emergency procedures will define that the discharge valve on the separator remains closed and all contaminated water removed by road tanker off site for disposal at an approved facility.

The construction design and methodology was previously approved by the Environment Agency following previous environmental permit applications for the site.

7.3 Well Cellar

Within the centre of the site are two well cellars housing within them the two wells. The drilling of the original Horse Hill 1 (HH-1) well was drilled in 2014 to a depth of 2,717m (8,915ft) MD / 2,421m (7,942ft) TVDSS into the Triassic formation. The HH-1 well discovered oil within both the Portland Sandstones and the Kimmeridge Limestones. The well was re-entered in 2016 and a series of short tests confirmed the oil potential of the Portland Sandstone and the Kimmeridge Limestones at KL#4 and KL#3 levels. In 2018 the well was re-entered again for an Extended Well Test which was successful in flowing significant amounts of oil from all three target levels.

HHDL currently have the necessary environmental permits in place to undertake the drilling of the HH-1z sidetrack. However, this has yet to be drilled.

The HH-2 well was subsequently drilled 4th quarter of 2019 and was drilled to a depth of 708m (2,322ft) MD / 627m (2,056ft) TVDSS and terminated in the Portland Mudstone. From the HH-2 well a sidetrack well known as HH-2z was drilled, kicking off from a depth of 397m (1,301ft) MD / 324m (1,062ft) TVDSS and entered the Portland Mudstone 720m (2,362ft) MD / 620m (2,035ft) TVDSS and reached a total depth of 1,245m (4,086ft) MD / 589m (1,934ft) TVDSS. The HH-2 well (HH-2 and HH-2z) is currently suspended pending well testing.

SECTION III ORIGINAL WELL SITE - ADDITIONAL CONSTRUCTION

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8. ADDITIONAL DRILLING

The existing well site has been constructed to a standard capable of accommodating exploratory operations and any subsequent production activity. The well site comprises a stable and flat surface of crushed and compacted stone overlaying a high-density polyethylene (HDPE) impermeable membrane and protective geotextile layers allowing for tertiary containment and controlled drainage. Construction within the existing well site will comprise of four (4) new concrete chambers to act as drilling cellars housing the four (4) new production/reinjection well.

A surface conductor, which is a large diameter pipe, will be installed to provide a stable structural foundation for the subsequent drilling of each well. A conductor setting rig will be mobilised to Site with a mast of up to 15m in height to drill and set the conductor casing to a pre-determined depth for each new well, isolating the shallow water systems underlying the Site from deeper strata, a further form of tertiary containment.

8.1 Additional Drilling Cellars

The installation of each additional drilling cellar will commence with the excavation of the site surface stone aggregate, geotextile membrane and the HDPE impermeable liner. The geotextile and HDPE liner will be cut at a specific length so as to provide enough material to ensure it can be appropriately joined to the well cellar. The well cellar forms part of the containment from which the borehole can be drilled, whilst also housing the wellhead.

The subsoil will be excavated to a depth sufficient to construct the well cellar, anticipated to be circa 3m and be very similar to those constructed for the pre-existing HH-1 and HH-2 well. A copy of the as built design has been provided within Appendix 1.

A short section of steel casing (large enough to allow the first drilling bit to drill through) will be installed approximately 1m below the bottom of the cellar before a concrete chamber is sunk into the ground acting as a well cellar. A 400mm thick reinforced concrete base will be set in the bottom of the excavation. A Precast Cast Concrete (PCC) ring will then be set into the concrete base, providing a slight overlap of the concrete above the base of the PCC ring. Additional PCC rings are added to line the well cellar wall back to surface. Each PCC ring is sealed together using Tockstrip concrete joint sealant and all PCC lifting points will be suitably plugged and sealed. Once installed, the PCC rings are then encased in a 200mm thick concrete jacket surround, set to a depth immediately below the surface construction detail of the site. Subsurface soils will be reinstated once the concrete jacket has been installed. The HDPE liner and geotextile membrane will be folded upward along the external wall of the well cellar and banded to the cellar to ensure well site integrity.

At surface, a 200mm thick reinforced concrete slab will be set around the well cellar to provide additional load bearing capacity for the proposed drilling rig. When cast, the concrete slab will also provide additional protection to the HDPE sealing the wall of the well cellar.

8.1 Installation of Surface Conductor

Upon completion of the cellar construction, a vertical hole will be drilled and a conductor casing will be run and cemented in the top section of the wellbore. The top section will be drilled with a conventional waterwell drilling rig. This initial section will be drilled with air and/or water/bentonite.

Once the hole has been drilled a conductor casing will be run and cemented to surface. The primary purpose of this conductor is to create a stable foundation for the main drilling rig. The waterwell rig will be demobilised once this hole section has been completed.

In the event that a mousehole is required, it may be installed by the construction contractor or alternatively may be installed by the drilling contractor, prior to commencement of the main drilling operation. Depending on the drilling rig selected, it may be drilled vertically or at a slight inclination.

The mousehole will be drilled using fresh water either whilst drilling the conductor hole or prior to drilling the main hole. Once drilled to the required depth, circa 6m below ground level, a steel casing will be installed and cemented back to the base of the cellar, flush with the concrete pad. This method of construction will ensure that the mousehole has environmental integrity, preventing any ingress of drilling fluid or well fluid through the cellar construction.

8.2 Rat Hole and Mouse Hole

A rat hole and/or mouse hole may need to be drilled to accommodate the drilling rig and associated equipment during any drilling phase. The exact location of the mouse hole and/or rat hole cannot be confirmed until the drilling contractor, and associated drilling rig, has been selected. Once each hole has been drilled a casing will be run to the base of the hole and the annulus cemented back to surface. For clarity, the casing installed will be a closed ended steel casing ensuring that residual fluids i.e. drilling fluids cannot migrate down the casing into the subsurface due to being "capped".

In the event the hole(s) are drilled through the bottom of the well cellar it may be necessary to remove the reinforced concrete. The hole will be drilled to the necessary depth through base of the well cellar and cemented back to surface (i.e. the base of the cellar). The 'capped' casing will be run to the base of the hole and will protrude out of the base of the well cellar to the drill floor. The casing will be grouted to the cellar floor.

Should the hole(s) be drilled outside of the well cellar, a small excavation (up to 1m x 1m) will be constructed on the concrete pad. The cement cuttings and hardcore will be excavated and the liner, once encountered, will be cut and folded back. A 'top hat' shall be formed with the liner being resealed around a steel/concrete box within the cut out and cemented back to the concrete pad (surface). The hole(s) will then be drilled using the appointed drilling rig and a casing (capped at the base) installed and cemented back to surface.

Following the installation of the hole(s) within the cellar an integrity test will be carried out using water to measure whether any losses are incurred over a period of 24 hours. Should losses be encountered the mouse and rat hole installation will be remediated to ensure any pathways to the underlying subsoils are prevented.

8.3 Cellar Integrity Test

Once the well cellar has been constructed, or following any subsequent construction works such as mouse or rat hole installation, an integrity test will be carried out to confirm that it provides suitable and effective containment.

The test consists of filling the cellar with water and monitoring water loss over a period of 24 hours. The water level is marked on the side wall of the cellar using marker dye to provide a reference point. The cellar is then covered to avoid both water fill (precipitation) and water loss through evaporation. If no water loss within the drilling cellar is observed the test is determined as being successful. Should, however, the test identify that the cellar does not have integrity, the leak point shall be identified, repaired and the integrity test repeated. Immediately following installation of the surface conductor casing, the cellar integrity test will be repeated. A bucket may also be filled to calculate the evaporation rate of water if required.

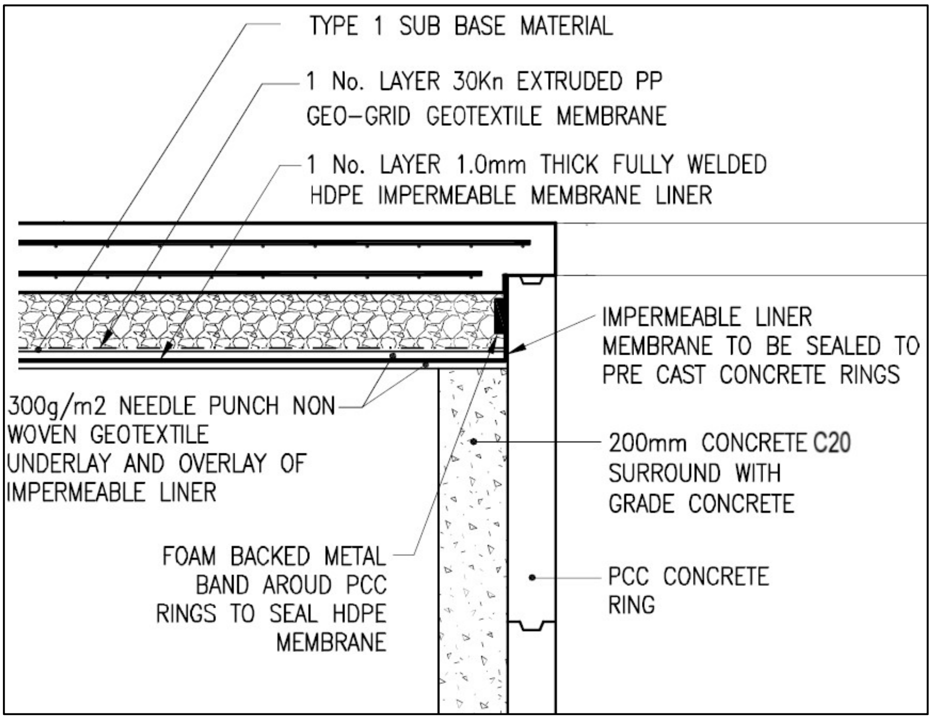

Figure 8.1: Typical HDPE Geomembrane being installed around the Well Cellar PCC Rings

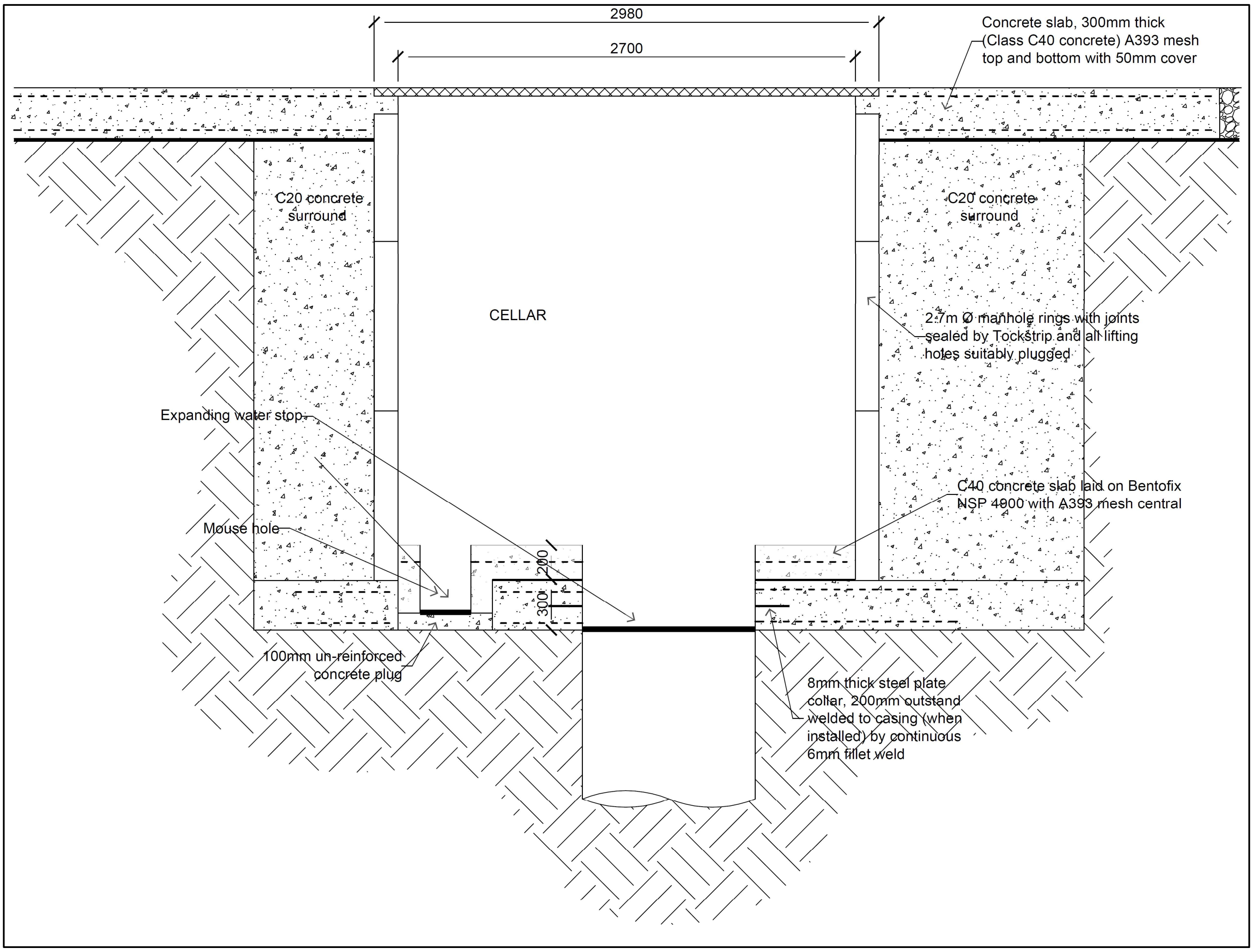

Figure 8.2: As Built Schematic of HH-1 & 2 Well Cellar

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SECTION IV GROUNDWATER MONITORING BOREHOLE INSTALLATION

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9. SCHEME OF MONITORING

In accordance with the Environmental Permitting (England and Wales) Regulations 2016, a scheme of groundwater monitoring is to be submitted, for approval, by the Environment Agency.

