HORSE HILL DEVELOPMENTS LTD

Horse Hill Developments Ltd

Title: Waste Management Plan

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Rev. 5

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Revision History						

	REVISION DESCRIPTION SHEET	

This sheet must be completed in detail, at each revision, once this document has been issued at revision 0.

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
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GLOSSARY

ALARP	As Low As Reasonably Practicable
bbl	Barrels
bpm	Barrels per minute
BSOR	Borehole Sites and Operations Regulations, 1995
BOP	Blowout preventer
bopd	Barrels of oil per day
CBL-VDL	Cement bond log-variable density log
CEO	Chief Executive Officer
COO	Chief Operating Officer
COSHH	Control of Substances Hazardous to Health
CT	Coiled tubing
DWOP	Drill Well on Paper
EA	Environment Agency
EMW	Equivalent mud weight (to represent a pressure gradient)
EWC	European Waste Catalogue code
EWT	Extended well test
FIT	Formation integrity test
GL	Ground level above mean sea level
GR	Gamma ray log
HC	Hydrocarbons
HCl	Hydrochloric acid
HGV	Heavy goods vehicle
HHDL	Horse Hill Developments Ltd
HH-1	Horse Hill-1 well
HSE	Health, safety and environment, or Health and Safety Executive
HRA	Hydrological risk assessment
KPI	Key performance indicators
Lead Contractor	Contractor either carrying out workover or drilling operations
LEL	Lower explosive limit
LOLER	Lifting operations and lifting equipment regulations
LOT	Leak-off test
mscf/d	Thousand standard cubic feet per day
MD	Measured depth
MWD	Measurement-while-drilling (logging tool)
PEDL	Petroleum Exploration and Development License
PPE	Personal protective equipment
POB	Persons on Board
psi	Pounds per square inch
PTW	Permit to Work
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
RTE	Rotary table elevation
SAL	Security and logistics
TD	Total depth (either for a given hole size or for the well)
TOC	Top of cement
TVD	True vertical depth
TVD-RT	True vertical depth below rotary table
TVDSS	True vertical depth below sea level

1. INTRODUCTION

1.1 Background

Horse Hill well site is located in licence PEDL137, which is operated by Horse Hill Developments Ltd (HHDL), a special purpose joint venture company established specifically to explore and develop the Horse Hill licences. UK Oil & Gas Investments PLC (UKOG) is the largest shareholder of HHDL (48%) and provides the management of the licence.

Horse Hill-1 (HH-1) is an S-shaped exploration well, which was drilled to Triassic formations and suspended on 4 November 2014 following electric logging. The well was tested across three reservoir zones of interest from 1 February to 18 March 2016. The intervals tested were:

- The Upper Kimmeridge Limestone over the interval 3,102-3,185ft measured depth (MD);
- The Middle Kimmeridge Limestone, initially over 2,827.1-2,847.9ft MD and followed by additional perforating over 2,864.8-2,930ft;
- The Portland Sandstone across 2,043.9-2,143.1ft MD.

The Horse Hill site is currently non-operational and has been since HH-1 well testing was completed in March 2016.

HH-1 well testing was highly successful, producing high flow rates of oil but the time constraints of the previous planning permission did not permit full evaluation of the productive potential of the reservoirs and hence additional testing is now planned, including the addition of a fourth reservoir unit, as well as the drilling of two appraisal wells. A new planning application is being pursued with Surrey County Council (SCC), in parallel with the necessary permits with the Environment Agency (EA).

The planned activities (together the Appraisal Project) can be separated into four phases of operations:

- Phase 1 - the carrying out of extended well tests (EWTs) and a short-term well test of the existing HH-1 well, to appraise the technical and commercial viability of the hydrocarbon accumulations discovered. Each of the well tests will involve a well workover, followed by flowing, pumping (as required) and pressure testing with the purpose of evaluating the characteristics of the oil resource that was discovered during the original exploration of HH-1;
- Phase 2 - this is dependent on the outcome of Phase 1 and involves the drilling of a deviated sidetrack from the existing HH-1 borehole; this will be followed by the carrying out of an EWT of up to 75 days;
- Phase 3 - this is also dependent on the outcome of Phase 1 and involves the drilling of a new appraisal well Horse Hill-2 (HH-2) from the existing well pad; this will be followed by an EWT of up to 75 days;
- Phase 4 - restoration of the site to agriculture and woodland.
- Nevertheless, while recognising the planning requirement to restore the site, in the event that the appraisal programme demonstrates commercial viability HHDL intends to submit a further planning application for a production phase in due course.

Details of the planned activities are provided in Section 2.2.

1.2 Reference Documentation

This Waste Management Plan is part of a suite of documentation submitted by HHDL to EA as part of its new Horse Hill permit applications. The full list of documents is as follows:

- Summary of HHDL's HSE Management System, document number HH-PR-Q01;
- Non-Technical Summary, document number HH-PR-Q02;
- Environmental Method Statement, document number HH-PR-Q08;
- Site Condition Report, document number HH-PR-Q04; and
- Green Line Site Plan, document number HH1-PR-Q05.

This document has been written to be as self-contained as possible resulting in some repetition of the information contained in these referenced documents, particularly with regard to the Environmental Method Statement (HH-PR-Q08).

1.3 Document Structure

This document is structured as recommended by the Environmental Permitting Regulations (EPR) 6.14, "How to comply with your environmental permit, additional guidance for mining waste operations", as follows:

- **Section 2** defines the **Facility Classification**;
- **Section 3** describes the arrangements in place for **Waste Prevention and Reduction** and the prevention of Environmental Pollution;
- **Section 4** addresses **Fluids and Chemicals** information;
- **Section 5** addresses **Site Operations and Waste Treatment**;
- **Section 6** summarises the arrangements in place for **Environmental Risk Management,** addressing both risk assessment and risk mitigation;
- **Section 7** summarises the arrangements in place for the **Control and Monitoring** of emissions;
- **Section 8** summarises the **Plan for Closure**, addressing the requirements for closure and restoration of t he site;
- **Section 9** summarises the **Measures to Prevent Pollution.**

In addition, the following appendices support the Waste Management Plan:

- **Appendix 1:** Mud and Drill Cuttings Volumes, HH-1 Sidetrack; gives estimates of the volumes of drilling fluids and cuttings that are expected to result in waste streams for disposal;
- **Appendix 2:** Mud and Drill Cuttings Volumes, HH-2 New Well; gives estimates of the volumes of drilling fluids and cuttings that are expected to result in waste streams for disposal;
- **Appendix 3**: Flare Information;
- **Appendix 4**: Well Test Package;
- **Appendix 5**: Environmental Risk Assessment; detailed risk assessment, which demonstrates that with the application of the controls described in this Waste Management Plan, the potential hazards arising from the activities will be minimal;
- **Appendix 6**: H1 Risk Assessment has been replaced by the air emission report from Air quality consultants for all the emissions to air of all the equipment on site;
- **Appendix 7**: Ground Water Risk Assessment and Flood Risk Assessment; detailed risk assessments carried out by Hydrock, which demonstrate that the Horse Hill boreholes pose no significant risk to

controlled waters and that the Appraisal Project works do not constitute a groundwater activity;

- **Appendix 8**: Safety Data Sheets; for all the hazardous chemicals to be used during the works at the site;
- **Appendix 9:** Transport Statement;
- **Appendix 10:** Noise and Vibration Assessment;
- **Appendix 11:** Lighting Assessment;
- **Appendix 12:** Site Diagram, EWT;
- **Appendix 13**: Site Diagram, Drilling.

1.4 Site Location

The location of the licence is shown in Figure 1.1, and the site location in Figure 1-2. The site address is:

Horse Hill,
Hookwood,
Horley, Surrey RH6 0HN

The Ordnance Survey National Grid reference of the location of the top of the well is:

System: Datum:	British National Grid OSGB	525254.9E	143600.3N

It is planned that the new HH-2 well will be drilled from a well cellar to be installed approximately 6m north of the existing HH-1 well cellar.

Figure 1.1: Location of PEDL137

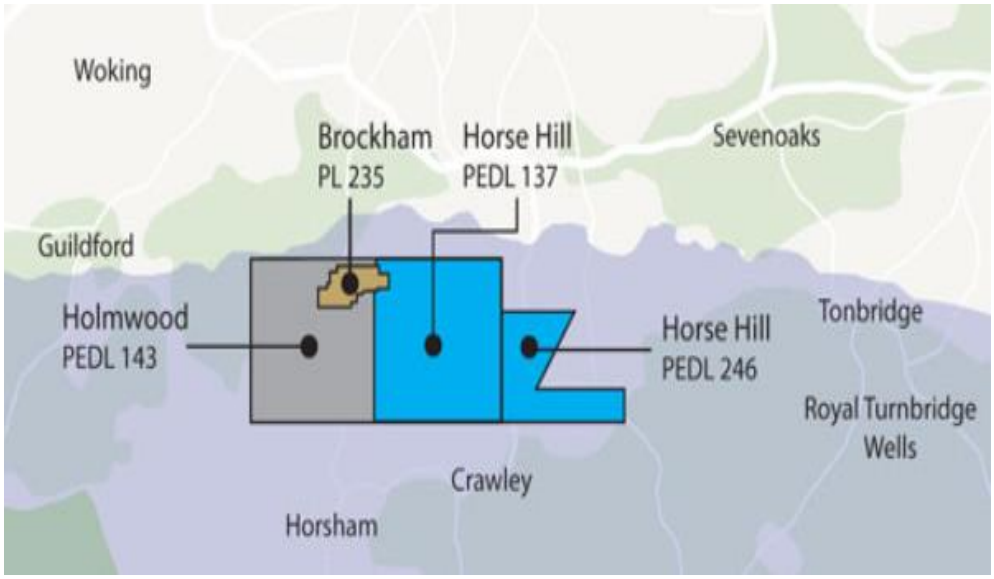
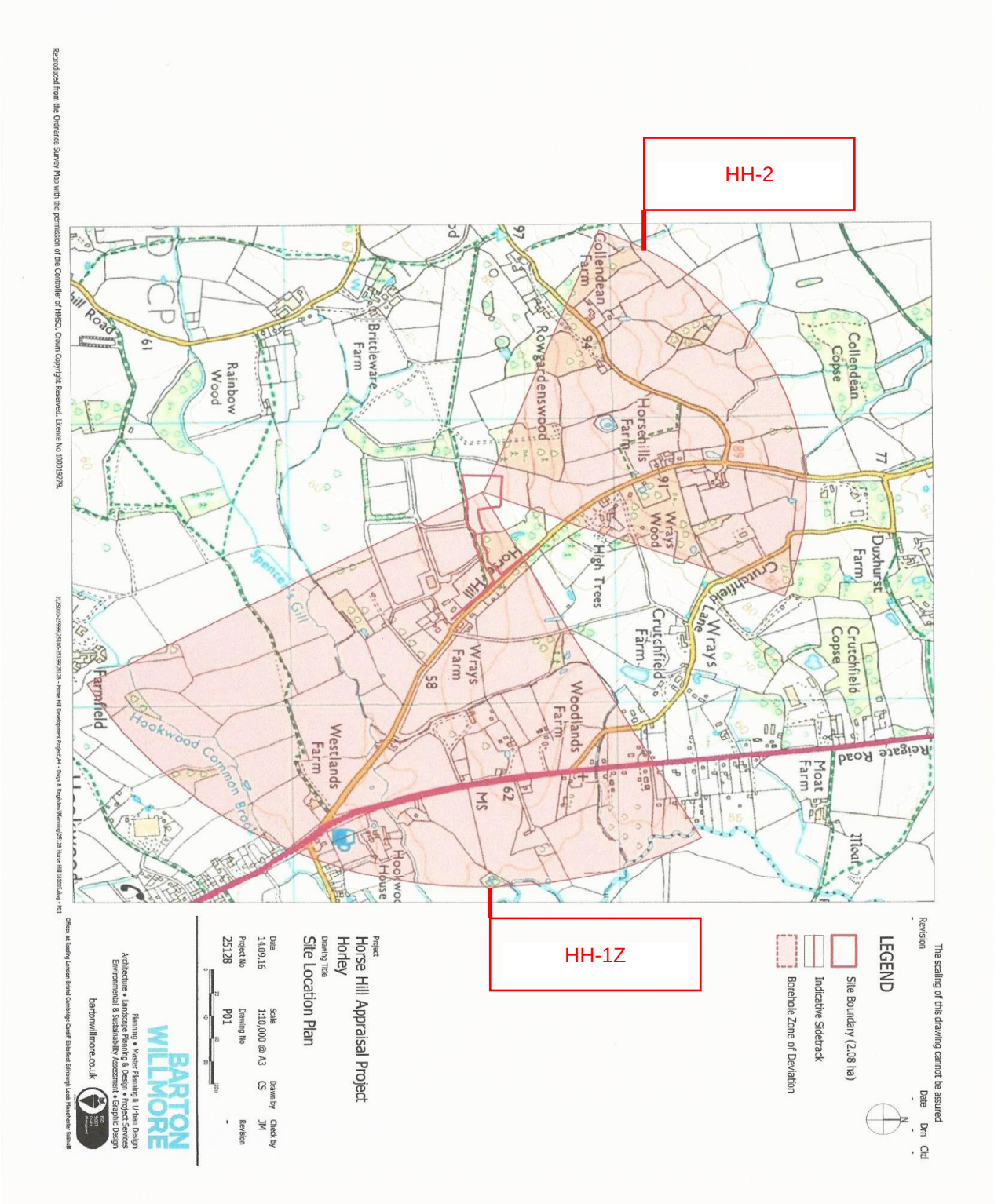


Figure 1.2: Site Map, HH-1z and HH-2 trajectory



2 WASTE DESCRIPTION AND CLASSIFICATION

2.1 Overview

The well operations incorporate a closed loop system whereby fluids are circulated down through the workover string and back up the well bore to create hydrostatic pressure (primary well control), returning any solid materials created in perforating the well-bore back to the surface.

A waste is defined in Annex 1 of Article 3(1) of the Mining Waste Directive as any substance or object (in three categories), which the holder discards or intends to discard or is required to discard. The three categories are:

- **Inert Waste:** waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater;
- **Hazardous Waste:** Article 3(2) of the Hazardous Waste Directive lists properties of wastes that render t hem hazardous. These properties are: explosive, oxidising, highly flammable, flammable, irritant, harmful, toxic, carcinogenic, corrosive, infectious, toxic for reproduction, mutagenic, waste which releases toxic or very toxic gases in contact with water/air sensitising, ecotoxic, waste capable by any means after disposal of yielding another substance which possesses any of the above characteristics;
- **Non-Hazardous Waste:** waste which is neither classified as inert or hazardous waste.
  The extractive and non-extractive wastes generated in the well operations on the site are summarised in Table 2.1 below and described in detail in Section 4.

Extractive waste will be generated by the drilling and associated processes of constructing a borehole to take samples, suspension and the subsequent decommissioning of the borehole only. This will include extractive waste generated by open-hole drilling at diameters which decrease with increasing depth after each well casing has been set.

For greater detail regarding the well operations, the reader is referred to the Evironmental Method Statement, HH-PR-Q08. However, information pertaining to relevant waste management is presented below.

Table 2.1: Extractive and Non-Extractive Waste

Waste Type	Classification
Non-Hazardous	Water based drilling fluids, referred to as water based muds (WBM)
Non-Hazardous	Formation cuttings from sections drilled with WBM (cuttings are the broken bits of rock naturally occurring underground and removed from a borehole while drilling into underground formations)
Non-Hazardous	Surplus cement
Hazardous	Natural gas and fluids from the reservoir

2.2 Waste Generating Activities

2.2.1 Summary

The well operations inherently minimise waste through only using those volumes of raw materials and components that are required to complete the process. Waste prevention and minimisation is further reinforced through the following processes:

- **Drilling fluids**: the volumes required to drill to the target depth are calculated in advance of the drilling operation (refer to Section 3.1). The drilling process is monitored by the Drilling Fluids Engineer, and along with the real time drilling monitoring readings and the mud logging process the volumes of fluids pumped downhole and returned are assessed and monitored.

  The primary considerations when selecting drilling mud are to manage the safety of the well. This aim is impacted by the particular well design, formations and geology to be drilled and achieving the well objectives safely without environmental impact. The general principle followed is that water based mud (WBM) is used unless its use is not reasonably practicable due to the need to ensure the safety of the well. In the case of this application, only WBM will be used.

  Geological conditions are also a key factor in preventing reactive clays swelling during the drilling phase causing the drill string to become stuck.

- **Drill cuttings**: only cuttings from the drilled borehole to the target depth are generated (refer to Section 3.2). Reducing-size drill bits are used to reduce the hole size of each well section and therefore reduce the volumes of returned cuttings.

- **Cement**: Volumes pumped into the well are controlled to minimise returns at surface (refer to Section 3.3).

- **Other chemicals**: A list can be found in Appendices 1 and 2 of all of the chemicals to be used in the Appraisal Project. SDS will be available for all hazardous chemicals. Waste streams will be set up.

