SITE CLOSURE REPORT

Thor Group Ltd, Ramsgate Road, Margate, Kent, CT9 4JY

Report

Ecologia™
experts on the ground

Report

SITE CLOSURE REPORT

Thor Group Ltd, Ramsgate Road, Margate, Kent, CT9 4JY

Prepared for: Thor Group Ltd

Reference: EES 00.141.54

Date: 10th September 2025

Building 711 & 712
Kent Science Park
Sittingbourne
Kent
ME9 8BZ UK

Tel: +44 (0)1795 471611
Fax: +44 (0)1795 430314
e-mail: info@ecologia-environmental.com
Website: www.ecologia-environmental.com

Ecologia
experts on the ground

Title:	**SITE CLOSURE REPORT** **Thor Group Ltd, Ramsgate Road, Margate, Kent, CT9 4JY**

Ecologia Reference: EES 00.141.54

Client:	Thor Group Ltd.	**Client Reference:**	Thor, Margate

Management Systems Control

Ecologia operates under an integrated management system certified to ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018.

Version No.	**Status:**	**Prepared by:**	**Checked by:**	**Authorised by:**	**Date:**
1	DRAFT	O. Crockford *BSc (Hons), MSc* L. Allen *BSc (Hons)*	C. Munns *BSc (Hons), CSci MIEnvSC*	G. Maini *BSc (Hons), PhD, CWEM, FCWEM, CSci*	05/06/2025
2	FINAL	O. Crockford *BSc (Hons), MSc* O Crockford L. Allen *BSc (Hons)* L Allen	C. Munns *BSc (Hons), CSci MIEnvSC* C J Munns	G. Maini *BSc (Hons), PhD, CWEM, FCWEM, CSci*	10/09/2025

Report

Executive Summary

Site	Located on the A254 (Ramsgate Road, Margate, Kent, CT9 4JY) between Margate and Ramsgate on the Isle of Thanet, East Kent.
Objectives	The purpose of this Site Closure Report is to provide a narrative of the Phase 3 and Phase 4 remediation works completed and demonstrate that remediation objectives have been met upon cessation of treatment activities and associated rebound monitoring period. The objectives of the remediation works are described more fully in the Addendum Remediation Strategy[ref 49]; however, in summary the key objectives were to manage the remaining contaminant linkages, minimise risks to controlled waters and human health, and surrender the environmental permit. Therefore, allowing the site to be suitable for future redevelopment works subject to requirements set out for future site end users in line with planning requirements.
Identified Contaminant Linkages	The Addendum Remediation Strategy[ref 49] identifies the contaminant linkages that need addressing. The site is directly underlain by the Chalk Principal Aquifer, the protection of which is considered to be the primary risk driver. Following cessation of the previous pump and treat system and subsequent rebound monitoring, concerns were raised over the extent to which benzene would rebound over time as concentrations were found to be fluctuating between 0.1mg/l and 5.4mg/l. Additionally, due to site constraints at the time of previous bulk excavation works in 2017 (access road usage), soil samples from the side walls north and south of the excavation area could not be fully validated (mercury hotspots). Therefore, further investigation / assessment of soils and groundwater was required to provide baseline conditions.
Remediation Strategy & Approach	A combined and phased approach has been adopted to effectively manage the identified contaminant linkages, as follows: • **Phase 3:** groundwater remediation across the former MPA to minimise risks to controlled waters, including a combination of in-situ thermal heating to raise soil and groundwater temperatures to 80ºC (boiling point of benzene), soil vapour extraction, dual phase extraction, steam injection and air sparging in the saturated zone. • **Phase 4:** soil remediation to mitigate human health risks, including source removal of mercury contaminated soils from identified hotspots, and in-situ remediation of benzene contaminated soils within the unsaturated zone close to the original point of loss. The agreed lines of evidence required for treatment cessation and permit surrender were: **Soils *(Mercury Hotspots)*** • Compliance against RTVs, protective of a commercial end use and Principal Aquifer. • Placement of a chemically compliant capping system and membrane. **Groundwater *(Treatment Cessation)*** • Source area benzene reduction (< baseline, 2020/2021). • Mass recovery. **Groundwater *(Permit Surrender)*** • Demonstrate declining groundwater trends of the CoC. • Further treatment works are unlikely to yield significant further reductions over a reasonable timeframe (i.e. asymptotic conditions are reached). • Rebound monitoring over a period of 12-months to demonstrate CoC do not rebound. • Numerical assessment of residual groundwater concentrations demonstrating no significant impaction at a conservative 50m compliance point, at a 30-year timescale. However, should the above requirements not be met then an analysis of the cost benefit and continuing sustainability of the approach should be undertaken.

Implementation of the Works	Phase 3 and Phase 4 remediation works have successfully achieved the following objectives:
	• Bulk mercury contamination from Area 1 and Area 2 excavated and disposed of at a licensed waste facility (total of 230.64 tonnes). A low-permeability cap has been installed across both areas to minimise the potential for future infiltration from any residual contamination.
	• During the final round of remediation monitoring, groundwater benzene concentrations had reduced by >99% compared to the baseline assessment in 2020/2021.
	• The combined mass recovery following remediation works has significantly exceeded the initial calculations by 114%; estimated mass of 619.09kg vs actual mass of 1,323.59kg.
	• Post-remediation drilling in June 2024 (DW20 and DW21) confirmed a significant reduction in organic contamination at depth in the unsaturated zone of >99%.
	• Rebound monitoring has been undertaken between Jan 2023 – Jan 2025 (24No. months).
	  – Benzene concentrations correlate to fluctuations in groundwater levels. The trend is mostly stable / asymptotic when groundwater levels remain below 22m bgl. When groundwater levels rise between 20-22m bgl, higher concentrations are present in DW14, DW16 and DW19 (former MPA); however, lower than the baseline concentrations. This is potentially evidence of a small contaminant release from the unsaturated zone at the POL during periods of prolonged rainfall; however, there is not enough remaining contaminant mass to sustain high concentrations.
	  – A significant percentage reduction is calculated for the maximum CoC concentrations for VOCs (benzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene and toluene) of between 79-99%.
	Based on the most conservative predictive model, using worst case conditions, in approximately 2.5 years' time benzene concentrations are below the DWS of 1µg/l. Therefore, no significant impacts are predicted at a 50m compliance point, at a 30-year timescale.

Residual Liabilities / Monitoring & Maintenance Plan	**Residual Liabilities** i. Well decommissioning works will be undertaken in accordance with Environment Agency guidelines(ref 69), following the outcome of permit surrender. **Future Development Works** ii. Any future development works on site should be undertaken cognisant of the low permeability capping layer in the centre of the site (former MPA). Should the layer be breached then this will need reinstatement. iii. Given the previous history of the site any future construction works shall be undertaken with further assessment, investigation where / if required and a discovery strategy in place. The CSM will need to be updated if there is a proposed change to the current commercial end use. iv. Should any deep foundations be adopted in future, then appropriate foundation and piling risk assessments shall be undertaken in accordance with relevant guidance.
Conclusions	The lines of evidence required for treatment cessation and permit surrender have been met. Therefore, the Phase 3 and Phase 4 works have been completed and verified in accordance with the Addendum Remediation Strategy(ref 49).

CONTENTS

TABLES

PLANS

APPENDICES

1. INTRODUCTION

1.1. Background

Ecologia was instructed by Thor Group Ltd. (the 'Client'), to complete remediation works at the former chemical production facility in Margate (hereafter 'the site'). The objective was to support the surrender of the existing Environmental Permit (EPR/BV3898IR), render the site suitable for divestment, and minimise risks to controlled waters.

The Environmental Permit was initially issued in 2003 following the introduction of permitting regulations(ref 58). During the baseline survey(ref 1), several pollution incidents were discovered resulting from the operation of the chemical facility (discussed in Section 2.4.1). Consequently, the production of organic chemicals (speciality biocides) ceased in 2005 and a 'pump and treat' groundwater remediation system was operated from 2006 to reduce the contamination plume. In 2013 the permit was varied to reflect the groundwater treatment activities taking place on-site as the original permit could not be surrendered.

Ecologia have completed several previous phases of investigation works since 2003, which identified that groundwater contamination comprises of mono-aromatic hydrocarbons and mercury beneath the former main processing area (MPA). Benzene concentrations were used as a marker compound for the contaminant plume and were found at several orders of magnitude over the Drinking Water Standards (DWS). Consequently, a combination of in-situ and ex-situ remediation works were recommended in the Integrated Remediation Strategy(ref 44) to reduce source area contamination:

- Phase 1: pump and treat system supplemented by air sparging to reduce the source and minimise risks to controlled waters; and,
- Phase 2: excavation of soils and soakaways across the former MPA to remove the source and provide a cover system to mitigate human health risks and minimise leaching potential during rainfall events.

The pump and treat system operated between 2006 and 2018 reduced benzene concentrations from a maximum of 102,759µg/l in 2006 (DW14), to a maximum of 1,980µg/l in 2018 (DW16). During the final monitoring round in December 2018, average concentrations beneath the former MPA were 27µg/l. Phase 2 excavation works successfully removed bulk contamination from the former MPA and a low permeability clay capping layer was installed. Verification reports for each phase of works have previously been submitted to the EA as part of the initial permit surrender attempt in 2019(ref 45 and ref 46).

Subsequent rebound monitoring rounds carried out by the Environment Agency (EA) and Thor Group Ltd in 2019 found benzene concentrations to fluctuate between 100µg/l and 5,400µg/l, with a general increasing trend over time. Therefore, concerns were raised over the extent to which benzene would rebound overtime and consequently the requirements for permit surrender could not be met.

To determine the remaining remediation requirements, additional soil and groundwater monitoring were carried out by Ecologia in 2020 and 2021 to assess benzene concentrations on-site and off-site. Results found that benzene concentrations had increased to a peak of 10,600µg/l in the source area (recorded in DW14) and were found to extend to a monitoring borehole approximately 80m from the site boundary (356µg/l in DW11). Additionally, the point of loss was confirmed to be east of DW8, which detected high concentrations of VOCs (benzene and trimethylbenzenes) in the unsaturated soil requiring treatment. The recommendations were set out in an Addendum Remediation Strategy(ref 49), which included two additional phases of works to mitigate remaining soil and groundwater contamination risks:

- Phase 3: groundwater remediation across the former MPA to minimise risks to controlled waters, including a combination of in-situ thermal heating, soil vapour extraction, dual phase extraction, steam injection and air sparging in the saturated zone.
- Phase 4: soil remediation to mitigate human health risks, including source removal of mercury contaminated soils from identified hotspots, and in-situ remediation of benzene contaminated soils within the unsaturated zone close to the original point of loss.

This report presents verification of the works required to complete Phase 3 and Phase 4 remediation, including rebound monitoring and the updated Detailed Quantitative Risk Assessment (DQRA) used in the predictive modelling.

1.2. Objectives

The objective of this Site Closure Report is to provide a narrative of the Phase 3 and Phase 4 remediation works completed and demonstrate that remediation objectives have been met upon cessation of treatment activities and associated rebound monitoring period. The remediation works have been undertaken cognisant of the objectives summarised in Table 1.1, below.

Table 1.1. Remediation Objectives (Phase 3 & 4)

Objectives		Phased Approach
General	i. The site is suitable for re-development as a commercial site. ii. Risks to controlled waters underneath the site are minimised.	Phase 3 & Phase 4
Legal Compliance	i. All works shall be undertaken cognisant of Health and Safety legislation and requirements. ii. The scheme must ensure that the site shall not be determined as contaminated land under Part 2A of the Environmental Protection Act 1990(ref 59). iii. Compliance with the permit surrender requirements under the Environmental Permitting (England and Wales) Regulations 2018(ref 60), and any other relevant guidance.	Phase 3 & Phase 4
Technical Attributes	i. Risk based approach to acceptable standard of remediation and satisfactory condition. ii. The use of appropriate DWS as water quality standards in any assessment undertaken cognisant of EA guidance(ref 61). iii. Groundwater monitoring and trend analysis of the Contaminants of Concern (CoC). iv. Source reduction of organic contamination at depth in the unsaturated zone.	Phase 3 & Phase 4
	v. The use of appropriately derived Remedial Target Values (RTV's) using Ecologia's Generic Assessment Criteria (GAC) protective of human health exposure pathways using the CLEA model(ref 62).	Phase 4 *(mercury hotspots)*
General Site Constraints	i. The protection of controlled water receptors is safeguarded with limited maintenance (for example without having to operate an active pump and treatment system) beyond divestment of the site.	Phase 3
	ii. The site can be used with as little limitations or restrictions as possible. For example, if placed at a shallow depth, a capping layer, that was introduced to reduce rainfall through contaminated soil materials would have to be maintained and reinstated, if breached, at any stage by earthworks related activities in future.	Phase 4 *(mercury hotspots)*
Programme / Timescales	i. Remedial works are to be undertaken as soon as it practicable to support the divestment of the site and the surrender of permit.	Phase 3 & Phase 4
Cost Effectiveness	i. Demonstrable cost effectiveness and identification / implementation of the best practical strategy employing readily available and proven techniques.	Phase 3 & Phase 4

Objectives		Phased Approach
Sustainability Requirements	i. Maximise the use of sustainable treatment technologies.	Phase 3 & Phase 4
	ii. Minimise energy consumption and carbon footprint of treatment technologies.	
	iii. Minimise off-site disposal to landfill by re-use wherever possible of site won materials.	Phase 4 *(mercury hotspots)*
Stakeholder / Regulatory Expectations	i. Demonstration of declining groundwater trends of the CoC.	Phase 3 & Phase 4
	ii. Further treatment works are unlikely to yield significant further reductions in groundwater concentrations of the CoC over a reasonable time frame (i.e. asymptotic conditions are reached).	
	iii. An appropriate rebound monitoring period over 12-months (after system shutdown) and analysis of groundwater at an accredited MCERTS laboratory to demonstrate the CoC do not rebound.	
	iv. A numerical assessment of residual groundwater concentrations (after rebound monitoring) demonstrating no significant impaction at a 30-year timescale at the compliance point (50m).	
	v. Cost benefit analysis for continuing remediation *if the above requirements cannot be demonstrated satisfactorily.*	

1.3. Report Structure

This report has been prepared with due consideration of the Land Contamination Risk Management (EA, 2023)[ref 63], as well as information provided by the EA as part of their enhanced pre-application advice service (Ref: CRM:0264047), and includes the following:

- A description of the site setting, including location, environmental setting, historical development and pollution incidents (Section 2).
- A narrative summarising the source area investigation and groundwater monitoring works completed pre-remediation, in order to better understand groundwater conditions (Section 3).
- An overview of the Conceptual Site Model (CSM) prior to remediation, including the recommended remediation approach and verification plan for managing the identified contaminant linkages (Section 4).
- A narrative summarising the ex-situ remediation works undertaken to manage the identified contaminant linkages related to mercury hotspots (Section 5).
- A narrative summarising the in-situ remediation works undertaken to manage the identified contaminant linkages and support treatment cessation (Section 6).
- A comparison between pre-remediation and post-remediation soil conditions following an additional drilling investigation in the source area in June 2024 (Section 7).
- Results of the rebound monitoring completed between January 2023 and January 2025 to demonstrate reduction in benzene concentrations in the source area and asymptotic conditions (Section 8).
- Results of the predictive modelling (DQRA) using data from historic spill conditions and rebound monitoring results to predict the significant of future impacts off-site at the 50m compliance point (Section 9).
- An updated CSM following completion of remediation works and rebound monitoring to assess any remaining contaminant linkages (Section 10).
- Final conclusions to satisfy requirements that remediation objectives have been met and to support recommendation for permit surrender (Section 11).

2. SITE SETTING

2.1. Site Location

The site comprises an L-shaped plot of land, which is situated in mixed residential, agricultural and industrial area of Margate, Kent. The site is accessed from the A259, which runs along the northeast boundary, as shown in Plan 1, below.

Plan 1. Site Location (*Source: Google Maps, 2025)*

The general site setting summarised in Tabe 2.1, below.

Table 2.1. General Site Setting

National Grid Reference	Approx. 636050 168900	
Site Area	1.9 hectares (ha)	
Approximate Elevation	35m above ordnance datum (AOD)	
Site Geometry	Irregular	
Site Boundary Adjacent Land	North	Residential housing and A259, with agricultural land beyond.
	East	A259, with agricultural land beyond.
	South	Industrial units.
	West	Industrial units, with a disused railway beyond.

2.2. Environmental Setting

Information with regards to the environmental setting of the site has been obtained from readily available public sources, including the British Geological Survey (BGS)[(ref 64)], MAGIC (Natural England *et al*)[(ref 65)], and GOV.UK [(ref 66)] websites.

Information indicated online has since been confirmed with site-specific ground conditions encountered during various phases of investigation works since 2003, included in Table 2.2 overleaf. The previous investigation reports are included in Appendix I, with a summary table of key results included in Appendix II.

Table 2.2. Site Geology & Hydrogeology

Age	Formation / Unit	Lithology	Aquifer Designation	Thickness (m)
N/A	Made Ground	Brown gravelly silty clays, with gravels of chalk fragments	N/A	0.30 – 2.00
Cretaceous	Margate Chalk Member	Marl-free smooth white chalk with little flint, weakly developed indurated iron-stained sponge beds	Principal Aquifer	Not proven

The site is not located within a Source Protection Zone (SPZ), albeit an Outer Zone (Zone II) and Inner Zone (Zone I) are located approximately 600m and 880m southeast of the site.

Several licenced abstractions are located within 2km of the site. The nearest groundwater abstraction point listed for 'public supply' is located approximately 1.3km north of the site (Southern Water Services). The closest abstraction for non-potable uses is located approximately 157m southwest of the site (Agfa-Gavaert Ltd and used for 'process water').

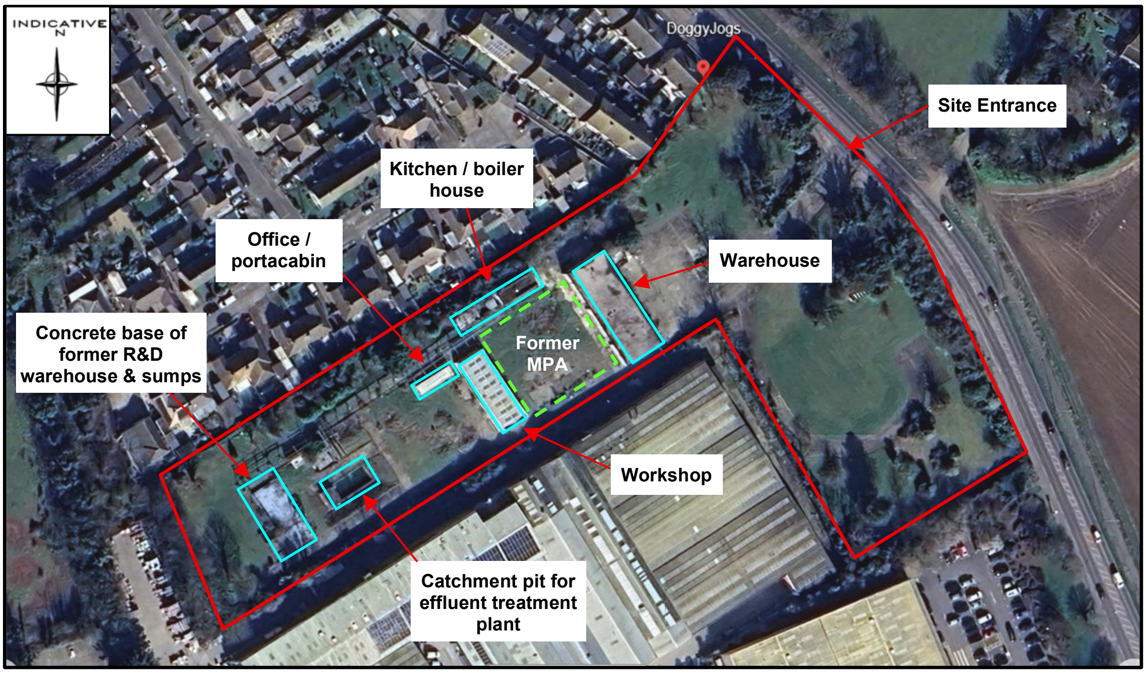
There are no surface water courses located within 250m of the site boundary. The nearest surface water course is a tributary of the River Stour located some 6km to the southwest. The north-sea coast (tidal line) is located approximately 2.5km northeast of the site.

2.3. Current Site Layout

Remaining key features on-site currently comprise the former MPA, surrounded by a workshop, warehouse, office / laboratory portacabin, boiler house and kitchen.

The front of the site comprises an access road and carpark, with areas of soft landscaping, trees and shrubs. Beyond the warehouse, to the western most point of the site, are remnants of the former operational areas. Although the above ground plant has all been removed; a concrete base and sumps remain beneath the former R&D warehouse, as well as a water catchment pit from the former effluent treatment plant.

The current site layout is presented in Plan 2, below.



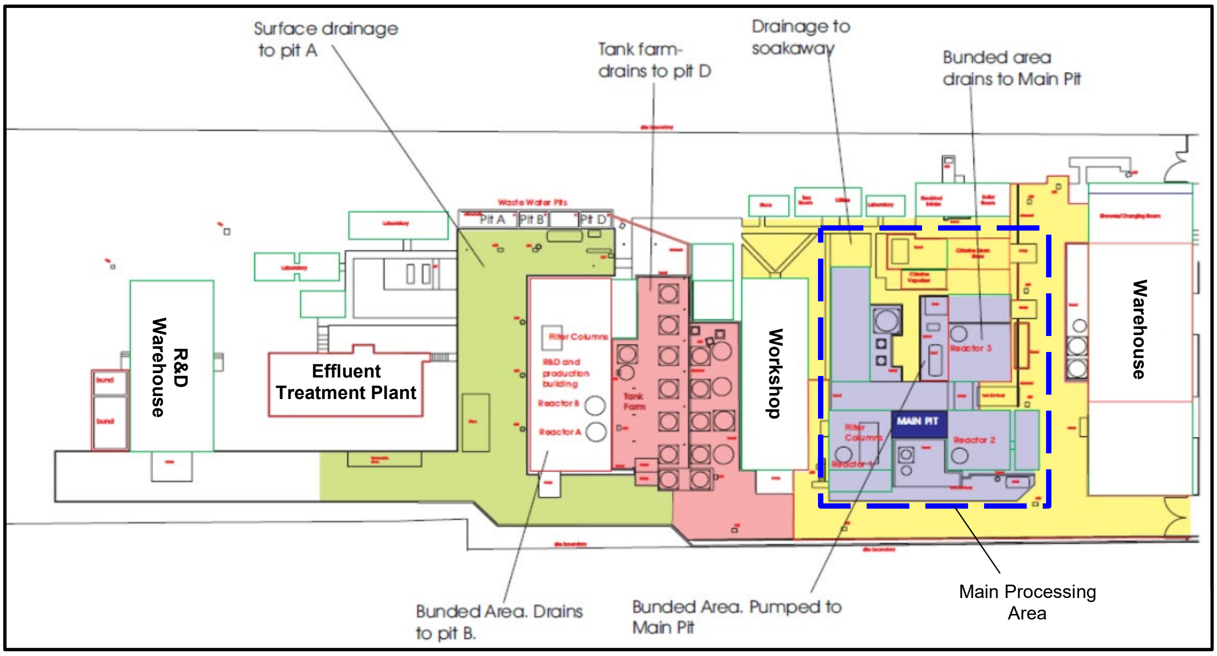
Plan 2. Current Site Layout (*Source: Google Earth, 2025*)

2.4. Historical Development

The chemical manufacturing facility was operational between 1973 and 2005. Manufacture included the production of speciality biocides used in the protection of finished products, such as paints, polymer emulsions and adhesives from microbial spoilage and degradation. The key manufacturing dates and chemicals used are provided below:

- 1973-1988: Manufacture of mercury-based products, including phenyl mercury acetate / phenyl mercury salts, mercuric chloride and halogenated phenols.
- 1988-2005: Manufacture of isothiazolones and the production of Octylisothiazolinone (OIT), *(including 2-octyl-2H-isothiazolone)*; active ingredients in biocide formulations.

Plan 3, below, shows the former site layout during operation.



Plan 3. Former Site Layout (operational areas)

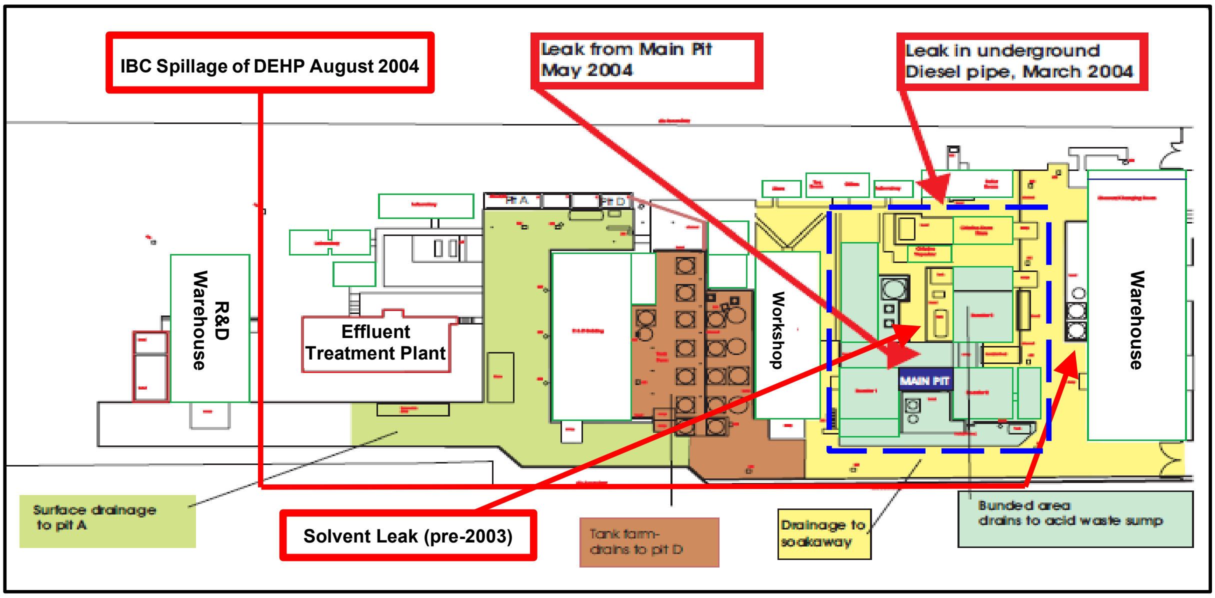
2.4.1. Pollution Incidents

The pollution incidents identified from the baseline permitting survey in 2003 are detailed in detailed in Table 2.3, below, and visually depicted on Plan 4, overleaf.

Table 2.3. Pollution Incidents

Prior to Permit Requirements (1973 – 1988)	***Mercury Releases (prior to 2003)*** Anecdotal information suggested that any mercury, excess to requirements, was directly poured to ground / into the drainage system around the former MPA on completion of production activities. ***Solvent Pump Leak (prior to 2003)*** A solvent leak was observed from a pump approximately 3m north of the main pit. This was an uncontained area of the site for some years during early production operations, which included chemicals of Aromasol H, comprising of a mixture of substituted-benzene compounds (incorporating 1,2,4-trimethylbenzene, 1-ethyl3-methylbenzene, 1,3,5-trimethylbenzene, 1-ethyl4-methylbenzene, 1,2,3-trimethylbenzene, 1,2-diethylbenzene and ethyldimethylbenzene). Additionally, it is anecdotally understood that general site practices during the historical operation of the site may have led to solvent releases, mainly comprising benzene, toluene, 2,2,4-trimethyl pentanediol (Texanol) and alkylated benzenes (trimethylbenzenes and xylenes) into the drainage system and underlying groundwater.

During Permit Requirements (2003 – 2005)	***Diesel Pipe Leak (2004)*** A diesel pipe leak was reported in 2004 in the location adjacent to the boiler room. Following investigations, contamination was confined to the top 1m of Made Ground, directly under the concrete (reported in ref 6). The lack of any visible free product and the low concentrations encountered, even close to the source of the leak, suggested that only a small quantity of oil had escaped from the pipe.
	Main Pit Process Water Release (2004) Approximately 2m^3 to 3m^3 of acidic waste process liquids were released via a small hole found at the centre of the pit base (reported in ref 14). The pit was subsequently drained and repaired. Concentrations of carboxylic acids were subsequently identified in groundwater analyses from boreholes DW1, DW4 and DW5 from May 2004 until August 2005. Versatic acid (a carboxylic acid) was identified in subsequent soil analysis sampled in proximity of the main pit; concentrations of carboxylic acid since declined in 2005 and were no longer considered a risk.
	IBC Spillage (2004) A spill of DEHP (*Bis-2-ethylhexyl phthalate)* was reported in August 2004 from an overturned IBC storage container. This was contained on the warehouse bund but potentially entered into the drainage system (soakaway SO7 being the nearest). The spillage was pumped out and estimated to comprise approximately 60kg of DEHP with up to 5% OIT potentially present in the release. Historic groundwater monitoring has identified DEHP on a single occasion within the groundwater table at trace concentrations only. As such, the spillage was considered to be contained, and the groundwater treatment plant successfully captured any releases to groundwater.

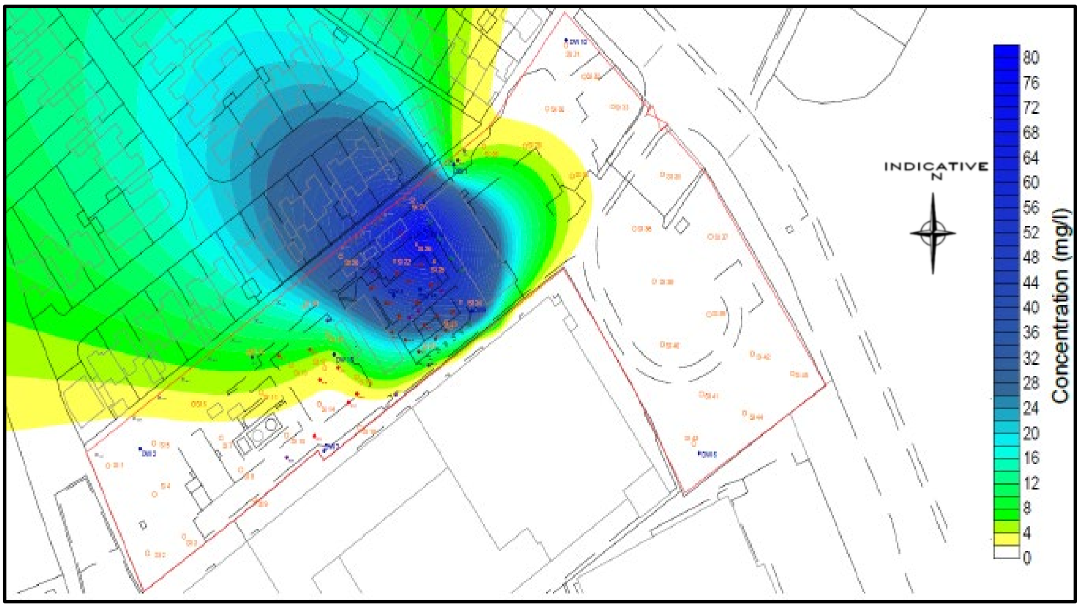


Plan 4. Historic Spill Locations

2.4.2. Contaminant Distribution

The main pollution incident of ongoing concern was determined to be the solvent pump leak, which comprised of mono-aromatic hydrocarbons, with concentrations of benzene greatly exceeding the DWS. Additionally, site practices leading to the release of mercury was also of concern to human health and controlled waters.

The contaminant plume was determined to extend approximately 100m north / northwest of the site boundary in the direction of groundwater flow. Plan 5 overleaf models the likely spread of the solvent contamination plume in 2006.



Plan 5. Modelled Benzene Plume (2006)

2.5. Previous Remediation Works

Several phases of remediation have been completed at the site to reduce the identified contamination and minimise risks to controlled waters and human health. A summary of the previous remediation works is provided in Table 2.4, below.

Table 2.4. Previous Remediation Works

Date	Previous Remediation Works
2006-2018	Pump and treat system to reduce the contaminant plume (operated by Thor Group Ltd). • Over 40,000m^3 of groundwater treated prior to discharge to sewer under consent. • By 2015 the solvent plume had been confined to within the boundary of the former MPA on-site, with no detectable concentrations in the outer wells and off-site boreholes. • Benzene reduction of >99% from 102,759µg/l to 27µg/l between 2006 and 2018.
2016-2017	Air sparging and Soil Vapour Extraction (SVE) of the mono-aromatic hydrocarbons in the former MPA; 82kg of Volatile Organic Compounds (VOCs) were recovered after 239 days of operation (ref 45).
2003-2019	Soakaway remediation / removal works around the former MPA: • Sediment removal in S05, S06, S07, S08 and S12 via combined manual excavation and high airflow vacuum extraction in 2003 (ref 5). • Excavation and removal of soakaway chambers and associated drainage runs between S05, S06, S07, S08, S09, S10, S11 and S12 via manual excavation. Backfill with a clay cap (ref 45).
2017	Bulk excavation earthworks works across the former MPA (ref 45): • Removal of surficial concrete hardstanding followed by excavation of the underlying chalk to a depth of 2.5m bgl to remove mercury and benzene contamination. • Installation of a low permeability cap to prevent leachate following rainfall events. However, due to site constraints at the time of earthworks (access road usage), soil samples from the side walls north and south of the excavation area could not be fully validated. Further investigation and delineation works were therefore required.
2017	Lead hotspot excavation works (ref 45): • Excavation of three (3No.) localised lead hotspots to the east of the warehouse, potentially associated with limited Made Ground on-site in areas of former buildings / structures.

Table 2.5, below, details the maximum CoC concentrations in groundwater recorded between 2006 and 2018.

Table 2.5. Reduction in Maximum CoC Concentrations

Contaminant	Maximum Concentrations		Approximate Percentage Reduction
	2006	2018	
Benzene	102,759 µg/l	1,980 µg/l	>98%
Trimethylbenzenes*	12,274 µg/l	123 µg/l	>99%
Toluene	21,348 µg/l	107 µg/l	>99%
Mercury	3,100 µg/l *(2009)*	0.4 µg/l	>99%
*Trimethylbenzenes is the combined concentration of 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene.			

Despite the significant reduction in CoC concentrations, subsequent rebound monitoring carried out in 2019 identified fluctuating benzene concentrations between 0.1mg/l and 5.4mg/l, with a general increasing trend over time. Therefore, concerns were raised over the extent to which benzene would rebound overtime and consequently the requirements for permit surrender could not be met.

Additionally, because of site constraints present at the time of bulk excavation works in 2017, additional assessment of shallow mercury contamination was also recommended.

Therefore, further assessment of the CoCs was required to provide the EA with information regarding the nature of remaining benzene contamination on-site and confirm any remaining hotspot excavation areas for mercury.

3. GROUNDWATER MONITORING & SOIL INVESTIGATION

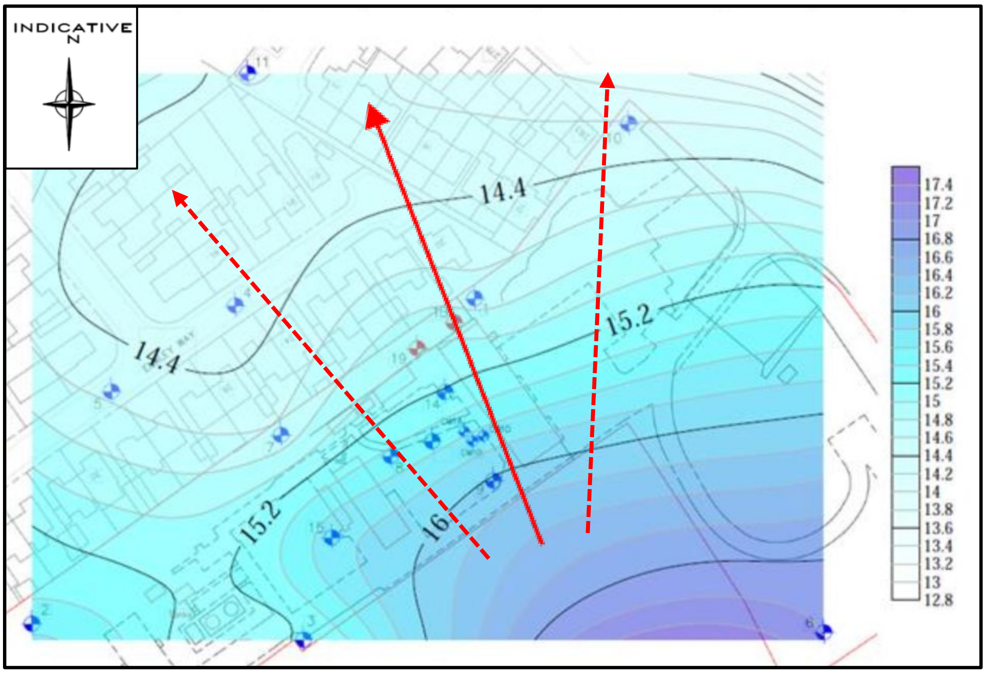
Ecologia undertook groundwater monitoring, between March 2020 and March 2021, to monitor benzene levels on-site and off-site and establish baseline conditions following the cessation of pump and treat operations in 2018. A summary report has previously been submitted to the EA(ref 47), with the findings summarised in subsequent sections.

