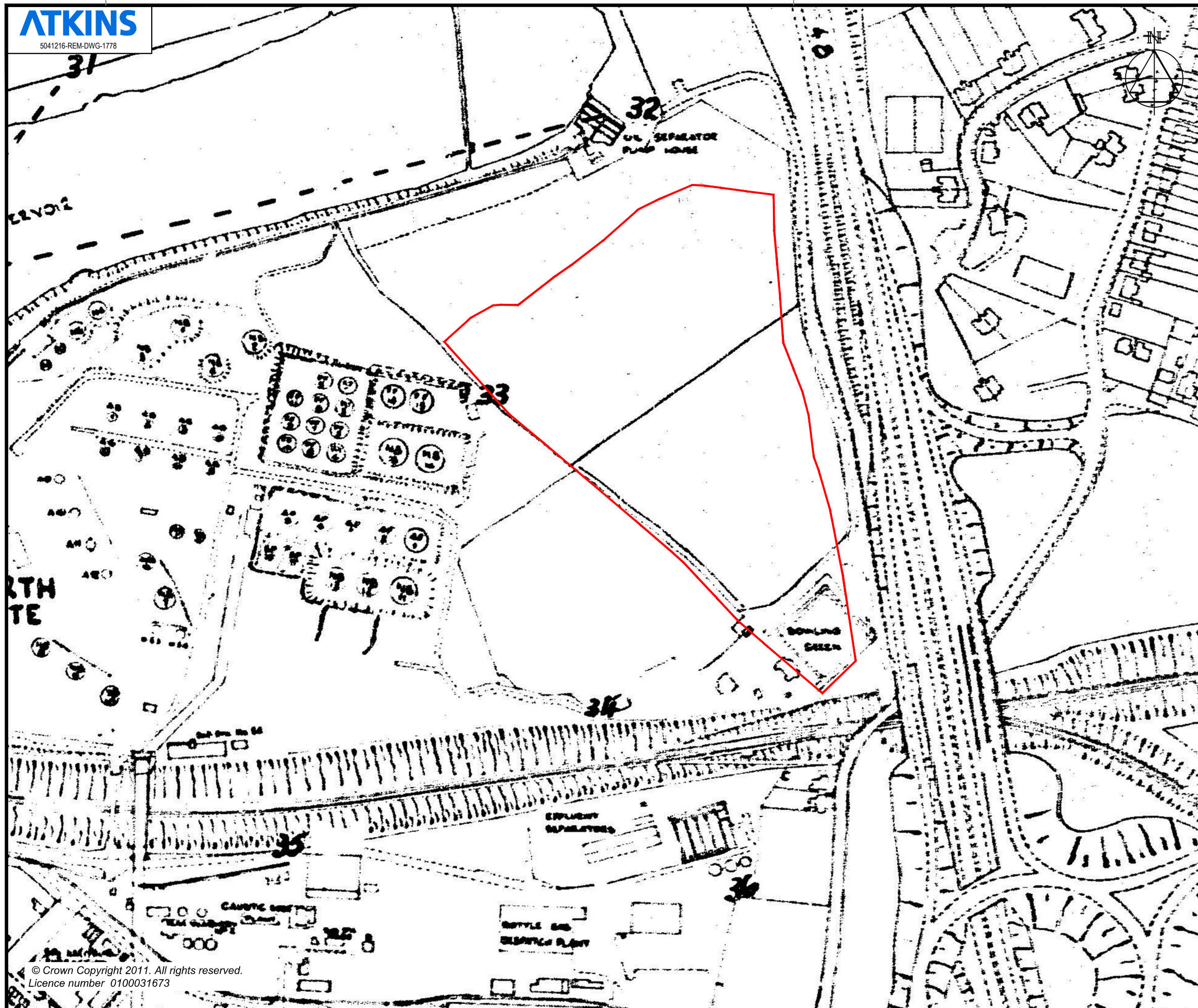




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MONITOR BOUNDARY PHASE 53

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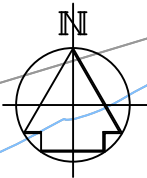
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HISTORICAL LAYOUT

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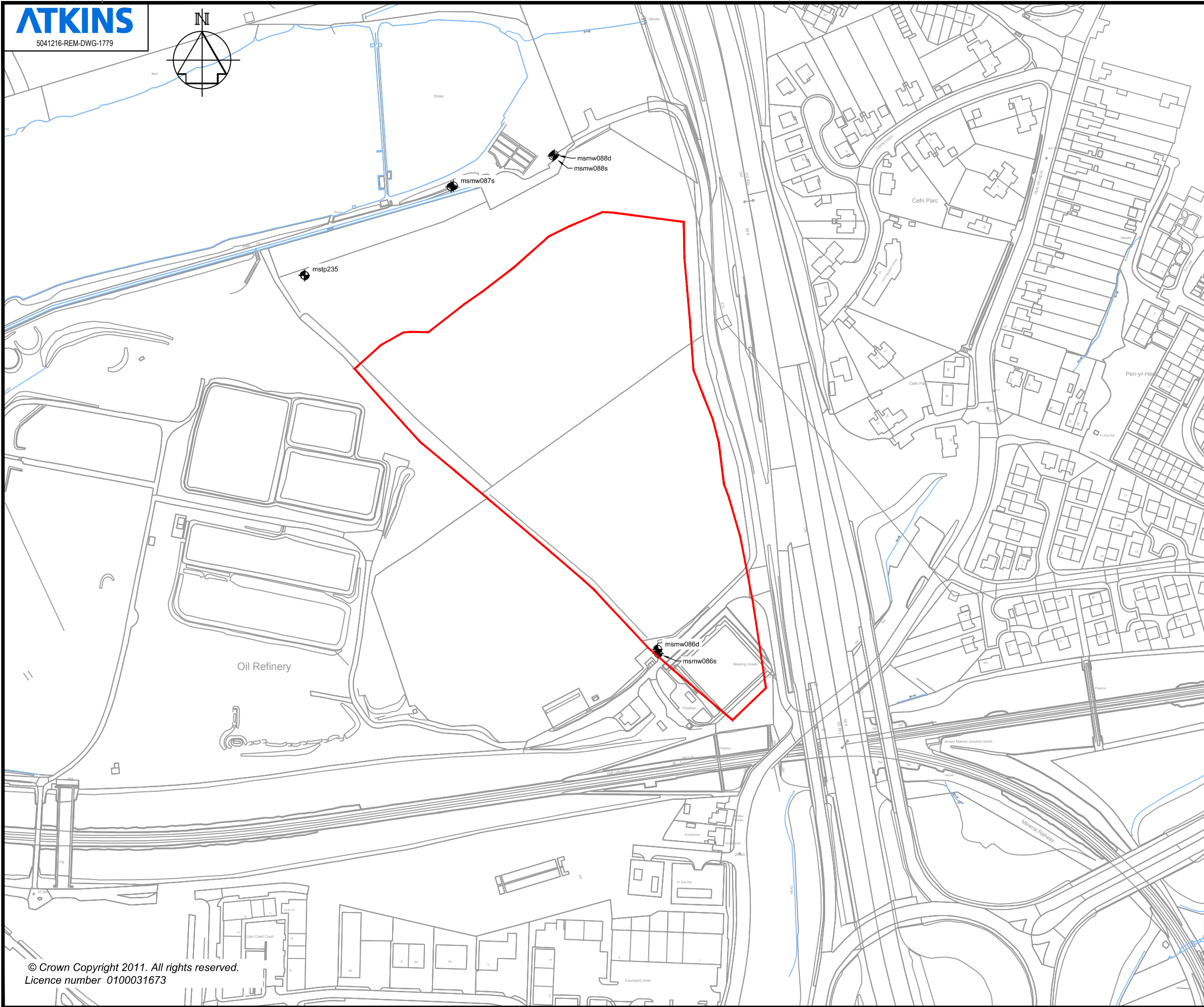
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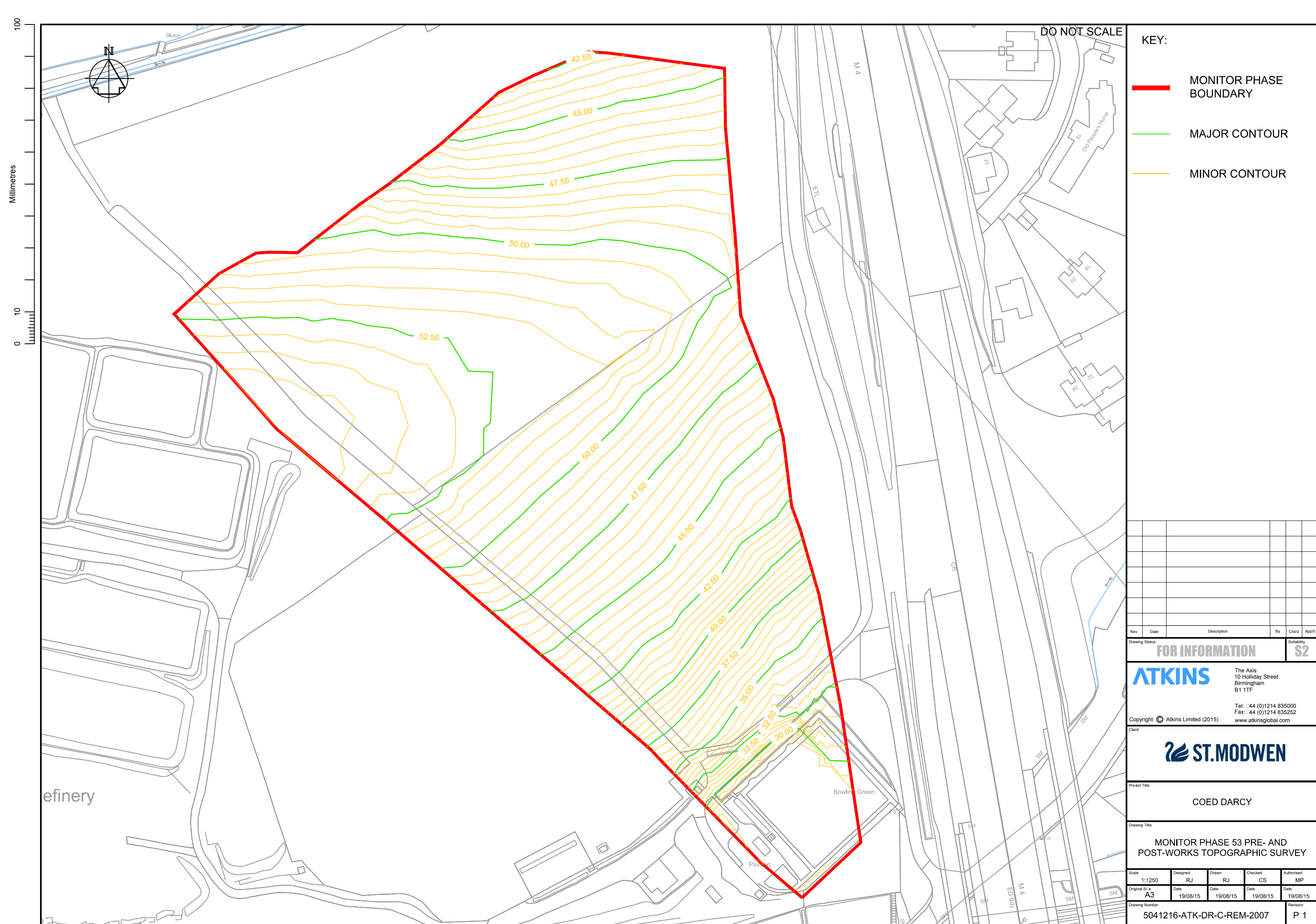
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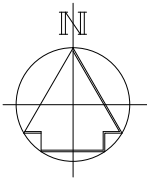


