



Allied London

St Johns, Manchester

Hydrogeological and Dewatering Assessment

Project no. 11314 R01 (01)

OCTOBER 2018



RSK GENERAL NOTES

Project No.: 11314 R01 (01)

Title: Hydrogeological Assessment

Client: Lendlease

Date: October 2018

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Status: Final

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EXECUTIVE SUMMARY

Site description and proposed development	The site is the former Granada Television Studio. Proposed development includes a series of medium to high-rise developments. The River Irwell is close to the site (west) and a former canal is found beneath part of the site.
Purpose of assessment	A refinement on the hydrogeological regime was required through the collection of hydraulic conductivity data from a series of small-scale tests. A dewatering risk assessment and piling risk assessment was requested.
SITE CONCEPTUALISATION	
Canal	A former canal is present beneath part of the site. It is understood to be backfilled and covered. It is not known if the canal leg beneath the site is hydraulically connected to the rest of the canal (upstream and downstream).
Geology	Made ground (up to 6.25m) is underlain by alluvium (0.0m to 5.32m) and bedrock of the Chester Formation (sandstone). The proposed development will result in the excavation of all made ground and alluvium with construction commencing on the sandstone.
Hydrogeology	The Chester Formation is classified as a principal aquifer by the Environment agency. The closest licensed groundwater abstraction is >500m from the site. The aquifer is vulnerable to surface contamination due to the lack of low permeable superficial layers and the shallow nature of the groundwater.
Contamination	Four groundwater samples have been collected and the results show there are exceedances of the freshwater environmental quality standards (EQS) for several chemicals, including cyanide (14 x EQS), copper (3 x EQS), chromium (1.6 x EQS), nickel (1.5 x EQS), zinc (1.2 x EQS), anthracene (7.4 x EQS), fluoranthene (943 x EQS) and chloroform (2 x EQS).
Hydraulic testing	Hydraulic testing (rising and falling head tests) were undertaken on four monitoring wells has yielded an average hydraulic conductivity of 7.45×10^{-6} m/sec (6.43×10^{-1} m/day). A pumping test will be required to provide more reliable estimates of hydraulic conductivity.

CONCLUSIONS AND RECOMMENDATIONS	
Recommendations including issues for further assessment	Pumping tests should be undertaken to provide more representative estimates of hydraulic conductivity for the sandstone. This type of test will stress the aquifer away from the test well. Water quality information suggests groundwater has been impacted from metals and hydrocarbons and the concentration of these compounds must be considered when obtaining a discharge consent.
<i>The information given in this summary is necessarily incomplete and is provided for initial briefing purposes only. The summary must not be used as a substitute for the full text of the report.</i>	

1 INTRODUCTION

RSK Environment Limited (RSK) was commissioned by Allied London (Client) to carry out a preliminary hydrogeological assessment at the St. Johns site, Manchester.

This report is subject to the RSK service constraints given in Appendix A.

1.1 Objective

The objective of the report is to:

- provide an understanding of the geological and hydrogeological setting
- highlight any potential impacts due to the construction
- outline options and recommend groundwater control measures
- highlight any potential impacts due to dewatering activity
- precautions and recommendations for site operations to control groundwater

1.2 Scope

The scope of works included:

- Design and manage a series of hydraulic tests on selected groundwater monitoring wells and collect data. Assess data to determine estimates of hydraulic conductivity of the targeted formation
- Review existing site data and collect other data to allow an understanding of the site geological and hydrogeological setting
- Liaise with the Environment Agency to collect details on local groundwater resources and identify the most likely route for groundwater dewatering licensing (including associated testing)
- Complete a piling risk assessment using Environment Agency guidance
- Complete a dewatering risk assessment

1.3 Existing reports

The following reports detailing the previous works at the site were obtained from the Client. The reports were reviewed to obtain a better understanding of the ground conditions and the previous activities at the site which have been undertaken in order to obtain planning development consent. It is possible that information for the site has not been made available or reviewed and therefore potentially useful information may not have been considered in this assessment. The following documents were reviewed:

- Curtins. Phase 1 Preliminary Site Assessment of Central Village, Manchester and Old Granada Studios, Manchester

- The Land Consultancy Limited. Letter report: Ground Investigation at St. Johns, Manchester. 26 May 2016

The findings of these reports are summarised in Section 2.

At the time of writing, a further report on site investigation works undertaken by Curtins was awaited. This additional report presented data collected during intrusive investigation undertaken by Ian Farmer Associates. RSK were provided some preliminary borehole logs to assist with the hydraulic testing but interpretation was unavailable for review.

1.4 Limitations

The comments given in this report and the opinions expressed are based on the information available and obtained as part of the research for this report. However, there may be information pertaining to the site that have not been disclosed by the research and therefore could not be taken into account.

The estimates of hydraulic conductivity that have been presented are from small scale hydraulic testing that stresses the aquifer very close to the test borehole. Consequently the results can only be considered a rough estimate and should not be used for design purposes without using caution.

2 THE SITE

2.1 Site location

The site is located in Manchester city centre, approximately 550m northwest of Deansgate railway station at National Grid reference (NGR) SJ829 980. Approximately 65m west of the site is the River Irwell.

2.2 Site description

The site is the former Granada Studios with Water Street to the west, Atherton Street to the east and New Quay Street to the north. Quay Street bisects the northern part of the site and the Museum of Science and Industry (MOSI) forms the site southern boundary.

At the time of reporting, demolition activities were underway within the northern part of the site (north of Quay Street) and drainage works were also underway along Water Street. The site includes a large area of carparking, which is surrounded to the east and south by large buildings; the building to the south was also in the process of being demolished at the time of reporting.

The River Irwell, which is approximately 65m west of the site runs parallel to Water Street. A former canal, which previously flowed beneath the site is connected to the River Irwell at a lock immediately west of Water Street.

2.2.1 Manchester and Salford Junction Canal

The Manchester and Salford Junction Canal connected the Rochdale Canal with the River Irwell and it passed beneath the site. The Brunswick Basin, which was connected to the canal was also located on site. It is understood that the former canal and basin have been backfilled beneath the site although the nature of the backfill is not known. It is understood exploratory works are planned to confirm the nature of this fill material.

Within the canal there were two sets of locks. The lower set, which were closer to the River Irwell incorporated Lock No. 1 and No. 2. Lock No. 1 is west of Water street and is still visible whereas Lock 2 is located beneath the site. Lock No. 1 is a single channel arrangement with one pair of gates, while Lock No. 2 had a double channel (i.e. two parallel locks each with two gates). It is likely that Lock No. 2 was backfilled at the time of the site development. Lock 2 is likely to be a relatively large structure.

At the time of construction it had been stipulated that the canal must not take any water from the Rochdale Canal (upstream and to the east) and it was therefore necessary to draw water from the River Irwell and pump to the section between the two sets of locks at a point beneath the site. One of the two pumping engines was located on site, alongside Brunswick Wharf. River water would be diverted through a pipe to the pump house before being pumped and discharged higher up the system. It is likely that the intake to the pump house is at a lower elevation than the adjacent canal. It is not known how this feed pipe has been isolated at the River Irwell.

2.3 Proposed site use

The site will be developed for a series of commercial and residential buildings of varying heights. To accommodate the proposed development and the foundations it is necessary to excavate below the existing ground level. The proposed base of excavation for each part of the site is presented below:

- Nickel & Dime (Tower 1) 19.90m AOD
- No.1 Grape Street 17.15m AOD
- Manchester Goods Yard 18.15m AOD
- St. Johns Tower 18.90m AOD
- Globe & Simpson 19.40m to 21.40m AOD

From borehole logs for the site it is estimated that ground level is approximately 26.5m to 27.5m AOD. Proposed ground levels will therefore need to be lowered by approximately 9.0m. To facilitate construction of the foundation excavation it is proposed to use a piling solution to control ground stability.

2.3.1 Piling

Due to uncertainty as to how the former canal was decommissioned it is possible this feature could represent a conduit for groundwater and surface water ingress into the proposed excavation. To mitigate this risk secant piles are proposed to cut off either end of the canal and the pump intake (this is also referred to as a bye-water tunnel).

All other edges of the excavation will be defined by contiguous piles at 750mm and 900mm diameters, each with a designed 150mm separation.

2.4 Ground Conditions

The ground conditions have been determined following a review of data from the British Geological Survey (BGS) and from borehole records from site investigation that has recently been completed by Ian Farmer Associates (2018).

In general, made ground overlies alluvium and sandstone bedrock.

2.4.1 Made ground

Made ground is generally described to comprise gravelly sand and gravel, with fine to coarse fragments of brick, slate, mudstone, sandstone, tile and glass. The thickness of made ground is reported to vary between 1.10m and 6.25m. The location where made ground is reported to be 6.25m bgl (RBH02) included arisings that were described as strong red brick and strong light grey concrete (possible canal wall). If this structure is a canal wall it may relate to the Manchester and Salford Junction canal.

For the proposed site development all the made ground will be removed from site.

2.4.2 Superficial soils

According to BGS data superficial soils are absent from most of the site although alluvium in the form of clay, silt sand and gravel associated with the River Irwell encroaches from the west.

The site investigation confirmed that the superficial soils are generally granular in nature, comprising coarse sand and gravel with peat identified in RBH03 (0.2m). A strong organic odour was noted in the thin (0.25m) layer of gravel within the borehole BH04B. Depth to the base of the superficial deposits varies between 3.65m and 5.5m bgl and the nature of these granular soils is very similar to the underlying weathered sandstone. The thickness of superficial deposits varies between 0.00m (i.e. absent) and 5.32m, which demonstrates that in some areas of the site made ground is directly in continuity with the underlying (weathered) bedrock.

For the proposed development it is anticipated that all superficial soils will be removed from the site during foundation excavation works.

2.4.3 Bedrock

According to the BGS, bedrock beneath the site is the Chester Formation of the Sherwood Sandstone Group. Following the site investigation the rock is described in varying degrees of weathering status from completely weathered sand, through extremely weak to weak laminated sandstone and medium strong to very strong coarse grained sandstone. The logs demonstrate an abundance of closely spaced planar discontinuities that vary from smooth to rough with some filled and others clean. Total core recovery (TCR) within bedrock varies from 100% (i.e. all core is recovered) to 39%; the lower values being recorded in the shallower weathered sandstone. Rock quality designation (RQD) is a fracture quantification on borehole cores and this varies between 100% and 0%. Fracture spacing does not appear to relate to depth since RQD values vary up and down borehole logs and from one location to another. For example, borehole RBH04 has relatively variable RQD values for the full depth of drilling with zero (0%) readings from 37.0m to 40.5m bgl. By comparison, the logs for RBH02 show

2.5 Hydrogeology

2.5.1 Aquifer characteristics

The shallow alluvium within the area is classified by the EA as a secondary A aquifer and the alluvium as a secondary (undifferentiated) aquifer. Secondary A aquifers can contain layers of sediment that are capable of supporting water supplies at a local rather than strategic scale. These sediments can be an important supply of base flow to surface water. The alluvium has been given no formal classification (A or B) owing either to its variable character or its previous classification.

The underlying Chester Formation is classified by the EA as a principal aquifer. This level of classification is assigned bedrock that have a high intergranular and/or fracture permeability and storage. These rock may support water supply and-or river base flow on a strategic scale.

2.5.2 Groundwater levels

In August 2018 the groundwater levels on site were measured at between 23.0m AOD (RBH02) and 24.1m AOD (BH02). Groundwater flow is to the west, towards the River Irwell.

During the site investigation drilling techniques generally comprised rotary with air/mist flush. On the boreholes logs, groundwater is reported to have not been encountered during the drilling works. The borehole logs do not include a description of a geological layer, which could provide confinement to groundwater within the Chester Formation. It is concluded that groundwater within the Chester Formation is unconfined.

2.5.3 Environment Agency Liaison

The Environment Agency were approached to discuss the local aquifer characteristics and any specific features that may be relevant on site and in the surrounding area. They confirmed there are no records of wells, shafts or sumps present on site but this does not mean none will be encountered. The Museum of Science and Industry (MOSI) are understood to have a 6' diameter stone lined well with a deeper unrecorded borehole extending through the base. It is understood that MOSI undertook a pumping test on the well in 2016 for the purpose of designing a ground source heat pump system but the EA confirmed this has yet to be taken forward. In the event of undertaking a pumping test or dewatering operations on site the EA would request that the groundwater level in the MOSI well is recorded to determine lateral groundwater impacts.

The EA confirmed the licensing regime for groundwater abstraction had changed in January 2018 and the information contained within this report reflects the updated advice. In the likely event that a pumping test is required on site the EA confirmed they are unlikely to require surface water monitoring to be undertaken during the test but that on-site groundwater monitoring wells would need to be used for the duration of the test.

The EA confirmed the presence of historical canal infrastructure on site, including the locks and Brunswick Basin. It is possible that underdrainage features may be present beneath the Brunswick Basin, which was described by the EA as a graving dock. In addition there are likely to be several features used for pumping water from the River Irwell, which have been discussed in this report elsewhere. The following potential sources of information may be appropriate for obtaining more information about the canal construction:

- Canal and Rivers Trust
- Peel Holdings
- Manchester Canal Ship Company archive (see Peel holdings)
- Museum of Science and Industry
- local history records (central library)
- title deeds

A very good understanding of the underground conditions is necessary if a pumping test is to be conducted since features can interfere with the drawdown rates of groundwater.

2.5.4 Vulnerability of groundwater resources

The Chester Formation is classified by the EA as having a high vulnerability to surface contamination. For this geological setting it will be necessary to confirm that groundwater within the underlying bedrock is not at risk from shallow contamination during and post construction.

2.5.5 Licensed groundwater abstraction

The site is not located within a source protection zone (SPZ), which have been defined by the EA to be protective of licensed groundwater abstractions.

There is a Zone III (total catchment) identified approximately 570m east-southeast of the site and this is for a licensed abstraction that is located 2,250m south-southeast of the site. It is understood the abstraction is to provide water to the brewing industry and therefore the source is used for human consumption.

2.6 Hydrology

2.6.1 Surface watercourses

The River Irwell (Irk to confluence with Upper Mersey) is located approximately 65m west of the site. The River Irwell is classed as being heavily modified with an overall classification (2016) as moderate. The classification scheme distinguishes the environmental condition of the water body by placing it into a specific category; moderate is the middle category. The river has achieved an overall status of moderate each year between 2013 and 2016. Ecological classification has been moderate through this period but chemical classification has improved from fail (2013-2014) to good (2015-2016).

The closest river flow station to the site (upstream) is the Irwell at Adelphi Weir (69002), which is located at NGR SJ824 987 and is reported at 24.1m AOD. For the period 1949-2017 the mean flow rate was 17.579m³/s. Upstream of the site and downstream of the Adelphi Weir the Irk discharges into the River Irwell and the daily flow data for this river is recorded at a station (69003) located at NGR SJ841 991 (26.2m AOD) with a mean flow between 1937 and 2001 of 1.794m³/s.

The former Manchester and Salford Junction Canal enters the River Irwell to the west of the site. The canal is disused and no longer discharges water into the River Irwell. However, the short limb of the canal between the River Irwell and Water Street has previously been restored access is given to the towpath in this area. The head of the channel is bricked up above the water line but it is not known if the wall extends to the base of the former canal channel.

In January 2015 an elevation of the water in the River Irwell was recorded at 21.6m AOD (i.e. approximately 4.9m below the site ground level and between 1.2m and 1.8m below groundwater that was measured in August 2018)

2.7 Water features

A review of water features close to the site has been undertaken. This considers the nature and location of features within 500m of the site although the River Irwell is

considered to be a natural barrier to this search towards the west. The following features have been identified:

Canal stub – 20m west (NGR 383033 398052) Connected to the River Irwell (west) and possibly connected to the canal channel beneath the site

River Irwell – 61m west (NGR 382996 398075). Major river flowing east to west.

Borehole (MOSI) – 125m south (NGR 382979 397890). The Museum of Science and Industry has a deep well into the sandstone, which it is understood is accessible and may form part of a future project to develop ground source heating.

Bridgewater Canal/River Medlock (Castlefield Marina – truncated) – 200m south (NGR 383068 397778). Marina with several docking areas connected to the Bridgewater Canal/River Medlock towards the south

Unnamed Canal – 310m south (NGR 382942 397720). A truncated section (Potato Wharf) of a former canal, which remains linked to the River Irwell.

