
Addendum Site Investigation Report

at Horsham Enterprise
Park, land off Parsonage
Road, Horsham,
West Sussex,
RH12 4AN

for West Sussex County
Council

Report Reference : LP2575

Report Date : 7th July 2021

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EXECUTIVE SUMMARY

The site comprises a former pharmaceutical works currently undergoing demolition and clearance with a single 1930s Art Deco building retained in the centre, surrounded by areas of open ground. The site is approximately 7.5 Ha in size and has been the subject of a number of historic investigations, as well as remediation and validation activities carried out by the previous owners. It is proposed to be redeveloped for mixed residential and commercial use, including conversion of the retained building.

This report summarises additional investigations that targeted areas reported as previously remediated; further trial pitting to the south of the retained building; around a borehole where xylene and phenol had been reported; investigation of the surface water drains; and additional land gas monitoring.

During 2016 KDC Contractors Ltd remediated fifteen areas that they determined posed a risk to a future residential development due to vapour inhalation pathways or where gross contamination was present. The remedial works comprised excavation and removal offsite sidewall and base verification and backfill with site won verified material or quarries type 1 aggregate. Dewatering also occurred in places.

An additional 13 trial trenches and two trial pits targeted the KDC remediated areas to confirm the absence of gross contamination, to confirm the thickness of fill material, where possible and collect additional soil samples for laboratory analysis. The samples were screened for the presence of volatile organic compounds using a handheld photo-ionisation detector.

In all locations made ground was encountered up to 3.0 m thick and comprised gravels of brick and concrete, with occasional plastic, wire, and metal fragments. No non-aqueous phase liquids or strong hydrocarbon odours were identified. Discoloured soils were encountered at the base of the made ground in one location and an oil sheen was noted in standing water in one location.

Laboratory testing targeted samples where visual signs of contamination was identified; at the base of the made ground layer (where hydrocarbons may accumulate); and near surface samples of made ground. The testing was predominantly for CWGTPH with BTEX, based on the KDC remediation works. In the samples tested, the potential contaminants of concern were reported at concentrations below residential with home grown produce generic assessment criteria.

Two trial pits were excavated approximately northwest and southwest of BH101, where groundwater testing had identified xylene and phenol above detection limits in the deep aquifer. Soil testing did not record elevated concentrations of xylenes or speciated phenols.

The trial trench in an area south of the retained building did not identify visual signs of hydrocarbon contaminated soils and the soil sample tested reported TPH fractions and BTEX below residential with home grown produce generic assessment criteria.

Where accessible, water samples were collected from five onsite locations within the surface water drains. In addition, one offsite upgradient and four offsite down gradient surface water samples were collected, as was one sample from the location of the outfall at Horsham Pond. The samples were tested for heavy metals, speciated PAHs, CWG-TPH and BTEX. PAHs and TPHs were detected at concentrations above analytical detection limits in the onsite samples. The highest contamination was localised to an area northeast of the retained building. CCTV surveys indicated that in this area that the drains were blocked. CCTV surveys also identified damage and unmarked connections to the surface water drains throughout the eastern half of the site, which could allow shallow groundwater to enter the drains.

The downgradient surface water samples recorded PAHs and TPHs at less than detection limits or at low concentrations that were generally marginally above analytical detection limits. The Horsham Pond reported high concentrations of PAH and TPH. Based on the sampling and laboratory analysis undertaken to date the contaminants identified onsite do not appear to be migrating offsite, although a plausible pathway does exist.

The additional land gas monitoring included the collection of bulk gas and vapour samples from BH106 and WS106 for laboratory analysis. Continuous gas monitoring occurred at BH106 and WS106 for a period of six-weeks and periodic monitoring (over four visits) occurred at the other deep groundwater monitoring wells for land gases.

The data evaluation concluded that the initial peak flows of carbon dioxide released from BH106 were likely due to a trapped pocket of carbon dioxide within a sandstone layer beneath a layer of clay with low permeability. Continuous gas monitoring results suggest that the gas source generated in BH106 was indicative of microbial respiration. Provided that in residential areas the foundation design does not create permeable pathways, the proposed residential properties are considered unlikely to require gas protection measures.

In commercial areas, where a piled foundation solution may be adopted the method used must adequately seal into the surrounding bedrock, so as not to create new pathways i.e. use of CFA piles.

This report recommends that the land gas risk assessment is reviewed by a competent geo-environmental consultant once the detailed foundation design details are finalised. Limited further assessment may be required at that time by way of validation. The surface water drains in the east of the site should be repaired to remove blockages, fix cracked or damaged pipes and seal redundant connections, which could act as preferential pathways for shallow groundwater to enter the network.



A INTRODUCTION

1 Authority

Leap Environmental Ltd (hereafter referred to as **LEAP**) has been appointed by West Sussex County Council (WSCC) to undertake an addendum site investigation of a site referred to as Horsham Enterprise Park, land off Parsonage Road, Horsham, West Sussex, RH12 4AN. The site was formerly occupied by Novartis Pharmaceuticals Ltd. The instruction was given in an email dated 06th May 2021 by Gary Cox of WSCC under order reference PO4100185400.

A site location plan is included as Figure 1 in Appendix B

2 Proposed Development

Outline planning permission has been granted for the site under planning application reference DC/18/2687 dated 6th August 2019. The outline application includes for the erection of up to 300 residential dwellings (C3) including the conversion of an existing office to 123 residential units and the provision of 618sqm of flexible commercial/community space (A1 A2 A3 D1 Creche) within the ground floor of the building. Land to the west of the retained building is proposed to include approximately 177 dwellings, which include flats 3 to 4 storeys in height and low rise residential houses. East of the retained structure up to 25,000sqm of new employment (B1) floorspace is proposed. We understand that this will be made up of 10 to 15 separate buildings up to 5 storeys tall. Class B1 land use includes research and development of products or processes, light industrial processes, and offices. The application also allows for improvements to existing pedestrian and vehicular accesses from Parsonage Road and Wimblehurst Road, a new cycle and pedestrian access, together with associated parking and landscaping. An illustrative masterplan (drawing ref: MP001 rev C dated 14/12/18) is provided Appendix B.

3 Objective

The objectives of this report are to:

- Assess potential residual health and other environmental risks posed in areas described as being ‘remediated’ by KDC Contractors Ltd in 2016 on behalf of Novartis Pharmaceuticals Ltd;
- Assess the land gas risk to residential areas from a deep gassing well; and
- Assess the water quality within the surface water drains that extend through the eastern part of the site and the risk that it poses to the Horsham Pond, located offsite.

4 Previous Studies

The site has been the subject of previous investigations by LEAP and others. The following site investigation reports should be read in conjunction with this report.

- *Phase III Site Investigation Report* at Horsham Enterprise Park, land off Parsonage Road, Horsham, West Sussex, RH12 4AN by LEAP ref. LP2441 dated 6th May 2021
- *Phase 1 Desk Study & Site Reconnaissance Report* by LEAP ref. LP2441 dated 5th March 2021
- *Asbestos Investigation Letter Report*, Parsonage Road, Horsham, RH12 4AN by LEAP ref. OA/20/LP2309 dated 18th September 2020
- *Phase I Geo-Environmental Site Assessment* by REC Ltd dated June 2018
- *Land Quality Interim Report* by KDC Contractors Ltd dated November 2016
- *Phase 2 Environmental Investigation* by KDC Contractors Ltd dated June 2016
- *Historical Land Quality Investigations Data Review and Preliminary Risk Assessment* by KDC Contractors Ltd March 2016
- *Asbestos Demolition Survey Reports* by Riverside Environmental Services Ltd dated January 2015
- *Further Land Quality Investigation* by Jacobs dated 17 October 2014
- *Phase 2 Land Quality Assessment* by SKM Enviros dated 12 July 2013

5 Scope of Works

On completion of an intrusive site investigation by LEAP in May 2021 further works were commissioned to assess residual risks arising from areas identified as remediated by others; surface water drains present in the eastern half of the site; and to further characterise the land gas risk relating to carbon dioxide gas in one deep monitoring well located in the northwest of the site.

On the basis of the above, a further targeted geo-environmental site investigation including land gas monitoring and laboratory analysis to address the outstanding areas was commissioned.

This report does not consider geotechnical conditions further.

5.1 Intrusive Investigation Scope

The results of this and previous investigation and remediation reports are used to validate and/or update the initial site conceptual model. This phase of site investigation comprised the following tasks:

- 14 No. trial trenches up to 3 m deep;
- 4 No trial pits up to 3 m deep;
- Bulk gas and volatile organic compound sampling from WS106 and BH106;
- Installation of GasfluX™ continuous monitoring devices in two locations (BH106 and WS106);
- Water sampling from accessible manhole chambers along the eastern surface water drainage network, in land south of the site at Collyer's College and the Horsham Pond; and
- Chemical Laboratory tests including 2No. bulk gas and volatile organic compounds; 2 No. LEAP standard soil suite tests; 18 BTEX and CWGTPH soil tests; and up to 10 water test suites.

The additional intrusive works were completed by contractors who have been scrutinised and are on LEAP's approved contractor list. The machine excavated trial trenches and trial pits were carried out by Spillane Plant Limited and supervised by LEAP. The GasfluX units were installed by subcontractors employed by Ambisense.

Selected samples of soil and surface water were scheduled for laboratory testing for a wide range of potential contaminants including metals, non-metals, asbestos, polycyclic aromatic and petroleum hydrocarbons and volatile organic compounds. The laboratory testing has been carried out by The Environmental Laboratory Ltd at its laboratories in East Sussex.

Bulk gas and vapour samples were collected from two locations and scheduled for a range of determinands including carbon dioxide, methane, oxygen, hydrogen sulphide, carbon monoxide, volatile organic compounds and short-carbon length petroleum hydrocarbons. The laboratory testing has been carried out by ALS Environmental at its laboratories in Hawarden.

As part of the enabling works Axio (Special Works) Ltd on behalf of WSCC commissioned a CCTV survey of sections of the eastern drainage network, which has been made available to LEAP for review.

6 Limitations

This report has been prepared by Leap Environmental Ltd on the basis of information received from a variety of sources which Leap Environmental Ltd believes to be accurate. Nevertheless, Leap Environmental Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Leap Environmental Ltd has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all

relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed.

The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.

This report is confidential to the Client, and Leap Environmental Ltd accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental Ltd beforehand. Any such party relies upon the report at their own risk.

Full details of the limitations are provided in Appendix A.

B SITE SETTING

7 Site Location and Description

A site location plan is provided as Figure 1, Appendix B and the layout of the site at the time of the investigation is provided as Figure 2, Appendix B. Historical structures relating to former pharmaceutical land uses at the site is provided as Figure 3, Appendix B. A summary of the site location, historical and environmental setting, based on LEAP's Phase 1 Desk Study Report dated March 2021 is provided in Table 1, below:

Table 1: Summary of Site Description and Environmental Setting

Information ¹	Details
Name and site address	Horsham Enterprise Park, land off Parsonage Road, Horsham, West Sussex, RH12 4AN
National Grid Reference	TQ 1789 3170
Site area	Approximately 7.5 hectares
Topography and elevation	Central areas are broadly flat and level, with a gentle downward slope from west to east (~57.5 m to 56.5 m AOD). North eastern and eastern boundaries slope downwards into the site from ~60 m AOD at the crest of the slope to ~58-57 m AOD at the toe of the slope. Slope angles are estimated to be between 20-22° on the north-eastern and eastern boundaries. Regionally, the topography of the surrounding area slopes downwards to the southwest.
Site description and current use	The site is currently unoccupied and cleared of most of the former pharmaceutical buildings, with the exception of the retained central structure (historically numbered as Building 3/36). The site is bound by Parsonage Road to the north, Wimbleshurst Road to the west, and railway lines to the south (extending to the southwest) and to the east. The railway line on the eastern boundary is on an embankment raised by 2-3 m relative to the land to the west. The railway line to the south is

¹ Source: LP2441 Phase 1 Desk Study and Site Reconnaissance by LEAP dated March 2021. The report includes publicly available data in the form of an Envirocheck Report.

Information ¹	Details
	broadly level with the site (although in a slight cutting in the far northeast of the site). The raised ground present along the north-eastern and eastern boundaries appears in part to be related to earthworks during the construction of the pharmaceutical works, where land was presumed to have been 'cut' into to create a level construction platform for buildings. A concrete crib wall is present along the eastern boundary embankment ~95 m south of Parsonage Road. It is ~15 m long and ~2 m high and formed of interlocking precast concrete.
Surrounding area	The site is located to the north of Horsham town centre in a predominantly residential setting, with residential housing to the north, southwest and west of the site. A commercial/light industrial development is located beyond the railway line to the east. To the south beyond the railway line are college playing fields and a mix of residential and light industrial land uses. Approximately 230 m to the northeast of the site is Parsonage Farm Industrial Estate.
Site history	In summary, from the earliest provided mapping (1875) the site is shown as open land with an 'old clay pit' in the far south-eastern corner. Three historical drainage ditches are mapped for the site, two in the eastern half of the site and one in the western half. Railway lines are shown to be present forming the southern and eastern boundaries. Mapping from the late 1930's show Building 3 present and labelled as 'laboratories'. Further expansion of the site with new structures, is shown on historical maps dating from the 1960's, 1980's and 1990's. Minor additions to the site layout are noted from the 2000's. Land immediately surrounding the site broadly follows a similar trajectory in that it was largely open fields, but with minor areas of residential development to the southwest and industrial usage (Horsham Iron Works) to the southeast from the late 19th century. From the 1930's and 1960's further residential expansion of Horsham town is noted to the west, south and east. By the 1980's extensive industrial / commercial land use is mapped on land to the east and southeast of the site, but with residential use shown beyond that. Playing fields are mapped to the north of the site in the 1980's and but are mapped as residential land use from the 2010's. Features associated with the pharmaceutical works included: fuel / solvent storage; boiler houses; above ground heating oil tanks; below ground fuel storage; below ground fire water storage; LPG storage; interceptors; tunnels; extensive below ground utility services including condensate and compressed air; coal hopper; chillers; electrical sub-

Information ¹	Details
	station; pharmaceutical research, development and manufacture; engineering works; water treatment; and offices.
Regional geology	The site is mapped as being underlain by the sandstone and mudstone of the Upper Tunbridge Wells Sand on the north western part of the site and mudstone of the Upper Tunbridge Wells Sand across the remainder of the site. Superficial deposits are not mapped for the site.
Regional hydrogeology	The Upper Tunbridge Wells Sand - Sandstone and Mudstone which is mapped in the northwest of the site, is classified as a Secondary A Aquifer. These represent permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases form an important source of base flow to rivers. The Upper Tunbridge Wells Sand - Mudstone across the remainder of the site is mapped as an unproductive strata. The site is not located within a groundwater source protection zone (SPZ). It is noted that there are two historical groundwater abstraction licences for the site which are mapped to a single point southwest of Building 3.
Surface water	There are no mapped surface water features on site or immediately bounding the site (within 250 m). An unnamed surface water feature is mapped 326 m to the northeast of the site. It is understood that two surface water drains are present in the eastern half of the site and connect to the Horsham Pond ~800 m to the southwest of the site. One of the drains extends from the northeast corner of the site along the northern boundary towards Building 3/36, where it turns to the south and extends southwards and eastwards towards the southern boundary, before exiting the site beneath the railway line. A second surface water drain is present in the southern half of the site aligned east to west from the Foundry Lane industrial estate apparently connecting to the same outfall along the southern boundary. It has been reported to LEAP anecdotally that the site drainage from stormwater / foul did not connect into these features. A historical decommissioned drain is mapped extending from the north east crossing the centre of the eastern half of the site and connecting to an outfall along the southern boundary. We understand that this was decommissioned with the construction of Building 42. The approximate routes of the drains are shown on Southern Water plans, Appendix C. It is not known if historical drains / ditches (that were mapped pre-development of the site) are still active.

Information ¹	Details
Flood risk	According to the Envirocheck data, the site is not located within a flood zone at risk from Rivers or Sea. The north-western part of the site, where the Upper Tunbridge Wells Sand - Sandstone and Mudstone is present is mapped in the Envirocheck Report as an area with 'limited potential for groundwater flooding to occur'. The remainder of the site is not mapped as being at risk of groundwater flooding. Parts of the site are mapped² as being at risk from surface water flooding. The main areas at risk of surface water flooding are mapped in the eastern half of the site and land to the west of Building 3.

8 Previous Investigations

The site has been the subject to numerous intrusive investigations undertaken by others and a Phase I Desk Study and Phase III Site Investigation Report by LEAP, as listed above. A summary of the reports by other consultants is provided in the Phase I Desk Study report, which should be reviewed in conjunction with this report.

8.1.1 Phase III Site Investigation Report at Horsham Enterprise Park LEAP dated May 2021

The Phase III Site Investigation Report by LEAP, comprised the excavation of 77 trial holes across the development boundary on a non-targeted grid at approximately 30 m spacing. Phase III exploratory hole locations are provided as Figure 4.

Selected soil samples were tested for commonly occurring contaminants of concern including heavy metals; speciated polycyclic aromatic hydrocarbons; petroleum hydrocarbons; volatile organic compounds and asbestos containing materials.

The results of the soil testing identified contaminant concentrations above generic assessment criteria (GAC) for a residential land use with home grown produce in isolated areas. Arsenic, lead, nickel and benzo(a)pyrene were above residential GAC in trial holes to the northwest of the retained structure. Asbestos containing material was identified in one location in the commercial area to the east of the site. Arsenic lead and benzo(a)pyrene were detected at concentrations above residential GAC in the eastern half of the site, but below commercial GACs.

² <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

The land gas monitoring characterised the majority of the site as characteristic situation CS1 (very low risk) with the exception of one deep monitoring well (BH106) which recorded high flow rates and a carbon dioxide concentration of 13.6% and was classified as CS4, moderate to high risk. Further land gas monitoring and gas risk characterisation was recommended with respect to BH106.

Groundwater monitoring was undertaken within six deep monitoring wells only. With respect to groundwater receptors nickel was detected at concentrations above UK Drinking Water Standards in several monitoring wells (BH101S; BH104 and BH106). Xylene was detected above minimum reporting values in BH101S/D; petroleum hydrocarbons were detected above analytical detection limits in BH101D; and benzo(a)pyrene was detected at analytical detection limits in BH101S/D. The risk to groundwater receptors was discounted on the basis of the lack of a significant identifiable soil source; generally low margin of exceedance of screening criteria; and the lack of plausible source-pathway-receptor linkages.

However, the report highlighted a residual risk from onsite surface water drains that extended through the eastern half of the site that were reported to discharge into the Horsham Pond located approximately 800 m to the southwest of the site.

8.1.2 Appendices to 'Land Quality Interim Report' by KDC Contractors Ltd dated November 2016

The appendices were made available to LEAP following the completion of the Phase III intrusive investigation works. They included plans showing the locations of the remediation excavation areas. KDC only excavated areas that they deemed as posing an inhalation risk to a future residential land use or where 'gross' contamination was identified. Some areas were dewatered to enable base verification sample collection or to 'address shallow groundwater contamination'. Where the pathway linkage was via dermal contact / ingestion KDC proposed a capping solution to break the linkage.

Information on the recorded remedial excavation works is summarised below:

Table 2: Known KDC Remediation Areas

KDC remediation areas ³	Comments ⁴
TP3	Located to east of Building 15 (production and stores) and over Building 22 (ancillary services). KDC reported 1,2,4 trimethylbenzene, naphthalene, Ali TPH C8-C10, C10-C12, C12-16 and Aro TPH C10-C12, C12-C16 at concentrations above screening criteria between 1.4-1.7 m bgl. Remedial works included the excavation to depths between 1.0-3.5 m bgl until visual and olfactory evidence of contamination was removed and confirmed by verification sampling. Reported as

³ As per KDC Drawing Ref: KDC/Novartis-Horsham/25 Rev B 'Excavation Plan'

⁴ Based on information contained within KDC Land Quality Interim Report dated Nov 2016 ref: I5606-REP-002

	including the removal of a concrete service duct and redundant service pipelines and bedding material. The void was backfilled with crushed site won material (U1 exempt) and quarried type 1 aggregate. KDC listed that 2127tonnes(t) of material were disposed of offsite and 29.82m ³ of water was also removed.
TP16	Located on centrally within footprint of Building 38 (ADDR building). KDC reported that TP16 identified exceedances of Ali TPH C5-C6. A 25m ² hotspot was excavated to 1.0 m and backfilled with quarried type-1 material. Reported that 78.82t of material was disposed of offsite.
TP28/TP46	Located south of Building 21 (Engineering) KDC reported benzene at concentrations above screening criteria in TP28 at 1.5-2.0 m bgl. Lead reported at 359 mg/kg and asbestos identified at 1.70 m in TP46. An initial 25m ² hotspot excavation was completed. However, KDC noted that a clay pipe with black sludge / hydrocarbon odour was encountered, as was a 'decommissioned' service duct. These were also removed. Validation samples were collected. Excavation extents were reported as limited due to 'underground drainage' present to the north of the remediation area. KDC listed that it was backfilled with validated site won material and quarried type 1 aggregate. They reported that 1026t material was disposed of offsite. The excavation was also dewatered for 2 weeks resulting in 112m ³ water being removed.
TP30	Located south of Building 8 (Boiler house). No inhalation risk from soils identified. However, KDC undertook a dewatering exercise and 63.46 m ³ water was disposed of offsite.
TP37	Located over former solvent stores (Building 17). KDC identified 1,2,4- trimethylbenzene, and Ali TPH C8-C10 exceeding GACs in soils from 1.5-2.5 m bgl. KDC report that 25m ² hotspot was excavated to 3.7 m bgl. This included the removal of a service duct towards Building 3 in the north. It was recorded as backfilled with validated overburden and quarried type-1 material. 56m ³ of water and 546.74 t material were disposed of offsite
TP40/US18/Metal petrol tank	Located over former petrol station area KDC identified a metal UST at US18, which contained a small amount of residual petrol. Sidewalls and the tank base were noted as being impacted with strong hydrocarbon odour. KDC report that they removed the tank, sand that was in the tank and the residual petrol; excavated sidewalls and bases, which were then verified. The excavation was backfilled with quarried type-1 material. Soils at TP40 were not considered to pose a human health risk, but a dewatering exercise was required. KDC list that 23.81 m ³ water was purged and disposed from site as was 632.1t of soils.
TP33/TPCP4*	Located outside of the current development boundary in the former clay pit area. KDC identified black sandy clay from 1.00 to 1.35 m bgl and soft black clay and ash from 1.35-1.65 m bgl with elevated concentrations of chloromethane detected. An area 64.56 m ² was excavated to 0.8-1.2 m. KDC recorded that it was backfilled with validated overburden soil and 126t material was disposed of offsite.
TP52	Located on northeast corner of Building 15 (Production and Stores) KDC identified an additive TPH inhalation risk in soil samples collected from depths between 0.0-0.4 m and 0.9-1.2 m bgl. A 25m ² hotspot was excavated to 1.3 m and backfilled with quarried type-1 material. KDC reported that 50.68t of material was disposed of offsite.
Building 11 ⁵	Building 11 is the former Boiler House

⁵ KDC Phase 2 Environmental Investigation June 2016 ref: 01140

	A watching brief was undertaken by KDC during the removal of building slabs and foundations in the area of Building 11. A gravel / brick layer was noted beneath the slab and a sump containing NAPL was identified to the southeast of the slab. KDC reported that NAPL within the sump was removed from site, as was the gravel / brick layer beneath the floor slab and soils around the sump. An oil filled service duct was also identified during this work and the product and surrounding soils were removed. Validation samples were collected as part of the works. KDC recorded that 784t of material was disposed of offsite.
Building 42 ^{7,8,9}	Building 42 is a former laboratory Approximately 320t of material were reported to have been removed in the June 2016 KDC Report, due to hydrocarbon impacted gravels. A diesel contaminated pipe and hydrocarbon contaminated chamber was also removed. In the November 2016 Report KDC note that due to validation sidewall failures KDC excavated a further 300.5m² area to 1.5-1.8 m. It is reported that redundant pipes and bedding materials were also 'chased out'. The excavation was reported to be backfilled with site won crushed material. KDC reported that 1059.7 t of soil and 32.73m³ of water were disposed of offsite.
Former Diesel Tank Area (FDTA)	Located in the far southeast of the site. KDC list that an area circa 55.5m² was excavated to 1.5 m depth. The void was listed as being backfilled with site won crushed material and 124.94 t material was disposed of offsite.
US07	Located on western boundary of Building 38 (ADDR building). KDC identified an inhalation risk from Ali TPH C10-C12 and additive TPH inhalation risk. Reported that a 25m² hotspot was excavated to 1.8 m bgl and backfilled with quarried type-1 material and verified site won material. KDC reported that 73.48t of material was disposed offsite.
US25	Located along the northern extent of Building 21 (Engineering) KDC identified Aro TPH C21-C35 at concentrations above GAC from a side wall sample between 1.2-1.4 m bgl. The material was identified as black gravel and possible fine ashes on the eastern site of a service duct. The material was excavated until no visual evidence of ashes/gravel were noted. The excavation was backfilled with validated site won material. KDC listed that an area approximately 42.4 m² was excavated to 1.9-2.1 m bgl and 15.6 of material was disposed of offsite.
US33	Located over Building T1 (Temporary Offices) KDC report that a base sample of pipe bedding material failed TPH GAC for individual Ali C10-12 and additive TPH GAC. Soils were reported to have been removed until no visual or olfactory evidence of contamination were recorded. A manhole chamber, pipelines and surrounding soils were listed as being removed. KDC note that verification samples were collected. The excavation was listed as being backfilled with quarries type 1 and site won material. KDC listed that an area approximately 71.7 m² was excavated to 1.7-2.4 m bgl and 15.6t of material was disposed of offsite.
US46	Located along the northern boundary of Building 15(Production and Stores) Samples collected from pipe bedding material were reported at concentrations above TPHCWG GAC. KDC list an area approximately 239.5 m² was excavated to 1.4-2.7 m depths and 354.52m³ material was disposed of offsite. The void was backfilled with quarried type 1 material.