3.1. Groundwater Geometry

The groundwater geometry was proven to flow to the north / northwest of the site depending on high / low groundwater levels. The highest groundwater level was consistently recorded in DW6 (southeast) and the lowest in DW11 (northwest), with seasonal fluctuations recorded between 18.0 – 25.9m bgl (13.3 – 11.7m AOD). Groundwater direction is generally towards the north when water levels are higher and to the northwest when water levels are lower.

Consequently, two (2No.) additional boreholes were installed down-gradient of the source area in May and November 2020 on the northern-most site boundary (DW19 and DW1B) to assess the potential risks from contaminant migration.

Plan 6, below, shows the groundwater levels recorded during the March 2021 monitoring round. The indicative direction is shown by the solid red line, with the dotted lines showing the fluctuations observed during monitoring rounds.



Plan 6. Groundwater Geometry (March 2021)

3.2. Contaminant Migration Pathways

Changes in groundwater levels can create hydraulic connections between chalk fissures, in turn causing a redistribution of benzene from the point of loss. Previous investigations dating back to 2005 have included geophysics surveys in several boreholes on-site to identify the possible flow horizons and fissures. The relevant findings are summarised below:

- DW8 (former MPA) – possible flow horizons between 26-29m bgl. Fissures identified between 18-28m bgl with some evidence of caving between 22-28m bgl(ref 16).
- DW11 (off-site) – possible flow horizons between 25-29m bgl and at 31.5m bgl(ref 16).

- DW16 (former MPA) – possible flow horizons between 24-30m bgl, 35-37m bgl and at 50m bgl. Prominent fissures identified at 19m and 23m, with lesser fissuring between 24-27m bgl. Major fissure identified between 39-40m bgl and caving between 47-49m bgl(ref 27).

3.3. Groundwater Laboratory Results

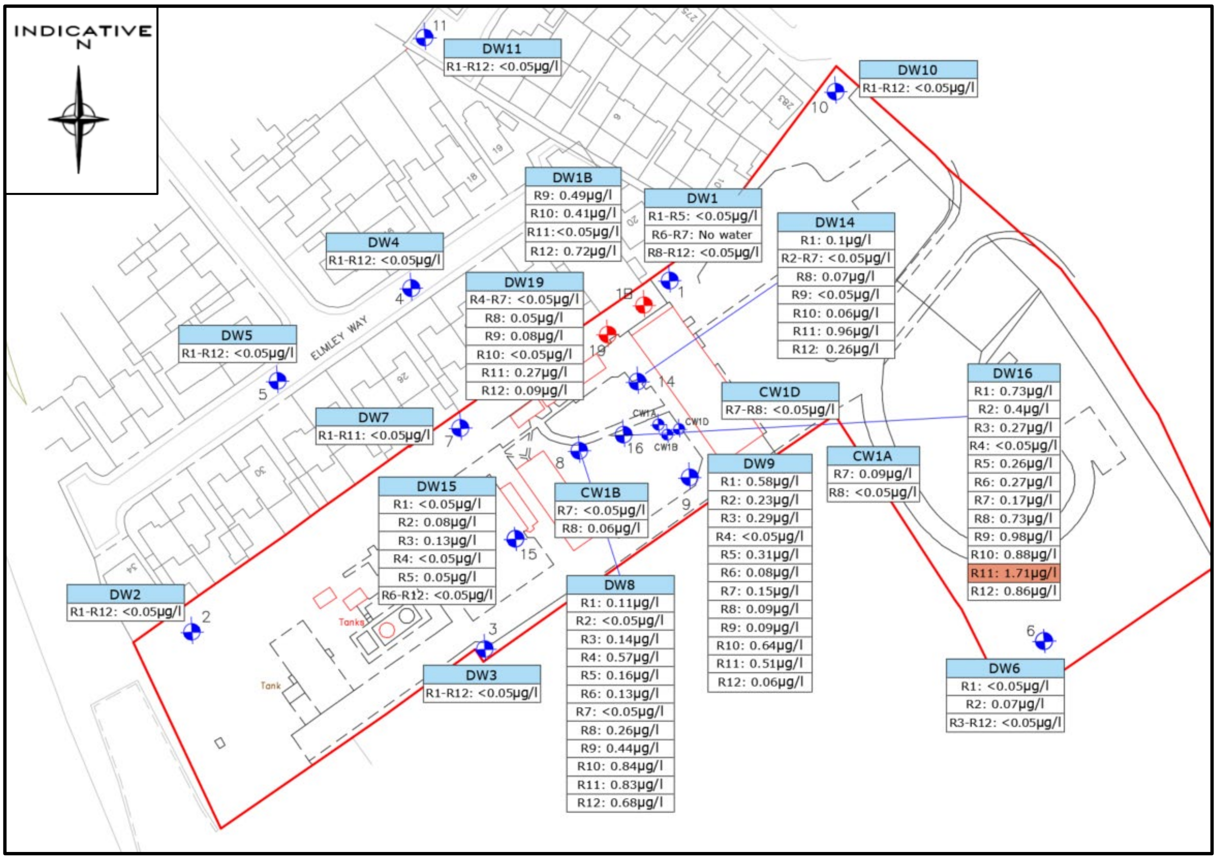
The groundwater was monitored using low flow techniques to induce minimal drawdown and provide non-biased groundwater samples with reduced suspended particles. Samples were submitted to an accredited MCERTS laboratory for analysis of VOCs and mercury.

Physico-chemical parameters were recorded on-site, including pH, temperature, redox, dissolved oxygen and electrical conductivity, which generally indicated anaerobic conditions in the source area with mostly aerobic conditions for the remainder of boreholes on-site and off-site.

The tracking spreadsheet for all physico-chemical parameters is provided in Ecologia's 'Groundwater Monitoring Summary Report'(ref 47) alongside benzene concentrations recorded each round.

3.3.1. Mercury

Mercury concentrations above the laboratory limit of detection (LOD) were only recorded in boreholes beneath the former MPA. In most cases, detectable mercury was below the DWS of 1µg/l, except for an isolated exceedance in DW16 (concentration of 1.71µg/l), as shown in Plan 7, below.



Plan 7. Mercury Concentrations (March 2020 – March 2021)

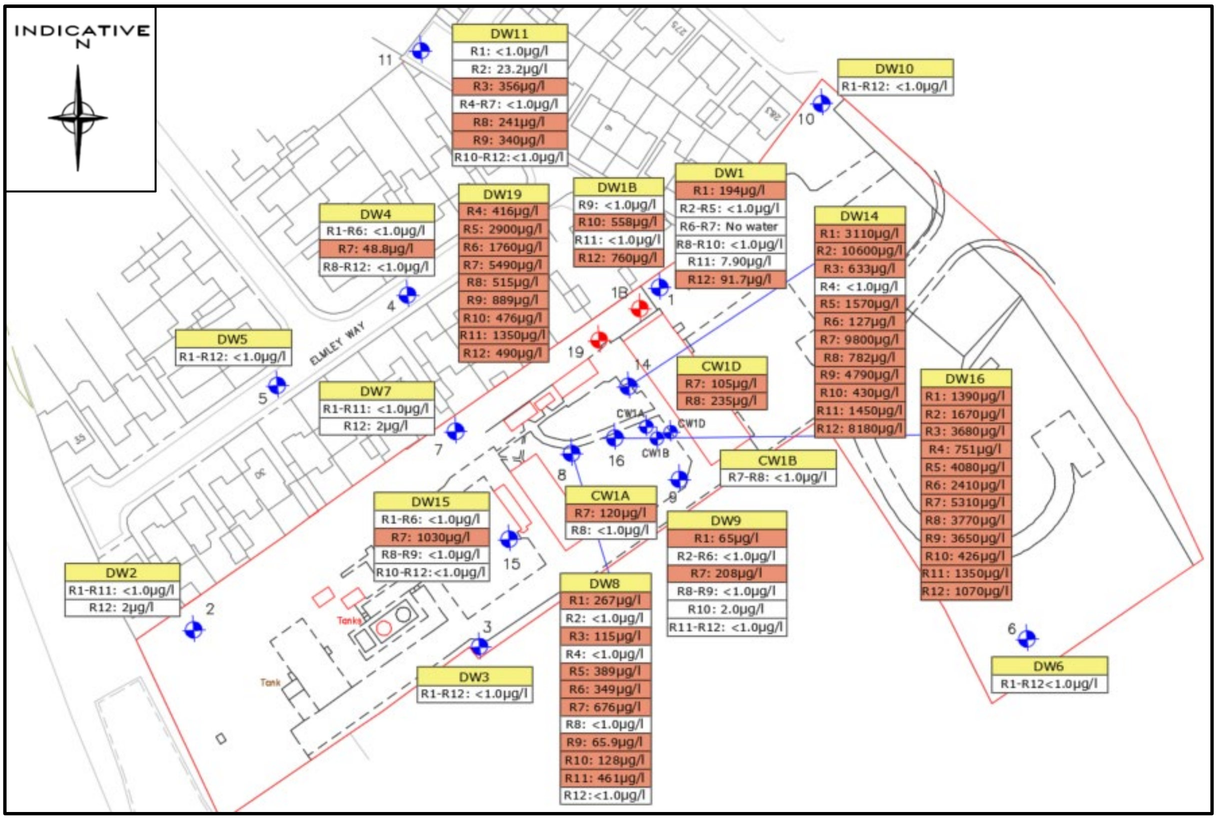
Therefore, the previous bulk excavation works across the former MPA in 2017(ref 45) have been effective in reducing mercury contamination in the shallow soils; however due to site constraints at the time of earthworks, soil samples from the side walls north and south of the excavation area could not be fully validated. Further investigation and delineation works were therefore required, as detailed in Section 3.7.

3.3.2. Benzene

The highest benzene concentrations were recorded on-site in DW8, DW14 and DW16 (source area). Additionally, benzene was detected in three down-gradient boreholes: DW19 and DW1B (on-site) and DW11 (off-site). Borehole DW11 is located approximately 80m northwest of the site boundary and last detected benzene during active pump and treat operations in 2016 / 2017; evidence of contaminant rebound.

Previously, during active pump and treat operations in December 2018, an average benzene concentration of 27µg/l was calculated for DW8, DW14 and DW16, reported in 'Ecologia's Verification Report (Phase 1 Works)'(ref 46). In comparison, an average benzene concentration of 2,041µg/l was calculated for the same boreholes over the 12-month monitoring period (between March 2020 and March 2021), which is a two order of magnitude increase.

Plan 8 below, depicts the benzene concentrations recorded between March 2020 and March 2021, highlighted in red if exceeding the December 2018 average concentration of 27µg/l.



Plan 8. Benzene Concentrations (March 2020 – March 2021)

3.4. Microbial Degradation

Benzene is known to degrade much faster in aerobic conditions, with the microbes driving this process reducing dissolved oxygen levels and turning the groundwater anaerobic. Physico-chemical parameters recorded on-site during the groundwater monitoring rounds consistently recorded an anaerobic environment in the source area (former MPA).

Consequently, Ecologia collected samples for genetic screening (ORVI*detect*) and microbial community analysis (ORVI*decode*) to demonstrate the presence of functional genes involved in benzene degradation and the presence of microbes which express them.

3.4.1. ORVI*detect*

Samples were taken from DW6, DW8, DW11, DW14, DW16 and DW19 and analysed for specific genes which degrade benzene anaerobically and the products of benzene degradation (known as 'daughter products').

Laboratory results found a strong *indirect* evidence that benzene is being degraded at the source – i.e. downstream genes only have use if benzene is degraded in the first step. The results are summarised in Table 3.1, below.

Table 3.1. Benzene Degrading Genes (pre-remediation)

Details		**DW6**	**DW8**	**DW14**	**DW16**	**DW19**	**DW11**
Location		Upgradient of source area	Outskirts of source area	Source area	Source area	Downgradient of source area (on-site)	Downgradient of source area (off-site)
Redox		457.9	-162.8	-156.2	-102.8	-88.9	216.1
Benzene (µg/l)		< 1.0	389	< 1.0	4,080	2,900	< 1.0
Benzene maximum (µg/l) – all rounds		< 1.0	676	10,600	5,310	5,490	356
Gene	**Function**	**DW6** (copies/ml)	**DW8** (copies/ml)	**DW14** (copies/ml)	**DW16** (copies/ml)	**DW19** (copies/ml)	**DW11** (copies/ml)
abcA	*First step of benzene degradation*	< 2	2	< 2	< 1	< 1	330
bzdN	*Downstream pathway of benzene degradation: various microbes & mechanisms*	160	1,400	51,000	62	6,400	170,000
bcrC		70	6	20	< 9	20	700
bamA		44	< 1	4	< 1	89	38
bamB		< 2	140	< 2	7	710	< 2

3.4.2. ORVI*decode*

The microbial types in boreholes DW6, DW11 and DW14 were then screened against reported microbes which are known to biodegrade benzene. These boreholes were selected to be representative of conditions up-gradient (DW6), down-gradient (DW11) and centrally in the source area (DW14). The results are summarised below:

- **DW6 (up-gradient):** No benzene-degrading microbes were found in this well, which is in line with site monitoring results (aerobic conditions and no detectable benzene).
- **DW11 (down-gradient):** Evidence of anaerobic biodegraders, which suggests that benzene is being degraded in the well or that benzene and microbes are being transported from the site via fissures.
- **DW14 (source area):** Greatest evidence of anaerobic biodegraders, which suggests that benzene is being degraded; however, the half-lives are very slow (confirmed in Section 3.4.3). Screening for aerobic degraders showed the presence of bacteria belonging to the genus *Rhodococcus* and three genera of *Pseudomonas* (*P. putida, P. fluorescens* and *P. aeruginosa.* Therefore, if dissolved oxygen levels can be increased, then this would allow the removal of benzene via aerobic respiration, promoting ongoing natural attenuation.

3.4.3. Stable Isotope Probes (SIPs)

SIPs were placed in boreholes DW11, DW16 and DW19 for a 6-week period to calculate benzene degradation rates. Note, DW16 was chosen over DW14 due to the more consistent levels of benzene detected and more prevalent anaerobic conditions over the monitoring rounds. Due to the proximity and similar nature of the previous groundwater analysis, the SIP result from DW16 were expected to be similar to conditions in DW14.

- **DW11:** degradation rate was too low to be measured and that without leaving a SIP in the well for an extended period, the analytical sensitivity required to measure the ^{13}C benzene is not commercially available.
- **DW16 and DW19:** showed similar benzene degradation rates with half-lives of 369 and 464 days respectively *(average of 417 days)*.

3.5. Baseline Groundwater Monitoring Conclusions

The initial DQRA, included in Ecologia's Verification Report (Phase 1 Works)[ref 46], used the benzene input parameter of 27µg/l, based on the average concentration reported in DW8, DW14 and DW16 from December 2018 (final month of pump and treat operations). Baseline groundwater monitoring data collected between 2020-2021 suggests this input parameter should likely be closer to 2,000µg/l; if the DQRA were to be repeated, the numerical assessment would indicate concentrations significantly above the DWS at the 50m compliance point.

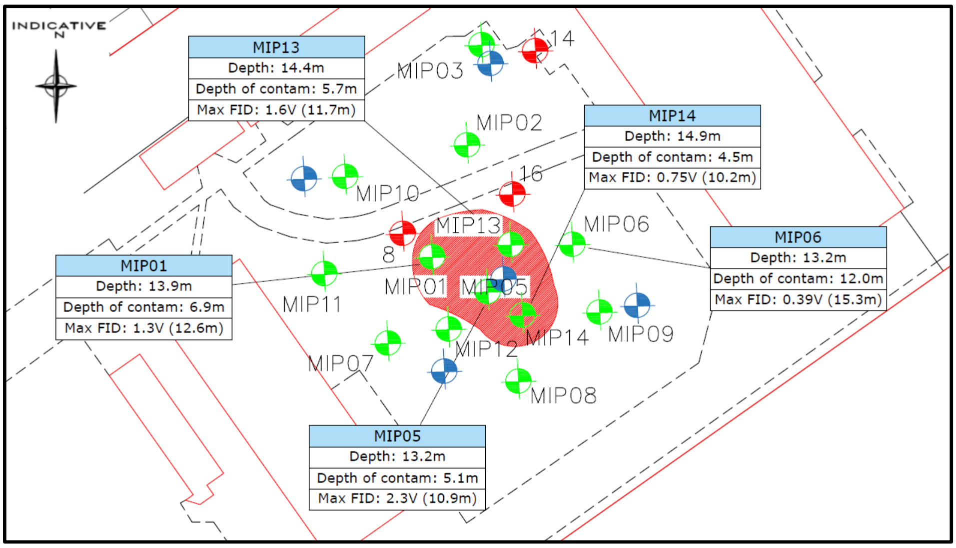
Although the previous pump and treat works were significant in reducing benzene concentrations; there is still evidence to suggest that the plume is regenerating from the original spill point and causing an ongoing risk to controlled waters. Albeit, the plume is now mostly confined to the former MPA, with only slight benzene concentrations detected in the off-site monitoring borehole DW11 (maximum of 356µg/l detected in May 2020).

Additionally, the groundwater condition underlying the former MPA is predominantly anaerobic with benzene degradation half-lives calculated to be on average 417 days. Therefore, in accordance with CL:AIRE guidance on Monitoring of Natural Attenuation (MNA)[ref 67] and Natural Source Zone Depletion (NSZD)[ref 68], MNA was not considered a viable option as the time for concentrations to be migrating beyond the default point distance should typically not be more than 1 generation or 30 years (i.e. would be excessively long in comparison to other remediation methods). Consequently, a high intensity remediation approach was selected to meet timescales for permit surrender and site divestment.

3.6. Source Area CPT Investigation

To assist with the design of the remediation system, an initial investigation was carried out using a CPT (Cone Penetration Test) rig with MiHpt probe (Membrane interface and Hydraulic profiling tool). The rig was capable of recording VOC concentrations in the unsaturated soils and more accurately pinpoint the POL.

The results identified a clear zone of highly elevated VOCs in the shallow subsoil (approximately 4.5m bgl) in MIP01, MIP05, MIP13 and MIP14, which confirmed the likely historical spill point as being east of DW8, as depicted in Plan 9, overleaf (red zone).



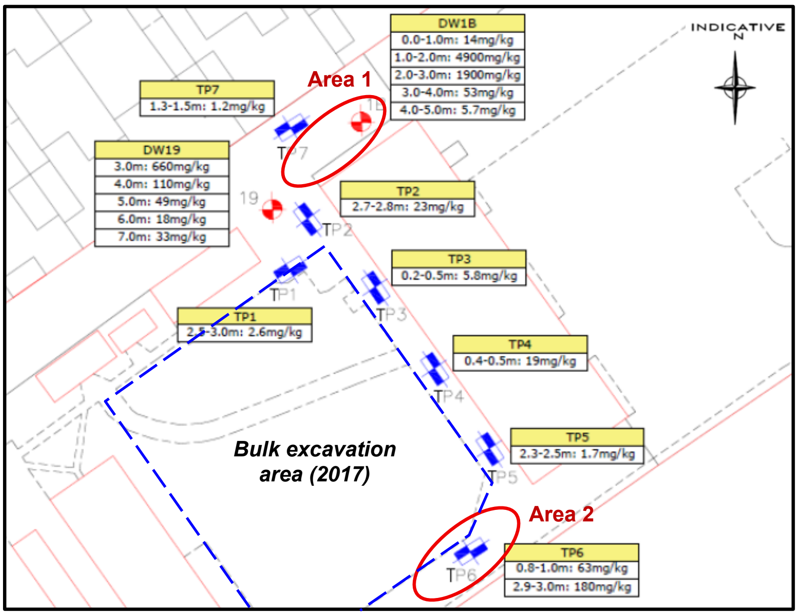
Plan 9. CPT & MiHpt Location Plan

Slightly elevated VOCs were discovered in MIP06 at 15.3m bgl, which continued until the CPT termination depth of 16.0m bgl. This suggests that contamination may have extended past the maximum capability of the rig, due to the high competency of the underlying chalk (Grade 2). The maximum depth achieved ranged from 10.02m bgl at MIP04, to 20.04m bgl at MIP10; no groundwater was encountered during the investigation. Remaining locations found minimal / no VOCs in the unsaturated zone.

Therefore, the CPT investigation was crucial in identifying the point of loss and remaining source area requiring treatment in the unsaturated zone. Treatment of the unsaturated zone would in turn reduce the contamination mass and minimise ongoing risks to controlled waters. The full report is included in Ecologia's 'CPT Source Area Investigation' report(ref 50).

3.7. Trial Pitting Investigation (mercury)

To close out the final mercury contaminant linkage, a trial pitting investigation was carried out in March 2021, to determine whether additional excavation works were required. Trial pit locations and laboratory results are presented in Plan 10, below.



Plan 10. Trial Pit Locations (mercury investigation)

At the time of the investigation, soil samples were compared against Generic Assessment Criteria (GAC) for a residential without plant uptake end use (1% Soil Organic Matter), as a conservative measure. Two localised areas were identified as having mercury concentrations above soil GAC for inorganic mercury (value of 56mg/kg):

- **Area 1: north of the warehouse** between boreholes DW19 and DW1B. Both boreholes are located on the southern side of the service corridor, which indicates that further lateral migration of contamination was limited by the concrete service tunnel. TP7 was excavated north of the service corridor, which supports this theory as very low mercury concentrations were recorded; and,
- **Area 2: south of the warehouse** along the previous extent of bulk excavation area / access road (in the vicinity of TP6).

As a result, localised excavation works were recommended to remove remaining bulk contamination and mitigate risks to human health from shallow impacted soils and minimise risks to controlled waters from leaching into the underlying Principal Aquifer.

The full report is included in Ecologia's 'Trial Pitting Investigation' report[ref 48].

The updated CSM and remediation approach are detailed in Section 4.

4. UPDATED CSM & REMEDIATION APPROACH

Following completion of the baseline groundwater assessment, the CSM was updated in the Addendum Remediation Strategy, 2021(ref 49), to inform the remediation design for Phase 3 and Phase 4 works.

4.1. Remaining Sources of Contamination

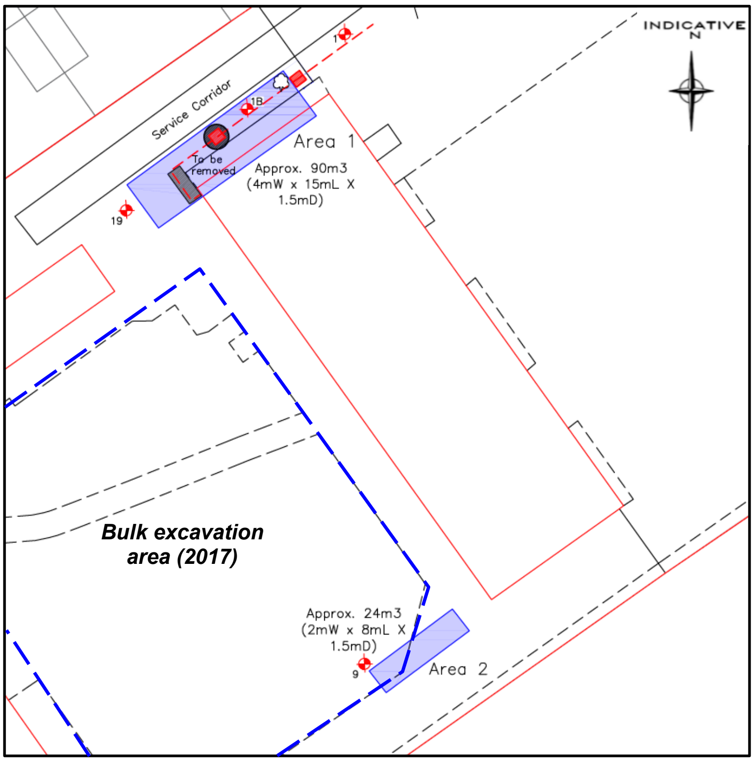
4.1.1. Soils

Several elevated benzene concentrations were reported in former MPA (beneath the clay cap) as well as inorganic mercury exceedances.

Localised elevated VOCs were identified in the unsaturated soils in the central area in the former MPA (source zone). The historic spill point was anticipated to be east of DW8, with the shallowest contamination starting between 4-8m bgl and dissipating laterally into surrounding soils and vertically into the groundwater table. Benzene contamination was confirmed within the saturated zone of borehole DW1B during drilling works in November 2020, confirming contamination had spread to the northernmost extent on-site.

Additionally, localised elevated concentrations of inorganic mercury were identified surrounding the former MPA in two areas: alongside the service corridor and alongside the south-eastern boundary of the former bulk excavation. Although there were no soil exceedances of the thresholds protective of human health for a commercial end use (RTV of 1,120mg/kg for inorganic mercury); excavation of soils and provision of a low permeability capping layer (protective of controlled waters) was considered to afford a degree of further protection to end users.

The two areas recommended for mercury hotspot removal are included in Plan 11, below.

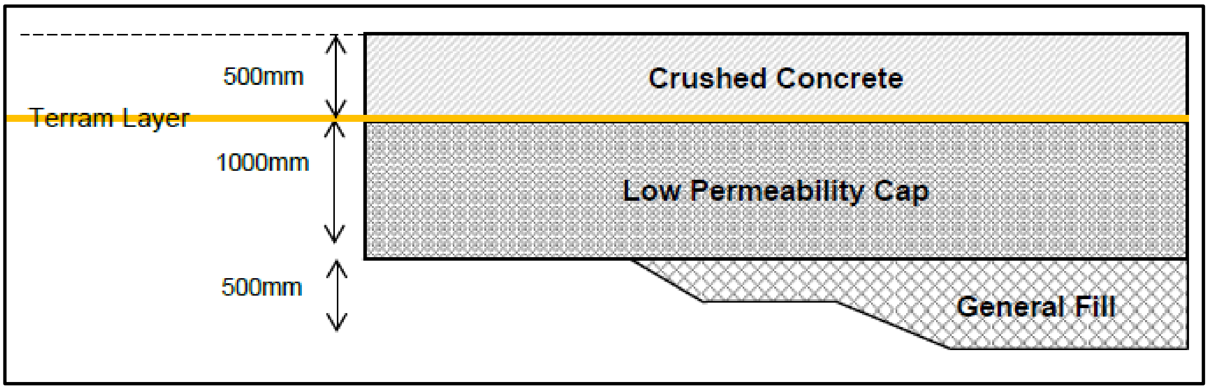


Plan 11. Proposed Excavation Areas (mercury contamination)

The capping strategy across both excavation areas comprised the following:

- Crushed concrete to provide a hardstanding cover for vehicle movements / installation of future remediation wells (0.5m thick).
- Terram layer placed at the base of the crushed concrete.
- A low permeability clay cap (1m thick) placed between 0.5m and 1.5m to minimise leachate induced by rainfall infiltration. The cap should be constructed from chemically compliant materials in accordance with the leachate RTVs derived in the Addendum Remediation Strategy(ref 49) (value of 0.180µg/l) and should not be less than 10^{-10} m/s permeability.
- General fill materials should be chemically compliant in accordance with the leachate RTVs (value of 0.180µg/l).

The capping layer is visually depicted on Plan 12, below.



Plan 12. Capping Strategy

4.1.2. Groundwater

Elevated benzene concentrations were reported in the former MPA, which have the potential to migrate via fissure flow and impact down-gradient controlled water resources as well as the underlying Principal Aquifer.

Additionally, mercury concentrations in some areas were close to exceeding the DWS of 1µg/l, with one isolated exceedance noted for DW14 in February 2021 (1.71µg/l).

Therefore, the following CoC's were identified within the groundwater beneath the site and considered to pose a risk to the underlying Principal Aquifer:

- Mono-aromatic hydrocarbons (Aromasol-H) comprising of benzene, toluene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene; and,
- Mercury.

4.2. Remaining Contaminant Linkages

Following completion of additional investigations and groundwater monitoring, the remaining contaminant linkages (CL) requiring further action are included in Table 4.1, below.

Of note, it is recognised that the CSM will need further review as the site is developed in the future, particularly from a risk to human health perspective should there be a proposal end use change from commercial land use.

Table 4.1. Remaining Contaminant Linkages

CL	Source		Contaminant	Pathway	Receptor
1	Areas 1 & 2	Former MPA – north of warehouse (Area 1) and south of warehouse (Area 2)	Leachable mercury (inorganic)	Dissolved phase via rainfall infiltration induced leaching	Principal Aquifer (Margate Chalk Member)
2	Spill Point	MPA – east of DW8 (spill point) from beneath the clay cap to the full depth of the unsaturated zone (between 5-15m bgl)	Benzene, toluene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene	Vertical migration via chalk fractures	
3	Groundwater	Saturated zone beneath former MPA and down-gradient		Lateral groundwater migration	

4.3. Remediation Techniques

The following remediation techniques in Table 4.2 were selected to manage the remaining contaminant linkages identified and provide a 'suitable for use' site that is protective of human health and controlled waters.

Table 4.2. Remediation Techniques

	Phase 3 (Groundwater)	Phase 4 (Soil)
Controlled Waters	*Source Reduction* Combination of in-situ thermal heating, soil vapour extraction, dual phase extraction, steam injection and air sparging in the saturated zone.	*Source Reduction* In-situ thermal heating and soil vapour extraction within the unsaturated zone.
Human Health	N/A	*Source Removal* Soil excavation and disposal. *Pathway Modification* Provision of a cover system (clay cap).

4.4. Verification Plan

To demonstrate that remediation objectives have been met, the following lines of evidence in Table 4.3, overleaf, were agreed with the EA for verification purposes of Phases 3 and 4.

Table 4.3. Remediation Lines of Evidence

	Lines of Evidence	
Soils	*Mercury Hotspot Excavations*	1. Compliance against RTVs for soils and leachates, protective of a commercial end use and Principal Aquifer.
		2. Placement of a chemically compliant capping system and membrane.
Groundwater	*Treatment Cessation*	1. Source area benzene reduction (< updated baseline, 2020/2021).
		2. Mass recovery.
	Permit Surrender	1. Demonstrate declining groundwater trends of the CoC.
		2. Further treatment works are unlikely to yield significant further reductions in groundwater concentrations of the CoC over a reasonable time frame (i.e. asymptotic conditions are considered to be reached).
		3. Rebound monitoring period over a 12-month period and analysis of groundwater samples at an accredited MCERTS laboratory to demonstrate the CoC do not rebound.
		4. Numerical assessment of residual groundwater concentrations (after rebound monitoring) demonstrating no significant impaction at a conservative 50m compliance point, at a 30-year timescale.
		5. If requirements from 1-4 cannot be demonstrated satisfactorily, then an analysis of the cost benefit and continuing sustainability of the system shall be undertaken.

The SCR herein is intended to provide the necessary evidence to support treatment cessation and permit surrender. A photographic report covering the remediation works can be found in Appendix VI.

5. HOTSPOT REMOVAL WORKS (PHASE 4)

Hotspot excavation works around the former MPA were completed in May 2021. A summary of the works is provided in subsequent sections, with the full report included in Ecologia's 'Mercury Hotspot Excavation Works' report(ref 52).

The scope of works comprised the following:

- Excavation of contaminated shallow soils to at least 1.50m bgl and disposal at a licenced waste facility.
- Validation soil sampling of the side walls and the base of each excavation area following removal of contaminated soil.
- Backfilling of excavation voids with an impermeable clay cap (at least 1m thick) to minimise leachate induced by rainfall infiltration.

5.1. Excavation Works

Headspace testing was undertaken during excavation works for mercury and VOCs to determine the final excavation extents. Validation soil samples were collected from the side walls and base of each excavation area and submitted to an accredited MCERTS laboratory for analysis.

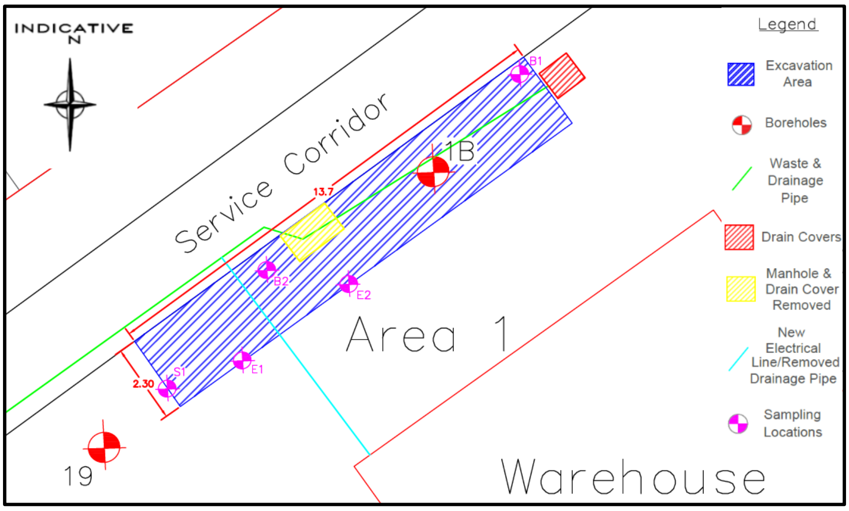
Samples were screened against RTVs derived in the Addendum Remediation Strategy(ref 49). Site-won soils were screened against criteria for a commercial end use whilst imported materials (topsoil / subsoil) were screened against criteria for a residential end use (most conservative). The RTVs are summarised in Table 5.1, below.

Table 5.1. Hotspot Excavations (mercury RTVs)

Criteria	**Topsoil / Subsoil** *(0.0-0.5m bgl)* Soil RTV	**Capping Layer / General Fill** *(>0.5m bgl)* Leachate RTV
Site-won soils	1,120 mg/kg	180 µg/l
Imported soils	39 mg/kg	

5.1.1. Area 1 (north of warehouse)

The excavation area was determined as 13.7m in length, 2.3m in width and 1.8-2.3m in depth, spanning between the previous soakaway 'S6' and the drainage cover, depicted in Plan 13.



Plan 13. Hotspot Excavation (Area 1)

A total of six (6No.) environmental samples were collected from Area 1 (4No. from the side walls and 2No. from the base). Laboratory results revealed all VOCs to be below the laboratory Limit of Detection (LOD), with mercury results for both soil and leachate summarised in Table 5.2, below.

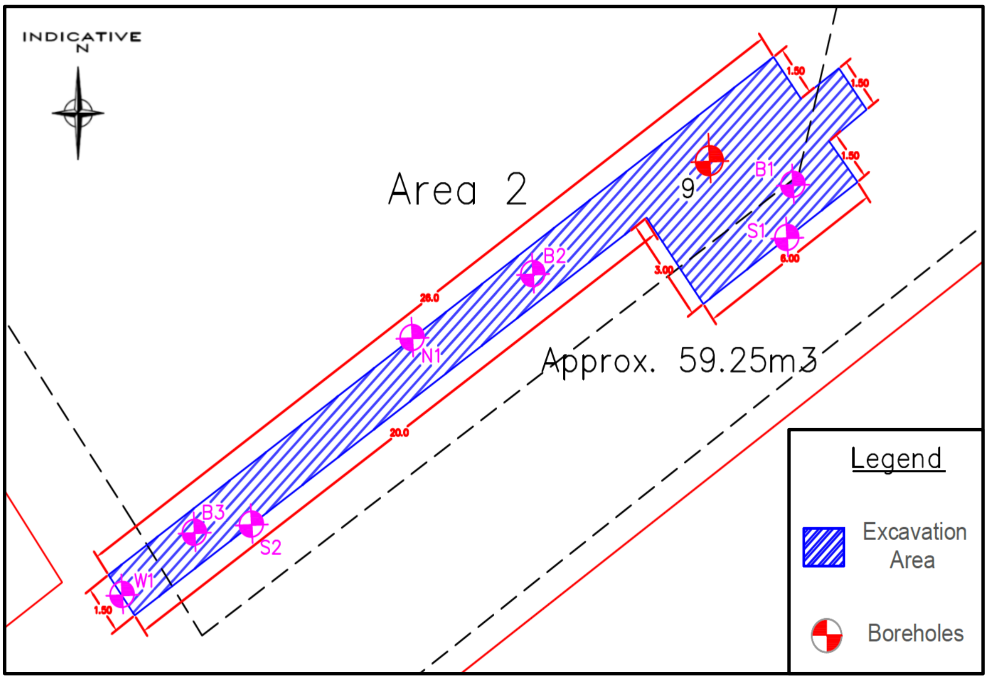
Table 5.2. Mercury Laboratory Results (Area 1)

Location	Depth *m bgl*	Description	Mercury (soil) *mg/kg*	Mercury (leachate) *µg/l*
Area 1 – North 'N1'	0.75	Cream White Chalk	3.1	< 0.5
Area 1 – East 1 'E1'	0.75	Cream White Chalk	99	4.7
Area 1 – East 2 'E2'	0.75	Cream White Chalk	88	1.9
Area 1 – South 'S1'	0.75	Cream White Chalk	4.6	< 0.5
Area 1 – Base 1 'B1'	2.30	Cream White Chalk	6.6	1.4
Area 1 – Base 2 'B2'	1.80	Cream White Chalk	14	5.7

Laboratory results revealed that no mercury exceedances remain on the side walls or base samples for soil or leachate.