2.2.2 Programme Overview

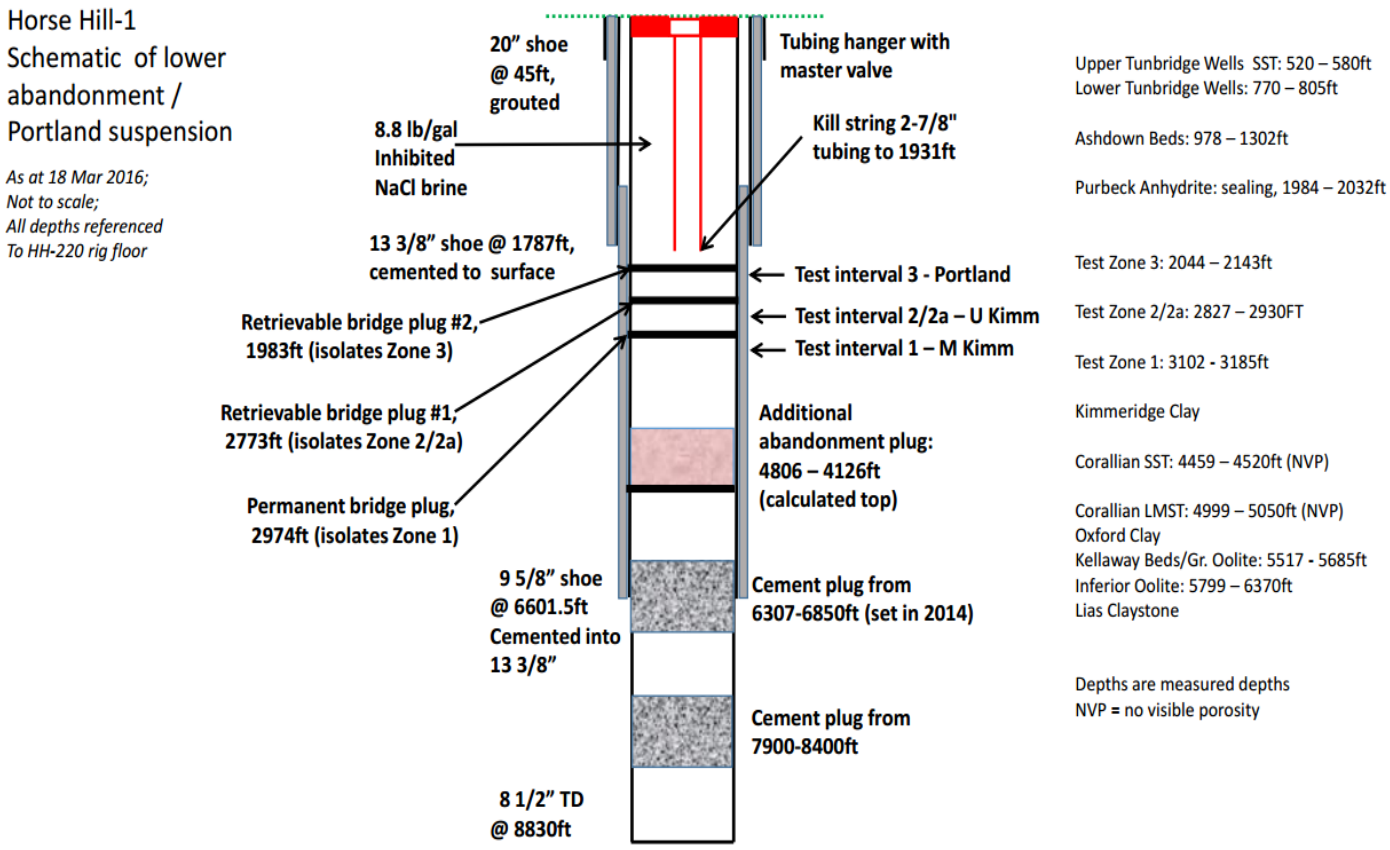
As stated in section 1.1, the planned activities (Appraisal Project) are:

- Three extended well tests (EWTs) and one short-term well test in HH-1;
- The short-term well test of the fourth reservoir unit will include perforation and acidisation, as was carried out in other reservoir units in February and March 2016;
- Drilling and EWT of a deviated appraisal sidetrack from the existing HH-1 well; and
- Drilling and EWT of a new deviated HH-2 appraisal well. HH-2 could be drilled before the HH-1 sidetrack, as outlined in the Planning Application.

2.2.3 Current Well Status, HH-1

Figure 2.1 shows the three zones tested to date in HH-1, and their current isolated state. The well has been suspended with both deep-set and shallow-set barriers, which were pressure-tested after installation. The deep-set barriers will be removed successively in a controlled manner for the planned extended testing of each zone.

Figure 2.1: HH-1 Suspension Diagram, Post Testing



2.2.4 Subsurface Formations and Pressures

The general stratigraphic column for the Weald Basin is shown in Figure 2.2. The formation tops as encountered in HH-1 are given in Table 2.2, including the intervals tested to date. A new interval, Lower Kimmeridge Limestone, is to be tested in the planned campaign. The section of the wellbore below the Kimmeridge Clay has been permanently abandoned with cement plugs.

Table 2.2: Formation Tops, HH-1

Lithostratigraphy	MD (ft)
Purbeck Carbonate	1525
13-3/8" casing shoe *within Purbeck Group*	1787
Purbeck Anhydrite	1984
Portland Sandstone, *3rd tested interval*	2042
Upper Kimmeridge Clay Formation	2480
Upper Kimmeridge Limestone, *2nd tested interval*	2800
Middle Kimmeridge Limestone, *1st tested interval*	3090
Lower Kimmeridge Limestone, *new unit to be tested*	3410
Isolating cement plug *abandonment of lower well section*	4126
Corallian Formation	4459
Original well total depth	8815

No cores were cut during the drilling of HH-1. All potential reservoir intervals were logged with electrical logging tools for characterisation.

Throughout the drilling of HH-1 there were no indications of abnormal pressures or temperatures. Cuttings samples were closely monitored for claystone pressure cavings, but there were no significant observations. Drilling fluid densities ("mud weights") were broadly hydrostatic, varying from 8.6 – 8.9 lb/gal over the sections of interest, and total gas levels recorded with these mud weights were consistently low.

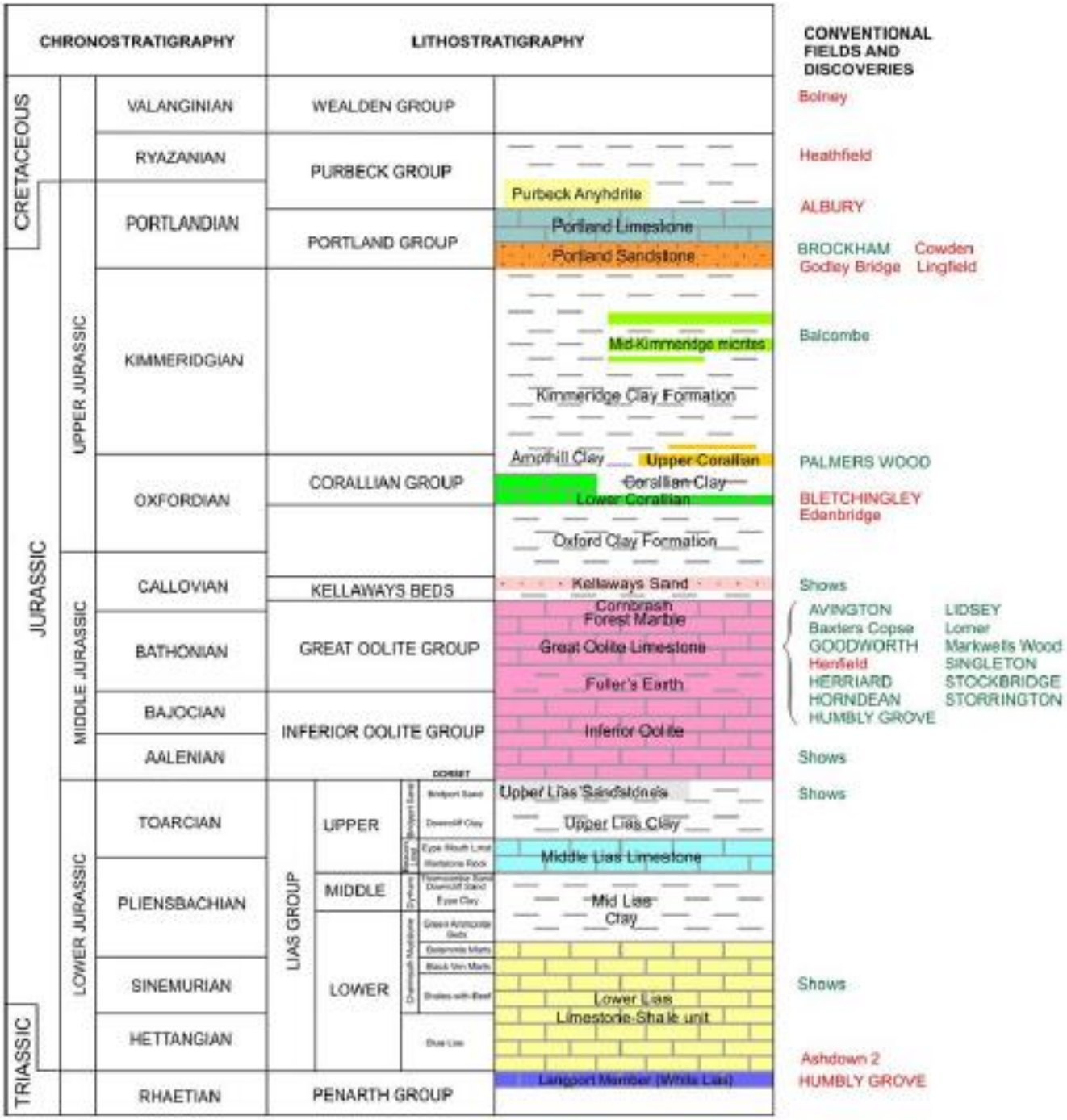
2.2.5 Extended Well Testing Operations from Existing Well Bore

The EWTs from within the existing well bore are planned as follows:

- EWT, with downhole pumping, of the Portland Sandstone;
- Flow-testing, with downhole pumping if required, of the Lower Kimmeridge Limestone;
- EWTs, with downhole pumping if required, of the Middle and Upper Kimmeridge Limestones;

Flow test periods may be curtailed depending on conclusions drawn from data acquired during each test.

Figure 2.2: General Stratigraphic Column, Weald Basin Including Well HH-1



Source: HHDL, redrawn from Andrews 2014

2.2.5.1 Workover Rig Details

It is proposed that a small workover rig carries out well operations required for each of the workovers listed above. Contractor selection for the work would take place closer to the time of the operations, but details of the typical workover rig and associated equipment currently available in the UK and suitable for this work are shown in Table 2.3.

Table 2.3: Indicative Details of Workover Unit

Model:	"Moor 400" self-propelled workover rig *(but brought to site on low-loader trailer)*
Servicing Depth	4000m (13123 feet) using 2 7/8 inch tubing)
Work Over Depth	3200m (10499 feet) using 2 3/8 drilling pipe)
Maximum Hook Load	212,500 lb
Engine	Detroit diesel engine Series 60
Rated Power of Engine	475 HP
Mast	Double stand
Mast Height (net height)	31.6m (103.6ft)
Diameter of Hoisting Line	26mm (1 inch)
Hook Lifting Speed	0.25-1.4m/s (0.82-4.59 ft/s)
Ground Clearance	310mm (12 inch)
Breaking system	Disk assisted brake
Rig Floor	Adjustable rig floor
Manufactured to	API standards and European Directives (CE Marked)
Other	Complete with 2 x Braden 2.5MT winches, air compressor and hydraulically-powered tubing power tongs.
Blow-out Preventer	11" 5000psi double ram preventer (blind + pipe ram) + 11" 5000psi annular preventer; includes accumulator unit and 5000psi choke manifold with choke and kill lines connected as well operations require.
Workover pump	Pump - 1 x Omega well Service T600 Triplex Output – 4.5" liners, max 281gal/min and 5000psi Power unit – Caterpillar Diesel
Circulating System	Bell nipple to intermediate tank; transfer via Sykes pump to single shale shaker mounted onto settling/suction tank. Additional standalone storage tanks will be used as required.
Additional Workover Equipment	Cementing equipment including high-pressure pump unit plus mixing system and bulk cement-handling equipment (pneumatic tank-trailer).

2.2.5.2 Waste Streams for Workovers

The waste streams expected to be generated by the above workovers are shown in Table 2.4 below, applying for each workover operation. The accumulation of waste will be stored on site within labelled skips or steel storage tanks, on top of an impermeable membrane, before being taken off site. The waste will be managed in accordance with the waste duty of care regulations and be transported via a licenced waste provider to a permitted waste facility. A daily inspection of the skips and tanks will take place by the Site HSE Advisor for integrity and segregation of waste.

Any waste leaving the site will be documented on a waste transfer note, which will be retained for 3 years. Records of waste movement will be available for inspection.

Table 2.4: Expected Waste Streams from HH-1 Workovers (Each)

Waste Stream	EWC	Estimated Quantity	Storage method
Cement (if used during workover)	17 01 01	5-10 tonnes	Mixed on site in mixing tanks; waste stored in sealed skips; these will be located in secondary bunds, removed by skip lorries to a licensed waste site.
Cementing pre-flush/casing cleaning pills and remnant mix water	01 05 04 01 05 06	10-15m³	Mixed on site in mixing tanks; waste stored in sealed skips; these will be located in secondary bunds, removed by skip lorries to a licensed waste site.
Inhibited light brine (suspension fluid)	01 05 04	25-50m³	Held in water tanks, removed by tanker to a license waste site.
Surface pad rain water runoff during operations	16 10 02	0-1,000m³	Held in site ditch, removed by tanker to a licensed waste site.
General waste	20 01 01 / 20 01 08	0-1,000 kg	Site skips removed by skip lorries to a licensed waste site.

2.2.5.3 Extended Well Testing Operations

Once the well testing completion equipment, including production tubing and downhole pumping equipment (if required), has been installed in the well, production testing is conducted through surface-based equipment, which provides for:

- Shutting in the well at any time with a remotely operable safety valve;
- Control of the production via a "choke manifold";
- Flow of produced reservoir fluids through high-pressure pipework;
- Separation of the produced fluid's 3 phases of oil, gas and water into individually controllable and metered flow streams;
- Storage of produced oil and produced water in segregated, vented tanks; and
- Safe disposal of produced gas via an enclosed flare system of a design approved by EA for this purpose. See Appendix 3 for design and functionality.

A detailed list of the typical equipment is given in Table 2.5. Exact equipment details are contractor-specific and may vary.

Well testing operations are conducted on a continuous basis, i.e. 24 hours/day and 7 days/week, and are also continuously manned by production testing technicians working on day-shifts and night-shifts (where necessary).

Table 2.5: Typical Well Testing Equipment

Item	Description
1	5000psi surface safety valve *connected to the flow head via high pressure pipework*
2	Emergency shut-down system *for remote activation of the surface safety valve*
3	Data header *manifold for pressure and temperature readings*
4	5000psi choke manifold *for control of flow rates from the well*
5	5000psi heater *to provide heat for efficient separation of oil, water and gas, and to avoid both hydrates and wax deposition*
6	1440psi 3-phase test separator *to separate and meter oil, gas and water*
7	Oil diverter manifold *to direct oil to the storage tank*
8	180 bbl stock tanks (3), 500 bbl Stock tanks (2) with vent *to separately store oil and water*
9	Transfer pump with air supply connection *to transfer oil and water from tanks and to road transport*
10	6000 psi flow head to choke manifold and 2000 psi pipework (to heater and test separator) *for transfer of separated oil and water*
11	Approved ground-mounted enclosed flare (EWT9.5) *for safe disposal of natural gases*
12	Well test lab/office and welfare facilities
13	Well test workshop container
14	Meter factor tank *for calibration of flow meters*
15	Pressure test pump *for pressure testing pipework and vessels*
16	Pressure test chart recorder + charts
17	Chemical injection pump *e.g. for wax inhibitor, glycol*
18	Surface sampling kit *for fluid sampling during testing*
19	Pipework thickness tester *for periodic equipment checks*
20	Manual data reporting system *for half-hourly recording of test data*

2.2.5.4 Acid Treatment for Formation Damage Removal

The productive capacity of the reservoir formations may have been impaired or “damaged” by the previous well suspension operations, and may be subject to further damage by the planned completion operations. To remove such damage and improve the flow of hydrocarbons from the formation, hydrochloric acid (HCl) at 15% concentration by weight with water (i.e. up to 150 kg of HCl with 850 kg of water), will be applied to the formation through the existing perforations within the well bore.

The operation is very similar to that used in the rehabilitation of public water supply and commercial water wells constructed within carbonate formations within the UK. The treatment formulation for an oil well includes a corrosion inhibitor to protect steel tubulars and a surfactant to aid in penetration and flow-back. Such an acid treatment is applied to the formation at low pressures and pump rates determined by an injectivity test, resulting in the acid being displaced into the near well bore formation to removed induced damage and increase the near well bore permeability. The typical treatment comprises:

- A pre-flush (spearhead) of 5m^3 surfactant solution;
- The main treatment of 16m^3 (100 bbl) of 15% HCl with corrosion inhibitor and surfactant;
- A displacement fluid of 20m^3 light potassium chloride or alternatively ammonium chloride brine containing typically 10% ethylene glycol monobutyle ether (EGMBE).

The treatment is applied down the production tubing in the well. Once the formation damage-removing treatment has been applied, the well is returned to production via the testing facility.

Other than the above damage removal treatment, well operations may be conducted from time to time during the testing phase in order to:

- Repair or replace the downhole pump;
- Install or remove a downhole shut-in tool with pressure gauges, for acquisition of reservoir pressure data;
- Acquire bottomhole samples of produced fluids;
- Conduct wax removal treatments, which may involve “hot oiling” (see below).

The additional equipment for the above, including the damage removal treatment, is listed in Table 2.6 below.

2.2.5.5 Hot Oil Treatment

Earlier testing at HH-1 confirmed the presence of dissolved waxes in the crude oil that can precipitate in the production tubing and wellbore area, restricting both the flow of hydrocarbons to the well, and the passage of mechanical tools in the tubing. Hot oil washing is a process of removing the build-up of wax precipitates within the production tubing and casing (if affected).

If required, heated oil, previously produced from the formation, will be pumped from the oil storage tanks, via a heater and mobile hot oil pump, and circulated down the well. The hot oil is pumped down the tubing to immediately above the perforations and circulated back to surface, dissolving or dislodging wax precipitates. The returning oil is diverted from the well at surface back to the oil storage tanks, where it is commingled with the produced oil. No waste is generated, as the returned waxy oil becomes part of the oil for export from site.

2.2.5.6 Waste Streams from Extended Well Testing

The waste streams expected to be generated by the above EWT operations are shown in Table 2.7 below.