8.1.3 CCTV Surveys

We are aware of two CCTV drainage surveys that have been undertaken at the site on behalf of WSCC, namely:

- Lanes Group Plc Hampshire CC Novartis RH12 2EE dated 31 August 2018

- Sweeptech Environmental Services Ltd 21_05_07 Axio Parsonage Road Horsham dated 7th May 2021.

The Sweeptech 2021 survey maps the route of belowground drainages pipes as marked on a 2020 below ground utility mapping survey including ground penetrating radar, by SubVision Ltd.

Both CCTV reports are appended to this document in Appendix C. A summary of the findings of both surveys are provided in Table 3 below.

Table 3: Summary of 2018 and 2021 CCTV Surveys

Section	Southern Water cover reference	CCTV survey cover reference	Approximate location on site	Comments
East of Building 3/36 aligned north to south	9854	MHSW25 (2018)	Approximately 30 m northeast of Building 36	450 mm concrete pipe aligned to north east. Survey abandoned at 9.26 m 95% area loss, possible collapse. 450 mm concrete pipe aligned north not able to progress beyond 0.23 m 600 mm concrete pipe aligned south to MHSW26 no defects noted survey length 33.09 m.
		S1 (2021)		600 mm concrete pipe aligned south to S2 no structural defects noted along length of survey 32.87 m
	8750	MHSW26 (2018)	Adjacent to the northeast of Building 36	600 mm concrete pipe aligned south to MHSW27 no structural defects noted. Length of survey 19.02 m Second inlet to MHSW26 aligned to east. Abandoned at 8.37 m due to blockage.
		S2 (2021)		600 mm concrete pipe aligned south to S3. Survey abandoned at 6.19 m towards S3 due to blockage
	8751	MHSW27 (2018)	East of centre of Building 36	Chamber cover buried under speed ramp.
		S3 (2021)		600 mm concrete pipe aligned north to S2, survey abandoned at 3.02 m due to debris
	8752	MHSW28 (2018)	East of centre of Building 36	600 mm concrete pipe aligned south to MHSW29 infiltration seeping at joint at 19.70m. Survey completed at 53.41 m.
		S4 (2021)		600 mm concrete pipe aligned south to S5. No structural defects noted along length of survey 54.36 m
	8753	MHSW29 (2018)	Approximately 15 m southeast of Building 36	600 mm concrete pipe. Survey terminated at 28.74, end manhole chamber outside of survey boundary. No structural defects noted.
		S5 (2021)		600 mm concrete pipe aligned south to S6. No structural defects noted along length of survey 28.89 m
	8754 (assumed)	S6 (2021)	Approximately 46 m south of Building 36	600 mm concrete pipe aligned southeast to S7. No structural defects noted along length of survey 53.88 m
	-	S7 (2021)	Approximately 50 m southeast of S6	450 mm concrete pipe aligned south to S8. No structural defects noted along length of survey 4.92 m
	-	S8 (2021)	Approximately 5 m south of S7 (assumed)	450 mm concrete pipe aligned southeast to S9. Rootlets noted at joint 8.35 m and 13.0 m; polyester patch noted from 10.87 to 11.71 m. Survey length 14.63 m

Section	Southern Water cover reference	CCTV survey cover reference	Approximate location on site	Comments
	-	S9 (2021)	Approximately 10 m southeast of S8 (assumed)	Not surveyed. Marked on the survey plan by Sweeptech as an outlet exiting the site to the south.
	-	S21 (2021)	Approximately 5.5 m southeast of S7	450 mm concrete pipe aligned south to S8. Settled deposits in chamber. Survey length 1.63 m.
Southern Drain aligned East to West from Railway Embankment	-	S11 (2021)	Along eastern railway embankment	750 mm concrete pipe aligned south to S12. No structural defects noted along length of survey 10.54 m
		S12 (2021)	~10 m south of S11	750 mm concrete pipe aligned northwest to S13. No structural defects noted along length of survey 20.03 m. Connections noted at 3.67 m; 12.37 m; 18.29 m (recorded as defective).
	0558	S13 (2021)	~20 m northwest of S12	750 mm concrete pipe aligned southwest to S14. Patch lining noted at 6.90 m to 7.71 m; defective connection at 13.46 m. Length of survey 15.29 m
	9554	S14 (2021)	~15 m southwest of S13	750 mm concrete pipe aligned west to S15. Defective connections at 16.97m; 17.19 m; and 17.46 m. Length of survey 25.85 m.
	9559	S15 (2021)	~25 m west of S14	750 mm concrete pipe aligned north of S16. Settled deposits in chamber. Length of survey 1.17 m
	9553	S16 (2021)	~1 m north of S15	750 mm concrete pipe aligned west to S17. Crack in joint at 0.52 m, 5.36 m fine roots noted at 5.36 m. Length of survey 9.15 m
	-	S17 (2021)	~9 m west of S16	750 mm concrete pipe aligned west to S18. Fine roots at 1.98 m. Length of survey 5.91 m
	-	S18 (2021)	~6 m west of S17	750 mm concrete pipe aligned southwest to S19. Patch lining noted at 1.05 to 1.75 m; defective connections at 10.35 and 15.96 m; fracture and infiltration dripping into pipe at 17.79 m; connection at 18.90 m. Survey abandoned at 35.49 m loss of vision. We note this is ~7 m short of S19
	9551 (possibly)	S19 (2021)	~26 m southwest of S18	600 mm concrete pipe. Settled deposits in chamber. No structural defects noted. Length of survey 2.75 m
	9557 (possibly)	S20 (2021)		Two surveys sections presented from S20 to S9. Survey A (600 mm) – abandoned at 2.35 m Survey B (600 mm) – abandoned at 23.76 m. settled deposits noted at 0.70, 4.53, 11.0 m, 13.33 m and 16.11 m. Defective connection at 11.63 m.

As described above the two CCTV surveys indicate blockages and damage to both sections of the surface water drains. In particular, on the north to south network (east of building 36) the northerly inlet coming onto site from Parsonage Road appears to be blocked; a recent blockage (not evident on the 2018 survey) also appears present between two chambers (8750 to 8751 ref: Southern Water) between the north east of building 36 to the central part of building 36. No major structural defects are noted along the remainder of this survey section to S8/S9 where the drains appear to exit the site. Although a patch lining is noted towards the

end of S8 and fine rootlets are present at the joint. S9 was not surveyed, but is shown on the Sweeptech drawing that an outlet is present exiting the site beneath the railway lines.

The east to west drain appears to be in better condition in the section closer to the eastern boundary. Along the route numerous inlets (not surveyed) are noted and some are defective. Patches are also recorded in places, which are evidence of repair work. A crack is noted between S16 and S17 and rootlets are also recorded from S16 to S17 to S18 indicating poor joints or cracks. A fracture is noted in towards the end of S18 and the survey was abandoned at ~7 m from S19 due to loss of vision. It is not detailed whether the pipe was blocked or damaged. From S20 to S9 two attempted surveys are reported. However, it is not certain if they relate to two different outlets in chamber S20 or two attempts at the same outlet.

We note that the Southern Water Drainage plans in places, does not correlate with the CCTV surveys or the GPR below ground utility service surveys. The locations shown where the drains exit the site on Southern Water plans (chamber references: 8657, 8655, 8652) do not match the GPR surveys when overlaid. Also the drainage network east of building 36 is shown on Southern Water plans to extend offsite to the north and then to the east. This section has not been CCTV surveyed nor was shown on GPR utility service surveys.

We also understand, anecdotally, that Axio (Special Works Ltd) have trial trenched across the possible route of the abandoned drain (aligned northeast to southwest) and the drain was not identified.

8.1.4 Other information

LEAP have been provided with a GPR below ground utility survey plan that maps the route of the surface water drains extending through the Collyer's College Site. We have also obtained Southern Water drainage plans for land south of Collyer's College up to the Horsham Pond. These plans are provided as Appendix C.

Anecdotally it has been reported to LEAP that a significant discharge of hydrocarbon was accidentally released from Horsham Hospital and entered the Horsham Pond via drains. The dates and details of this event are not known. However, the Envirocheck report in the Phase 1 Desk Study by LEAP records a category 3 – minor incident from the Hospital in 1996, where kerosene fuel oil was released into the pond.

C PHASE II - INTRUSIVE INVESTIGATION

9 Investigation Rationale

A total of 18 additional trial holes were excavated. These included 14 No. machine excavated trial trenches and 4No. pits to depths up to 3m.

The trial trenches were positioned to target KDC remediation areas; land around BH101 in the southeast of the site; and an additional trial hole south of Building 3/36.

The investigation rationale for the trial holes is summarised below:

Table 4: Rationale for Exploratory Hole Locations

Trial Hole/Test Location	Rationale	Proposed Depth (mbGL)	Notes
TT201-TT214 and TP201-TP202	Target known KDC remediation areas	3.0	The excavations were to confirm the presence of remnant hydrocarbon contamination (TPH fractions) in KDC remediation areas. To identify if visual (i.e. discoloured soils, non-aqueous phase liquids (NAPL), oil sheens) or olfactory (strong hydrocarbon odours or elevated PID readings) evidence of contaminated soils.
TT213	Target land to the south of Building 3/36	3.0	To provide additional coverage
TP203-TP204	Target land around BH101, where phenol and xylene had been detected in groundwater	3.0	To collect soil samples from made ground soils in vicinity of BH101 for laboratory analysis.

The site investigation locations are shown on Figure 5, Appendix B and a photographic record of the exploratory hole locations is provided as Appendix D. TT202 was moved ~5 m east and sited over a location that was considered to be the remediated area (slightly lowered ground level in a rectangular shape) rather than the set-out position.

Over three monitoring events onsite and offsite the surface water drains were sampled to confirm water quality coming into the site, as it exits the site and at downstream locations. The sample locations are tabulated in Section 10.5 and presented on Figure 6.

10 Site Work

10.1 Date and Weather Conditions

The additional intrusive investigation was undertaken between 25th and 26th May 2021. At the time of the investigation, the weather was warm, with occasional light drizzle.

Based on long term averages⁶ the weather preceding the investigation in March 2021 reported mean average temperatures close to the long term average, with a generally dry and sunny month. In April 2021 temperatures were reported at slightly above the long term average and with below average rainfall.

10.2 Site Work Methods

10.2.1 Trial Trenching / Pitting

Trial pits and trenches were dug by a backhoe excavator. The trial trenches were to prove the depth of made ground in the positions excavated and were typically 0.5 m wide by 10 m long. Spoil was replaced in reverse order to prevent cross-contamination. Trial pits were typically 0.5 m wide by 2m long. The material was backfilled in the order it was excavated and left mounded to allow for future settlement. The trial trench/pit logs are available in Appendix E.

10.2.2 Soil Logging and Sampling

Soil samples were recovered from the boreholes and trial pits for field screening, logging and sampling.

Boreholes were logged in general accordance with the requirements of BS 5930:⁷ and BS EN ISO 14688⁸.

⁶<https://www.metoffice.gov.uk/research/climate/maps-and-data/summaries/index>

⁷ BS5930:2015+AI:2020 Code of Practice for Ground Investigation

⁸ BS EN ISO 14688 Parts 1-2 (2018) Geotechnical Investigation and Testing. Identification and classification of soil

Visual and olfactory evidence of contamination was noted if encountered. These observations were used to aid scheduling of samples for chemical laboratory analyses, and are included on the exploratory hole logs in Appendix E and summarised in Section 11.4.

Samples were collected with a clean sampling trowel or by hand (using dedicated nitrile gloves for each sampling location). Samples were placed into laboratory supplied sampling containers, specific to the type of analyses required.

All sample containers were sealed and labelled with a unique location identity, depth and date of sampling.

10.3 Field Tests

10.3.1 Photo-ionisation Detection (PID)

Environmental samples collected from trial trenches / pits were screened for the presence of volatile organic compounds (VOC) using a PhoCheck+ portable PID. A soil sample was placed in a sealed container or plastic bag and soil / headspace allowed to equilibrate for approximately 20 minutes, the PID was inserted into the container and the results recorded. Where visual evidence of hydrocarbon contamination was noted on a sidewall or base of a trial pit/trench and it was considered safe to do so, a PID reading at the surface of the contamination face was also recorded.

10.4 Ground Gas Monitoring

10.4.1 Land gas monitoring

Ambisense GasfluX units were installed in BH106 and WS106 to provide continuous gas monitoring records. The units log various parameters including atmospheric pressure (mbar), flow (l/hr), and concentrations of CH₄ (%), CO₂ (%), O₂ (%), CO(ppm), and H₂S(ppm). Readings were recorded at approximately one hour intervals. The high frequency monitoring took place between 12th May to 25th June 2021. Volatile organic compounds and water levels in both locations were also continuously logged.

In addition, periodic readings of the other deep groundwater monitoring wells (BH101-105) were also undertaken on four occasions (12/05/21, 25/05/21, 18/06/21 and 24/06/21).

The wells were also monitored for volatile organic compounds using a PhoCheck+ portable Photo-Ionisation Detector (PID).

10.5 Surface Water Drains

A number of on site and off site manhole chambers were lifted and attempts to sample water within the drains was made over three visits (26th May, 24th June and 30th June 2021). The Horsham Pond was also sampled. Samples were collected using laboratory supplied

containers. Samples were not collected from chambers that required manual entry or where insufficient water was present within a chamber.

10.6 Laboratory Analysis

10.6.1 Chemical Soil Analysis

Selected samples of soil have been subjected to laboratory testing. Sampling techniques and storage have been undertaken as per BS 10175:2011+A2:2017 Code of Practice for Investigation of Potentially Contaminated Sites. The laboratory testing has been carried out by The Environmental Laboratory Ltd at its laboratories in East Sussex. Where available, the tests procedures are UKAS and MCERTS accredited.

The following analyses were completed on selected samples:-

- LEAP standard Soil suite (metals, speciated PAHs, asbestos); and
- Speciated Petroleum Hydrocarbons (CWG-TPH).

The KDC remediation rationale was predominantly based on the visual and olfactory signs of land contamination, and/or where laboratory testing exceeded generic assessment criteria for petroleum hydrocarbon compounds. Thus the testing was focussed on CWG-TPH with BTEX. In two locations, TT205 and TP202 where visual signs of contamination (black stained soils and oily sheen) were noted LEAP standard Soil suite were also scheduled. The full laboratory test results are presented in Appendix F.

10.6.2 Surface Water Samples

The laboratory testing on the surface water samples has been carried out by The Environmental Laboratory Ltd at its laboratories in East Sussex.

Analyses included:

- Heavy metals, dissolved organic carbon and pH;
- Dissolved calcium on selected samples;
- Speciated CWGTPH +BTEX;
- Speciated PAH; and
- Speciated phenols on selected samples.

10.6.3 Gas and Vapour Analysis

A single round of land gas sampling has been undertaken at BH106 and WS106 using laboratory supplied Silonite canisters. The samples were collected and analysed for:

- Bulk gases;
- C4-C12 TPH; and
- Volatile organic compounds.

The full laboratory test results are presented in Appendix F.

11 Ground Conditions

The previous LEAP investigation identified that made ground varied between the land west and east of Building 3/36.

The ground conditions encountered throughout this phase of works were in general agreement with the phase III investigation undertaken by LEAP. Within some KDC remediation areas the made ground contained a coarse, subangular to sub rounded crystalline gravel (possible natural aggregate type material) namely in TP201, TP202, TT202B, TT203, TT204, TT205, TT206, TT209, TT210, TT211 and T212.

The findings of both phases of investigation have been updated and are summarised in the tables below. The stratigraphy encountered is described on the trial hole logs in Appendix E.

11.1 Western Area

Table 5: Summary of soils encountered within the western half of the site

Depth From (m)	Depth To ⁹ (m)	Soil Type	Description
GL (56.58 / 57.52)	0.15 / 0.4 (56.18 / 57.12)	TOPSOIL	Dark brown silty clay TOPSOIL.
GL (56.03 / 56.64)	0.9 / 2.0* 54.22 / 55.64	MADE GROUND	Grey MADE GROUND comprising sandy gravel of coarse, subangular to subrounded crystalline rock. Occasionally present with brick and concrete inclusions.
GL (56.03 / 57.83)	0.2 / 3.0* (54.06* / 57.53)	MADE GROUND	Variable MADE GROUND generally comprising grey demolition fill of fine to coarse and cobbles of brick and concrete and occasional blacktop and areas of red sandy gravelly fill with gravel of fine to coarse brick and concrete.

⁹ Average strata thicknesses have not been quoted due to the variability across the site.

GL / 2.7 (57.03 / 54.36)	0.5* / 2.9 (56.73 / 53.41)	REWORKED SOIL ¹⁰	Reworked soils comprising grey to brown clayey silt and silty clay with occasional fragments of fine to coarse brick or concrete.
0.3 / 1.7 (57.12 / 55.88)	1.1 / 3.7 (55.30 / 55.36)	Interbedded CLAY and SILT	Interbedded firm to stiff mottled grey and brown and orangish brown and silty CLAY and clayey SILT.
1.1 / 3.1 (55.30 / 53.21)	3.35 / 3.7 (52.96 / 53.86)	Interbedded MUDSTONE, SILTSTONE & SANDSTONE	Extremely weak to very weak reddish brown to dark grey interbedded occasionally laminated ferruginous MUDSTONE, SILTSTONE and SANDSTONE. Occasionally thin coal (lignite) layers encountered within the sandstone strata.
3.35 / 3.7 (52.96 / 53.86)	20.3* (37.26*)	Interbedded MUDSTONE, SILTSTONE & SANDSTONE	Weak reddish brown to dark grey interbedded laminated ferruginous MUDSTONE, SILTSTONE and SANDSTONE. Occasionally thin coal(lignite) layers encountered within the sandstone strata.

* - full depth of excavation

11.2 Eastern Area

Table 6: Summary of soils encountered within eastern half of the site

Depth From (m AOD)	Depth To ¹⁷ (m)	Soil Type	Description
GL (56.58 / 57.52)	0.15 / 0.4 (56.18 / 57.12)	TOPSOIL	Dark brown silty clay TOPSOIL.

¹⁰ 'Reworked' is a generic term used by LEAP to describe soils that are predominantly formed from the 'natural' superficial or bedrock deposits, but may have minor inclusions of anthropogenic material such as glass or brick/concrete gravels. These minor inclusions may have been introduced into underlying stratum during construction or demolition works. They are visually different from 'made ground' soils which are predominantly formed of construction or demolition waste, waste material, or clearly definable 'natural' soils that have been placed to an engineered specification e.g. above a marker layer or a chalk capping layer above a made ground layer.

GL / 0.5 (55.78 / 56.97)	1.0 / 2.0 (54.78 / 55.54)	MADE GROUND	Grey MADE GROUND comprising sandy gravel of coarse subangular to subrounded dark grey crystalline rock. Occasionally present with brick and concrete inclusions.
GL / 1.2 (57.28 / 56.01)	0.2 / 4.05 (56.14 / 52.88)	MADE GROUND	Variable MADE GROUND generally comprising grey demolition fill of fine to coarse and cobbles of brick and concrete and occasional blacktop with localised pockets of black gravel of crystalline rock and areas of red sandy gravelly fill with gravel of fine to coarse brick and concrete
GL / 1.2 (56.42 / 56.08)	0.5 / 2.0* (55.92 / 54.36*)	REWORKED SOIL ¹⁰	Reworked soils comprising grey to brown clayey silt or silty clay occasionally with fragments of fine to coarse brick or concrete pockets containing frequent reworked sandy siltstone or silty sandstone fine to coarse gravel was noted in locations TP118, TP132 and TP136.
0.15 / 2.0 (57.68 / 54.70)	0.6* / 3.1* (57.23* / 54.52*)	Interbedded CLAY & SILT	Interbedded firm becoming very stiff mottled grey to brown and silty CLAY and clayey SILT.
0.8 / 4.05 (56.51 / 52.88)	6.0 / 13.55 (51.37 / 43.38)	Interbedded MUDSTONE, SILTSTONE & SANDSTONE	Extremely weak to very weak reddish brown to dark grey interbedded occasionally laminated ferruginous MUDSTONE, SILTSTONE and SANDSTONE. Occasionally thin coal layers (lignite) and minor deposits encountered within the sandstone strata.
2.6 / 7.3 (54.77 / 49.12)	20.5* (36.63*)	Interbedded MUDSTONE, SILTSTONE & SANDSTONE	Weak reddish brown to dark grey interbedded laminated ferruginous MUDSTONE, SILTSTONE and SANDSTONE. Occasionally thin coal layers (lignite) and minor deposits encountered within the sandstone strata.

* - full depth of excavation

11.3 Groundwater

Groundwater strikes during this phase of investigation were recorded in the following trial holes:

Table 7: Groundwater Strikes in Western Area During Addendum Works

Trial Hole	Depth to Groundwater strike mbGL (m AOD)	Stratum	Comments
TP201	1.6 (54.93)	Made ground	Groundwater seepage
TT201	0.6 (55.58)	Made ground	Groundwater seepage
TT203	1.9 (54.32)	Made ground	Groundwater seepage
TT213	1.7 (54.86)	Made ground	Groundwater seepage

During this phase of investigation groundwater seepages were only noted in made ground largely towards the base of the excavation in the majority of the trial hole locations.