Additional water features may be present within 500m of the site and these could be identified through discussion with the Environment Agency. It is possible that if any pumping test is undertaken on site or during the proposed dewatering it may be necessary to undertake monitoring of the water level in water features close to the site. Of the features identified, only the water level in the MOSI borehole is likely to be affected by pumping groundwater on the site. However, this will need to be confirmed with the Environment Agency.

2.8 Existing reports

The following reports have been reviewed by RSK with a summary of the pertinent information included.

2.8.1 Curtins. Phase 1 Preliminary Site Assessment of Central Village, Manchester and Old Granada Studios, Manchester (2016)

Historical site use has been determined using Ordnance Survey maps, which start in 1848 although by this date significant development on site and in the surrounding area was already present. A canal bisects the site and a dry dock is located immediately north. A timber wharf and other commercial and industrial buildings are identified on site and in the surrounding area between 1848 and 1951. Between these dates some demolition work is noted although this could be associated with the second world war. By 1951 the site is part of the Granada Television Centre with associated filling of underground canal features. The site has been used as a television studio until present.

The following contaminants of concern have been reported, on the basis of the historical use on site:

- Aliphatic and aromatic hydrocarbons
- Polycyclic aromatic hydrocarbons (PAH)
- Polychlorinated biphenyl (PCB)
- Inorganic compounds (including heavy metals)

- Asbestos

The following potentially complete pollutant linkages were identified in the report:

1. Moderate risk of direct contact / vapour inhalation of on-site contamination and site end-users. Recommended: generic quantitative risk assessment based on chemical composition of made ground on site
2. High risk of gas inhalation from on-site and off-site sources by site end-users. Recommended: generic quantitative risk assessment based on chemical composition of made ground on site
3. High risk of encountering UXO during construction. Recommended: detailed UXO risk assessment and report

RSK note that the proposed site development will result in the excavation of all made ground and all superficial soils, including the weathered surface of the underlying Chester Formation (sandstone bedrock). The potentially complete pollutant linkages that are taken from the PRA (listed above) should therefore be revised. It is suggested that the following assessment is considered:

1. Direct contact / vapour inhalation of on-site contamination and site end-users – reduce to low risk. Direct contact pathway will be removed through the proposed construction methods and the use of construction material (hardstanding) between site soils and site end users. In order to construct the proposed foundations, all made ground and superficial soils (to approximately 9.0m bgl) will be excavated and removed from site. These soils will not be on site to produce ground gas. It is proposed therefore that the pollutant linkage has been broken (source removal) for both pathways and so no further action is required.
2. Gas inhalation from on-site and off-site sources by site end-users – reduce to low risk. The proposed development includes the excavation and removal from site of all the made ground and superficial soils. It is therefore considered that any material with a gas generation potential will be removed from site. In addition, the PRA identifies that no significant off-site sources of ground gas are noted. It is therefore considered that the contaminant linkage has been broken (source removal)
3. RSK has not seen evidence of a detailed UXO risk assessment and therefore the likely risk from this remains medium to high. Mitigation measures such as UXO detection during proposed works would need to remain unless a detailed assessment can confirm the risk can be reduced.

2.8.2 The Land Consultancy Limited. Letter report: Ground Investigation at St. Johns, Manchester. 26 May 2016

The site investigation involved drilling three boreholes to between 5.0m and 5.5m bgl using cable tool percussion drilling. The boreholes were then extended to 20.0m to 21.5m bgl using rotary coring methods (air mist flush). Made ground was encountered to a depth of 1.0m to 3.0m bgl and hydrocarbon odours were noted in BH1 and BH2. Possible alluvium was reported to depths of 3.6m and 4.0m bgl.

The Chester Formation is reported as a residual soil / destructured sandstone, which was recovered as medium sand to depths between 5.0m bgl (BH1) and 5.5m bgl (BH2). The

Chester Formation is described as extremely weak to very weak reddish brown medium grained sandstone, with the only exception in BHR3 (5.5m to 7.5m bgl) where it was described as weak to medium strong. In BHR1 RQD values ranged from 0-59%, in BHR2 and BHR3 they ranged 0-31%. Overall fracture spacing within the core runs were in the range 10mm to 230mm with fractures generally inclined 0-10°. Fractures were described as being incipient to open. No groundwater was encountered in the boreholes during drilling.

No samples were collected for contamination testing and no follow-on groundwater or ground gas monitoring has been reported.

2.9 Groundwater Quality Assessment

Groundwater samples were obtained from four wells screened in the Chester Formation (sandstone) during site works on the 9th August 2018. The samples were sent to a UKAS and MCERTS accredited laboratory for a range of chemical analysis. The results of the analysis have been obtained and these have been compared to target concentrations set by the EQS freshwater criteria. These criteria are considered to be the most appropriate since they are protective of surface water (i.e. River Irwell). These criteria are considered to be the most appropriate since the River Irwell is likely to act as discharge for regional groundwater in the area and there are no licensed groundwater abstractions close to the site.

Comparison of the chemical test data with the EQS confirmed that most of the parameters fall within the targets set by the EQS, however some failed to meet the criteria and these are listed below:

- **Cyanide – (EQS = 0.001 mg/l *)**
 - WS10 = 0.007 mg/l (7 x EQS)
 - RBH02 = 0.014 mg/l (14 x EQS)
- **Copper – (EQS = 1 bioavailable µg/l *)**
 - RBH02 = 3 µg/l (3 x EQS)
- **Chromium – (EQS = 8.1 µg/l *)**
 - RBH02 = 10 µg/l (1.2 x EQS)
 - BH04 = 13 µg/l (1.6 x EQS)
- **Nickel – (EQS = 4.0 bioavailable µg/l *)**
 - BH02 = 6 µg/l (1.5 x EQS)
- **Zinc – (EQS = 10.9 bioavailable µg/l *)**
 - BH02 = 13 µg/l (1.2 x EQS)
- **Anthracene – (EQS = 0.1 µg/l *)**
 - RBH02 = 0.74 µg/l (7.4 x EQS)
 - BH02 = 0.69 µg/l (6.9 x EQS)

- **Fluoranthene – (EQS = 0.0063 µg/l *)**
 - WS10 = 0.01 µg/l (1.6 x EQS)
 - RBH02 = 5.94 µg/l (943 x EQS)
 - BH04 = 0.03 µg/l (4.8 x EQS)
 - BH02 = 4.71 µg/l (748 x EQS)
- **Chloroform – (EQS = 2.5 µg/l *)**
 - RBH02 = 5 µg/l (2 x EQS)

Note: * denotes criteria that are based on annual average concentrations.

The full suite of EQS Freshwater target values and the laboratory certificates for the four groundwater samples are presented in C and D respectively. The assessment shows a slight exceedance of the EQS for copper, chromium, nickel, zinc and chloroform (i.e. <3x EQS) but a greater exceedance of the EQS (i.e. > 3 x) is recorded for anthracene, cyanide and fluoranthene. These samples were collected from groundwater monitoring wells that are screened in the Chester Formation (sandstone), but the screens travers the whole length of the borehole that encountered sandstone. It is not possible therefore to say with any certainty how deep any of the contamination may have impacted. It is also not possible to confirm with this data alone, if this contamination is representative of groundwater within the whole of the site and if the source of the contamination is on site or from an off-site source. Clearly during pumped conditions groundwater will be drawn from all over the site and from off site and therefore the groundwater chemistry has the potential to change (increase or decrease).

These data will need to be considered in the piling risk assessment and in the discharge from site during pumping operations.

3 HYDRAULIC TESTING

A series of small scale hydraulic tests were undertaken on site during August 2018. This section presents the work that was completed and the results that were obtained.

3.1 Introduction

An initial survey of the site and the available data was undertaken to determine the most appropriate groundwater monitoring for hydraulic testing. Not all borehole logs included details of the monitoring well diameter so it was necessary to confirm this during a site walkover, which was undertaken 20th August 2018.

A groundwater monitoring well of at least 500mm diameter is required to allow the proposed testing to be undertaken.

3.2 Testing

Hydraulic conductivity testing was undertaken on 23rd August 2018. The testing was undertaken in general accordance with BS EN ISO 22282-2:2012, Geotechnical investigation and testing – Geohydraulic testing. Part 2: Water permeability tests in a borehole using open systems.

The testing utilised a groundwater pressure transducer, which collected groundwater level data every second within the test borehole. The transducer was placed in the water column at a depth of approximately 4.0m below the measured groundwater level. The test requires an instantaneous change in groundwater level to initiate the test and so a plastic displacer was used. The main benefits of the adopted test methodology are the low cost, the high number of tests that can be completed and no groundwater is pumped from the borehole, which would normally require disposal. The main disbenefit of the test is the limit volume of ground that is subject to testing and so the test results apply to a relatively small volume of ground close to the test borehole.

Testing commences as soon as the displacer is introduced into the groundwater. The test is considered to be complete when groundwater returns to the level that was recorded immediately before the test commenced ($\pm 10\%$).

The form of test undertaken is known by several names, including slug test, bailer test, rising head test or falling head test. A slug test and falling head test are the same and refer to an increase in groundwater level through the introduction of a displacer and the water level then falls for the duration of the test. A bailer test or rising head test refers to a test methodology where a volume of water is removed from the column and the water level rises to pre-test levels during the test. For the purpose of this report all testing is referred to as hydraulic conductivity testing and the water level is changed through the introduction and removal of a solid displacer. The displacer used for testing comprised five separate sections that when combined result in a water level change of 1.67m in a 50mm monitoring well. The use of a solid displacer can result in the generation of early-time 'noise' in the response data. This noise can be attributed to either the production of

short-term dynamic pressure disturbances caused by the movement of the slug of the cables of the transducer and the slug interfere during insertion or removal.

The slug test presents numerous benefits, but also some disbenefits. Indeed, the reliability of a slug test is less than a pumping test that, when it is possible to use, undoubtedly more accurately estimates permeability. A slug test is simple, fast, inexpensive and does not require pumps or complex equipment. The test indicates the permeability of the localised area near the testing site. Testing was undertaken in the following monitoring wells:

- RBH02
- BH04
- BH02
- BHR3

A brief description of each monitoring well is presented below.

3.2.1 RBH02

Six hydraulic conductivity tests were undertaken in RBH02. Groundwater level before testing commenced (t_0) was measured at 3.42m bgl (23.0m AOD). RBH02 is screened between 6.3m and 20.0m bgl and so the measured groundwater level relates to the rock along the entire screened section, which includes numerous layers of sandstone of varying strength and competence.

The borehole was drilled using rotary boring techniques and it is assumed air mist was used for the circulation medium (not recorded on the logs). Rock quality designation (RQD) data collected during the drilling ranges from 48 to 100 (87, 100, 100, 100, 100, 100, 48, 100, 100 – top to bottom) suggesting a medium to strong sandstone with few discontinuities.

Graphs from the test data collected on site are presented in Appendix B.

3.2.2 BH04

Four hydraulic conductivity tests were undertaken in BH04. BH04 is screened from 5.0m to 20.0m bgl across sandstone described with various strengths. Groundwater level before testing commenced (t_0) was measured at 3.17m bgl (23.38m AOD). The base of the monitoring well was plumbed at 19.63m bgl (6.92m AOD).

The borehole was drilled using rotary boring techniques and it is assumed air mist was used for the circulation medium (not recorded on the logs). RQD data collected during the drilling range from zero (0) to 85 (0, 0, 0, 33, 0, 53, 23, 53, 53, 85, 61 – top to bottom) suggesting a very fractured or jointed rock with bands of stronger rock.

Graphs from the test data collected on site are presented in Appendix B.

3.2.3 BH02

Four hydraulic conductivity tests were undertaken in BH02. BH02 is screened from 5.0m to 20.0m bgl through sandstone. Groundwater level before testing commenced (t_0) was

measured at 3.17m bgl (24.1m AOD). The base of the monitoring well was plumbed at 19.63m bgl (7.64m AOD).

The borehole was drilled using rotary boring techniques with air mist flush. No groundwater entries are recorded but groundwater measurements were noted during the drilling works. For all measurements the well was cased to 4.6m bgl and the measured water level varied between 2.1m bgl and 7.2m bgl. Rock quality designation (RQD) values range from zero (0) to 82 (0, 0, 42, 0, 6, 6, 52, 41, 30, 46, 56, 71, 82, 78 – top to bottom) suggesting a very fractured or jointed rock with bands of stronger rock.

Graphs from the test data collected on site are presented in Appendix B.

3.2.4 BHR3

Four hydraulic conductivity tests were conducted in BHR3. The monitoring well is screened from 6.0m to 21.5m bgl through weathered sandstone. The groundwater level immediately before testing commenced (t_0) was recorded at 3.46m bgl.

The borehole was drilled using rotary drilling techniques and air mist and the drillers report no groundwater being encountered during the drilling works. RQD values range from zero (0) to 31 (0, 0, 0, 16, 19, 31, 0, 0 – top to bottom) suggesting a very fractured or jointed rock.

Graphs from the test data collected are presented in Appendix B.

3.3 Analysis

Data from all tests undertaken in each of the three monitoring wells have been assessed using Aquifer^{Win32}, which is a Windows based visualisation toolkit for assessing groundwater test data. Data was assessed using the Black (1978) solution for an unconfined aquifer. The Black (1978) solution is a modified Bouwer and Rice (1976) solution, which allows data assessment on an exponential type curve.

For data analysis, initial displacement was fixed for each test at 1.67m as per the manufacturers specification for a 50mm diameter well using the displacer. However, in some monitoring wells this estimate of initial displacement was inappropriate due primarily to early test 'noise'. In these cases the early test data was ignored and the later test data used for the assessment. An estimate of the test initial displacement was based on the start of the reliable data used for the analysis.

The analysis from all testing are presented in Appendix B and are summarised below. The initial displacement value is presented on the analysis and also with the results from testing (below).

3.3.1 BHR3

Displacement of groundwater for the falling head tests is consistently greater than for the rising head tests (difference is 0.54m). Hydraulic conductivity data for BHR3:

- BHR3 (T1) $1.35 \times 10^{-5} \text{m/sec}$ (1.65m)
- BHR3 (T2) $1.33 \times 10^{-5} \text{m/sec}$ (1.11m)

- BHR3 (T3) $1.64 \times 10^{-5} \text{m/sec}$ (1.65m)
- BHR3 (T4) $1.43 \times 10^{-5} \text{m/sec}$ (1.10m)
- **Average** **$1.44 \times 10^{-5} \text{m/sec}$**

3.3.2 BH02

Early test data at this location is very 'noisy' with the rising head tests being slightly impacted through interference with the cable used to suspend the pressure transducer. The later test data is used for the analysis with earlier data being 'off' the type curve. Some of the 'noise' may be attributed to interference with the transducer cable but the majority of data fluctuation is likely to be due to aquifer performance, i.e. higher hydraulic conductivity than the analysis of late data suggests. Hydraulic conductivity data for BH02:

- BH02 (T1) $4.72 \times 10^{-6} \text{m/sec}$ (0.90m)
- BH02 (T2) $1.27 \times 10^{-5} \text{m/sec}$ (1.56m)
- BH02 (T3) $1.00 \times 10^{-5} \text{m/sec}$ (1.70m)
- BH02 (T4) $9.74 \times 10^{-6} \text{m/sec}$ (1.60m)
- **Average** **$9.29 \times 10^{-6} \text{m/sec}$**

3.3.3 RBH02

The data shows a distinctive difference in groundwater level recovery between the falling head tests and the rising head tests; recovery in rising head tests (T2, T4 and T6) are recorded to be faster. In all cases there was a rapid recover of groundwater level recorded within the first five seconds of the test. Since the well screen is submerged this effect is unlikely to be due to the well annulus filling/draininag and is therefore likely to be due to movement within hydraulically responsive ground. It is noted that this location is close to the former canal and so hydraulic performance is unlikely to be representative of the natural soils without being influenced by the man made infrastructure. Hydraulic conductivity data for RBH02:

- RBH02 (T1) $3.62 \times 10^{-7} \text{m/sec}$ (1.55m)
- RBH02 (T2) $2.30 \times 10^{-6} \text{m/sec}$ (1.65m)
- RBH02 (T3) $3.57 \times 10^{-7} \text{m/sec}$ (1.55m)
- RBH02 (T4) $2.22 \times 10^{-6} \text{m/sec}$ (1.10m)
- RBH02 (T5) $3.45 \times 10^{-7} \text{m/sec}$ (1.55m)
- RBH02 (T6) $2.14 \times 10^{-6} \text{m/sec}$ (1.55m)
- **Average** **$8.10 \times 10^{-7} \text{m/sec}$**

3.3.4 BH04

Recovery of groundwater in falling head tests is slightly slower than that recorded in the rising head tests. In the former tests, recovery was not fully achieved in the data so an off-set was used for subsequent tests. Except for the initial few readings in T3 the hydraulic performance in the falling head tests was similar; T3 data is considered to be

attributed to the speed the displacer was introduced into the well. Hydraulic conductivity data for BH04:

BH04 (T1)	$1.87 \times 10^{-6} \text{m/sec}$ (1.25m)
BH04 (T2)	$8.64 \times 10^{-6} \text{m/sec}$ (1.25m)
BH04 (T3)	$2.01 \times 10^{-6} \text{m/sec}$ (1.25m)
BH04 (T4)	$8.64 \times 10^{-6} \text{m/sec}$ (1.25m)
Average	$5.29 \times 10^{-6} \text{m/sec}$

3.3.5 Averages

An overall estimate of hydraulic conductivity has been calculated by calculating the average value of all the test averages:

- **$7.45 \times 10^{-6} \text{m/sec}$ ($6.43 \times 10^{-1} \text{m/day}$)**

By comparison, this average value compares to the lower-end of a clean sandstone and fractured rock or within the anticipated range of a fine sand. This is not unexpected given the description on the borehole logs of weathered sandstone including frequent discontinuities, which are either open or filled. The long screened section within the monitoring wells may mask zones of higher hydraulic continuity and the more rapid recovery of groundwater levels recorded in the early phases of some tests (where identified) have not been analysed.