5.1.2. Area 2 (south of former MPA)

The excavation area was determined as 26m in length, 1.5-4.5m in width and 1.9m in depth. This area was larger than originally anticipated due to high headspace results recorded at the side walls; consequently, the excavation area was extended both laterally and vertically to remove gross contamination. The excavation area spanned between the previously excavated soakaway 'S7', and the drainage run from soakaway 'S8', as depicted in Plan 14.



Plan 14. Hotspot Excavation (Area 2)

A total of seven (7No.) environmental samples were collected from Area 2 (4No. from side walls and 3No. from the base). The eastern side wall was extended up to the previous clay cap installed for 'S7' and consequently no additional sample taken. Laboratory results revealed all VOCs to be below the laboratory LOD, with mercury results for both soil and leachate summarised in Table 5.3, overleaf.

Table 5.3. Mercury Results (Area 2)

Location	Depth *m bgl*	Description	Mercury (soil) *mg/kg*	Mercury (leachate) *µg/l*
Area 2 – South 1 ‘S1’	0.75	Cream White Chalk	24	44
Area 2 – South 2 ‘S2’	0.75	Cream White Chalk	3.1	< 0.5
Area 2 – North 1 ‘N1’	0.75	Reworked Clay/Chalk	9.7	< 0.5
Area 2 – West 1 ‘W1’	0.70	Reworked Clay/Chalk	250	52
Area 2 – Base 1 ‘B1’	1.90	Cream White Chalk	-	160
Area 2 – Base 2 ‘B2’	1.85	Cream White Chalk	-	240
Area 2 – Base 3 ‘B3’	1.90	Cream White Chalk	-	150

The laboratory results revealed no exceedances of mercury on the side wall samples. Base samples (taken from below the clay cap) revealed one slight exceedance against the RTV. However, the average concentration taken from the three base samples is 183µg/l, which is only marginally above the RTV of 180µg/l. Considering the minor nature of the exceedance and the increased thickness of the impermeable capping layer, we do not anticipate remaining concentrations to pose an ongoing risk to the Principal Aquifer.

5.2. Backfilling of Excavations

Each excavation area was backfilled using a low-permeability clay from the base to 0.5m bgl (intended as a capping layer), which was compacted every 250mm using a remote-controlled trench roller. A geotextile membrane was then laid, followed by crushed concrete backfill from 0.5m to ground level, compacted with the trench roller.

Three (3No.) samples were collected from the stockpiled clay material at TW Services Yard prior to import and analysed for a general contamination suite (leachate only), in line with the Addendum Remediation Strategy[(ref 49)]. Results revealed both mercury and benzene to be below the laboratory LOD and associated RTV; therefore, suitable for use on-site.

Results of the permeability testing revealed a value of 9.7^{-11} m/s, which is considered to be within acceptable limits.

Materials imported to site for excavation backfill are included in Table 5.4, below, with import tickets included in the main report[(ref 52)].

Table 5.4. Import Record

Material	Weight	Haulier Details	Import Site
Clay	151.72 T	TW Services (Waste Carrier: CBDU223059)	TW Services, Richborough Hall, Ramsgate Road, Sandwich, CT13 9NW
Crushed Concrete	58.38 T		
Crushed Concrete	80 T	DDS Demolition (Waste Carrier: P08023/T002)	DDS Demolition, Charles Anthony House, Manston Road, Margate, CT9 4JW

5.3. Waste Disposal

All excavation arisings were disposal of at a licensed disposal facility. Prior to disposal, the stockpile was classified by taking composite soil samples for a general suite of contaminants and Waste Acceptance Criteria (WAC).

Table 5.5, overleaf, detailed the waste disposal record for stockpiled materials, with copies of the waste tickets included in the main report[(ref 52)].

Table 5.5. Disposal Record

Material	EWC	Haulier	Disposal Facility	Quantity
Chalk (Soils & Stone)	170504	Lime Logistics Ltd (Waste Carrier: CBDU44730)	Biffa Landfill Site, Cormongers Lane, Redhill, RH1 4ER (Site Licence: BU8126)	230.64 T

5.4. Hotspot Removal Conclusions

In total, 230.64 tonnes of contaminated soils have been removed from the previously identified mercury hotspot excavations (Area 1 and Area 2).

Sufficient remediation works are considered to have been undertaken to render the site suitable for a commercial use and to minimise risks to controlled waters. In addition, a low-permeability cap has been installed across both areas to minimise the potential for future infiltration from any residual contamination.

Consequently, no further excavation works are recommended.

6. IN-SITU THERMAL REMEDIATION WORKS (PHASE 3 & 4)

In order to treat benzene contamination in the source area, a high intensity remediation programme was designed to raise groundwater and soil temperatures above the boiling point of benzene (80ºC) and enable extraction of VOCs.

The following permits / licenses were obtained to support the remediation works, with copies included in Appendix III:

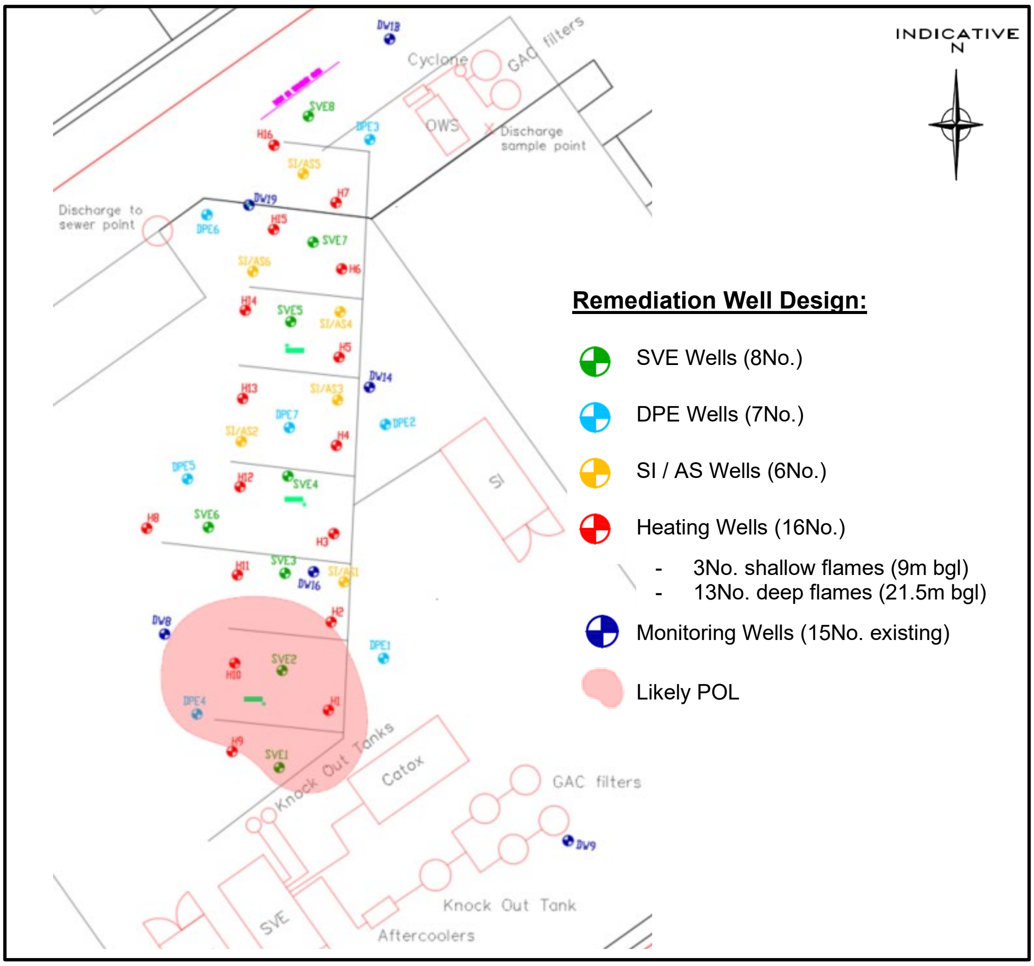
- Deployment for 12-months operation – ZP3595HA/W0025, dated 06/09/2021; and,
- Discharge consent (Southern Water) – 17817, dated 02/11/2021.

6.1. Remediation System Design

The remediation system was operated in a staged approach, using five different technologies:

1. *Dual Phase Extraction (DPE)* to lower the groundwater table to 29m bgl combined with vapour extraction to capture and treat VOCs, whilst maintaining hydraulic control.
2. *Thermal Conductive Heating (TCH)* to raise soil temperatures within the unsaturated soils at the point of loss (3No. shallow flames at 9m bgl) and within the capillary fringe (13No. deep flames at 21.5m bgl) to enable volatilisation of VOCs for recovery.
3. *Soil Vapour Extraction (SVE)* to capture and treat VOCs in the unsaturated soils (up to 27m bgl).
4. *Steam Injection* to raise groundwater temperatures and mobilise dissolved phase contamination (targeted injection depth of between 31-34m bgl).
5. *Air Sparging* to further volatilise benzene and provide oxygenation to enhance residual degradation of VOCs (targeted sparging depth of 35m bgl).

The borehole network was designed based on results of the baseline groundwater monitoring (discussed in Section 3). The layout and quantity of treatment wells are depicted in Plan 15, overleaf.



Plan 15. Remediation Well Design

6.1.1. Borehole Installations

Boreholes were drilled using a cable percussion (CP) rig and logged in accordance with BS 5930:2015+A1:2020. Disturbed soil samples were collected at 1.0m intervals and recorded for VOC vapour (using a PID) and mercury vapour (using a Jerome analyser). Selected soil samples were submitted to an accredited MCERTS laboratory for VOCs and mercury analysis (4No. samples per borehole).

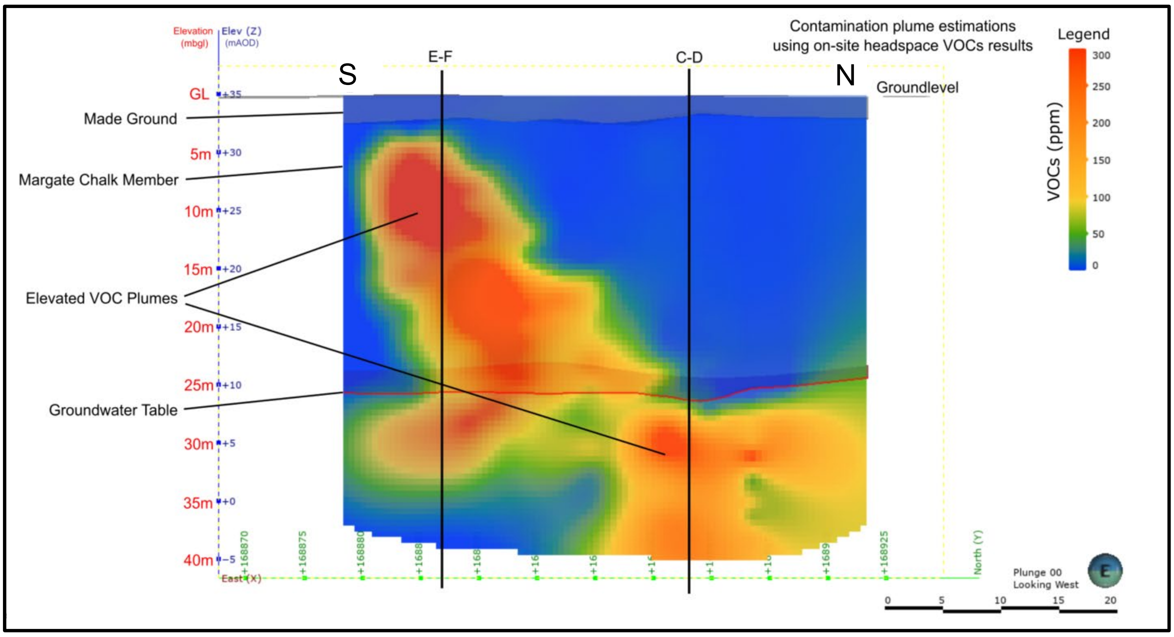
The findings are reported in Ecologia's 'Remediation Drilling' report[ref 53], which includes the associated borehole logs and laboratory certificates in the appendices.

6.1.2. Contamination Modelling

All results obtained during the drilling works (headspace testing and laboratory analysis) were inputted into a 3D contamination modelling software (Leapfrog Works), to create an interactive model to better understand the underlying plume. This software uses the known contaminant concentrations, distribution, and mass, to create estimations and block models.

Headspace results found that elevated VOCs increased with how far south the positions are located, indicating the likely POL (east of DW8) and subsequent pathway through fissures / fractures. These results were consistent with the previous CPT and MiHpt probe investigation

Plan 16, overleaf, illustrates a cross-section through the centre of the site.

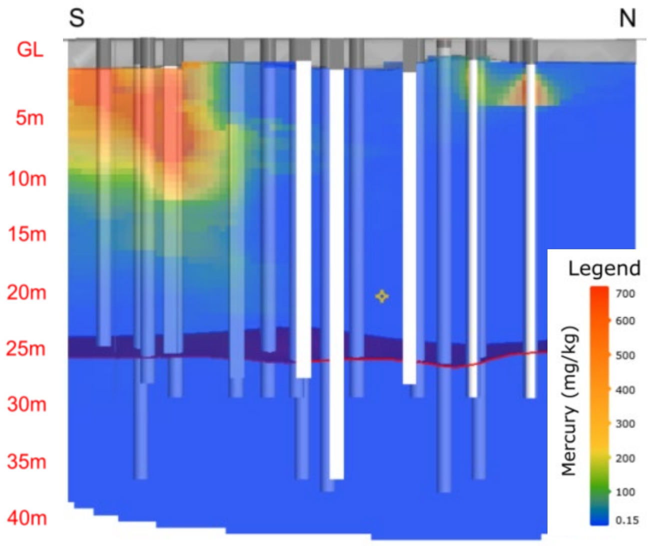


Plan 16. Cross-section of Headspace VOC Model

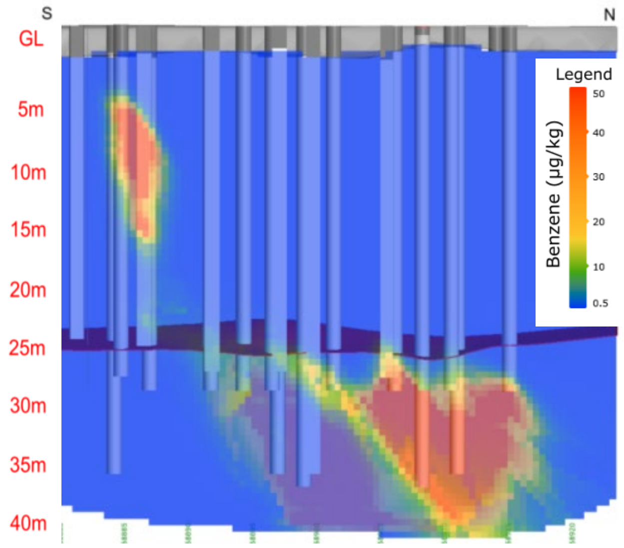
Models were also created for the main contaminants encountered, including mercury, benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene, with results summarised in Table 6.1, below. Results were consistent with previous findings and the updated CSM.

Table 6.1. Contamination Modelling

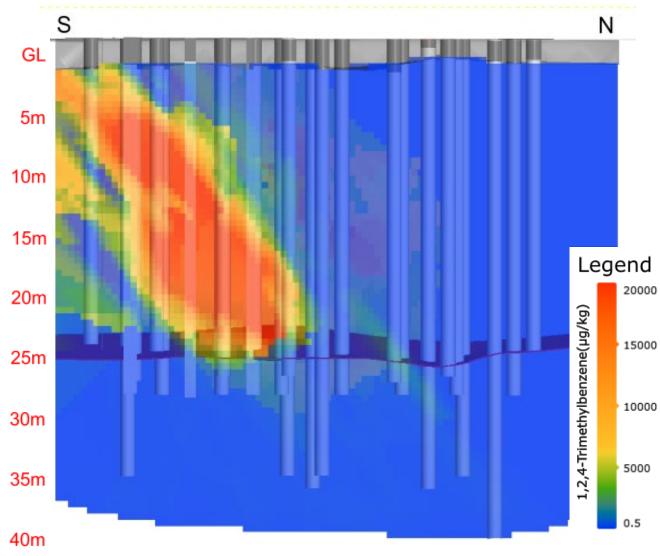
Contaminant	Results	Plan
Mercury	Mercury is largely contained within the top 5-6m of the underlying chalk within the former MPA. Trace amounts were identified in the Made Ground (including the placed capping layer of the former MPA) and to the northern end of the site. Elevated mercury was estimated to extend further southwest of the drilling area. However, previous excavation and sampling around the former MPA found that elevated mercury remains contained beneath the clay cap and not perceived to be a risk to human health / controlled waters (reported in ref 48 and ref 52).	Plan 17
Benzene	Elevated levels of benzene were found to be concentrated in two depths: • Shallower concentrations in the unsaturated zone (between 5-15m bgl) close to point of loss. • Deeper concentrations in the saturated zone (between 25-35m bgl) down-gradient of the point of loss towards the north. ***Remediation activities were designed to target these two contamination plumes and reduce overall benzene concentrations in the former MPA.***	Plan 18
1,2,4-trimethylbenzene	Similar plumes were modelled for these two contaminants, with slight variations in spread, but almost exclusively contained within the unsaturated chalk. 1,2,4-trimethylbenzene shows a wider distribution of the contaminant plume than 1,3,5-trimethylbenzene, but the highest concentration areas are the same (approximately 5-15m bgl beneath the MPA). Very low results were obtained for each contaminant within the saturated soil; this is attributed to the high insolubility of these types of compounds.	Plan 19
1,3,5-trimethylbenzene		Plan 20



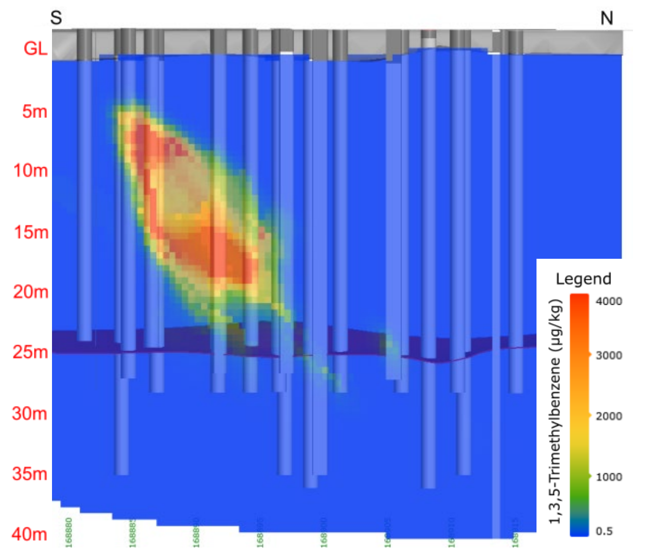
Plan 17. Mercury Contaminant Model



Plan 18. Benzene Contaminant Model



Plan 19. 1,2,4-trimethylbenzene Contaminant Model



Plan 20. 1,3,5-trimethylbenzene Contaminant Model

6.1.3. Estimated Contaminant Mass Calculation

Estimations of total contaminant mass were calculated using the 3D modelling software (Leapfrog Works). These totals were calculated by using the contaminant models and ground conditions in conjunction with the total mass of the chalk, using literature derived chalk density values.

Three (3No.) main CoC's were included in the estimated mass calculation: benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene. The model was also split into unsaturated and saturated zones, which allowed for further delineation of the calculated mass.

However, the calculations were only based on laboratory results for particular spot samples and their estimated contamination spread (i.e. maximum of 4No. samples per borehole). Additionally, only three (3No.) VOCs were used in the calculation of total mass; therefore, the total estimated mass pre-remediation is likely to be an underestimation. Results are presented in Table 6.2, overleaf.

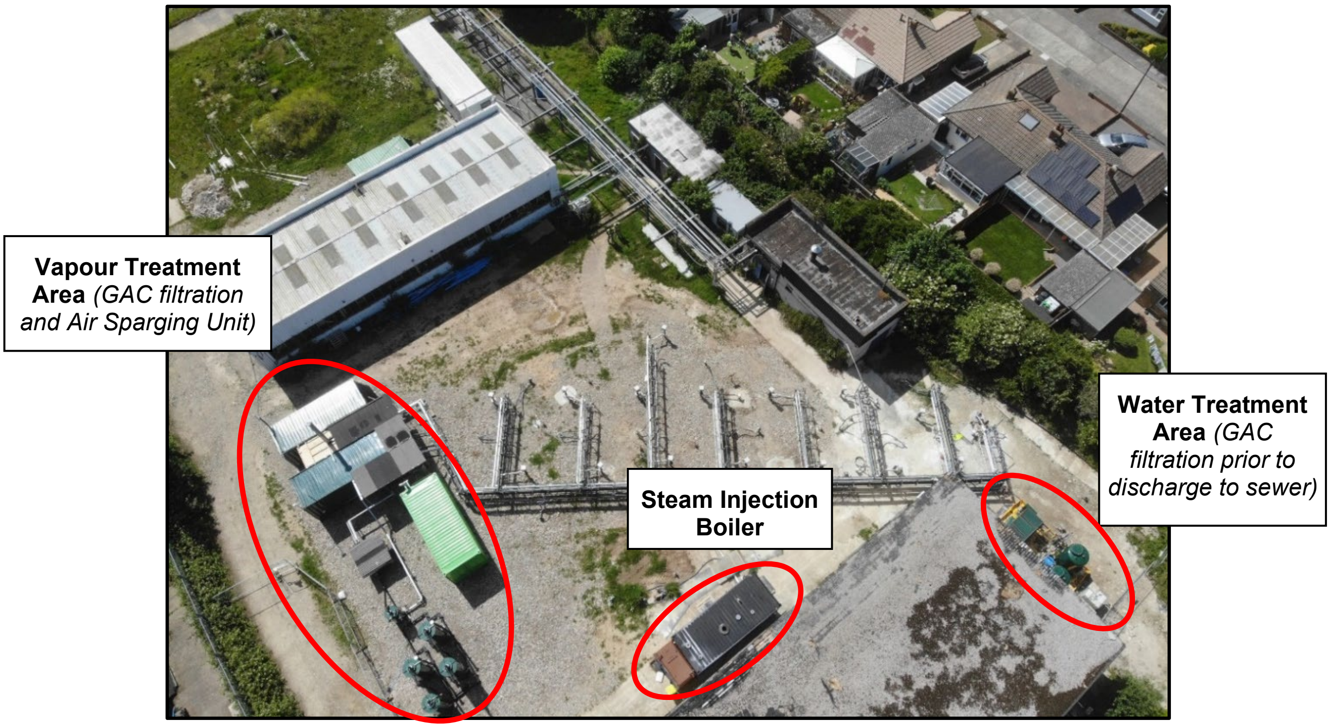
Table 6.2. Estimated Mass Calculation (pre-remediation)

Plume Area	Benzene (kg)	1,2,4-trimethylbenzene (kg)	1,3,5-trimethylbenzene (kg)	Total (kg)
Unsaturated	0.22	524.60	76.70	601.52
Saturated	3.69	12.20	1.68	17.57
Total	**3.91**	**536.80**	**78.38**	**619.09**

The actual total mass recovered post-remediation is calculated in Section 6.11.4.

6.2. System Commissioning & Operation

System commissioning was undertaken in accordance with the agreed deployment (reference: ZP3595HA/W0025). Remediation boreholes were connected to a gantry system with a series of pipework taking extracted water / vapour to different treatment zones on-site, as illustrated in Plan 21, below.



Plan 21. System Installation Layout

Three (3No.) main remediation operation areas were setup on-site, including:

1. *Vapour Treatment Area:* containing knock-out-tank (KOT), heat exchanger, 4No. x 1,000kg GAC filters containing a combination of CX65 (organic specific) and EX64-2 (mercury specific) granular activated carbon (GAC), and an air sparging unit housing a rotary vain blower and air compressor for operating the pneumatic borehole pumps.
2. *Water Treatment Area:* consisting of an oil water separator (OWS), bag filter, cyclone filter, 2No. x 1,000kg GAC filters (containing CX65), water totaliser, sampling point and discharge into mains drainage under consent.
3. *Steam Injection Boiler:* containerised unit housing a Byworth model MX1000 steam boiler, rated at 22,000lbs (1,000kgs) / hour, 100°C, with maximum working pressure of 150psi g (10.3bar g).

The operation areas were checked by a suitably qualified team prior to commencing active remediation works. The commissioning report was submitted to the EA in accordance with section B10.1 on the deployment application, with treatment works commencing on Monday 6th December 2021. Full details are included in the 'System Commissioning Validation Report'[ref 54].

During operation, on-site data was collected from the wellheads and the system to monitor the performance and keep a record of mass recovery. Additionally, vapour and water samples were sent to an accredited MCERTS laboratory for analysis. The results are included in Appendix IV.

6.3. System Operation Periods

During remediation works, supervision was maintained by a qualified Environmental Scientist with support from the engineering team. The TCH system was installed and operated by a specialist sub-contractor 'Haemers Technologies'.

The timeline of operations is included in Table 6.3, below. Most remediation operations were completed within the deployment period (52-week agreement), with final air sparging continuing to operate periodically under Thor's existing permit 'EPR/BV3898IR' to oxygenate the underlying aquifer and enhance residual degradation of remaining VOCs.

Table 6.3. Timeline of System Operations

Treatment Technology	Operation Period	
Dual Phase Extraction (DPE)	06/12/2021 – 05/12/2022	Active Remediation *(operating under deployment ZP3595HA/W0025)*
Soil Vapour Extraction (SVE)		
Steam Injection (SI)	31/01/2022 – 28/07/2022	
Thermal Conductive Heating (TCH)	18/03/2022 – 25/08/2022	
Air Sparging (AS) *(polishing step)*	17/08/2022 – 05/12/2022	
	08/02/2023 – 10/03/2023	Periodic Air Sparging *(operating under existing Thor permit EPR/BV3898IR)*
	17/04/2023 – 28/04/2023	
	31/05/2023 – 03/06/2023	
	15/06/2023 – 30/06/2023	
	19/07/2023 – 01/09/2023	

6.4. Hydraulic Control

The first stage of remediation works was to lower the groundwater table and allow the capillary fringe to be treated using TCH whilst maintaining hydraulic control. Six (6No.) outer wells ('DPE1-DPE6') were installed using HDPE pipe with one (1No.) central well ('DPE7') installed with steel pipe; slotted sections installed between 17-35m bgl.

Pneumatic borehole pumps were installed at 30m bgl within each borehole and operated automatously 24/7. Purged groundwater was collected in the OWS and pumped through GAC filters to remove organic contamination (and limited inorganic contamination), prior to discharge to foul sewer under consent from Southern Water. In total, 6,592m^3 of groundwater was treated, with an average daily pumping rate of 18m^3 per day.

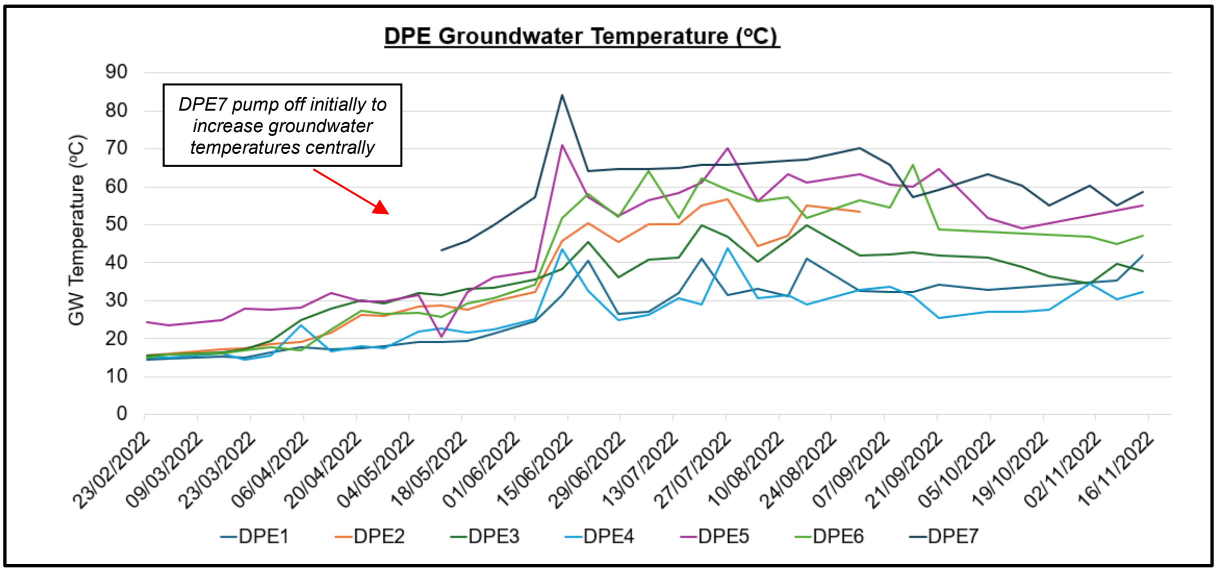
Overall, groundwater resting levels in the source area were successfully lowered during system operation by approximately 4.5m.

6.5. Steam Injection Works

Groundwater temperatures were recorded throughout the remediation works to monitor the effects of steam injection. A total of six (6No.) steam injection boreholes were installed in the northern half of the treatment area, where deeper contamination was prevalent in the groundwater table.

Steam injection was undertaken between 31st January 2022 and 28th July 2022 (total of 26No. weeks) using a boiler unit with injection pipework targeted at 31-34m bgl. The main line injection temperature ranged between 120-130ºC throughout the heating period.

During operation, groundwater temperatures were recorded from DPE wells (throughout works) and SI wells (towards the end of treatment only), to monitor temperature increases. The groundwater temperatures recorded from DPE wells are presented in Plan 22, below.



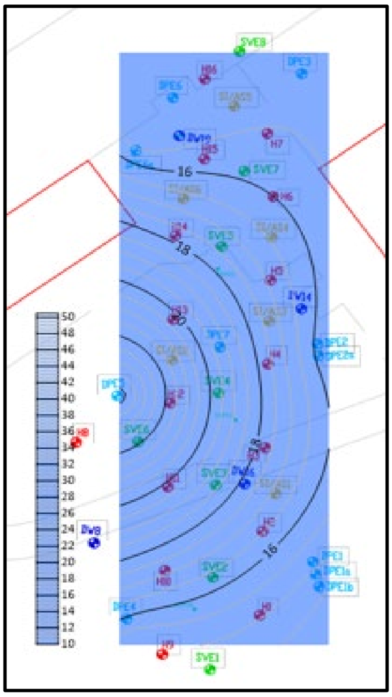
Plan 22. Groundwater Temperatures (DPE wells)

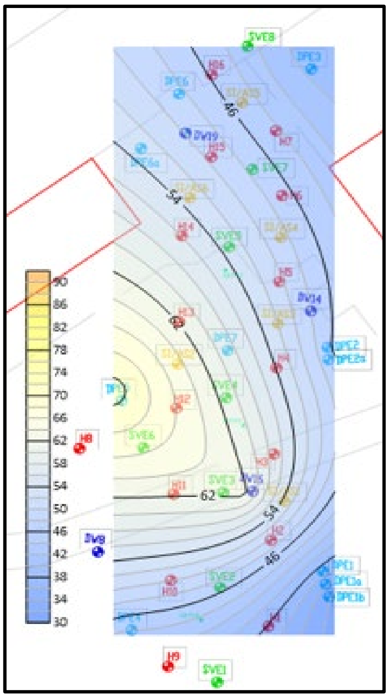
Groundwater temperature increases were slower than initially hoped due to issues with steam breakthrough at surface level. This was rectified on 24th and 25th March 2022 by excavating around each wellhead to 0.5m bgl and installing a 1.5m^2 concrete cap. Additionally, the majority of DPE wells were on the outskirts of the treatment area, with the southern wells impacted by cold water ingress (DPE1 and DPE4); groundwater direction proven to be to the north / northwest.

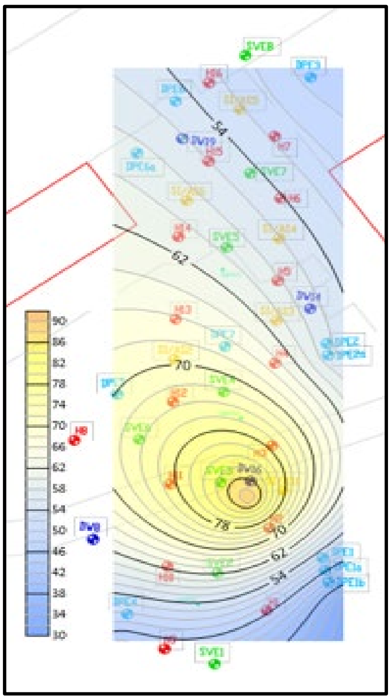
A limiting factor with heating groundwater on-site was the balance between heating operations (SI and TCH) and pumping operations (DPE). Hydraulic control was required to allow treatment of the capillary fringe (between 18-26m bgl), which meant an average of 18m^3 of water was pumped out each day. Occasionally, downtime was encountered due to limescale issues and steam breakthrough, which meant pumps were temporarily switched off.

The effect of this is clearly visible in Plan 22, where DPE7 recorded temperatures of 57.2ºC on 08/06/2022, 84.2ºC on 13/06/2022 and 64.2ºC on 20/06/2022; pumps were temporarily switched off between 08/06/2022 – 13/06/2022, supporting this theory. In general, the pump in DPE7 was kept switched off as much as possible to allow temperatures to increase more quickly in the central area, whilst the outer wells were installed for hydraulic control.

Groundwater surfer plots are presented for three different months during steam injection works in Plans 23-25, overleaf. Average groundwater temperatures were calculated as 16.8ºC (February 2022), 49.2ºC (June 2022) and 56.9ºC (July 2022).



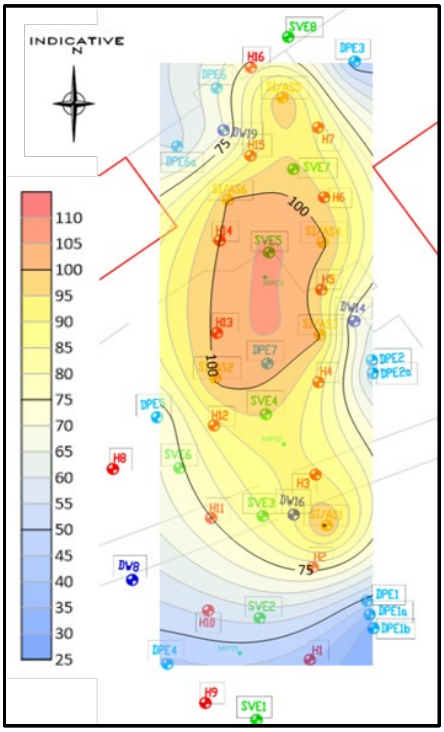




Plan 23. DPE Temp. (17/02/2022) **Plan 24.** DPE Temp. (13/06/2022) **Plan 25.** DPE Temp. (28/07/2022)

During the final stages of SI, the injection wellheads were temporarily opened to allow temperature readings to be taken, due to skewed data from inflow of cold water from DPE1 and DPE4. Furthermore, temperature readings were collected from selected source area monitoring wells (DW14, DW19 and DW19) to assist with calculations.

Additional readings were collected from SI and DPE wells from 11/07/2022, which recorded average groundwater temperatures of 82.29ºC on 28/07/2022, as shown in Plan 26, below.



Plan 26. Groundwater Temperatures (DPE & SI wells) – 28/07/2022

The highest groundwater temperature was recorded around SI2 (reading of 101.7ºC) and was observed to spread towards the northern half of the site where benzene contamination was most prevalent in the groundwater.

Following cessation of steam injection works (28/07/2022), groundwater temperatures remained steady at SI locations dropping to 72.2ºC by 20/09/2022 and continued to drop very slowly thereafter. Temperatures were recorded on monthly intervals during the rebound monitoring period, with results discussed in Section 8.