Table 8: Groundwater Strikes in Eastern Area During Addendum Works

Trial Hole	Depth to Groundwater strike mbGL (m AOD)	Stratum	Comments
TP202	0.2 (56.34)	Made ground	Groundwater seepage
TP203	1.2 (55.78)	Made ground	Groundwater seepage
TP204	1.4 (57.07)	Made ground	Groundwater seepage
TT205	1.0 (54.78)	At base of made ground	Groundwater seepage
TT206	1.0 (54.87)	Made ground	Groundwater seepage
TT207	1.6 (54.79)	Made ground	Groundwater seepage
TT208	1.4 (54.77)	Made ground	Groundwater seepage
TT209	1.3 (55.64)	At base of made ground	Groundwater seepage
TT210	0.9 (55.95)	Made ground	Groundwater seepage
TT211	1.5 (55.47)	Made ground	Groundwater seepage
TT212	0.65 (55.82)	Made ground	Groundwater seepage

11.4 Visual and Olfactory Evidence of Contamination

Visual and olfactory evidence of contamination noted during the addendum investigation works is summarised in the following table.

Table 9: Summary of Visual and Olfactory Evidence of Contamination

Hole ID	Depth (m)	Olfactory Evidence	Visual Evidence
TP202	0.3	-	Pinkish oily sheen noted at on groundwater surface within trial hole
TT205	1.0-1.2	-	Black stained clay

Non-aqueous phase product (NAPL) or strong hydrocarbon odours were not encountered in any of the trial holes. No elevated PID reading was recorded in any of the samples screened.

11.5 Other Observations

Table 10 below summarises obstructions encountered during this phase of investigation.

Table 10: Summary of obstructions encountered

Hole ID	Depth (m)	Comment
TT207	1.0-1.5	Concrete wall along full northern face of excavation with rebar extruding from the top surface. Aligned east to west.

Tunnels or voids were not encountered during this phase of investigation, however the presence of tunnels or voids across the site cannot be discounted.

D GEO-ENVIRONMENTAL APPRAISAL

12 Testing Strategy

12.1 Soil Sampling

The purpose of the additional intrusive investigation was to target known KDC remediation areas, and other areas of interest as listed in the table below.

Table 11: Soil Sampling Strategy

KDC remediation areas ¹¹	LEAP sampling locations	Comments
US07	TT201	Collection of soil samples from base or side wall of trial hole or where suspected contamination is present. Collection of representative samples of fill material. Selected soil samples to be analysed for TPHCWG and BTEX.
TP16	TT202	
TP40/US18/Metal petrol tank	TT203	
TP37	TT204	
TP30	TP201	
TP28	TT205	
Building 11	TT206	
US25	TT207	
US33	TT208	
Building 42	TT209 & TT210	
US46	TT211	
TP52	TP202	
TP3	TT212	
-	TP203/204	BH101 reported elevated phenol and xylenes in groundwater. Exploratory hole to collect soil samples for further testing to confirm if a soil source is present.
-	TT213	An additional location south of the retained building to provide increased coverage
FDTA	TT214	Collection of soil samples from base or side wall of trial hole or where suspected contamination is present.

¹¹ As per KDC Drawing Ref: KDC/Novartis-Horsham/25 Rev B 'Excavation Plan'

		Selected soil samples to be analysed for TPHCWG and BTEX.
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12.2 Land gas / vapour monitoring

The Phase III land gas investigation strategy was designed generally in accordance with BS8576:2013¹² and the approach described in the Phase III report should be read in conjunction with this report. No new land gas monitoring wells were installed during this phase of the investigation.

The placement of the gas monitoring wells in the previous **LEAP** investigation considered:

- Deep made ground (where identified).
- To provide a general coverage based on a preliminary non-targeted investigation of the land gas risks at the site. To include boundary monitoring of potential off-site sources.

Land gases from natural sources (deep groundwater monitoring) wells were not specifically targeted during previous monitoring rounds, as the Tunbridge Wells Sand Formation was not identified as a gas generating source in the initial CSM. But, due to the initial high flows and raised carbon dioxide identified in BH106 shortly after the well was installed, periodic monitoring at BH106 was included within the initial monitoring programme of works. BH106 has a response zone from 11 m to 20 m bgl. Groundwater level in BH106 typically lies at ~16 m bgl.

During this phase of works high frequency monitoring at BH106 and WS106 was proposed to further refine the CSM. WS106 was located approximately 2 m south of BH106 and has a response zone installed from 1.0 to 2.0 m bgl within a clay layer of weathered Tunbridge Wells Sand.

Periodic check monitoring of the other deep wells has also been undertaken to confirm our conceptual understanding of the gas regime at the site.

Bulk gas and vapour samples were also collected from BH106 and WS106 for laboratory analysis.

12.3 Surface water drainage sampling

¹² BS8576:2013 Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds ()

Based on the Southern Water drainage plans three up gradient and three down gradient manhole chambers were targeted and samples (where water was present) collected for laboratory analysis.

We note that following a meeting on 16/06/21 LEAP was further instructed to sample from accessible manhole chambers south of the site on the Collyer's College playing field and from the Horsham Pond.

The sampling locations are provided as Figure 6 Appendix B. A summary of all attempted sampling locations is provided, below.

Table 12: Summary of drainage sampling locations

Southern Water reference	CCTV survey reference	LEAP sample reference	Comments
0751	-	LWS1	Offsite (upgradient) manhole chamber to northeast of site located in the pavement on Parsonage Road
9854	S1/MHSW25	-	Manhole cover lifted but insufficient water present within chamber to sample.
8750	S2/MHSW26	LWS2	Located northeast of Building 36. Water sample collected.
8657 (possibly)	S7	LWS3	Located c. 80 m southeast of Building 36. No manhole cover was present over the chamber and building rubble was present within the chamber. Water noted as flowing.
-	S21	LWS4	Located c.6 m southeast of LWS3. No manhole cover was present over the chamber and building rubble was present within the chamber. Water noted as flowing.
8652 (possibly)	-	-	Attempted, but failed to lift two manhole covers present along a possible route of the decommissioned drain (as per Southern Water plan). For reference the 2020 GPR survey does not show the route of the chambers extending off site. It implies that the route is northwest to southeast and are not connected to other parts of the Southern Water drainage network.
9557	S19	LWS5	Located c.65 m southeast of WS5
	S11	LWS6	Located on the southern half of the eastern railway embankment
-	-	-	Attempted to lift manhole chamber in northeast of Collyer's College playing field, closest to Horsham Enterprise Park. Cover was rusted shut and not possible to open. GPR survey plan provided by Collyer's College indicates the route of the surface water drains extending offsite from Horsham Enterprise Park, through Collyer's College playing field,
-	-	LWS7	Shallow ditch present in the north of Collyer's College playing field. Water appeared to drain into the manhole chamber located at the south-eastern end of the ditch (which was not possible to open). Water sample collected from ditch.
-	-	LWS8	Manhole chamber at southern end of Collyer's College playing field. Water sample collected.
4251		LWS9	Manhole chamber south of Horsham skatepark. Water sample collected.
-	-	LWS10	Manhole chamber north of Horsham Pond. Not marked on the Southern Water plans, inlets and outlets aligned approximately east to west. Water sample collected.
-	-	LWS11	Horsham Pond. Water sample collected.

12.4 Groundwater monitoring

Water level data loggers have been installed in BH106 and WS106 during this investigation to inform the land gas risk assessment. Water levels have also been recorded during periodic land gas monitoring elsewhere. No further groundwater sampling and laboratory analysis was undertaken during this phase of the investigation. The monitoring results are provided in Appendix G and presented on Figure 7.

13 Assessment Criteria

13.1 Human Health Assessment Criteria

The generic quantitative risk assessment (GQRA) for human health compares the analytical results from the current investigation to Generic Assessment Criteria (GAC). These were selected using the following rationale and assumptions.

Defra and the EA have published a limited number of Soil Guideline Values (SGVs)¹³ that represent minimal chronic risk to human health. CL:AIRE has published a limited number of Category Four Screening Levels (C4SLs)¹⁴ which represent a low but still strongly precautionary level of chronic risk to human health. Both the SGVs and C4SLs have both been derived for a Soil Organic Matter (SOM) content of 6%, which is not always representative of the low SOM that are encountered within Made Ground on brownfield sites.

LQM responded to the demand for a more comprehensive set of screening values for a wider range of SOM and produced Suitable for Use Levels (S4ULs)¹⁵ which are a hybrid of SGVs and C4SLs. The S4ULs have been endorsed by the Chartered Institute of Environmental Health (CIEH).

LEAP uses C4SLs where they are available as generic assessment criteria to quantitatively assess the potential chronic risks to human health. Where C4SLs are not available, the S4ULs are used. It is noted that S4ULs are not equivalent to C4SLs in all their exposure assumptions but are generally more conservative in their assumptions. For benzene and benzo(a)pyrene, LEAP has calculated equivalent C4SLs for 1% and 2.5% SOM. This does not affect the inorganic contaminants.

¹³ Environment Agency Science Report SC050021 series.

¹⁴ CL:AIRE Final Project Report. SPI010 – Development of Category 4 Screening Levels for assessment of land affected by contamination. CL:AIRE, December 2013

¹⁵ The LQM/CIEH S4ULs for Human Health Risk Assessment, Nathaniel P et al, 2015. Copyright Land Quality Management Ltd, reproduced with permission: Publication Number S4UL3509

In accordance with current Public Health England (PHE) guidance¹⁶, the assessment of PAHs has been carried out using a surrogate marker approach, whereby the assessment of risk from benzo(a)pyrene also captures potential risks from other carcinogenic PAHs that may be present. The alternative S4ULs for PAHs using the Toxic Equivalent Factor (TEF) approach have not been used because this approach is likely to under predict the true carcinogenicity of PAHs and is not advocated by PHE. The threshold PAHs have been assessed similarly, by using naphthalene as a marker compound due to its high volatility relative to other PAHs.

Sets of GACs have been generated for SOMs of 1%, 2.5% and 6%. Previous laboratory testing of TOC in the Made Ground samples that were analysed averaged 1.6%. Using the conversion of $SOM = TOC \times 1.72$, this equates to a SOM of around 2.7% therefore 2.5% SOM was considered to be appropriate to maintain conservatism.

Whilst the details of the development proposals are not yet finalised, it is clear from the outline proposals that part of the site, mostly likely the western side, will include low rise residential development with private gardens and apartment blocks and the eastern side will be a commercial land use. Soil data will be initially screened against residential with homegrown produce generic assessment criteria (GAC) to maintain conservatism for the outline development. Where potential contaminants are identified at concentrations above this GAC in samples collected from the proposed commercial areas the results will also be compared to commercial land use GACs as an informative.

13.2 Land Gas Assessment Methodology

An assessment has been made using the method outlined in BS8485:2015+A1:2019. This includes the derivation of gas screening values (GSV) for both carbon dioxide and methane.

A GSV is assigned to the site / zone in conjunction with the conceptual site model and typical gassing levels associated with the identified source to characterise the gassing regime. The GSV is made on an assessment of all data available and based on the CSM.

We note that at this stage building designs plans have not been made available, as such proposed foundation designs, floor space areas, cut / fill assumptions are not known. These influence the outcome of the assessment and the type of design measures that may be required.

¹⁶ HPA Contaminated Land Information Sheet. Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs). Public Health England, 2017.

For the purpose of this assessment, we have assumed that the buildings in the western residential area will be Type A structures and in the eastern commercial area the buildings will be Type D structures, as detailed in Table 3 of BS8485:2015+A1:2019.

We assume that residential structures will be founded on competent natural ground at 2.0 m bgl. The properties will include a well ventilated sub-floor void. The residential properties do not include basement structures.

We assume that new commercial structures will be founded on a CFA piled solution with a reinforced cast *insitu* suspended floor slab with minimal penetrations. The new commercial buildings do not include basement structures.

When the foundation design is known the land gas risk assessment should be reviewed by a competent environmental consultant to check that the assumptions contained herein are aligned with the detailed design plans.

13.3 Vapour Assessment Methodology

If volatile organic compounds are detected at concentrations above analytical limits of detection in the laboratory testing a quantitative assessment will be undertaken to determine the potential significance to future land users. Results detected above analytical detection limits will be screened against tolerable indoor air concentrations ($TAC_{\text{indoor_air}}$). $TAC_{\text{indoor_air}}$ are concentrations at which volatile vapours are considered not to pose a significant risk of harm to end-users in an indoor space. The comparison of measured VOCs against $TAC_{\text{indoor_air}}$ is a conservative assessment as it does not assume attenuation between the source and indoor air space.

Tolerable indoor air concentrations ($TAC_{\text{indoor_air}}$) have been calculated using the inhalation Health Criteria Values (HCV) and adult inhalation Mean Daily Intakes (MDI) used by SoBRA to calculate groundwater inhalation Generic Assessment Criteria (GAC).

The CLEA generic residential land use scenario was considered to be an appropriately conservative scenario. As such, the inhalation HCV were converted from $\mu\text{gkg}^{-1} \text{ BW day}^{-1}$ to $\mu\text{g day}^{-1}$ by multiplying the HCV by 13.3 kg, which is the average body weight for a female across CLEA Age Classes AC1 to AC6 in the CLEA Software v1.071. The inhalation MDI for female children AC1 to AC6 was calculated by first determining the conversion factor of the inhalation rate for each Age Class from an adult inhalation rate of 20 m^3 , as described in Table 3.4 of SR2. The average conversion factor across the six Age Classes was then applied to the adult inhalation MDI to calculate an average female child inhalation MDI for AC1 to AC6. The child inhalation rates selected were the updated ones used in the C4SL programme and also by SoBRA to calculate the groundwater inhalation GAC. The values are provided as a standard option in the CLEA Software v1.071.

The average daily exposure (ADE) was calculated as described in SR2. The MDI was subtracted from the HCV where it was threshold tolerable daily intake (TDI), unless the MDI was $\geq 50\%$ TDI, in which case the ADE was set at 50% of the TDI. For non-threshold effects, the MDI was not subtracted i.e. HCV=ADE.

Finally, the ADE was converted to an indoor air GAC. The ADE was divided by the average inhalation rate across AC1 to AC6 ($8.767 \text{ m}^3\text{day}^{-1}$) and converted for the daily building occupation period for the CLEA generic residential land use scenario (the average of 23 hours per day for AC1 to AC4 and 19 hours per day for AC5 and AC6) i.e. multiplied by the average indoor occupation period (1.108) in a day.

It may not be possible to calculate tolerable indoor air concentrations ($\text{TAC}_{\text{indoor_air}}$) for all contaminants at concentrations above analytical limits of detection due limited peer-reviewed UK data for some volatile organic compounds. Where appropriate, surrogate $\text{TAC}_{\text{indoor_air}}$ values have been used as an alternative.

A direct comparison of volatile hydrocarbons with $\text{TAC}_{\text{indoor_air}}$ with measured vapour concentrations is taken as a preliminary screening exercise. Where compounds exceed $\text{TAC}_{\text{indoor_air}}$ a second assessment has been undertaken using Equations 10.1 10.4, 10.5 and 10.6 of SC050021/SR3 (listed below) to estimate indoor air concentrations (C_{air}), based on measured vapour concentrations (C_{vap}). Input parameters are provided in Appendix H. The 'predicted' indoor air concentrations will be compared to $\text{TAC}_{\text{indoor_air}}$, if predicted concentrations exceed $\text{TAC}_{\text{indoor_air}}$ then a potential hazard exists. This assumes that measured vapours are from a soil source, as no groundwater sources of TPH/BTEX were identified at BH106/WS106. The modelled numbers follow CLEA default parameters that assume a semi-detached house with the depth from base of floor slab to source is 0.50 m and the soil type is a silty clay. Note that in Equation 10.6 units have been converted to $\mu\text{g m}^{-3}$

Equation 10.1

$$D_{\text{eff}} = D_{\text{air}} \frac{\theta_a^{3.33}}{\theta_T^2} + D_{\text{water}} \frac{\theta_w^{3.33}}{K_{aw} \theta_T^2} \times 10000 \text{ cm}^2 \text{ m}^{-2}$$

Where: D_{eff} is the effective chemical diffusion coefficient in soil, $\text{cm}^2 \text{ s}^{-1}$
 D_{air} is the diffusion coefficient in air at ambient temperature, $\text{m}^2 \text{ s}^{-1}$
 D_{water} is the diffusion coefficient in water at ambient temperature, $\text{m}^2 \text{ s}^{-1}$
 θ_a is the air-filled soil porosity, $\text{cm}^3 \text{ cm}^{-3}$
 θ_w is the water-filled soil porosity, $\text{cm}^3 \text{ cm}^{-3}$
 θ_T is the total air- and water-filled soil porosity, $\text{cm}^3 \text{ cm}^{-3}$
 K_{aw} is the air-water partition coefficient at ambient temperature, $\text{cm}^3 \text{ cm}^{-3}$

Equation 10.4

$$\alpha = \frac{\left[\left(\frac{D_{eff} A_B}{Q_b L_T} \right) \exp \left(\frac{Q_s L_{crack}}{D_{crack} A_{crack}} \right) \right]}{\left[\exp \left(\frac{Q_s L_{crack}}{D_{crack} A_{crack}} \right) + \left(\frac{D_{eff} A_B}{Q_b L_T} \right) + \left(\frac{D_{eff} A_B}{Q_s L_T} \right) \left[\exp \left(\frac{Q_s L_{crack}}{D_{crack} A_{crack}} \right) - 1 \right] \right]}$$

Where: α is the steady-state attenuation coefficient between soil and indoor air, dimensionless
 D_{eff} is the effective diffusion coefficient for unsaturated soils, $\text{cm}^2 \text{s}^{-1}$
 A_B is the area of enclosed floor and walls below ground, cm^2
 Q_b is the building ventilation rate, $\text{cm}^3 \text{s}^{-1}$
 L_T is the source-building separation, cm
 Q_s is the volumetric flow rate of soil gas into the enclosed space, $\text{cm}^3 \text{s}^{-1}$ [25 to 150]
 L_{crack} is the foundation slab thickness, cm
 A_{crack} is the floor crack area, cm^2
 D_{crack} is the effective diffusion coefficient through the cracks, $\text{cm}^2 \text{s}^{-1}$ [= D_{eff}]
 Note: Appendix 1, Equation A10 where the Peclet number approaches infinity

Equation 10.5

$$Q_b = (H \times A_{foot} \times Ex) \times 1000000 \text{ cm}^3 \text{ m}^{-3} \times \frac{1}{3600} \text{ s hr}^{-1}$$

Where: Q_b is the building ventilation rate, $\text{cm}^3 \text{s}^{-1}$
 H is height of living space, m
 A_{foot} is the building footprint, m^2
 Ex is the building air exchange rate, hour^{-1}

Equation 10.6

$$C_{air} = \alpha C_{vap} \times 1000000 \text{ cm}^3 \text{ m}^{-3}$$

Where: C_{air} is the indoor air concentration, mg m^{-3}
 α is steady-state attenuation coefficient between soil and indoor air, dimensionless
 C_{vap} is the soil vapour concentration, mg cm^{-3}

13.4 Surface Water Assessment Methodology

The generic controlled waters risk assessment was conducted in accordance with the principles of EA '*Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination*' 2006 (EA 2006) and the 'prevent and limit' approach of the Water Framework Directive (2000/60/EC). Generic controlled waters risk assessments compare directly measured concentrations with standard assessment criteria.

Appropriate Water Quality Standards (WQS) are selected based on both a hierarchy of relevance to England and Wales and the receptor. In this case, the Horsham Pond located

approximately 800 m is an offsite receptor, if a preferential pathway via onsite drains is active and so the following hierarchy of WQS were considered to be appropriate:

Surface Water

- Environmental Quality Standards (EQS) from The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

The metal-bioavailability tool (MBAT) has been used to calculate site specific predicted no effect concentration (PNEC) for the Horsham Pond, based on measured pH, dissolved organic carbon and dissolved calcium concentrations at the Horsham pond using pH = 7.1, DOC = 11 mg/l and calcium = 61 mg/l.

Benzo(a)pyrene has been adopted as a surrogate marker compounds for polycyclic aromatic hydrocarbons, as per Environment Agency guidance¹⁷.

In the case of petroleum hydrocarbons, no current UK standard is available, so an initial assessment criterion of 10µg/l, based on the former target concentration for dissolved or emulsified hydrocarbons, is considered to represent a conservative tier 1 screening value for total petroleum hydrocarbons.

14 Analytical Test Results – Soils

14.1 Metals and Non Metals

Only samples collected from TT205 at 1.1 m and TP202 at 0.8 m were tested for metals and non-metals on the basis of discoloured soils and oil sheen. None of the contaminants tested recorded concentrations above generic assessment criteria for a residential with homegrown produce land use.

14.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Only samples collected from TT205 at 1.1 m and TP202 at 0.8 m were tested for PAHs, in these two samples benzo(a)pyrene and naphthalene were recorded at concentrations below the generic assessment criteria for residential with homegrown produce land use.

14.3 Petroleum Hydrocarbons (PHC)

¹⁷ Freshwater priority hazardous substances, priority substances and other pollutants excel spreadsheet downloaded from <https://www.gov.uk/guidance> dated 04/06/21

Eighteen soil samples were tested for speciated petroleum hydrocarbons (CWG-TPH), benzene, toluene, ethylbenzene, xylenes (BTEX) and methyl tert-butyl ether.

In the samples tested none of the contaminants tested were recorded at concentrations above generic assessment criteria for residential with homegrown produce land use.

The highest concentrations of PHC were recorded in two locations, namely in TT213 at 1.5 m bgl where total TPH was recorded at 465 mg/kg and in TP204 at 2.8 m bgl where total PHC was recorded at 833 mg/kg. TT213 was located to the south of Building 3 in the vicinity of Building 7, the former water treatment / substation building. TP204 is located south of BH101 in the former firewater runoff storage tank area.

BTEX compounds were only detected above analytical detection limits in the sample collected from TP204 at 2.8 m bgl. Ethylbenzene was recorded at 0.0372 mg/kg compared to the GAC of 110 mg/kg and total xylenes were recorded at 0.268 mg/kg compared to the GAC of 130 mg/kg.

14.4 Phenols

Speciated phenols were tested in two samples collected from an area of ground associated with former firewater runoff storage tank. No speciated phenols were detected at concentrations above analytical detection limits.

14.5 Asbestos

Soil samples from TT205 and TP202 were screened for asbestos containing materials / loose fibres. Asbestos fragments or fibres were not detected in the samples. Suspected asbestos containing materials were not observed in any of the trial hole locations during this phase of investigation.

15 Drains /Surface Water Sampling Results

The results of the laboratory analysis for samples collected from the surface sampling locations are summarised in Table 13, below. Laboratory test certificates are provided in Appendix F.