The purpose of the scheme is to acquire a baseline groundwater quality in advance of the commencement of hydrocarbon production and associated short duration well operations and to subsequently monitor the effectiveness of existing and future environmental mitigation, having been embedded into the design and construction of both the well site and the wells and now subject to additional mitigation at surface to accommodate the production of hydrocarbons.

The scheme of monitoring provides for the construction of four (4) monitoring boreholes which will provide samples targeting groundwater in the weathered clay. A copy of the monitoring borehole designs is included within Appendix 1.

After construction, the monitoring boreholes will be developed to remove sediments generated during the construction phase.

Once the monitoring boreholes have been constructed and developed, a programme of groundwater sampling will be undertaken from each monitoring borehole, which in turn will inform a baseline of groundwater quality at the well site.

All data and records of the design and construction of the monitoring boreholes will be retained by HHDL and made available for review by the Environment Agency and other Regulatory bodies, as required.

10. MONITORING BOREHOLE DESIGN

A Hydrogeological Risk Assessment (HRA) has been undertaken to fulfil the requirements of the planning and permitting process. The HRA demonstrates that the potential risks to the water environment have been adequately considered and that mitigation measures are put in place to reduce the risks to an acceptable level, where necessary.

The HRA has assessed that the main risks from the development is to surface water and shallow groundwater features underlying the well site.

Based on the findings of the HRA, local groundwater and surface water features are dependent on shallow groundwater within superficial deposits and the weathered top of the underlying bedrock (Weald Clay Formation). There are no other features supported from groundwater originating from deeper formations.

Provisional locations for the groundwater monitoring boreholes have been provided within the Groundwater Monitoring Plan.

11. SELECTION OF COMPETENT PERSONNEL

HHDL will ensure that competent personnel with sufficient skill, knowledge and experience commensurate with the operations to be undertaken are selected prior to commencement of operations.

11.1 Competent Construction Contractor

HHDL will appoint a competent contractor to construct and install the monitoring boreholes ensuring that the appointed contractor has adequate and sufficient industry skill, knowledge, resources and competency in the construction of groundwater monitoring boreholes.

The appointed contractor will be responsible for:

- Ensuring competent personnel are used within the construction process;
- Compliance with the agreed borehole designs;
- Compliance with BS 5667-22: 2010 Water Quality – Sampling. Guidance on the Design and Installation of Groundwater Monitoring Points;
- Compliance with the agreed Construction Programme;
- Compliance with Method Statements, Risk Assessments and Safe Working Practices;
- Compliance with Health, Safety and Environmental legislation and guidance; and
- Use of quality resources and materials used in the construction process.

11.2 Site Supervisor

HHDL will appoint a competent Site Supervisor with adequate and sufficient skills, knowledge, and competency in the construction industry, including experience in supervising the construction and installation of monitoring boreholes.

The Site Supervisor will supervise the construction of the boreholes and monitor for compliance against the following:

- Approved borehole designs;
- BS 5667-22: 2010 Water Quality – Sampling. Guidance on the Design and Installation of Groundwater Monitoring Points;
- Agreed Construction Programme; and
- Construction Contractor's Method Statements.

In the event that deviations from the approved design and/or construction programme are required, the Site Supervisor will communicate the proposed deviations to HHDL for approval prior to their implementation.

The Site Supervisor will be responsible for the following:

- Supervision of contractors;
- Monitoring construction works to ensure compliance with approved designs and standards;
- Submit a Daily Report to HHDL;
- Supervision and monitoring the development of the boreholes;
- Undertake quality assurance checks ensuring that the required level of service is provided;
- Undertake quality control checks ensuring that the resources and materials used within the construction process are up to the standard required;
- Health, safety and environmental compliance is maintained;
- Recording of non-conformances and corrective actions;
- Waste streams are identified and where possible, waste is eliminated or minimised;
- Site remedial works are completed on completion of construction works;
- Drilling data and logs are recorded and communicated to HHDL;
- Notify/liaise with utility companies that works have been completed;
- Record volumes / dates / times of water discharge during testing and commissioning;

- Compilation and distribution of a Final Construction Completion Report; and
- Sign off from HHDL or their representative upon completion of works.

11.3 Hydrogeologist

HHDL will appoint a competent Hydrogeologist with adequate and sufficient skill, knowledge, and competency in the construction of groundwater monitoring boreholes including experience in identifying target formations within the borehole construction.

The Hydrogeologist will be responsible for the following:

- Site reconnaissance to establish site conditions and borehole locations;
- Conduct underground utility survey;
- Review information on Upper Jurassic geology and develop a logging scheme;
- Undertake a survey of drilling locations to determine groundwater flow direction;
- Determine whether an additional borehole is required;
- Identification of target formations during the construction process;
- Re-survey position and elevation of boreholes following construction to AOD;
- Logging of all arisings;
- Compilation and distribution of a Factual Report describing the construction of the boreholes and geology encountered; and
- Complete a WR38 Form (Borehole Record) for each borehole installed and submit to BGS.

12. MONITORING BOREHOLE CONSTRUCTION

The construction programme will comprise of the following phases:

- Pre-Construction Activities
  - Site visit;
  - Identification of borehole locations; and
  - Contractor kick off meeting.
- Monitoring Borehole Construction
  - Construct 4 No. monitoring boreholes;
  - Complete headworks;
  - Complete remedial/civil works;
  - Rig down and demobilise equipment and materials;
  - Waste removal; and
  - Borehole development.
- Post Construction Activities
  - Conduct survey of installed boreholes;
  - Handover completed works to HHDL;
  - Notify Local Authority and Interested Parties of completed works; and
  - Contractor to issue WR38 Forms.

12.1 Description of the Works

The drilling of the monitoring boreholes will be undertaken using Rig 22 Beretta T151 Tracked Drilling Rig or similar, no contracts have yet been agreed. All works will be agreed by the Site Supervisor and the Contractor's Supervisor prior to commencement.

Monitoring boreholes will be constructed and installed to the design specification included within Appendix 1 and in accordance with BS 5667-22: 2010 Water Quality – Sampling. Guidance on the Design and Installation of Groundwater Monitoring Points.

The mobilisation and set up procedures will be supplied by the contractor and discussed in the prestart meeting and site induction process.

For clarity, commencement of construction operations will not be undertaken until a design of the proposed shallow boreholes has been approved by the Environment Agency.

The Site Supervisor will ensure that the approved design is available to the approved contractor prior to commencement of the construction operations.

12.2 Surveying

Prior to mobilisation, the appointed Contractor's Engineer will undertake a reconnaissance visit to assess site conditions and mark out the location of the monitoring boreholes using line marking paint at the specified location. The Engineer is to ensure that the position of the boreholes is practically achievable and check that the borehole locations are correct.

Post construction, the monitoring borehole locations and levels will be surveyed to ensure that an accurate position and elevation to AOD is recorded.

12.3 Drilling Operations

An underground utility survey will be undertaken prior to commencement of drilling operations. The contractor will carry out a two (2) stage assessment prior to setting up the drilling rig and will include:

- A CAT scan of the proposed borehole location will be undertaken by the Contractor Supervisor; and
- A 1m trial pit will be excavated and a second check conducted using a CAT Scanner in the pit.

The contractor will position the drilling rig at the borehole location ensuring that the rig is set up to drill vertically. The contractor will undertake verticality checks of the borehole during the drilling operations.

Records of the exact length of drilling equipment in the borehole are to be recorded by the contractor, kept up to date and made available to the HHDL Site Supervisor.

12.4 Monitoring Borehole Construction

Monitoring boreholes will be constructed and installed to the design specification included within Appendix 1 and in accordance with BS 5667-22: 2010 Water Quality – Sampling. Guidance on the Design and Installation of Groundwater Monitoring Points. A summary of the construction is detailed below.

The construction will consist of 50mm diameter slotted plastic well screen with 1mm slots installed from approximately 0.5m from the base of the borehole to approximately 1m below ground level. A solid 50mm diameter plain plastic casing will continue to approximately 600mm above ground level.

The annulus between the wellbore and the well screen will be filled as follows:

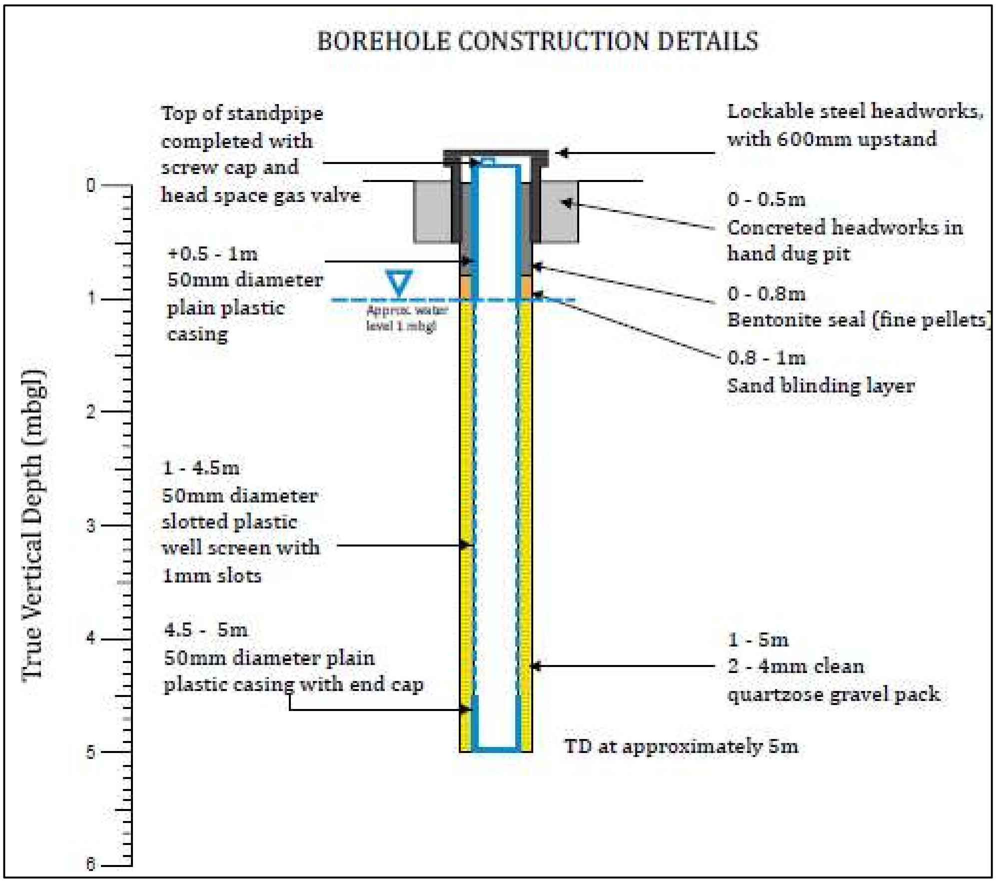

Figure 12.1: Borehole Construction Detail

A lockable steel headworks with a 600mm upstand will be concreted in place. The monitoring borehole will be completed with a screw cap to enable water level monitoring and sampling to be undertaken on its removal.