6.5.1. Carbon Offsetting

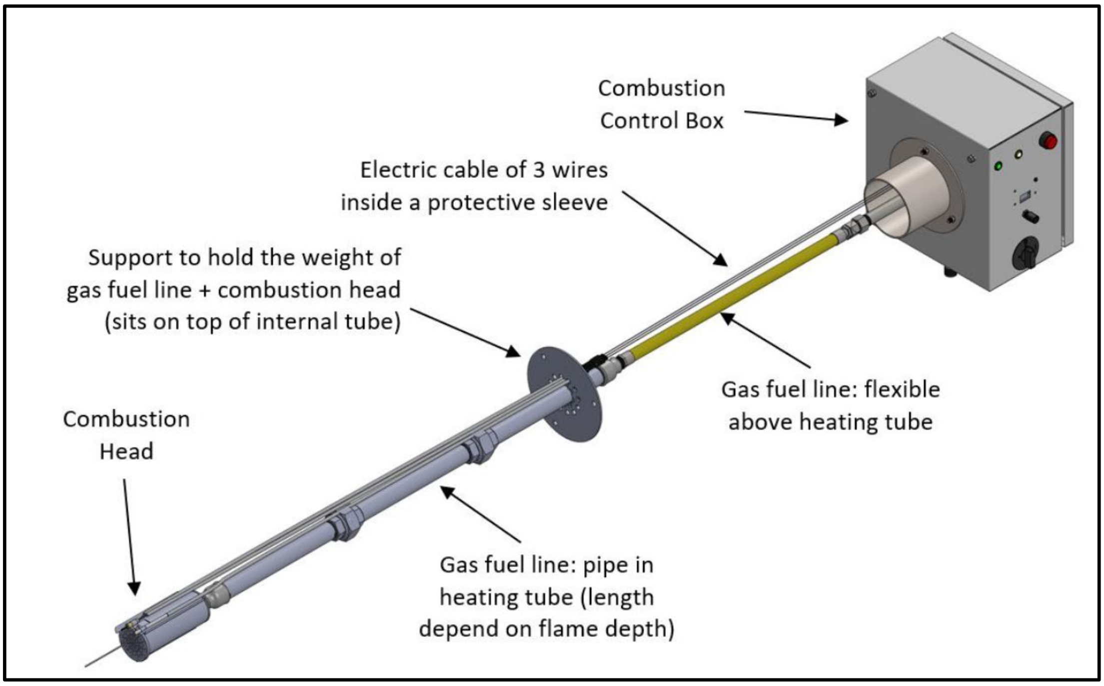
Throughout the 26-week steam injection period, a total of 84,237 litres of gas oil / industrial heating oil (IHO) was used to power the steam injection boiler. To compensate for the unavoidable carbon emissions produced and minimise the carbon footprint, Ecologia voluntarily supported environmental initiatives within the UK and across the world, including reforestation, building wind farms, reducing landfill and providing clean water projects (6.33 tonnes of carbon offset).

The carbon offsetting certificate is included in Appendix IV.

6.6. Thermal Conductive Heating (TCH)

Ecologia partnered with 'Haemers Technologies' (HT) for the TCH works. Smart Burners were installed at two specific depths to target contaminated soils: 3No. shallow burners at 9.0m bgl (point of loss) and 13No. deep burners at 21.5m bgl (capillary fringe). Smart burners were operated 24/7 using propane gas to heat soils ≥80ºC and maintain temperatures for a period of ≥10 days to enable VOC extraction. A separate treatment report has been commissioned by HT[(ref 55)], and included in Appendix I. The overall performance is summarised in subsequent sections.

Installation of the Smart Burners began in September 2021 during drilling works, with staged commissioning completed throughout March 2022. An illustration showing the Smart Burner technology is presented in Plan 27, below.



Plan 27. Smart Burner Technology *(Source: HT Report)*

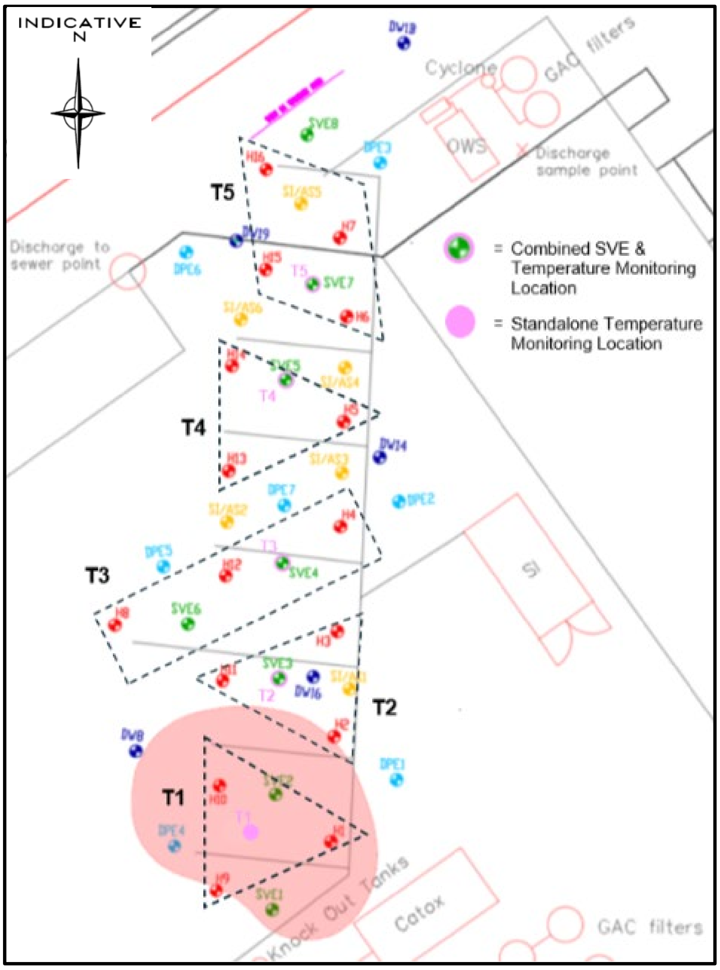
6.6.1. TCH Monitoring Points

Five (5No.) remediation boreholes were used as temperature monitoring points and installed with a series of thermocouples at the following depths:

- Monitoring well 'T1' (MIP05) – thermocouples installed at 4m, 8m, 9m, 18m and 27m bgl to monitor shallow soils around the point of loss; and,
- Monitoring wells 'T2' (SVE3), 'T3' (SVE4), 'T4' (SVE5) and 'T5' (SVE7) – thermocouples installed at 15m, 20.5m, 21.5m, 24m and 27m bgl to monitor deeper soils in the capillary fringe.

Additionally, thermocouples were installed within each TCH borehole, along the outer face of the internal tube, to ensure the produced energy was being well distributed.

Plan 28 below, shows the location of TCH wells and temperature monitoring wells, which were grouped into five (5No.) zones to represent 'cold points'. These 'cold points' were calculated as the geometrical centre of the triangle formed by three heating tubes. If the target temperature of 80ºC was reached in these wells, then this would ensure the entire radius around each TCH well had been sufficiently heated.

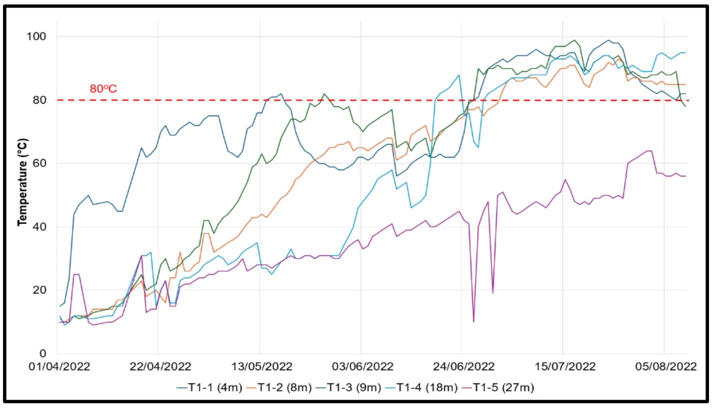


Plan 28. Batch Treatment Wells Layout *(Source: HT Report)*

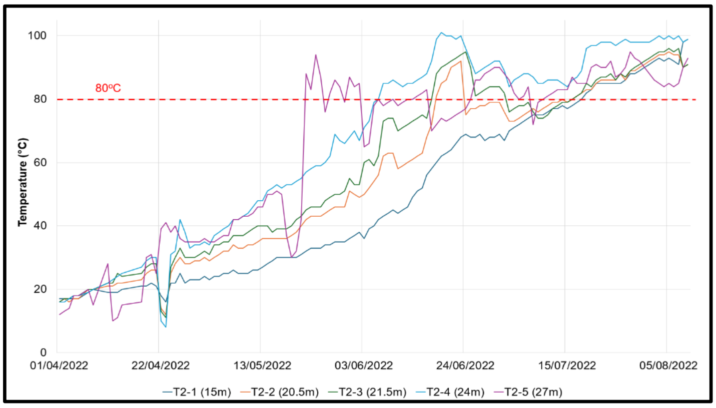
6.6.2. Soil Temperature Monitoring – HT Data

Soil temperature monitoring was conducted daily for each thermocouple depth using a hand-held metre. Plans 29 to 32 overleaf, show the temperature increases in these 'cold spot' monitoring boreholes during the heating period, between 1st April and 25th August 2022.

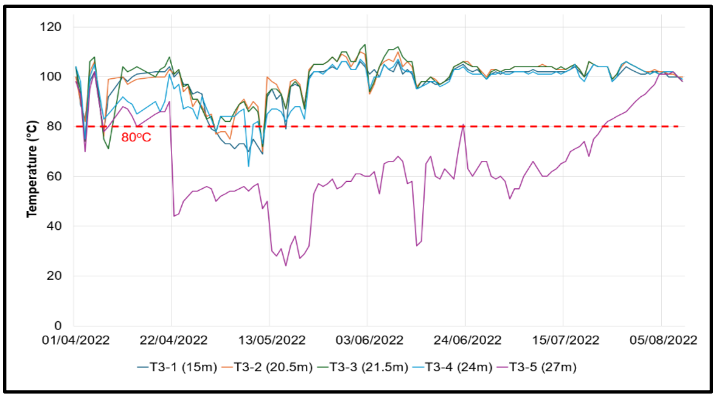
Monitoring Wells T1-T4



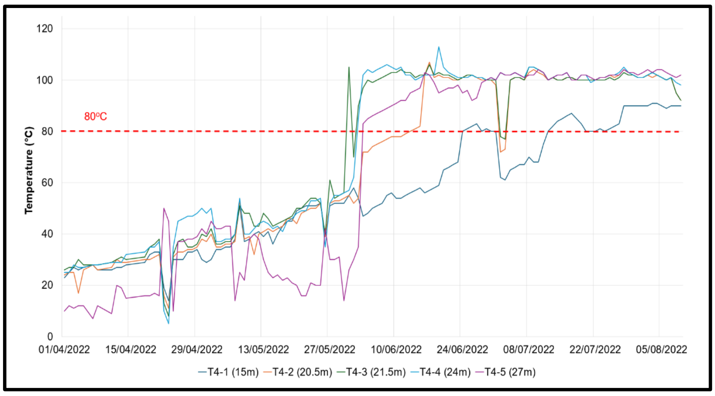
Plan 29. T1 Zone: Soil Temperatures



Plan 30. T2 Zone: Soil Temperatures



Plan 31. T3 Zone: Soil Temperatures



Plan 32. T4 Zone: Soil Temperatures

Results from 'cold-spot' zones T1 to T4 conclude the following:

- T1: target temperature of ≥80ºC achieved at all depths except for 27m bgl (maximum of 63ºC reached) and lasted for a period of between 39 and 50 days. This zone corresponds to where the highest contamination was found in the shallow soils around the point of loss; no significant contamination was found at depths >15m bgl. Therefore, treatment in this area was considered successful.
- T2: target temperature achieved at all depths and remained ≥80ºC for a period of between 32 and 65 days. Treatment in this area was considered successful.
- T3: target temperature of 80ºC achieved at all depths for a period of between 32 and 121 days. A maximum temperature of 110ºC was achieved. The sudden increase in temperatures at 27m bgl is thought to be because of fissure flow from the adjacent SVE well, which may have been heated from steam injection works targeted at 35m bgl in the surrounding wells. Treatment in this area was considered successful.
- T4: maximum temperature of 107ºC recorded in this monitoring well at 20.5-21.5m bgl. Target temperature of ≥80ºC achieved at all depths for a period of between 37 to 69 days. Treatment in this area was considered successful.

The total number of days with temperatures recorded at ≥80ºC (boiling point of benzene) is are shown in Table 6.4, overleaf.

Table 6.4. Days above Target Temperature (≥80ºC)

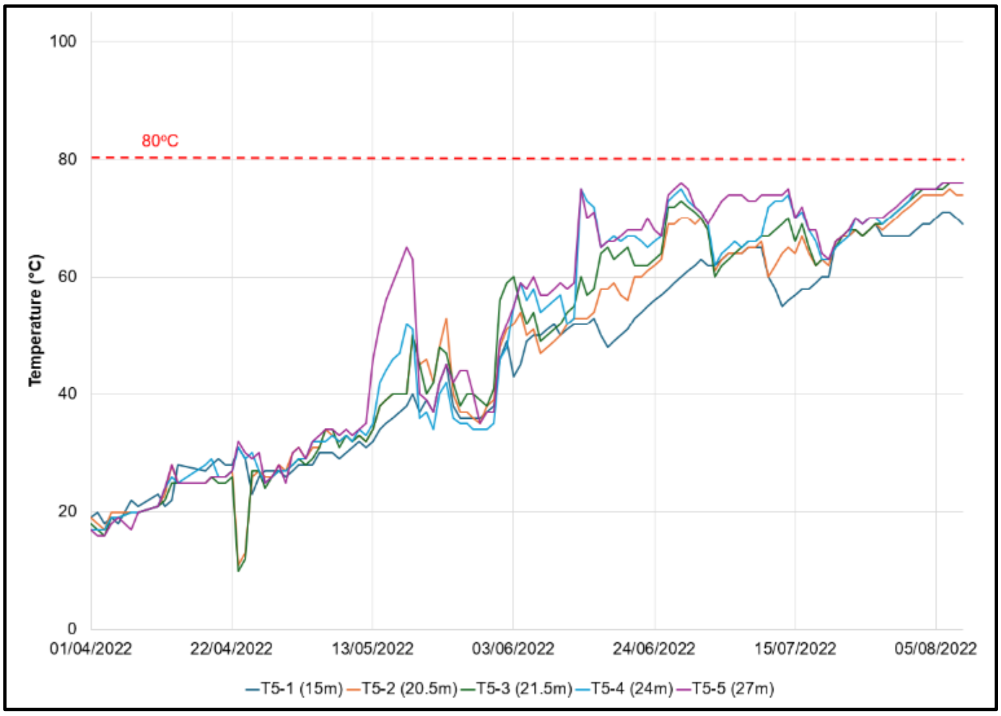
Cold Point Zone	T1-1 *(4.0m)*	T1-2 *(8.0m)*	T1-3 *(9.0m)*	T1-4 *(18.0m)*	T1-5 *(27.0m)*	T2-1 *(15.0m)*	T2-2 *(20.5m)*	T2-3 *(21.5m)*	T2-4 *(24.0m)*	T2-5 *(27.0m)*
Days at ≥80ºC	50	39	46	49	0	23	32	41	65	61
Maximum Temp. (ºC)	99	93	99	95	64	99	95	96	101	95
Cold Point Zone	**T3-1** *(15.0m)*	**T3-2** *(20.5m)*	**T3-3** *(21.5m)*	**T3-4** *(24.0m)*	**T3-5** *(27.0m)*	**T4-1** *(15.0m)*	**T4-2** *(20.5m)*	**T4-3** *(21.5m)*	**T4-4** *(24.0m)*	**T4-5** *(27.0m)*
Days at ≥80ºC	111	119	120	121	32	37	56	68	69	68
Maximum Temp. (ºC)	106	110	113	107	102	71	75	76	76	76

Monitoring Well T5

In comparison, the monitoring point 'T5' was the only location not to reach the target temperature of ≥80ºC at any depth (maximum recorded between 70-75ºC). This area of the site encountered issues with steam breakthrough, which meant that borehole dewatering pumps were not able to operate 24/7 as originally intended. To get the burners operating again, the installations had to be removed to check the electrical ignitors and flame detection probes were functioning properly; this resulted in several heating rods being damaged due to the fragility of the construction.

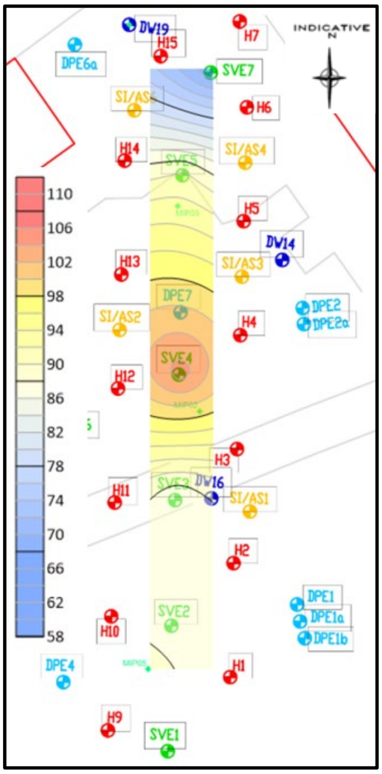
However, this area was in the far north of the site where deeper contamination was prevalent in the groundwater table only and therefore treated by steam injection.

The temperature increases recorded in monitoring point 'T5' are presented in Plan 33, below.

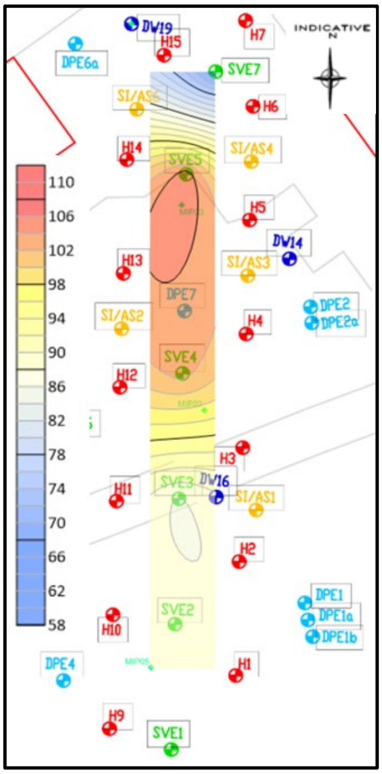


Plan 33. T5 Zone: Soil Temperatures

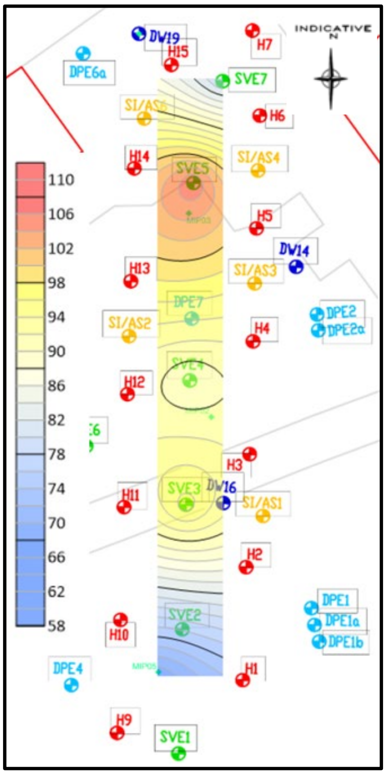
A visual representation to show the highest soil temperatures recorded on 28/07/2022 are presented using surfer plots in Plans 34-36 overleaf, to differentiate between the unsaturated zone, capillary fringe and saturated zone.



Plan 34. Unsaturated Zone (0-18m)



Plan 35. Capillary Fringe (18-26m)



Plan 36. Saturated Zone (>26m)

In summary, the temperature spread across each depth profile was as follows:

- Unsaturated Zone (0-18m): the primary heating source was the propane burners with little influence from the steam injection. In general, temperatures were lower in the north due to operational issues with the burners / dewatering pumps and ingress of groundwater (T5 Zone). However, shallow contamination in the unsaturated zone was not identified in this area of the site and so treatment was considered successful.
- Capillary Fringe (18-26m): the target temperature of ≥80ºC was successfully achieved across the majority of the site (except for northern site boundary wells) for reasons mentioned above, with the highest temperatures being recorded in the centre of the treatment zone (~107ºC). Temperatures were expectedly higher in this zone due to the majority of burners operating at 21.5m bgl.
- Saturated Zone (>26m bgl): soil temperatures were slightly lower due to the distance between the burners and the soil temperature monitoring point (burners installed at 21.5m bgl; maximum operating depth). This is particularly true for the southern part of the treatment zone (POL) as much shallower burners were installed to treat the highest contamination identified at depths of <15m bgl (burners installed at 9m bgl), with little to no influence from the steam injection.

6.7. Soil Vapour Extraction (SVE)

A total of eight (8No.) SVE boreholes were installed to 27m bgl to capture and treat VOCs, with the extraction system operating between 06/12/2021 and 05/12/2022.

VOCs were mobilised by the combined heating operations. The unsaturated zone was heated by shallow burners (installed at 9m bgl), the capillary fringe was heated with deep burners (installed at 21.5m bgl) and the saturated zone was heated by steam injection (targeted between 31-34m bgl).

The SVE system initially comprised two (2No.) branched extraction lines to separate the inner and outer wells, named 'high VOC' and 'low VOC'. This was to allow the most impacted soils to be directed through a separate treatment line and then through a catalytic oxidizer (CATOX) to save on carbon costs.

However, during remediation works, high mercury concentrations were identified in some boreholes, particularly SVE1, SVE2 and SVE3 (headspace results reaching the maximum limit of the Jerome, >0.999 mg/m^3). Therefore, the CATOX could not be used to treat the off-gases highly laden with VOCs as originally planned as mercury would poison the catalytic bed and risk releasing volatile mercury into the environment. Consequently, the dual lines were combined into a single extraction line from 18th July 2022 (named 'SP3').

Monitoring data and laboratory results collected from the SVE wells throughout remediation are discussed in Section 6.9.

6.8. Air Sparging

Eight (8No.) air sparging boreholes were installed to 36m bgl to further volatilise benzene and provide oxygenation to enhance residual degradation of VOCs (targeted sparging depth of 35m bgl).

The AS system was mostly operational towards the end of the remediation period between September 2022 and December 2022. Periodic operation then continued during post-remediation rebound monitoring between 08/02/2023-10/03/2023, 17/04/2023-28/04/2023, 31/05/2023-03/06/2023, 15/06/2023-30/06/2023 and 19/07/2023-01/09/2023.

The effect of AS was monitored during the monthly low-flow groundwater sampling using results of the physico-chemical parameters, including dissolved oxygen and redox. Rebound monitoring results are summarised in Section 8.

6.9. Contaminant Reduction (Soils)

6.9.1. Headspace Testing (SVE & DPE wells)

Headspace testing was undertaken on a twice weekly basis, using a PID and Jerome to monitor VOC and mercury vapours.

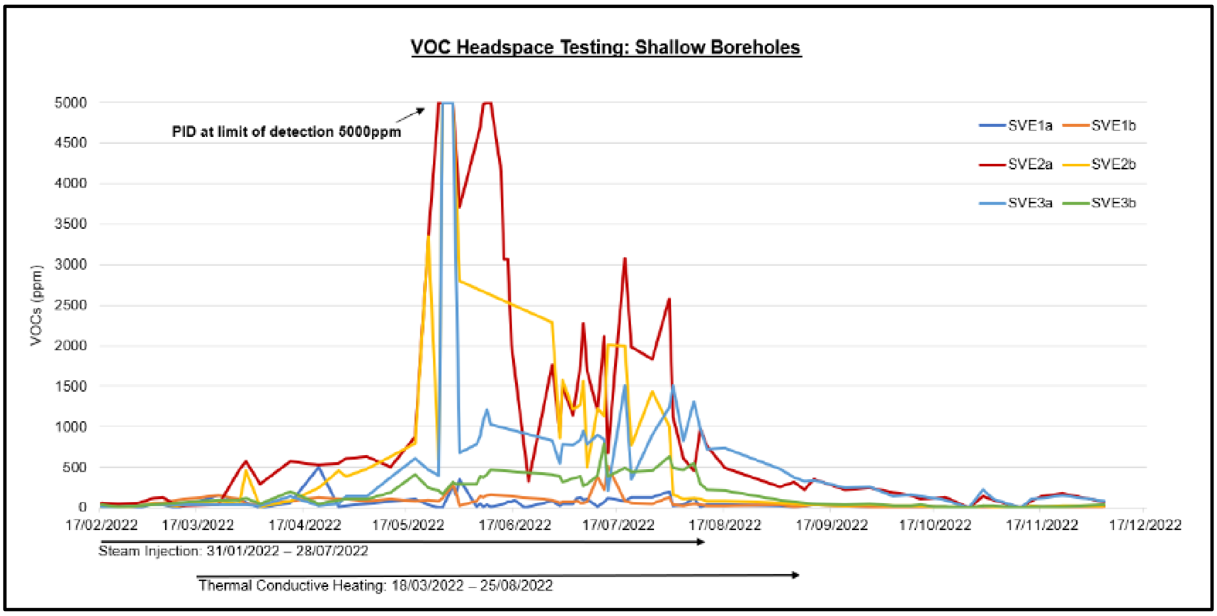
Boreholes SVE1, SVE2, SVE3 and SVE4 were positioned close to the POL and installed as dual extraction wells to capture vapours from both the shallow and deep soils. Of note, SVE4 (central well) could not be monitored due to consistent steam breakthrough throughout SI works; consequently, the wellhead was closed for safety reasons.

Shallow Installations

Boreholes SVE1a, SVE2a and SVE3a had response zones installed between 8-14m bgl to extract highly contaminated VOCs from the shallow soils around the point of loss.

As anticipated, these boreholes recorded the highest concentration of VOCs, with values reaching the maximum limit of the PID (>5,000ppm) towards the end of May 2022, as a result of heating operations. VOCs continued to remain on average between 1,000-2,500ppm throughout June and July 2022, with a significant decrease noted from August 2022. For example, in SVE2a, concentrations were on average 1,500ppm in July 2022 compared to an average of 250ppm by 21/09/2022. This suggests that gross contamination in this area has been successfully removed.

Headspace results from the shallow installations are visually presented in Plan 37, overleaf.

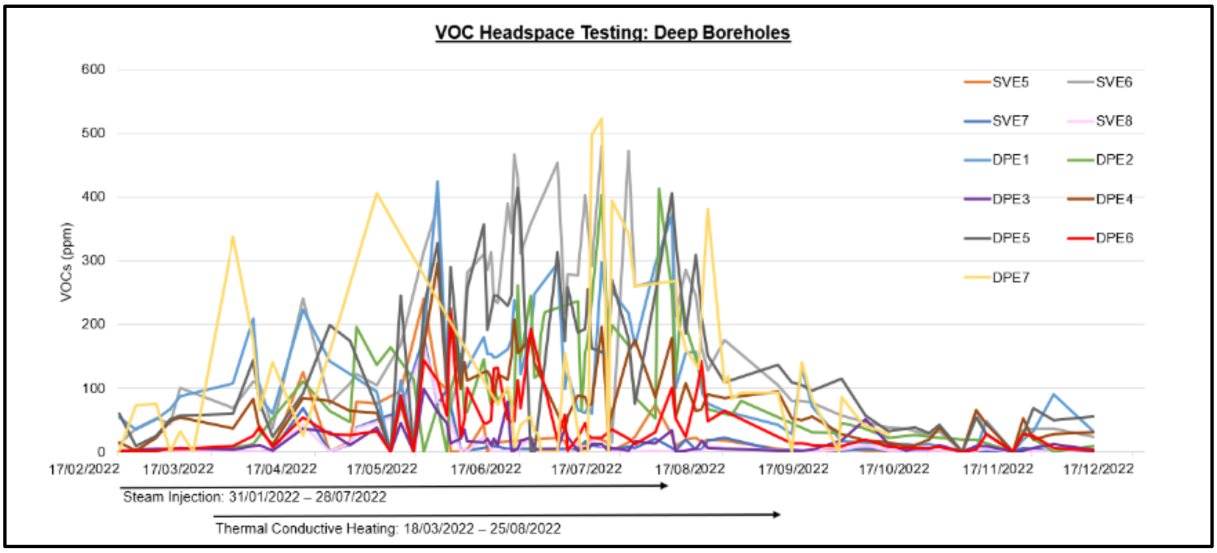


Plan 37. VOC Headspace Testing (shallow boreholes)

Deep Installations

Remaining SVE and DPE boreholes had response zones installed between 17-27m bgl (SVE wells) and 17-35m bgl (DPE wells) to extract VOCs from the capillary fringe.

As shown in Plan 38 below, the effect of heating operations was mostly observed between May and August 2022, where central deep wells recorded an average PID concentration of between 300-500ppm. Deeper wells in the north of the site recorded elevated PID concentrations between May and June 2022, with concentrations in DPE6 peaking at 216.6ppm on 27/05/2022. Contamination in the north of the site was treated by steam injection to raise groundwater temperatures and mobilise dissolved phase contamination. Dissolved phase benzene was then recovered by the DPE wells, with DPE6 recording the highest benzene concentrations during remediation (peak concentration of 22,600µg/l).



Plan 38. VOC Headspace Testing (deep boreholes)

6.9.2. SVE Laboratory Analysis: Summa Canisters

Vapour samples were collected from the extraction line(s) using summa canisters on eleven (11No.) occasions between 19/12/2021 – 14/11/2022 and submitted to an accredited MCERTS laboratory for a full gas suite, including:

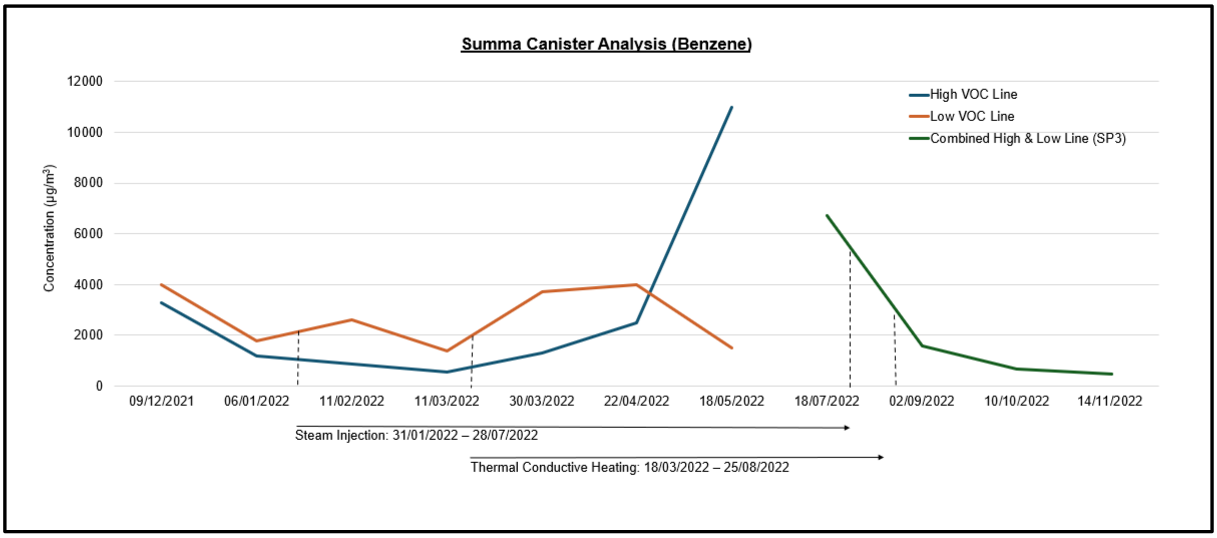
- VOC suite (including benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene);
- Total Petroleum Hydrocarbons (TPH) with aliphatic / aromatic carbon banding C5-C12;
- Tentatively Identified Compounds (TICs).

The combined VOC results for benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene are depicted on Plans 39-41, below and overleaf.

<u>Benzene Results</u>

In general, a steady rise can be seen in the extracted benzene concentrations from laboratory analysis, as presented in Plan 42, overleaf. This supports the on-site headspace testing which found VOC results to peak in May 2022 as a result of heating operations. The maximum benzene concentration was recorded at 11,000µg/m^3 within the 'high VOC' line on 18/05/2022, which corresponds well with headspace testing in SVE2a (5,000ppm).

Following completion of heating operations, benzene concentrations gradually decreased to 470µg/m^3 on 14/11/2022, in line with expectations; gross contamination at the POL was considered to be successfully extracted.

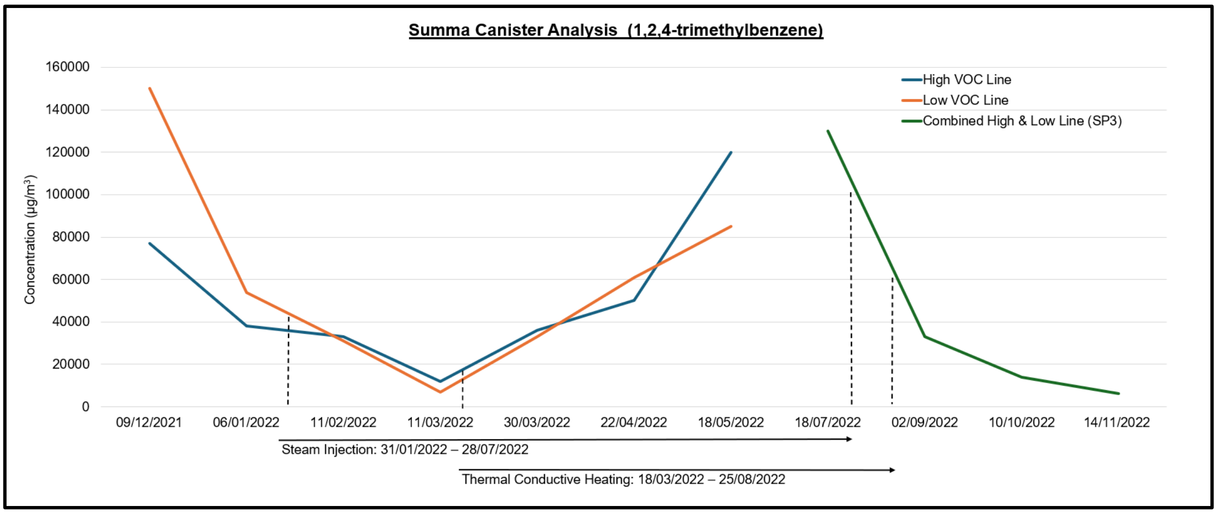


Plan 39. Summa Canister Analysis (benzene)

<u>1,2,4-trimethylbenzene Results</u>

An unexpected peak concentration of 1,2,4-trimethylbenzene was recorded in the 'low VOC' line at the start of remediation works (150,000µg/m^3 on 09/12/2022), which then significantly dropped down to 54,000µg/m^3 by the next sampling round. Concentrations were generally variable across the low VOC line, ranging 6,100 to 150,000µg/m^3 throughout the monitoring. A possible explanation for this could be that contamination within the chalk is heterogenous, with pockets of contamination being mobilised with the advancement of heat and vacuum through the chalk with the progression of treatment.

Since March 2022, a steady rise was recorded in 1,2,4-trimethylbenzene concentrations in both VOC lines (start of TCH operations), which reached 130,000µg/m^3 on 18/07/2022 (end of steam injection). Concentrations then gradually decreased to 6,100µg/m^3 on 14/11/2022, in line with expectations; gross contamination was considered to be successfully extracted.

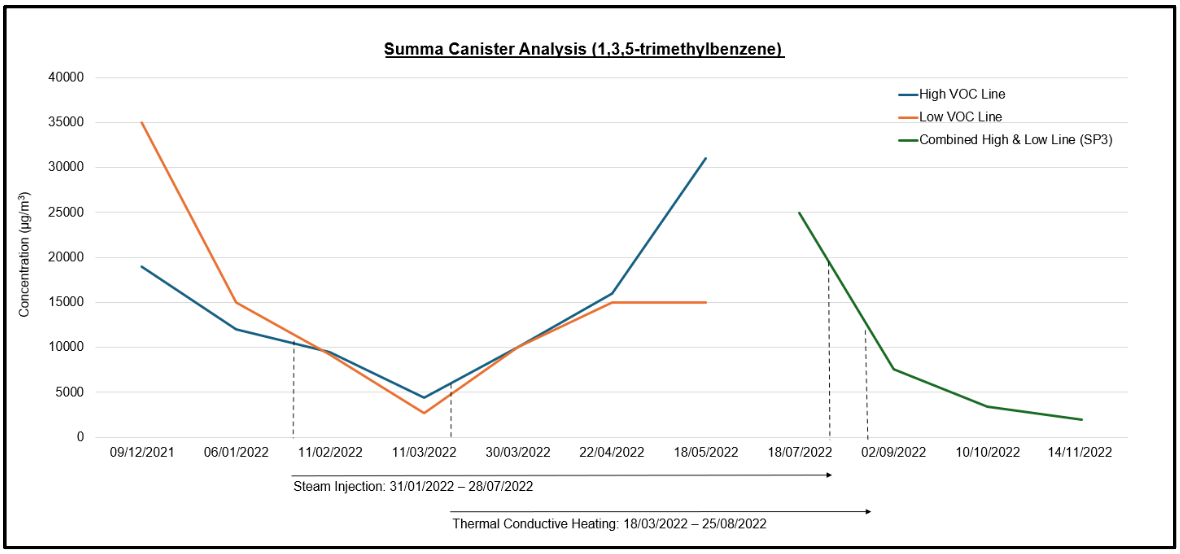


Plan 40. Summa Canister Analysis (1,2,4-trimethylbenzene)

1,3,5-trimethylbenzene Results

Similarly for 1,3,5-trimethylbenzene, an unexpected peak concentration was recorded in the 'low VOC' line at the very start of remediation works (35,000µg/m^3 on 09/12/2022), which then significantly dropped down to 15,000µg/m^3 by the next sampling round. Again, this is likely to have been because of the heterogenous nature of contamination within the chalk, with pockets of contamination being mobilised with the advancement of heat and vacuum during treatment.