Table 2.6: Additional Services and Equipment During HH-1 EWTs

Slickline/ wireline	Self-powered (diesel) slickline unit with 0.108 - 0.125" steel line with optional insulating coating for electric signal transmission and/or double-drum unit with multi-core electric wireline; minimum 1500m line spooled. Used to convey wireline tools in and out of the production tubing string.
Downhole pump surface drive	Surface electric pump drive, complete with control system.
Workover fluids pump	As per Table 2-2, together with steel tanks for a circulating system, for the application of the damage removal treatment in Section 2.2.1.
Hot oiling Equipment	Self-contained hot oiler unit comprising heating vessel and pump for application of the hot oil treatment (if required).
Further equipment	• Mobile crane for rod pump equipment installation and removal, and for support of slickline work • Silenced electric generator for total power requirements • Lighting towers for 24-hour operation • Silenced air compressor as required for services • Onsite office/accommodation and toilet facilities
Nitrogen gas	• Liquefied nitrogen in 2,000 gal cryogenic storage tanks for lifting of the well • A unit is used to heat up the liquid (convert to gas) and then it is pumped down the well • Nitrogen Lifting is the use of nitrogen gas circulated into the well to displace liquids and reduce the hydrostatic pressure created by the fluid column. • Nitrogen lifting will be used to initiate test production of the well following the work over

Table 2.7: Expected Waste Streams from HH-1 EWTs

Waste Stream	EWC	Estimated Quantity	Storage
Inhibited light brine (suspension fluid)	01 05 04	25-50m³	Water storage tank
Surface pad rain water runoff during operations	16 10 02	0-25m³	Containment ditch
Produced water	01 05 04	Capacity for storage is 180bbl; previous tests produced no water	180 bbl storage tank
General waste	20 01 01 / 20 01 08	0-1,000 kg	General skip
Gas to flare incinerated in enclosed flare system		250,000 scf/d maximum	Not stored
Venting from oil tanks		25,000 scf/d max	Not stored

The waste will be managed in accordance with the waste duty of care regulations and be transported via a licenced waste provider to a permitted waste facility.

2.2.6 Drilling Operations

Following the completion of the HH-1 EWTs, and contingent on favourable results of these tests, the subsequent drilling programme can be summarised as:

- Drill a deviated appraisal sidetrack from the existing HH-1 well and then conduct an EWT; and
- Drill a new deviated HH-2 appraisal well on the same site and conduct an EWT.

2.2.6.1 Sidetrack Drilling from HH-1

The drilling of the sidetrack will commence from within the existing 9-5/8" casing, by milling a “window” at a selected depth and then exiting from the donor well HH-1. A new 8-1/2" hole will then be drilled directionally, building inclination along the chosen azimuth. A 7" casing will then be installed and cemented into place. Following pressure testing, the shoe of the 7" casing is drilled out and nominally 6" hole is drilled laterally through the selected reservoir unit. A 4-1/2" drilled or slotted liner is then installed in the borehole.

The reservoir is prepared for production by circulating 15% hydrochloric acid along the length of the productive section of the borehole (see Section 3.4) and displacing it into the natural fracture system, to remove drilling-induced formation damage. A 2-7/8" or 3-1/2" tubing completion is run for the EWT, with downhole pumping as required with declining reservoir pressure.

2.2.6.2 Drilling of New Well HH-2

The concept for the new well will be as follows:

- A new well cellar to be constructed, around 6m north of the existing HH-1 well cellar;
- Conductor pipe set and grouted at a shallow depth below ground level;
- Surface casing set and cemented
- Production casing set and cemented
- Production borehole drilled through the reservoir and then lined with a drilled (or slotted) uncemented liner;
- Water-based “spud mud” to be used for the conductor and surface holes, followed by water-based polymer “drill-in” fluid for the intermediate and reservoir sections;
- Tubing completion installed for EWT.

2.2.6.3 Drilling Rig Details

The main contractor for drilling will be engaged closer to the time of operations, and so rig details are not fixed. However, an example of a drilling rig in the UK, which can meet the requirements is British Drilling & Freezing’s (BDF) Rig 28, and its details are listed in Table 2.8 below. There are other drilling rigs currently in the UK which could also meet the operational requirements, and they are similar to, or smaller than Rig 28 in terms of rated capacity and overall height.

2.2.6.4 Waste Stream from Drilling Operations

The waste streams expected to be generated by the above sidetracking drilling operations are shown in Table 2.9 below, and from the drilling of the new HH-2 well in Table 2.10.

Table 2.8: Example Details of a Suitable Drilling Rig

Rig Contractor / Unit Name	British Drilling & Freezing Rig 28
Rig Type	Ideco "Back In Rambler" (BIR) 5625
Mast	Ideco KM 108 270 KH telescopic mast - 32.93m (108') clear height with an API static hook load of 270,000 lb
Substructure	3.66m (12ft) clear working height with 300,000 lb setback capacity
Drawworks	Ideco H37 double drum drawworks with 349KW (465HP) Detroit 12 V 71 power
Mud pumps	2 no. Gardner Denver PZ9 triplex pumps each with Caterpillar 3512 power providing 1875kW (2500HP) in total.
Mud tanks	740 bbl mud tank system
Blow-out Preventers	13 5/8" x 5,000psi Cameron U double ram BOP stack with Hydril GK 13 5/8" x 3000psi annular BOP
Sound attenuation	All major units are acoustically clad allowing Rig 28 to operate in environmentally sensitive areas.
Additional Equipment (3rd party contractors)	Cementing equipment including high-pressure pump unit plus mixing system and bulk cement handling equipment (pneumatic tank-trailer); Mud logging unit Directional drilling equipment and work unit Wireline logging equipment

Table 2.9: Expected Waste Streams from HH-1 Sidetrack

Waste Stream	EWC	Estimated Quantity	Storage
Cement	17 01 01	5 – 10 tonnes	Skips
Cementing preflush / casing cleaning pill	01 05 04 01 05 06	50 – 100 bbl (8 - 16m³)	Tanks
Inhibited light brine (Suspension fluid)	01 05 04	25-30m³	Tanks
Surface pad rain water runoff	16 10 02	0-1000m³	Site ditch
Water based mud (see Section 4.1)	01 05 04	1000 bbl (160m³)	Tanks
Drill cuttings (see Section 4.1), including waste gravel and crushed rocks	01 04 08/ 01 04 09	360 tonnes	Skips
General waste	20 01 01 / 20 01 08 / 20 03 01	500 kg-1000 kg	Skips

As previously described, waste will be stored on site within labelled skips and steel storage tanks, on top of an impermeable membrane, before being taken off site. The waste shall be managed in accordance with the waste duty of care regulations and be transported via a licenced waste provider to a permitted waste facility. A daily inspection of the skips and tanks will take place by the Site HSE Advisor for integrity and segregation of waste.

Table 2.10: Expected Waste Streams from HH-2 New Well

Waste Stream	EWC	Estimated Quantity	Storage
Cement	17 01 01	5 – 10 tonnes	Skips
Cementing preflush / casing cleaning pill	01 05 04 01 05 06	50 – 100 bbl	Tanks
Inhibited light brine (Suspension fluid)	01 05 04	25-30m³	Tanks
Surface pad rain water runoff	16 10 02	0-1000m³	Site ditch
Water based mud (see Section 4.2)	01 05 04	1320 bbl (210m³)	Tanks
Drill cuttings (see Section 4.2), including waste gravel and crushed rocks	01 04 08/ 01 04 09	610 tonnes	Skips
General waste	20 01 01 / 20 01 08	500-1,000 kg	Skips

Any waste leaving the site will be documented on a waste transfer note, which will be retained for 3 years. Records of waste movement will be documented and be available for inspection.

2.2.6.5 Coil Tubing/Acidising Operations in New Wellbores

Each new well is expected to require acidising with coiled tubing in a similar manner, as outlined in Section 2.2.5.4, for the removal of drilling-induced formation damage. However, as the new production boreholes will be deviated, it is common to place the acid in the borehole using a reel of coiled tubing.

As each well is treated with acid, experience will be gained in the response of the formation to the treatment and this is expected to provide for treatment optimisation. Some beneficial variation to the treatment schedule may therefore be warranted, based on that growing experience. This section provides a summary of operational details associated with performing coiled tubing operations to enable acidising of the horizontal reservoir section. Coiled tubing size will be 1-3/4" to 2".

The coiled tubing service will be mobilised to site and rigged up over the well, see Table 2.11. A crane is used to spot the equipment and then to hold the coiled tubing injector head in place over the well during the operations. The coiled tubing is run into the hole and 15% hydrochloric acid (HCl) circulated over the nominally 6-1/8" production borehole section and squeezed into the formation porous spaces. The acid reacts (“spends”) quickly with the calcareous (limestone) formation rock, and the spent acid is then flowed back to surface. The flow-back and test production initiation is typically assisted with nitrogen lifting, via the coiled tubing. The coil tubing and associated equipment are then demobilised and the well is left available for flow testing and production.

An indicative schedule of treatment fluids and volumes, for the treating of up to 1,000m of drilled Kimmeridge Limestone section, is as follows:

- "Pre-flush" of circa 50bbl (8m^3) 3% potassium chloride brine containing 2 to 3 drums of PROTEKT-318 surfactant;
- Acid treatment of 200-300 bbl (32 – 48m^3) PROTEKT 15 PLUS formulation of 15% hydrochloric acid together with corrosion inhibitor (to protect the steel tubulars from acid corrosion) and surfactants (to aid the acid in entering the formation pores and then returning the spent acid from the well);
- Displacement fluid (volume dependent on the volume of the coiled tubing string) and overflush of circa 110 bbl (18m^3) 3% potassium chloride brine.

Table 2.11: Coiled Tubing and Acidising Equipment

Item	Description
Coiled tubing unit	Coiled tubing reel of 1.75" to 2" OD, 90,000 psi yield strength; 10,000ft (or more) on reel. Including tubing injector head and BOP stack.
Stimulation pump unit	Triplex pump unit, diesel-powered, with circa 4" triplex fluid end and 3,000-5,000 psi working pressure rating; suitable pump units are mounted on either a skid, a trailer or directly onto a truck chassis.
Acid storage / mixing	Typically supplied as 15% inhibited formulation in 1,000 litre transport containers; transported to site in lots of 16–20 on standard road transport trailers, for unloading on site in a bunded area.
Nitrogen converter	Single 90,000 scf/hr (or 180,000 – subject to availability) unit to convert liquid nitrogen to gas; minimum 5,000 psi working pressure, feed from two or more 2000 gal cryogenic nitrogen storage tanks.
Mobile crane	Typically, 80-100 tonne self-propelled and self-erecting crane to spot equipment and hold the coiled tubing injector head and pressure control equipment in place over the well.
Slickline unit	A slickline unit may be required for operations such as running/retrieving pressure gauges, running other measurement sondes into the wellbore, and manipulating flow control equipment run in the well completion (e.g. sliding side doors). Mounted on either a truck, a trailer or on a skid for spotting directly on the site.

2.2.6.6 Waste Streams from Acidising Operations

The waste streams expected to be generated by a single coiled tubing/acidisation as described above are shown in Table 2.12 below.

Table 2.12: Expected Waste Streams from Coiled Tubing/Acidising

Waste Stream	EWC	Estimated Quantity	Storage
Inhibited light brine (suspension fluid)	01 05 04	25-50m^3	Tanks
Surface pad rain water runoff during operations	16 10 02	0-500m^3	Site ditch
General waste	20 01 01 / 20 01 08	0-500 kg	Skips

The accumulation of waste will be stored on site within labelled skips or steel storage tanks on top of an impermeable membrane before being taken off site. The waste will be managed in accordance with the waste

duty of care regulations and be transported via a licenced waste provider to a permitted waste facility. A daily inspection of the skips or tanks will take place by the Site HSE Advisor for integrity and segregation of waste.

Any waste leaving the site will be documented on a waste transfer note, which will be retained for 3 years. Records of waste movement will be documented in a waste management plan and be available for inspection.

2.2.6.7 Waste Streams from Extended Well Testing of HH-1 Sidetrack and HH-2

The additional services and equipment for the EWTs of the HH-1 sidetrack and HH-2, including the damage removal treatment, are listed in Table 2.13 below. The waste streams expected to be generated by the EWT operations are shown in Table 2.14 below.

Table 2.13: Additional Services and Equipment During HH-1 Sidetrack and HH-2 EWTs

Slickline/ wireline	Self-powered (diesel) slickline unit with 0.108 - 0.125" steel line with optional insulating coating for electric signal transmission and/or double-drum unit with multi-core electric wireline; minimum 1500m line spooled. Used to convey wireline tools in and out of the production tubing string.
Downhole pump surface drive	Surface electric pump drive, complete with control system.
Workover fluids pump	As per Table 2-2, together with steel tanks for a circulating system, for the application of the damage removal treatment in Section 2.2.1.
Hot oiling Equipment	Self-contained hot oiler unit comprising heating vessel and pump for application of the hot oil treatment (if required).
Further equipment	• Mobile crane for rod pump equipment installation and removal, and for support of slickline work • Silenced electric generator for total power requirements • Lighting towers for 24-hour operation • Silenced air compressor as required for services • Onsite office/accommodation and toilet facilities
Nitrogen gas	• Liquefied nitrogen in 2,000 gal cryogenic storage tanks for lifting of the well • A unit is used to heat up the liquid (convert to gas) and then it is pumped down the well • Nitrogen Lifting is the use of nitrogen gas circulated into the well to displace liquids and reduce the hydrostatic pressure created by the fluid column. • Nitrogen lifting will be used to initiate test production of the well following the work over

The waste will be managed in accordance with the waste duty of care regulations and be transported via a licenced waste provider to a permitted waste facility.

Table 2.14: Expected Waste Streams from HH-1 Sidetrack EWT and HH-2 EWT (Each)

Waste Stream	EWC	Estimated Quantity	Storage
Inhibited light brine (suspension fluid)	01 05 04	25-100m³	Water storage tank
Surface pad rain water runoff during operations	16 10 02	0-500m³	Containment ditch
Produced water	01 05 04	Capacity for storage is 180bbl; previous tests produced no water	180 bbl storage tank
General waste	20 01 01 / 20 01 08	0-1,000 kg	General skip
Gas to flare incinerated in enclosed flare system		250,000 scf/d maximum	Not stored
Venting from oil tanks		2,500 scf/d maximum	Not stored

3. WASTE PREVENTION AND REDUCTION

The drilling process differs from a manufacturing process in that it is a relatively short duration operation that, in principle, uses only volumes of raw materials and components as needed to complete the drilling. The activities will be conducted so as to prevent waste production wherever possible, and to reduce the quantities generated in all other cases applying the Waste Hierarchy Principles. However, the nature of the operations giving rise to the extractive waste that are the subject of this Plan means that it is practically impossible to de-couple waste creation from the originating process. It is also subject to a degree of variation, and whilst every effort will be made to conserve natural resources and therefore generate as little waste as possible, the precise characteristics encountered in the target reservoir will mean this is subject
to change.

Prevention and minimisation will be applied as follows:

3.1 Fluids

Volumes are calculated in advance of the drilling operation, planned drill to target depth. The drilling process is monitored by the Drilling Fluids Engineer, and along with the mud logging process this enables monitoring of volumes of fluids pumped and returned.

Drilling muds deposit a thin layer of low permeability solids called a filter cake around the sides of the borehole. Loss circulation materials are added to the drilling muds in permeable formations to form a non-permeable layer that prevents any loss of drilling fluids into these formations.

The WBM is recirculated and reused until spent. Treatment for re-use consists of removal of solids (through the use of shale shakers and centrifuges) and fluid loss control (replacing lost water). WBM treatment generally becomes uneconomical after a certain amount of use of the mud, at which point the mud become waste.

Estimated waste quantities, classification and management controls are summarised in each section of the programme using the following logic:

- The drilling fluid used determines the total amount of waste. It is assumed that this results in a total waste volume when using WBM (factor 4 x volume of hole);
- The total anticipated volume of drill cuttings is very conservatively estimated as around 70% greater than the hole volume,
- This results in fluid waste volumes of WBM, see Appendices 1 and 2.

3.2 Cuttings

Cuttings only arise from the drilling of the borehole to its target depth. The drill bit size reduces with depth to reduce hole size and therefore reduce the cuttings volume. The volume of cuttings is conservatively estimated based on simple geometric considerations, as discussed in Section 3.1 above. Estimated waste quantities, classification and management controls are summarised in each programme section. Hazardous and non-hazardous waste are generated at different times in the well operation and will be kept separated throughout the programme, to enable appropriate waste classification as required under Hazardous Waste Regulations.

3.3 Cement

Pumped volumes are controlled to minimise returns at surface. Returning cement cannot be reused on site but, due to the small quantities involved, the solidified cement can be sent for recycling to an offsite permitted waste treatment facility. Estimated waste quantities, classification and management controls are summarised in each programme section. Hazardous and non-hazardous waste are generated at different times in the well operation and will be kept separated throughout the programme to enable appropriate waste classification as required under Hazardous Waste Regulations.

3.4 Natural Gas

Fugitive emissions will not occur in the normal operation of the borehole. The drilling fluids are designed to provide a hydrostatic overpressure above the expected formation pressure and thus prevent any such fugitive emissions. In addition, continuous monitoring instrumentation indicates any gas content/pressures during drilling and, on detection, the hydrostatic pressure of the drilling fluids will be increased (by use of heavier fluids) to prevent such gas releases. Additional control is provided by well shut-in procedure at surface (including the use of the Blow Out Preventer, BOP).

Gases liberated from drilling any hydrocarbon bearing formation and entrained in the drilling mud collect in a gas trap in the return mud line, which is continuously sampled in real time for total gas content.

Separate ambient H_2S detectors are also operating throughout the drilling operation with an audible alarm.

In the unlikely event of an unplanned accident scenario, when the above controls fail, the drilling rig will shut the well in by closing the BOP and will vent any such gas arriving at the surface to the enclosed flare to be incinerated.

Most of the gas separated from the oil will be incinerated by enclosed flare. See Appendix 3. Some of the gas will be carried over in the oil to the storage tanks. Any gas released from the oil in the storage tanks will be naturally vented. This will be monitored and volumes calculated.