12.5 Daily Meeting

A daily meeting will be held between the Site Supervisor and the Contractor's Supervisor. The purpose of the meeting will be to:

- Review the planned work activity and location;
- Ensure that HSE requirements are implemented prior to works commencing;
- Identify any simultaneous operations being undertaken onsite; and
- Discuss and highlight any problems and their solutions.

12.6 Construction Completion Report

Following completion of the construction works, the Site Supervisor will provide a Construction Completion Report on the construction works undertaken including reporting on the quality control measures undertaken during the works.

The Construction Completion Report will include details of the construction quality assurance together with an assessment of the works. As a minimum the Construction Completion Report will include:

- Description of the works compared to the planned construction;
- Daily records including conformance certificates and/or delivery notes of materials used;
- Photographic records;
- As-built Drawings of each Borehole; and
- Copies of the WR38 Forms (Borehole Records).

12.7 Remedial Works

After completion of the construction and installation of the boreholes, the liner will be repaired using an additional $1m^2$ section of 'geotextile and HDPE emplaced over the original liner and sealed. On completion of the installation of the $1m^2$ section the well site surface is restored to its original condition.

The Site Supervisor will supervise and monitor operations to ensure that damage to the liner is minimised and the quality of the liner is maintained.

During site remedial works, the Site Supervisor will supervise and monitor operations to ensure that damage to the liner is minimised, the quality of the liner is maintained and the well site surface is restored to its original condition.

12.8 Monitoring Borehole Development

Following installation, monitoring boreholes will be developed to remove any sediments generated during the drilling process. The development process will be accomplished by pumping of groundwater from the monitoring borehole using an airlift procedure (if there is no artesian flow).

SECTION V CONTAINMENT MEASURES

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13. COMPLIANCE WITH CIRIA C736 (2014)

HHDL is proposing to conduct production operations from its Horse Hill Well Site. The current configuration at the site facilitates 2 exploration boreholes and has been constructed for the purpose of ensuring containment during drilling, testing and production phases of the development.

Prior to the commencement of the well site production operations HHDL will undertake an in depth assessment of the site to ensure that it is built / modified in compliance with the requirements of the *CIRIA C736 - Containment Systems for the Prevention of Pollution*.

This section outlines the steps that shall be taken to ensure that the site will be constructed and developed in line with the criteria of CIRIA C736, which provides guidance and advice for existing installations, such as the current Horse Hill Well Site.

14. RISK ASSESSMENT AND CLASSIFICATION

Prior to the development of a Secondary and Tertiary Containment Plan HHDL shall conduct a risk assessment for the proposed longer term development to profile the site and identify the hazards that will be present.

The results of this risk assessment shall then be used to inform the Secondary and Tertiary Containment Plan of the overall Site Hazard, Site Risk Rating and the classification of containment systems to be implemented within the site.

The Risk Assessment Methodology is presented within this Section.

14.1 Source - Pathway - Receptor Model

The structure of the CIRIA Site Risk Assessment is consistent with Section 2 of the CIRIA C736 (2014) guidance using a Source – Pathway – Receptor model and includes:

- Identifying sources of potential pollutants and determining the **Source Hazard Rating**;
- Identifying pathways of potential pollutants and determining the **Pathway Hazard Rating**;
- Identifying sensitive receptors of potential pollutants and determining the **Receptor Hazard Rating**;
- Determining the overall **Site Hazard Rating**;
- Assessing site risks and determining the **Site Risk Rating**; and
- Determining the Design Classification of the Containment Systems.

14.2 Framework for Classification of Secondary and Tertiary Containment

The general framework for the risk assessment is a three-step approach and is detailed below.

1. Step 1 – Apply the source – pathway – receptor model to assess the hazard presented by the inventory to the surrounding environment. The assessment of the source – pathway – receptor is combined to provide a **Site Hazard Rating**.
2. Step 2 – Consider the likelihood of a loss of containment.
   a. This will depend on a number of factors such as:
      i. Reliability of operations;
      ii. Inspections undertaken;
      iii. Condition of the primary storage vessels;
      iv. Protection of primary vessels from impact damage etc.; and
      v. Security.
   b. The likelihood of a loss of containment is combined with the **Site Hazard Rating** to provide a **Site Risk Rating**.
3. Step 3 – The **Site Risk Rating** leads to a recommendation for an appropriate class of containment as defined within the CIRIA 736 guidance.

The general framework for the risk assessment is detailed in Figure 14.1.

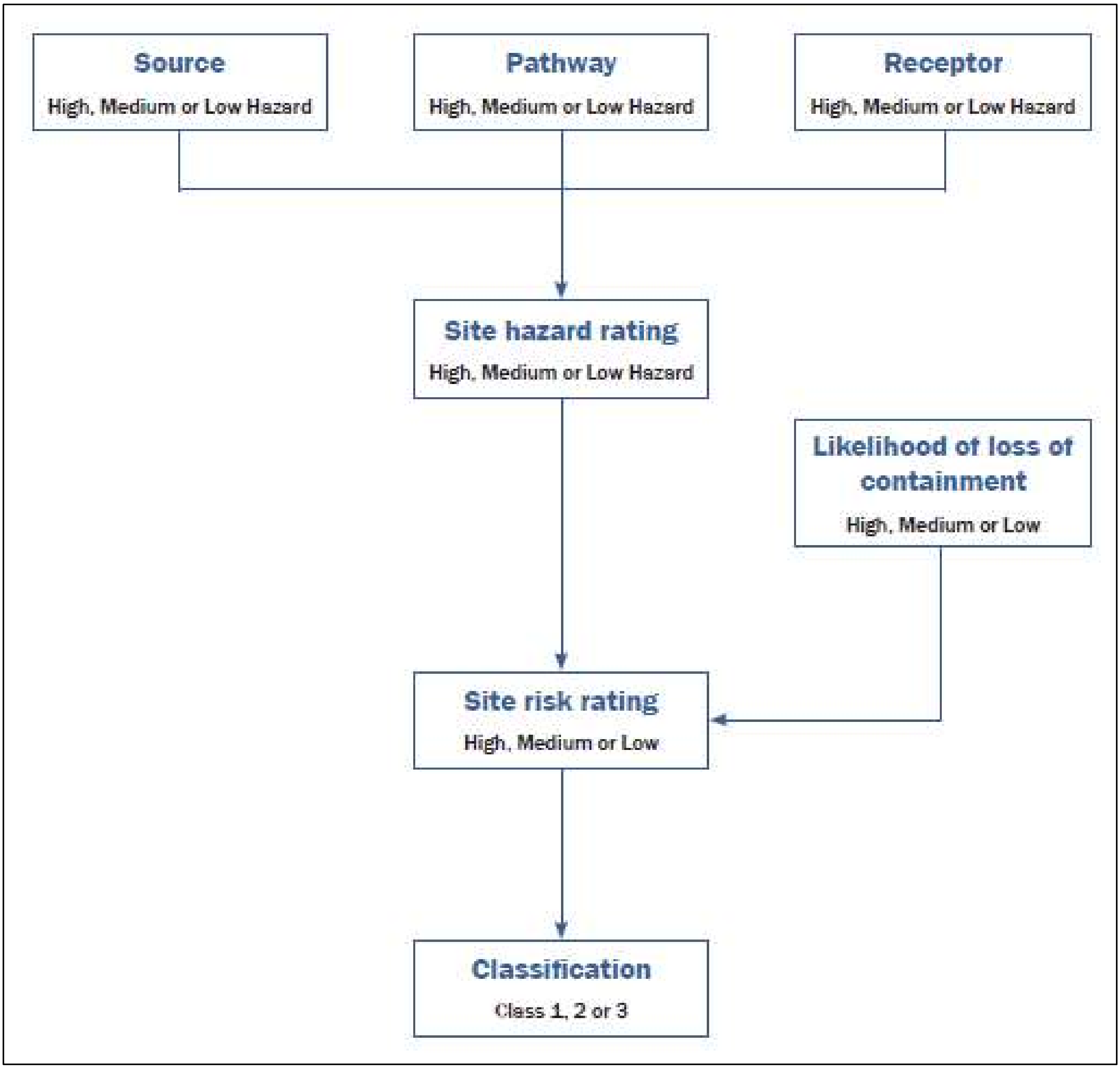


Figure 14.1: CIRIA Risk Assessment Framework

15. DETERMINING THE SITE HAZARD RATING

Determine the Site Hazard Rating using the SPR methodology.

The concept of the SPR model is detailed in Figure 15.1.

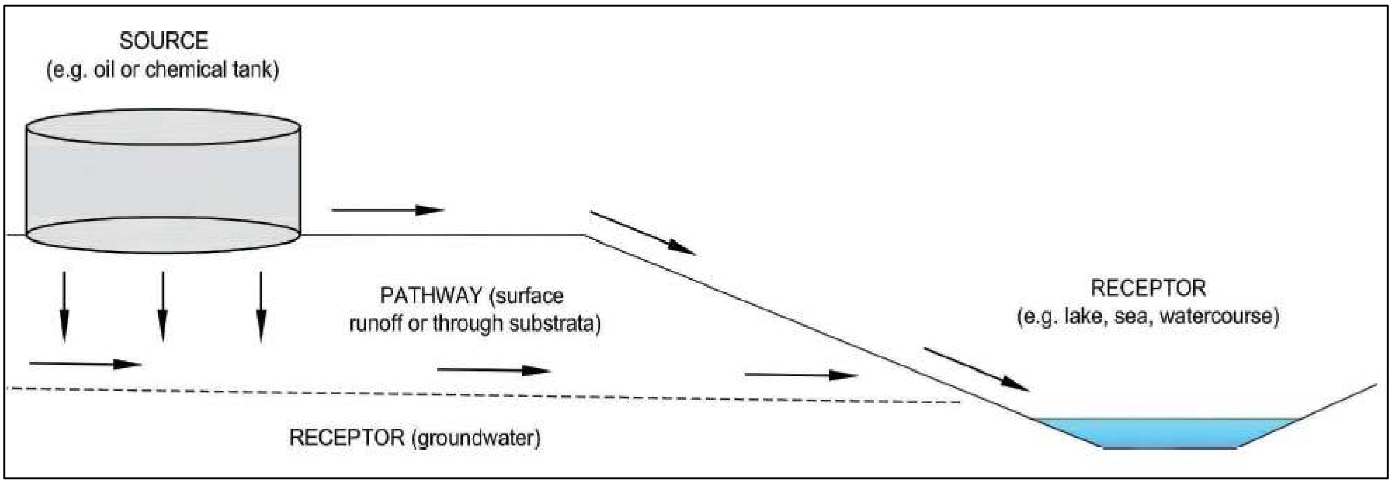


Figure 15.1: Source-Pathway-Receptor Model

15.1 Source

In the context of assessing hazard, the **source** refers to:

- The inventory;
- Rainwater or surface run-off water contaminated by the inventory;
- Effects of firefighting agents that are harmful to the environment in their own right and/or are contaminated by the inventory; and
- Firefighting and cooling water contaminated by the inventory.

15.1.1 Nature and Quantity of Potential Pollutants

The potential pollutants present on industrial sites will comprise a range of raw materials, products and fuels and wastes. The quantity and nature of these materials should be assessed in relation to their polluting potential, the extent to which their presence may trigger or exacerbate an incident (i.e. high flammable substances) and any physical or chemical properties that may call for special measures (i.e. corrosive materials that may damage concrete). In addition to potential duration of the release should be considered.