3.4 Other local testing

According to the CCG report (Northern Hub, Ordsall Chord GRIP 4 Ground Investigation (Final) November 2014) variable head permeability testing was undertaken on site. The results for the two tests that were subject to analysis are:

- G4WS01: response zone - 1.0m to 3.4m bgl (made ground). Reported estimate of hydraulic conductivity is $1.512 \times 10^{-7} \text{m/sec}$
- GBH07: response zone 3.6m to 5.8m bgl (silt, sand and gravel – weathered sandstone). Reported estimate of hydraulic conductivity is $4.737 \times 10^{-7} \text{m/sec}$

The reported values are at the lower end of the data set collected from the site. However, the report also states that with the exception of standpipes installed at G4WS01 and BH07, permeability was too high to enable accurate recording. It is reported that 2000-litres of water were discharged into each standpipe within a 10-minute period without discernable rise in the observed standing water level.

It is not reported which boreholes were able to accept such volumes of water or what strata was being targeted. It is also not clear where the boreholes are located. It does confirm potential significant variability in the hydraulic conductivity of the tested formation.

The Environment Agency confirmed that the MOSI undertook a pumping test in their well but did not divulge any results from the test. However, they were able to confirm the likely significant variability in aquifer performance within the shallow (weathered) sandstone, particularly in areas close to surface water features.

4 GROUNDWATER CONTROL

4.1 Introduction

The proposed site development requires construction of a basement excavation across the site to elevations of between 17.5m AOD (No. 1 Grape Street) to 21.4m AOD (Globe & Simpson). The present ground level is approximately 26m AOD and so it will be necessary to reduce ground levels by up to 8.5m. During August 2018 groundwater was measured between 23.0m and 24.1m AOD. It will therefore be necessary to reduce groundwater levels on site by approximately 6.6m to achieve a dry excavation, deeper if considering localised lowering of groundwater close to the pump.

4.2 Local dewatering projects

It is understood that Stuart Wells Services (SWS) has undertaken dewatering operations on several sites in Manchester (Owen Street, Crown Street and Chester Road). The dewatering followed pumping tests. It is possible this test data can be made available although permission from SWS client may be required.

The underlying bedrock for these three additional locations is the same as the John Street site, Chester Formation (sandstone) but the superficial soils are glacial sheet deposits comprising sand and gravel. Borehole logs for this area shows a layer of clay to be present in some areas over weathered sandstone. RQD values for the top 10m of sandstone encountered in boreholes in Owen Street range from 13 to 83 (average 58), compared to many records of 0 (zero) through to 100 recorded on the John Street site.

The river Medlock flows relatively close to the sites tested by SWS and the River Irwell flows close to the St John site. Both rivers are highly modified and present in stone lined channels but the River Irwell is significantly larger. Other underground features, formerly discharging into the River Irwell are also located beneath the St Johns site.

It is understood that the dewatering reduced groundwater levels by approximately 3.0m on these sites, unlike the 6.0m to 8.0m required at John Street. Actual pumping rates or specification for the scheme adopted by SWS was not made available.

4.3 Site dewatering

4.3.1 Estimated pumping rates

Assuming a hydraulic conductivity of 7.45E-6m/sec (average of hydraulic testing) and an excavation with radius 62m and 90m distance from a constant head boundary (River Irwell) it is estimated that up to 17.6l/sec (1.762E-2m³/sec or 1,522m³/day) of water will require pumping to maintain the required drawdown.

The estimated values are based on the average estimate of hydraulic conductivity achieved from site testing but the variability in the test data is at least two orders of magnitude (x100), which demonstrates significant variability. The variability in hydraulic conductivity will increase the uncertainty in estimates of:

- Required pumping rate to achieve drawdown
- Propagation of zone of influence from pumping
- Duration for steady state to be achieved

4.3.2 Dewatering Risk Assessment

A qualitative risk assessment has been undertaken to consider the potential risks for the project in relation to dewatering activities. This assessment considers several scenarios and looks at the likelihood of impacts (beneficial or detrimental) of the scenario occurring on specific receptors that have been identified. The assessment considers potential risks on the basis of very low, low, medium, high, critical and this is presented below in Table 1.

Table 1: Dewatering risk assessment

Scenario	Description	Assessment
Impact on water supply to licensed groundwater abstractions	Local groundwater levels will be lowered and this may impact the performance of nearby licensed groundwater abstractions.	Very low – the closest licensed groundwater abstraction is reported to be >570m from the site – this is the distance to the total catchment (SPZIII) of the closest licensed groundwater abstraction. It is unlikely that dewatering activities at the site will influence groundwater levels at this distance. The water features survey and abstraction license preparation work will confirm this initial assessment.
Affect water supply to unlicensed groundwater abstractions	Local groundwater levels will be lowered and this may impact the performance of nearby unlicensed groundwater abstractions.	Very low – there is a low likelihood of unlicensed groundwater abstractions being located close to the site although this remains a possibility. The site is within an area well covered with mains water and diminishing industrial activity The water features survey and abstraction license preparation work will confirm this initial assessment.
Impact on surface water flow (adjacent River Irwell)	Pumping operations will alter groundwater levels in the area surrounding the site. The River Irwell is approximately 65m west of the site. Gauging data (upstream) for the River Irwell suggests flows of approximately 18m ³ /sec.	Very low – although groundwater may discharge into the River Irwell the likely pumping rate of the dewatering is anticipated to be <20l/sec, compared to a flow rate of >18m ³ /sec in the river reach adjacent to the site.
Impact on groundwater levels (during construction)	Dewatering will have the effect of lowering groundwater levels within the site and the surrounding area. Lowering of groundwater levels can cause settlement if the reduction in bearing capacity reaches a critical value.	Critical – the most sensitive receptors shall be identified and monitoring strategies considered, including periodic topographical surveys, the use of sentry groundwater monitoring wells to monitor intermediate groundwater levels.

Scenario	Description	Assessment
Barriers to groundwater flow – changes in groundwater level (during operation)	Following development of the site a double height basement will be constructed below the groundwater table. The basement is close to the River Irwell, which is likely to be a discharge feature for groundwater and therefore the basement may interrupt groundwater flow towards the river channel. Groundwater mounding on the up-hydraulic gradient side of the basement may develop and groundwater lowering on the down-hydraulic gradient side of the basement may develop. These changes may have a permanent affect on the groundwater regime in the surrounding area.	Medium – the proposed basement is sub-parallel to the alignment of the River Irwell and is therefore likely to be perpendicular to groundwater flow within the sandstone. The basement will cause groundwater to rise on the up-hydraulic gradient edge of the development and this should be assessed to confirm the need for perimeter drains or other mitigation measures that may alleviate any unnatural changes in groundwater level within this area.
Impact surface water / drainage (via pump discharge) – chemical and physical	During the pumping test and the dewatering operations groundwater will need to be discharged to a feature that is outside the zone of influence, i.e. the River Irwell or the nearby drainage system. Physical (e.g. sand content) and chemical parameters within the water for discharge have the potential to cause an impact on the receiving water feature.	Medium / high – High pumping rates can result in the mobilisation of sediment, which can be incorporated into the discharge. Sediment loadings of discharges are one of the most significant impacts on features receiving discharge. A sand tester should be included in the pumping test to confirm sand generation at different pumping rates and this can be used to assist with the pumping scheme design and any treatment requirements that may be necessary – site space and residence time may be an issue for treatment on-site. The chemical composition of groundwater can also impact the receiving feature. Chemical testing information must be obtained and assessed against relevant EQS values and this data will be required to supplement the pumping test application and the dewatering license application process.
Impact surface vegetation	Dewatering will lower the water table, which may provide a necessary water supply for larger more mature trees.	Low – it may be necessary to identify potential vegetation at risk and consider alternative watering strategies for the

Scenario	Description	Assessment
		duration of the dewatering. This is particularly necessary during the growing season..
Incomplete drawdown within excavation / out of specification dewatering apparatus	There has been considerable variability found in the quality of the sandstone (RQD values ranging from 0 to 100) and the consequence this may have on estimates of hydraulic conductivity. A uniformly spaced dewatering system may struggle to generate sufficient drawdown in areas where it is installed with restricted hydraulic continuity from the surrounding aquifer material. Localised 'wet' areas may develop and this could impact the quality of the construction.	Medium – Consideration must be given to the retrofitting of additional dewatering points within the system if certain areas are identified to either be inundated with excess water or the installed dewatering points are ineffective at removing water from the immediate area. Contingency plans must also be drawn up for a series of anticipated/likely disruption scenarios so that appropriate equipment can be brought to site with no disruption to the programme of construction quality.
Sediment washout	Soils within the made ground and the underlying alluvium are described as granular comprising sand and gravel. Shallow bedrock is also described as sand, through very weak sandstone to weak sandstone. There is a potential that sediment could be mobilised due to the actions of dewatering. Washout can occur with sediment between the piles and from the base of the excavation due to upward migrating groundwater.	High / critical – Estimates of hydraulic conductivity over two orders of magnitude have been recorded and in areas where there is a high flow rate it is possible that sediment can be mobilised during dewatering operations. Aggressive dewatering may exacerbate this if high flow rates also lead to mobilisation of sediment. An appropriate pumping rate with suitably spaced abstraction/eductors is required and an estimate of sand/sediment generation at different pumping rates. As dewatering progresses it is possible that the shallow soils could dry out and lose stability between the piles leading to slumping if sediment. Sediment filled fractures have been identified in borehole logs along with other clean fractures and fissures. Dewatering can mobilise the sediment from these features resulting in some fluctuation in groundwater levels as they become active and extent the volume of ground influenced by the pumping and

Scenario	Description	Assessment
		they can also result in short term increases in sediment loading at the discharge. Unmitigated sediment washout from the pile walls can result in a reduction of bearing capacity for the ground behind and if this propagates laterally settlement can be induced. It will be necessary to maintain vigilance on the soil integrity between the piles.
Changes in water chemistry – impacts on ecology and human health	Water chemistry could alter as a result of introducing grout and cement into the piles – this can enter groundwater since the piles are designed to terminate below the groundwater table. Any grout/cement entering the dewatering system has the potential to be discharged and cause an exceedance of the discharge consent.	Medium – Develop and implement a system of water quality assessments to confirm the suitability of water quality for the discharge.
Insufficient licensed volume (abstraction and discharge)	The pumping test will provide more accurate estimates of hydraulic conductivity and a better understanding of the relationship between pumping rates and distance drawdown. The proposed dewatering system will be based on a design drawn up with data from the sources including the pumping test but there may still be ground conditions that have not been accounted for, which can influence the performance of a dewatering system. It is possible therefore that the licensed volume for abstraction is insufficient to permit the required drawdown to be achieved.	Low / medium – It would be normal to request additional capacity for abstraction and discharge over the anticipated design requirement. This would allow some scope for increasing the rate of abstraction/discharge. The license costs for the necessary abstraction will be minimal so it would be beneficial to have an overestimated abstraction rate proposed at the time of the license application so that sufficient water features are identified and assessed in case this limits future increases in abstraction rates being licensed. Similarly, for discharge volumes it will be necessary to confirm the likely availability for discharging additional water if a greater volume than anticipated is produced – this is more critical if the discharge is via a closed system (e.g. foul sewer) compared to an open system like the adjacent canal/river.

Scenario	Description	Assessment
Equipment failure (holidays, inclement weather, maintenance)	Failure of equipment such as generators, pumps, suction hoses, etc. can result in the dewatering system to either develop inefficiencies or to stop working completely. This can result in the partial recovery of groundwater levels with the associated disruption to construction activities and construction quality. Dewatering activities may need to be maintained over periods of holiday (Christmas) and through period of inclement weather (e.g. ice and heavy rainfall). Ice build up inside pipes experiencing intermittent flow can freeze with the consequence of restricted flow. Construction activities may cease during different phases of the project or during periods where works on site are temporarily suspended. It may not be possible to stop the dewatering operations due to the impact on construction material or the geotechnical properties of shallow soils.	High – Agreement must be made for the provision of stand-by equipment that may be required on site or the availability of critical replacements within a specified time to arrive and be installed on site (24hrs per day) – this must include the availability of human resources too, full time on site or within a specified time from site. An alarm system or constant monitoring must be put in place (as determined by the provision of engineers on the project) to monitor the performance of the system and the impacts caused by system failure. A system management plan should be generated and implemented on site.
Basement inundation from surface water run-off	Heavy rainfall and uncontrolled surface water run-off can enter excavations during periods of inclement weather – these are becoming more frequent and intense. Profiling of the excavation can result in surface water collecting in specific areas of the basement. Highly transmissive weathered sandstone can allow relatively rapid vertical migration of surface water into the subsurface. It is possible that the additional ‘load’ of surface water, which may enter the dewatering system could reduce the efficiency of the system to maintain a depressed groundwater table.	Medium – control of surface water at the site perimeter should be sufficient to prevent uncontrolled entry onto site. The proposed basement excavation is likely to be large unless it is proposed to excavate it in phases – the provision of surface water management (sump pumping) will be required. Confirmation that this water can be discharged with the dewatering scheme will need to be ascertained. Edge control will be required around the perimeter of the basement excavation to prevent surface water ingress particularly where CFA piles are used and there is a potential that preferential pathways could develop on the outside of the wall with water discharging onto the basement and scouring soil from between / behind the piles.

Scenario	Description	Assessment
Groundwater dependant features / ecosystems	Any local groundwater dependant ecosystems have the potential to be impacted during the pumping test and the dewatering operations if groundwater levels are significantly reduced for an extended period of time (i.e. dewatering).	Very low – these features are unlikely to be present within the built up area of Manchester and therefore no impacts are anticipated. This position will be confirmed at the time of the water features survey undertaken in support of the pumping test.
Pathways for groundwater flow – increased risk of aquifer pollution	It is likely that non-uniform groundwater drawdown will develop in the area surrounding the site. This can be exacerbated by underground structures including utilities corridors and building foundations. It is possible former land use outside the site has some former contaminative use and if it is mobile this contamination could be drawn towards the site and into the underlying aquifer. Preferential pathways may be present or may also develop during pumping. One example is the former canal and byewater connection, both of which pass through the site. It is unclear how these features have been isolated from the River Irwell (if at all). These features and other natural features could result in heterogeneous flow patterns developing where considerable higher groundwater flows are experienced in very localised areas with the consequence that the dewatering system is unable to manage the variability.	Medium / high – it will be necessary to collect routine water quality samples before during and after the dewatering to confirm if this is occurring. A sampling and management strategy must be drafted. System flexibility is required to allow changes in the density of groundwater abstraction once the operation has commenced. Performance monitoring of the system is necessary to maintain operational efficiency.
Discharges to groundwater – risk of fuel spills, etc	During construction work when the made ground and the superficial alluvium have been removed, leaving the Chester Formation exposed it is at a greater risk of being impacted through the spillage of chemicals and fuels – there is unlikely to	High / critical – Hazardous substances must not enter groundwater. Site rules to manage and monitor the use and storage of hazardous substances must be implemented in the area of the basement excavation. These rules must limit the location of refuelling, set guidelines for the use of

Scenario	Description	Assessment
	be any for of attenuation or retardation before the liquids enter groundwater.	secondary containment and drip trays, set inspectin regime for mobile plant, train staff on spill reponse and provide adequate spill kits and provide adequate, safe and appropriate material storage locations.