Table 13: Summary of Water Samples that Exceeded UK EQS

Determinant (Total, unless otherwise specified)	Measured Range	Annual Average Environmental Quality Standard	Samples that exceed assessment criterion
Chromium (total)	<5 -40 µg/l	3.4 µg/l	LWS1 11 µg/l LWS2 31 µg/l LWS3 40 µg/l LWS4 23 µg/l

Zinc	<5-46 µg/l	39 µg/l (PNEC)	LWS6 46 µg/l
pH	6.6-11.3	6-9	LWS2 9.4 LWS3 10.1 LWS4 11.3
Benzo(a)pyrene	<0.01 to 3.02 µg/l	0.00017 µg/l	LWS1 0.44 µg/l LWS2 3.02 µg/l LWS3 0.22 µg/l LWS4 1.36 µg/l LWS5 0.02 µg/l LWS7 0.02 µg/l LWS11 2.58 µg/l
>C10-C12 Ali TPH	<5 – 38.9 µg/l	-	LWS2 12.2 µg/l LWS11 38.9 µg/l
>C12-C16 Ali TPH	<5-172 µg/l	-	LWS2 31.3 µg/l LWS7 8.2 µg/l LWS11 172 µg/l
>C16-C21 Ali TPH	<5-235 µg/l	-	LWS2 56.8 µg/l LWS8 5.1 µg/l LWS11 235 µg/l
>C21-C35 Ali TPH	<5-712 µg/l	-	LWS2 481 µg/l LWS8 87.7 µg/l LWS10 15.6 µg/l LWS11 712 µg/l
>C35-C40 Ali TPH	<5-124 µg/l	-	LWS2 55.2 µg/l LWS8 13.2 µg/l LWS11 124 µg/l
>C7-C8 Aro TPH	<1-1.30 µg/l	-	LWS9 1.3 µg/l
>C10-C12 Aro TPH	<5-23.9 µg/l	-	LWS2 13.7 µg/l LWS11 23.9 µg/l
>C12-C16 Aro TPH	<5-126 µg/l	-	LWS2 28.1 µg/l LWS7 7.1 µg/l LWS11 126 µg/l
>C16-C21 Aro TPH	<5-228 µg/l	-	LWS2 62.4 µg/l LWS4 5.7 µg/l LWS9 5.1 µg/l LWS11 228 µg/l
>C21-C35 Aro TPH	<5-765 µg/l	-	LWS1 29.6 µg/l LWS2 656 µg/l LWS4 81.8 µg/l LWS11 765 µg/l
>C35-C40 Aro TPH	<5-224 µg/l	-	LWS2 199 µg/l LWS4 40.6 µg/l LWS11 224 µg/l

The drain and surface water sampling identified total chromium at concentrations above the UK EQS screening value for chromium VI, in three locations on site and one upgradient off site location. All off site sampling points did not record elevated concentrations above UK EQS. We note that chromium VI was also analysed, but the analytical limit of detection (100µg/l) was above screening criteria. In all samples tested chromium VI was not detected above LoD.

Zinc was detected at concentrations above site specific predicted no effect concentration (PNEC) for the Horsham Pond in one sample only, at LWS6, located on the eastern railway embankment. No offsite sampling locations exceeded the PNEC.

Alkaline pH readings outside of the UK EQS acceptable range limits were identified in three locations on site, namely LWS2, LWS3 and LWS4. LWS2 is located upgradient of a blocked section of the north to south surface water drain and manhole covers were missing on LWS3 and LWS4.

Benzo(a)pyrene (used as a marker for other PAHs) is above analytical detection limits in all on site sampling locations, with the exception of LWS6, located on the eastern railway embankment. The highest concentrations were recorded in LWS2 (3.02µg/l) and LWS4 (1.36 µg/l). LWS2 is upgradient of a blocked section of the north to south surface water drain and LWS4 appears to be a redundant chamber that connects into the surface water drain. The upgradient sampling point LWS1 records benzo(a)pyrene at 0.44µg/l. Offsite the drainage ditch to the north of the Collyer's College playing field records benzo(a)pyrene at marginally above analytical detection limits (0.02 µg/l compared with 0.01 µg/l). All other down gradient monitoring points record benzo(a)pyrene at concentrations at less than analytical detections limits, with the exception of the Horsham Pond, where benzo(a)pyrene is at 2.58µg/l.

With respect to PHC, aliphatic and aromatic fractions are most commonly detected at concentrations above analytical detection limits in LWS2 (up gradient of a blocked section of the drain) and in LWS11, the Horsham Pond. The Horsham Pond records the highest concentrations of TPH aliphatic / aromatic fractions out of all sampling locations. The offsite, downgradient sampling locations (LWS7-LWS10) record aliphatic / aromatic fractions slightly above analytical detection limits, with the exception of LWS8, at the southern end of the Collyer's College playing field where 87.7 µg/l >C21-C35 Aliphatic TPH was recorded. Sampling locations further down gradient of LWS8 (excluding the pond) do not detect >C21-C35 or only at concentrations marginally above LoD.

16 Land Gas Monitoring Results

16.1.1 Periodic Monitoring

Full gas monitoring results are summarised in Table 14. Field records are provided as Appendix I.

Table 14: Summary of Periodic Land Gas Monitoring

Monitoring Visit Date / Location Ref.	Target Strata (m)	Maximum Recorded Concentrations*							
		CO ₂ (%)	CH ₄ (%)	CO (%)	O ₂ (%)	VOC peak (ppm)	Peak Flow rate (l/hr)	Atmospheric Pressure (mB)	Was RZ flooded ?
WS102	1.0-2.0 TWS								
08/02/21		0.9	0.1	0	16.0	1.2	-1.7	996	Yes
22/02/21		0.1	0.1	0	20.5	0.7	0	1013	Yes
08/03/21		1.1	0.1	2	19.7	0.4	0	1025	Partially
15/03/21		0.2	0.2	0	20.8	n.m.	0.03	1017	Partially
22/03/21		0.7	0.2	0	20.2	n.m.	0	1024	Partially
06/04/21		2.0	0	0	20.2	0.1	0	1017	No
WS103	1.0-2.0 MG/TWS								
08/02/21		0.1	0	21	20.3	0	0.1	1008	Yes
22/02/21		0.1	0.1	9	20.8	1.1	-2.3	1013	Yes
08/03/21		0	0	1	21.0	0.8	-3.0	1022	Yes
15/03/21		0	0.1	1	20.9	n.m.	0.1	1017	Yes
22/03/21		0.1	0.1	7	20.0	n.m.	13.7	1024	Yes
06/04/21		0	0.1	15	19.8	5.3	0.0	1017	Partially
16/04/21		0.8	0.0	-10	20.1	n.m.	0.60	1025	No
18/06/21		0.0	0.2	11	14.4	0.9	0.9	1006	Yes
24/06/21		0.0	0.3	0	21.2	0	1.5 (0.6)	1015	Yes
WS105	1.0-1.9 TWS								
08/02/21		n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
22/02/21		8.6	0.1	4	18.3	3.9	-2.7	1013	Yes
08/03/21		0.6	0.1	0	21.1	1.0	0	1020	Yes
15/03/21		0.1	0.1	0	21.2	n.m.	0	1017	Yes
22/03/21		0.1	0.2	0	21.2	n.m.	0	1022	Yes
06/04/21		4.8	0.2	0	19.0	1.1	0	1017	Yes
WS106	1.0-2.0 TWS								
08/02/21		0.9	0.1	0	16.0	0	0	1009	Yes
22/02/21		0.6	0.5	0	16.2	1.2	-5.7	1013	Yes
08/03/21		1.7	0.4	0	15.3	0	0.1	1022	Partially
15/03/21		0.7	0.4	0	15.3	n.m.	3.8	1017	Partially
22/03/21		0.8	0.3	0	14.5	n.m.	0	1017	Partially
06/04/21		0.7	0.1	0	13.6	0.8	0	1017	Partially

Monitoring Visit Date / Location Ref.	Target Strata (m)	Maximum Recorded Concentrations*							
		CO ₂ (%)	CH ₄ (%)	CO (%)	O ₂ (%)	VOC peak (ppm)	Peak Flow rate (l/hr)	Atmospheric Pressure (mB)	Was RZ flooded ?
16/04/21		0.7	0.0	0	16.5	n.m.	0	1025	Partially
12/05/21		Gasflux installed 12/05/21 to 25/06/21							
WS108									
08/02/21	1.0-3.0 TWS	0.9	0.1	11	20.0	1.8	-5.1 (0.0)	997	Yes
22/02/21		1.5	0.1	1	19.7	1.5	0	1014	Yes
08/03/21		2.4	0.1	0	20.5	1.2	-0.2	1021	Yes
15/03/21		0.2	0.2	0	20.9	n.m.	0	1017	Yes
22/03/21		3.0	0.1	0	20.8	n.m.	4.1 (0.0)	1022	Yes
06/04/21		1.6	0.1	0	19.5	0.8	2.0 (0.0)	1017	Partially
WS109									
08/02/21	1.0-3.0 TWS	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
22/02/21		0.2	0.3	0	20.4	4.5	0	1013	Yes
08/03/21		0.5	0.1	0	21.1	0.1	0	1021	Yes
15/03/21		0.5	0.2	0	20.5	n.m.	0	1017	Yes
22/03/21		0.1	0.2	0	20.6	n.m.	0	1022	Partially
06/04/21		0.3	0.1	0	21.0	0.3	0	1017	Yes
WS111									
08/02/21	0.5-1.5 MG	0	0	0	14.8	0.8	0.4	1001	Yes
22/02/21		0.1	0.1	0	20.3	0.6	-0.1	1013	Partially
08/03/21		0.1	0.1	0	20.7	0.3	0	1021	No
15/03/21		0	0.1	1	20.8	n.m.	0	1016	No
22/03/21		0	0.2	0	20.8	n.m.	0	1022	No
06/04/21		0	0.1	0	21.1	0.6	0	1017	No
WS113									
08/02/21	0.9-1.9 TWS	0.1	0.1	3	20.5	3.1	0.8	1000	Yes
22/02/21		0.1	0.2	0	20.8	4.8	0	1013	Yes
08/03/21		0	0.1	0	20.7	2.5	0	1021	Partially
15/03/21		0	0.2	0	20.4	n.m.	0	1016	Partially
22/03/21		0	0.2	0	20.4	n.m.	0	1022	Partially
06/04/21		0.1	0.1	0	20.5	2.4	0	1022	No
WS115	1.0-2.0								

Monitoring Visit Date / Location Ref.	Target Strata (m)	Maximum Recorded Concentrations*							
		CO ₂ (%)	CH ₄ (%)	CO (%)	O ₂ (%)	VOC peak (ppm)	Peak Flow rate (l/hr)	Atmospheric Pressure (mB)	Was RZ flooded ?
08/02/21	TWS	0	0	0	16.2	0.8	17.7 (0.0)	1001	Yes
22/02/21		n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	1013	Yes
08/03/21		0.1	0	0	21.3	0.2	-0.1	1020	Partially
15/03/21		0	0.2	0	21.3	n.m.	-0.1	1016	Yes
22/03/21		0	0.2	0	16.5	n.m.	10.1 (0.0)	1022	Yes
06/04/21		0	0.1	3	17.9	1.2	0	1017	Yes
WS116	0.5-1.5 MG/TWS	0.7	0	0	16.1	0.1	-1.1	995	Yes
08/02/21		0	0.2	0	21.1	0.6	-0.1	1013	Yes
22/02/21		0.1	0	0	21.1	1.1	-0.1	1021	Yes
08/03/21		0	0.1	0	21.1	n.m.	0	1016	Yes
15/03/21		0	0.2	1	20.8	n.m.	0	1023	Yes
22/03/21		0	0.1	1	21.2	3.2	0	1016	Yes
06/04/21	0.5-1.5 SS/TWS	0.1	0	0	2.6	0.8	66.6 (1.5)	996	Yes
WS118		1.7	0.1	0	20.8	1.2	0	1012	Yes
08/02/21		1.6	0	0	19.3	0.2	0	1022	Yes
22/02/21		0.4	0.2	1	21.0	n.m.	0.5 (0.0)	1016	Yes
08/03/21		1.4	0	0	19.3	n.m.	0	1024	Yes
15/03/21		3.6	0.1	0	13.2	0.4	0	1016	Yes
22/03/21	1.0-2.0 MG	0	0	0	16.2	3.1	0.3 (0.1)	1000	Yes
06/04/21		0.1	0.2	0	21.0	0.4	0	1013	Partially
18/06/21		0.1	0.1	0	21.2	1.4	0	1021	Partially
24/06/21		0	0.2	1	20.8	n.m.	0	1016	Partially
BH101S		0	0.2	0	20.8	n.m.	0	1022	Partially
08/02/21		0	0.1	0	19.7	5.4	0	1022	Partially
22/02/21		0	0.2	1	20.9	2	0	1006	Partially
08/03/21		0	0.3	1	20.8	1.3 (0.8)	0	1015	Partially
15/03/21	8-14 TWS	0.3	0.2	0	21	0	0	1004	Partially
22/03/21									

Monitoring Visit Date / Location Ref.	Target Strata (m)	Maximum Recorded Concentrations*							
		CO ₂ (%)	CH ₄ (%)	CO (%)	O ₂ (%)	VOC peak (ppm)	Peak Flow rate (l/hr)	Atmospheric Pressure (mB)	Was RZ flooded ?
25/05/21		0.0	0.1	6	18.8	0	0	1011	Partially
18/06/21		0.0	0.2	5 (1)	17.1	0	0	1006	Partially
24/06/21		0.0	0.2	17(2)	17.8	2.7	0	1015	Partially
BH102	17.5-20.5 TWS	0.3	0.2	0	18.8	0.2	0.1	1003	Yes
12/05/21		0.2	0.2	1	6.2	0	-4.6	1011	Yes
25/05/21		1.4	0.3	1	4.6	13.2	0.0	1006	Yes
18/06/21		0.4	0.4	2	5.5	9.3	5.0(4.0)	1015	Yes
24/06/21	1.0-2.0 MG/TWS	0.1	0.1	0	16.0	1.2	-0.1	996	Yes
BH103S		0.1	0.1	0	21.1	1.7	-0.1	1013	Yes
08/02/21		1.2	0.1	0	15.6	0.6	0	1020	No
22/02/21		0.2	0.2	0	20.3	n.m.	0	1016	Partially
08/03/21		1.0	0.2	0	14.9	n.m.	0	1023	Partially
15/03/21		0.9	0.2	0	17.6	3.2	0	1016	Partially
22/03/21	17-20 TWS	0.4	0.1	2	20.4	0.6	0.0	1003	Yes
06/04/21		0.4	0.1	0	20.3	0	0.0	1012	Yes
BH103D		0.6	0.2	1	19.2	8.6	0.0	1006	Yes
12/05/21		0.4	0.2	1	19.5	0.2	0.0	1015	Yes
25/05/21	10-16 TWS	3.7	0.1	0	7.2	0	0	1004	Partially
18/06/21		3.6	0.2	0	1.8	0	0	1012	Partially
24/06/21		4.3	0.4	1	0.3	0.5	2.0 (1.5)	1006	Partially
BH104		3.9	0.4	1	1.5	1.1	0.2	1015	Partially
BH105	10-16 TWS	6.1	0.1	1	19.8	0	0	1005	Partially
12/05/21		0.1	0.1	0	1.9	0	-4.0	1012	Partially
25/05/21		0.0	0.4	1	0.3	4.2 (3.7)	1.5 (0.9)	1006	Partially
18/06/21		0.0	0.4	2	1.3	4.2	3.5(2.4)	1015	Partially
24/06/21									

Monitoring Visit Date / Location Ref.	Target Strata (m)	Maximum Recorded Concentrations*							
		CO ₂ (%)	CH ₄ (%)	CO (%)	O ₂ (%)	VOC peak (ppm)	Peak Flow rate (l/hr)	Atmospheric Pressure (mB)	Was RZ flooded ?
BH106	11.3-20.3 TWS	13.6	0.0	0	1.0	n.m.	104	984	n.m.
19/01/21		n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m..
08/02/21		0.1	0.1	0	21.2	0.3	5.7	1014	Partially
22/02/21		7.9	0	9	10.4	0.4	3.8	1022	Partially
08/03/21		0	0.1	0	21.2	n.m.	3.4	1022	Partially
15/03/21		0	0.1	0	20.8	n.m.	3.6	1024	Partially
22/03/21		8.1	0.1	32	10.1	0.5	2.8	1016	Partially
06/04/21		0.0	0.0	-10	20.5	n.m.	52 (7.2)	1025	Partially
16/04/21		GasfluX installed 12/05/21 to 25/06/21							

* With the exception of Oxygen which is recorded as minimum; n.m. – not measured; Values in bracket steady state readings; MG = Made Ground; TWS = Tunbridge Wells Sand Formation; SS = Sub soil

Table 15: Atmospheric Pressure Trends During Monitoring Period

Monitoring Visit Date	Atmospheric Pressure Trend on date of monitoring^
19/01/21	Rapid fall to a low on 21/01/21
08/02/21	Low, but rising after 09/02/21
22/02/21	Rising from a low on 20/02/21
08/03/21	Falling to a low on 11/03/21
15/03/21	High
22/03/21	Gradual fall to low on 26/03/21
06/04/21	Gradual rise from a low on 05/04/21
16/04/21	Falling from a high on 16/04/21
12/05/21**	Falling to low on 13/05/21
25/05/21**	Rising to high on 30/05/21
18/06/21**	High, falling to low on 20/06/21
24/06/21**	Falling from a high on 23/06/21

^ <https://www.weatheronline.co.uk> for Gatwick Airport ** from GasfluX units

Carbon dioxide concentrations in the shallow monitoring wells (WS102, WS103, WS105, WS106, WS108, WS109, WS111, WS113, WS115, WS116, WS118, BH101S and BH103S) varied between 0% to 8.6% across all monitoring rounds. The highest carbon dioxide concentrations were recorded in shallow wells within the weathered upper extents of the Tunbridge Wells Sand Formation, namely WS105 (8.6%), WS118 (3.6%), WS108 (3.0%). WS105 and WS118 were located in the western area (proposed residential). Wells screened within made ground recorded carbon dioxide concentrations ranging from 1.2% (BH103S) to 0.1% (BH101S,

WS111). Elevated concentrations of methane were not detected in the shallow monitoring wells, with typically values ranging from 0.1% to 0.2%. The highest methane concentration was detected in WS106 at 0.5%, which is screened within the upper extents of the Tunbridge Wells Sand Formation in the western half of the site.

The response zones of most of the shallow monitoring wells were fully or partially flooded during the early part of the monitoring period (08/02/21 to 15/03/21), but by the end of the first phase of monitoring (06/04/21) fewer wells were fully flooded.

Borehole flow rates in the shallow monitoring wells ranged from -5.7l/hr to 66.6 l/hr. These maximum values (positive and negative flow rates) were associated with flooded response zones. Excluding flows from flooded shallow wells the peak flows ranged from -0.1l/hr to 3.8l/hr. The maximum positive flow rate was recorded in WS106 on 15/03/21.

BH101D, BH102, BJH103D, BH104 to BH106 were intended for groundwater level monitoring and sampling within the deep aquifer of the Tunbridge Wells Sand Formation. However, as positive, and elevated flow rates of carbon dioxide were reported in BH106 in January 2021, this location was included in the first phase of land gas monitoring (08/02/21 to 06/04/21). The remaining deep wells were also monitored on four occasions during the second phase of gas monitoring (12/05/21 to 25/06/21).

In the deep wells, with the exception of BH106, typically low or slightly elevated concentrations of carbon dioxide were reported ranging from 0.0 to 6.1%. Excluding BH106, the highest carbon dioxide concentration of 6.1% was reported in BH105 on 12/05/21. Methane concentrations across all deep monitoring wells ranged from 0.3% to 0.1%.

Excluding BH106 flow rates ranged from -4.6l/hr to 0 l/hr. A negative flow rate was reported in BH102 on 25/05/21 and the response zone was flooded. BH105 also reported a negative flow rate of -4l/hr on 25/05/21, but this reduced to -0.4l/hr after 240 seconds. This monitoring event coincided with rising atmospheric pressure.

In BH106, seven days after the monitoring well was installed gas was observed bubbling through the ground, within the raised cover, which was flooded at surface. A gas reading of 13.6% carbon dioxide and a flow rate of 104 l/hr was recorded at BH106 on 19/01/21. Methane was not recorded, oxygen was at low concentrations. The bubbling of gases through groundwater was observed to have ceased after about one week. During periodic monitoring, steady state flow rates ranged from 3.4 l/hr to 7.2 l/hr, with the exception of an initial peak in BH106 of 52 l/hr reducing to 7.2 l/hr after 15 seconds on 16/04/21. Carbon dioxide concentrations ranged from 0.0% to 8.1% during this period.

Continuous gas monitoring devices were installed at BH106 and WS106 to better characterise the gas regime at BH106. The results are discussed below.

16.1.2 Continuous Gas Monitoring

Continuous gas monitoring at BH106 and WS106 occurred for a six week period from 12/05/21 to 25/06/21. Summary data for bulk gases (carbon dioxide, methane, oxygen), flow rates and

atmospheric pressure are provided in Charts 1 and 2, below. Data collected by the Gasflux units is provided in Appendix G.

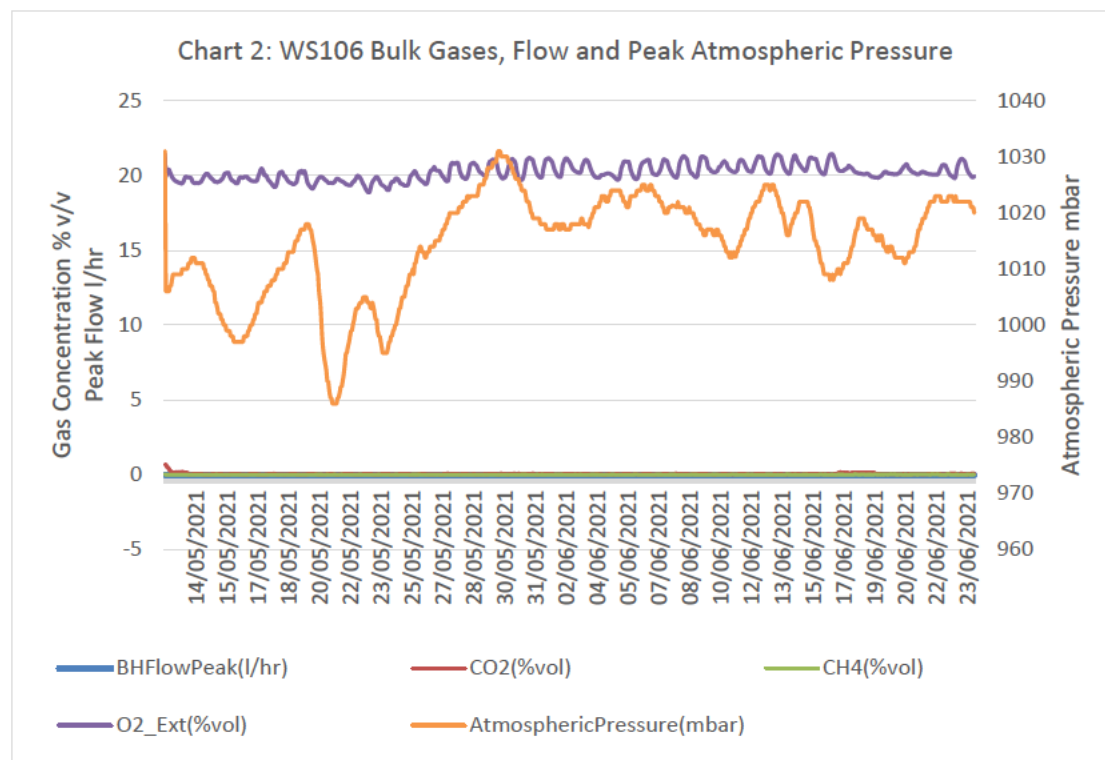
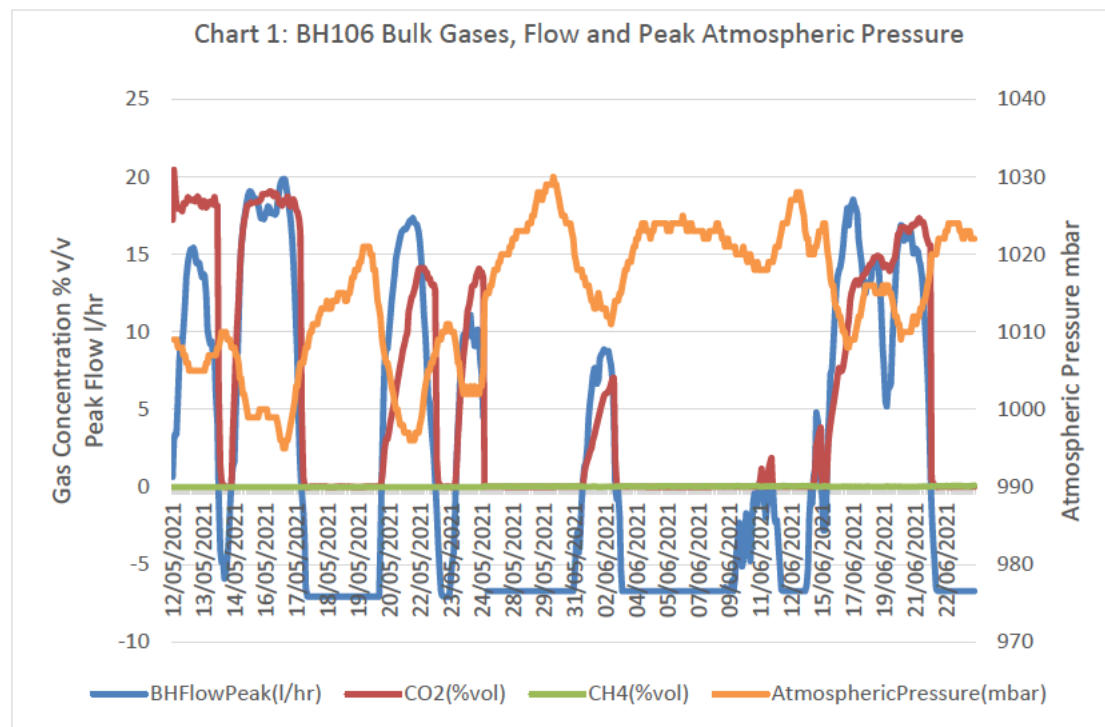


Chart 1 for BH106 shows that carbon dioxide, oxygen and flow rates are extremely responsive to changes in atmospheric pressure. During falling pressure conditions or when atmospheric pressure is below ~1002 mB flow rates and carbon dioxide concentrations increase rapidly

and oxygen levels fall. In BH106 six 'peaks' were recorded where carbon dioxide concentrations increased above 5% and with corresponding high flow rates. These events only coincided with falling or low atmospheric pressure. Conversely, negative flow rates are recorded during rising or high atmospheric pressure conditions. For extended periods negative pressures fell below the instrument detection limit of -6.72 l/hr.