In relation to pollution potential, a wide range of characteristics of the inventory and any material used to suppress the fire should be taken in to account including:

- Physical properties (e.g. density and viscosity);
- Chemical and biochemical properties (e.g. BOD and pH);
- Ecotoxicological properties;
- Bioaccumulation, biomagnification or persistence potential;
- By-products of fire / unwanted reactions; and
- Contaminated fire water.

The first stage is to assess whether the individual chemicals present onsite, or any combination of them, will pose a hazard to potential environmental receptors if released.

15.1.2 Toxicity and Hazard

The potential harm caused by a particular substance is a function of the sensitivity of the receptor to that substance. The severity of the impact is in turn a function of the potential extent over which spillage may occur and duration of the harm i.e. how persistent the substance is in the particular environment and therefore the following should be taken in to account:

- Globally Harmonised System of Classification and Labelling of Chemicals (GHS) i.e. CLP Hazard Statements; and
- LD50 and LC50 toxicity ratings.

15.1.3 Effects of Fires and Firefighting Water

One of the most significant hazards onsite is from fire. The potential effects from fire can alter the assessment of source hazard in a number of ways, including physical or chemical modification of the materials onsite and damage to other primary containers, which could result in further materials being released.

Firefighting water will become contaminated on contact with the inventory and so it is just as important to control its release to the environment as with the inventory itself.

Sites where flammable inventory is present should be considered as a high Source Hazard Rating.

The **Sources Hazard Rating** for the well site is expected to be considered high given the potential volume of hazardous substance stored at the site. However, a risk assessment will be undertaken prior to the commencement of any production and construction activities and will inform a Containment Plan.

15.2 Pathway

Pathways are the means by which a hazardous substance would reach a receptor. The area of search for potential receptors is governed by the potential pathways and these might include:

- Simple overland flow following the local topography.
- Existing pipes, sewers, drains or other underground features that could lead to a receptor such as a watercourse.
- Permeable sub-soils and strata underlying a site that could provide a pathway to groundwater or a water course.

Multiple combinations of pathways may exist and should be considered.

In considering the hazard rating of potential pathways the following should be considered:

1. The distance between the source and the various potential receptors;
2. Site layout (Inc. topography) and the position and effectiveness of drains / other internal and external pathways;
3. Geographical, geological and hydrogeological features that could either impede or facilitate escape of inventory from the site. In addition, building foundations may impede or alter sub-surface drainage paths;
4. Climatic conditions and expected variability;
5. The direct effects of fire and the introduction of firefighting water, or foam;
6. The presence of treatment plants (on or off site);
7. Modification of the inventory during passage through the pathway such as the cooling of a liquid;
8. Inventory that is not particularly mobile in ambient conditions may be mobile in water; and
9. The scale of potential incidents (larger incidents and firewater generally have greater potential for mobilisation in the environment than smaller spills.

The time it would take for an inventory to reach a receptor is an important factor. The potential for the substance to harm the environment is higher if it reaches the receptor quickly since:

- There will be less opportunity to contain the inventory (either onsite or offsite) and prevent escape to the wider environment;
- Mitigation of the effects of the substance by such factors as evaporation or dilution will be reduced; and
- There will be less time to warn other organisations and individuals likely to be affected, e.g. the regulator, downstream landowners and water users, and sewage treatment plant operators.

15.2.1 Proximity of Receptors

It is important first to identify all of the possible receptors and their locations in relation to the source(s).

Potential pathways for overland flow will be determined by the local topography and to an extent the permeability of near surface soils. Where permeable soils are present, the interaction with groundwater should be considered, which in itself is both a potential pathway and receptor.

15.2.2 Site Layout and Drainage

The layout of the plant, buildings, roadways, hardstanding's and other such features, and the surface finish and permeability of the surfaces over which the hazardous substance may flow in the event of an escape, are all relevant factors in deriving hazard rating.

The following issues will tend to increase the hazard ratings for pathways:

1. Hardstandings around the primary containment sloping towards a surface receptor;
2. Primary containment installations surrounded by flat or slightly sloping permeable ground permitting infiltration to groundwaters;
3. Onsite effluent drainage systems that provide pathways to outfalls, public sewers or onsite or off site treatment facilities;
4. The presence of below ground features such as:
    a. Services
    b. Ducts
    c. Pipelines
    d. Filled ground
    e. Tunnels
    f. Tanks
    g. Sumps
5. Other man made pathways such as:
    a. Old mine workings
    b. Storm drains
    c. Gullies
    d. Culverted watercourses;
    e. Land drains
    f. Rainwater soakaways

15.2.3 Topography, Geology and Hydrogeology

The topography of the site and permeability of the ground will have an effect on the transport of inventory to surface waters and infiltration to groundwaters.

15.2.4 Climatic Conditions

Climatic conditions, including precipitation and temperature, can affect ground conditions and permeability, vegetation and evapotranspiration, each of which affects the pathway.

Frozen or saturated ground will increase the tendency for rapid run-off from areas where, at other times, run-off may be very much slower or absent altogether.

Surface cracks and fissures in dry conditions will increase infiltration and may provide direct pathways to permeable substrata and groundwater.

Heavy rain is also to be considered as the higher run-off volume may increase the possibility of it reaching the receptor. A possible benefit may be that the rain will dilute the inventory before it reaches the receiving water. Areas susceptible to flooding should also be considered.

Combined sewer overflows should also be considered as there is the potential to provide a direct pathway to a receptor in the event that a wastewater treatment works is bypassed during periods of heavy rainfall.

15.2.5 Firefighting Water

Firefighting water has the potential to dilute significantly any hazardous substance released from the primary containment. It may also affect the pathway as the higher volume of run-off may increase the possibility of it reaching a receptor. It may also dilute the inventory before it reaches the receptor.

Another consideration is the effect that fire may have on the flow properties of the hazardous substance, particularly in the site drainage system. Fire and heat may cause an increase in the viscosity or surface crusting so that flow through the system is slowed down or even stopped completely. Conversely, fire may melt or destroy site features that under normal circumstances would divert flows elsewhere. Drains may also become blocked through debris flushed in to them by the firefighting water.

15.2.6 Treatment Plants

Pathways may lead to, and include, effluent treatment works both on and off site such as a wastewater treatment works. The unplanned entry in to the treatment plant at a level that exceeds the containment capacity of the works may cause major damage, which may effectively put the plant out of action. This damage may be long term. This in turn may lead to discharges from the damaged plant that may result in more serious pollution than would have resulted from a direct discharge of the primary pollutant.

15.2.7 Mitigating and Exacerbating Effects

When inventory escapes from the primary containment, it may be subject to a number of factors that alter its environmental impact potential, either by modifying its properties or its volume.

In assessing possible mitigating effects, the factors that should be taken in to account include:

- Likelihood of dilution in the drains;
- Possible dilution and treatment at an onsite or off site treatment plant which may also be severely affected by the pollutant to the extent that it can equally be regarded as a receptor;
- Chemical reactions (e.g. chemicals that may react with water);
- Application of neutralising agents that might dilute the escaped inventory;
- Evaporation (e.g. volatile solvents);
- Absorption (some materials may be absorbed by soil or other liquids);
- Settling (some materials may settle in drains, interceptors or lagoons); and
- Existing retention capacity on the site.

The dilution of an escaped inventory as part of spill management is not considered good practice.

Exacerbating factors might include:

- Larger volumes tend to spread further;
- Greater slopes result in faster run-off and less time to act to intercept;
- Inventory spread over large areas at shallow depth may be more difficult to recover; and
- Adverse chemical reactions between different inventories released during an incident.

15.2.8 Factors Affecting Transport Potential

Examples of pathways where the hazard rating is considered to be high might include:

- Short run-off time between source and receptor;
- Direct drainage links between source and receptor;
- Absence of holding capacity in drains and sewers;
- Highly permeable strata between source and groundwater receptor;
- Absence of treatment facilities;
- Little to mitigate the effects of the released hazardous substance; and
- Flooding.

The **Pathway Hazard Rating** for the well site is expected to be considered high. The risk assessment process will be conducted prior to production or construction works to confirm this is the case. A suitable Containment Plan will then be developed on this risk basis.

15.3 Receptors

A receptor includes:

- Humans
- Fish
- Fauna and flora
- Watercourse or water body
- Groundwater
- Soils
- A downstream process (e.g. a waste water treatment works

To assess the impact of a hazardous substance release on receptors, it is first necessary to identify any that could be affected. The **hazard rating** completed for pathways should be used to inform the area of search.

The presence and nature of the receptor can generally be thought of as a fixed point in any hazard or risk assessment. However, in areas at risk of flooding, there may be circumstances where the location of the receptor may change i.e. where the flood waters themselves would be considered a receptor. As with source and pathway, a receptor is assigned a **hazard rating** according to its sensitivity to the hazardous substance i.e. high, moderate or low.

15.3.1 Environmental Sensitivity

Sensitive receptors, i.e. those receptors that are sensitive to harm from the hazardous substances stored onsite, will be identified within the CIRIA Site Risk Assessment. Other Factors

There are other factors that may reduce or increase the severity of the environmental impact. Mitigating factors include:

- Biodegradation (e.g. compounds broken down by microbes);
- Evaporation;
- Photolysis (e.g. compounds broken down by sunlight);
- Hydrolysis (e.g. compounds broken down by water); and
- Absorption (e.g. compounds absorbed by another substance, for example the deployment of chemical spill kit).

Aggravating factors include:

- Bioaccumulation (e.g. in fish);
- Biomagnification (e.g. along a food chain); and
- Biodegradation (e.g. discharge of inventory with a high biological oxygen demand).

15.3.2 Uncertainties

There are considerable gaps when it comes to quantifying the effects of inventory on receptors. In particular, toxicity effects on man and ecotoxicity effects on ecosystems are only readily available for those substances commonly used in industrial and manufacturing processes.

The hazardous substance may not be a single chemical, but may be, for example, a complex mixture of hydrocarbons as in fuels and oils. In such cases it will be necessary to consider whether to assess all individual chemicals separately, or to treat the mixture as a single substance using available whole product data.

15.3.3 Nature and Classification of Receiving Waters

The Environment Agency uses aquifer designations that are consistent with the Water Framework Directive (WFD). These designations reflect the importance of aquifers not only in terms of groundwater bodies as a resource but also their role in supporting surface water flows and wetland ecosystems. Geological units are broadly divided in to:

- Principal Aquifers;
- Secondary Aquifers; and
- Non-productive Strata.

15.3.4 Wastewater Treatment Works

Onsite effluent treatment plants and off site Wastewater Treatment Works may be considered as receptors.

The effects of pollutants on Wastewater Treatment Works need to be considered. Tolerable levels and loads of inventory should be established in collaboration with the Wastewater Treatment Works particularly in respect of their trade effluent consents.

15.3.5 Dilution and Mixing

Receptors may be situated many miles away from the point at which the inventory is released in to the environment. Where a pathway includes surface or groundwaters, dilution and dispersion takes place that can mitigate the potential impact. Generally, Regulators would not condone dilution and dispersion as a means of mitigation, except as an authorised discharge.

If there is a risk of inventory entering the water environment, regulators would expect to see Best Available Techniques (BAT) applied to reduce the risk. Modelling may be used to demonstrate the effect of residual risk following installation of BAT, or for assessing the impact of a major accident of low frequency.

Depending on the complexity of the model to be used, the following information is likely to be required:

- Duration and mode of release;
- Flow of the receiving water and dilution potential;
- Periods of low flow where the dilution potential may be limited;
- Background levels of the inventory;
- Mixing characteristics, stratification, turbulence etc;
- Density and solubility of the inventory;
- Climatic conditions; and
- Impact on climate change.

The **hazard rating** for **receptors** at the well site is expected to be considered high. The risk assessment process will be conducted prior to production or construction works to confirm this is the case. A suitable Containment Plan will then be developed on this risk basis.

15.4 Overall Site Hazard Rating

The preceding sections provided an approach to determining a hazard rating for the source, pathway and receptor. The three factors are now combined to obtain an overall **Site Hazard Rating** designated as **high**, **medium** or **low**.

As a general guide it can be anticipated that the regulators initial expectations in terms of the components of the **Site Hazard Rating** will be as follows:

Source Hazard

- Main inventory at COMAH establishments likely to be **high**.
- EPR establishments likely to be **high / medium**.
- EPR exempt establishments likely to be **medium / low** (though some could be **high**, e.g. certain large storage facilities otherwise exempt from COMAH / EPR).