5 PILING RISK ASSESSMENT

The site is underlain by the Chester Formation, which is classified by the Environment Agency as a principal aquifer. There is specific legislation that provides a duty on land owners to not knowingly allow certain substances enter groundwater. For developments where pile foundations are proposed it is necessary to demonstrate that the quality of groundwater isn't impacted through construction of the piles.

5.1 Planning condition

This section of the report has been designed to address the following planning condition:

Piling or any other foundation designs using penetrative methods shall not be permitted other than with the express written consent of the local planning authority, which may be given for those parts of the site where it has been demonstrated that there is no resultant unacceptable risk to groundwater. The development shall be carried out in accordance with the approved details.

Reason: to ensure a safe form of development that poses no unacceptable risk of contamination to controlled waters pursuant to Section 10 of the National Planning Policy Framework and Core Strategy policies EN14 and EN17.

5.2 Standards

The study was designed generally to meet the requirements of the Environment Agency and reference has been made to the Environment Agency's guidance 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention (2001) and Piling in Layered Ground: risks to groundwater and archaeology – Science Report SC020074/SR.

This piling risk assessment has been prepared in accordance with current legislation:

- The Water Resources Act 1991
- Groundwater Regulations 1998 (amended January 2009) make particular reference for the protection of controlled waters.

This report should be considered in the light of any changes in legislation, statutory requirement or industry practices that may have occurred subsequent to the date of issue. The data presented in this report is based on the ground conditions encountered during site work, fieldwork and laboratory testing conducted by others and as such, RSK cannot be held responsible for the veracity of this data.

5.3 Piling design

5.3.1 Basement work

A combination of contiguous piles and secant piles are proposed for the basement works. The contiguous piles are proposed for the majority of areas around the basement with a

variation in size determined by the anticipated ground conditions. Generally the CFA piles will be either 900mm diameter at 1050mm centres or 750mm diameter at 900mm centres. In both cases the piles will be separated by 300mm. For the secant piles the provisional design is for 800mm diameter piles at 775mm centres (i.e. 25mm overlap).

The secant piles are proposed in areas of the site where there is a greater risk of encountering structures that could readily transmit water from the surrounding area onto site, such as the former infilled canal and the associated water intake. It is unclear if these features have previously been isolated from nearby surface water. The secant piles will prevent water entering the site through these features.

It is understood that the piles will pass through made ground, alluvium (where present) and enter the underlying Chester Formation – sandstone bedrock. The piles will terminate within the bedrock at a depth of approximately 25m bgl.

Piles extending from the base of the floor slab are provisionally included in the design although these could be removed at a later date. It is understood these piles will be constructed by displacement methods but the number, frequency and spacing of the piles is not known.

5.4 Previous site investigations

See Section 2 for details of reports that have been reviewed in the production of the risk assessment.

5.4.1 Soil and groundwater contamination

Chemical test data relating to soil and groundwater quality of the made ground, alluvium and underlying sandstone were not available at the time of writing. However, it is understood this data has been collected but not yet reported.

5.4.2 Remedial measures

All made ground and superficial soils will be removed during the site development. If any hot spots of contamination are identified during this phase of earthworks they will be removed from site. No contaminated soils are anticipated but following completion of earthworks no remedial measure will be required.

5.4.3 Hazard identification and risk assessment

The six pollution scenarios outlined in the Environment Agency guidance noted above, their applicability to the site and the proposed use of piles and subsequent hazard assessment is given in Table 2. At the time of assessment chemical test data had not been provided for the made ground or alluvium so it is not possible to undertake a quantitative assessment of the potential impact of these shallow soils on controlled waters.

The Phase 1 Preliminary Risk Assessment (PRA) did not consider the potential impact on the Chester Formation, which is classified as a principal aquifer. The report looked at the potential risks to the superficial alluvium, which is present between the made ground and the Chester Formation. The Land Consultancy letter report identifies made ground to a

thickness of only 1.0m to 3.0m although a hydrocarbon odour is noted in BH1 and BH2. The underlying superficial soils were recorded at a thickness of between 3.6m and 4.0m.

Table 2: Hazard identification and risk assessment

Pollution Scenario	Description	Site Applicability	Hazard Assessment
1	Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer	Basement piles (Displacement)	Low - Well constructed CFA piles cause a minimum deformation of the surrounding soils – good seals can be achieved with CFA piles and although the alluvial deposits are relatively thin beneath the site it is likely that a relatively good seal will be maintained. The present geology doesn't provide a significant aquitard between the made ground and the underlying aquifer, indeed it is missing in some locations. Upon completion of the basement piles all made ground and alluvium will be excavated. If any contamination is present this will be removed and so minimising any potential residual risks to the underlying aquifer. The basement piles will start at ground level within made ground and they will terminate in the underlying Chester Formation. Any contaminated soils will be brought to the surface and not pushed into the aquifer.
		Foundation piles (Displacement)	Not applicable - Piles incorporated into the foundation design will be extended into the ground from the base of the basement excavation. All made ground and superficial soils will be excavated to create the basement therefore any contamination will be removed from the shallow soils before the piles are constructed. Significant contamination is not anticipated although if this were encountered it will be characterised and disposed off site accordingly. Foundation piles will start and terminate within the Chester Formation.
2	Creation of preferential pathways through a low permeability surface layer, allowing migration of landfill gas, soil gas or	Basement piles (Displacement)	Not applicable – Made ground on site is recorded to depths of between 1.0m and 3.0m bgl and therefore significant sources of ground gas on site are not anticipated. Localised thickening of made ground associated with the infilled former canal channel is anticipated but this will be removed as part of the site construction and so any putrescible material will

Pollution Scenario	Description	Site Applicability	Hazard Assessment
	contaminant vapours to the surface	Foundation piles (Displacement)	be removed from site. No sources of ground gas or material of significant gassing potential (landfills, etc) have not been identified in the area surrounding the site. There is no source and therefore this scenario is not applicable.
3	Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface	Basement piles (Displacement)	Low - The piles will be constructed through made ground and alluvium before terminating in the underlying Chester Formation. Made ground up to a depth of 3.0m gl has been rerecorded on site and hydrocarbon odours have been identified. No chemical testing has been undertaken but significant contamination is not anticipated. Any contamination brought to the surface has the potential for direct contact with site workers. Site rules will require the use of appropriate PPE, which will be worn at all times. If visual or olfactory evidence of contamination is identified within the pile arisings chemical testing will be undertaken and this material will be quarantened before an appropriate off-site disposal route is confirmed. Significant amounts of contamination are not anticipated, especially given the relatively thin made found on site.
		Foundation piles (Displacement)	Not applicable - All made ground and superficial soils (aluvium) will be removed from site as part of the basement construction. These piles will start and terminate in the Chester Formation and so contamination is not anticipated.
4	Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of materials	Basement piles (Displacement)	Low – Basement piles will surround the proposed excavation. Significant contamination is not anticipated on site. However if contaminated or aggressive soils are present along the alignment of the piles it would be in contact with the pile material inside the excavation for several months only. The pile material facing outwards would however, remain in contact with the contamination for a longer period of time. The pile design specification will consider the presence of aggressive ground conditions from samples collected from the recent ground investigation and it will be designed accordingly.

Pollution Scenario	Description	Site Applicability	Hazard Assessment
		Foundation piles (Displacement)	Not applicable - Any contamination will be removed from the site during the bulk excavation, which will included the made ground and the alluvium. Piling will be through natural bedrock only and so contamination and leachate within the Chester Formation is not anticipated.
5	The pushing of solid contaminants down into an aquifer during pile driving	Basement piles (Displacement)	Not applicale – displacement piling is proposed and all arisings will be brought to the surface. Driven piles are not proposed.
		Foundation piles (Displacement)	Not applicale – displacement piling is proposed and all arisings will be brought to the surface. Driven piles are not proposed.
6	Contamination of groundwater and subsequently surface waters by wet concrete, cement paste or grout	Basement piles (Displacement)	Low / moderate – Grout / cement only remains mobile until hardened. Piles terminate below the water table. The proposed dewatering operations will follow the piling works so dewatering will have a limited interaction with piling. Any impacted groundater will generally be contained by the dewatering system and the managed at the point of discharge.
		Foundation piles (Displacement)	Low / moderate – Grout / cement only remains mobile until hardened. Piles terminate below the water table. The proposed dewatering operations will follow the piling works so dewatering will have a limited interaction with piling. Any impacted groundater will generally be contained by the dewatering system and the managed at the point of discharge.
7		Basement piles (CFA)	Not applicable – Pile arisings are to be removed off-site for disposal.

Pollution Scenario	Description	Site Applicability	Hazard Assessment
	Other – Contact with potentially contaminated soils (pile arisings) during future use of the site.	Foundation piles (Displacement)	Not applicable – Pile arisings are to be removed off-site for disposal.

6 LICENSE REQUIREMENTS

6.1 Regulatory Position Statement

The Environment Agency have issued a regulatory position statement (RPS) on the temporary dewatering of excavations to surface water. If the specific conditions of the RPS can be followed it is deemed unnecessary to obtain a bespoke permit. The following conditions are presented in the RPS (comments in **bold** relate to the condition being satisfied):

- be clean water, for example clear rainwater or infiltrated groundwater which has collected in the bottom of temporary excavations (**Yes**)
- not result in water containing fine or coarse suspended solids (silty water) entering surface water (**Yes - following basic treatment before discharge**)
- not last more than 3 consecutive months (the activity may stop and restart but the clock does not restart) - if the activity is likely to go over 3 consecutive months then you need to apply for a permit (**No – duration likely to be 9+ months**)
- be made to surface water, such as a river, stream or the sea (**Yes**)
- have a method statement that minimises the risk of pollution (**Yes**)

On the basis of the programmed construction for excavation works and the likely pumping duration it is unlikely that dewatering will comply with the RPS. An abstraction license will therefore be required. However, it may be possible to adopt the RPS if all other conditions can be satisfied to prevent programme delay. However, this could be at the risk of not receiving the actual license at or before the RPS expires (3-months from adopting). If this eventuality occurs the dewatering pumps would need to be turned off.

6.2 Exemption

In addition to the RPS it may not be necessary to apply for a water abstraction licence if groundwater is being pumped and the activity meets the conditions of the groundwater abstraction exemption under Regulation 5 of the Water Abstraction and Impounding (Exemptions) Regulations 2017. Specifically, this regulation states that:

Small scale dewatering in the course of building or engineering works

5. (1) The restriction on abstraction does not apply to an abstraction or series of abstractions of water carried out in the course of building or engineering works for the purpose of dewatering from a sump or excavation if:

- (a) the abstraction or series of abstractions are temporary and in any event carried out over a period of less than six consecutive months beginning with commencement of the first abstraction,
- (b) each abstraction does not cause or is not likely to cause damage to a conservation site or specific features in such a site,

(c) each abstraction does not cause or is not likely to cause damage to protected species, and

(d) either:

(i) the water abstracted is immediately discharged to a soakaway, or

(ii) the volume of water abstracted is less than 100 cubic metres of water per day and there is no intervening use of that water before discharge (but see paragraph (2)).

5. (2) Where the abstraction is undertaken within 500 metres of a conservation site or within 250 metres of a spring, well or borehole used to supply water for any lawful use, paragraph (1)(d)(ii) applies in respect of that abstraction as if the reference to 100 cubic metres of water per day were a reference to 50 cubic metres of water per day.

The key criteria here is the duration of the proposed pumping (<9-months) and the volume of water proposed to be pumped each day (<100m³). It will be necessary to confirm that no other licensed groundwater abstractions are located within 250m of the proposed dewatering then a daily limit of 50m³ will apply. If either of these criteria are exceeded a license will be required. It may also be necessary to apply for the exemption that the works will operate under.

6.3 Groundwater abstraction license

If the RPS cannot be satisfied and the exemption conditions are also inappropriate it will be necessary to obtain a groundwater abstraction license from the Environment Agency. If greater than 20m³ of groundwater is planned to be pumped in any 24-hour period a water abstraction license will be required. It is likely that a full licence will be required. I

Once the Environment Agency has received the licence application they have up to 4-months to review and grant the licence. If a licence is issued it will contain any specific conditions that must be followed but these should not come as a surprise if close liaison with the licence issuer is maintained through the process.

An annual charge is likely to be applicable to the license and this is made up of the standard charge and the compensation charge. Once the known volume of water to be abstracted is confirmed the likely costs (projected) can be calculated. For dewatering operations these costs are unlikely to be significant.

6.4 Discharge

In all cases, whether the RPS is followed, where the exemption applies or where a license is issued the following conditions will apply, such that the discharge must not (**bold** text relates to site specific comments):

- pollute surface water (**unlikely but the groundwater chemistry from the site must be checked and confirmed with the EA**)

- contain any chemical dosing agents, flocculants or coagulants **(No)**
- be from a site which is contaminated by oil, metals, hydrocarbons, solvents or pesticides or other polluting substances **(unlikely but the groundwater chemistry from the site must be checked and confirmed with the EA)**
- result in the spread of non-native invasive species, parasites or disease **(No)**
- cause flooding from surface water **(No)**
- cause erosion of the banks or bed of the receiving watercourse **(No – a correctly designed discharge point must be proposed and agreed with the EA)**
- contain concrete wash water even if it has been treated **(No)**
- contain site drainage from surface areas such as haul roads, storage or working areas **(No – if managed correctly)**
- be from a site with naturally elevated concentrations of substances which exceed environmental quality standards **(Unlikely but will need to confirm)**

Pumped groundwater will need to be discharged either to the River Irwell or to foul sewer. Since recent changes in competition law the market for managing foul water discharge means that United Utilities are not the only company that can manage foul water discharge in the area.

To discharge into the River Irwell, it is considered likely that any dewatering system would have a common discharge into the former leg of the Manchester and Salford Junction canal across water Street, which is open to the River Irwell. A discharge consent would be required from the Environment Agency.

Clearly the option to discharge into United Utilities infrastructure is likely to be constrained by the volume discharged when compared to discharge into surface water. In addition, certain areas of the United Utilities network do not accept water from dewatering operations so availability of the foul sewer will need to be confirmed.

Chemical test data included in Section 2.8 will need to be considered when making an application to discharge groundwater. It will be necessary to include an environmental management plan to allow testing to be undertaken periodically to confirm compliance with the discharge consent.

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APPENDIX A

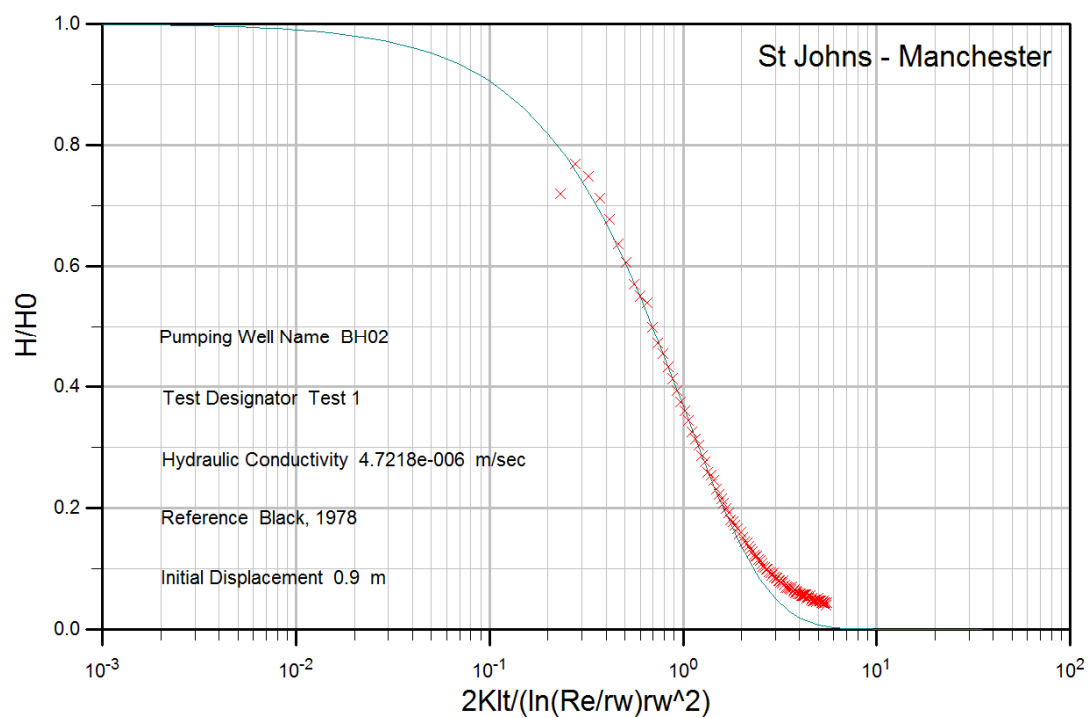
SERVICE CONSTRAINTS

1. This report and the preliminary risk assessment carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Allied London (the "client") in accordance with the terms of a contract between RSK and the "client", dated 15 August 2018. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.
2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date hereof, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.
8. The phase II or intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.