Since March 2022, a steady rise was recorded in 1,3,5-trimethylbenzene concentrations in both VOC lines (start of TCH operations), which reached 31,000µg/m^3 on 18/05/2022. Concentrations then gradually decreased to 2,000µg/m^3 on 14/11/2022, in line with expectations; gross contamination was considered to be successfully extracted.



Plan 41. Summa Canister Analysis (1,3,5-trimethylbenzene)

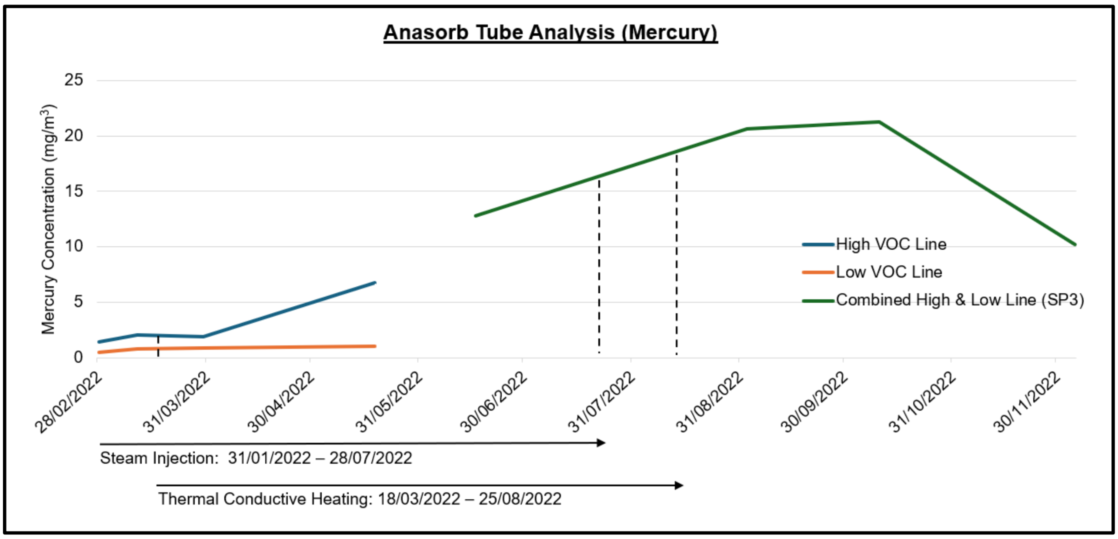
In addition to benzene and trimethylbenzenes, significant concentrations of toluene, o-xylene, m/p-xylene, 4-ethyletoluene and PROs were also recorded in the extracted vapours:

- Toluene ranged from 850µg/m^3 (18/05/2022) to 11,000µg/m^3 (09/12/2021);

- o-xylene ranged from 470µg/m^3 (11/03/2022) to 3,200µg/m^3 (09/12/2021);
- m/p-xylene ranged from 170µg/m^3 (11/03/2022) to 1,500µg/m^3 (09/12/2021);
- 4-ethyletoluene ranged from 1,700µg/m^3 (11/03/2022) to 24,000µg/m^3 (18/05/2022);
- Petroleum range organics (PRO >C5-C12) ranged from 43,000µg/m^3 (11/03/2022) to 2,200,000µg/m^3 (06/01/2022).

6.9.3. SVE Laboratory Analysis: Anasorb Tubes

Laboratory analysis was also conducted using anasorb tubes on eight (8No.) occasions between 28/02/2022 – 05/12/2022 to quantify the extracted mercury concentrations at an accredited MCERTS laboratory. Laboratory results are presented on Plan 42, below



Plan 42. Anasorb Tube Analysis (mercury)

The maximum mercury concentration of 21.3mg/m^3 was recorded on 10/10/2022 from the combined 'SP3' line. Extracted mercury concentrations can be seen to increase throughout treatment works with increasing soil temperatures, despite our target soil temperature of ≥80°C and mercury having a high boiling point of 356.7°C. Overall, a vapour mass recovery of 48.56kg of mercury was calculated to be extracted from the former MPA, which is further evidence of contaminant reduction.

6.10. Contaminant Reduction (Groundwater)

6.10.1. VOC Recovery (DPE Wells)

The DPE boreholes were installed to 35m bgl for the purpose of lowering the groundwater table, maintaining hydraulic control and allowing vapour extraction during the remediation works.

Groundwater samples were collected from each DPE well on a weekly basis, where possible, during remediation works to monitor the contaminant mobilisation. On occasion, groundwater temperatures exceeded the operating capabilities of the borehole pumps and so a water sample could not be taken.

Groundwater samples were submitted to an accredited MCERTS laboratory for the following analysis:

- VOC suite (including benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene).

Laboratory results for the main CoC 'benzene' have been presented in Table 6.5 overleaf.

Table 6.5. Benzene Concentrations during Remediation (DPE Wells)

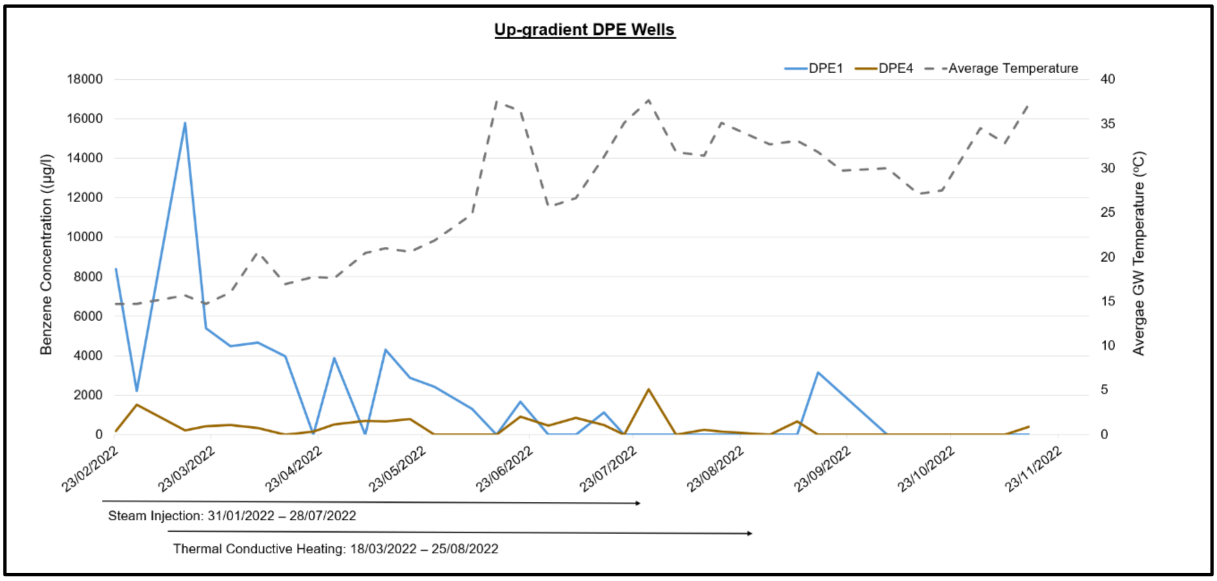
	Benzene Concentrations (µg/l)						
Date	**DPE1**	**DPE2**	**DPE3**	**DPE4**	**DPE5**	**DPE6**	**DPE7**
23/02/2022	8,380	1,990	7,070	172	5,220	7,390	-
01/03/2022	2,210	462	1,030	1,520	769	1,600	-
15/03/2022	15,800	1,830	7,140	209	7,250	11,700	1,330
21/03/2022	5,380	1,740	4,350	422	2,970	6,200	-
28/03/2022	4,470	1,820	5,930	491	895	10,900	-
05/04/2022	4,660	2,190	5,600	339	5,620	9,340	-
13/04/2022	3,960	2,220	6,010	<1.0	5,310	7,910	-
21/04/2022	<1.0	2,630	12,400	165	13,500	14,700	-
27/04/2022	3,870	2,800	7,900	517	6,550	11,200	-
06/05/2022	<1.0	813	18,200	702	16,700	24,700	-
12/05/2022	4,310	2,990	11,000	656	12,700	29,700	5,170
19/05/2022	2,870	2,170	6,140	798	4,060	6,310	2,030
26/05/2022	2,420	3,370	6,340	<1.0	4,570	4,070	2,980
06/06/2022	1,310	1,730	1,040	<1.0	1,890	7,650	3,180
13/06/2022	<1.0	396	1,120	<1.0	2,690	8,670	2,790
20/06/2022	1,660	<1.0	3,130	898	498	5,080	1,930
28/06/2022	<1.0	447	3,810	451	822	3,420	-
06/07/2022	<1.0	256	3,820	837	3,240	5,960	-
14/07/2022	1,130	1,270	2,210	474	1,740	4,070	-
20/07/2022	<1.0	547	851	<1.0	8,900	22,600	-
27/07/2022	<1.0	2,230	375	2,290	3,670	5,450	-
04/08/2022	<1.0	229	4.4	<1.0	6,970	18,200	-
12/08/2022	<1.0	231	2,060	252	6,700	8,930	-
17/08/2022	<1.0	<1.0	538	160	2,550	9,910	<1.0
31/08/2022	<1.0	<1.0	<1.0	<1.0	14,200	21,600	12,500
08/09/2022	<1.0	-	<1.0	678	5,240	10,200	11,000
14/09/2022	3,140	-	248	<1.0	3,960	1,889	-
21/09/2022	-	-	49.1	<1.0	2,170	11,300	5,950
04/10/2022	<1.0	-	<1.0	297	409	-	2,830
13/10/2022	-	-	<1.0	<1.0	1,510	264	1,190
20/10/2022	-	-	<1.0	<1.0	214	-	282
31/10/2022	<1.0	-	1,170	<1.0	-	-	1,430
07/11/2022	<1.0	-	11,800	<1.0	-	<1.0	924
14/11/2022	<1.0	-	<1.0	<1.0	-	2,860	2,120
21/11/2022	-	-	<1.0	402	471	192	493
01/12/2022	-	-	<1.0	<1.0	<1.0	<1.0	<1.0

Key:
Colour coding system: Green: <500 µg/l, Amber: 500-1,000 µg/l, Red: >1,000 µg/l.
(-) no sample collected due to the following reasons:
- DPE1 & DPE2 frequently run dry due to low water levels.
- DPE5 & DPE6 encountered limescale issues and high temperatures impacting pumping operations.
- DPE7 experienced steam breakthrough (central well), which prevented the collection of water samples.

Laboratory results show that the highest benzene concentrations were recovered from boreholes in the central and northern half of the site (DPE3, DPE5, DPE6 and DPE7), as expected from results obtained during the pre-remediation monitoring and 3D contaminant modelling exercise.

The benzene results have been presented on Plans 43-45 overleaf, to group together the up-gradient wells, central wells and down-gradient wells to see the effect of heating operations and VOC recovery.

Up-gradient wells (DPE1 & DPE4)



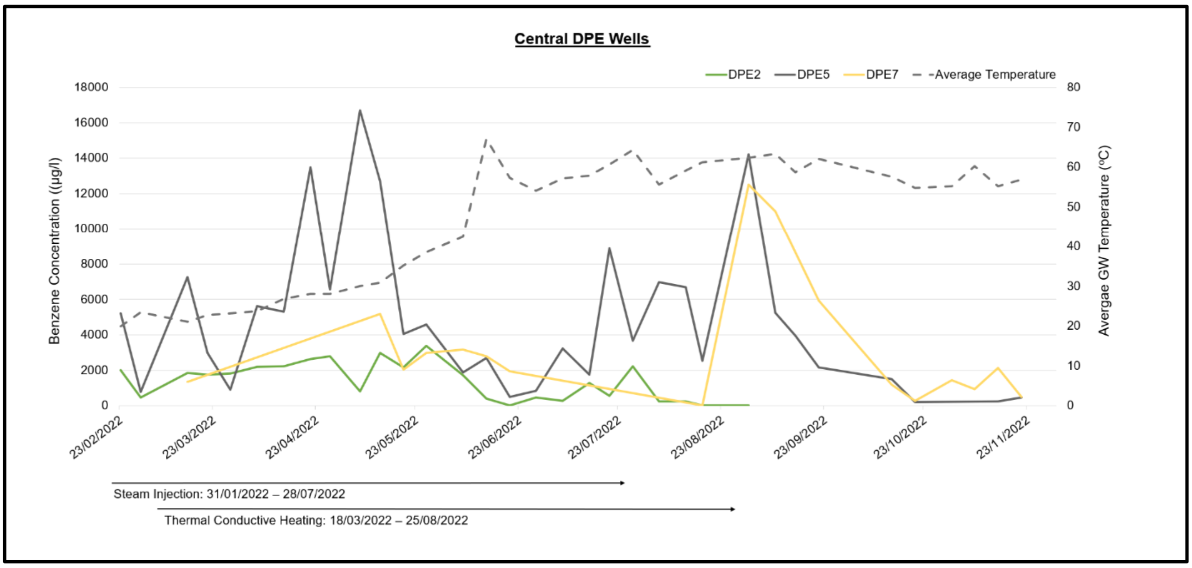
Plan 43. Benzene Recovery (up-gradient DPE wells)

DPE1 recorded a maximum benzene concentration of 15,800µg/l on 15/03/2022, during the initial stages of steam injection. Concentrations then steadily reduced until July 2022 when results remained below the LOD until mid-November 2022, except for a one-off spike of 3,140µg/l recorded on 14/09/2022.

The majority of DPE4 benzene concentrations were low throughout remediation works, with a maximum of 2,290µg/l recorded on 27/07/2022, towards the end of heating operations. This was expected as very minimal soil contamination was present during pre-remediation drilling works in July 2021 (only trimethylbenzenes recorded at 18m bgl, maximum of 140mg/kg).

Remaining VOCs of concern (toluene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene) in both wells remained low throughout remediation works (<500µg/l).

Central wells (DPE2, DPE5 & DPE7)



Plan 44. Benzene Recovery (central wells)

DPE2 is located on the far eastern extent of the contamination plume and recorded a maximum benzene concentration of 3,370µg/l on 26/05/2022, mid-way through heating operations. Since August 2022, low concentrations of benzene were recorded (<250µg/l) with two consecutive results below the LOD recorded on 17/08/2022 and 31/08/2022. Following this period, the borehole pump frequently ran dry due to low water levels in the summer months and so laboratory analysis could not be completed.

Remaining VOCs in DPE2 (toluene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene) were detected at relatively low concentrations throughout the sampling works. The majority of VOCs were <500µg/l, except for a peak concentration of 1,2,4-trimethylbenzene (1,440µg/l), recorded on 04/08/2022.

DPE5 recorded a maximum benzene concentration of 16,700µg/l on 06/05/2022, with concentrations fluctuating significantly throughout the sampling rounds. This borehole is located on the western extent of the contamination plume, which recorded high levels of VOC contamination during drilling works (maximum of 1,000mg/kg of 1,2,4-trimethylbenzene at 23m bgl). Consequently, this borehole recorded the highest levels of remaining VOCs of concern compared with any other location:

- Toluene was detected on thirty-one (31No.) occasions, with a peak concentration of 1,870µg/l recorded on 21/04/2022.
- 1,2,4-trimethylbenzene was detected on thirty-two (32No.) occasions, with a peak concentration of 13,700µg/l recorded on 20/07/2022.
- 1,3,5-trimethylbenzene was detected on thirty-one (31No.) occasions, with a peak concentration of 1,970µg/l recorded on 20/07/2022.
- By mid-October 2022, these had all reduced to <500µg/l.

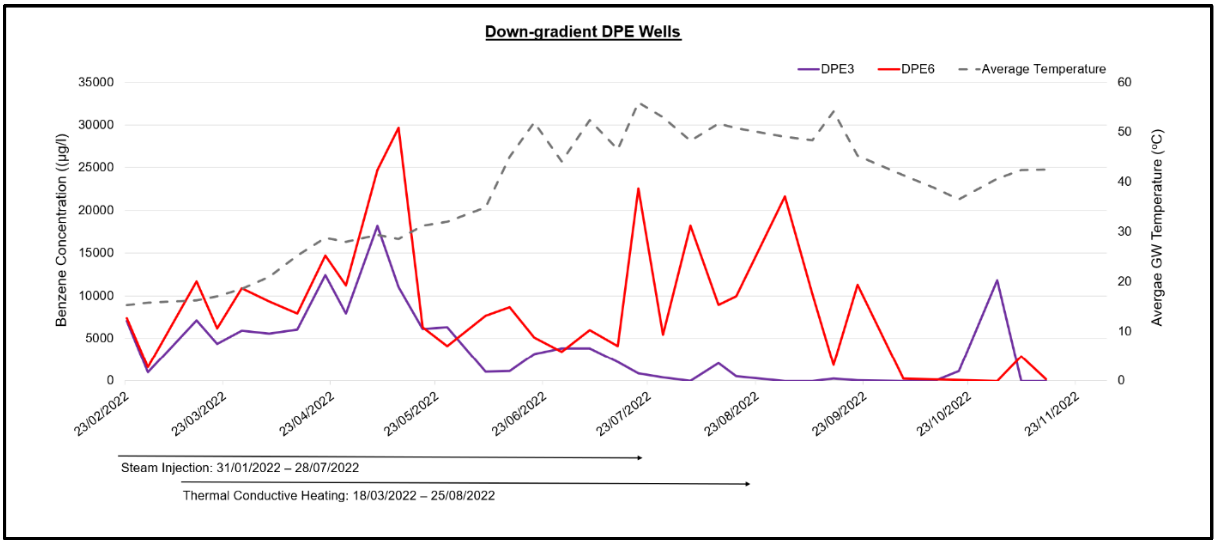
During remediation works, DPE7 often experienced steam breakthroughs or excessively high groundwater temperatures which limited the collection of water samples. Laboratory results recorded a maximum benzene concentration of 12,500µg/l on 31/08/2022. Since mid-October 2022, benzene concentrations have remained <3,000µg/l with the final round in November 2022 recording concentrations below the LOD. Being a centrally located well with steam breakthrough, rapid mobilisation of volatile contaminants may have occurred and have been undocumented by laboratory results (significant periods of time where sampling could not take place). Steam was found to breakthrough to DPE7 and SVE4 almost immediately with the initiation of steam injection.

Remaining VOCs of concern in DPE7 (toluene and 1,2,4-trimethylbenzene) were detected at moderate concentrations throughout the sampling works, with 1,3,5-trimethylbenzene detected at low levels (<500µg/l):

- Toluene was detected on seventeen (17No.) occasions, with a peak concentration of 1,310µg/l recorded on 15/03/2022.
- 1,2,4-trimethylbenzene was detected on sixteen (16No.) occasions, with a peak concentration of 4,740µg/l recorded on 13/06/2022.

Overall, a trend was observed with increases in groundwater temperatures leading to decreases in VOC concentrations, suggesting that VOCs were successfully mobilised and extracted from the central DPE wells.

Down-gradient Wells (DPE3 & DPE6)



Plan 45. Benzene Recovery (down-gradient wells)

DPE3 recorded a maximum benzene concentration of 18,200µg/l on 06/05/2022, mid-way through heating operations. Concentrations continued to reduce for the remainder of heating operations until results below the LOD were mostly recorded from October 2022. An isolated peak of 11,800µg/l was recorded on 07/11/2022, which had reduced back to <LOD for the final three (3No.) consecutive rounds of monitoring.

Remaining VOCs of concern in DPE3 (toluene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene) were detected at relatively low concentrations throughout the sampling works (<500µg/l), except for 1,2,4-trimethylbenzene. A peak concentration of 1,460µg/l was recorded on 26/05/2022.

DPE6 recorded a maximum benzene concentration of 29,700µg/l on 12/05/2022, with fluctuations recorded throughout most of the remediation works. Since October 2022, benzene concentrations were mostly low (<500µg/l), with one exception of 2,860µg/l recorded on 14/11/2022. Remaining VOCs of concern in DPE6 (toluene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene) recorded higher levels as follows:

- Toluene was detected on thirty-one (31No.) occasions, with a peak concentration of 2,510µg/l recorded on 12/05/2022.
- 1,2,4-trimethylbenzene was detected on thirty (30No.) occasions, with a peak concentration of 7,790µg/l recorded on 12/05/2022.
- 1,3,5-trimethylbenzene was detected on thirty-one (31No.) occasions, with a peak concentration of 587µg/l recorded on 20/07/2022.

A similar trend was observed with increases in groundwater temperatures leading to decreases in VOC concentrations, suggesting that VOCs were successfully mobilised and extracted from the source area.

6.10.2. Monitoring Borehole Network (DW Wells)

During remediation works, monthly groundwater monitoring was undertaken to maintain the dataset in the existing borehole network (15No. locations) and assess the effectiveness of treatment operations.

The groundwater was monitored using low-flow techniques to induce minimal drawdown and provide non-biased groundwater samples with reduced suspended particles. Samples were submitted to an accredited MCERTS laboratory for the following analysis:

- VOC suite (including benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene);
- Mercury (dissolved); and,
- Sulphate, sulphide, nitrate and nitrite (source area wells only).

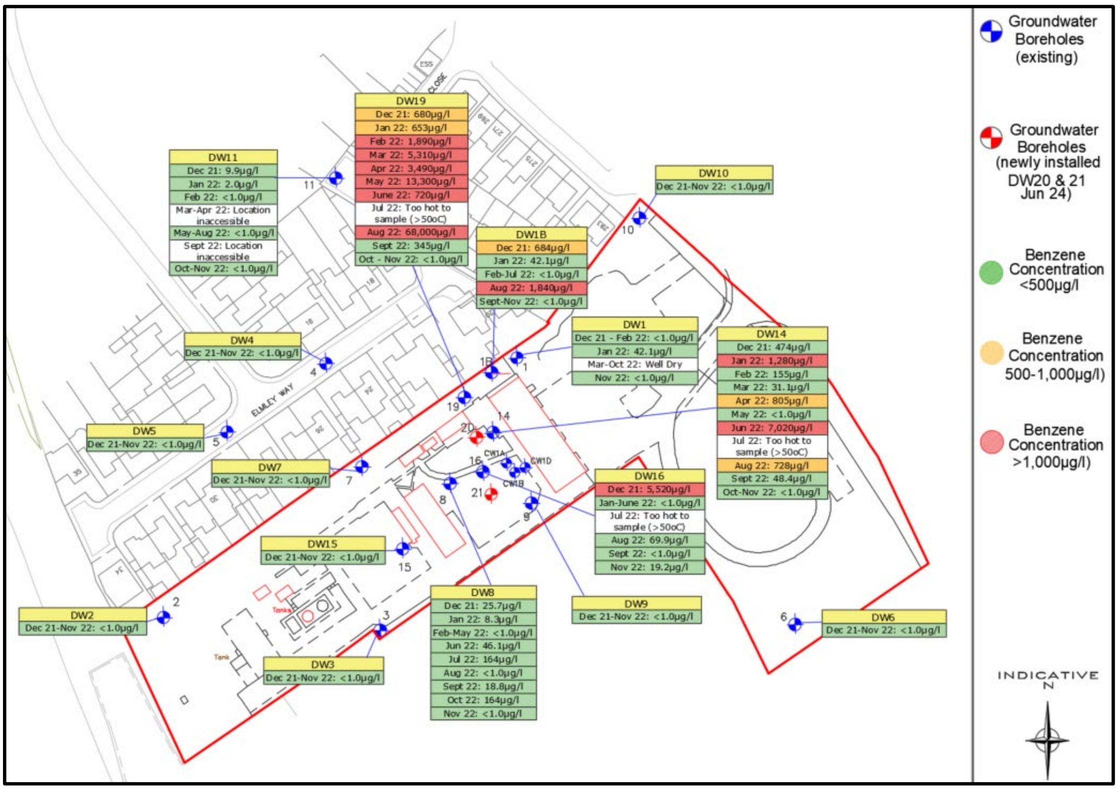
Laboratory results confirm that no benzene was detected outside of the site boundary during the majority of active remediation, except for very low levels in DW11 recorded during the first two months of operation (9.9µg/l in December 2021 and 2.0µg/l in January 2022).

A peak benzene concentration of 68,700µg/l in DW19 on 22/08/2022, which coincided with the highest report of 1,2,4-trimethylbenzene (peak of 17,900µg/l in the same sample).

The majority of mercury results were below the DWS (1µg/l) throughout operations, except for DW9 which exceeded on three occasions (concentrations of 2.44µg/l, 1.3µg/l and 1.35µg/l) and one isolated reading in DW16 (concentration of 1.14µg/l). No additional mercury exceedances were detected in any other boreholes on-site / off-site during remediation works.

These results indicate successful containment of the benzene plume and hydraulic control during the treatment period. Results from the physico-chemical parameters are discussed in Section 8 as part of the rebound monitoring.

Benzene concentrations in the existing monitoring well network during active remediation are presented in Plan 46, below.



Plan 46. Benzene Concentrations (during remediation)

6.11. Treatment Cessation

6.11.1. Source Area Benzene Reduction (< 2020/2021 baseline)

To assess the effectiveness of remediation works, source area benzene concentrations during the final round of remediation (November 2022) have been compared to the maximum concentrations recorded during the baseline groundwater monitoring rounds (between March 2020 and March 2021).

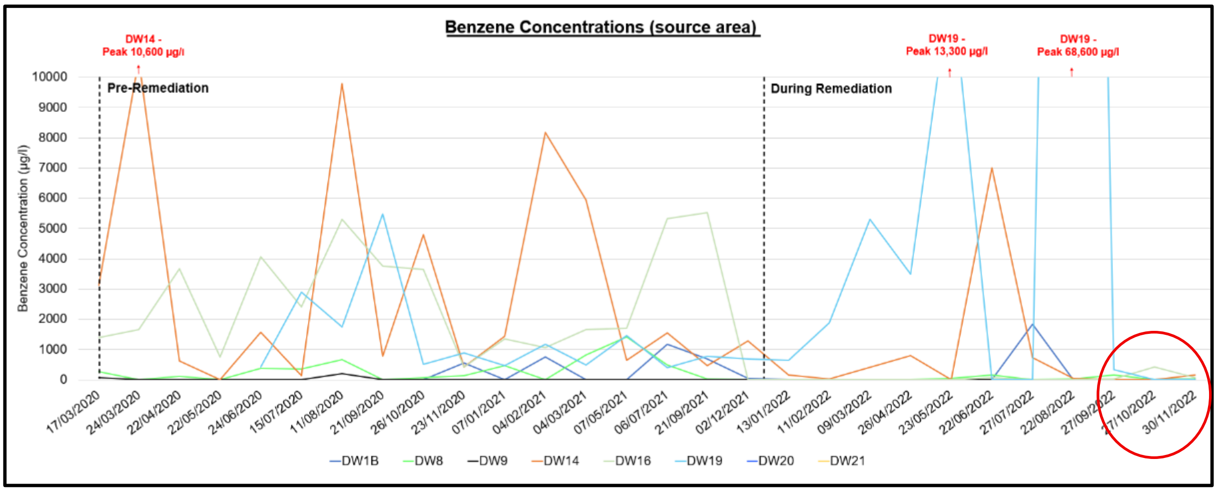
Results have been presented in Table 6.6, below, with percentage reductions calculated for each source area borehole.

Table 6.6. Benzene Concentration Reductions (groundwater)

Borehole	Maximum Benzene Concentration (µg/l)		Average Percentage Reduction
	Baseline (2020/2021)	November 2022	
DW1B	1,170	<1.0	>99%
DW8	1,430	<1.0	>99%
DW9	208	<1.0	>99%
DW14	10,600	<1.0	>99%
DW16	5,340	19.6	>99%
DW19	5,490	<1.0	>99%

Results show that the maximum benzene concentrations have decreased by >99% by the final monitoring round (November 2022), with the majority of wells below the laboratory LOD.

Plan 47, below, visually depicts benzene concentrations from the start of baseline groundwater monitoring in March 2021 to the final round of remediation monitoring in November 2022.



Plan 47. Source Area Benzene Reduction (< 2020/2021 baseline)

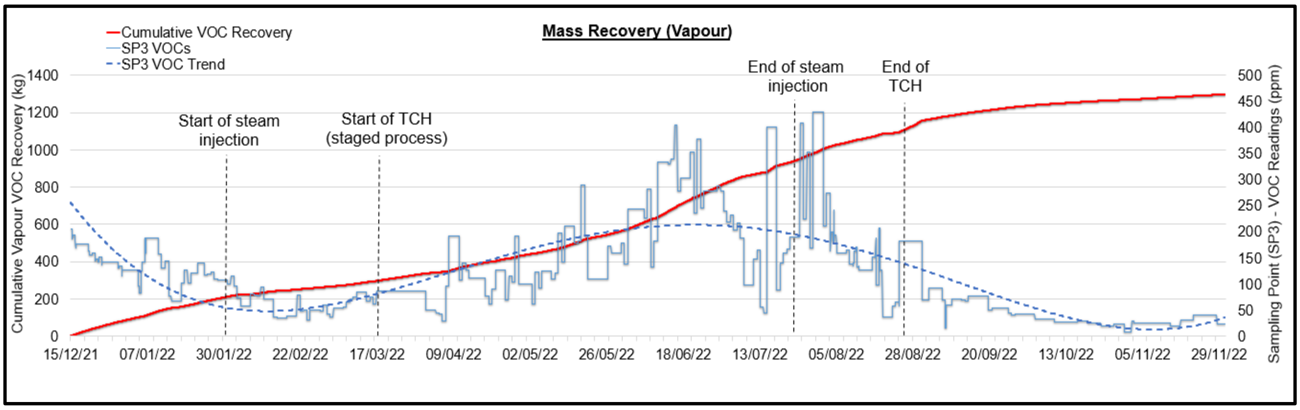
Results show that the final three months of remediation monitoring (between September-November 2022) all have consistently low benzene concentrations in the source area boreholes of <500µg/l.

Therefore, these results show a significant reduction in groundwater contamination, confirming successful ISTR and achievement of the treatment cessation objective.

6.11.2. Mass Recovery (VOC vapour)

During system operation, the cumulative vapour mass recovery was calculated using on-site ppm results, collected manually with a PID and automatously using a system TVOC, from the SVE line(s). The TVOC readout recorded continuous measurements of VOCs passing through the system adjusted to pressure, temperature, and flow rate. The off-gases were analysed every 3-weeks using GC-MS data from summa canister results.

Mass recovery was re-calculated following completion of each sampling round, using the relative average molar mass of the highest VOC concentrations from the laboratory analysis (i.e. benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene). The cumulative VOC recovery is presented in Plan 48, below.



Plan 48. Mass Recovery (vapour)

The cumulative VOC recovery is shown by the red line, with an additional trendline presented for the manual PID measurements taken from 'SP3'. The peak VOC trendline is consistent with the steepest curve of mass recovery recorded in June 2022. This correlated well with the maximum VOC results from headspace testing.

Overall, the cumulative vapour recovery shows a general increase with the initiation of SI and TCH, which then tapers off as expected following cessation of heating works. A total of 1,302.07kg of VOC vapour was recovered between 15/12/2021-05/12/2022.

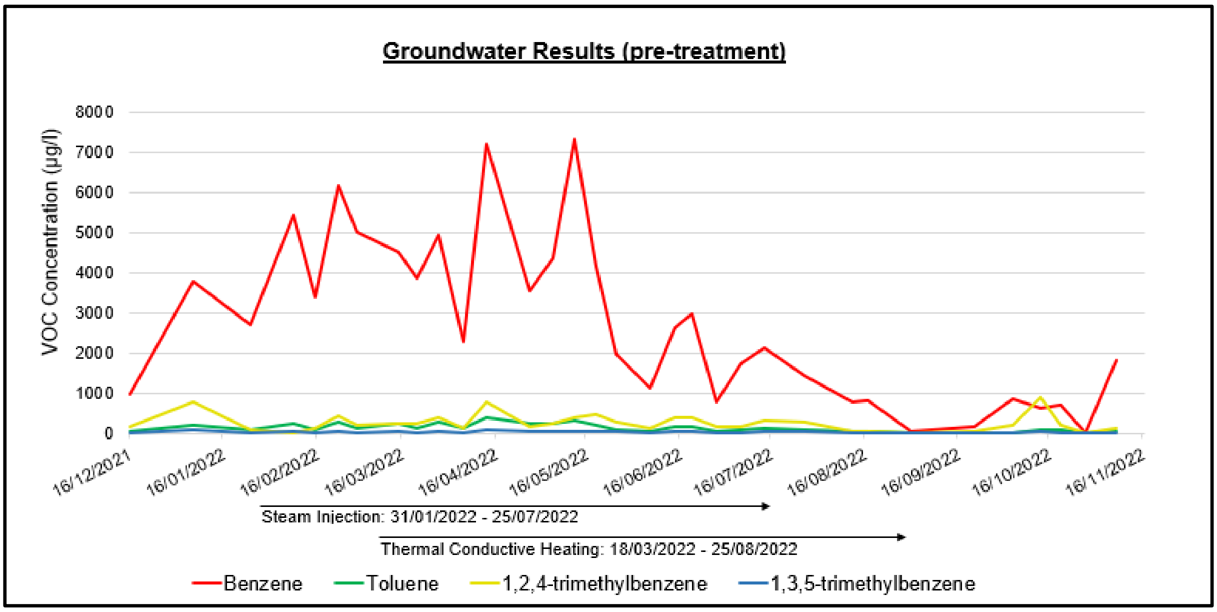
Additionally, mass recovery for mercury during remediation works was determined to be 48.56kg, which was calculated from the anasorb laboratory results and cumulative flow rate during remediation works.

6.11.3. Mass Recovery (groundwater)

Mass recovery was also calculated for groundwater during treatment works. A pre-treatment sampling point was installed on the OWS to allow sample collection for mass recovery calculations. Weekly samples were submitted to an accredited MCERTS laboratory for the following analysis:

- VOC suite; and,
- Mercury (dissolved).

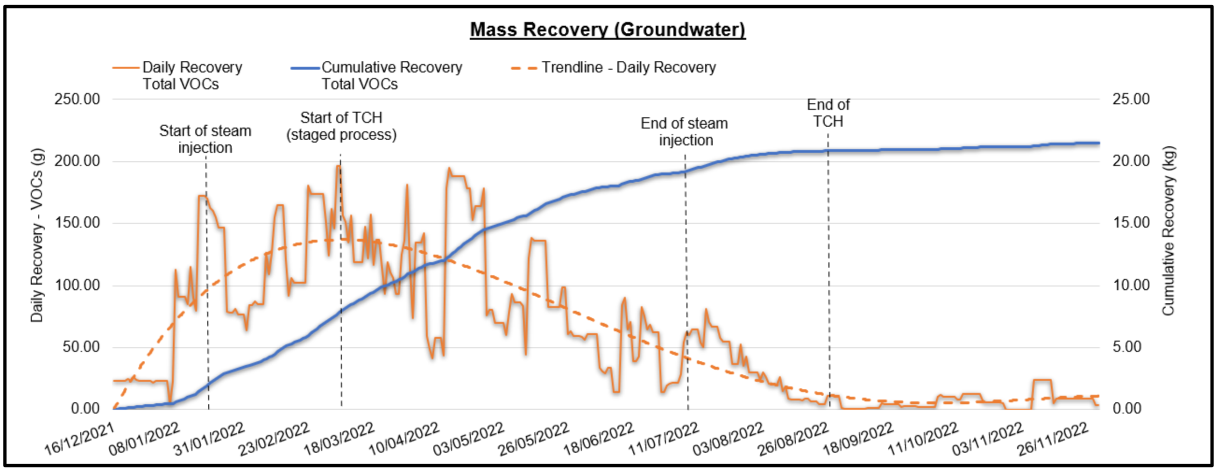
The extracted water was a combination of all DPE pumping locations, with results of the laboratory analysis depicted in Plan 49, overleaf.



Plan 49. Combined Pre-Treatment Analysis (VOCs)

Laboratory results show a steady increase in recovered benzene concentrations up until 12/05/2022 (peak concentration of 7,350µg/l), as a result of the combined SI and TCH works. Remaining VOC concentrations all remained below 1,000µg/l throughout the treatment works, supporting the knowledge that benzene is the prevalent contaminant in the groundwater table.