Receptor Hazard

- Nationally designated sites (SSSIs / SPAs / SACs) and drinking water sources (Source Protection Zones (SPZs)) are likely to be **high**.
- Locally designated sites, surface or groundwater bodies defined as such by the WFD are likely to be **medium**.
- Non-designated sites and other water and groundwaters are likely to be **low**.

15.5 Site Risk Rating

To assess the risk, it is necessary to consider the events that may lead to the release of inventory from the primary containment and the likelihood that this would occur i.e.:

1. Identification of all the events that are capable of causing loss of containment; and
2. Assessment of the likelihood of occurrence of each event.

The potential failures and the reasons for failure include:

- Operational failures, such as failure of plant, or human failure by operators;
- Shortfalls in design – lack of alarms and failsafe devices;
- Structural failure – materials, components, corrosion or when exposed to heat and flame;
- Abuse – inappropriate change of use or other misuse;
- Impact e.g. from a vehicle;
- Vandalism, terrorism, force majeure etc;
- Flood, fire or explosion;
- Geological factors – subsidence etc; and
- Ageing or deteriorating assets / sub-components.

By analysing the events and circumstances that may affect a site it is possible to arrive at an assessment of the probability of a loss of containment and release of inventory expressed as **low**, **medium** or **high**.

It is unlikely to be possible to precisely estimate the probability of a failure of the primary containment and/or secondary containment due to the inherent uncertainties involved. It is therefore advised that any such estimates that are made to inform the classification and the design processes are discussed with the regulator.

However, as a general guide, the following typical probabilities might be considered appropriate for use in establishing the **Site Risk Rating**.

FREQUENCY OF LOSS OF CONTAINMENT	
Risk of loss of containment	**Annual probability of loss of containment per site**
High	Greater than 1% (1 in 100)
Medium	Between 1% (1 in 100) and 0.001% (1 in 1 million)
Low	Less than 0.001% (1 in 1 million)

Table 15.1 – Frequency of Loss of Containment

Typical examples of incidents that could lead to a loss of containment (listed in order of reducing probability) might include:

- Small spills
- Localised flooding
- Major flooding
- Terrorism
- Pipe failures
- Site-wide fires
- Vandalism
- Plane crash
- Single IBC incident
- Whole vessel failures
- Subsidence
- Earthquake

It will also be necessary to consider multiple credible potential failure scenarios.

The combination of **Site Hazard Rating**, with the **frequency of loss of containment**, provides an assessment of the overall site risk. The ways in which the ratings for hazard and risk can be combined to provide an assessment of the overall site risk are shown in Table 15.2 where the hazard and the probability are given equal weighting.

OVERALL SITE RISK RATING	
Site Hazard Ratings:	
High (H), Moderate (M) or Low (L)	
Frequency of Loss of Containment:	
High (H), Moderate (M) or Low (L)	
Possible Combination of Ratings:	**Suggested Consequent Overall Site Hazard Rating**
HH or HM or MH	**High**
MM or HL or LH	**Moderate**
LL or ML or LM	**Low**

Table 15.2 – Overall Site Risk Rating *(Defined by combining site hazard and probability of loss of containment)*

Where the risk assessment indicates that an event could result in significant environmental damage at an intolerable frequency, the operator or designer would need to consider one or more of the following risk reduction measures:

- Change to less hazardous inventory or reduce quantities held;
- Change or relocate the process or activity to a less environmentally sensitive location;
- Install new, or improve existing, containment systems;
- Provide smaller storage units;
- Modify the onsite pathways to minimise the likelihood of escape of pollutant;
- Change or relocate the process or activity; and
- Change operational and/or management practices.

15.6 Containment Classification System

15.6.1 Hazard and Risk Assessment and Design Classification

This guidance sets out a classification of containment systems based on three categories (Classes 1,2 and 3) each representing a different level of integrity to match the different requirements of high, moderate and low overall site risks.

It should be noted that the legal requirements for containment systems such as the Oil Storage Regulations would have priority.

Although there is no direct quantifiable link between the site hazard or site risk and the design of the containment system the following simple relationship is considered appropriate in most circumstances:

- Low overall site risk containment type Class 1 i.e. base level of integrity;
- Moderate overall site risk containment Class 2, i.e. intermediate degree of integrity;
- High overall site risk containment type Class 3 i.e. highest degree of integrity.

The difference in performance between the three classes of containment can be expressed in terms of:

- System safeguards (e.g. whether or not fail-safe alarms form part of the system;
- System and component redundancies (e.g. where there are back up collection and storage facilities in the event of the failure of containment);
- Structural integrity and quality of construction (e.g. increasing design requirements); and
- Operation and maintenance (e.g. enhanced inspection and maintenance regimes).

16. SECONDARY AND TERTIARY CONTAINMENT OPTIONS

System selection is an important first step in the design process and shall be informed by the site risk rating as determined by the risk assessment process.

System requirement can also be influenced by containment volume and further considerations under the scope of the Control of Major Accident Hazards 2015 (COMAH).

There is no universally recognised definition of the term 'bund' however CIRIA C736 has defined a bund as:

'a facility (including walls and a base) built around an area where potentially polluting materials are handled, processed or stored, for the purpose of containing any unintended escape of material from that area until such time as remedial action can be taken. Bunds are usually structurally independent from the primary containment tank'.

Containment options can be categorised into the follow categories:

- Local Containment Systems;
- Remote Containment Systems; and
- Combined Containment Systems

Factors to be considered when selecting containment systems are presented in Table 16.1.

Issue	Factors to Consider
Storage Inventory	• Inventory quantity, rainwater, firefighting agents (foam) plus an allowance for firefighting water, if required; • Nature of inventory and any 'cocktails' that may result from an incident where remote secondary containment is shared by a number of different inventories (incompatible substances, water-miscible and water-immiscible substances etc.); and • The nature of the primary system, for example whether single tank, tank farm, process plan, warehouse, pipeline, loading point or drum store.
Receptors	• The proximity and sensitivity of receptors; and • The level of unmitigated risk to receptors.
Site Constraints	• Space available for containment works; • The potential for using or adapting existing containment facilities, for example interceptors, lagoons and bunds and on-site or external treatment plant facilities which may have spare storage or treatment capacity; • The potential for sharing containment facilities across different process areas of a site here a range of different inventories may be present; • Site topography; • The type of drainage system, including the method of disposal of trade effluents, sewage and stormwater, and how the drains interconnect; and • Future development plans for the site, either physical changes in layout, plant or buildings, or in the processes to be carried out.
Financial	• Cost constraints.

Table 16.1: System Selection

Where a range of inventories are stored on a site, the site hazard rating for each inventory shall be considered individually. Where such analysis results in differing ratings for each, or groups of inventories, it may be necessary to consider zoning of the site. However, site size and economic constraints shall be considered.

16.1 System Reliability

Whilst not intended that the reliability of the overall containment strategy should influence the class of containment system, it is a matter that should be considered as part of the design of the containment facilities. The reliability of any containment system will depend on factors such as complexity, manual or automation, maintenance and management.

17. CONTAINMENT SYSTEM CAPACITY

The Horse Hill Well Site is currently in its exploration phase of development. Although the exact inventory at the site has yet to be identified (it will be identified prior to the construction of the well site extension or production, whichever is sooner), it can be assumed that oil and other flammable liquids will be present at the site all the time. As such there are a number of guidance documents that shall be considered by HHDL when identifying a suitable capacity for a containment system.

A summary of the containment requirements in regulations, policies, schemes and publications has been provided below. For clarity the Basis Registration Scheme has not been included as it relates to pesticides.

Regulation / Guidance	Containment Requirements	Scope	Typical Inventory
The Control of Pollution (Oil Storage) (England) Regulations (OSR) 2001 Pollution Prevention Guidelines	110% of the capacity for a single container or, where there is more than one container, not less than 110% of the largest container or 25% of their aggregate capacity, whichever is greater.	Greater than 200 litres.	Oil
COMAH	Take all measure necessary to prevent major accidents based on the principle of reducing risk to ALARP.	Qualifying inventory for COMAH	Dangerous Substances
CA containment policy for fuels	Sufficient capacity to allow for tank failure and firewater management. This will normally be a minimum capacity of either 110% of the capacity of the largest tank or 25% of their aggregate capacity, whichever is greater.		
HSE (2009a)	110% of the 'tank rated capacity' (TRC) as a minimum provide that minimum standards for overfill protection systems of control are in place. For bund capacity calculations based on 25% of the total capacity of all the tanks, the normal fill levels of all the tanks within the bund should be used.		
HSE (1998a)	110% of the largest containers are provided for both indoor and outdoor storage.	Less than 1000 litres	Flammable Liquids in Containers
HSE (1998b)	Should contain the largest predictable spillage and that 110% capacity of the largest storage vessel located within the bund will normally be sufficient. Advises that smaller capacity bunds may be acceptable where liquid can be diverted to a remote or tertiary containment area.	Greater than 1000 litres	Flammable Liquids in Tanks
HSE (2009b) PPG26	In outdoor areas at least 110% of the capacity of the largest single container. For multiple containers storage at least 25% of the total volume of containers being stored, or 110% of the largest container., whichever is greater. Allowance for firefighting water should be made. Containment should be based on risk assessment.		Packaged Dangerous Substances
Energy Institute (2012b)	Refers to CA containment policy for advice on appropriate secondary containment volumes.		Petroleum

Table 28.1: Summary of Containment Requirements

17.1 Method for Assessing Containment Capacity

The final design of the proposed production facility has yet to be confirmed, however the methodology for the assessment of containment capacity shall apply regardless, one the final design has been confirmed. The method shall be undertaken in accordance with Section 4.3 of the CIRIA C736 publication.

A process for estimating containment capacity has been provided below in Figure 17.1 below.