Methane was not detected at meaningful concentrations in BH106 during the monitoring period. Gauge pressures in BH106 also correlate with atmospheric pressure changes i.e. when atmospheric pressure falls, gauge pressure rises, negative gauge pressures were reported typically when atmospheric pressure was above 1014mB. From late May, a correlation between gauge pressure and temperature emerged, but atmospheric pressure changes have the biggest influence.

In WS106 carbon dioxide and methane were not detected at concentrations above 1% during the monitoring period. Flows rates were also low in WS106. Gauge pressure in WS106 was not responsive to atmospheric pressure changes, but from 29th May 2021 when peak temperatures were above 18°C a diurnal pattern to the gauge pressure emerged, which also matched increases in humidity within the borehole.

16.2 Data Evaluation

16.2.1 Land Gas Sources

In the western area (proposed residential land use) made ground outside of KDC remediated areas was locally up to 1.95 m deep with the thickest made ground identified in BH105 and TP115, which are on the edge of KDC remediated areas. Elsewhere outside of the remediated areas made ground was typically <1.0 m thick. In these areas made ground comprised grey demolition fill of fine to coarse gravel and cobbles of brick and occasional black top, over reworked soil comprising grey to brown clayey silt and silty clay up to 2.9 m bgl. In the KDC remediated areas made ground was reported up to 2.0 m thick (base not proven in TT203) and comprised a grey sandy gravel with concrete and brick and occasional fragments of plastic and metal. In all trial holes in the western area no deleterious organic waste materials (wood fragments, paper, cloth etc) were identified. Non-aqueous phase liquids were not identified in soils or groundwater in areas investigated by Leap.

In the Eastern Area (proposed commercial land use) made ground was locally up to 4.05 m deep, with the deepest made ground identified in BH101, located over a backfilled firewater runoff reservoir. In the footprints of the larger demolished buildings 15 and 42 in the central eastern area of the site, made ground reached 2.1m and 2.2m bgl at WS111 and TP128 respectively. Made ground shallower than 1m bgl was predominantly found outside of the former building footprints and was generally near to the sites eastern margin. In the remediated areas made ground extended up to a maximum depth of 3.0 m (base not proven) in TP204, which was also located in the backfilled firewater runoff reservoir. Rare wood

fragments were identified in made ground in WS112 and WS117, with made ground thicknesses recorded as 1.10 m and 0.95 m, respectively.

The made ground identified on site was not considered to be a significant gas generating source, as it was identified as crushed demolition type material in both remediated and un-remediated areas and no large volumes of deleterious organic type wastes were identified onsite in the areas investigated.

With respect to a potential deep gas source at BH106 public records do not report landfilling on or offsite. However, the Phase 1 Desk Study identified an infilled clay pit in the southeast of the site and an offsite infilled pond located ~110 m to the north of the site. These have been discounted as significant land gas sources as:

- The infilled clay pit was remediated by KDC in 2016 and located +400 m to the southeast of BH106.
- The infilled pond was remediated as part of an offsite residential development in 2015 and we understand that up to 4000 m³ of organic material was removed as part of the works.

No known pressurised gas services are located in the vicinity of BH106. Laboratory analysis of BH106 did not detect methane or odorants typically added to mains gas supply. An offsite foul sewer is present approximately 30 m north of the BH106. This has been discounted as an ongoing source, due to depth of inverts suggest that the sewer is shallow. Further, leakages from the drain are expected to be retarded by the underlying low permeable geology and the gas composition in BH106 did not record methane, a typical component of sewer gases.

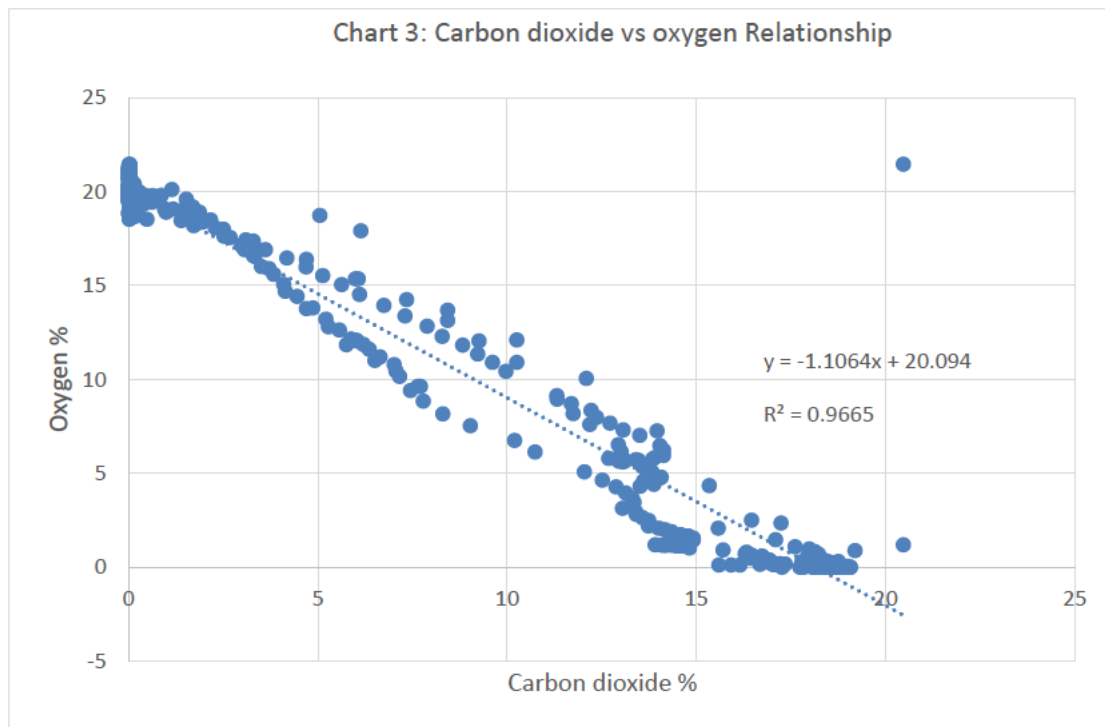
In the Tunbridge Wells Sand Formation occasional 'coal' deposits were identified in the SANDSTONE layers in BH101 from 7.05 m bgl (49.88 m AOD), in BH102 from 6.0 m bgl (51.13 m AOD), in BH103 from 7.75 m bgl (49.62 m AOD), in BH104 from 7.30 m bgl (49.12 m AOD) and from 15.95 m bgl (40.47 m AOD) in BH105 from 3.35 m to 3.85 m bgl (52.96 m to 52.46 m AOD) and from 9.45 m to 9.70 m (46.86 m to 46.61 m AOD) and in BH106 from 10.01 m (47.55 m AOD) in BH106. These interbedded 'coal' layers within the SANDSTONE are not particularly thick typically <1.0m. SANDSTONE with layers of coal was also recorded on a historical borehole log (GBS ref:TQ13SE156) located to the southwest of Building 3 from ~38 to 40 m bgl.

In BH102, BH104 and BH106 a CLAY layer was encountered beneath made ground / reworked ground that overlaid a sandstone layer. This was thickest in BH106 (3.20 m).

Three shallow soakaway tests were undertaken in near-surface soils across the site in which all three failed i.e. water levels did fall to the required level over a 5 hour test period. A perched ground water was present in many locations, generally at the base of the made ground and top 1.0 m of the Tunbridge Wells Sand Formation. The soakaway tests and

perched groundwater indicate a low permeability layer at the top of the Tunbridge Wells Sand Formation, this likely acts as a confining layer between organic material present in the SANDSTONE layer at depth and the ground surface.

The relationship between recorded oxygen and carbon dioxide concentrations have been plotted, following Card *et al* 2019¹⁸. The results are shown in Chart 3, below.

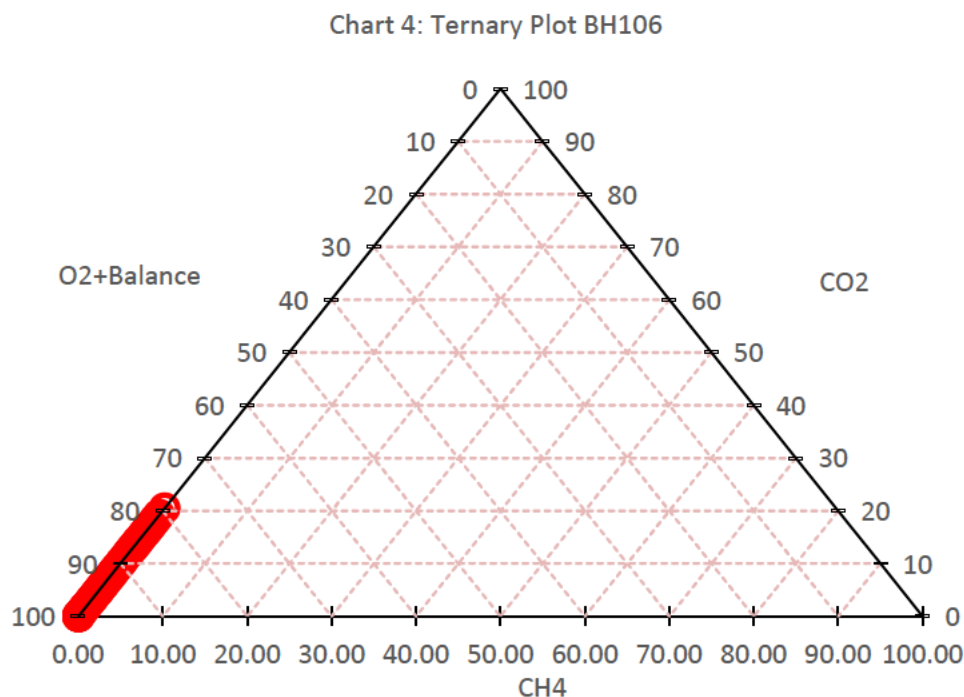


Card *et al* 2019 record that the act of drilling into soil introduces oxygen that can cause chemical and biological processes around the well and cause high carbon dioxide concentrations. Where microbial respiration is the main gas generating process, the oxygen vs carbon dioxide relationship produces a slope angle of -1. In the case of BH106 the slope angle is -1.1 (2sf), which is strongly indicative of microbial respiration.

¹⁸ Technical Paper: Risk and reliability in gas protection design – 20 years on. Part I Ground Engineering August 2019 Geoff Card, GN Card and Partners; James Lucas, The Environmental Protection Group; and Steve Wilson EPG

To further assess this a ternary plot of carbon dioxide, methane and oxygen balance recorded from BH106 using the GasfluX device is shown on Chart 4, below. The records fall within a zone characteristic of microbial respiration, as shown in Figure 6 of Wilson *et al* 2018¹⁹.

The rate of gas generation from microbial respiration is very low and unlikely to build pressures of gas that pose a risk to structures via advection.



However, in the case of BH106 elevated carbon dioxide concentrations corresponded with initial high flow rates. In January 2021 gas was noted bubbling through water inside the raised cover (which was flooded) with a flow rates at +100 l/hr measured at the standpipe. The bubbling effect was noted to continue for approximately one week after the initial observation. However, by the time the first phase of monitoring started, in February 2021 the bubbling had stopped and flow rates were significantly reduced.

As described above in section 15.1.2 gauge pressure and flow rate changes in BH106 were extremely responsive to barometric pressure changes, with positive gas flows in falling or low atmospheric pressure conditions and negative gas flows in rising or high atmospheric pressure conditions. Card *et al* 2019¹⁷ note this effect is unlikely to be due to an underlying pressure

¹⁹ Using ternary plots for interpretation of ground gas monitoring results. Ground Gas Information Sheet No. 1 July 2018 by Wilson, Collins and Lavery.

driven flow and gas flow to the surface will be limited by diffusion. Flow rates and gauge pressures in the shallow well at WS106 were not responsive to atmospheric change.

16.2.2 Spatial Distribution and Response Zones

In the proposed residential area, west of the retained building, five shallow land gas monitoring wells and two deep groundwater monitoring wells were installed.

Four of the shallow wells (WS102, WS103, WS105, WS106) were installed in land north of the access road within the former footprint of the building 18 and land to the east and west of this feature. One shallow monitoring well (WS118) was located to the south of the access road and to the west of the footprint building 38.

Two deep wells were installed namely, BH106 just north of the former building 18 and BH105, just west of the former building 38. The distribution of trial holes (including window sampler locations) was primarily based on a non-targeted pattern.

The response zone of WS103 was installed across made ground, the remaining shallow wells were installed into the top of the Tunbridge Wells Sand Formation (Sandstone and Mudstone).

BH105 and BH106 were installed within the Tunbridge Wells Sand Formation (Sandstone and Mudstone) from 10 m to 16m in BH105 and 11 m to 20 m in BH106.

In the proposed commercial area eight shallow gas monitoring wells were installed across the site. WS108 was located south of the former footprint of building 21; WS109 was located to the south of former building 42; WS111 and WS113 were located within the footprint of building 15, WS115 and WS116 were located close to the eastern boundary, BH101S was located in the southeast of the site and BH103S was located along the northern boundary.

The response zones of WS111, WS116, BH101S and BH103S were installed within made ground soils. The remaining shallow monitoring wells were installed within the top of the Tunbridge Wells Sand Formation.

Across the site, the shallow monitoring wells provide good spatial coverage to confirm that the made ground is not a gas generating source; to monitor diffuse gas potential from depth; and to provide coverage along the northern, eastern and south-eastern boundaries with regards to potential offsite sources.

16.2.3 Monitoring period

The first phase of monitoring consisted of six periodic monitoring rounds that primarily targeted the shallow monitoring wells occurred over a 3 month period. Land gas concentrations were recorded during low (<1000 mb) and falling atmospheric pressure conditions on four occasions.

The second phase of monitoring was primarily focused on land gas trends arising from BH106 and WS106, but also include four periodic gas monitoring rounds across the other deep monitoring boreholes. The periodic gas monitoring in the second phase occurred during falling atmospheric pressure conditions on two occasions on 12/05/21 and on 24/06/21.

Where barometric pressure is the only driver for gas concentration and flow, TB17²⁰ suggests a short period of monitoring may be appropriate to cover three or four critical pressure drops. Over the continuous gas monitoring period six falls in atmospheric pressure were recorded. Within the six events, two sharp pressure drops (4mB over a three hour period or less) were recorded during the 20/05/21. On other occasions pressure drops of 4mB occurred, but over slight longer time periods, namely on 15/05/21 a 4 mB pressure drop occurred over a 3 hr 51 min period; 23/05/21 a 4 mB pressure drop occurred over a 3 hr 51 min period; on 30/05/21 a 4 mb pressure drop occurred over a 7hr 30 min period; 15/06/21 a 4 mB pressure drop occurred over a 5hr 38 min duration.

Given that both the periodic and continuous monitoring occurred during periods of low atmospheric pressure and short duration pressure changes the monitoring period is considered sufficient to capture a worst case condition for the site.

16.3 Volatile Vapours

VOCs recorded during the periodic gas monitoring visits are recorded in Table 14, above. In shallow monitoring wells, VOC readings ranged from 0.0 to 5.4 ppm. VOC readings were detected above 1ppm on 22 occasions, of which 20 readings were from flooded or partially flooded wells. The maximum VOC reading from a well that was not flooded or partially flooded was 2.4 ppm in WS113 on 06/04/21. The response zone for WS113 is in the Tunbridge Wells Sand Formation. WS113 is located to the southwest of the former Building 15. In deep monitoring wells VOC readings ranged from 0.0 ppm to 13.2 ppm during the periodic monitoring. The maximum reported concentration of 13.2 ppm was recorded in BH102 on 18/06/21, the well was recorded at 'flooded'. Excluding VOC readings from flooded response zones VOC peaks in deep monitoring wells ranged from 0.0 ppm to 0.5 ppm.

Charts 5 and 6 below plot VOC, temperature and humidity records during the high frequency monitoring period for WS106 and BH106.

²⁰ CL:AIRE Technical Bulletin TBI7:2018 Ground Gas Monitoring and 'Worst-Case' Conditions

Chart 5: WS106 VOC, Temperature and Humidity

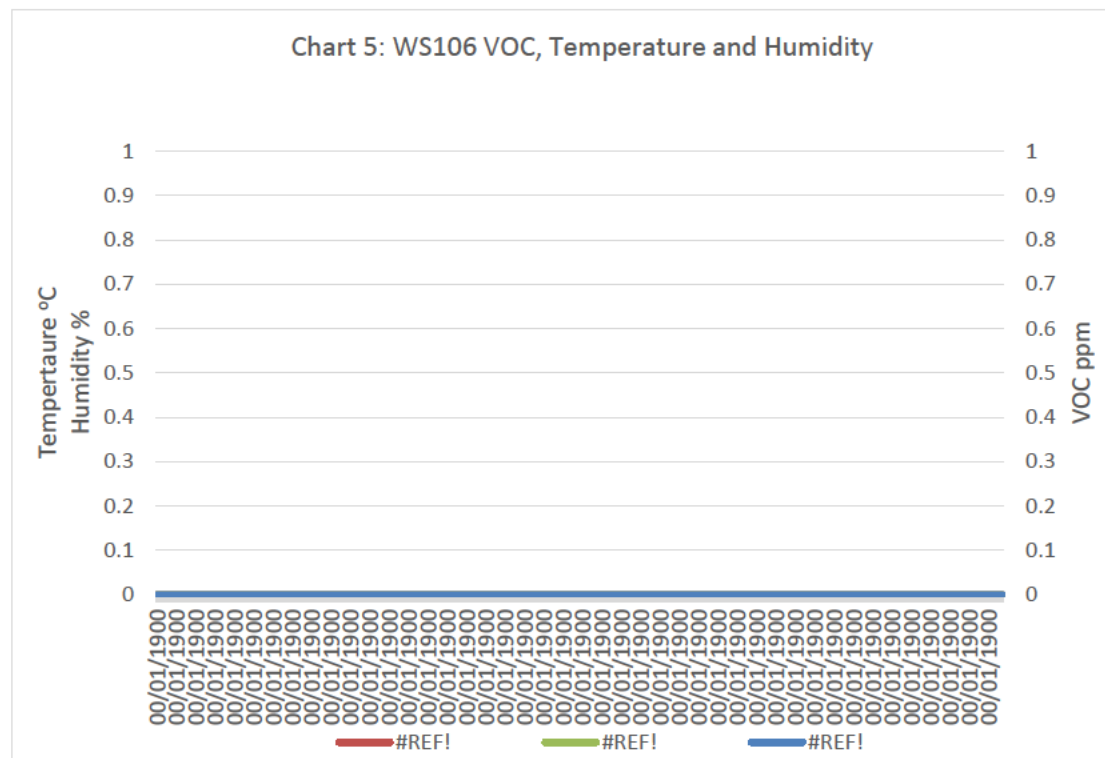
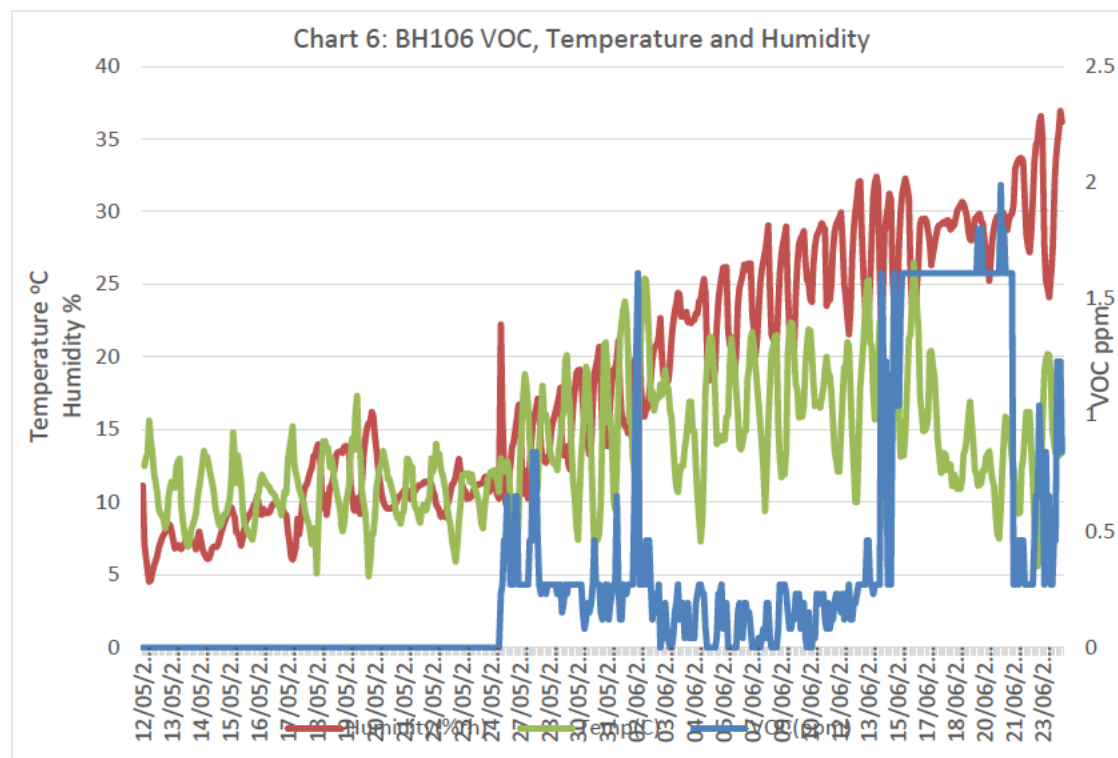


Chart 6: BH106 VOC, Temperature and Humidity



WS106 consistently recorded higher VOC concentrations than BH106. A maximum VOC reading of 8.59 ppm was recorded in WS106 on 24/06/21 at 13:08 and 14:26, in BH106 a maximum VOC reading of 1.99 ppm was recorded on 21/06/21 at 07:41. The mean average VOC reading in BH106 was 0.55ppm and in WS106 the mean average VOC reading was 2.98

ppm. Given the accuracy of the VOC units used in the GasfluX devices (+/-10%) BH106 recorded close to zero VOCs during the continuous gas monitoring period, minor increases recorded after 26/05/21 are likely to be 'noise' due to increases in humidity levels as temperature levels increased.