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1:2500	MJ	CS		
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5041216-REM-DWG-1779		A3	09.02.15	
		REV		





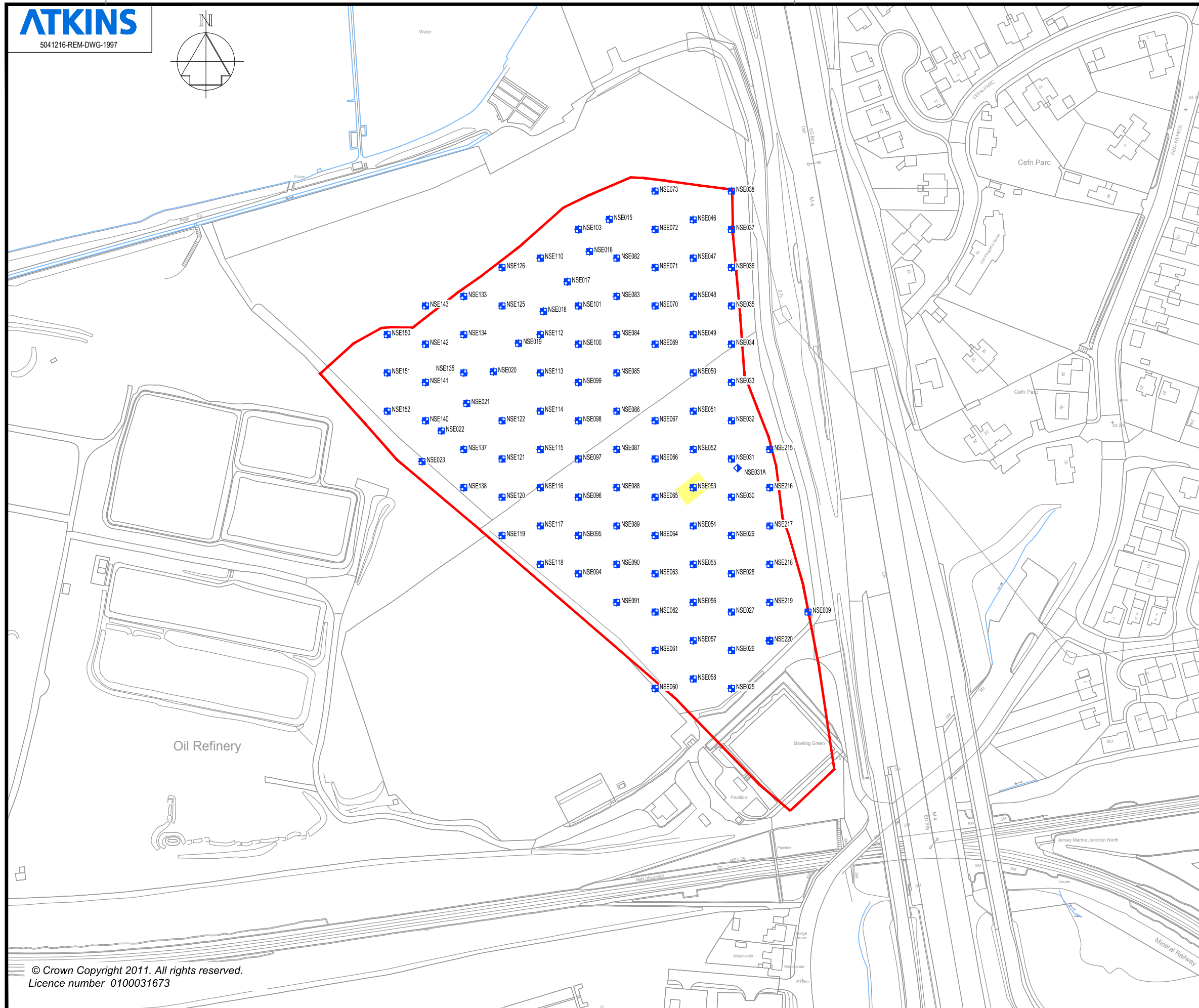
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MONITOR BOUNDARY PHASE 53



INVESTIGATION TRENCH



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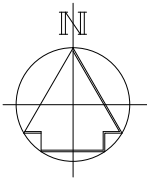
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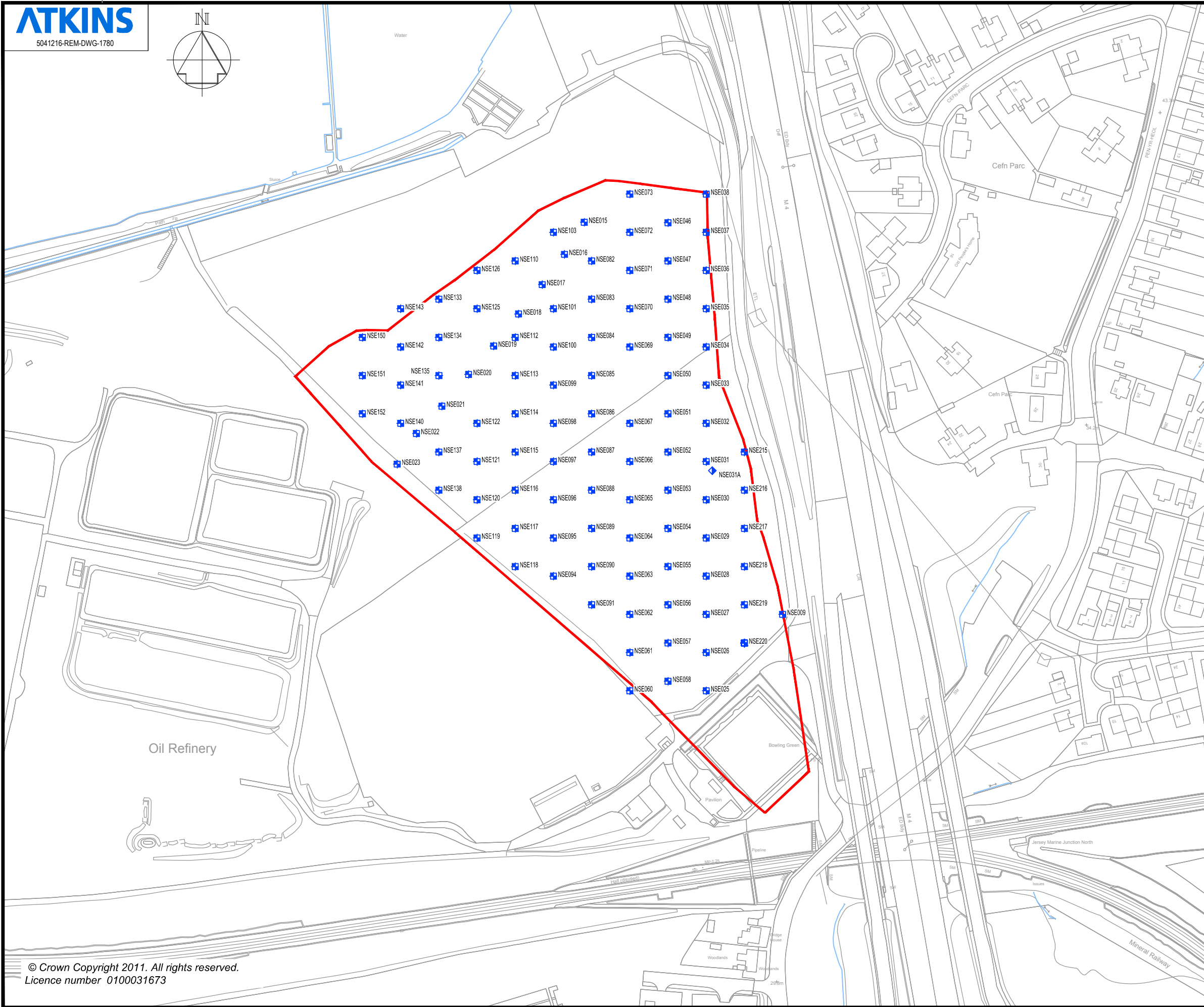
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MONITOR BOUNDARY PHASE 53



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Coed Darcy

Validation Report
Monitor Phase 54

St Modwen Developments Limited



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Table of contents

Chapter	Pages
1. Introduction	5
1.1. Background	5
1.2. Aims and Objectives	5
1.3. Scope of Work	5
1.4. Soil Quality Assessment Standards	6
1.5. Information Sources	7
1.6. Limitations	7
2. The Site	8
2.1. Location and Description	8
2.2. Historical Land Use	8
2.3. Published Geology	9
2.4. Hydrogeology and Hydrology	9
2.5. Landfills and Waste Management Facilities	9
2.6. Sensitive Land Uses	9
3. Historical Ground Investigation	11
3.1. Recorded Ground Conditions	11
3.2. Soil and Groundwater Contamination	13
3.2.2. Visual and Olfactory Evidence of Contamination	13
4. Requirements under the S106	15
4.1. Section 106 Deed of Planning Obligations Requirements	15
5. Recent Ground Investigation	16
5.1. Introduction	16
5.2. Recorded Ground Conditions	16
5.3. Laboratory Analysis	16
5.4. Soil and Groundwater Contamination	17
5.5. Relict Pipework	19
6. Identified Issues Requiring Further Works	21
7. Validation	22
7.1. Requirements of the S106	22
7.2. Sampling Frequencies	22
7.3. Further Investigation	23
7.4. Hotspot Excavation	26
7.5. Pipework Removal	28
8. Summary	31
Drawings	32
Appendix A. Summary of Adopted Thresholds	
Appendix B. Exploratory Hole Logs	
Appendix C. Laboratory Analytical Results – Ground Investigation	
Appendix D. Laboratory Analytical Results – Remedial Works	
Appendix E. Photosheet	

Glossary of Terms

Term	Meaning / Definition
CSM	Conceptual Site Model
RBSL	Risk Based Screening Level
ACM	Asbestos Containing Material
TPH	Total Petroleum Hydrocarbons
PAH	Polycyclic Aromatic Hydrocarbons
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
FFL	Finished Floor Level
mAOD	metres Above Ordnance Datum
RAP	Remedial Action Plan
VO	Visual/Olfactory Observations
BGL	Below Ground Level

1. Introduction

1.1. Background

Atkins Limited has been commissioned by St. Modwen Developments Ltd (St. Modwen) to provide consultancy advice with regard to the redevelopment of the former Llandarcy Oil Refinery as Coed Darcy.