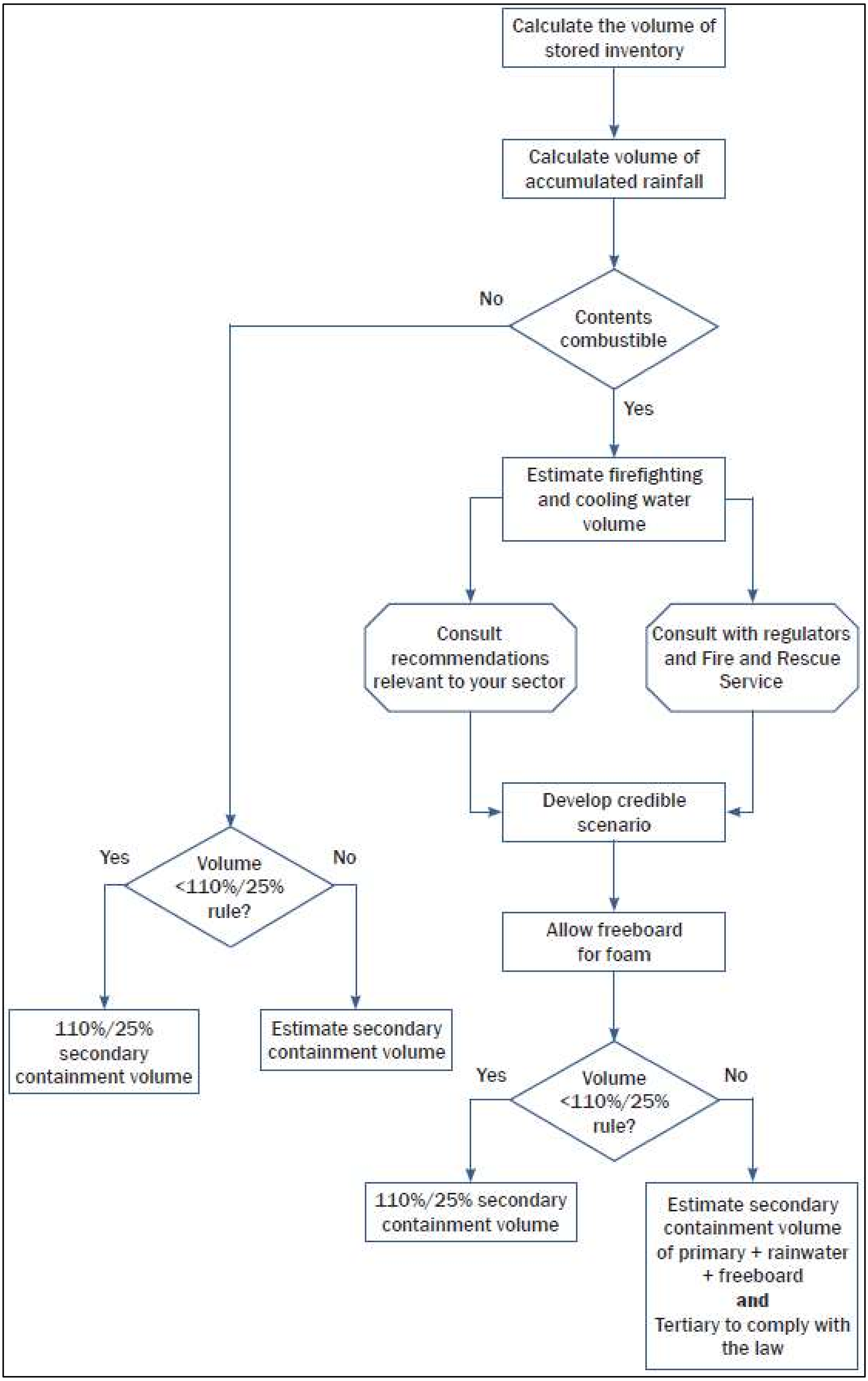


Figure 17.1 Process for Containment Capacity Estimation

18. EXISTING INSTALLATIONS

The existing well site is currently being used for exploration activities for the short term. As the proposal is to produce from the well site for the long term the existing site must be the subject of a GAP analysis to ensure that the containment measures proposed are suitable or, where they are considered deficient modified to a suitable standard.

The Gap Analysis will commence with a baseline survey for the purpose of identifying:

- **Primary Containment**
  - Rated Capacity (Volume); and
  - Nature of Inventory.
- **Secondary Containment**
  - Local, Remote and/or Combined;
  - Containment Volumes;
  - Secondary and/or Tertiary; and
  - Construction Standard.
- **Type of Construction**
  - Concrete, blockwork, earth bund, tank etc.;
  - Design Standard;
  - Details of any linings/coating;
  - Reinforced Masonry Walls; and
  - Watertight Containment.
- **Potential Leakage Pathways**
  - Presence of Water stops;
  - Presence of joint armouring plates across joints;
  - Penetrations through the containment;
  - General water tightness;
  - Leak detection system installed;
  - Means of removing surface run-off water; and
  - Details of site drainage system.

This baseline survey will inform the GAP Analysis and the CQA Plan.

The baseline survey will include visual inspections of the following plant, storage vessels and equipment. This list is not exhaustive:

- Storage vessels including:
  - Crude oil storage vessels;
  - Produced water storage vessels; and
  - Three phase separator.
- Secondary and tertiary containment systems;
- Areas used for the loading, unloading and transfer of products and chemicals;
- Transfer pipework;
- Pumps;
- Areas used for temporary storage; and
- Liners underlying the wellsite.

19. Maintenance Plan

Once a suitable containment system for the proposed development has been established, suitable maintenance plans will be adopted for the well site inclusive of all identified zones. HHDL understands that a regular maintenance and inspection regime is essential if defects or leaks that could compromise the integrity of the primary secondary or tertiary containment are identified in a timely manner.

The maintenance plan will be informed by the as built design and will include primary, secondary and tertiary containment. The necessary regulations such as COMAH and PPC shall also be used to ensure that a suitable maintenance plan is designed for the site.

20. Membrane Integrity

A liner inspection regime will be designed consistent with EA guidance documents *LFE8: Geophysical testing of geomembranes used in landfill*. In spite of the guidance being primarily designed for landfill engineering it can inform the use of geo-membranes in other industries including onshore oil & gas exploration. Adopting the methodology will ensure the integrity of the lining system is maintained during operations consistent with *CIRIA 736: Containment Systems for the Prevention of Pollution*.

The primary objectives of the scheme would be:

- Detect potential leaks in the HDPE membrane;
- Investigate the potential for dissolution features in the bedrock and recommend remediation measures if necessary; and
- Investigate the integrity of the engineered upper surfaces (including the membrane layer) and recommend appropriate remediation measures if necessary.

It is likely that leaks within the HDPE membrane would be detected by way of an Electrical Leak Location Survey (see Figure 10.1). This involves establishing an electrical potential between two transmitting/receiving electrodes across an insulating membrane and the underlying sub-strata. A leak in a membrane creates a characteristic flip in the polarity of measured readings across an isolated area indicative of a potential leak derived from any unintended opening, perforation, slit, tear puncture, crack, hole, cut, or similar breach which may allow the passage of liquid.

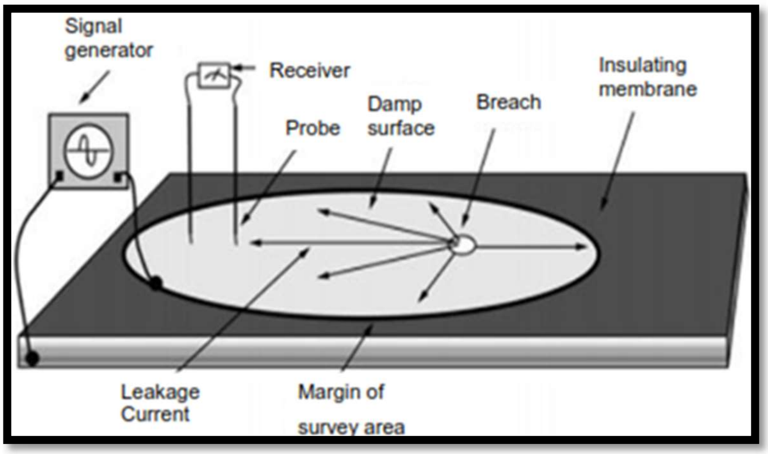


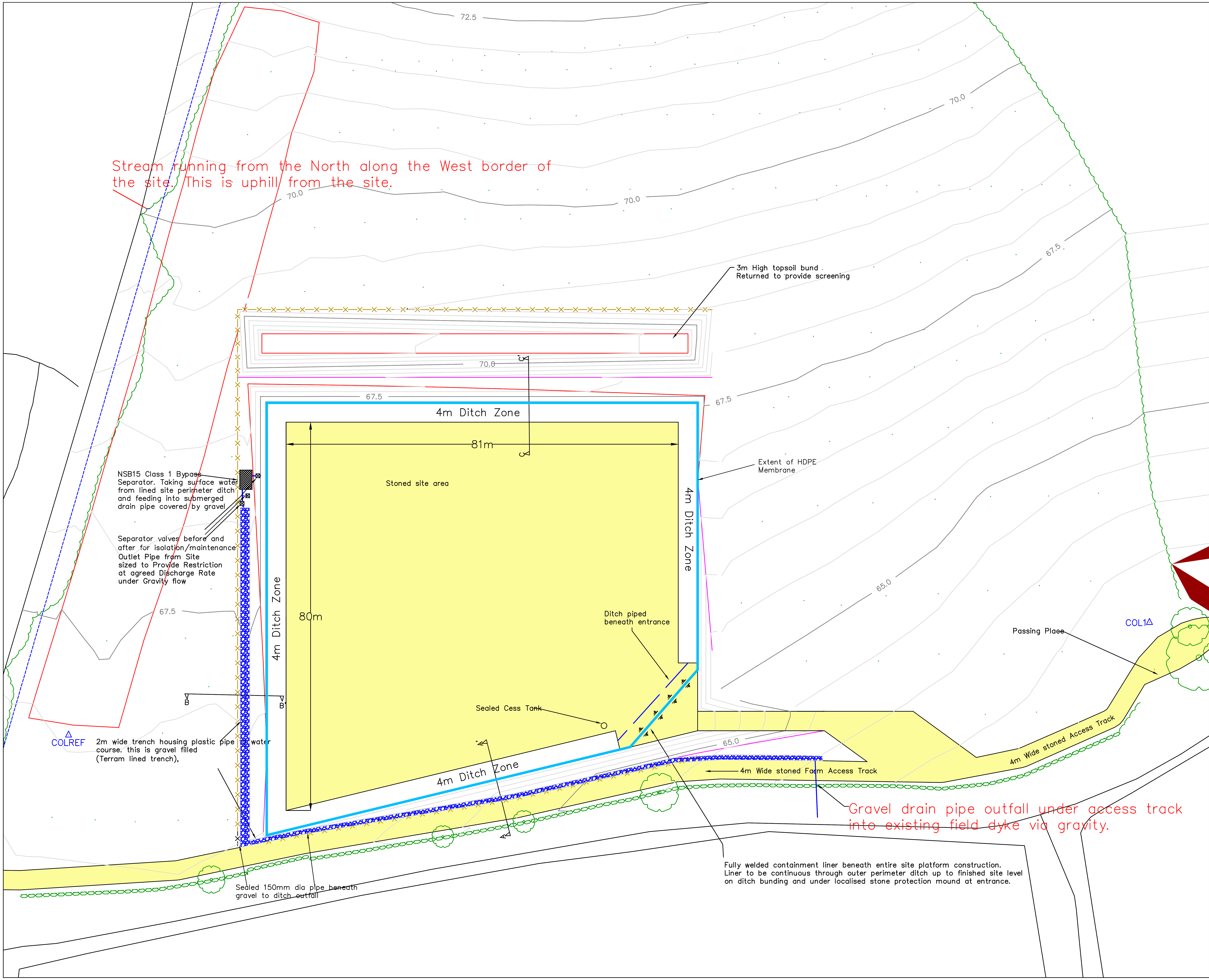
Figure 20.1: Indicative Electrical Leak Location Survey Arrangement

It is likely that potential dissolution of the bedrock would be detected by way of a Ground Penetrating Radar Survey generating detailed cross-sectional images that identify shallow features of interest, subsurface voiding or dipping geological boundaries. This survey involves the transmission of a pulsed electro-magnetic (radio) wave and the recording of any returning reflections. The transmitted waves are focused into the ground and can penetrate soils, rock and concrete. Waves reflected from geological or hydrological boundaries can be observed as 'point' sources indicative of voids or anomalies.

It is likely that the integrity of the engineered upper surfaces would be monitored by way of an Electromagnetic Ground Conductivity Survey generating contour plans of the variation in ground conductivity across the site. Conductive materials e.g. clay, water and some contaminants can be distinguished from areas of sediment, dry zones or bedrock.

These non-invasive methods have been used on other well sites to establish the integrity of HDPE membranes, identify void spaces in the underlying bedrock and anomalies in the engineered upper surfaces of constructed well pads.

HHDL are proposing to conduct such non-intrusive integrity testing every three (3) years or following the demobilisation of drilling and workover rigs, whichever is sooner. Records of tests shall be held by HHDL and shall act on repairing any deficiencies in liner integrity.