EWT9.5 Enclosed Flare

General Description

Landfill Systems and PWWT have collaborated to design and manufacture the EWT range of enclosed gas flares for short-term and extended gas well testing applications.

The model nomenclature is defined by the range type and the maximum capacity; e.g. “EWT 9.5” denotes an enclosed well test gas flare with a height of 9.5m and a maximum flow capacity modified to restrict capacity to 250 mscf/d.

The flare design is based on a 2-stage burner for a varied range in flow rates. The capacity is restricted by reducing the number of burner nozzles in the second stage. The first stage will contain around 50 burner nozzles. The second stage has been reduced from 50 to 25 burner nozzles to cap capacity whilst keeping the flexibility to allow the unit to maintain efficient combustion.

The plant components are mounted on a substantial galvanised steel underbed ("skid"). The weatherproof control enclosure is also mounted on the skid. The control system is PLC based with control interface and process indications provided by a colour HMI touch-screen panel.

The plant has a compact footprint. Typically, it is delivered ready assembled on a single vehicle. If the vehicle has an on-board crane of sufficient capacity, it can be used to off-load the gas flare in a very short time. Once the gas, electrical and pneumatic supplies are connected, the plant is ready to run.

1. Applications

The plant is an economical solution for gas well testing and safely flaring well gas. It can be used for short-term well testing and extended well testing.

2. Principal Features

- Designed to be UK EA emissions compliant.
- Safe and controlled combustion process.
- Ignition of the gas via proprietary high integrity propane ignition lance.
- Concealed combustion process; no visible flame thus minimising visibility impact.
- Automatic temperature control.
- Rapid installation and commissioning.
- Ready to run.
- Easy maintenance.
- High quality components.
- Rugged construction.
- Remote monitoring and control by smart phone or internet enabled computer.

The EWT9.5 enclosed flare is similar in construction to a conventional landfill gas flare in that it consists of a large open topped steel cylinder, which is lined with a refractory material. The main function of this material is to reduce heat losses from the combustion process thus helping to maintain the temperature of the combusted gases for the required residence time. The secondary (though essential) function is to prevent thermal damage to the steel cylinder. The lined cylinder forms a combustion chamber and exhaust stack. The flow of combustion and cooling air in to the chamber is controlled by automatically actuated air dampers fitted at the base of the cylinder. Here the similarity to a landfill gas flare ends.

A stainless-steel combustion system is installed within the chamber at low level but above the air dampers. The combustion system consists of multiple pre-mix burner heads, each with an interchangeable gas nozzle and venturi gas mixing system. The combustion system is divided into two sets of burners, which can be controlled sequentially. The combustion process is ignited by a proprietary industrial pilot light system. The pilot light is fed from a bank of propane cylinders. Once the pilot light is lit and is stable, the control system will allow the main gas flow to be introduced to the combustion chamber by one or both gas flow control valves, depending on the gas flow available. The pilot light remains lit throughout the flare operation.

There will be a small amount of venting from the oil storage tanks, as a standard safety precaution. The oil storage tanks are intended to operate at atmospheric pressure.

3.5 Normally Occurring Radioactive Material (NORM)

HHDL already holds a RSR Standard rules permit, number EPR/AB3498DZ/A001.

HHDL will regularly monitor fluids, solids and equipment being removed from the borehole for NORM. The Radiation Protection Supervisor (RPS) will undertake monitoring to determine if equipment or items are NORM contaminated.

Samples should be taken from all material either known (positive hand held monitoring indication) to be NORM contaminated or if it is suspected of being NORM contaminated. When monitoring by the RPS identifies NORM contaminated or suspected NORM contaminated items, they will collect one or more representative samples of the material. Where the material produces a radiation signal then the sample should be taken from the most accessible point where the radiation signal is the highest.

The minimum sample size should be approximately 100-200g and should be collected in a standard gamma spectrometry pot. The sample containers will be requested by HHDL from an appropriate supplier and HHDL will undertake the sampling.

Each sample container will be allocated a unique reference number (URN) upon issue, by HHDL Operations, to allow tracking of the sample through the analysis process. The RPS will collect, monitor and package the sample, to ensure that the items falls within the transport definition of an accepted package, and return it to the appropriate Manager who is responsible for arranging shipment to an analysis laboratory. HHDL will contact the Radiation Protection Advisor (RPA) prior to samples being dispatched who will provide the appropriate documentation to HHDL and will contact the analysis laboratory informing them to expect samples for analysis. It is important that HHDL do not ship samples until the receiving laboratory has acknowledged that they are willing to accept the samples. HHDL will package the samples in accordance with ADR legislation and arrange shipment.

Where NORM contaminated equipment is to be stored, the items must be protected to minimise the loss of NORM from the item. This will usually involve wrapping and sealing the object in polythene, end-capping tubulars, valves etc. NORM contaminated materials and NORM waste will be stored separately from other materials and wastes.

The NORM contaminated items must then be placed in secure bunded storage with a roof to provide weather protection, and signage to indicate NORM storage and any prohibitions as appropriate e.g. Controlled Area etc. Controlled areas will be signed and monitored as identified in the local rules for the storage area. NORM items identified for disposal must be disposed of in accordance with permit conditions via a permitted 3rd party waste recipient.

4 FLUIDS AND CHEMICALS

The drilling process involves the use of drilling fluids (muds) that are circulated down the drill string and through the drill bit in order to remove the drilled formation cuttings, maintain hydraulic pressure and lubricate and cool the drill string and drill bit. Drilling fluids used in Horse Hill wells will be water based inhibitive drilling fluids (WBM) containing salts such as potassium chloride (generally at a level of 3 to 7%).

Clay inhibitors will also be added to the WBM drilling fluids to prevent clay swelling in upper formations. They are typically used for drilling water sensitive formations. The additives reduce clay swelling or dispersion and the consequent borehole sloughing and colloidal solids retention in the mud.

WBM contains additives to improve drilling performance, or to address contingent impacts. The base chemicals and potential additives that may be used in the Horse Hill wells are listed in Appendices 1 and 2.

Note that the Ground Water Risk Assessment (Appendix 4) provides detailed information and should be used as the reference source if more information is required.

5 SITE OPERATIONS AND WASTE TREATMENT

5.1 General

The activities will be conducted so as to prevent waste production wherever practicable, reducing the quantities generated. In all cases the Waste Hierarchy Principles will be applied, in order to reduce the amount of material sent to landfill for final disposal, applying recovery/recycling best practice where appropriate. However, the nature of the operations giving rise to the extractive wastes means that it is in essence impossible to de-couple waste creation from the originating process. The drilling process is also subject to a degree of variation, and, whilst every effort will be made to conserve natural resource, and therefore generate as little waste as possible, uncertainty around the precise rock/material characteristics encountered in the target reservoir will mean that this is subject to change.

5.2 Fluids

Drilling muds are stored on site in high volume watertight storage tanks, circulated down through the drill bit and returned to surface via enclosed lines. The returned drilling muds are passed through mechanical separation devices (known as “shakers”) which are used to extract solid drill cuttings.

Further centrifugal treatment is used to remove finer drill cuttings from the muds. Continual sampling and analysis of the drilling muds monitors solids content within the circulated fluids.

Once the drilled solids content of the WBM mud reaches 6 to 10% by volume, it is considered degraded in terms of drilling performance and is pumped to open topped skips for off-site transfer via vacuum loading road tanker.

The waste drilling muds will be removed by vacuum loading road tanker to a permitted waste treatment facility. The ultimate end waste management route for drilling muds will be dependent on the material composition; it is anticipated that WBM will be transferred for disposal.

The mud storage tanks will be subject to thickness inspections and weekly visual integrity inspections.

5.3 Cuttings

Cuttings that are separated at the surface from the drilling muds, as described above, are stored in steel rectangular watertight open skips with a capacity of up to 40m³. Skips are covered during storage and for transportation off site. The cuttings containers are subject to thickness inspections and daily visual integrity inspections. The containers are transferred onto trailers and subsequently removed to one of several facilities that are appropriately permitted to receive, keep, store and treat industrial wastes of this nature (or exempt from the requirement to hold a permit) and are typically graded into recycled aggregate. Vacuum loading road tankers will be used for drill cuttings waste with a high liquid content.

5.4 Cement

Cement returned to the surface is temporarily stored in skips before being sent off site to a permitted waste treatment facility. Cement returns are minimised by controlling the volumes pumped into the well.

6 ENVIRONMENTAL RISK MANAGEMENT

6.1 Environmental Risk Assessment

An Environmental Risk Assessment has been carried out and is documented in Appendix 5. It is in compliance with the requirements of the EA guidance, H1 Environmental Risk Assessment for Permits, Version 2.1, December 2011 and EPR6.14 "How to comply with your environmental permit, additional guidance for: mining waste operations, Version 2, February 2011". This qualitative assessment has considered noise, traffic movement, fugitive emissions, air emissions, releases to water environment, waste and potential for accidents and incidents as these relate directly to the activities.

The assessment concluded that, with the implementation of appropriate risk management measures, potential hazards from the activities are unlikely to be significant.

6.2 Environmental Risk Mitigation

The Environmental Risk Assessment in Appendix 5 details the risk control and mitigation measures that HHDL will put in place.

7 CONTROL AND MONITORING

The Environment Risk Assessment demonstrates that, due to the nature of the waste to be generated and the proposed risk control and mitigation measures, there will be no significant environmental risk and hence only limited monitoring of selected parameters is proposed as listed below.

The quantity of waste arising each day will be monitored and recorded, along with the quantities despatched off-site for disposal. This data will be reviewed in daily operational site meetings and used to inform waste prevention and reduction strategies.

The results of all such monitoring will be used: to inform changes to this Waste Management Plan, and be shared with EA.

7.1 Fugitive Air Emissions

The Environmental Risk Assessment has concluded that any air emission quantities are expected to be very minor and deemed to pose a low environmental risk, as all emissions from the well will be incinerated via the enclosed flare system. See Appendix 3 for details.

A small amount of air emissions will be vented via the vent stack on the oil storage tanks.

7.2 Mud

The well pad is designed, following standard industry practices, as a stable working platform to support the rig and all associated equipment. The surface is formed with a minimum of 300 mm of granular material (Type 1 material) and is fully lined underneath the stone with a 1mm thick impermeable geomembrane made from HDPE, which is continuous through to a perimeter interceptor ditch. Access to the site is achieved via use of a tarmac entry point from the Horse Hill road and the existing access track, with surface improvements where necessary (involving the widening of the track width to accommodate large vehicles and upgrading using surface stone, where necessary).

A daily inspection of the road immediately at the junction of the site entrance will be performed to ensure that any potential mud deposits from road tankers visiting to collect extractive waste does not become a problem. Should mud deposits be a problem on Horse Hill road, this mud shall be cleaned away using a roadsweeper vehicle.

7.3 Odour

Based on prior experience, the extractive waste that will be generated is not malodorous and nor are any of the associated processes that will be performed. All Gaseous emission will be incinerated by an enclosed flare system, see Appendix 3.

There will be a small amount of venting from the oil storage tanks, as is standard practice. The emissions volumes will be insignificant.

7.4 Noise/Vibration

Road contractors are required to manage HGV deliveries via a Traffic Management Plan agreed with SCC. Road tankers visiting the site to collect extractive waste may be fitted with audible reversing alarms. Noise will be maintained within the levels specified by the relevant planning condition.

The site is not in close proximity to residential properties and the anticipated noise levels during well testing and drilling at the site are not predicted to be significant, see Appendix 10. In addition, the site will be screened by both natural features (established woodland) and an 81m long x 6m high acoustic and light barrier, to the south of the well pad, providing additional sound attenuation.

As defined in the Site Condition Report, HH-PR-Q04, noise monitoring will be undertaken at pre-determined locations around the boundary of the site and close to sensitive receptors throughout construction and drilling activities. If any complaint is received, the complaint will be logged and recorded and an investigation will be conducted into the causes of the complaint. The findings will inform further monitoring and risk control arrangements and may lead to additional mitigation measures. Details of any such complaints and any remedial action taken or planned will be discussed with EA.

7.5 Accidents

The environmental risk of an accident is predominantly associated with the potential for spillage of extractive wastes. Given that (i) the site is constructed with a large impermeable geo membrane layer providing spillage containment, (ii) that pipework and the associated storage tanks will be installed in protective bunds of the same material and inspected daily for leaks and damage, (iii) that the site has a perimeter ditch to prevent any spills leaving the site, and (iv) that the site is not situated in a Source Protection Zone (with no potable water abstraction activities in the site boundary or immediately nearby, see Appendix 7), the environmental risk assessment has concluded the risk of spills to be low.

Nonetheless, it is proposed that nearby surface water features will be sampled and tested to identify the presence of extractive waste contaminants prior to construction starting and at regular intervals during construction and drilling as defined in the Site Condition Report, HH-PR-Q04.

The results of this monitoring will be recorded and will form the future monitoring for the Site Closure Plan, see Section 8. Details of any accidents, and HHDL's response, will be shared with EA and with other regulators as appropriate.

7.6 Fluids and Cuttings

Appropriate storage capacities will be provided for WBM that is to be disposed of. It will be handled as a non-hazardous material/waste.

Quantity of waste arising each day will be monitored and recorded, along with quantities dispatched off site for disposal. This data will be used to inform waste prevention and reduction strategies. Fluid and solid drilling waste are sampled at the first available opportunity when drilling commences, for chemical analysis and any other additional waste acceptance criteria, as requested by the offsite permitted waste treatment facility.

7.7 Cement

The quantity of waste arising each day will be monitored and recorded, along with the quantities dispatched off site to a permitted waste treatment facility. Records will be kept on site

7.8 Complaints

If any complaints are received from stakeholders, including local residents, they will be recorded, investigated and responded to without delay in accordance with HHDL's existing complaints handling procedures. Complaints will additionally be reported to EA, with whom actions to avoid recurrence will be agreed.

8 PLAN FOR CLOSURE

In the event that neither new well encounters hydrocarbons, or that the Phase 1 flow testing results do not justify drilling of new wells, the wells will be permanently plugged and abandoned (P&A) by setting cement plugs and the drilling rig released.

This P&A operation will be carried out in compliance with regulatory and industry guidelines, to leave the well in a permanently safe state.

This process will involve the following:

- Conditions of the current planning consent for the Horse Hill-1 site set out the requirements for restoration and aftercare of the site (ref RE10-2089 of 16th January 2012) as follows:
    - **Condition 34:** the agricultural restoration of the access track within the field, the farmers track and the drill site shall be carried out in accordance with the principles set out in Appendix G of the planning application. Prior to the commencement of the development hereby permitted, further details of the restoration to be implemented on the cessation of the site decommissioning shall be submitted to the County Planning Authority for approval in writing. Details shall be provided of:
        - The programme for the implementation of the restoration;
        - The removal of the site access and its tarmac surface, the restoration of the access to woodland shall extend 20 m from the boundary of Horse Hill and include the bell mouth radii and vehicle passing place;
        - Planting specification including details of species, size and spacing for the woodland area;
        - The regeneration of the access track;
        - The planting specification for the agricultural restoration of the access track, farmers track and drill site including planting specification. The details as approved shall be carried out in full.
    - **Condition 35:** all planting implemented pursuant to this permission shall be maintained in good healthy condition and be protected from damage for five years from the completion of site restoration. During that period any trees or shrubs which die, or are severely damaged or diseased shall be replaced in the next available planting season with others of a similar size and species.
    - **Condition 36:** the restored land shall be brought to the required standard for agricultural and woodland use. The applicant shall notify the County Planning Authority when the planting or seeding has been completed and not more than one year after that date there shall be a meeting at the site which shall be attended by representatives of the applicant, the owners or their successors in title and the County Planning Authority, to monitor the success of the aftercare. Should it prove necessary, further meetings will be held within the period of five years from the commencement of aftercare. These, and all other Planning Conditions, will be complied with.
- The well will be plugged and abandoned following industry best practice and regulatory requirements as set out in guidance by:
    - Borehole Sites & Operations Regulations 1995 (BSOR);
    - Land based requirements of the Offshore Installations and Wells (Design & Construction, etc.) Regulations 1996 (DCR);
    - Oil & Gas UK Guidelines for the Suspension & Abandonment of Wells, July 2012; and

- UK Onshore Operators Group Guidelines.

These approaches will be reviewed and endorsed by both an independent well Examiner and the regulator (HSE).

The process to plug and abandon the well will involve:

- Pumping cement into the well to create a series of plugs
- Removal of the wellhead,
- Cutting the casings and sealing them below ground level.
- Pollution control requirements will be maintained as per the drilling phase until the abandonment of the well has been completed.

When the well is plugged and abandoned, a closure plan will be developed, agreed with SCC, EA and the site landowner and implemented as discussed above; the Mining Waste Permit will then be surrendered.

During the period prior to surrender of the permit, as required by EA's guidance "How to comply with your environmental permit. Additional guidance for: mining waste operations", the following actions will be implemented:

- Any environmental management and monitoring systems (as defined in the Site Monitoring Plan, HH-PR-Q04) will be maintained and operated until the point of surrender;
- Any aftercare requirements necessary to satisfy other regulatory regimes will be implemented and followed;
- EA will inspect the facility to confirm that all required actions under the permit have been completed.

9 MEASURES TO PREVENT POLLUTION

The detailed site condition assessments submitted to SCC, in support of the new planning application for the Appraisal Project at Horse Hill, along with the risk assessments for this Waste Management Plan (see Appendices 5,6 and 7) have identified all the potential hazards and pollutant linkages at the site relating to the management of the extractive waste, the risks they pose, and the risk control measures that HHDL will implement in order to mitigate those risks.

These risk control measures are considered to meet the requirements of the Mining Waste Directive, including the need to prevent water status deterioration and soil pollution and are listed below:

- **Direct discharges of extractive waste**: There will be no leachate generated at the site. There will be no deliberate discharges of extractive liquid waste directly to the environment from the site. Measures to prevent the pollution of soil and accidental releases of waste that could cause pollution of surface water and groundwater have been considered and mitigation measures within the environmental risk assessment implemented on site.
- **Indirect discharges of extractive waste**: Mitigation measures are in place to prevent indirect discharges of extractive waste arising from accidents, leaks or percolation into the environment. The mitigation measures are documented with the environmental risk assessment.