16.3.1 Laboratory Analysis

Two bulk gas and volatile vapour samples were collected for analysis from BH106 and WS106 via laboratory supplied Silonite canisters. The results of compounds that were detected above analytical limits of detection are presented in Table 16, below and the laboratory test certificates are provided in Appendix F.

Table 16: Bulk Gas and Vapour Testing Results

Determinant	Unit	Indoor Tolerable Air Concentration (residential)	Analytical test results		Predicted Indoor Air Concentrations	
			BH106	WS106	BH106	WS106
Oxygen	%	-	8.79	18.2	-	-
Nitrogen	%	-	80	81.5	-	-
Carbon dioxide	%	-	11.2	0.354	-	-
MTBE	µg/m ³	1203	64.6	87.2	-	-
Benzene	µg/m ³	2.35	67.4	90.6	3.87E-03	5.2E-03
Toluene	µg/m ³	2348	994	1040	-	-
Ethyl benzene	µg/m ³	124	132	130	6.09E-03	6.00E-03
m/p xylene	µg/m ³	95.1	640	672	2.99E-02	3.14E-02
o xylene	µg/m ³	95.1	160	157	7.58E-03	7.44E-03
TPH (C4-C6)	µg/m ³	n.c.	1780	2130	-	-
TPH (C6-C8)	µg/m ³	n.c.	2590	3000	-	-
TPH (C8-C10)	µg/m ³	n.c.	2000	1820	-	-
TPH (C4-C12)	µg/m ³	n.c.	6370	6950	-	-
Aliphatic (C4-C6)^	µg/m ³	4,202	1780	2130	-	-
Aliphatic (C6-C8)	µg/m ³	4,202	1530	1870	-	-
Aliphatic (C8-C10)	µg/m ³	244	656	498	3.96E-02	3.01E-02
Aromatic (EC5-EC7)	µg/m ³	1,177	67.4	90.6	-	-
Aromatic (EC7-EC8)	µg/m ³	1,177	994	1040	-	-
Aromatic (EC8-EC10)	µg/m ³	50.43	1340	1320	8.46E-02	8.33E-02
1,2,4 Trichlorobenzene	µg/m ³	1.93	256	264	1.23E-02	1.27E-02
1,2,3 Trimethylbenzene	µg/m ³	n.c.	30.4	<LOD	-	-
1,3,5 Trimethylbenzene	µg/m ³	n.c.	42.8	48.6	-	-

2-Butanone (MEK)	µg/m ³	n.c.	36	36.4	-	-
Acetone+Propanol	µg/m ³	n.c.	111	82.6	-	-
Carbon disulphide	µg/m ³	24.04	80.2	<LOD	5.14E-03	-
Cyclohexane [^]	µg/m ³	4202	58.2	46.6	-	-
Hexane [^]	µg/m ³	4202	200	604	-	-
Isobutene [§]	µg/m ³	4202	55.9	196	-	-
Pentane [^]	µg/m ³	4202	309	117	-	-
Trichlorofluoromethane	µg/m ³	n.c.	29.7	442	-	-

n.c. = not calculated insufficient data available; [^] Aliphatic C6-C8 adopted as surrogate screening value; ^{^^} Assumed for Aliphatic C5-C6 in calculating Tolerable Indoor Air concentration, as no published HCV/MDI values available for Aliphatic C4; [§] Aliphatic C4-C6 assumed for isobutene

Benzene, ethyl benzene, m/p xylene, o xylene, aliphatic C8-C10, aromatic EC8-EC10, 1,2,4 trichlorobenzene and carbon disulphide are recorded at concentrations above TAC_{indoor_air} concentrations.

A number of other compounds have been detected at concentrations above analytical detection limits. For aliphatic compounds, (cyclohexane, hexane, and pentane) the TAC_{indoor_air} for aliphatic TPH C6-C8 have been used as a surrogate screening value. For isobutene the TAC_{indoor_air} for Aliphatic C4-C6 has been used.

TPH banded compounds (that include both aliphatic and aromatic fractions) which are reported above analytical detection limits have not been assessed, as TAC_{indoor_air} have been calculated for aliphatic and aromatic hydrocarbon bands separately.

Where compounds exceed TAC_{indoor_air} a predicted indoor air concentration for the compounds have been modelled using the analytical results and the method outlined in S13.3, above. No predicted air concentrations exceed the TAC_{indoor_air} concentrations. This assumes that the vapours are from a soil source. No NAPL or elevated PHC / BTEX in deep groundwater samples collected from BH106 have been identified.

E UPDATED CONCEPTUAL SITE MODEL

17 Environmental Risk Assessment

The CSM has been updated based on the findings of the LEAP Phase III Site Investigation and the additional ground investigation reported above.

17.1 Qualitative Risk Assessment of Contaminant Linkages

Based on the findings of the LEAP investigations the following onsite sources of contamination have been identified:

17.2 Onsite Sources

17.2.1 Made Ground

Based on the recent ground investigations the made ground encountered was predominantly demolition type material of greyish brown sandy gravelly brick and concrete with occasional fragments of plastic and metal. Thicknesses of made ground were typically shallow <1.0 m in areas outside of demolition footprints or remediation areas, where thicknesses up to 4.05 m were identified. Made ground in land to the east of the retained building was typically thicker than land to the west.

The Phase III ground investigation identified arsenic, lead, nickel and benzo(a)pyrene at concentrations above screening criteria for residential with home grown produce in isolated sampling locations. The previous LEAP investigation and the additional investigation did not identify significant visual or olfactory signs of hydrocarbon contamination on site or in the areas recorded as remediated by KDC that would be considered to pose an inhalation risk via volatile vapours.

Significant concentrations of deleterious organic material such as wood fragments, paper, cloth or buried household waste was not identified in the areas investigated by LEAP.

The made ground has not been identified as a significant ground gas generating source, based on the type of material identified and the periodic land gas monitoring that was undertaken.

17.2.2 Asbestos

One sample of asbestos containing material was identified in the soil samples tested during the LEAP investigations. No loose asbestos fibres were recorded in the samples tested by LEAP. Previous KDC investigations noted a residual risk to future land users from asbestos containing material / loose fibres in isolated areas across the site.

17.2.3 Organic material in Tunbridge Wells Sandstone Formation

Thin laminae of 'coal' was identified in SANDSTONE layers of the Tunbridge Wells Sandstone Formation across the site, generally from ~6.0m bgl up to ~15.0 m bgl in recent investigations and at greater depths, based on historical borehole logs. Overlying these layers was a low permeable layer, especially around BH106 where a near surface CLAY layer at +3.0 m thick and a shallow perched water was also recorded. These may act as a confining layer preventing trapped pockets of gas to reach ground surface. The gas generating potential of these organic rich layers is considered to be low, and mainly to occur via to microbial respiration when exposed to air.

17.2.4 Groundwater

The KDC investigations identified some potential contaminants of concern at concentrations above conservative Tier 1 screening criteria in shallow groundwater samples. Sampling of the deep aquifer by LEAP in the Phase III investigation identified nickel and xylene at concentrations above Tier 1 UK DWS or maximum reporting values for substances hazardous to groundwater. Copper, mercury, zinc, cyanide, phenols and benzo(a)pyrene were detected at concentrations above UK EQS values. A significant soil source was not identified for these compounds.

17.2.5 Unidentified Contamination

As with all brownfield sites it is not possible to investigate all areas and there may be localised areas of previously unidentified contamination. However, noting that the site has been subjected to extensive ground investigations by others and hotspots of gross contamination (non-aqueous phase liquids) or hydrocarbon contaminated soils that pose an inhalation risk have been previously remediated. These areas are likely to be very localised, if present at all.

17.3 Offsite Sources

No significant off site sources that pose a risk to human health have been identified. With respect to offsite ground gas risks potential sources that pose a risk to the site have not been identified or discounted in Section 15.2.1.

17.4 Identified Receptors

The identified receptors include:

- Future residential and commercial users;
- Construction and maintenance workers;
- Groundwater – Secondary A Aquifer;
- Horsham Pond via surface water drainage; and
- Material construction of buildings and infrastructure.

17.5 Plausible contaminant linkages

17.5.1 Human Health

The outline planning consent for the site development allows for residential properties, communal open space and commercial development. Whilst the details for the proposed development have not been finalised, it is likely that some of the residential development will include low rise housing with private gardens. Preliminary plans suggest the residential development will be on the western part of the site, although this is not finalised. As a conservative assessment, this risk assessment therefore considered all potential contaminant linkages involving residential land users and soil contaminants i.e. direct ingestion of soil, ingestion of soil attached to plants as well as via plant uptake, inhalation of indoor and outdoor vapour and of dust tracked back into the house and finally ingestion of water carried by plastic water pipes through contaminated ground. In public open spaces, communal gardens and soft landscaping associated with commercial activities the pathways will be different, which generally results in lower levels of exposure and therefore risk.

Ground workers, construction workers and maintenance workers are at risk from all of the above, except for those involving edible plants.

17.5.2 Land gases

As described above the made ground identified on site to date is not anticipated to be a significant land gas generating source and does not pose a significant risk to the development.

Trapped pockets of gases may be present in the SANDSTONE of the Tunbridge Wells Sand Formation, beneath confining low permeability layers. An initial short-term release of trapped gases may occur, if the confining layer was punctured. This was likely to be the initial case in BH106. Gases would be expected to stabilise once the gases are released. Charts 3 and 4 in section 16.2.1 above indicate that after the initial release of gases, was likely to be main carbon dioxide generation process at BH106. Microbial respiration has low gas generation potentials.

Continuous monitoring in BH106 showed that flow rates were extremely responsive to barometric pressure changes, with positive gas flows in falling or low atmospheric pressure conditions and negative gas flows in rising or high atmospheric pressure conditions. This effect was considered to be unlikely due to underlying pressure driven flow and gas flow to the surface will be limited by diffusion or by preferential pathways. Monitoring of land gases in the shallow wells installed within top elevations of the Tunbridge Wells Formation have not repeated the high flow rates or gas concentrations, as was seen in the BH106. This supports the assumption that land gases at depth are diffuse flow driven and, in the absence of any preferential pathways, will not reach near surface soils at concentrations that would pose a risk to the development.

Carbon dioxide and flow rates were reactive to barometric pumping effects (gas expansion). Pathways may exist where fault zones are present or are created by foundation / construction methods that penetrate the confining layer, but do not adequately seal in the surrounding soils, such as stone columns.

17.5.3 Controlled Waters

The site is underlain by the Tunbridge Wells Sand Formation mapped as a Secondary A Aquifer in the north-western part of the site, and as unproductive aquifer²¹ elsewhere including along the full length of the southern boundary. The site is not located within a potable water source protection zone. There are no surface water features that immediately bound the site or are located within 250 m of the site boundary, with the exception of an unmapped offsite ditch along the northern boundary of the Collyer's College playing field. A plausible contaminant linkage has not been identified between onsite groundwater (shallow and deep) and offsite groundwater resources.

With respect to surface water receptors the 2018 and 2021 CCTV surveys indicate that the onsite Southern Water drains in the eastern part of the site are damaged, blocked or have unmarked connections along their length. A plausible linkage exists at these points of entry along the surface water drains, shallow groundwater onsite and the Horsham Pond.

However, sampling of the drainage network downstream of the site has not identified significant concentrations of metal, PAHs or TPHs contaminants of concern. The pathway linkage between the site and the surface water drains does not, therefore, appear to be active.

18 Risk Assessment

18.1 Human Health

Of the trial holes excavated across known KDC remediation areas only two locations identified visual signs of residual contamination, namely TT205 where black clay was identified at the base of the made ground and TP202 where an oil sheen was noted on the surface of standing water. Olfactory evidence (strong odours or elevated PID readings) of hydrocarbon contamination was not identified in any location.

Soil samples were tested for TPH and BTEX, with the exception of samples from TT205 and TP202 which were also tested for heavy metals, PAHs and asbestos.

²¹ areas comprised of rocks that have negligible significance for water supply or baseflow to rivers, lakes and wetlands. They consist of bedrock or superficial deposits with a low permeability that naturally offer protection to any aquifers that may be present beneath.

In the samples tested none of the contaminants were recorded at concentrations above residential with home grown produce generic assessment criteria.

On the basis of the site investigation and laboratory analysis a significant risk to future land users was not identified from residual contamination in the KDC remediation areas.

18.2 Drains / Surface Water Sampling

The CSM identified a plausible preferential pathway via the surface water drains that extend through the eastern half of the site and connect to the Horsham Pond ~800m to the southwest of the site. However, this did not appear to be active.

The 2018 and 2021 CCTV surveys identified blockages, damaged sections and unmarked connections into the two surface water drains that extend through the site. The decommissioned drain mapped aligned northeast to southwest was not located. This may well have been 'grubbed' out as part of the demolition works, although this was not recorded on the KDC surveys made available to LEAP.

Elevated contaminants of concern in the onsite sampling locations were predominantly hydrocarbons, both aliphatic and aromatic PHC and PAHs. The surface water drain to the east of building 36 is locally contaminated at LWS2, but down gradient of this at LWS3 the PAH and TPH loading is much lower, suggesting that either the blockage is preventing the hydrocarbons impacted water moving downstream or it is leaking onto site.

LWS4 appears to be part of a redundant drainage system and is also locally contaminated. It was initially thought to be part of the decommissioned surface water drain. However, overlaying the Southern Water plans onto the 2020 GPR utility survey implies that it is not related to the old network. Notwithstanding this the 2021 CCTV survey shows that it discharges into the Southern Water surface water drains.

In the down gradient off-site monitoring locations the most locations recorded TPH aliphatic / aromatic fractions and PAHs at less than analytical limits of detection. Where detected they were at considerably lower concentrations than the onsite sampling locations. This shows that the hydrocarbons detected in onsite sampling locations are not significantly impacting the offsite sampling points.

The Horsham Pond records high concentrations of PAHs and TPH, but based on the sampling upgradient of the pond it does not appear to have been contaminated from the Horsham Enterprise Park. We note there have been pollution incidents from Horsham Hospital that have impacted the pond.

18.3 Land Gases

Adopting the methods described in section 13.2, a semi-quantitative approach has been used to define a characteristic situation using in part gas screening values (GSV). An evaluation of the data to inform the approach has been undertaken, as per Section 16.2, above.

Monitoring results from flooded wells during periodic monitoring events have not been assessed, this includes negative flow readings as they are judged unrepresentative of a worst case scenario. Steady state flow rates are used on the basis that land gas sources are not considered likely to generate high volumes of gas that would create a sustained driving flow and that steady state values represent a conservative approach.

18.3.1 Gas Screening Values

Gas screening values for each borehole per monitoring round are provided in Appendix J. A summary of the highest GSVs for carbon dioxide and methane are summarised in Table 17 and 18, below.

Table 17: Summary of Maximum Carbon Dioxide Gas Screening Values

Borehole	Date	Atmospheric Pressure	Strata	Gas Screening Value L/hr
				Carbon dioxide
WS102	06/04/21	1017	TWS	0.002
WS103	16/04/21	1022	MG/TWS	0.0048
WS105	-	-	TWS	Flooded on all occasions
WS106	15/03/21	1017	TWS	0.0266
WS108	06/04/21	1017	TWS	0.0016
WS109	22/03/21	1022	TWS	0.0001
	08/03/21	1021		0.0001
WS111	08/03/21	1021	MG	0.0001
WS113	06/04/21	1022	TWS	
WS115	08/04/21	1020	TWS	0.0001
WS116	-	-	MG/TWS	Flooded on all occasions
WS118	-	-	TWS	Flooded on all occasions
BH101S	22/02/21	1013	MG	0.0001
	08/03/21	1021	MG	0.0001
BH101D	12/05/21	1004	TWS	0.0003
BH102	-	-	TWS	Flooded on all occasions
BH103S	08/03/21	1020	MG	0.0012
BH103D	-	-	TWS	Flooded on all occasions

Borehole	Date	Atmospheric Pressure	Strata	Gas Screening Value L/hr
				Carbon dioxide
BH105	12/05/21	1005	TWS	0.0061
BH106 [^]	16/05/21	995	TWS	3.68

⁵ steady state or instrument detection limit due to flooded response zone; [^] based on maximum Gasflux data; green shading is GSV <0.07 (CS1 very low risk); red shading >3.5 to <15 (CS4 moderate to high).

Table 18: Summary of Maximum Methane Gas Screening Values

Borehole	Date	Atmospheric Pressure	Strata	Gas Screening Value L/hr
				Methane
WS102	22/03/21	1024	TWS	0.0002
WS103	06/04/21	1017	MG/TWS	0.0001
WS105	-	-	TWS	Flooded on all occasions
WS106	15/03/21	1017	TWS	0.0152
WS108	06/04/21	1017	TWS	0.0001
WS109	22/03/21	1022	TWS	0.0002
WS111	22/03/21	1022	MG	0.0002
WS113	15/03/21	1016	TWS	0.0002
	22/03/21	1022		0.0002
WS115	08/03/21	1020	TWS	0.0001
WS116	-	-	MG/TWS	Flooded on all occasions
WS118	-	-	TWS	Flooded on all occasions
BH101S	24/06/21	1015	MG	0.0003
BH101D	12/05/21	1004	TWS	0.0002
	18/06/21	1011		0.0002
	24/06/21	1015		0.0002
BH102	-	-	TWS	Flooded on all occasions
BH103S	12/05/21	1004	MG	0.0002
	18/06/21	1011		0.0002
	24/06/21	1015		0.0002
BH103D	-	-	TWS	Flooded on all occasions
BH105	24/06/21	1015	TWS	0.0096
BH106 [^]	16/06/21	1009	TWS	0.00718

⁵ steady state or instrument detection limit due to flooded response zone; [^] based on maximum Gasflux data; green shading is GSV <0.07 (CS1 very low risk).

A check of the maximum values (maximum flow and maximum concentration irrespective of monitoring rounds) for each borehole has been undertaken to confirm conservatism. The maximum value test is provided in Appendix J. The maximum test changes the characteristic situation (CS) for BH105 only, where a GSV of 0.086 l/hr is recorded for BH104 and a GSV of 0.2135 l/hr is for BH105 i.e. the characteristic situation increases from very low risk (CS1) to low risk (CS2).

The gas screening values, based on a borehole per monitoring event value characterises the majority of the site as GSV1 very low risk with respect to carbon dioxide and methane, with the exception of BH106, which is assigned a gas screening value of 3.68 l/hr moderate to high risk with respect to carbon dioxide.

However, taking into account the foundation assumptions in Section 13.2, the data evaluation in section 16.2 and the updated CSM in Section E it is evaluated at this preliminary design stage that the 'coal' in the sandstone layers at depth does not pose an unacceptable land gas risk to the proposed development. This is validated by the shallow monitoring wells installed in both made ground and the top of the Tunbridge Wells Sand Formation which have not resulted in high carbon dioxide or flow rates (in non-flooded wells).

This assessment is on the understanding that in the western area, proposed foundations shall be designed not create preferential pathways through the low permeability confining layer. In the eastern area the piled foundation solution comprising properly constructed CFA piles would not be expected to create active pathways and will also include reinforced cast *in situ* suspended floor slab with minimal penetrations as further mitigation.

This assessment shall be reviewed when detailed design plans are known.

18.4 Volatile Vapours

The sampling and laboratory testing of volatile organic compounds at WS106 and BH106 identified low concentrations of predominantly gasoline range hydrocarbons, 1,2,4 trichlorobenzene, and carbon disulphide above initial soil vapour screening criteria. During continuous gas monitoring the mean average VOC reading in BH106 was 0.55ppm and in WS106 the mean average VOC reading was 2.98 ppm. A soil or groundwater VOC source was not identified during the investigations undertaken by LEAP.

To provide reassurance that these compounds would not pose a risk to future end-users the predicted indoor air concentrations for the compounds were modelled and none were found to exceed tolerable indoor air concentrations for a residential land use. On this basis the volatile vapours reported in WS106 and BH106 are not considered to pose a risk to future end-users.

F GEO-ENVIRONMENTAL CONCLUSIONS

On the basis of the additional targeted ground investigation within the KDC remediated areas, made ground was found to locally extend up to 3.0 m in thickness and comprise gravels of brick and concrete and a coarse subangular to sub round crystalline rock. The KDC areas investigated did not contain gross hydrocarbon contamination (NAPL or strong hydrocarbon odours). Laboratory testing did not identify elevated concentrations of BTEX or aliphatic / aromatic hydrocarbons at concentrations above generic assessment criteria for a residential end-use. On the basis of the above, it can be concluded that the KDC remediated areas do not pose a significant risk to human health from volatile vapours or hydrocarbon contamination.

With respect to the surface water drains, there is a plausible pathway between the onsite drains and the offsite Horsham Pond, as CCTV surveys in 2018 and 2021 identified cracks, blockages and unmarked connections within the surface water drains. The cracks and unmarked connections could allow shallow groundwater to enter the drains. Targeted sampling of accessible onsite chambers identified localised onsite contamination with respect to polycyclic aromatic hydrocarbons and +C10 aliphatic / aromatic TPH fractions. The highest concentrations were located around blocked sections of the network or a redundant chamber.

However, manhole chambers sampled downstream of the site between the Horsham Enterprise Park and the Horsham Pond recorded negligible or low concentrations of PAH / aliphatic and aromatic TPH fractions. This suggests that the localised contamination identified on site is not migrating off site. The Horsham Pond itself reported high TPH and PAH concentrations.

Additional land gas monitoring included continuous monitoring at BH106 (deep) and WS106(shallow) and periodic monitoring at the remaining deep groundwater monitoring boreholes. The data evaluation concluded that the initial peak flows of carbon dioxide released from BH106 were likely due to a trapped pocket of carbon dioxide, within a sandstone layer beneath a layer of low permeable clay. Continuous gas monitoring showed a gassing regime very responsive to atmospheric pressure changes, supporting that conclusion. Ternary plots and oxygen vs carbon dioxide relationships indicated that the gas source generated in BH106 during the continuous gas monitoring was indicative of microbial respiration. Provided that in residential areas the foundation design does not create preferential pathways, the risk to the proposed residential properties is considered unlikely to require gas protection measures.

In commercial areas, where a piled foundation solution may be adopted the method used must adequately seal into the surrounding bedrock, so as not to create new pathways i.e. use of properly constructed CFA piles.