KEY:

EXTENT OF HDPE MEMBRANE

NOTES:

REVISION HISTORY

REV	DATE	BY	DETAILS	APR
–	–	–	–	–
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0	MAR20	JF	ORIGINAL FOR ISSUE	JF

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SITE: HORSE HILL WELLSITE, SURREY

PROJECT: APPLICATION FOR PLANNING PERMISSION

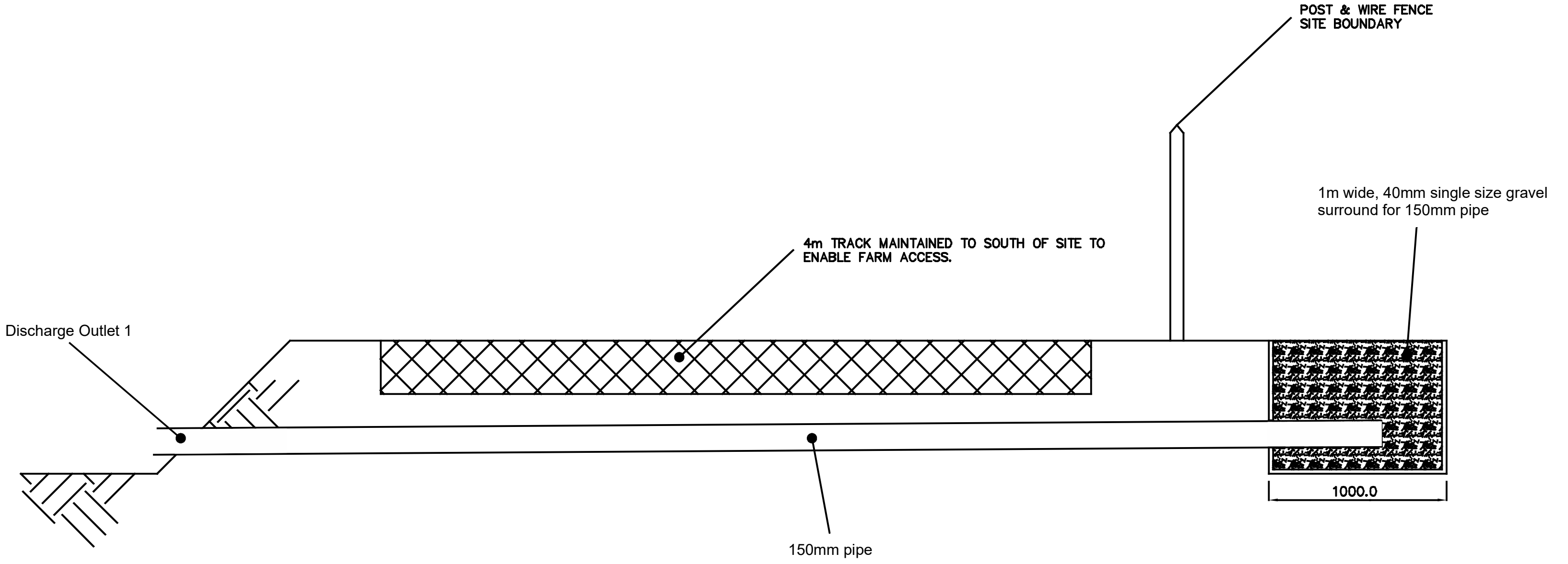
TITLE: AS-BUILT SITE DESIGN SHOWING EXTENT OF HDPE MEMBRANE

CLIENT: HORSE HILL DEVELOPMENTS

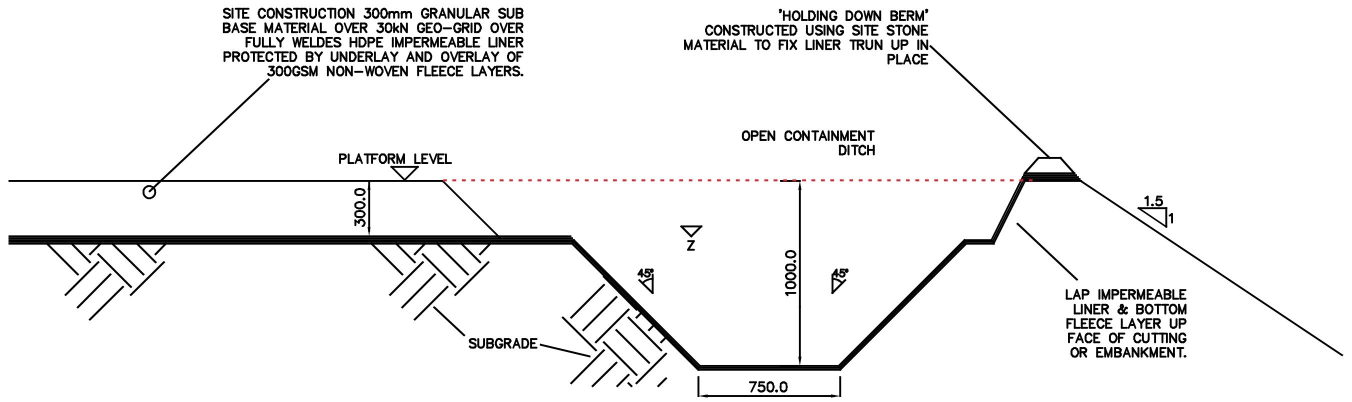
Scale: 1:500
Size: A2
Sheet: 1 of 1

DWG. No: ZG-HHD-HH-PA-03

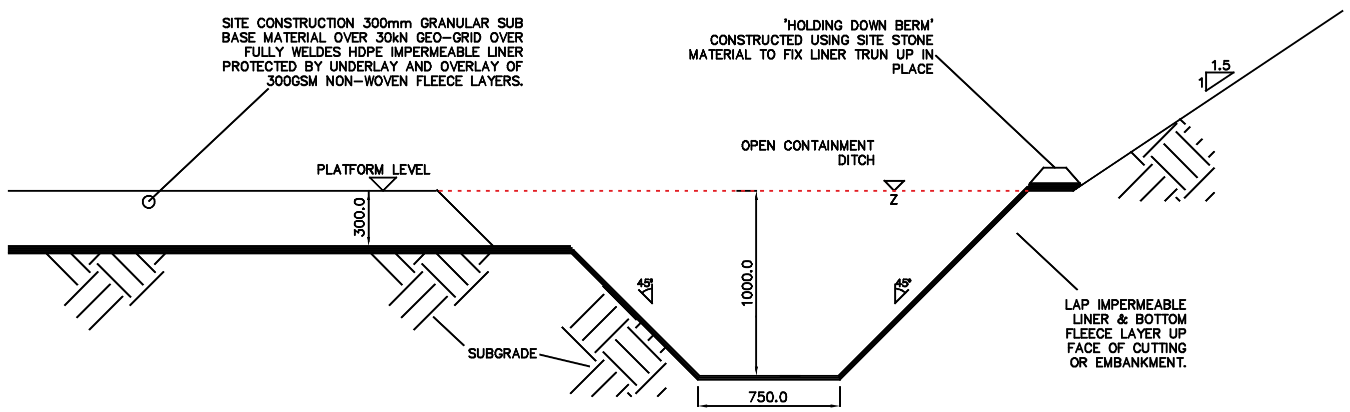
SECTION A–A' SOUTHERN BOUNDARY
1: 40



SECTION B–B' EASTERN BOUNDARY
1: 40



SECTION C–C' NORTHERN BOUNDARY
1: 40



KEY:

NOTES:

FOR LOCATION OF CROSS-SECTIONS, REFER TO DRAWING NO. ZG-HHD-HH-PA-01

REVISION HISTORY

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0	NOV17	JF	ORIGINAL FOR ISSUE	JF

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SITE: HORSE HILL WELLSITE, SURREY

PROJECT:

TITLE: AS-BUILT SITE DESIGN CONTAINMENT DITCH DETAIL SECTIONS

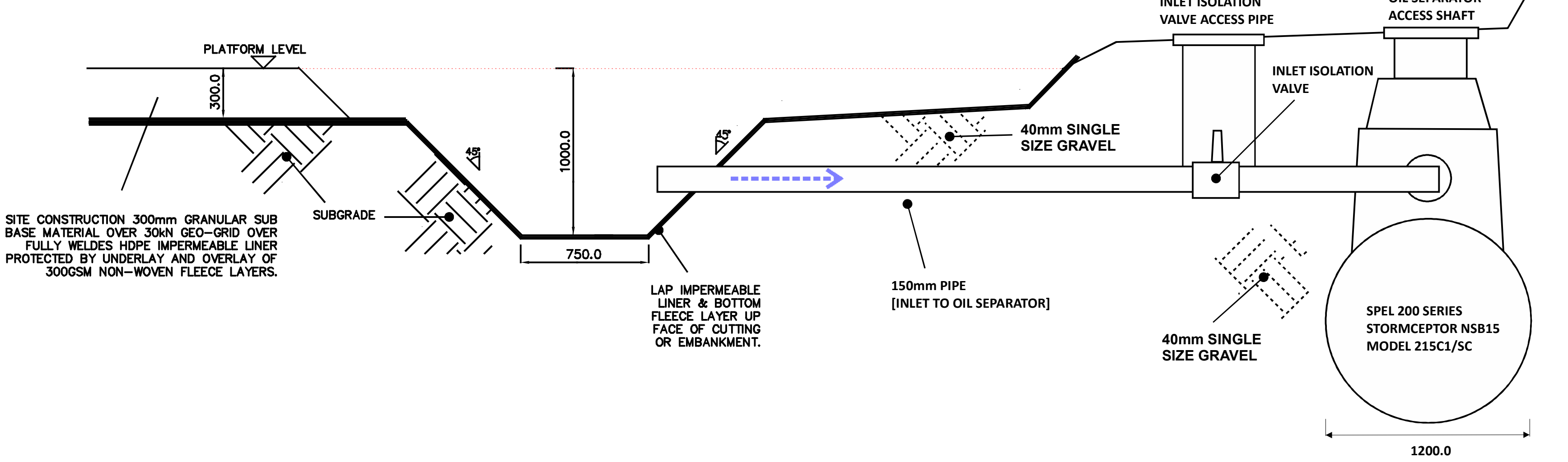
CLIENT: HORSE HILL DEVELOPMENTS

Scale:	1:40
Size:	A3
Sheet:	2 of 2

DWG. No: ZG-HHD-HH-PA-02

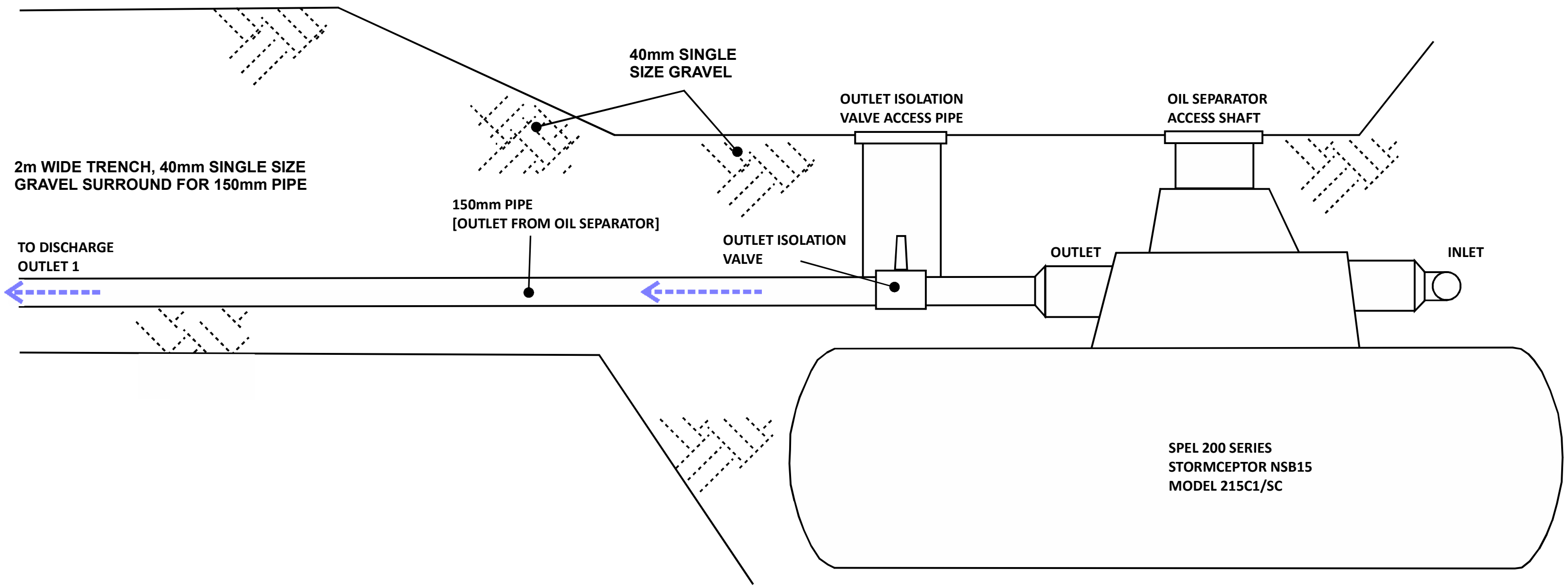
SECTION D-D' CONTAINMENT DITCH INLET TO OIL SEPARATOR

1:40



SECTION E-E' OIL SEPARATOR OUTLET TO DISCHARGE OUTLET

1:40



envireau WATER

Ref: P:\UKOG Horse Hill (2165)\40 - Reporting\Appendices Date: 13/02/2018	**Horse Hill Well Site**
Appendix A	Sections D-D' and E-E'