Groundwater mass recovery was calculated by combining the weekly laboratory data for 'pre-treatment' samples to obtain an average VOC concentration from all pumping locations. This figure was then combined with the pumping rate measured through the GAC filters to calculate the cumulative recovery, as shown in Plan 50 below.



Plan 50. Mass Recovery (groundwater)

Overall, a cumulative mass recovery of 21.52kg was calculated for groundwater following treatment works, between 16/12/2021 and 26/11/2022. In total, 6,592m^3 of groundwater was treated and disposed to sewer under consent from Southern Water.

An initial rise in VOCs was observed in January 2022, which coincided with the beginning of a slight oily sheen on the surface of the OWS (observed from 05/01/2022). There was a noticeable increase in free product with the introduction of heat into the groundwater via SI. Free product similar to that shown in Plates 1 and 2 continued to be recorded between

February-May 2022, which then gradually tapering off throughout treatment. This level of free product has never been observed on-site before ISTR works.

Plate 1. Oily sheen and emulsified product frequently observed in OWS (*30.03.2022*)

Plate 2. Oily sheen and emulsified product frequently observed in OWS (*09.05.2022*)

Additionally, strong hydrocarbon odours were frequently recorded around the OWS during remediation, which led to concerns about the level of volatilisation taking place before sampling.

Consequently, two (2No.) consecutive rounds of analysis was completed using 'hot' and 'chilled' samples. The 'hot' sample was collected from the usual pre-treatment sampling point, whereas the 'chilled' sample was collected using a 10.0m length of 6mm tubing, submerged in chilled fridge water to approximately 5ºC. Benzene results from these sampling rounds are presented in Table 6.7, below.

Table 6.7. Pre-treatment: Hot vs Chilled Samples

Sampling Date	Hot		Chilled		Percentage Loss (%)
	Temperature (ºC)	Benzene (µg/l)	Temperature (ºC)	Benzene (µg/l)	
06/07/2022	44.3	1,190	14.5	1,730	36
14/07/2022	44.6	1,510	15.4	2,130	34

Results confirm the theory that when sampling heated groundwater, a significant portion of dissolved phase benzene is being lost due to volatilisation prior to analysis (between 34-36%).

Remaining VOCs, including toluene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene, did not demonstrate a similar percentage loss; however, this is expected due to the higher boiling points (including 110ºC for toluene, 169ºC for 1,2,4-trimethylbenzene and 170ºC for 1,3,5-trimethylbenzene).

Therefore, based on the findings presented above, we can conclude that laboratory benzene concentrations recovered from DPE wells are a significant underestimation and therefore total mass recovery is likely to be higher.

6.11.4. Actual Contaminant Mass Recovery

In summary, the total mass recovery calculated at the end of remediation works is presented in Table 6.8, overleaf.

Table 6.8. Actual Contaminant Mass Calculation (post-remediation)

Source Area	Total (kg)	Overall Total (kg)
Groundwater *(calculated from 'pre-treatment' samples, specifically benzene, toluene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene, and pumping rates)*	21.52	**1,323.59**
Vapour (VOCs) *(calculated from TVOC readout, manual SP3 PID measurements, and summa canister samples inc. benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene)*	1,302.07	
Vapour (mercury) *(calculated from the linear change between anasorb samples and flow rates taken from cumulative vapour flow in m^3/hr)*	48.56	

Known Limitations

- Groundwater calculations are likely to be an underestimation following volatilisation of benzene when waters are heated (approximately 34-36% contaminant loss);
- Groundwater calculations are based on weekly laboratory results instead of a constant monitored concentration (i.e. peak concentrations may have been missed); and,
- Total mass calculations are only based on three (3No.) VOCs (benzene, 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene); therefore, these may not be fully representative of the entire contamination plume and are likely to be an underestimation.

Overall, following remediation works, the final calculated mass recovery from soils and groundwater has significantly exceeded the initial calculations by 114% (estimated mass of 619.09kg vs actual mass of 1,323.59kg). Additionally, 48.56kg of mercury has been extracted from the source area, which has exceeded our initial objectives.

6.11.5. System Termination

Treatment was therefore terminated in December 2022 following successful removal of bulk contamination in the source area and achievement of remediation objectives.

The final calculated mass recovery from soils and groundwater has significantly exceeded the initial calculations by 114% (estimated mass of 619.09kg vs actual mass of 1,323.59kg), together with greatly reduced benzene concentrations when compared to the baseline assessment in 2020/2021 (average percentage reduction of >99% across all source area wells).

In accordance with the Addendum Remediation Strategy[ref 49], rebound monitoring was then undertaken for a minimum period of 12-months, with results discussed in Section 8.

The above ground remediation equipment was decommissioned in July 2024, with remaining underground equipment (i.e. borehole installations) anticipated to be decommissioned during 2025, following the outcome of permit surrender. Ecologia intend to decommission all redundant boreholes in line with industry and Environment Agency guidance[ref 69].

7. POST-REMEDIATION SOIL INVESTIGATION

Ecologia undertook additional drilling works in the source area in June 2024, part way through the rebound monitoring, to obtain information on site-specific conditions post-remediation, in order to validate the assumptions used in the predictive modelling sensitivity analysis.

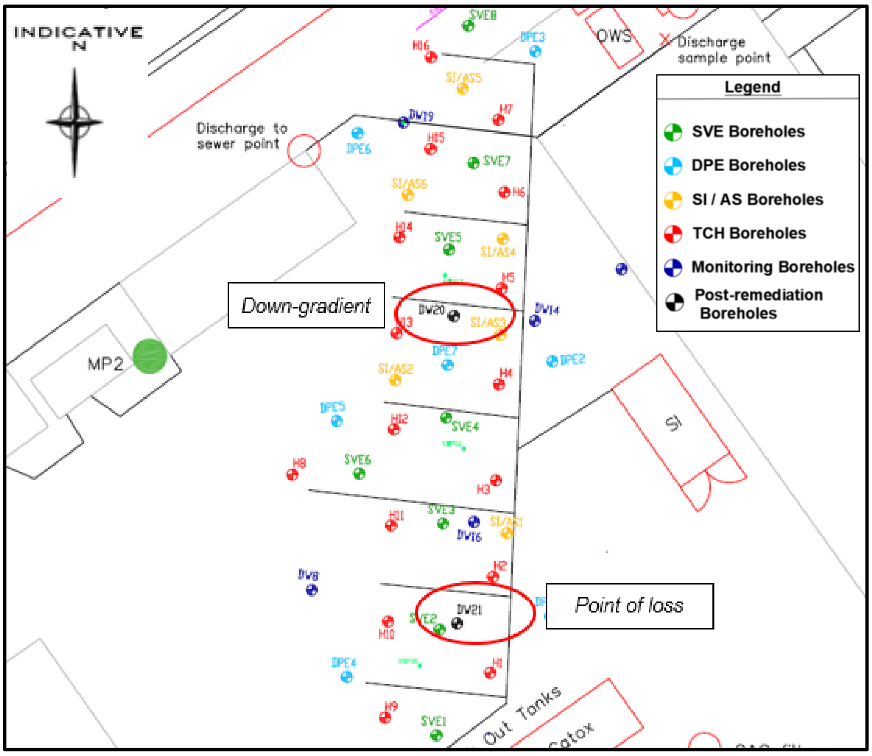
A copy of the factual drilling report(ref 56) is included within Appendix I, with findings summarised in subsequent sections.

7.1. Drilling Works

Two (2No.) additional rotary cored boreholes were drilled in the source area to 61.0m bgl, between the 3rd and 12th June 2024. Drilling works comprised the following:

- Soil logging in accordance with British Standard BS 5930:2015+A1:2020, with particular focus on fracture spacing, aperture and infill.
- On-site headspace testing using a PID and an ION Mercury Vapour Indicator (MVI) at 0.50m intervals.
- Retrieval of forty (40No.) soil samples for environmental analysis and / or geotechnical laboratory analysis.
- Geophysical logging in one (1No.) borehole, including an optical televiewer, calliper sonde, natural gamma, fluid temperature, conductivity and magnetic resonance (NMR) probe.

The newly drilled borehole locations 'DW20' and 'DW21' are highlighted in Plan 51, below. Locations were selected to be representative of post-remediation conditions close to the point of loss (DW21), as well as a down-gradient location where benzene levels in the groundwater have fluctuated during the monthly rebound monitoring rounds (DW20).



Plan 51. Location of DW20 and DW21 (post-remediation boreholes)

7.2. Ground Conditions

General ground conditions encountered during the drilling works comprised the following:

- Reworked clay cap (between 0.7-1.7m bgl)*;*
- Margate Chalk Member – Structureless (between 1.7-7.5m bgl); and,
- Margate Chalk Member – Structured (from ~7.5m bgl to base).

7.2.1. Chalk Fracturing

Both boreholes identified fractures within the bedrock geology (Margate Chalk Member), with a summary of the measurements included in Table 7.1, below. However, as with any drilling technique, there is the likelihood of drilling induced fractures, and so results from the downhole geologging probe are considered more representative of in-situ conditions (confirmed in Section 7.3).

An extract from CIRIA 574-Engineering in Chalk guidance(ref 70) supports this:

"The aperture of a discontinuity seen in a drill core is unlikely to represent the in-situ aperture. Discontinuity aperture can only be determined reliable in-situ from trial pits of exposures. In drill core the amount of infill on the discontinuity can be measured, and this is likely to represent a minimum for the in-situ aperture. The only exceptions might be if 100 per cent core recovery has been achieved, there are few fractures and the core pieces of either side fit together."

Fracture spacing refers to the measurements between each logged fracture (minimum / mean / maximum), whilst the aperture spacing measures the thickness of the fracture observed (minimum / mean / maximum).

Table 7.1. Identified Chalk Fracturing Summary

Borehole	Depth *(m bgl)*	Fracture Spacing *(mm)*	Aperture Spacing *(mm)*
DW20	7.50 – 11.50	Closely spaced – (20/100/200)	2/10/30
	11.50 – 20.00	Closely spaced – (50/150/400)	1/5/20
	20.00 – 38.00	Closely spaced – (50/150/500)	1/10/40
	38.00 – 61.00	Medium spaced – (50/200/600)	2/15/30
DW21	7.50 – 9.30	Closely spaced – (50/100/200)	1/5/10
	9.30 – 15.25	Closely spaced – (50/100/250)	2/10/40
	15.25 – 61.00	Medium spaced – (30/300/500)	0/10/40

7.2.2. Headspace Testing

Headspace testing was undertaken to provide an indicative assessment of the contamination levels in each borehole to support the laboratory analysis. Samples were taken at 0.50m intervals and tested for VOCs and mercury vapour.

In total, 240No. headspace tests were completed during the drilling works, with results included on the borehole logs in the factual drilling report(ref 56). Headspace results for VOCs are summarised below, with a comparison made against nearby previously drilled boreholes (pre-remediation).

DW20 (comparison with 'SVE5' and 'H13' boreholes)

- Unsaturated zone (0-18m bgl): all <1ppm in DW20 *(post-remediation),* compared with a maximum of 15.6ppm at 17m bgl in H13 *(pre-remediation).*

- Capillary fringe (18-28m bgl): maximum of 14.8ppm at 28m bgl in DW20 *(post-remediation),* compared to a maximum of 321.2ppm at 25m bgl in H13 *(pre-remediation).*
- Saturated zone (>28m bgl): maximum of 384ppm at 32m bgl in DW20 *(post-remediation),* compared to a maximum of 186.2ppm at 28.5m bgl in H13 *(pre-remediation).* Remaining high headspace readings appear to be an isolated area below the target treatment depth. Concentrations of <5ppm from 39m bgl.

DW21 (comparison with 'H1' and 'H10')

- Unsaturated zone (0-18m bgl): maximum of 69ppm at 17.5m bgl in DW21 *(post-remediation),* compared to a maximum of 657.5ppm at 9m bgl in H1 *(pre-remediation).*
- Capillary fringe (18-28m bgl): maximum of 44.5ppm at 22.5m bgl in DW21 *(post-remediation),* compared to a maximum of 214.6ppm at 21m bgl in H10 *(pre-remediation).*
- Saturated zone (>28m bgl): maximum of 294ppm at 28.5m bgl in DW21 *(post-remediation),* compared to a maximum of 216.2ppm at 28.5m bgl in H1 *(pre-remediation).* Remaining high headspace readings appear to be an isolated area below the target treatment depth. Concentrations of <1.5ppm from 30.5m bgl.

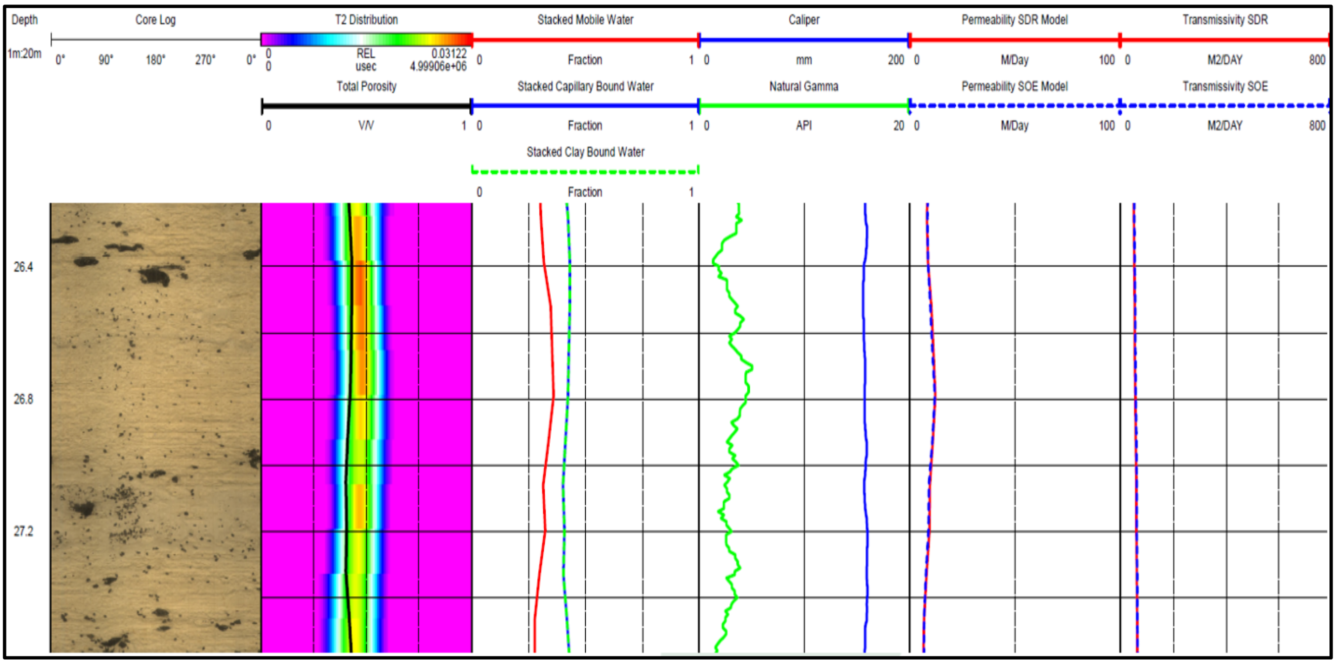
7.3. Geophysical Logging (DW21)

Geophysical logging was carried out by 'Structural Soils Ltd' in borehole DW21 to determine the physical properties of the rock and provide data on the well construction, density, lithology, fractures, permeability, porosity and water quality.

The following geologging tools were used for the assessment:

- Optical Televiewer – to observe any fissures, fractures and caving and also visible signs of trapped product.
- Caliper Sonde – to measure the size and shape of the borehole and aid in measuring any caving features.
- Natural Gamma, Fluid Temperature and Conductivity Sonde – to delineate water bearing zones and identify vertical flow between zones of different hydraulic head.
- NMR Probe – to measure hydrogeological properties: transmissivity, porosity, hydraulic conductivity, pore size distribution, pore mobile water volume, clay-bound water volume and capillary-bound water volume.

A screenshot of the geologging probe output from DW21 is included in Plan 52 overleaf, with the entire sheet included in the factual drilling report(ref 56).



Plan 52. Geologging Output (DW21)

Results from the geologging tools were as follows:

- A total of 107No. partially open / filled fractures were identified between 7.5m and 60m bgl. However, only 8No. infilled fractures with measurable apertures were identified within the saturated zone (between 4.0-11.6mm thickness).
- Temperature generally decreases with depth from 28ºC (7.5m bgl) to 14.41ºC (60m bgl), as expected.
  - Temperature increases were noted between 20.33-22.88m bgl (from 26.24ºC to 29.59ºC), which is due to the previous ISTR works.
  - There was no indication of any additional egress / ingress of water below the water level (recorded as 22.6m bgl during probing).
- Conductivity increased between 25.07m and 26.10m bgl (possibly indicating water ingress; however, not consistent with temperature findings); the optical televiewer shows a single partially open discontinuity at this depth.
- Permeability shows no indication of additional fractured zones, washout zones, or zones of high permeability (only at water level).
  - Permeability at the water level (22.6m bgl) was 11m/day, dropping to between 6.8m/day and 7.8m/day for the remainder.
- Transmissivity increased uniformly with depth in the saturated zone (22.6-60m bgl), as expected with a greater aquifer thickness (no anomalies identified).
- Natural gamma of the chalk is <20 API. Phosphatic chalk is considered to represent a source of contamination and would produce API of up to 140 or more; therefore, chalk seems to be clean and homogeneous throughout with bands of flint.

7.4. Laboratory Analysis

7.4.1. Geotechnical

Five (5No.) soil samples were taken from each borehole to determine the porosity of the soil and strengthen the groundwater model outputs.

Analysis for soil density, water content, particle density and porosity were scheduled at an accredited MCERTS laboratory, with results presented in Table 7.2 below.

Table 7.2. Laboratory Results – Geotechnical

Borehole	Depth *(m bgl)*	Water Content *(%)*	Particle Density *(mg/m^3)*	Total Porosity *(%)*
DW20 *(down-gradient)*	8.60 – 9.00	14.2	2.71	37
	14.60 – 15.10	15.6	2.68	40
	21.20 – 21.80	22.3	2.64	28
	38.50 – 39.00	19.1	2.71	32
	56.50 – 57.00	15.0	2.70	36
DW21 *(point of loss)*	11.90 – 12.50	22.1	2.64	30
	18.50 – 19.00	20.8	2.66	33
	28.00 – 28.60	23.3	2.70	31
	34.50 – 35.30	23.0	2.70	30
	46.90 – 47.50	24.8	2.64	31

Results show that on average, porosity within the soil profile is calculated as 32.8%, which is typical for the chalk matrix.

7.4.2. Environmental

Forty (40No.) soil samples were sent to an accredited MCERTS laboratory for a VOC suite and Fraction Organic Carbon (FOC).

A summary of the key results for benzene and trimethylbenzenes are presented in Table 7.3, overleaf, which have been compared against similar depth results pre-remediation for nearby boreholes:

- DW20 (down-gradient borehole): comparison has been made to 'SVE5' and 'H13'.
- DW21 (POL): comparison has been made to 'H1' and 'H10'.

The full laboratory certificates are included within the factual drilling report(ref 56), which can be found in Appendix I.

Table 7.3. Laboratory Results – Soil (pre-remediation vs post-remediation)

Borehole	Depth (m bgl)	Benzene *(µg/kg)*			1,2,4-trimethylbenzene *(µg/kg)*			1,3,5-trimethylbenzene *(µg/kg)*		
		Before	After	% Reduction	Before	After	% Reduction	Before	After	% Reduction
DW20 *(down-gradient)*	21.3-21.5	3.5	<1	>71	1,500	<1	>99	250	<1	>99
	24.5-24.7	11	<1	>90	2,300	<1	>99	430	<1	>99
	27.3-27.5	370	6	>98	410	1	>99	93	22f	>76
	30.7-31.0	-	24	-	-	9	-	-	96	-
	34.5-34.7	-	3	-	-	<1	-	-	48	-
DW21 *(point of loss)*	8.0-8.2	600	4	>99	80,000	151	>99	11,000	10	>99
	15.7-16.0	110	<1	>99	51,000	194	>99	8,600	26	>99
	21.7-28.0	6.6	<1	>84	640	1	>99	80	<1	>99
	27.7-28.0	-	137	-	-	10	-	-	<1	-
	29.5-29.7	-	133	-	-	<1	-	-	<1	-
	33.0-33.2	-	<1	-	-	<1	-	-	<1	-

7.5. Conclusions

Comparison of laboratory results between pre-remediation and post-remediation boreholes show a significant reduction in organic contamination at depth in the unsaturated zone, confirming successful ISTR.

The highest benzene concentrations remain at depth in the saturated zone (~30-35m bgl), which is below the targeted remediation depth and outside of the capabilities of the propane burners. Furthermore, some contamination remains in the unsaturated zone near the point of loss (DW21), which could be mobilised if groundwater rise with seasonal variation; albeit a much smaller mass now exists post-remediation.

Information obtained from the post-remediation drilling investigation was used in the modelling exercise to predict the future off-site transport of the benzene plume and quantify previous uncertainties (as discussed in Section 9).

8. REBOUND MONITORING

In accordance with the Addendum Remediation Strategy[ref 49], rebound monitoring was required over a minimum period of 12-months to assess benzene concentrations following completion of remediation works in 2022.

Rebound monitoring has been carried out in line with 'Guidance on the Assessment and Monitoring of Natural Attenuation of Contaminants in Groundwater'[ref 67]. Lines of evidence to prove ongoing natural attenuation include the following:

i. A reduction in contaminant mass concentrations;

ii. Field demonstration to obtain site-specific groundwater / aquifer properties; and,

iii. Predictive forward modelling and performance monitoring to confirm the effectiveness of MNA.

All site monitoring data, laboratory certificates and screening spreadsheets produced during the rebound monitoring have been included in Appendix V.

8.1. Groundwater Monitoring Methodology

Monthly groundwater monitoring to assess rebound concentrations has been conducted between January 2023 and November 2024 (23No. months). An additional standalone monitoring round was completed in January 2025 for three (3No.) boreholes: 'DW21' (point of loss), DW19 (down-gradient, on-site) and DW11 (down-gradient, off-site), in the direction of groundwater flow.

Groundwater monitoring has been undertaken within the existing borehole network to maintain consistency with pre-remediation sampling points. Two (2No.) additional boreholes were drilled in June 2024 and incorporated into the borehole monitoring network thereafter (DW20 and DW21).

The groundwater was monitored using low-flow techniques to induce minimal drawdown and provide non-biased groundwater samples with reduced suspended particles. Samples were submitted to an accredited MCERTS laboratory for the following analysis:

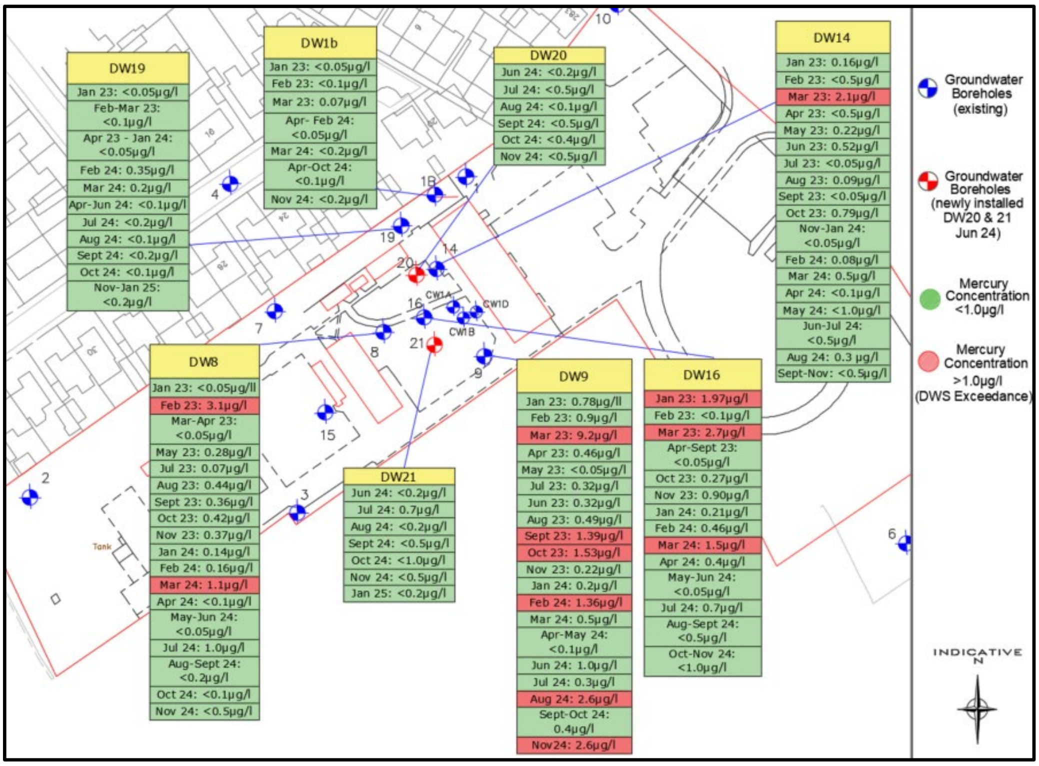
- VOC suite;
- Mercury (dissolved); and,
- Sulphate, sulphide, nitrate and nitrite (on-site source area wells only).

Additional microbial analysis was scheduled in December 2023 to quantify updated half-life calculations following the completion of ISTR. Samples were collected from DW8, DW16 and DW19 when groundwater temperatures had reduced to <37ºC, as detailed in Section 8.4.

8.2. Contaminant Rebound

8.2.1. Mercury Concentrations

The mercury concentrations recorded during the rebound period have been visually depicted in Plan 53, overleaf, to show the spatial distribution in the source area. Results above the DWS of 1.0µg/l have been highlighted in red.



Plan 53. Mercury Concentrations (rebound)

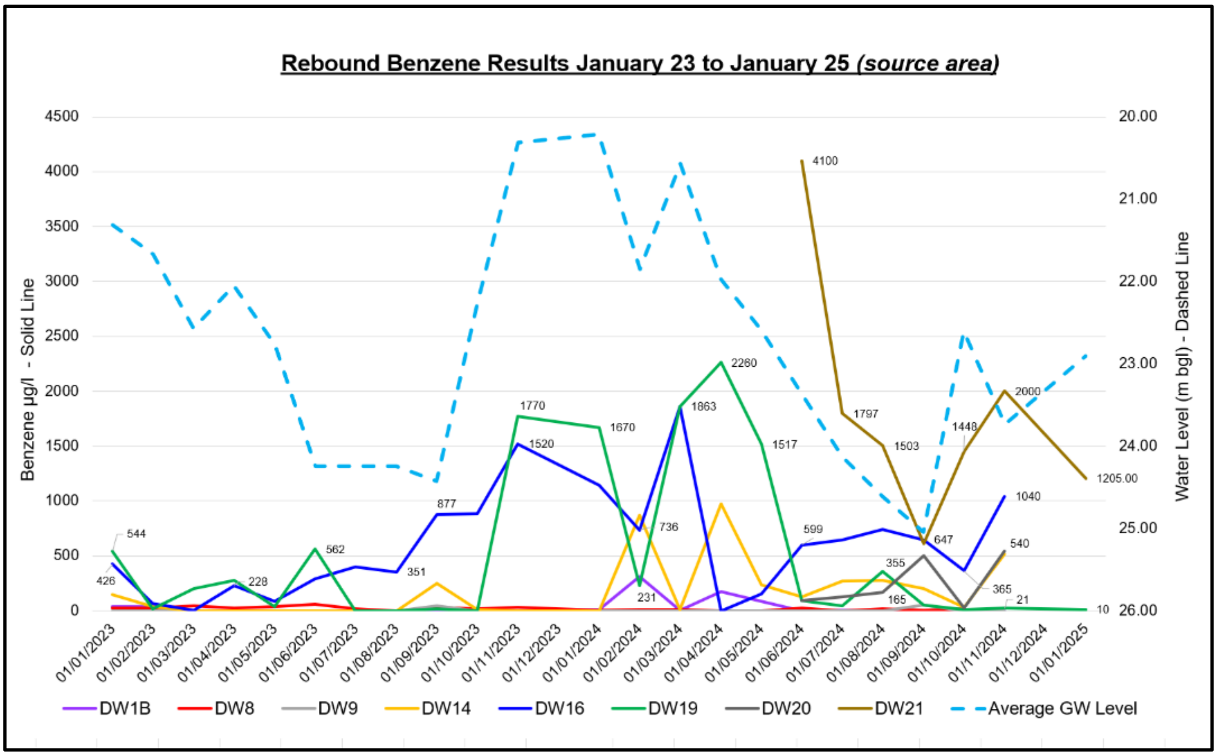
In most cases, mercury concentrations have remained below the DWS of 1.0µg/l, with isolated exceedances recorded occasionally in DW8, DW9, DW14 and DW16 until March 2024. The ISTR unintentionally mobilised residual mercury concentrations beneath the capping layer across the former MPA (despite the boiling point of approximately 356.7ºC). However, calculated mass recovery from extracted mercury vapours confirm that the remediation works has assisted with the reduction of remaining mercury concentrations beneath the former MPA. A total of 44.1kg was calculated to be removed by SVE.

As discussed in Section 6.7, high mercury concentrations were identified in some boreholes, particularly SVE1, SVE2 and SVE3 (headspace results reaching the maximum limit of the Jerome, >0.999mg/m^3). This likely resulted in the increased dissolved mercury concentrations detected in the groundwater; however, conditions in the final eight consecutive months of monitoring (between April-November 2024) have recorded very low concentrations, which are considered to be indicative of stable conditions.

No other exceedances of the mercury DWS was detected in any other borehole on-site / off-site throughout the groundwater rebound monitoring.

8.2.2. Benzene Concentrations

Laboratory results for the main CoC 'benzene' have been plotted in Plan 54, overleaf. Benzene concentrations are presented for all source area boreholes, with the average groundwater level plotted for the same time period with the blue dashed line.



Plan 54. Benzene Concentrations vs Groundwater Level

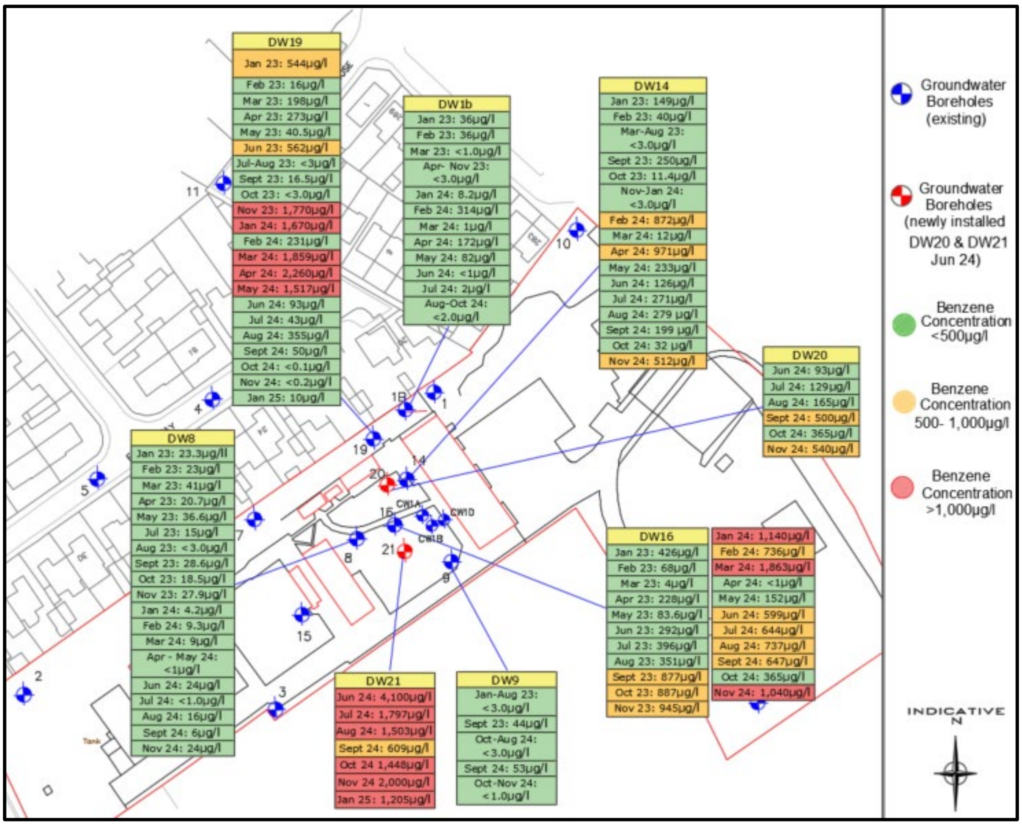
Benzene concentrations mostly correlate well to fluctuations in groundwater levels. The trend is mostly stable / asymptotic when groundwater levels remain below 22m bgl. The highest benzene concentrations were reported when groundwater levels rose between 20-22m bgl, particularly true for DW14, DW16 and DW19.

This is potentially evidence of a small contaminant release from the unsaturated zone at the POL during periods of prolonged rainfall; however, not enough remaining contaminant mass to sustain high concentrations. This supports the post-remediation drilling results in Section 7. The higher concentrations were recorded towards the end of the 12-month rebound period, and so consequently the rebound monitoring period was extended to monitor the relationship between groundwater levels and contaminant rebound.

Benzene concentrations in the on-site, down-gradient boreholes ‘DW19’ and ‘DW1B’, have recorded low benzene concentrations since June 2024 (<500µg/l), which suggests that only limited contamination is potentially being mobilised off-site. However, no VOCs have been detected in any off-site monitoring borehole during the rebound monitoring period.

A peak benzene concentration of 4,100µg/l was recorded in DW21 (near to the POL), which was purged on 17/06/2024 and sampled on 24/06/2024; therefore, it’s possible that conditions had not stabilised following the drilling disturbance and results may not be representative. Benzene concentrations in DW21 in subsequent monitoring rounds have generally fluctuated between 600-2,000µg/l, which is considered to be stable / asymptotic.

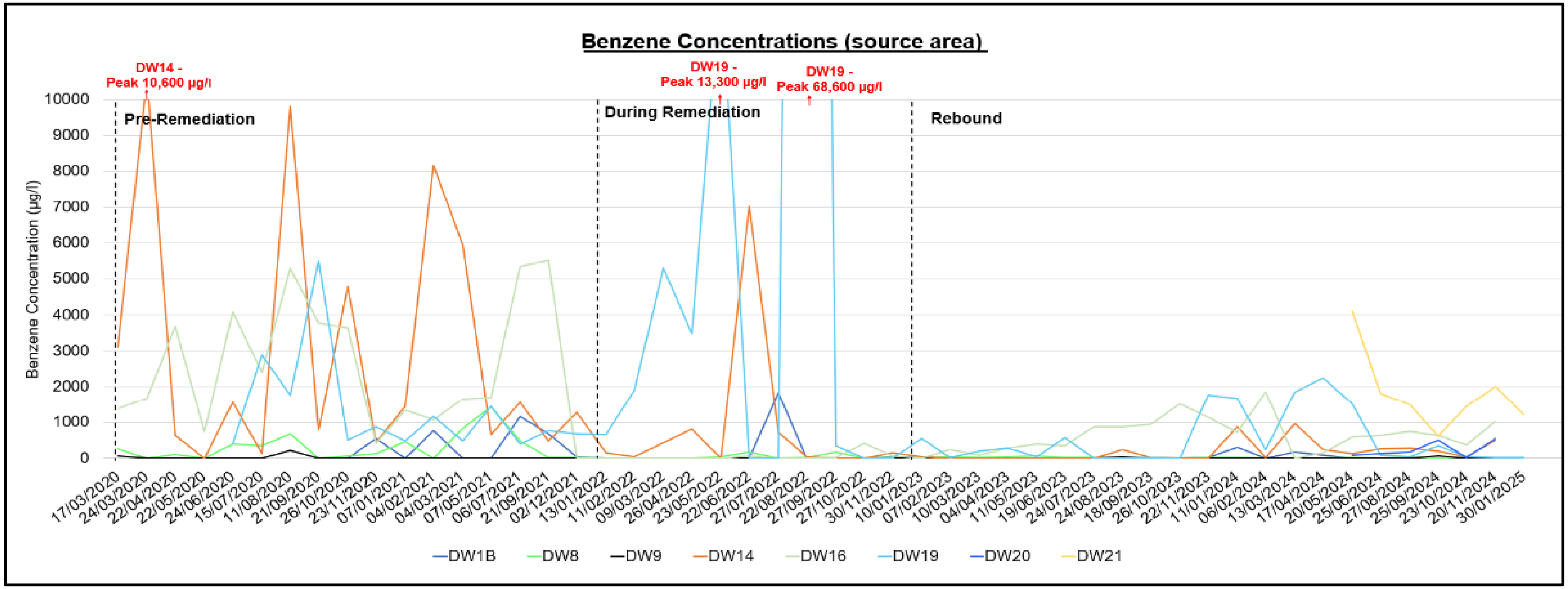
The benzene concentrations recorded during the rebound period have been visually depicted in Plan 55 overleaf, to show the spatial distribution in the source area.