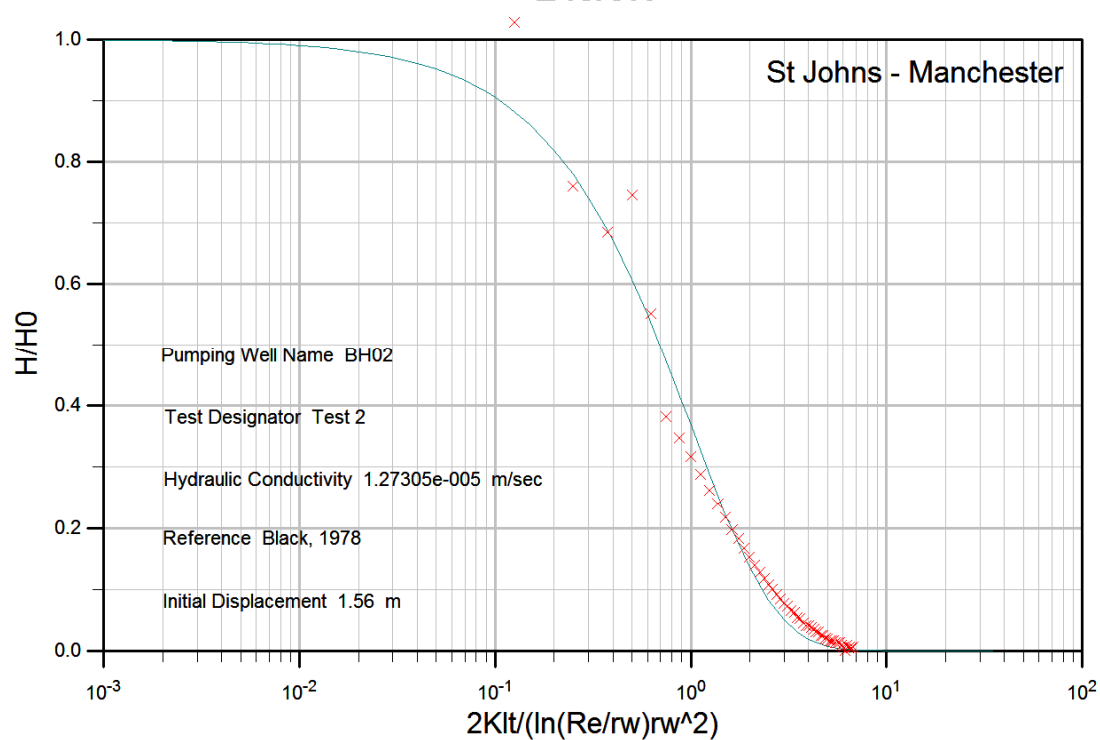
APPENDIX B

AQUIFER^{WIN32} OUTPUTS

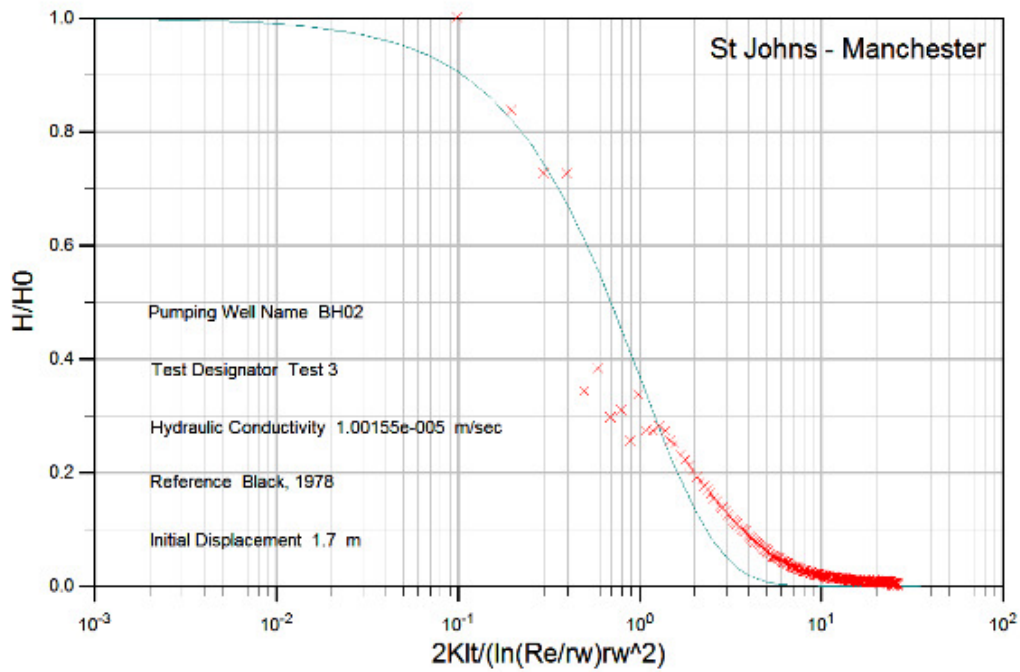
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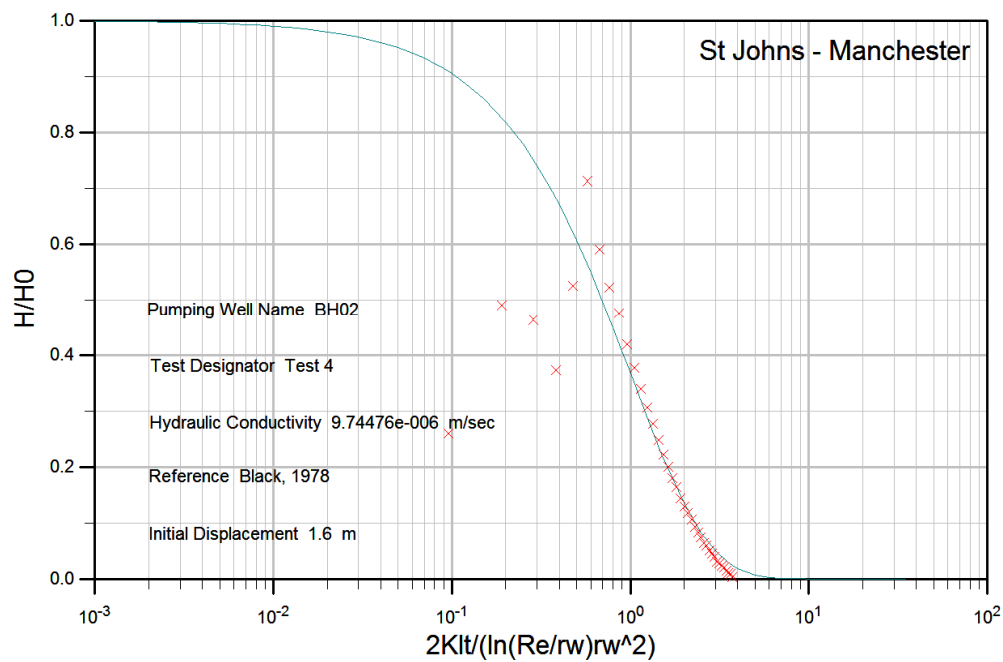
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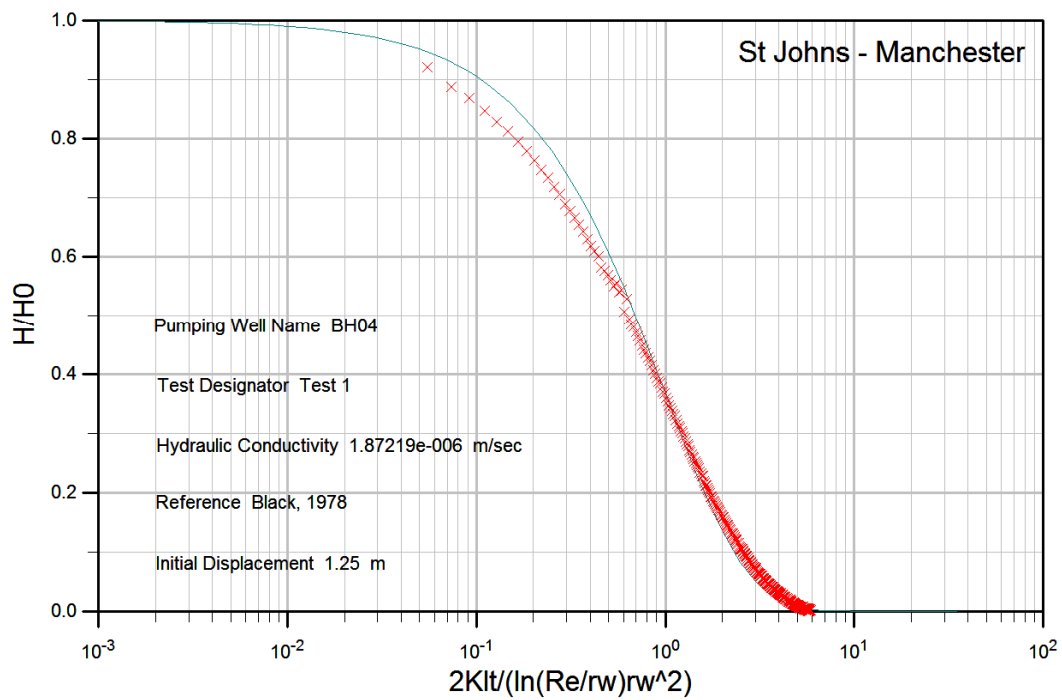
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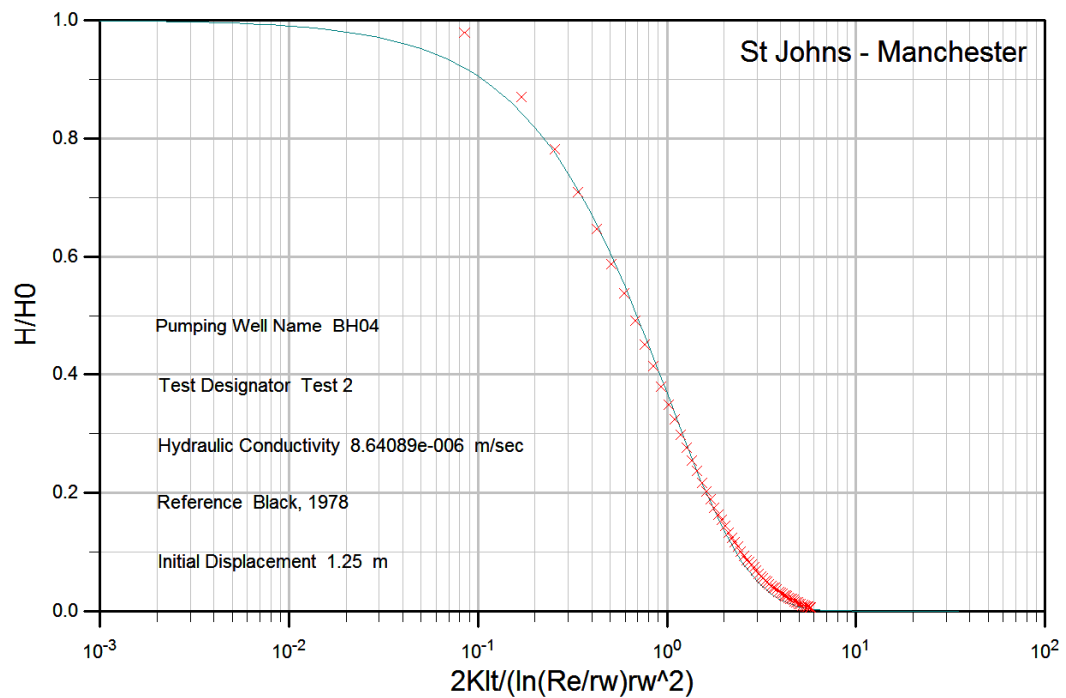
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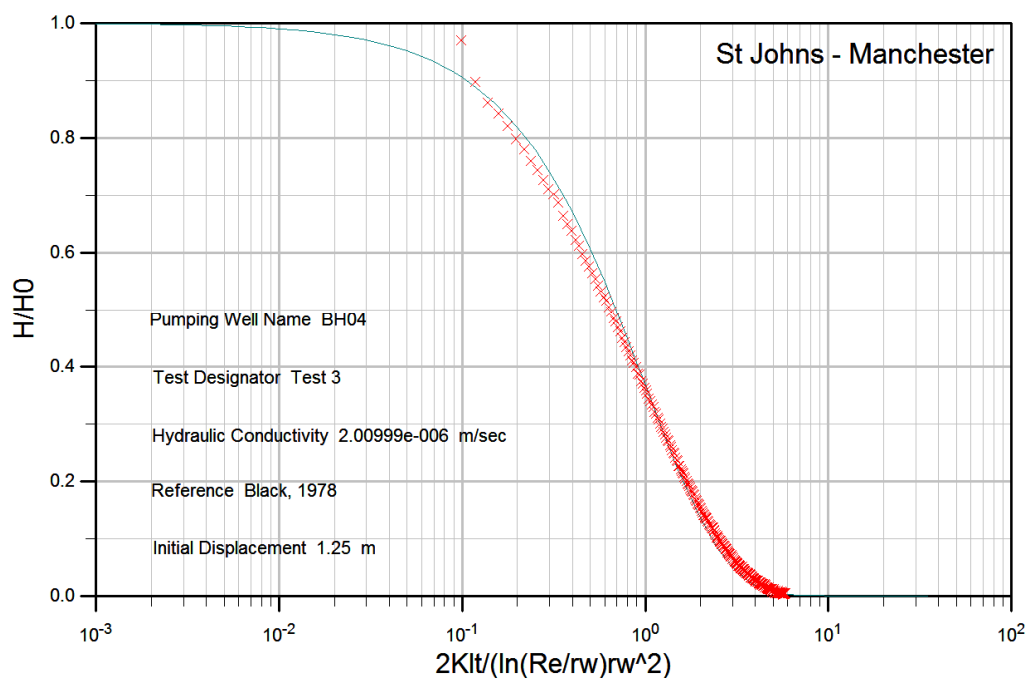
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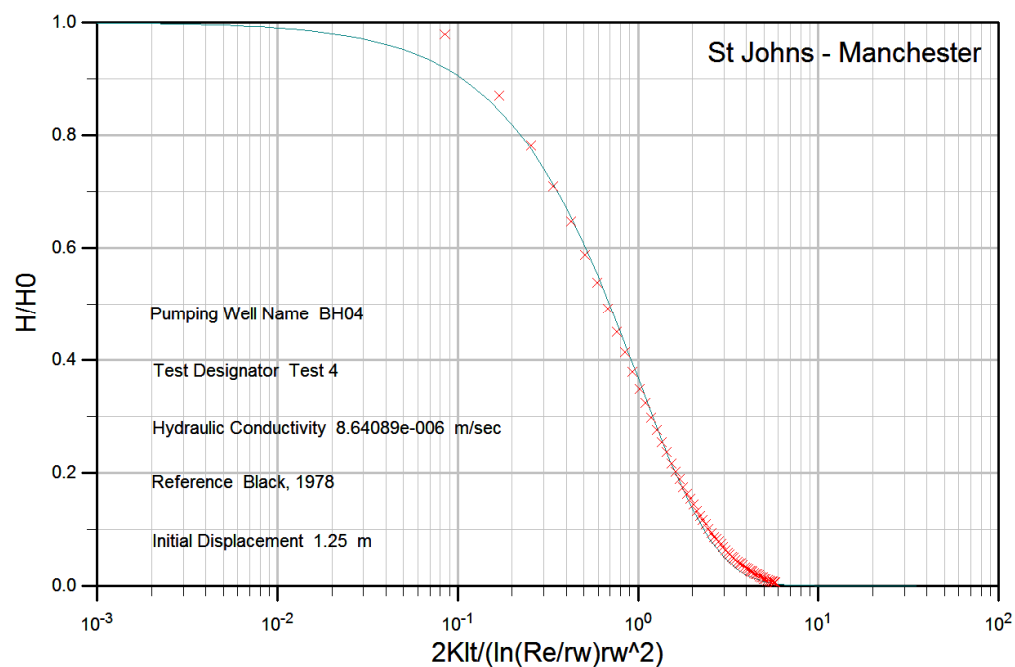
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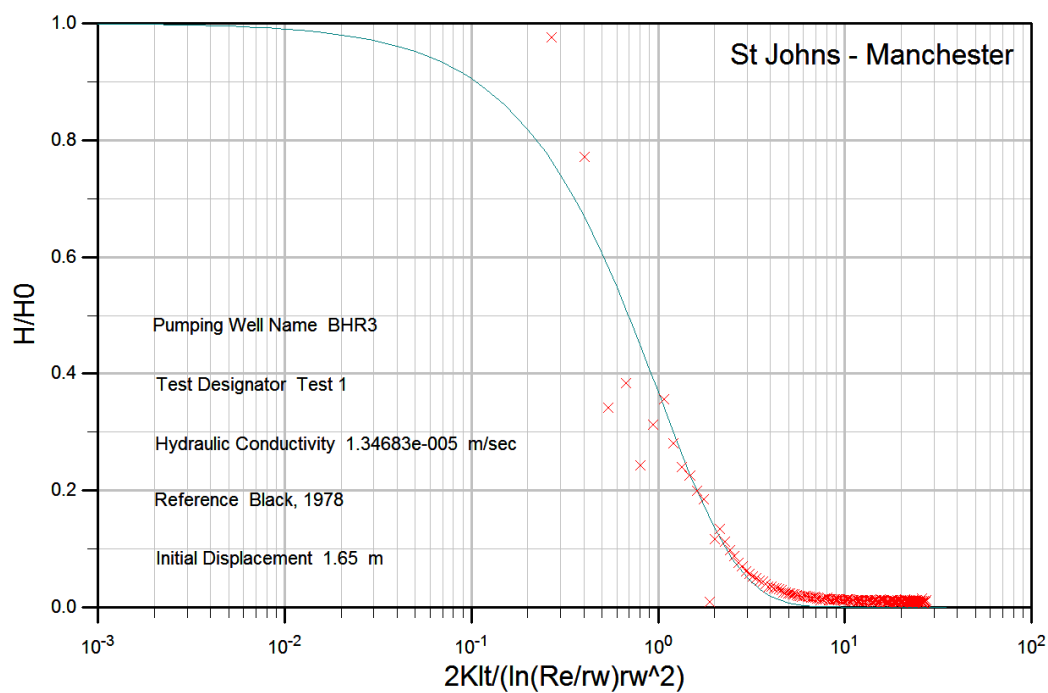
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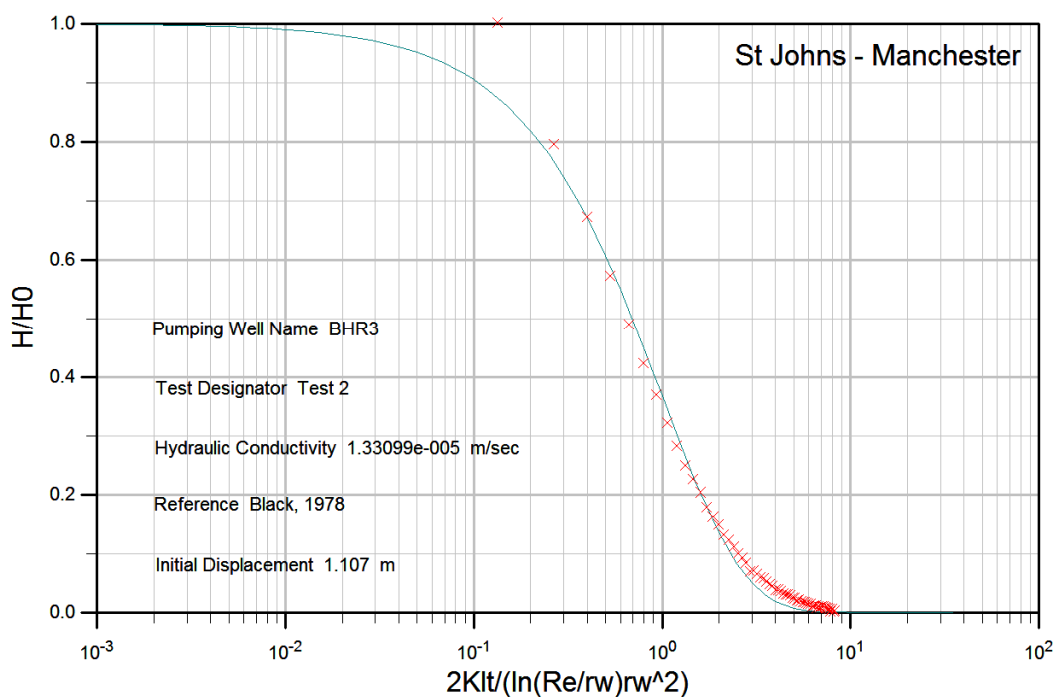
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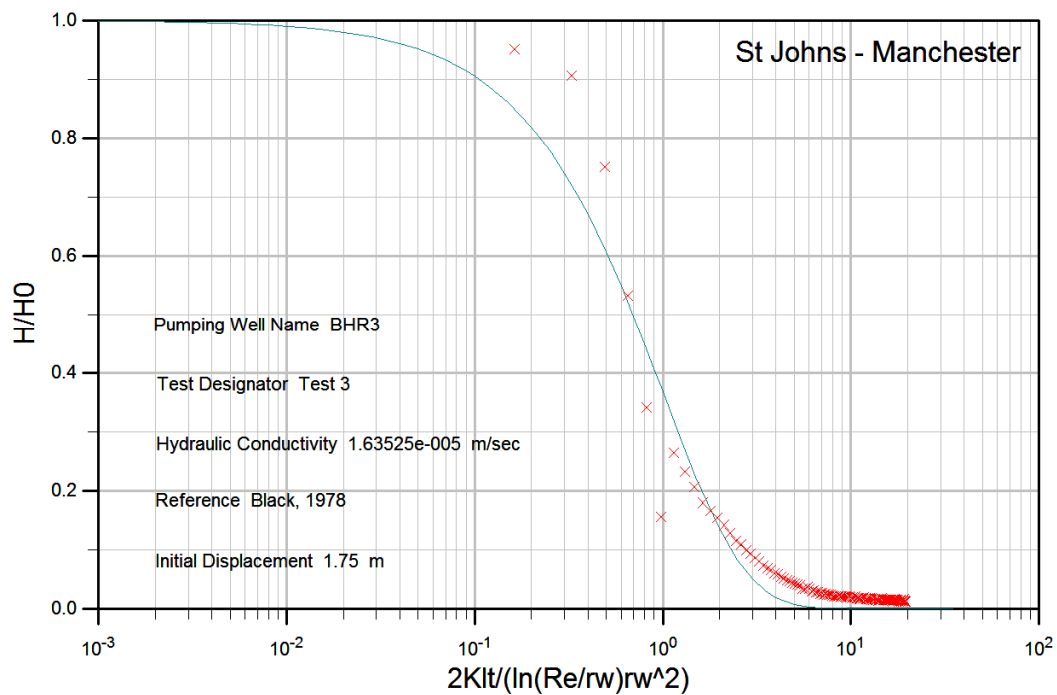
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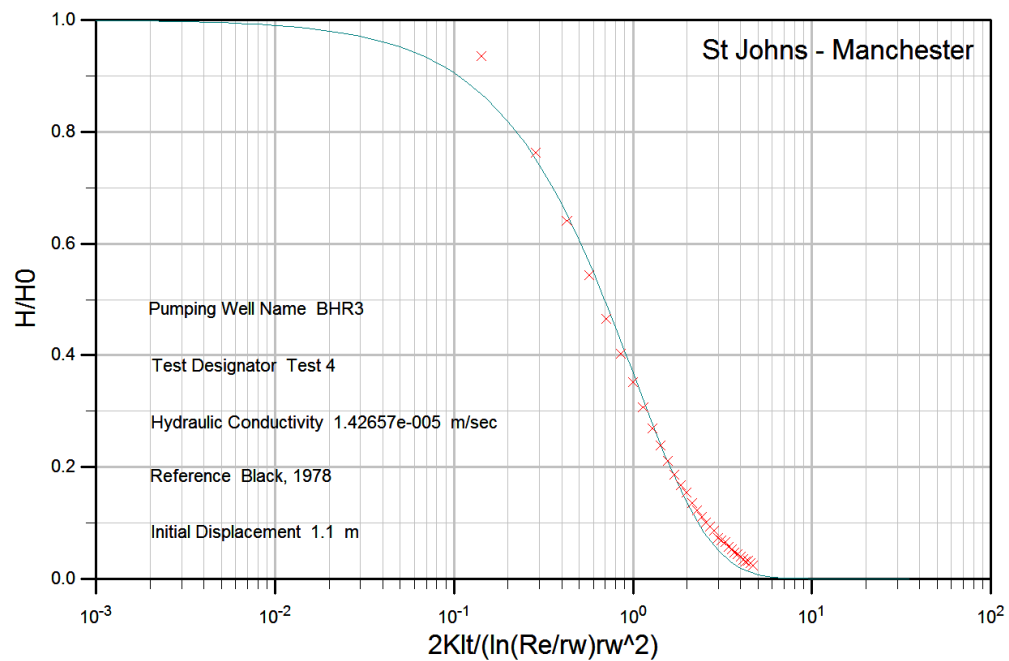
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APPENDIX C