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Drawing Number: HH-2 CELLAR
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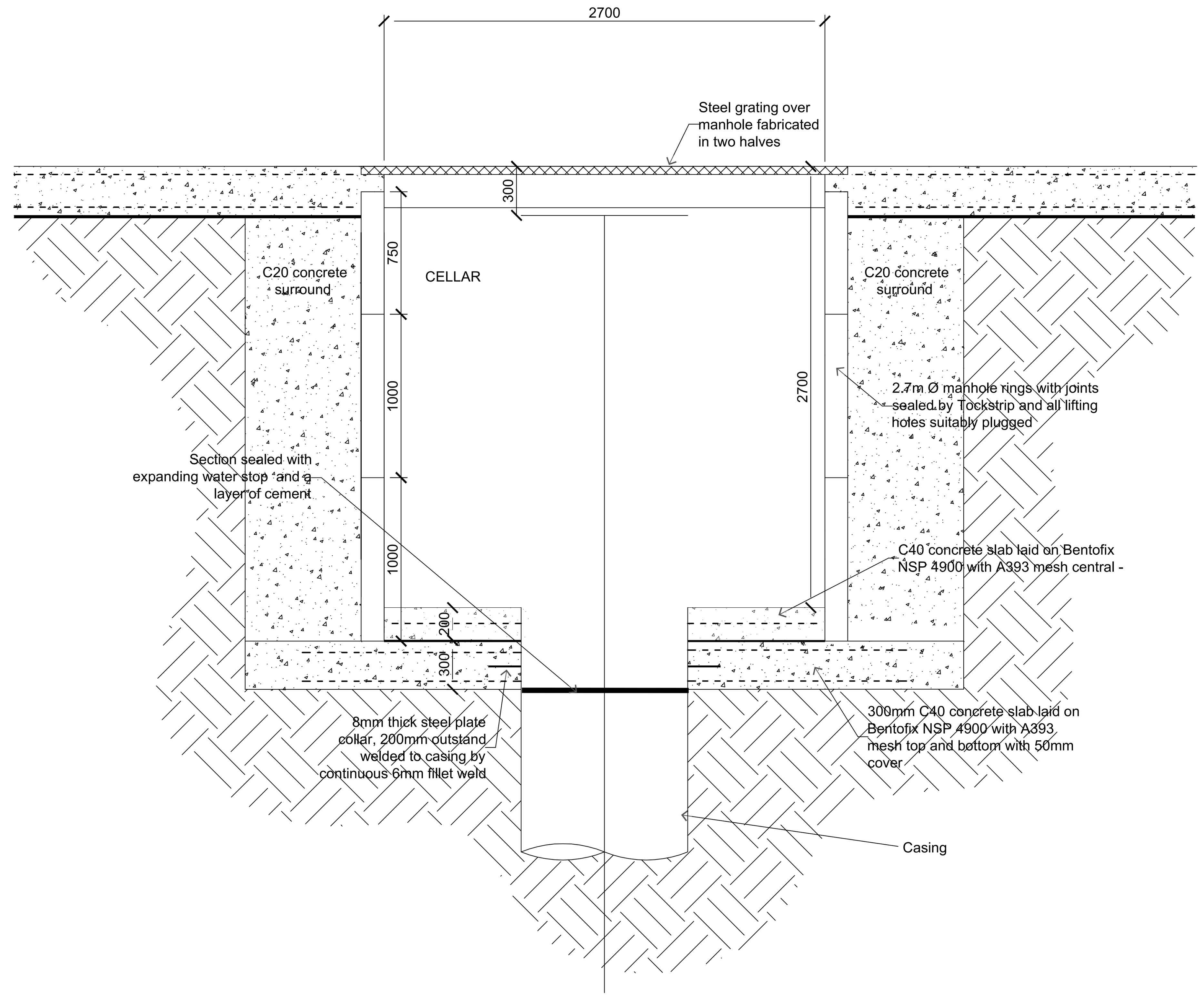
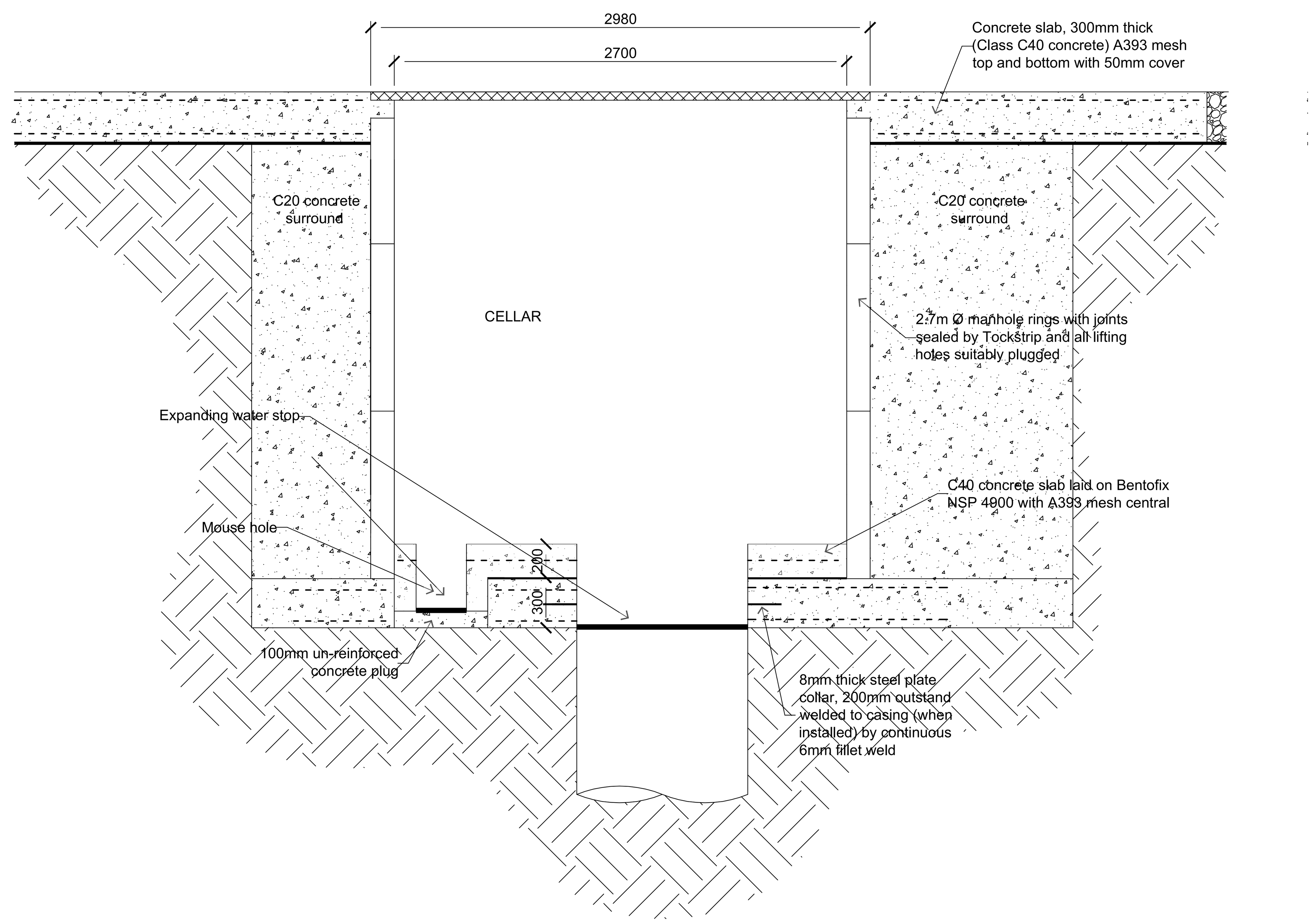
Drawn: DAW
Date 20/06/18



Detail

Scale 1:25



Detail

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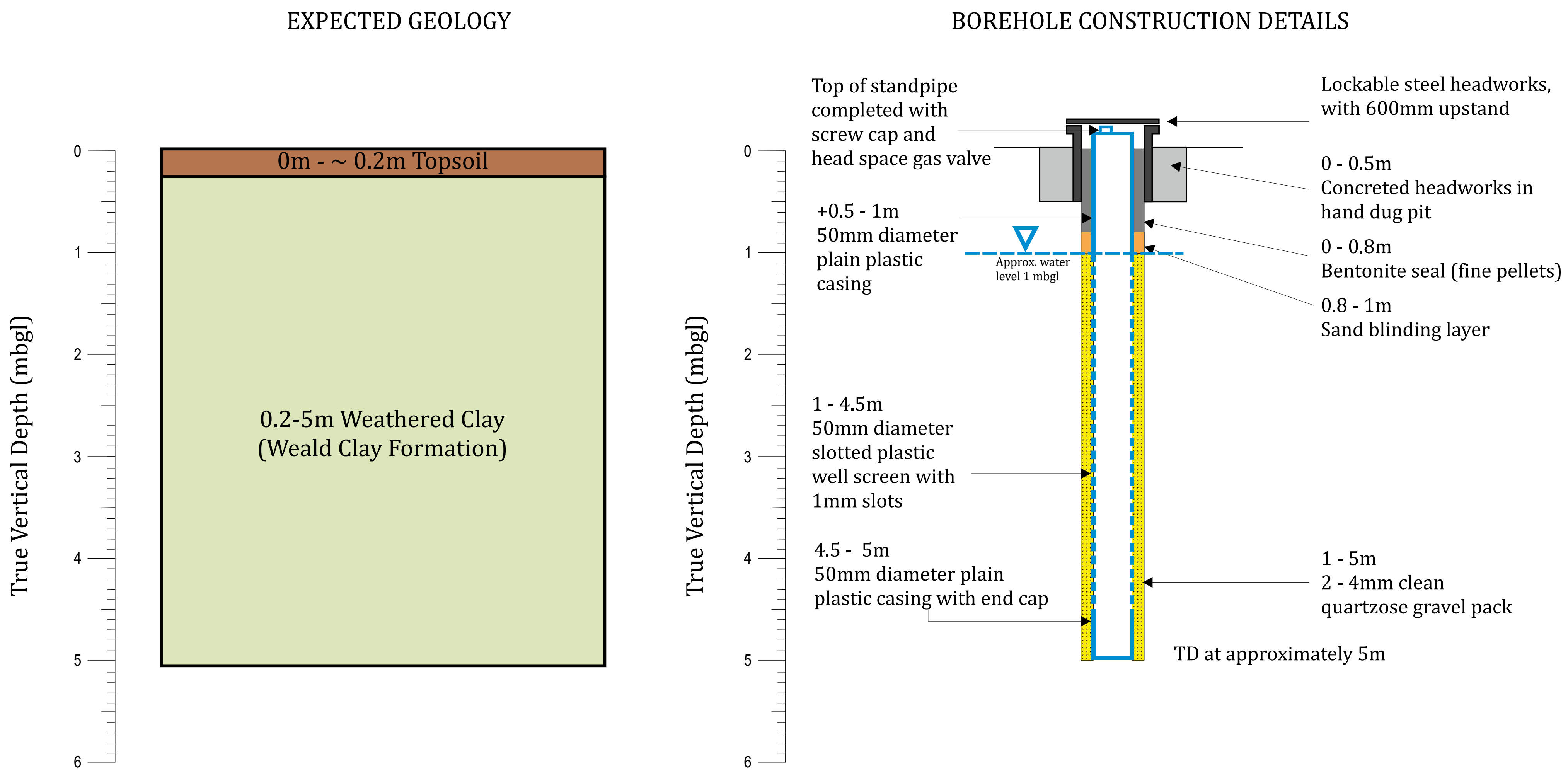

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Ref: P18-022 UKOG Horse Hill 2018/RPT Horse Hill Production GMP/ FIG 2 Date: 26/11/2018	**Horse Hill Developments Ltd**
Figure 2	Outline Monitoring Borehole Design