Plan 55. Benzene Concentrations (rebound)

8.2.3. 'Before and after' Benzene Comparison

To further demonstrate declining groundwater trends and asymptotic conditions, an overall comparison between pre-remediation concentrations (2021/2022), during remediation concentrations (2022) and post-remediation concentrations (2023/2025) has been provided in Plan 56, overleaf.



Plan 56. 'Before and after' Benzene Comparison

Aside from a peak concentration of 4,100µg/l recorded in DW21 (June 2024); benzene concentrations have mostly remained steady and at a much lower concentrations throughout rebound monitoring when compared to the pre-remediation baseline assessment. The highest benzene concentrations were recorded when groundwater levels rose into the upper 2.0m of fluctuation zone (between 20-22m bgl); however, were not sustained for a long period of time.

When compared to the previous rebound monitoring following cessation of pump and treat operations in 2019, the original source area boreholes (DW8, DW14 and DW16) recorded benzene concentrations rising from 27µg/l in December 2018 (final round of pump and treat operations), to a maximum of 2,310µg/l in May 2019 (during Thor's 6-month rebound period), and further rising to 5,262µg/l in September 2020 (during Ecologia's baseline groundwater assessment).

Comparison between the baseline CoC concentrations (2020-2021) and rebound concentrations (2023-2025) for VOCs only have been calculated in Table 8.1 overleaf, to show the percentage reductions following completion of Phase 3 and 4 remediation works.

Table 8.1. Reduction in Maximum CoC Concentrations

Contaminant	Maximum CoC Concentrations		Approximate Percentage Reduction
	2020-2021 *(baseline)*	**2023-2025 *(rebound)***	
Benzene	10,600 µg/l	2,260 µg/l*	79%
1,2,4-trimethylbenzene	5,000 µg/l	76.3 µg/l	98%
1,3,5-trimethylbenzene	926 µg/l	14 µg/l	98%
Toluene	5,930 µg/l	44.1 µg/l	99%
The peak benzene concentration of 4,100µg/l reported for DW21 in June 2024 has been excluded from the calculations as it is considered unrepresentative following the recent drilling disturbance.			

The above calculations confirm that significant groundwater improvement has been achieved following the intensive 12-months of ISTR works. A percentage reduction of between 79-99% has been calculated for the key CoC concentrations, which is supported by the mass recovery calculations during remediation (total of 1,368.15kg mass recovered).

8.3. Assessment for Natural Attenuation

During each monitoring round, on-site physico-chemical parameters were recorded for temperature, dissolved oxygen and redox. A summary of the average results recorded for source area boreholes alongside benzene concentrations are presented in Table 8.2, below.

Table 8.2. Benzene & Physico-chemical Parameters (rebound)

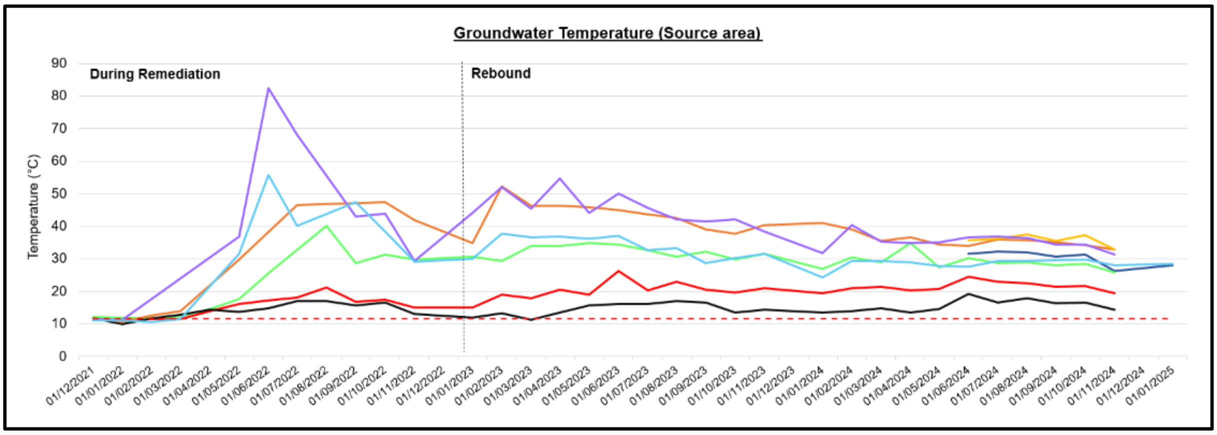
Average of Source Area Boreholes						
Boreholes	**Month**	**Water Level (m bgl)**	**Redox (mV)**	**DO (mg/l)**	**Temp (ºC)**	**Benzene (µg/l)**
DW1B, DW8, DW9, DW14, DW16 & DW19	Jan-23	21.31	-84.93	1.49	27.79	196.38
	Feb-23	21.67	-122.00	0.44	33.94	30.50
	Mar-23	22.57	-67.03	3.89	31.89	40.50
	Apr-23	22.05	-114.23	0.53	34.31	86.95
	May-23	22.77	-135.53	0.34	32.66	26.78
	Jun-23	24.21	-136.57	0.47	34.80	151.78
	Jul-23	24.31	-42.28	3.45	31.87	68.50
	Aug-23	24.09	-131.07	3.10	31.47	58.50
	Sep-23	24.82	-225.57	0.74	29.73	202.68
	Oct-23	22.66	-101.70	1.34	28.87	152.82
	Nov-23	20.31	-118.65	1.12	29.53	552.98
	Jan-24	20.23	-153.33	0.80	27.30	470.40
	Feb-24	21.57	-175.03	0.63	29.07	360.38
	Mar-24	20.57	-135.78	0.57	27.54	624.00
	Apr-24	21.97	-152.47	0.54	28.16	567.17
	May-24	22.59	-140.88	0.61	26.70	77.83
DW1B, DW8, DW9, DW14, DW16, DW19, DW20 & DW21	Jun-24	23.36	-115.75	1.64	28.72	629.38
	Jul-24	24.12	-142.88	0.26	28.42	360.75
	Aug-24	24.55	-149.47	0.18	28.53	381.88
	Sep-24	25.04	-195.70	0.25	27.48	258.00
	Oct-24	22.62	-146.82	0.99	27.55	236.25
	Nov-24	23.71	-165.68	0.49	25.34	517.13
DW21 & DW19	Jan-25	22.91	-150.75	0.20	28.32	607.50
Key: Colour coding system (benzene concentrations): Green: <500 µg/l, Amber: 500-1,000 µg/l, Red: >1,000 µg/l. Colour coding system (water level): Blue: between 20.0-22.0m bgl.						

In most cases, the highest average benzene concentrations (>500µg/l) were recorded when groundwater levels rose into the upper 2m of fluctuation zone, between 20-22m bgl. The highest groundwater levels were recorded over the winter / spring months, between November 2023 and April 2024, with other observations as follows:

- The initial sampling rounds (Jan 2023 and Feb 2023) did not follow this trend; however, benzene concentrations may not have fully stabilised post-remediation works (November 2022); therefore, they may not be representative of rebound conditions.
- The average benzene concentration recorded in June 2024 (629.38µg/l), included the highest recorded result for DW21 (4,100µg/l). As mentioned previously, this borehole likely had not stabilised following the drilling disturbance and is therefore considered an outlier.

8.3.1. Groundwater Temperatures

Since completion of ISTR works in November 2022, groundwater temperatures in the source area have decreased very slowly, as presented in Plan 57 below.



Plan 57. Groundwater Temperatures (source area)

Throughout the rebound monitoring period, groundwater temperatures have remained relatively steady and have not yet returned to baseline levels (11.65ºC in December 2021).

Groundwater temperatures recorded in November 2024 ranged between 14.47ºC and 32.87ºC, with DW20 being the highest (down-gradient, towards northern boundary) and DW9 being the lowest (up-gradient of POL). The standalone monitoring round completed in January 2025 recorded a temperature of 28.5ºC in DW19 and 28.1ºC in DW21 (central boreholes).

Of note, the steam injection boreholes continue to record the highest groundwater temperatures in the source area, as expected. The most recent temperatures recorded were in January 2024, which were 39.6ºC on average. In comparison, the nearby DW monitoring wells (DW14, DW16 and DW19) were on average 32.34ºC in January 2024; therefore, groundwater temperatures across the source area are considered to be decreasing in unison.

Remaining monitoring boreholes (both on-site and off-site) have groundwater temperatures ranging between 11.89ºC (DW2) and 14.46ºC (DW11), as expected with seasonal fluctuations.

8.3.2. Sulphate Reduction

Sulphate reduction utilises sulphate as an electron acceptor. The product of respiration in this case is sulphide, which will normally be present as hydrogen sulphide (H_2S) and/or metal sulphide salts. Groundwater samples were collected from source area boreholes, as well as up-gradient (DW6) and down-gradient (DW11) boreholes for analysis of sulphate, sulphide and nitrates, since 2021.

Sulphate reductions were observed within source area boreholes, whilst remaining steady in the up-gradient and down-gradient boreholes. For instance, average concentrations in DW6 (up-gradient) ranged between 72.9mg/l – 81.9mg/l, and average concentrations in DW11 (down-gradient) ranged between 76.8mg/l – 84.2mg/l.

In contrast, DW16 (central source area), recorded average sulphate concentrations of 65.2mg/l (pre-remediation), 26.0mg/l (during remediation), and predominantly <1.0mg/l (during rebound).

Sulphide concentrations are observed to have an inversely proportional relationship to sulphate concentrations within the source area. Sulphide was mainly recorded at below the laboratory LOD (<5.0mg/l) during pre-remediation and remediation monitoring rounds, where detectable levels of sulphate were present; however, when sulphate had reduced to <1.0mg/l during rebound monitoring, sulphide levels had increased to between 200mg/l and 700mg/l.

These findings indicate that sulphate reduction is occurring in the groundwater beneath the former MPA, and therefore prevailing conditions are favourable for breakdown of residual contamination and ongoing natural attenuation.

8.3.3. Nitrate Reduction

Depletion in nitrate concentrations (the electron acceptor) within the aquifer is an indication that nitrate reduction, or de-nitrification is occurring.

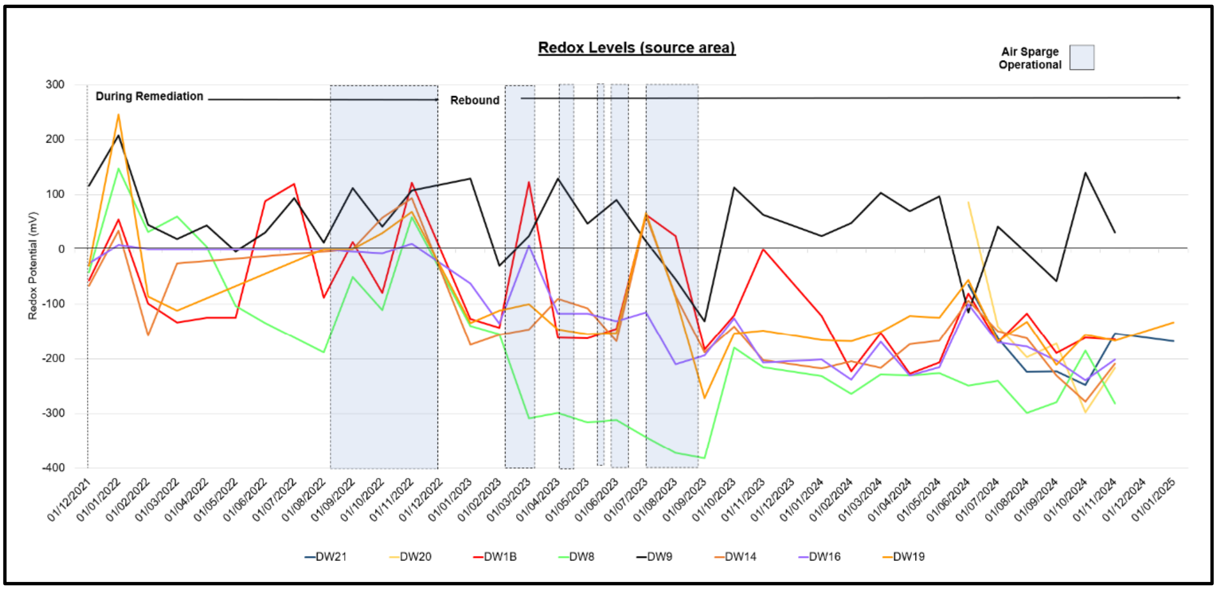
During the monitoring rounds, nitrate concentrations in DW6 (up-gradient borehole) remained stable, with average concentrations ranging between 7.4mg/l – 10.7mg/l. Lower concentrations were recorded in DW11 (down-gradient borehole), with average concentrations increasing from 0.6mg/l during remediation to 3.8mg/l during rebound.

In contract, DW16 (central source area borehole) recorded consistently low nitrate levels, with average concentrations of 0.1mg/l (pre-remediation), 0.4mg/l (during remediation), and 0.1mg/l (during rebound). Therefore, nitrate depletion was observed within the source area, which indicate that nitrate reduction / de-nitrification is occurring in the groundwater beneath the former MPA, and therefore prevailing conditions are favourable for breakdown of residual contamination and ongoing natural attenuation.

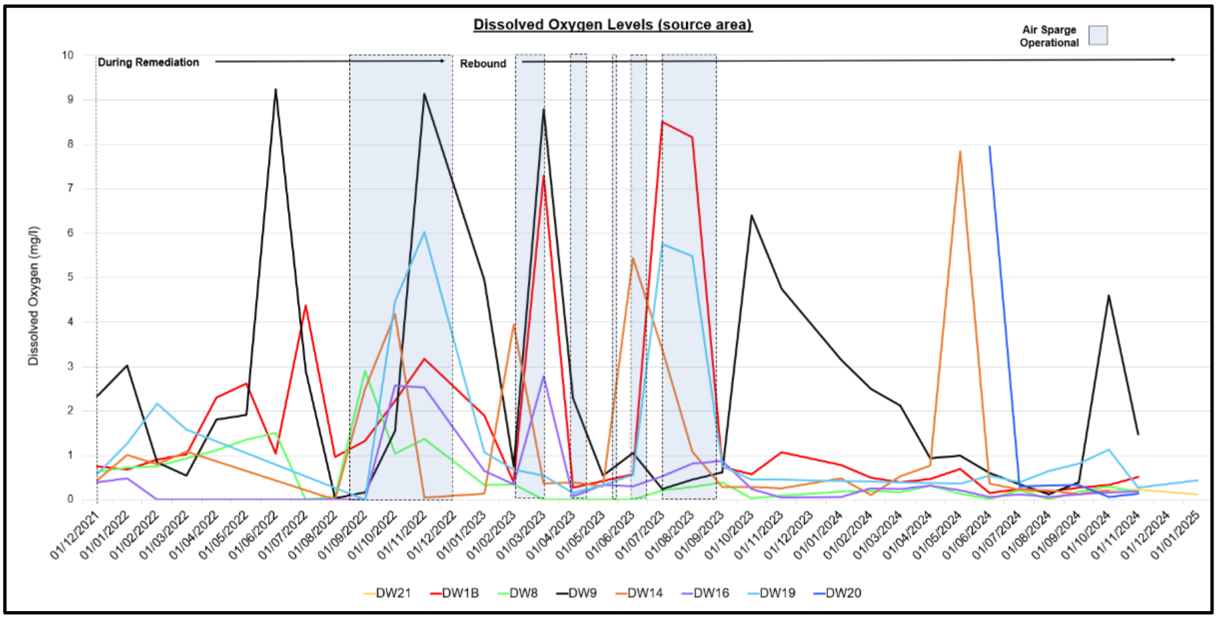
8.3.4. Redox and Dissolved Oxygen (DO) Levels

Redox levels in the groundwater can affect the mobility and continuity of many contaminants. DO levels are an indicator for ongoing aerobic degradation. The correlation between DO and Redox is generally expected to increase / decrease simultaneously with one another.

The redox and DO levels recorded on-site during remediation and during rebound for source area boreholes are presented in Plan 58 and Plan 59, overleaf.



Plan 58. Redox Levels (source area)



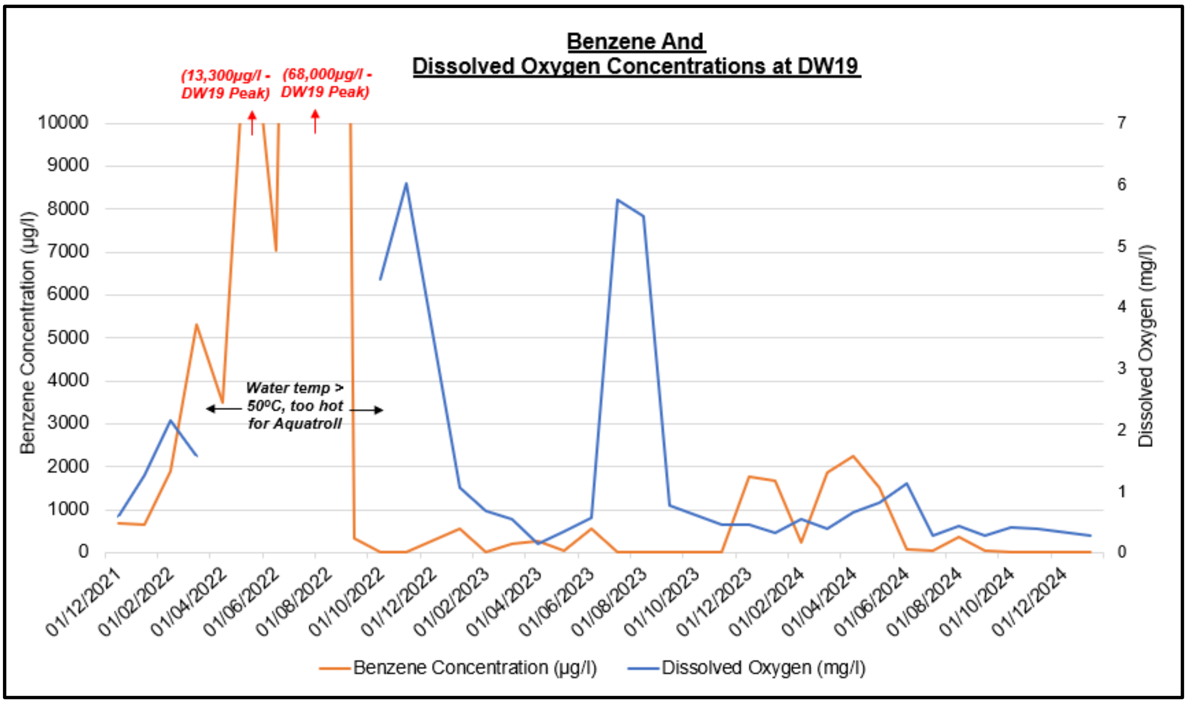
Plan 59. Dissolved Oxygen Levels (source area)

Since February 2024, redox levels in the majority of source area boreholes have remained steady between -100mV to -300mV, except for DW9 which is slightly up-gradient of the POL. Similarly, since October 2023, DO levels for the same boreholes have remained steady between 0-1mg/l, except for a single spike each in DW14 and DW20 to levels of approximately 8.0mg/l.

Prior to this, redox and DO levels fluctuated between operational periods of air sparging, which saw rapid increases initially, as expected, followed by sharp decreases following cessation. This could suggest that microbial activity is degrading organic compounds, including dissolved phase benzene), as discussed below.

8.3.5. Dissolved Oxygen vs Benzene Concentrations

The relationship between benzene and dissolved oxygen has been plotted for DW19 to assess the extent of ongoing bacterial degradation. Results are presented in Plan 60, overleaf.



Plan 60. DO vs Benzene Concentrations

Results indicate that aerobic decay is ongoing in the source area as the oxygen levels recover when the benzene concentrations decrease. This is further supported by the improvement in benzene half-life calculations, discussed in Section 8.5.1.

8.4. Microbial Analysis

8.4.1. SIP Biotraps *(half-life calculations)*

During the rebound monitoring period, SIPs were placed in boreholes DW8, DW11 and DW19 for 6-weeks to calculate benzene degradation rates post-remediation and compare to pre-remediation conditions in 2020.

- 2020 boreholes: DW11, DW16 and DW19.
- 2023 boreholes: DW8, DW11 and DW19. *Borehole DW16 was not suitable for repeat testing due to sustained elevated groundwater temperatures (>37ºC) resulting from the ISTR works.*

Significant improvements have been measured across all boreholes post-remediation works, as presented in Table 8.3, overleaf.

Table 8.3. Half-life Calculations

Benzene Degradation Rates (pre-remediation: 22/09/2020)						
	A_0	A^T	Loss	*-kt*	k^{-day}	λ (day)
DW11	138	147	-9	-0.06318	-0.00158	-438.75
DW16	138	128	10	0.075223	0.00188	368.50
DW19	138	130	8	0.059719	0.00149	464.17
Benzene Degradation Rates (post-remediation: 14/12/2023)						
	A_0	A^T	Loss	*-kt*	k^{-day}	λ (day)
DW8	133	94	-39	0.347054	0.008676	79.87
DW11	133	114	-19	0.154151	0.003854	179.82
DW19	133	108	-25	0.208218	0.005205	133.13
$ln(\frac{(A)t}{(A)0}) = -kt$, *where 'A' refers to the concentration, 'k' is the decay constant, 't' is time and the subscripts 't' and '0' refer to concentrations before SIP was placed into the well.*						

Results of the SIP analysis confirmed a significant improvement in benzene half-lives following remediation works (from approximately 400 days to 79 days), which confirms aerobic decay is ongoing in the source area.

For modelling purposes in Section 9, DW8 is considered to be the most representative of the source area degradation rates as this borehole is a boundary monitoring well and was not subjected to the high groundwater temperatures. For reference, DW8 recorded a maximum temperature of 45ºC during, which has decreased to 31ºC prior to SIP analysis.

8.4.2. ORVI*detect* Analysis *(post-remediation)*

During the rebound monitoring, groundwater samples were scheduled for bacterial gene analysis to assess the anaerobic degradation of benzene within the aquifer (same five targets as 2020 analysis).

Additionally, during the post-remediation monitoring round (2023), samples were scheduled for Universal Bacteria to assess the bacterial abundance, which would be mostly related to the presence of fast-growing aerobic bacteria.

Laboratory results from pre-remediation and post-remediation conditions are compared in Table 8.4, overleaf.

Table 8.4. Benzene Degrading Genes (2020 vs 2023)

		DW6 *(up-gradient)*		**DW19** *(down-gradient, source area)*	
		Pre-remediation (June, 2020)	**Post-remediation (Nov, 2023)**	**Pre-remediation (June, 2020)**	**Post-remediation (Nov, 2023)**
Redox (mV)		475.9	114.0	-88.9	-148.8
Benzene (µg/l)		< 1.0	< 3.0	2,900	1,770
Gene	**Function**	**GU/ml**	**GU/ml**	**GU/ml**	**GU/ml**
abcA	*First step of degradation*	< 2	< 0.31	< 1	< 3
bzdN	*Downstream pathway of benzene degradation: various microbes & mechanisms*	160	< 0.1	6,400	< 3
bcrC		70	4	20	< 3
bamA		44	28	89	720
bamB		< 2	0.1	710	3
Universal Bacteria		Not tested	100,000	Not tested	3,600,000

Overall, DW19 is confirmed as being more active in the process of biodegrading BTEX compounds anaerobically and likely has more favourable conditions for anoxic degradation; which is consistent with on-site physico-chemical parameters. However, the specific genes related to benzene degradation are not all detected (i.e. the abcA gene is important to start the degradation of benzene in anaerobic conditions). Results for universal bacteria were reasonably elevated in both boreholes (3,600,000 GU/ml in DW19 and 100,000 in DW6), which could be an indicator of aerobic degradation.

Results therefore suggest that natural attenuation is ongoing in the source area, coupled with greatly improved half-lives.

9. PREDICTIVE MODELLING (DQRA)

Ecologia appointed an independent consulting company 'H Fraser Consulting Ltd (HFCL)' to review the site-specific data obtained from the rebound monitoring and post-remediation site investigation (DW20 and DW21). The objective was to predict future off-site migration of the benzene plume, quantify any uncertainties in the predictions, and make recommendations regarding further mitigation and/or monitoring.

The full DQRA report is included in Appendix I[(ref 57)], with the input parameters, justifications, model predictions and conclusions summarised in subsequent sections.

9.1. Modelling Approach

Contaminant transport has been modelled using RAM software. Due to the history and complexity of the site, three models representing historic conditions have been developed to ensure consistent parameterisation can be applied to varying historic conditions. Additionally, one forward model has been developed with varying sensitivity analysis. Benzene is the sole contaminant of concern for each model.

1. **2006 plume (pre-remediation):** benzene extent and concentrations recorded in the initial plume used to calibrate the model input parameters.
2. **2020 concentrations (pre-remediation):** using peak benzene concentrations in on-site boreholes (DW8, DW14, DW16 and DW19), compared to an off-site, down-gradient borehole (DW11).
3. **2023 / 2024 concentrations (post-remediation):** using a pulse source model to reflect the release of benzene contamination remaining in the unsaturated zone resulting from groundwater level fluctuations (i.e. in the top 2m of fluctuation between ~20-22m bgl).
4. **Forward predictive model:** looking at the bulk flow off-site in a worst-case scenario, where the groundwater levels remain consistently high leading to contamination below the water table for an extended period.

The following input parameters in Table 9.1 have been used as the basis across all models.

Table 9.1. Model Input Parameters

Parameter	Value	Unit	Source of Information / Justification
Target Concentration	1	µg/l	DWS for benzene
Saturated Aquifer Thickness	50	m	Historic geophysical logging of the chalk on-site indicated flow horizons are present between 17-71m bgl (up to 53m of saturated thickness)
Bulk Density	1,800	g/cm^3	Site data
Effective Porosity of Aquifer	0.22	fraction	Conservative based on site water content data to represent effective porosity (site total porosity is 0.32)
Hydraulic Gradient	0.03	fraction	Site data
Bulk Hydraulic Conductivity	7	m/day	Site data from DW21 geologging
Matrix Hydraulic Conductivity	0.01	m/day	Estimated data
Fraction of Organic Carbon *(in soil)*	0.001	fraction	Site data
Organic Carbon Partition Coefficient	60	l/kg	Calculated from linear partition coefficient

9.1.1. 2006 Plume Model *(pre-remediation)*

The 2006 plume model assumes the following, with additional input parameters included in Table 9.2, below:

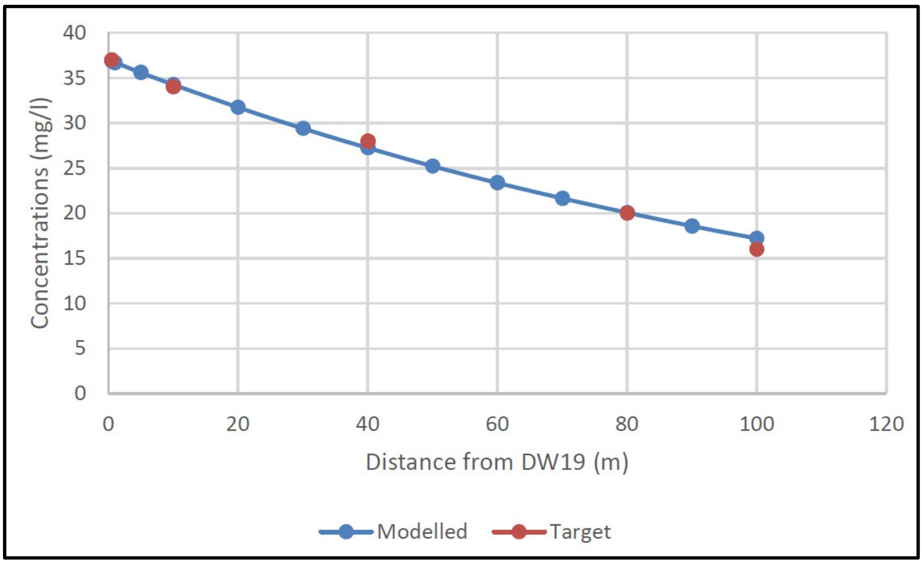
- Constant source of contamination (37,000µg/l);
- Chalk hydraulic conductivity represents bulk flow;
- No dilution in groundwater as source thickness assumed to equal mixing depth; and,
- Source located at site boundary; downstream of the actual point of loss, but high benzene concentrations developed overtime up to this point.

Table 9.2. 2006 Model Input Parameters

Parameter	Value	Unit	Source of Information / Justification
Benzene Concentration in Groundwater	37,000	µg/l	Average benzene concentrations at DW8, DW14 and DW16 prior to remediation
Bulk Hydraulic Conductivity	2	m/day	Calibrated value
Half-life	465	days	Site-specific data for DW19 from 2020 (longest half-life to represent conditions pre-remediation)

To ensure accurate predictions, the bulk hydraulic conductivity was inputted using a calibrated value of 2m/day instead of the on-site measured value of 7m/day (geophysical logging in DW21).

As shown in Plan 61 below, the 2006 plume model concentrations compare well to the target plume concentrations (actual data taken from Ecologia 'Verification Report Phase 1 Works'[ref 46]). This therefore suggests that a lower bulk hydraulic conductivity is more appropriate for off-site transport as increased travel time gives more opportunity for degradation.



Plan 61. Model Results, 2006 Plume Concentrations *(Source: HFCL)*

9.1.2. 2020 Model *(pre-remediation)*

The 2020 model looks at possible fissure flow prior to remediation works, with assumptions included below:

- Dilution only, as short-lived high concentration at DW11 resulting from fissure flow;

- Fissure aperture estimated as 0.1mm; conservative assumption as dilution increases with aperture size; and,
- Contaminant flux estimated from flow through matrix thickness that represents the fracture spacing in the source zone (on-site measurements from borehole logs of DW20 and DW21).

Table 9.3 below details the additional input parameters used in the model alongside the model predictions.

Table 9.3. 2020 Model Input Parameters & Predictions

Parameter	Value	Unit	Source of Information / Justification	Model Output	Unit	Justification
Groundwater Concentration	2,230	µg/l	Average of DW8, DW14, DW16 and DW19 *(April & May 2020)*			
DW11 Concentration	356	µg/l	Maximum concentration in DW11 *(May 2020)*			0.00000986
Contaminant Flux	6.94E-09	m^3/s	Estimated for matrix flow through estimated fracture spacing of 2m			
Dilution Flux (fissures)	2.45E-08	m^3/s	Calculated assuming fissure aperture of 0.1mm	492	µg/l	Concentration diluted in fissure
Dilution Factor (fissures)	0.221	-	Calculated			
Dilution Flux (fractures)	1.57E-03	m^3/s	Calculated assuming fracture spacing of 4mm	0.00986	µg/l	Concentration diluted in fracture
Dilution Factor (fractures)	4.43E-06	-	Calculated			

The model shows that the maximum benzene concentration recorded in DW11 (356 µg/l in May 2020), can be accurately modelled by applying a dilution factor associated with a fissure flow of 0.1mm aperture. In comparison, when using a dilution factor associated with a wider fracture network (aperture of 4mm), dilution predictions are significantly higher and do not correlate well with actual concentrations recorded in DW11.

This therefore suggests that any remaining benzene contamination entering the fracture network will be highly diluted, negating risks to off-site receptors.

9.1.3. 2023 / 2024 Pulse Source Model *(post-remediation)*

The 2023 / 2024 pulse source model looks at the current day contaminant transport post-remediation works. A pulse source has been used to reflect the fluctuations in groundwater levels mobilising contaminants remaining in the unsaturated zone.

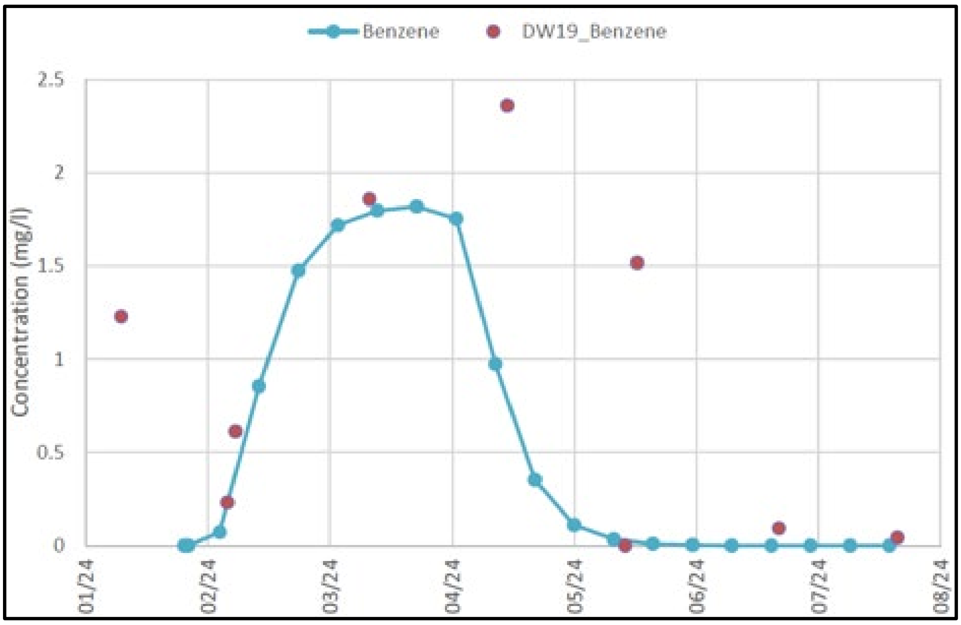
The following assumptions are made, with additional input parameters included in Table 9.4:

- Remaining contamination zones are being intercepted as groundwater levels rise and fall (assumed to occur in top 2m of groundwater level fluctuations);
- Chalk hydraulic conductivity represents bulk flow (value of 7m/day taken from on-site geologging measurement in DW21); and,
- Duration of pulse estimated from groundwater levels and period of observed higher benzene concentrations (estimated to be 60-days).

Table 9.4. 2023 / 2024 Pulse Model Input Parameters

Parameter	Value	Unit	Source of Information / Justification
Groundwater Concentration	4,100	µg/l	Maximum concentration in DW21 *(June 2024)*
Plume width perpendicular to source	7	m	Site specific measurement
Plume length perpendicular to source	20	m	Site specific measurement
Plume thickness at source	2	m	Estimated thickness in unsaturated zone
Half-life	79	days	Site-specific data post-remediation (DW8)
Distance to Compliance Point (CP)	15	m	Distance from mid-point of site to DW19
Pulse Duration	60	days	Estimated duration of groundwater level rise across source zone

As can be seen in Plan 62, the output predictions of the pulse source model corelate well to concentrations observed on-site. Results have been modelled for borehole 'DW19', which predict that benzene concentrations decline after the 60-day pulse release.



Plan 62. Model Results – 2023 / 2024 Pulse Source *(Source: HFCL)*

The pulse source model predicts a peak benzene concentration of 0.055mg/l (55µg/l) in DW11 after 5-months, with the laboratory LOD being exceeded after 2-months. However, laboratory results from the on-site testing in DW11 has been below the laboratory LOD since February 2022, which indicates that the model is over-estimating benzene concentrations.

If a calibrated bulk hydraulic conductivity value of 2m/day is used instead, the model predicts concentrations marginally above the laboratory LOD between 9 and 15-months (maximum of 0.0016mg/l [1.6µg/l]), which is more in line with on-site findings. Therefore, these results also support the assumption that a lower bulk hydraulic conductivity is more appropriate for predicting off-site transport.

9.1.4. Forward Predictive Model *(declining source)*

The forward predictive model has been set up with the following assumptions listed below (base case) and presented in Table 9.5, overleaf:

- Groundwater levels remain high so remaining contamination in the current unsaturated zone is below the water table;

- Declining source term of remaining mass;
- Hydraulic conductivity represents bulk flow (7m/day from geologging results); and,
- Soil concentrations back-calculated from groundwater concentrations and source volume.

Table 9.5. Forward Predictive Model Input Parameters

Parameter	Value	Unit	Source of Information / Justification
Groundwater Concentration	880	µg/l	Average of DW14, DW16, DW19, DW20 & DW21 *(highest readings between April and July 2024)*
Plume width perpendicular to source	7	m	Site specific measurement
Plume length perpendicular to source	20	m	Site specific measurement
Plume thickness at source	2	m	Estimated thickness of source in unsaturated zone
Equivalent soil concentrations	0.16	mg/kg	Back - calculated from average groundwater concentration *(compares well to soil concentrations at DW21: ~135 µg/l of benzene)*
Half-life	79	days	Site-specific data post-remediation (DW8)
Mixing depth for dilution	7	m	Estimated from site data
Mixing depth for dilution	0.1 of travel distance	m	Calculated
Distance from CP	50	m	From point of loss (POL)
	120		Distance to off-site borehole (from POL to DW11)

In order to generate reliable prediction models, five different sensitivity runs have been produced in addition to the base case, which is most representative of current site conditions.