10 APPENDICES

Appendix 1: Mud and Drilled Cuttings Volumes, HH-1 Sidetrack

The tables below give estimates of the volumes of drilling fluids and cuttings that are expected to result in waste streams for disposal. The table overleaf gives a list of the expected components used in the drilling fluids, including cementing pre-flushes and completion brine, and a list of contingency products that may be required. Volumes and quantities are estimates only, and will vary according to geological, drilling conditions and final depths drilled.

Drilling Fluids Calculations: HH-1 Sidetrack

Mud Type		N/A	9-5/8" csg	Salt-Polymer	KCl-Polymer	Total
Drilled hole diameter, in		N/A	N/A	8.5	6.125	
Hole start, ft		0	0	2500	3400	
Hole TD, ft		0	2500	3400	8000	
bbl/ft		0.30	0	0.07	0.04	
% Excess		30	0	25	25	
Installed casing:		13.375	9.625	7		
lb/ft		61	40	26	n/a	
bbl/ft		0.15	0.08	0.04	0	
Mud dilution bbl/ft		0	0	0.3	0.2	
Start surface, bbl		0	0	200	200	
Last casing, bbl		0	0	190	131	
Hole volume, bbl		0	0	64	168	
Over-gauge, bbl		0	0	16	42	
Maintenance volume, bbl		0	0	270	920	
Total required, bbl		0	0	740	1461	
Volume behind casing, bbl		0	0	0	0	
Transfer/dispose	Transfer	N/A	N/A	Dispose	Dispose	
Transfer volume, bbl		0	0	0	0	
Mud volume, bbl		0	0	740	1461	
Liquid disposal * volume, bbl		0	0	470	541	1011
Wet cuttings ** volume, bbl		0	0	334	1088	1422
Wet cuttings, tonne		0	0	107	346	453

* Liquid disposal = whole mud left at end of section, if not transferred
** Wet cuttings = rock volume + mud maintenance (dilution) volume

Drilling Fluids Calculations: HH-1 Sidetrack

GENERIC PRODUCT REQUIREMENT *subject to change depending on supplier*

per bbl	Mud Composition:	Total Amounts						Units
	Drilled hole diameter, in		N/A	N/A	8.5	6.125		in
	Mud volume, bbl		0	0	740	1461		bbl
0.9	Water		0	0	666	1315	1981	bbl
0.125	Caustic soda		0	0	93	183	276	lb
0.125	Soda ash		0	0	93	183	276	lb
20	Bentonite		0	0			0	lb
20	Barite						0	lb
110	Salt				81400		81400	lb
5.0	Potassium chloride					7305	7305	lb
0.5	Magnesium oxide					731	731	lb
25	Safe-carb (ground marble)					36525	36525	lb
Cementing Spacer Formulation							**50**	bbl
12	Tuned Space E+	*Halliburton viscosifier*	*Halliburton viscosifier*				600	lb
Completion Brine							**400**	bbl
14	Potassium chloride	*Clay inhibitor*	*Clay inhibitor*				5600	lb
0.5	Protekt 4144	Biocide	Biocide		*Chemiphase*		200	litre
0.5	Protekt 4200	O_2 Scavenger	O_2 scavenger		*Chemiphase*		200	litre
2	Protekt 4852	Corrosion Inhibitor	Corrosion inhibitor		*Chemiphase*		800	litre
						Contingency		
	Contingency Products		**Package**	**Unit**	**Qty**	**Total**		
	Bentonite (OCMA)	Viscosifier	25	kg	200	5000		kg
	Duo-vis xanthan	Viscosifier	25	kg	80	2000		kg
	PolyPAC UL	Water loss	25	kg	80	2000		kg
	Drilling starch	Water loss	25	kg	200	5000		kg
	Barite	Weighting	25	kg	800	20000		kg
	Sodium chloride	Brine	25	kg	400	10000		kg
	Potassium chloride	Shale inhibitor	25	kg	120	3000		kg
	Magnesium oxide	pH buffer	25	kg	10	250		kg
	Ground marble (all grades)	Plugging	25	kg	120	3000		kg
	Defoamer EMI2224	Defoamer	25	litre	1	25		litre
	KwikSeal M (LCM)	Plugging	40	lb	100	4000		lb
	Radiagreen EME	Lubricant	210	litre	5	1050		litre
	Glydril HC (alternative)	Lubricant	1000	ltr	0			litre
	Sugar (cement retarder)		25	kg	20	500		kg
	Sodium bicarbonate	Hardness	25	kg	84	2100		kg
	Cellulose fibers (LCM)	Plugging	40	lb	50	2000		lb
	Biocide CT-60/03		80	litre	1	80		litre

	Oxygen scavenger CT31/02WT		100	litre	1	100		litre
	Corrosion inhibitor CT-17/02 WT		100	litre	1	100		litre
	Conqor 404 NS	Corrosion	25	litre	20	500		litre
	Safe-Cor EN	Inhibitor	25	litre	20	500		litre

Item No.	Trade Name	Function	Chemical Name	Supplier
1	Ultrabore	Increases viscosity	Bentonite, natural clay	CSI
2	Salt	Increase chlorides for inhibition and weight	Sodium chloride	CSI
3	Potassium chloride	Provides chlorides and Potassium ion for inhibition	Potassium chloride	CSI
4	Pure-Bore	Fluid loss and clay/shale inhibition management	Proprietary polysaccharide	CSI
5	Pure-Bore LV	Viscosity, fluid loss and clay/shale inhibition management	Proprietary polysaccharide	CSI
6	Citric acid	pH control	Citric acid	CSI
7	Sodium bicarbonate	Counter cement contamination	Sodium bicarbonate	CSI
Cementing				
8	Tuned Spacer E+	Increases viscosity		Halliburton
9	Class G cement	Cement grout base	Cement	Halliburton
10	CFR-8L	Dispersant		Halliburton
11	Gas Stop	Gas migration control		Halliburton
12	Halad-300L NS	Fluid loss control		Halliburton
13	HR-4L	Retarder		Halliburton
14	NF-6	Defoamer		Halliburton
15	Silicate	Extender		Halliburton
Completion Brine				
16	Protekt 4144	Biocide – controls bacteria growth		Chemiphase
17	Protekt 4200	Removes oxygen from the fluid		Chemiphase

18	Protekt 4852	Corrosion Inhibitor		Chemiphase
Contingency Products				
19	Biocide CT-60/03	Biocide - controls bacteria growth		Chemiphase
20	Oxygen scavenger CT31/02WT	Removes oxygen from the fluid		Chemiphase
21	Corrosion inhibitor CT-17/02 WT	Corrosion inhibitor for steel		Chemiphase
22	Barite	Weighting media	$BaSO_4$	CSI
23	Calcium carbonate	Bridging & Weighting Media	$CaCO_3$	CSI
24	Caustic potash or soda	pH Control	KOH / NaOH	CSI
25	Clear gel	Viscosifier	Xanthan Gum	CSI
26	Corrosion Inhibitor (RO WT C348)	Corrosion inhibitor for steel		Reda
27	Clear Stabiliser LV	Deflocculent	Polyanionic Cellulose	CSI
28	Defoamer	Anti foam		CSI
29	Drill Slip Plus	Lubricant	Radiagreen	CSI
30	Drill Sorb	Lost circulation media		CSI
31	Drill Thin	Thinner		CSI
32	Hydrosure B2080 (biocide)	Biocide - controls bacteria growth	THPS	Nalco
33	Lime	Counter carbonate contamination	$Ca(OH)_2$	CSI
34	Liquimud Environmental	Spotting fluid		CSI
35	Mica	Lost circulation media		CSI

36	Oxygen scavenger (RO WI V662)	Removes oxygen from the fluid		Reda
37	Soda Ash	pH Control	Na_2CO_3	CSI
38	Sugar	Counter severe cement contamination		CSI

Note: where products shown are trade names, information is provided in the SDS in Appendix 8, all highlighted cells show a new provider is in place

Appendix 2: Mud and Drilled Cuttings Volumes, HH-2 New Well

The tables below provide the same information on drilling fluids (including cementing preflush and completion brine) and drilled cuttings as per Section 4.1, with the same assumptions.

Drilling Fluids Calculations: HH-2 New Well

Mud Type		Bentonite	Bentonite	Salt-Polymer	KCl-Polymer	Total
Drilled hole diameter, in		17.5	12.25	8.5	6.125	
Hole start, ft		0	70	1320	2400	
Hole TD, ft		70	1320	2400	5681	
bbl/ft		0.2976	0.1458	0.0702	0.0365	
% Excess		30	30	25	25	
Installed casing:		13.375	9.625	7		
lb/ft		61	40	26	n/a	
bbl/ft		0.1522	0.0759	0.0383	0	
Mud dilution bbl/ft		0.4	0.4	0.3	0.2	
Start surface, bbl		250	200	200	200	
Last casing, bbl		0	11	101	92	
Hole volume, bbl		21	183	76	120	
Over-gauge, bbl		7	55	19	30	
Maintenance volume, bbl		28	500	324	657	
Total required, bbl.		306	949	720	1099	
Volume behind casing, bbl		0	0	0	0	
Transfer/dispose	Transfer	Transfer	Dispose	Dispose	Dispose	
Transfer volume, bbl		278	0	0	0	
Mud volume, bbl		306	671	720	1099	

Liquid disposal* volume, bbl		28	449	396	442	1315
Wet cuttings** volume, bbl		49	683	400	777	1909
Wet cuttings, tonne		16	218	128	248	610

* Liquid disposal = whole mud left at end of section, if not transferred

** Wet cuttings = rock volume + mud maintenance (dilution) volume

Drilling Fluids Calculations: HH-2 New Well

GENERIC PRODUCT REQUIREMENT *subject to change depending on supplier*

per bbl	Mud composition:	Total amounts						Units
	Drilled hole diameter, in		17.5	12.25	8.5	6.125		in
	Mud volume, bbl		306	671	720	1099		bbl
0.9	Water		276	604	648	990	2518	bbl
0.125	Caustic soda		39	84	90	138	351	lb
0.125	Soda ash		39	84	90	138	351	lb
20	Bentonite		6120	13420			19540	lb
20	Barite						0	lb
110	Salt				79200		79200	lb
5.0	Potassium chloride					5495	5495	lb
0.5	Magnesium oxide					550	550	lb
25	Safe-Carb (ground marble)					27475	27475	lb
Cementing Spacer Formulation							**50**	bbl
12	Tuned Space E+	*Halliburton viscosifier*	*Halliburton viscosifier*				600	lb
Completion Brine							**400**	bbl
14	Potassium chloride	*Clay inhibitor*	*Clay inhibitor*				5600	lb
0.5	Protekt 4144	Biocide	Biocide		*Chemiphase*		200	litre
0.5	Protekt 4200	O_2 Scavenger	O_2 Scavenger		*Chemiphase*		200	litre
2	Protekt 4852	Corrosion inhibitor	Corrosion inhibitor		*Chemiphase*		800	litre
	Contingency Products		**Package**	**Unit**	**Qty**	**Total**		

	Bentonite (OCMA)	Viscosifier	25	kg	200	5000		kg
	Drilling starch	Water loss	25	kg	200	5000		kg
	Barite	Weighting	25	kg	800	20000		kg
	Sodium chloride	Brine	25	kg	400	10000		kg
	Potassium chloride	Shale inhibitor	25	kg	120	3000		kg
	Magnesium oxide	pH buffer	25	kg	10	250		kg
	Ground marble (all grades)	Plugging	25	kg	120	3000		kg
	Defoamer EMI2224	Defoamer	25	litre	1	25		litre
	KwikSeal M (LCM)	Plugging	40	lb	100	4000		lb
	Radiagreen EME	Lubricant	210	litre	5	1050		litre
	Glydril HC (alternative)	Lubricant	1000	litre	0			litre
	Sugar (cement retarder)		25	kg	20	500		kg
	Sodium bicarbonate	Hardness	25	kg	84	2100		kg
	Cellulose fibers (LCM)	Plugging	40	lb	50	2000		lb
	Biocide CT-60/03		80	litre	1	80		litre
	Oxygen scavenger CT31/02WT		100	litre	1	100		litre
	Corrosion inhibitor CT-17/02 WT		100	litre	1	100		litre
	Conqor 404 NS	Corrosion	25	litre	20	500		litre
	Safe-Cor EN	Inhibitor	25	litre	20	500		litre

Item No.	Trade Name	Function	Chemical Name	Supplier
1	Ultrabore	Increases viscosity	Bentonite, natural clay	CSI
2	Sodium chloride	Increase chlorides for inhibition and weight	Sodium chloride	CSI
3	Potassium chloride	Provides chlorides and Potassium ion for inhibition	Potassium chloride	CSI

4	Pure-Bore	Fluid loss and clay/shale inhibition management	Proprietary polysaccharide	CSI
5	Pure-Bore LV	Viscosity, fluid loss and clay/shale inhibition management	Proprietary polysaccharide	CSI
6	Citric acid	pH control	Citric acid	CSI
7	Sodium bicarbonate	Counter cement contamination	Sodium bicarbonate	CSI
Cementing				
8	Tuned Spacer E+	Increases viscosity		Halliburton
9	Class G cement	Cement grout base	Cement	Halliburton
10	CFR-8L	Dispersant		Halliburton
11	Gas Stop	Gas migration control		Halliburton
12	Halad-300L NS	Fluid loss control		Halliburton
13	HR-4L	Retarder		Halliburton
14	NF-6	Defoamer		Halliburton
15	Silicate	Extender		Halliburton
Completion Brine				
16	Protekt 4144	Biocide – controls bacteria growth		Chemiphase
17	Protekt 4200	Removes oxygen from the fluid		Chemiphase
18	Protekt 4852	Corrosion Inhibitor		Chemiphase
Contingency Products				
19	Biocide CT-60/03	Biocide - controls bacteria growth		Chemiphase
20	Oxygen scavenger CT31/02WT	Removes oxygen from the fluid		Chemiphase

21	Corrosion inhibitor CT-17/02 WT	Corrosion inhibitor for steel		Chemiphase
22	Barite	Weighting media	$BaSO_4$	CSI
23	Calcium carbonate	Bridging & Weighting Media	$CaCO_3$	CSI
24	Caustic potash or soda	pH Control	KOH / NaOH	CSI
25	Clear gel	Viscosifier	Xanthan Gum	CSI
26	Corrosion inhibitor (RO WT C348)	Corrosion inhibitor for steel		Reda
27	Clear stabiliser LV	Deflocculent	Polyanionic cellulose	CSI
28	Defoamer	Anti foam		CSI
29	Drill Slip Plus	Lubricant	Radiagreen	CSI
30	Drill Sorb	Lost circulation media		CSI
31	Drill Thin	Thinner		CSI
32	Hydrosure B2080 (biocide)	Biocide - controls bacteria growth	THPS	Nalco
33	Lime	Counter carbonate contamination	$Ca(OH)_2$	CSI
34	Liquimud Environmental	Spotting fluid		CSI
35	Mica	Lost circulation media		CSI
36	Oxygen scavenger	Removes oxygen from the fluid		Reda
37	Soda ash	pH Control	Na_2CO_3	CSI
38	Sugar	Counter severe cement contamination		CSI

Note: where products shown are trade names, information is provided in the SDS in Appendix 8, all highlighted cells show a new provider is in place

Appendix 3: Enclosed Flare Information

PWWT

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Enclosed Flare Model EWT9.5

Glossary

ATEX	European Directives for controlling explosive atmospheres
CO_2	Carbon dioxide
CH_4	Methane
EA	Environment Agency
EWT	Extended well test
HH-1	The Horse Hill-1 well
HMI	Human Machine Interface
HSE	Health and Safety Executive
mscf/d	Thousand standard cubic feet per day
N_2	Nitrogen
O_2	Oxygen
PLC	Programmable Logic Controller
PSI	Pounds per square inch
PVT	Pressure Volume Temperature
PWWT	PW Well Test

EWT9.5 Combustion Process

Background

The Environment Agency (EA) has produced new guidance on flaring relating to the testing of new oil or gas wells. Previously, raw gas emissions from the well testing process have been burned in simple open flame elevated gas flares or ground-based flares with cylindrical shrouds which contain and conceal most of the combustion process. Neither of these methods provides optimum control of the combustion processes and therefore undesirable exhaust emissions cannot be controlled or monitored. The proposed unit has been designed to meet the EA guidance, a first for the UK onshore oil & gas industry.

Other industries with similar gas disposal issues have been required by the EA to control and limit undesirable exhaust emissions for many years. The EA now seeks to achieve similar requirements in the UK oil & gas (O&G) industry. Initially it appears that the EA are calling on previous experience with the landfill gas industry as a reference point for controlling emissions from the O&G industry (Table A).

Table A: Summary of emissions testing requirements for enclosed landfill gas flares from Environment Agency document LFTGN05 V2 2010.

Table A summarises the emissions testing requirements for enclosed landfill gas flares. For each determinand, the reference method and recommended analytical techniques used are identified, along with the required testing frequency and emission standards based on best practice.

Table A Summary of emissions testing requirements for enclosed landfill gas flares

Determinand	Reference method	Sampling and analytical technique	Minimum testing frequency	Emission standard (mg/m3)b	
				Flare commissioned before 31 December 2003	Flare commissioned after 31 December 2003
NO_x[c]	BS EN 14792:2005	Chemiluminescence	Annually	150	150
CO	BS EN 15058:2006	Non-dispersive infra-red analysis	Annually	100	50
Total VOCs	BS EN 12619[d] BS EN 13526[e]	Extractive sampling and flame ionisation detector analysis	Annually	10	10

[a] Technical guidance note M2
[b] These limits are based on normal operating conditions and load. Temperature: 0°C (273K); pressure: 101.3 KPa; and oxygen: 3 percent (dry gas).
[c] NO_x expressed as NO_2
[d] At sites with low VOC concentrations.
[e] At sites with low to moderate VOC concentrations.

These emission standards are for a minimum suite of determinands; emission limits may be modified and additional determinands identified by site-specific risk assessment. Alternatives to the reference methods stipulated in Table A can be used, provided they are shown to be fit-for-purpose and a suitable justification is presented before sampling is undertaken.