EQS TARGET PARAMETERS FOR CONTROLLED WATERS

GENERIC ASSESSMENT CRITERIA FOR CONTROLLED WATERS

Protection of the water environment

The water environment in the United Kingdom is protected under a number of regulatory regimes. The relevant environmental regulator is consulted where there may be a risk that pollution of 'controlled waters' may occur or may have occurred in the past.

The term 'controlled waters' refers to coastal waters, inland freshwaters and groundwater. The EU Water Framework Directive (WFD) (2000/60/EC) is implemented via domestic regulations and guidance, covering aspects of groundwater and surface water protection as well as drinking water supply policy. Domestic legislation and guidance will vary across the United Kingdom. Therefore, the relevant legislation for England, Wales, Northern Ireland and Scotland should be reviewed, alongside guidance provided by the Environment Agency (EA), Natural Resource Wales (NRW), the Scottish Environmental Protection Agency (SEPA) or the Northern Ireland Environment Agency (NIEA), as appropriate.

The main objectives of the protection and remediation of groundwater under threat from land contamination are set out within "The Environment Agency's approach to groundwater protection", version 1.0 (March 2017)⁽¹⁾ and the associated guidance "Land contamination groundwater compliance points: quantitative risk assessments (March 2017)^(1a) that have replaced the previous guidance document "Groundwater Principles and Practice (GP3)". When assessing risks to groundwater, the following need to be considered:

- Where pollutants have not yet entered groundwater, all necessary and reasonable measures must be taken to:
 - **prevent** the input of **hazardous** substances into groundwater (see description of hazardous substances below)
 - **limit** the entry of other (non-hazardous) pollutants into groundwater to avoid pollution, deterioration in the status of groundwater bodies and to prevent sustained, upward trends in pollutant concentrations in groundwater.
- Where pollutants have already entered groundwater, the priority is to take all necessary and reasonable measures to:
 - **minimise** further entry of "contaminants" where there is a defined source
 - **limit the pollution** of groundwater or any effect on the status of the groundwater body from the future expansion of the 'plume', if necessary, by actively reducing its extent.

Within the context of groundwater risk assessments on sites affected by land contamination, "reasonable" means feasible without involving disproportionate costs. What costs are "disproportionate" depends on site-specific circumstances, which may include:

- Considerations of technical feasibility such as identified by the remedial options appraisal, this may be due to the distribution or nature of the contamination and the available remedial methods to treat the identified contamination;
- Sustainability considerations.

DEFINITIONS AND SUBSTANCE CLASSIFICATIONS

Risks to surface waters:

When assessing risks to surface waters, the following list of definitions should be understood:

Priority substances (PS) are harmful substances originally identified under the Water Framework Directive (WFD) 2000/60/EC as substances ‘presenting a significant risk to or via the aquatic environment’ at a European level. Member States are required to incorporate the identified **PS** into their country-wide monitoring programmes. There are currently 33 **PS** defined within the Priority Substances Directive (2013/39/EU; Annex 1), with a further 12 additional substances due to come into force from 22 December 2018. Directive 2013/39/EU has been transposed into domestic legislation for England and Wales by The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Under the umbrella of **PS**, there is a sub-set of substances identified as being “hazardous”, and these are referred to as **Priority hazardous substances (PHS)**. The list of **PHS** is defined at EU level within the Priority Substances Directive (2013/39/EU). The WFD defines hazardous substances as ‘substances (or groups of substances) that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances that give rise to an equivalent level of concern.’ There are currently 15 **PHS**, with a further 6 additional substances due to come into force from 22 December 2018.

There is also another group of substances defined at EU level and which are referred to as **other pollutants (OP)** in Directive 2013/39/EU. These are additional substances which although not **priority substances**, have EQS which are identical to those laid down in the legislation which applied prior to 13 January 2009 (Directive 2008/105/EU). The **OP** are listed along with the **priority substance (PS)** within the Priority Substances Directive (2013/39/EU), and their associated EQS are also listed therein. There are 6 **OP** defined within the Priority Substances Directive (2013/39/EU).

In addition to the EU level substances, there are also a group of pollutants defined at a Member State level, referred to as **Specific pollutants (SP)**. These substances are pollutants which are released in significant quantities into water bodies in each of the individual European Member States. Under the WFD, Member States are required to set their own EQS for these substances. An indicative list of **SP** is given in Annex VIII of the WFD. Many of the substances categorised as **SP** in the UK were formerly List 2 substances under the old Groundwater Directive (80/68/EEC). The **SP** are defined within Part 2 (Table 1) of The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Risks to groundwater:

When assessing risks to groundwater, the following definitions should be understood:

Under the requirements of the Groundwater Daughter Directive (2006/118/EU), the UK has published a list of substances it considers to be **hazardous substances** with respect to groundwater. In their advisory capacity to the government, this list has been derived by the UK Joint Agencies Groundwater Directive Advisory Group (JAGDAG), of which the Environment Agency is a member. The JAGDAG list of **hazardous substances** was published in January 2017 and the Environment Agency will use the updated list of hazardous substances from this date for all new activities that may lead to the discharge of hazardous substances to groundwater. The list is extensive and can be found in full at:

<https://www.wfduk.org/stakeholders/jagdag>

Selecting the appropriate assessment criteria

When assessing the risks to controlled waters, various assessment criteria apply, depending on the nature of the assessment and the conceptual site model.

Where a surface water body is involved, then Environmental Quality Standards (EQS) are the relevant assessment criteria as they are designed to be protective of surface water ecology.

Where a public water supply or a Principal aquifer is involved, then the standards defined in The Water Supply (Water Quality) Regulations⁽²⁾ are the primary source of assessment criteria. The Private Water Supplies Regulations⁽³⁾ may also be applicable in some cases. For instances where there are no UK assessment criteria, then the World Health Organisation (WHO) drinking water guidelines⁽⁴⁾ may be used.

This appendix presents the generic assessment criteria (GAC) that RSK considers suitable for assessing risks to controlled waters for our most commonly encountered determinants. A full list of EQS for England and Wales are included in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

The RSK GAC for controlled waters are presented in **Table 1** and **Table 2**. In line with the Environment Agency's Remedial Targets Methodology, the GAC for controlled waters are termed 'target concentrations'.