19 Recommendations for Remediation

The Phase III report, recommended in areas of soft landscaping and where made ground is present a capping solution of verified clean cover material and clean corridors for below ground service; in areas of existing hardstanding an inspection of the formation levels once the hardstanding has been removed by a competent environmental consultant; and due to the presence of asbestos containing material any groundworks should be carried out following suitable health and safety protocols, for example, dust suppression measures and reassurance monitoring, as required. In addition to the above this report recommends that:

- The land gas risk assessment is reviewed once detailed design plans are known for both residential and commercial land use areas. Limited further assessment may be required at that time by way of validation.
- The existing Southern Water drains that extend through the eastern half of the site are damaged and where blockages, cracks, seepages are recorded then suitable remedial action should be undertaken. Including blocking of redundant inlets and full decommissioning of chamber S21 to prevent water discharging into chamber S8. Any repair works that affects the surface water drains shall only be undertaken after consultation with Southern Water Ltd.

20 Validation of Remediation

A final remediation method statement will be required to be prepared once the final site designs are complete. This method statement should be submitted to the appropriate regulatory authorities. We advise that the local authority is informed of the intended build programme in order that they can phase the sign off of planning conditions as required.

The remediation strategy will require the importation of clean topsoil, and possibly subsoil. Imported soils should be tested at source by the supplier. The validation engineers should then make spot checks as and when necessary once material has been imported.

Provision should also be made for dealing with further localised hotspots of contamination which may come to light during construction. Any such soils should be inspected by the validation engineers and appropriate remedial action taken as necessary.

APPENDIX A – Limitations

Limitations

LIMITATIONS

This report is confidential to the Client, and Leap Environmental Ltd accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental Ltd beforehand. Any such party relies upon the report at their own risk. Unless explicitly agreed otherwise in writing, this report has been prepared under LEAP's standard terms and conditions, as included in the quotation for this works.

This report has been prepared by Leap Environmental Ltd on the basis of information received from a variety of sources which Leap Environmental Ltd believes to be accurate. Nevertheless, Leap Environmental Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Leap Environmental Ltd has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed. LEAP cannot be held responsible for any disclosures or changes in regulation that are provided post production of this report, and will not automatically update the report.

The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted, and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.

The extent of the exploratory holes, laboratory testing and monitoring undertaken may have been restricted due to a number of factors including accessibility, the presence of buried or overhead services, current development and site usage, timescales or clients specification. The exploratory holes only assess a small proportion of the site area with respect to the site as a whole, and as such may only provide an overall assessment of ground conditions on site. The presence of hotspots of undisclosed contamination or exceptional and unforeseen ground conditions cannot be discounted.

Eurocode 7 gives guidance on the type of sampling, sample quality, number and spacing of intrusive investigations, and number of laboratory tests required. It is intended that the Geotechnical Information section of this report will fulfil the general requirements of the Ground Investigation Report as set out in section 6 of Eurocode7²², although this is subject to

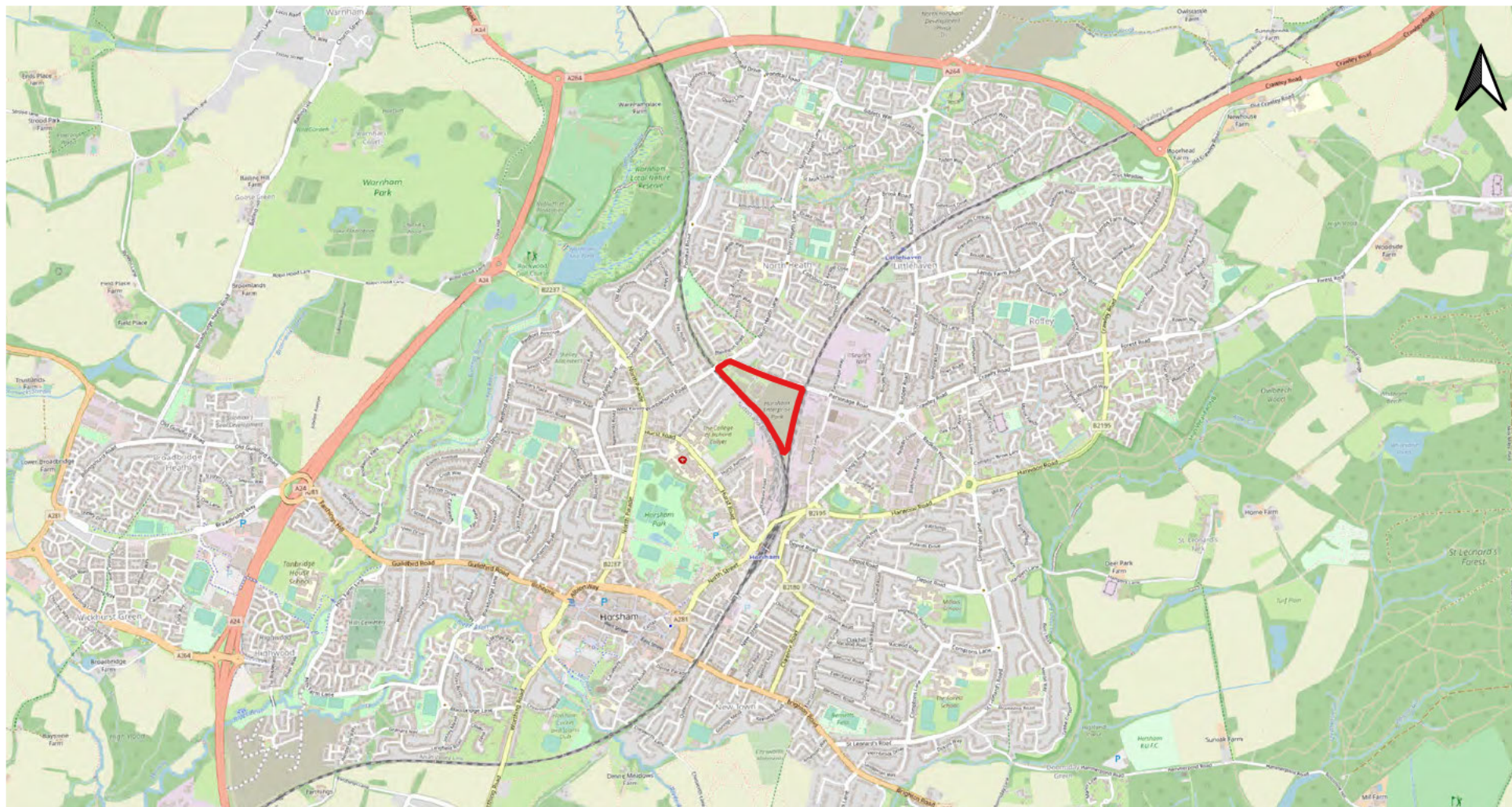
²² BS EN 1997 Eurocode 7- Geotechnical Design - Part 1: General Rules (2004) and Part 2: Ground Investigation and Testing (2007)

the restrictions imposed on the investigation as listed above. For geotechnical design, Eurocode 7 requires the Geotechnical Design Report to address both the geotechnical and structural aspects of the geotechnical design for both the limit and serviceability states. The Geotechnical Appraisal section of this report will not meet the requirements of a Geotechnical Design Report (GDR), and should therefore be used for preliminary guidance only.

The presence of asbestos may be noted during the site walkover survey, intrusive investigations and/or from the results of contamination testing. However, this report does not constitute an asbestos survey. On this basis, the presence of asbestos on site cannot be discounted and a full asbestos survey should be undertaken.

APPENDIX B – Figures

Figures



0 0.5 1 1.5 2 km



 Site Boundary



Client: WSCC

Title: Site Location

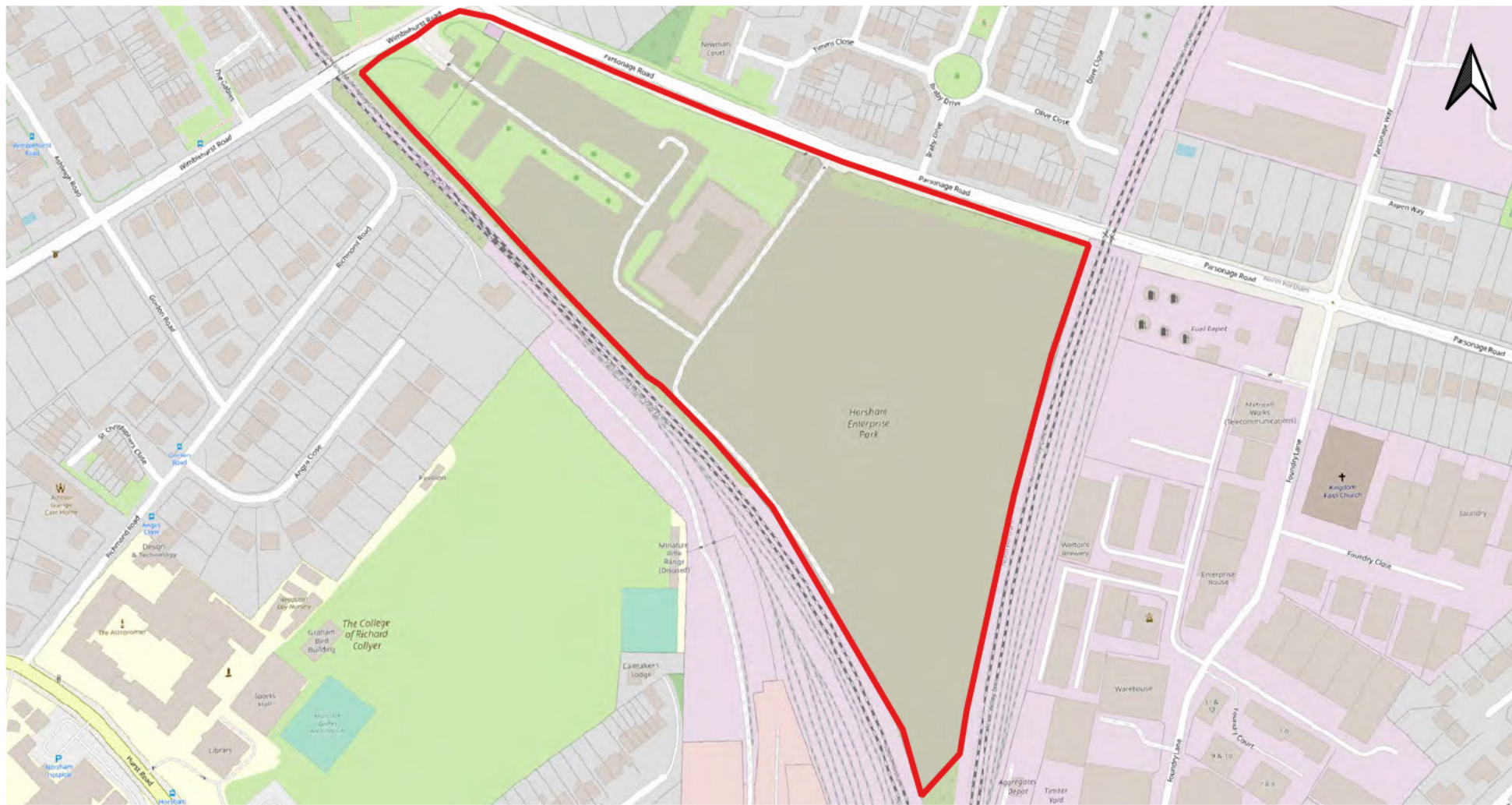
Project ID:

Project: Horsham Enterprise Park

Date: 02/03/21

Figure No.

01



0 100 200 m



 Site Boundary



Client: WSCC

Title: Site Layout

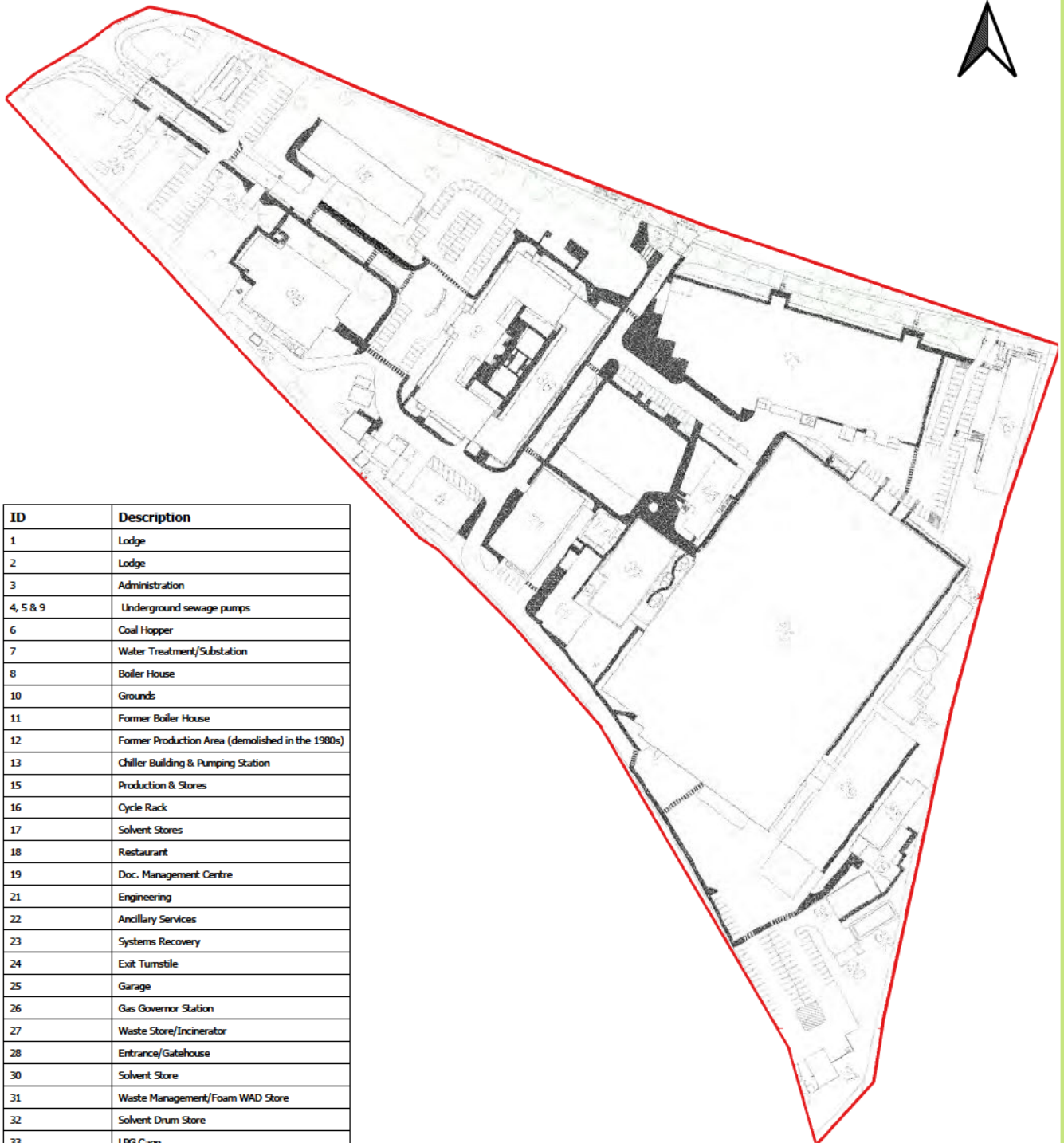
Project ID:

Project: Horsham Enterprise Park

Date: 03/01/21

Figure No.

02



ID	Description
1	Lodge
2	Lodge
3	Administration
4, 5 & 9	Underground sewage pumps
6	Coal Hopper
7	Water Treatment/Substation
8	Boiler House
10	Grounds
11	Former Boiler House
12	Former Production Area (demolished in the 1980s)
13	Chiller Building & Pumping Station
15	Production & Stores
16	Cycle Rack
17	Solvent Stores
18	Restaurant
19	Doc. Management Centre
21	Engineering
22	Ancillary Services
23	Systems Recovery
24	Exit Turnstile
25	Garage
26	Gas Governor Station
27	Waste Store/Incinerator
28	Entrance/Gatehouse
30	Solvent Store
31	Waste Management/Foam WAD Store
32	Solvent Drum Store
33	LPG Cage
35	Archive Building
36	Administration
37 & 46	QC and Development
38	ADDR Building
39	Dispatch
40	Sports Pavilion

Basemap: © Client supplied

	Client:	WSCC	Title:	Historical Layout	Project ID:	
	Project:	Horsham Enterprise Park	Date:	01/03/21	Figure No.	03

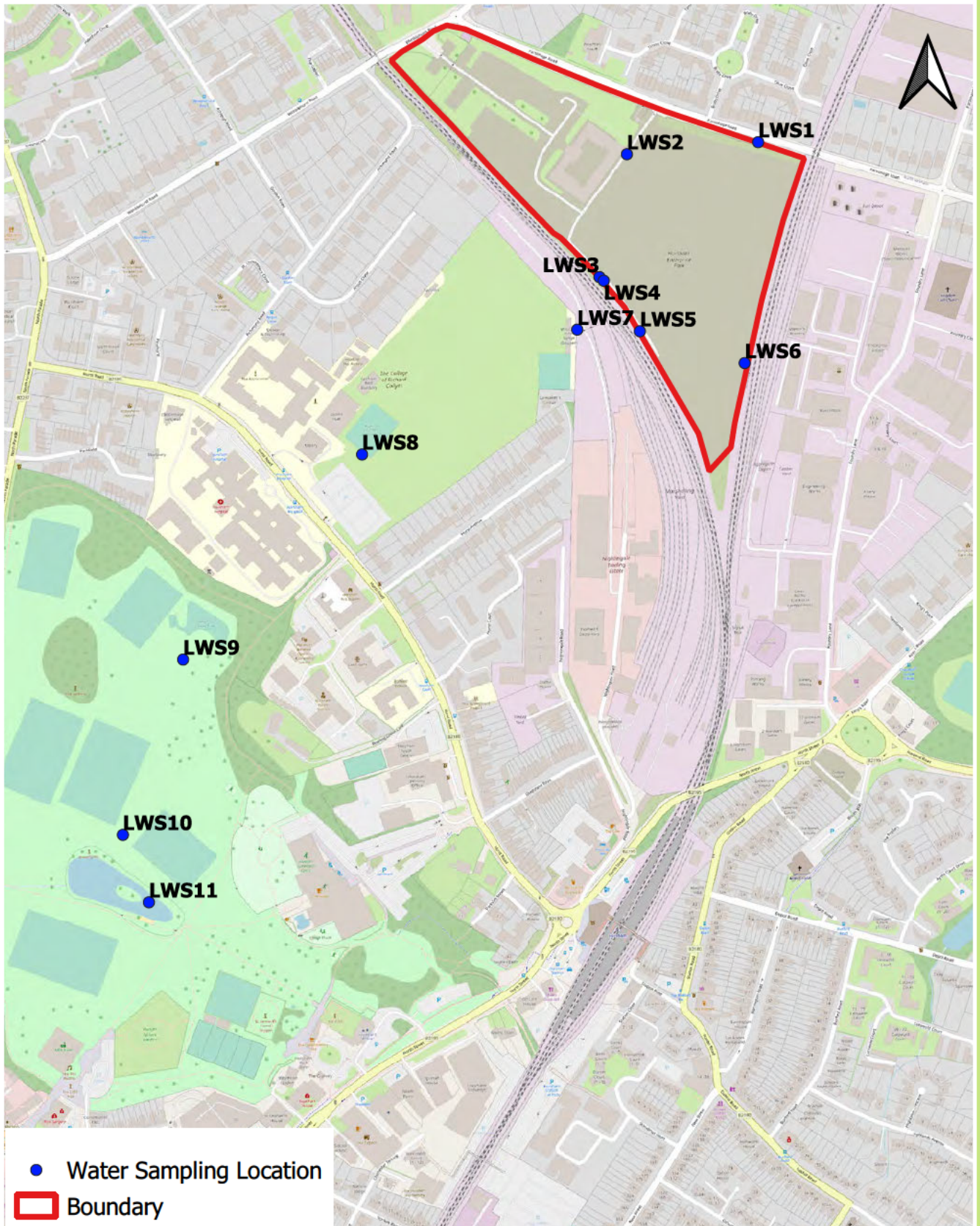


Basemap: © OpenStreetMap contributors
 & Client supplied.
 Exploratory hole locations and remediation areas estimated

KDC Remediation Areas
 Trial-trenches
 + Trial Pits



Client:	WSCC	Title:	Proposed Additional SI Locations	Project ID:	LP2575
Project:	Horsham Enterprise Park	Date:	06/07/21	Figure No.	05



Basemap: © OpenStreetMap contributors



Client:

WSCC

Title:

Surface Water
Sampling Plan

Project ID:

LP2575

Project:

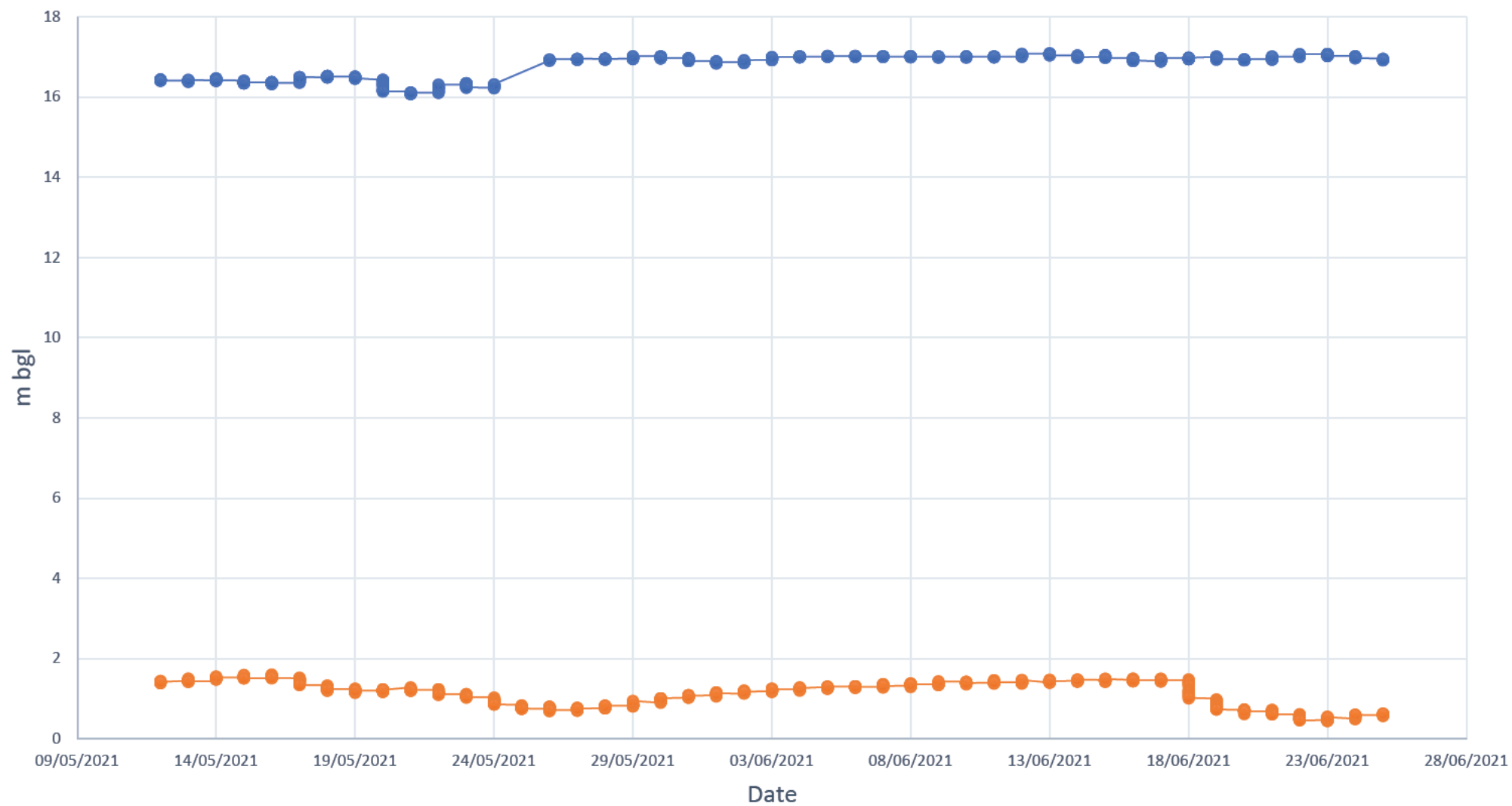
Horsham Enterprise
Park

Date:

06/07/21

Figure No.