Enclosed flares are used overseas for gas well testing. Generally, these tend to consist of large refractory lined steel cylinders designed to cope with very large gas flows. Most designs appear to be mainly concerned with concealing the combustion process from view, rather than controlling exhaust gas emissions.

For the UK, a solution is needed that conceals the combustion process and controls exhaust gas emissions.

EWT9.5 Enclosed Flare

The EWT9.5 enclosed flare is similar in construction to a conventional landfill gas flare in that it consists of a large open topped steel cylinder which is lined with a refractory material. The main function of this material is to reduce heat losses from the combustion process thus helping to maintain the temperature of the combusted gases for the required residence time. The secondary (though essential) function is to prevent thermal damage to the steel cylinder. The lined cylinder forms a combustion chamber and exhaust stack. The flow of combustion and cooling air in to the chamber is controlled by automatically actuated air dampers fitted at the base of the cylinder. Here the similarity to a landfill gas flare ends.

A stainless-steel combustion system is installed within the chamber at low level but above the air dampers. The combustion system consists of multiple pre-mix burner heads, each with an interchangeable gas nozzle and venturi gas mixing system. The combustion system is divided into two sets of burners, which can be controlled sequentially. The combustion process is ignited by a proprietary industrial pilot light system. The pilot light is fed from a bank of propane cylinders. Once the pilot light is lit and is stable, the control system will allow the main gas flow to be introduced to the combustion chamber by one or both gas flow control valves, depending on the gas flow available. The pilot light remains lit throughout the flare operation.

Control System

The control system is based upon a combined HMI and PLC with a colour touch-screen and multi-page information and display format. A process mimic shows the operation of the plant in real time. Operating data can be logged to a removable memory card if required. Various telemetry options are also available. The plant can be operated automatically or manually, depending on the application (short-term well testing, or extended well testing, etc.). A rolling graph of operating parameters can be viewed. Depending on the log rate chosen, the graph can display historic data from a few minutes passed to several hours.

The control system monitors safety critical conditions such as stack/gas manifold temperatures. Stack temperature is monitored by a Type N thermocouple. This thermocouple is protected by an Inconel thermopocket. This is a high temperature steel sleeve, which isolates the thermocouple from direct contact with exhaust gases but transmits the heat. They are reliable and normally operate for thousands of hours.

This information is used to control the combustion temperature by automatically adjusting the air dampers. Thermocouple failure will be sensed as a high-high temperature condition and will cause the plant to shut down. A quantity of spares will be kept onsite for critical items such as thermocouples. The admission of combustion and cooling air is thereby controlled. Control of the combustion temperature is how the exhaust gas emissions are also controlled. As the gas flow through the system varies, the combustion temperature begins to change. The change is detected by the control system and the combustion and cooling air is adjusted to bring the combustion temperature back to the set point (typically 1000^{o}C).

Potential flash-back from the combustion process in to the upstream pipework system is detected by strategically placed temperature sensors. Flash-back is mitigated by maintaining burner nozzle velocity. This is achieved by burner staging and monitoring of the burner upstream pressure.

Prolonged high stack temperature or instantaneous flash-back detection will result in immediate cut-off of the main gas supply via quick-closing, pneumatically actuated, spring-return closed butterfly valves. Resetting of the shutdown condition requires manual intervention.

Before any shutdown of the flare occurs, the operator will hear a sequence of alarms, so adjustments can be made to equipment to prevent this. If a shutdown does occur a high pilot in the flare knock-out pot will shut the surface safety valve (SSV) in on high pressure to protect the system.

Flare Stack Sizing and Combustion

Landfill gas flares are designed on the basis of a 'standard gas' normally taken as 50% methane, 35% carbon dioxide, 2% oxygen, the remainder being nitrogen. The combustible gas is predominantly methane with only trace levels of other combustible gases present. For each unit of methane, 9.52 units of air are required for stoichiometric combustion. To ensure near complete combustion and to provide cooling to reduce NO_x formation, excess air is required. This can typically be 130% of the air required for combustion.

In the gas from oil & gas wells methane is present in higher concentrations but other combustible gases are also present in significant quantities, such as ethane, propane, butane and others. The stoichiometric combustion air requirements for these gases can be many times more than that for methane. It follows that to produce the same combustion conditions in a flare stack designed for 2,000 Nm^3/hr of landfill gas a much smaller flow of well gas is needed, typically around 500 Nm^3/hr. Furthermore, it can be seen that greater flows than, say, 500 Nm^3/hr of well gas will cause high operating temperatures.

The burners used in landfill gas flares vary considerable between models and manufacturers. However, the prominent form is a low pressure pre-mixing burner which often relies on a diffuser system for final air / fuel mixing. Because the combustion air requirements for the gases in well gas (other than methane) are much higher, the conventional landfill gas burner will not operate successfully, simply because insufficient air/fuel mixing will occur. The burner design described above addresses this issue.

The flare combustion system will restrict the flow by virtue of the size and number of burner nozzles used. Based on the highest density gas in the Kimmeridge Limestone reservoirs, flow calculations have been made that provide a total flow of 304 m^3/hr at a pressure drop of 100 mbar across the burner nozzles. For the Kimmeridge gas, a flow of 295m^3/hr equates to 8.59 tonnes per day mass flow. The control system will generate an alarm when both burner stages are open and the burner pressure reaches 100 mbar.

The flare burner system is designed to provide the flow and pressure drop as described above. The flare stack is capable of handling a thermal load of approximately 50% more than that provided by that flow.

HH-1 Operation

The EWT9.5 burner has been developed using the gas composition from the Portland Sandstone, Lower Limestone and Upper Limestone formations through PVT sampling completed in the first HH-1 well test operation. Using each gas composition, the unit has been calculated using conventional combustion calculations for all the component gases except those at trace levels. The combustion data is shown in documents 'UKOG Site Gas Calcs.pdf'. The design ensures the burner could meet emissions at all flow rates up to the permit limit of 250 mscf/d. The nominal operating temperature of the flare is 1000°C +/- 20°C in steady state conditions. The operating temperature may need to be adjusted during site operation, to provide the best exhaust emissions results. An extra relief capacity in case of emergency situations has been included.

EWT9.5 has the versatility of both automatic and manual controls to allow safe operations, from initial periods of opening the well to extended well tests. On the first day of the operation the unit will be commissioned and tested to be fully functional inclusive of PWWT pre-flow equipment checks and pressure tests.

Upon opening the well, the pilot will be ignited via the propane and burner ignition panel. Manual and slam shut type valves will be checked to be in open position. A nitrogen blanket will be put on the separator vessel at about 20 psi and the gas line to the flare will be purged through and monitored to check there are no flow restrictions to the burner tips. The well choke will be in the closed position with the well open up to the choke and pressure indications monitored via gauges on the manifold.

The well will be initially opened on a small choke and PWWT will operate equipment and monitor the flare until stable flow rates are maintained. All adjustments to PWWT equipment will be in a controlled manner to allow the flare to adjust the combustion process to suit.

Monitoring of the flare is achieved by rigorous checks upon any adjustment in equipment as per PWWT operating procedure (PWWT-03-SOP-030) and through the telemetry readouts on the monitor in the PWWT Well Test cabin. Data is recorded every second throughout the constantly manned operation.

Gas is delivered to the flare via the well test spread. Three-phase separation is achieved by a well test separator with any entrained moisture in the gas line removed by a second knock out vessel before ignition at the flare. Monitoring of equipment performance and checks of the knock out vessel for fluids is done regularly. Any fluids removed from the vessel will be pumped into the stock tanks on site.

Maintenance/Training /Spares

PWWT personnel will operate and maintain the enclosed flare equipment per service schedules, and offer full backup for the duration of the operation. PWWT operators will be fully trained on all aspects of the enclosed flare. PWWT will carry a selection of spares for the unit with support from Landfill Systems. Advantages of the unit will be the data captured for further development and any changes could be implemented swiftly on site. PWWT operators will be fully trained on what to do in the event of any alarms or plant trips and in EWT9.5 process controls.

Commissioning

Because gas flows of adequate volume and gas mixes are not available, testing of the flare prior to installation on site is limited to operating the control system using air. This willl allow full testing of the burner control system and pressure monitoring, etc. The flare ignition, flame monitoring and flash-back systems will be factory tested prior to delivery. Limited testing of a sample burner will be carried out using cylinder propane.

Where the initial site testing indicates that adjustments or modifications to the system are needed these will be carried out swiftly before further testing and verification is carried out.

Telemetry Monitoring and Operator Checks

There is no reliable method of accurately predicting the noise emission levels with the correct gas composition. However, experience provides confidence in the predicted maxiumum level of 78 dBa at 3m distance. This noise level relates to a flare designed and built to burn 700m^3/h (600 mscf/d) of a propane/air or butane/air mixture.

Information captured will be a vital part of the operation for efficient equipment operation and further project developments. A separate monitor in the control cabin will give full details of the unit. This will also give operators low/high alarm notification to adjust equipment before burner shutdown and offer a safe visual. Data captured will be used in further project flare development projects.

Enclosed Well Test Gas Flare EWT9.5

Maximum Thermal Capacity: 5.0 MWth
Maximum Flow: 250 mscf/d

General Description

Landfill Systems and PWWT have collaborated to design and manufacture the EWT range of enclosed gas flares for short-term and extended gas well testing applications.

The model nomenclature is defined by the range type and the maximum capacity; e.g. "EWT 9.5" denotes an enclosed well test gas flare with a height of 9.5m and a maximum flow capacity modified to restrict capacity to 250 mscf/d.

The flare design is based on a 2-stage burner for a varied range in flow rates. The capacity is restricted by reducing the number of burner nozzles in the second stage. The first stage will contain around 50 burner nozzles. The second stage has been reduced from 50 to 25 burner nozzles to cap capacity whilst keeping the flexibility to allow the unit to maintain efficient combustion.

The combustion system employs multiple burners arranged concentrically to operate in two stages. Stage 1 will handle flows from 60 to 166m^3/h (51 to 142 mscf/d). The burner pressure is used to control the staging of the burners. Stage 1 full flow condition is detected by the control system which responds by opening the Stage 2 burners. At 295 m^3/h (250 mscf/d) the resulting burner pressure will cause an alarm to be generated, alerting the flare operator to the daily gas flow limit. In reducing flow conditions, hysteresis in the control system allows the gas flow to reduce to under 166m^3/h (142 mscf/d) before the Stage 2 burner closes, thus avoiding hunting.

The plant components are mounted on a substantial galvanised steel underbed ("skid"). The weatherproof control enclosure is also mounted on the skid. The control system is PLC based with control interface and process indications provided by a colour HMI touch-screen panel.

The plant has a compact footprint. Typically, it is delivered ready assembled on a single vehicle. If the vehicle has an on-board crane of sufficient capacity, it can be used to off-load the gas flare in a very short time. Once the gas, electrical and pneumatic supplies are connected, the plant is ready to run.

a. Applications

The plant is an economical solution for gas well testing and safely flaring well gas. It can be used for short-term well testing and extended well testing.

b. Principal Features

- Designed to be UK EA emissions compliant.
- Safe and controlled combustion process.
- Ignition of the gas via proprietary high integrity propane ignition lance.
- Concealed combustion process; no visible flame thus minimising visibility impact.
- Automatic temperature control.
- Rapid installation and commissioning.
- Ready to run.
- Easy maintenance.

- High quality components.
- Rugged construction.
- Remote monitoring and control by smart phone or internet enabled computer.

c. Safety Features

The design incorporates all the safety features required for the safe handling and combustion of well test gas. Construction is in accordance with guidance contained in ***BS EN 60079-0*** (ATEX).

Specification

Gas Plant EWT 9.5

Gas flow capacity:	**max.**	**250 mscf/d**
Methane fraction:		**40 to 100%**
Combustion temperature:		**1,000 +/- 20 °C**
Retention time:		**>0.4s**
Turn down Ratio:		**>5:1**
Flare combustion capacity:	**max.**	**5.0 MW**
	min.	**≈ 1.0 MW**
Target Nox:		**<100 mg/m^3**
Target CO:		**<50 mg/m^3**
Target Total VOC's:		**<10 mg/m^3**
Target NMVOC's:		**<5 mg/m^3**
Gas inlet temp.	**max.**	**25 °C**
Inlet flange:		**Class #150**
Power supply:		**230VAC, 1Ph, 50Hz**
Compressed air supply:		**7 bar,clean & dry**
Expected noise emissions at 3m x 1m height:		**<78dB(A) (t.b.c.)**
Footprint (approx.):		**2,500 x 2,800mm**
Height:		**≤9,540mm**

Main Components

d. Underbed (Skid):

150 x 150 x 75mm MS channel frame, hot dip galvanised to ISO 1461.

e. Downstream of the gas connection flange:

Manual burner flow control valve.
Pipework in stainless steel 304.
Pressure gauge, 0 to 2 bar.
Quick closing electro-pneumatic actuated valve ("Slam Shut Valve"), ATEX approved (logged).
Gas pressure transmitter (logged).

Gas distribution manifold.
High burner feed temperature monitoring system (shutdown, logged).

f. Flare Stack:

Steel support structure, hot dip galvanised.
Flare stack cylinder, hot dip galvanised.
4 x PN16 DN125 emissions monitoring ports, flanged and blanked, 1m below exhaust (EA guidance compliant).
High temperature insulating lining, refractory ceramic fibre, 1260 C rated.
Combustion air flow control louvres x 3.
JE170 propane ignition lance.
UV flame detector.
Stack temperature monitor thermocouple, Type N (shutdown and control, logged).

g. Control System:

IP65 weatherproof enclosure.
Colour HMI operating panel, with process value displays and operator interfaces in the English language, under an environmental cover.
Flame monitoring (UV sensor).
Automatic control of gas ignition and re-ignition.
Automatic control of stack temperature.
Hazardous area interface devices.
Text out alarms *
Remote text status enquiry *
Remote control via text (Start, Stop, Reset, Pressure / Flow setting) *
SD Card data logging of selected parameters.

* Only with telemetry options.

Displays:

Process mimic.
Stack temperature.
Run state.
Flame state.
Flare hours.
Alarm state.
Gas inlet pressure.
Slam Shut Valve state.
Recent history (rolling graph).
External warning beacon (alarm indication).

Shut Down Conditions:

Stack high high temperature.
Burner feed high high temperature.
Flame failed to light.

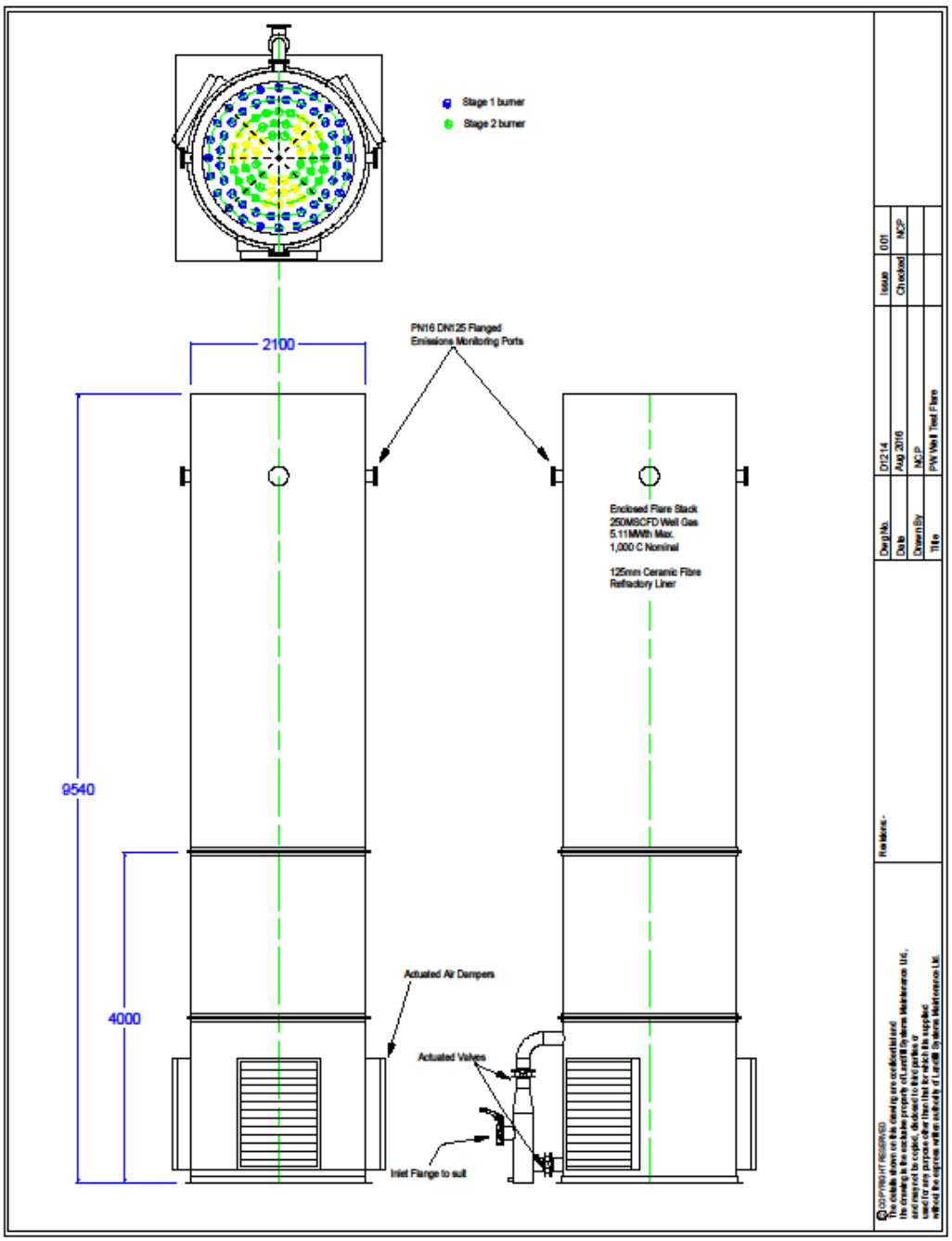
External Signals:

External start / stop (DI through external volt free contact)
Emergency Stop (DI through external volt free safety circuit)
Fault condition (DO – volt free contact).