The appropriate target concentrations should be selected with consideration to:

- the site conceptual model (i.e. the receptor at potential risk);
- whether the substance is already present in groundwater at the site;
- whether or not the substance is classified as a priority hazardous substance under the Priority Substances Directive (2013/39/EC) (see above), or as a hazardous substance according to the current list of JAGDAG determinations⁽⁵⁾; and
- background concentrations in the aquifer (if applicable).

It is important to remember that the WFD and Environment Agency guidance^(1 & 1a) support a sustainable, risk-based approach be applied to groundwater contamination. Exceedance of any target concentration does not necessarily imply that an unacceptable risk exists or that remediation is inevitably required.

Target concentrations shaded in green are <u>statutory values</u>	Target concentrations shaded in orange are <u>non-statutory values</u>
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Note: Units µg/l throughout (unless otherwise stated)

Table 1: Target concentrations for controlled waters (excluding TPH CWG fractions)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Metals & other inorganics						
Hazardous substance	Specific pollutant	Arsenic	-	10 ⁽²⁾	50 ^(6a)	25 ^(6a)
Non-hazardous pollutant	Priority substance	Cadmium	0.1 ⁽⁷⁾	5 ⁽²⁾	≤0.08, 0.08, 0.09, 0.15, 0.25 ^(6b)	0.2 ^(6a)
(Not determined)	-	Chromium (total)	-	50 ⁽²⁾	Sum values for chromium III and VI	
(None	Specific pollutant	Chromium (III)	-	Use value for total chromium	4.7 ^(6a)	-
Hazardous substance	Specific pollutant	Chromium (VI)			3.4 ^(6a)	0.6 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
(Not determined)	Specific pollutant	Copper	-	2,000 ⁽²⁾	1 bioavailable ^(6a)	3.76 dissolved, where DOC ≤1mg/l ^(6a)
						3.76µg/l + (2.677µg/l x ((DOC/2) – 0.5µg/l)) dissolved, where DOC >1mg/l ^(6a)
Hazardous substance	Priority substance	Lead	-	10 ⁽²⁾	1.2 bioavailable ^(6a)	1.3 ^(6a)
Hazardous substance	Priority hazardous substance	Mercury	0.01 ⁽⁷⁾	1 ⁽²⁾	0.07 ^(6c)	0.07 ^(6c)
Non-hazardous pollutant	Priority substance	Nickel	-	20 ⁽²⁾	4.0 bioavailable ^(6a)	8.6 ^(6a)
Non-hazardous pollutant	-	Selenium	-	10 ⁽²⁾	-	-
Non-hazardous pollutant	Specific pollutant	Zinc	-	3,000 ⁽⁸⁾	10.9 bioavailable ^(6a)	6.8 dissolved ^(6a)
None	Specific pollutant	Iron	-	200 ⁽²⁾	1000 ^{(6a)*1}	1000 ^(6a))*1
None	Specific pollutant	Manganese	-	50 ⁽²⁾ (0.05mg/l)	123 bioavailable ^(6a) (0.123mg/l)	-
(Not determined)	-	Aluminium	-	200 ⁽²⁾	-	-

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Priority hazardous substance	Tributyltin compounds (Tributyltin-cation)	0.001 ⁽⁷⁾	-	0.0002 ^(6a)	0.0002 ^(6a)
(Not determined)	-	Sodium	-	200,000 ⁽²⁾ (200 mg/l)	-	-
Non-hazardous pollutant	Specific pollutant	Cyanide (Hydrogen cyanide)	-	50 ⁽²⁾ (0.05 mg/l)	1 ^(6a) (0.001 mg/l)	1 ^(6a) (0.001 mg/l)
Non-hazardous pollutant	-	Total ammonia ^{\$} (ammonium (as NH ₄ ⁺) plus ammonia (NH ₃))	-	500 ⁽²⁾ (0.5 mg/l)	300 ^(6f) (0.3 mg/l)	-
Non-hazardous pollutant	Specific pollutant	Ammonia un-ionised (NH ₃)	-	-	-	21 ^(6a) (0.021 mg/l)
Non-hazardous pollutant	Specific pollutant	Chlorine	-	-	2 ^(6a) (0.002 mg/l)	10 ^(6d) (0.01 mg/l)
(Not determined)	-	Chloride	-	250,000 ⁽²⁾ (250 mg/l)	-	-
(Not determined)	-	Sulphate	-	250,000 ⁽²⁾ (250 mg/l)	-	-
(Not determined)	-	Nitrate (as NO ₃)	-	50,000 ⁽²⁾ (50 mg/l)	-	-
(Not determined)	-	Nitrite (as NO ₂)	-	500 ⁽²⁾ (0.5 mg/l)	10 ⁽⁹⁾ (0.01 mg/l)	-

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Volatile organic compounds (VOC)						
Non-hazardous pollutant	Other pollutant	Tetrachloroethene (tetrachloroethylene; PCE)	0.1 ⁽⁷⁾	10 ⁽²⁾ sum of TCE and PCE	10 ^(6a)	10 ^(6a)
Hazardous substance	Other pollutant	Trichloroethene (trichloroethylene; TCE)	0.1 ⁽⁷⁾		10 ^(6a)	10 ^(6a)
None	Specific pollutant	Tetrachloroethane	-	-	140 ^(6a)	-
Hazardous substance	Other pollutant	Carbon tetrachloride (tetrachloromethane)	0.1 ⁽⁷⁾	3.0 ⁽²⁾	12 ^(6a)	12 ^(6a)
Non-hazardous pollutant	Priority substance	1,2-Dichloroethane	1.0 ⁽⁷⁾	3.0 ⁽²⁾	10 ^(6a)	10 ^(6a)
Non-hazardous pollutant	-	1,2-Dichloroethene (DCE)	-	50.0 ⁽⁴⁾	-	-
Hazardous substance	-	Vinyl chloride (chloroethene)	-	0.5 ⁽²⁾	-	-
Non-hazardous pollutant	Priority substance	Dichloromethane	-	20 ⁽⁴⁾	20 ^(6a)	20 ^(6a)
Non-hazardous pollutant	Priority substance	Trichlorobenzenes	0.01 ⁽⁷⁾	-	0.4 ^(6a)	0.4 ^(6a)
(Not determined)	-	Trihalomethanes	-	100 ^(2a)	-	-

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Priority substance	Trichloromethane (Chloroform)	0.1 ⁽⁷⁾	(see “Trihalomethanes” above)	2.5 ^(6a)	2.5 ^(6a)
Non-hazardous pollutant	Priority hazardous substance	Di(2-ethylhexyl) phthalate (bis(2-ethylhexyl) phthalate, DEHP)	-	8 ⁽⁴⁾	1.3 ^(6a)	1.3 ^(6a)
None	Specific pollutant	Benzyl butyl phthalate	-	-	7.5 ^(6a)	0.75 ^(6e)
Hazardous substance	Priority hazardous substance	Hexachlorobutadiene	0.005 ⁽⁷⁾	0.6 ⁽⁴⁾	0.6 ^(6c)	0.6 ^(6c)
Semi-volatile organic compounds (SVOC)						
(Not determined)	-	Acenaphthylene (C12-C16)	-	-	5.8 ⁽¹⁰⁾	
Hazardous substance	Priority hazardous substance	Anthracene (C16-C21)	-	-	0.1 ^(6a)	0.1 ^(6a)
Non-hazardous pollutant	Priority substance	Naphthalene (C10-C12)	-	-	2 ^(6a)	2 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Priority substance	Fluoranthene (C21-C35)	-	-	0.0063 ^(6a)	0.0063 ^(6a)
Hazardous substance(s)	Priority hazardous substance(s)	Benzo(a)pyrene (C21-C35)	-	0.01 ⁽²⁾	0.00017 ^(6a)	0.00017 ^(6a)
		Benzo(b)fluoranthene (C21-C35)	-	0.1 ⁽²⁾ sum of the concentration of the four specified compounds	No EQS for these substances. B(a)P should be used as the indicator compound instead.	
		Benzo(k)fluoranthene (C21-C35)	-			
		Benzo(g,h,i)perylene (C21-C35)	-			
		Indeno(1,2,3-cd) pyrene (C21-C35)	-			
Non-hazardous pollutant	Specific pollutant	Phenol		-	7.7 ^(6a)	7.7 ^(6a)
Hazardous substance	Specific pollutant	2,4-Dichlorophenol	0.1 ⁽⁷⁾	-	4.2 ^(6a)	0.42 ^(6a)
Hazardous substance	Priority substance	Pentachloro-phenol (PCP)	0.1 ⁽⁷⁾	g ⁽⁴⁾	0.4 ^(6a)	0.4 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Petroleum hydrocarbons						
Hazardous substance	-	Total petroleum hydrocarbons	-	See Table 2 for individual (non-statutory) TPH CWG fractions with respect to drinking water receptors	See individual risk driving compounds (i.e. BTEX and PAH) for specific EQS	
Hazardous substance	Priority substance	Benzene (C5-C7)	1 ⁽⁷⁾	1 ⁽²⁾	10 ^(6a)	8 ^(6a)
Hazardous substance	Specific pollutant	Toluene (C7-C8)	4 ⁽⁷⁾	700 ⁽⁴⁾	74 ^(6a)	74 ^(6a)
Hazardous substance	-	Ethylbenzene (C8-C9)	-	300 ⁽⁴⁾	-	-
(Not determined)	-	Xylenes (C8-C10)	3 ⁽⁷⁾	500 ⁽⁴⁾	30 ⁽¹¹⁾	-
Non-hazardous pollutant	-	Methyl tertiary butyl ether (MTBE)	-	15 ⁽¹²⁾	-	
Pesticides, fungicides, insecticides and herbicides						
Hazardous substance(s)	Other pollutant (Cyclodiene	Aldrin	0.003 ⁽⁷⁾	0.03 ⁽²⁾	0.01 ^(6a) (sum of all four)	0.005 ^(6a) (sum of all four)
		Dieldrin	0.003 ⁽⁷⁾	0.03 ⁽²⁾		

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
	pesticides)	Endrin	0.003 ⁽⁷⁾	0.1 ^(2b)		
		Isodrin* ²	0.003 ⁽⁷⁾	0.1 ^(2b)		
Hazardous substance	Other pollutant	DDT (total)	0.002 ⁽⁷⁾	1 ⁽⁴⁾	0.025 ^(6a)	0.025 ^(6a)
(Not determined) – assume to be Hazardous Substance	-	Total pesticides	-	0.5 ⁽²⁾	-	-
(Not determined) - assume to be Hazardous Substance	-	Other individual pesticides	-	0.1 ⁽²⁾		
Hazardous substance	Specific pollutant	Carbendazim	-	-	0.15 ^(6a)	-
Hazardous substance	Specific pollutant	Chlorothalonil	-	-	0.035 ^(6a)	-
Hazardous substance	Specific pollutant (until 22/12/18, after which it becomes a Priority substance)	Cypermethrin	-	-	0.0001 ^(6a) From 22/12/18: 8.0E-5 ^(6a)	0.0001 ^(6a) From 22/12/18: 8.0E-6 ^(6a)
Hazardous substance	Specific pollutant	Dimethoate	0.01 ⁽⁷⁾	-	0.48 ^(6a)	0.48 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
(Not determined)	Specific pollutant	Glyphosate	-	-	196 ^(6a)	196 ^(6a)
Hazardous substance	Specific pollutant	Linuron		-	0.5 ^(6a)	0.5 ^(6a)
Non-hazardous pollutant	Specific pollutant	Mecoprop	0.04 ⁽⁷⁾	-	18 ^(6a)	18 ^(6a)
Non-hazardous pollutant	Specific pollutant	Methiocarb	-	-	0.01 ^(6a)	-
Non-hazardous pollutant	Specific pollutant	Pendimethalin	-	20 ⁽⁴⁾	0.3 ^(6a)	-
Hazardous substance	Specific pollutant	Permethrin	0.001 ⁽⁷⁾	-	0.001 ^(6a)	0.0002 ^(6a)
Hazardous substance	Priority substance	Alachlor	-	20 ⁽⁴⁾	0.3 ^(6a)	0.3 ^(6a)
Hazardous substance	Priority substance	Atrazine	0.03 ⁽⁷⁾	100 ⁽⁴⁾	0.6 ^(6a)	0.6 ^(6a)
Hazardous substance	Priority substance	Diuron	-	-	0.2 ^(6a)	0.2 ^(6a)
Hazardous substance	Priority hazardous substance	Endosulphan	0.005 ⁽⁷⁾	-	0.005 ^(6a)	0.0005 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Non-hazardous pollutant	Priority substance	Isoproturon	-	9 ⁽⁴⁾	0.3 ^(6a)	0.3 ^(6a)
Hazardous substance	Priority substance	Simazine	0.03 ⁽⁷⁾	2 ⁽⁴⁾	1 ^(6a)	1 ^(6a)
Hazardous substance	Priority hazardous substance	Trifluralin	0.01 ⁽⁷⁾	20 ⁽⁴⁾	0.03 ^(6a)	0.03 ^(6a)
(Not determined)	From 22/12/18: Priority substance	Dichlorovos	-	-	From 22/12/18: 6.0E-4 ^(6a)	From 22/12/18: 6.0E-5 ^(6a)
Hazardous substance	From 22/12/18: Priority substance	Heptachlor and heptachlor epoxide	-	0.03 ⁽²⁾	From 22/12/18: 2.0E-7 ^(6a)	From 22/12/18: 1.0E-08 ^(6a)
Miscellaneous						
None	Specific pollutant	Triclosan (antibacterial agent)	-	-	0.1 ^(6a)	0.1 ^(6a)
Hazardous substance	From 22/12/18: Priority hazardous substance	Perfluoro-octane sulfonic acid (and its derivatives) (PFOS)	-	-	From 22/12/18: 6.5E-4 ^(6a)	From 22/12/18: 1.3E-4 ^(6a)
Hazardous substance	From 22/12/18: Priority hazardous substance	Hexabromo cyclododecane (HBCDD)	-	-	From 22/12/18: 0.0016 ^(6a)	From 22/12/18: 0.0008 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters

Notes:

‘-’ A target concentration is not available.

^{\$}Please note that total ammonia (NH₄⁺ and NH₃) is equivalent to ammoniacal nitrogen in laboratory reports

^{*1} Please note that although iron is listed in the 2015 Direction as 1.000 µg/l, the EQS remains at 1mg/l in Scotland and it is assumed this is an error and should read either 1,000 or 1000µg/l.

^{*2} Please note that although Isodrin is not listed in name within the group of “Cyclodiene pesticides” in Table 1 of Schedule 3 Part 3 of the 2015 Direction⁽⁶⁾, the CAS number for Isodrin (465-73-6) is listed and therefore it is assumed that it has been missed off the named list of substances.

^{*3} Total petroleum hydrocarbons is used for consistency, but is an analytical method-defined measurement for a mixture of hydrocarbons subject to environmental analysis¹¹.

“Bioavailable” in relation to copper, zinc, nickel and manganese (but not lead) is the generic EQSbioavailable^(6a) derived from the Metal Bioavailability Assessment Tool (M-BAT) developed by the Water Framework Directive UK Technical Advisory Group (WFDTAG). Exceedance of this value should prompt a site-specific assessment using the M-BAT with pH, DOC and Ca to derive a site-specific EQS termed the PNEC_{dissolved}.
<http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat>.

For zinc, if there is an exceedance of the EQSbioavailable in an initial GQRA, Tier 2 required that the EQS for zinc should also have the ambient background concentration of zinc added as well

Table 2: World Health Organization (WHO) guide values for TPH CWG fractions in drinking water⁽¹³⁾ (as referenced in CL:AIRE, 2017⁽¹¹⁾)

TPH CWG fraction	WHO guide value for drinking water ⁽¹³⁾ (µg/l)
Aliphatic fractions:	
Aliphatic EC5-EC6	15,000
Aliphatic >EC6-EC8	15,000
Aliphatic >EC8-EC10	300
Aliphatic >EC10-EC12	300
Aliphatic >EC12-EC16	300
Aliphatic >EC16-EC21	-
Aliphatic >EC21-EC35	-
Aromatic fractions:	
Aromatic EC5-EC6	10 (benzene)
Aromatic >EC6-EC8	700 (toluene)
Aromatic >EC8-EC10	300 (ethyl benzene) 500 (xylenes)
Aromatic >EC10-EC12	90
Aromatic >EC12-EC16	90
Aromatic >EC16-EC21	90
Aromatic >EC21-EC35	90
Reference: World Health Organisation (WHO), 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/05.08/123. World Health Organisation, Geneva ⁽¹³⁾ .	