The main differences between the base case model and sensitivity analysis are as follows:

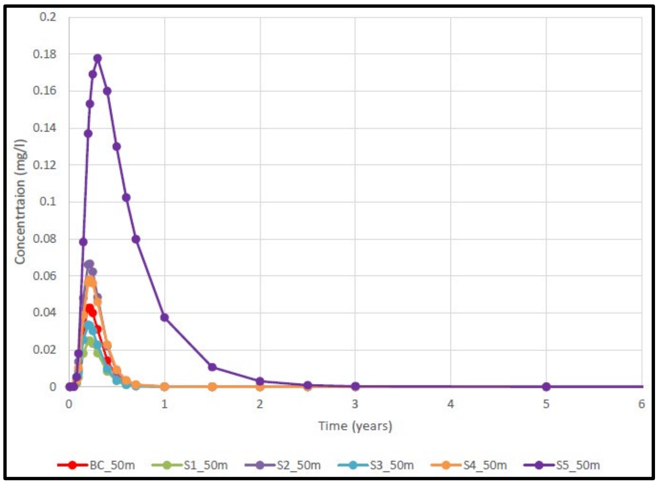
- Base case model uses the average of the recent maximum groundwater concentrations (880µg/l), whereas Sensitivity 5 uses only the maximum concentration from DW21 (4,100µg/l) to back-calculate the soil concentration;
- Base case model assumes concentrations are contained in a 2m thickness at the top of the groundwater table, whereas Sensitivity 5 doubles the thickness to 4m to represent an increase in water levels above the observed range; and,
- Base case model uses a half-life of 79 days, whereas Sensitivity 5 uses a half-life of 150 days to demonstrate the impact of aerobic and anaerobic decay.

The different sensitivity values have been tabulated alongside base case values in Table 9.6, overleaf.

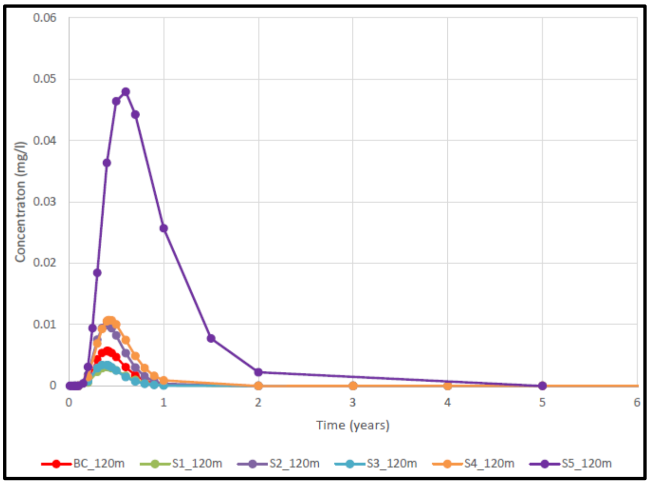
Table 9.6. Forward Predictive Model Input Parameters

Parameter	Value	Unit	Base Case	Sensitivity Value	Justification
Sensitivity 1	Plume thickness	m	2	1	Groundwater fluctuations between saturated and unsaturated zones
Sensitivity 2		m	2	4	
Sensitivity 3	Half-life	days	79	50	Site data – demonstrates impact of anaerobic and aerobic degradation
Sensitivity 4		days	79	150	
Sensitivity 5 (*worst case*)	Plume thickness at source	m	2	4	Groundwater fluctuations between saturated and unsaturated zones
	Half-life	days	79	150	Site data – combined anaerobic and aerobic degradation
	Equivalent soil concentrations	mg/kg	0.16	0.74	Back-calculated from maximum benzene concentration of 4,100µg/l *(June 2024)*
	Initial soil inventory	kg	0.08	0.75	Calculated from equivalent soil concentration and source thickness

Results of the forward predictive modelling at each compliant point (50m and 120m) are depicted in Plans 63 and 64, below.



Plan 63. Predicted Concentrations at 50m *(Source: HFCL)*



Plan 64. Predicted Concentrations at 120m *(Source: HFCL)*

The base case model in Plan 63 predicts a peak concentration of 0.045mg/l (45µg/l) at 50m, falling to below the DWS after 215 days (6 months), and a peak concentration of 0.006mg/l (6µg/l) at 120m (Plan 64), falling to below the DWS after 213 days (6 months).

In the worst-case scenario, Sensitivity 5 predicts a peak concentration of 0.178mg/l (178µg/l) at 50m (from the POL), which falls below the DWS after 865 days (2.5 years), and a peak concentration of 0.048mg/l (48µg/l) at 120m (from POL), falling below the DWS after 783 days (2.1 years). This scenario uses a source zone mass nine times higher than that of the base case.

This is a conservative model assuming high groundwater levels, a declining source and bulk hydraulic conductivity of 7m/day. When using a bulk hydraulic conductivity of 2m/day, travel time is increased, and concentrations are lower (increased degradation).

The calculated time benzene concentrations remain above the DWS at each compliance point is presented in Table 9.7, overleaf.

Table 9.7. Predictive Forward Modelling Results

Parameter	Value	Unit	Base Case	Sensitivity Value	Receptor	Model Peak Conc. (mg/l)	Time above DWS (days)
Sensitivity 1	Plume thickness at source	m	2	1	Site boundary (50m)	0.025	195
					Off-site borehole (120m)	0.003	168
Sensitivity 2		m	2	4	Site boundary (50m)	0.067	231
					Off-site borehole (120m)	0.010	249
Sensitivity 3	Half-life	days	79	50	Site boundary (50m)	0.034	199
					Off-site borehole (120m)	0.003	163
Sensitivity 4		days	79	150	Site boundary (50m)	0.058	237
					Off-site borehole (120m)	0.011	290
Sensitivity 5 (*worst case*)	Plume thickness	m	2	4	Site boundary (50m)	0.178	865
	Half-life	days	79	150			
	Equivalent soil concentrations	mg/kg	0.16	0.74	Site boundary (120m)	0.048	783
	Initial soil inventory	kg	0.08	0.75			

9.2. Modelling Conclusions

Following a review of the site data post-remediation, some benzene contamination remains in the zone of water table fluctuation, albeit at a much smaller mass compared with pre-remediation baseline conditions.

The modelling indicates that the observed rebound of benzene concentrations in groundwater can be explained by benzene in the unsaturated zone becoming mobilised as groundwater levels rise into the top 2m of seasonal fluctuations (pulse release lasting 60-days). Additionally, the comparison between dissolved oxygen and benzene (Section 8.3.5) indicate that natural attenuation is ongoing, combined with greatly improved benzene half-lives (from ~400 days pre-remediation to 79 days post-remediation).

The 2023 / 2024 pulse source model (Section 9.1.3) best mimics the observed site concentrations and indicates that off-site transport of benzene is not likely to be significant, due to decay of benzene along the travel path. Using a bulk hydraulic conductivity of 2m/day is a more realistic measurement and demonstrates that the site does not pose a risk to off-site receptors.

The predictive models (Section 9.1.4) are more conservative than the current model but also demonstrate that the modelled groundwater concentrations predict no significant impact at a conservative 50m compliance point, at a 30-year timescale. Based on model, using worst case conditions, in approximately 2.5 years' time benzene concentrations are below the DWS of 1µg/l.

Consequently, no recommendations were made for further mitigation and / or monitoring.

10. CONCEPTUAL SITE MODEL (POST-REMEDIATION)

Following completion of ISTR, rebound monitoring and modelling, the CSM has been updated in accordance with best practice risk assessment methodology, outlined in the guidance for LCRM (EA, 2023)(ref 63).

The risk assessment process is underpinned by the concept of establishing whether a contaminant linkage exists between a source and a sensitive receptor. For a potential risk to be realised all three components must be identified and a contaminant linkage established. The risk assessment process aims to establish whether unacceptable risks exist and, if so, what further action needs to be taken in relation to the site.

10.1. Previously Identified Contaminant Linkages

The previously identified contaminant linkages (CL) are summarised below:

1. Shallow soil contamination (leachable inorganic mercury) around the former MPA, north of the warehouse (Area 1) and south of the warehouse (Area 2).
2. Spill point in the former MPA, east of DW8, contaminated with benzene, toluene and trimethylbenzenes beneath the clay cap to the full depth of the unsaturated zone (between 5-15m bgl).
3. Groundwater within the Principal Chalk Aquifer beneath the former MPA and down-gradient, contaminated with benzene, toluene and trimethylbenzenes.

The remediation techniques selected to control the unacceptable risks are summarised below:

- **Human Health (Phase 4):**
    - Soil excavation and disposal at a licensed waste facility, and provision of a cover system (clay cap) to minimise rainfall infiltration induced leaching (CL1).
- **Controlled Waters (Phase 3 and Phase 4):**
    - In-situ thermal heating and soil vapour extraction within the unsaturated zone (CL2).
    - Combination of in-situ thermal heating, soil vapour extraction, dual phase extraction, steam injection and air sparging in the saturated zone (CL3).

10.2. Remaining Contaminant Linkages

Previously identified contaminant linkages have been excavated and / or treated using in-situ thermal remediation. Results of the ISTR works (Phase 3 and 4) have been validated in this report, including an overview of remediation works carried out, results of the mass recovery and comparison of concentrations post-remediation and rebound monitoring.

Hotspot excavation works for Areas 1 and 2 (Phase 4) were completed in May 2021 have been validated using previously derived Remedial Target Values (RTV's) protective of a commercial end use and the Principal Aquifer, using the CLEA model(ref 62).

The remaining contaminant linkages / source pathway receptor linkages are presented in Table 10.1, overleaf.

Table 10.1. Updated CSM & Risk Assessment

Potential Onsite Sources	Potential Receptor	Possible Pathway	Probability		Consequence		Risk
Shallow soil contamination	Future Site Users On-site workers	Direct contact / ingestion and / or dust inhalation	Low Likelihood	Several phases of previous site investigation had identified the majority of shallow soil contamination to be confined to the former MPA (mercury and VOCs) as well as some hotspots to the east of the warehouse (lead). These areas have been remediated via excavation works and installation of an impermeable cap to break the dermal contact pathway with human health. The majority of the site is therefore suitable for a commercial land use; however, some areas could be allocated as residential land upon further assessment / view of development plans. Additionally, some former operational areas have not been fully decommissioned (for instance the water catchment pit, concrete base of the former R&D warehouse and remaining buildings around the former MPA). Although some investigation has been undertaken beneath the base of the warehouse and workshop (no exceedances of commercial RTVs), there remains the potential for localised contamination following demolition. Therefore, awareness of residual contamination needs to be considered in the site file for future redevelopment works and site-specific risk assessments for PPE and controls (e.g. vapour).	Medium	Potential for chronic damage to Human Health.	Moderate / Low
		Inhalation / direct contact with dusts that have blown off-site					
	Groundwater (Principal Aquifer)	Vertical soil leaching	Unlikely	Previous excavation works across the former MPA have been successful in removing the bulk contamination and an impermeable cap has been installed, which is managing the risk from rainfall induced leachate to the underlying Principal Aquifer. If any earthworks are proposed which would damage the cap, additional assessment is required. Advisory recommendation for this area of the site to be developed as an area of Public Open Space (POS) or parking to avoid breaking through the capping layer.	Medium	Short term risk of pollution of sensitive water resources (Secondary Undifferentiated Aquifer).	Low

Potential Onsite Sources	Potential Receptor	Possible Pathway	Probability		Consequence		Risk
Point of loss (east of DW8)	Groundwater (Principal Aquifer)	Vertical soil leaching Transport through fissures / fractures in the Chalk	Unlikely	Previous contamination comprised of mono-aromatic hydrocarbons beneath the clay cap to the full depth of the unsaturated zone at the POL. Following completion of remediation works, a total of 1,368.15kg of contaminant mass was recovered from beneath the former MPA. Additional drilling (post-remediation) confirmed a significant reduction in benzene and trimethylbenzenes in the unsaturated zone (>99%). Therefore, most of the POL source has been successfully removed. The highest benzene concentrations remain at depth in the saturated zone (~30-35m bgl), which is below the targeted remediation depth. Rebound monitoring has found potential evidence of a small contaminant release from the unsaturated zone at the POL during periods of prolonged rainfall; however, not enough remaining contaminant mass to sustain high concentrations. The predictive models show that, even when using worst case conditions, in approximately 2.5 years' time benzene concentrations are below the DWS of 1µg/l at a conservative 50m compliance point, at a 30-year timescale.	Medium	Short term risk of pollution of sensitive water resources (Secondary Undifferentiated Aquifer).	Low

11. CONCLUSIONS

Ecologia was instructed by Thor Group Ltd. to complete additional remediation works to support the surrender of the Environmental Permit (EPR/BV3898IR), whilst ensuring the site is suitable for re-development as a commercial site and risks to controlled waters are minimised.

Additional remediation works were required as concerns were raised by the EA that rebound monitoring, following the cessation of pump and treat operations in 2019, identified fluctuating benzene concentrations between 100µg/l and 5,400µg/l, with a general increasing trend over time. Therefore, additional soil and groundwater baseline assessments were carried out by Ecologia in 2020 and 2021 to assess benzene concentrations on-site and off-site.

Results of the baseline assessments found that benzene concentrations had increased to a peak of 10,600µg/l in the source area (DW14) and were found to extend to a monitoring borehole approximately 80m from the site boundary (356µg/l in DW11). Additionally, the point of loss was confirmed to be east of DW8, which detected high concentrations of VOCs (benzene and trimethylbenzenes) in the unsaturated soil requiring treatment.

The recommendations were set out in an Addendum Remediation Strategy(ref 49), which included two additional phases of works to mitigate remaining soil and groundwater contamination risks:

- Phase 3: groundwater remediation across the former MPA to minimise risks to controlled waters, including a combination of in-situ thermal heating, SVE, DPE, SI and AS in the saturated zone. *During the baseline assessment, groundwater conditions underlying the former MPA were predominantly anaerobic with benzene degradation half-lives calculated to be 417 days. Therefore, MNA was not a viable option.*
- Phase 4: soil remediation to mitigate human health risks, including source removal of mercury contaminated soils from identified hotspots, and in-situ remediation of benzene contaminated soils within the unsaturated zone close to the original POL.

11.1. Summary of Remediation Works (Phase 3 & 4)

Ex-situ remediation works (Phase 4) to remove the mercury hotpots (Area 1 and Area 2) were completed in May 2021. A total of 230.64 tonnes of contaminated soils were removed and a low-permeability cap was installed across both areas to minimise the potential for future infiltration from any residual contamination. Additional detail is provided in Section 5.

In-situ remediation works (Phase 3 and Phase 4) were carried out between December 2021 and December 2022 under an Environmental Deployment (Ref: ZP3595HA/W0025). The system was operated in a staged approach:

1. *DPE* to lower the groundwater table and extract VOCs.
2. *TCH* to raise soil temperatures within the unsaturated soils at the POL and capillary fringe to volatilise VOCs for recovery.
3. *SVE* to capture and treat VOCs in the unsaturated soils.
4. *SI* to raise groundwater temperatures and mobilise dissolved phase contamination.
5. *AS* to provide oxygenation to enhance residual degradation of VOCs.

Extensive monitoring and laboratory analysis was carried out during system operation to ensure optimum performance and provide the necessary lines of evidence for treatment cessation. The following key performances are summarised in Table 11.1 overleaf, with additional detail provided in Section 6.

Table 11.1. In-situ Remediation Key Performances

Key Performances: In-situ Remediation (Phase 3 & Phase 4)	
Heating Operations (TCH and SI)	Lowering of the groundwater level by approximately 4.5m to allow successful heating of the capillary fringe (between 18-26m bgl). Additional detail in Section 6.4. Average groundwater temperatures across the former MPA reached 82.29ºC on 28/07/2022. The highest groundwater temperature was recorded around SI2 (101.7ºC) and was observed to spread towards the northern half of the site where benzene contamination was most prevalent in the groundwater. Additional detail in Section 6.5. TCH achieved the target temperature of ≥80ºC at most depths using shallow burners at the POL (installed at 9m bgl) and deeper burners across the remaining area (installed at 21.5m bgl), resulting in successful volatilisation of VOCs. Additional detail in Section 6.6.
SVE	High VOC concentrations were successfully recovered from across the former MPA, with particularly high concentrations recovered from the POL. Headspace testing at the POL reached the maximum limit of the PID (>5,000ppm) at the end of May 2022, as a result of heating operations. VOCs continued to remain on average between 1,000-2,500ppm throughout June and July 2022, with a significant decrease noted from August 2022 (suggesting successful removal of gross contamination). SVE from the deeper wells was mostly observed between May and August 2022, where PID concentrations were between 300-500ppm in the central wells. Only slightly elevated PID concentrations (<50ppm) were recorded in the down-gradient DPE wells; however, this area was treated by steam injection to mobilise dissolved phase contamination in the groundwater. Unexpectedly high mercury concentrations were mobilised in some boreholes, particularly SVE1, SVE2 and SVE3, with headspace testing reaching the maximum limit of the Jerome (>0.999 mg/m^3). Therefore, the CATOX could not be used to treat the off-gases highly laden with VOCs as originally planned. Additional detail in Section 6.7.
Contamination Reduction (Soils)	Extracted benzene concentrations steadily rose from the start of remediation works until a peak in May 2022 (11,000µg/m^3), which corresponds well with headspace testing during the same time period (5,000ppm). Following completion of heating operations, benzene concentrations gradually decreased as the gross contamination was successfully removed. Extracted trimethylbenzene concentrations steadily rose from March 2022, which coincided with the start of TCH operations. A peak concentration of 130,000µg/m^3 was reached for 1,2,4-trimethylbenzene, and a peak of 31,000µg/m^3 was reached for 1,3,5-trimethylbenzene; both recorded at the end of SI works. Concentrations then gradually decreased as the gross contamination was successfully removed. Extracted mercury vapours increased steadily until reaching a peak of 21.3mg/m^3 in October 2022, which then decreased in the final November monitoring round. Additional detail in Section 6.9.
Contamination Reduction (Groundwater)	Highest benzene concentrations were recovered from boreholes in the central and northern half of the site (DPE3, DPE5, DPE6 and DPE7), with a peak concentration of 22,600µg/l recorded in DPE6. There is evidence to suggest that increases in groundwater temperatures led to decreases in VOC concentrations, indicating that VOCs were successfully mobilised and extracted. The existing borehole network (DW wells) was monitored throughout remediation works, which recorded a peak benzene concentration of 68,700µg/l in DW19 on 22/08/2022, which coincided with the highest report of 1,2,4-trimethylbenzene (peak of 17,900µg/l in the same sample). No benzene was detected in the off-site monitoring wells during remediation, except for very low levels in DW11 during the first two months of operation (<10µg/l). Results indicate successful containment of the benzene plume and hydraulic control. Most mercury results were below DWS throughout operations, except for isolated exceedances in DW9 and DW16. No other exceedances were recorded on-site / off-site. Additional detail in Section 6.10.
Treatment Cessation	Treatment cessation was therefore determined after the 12-months operation period: • Source area benzene reduction of >99% when compared to the maximum concentrations recorded during baseline monitoring (2020/2021). Consistently low benzene concentrations recorded for final three rounds of remediation monitoring between September-November 2022 (<500µg/l).

Key Performances: In-situ Remediation (Phase 3 & Phase 4)	
	• Mass recovery from both groundwater and vapour extraction was calculated to be 1,323.59kg, which significantly exceeded the initial calculations by 114% (previous estimation of 619.09kg). The above ground remediation equipment was decommissioned in July 2024, with remaining equipment (i.e. borehole installations) anticipated to be decommissioned in 2025, following the outcome of permit surrender. Ecologia intend to decommission all redundant boreholes in line with industry and Environment Agency guidance(ref 69).

11.2. Post-Remediation Soil Investigation

Post-remediation drilling in June 2024 (DW20 and DW21) confirmed a significant reduction in organic contamination at depth in the unsaturated zone (>99%), indicating successful remediation and achievement of the objectives.

The highest benzene concentrations remain at depth in the saturated zone (~30-35m bgl), which is below the targeted remediation depth. Furthermore, some limited contamination remains in the unsaturated zone near the point of loss (DW21), which could be mobilised if groundwater rise with seasonal variation; albeit a much smaller mass now exists post-remediation.

11.3. Rebound & Predictive Modelling

Rebound monitoring was carried out between January 2023 and January 2025 (24No. rounds). The following key findings are concluded with additional detail in Section 8:

- Mercury concentrations mostly remained below the DWS (1.0µg/l), with isolated exceedances recorded in DW8, DW9, DW14 and DW16 (former MPA). The ISTR unintentionally mobilised residual mercury concentrations beneath the capping layer. However, mass recovery calculations confirm that a total of 44.1kg of mercury was extracted during remediation works, which reduced the remaining contamination mass. Groundwater conditions since April 2024 have been below the DWS, indicative of stable conditions.

- Benzene concentrations mostly correlate to fluctuations in groundwater levels. The trend is mostly stable / asymptotic when groundwater levels remain below 22m bgl. When groundwater levels rise between 20-22m bgl, higher concentrations are present in DW14, DW16 and DW19 (former MPA); however, much lower than baseline concentrations. This is potentially evidence of a small contaminant release from the unsaturated zone at the POL during periods of prolonged rainfall; however, there is not enough remaining contaminant mass to sustain high concentrations.

- The on-site, down-gradient boreholes ‘DW19’ and ‘DW1B’, have recorded low benzene concentrations since June 2024 (<500µg/l), which suggests that only limited contamination is potentially being mobilised off-site. However, no VOCs have been detected in any off-site monitoring borehole during the rebound monitoring period.

- The peak benzene concentration of 4,100µg/l was recorded in DW21 (near to the POL), soon after installation, which was likely not representative of stable conditions following the drilling disturbance. Benzene in DW21 generally fluctuate between 600-2,000µg/l, which is considered to be stable / asymptotic.

- Groundwater temperatures in the source area have not yet returned to baseline levels. The highest temperature was recorded in DW20 in November 2024 (32.87ºC), with outside boreholes ranging between 11.89ºC and 14.46ºC.

- Laboratory results suggest that sulphate and nitrate reduction is occurring in the groundwater beneath the former MPA, and therefore prevailing conditions are favourable for breakdown of residual contamination and ongoing natural attenuation. Additionally, the relationship between benzene and dissolved oxygen indicates that aerobic decay is ongoing as the oxygen levels recover when the benzene concentrations decrease. This is further supported by the improvement in benzene half-life calculations from 417 days to 79 days.

Overall, there has been a significant percentage reduction in the maximum CoC concentrations for VOCs (benzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene and toluene) of between 79-99%. Although benzene concentrations may increase in periods of high groundwater levels; rebound monitoring has proven this is not sustained.

The predictive model, based on worst case conditions, identifies no significant impact at a conservative 50m compliance point, at a 30-year timescale. In approximately 2.5 years' time benzene concentrations are below the DWS of 1µg/l.

11.4. Evidence for Permit Surrender

To demonstrate that remediation objectives have been met, the following lines of evidence in Table 11.2 below, were agreed with the EA for verification purposes of Phases 3 and 4.

Table 11.2. Remediation Lines of Evidence

<table>
<tr><th></th><th colspan="2">Lines of Evidence</th><th>Status</th></tr>
<tr><td rowspan="2">Soils</td><td colspan="2">Compliance against Remedial Target Values (RTVs) for soils and leachates, protective of a commercial end use and Principal Aquifer.</td><td rowspan="2">Bulk mercury contamination from Area 1 and Area 2 excavated and disposed of at a licensed waste facility (total of 230.64 tonnes).
Sufficient remediation works are considered to have been undertaken to render the site suitable for a commercial use and to minimise risks to controlled waters. In addition, a low-permeability cap has been installed across both areas to minimise the potential for future infiltration from any residual contamination (validated in Section 5).</td></tr>
<tr><td colspan="2">Placement of a chemically compliant capping system.</td></tr>
<tr><td rowspan="5">Groundwater</td><td rowspan="2">Treatment Cessation</td><td>1. Source area benzene reduction (< updated baseline, 2020/2021).</td><td>Overall source area benzene reduction of 99% since the baseline groundwater assessment in 2020/2021 (validated in Section 6.11.1).
Post-remediation drilling in June 2024 (DW20 and DW21) confirmed a significant reduction in organic contamination at depth in the unsaturated zone of >99% (validated in Section 7).</td></tr>
<tr><td>2. Mass recovery.</td><td>Mass recovery calculated for groundwater: 21.52kg.
Mass recovery calculated for vapour: 1,302.07kg (VOCs only).
The combined mass recovery following remediation works has significantly exceeded the initial calculations by 114%; estimated mass of 619.09kg vs actual mass of 1,323.59kg (validated in Section 6.11.4).</td></tr>
<tr><td rowspan="3">Permit Surrender</td><td>1. Demonstrate declining groundwater trends.</td><td rowspan="3">Monthly rebound monitoring has been undertaken between Jan 2023 – Jan 2025 (24No. months).
Benzene concentrations correlate to fluctuations in groundwater levels. The trend is mostly stable / asymptotic when groundwater levels remain below 22m bgl. When groundwater levels rise between 20-22m bgl, higher concentrations are present in DW14, DW16 and DW19 (former MPA). This is potentially evidence of a small contaminant release from the unsaturated zone at the POL during periods of prolonged rainfall; however, there is not enough remaining contaminant mass to sustain high concentrations.</td></tr>
<tr><td>2. Demonstrate asymptotic conditions.</td></tr>
<tr><td>3. Rebound monitoring period over a 12-month period and analysis of groundwater samples at an accredited MCERTS laboratory.</td></tr>
</table>

	Lines of Evidence		Status
			A significant percentage reduction is calculated for the maximum CoC concentrations for VOCs (benzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene and toluene) of between 79-99% (validated in Section 8).
		4. Numerical assessment (DQRA) of groundwater concentrations confirming no significant impaction at a conservative 50m compliance point, at a 30-year timescale.	Based on the most conservative predictive model, using worst case conditions, in approximately 2.5 years' time benzene concentrations are below the DWS of 1µg/l. Therefore, no significant impacts are predicted at a 50m compliance point, at a 30-year timescale (validated in Section 9).
		If requirements from 1-4 cannot be met, then a cost benefit analysis is required.	Lines of evidence required for permit surrender (objectives 1-4) are considered to be met; therefore, a cost benefit analysis is not required.

Overall, following remediation works, rebound monitoring and predictive modelling, Ecologia considers the previously identified contaminant linkages to be successfully remediated and the agreed objectives met.

Benzene concentrations remaining in the saturated zone beneath the former MPA are considered to represent asymptotic conditions with no additional remediation required to safeguard controlled water receptors. Predictive modelling has demonstrated that, even in the worst-case conditions, in approximately 2.5 years' time benzene concentrations are below the DWS of 1µg/l (i.e. no significant impacts).

The site is therefore considered suitable for divestment. Future considerations during development works are as follows:

- Any future development works on site should be undertaken cognisant of the low permeability capping layer in the centre of the site (former MPA). Should the layer be breached then this will need reinstatement.
- Given the previous history of the site, any future construction works shall be undertaken with further assessment, investigation where / if required and a discovery strategy in place. The CSM will need to be updated if there is a proposed change to the current commercial end use.
- Should any deep foundations be adopted in future, then appropriate foundation and piling risk assessments shall be undertaken in accordance with relevant guidance.

Remaining works on-site include decommissioning of the remediation and monitoring boreholes. This will be completed in line with industry and Environment Agency guidance[ref 69] following the outcome of permit surrender.

This Site Closure Report should be submitted to the Environment Agency and National Permitting Services in support of permit surrender (EPR/BV3898IR).

12. REFERENCES

12.1. Previous Ecologia Reports

The following reports produced by Ecologia are included in Appendix I, with a summary of works table presented in Appendix II.

ref 1. Phases I & II Report. IPPC Permit Application Baseline Survey (EES 00.141.01), 2003.

ref 2. Report on the Investigation of Sources of Groundwater Contamination (EES 00.141.01), 2003.

ref 3. Groundwater Monitoring Programme: November 2003 (EES 00.141.02).

ref 4. Groundwater Monitoring Programme: January to February 2004 (EES 00.141.02).

ref 5. Removal of Contaminated Sediments from Soakaways (EES 00.141.03), 2004.

ref 6. Factual Report for Intrusive Ground Investigation Following an Escape of Diesel (EES 0.259), April 2004.

ref 7. Completion Report for Installation of Three Deep Boreholes (EES 00.141.04), September 2004.

ref 8. Groundwater Monitoring Programme: March to December 2004 (EES 00.141.04).

ref 9. Sampling of Sediments and Base Material from Soakaways (EES 00.141.05), 2004.

ref 10. Human Health Risk Assessment for Benzene Vapour from Groundwater (EES 00.141.06), 2004.

ref 11. Soil Vapour Monitoring Conducted in March 2005 (EES 00.141.07).

ref 12. Groundwater Monitoring Programme: 2005 (EES 00.141.08).

ref 13. Drilling and Installation of One Deep Well (DW7) and Geophysical Logging (EES 00.141.09), 2005.

ref 14. Revised Application Site Report – Thor Overseas Limited Ramsgate Road Margate. Permit No. BV3898 (EES 00.141.10), 2005.

ref 15. Report on a Laboratory Feasibility Trial to Demonstrate Biological Treatment of Groundwater Contaminants (EES 00.141.11), 2006.

ref 16. Completion Report for Installation of Boreholes DW8 to DW13 and Geophysical Logging (December 2005 to March 2006) (EES 00.141.12).

ref 17. Report on the Assessment of the Modification of the Existing Effluent Treatment Plant for the Treatment of Contaminated Groundwater (EES 00.141.13), 2006.

ref 18. Groundwater Monitoring Programme. January to March 2006 (EES 00.141.14).

ref 19. Soil Sampling near Soakaways and the Main Pit (EES 00.141.15), 2007.

ref 20. Report from Additional Drilling and Aquifer Testing (EES 00.141.16), 2006.

ref 21. Report on the Continued Operation of the Existing Effluent Treatment Plant for the Treatment of Contaminated Groundwater (EES 00.141.17), 2007.

ref 22. Multilevel Sampling (EES 00.141.18), 2007.

ref 23. Groundwater Monitoring Programme: 2007 to 2010 (EES 00.141.19).

ref 24. Installation and Initial Sampling of Clustered Borehole CW1 (EES 00.141.20), 2007.

ref 25. Soil Survey in the Former Main Production Area (EES 00.141.21), 2008.

ref 26. Sampling of the Unsaturated Zone under the Soakaways (EES 00.141.22), 2009.

ref 27. Installation of Two off-site Monitoring Wells and a Single on-site Monitoring and Remediation Pumping Well (EES 00.141.23), 2009.

ref 28. Shallow Soil Sampling Bordering Elmley Way (EES 00.141.24), 2009.

ref 29. Shallow Soil Sampling Bordering Elmley Way (EES 00.141.25), 2009.

ref 30. Soil Sampling and Mercury Speciation (EES 00.141.26), 2009.

ref 31. Soil sampling beneath the Former Research and Development Building with Gas Monitoring (EES 00.141.27), 2010.

ref 32. Scoping Document for Thor Group Ltd – Version 1 (EES 00.141.13.1), 2009.

ref 33. Soil Vapour Extraction Trial (EES 00.141.28), 2010.

ref 34. Completion Report for Concrete Removal from Former R&D Building and Effluent Pits (EES 00.141.30), 2010.

ref 35. Sampling of Residential Gardens on Elmley Way, adjacent to Thor Group Ltd (EES 00.141.31), 2010.

ref 36. Supervision of Concrete Removal from Periphery of Former Main Process Area (EES 00.141.32), 2011.

ref 37. Second Stage SVE Trial (EES 00.141.33), 2011.

ref 38. Soil Sampling and Mercury Speciation (EES 00.141.35), 2012.

ref 39. Soil Sampling and Mercury Analysis (EES 00.141.36), 2012.

ref 40. Scoping Document for Thor Group Ltd – Version 2 (EES 00.141.13.2), 2013.

ref 41. Detailed Quantitative Risk Assessment (DQRA) for Controlled Waters (EES 00.141.39), 2013.

ref 42. Addendum to Controlled Waters DQRA (EES 00.141.40), 2015.

ref 43. Confirmation of the extent of mercury contamination over the entire site and establishment of a depth profile of leachable mercury down to 1.5m in the main process area (EES 00.141.42), November 2015.

ref 44. Integrated Remediation Strategy (EES 00.141.48), June 2019.

ref 45. Verification Report (Phase 2 Works) (EES 00.141.48), June 2019.

ref 46. Verification Report (Phase 1 Works) (EES 00.141.49), July 2019.

ref 47. Groundwater Monitoring Summary Report (2020 - 2021) (EES 00.141.53), March 2021.

ref 48. Trial Pitting Investigation (EES 00.141.57), March 2021.

ref 49. Addendum Remediation Strategy (EES 00.141.53), June 2021.

ref 50. CPT Source Area Investigation (EES 00.141.55), June 2021.

ref 51. Partial Demolition of Warehouse (EES 00.141.58), July 2021.

ref 52. Mercury Hotspot Excavation Works (EES 00.141.59), September 2021.

ref 53. Remediation Drilling (EES 00.141.54), February 2022.

ref 54. System Commissioning Validation Report (00.141.54), December 2021.

ref 55. PKEN – Margate, Treatment Final Report (Haemers Technologies), November 2022.

ref 56. Additional Drilling to support Permit Surrender (EES 00.141.61), September 2024.

ref 57. Thor Margate DQRA (H Fraser Consulting Ltd), October 2024.

12.2. General Guidance

ref 58. DEFRA. 2002. The Pollution Prevention and Control (England and Wales) Regulations.

ref 59. DEFRA. 2012. Environmental Protection Act 1990: Part 2A.

ref 60. The Environmental Permitting (England and Wales) (Amendment) Regulations 2018.

ref 61. DEFRA and Environment Agency. 2018. Groundwater protection position statements. https://www.gov.uk/government/publications/groundwater-protection-position-statements

ref 62. Environment Agency. 2015. Contaminated land exposure assessment tool (CLEA). https://www.gov.uk/government/publications/contaminated-land-exposure-assessment-clea-tool

ref 63. Environment Agency. 2023. Land Contamination Risk Management.

ref 64. BGS. (n.d.). BGS. Retrieved from BGS: http://www.bgs.ac.uk/

ref 65. Natural England et al. (n.d.). MAGIC. Retrieved from MAGIC: http://www.natureonthemap.naturalengland.org.uk/home.htm

ref 66. GOV.UK (n.d.). Retrieved from: https://www.gov.uk/check-flooding

ref 67. CL:AIRE. 2024, 'Guidance on the Assessment and Monitoring of Natural Attenuation of Contaminants in Groundwater'.

ref 68. CL:AIRE. 2024, 'Guidance on Natural Source Zone Depletion'.

ref 69. Environment Agency, 2004, Decommissioning Abandoned Boreholes and Wells.

ref 70. CIRIA Engineering in Chalk (C574), Lord, J A, Clayton, C R I and Mortimore, R N, October 2002. ISBN: 978-0-86017-574-24.

APPENDIX I

PREVIOUS REPORTS

APPENDIX II

SUMMARY TABLE OF PREVIOUS WORKS

APPENDIX III

PERMITS & LICENSES

APPENDIX IV

MONITORING DATA (DURING REMEDIATION)

APPENDIX V

MONITORING DATA (DURING REBOUND)

APPENDIX VI

PHOTOGRAPHIC REPORT

Headquarters
Building 711 & 712
Kent Science Park
Sittingbourne
Kent
ME9 8BZ
TEL **+44 (0)1795 471611**
mailto:info@ecologia-environmental.com

Midland Office
4 Romford Road
Astonfields
Stafford
ST16 3DZ
TEL +44 (0)1785 878010
mailto:midlandinfo@ecologia-environmental.com

South West Office
Unit 1 Kingsgate Business Centre
Duchy Road
Heathpark Industrial Estate
Honiton
Devon
EX14 1YG
TEL +44 (0)1404 47714
mailto:swinfo@ecologia-environmental.com

Northern Office
Alliance House
South Park Way
Wakefield
WF2 0XJ
TEL: +44 (0)7890 387797
mailto:northinfo@ecologia-environmental.com

Italian Subsidiary
Ecologia Environmental Solutions Sri
Via Irma Bandiera 6
Monte San Pietro (BO)
CAP 40050
Italia
TEL +39 051 754754
infoitaly@ecologia-environmental.it

MANAGEMENT SYSTEM CERTIFICATION
DNV
ISO 9001 · ISO 14001
ISO 45001

www.ecologia-environmental.com

Registered in England No: 3951107
Ecologia is the trading name of Ecologia Environmental Solutions Ltd Registered Address: Spring Lodge, 172 Chester Road, Helsby, Cheshire, England, WA6 0AR