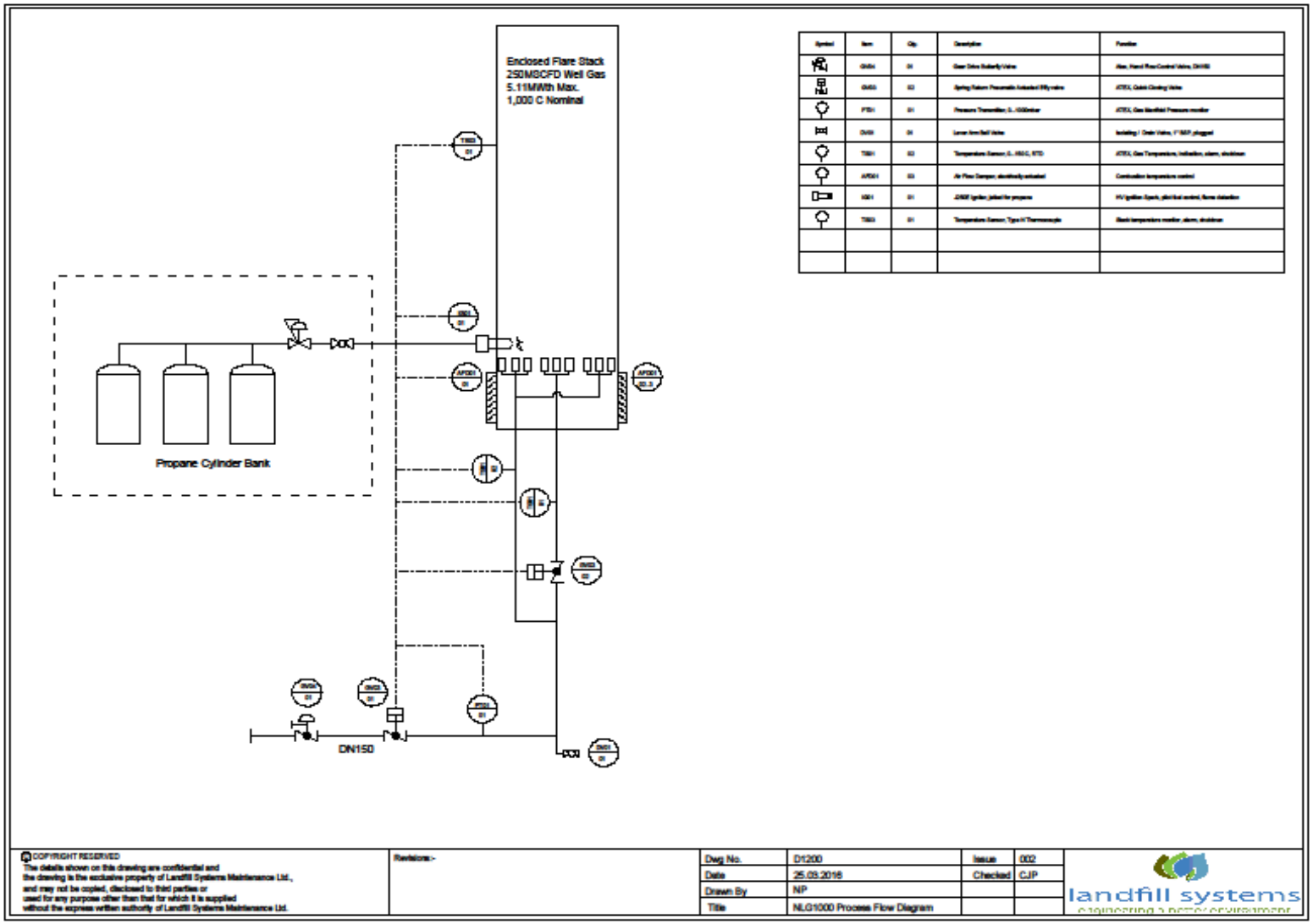
h. Documentation:

Operating and routine maintenance manual in the English language, including:
Operating instructions.
General arrangement drawing.
Main component manufacturer's technical documentation (included in O&M manual).

Stack Drawing



Process Flow Diagram


Enclosed Flare Stack
250MSCFD Well Gas
5.11MWth Max.
1,000 C Nominal
Propane Cylinder Bank
DN150
COPYRIGHT RESERVED
Revisions:-
Dwg No. D1200
Date 25.03.2016
Drawn By NP
Title NLG1000 Process Flow Diagram
Issue 002
Checked CJP
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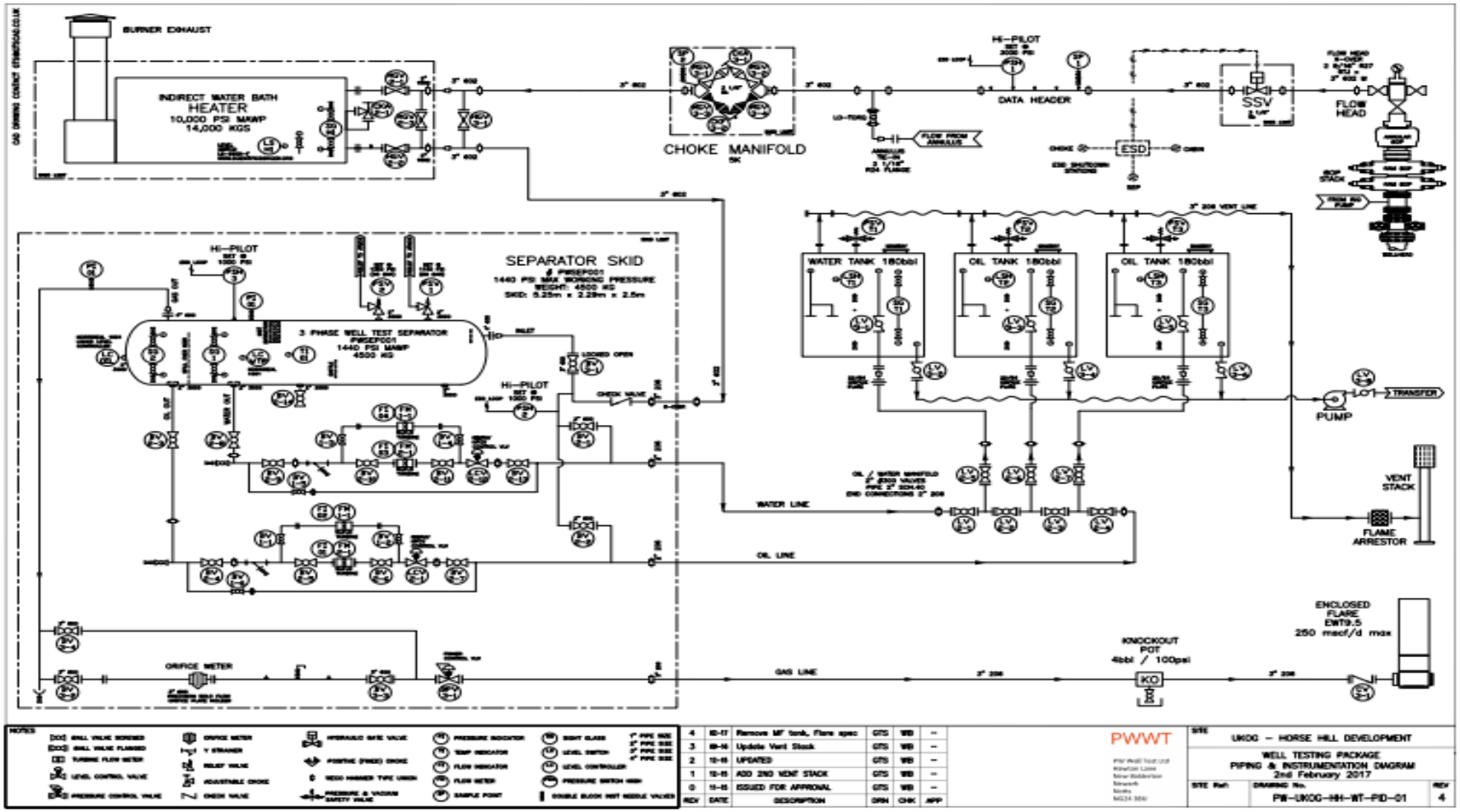
P&ID of well test equipment and enclosed flare set-up



Calculations for gas tonnage

Site: Lower Kimmeridge Flow: 250 MSCFD 295 m^3/hr.

Component Gas		Mol %	$LC_{V\ KJ/Kg}$	S.G	MJ/m3	M3/hr	kW	Combustion Air Stoich AFR	Combustion Air Stoich Air Flow
Helium	He	0.000		0.138			0.000	-	
Hydrogen	H2	0.000	12100	0.696	10.10592	0	0.000	2.88	0.00 m^3/hr.
Hydrogen Sulphide	H2S	0.000		1.1763	0	0	0.000	-	-
Nitrogen	N2	1.596		0.9669	0	4.707701	0.000	-	-
Oxygen	O2	0.000		1.1044	0	0	0.000	-	-
Carbon Dioxide	CO2	1.038		1.5189	0	3.061776	0.000	-	-
Methane	CH4	56.126	50000	0.5537	33.222	165.5542	1527.789	9.52	1,576.08 m^3/hr.
Ethane	C2H6	9.902	47800	1.0378	59.52821	29.20781	482.969	16.66	486.60 m^3/hr.
Propane	C3H8	15.209	46350	1.5219	84.64808	44.8618	1054.851	23.8	1,067.71 m^3/hr.
I-Butane	C4H10	3.437	44862	2.0068	108.0349	10.13808	304.240	30.78	312.05 m^3/hr.
N-Butane	C4H10	7.344	49700	2.0061	119.6438	21.66251	719.940	30.78	666.77 m^3/hr.
I-Pentane	C5H12	1.789	48955	2.4911	146.3422	5.276991	214.513	37.8	199.47 m^3/hr.
N-Pentane	C5H12	1.783	49067	2.4911	146.677	5.259293	214.283	37.8	198.80 m^3/hr.
Neo Pentane	C5H12	0.023	45350	2.491	135.5602	0.067843	2.555	37.8	2.56 m^3/hr.
Heptanes	C7H16	0.359	44560	3.4596	184.9917	1.058938	54.415	52.36	55.45 m^3/hr.
Hexanes Plus	C6+	1.394	48766	2.9753	174.1122	4.111864	198.868	52.36	215.30 m^3/hr.
	Total:	100.000					4774.423 kW		
						Heat:	4.774423 MW		

Density	1.2132	kg/m^3
Mass flow	357.8561	kg/hr.
Mass flow	8.588546	tonnes /day

Comb. Chamber Length	7.000	m
Retention Time	1.255	s

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Combustion Air	4,780.789	m^3/hr.
Excess Air	6,382.354	m^3/hr.
Fuel+Total Air	11,458.112	m^3/hr.
Stack ID	1.840	m
Exhaust gas flow at 1000°C	53,406.171	m^3/hr.
Comb. Chamber CSA	2.659	m^2
Exhaust gas velocity	5.579	m/s

Site: Upper Kimmeridge Flow: 250 MSCFD 295 m^3/hr.

Component Gas		Mol %	$LC_{V\ KJ/Kg}$	S.G	MJ/m3	M3/hr	kW	Combustion Air Stoich AFR	Combustion Air Stoich Air Flow
Helium	He	0.000		0.138			0.000	-	
Hydrogen	H2	0.000	12100	0.696	10.10592	0	0.000	2.88	0.00 m^3/hr.
Hydrogen Sulphide	H2S	0.000		1.1763	0	0	0.000	-	-
Nitrogen	N2	1.852		0.9669	0	5.462821	0.000	-	-
Oxygen	O2	0.000		1.1044	0	0	0.000	-	-
Carbon Dioxide	CO2	1.409		1.5189	0	4.15611	0.000	-	-
Methane	CH4	57.501	50000	0.5537	33.222	169.61	1565.217	9.52	1,614.69 m^3/hr.
Ethane	C2H6	10.070	47800	1.0378	59.52821	29.70335	491.163	16.66	494.86 m^3/hr.
Propane	C3H8	14.341	46350	1.5219	84.64808	42.30147	994.649	23.8	1,006.77 m^3/hr.
I-Butane	C4H10	3.152	44862	2.0068	108.0349	9.297415	279.013	30.78	286.17 m^3/hr.
N-Butane	C4H10	6.731	49700	2.0061	119.6438	19.85435	659.847	30.78	611.12 m^3/hr.
I-Pentane	C5H12	1.789	48955	2.4911	146.3422	5.276991	214.513	37.8	199.47 m^3/hr.
N-Pentane	C5H12	1.783	49067	2.4911	146.677	5.259293	214.283	37.8	198.80 m^3/hr.
Neo Pentane	C5H12	0.022	45350	2.491	135.5602	0.064893	2.444	37.8	2.45 m^3/hr.
Heptanes	C7H16	0.353	44560	3.4596	184.9917	1.04124	53.506	52.36	54.52 m^3/hr.
Hexanes Plus	C6+	0.997	48766	2.9753	174.1122	2.940838	142.232	52.36	153.98 m^3/hr.
	Total:	100.000					4616.867 kW		
						Heat:	4.616867 MW		

Density	1.2132	kg/m^3
Mass flow	357.8561	kg/hr.
Mass flow	8.588546	tonnes /day

Comb. Chamber Length	7.000	m
Retention Time	1.296	s

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Combustion Air	4,622.837	m^3/hr.
Excess Air	6,171.488	m^3/hr.
Fuel+Total Air	11,089.293	m^3/hr.
Stack ID	1.840	m
Exhaust gas flow at 1000°C	51,687.110	m^3/hr.
Comb. Chamber CSA	2.659	m^2
Exhaust gas velocity	5.400	m/s

Appendix 5: Environmental Risk Assessment

HHDL - HSE Risk Matrix

Consequence Definitions

Health	Safety	Environment	Community/Reputation	Financial	Multiplier	Probability 1	2	3	4	5
Major health exposure for 10 or more people on site or in local community;	**Multiple Fatalities** (or permanent total disabilities) to staff and/or contractors	Major oil spill, blow-out or loss of integrity with effects outside site boundaries. Major national news event	Widespread anger within community; national protest; loss of licence to operate	Cost of response/clean-up/production loss/**asset loss >US$ 10 million**	**5**	*5*	*10*	*15*	*20*	*25*
Major health exposure fo r up to 10 individuals; irreversible	**Single Fatality** or permanent total disability	Major loss of integrity with effects outside site boundaries; contained with limited environmental damage	Licence to operate threatened; significant local protest/anger; interruption to operations	Cost of response/clean-up/production loss/**asset loss US$ 10m to 1m**	**4**	*4*	*18*	*12*	*16*	*20*
Exposure of up to 5 individuals; serious health effect, but reversible.	**Serious Injury,** reversible, to one or more individuals medical treatment required (LTI>3 days)	Major loss of integrity; contained within site boundaries	Significant concern/ anger in local community; reputation of company damaged locally	Cost of response/clean-up/production loss**/asset loss US$ 1m to 0.1m**	**3**	*3*	*6*	*9*	*12*	*15*
Exposure to minor health risk for up to 5 individuals No lasting health effects.	Minor Injury / **Medical Treatment** to one or more individuals.	Localised loss of integrity. Minor contamination within site boundaries.	Complaints from local communities; effects reversible but some social impact	Cost of response/clean-up/production loss/**asset loss US$ 100,000 to 10,000**	**2**	*2*	*4*	*6*	*8*	*10*

	Exposure to minor health risk for one individual; no lasting health effect	**First Aid Case**; administered locally; no external resources required	Minor loss of integrity within site boundaries; no environmental damage after clean-up	Minor complaints from local community, low social impact	Cost of response/clean-up/production loss/**asset loss** **<US$ 10,000**	**1**	*1*	*2*	*3*	*4*	*5*

Risk Score	Risk Ranking Categories
1 to 4 (Low)	Risk acceptable without further risk reduction
5 to 12 (Medium)	Risks are acceptable but further risk mitigation / reduction measures should be considered. They do not necessarily require the instigation of additional risk reduction measures provided that it can be demonstrated that it is not practicable to reduce risks further. This is the area in which ALARP (As Low as Reasonably Practicable) or BAT (Best Available Technique) considerations are relevant, and these can involve cost benefit analysis. Often this requires judgement on the part of the operator and the regulator.
15 to 25 High)	Risk considered unacceptable and, except in extraordinary circumstances and with Regulatory and Management Team approval, activity cannot progress without action to reduce risks

HHDL - RISK ASSESSMENT WORKSHEET													
Activity /Project Description: HORSE HILL APPRAISAL PROJECT													
Ref	Risk Description					Risk without Mitigation			Mitigation Measures	Residual Risk			Recommended Additional Controls/ Mitigation Measures
	Activity /Event *(what are the operational activities)*	Hazard *(what has the potential to cause harm – H1 risk)*	Source *(where is it coming from)*	Pathway *(how can the Hazard get to the receptor)*	Receptor *(what is at Risk and must be protected)*	C	P	Risk		C	P	Current Risk	

1	Circulating Fluids	Returned fluids (waste)	Spillage and /or Leakage From mud Tanks or surface pipes. Leaks or ruptures of pipelines or valves	Surface runoff and percolation into the ground	Surface soil surface water	3	3	M	1) Mud tanks are sited in secondary bunding made from impermeable membrane laid on the site 2) Site surrounded by a drainage ditch to contain spills 3) Fluids flow to a Class 1 SPEL oil bypass separator to manage the liquids contained within the bunded area and remove oil before discharge to the water environment. If contaminated, water tankered off site for disposal 4) Procedural controls in place to manage all fluids. These include: visual monitoring and good housekeeping by mud engineers and drilling crew, visual inspection of pipes and tanks during site daily HSE tours 5) Pollution Incident Plan in place on site with staff briefed and trained on the required response to mitigate consequences; spill kits available on site 6) Local surface water quality sampling at agreed locations. Determinants to represent chemicals/diesel/oils on site (e.g. heavy metals,TPH, BTEX, chlorides, sodium).	2	2	L	