The purpose of this report is to provide data relating to Monitor Phase 54 to confirm the suitability of this area for redevelopment in line with the specific requirements of the S106 and in order for St. Modwen to achieve sign off by the Monitor. For the purpose of Monitor sign off, the extent of Monitor Phase 54 is shown on Drawing 5041216-REM-DWG-1830.

This document represents an updated version of an earlier report and takes into account Monitor comments in RFI0129, dated 6^h May 2015.

Based upon the current Masterplan, Monitor Phase 54 is shown as a mixed use area in the final development. Further to discussion with St. Modwen, however, the following assessment assumes a proposed commercial end use for Monitor Phase 54 in terms of comparison with the requirements of the S106.

In the absence of detailed information relating to any proposed layout and/or finished floor levels (FFL) across this area, the following assessment assumes that existing ground levels represent a depth of 1m below FFL for the purpose of comparison with the requirements of the S106.

1.2. Aims and Objectives

This report provides an overview of the site including information regarding the site setting, local geology and hydrogeology, identified contamination and discussion of remedial works undertaken, where required.

In the long term, it is anticipated that the suitability of remedial works will need to be reassessed once detailed development proposals for each area are defined.

Planning Condition 44 of the Outline Planning Permission for the site (P2005/0393) requires that:

Prior to the submission of the first reserved matters application on each phase of development, notwithstanding the provisions of Condition 26, a phase specific remediation strategy focusing upon the remediation requirements of that area shall be submitted to and approved in writing by the Local Planning Authority. The submitted documents shall include the results from the site investigation and risk assessment; and using the above information a method statement shall be submitted detailing remediation measures and a detailed programme for the submission of verification reports upon completion of the remedial works confirming implementation of agreed measures, together with proposals for future monitoring and reporting. The approved details shall be fully implemented on site, in line with a schedule of works that shall form part of the details submitted to the Local Planning Authority for approval.

In line with the detailed information relating to historical and recent ground investigation and laboratory analysis for Monitor Phase 54 as provided in the following report, it is envisaged that this document would form part of any later planning submission for this part of the site in line with the requirements of Planning Condition 44.

1.3. Scope of Work

The scope of works includes:

- A review of information on geological, hydrogeological, historical site plans, Environment Agency and British Geological Society (BGS) records.
- A review of available historical maps relating to Monitor Phase 54;
- A review of historical (1998-2004) and recent ground investigation (2014) information relating to Monitor Phase 54;
- Comparison of the available ground investigation information and laboratory data against the requirements of the S106, specific to the proposed end use for Monitor Phase 54;
- Details of any remedial works undertaken; and
- Details of all further investigation/validation in order to confirm that the remedial works were successfully carried out and to demonstrate that this area is now suitable for use in line with the required criteria.

1.4. Soil Quality Assessment Standards

To maintain consistency of approach, the assessment standards for historical and recent data are those stated in the S106 Agreement for Coed Darcy. The visual and aesthetic classification system as previously defined by BP within the S106, is provided as Table 1.1.

Atkins proposes to continue this system for the classification of all soils encountered to aid assessment of each area in terms of the required remediation requirements. The assigned classifications for each strata are quoted on the trial pit logs for recent ground investigation (refer to Section 5).

Table 1.1 – Scale of Aesthetic Criteria

Class	Visual	Olfactory
0	No visible staining of soil, no visible suspect ACM*.	No detectable odour on soil.
1	Occasional staining of soil, no visible suspect ACM*.	Faint odour on soil.
2	Frequent staining of soil.	Distinct but not strong odour on soil.
3	Occasional heavy staining of soil.	Strong odour on soil.
4	Heavy staining of soil.	Strong odour discernible in ambient air.
5	Visible hydrocarbon present.	Overwhelming odour.

* visible suspect ACM refers to asbestos containing material visible to the naked eye which a reasonable and prudent person used to managing asbestos may suspect to be asbestos-containing.

The S106 for the proposed development presents a series of Risk Based Screening levels (RBSLs). These levels are defined in the S106 as being the 'minimum base level standard' for redevelopment remediation works (Schedule 8, Part 2, Paragraph 2,5).

In order to update the assessment of contamination in line with current UK guidance, these RBSLs are also now supplemented by a series of Remedial Target Concentrations (RTCs) derived by Atkins (Atkins reference: 5041216-REM-REP-000476 v1). A summary of the adopted thresholds for Monitor Phase 54 are presented in Appendix A.

Details of the required frequencies of testing, as stated within the S106, are presented in Section 7.

Compliance with the redevelopment remediation requirements stated within Schedule 8 of the S106 (refer to Section 4) form the basis for obtaining the relevant sign off from the Monitor.

1.5. Information Sources

Information, reviewed as part of the following assessment, has been obtained from the following sources:

- URS BP Llandarcy Refinery Desk Study 44382742/BRRP0001, July 2007
- URS Report FR1287 Final Factual Report for Ground Investigation, August 2005
- Section 106 Deed of Planning Obligations (Dewey & LeBoeuf report GNP/NJR/13773-2), February 2008

1.6. Limitations

As previously indicated, this report has been prepared with the sole intention of providing sufficient information to enable St. Modwen to obtain Monitor sign off for Monitor Phase 54 in accordance with criteria set out in the Coed Darcy Section 106 Agreement. Whilst the report may be relevant for submission as part of a reserved matters planning application, additional reports and submissions will be required as part of any future plot development.

The investigation works undertaken and summarised within this report represent a sampling exercise to determine ground conditions, in line with the required methodology outlined within the S106. The proposed works were carried out predominantly to investigate contamination across this area and do not include a review of any geotechnical issues or constraints that may exist which would need to be taken into account as part of any proposed redevelopment.

In addition, it should be noted that ground and groundwater conditions can vary over time and between sampling points. Whilst this report provides information relating to the removal of identified pipework and below ground structures encountered during the works, unidentified pipework and/or structures may still exist in situ.

2. The Site

2.1. Location and Description

Monitor Phase 54 is an irregular-shaped area of land of approximately 13 ha (hectares) in size. This area is located in the northern part of the former Llandarcy Oil Refinery, to the north of a railway cutting for the Swansea District Line of the Great Western Railway. The extent of Monitor Phase 54 is shown on Drawing 5041216-REM-DWG-1830.

The north eastern part of Monitor Phase 54 forms a plateau at an elevation of approximately 51 metres above Ordnance Datum (mAOD) and the ground falls to the north, south east, south and west to approximately 47mAOD, 36mAOD, 41mAOD, 35mAOD respectively. A topographical survey of the area is presented as Drawing-ATK-DR-C-REM-2055.

Prior to acquisition of the site by St. Modwen in 2008, above ground structures and infrastructure were removed from Monitor Phase 54 by others. A live electricity cable, which provides power to the existing pumps for North Site Reservoir, currently runs from east to west along the southern boundary of Monitor Phase 54. Due to the continued operation of these pumps, this cable is to be retained for the foreseeable future within this part of the site.

North Site is defined to the north and west by areas of scrub, to the northwest by North Site Reservoir, to the east by fields (Monitor Phase 53) and to the south by a live railway line in cutting.

2.2. Historical Land Use

Construction of Llandarcy Oil refinery commenced in 1917 but was temporarily suspended during the war due to the lack of men and resources. Construction started again in 1919 with production beginning in 1921. The refinery was officially opened in 1922.

The purpose of the refinery was to produce motor spirit, kerosene, gas fuel oil, fuel residue and lubricating oil and wax from imported crude oil. Between the wars, the oil industry developed rapidly. By 1939, the refinery had little of the original plant in operation.

In the mid 1980's a number of rationalisations occurred with the closure of the refinery being formally announced in 1997.

Based upon the information in URS Report 44382742/BRRP0001, Monitor Phase 54 was historically occupied by 50 above ground storage tanks, associated pipework and other ancillary infrastructure. According to the report, storage tanks in the east of Monitor Phase 54 were constructed in the 1950s or earlier and were used until decommissioning of the refinery. These tanks are indicated to have been primarily used for storage of middle distillates (paraffin/kerosene). A drain along the southern boundary is known to have captured oil.

The API oil-water separators to the north of the reported area are likely to date back to the 1950s and were used to separate product from water prior to discharge into the North Site Reservoir. Any oil recovered was stored in tanks located in the west of North Site. An acid tar pit was located to the south east of the separators based on historical maps.

Tanks and above ground infrastructure were removed from Monitor Phase 54 prior to acquisition of the refinery by St. Modwen in 2008. It is not known, therefore, what condition these were in when they were removed in relation to the potential for historical spillage and leakages within this area.

An electrical substation (No.5) is shown to be in the south western corner of North Site with electrical substation No.5A in the central south.

Historical land use of Monitor Phase 54, based on the information available, is shown on Drawing 5041216-REM-DWG-1831.

Not shown on historical maps, a concrete structure containing acid tar was found to be present on site. The acid tar was removed and is awaiting disposal off-site, and the concrete structure was broken out.

2.3. Published Geology

A review of published geological information (BGS map 247, Swansea (1:50,000 scale) indicates Monitor Phase 54 to be underlain by:

- Till (Diamicton), a heterogeneous deposit of glacial origin, which extends across almost all of the area with the exception of the far south.
- Pennant Sandstone Formation, specifically the Hughes Member which is described by the BGS as *'green-grey, lithic arenites ("Pennant sandstones") with thin mudstone/siltstone and seatearth interbeds and mainly thin coals'*.

2.4. Hydrogeology and Hydrology

2.4.1. Groundwater

Environment Agency data suggests that the Till (Diamicton) underlying Monitor Phase 54 is classified as 'Unproductive Strata'. These are defined as:

'...rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.'

The underlying sandstone bedrock is classified as a 'Secondary A Aquifer'. This is defined as:

'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.'

Groundwater flow within Monitor Phase 54 has been previously suggested to be generally radial from the central plateau of the site (URS FR1287).