06



● Water_Level(m)_WS106 ● Water_Level(m)_BH106



Client: WSCC

Date: 07/07/21

Project ID: LP2575

Project: Horsham Enterprise Park

Title: BH16 & WS106
Groundwater Levels

Fig. No. 7

Illustrative Masterplan

for illustrative purposes only



-  Residential
-  Employment
-  Parking areas
-  Paths and cycle routes
-  Open space
-  Indicative new tree planting
-  Bus stop
-  Cycle route
-  Local facilities
-  Open space
-  Play space

 1:2500 @ A3

title **Illustrative Masterplan**

drawing no MP001

revision C

client West Sussex County Council

date 14 Dec 2018

project Wimblehurst Road: Horsham

drawn by SM

job no SNUD415744

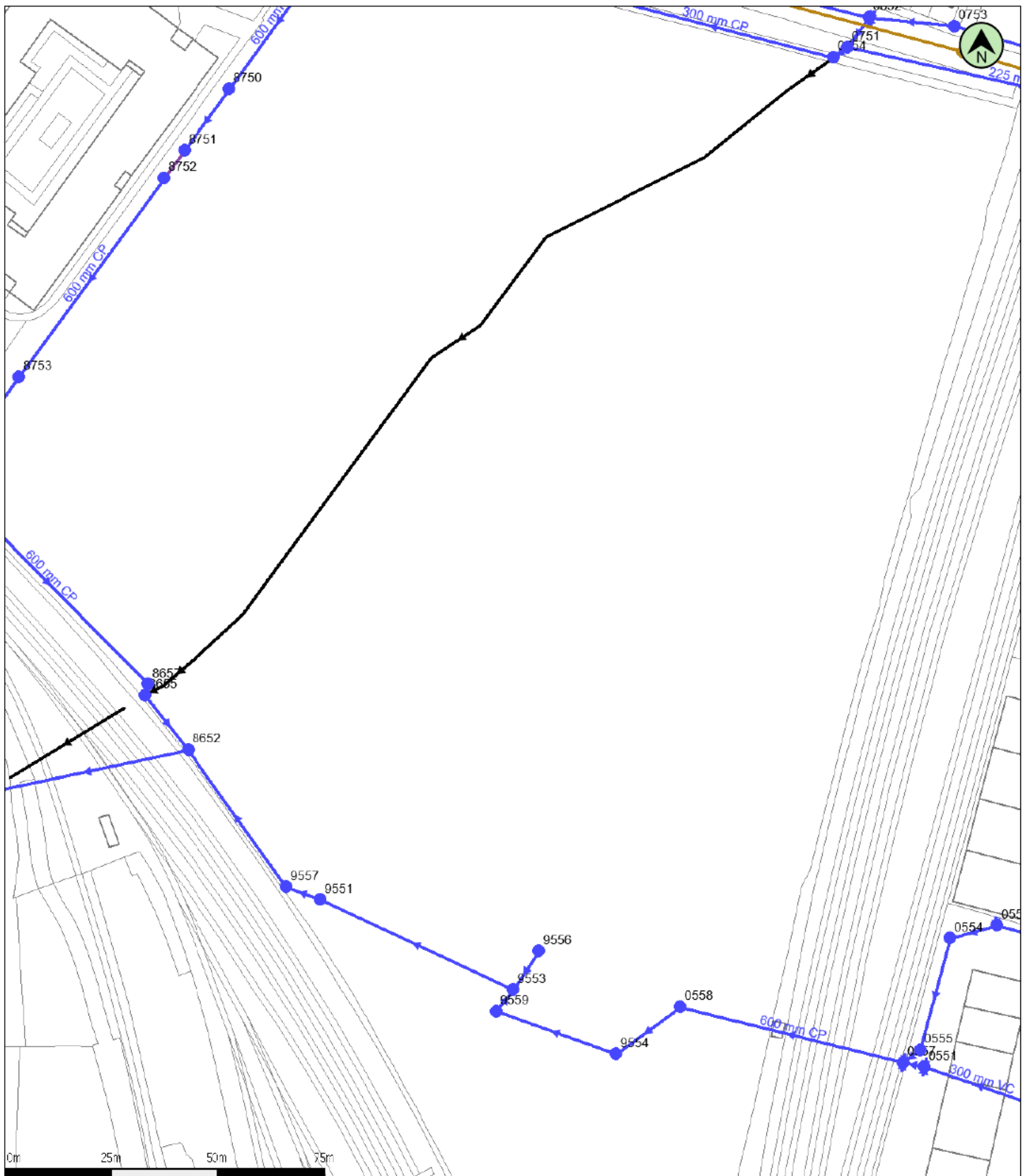
checked by PF

urban design studio
 Southampton
 Birmingham
 Cambridge
 London
 Oxford
 savills.com/urbandesign



APPENDIX C – Drainage Plans and CCTV Surveys

Drainage Plans and CCTV Surveys



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Scale: 1:1250

Date: 07/01/21

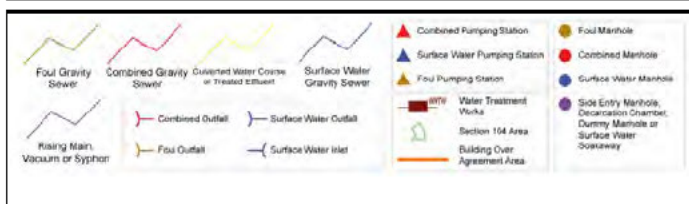
Wastewater Plan A4

Data updated: 21/12/20

Map Centre: 517963,131667

Our Ref: 472011 - 3

Powered by digdata



adc@leapenvironmental.com

2

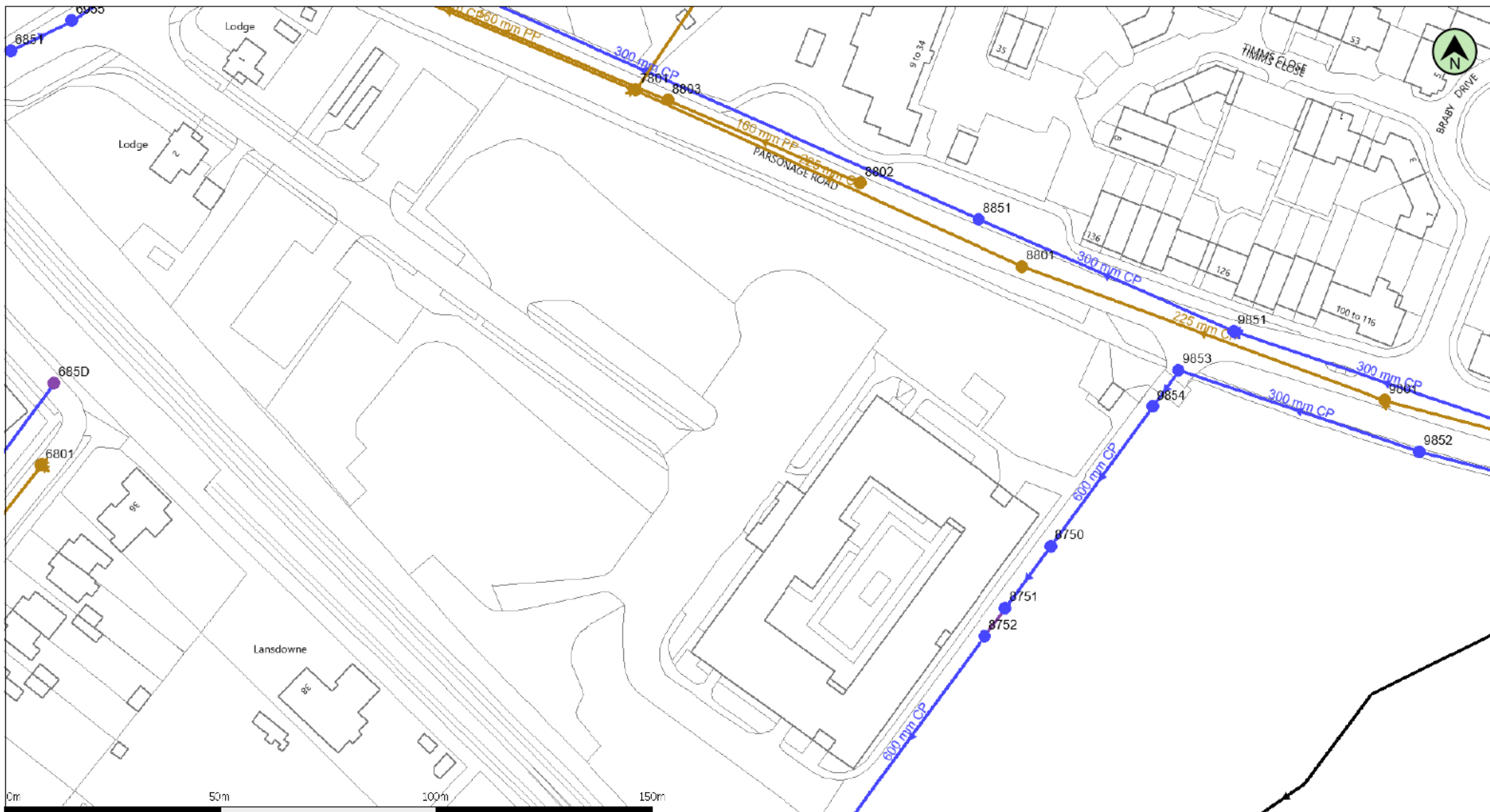


The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. This plan is produced by Southern Water Services Ltd (c) Crown copyright and database rights 2020 Ordnance Survey 100031673. This map is to be used for the purposes of viewing the location of Southern Water plant only. Any other uses of the map data or further copies is not permitted.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.

[illegible]



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Date: 07/01/21

Scale: 1:1250

Map Centre: 517827,131816

Data updated: 21/12/20

Our Ref: 472011 - 4

Wastewater Plan A4

The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. This plan is produced by Southern Water Services Ltd (c) Crown copyright and database rights 2020 Ordnance Survey 100031673. This map is to be used for the purposes of viewing the location of Southern Water plant only. Any other uses of the map data or further copies is not permitted.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

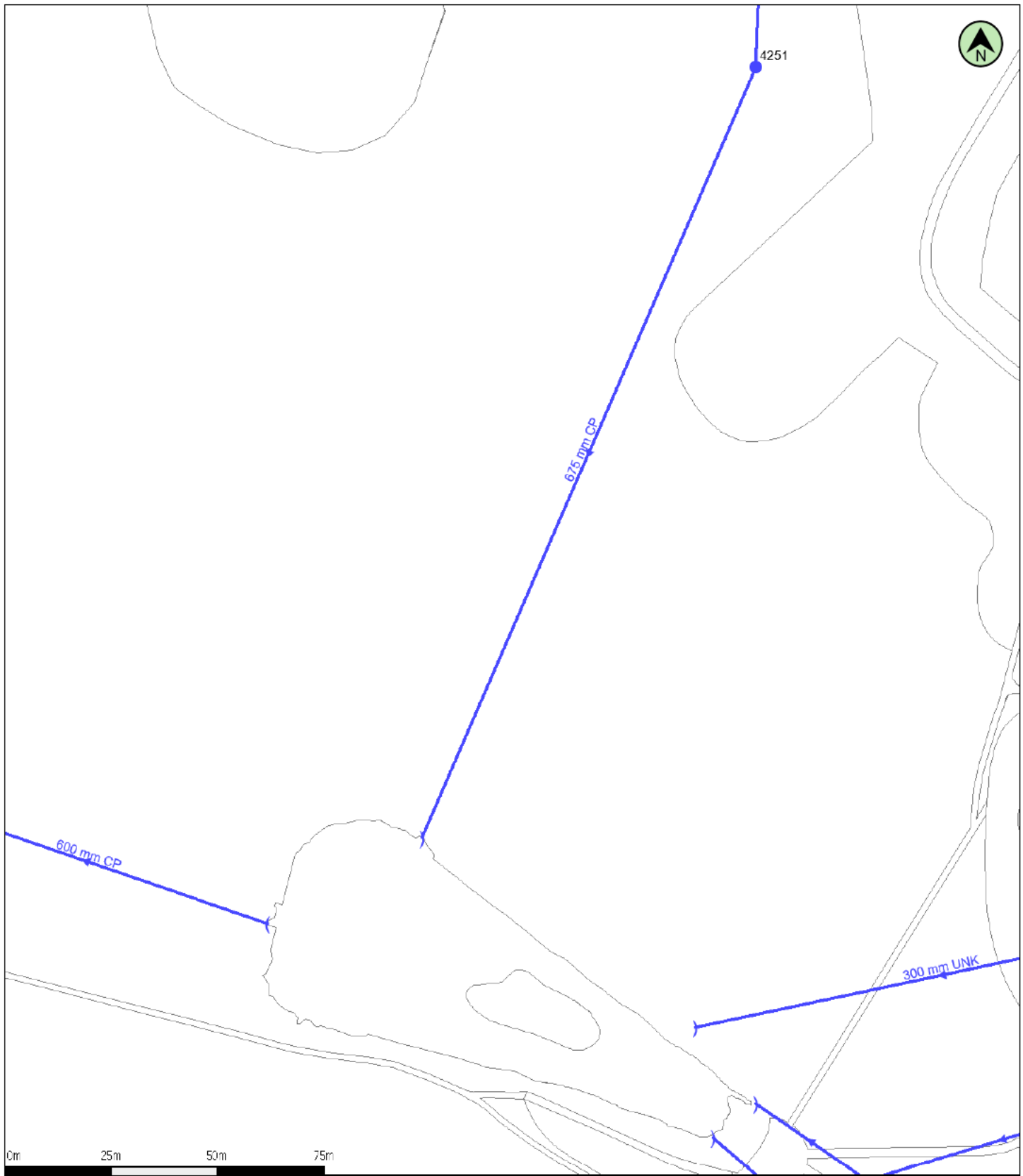
WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.



adc@leapenvironmental.com

1





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 Data updated: 21/06/21

Scale: 1:1250
 Map Centre: 517373,131108

Date: 30/06/21
 Our Ref: 588588 - 1

Wastewater Plan A4
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adc@leapenvironmental.com

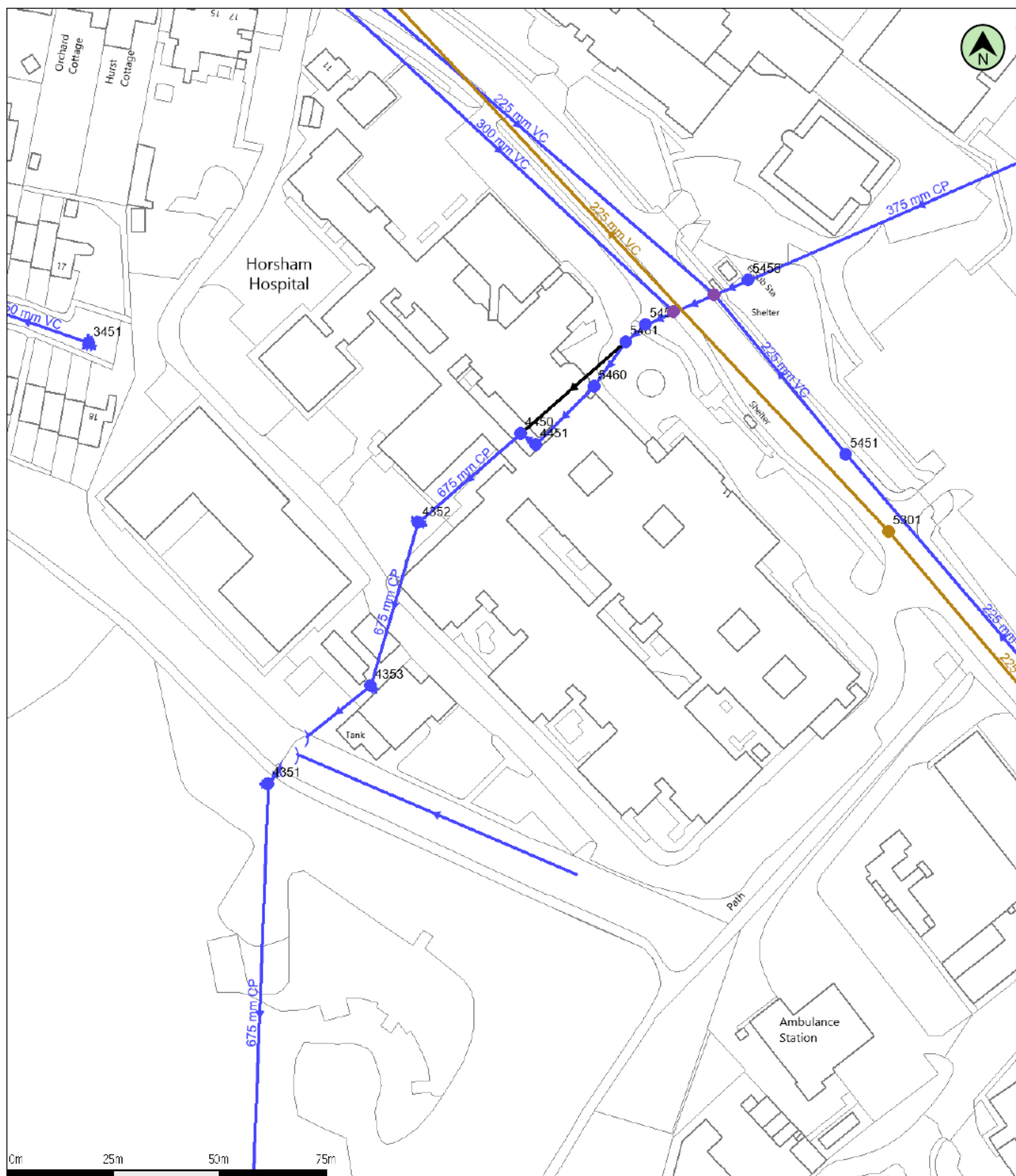
1



The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. This plan is produced by Southern Water Services Ltd (c) Crown copyright and database rights 2021 Ordnance Survey 100031673. This map is to be used for the purposes of viewing the location of Southern Water plant only. Any other uses of the map data or further copies is not permitted.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.



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Scale: 1:1250

Date: 30/06/21

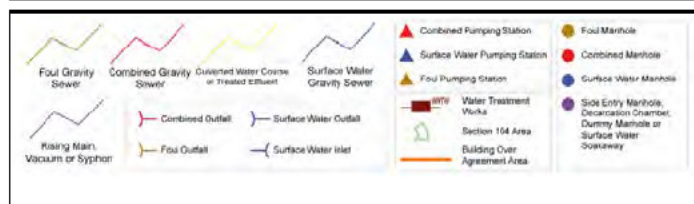
Wastewater Plan A4

Data updated: 21/06/21

Map Centre: 517491,131381

Our Ref: 588588 - 2

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2

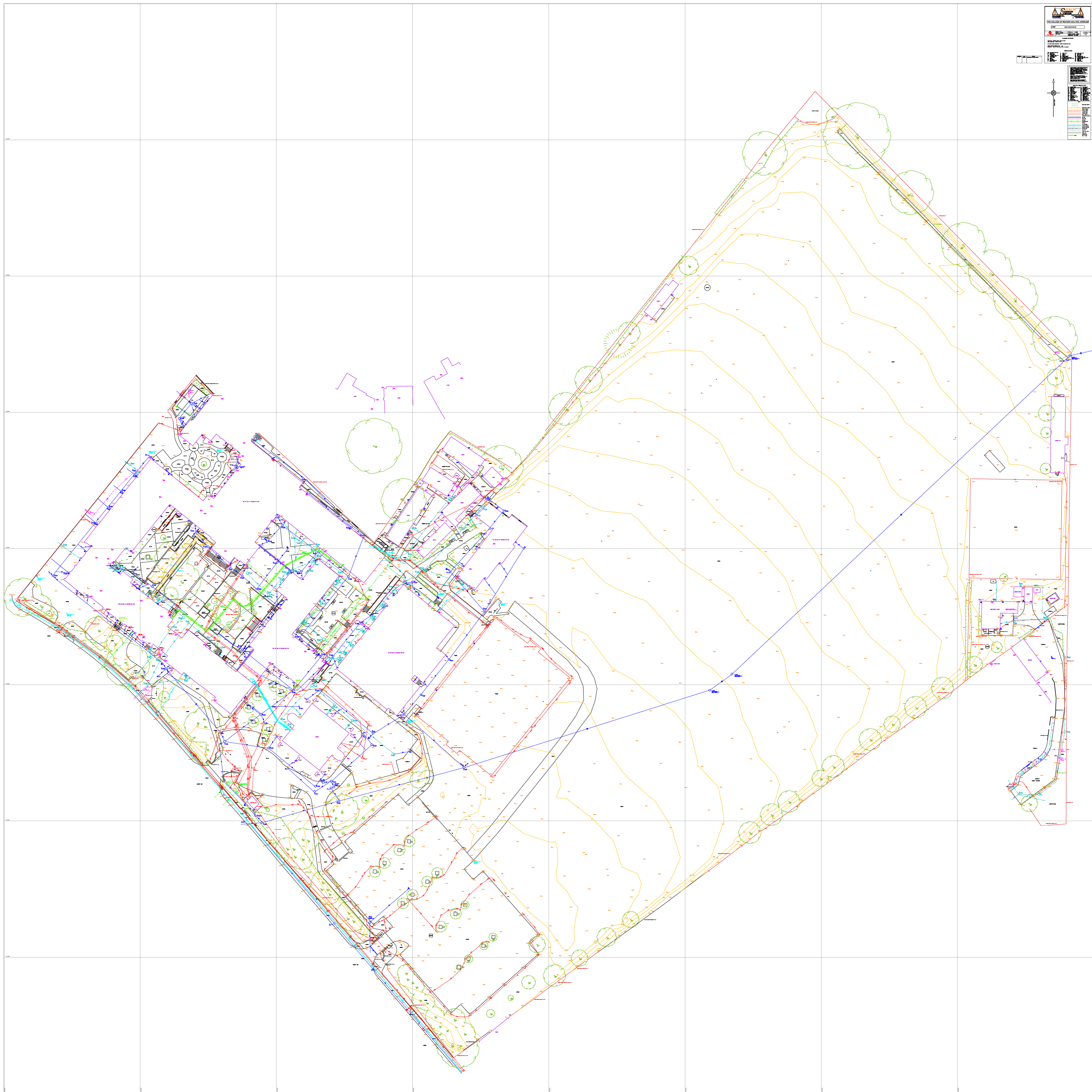


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[illegible]



Lanes Group Plc

Hampshire CC-Novartis RH12 2EE-PJ00305566

31 August 2018