2	Circulating fluids	Returned cuttings (waste)	Overfilling cuttings skips	Surface runoff and percolation into the ground	Surface soil, surface water	**3**	**3**	**M**	1) Cuttings are largely solid and not of a consistency to flow easily or quickly if spilled at surface 2) Cuttings skips are situated on top of an impermeable membrane laid on the site 3) Site surrounded by a drainage ditch to contain spills. Fluids flow to a Class 1 SPEL oil bypass separator to manage the liquids contained within the bunded area and remove oil before discharge to the water environment. If contaminated, water tankered off site for disposal. 4) Visual inspection of pipes and tanks during daily HSE tours	**2**	**2**	**L**	

									5) Visual monitoring and good housekeeping by on-site waste contractor 6) Pollution Incident Plan in place on site with staff briefed and trained on the required response to mitigate consequences 7) Local surface water quality sampling at agreed locations. Determinants to represent chemicals/diesel/oils on site (e.g. heavy metals, TPH, BTEX, chlorides, sodium). 8) Waste management company on site to monitor disposal of waste and prevent skip overfilling				
3	Circulating fluids	Fluids left in situ through any losses to surrounding underground rock whilst drilling the well	Fluid System	Geological matrix	Ground water	**3**	**3**	**M**	1) Aquifers cased and cemented to provide isolation. Wellbore is not a conduit for migration. 2) Casing shoes set into non permeable strata 3) Geological separation through non-permeable formations. 4) Formation Integrity Test (FIT) and casing pressure tests to prove seal 5) Minimum amount of additives used consistent with ensuring safe well operation 6) Monitoring Pit Volume Totaliser (PVT) to react to formation loss	**1**	**2**	**L**	

4	Cementing (fluid displacement back to surface)	Incomplete fluid displacement from wellbore	Bypassed by cement	Geological matrix	Ground water	**3**	**3**	**M**	1) Cement is a non-hazardous pollutant against the EU groundwater directive. 2) Minimum quantities of cement used consistent with safe operating design 3) Competent Cementing Contactor 4) Use of pre-flush and a displacement regime (turbulent flow) prior to cementing and a casing scraper run 5) Effective QA/QC to assure the quality of the cement job. This includes: monitoring cement volumes pumped in and out of well, carrying out a cement bond log (CBL) on production string; carrying out a formation integrity test (FIT) on the casing shoe	**1**	**1**	**L**	
5	Cement returns	Cement at surface with residue of extractive waste (muds and some mud contamination)	Well bore (annular)	Surface runoff and percolation into the ground	Surface water, soil, ground water	**4**	**2**	**M**	1) Cement volumes calculated according to annular spaces and are designed to minimise volumes commensurate with safe operations 2) Management controls of cement pumping down annulus and checking for returns to surface. In addition, pumping rate very carefully monitored in the final stages of cementing	**2**	**2**	**L**	

									3) Returns are situated on top of an impermeable membrane laid on site 4) Competent cementing contractor 5) Excess cement at surface captured into cuttings				
6	Transportation of waste materials/ drill cuttings/ drill fluids/ liquids	Accident (fugitive emission)	Spill onto highway	Surface run off into drains or soft ground	Surface water and soils	**4**	**3**	**M**	1) Management by competent waste management contractor 2) Duty of care waste transfer notes and known disposal sites with documentation trail 3) Wastes correctly segregated 4) Transport Management Plan including reduced speed limit in built-up areas and single carriage roads 5) Site spill kits to respond to spillages along the access road. Spill kits also available on each delivery carrying liquids/fuels 6) Support from 24-hour emergency suction tankers and spill response 7) SDS to accompany movement of liquids; Pollution Incident Plan in place on site with all staff	**1**	**2**	**L**	

7	Drilling borehole	Noise	Mechanical equipment, power generation equipment, materials movement	Sound waves	Local community	**3**	**4**	**M**	1) Equipment chosen for low noise and silencers fitted 2) Noise analysis carried out as part of the planning process to demonstrate acceptable noise levels and targets clearly specified 3) Site activities restricted to mitigate night time and weekend noise pollution 4) Noise monitoring programme detailed in permit submissions and response plan in place to rectify any risk of non-compliances and meet noise targets, see Noise and Vibration Assessment, report 3388.01	**2**	**2**	**L**	

8	Drilling borehole	Gas release	Gas from formation	Released from wellbore through drill pipe and wellbore	Atmosphere	**3**	**4**	**M**	1) Fluids maintain hydrostatic pressure above that in the reservoir to prevent such gas releases 2) Constant instrumentation monitoring will detect any indication of gas 3) Any gas "kick" will be controlled by increasing the density of drilling fluids and hence increasing their hydrostatic pressure to prevent release 4) Physical well control equipment enables shut-in of wellbore at surface (BOP, valves) to prevent escape of gas 5) Surface equipment functionality maintained through: regular checks & inspections, planned maintenance, external validation/ certification 6) Crews are competent and trained to deal with such contingencies through externally validated training	**2**	**2**	**L**	

9	Site operations	Contaminants or pollutants on site surface (e.g. oils/ lubricants) Venting from stock tanks	Vehicles, generators, machinery, fluids transfer from storage tanks Fugitive emissions from stock tanks	Runoff from site with rainwater	Surface water, surface soils	**2**	**4**	**M**	1) Site is sealed with impermeable membrane so that no contaminants will penetrate 2) Site surrounded by a drainage ditch to contain spills. Fluids flow to a Class 1 SPEL bypass separator to remove spill before discharge to the water environment. Separator valves to be kept shut when operations on site. Contaminated, water will be tankered off site for disposal 3) Pollution incident Plan in place on site with staff briefed and trained on the required response to mitigate consequences, spill kits available on site 4) Good housekeeping and site inspection 5) Gas vented from tanks will be minimal, it will be monitored. for odour and volume, Necessary controls; Scrubbers will be utilised if odour is an issue.	**2**	**1**	**L**	

10	Chemicals	Packaged chemicals spilt on site	Accident or spillage on site when moving or mixing chemicals	Run off from site with rainwater	Surface water, surface soils	**2**	**4**	**M**	1) Majority of chemicals are classified as non-hazardous 2) Correct management procedures and supervision when chemicals used 3) Banksman in place for manoeuvring vehicles on site 4) Restricted speed limit on site (5mph) 5) Site is sealed with impermeable mdembrane so that no contaminants will penetrate 6) Pollution Incident Plan, HH-PR-Q07 in place on site with staff briefed and trained on the required response to mitigate consequences, spill kits available on site 7) Good housekeeping and site inspection	**2**	**1**	**L**	
11	Waste road tankers reversing	Noise	Reversing alarm	Sound waves	Local community	**2**	**4**	**M**	1) Vehicular movement will be restricted in compliance and agreed with SCC; Traffic Management Plan to mitigate impacts 2) Distant from population. Nearest dwelling around 0.3 km 3) Trees provide natural sound abatement 4) 81m x 6m acoustic barrier erected on the south side of the well pad	**2**	**2**	**L**	

12	Holes/tear in impermeable membrane	Waste spill (fugitive emission)	Hole/tear in the impermeable membrane	Surface runoff and percolation into the ground	Surface soils, ground water	**3**	**2**	**M**	1) Full details of the controls in place to prevent damage to the geomembrane and to monitor site conditions to detect damage of the effects of damage are contained in the Environmental Method Statement, HH-PR-Q08 and summarised below: a) Designed to best industry practice with 300mm of crushed stone, compacted in accordance with the specification for Highway Work on top of an appropriate geogrid for added strength b) This surface lies over and protects a 1mm thick impermeable geomembrane made from HDPE, protectd by being sandwiched between two layers of non woven geotextile (300g/m^2) c) Use of competent and experienced contractors to build the site and install the geomembrane. QA/QC tests for membrane quality and installation (including overlapping and welding of the geomembrane). Full installation records maintained d) The above controls minimise defects arising during construction. Controls to prevent defects arising as a result of surface activity include the use of competent contractors, best practice controls and good housekeeping e) Regular site monitoring will identify any surface issues and repairs would be effected	**2**	**1**	**L**	

13	Failure of skips or containers integrity	Produced water, drill cuttings, drilling muds (fugitive emissions)	Leaking skips or containers	Surface runoff and percolation into the ground	Surface water, soil, ground water	**3**	**2**	**M**	1) All skips and temporary tanks provided by mud waste contractor. They undergo visual inspection before being accepted on site 2) Visual inspection of tanks during site daily HSE tours. Visual monitoring by on-site waste contractor 3) Skips are only used to contain non-hazardous pollutant against the EU Ground Water Directive. Hazardous materials contained in tanks 4) Cuttings are not of a consistency to flow easily or quickly if spilled 5) Extractive waste skips are situated on top of an impermeable membrane laid on the site 6) Site surrounded by a drainage ditch to contain spills. Fluids flow to a Class 1 SPEL oil bypass separator to remove oil before discharge. When drilling or workover operations occur on site the separator valves are kept shut. All ditch water will be tankered off site for disposal at a licensed waste site. 7) Pollution Incident Plan, HH-PR-Q07, in place on site with all contractors briefed and trained and spill kits available on site 8) Local surface water quality sampling at agreed locations. Determinants to represent chemicals/diesels/oils on site (e.g. heavy metals, TPH, BTEX, chlorides, sodium). See Environmental Method Statement	**2**	**1**	**L**	

14	Site activities	Litter	Packaging, domestic wastes	Airborne, blown off site	Local communities, surrounding area	**2**	**2**	**L**	1) Management controls on site when dealing with packaging 2) Segregation of general purpose skips sheeted over for windy conditions 3) Daily visual checks 4) Site inspection and audit process	**1**	**1**	**L**	

Appendix 6: H1 Information

See Air Quality Assessment, Air Quality Consultants, J2597, December 2016.

Appendix 7: Ground Water Risk Assessment and Flood Risk Assessment

a) Ground Water Risk Assessment, HHL-HYD-XX-RA-RP-G-0001-S2-P6
b) Flood Risk Assessment, HHL-HYD-XX-RA-RP-G-5000_P6

Appendix 8: Safety Data Sheets

Safety Data Sheets (SDS) have been provided within the Ground Water Risk Assessment, HHL-HYD-XX-RA-RP-G-0001-S2-P6 new SDS can be found attached as SDS.zip.

Appendix 9: Transport Statement

Report number LS/16286/TS/2.

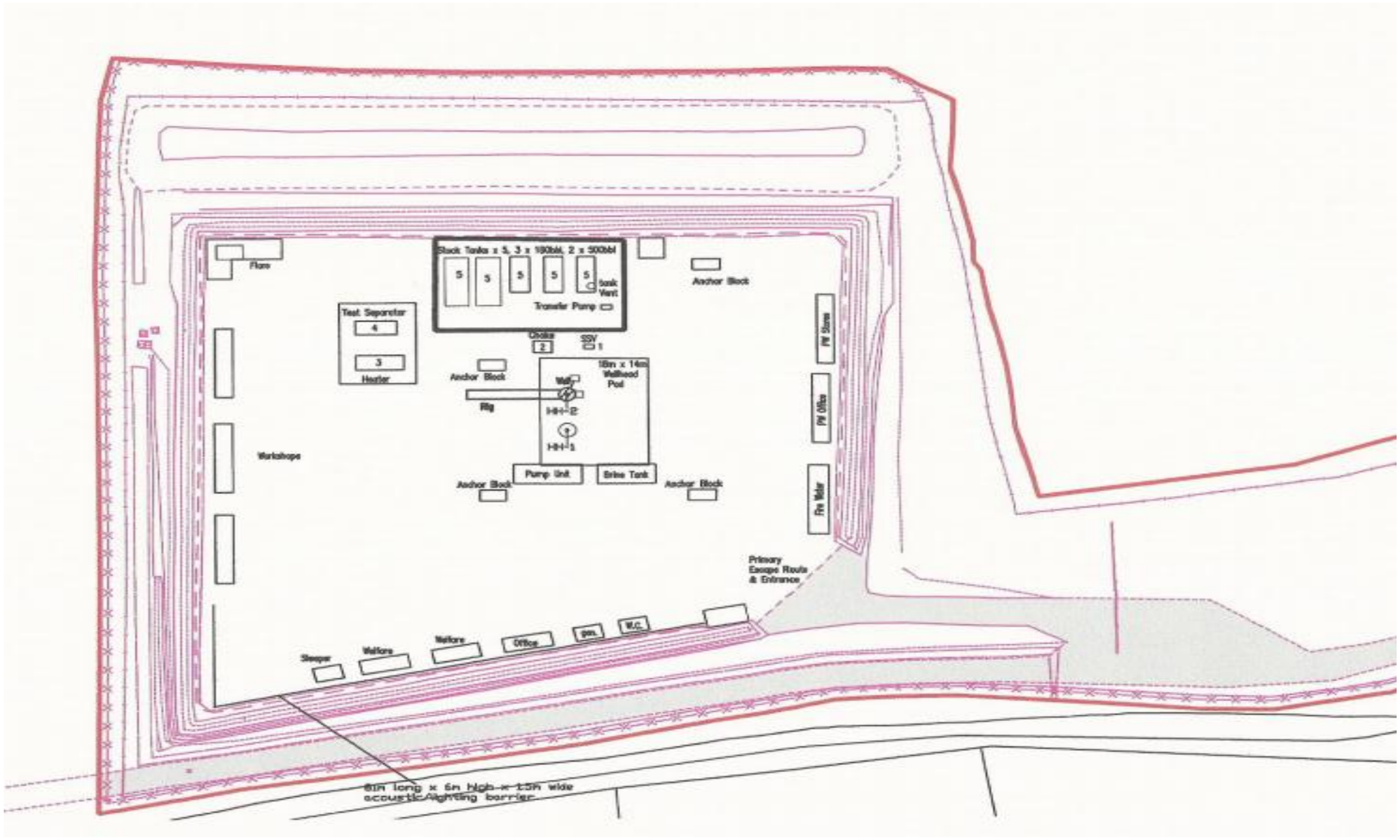
Appendix 10: Noise and Vibration Assessment

Report number 3388.01.

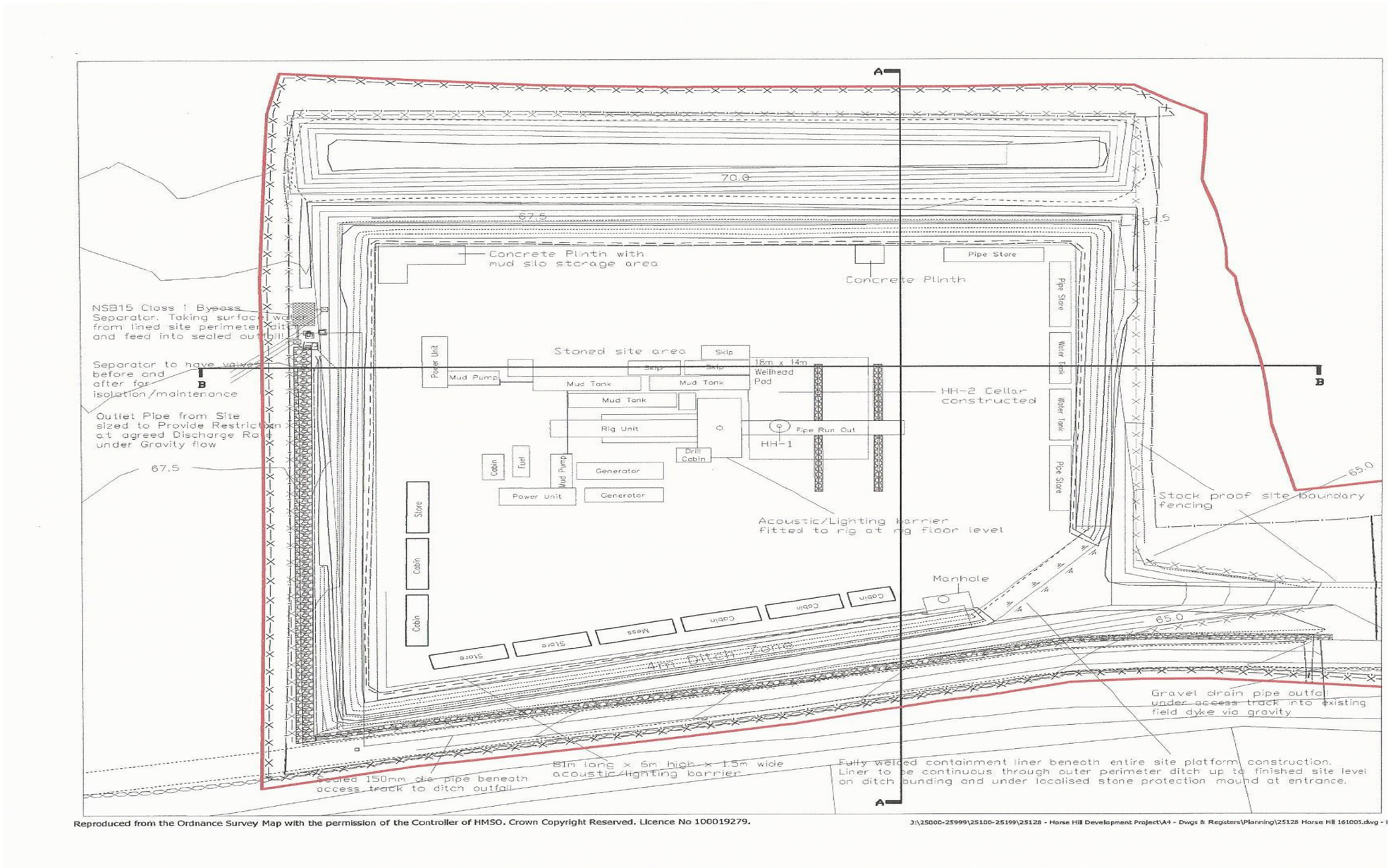
Appendix 11: Lighting Assessment

Report number: BI&BPB5986R001F01.

Appendix 12: Site Layout, EWT



Appendix 13: Site Layout, Drilling



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