2.4.2. Surface Waters

The closest significant water feature is the North Site reservoir, which lies immediately to the north of Monitor Phase 54.

The Tennant Canal is located approximately 815m to the south east of Monitor Phase 54. Crymlyn Bog Site of Special Scientific Interest (refer to Section 2.6) is located approximately 725m to the south west.

2.5. Landfills and Waste Management Facilities

There are no recorded landfills within, or immediately adjacent to, Monitor Phase 54.

The nearest recorded landfill is the former refinery landfill which is classified as being a 'closed' landfill. Atkins is currently in the process of remediating and restoring the landfill and are in ongoing discussion with Natural Resources Wales relating to the surrender of Environmental Permit No. EPR/AP3990LR.

2.6. Sensitive Land Uses

Crymlyn Bog Site of Special Scientific Interest (SSSI) lies approximately 725 m to the south west of Monitor Phase 54 and represents the most extensive area of lowland fen in Wales.

Crymlyn Bog SSSI is internationally important for its very wet mires often identified by an unstable `quaking` surface. Bottle sedge and bogbean are important components of some stands, together with common cottongrass, water horsetail, star sedge, mud sedge, and in places, the nationally rare slender cottongrass. Crymlyn Bog supports the largest area of calcium-rich fen dominated by great fen sedge vegetation in south Wales. Some of these stands are dominated by great fen sedge, but other areas display a more diverse vegetation in which tufted-sedge, royal fern and a range of tall-herb fen species are prominent. Some of these stands are unique in a Welsh context. In addition there are areas of wet woodland with alder and willow being the dominant species (<http://www.ccg.gov.uk/landscape--wildlife>).

3. Historical Ground Investigation

3.1. Recorded Ground Conditions

3.1.1. General

Approximately 65 no. exploratory holes are reported to have been historically carried out by URS within Monitor Phase 54 on behalf of the previous site owner, BP. The locations of known exploratory holes are presented on Drawing 5041216-REM-DWG-1832.

The exploratory holes were completed between 1998 and 2004, as part of a series of investigations across the former refinery (URS Report FR1287).

Made Ground was noted to be present where many of the old tanks were located historically within Monitor Phase 54 (refer to Drawing 5041216-REM-DWG-1831). Made ground is known to have been historically used around the refinery for the creation of bunds around the tanks. Made ground was described to comprise sandy gravel with varying amounts of ash, slag and clinker and was recorded to a maximum depth of 2.6m bgl in NSMW015(pit) which was excavated adjacent to the borehole of the same reference.

Existing superficial deposits across Monitor Phase 54 were reported to comprise glacial materials, typically grey – brown silts, with clays, sands and gravels.

Bedrock was reported to outcrop at the surface towards the north of Monitor Phase 54, becoming deeper towards the south to a maximum depth of 16.5m bgl.

During the investigative works, shallow groundwater was reported at depths of between 0.002m and 5.14m bgl across Monitor Phase 54, and is considered to represent 'perched' water within the more granular material of the glacial deposits. True groundwater beneath Monitor Phase 54 was suggested to lie within the underlying bedrock, at depths of between 0.035m and 17.59m bgl.

3.1.2. Exploratory Hole Summary

Based on a review of this historical information, olfactory evidence of contamination was reported across many areas of Monitor Phase 54. Frequent VO scores of 3-4 were noted across much of the southern and western parts of this phase. VO scores of 5 are reported to have been encountered within the central part of Monitor Phase 54.

The available historical borehole and trial pit logs have been reviewed in detail, where available, and salient detail from which is summarised below for reference. The locations of all of the exploratory holes referenced below are shown on Drawing 5041216-REM-DWG-1832.

- NSTP010 was excavated to 2.0m bgl down to sandstone bedrock. Made ground was recorded to 0.4m bgl and soft to firm sandy silt thereafter until weathered sandstone at 1.3m bgl. No visual or olfactory evidence of contamination was observed during excavation and the hole was reported as dry throughout.
- MSTP230 was excavated to 'refusal' at 1.6m bgl. Black peat was recorded to 0.5m bgl and soft light brown clayey sand thereafter to the base of the pit. Visual and olfactory evidence increased with depth until the base of the trial pit.
- MSTP244 was excavated to 3.2m bgl until 'refusal'. Dark brown slightly gravelly clay was recorded to 0.1m bgl, then clayey sand of varying gravel content was recorded to the base. No visual or olfactory evidence was recorded until 2.0m bgl where it was then described as a moderate hydrocarbon sheen and odour.. Water inflow was also recorded at 2.4m bgl.
- MSTP286 was a window sample hole completed and installed to 4.0m bgl. Made ground was recorded down to 0.4m bgl then firm to stiff very gravelly clay thereafter to 3.0m bgl.

Gravel was then recorded to the base of the hole. Strong hydrocarbon odours were recorded from 1.6m bgl to the base of the holes.

- MSMW009 was drilled to 10.5m bgl and then a monitoring installation was installed within the mudstone bedrock. Slight 'apple' odours are reported to have been observed at 3.0m bgl. Perched water was recorded at 3.0m bgl. Bedrock was encountered at 8.2m bgl and is described as a medium to dark grey mudstone.
- NSMW010 was drilled to 5.0m bgl. Made ground was recorded down to 1.2m bgl, then weathered sandstone, overlying sandstone bedrock at 1.7m bgl.
- NSMW026 was drilled to 3.8m bgl. No made ground was observed. Heavy staining and strong odours were recorded between 1.0m and 2.3m bgl. No free product was identified and the hole was reported as damp throughout.
- MSMW075 was drilled to 10.0m bgl. Sandstone bedrock was recorded at 4.7m bgl and 'perched' water was recorded at 2.1m bgl. 'Gasoline odours' were recorded associated with a water strike at 3.0m bgl.
- MSMW090 was drilled until 'refusal' at 2.2m bgl. Hydrocarbon odours were observed from 1.0m bgl. No free product was identified.
- MSMW141 was drilled to 'refusal' at 3.0m bgl. Moderate to strong hydrocarbon odours were observed from 1.5m bgl to the base of the holes. The hole is described as being wet from 1.5m bgl.
- NSMW007 comprised superficial deposits (soft to firm sandy clay with frequent sandstone cobbles) overlying sandstone bedrock at 4.5m bgl. Moderate to strong hydrocarbon odours were observed down to 2.0m bgl.
- NSMW008 comprised superficial deposits (sandy silt with sandstone gravel, cobbles and boulders) overlying bedrock at 3.2m bgl. Bedrock is described as a closely fractured medium grained sandstone. A slight hydrocarbon odour was observed from 0.4m bgl to base of superficial soils, where the odour is reported to have become fainter.
- NSMW015 was drilled to a depth of 5.3m bgl. Bedrock was not encountered however sandstone cobbles were encountered towards the base of the borehole. Superficial deposits are described as a silty gravelly fine to medium sand with frequent sandstone cobbles with increasing depth. Strong hydrocarbon odours were observed from 1.5m bgl down to 3.2m bgl where the odours and staining were described as light to moderate.
- NSMW021 was drilled to a depth of 3.6m bgl. Bedrock was not encountered, however, the base of the hole was reported as becoming 'denser with cobble content increasing'. Superficial deposits are described predominantly as a 'sandy silt with sandstone gravel, cobbles and boulders'. Strong hydrocarbon odours were reported from 0.2m bgl to 1.1m bgl, at which depth the odours were recorded as moderate.
- NSMW022 was drilled to a depth of 3.6m bgl. Bedrock was not encountered. Superficial deposits are described as a soft brown sandy silt with occasional gravel, becoming more gravelly with depth. Hydrocarbon odours were observed from 0.6m bgl and are indicated to have become stronger with depth. Staining was also observed with depth. No free product was identified.
- NSMW023 was drilled to 3.5m bgl in bedrock. Strong fine to medium grained sandstone was encountered from 2.2m bgl. Very faint to slight hydrocarbon odours were recorded from 1.5mbgl to base.

3.2. Soil and Groundwater Contamination

3.2.1. Introduction

A review of the historical logs, laboratory and monitoring data for Monitor Phase 54 has been undertaken. This suggests visual and olfactory evidence of contamination, including free product, and exceedances of the RBSLs, as further detailed below:

3.2.2. Visual and Olfactory Evidence of Contamination

As previously discussed (section 3.1.2), visual and olfactory evidence of contamination was identified within a number of historical boreholes and trial pits across Monitor Phase 54, as summarised below.

- MSTP230 exhibited strong odours at the base with obvious black staining throughout, no free product was observed.
- MSTP244 exhibited moderate odours at the base with a sheen and 'foam' on the slow ingress of groundwater.
- MSTP286 exhibited strong odours from 0.5m to base, no groundwater or free product as observed.
- NSMW026 exhibited heavy staining and strong odours.
- MSMW090 exhibited odours but no free product or groundwater was recorded.
- MSMW141 exhibited moderate to strong hydrocarbon odours.
- NSMW007 exhibited strong odours and staining with the pit becoming damp with depth.
- NSMW015 exhibited strong odours.
- NSMW021 exhibited strong hydrocarbon odours and was reported as damp with depth.

3.2.2. Free Product

No free product is reported to have been encountered during excavation or drilling of historical trial pits/boreholes across Monitor Phase 54.

Subsequent monitoring carried out between 1998 and 2003, however, suggests the presence of free product in a number of monitoring wells across Monitor 54.

The greatest frequency of wells in which free product was historically encountered would appear to lie within the western part of Monitor Phase 54.

Free product is reported to have been historically recorded within the following boreholes, which were installed by URS across Monitor Phase 54 between 1998 and 2004; MSMW080, MSMW075d, MSMW075s, MSMW077d, MSMW078d, MSMW078s, MSMW079s, MSMW082d, MSMW082s, MSMW084, MSMW092, MSMW092, MSMW093, MSMW141s2, MSTP247, MSTP292, NSMW003, NSMW006, and RFSW038.

Of these 19 boreholes, the following 6 are reported to have contained more than 1mm thickness of product during historical monitoring: MSMW078d, MSMW078s, MSMW092, MSMW141s, MSTP292, NSMW003, and NSMW006.

MSMW078s was found to contain the most product, with up to 61mm recorded during a monitoring round in 1999. This monitoring well was constructed to screen the superficial deposits and is located directly west, and down gradient of several historical tank locations.

3.2.3. Soil Contamination

Available laboratory analytical data for historical ground investigation across Monitor Phase 54 indicates numerous exceedances of the adopted thresholds in soil for retention at depth (>1m below FFL) within a proposed commercial area, including TPH aromatics (C9-C10), benzene and toluene. This is consistent with the historical use of this area for the storage of hydrocarbons (refer to section 2.2).

Historical analysis for PCBs on a sample from the location of electricity substation 5A, suggests concentrations of five of the seven congeners were found lie above the laboratory method detection limits.

3.2.4. Groundwater Contamination

A review of historical laboratory analytical data for Monitor Phase 54 suggests that TPH and benzene concentrations within groundwater are greatest within the south and west of the site.

Laboratory analysis of groundwater samples indicated exceedances of the commercial RBSL for benzene in MSMW141 (shallow) and MSMW026d (refer to Drawing 5041216-REM-DWG-1832). Elevated levels of benzene were also detected in boreholes NSMW007, 124mg/l and NSMW015, 82.6mg/l during the 2003 monitoring round.

3.2.5. Special Process Areas

Based upon the findings of previous ground investigation, previous assessment of Monitor Phase 54 has led to the designation of six 'Special Process Areas'. These areas represent areas where there is a greater potential for contamination within the former refinery, based on historical end use.

Details of the Special Process Areas within Monitor Phase 54, as defined by URS, are provided below. The locations and extent of the Special Process Areas are shown on Drawing 5041216-REM-DWG-1832.

- 8 *North Site_Product*
- 20 *TPH North_Dissolved*
- 21 *TPH North 2_Dissolved*
- 26 *Substation 5A*
- 27 *Substation 5*
- 29 *Tar Pit*

4. Requirements under the S106

4.1. Section 106 Deed of Planning Obligations Requirements

The S106 only defines remediation requirements for a single commercial classification and this is based on a '**commercial end use where groundwater is in soil**' scenario.

Following a review of available data, true groundwater beneath Monitor Phase 54 has been shown to lie within the underlying bedrock. In the absence of a 'commercial end use where groundwater is in rock' scenario in the S106, it is proposed that the existing S106 requirements for a commercial land use are adopted but that the depth of the remediation is defined by the surface of the underlying bedrock rather than being defined by the depth to groundwater.

Based upon this classification, the following remediation requirements are stated in the S106 (Schedule 8, Section 6.0) as being the minimum remediation requirements required in order to release this area for redevelopment for a commercial end use.

- *All oil saturated soils and soil containing free product other than minor sheens shall be removed down to underlying bedrock.*
- *All soils must meet the RBSL for TPH to at least 1m below FFL.*
- *All soils must meet in bulk, considering both dispersed fibres and pieces of ACM, the RBSL for ACM to at least 1m below FFL. Any visible ACM encountered during construction in the first 1m below FFL is to be removed.*
- *Where there is a risk of the migration in the ground of hazardous gas or contaminated liquid into remediated areas, the Developer shall take all appropriate measures to prevent this occurring. Such measures could include the installation of interception trenches and management of discharge from those. The Developer shall monitor whatever measures are put in place after their installation to continue to demonstrate their effectiveness.*
- *Where necessary, seeps, sheens and iron rich discharges from the bedrock must be controlled such that there is no visible discharge at surface and little or no odour. Acceptable methodologies for remediation may include, but are not limited to the use of land drainage via interceptors.*

Schedule 10, Paragraph 6 of the S106 states that 'Irrespective of the Intended Use of each Phase or part thereof, all existing buried services at the Property shall be removed and the routes of those services shall be backfilled with material no more permeable than the general material in the vicinity'.

In the absence of any information relating to finished floor levels associated with any proposed redevelopment of this area, the following assessment assumes that the current ground levels, shown on Drawing 5041216-ATK-DR-C-REM-2055, within Monitor Phase 54 represent 1m below FFL.

5. Recent Ground Investigation

5.1. Introduction

With the aim of supplementing and updating the historical investigation, a total of 1079 machine excavated trial pits were undertaken across Monitor Phase 54 between October and November 2014.

Environmental Scientifics Group (ESG) were employed by the client, St Modwen, to complete the works, under direction from Atkins.

Trial pits were advanced to the maximum reach of the excavator, unless terminated on bedrock or obstructions or because of collapse or contamination. All trial pits were backfilled with arisings in the reverse order to which they were excavated, then compacted with the back of the excavator bucket. Excess arisings were left in a mound above the surrounding ground surface to allow for subsequent settlement.

The locations of the recent trial pits are shown on Drawing 5041216-REM-DWG-1833.

Copies of all relevant exploratory hole logs for the recent investigation works are presented in Appendix B.

5.2. Recorded Ground Conditions

Consistent with historical investigation, Made Ground was encountered in 500 trial pits across Monitor Phase 54 and is described as comprising a greyish brown slightly silty gravelly sand with rare clinker and brick fragments to depths of between 0.05m (NSW732) and 5.4m bgl (NSW382).

Pipework was encountered in 33 locations across Monitor Phase 54 and is discussed further in Section 5.3.2.

Natural superficial deposits were found to underlie the Made Ground and is described as a silty gravelly sand, with occasional sandstone cobbles or sandy gravelly silt with occasional sandstone cobbles.

Sandstone bedrock was encountered beneath Monitor Phase 54 as a weathered zone comprising clayey sandy tabular sandstone gravel, cobbles and occasional boulders. Where proven, the depth to bedrock varied across the reported area, ranging from 0.6m bgl to 5.4m bgl and generally becoming shallower towards the north of the site.

Water strikes (described as seepages or slow ingress) were recorded in many of the trial pits excavated in Monitor Phase 54, at depths ranging from 0.3m bgl to 4.7 m bgl.

Some of the water strikes were noted to be associated with redundant underground services.

The achieved frequency of investigation, based on the recent trial pitting, is discussed in Section 7.

5.3. Laboratory Analysis

A total of 3315 soil samples, representing identified soils from across collected from Monitor Phase 54, were analysed by Alcontrol Laboratories for a general suite of contaminants considered appropriate for the former use of the area.

Due to the uncertainty over final floor levels, a generic suite comprising the majority of determinands listed in the RBSLs, was scheduled on all soil samples collected during the ground investigation. The availability of this additional data should help to minimise the need for further sampling/investigation, should final floor levels be designed to lie at or below the current ground levels.

Due to the absence of any identified sources of historical solvent use within this area, no testing for volatile organic compounds was undertaken for this area.

The analytical suite comprised:

- Metals - arsenic, cadmium, chromium, copper, lead, nickel, mercury, selenium, vanadium, zinc (all samples);
- pH (all samples);
- Polycyclic Aromatic Hydrocarbons (all samples);
- Speciated Petroleum Hydrocarbon plus BTEX Hydrocarbons (all samples);
- Soil Organic Matter (selected samples); and
- Asbestos screen and identification (samples within top 1m from existing ground level only, assuming that current levels represent 1m below FFL and the asbestos RBSL does not apply at depths greater than 2m below FFL in any land use scenario).

The achieved frequency of testing, based on the recent trial pitting, is discussed in Section 7.

5.4. Soil and Groundwater Contamination

5.4.1. Visual and Olfactory Evidence of Contamination

A review of the logs for the 1079 trial pits recently excavated by ESG within Monitor Phase 54 suggests that visual and/or olfactory evidence scores of 5 were identified in 45 locations.

Table 5.2 below provides a summary of 45 trial pits in which visual and/or olfactory scores of 5 were recorded along with details of locations in which oil-saturated soils and free product were recorded during excavation.

In some instances, a distinction has been made between a VO score of 5 relating to staining or odours associated within contamination within in situ soils and a VO score of 5 associated with the presence of free product associated with in situ structures or seepage associated with shallow groundwater i.e. free product present within a relict pipe.

Table 5.2 – Recorded VO scores of 5 and Free Product Observations

Trial Pit	Depth		Scores		Comments
	From (m)	To (m)	Visual	Olfactory	
NSW100	0.5	1.0	4	3	Oozing viscous black liquid from pipe left in ground
NSW105	0.2	2.0	0	5	
NSW142	0.0	0.5	4	3	Thick oily sludge
NSW198	0.0	1.8	1	3	Inflow of contaminated water
NSW238	0.9		3	2	Oozing black liquid from side
NSW269	0.0	1.0	5	5	Terminated due to ingress of oil
NSW347	0.0	0.7	5	0	
NSW395	0.0	2.0	5	4	
NSW397	0.8	1.4	5	4	Pipe at 0.90m coated in oil
NSW402	2.0	2.9	4	3	Visible free product
NSW417	1.4	2.6	4	2	Oily sheen on some boulders with visible free product
NSW419	4.0	4.8	4	4	Visible free product in soil
NSW441	1.1	1.7	5	3	
NSW448	0.0	0.41	5	1	
NSW529	3.5	4.71	5	3	Free product observed

Trial Pit	Depth		Scores		Comments
	From (m)	To (m)	Visual	Olfactory	
NSW545	0.0	3.0	3	5	
NSW546	1.1	2.0	5	3	
NSW621	2.95	3.0	2	3	Groundwater looks contaminated
NSW628	2.0		3	3	Oil seepage
NSW639	1.3	4.4	2	5	
NSW640	1.9	3.3	3	5	
NSW731	1.15	1.6	5	3	Geological description indicates natural black rather than hydrocarbon staining or free product. No further action proposed.
NSW793	1.2	2.2	5	5	Boulder size pockets of white unknown product
NSW826	2.3				Slight seepage below 2.3m with very oily sheen. Sandstone bedrock was encountered at 2.3m and no further action is proposed.
NSW900	0.8	1.6	5	3	
NSW910	1.1	2.1	5	3	
NSW912	4.3				Water strike with thick black oily layer
NSW918	5.0				Seepage from bedrock at base with very oily layer. No further action proposed.
NSW929	0.6	3.5m	2	5	
NSW931	1.5				Thick oily sheen on groundwater
NSW938	4.0	4.2	5	4	
NSW942	3.0		4	3	Thick oily sheen on groundwater
NSW943	0.8		2	4	Black oily sheen on groundwater
NSW956	1.6		3	4	Thick oily layer on groundwater
NSW957	0	2.2	5	2	
NSW965	0	1.6	5	4	
NSW974	2.8	4.1	2	5	
NSW977	0	0.7	5	2	
NSW1001	4	4	2	5	Odours encountered at depth in cobbles and boulders of sandstone interpreted as weathered bedrock. No further action is proposed.
NSW1004	1.2	2.7	2	5	
NSW1005	1.0	1.1	5	3	Thin bed of dark grey very oily tarmac gravel with strong hydrocarbon odours. Slight sheen on groundwater
NSW1081	1	4.4	2	5	
NSW1085	0.25	0.5	5	3	

5.4.2. Comparison with Risk Based Screening Levels

Exceedances of the Risk Based Screening Levels (RBSL) for deep soils (>1m below FFL) in a commercial land use have been recorded for TPH Aromatic C8-C10, based on a 1% SOM which was considered to be most appropriate for the ground conditions encountered in Monitor Phase 54.

A summary of chemical exceedances are summarised in Table 5.1 and laboratory analytical results are included as Appendix C.

Table 5.1 – Summary of chemical exceedances in Monitor Phase 54

Determinand	Commercial Risk Based Screening Level (mg/kg)	Number of exceedances	Total samples tested	Maximum recorded concentration (mg/kg)	Location of maximum recorded concentration
TPH Aromatic C8-C10	547	15	3352	1080	NSW877 1.3m

Drawing 5041216-REM-DWG-1841 presents the locations of RBSL exceedances and VO criteria of Class 5 as well as observations of hydrocarbon sheens and free product.

No soils were removed from within Monitor Phase 54 as part of the trial pitting works.

5.4.3. Asbestos contamination

No visible evidence of any asbestos containing materials (ACMs) were identified across Monitor Phase 54 during recent investigation.

A total of 1093 samples underwent laboratory analysis for asbestos as part of the recent investigative works across Monitor Phase 54. Loose asbestos fibres or debris is reported to have been detected in 308 of the samples taken from the trial pits across Monitor Phase 54. Laboratory analytical results are included as Appendix C.

As previously highlighted, the assessment is based upon the assumption that existing ground levels across Monitor Phase 54 represent 1m below FFL for the purpose of comparison with the requirements of the S106. Based on this assumption, existing soils across this area would lie at depths greater than 1m within any final development.

In line with the adopted scenario of a commercial end use (refer to section 4), there are no specified thresholds for asbestos at depths >1m below FFL and all soils in which asbestos was identified during laboratory analysis are considered to be suitable for retention given the adopted scenario.

5.5. Relict Pipework

Relict pipework was encountered in 33 trial pits within Monitor Phase 54.

The locations and depths of identified pipework are summarised in Table 5.3, together with any relevant comments from the exploratory hole logs.

Table 5.3 –Locations of pipework encountered in Monitor Phase 54

Trial Pit	Depth	Comments
NSW005	0.10m	250mm diameter
NSW100	0.50-1.00m	Oozing black liquid from pipe
NSW125	0.40m	
NSW150	0.30m	Metal pipe
NSW161	1.80m	
NSW205	-	Pit flooded with water (pipe hit)
NSW210	0.70m	
NSW367	1.20m	Brick foundation and steel pipe (100mm diameter)

Trial Pit	Depth	Comments
NSW374	1.50m	
NSW383	2.00m	
NSW384	0.50m	
NSW397	0.90m	Cast iron pipe 200mm diameter coated in oil
NSW399	0.80m	Cast iron pipe 200mm diameter
NSW430	1.50m	Water pipe
NSW433	1.00m	
NSW523	0.25m	
NSW524	0.50m	
NSW530	0.36m	Metal pipe
NSW543	0.90m	180mm diameter iron pipe 4m in length with chalk infill.
NSW548	1.00m	
NSW568	0.20m	
NSW578	0.40m	
NSW594	0.10-0.30m	
NSW610	0.30m	
NSW638	1.40m	Oil pipe
NSW665	0.30m	Water pipe
NSW696	0.40m	Old pipe
NSW719	0.30m	
NSW726	0.20m	
NSW748	0.90-1.00m	
NSW1055	1.00m	
NSW1083	3.00m	

6. Identified Issues Requiring Further Works

Recent trial pitting works across Monitor Phase 54 have identified the following issues requiring further investigation and/or removal to meet with the requirements of the S106, as summarised in Section 4:

- RBSL failures within existing soils;
- Hydrocarbon saturation or free phase oil;
- The presence of pipework identified in situ at 30 locations during the trial pitting.
- Further investigation of an area of Monitor Phase 54, near to the existing API Separators. This area was inaccessible at the time of the trial pitting works carried out by ESG.

In line with the presence of two former substations (refer to Drawing 5041216-REM-DWG-1832) further investigation and PCB laboratory analysis was also proposed as part of the ongoing assessment of Monitor Phase 54.

It should be noted that identified concrete or other structural remnants, such as brickwork, will be broken out and removed as part of the proposed remedial works across Monitor Phase 54 only if the presence of these materials prevents the delineation or excavation of identified contaminated material.

In the absence of a full 'turnover' of soils across Monitor Phase 54, the potential for remaining concrete/brickwork within this area exists. The removal of relict below ground structures from across this area does not form a requirement of the S106 and is, therefore, outside of the scope of these works.

Identified areas within Monitor Phase 54 requiring further investigation and/or removal are shown on Drawing 5041216-REM-DWG-1841.

7. Validation

7.1. Requirements of the S106

The S106 (Schedule 8, Part 3, Section 8) sets out the requirements for validation testing which need to be complied with to enable Monitor sign off as part of the ongoing redevelopment of the former Llandarcy Oil Refinery. Details of relevant frequencies relating to Monitor Phase 54 are presented in Table 7.1.

Table 7.1 - Minimum Validation Testing Frequencies - Commercial End Use

Testing for the Validation Suite ¹ at the following frequency:	Deeper Soils (Commercial >1m below FFL)
Imported quarried material	1 per 1000m ³ ex situ, composite of 5 regular sub-samples.
Imported soil from verified greenfield site	1 per 500m ³ ex situ, composite of 5 regular sub-samples.
Imported soil from characterised brownfield site ¹	1 per 100m ³ ex situ, composite of 5 regular sub-samples.
0.5-1m below FFL in-situ	Regular grid of 1 per 400m ² , sample over 0.5m depth.
>1m below FFL in-situ	Regular grid of 1 per 400m ² , sample over 0.5m depth.
Stockpiled excavated site materials for re-use	1 per 400m ³ ex situ, composite of 5 sub-samples.
Face of remedial excavations <1m deep	1 per 15m ² , minimum of 1 per face, worst case VO sample.
Face of remedial excavations >1m deep	1 per 15m ² , minimum of 1 per face, worst case VO sample.
Along redundant service excavations	1 per 20m of trench, worst case VO sample.
Soil treated ex-situ and homogenised	1 per 500m ³ ex situ, composite of 5 regular sub-samples.

¹ Validation suite to reflect prior use of the originating brownfield site and the design and purpose of the relevant area of Coed Darcy.

VO = visual/olfactory (i.e. aesthetic) observation

As previously stated, in the absence of any information relating to proposed development levels for this area current ground levels within Monitor Phase 54 (Drawing 5041216-REM-DWG-1830) represents a level of 1m below FFL for the purpose of comparison with requirements of the S106.

7.2. Sampling Frequencies

7.2.1. Ground Investigation

The locations of all recent exploratory holes are shown on Drawing 5041216-REM-DWG-1833. Relevant exploratory logs are presented in Appendix B.

A total of 1079 recent trial pits have been undertaken by ESG within Monitor Phase 54.

A total of 3315 environmental samples from Monitor Phase 54 have been subject to laboratory analysis as part of the recent investigation works (refer to Appendix C).

Based on an approximate area of 130,000m², 1079 trial pits equates to an approximate frequency of one pit per 120m². A total of 3315 samples equates to an approximate sample validation frequency of 1 test per 39m².

All of these validation frequencies are compliant with the adopted thresholds and S106 frequency (refer to Table 7.1) of 1 test per 400m² for in situ materials within an area of intended commercial end use.

7.3. Further Investigation

7.3.1. Visual and Olfactory Evidence of Contamination

The results of further investigation into recorded VO scores of 5 and free product are summarised in Table 7.2.

Where additional investigation suggested a reduced level of contamination from the previous ESG investigation, the presence of any RBSL exceedances and the reported VO classifications have been reviewed in order to determine the need for any further works at this location.

Table 7.2 – Results of Further Investigation into Recorded VO scores of 5 and Free Product Observations

Location	Initial Investigation Observations	RBSL Failures in Recent Ground Investigation	Summary of Further Investigation	Validation
NSW100	Oozing viscous black liquid from pipe left in ground Surrounding soils VO 4,3	None	VO 5,4 recorded in excavation. Excavation extended in all directions to approximate dimensions of 8m x10m. Pipe removed. Excavated material removed directly to on-site material quarantine area.	Excavation delineated by VO 4,3 in surrounding soils. No further action proposed.
NSW105	VO 0,5 No odour description provided on trial pit log	None	VO 0,4 recorded in excavation, no overwhelming hydrocarbon odour.	No further action proposed.
NSW142	Thick oily sludge VO 4,3	None	VO 1,2 recorded in excavation. Refer to Photograph 1 in Appendix E.	No further action proposed.
NSW198	Inflow of contaminated water Surrounding soils VO 1,3	None	VO 2,3. Pipe found and removed. No water strike recorded.	No further action proposed.
NSW238	Oozing black liquid from side Surrounding soils 3,2	None	VO 3,3 Black liquid not observed. Refer to Photograph 2 in Appendix E.	No further action proposed.
NSW269	Terminated due to ingress of oil VO 5,5	None	Oil ingress not encountered. Refer to Photograph 3 in Appendix E.	No further action proposed.
NSW347	VO 5,0	None	VO 0,0. Refer to Photograph 4 in Appendix E.	No further action proposed.
NSW395	VO 5,4 Heavily stained soils	None	Hydrocarbon staining observed with a maximum assigned score of VO 3,4. No free product observed.	No further action proposed.
NSW397	Pipe at 0.90m coated in oil Surrounding soils VO 5,4	None	Short section of pipe removed, surrounding soils assigned score of VO 3,2.	No further action proposed.
NSW402	Visible free product VO 4,3	None	No hydrocarbon staining noted, no visible free product at base	No further action proposed.
NSW417	Oily sheen on some boulders with visible free product VO 4,2	None	Hydrocarbon staining observed with a maximum assigned score of VO 3,4. No free product observed.	No further action proposed.
NSW419	Visible free product in soil VO 4,4	None	No hydrocarbon staining noted, no visible free product at base	No further action proposed.
NSW441	VO 5,3	None	Black staining observed, no free product.	No further action proposed.

Location	Initial Investigation Observations	RBSL Failures in Recent Ground Investigation	Summary of Further Investigation	Validation
NSW448	VO 5,1	None	Ashy layer noted between ground level and a depth of approximately 0.4m. No free product observed.	Score of '5' is attributed to ash which does not require excavation - no further action proposed.
NSW529	Free product observed VO 5,3	None	No free product observed, maximum assigned score of VO 3,4. Refer to Photograph 6 in Appendix E.	No further action proposed.
NSW545	VO 3,5	None	Hydrocarbon odour noted but not overwhelming, maximum assigned score of VO 3,3	No further action proposed.
NSW546	Visible black hydrocarbon product VO 5,3	None	No free product observed, maximum assigned score of VO 3,4.	No further action proposed.
NSW621	Groundwater looks contaminated Surrounding soils VO 2,3	None	No groundwater strike recorded.	No further action proposed.
NSW628	Oil seepage Surrounding soils VO 3,3	None	VO 2,2. No oil seepage noted. Refer to Photograph 7 in Appendix E.	No further action proposed.
NSW639	VO 2,5	None	Acrid odour and black staining of silty layer between approximately 0.5m and 2m depth.	No further action proposed.
NSW640	VO 3,5	None	Hydrocarbon odour and layer of black ash.	No further action proposed.
NSW793	Boulder size pockets of white unknown product VO 5,5	None	VO 5,4	Excavated as part of wider removal of contamination hotspot with RBSL failures.
NSW900	VO 5,3	None	Free product noted in fractured/weathered bedrock, water seeping in at base.	Excavation left open but amount did not increase and not sufficient volume for recovery - no further action proposed.
NSW910	VO 5,3	None	VO 5,3	Excavated to bedrock as part of wider dig to remove oil saturated soils/free product. Refer to Photograph 8 in Appendix E - no further action proposed.
NSW912	Water strike with thick black oily layer	None	Free product noted in fractured/weathered bedrock, water seeping in at base.	Excavation left open but amount did not increase and not sufficient volume for recovery - no further action proposed.
NSW929	VO 2,5 Oily sheen on surface of water strike	None	VO 3,4. Oily sheen identified as water with ash on surface.	No further action proposed.
NSW931	Thick oily sheen on groundwater	None	Black staining of material between 0.5m and 0.7m. Hydrocarbon odour, no free product. No groundwater encountered.	No further action proposed.
NSW938	VO 5,4	None	Free product noted at base.	Excavation left open but amount did not increase and not sufficient volume for recovery - no further action proposed.

Location	Initial Investigation Observations	RBSL Failures in Recent Ground Investigation	Summary of Further Investigation	Validation
NSW942	Thick oily sheen on groundwater Surrounding soils VO 4,3	None	Black free product observed in base of excavation.	Area excavated and material removed directly to on-site material quarantine area. Refer to Photograph 8 in Appendix E - no further action proposed.
NSW943	Black oily sheen on groundwater Surrounding soils VO 2,4	None	Black free product observed in base of excavation.	Area excavated and material removed directly to on-site material quarantine area. Refer to Photograph 8 in Appendix E - no further action proposed.
NSW956	Thick oily layer on groundwater Surrounding soils VO 3,4	None	Oily sheen noted on groundwater at base of excavation.	Groundwater sample taken and no exceedances of commercial RBSL for groundwater recorded. Laboratory analytical results are included as Appendix D, report reference 150411-75. No further action proposed.
NSW957	VO 5,2	None	VO 1,2. Metal hydrant pipe 5m long encountered and removed along with two 5m long plastic pipes.	No further action proposed.
NSW965	VO 5,4	None	VO 3,3. Hydrocarbon staining noted but no free product observed.	No further action proposed.
NSW974	VO 2,5	None	Black staining and hydrocarbon odour noted, not overwhelming. Excavation backfilled.	No further action proposed.
NSW977	Heavy staining of hydrocarbon free product VO 5,2	None	Thin band of black heavily stained gravel. No free product observed.	No further action proposed.
NSW1004	VO 2,5	None	Slight hydrocarbon odour, thin layer of black staining. VO 2,2.	No further action proposed.
NSW1005	Thin bed of dark grey very oily tarmac gravel with strong hydrocarbon odours. VO 5,3	None	VO 3,4. Hydrocarbon staining noted but no free product observed.	No further action proposed.
NSW1081	VO 2,5	None	Excavated to bedrock, no sheen or product observed on groundwater in base of excavation. No overwhelming hydrocarbon odour encountered.	No further action proposed.
NSW1085	Frequently stained black clayey silt VO 5,3	None	Excavated to bedrock and hydrocarbon staining noted in soils and on cobbles. No free product observed,	No further action proposed.

7.3.2. Former Electricity Substations

Additional sampling was undertaken in and directly adjacent to the footprints of two electricity substations shown on historical maps (refer to Drawing 5041216-REM-DWG-1831) in order to obtain further samples for additional laboratory analysis for Polychlorinated Biphenyls (PCBs).

Formal logs were not made of the excavations because designated trial pits had already been completed in these areas to the required frequency. No evidence of any significant contamination was noted at either of the locations.

Two locations were excavated at each former substation footprint and two samples were taken in each location – samples 1A and 1B from electricity substation 5 and samples 2A and 2B from electricity substation 5A. No evidence of any PCBs (WHO 12) were recorded in any of the samples tested.

The laboratory analytical results are included in Appendix D (laboratory report reference 150411-72).

7.3.3. Additional Ground Investigation

Additional investigation, comprising eight machine excavated trial pits, has been carried out across an area of Monitor Phase 54 near to the existing API separators. This area had been inaccessible at the time of the previous trial pitting by ESG.

Made Ground, comprising a sandy silty gravelly clay with cobbles of concrete, was encountered in five of the trial pits to a maximum depth of 1.3m bgl. Natural soils, comprising topsoil overlying a sandy clay and weathered bedrock (clayey/sandy sandstone cobbles) was present in four trial pits to a maximum depth of 1.6m bgl. Two seepages of groundwater were encountered at the upper bedrock surface during the works.

A maximum visual and olfactory criteria score of 3 was assigned in NSW858 between 0.05m and 0.15m depth. No exceedances of the RBSL for deep soils (>1m below FFL) in a commercial land use were recorded.

Laboratory analytical results for these additional pits are included in Appendix D (laboratory report 15-09852).

7.4. Hotspot Excavation

Excavation of soils was carried out where exceedances of the RBSL for TPH Aromatic C8-C10 of 547 (mg/kg) were recorded in Monitor Phase 54, as summarised in Table 7.3.

Excavations were commenced at the location of the recorded sample and were advanced beyond the depth of the recorded failures and generally extended laterally by approximately 5m in all directions. As a guide, visual and olfactory evidence of contamination was used to assess whether the excavations needed to be extended further to achieve complete removal of the hotspot.

Validation soil samples were taken from the completed excavation faces to meet a 1 per 15m² frequency and from the base of excavation to meet a 1 per 400m² frequency, as set out in the S106 (refer to Table 7.1).

7.3 – Summary of Contamination Hotspot Excavation

Location	Recorded RBSL Exceedance (mg/kg)	Details of Excavation	Validation
NSW084 1.5m	828	Excavated to bedrock at 2.9m. VO score of bedrock at base 1/1	Two validation samples taken from each face of excavation. No RBSL exceedances recorded. Laboratory analytical results are included in Appendix D, report reference 150401-78.
NSW217 3.5m	624	Excavated to a depth of 3.7m to below the recorded RBSL failure at 3.5m.	Four validation samples taken from each of the four excavation faces and one validation sample taken from the base. Laboratory analytical results are included in Appendix D, report reference 15-09295.
NSW263 2.5m	649		

Location	Recorded RBSL Exceedance (mg/kg)	Details of Excavation	Validation
NSW378 4.5m	747	Large trial pit excavated to bedrock at 5.0m depth to remove contaminated material around the depth of 4.5m. Refer to Photograph 5 in Appendix E.	One validation sample taken at 4.5m from each face of trial pit excavation. No RBSL exceedances recorded. Laboratory analytical results are included in Appendix D, report reference 150418-52.
NSW385 2.5m	823	Excavated to 2.9m	One validation sample taken from the base of excavation, three validation samples taken from the north, east and south faces and two from the west face. No RBSL exceedances recorded. Laboratory analytical results are included in Appendix D, report reference 15-09295.
NSW578 3.5m	548	Excavated to 3.65m	Two validation samples taken from the base of excavation, six validation samples taken from the east and west faces and four validation samples from the north and south faces. No RBSL exceedances recorded. Laboratory analytical results are included in Appendix D, report reference 15-09538.
NSW595 1.5m	710		
NSW734 1.5m	636	Excavated approximately 20m x 11m to 3.5m depth	Five validation samples taken from both east and west faces of excavation, three validation samples taken from both north and south faces of excavation and one validation sample taken from the base of excavation. No RBSL exceedances recorded. Laboratory analytical results are included in Appendix D, report reference 150926-42
NSW735 2.5m	763		
NSW785 2.5m	782	Excavated to 3.0m depth	Five validation samples taken from the base, seven validation samples taken from the north and south faces, ten validation samples taken from the east face and eight validation samples from the west face. No RBSL exceedances recorded. Laboratory analytical results are included in Appendix D, report reference 15-09295.
NSW786 1.0m	973		
NSW788 1.5m	692		
NSW834 3.5m	625		
NSW842 0.5m	577		
NSW877 1.3m	1,080	Excavated 10m x 10m to a depth of 1.8m.	Two validation samples taken from each face and one from the base of excavation. No RBSL exceedances recorded. Laboratory analytical results are included in Appendix D, report reference 15-09295.

A drawing showing the extent of the soils removed from within Monitor Phase 54 is presented as Drawing 5041216-ATK-DR-C-REM-2060.

Laboratory analytical results for the validation samples are included in Appendix D and confirm concentrations below the adopted RBSLs for deep soils in a commercial end use.

Hydrocarbon-contaminated material excavated from Monitor Phase 54 was removed to the temporary on-site material quarantine area pending treatment. Formal backfill of these remedial excavations is yet to be carried out.

Topographical survey information for Monitor Phase 54 following completion of the remedial works is shown on Drawing 5041216-ATK-DR-C-REM-002079.

7.5. Pipework Removal

Pipework was encountered in situ in 30 trial pits during the recent ground investigation in Monitor Phase 54. Each of these locations was subject to further investigation, the results of which are summarised in Table 7.4.

Table 7.4 – Results of Relict Pipework Investigation

Trial Pit	Results of Further Pipework Investigation	Validation
NSW005	30cm diameter clay pipe encountered and broken up in situ.	No further action following investigation
NSW100	Pipe removed during larger scale excavation for VO 5,4	No further action following investigation
NSW125	No pipe found in situ. Query raised with ESG engineer who advised that pipework was removed during the ground investigation.	No further action following investigation
NSW150	Two 50mm diameter 1m long sections of metal pipe removed and excavation extended lengthways to confirm absence of further pipework.	No further action following investigation
NSW161	Clay pipe encountered and broken up in situ.	No further action following investigation
NSW205	Clay pipe encountered and broken up in situ.	No further action following investigation
NSW210	Section of 50mm metal pipe chased for 15m and fully removed.	No further action following investigation
NSW367	No pipe found in situ. Discarded length of metal pipe observed on the surface adjacent to location.	No further action following investigation
NSW374	One 2m long section of 50mm metal pipe and one 1m long section of 200mm pipe removed.	No further action following investigation
NSW383	Clay pipe encountered and broken up in situ.	No further action following investigation
NSW384	Section of metal pipe chased northwards for 15m and removed.	No further action following investigation
NSW397	Short section of metal pipe encountered and removed. Extended lengthways to ensure pipe had been fully delineated.	No further action following investigation
NSW399	No pipe found in situ. Query raised with ESG engineer who advised that pipework was removed during the ground investigation.	No further action following investigation
NSW430	Clay pipe encountered and broken up in situ.	No further action following investigation
NSW433	Section of 200mm metal pipe chased eastwards for 35m. Removed and sampled.	Validation samples taken along pipe route. All below commercial deep (>1m below FFL) RBSL.
NSW523	Pipework not encountered during the ground investigation in trial pits located to the north, south, east or west of NSW523, NSW524. And NSW548. Trench excavated approximately 10m to the south of NSW524 in accessible area to an approximate depth of 2m to confirm the absence of a large extent of pipe which required removal.	No further action following investigation. No contamination hotspots present in the vicinity of these trial pits from which contamination could migrate along preferential pathway of pipework route. Investigation has demonstrated only discrete sections of pipework present.
NSW524		
NSW548		
NSW530	Two 2m long sections of 200mm diameter pipe and scrap 50mm diameter metal pipe encountered and removed.	No further action following investigation
NSW543	One 5m long section of 200mm pipe diameter metal pipe encountered and removed.	No further action following investigation
NSW568	Location now within footprint of materials quarantine area. Evidence of contamination in the form of exceedances of the RBSLs or free product was not encountered in trial pits located within the quarantine area footprint. As such, the potential for creation of a preferential pathway for the migration of contamination is considered unlikely.	No further action following investigation

Trial Pit	Results of Further Pipework Investigation	Validation
NSW578	One 'L-shaped' section of pipe (0.5m x 0.8m dimensions) encountered and removed.	No further action following investigation
NSW594	No pipe found in situ. Query raised with ESG engineer who advised that pipework was removed during the ground investigation.	No further action following investigation
NSW610	One 1m long section of 100mm diameter metal pipe encountered and removed.	No further action following investigation
NSW638	One section of metal pipe encountered and removed.	No further action following investigation
NSW665	Two sections of 50mm diameter 1.5m long metal pipe encountered and removed	No further action following investigation
NSW696	Clay pipe encountered and broken up in situ.	No further action following investigation
NSW719	No pipe found in situ. Query raised with ESG engineer who advised that pipework was removed during the ground investigation.	No further action following investigation
NSW726	Clay pipe encountered and broken up in situ.	No further action following investigation
NSW748	One section of metal pipe encountered and removed.	No further action following investigation
NSW1055	Broken terracotta drainage pipe encountered. Broken up in situ	No further action following investigation
NSW1083	Large concrete water pipe encountered and left in situ	No further action following investigation

7.6. Summary

A summary of the status of Monitor Phase 54, in line with the requirements of the S106 is presented in Table 7.5 below:

Table 7.5 – Validation Summary

Requirement	Status	Comment
Chemical quality of soils in situ	Complete	Trial pitting and sampling has been undertaken to the S106 frequency for validation of soils in situ (refer to Section 7.2.1). It should be noted that investigation along the eastern boundary of Monitor Phase 54 was scoped in accordance with the proposed masterplan, with the highest density of trial pits undertaken within areas of proposed development 'plots' and a reduced frequency in areas shown to comprise proposed landscaping or open space. No significant contamination was shown within this part of Monitor Phase 54, which is consistent with the absence of any known historical refinery activities. The frequency of investigation along this eastern boundary is therefore considered to be sufficient for the current assessment of this area.
VO quality of soils in situ	Complete	A maximum recorded VO of 4 was recorded for retained soils. This is acceptable in line with the requirements of the S106 for 'deep' use (>1m below FFL) within a commercial area.
Observations of groundwater for the	Complete	Observations of free product were reviewed and further investigation undertaken. Where found to be present on groundwater, pumping was

Requirement	Status	Comment
presence of free phase product		undertaken to removal the observed free product.
Chemical and VO quality of imported material	N/A	No imported soils were utilised as part of the works.
Compliance with adopted thresholds	Complete	Remedial excavations have been carried out to remove material in 15 locations which was shown to exceed the adopted thresholds (refer to Section 5.4). Validation samples from the excavations were taken in accordance with the required frequency and recorded concentrations are below the available RBSL. Remaining soils in situ within Monitor Phase 54 have been shown to be suitable for retention.
Removal of oil saturated soils	Complete	Oil saturated soils were excavated as part of remedial works across Monitor Phase 54 and removed to the temporary on-site material quarantine area pending treatment.
Asbestos Assessment	Complete	Visible ACM was not identified during the ground investigation works in Monitor Phase 54. The assessment which has been carried out assumes a depth >1m below FFL and the RBSL does not apply at depths greater than 1m below FFL in a commercial scenario.
Control of seeps, sheens and iron staining from bedrock	Complete	No seeps, sheens or iron staining observed which are considered to require control to prevent discharge at the surface.

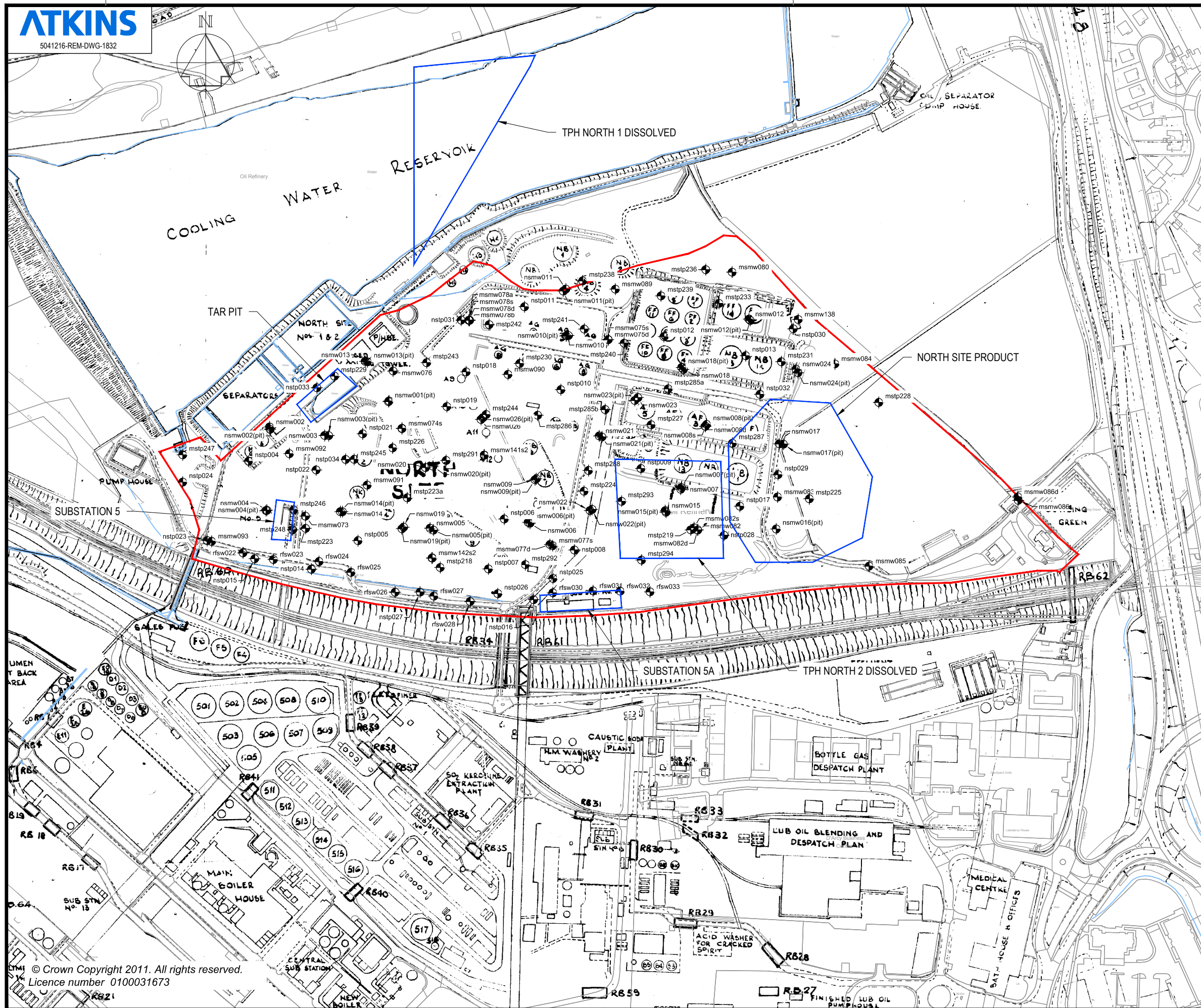
8. Summary

Atkins has been commissioned by St Modwen Developments Ltd to undertake an assessment of an area of the former refinery with a view to enabling Monitor sign-off for this area in terms of a proposed commercial end use. For the purpose of Monitor Sign off, this area shall be referred to as Monitor Phase 54.

Based upon the findings of recent investigation and in line with the scope of recent remedial works undertaken, this area has been validated in accordance with the S106 and Monitor Phase 54 has been deemed to be suitable for commercial end use >1m bgl in line with the requirements of the S106.

It should be noted that recent ground investigation works focussed predominantly on contamination across this area and further assessment to assess potential geotechnical constraints within this Phase should be carried out prior to any proposed development.

Drawings



KEY



MONITOR BOUNDARY PHASE 54



EXPLORATORY HOLE LOCATION

REVISIONS	Drawn By	Checked By	Date
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PURPOSE OF ISSUE	Rev.	Authorised for issue	Date
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Atkins Limited Telford Office Cornerstone House Stafford Park 13 Telford TF3 3AZ Tel 01952 201234 Fax 01952 200981			
Birmingham Office The Axis, 10 Holliday Street Birmingham West Midlands B1 1TF Tel 0121 483 5000 Fax 0121 483 5252			

THIS DRAWING IS NOT TO BE SCALED

CLIENT



PROJECT

COED DARCY

DRAWING TITLE

MONITOR BOUNDARY PHASE 54
HISTORICAL EXPLORATORY HOLE LOCATIONS

SCALES	DRAWN	CHECKED	CO-ORD CHECK
N.T.S.	MJ	CS	
	DATE	DATE	DATE
	26.03.15	26.03.15	

DRAWING NO	SHEET A3	PLOT DATE 15.04.15
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5041216-REM-DWG-1832