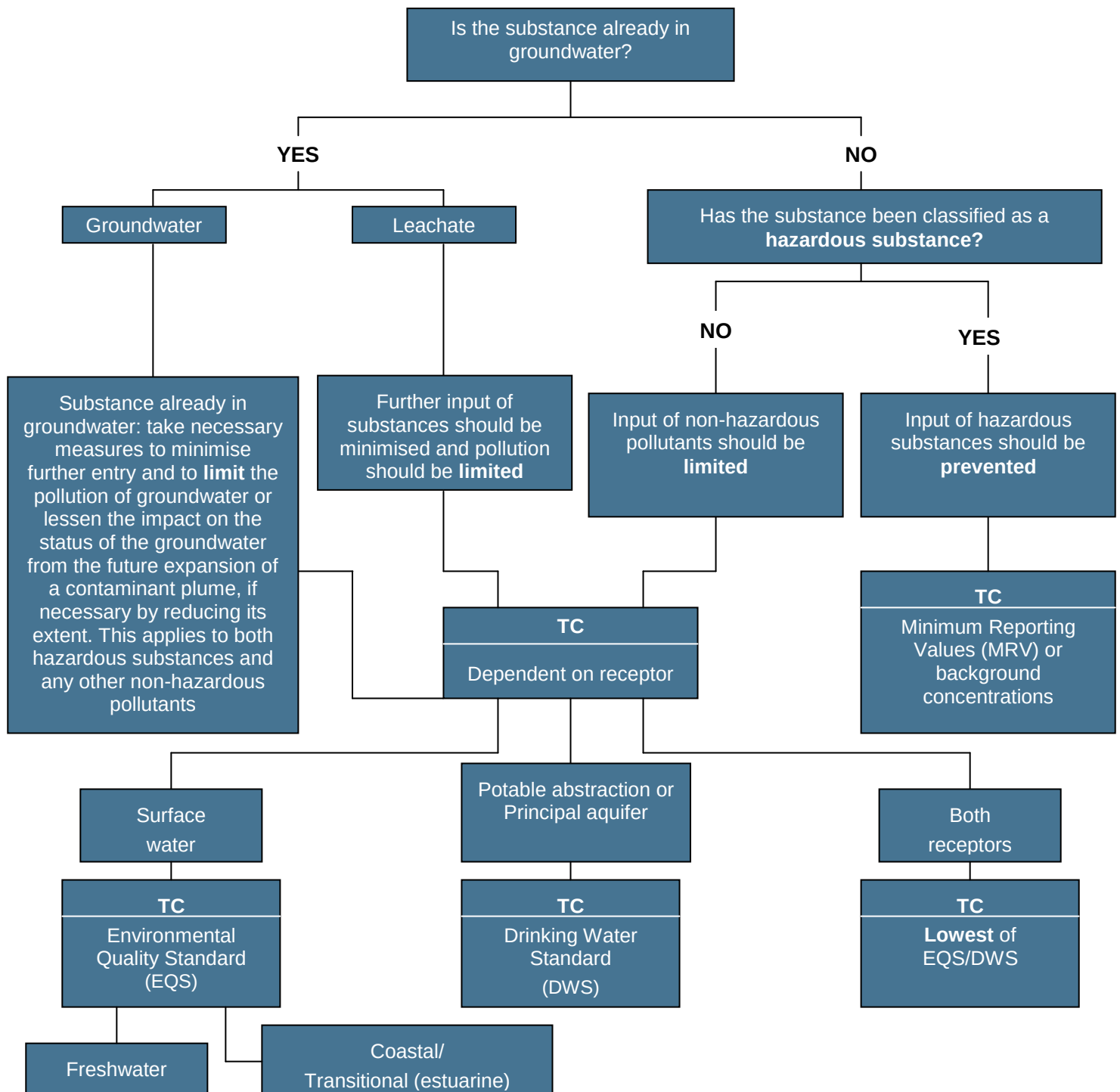
References

1. Environment Agency (2017), 'The Environment Agency's approach to groundwater protection', version 1.0, March 2017 (formerly contained within GP3) [accessed 29 March 2017].
<https://www.gov.uk/government/collections/groundwater-protection>
- 1a. Environment Agency (2017), 'Land contamination groundwater compliance points: quantitative risk assessments', March 2017 (formerly contained within GP3) [accessed 29 March 2017].
<https://www.gov.uk/government/collections/groundwater-protection>
2. The Water Supply (Water Quality) Regulations 2016 (SI 2016/619)
 - 2a. Sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane
 - 2b. Standard applies to individual pesticides except aldrin, dieldrin, heptachlor and heptachlor epoxide, for which a separate standard is defined.
3. The Private Water Supplies (England) Regulations 2016. SI 2016 / 618
4. WHO (2011), *Guidelines for drinking-water quality*, 4th edn
5. JAGDAG hazard substance determinations: This list contains substances that are determined to be hazardous substances or non-hazardous pollutants for the purposes of the groundwater directive 2006/118/EC. The absence of an assessment or substance from the list means an assessment has not been done yet and is presented as 'Not yet determined'; if a substance has been assessed but does not fall into either category it is presented as 'None'. For further details on how substances are assessed, see the Joint Agencies Groundwater Directive Advisory Group (JAGDAG) 'Methodology for the determination of hazardous substances in groundwater for the purposes of the groundwater directive 2006/118/EC' which is available from the JAGDAG website. The methodology is a UK –wide framework that sets criteria for how to assess whether a substance is a hazardous substances in groundwater. The list of substances can be found at:
<https://www.wfduk.org/stakeholders/jagdag>
6. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.
 - 6a. The EQS for these substances are based on a "long term mean" or an "annual average (AA)" EQS.
 - 6b. For cadmium and its compounds the EQS values vary depending on the hardness of the water as specified in five class categories (Class 1: < 40 mg CaCO₃/l, Class 2: 40 to < 50 mg CaCO₃/l, Class 3: 50 to < 100 mg CaCO₃/l, Class 4: 100 to < 200 mg CaCO₃/l and Class 5: ≥ 200 mg CaCO₃/l).
 - 6c. The EQS for Mercury and hexachlorobutadiene are based on a "maximum acceptable concentration (MAC)" EQS in absence of an "annual average (AA)" EQS.
 - 6d. The EQS for chlorine in saltwater is based on the 95th percentile concentration of total residual oxidant, which refers to the sum of all oxidising agents existing in water, expressed as available chlorine.
 - 6e. The recommended saltwater standard is derived using a safety factor of 100. Where the standard is failed, it is recommended that supporting evidence of ecological damage should be obtained before committing to expensive action.
 - 6f. EQS for total ammonia is as per Schedule 3, Part 1, Table 7 of of the above directions. EQS applies to river types 1, 2 and 4 and 6 (namely upland and low alkalinity). The EQS for a lowland and high alkalinity rivers (types 3, 5 and 7) is 600µg/l (0.6mg/l).

Additional information on the Metal Bioavailability Assessment Tool (M-BAT) is available at <http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat>

7. Minimum reporting values listed at <https://www.gov.uk/government/publications/values-for-groundwater-risk-assessments/hazardous-substances-to-groundwater-minimum-reporting-values> (updated 13 January 2017; accessed 29 March 2017). Note target concentration for xylenes is 3 µg/l each for o-xylene and m/p xylene as it may not be possible to separate m- and p-xylene; 135 tcb, 124 tcb, 123 tcb each to 0.01 µg/l)
8. The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 (as amended). SI 1996 / 3001
9. Council Directive on the Quality of Fresh Waters Needing Protection or Improvement in Order to Support Fish Life (Freshwater Fish Directive) (78/659/EEC)
10. WRc plc (2002), R&D Technical Report P45.
11. CL:AIRE, 2017. Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies. V1.1.
12. Drinking Water Inspectorate (London, UK). Environmental Information Request on MTBE in drinking water. Ref. DWI 1/10/18; dated 28 November 2006. Value is based on the odour threshold for MTBE, which is lower than a health-based guideline value
13. World Health Organisation (WHO), 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/05.08/123. World Health Organisation, Geneva. [accessed 29 March 2017] http://www.who.int/water_sanitation_health/dwq/chemicals/petroleumproducts_2add_june2008.pdf

FLOW CHART TO ASSIST WITH SELECTION OF TARGET CONCENTRATIONS



TC = Target concentration

When leachate is being assessed the 'compliance point' is the groundwater body. Therefore dilution within the groundwater body may be applied with caution before comparing with the TC.

When directly assessing a receptor, e.g., a river, the appropriate TC should be selected.

APPENDIX D

WATER SAMPLE RESULTS

FINAL ANALYTICAL TEST REPORT

Envirolab Job Number: 18/06429
Issue Number: 1

Date: 21 August, 2018

Client: Ian Farmer Associates (Warrington)
14/15 Rufford Court
Hardwick Grange
Warrington
WA1 4RF

Project Manager: Hannah Hadwin
Project Name: St Johns
Project Ref: 42206
Order No: 45039
Date Samples Received: 10/08/18
Date Instructions Received: 13/08/18
Date Analysis Completed: 21/08/18

Prepared by:



Melanie Marshall
Laboratory Coordinator

Approved by:



Danielle Brierley
Client Manager

Envirolab Job Number: 18/06429

Client Project Name: St Johns

Client Project Ref: 42206

Lab Sample ID	18/06429/1	18/06429/2	18/06429/3	18/06429/4					Units	Method ref
Client Sample No										
Client Sample ID	WS10	RBH02	BH04	BH02						
Depth to Top										
Depth To Bottom										
Date Sampled	09-Aug-18	09-Aug-18	09-Aug-18	09-Aug-18						
Sample Type	Water - EW	Water - EW	Water - EW	Water - EW						
Sample Matrix Code	N/A	N/A	N/A	N/A						
pH (w) _A [#]	6.96	8.54	8.42	7.00					pH	A-T-031w
Hardness Total _A [#]	536	119	232	495					mg/l Ca CO3	A-T-049w
Sulphate (w) _A [#]	254	187	114	195					mg/l	A-T-026w
Cyanide (total) (w) _A [#]	0.007	0.014	<0.005	<0.005					mg/l	A-T-042wTCN
Phenols - Total by HPLC (w) _A	<0.01	<0.01	<0.01	<0.01					mg/l	A-T-050w
Sulphide (w) _A	<0.1	<0.1	<0.1	<0.1					mg/l	A-T-S2-w
Arsenic (dissolved) _A [#]	<1	8	1	<1					µg/l	A-T-025w
Boron (dissolved) _A [#]	158	64	155	99					µg/l	A-T-025w
Cadmium (dissolved) _A [#]	<0.2	<0.2	<0.2	<0.2					µg/l	A-T-025w
Copper (dissolved) _A [#]	<1	3	<1	<1					µg/l	A-T-025w
Chromium (dissolved) _A [#]	1	10	13	7					µg/l	A-T-025w
Lead (dissolved) _A [#]	<1	<1	<1	<1					µg/l	A-T-025w
Mercury (dissolved) _A [#]	<0.1	<0.1	<0.1	<0.1					µg/l	A-T-025w
Nickel (dissolved) _A [#]	<1	4	2	6					µg/l	A-T-025w
Selenium (dissolved) _A [#]	<1	27	2	<1					µg/l	A-T-025w
Zinc (dissolved) _A [#]	8	3	1	13					µg/l	A-T-025w

Envirolab Job Number: 18/06429

Client Project Name: St Johns

Client Project Ref: 42206

Lab Sample ID	18/06429/1	18/06429/2	18/06429/3	18/06429/4					Units	Method ref
Client Sample No										
Client Sample ID	WS10	RBH02	BH04	BH02						
Depth to Top										
Depth To Bottom										
Date Sampled	09-Aug-18	09-Aug-18	09-Aug-18	09-Aug-18						
Sample Type	Water - EW	Water - EW	Water - EW	Water - EW						
Sample Matrix Code	N/A	N/A	N/A	N/A						
PAH 16MS (w)										
Acenaphthene (w) _A [#]	<0.01	0.23	<0.01	0.45					µg/l	A-T-019w
Acenaphthylene (w) _A [#]	<0.01	0.05	<0.01	0.13					µg/l	A-T-019w
Anthracene (w) _A [#]	<0.01	0.74	<0.01	0.69					µg/l	A-T-019w
Benzo(a)anthracene (w) _A [#]	<0.01	2.47	0.02	2.03					µg/l	A-T-019w
Benzo(a)pyrene (w) _A [#]	<0.01	3.06	0.02	2.01					µg/l	A-T-019w
Benzo(b)fluoranthene (w) _A [#]	<0.01	2.96	0.02	2.01					µg/l	A-T-019w
Benzo(ghi)perylene (w) _A [#]	<0.01	1.51	<0.01	0.80					µg/l	A-T-019w
Benzo(k)fluoranthene (w) _A [#]	<0.01	1.08	<0.01	0.66					µg/l	A-T-019w
Chrysene (w) _A [#]	<0.01	2.63	0.02	2.28					µg/l	A-T-019w
Dibenzo(ah)anthracene (w) _A [#]	<0.01	0.32	<0.01	0.22					µg/l	A-T-019w
Fluoranthene (w) _A [#]	0.01	5.94	0.03	4.71					µg/l	A-T-019w
Fluorene (w) _A [#]	<0.01	0.17	<0.01	0.46					µg/l	A-T-019w
Indeno(123-cd)pyrene (w) _A [#]	<0.01	2.05	0.01	0.96					µg/l	A-T-019w
Naphthalene (w) _A [#]	<0.01	0.01	<0.01	0.18					µg/l	A-T-019w
Phenanthrene (w) _A [#]	0.01	2.29	0.01	3.79					µg/l	A-T-019w
Pyrene (w) _A [#]	0.01	5.39	0.03	4.97					µg/l	A-T-019w
Total PAH 16MS (w) _A [#]	0.03	30.9	0.16	26.4					µg/l	A-T-019w

Envirolab Job Number: 18/06429

Client Project Name: St Johns

Client Project Ref: 42206

Lab Sample ID	18/06429/1	18/06429/2	18/06429/3	18/06429/4					Units	Method ref
Client Sample No										
Client Sample ID	WS10	RBH02	BH04	BH02						
Depth to Top										
Depth To Bottom										
Date Sampled	09-Aug-18	09-Aug-18	09-Aug-18	09-Aug-18						
Sample Type	Water - EW	Water - EW	Water - EW	Water - EW						
Sample Matrix Code	N/A	N/A	N/A	N/A						
SVOC (excluding PAH-16) (w)										
2,4,5-Trichlorophenol _A	<1	<1	<1	<1					µg/l	A-T-052w
2,4,6-Trichlorophenol _A	<1	<1	<1	<1					µg/l	A-T-052w
2,4-Dichlorophenol _A	<1	<1	<1	<1					µg/l	A-T-052w
2,4-Dimethylphenol _A	<1	<1	<1	<1					µg/l	A-T-052w
2,4-Dinitrotoluene _A	<1	<1	<1	<1					µg/l	A-T-052w
2,6-Dinitrotoluene _A	<1	<1	<1	<1					µg/l	A-T-052w
2-Chloronaphthalene _A	<1	<1	<1	<1					µg/l	A-T-052w
2-Chlorophenol _A	<1	<1	<1	<1					µg/l	A-T-052w
2-Methylnaphthalene _A	<1	<1	<1	<1					µg/l	A-T-052w
2-Methylphenol _A	<1	<1	<1	<1					µg/l	A-T-052w
2-Nitrophenol _A	<1	<1	<1	<1					µg/l	A-T-052w
4-Bromophenyl phenyl ether _A	<1	<1	<1	<1					µg/l	A-T-052w
4-Chloro-3-methylphenol _A	<1	<1	<1	<1					µg/l	A-T-052w
Bis(2-chloroisopropyl)ether _A	<1	<1	<1	<1					µg/l	A-T-052w
4-Methylphenol _A	<1	<1	<1	<1					µg/l	A-T-052w
4-Nitrophenol _A	<1	<1	<1	<1					µg/l	A-T-052w
Bis(2-chloroethyl)ether _A	<1	<1	<1	<1					µg/l	A-T-052w
Bis(2-chloroethoxy)methane _A	<1	<1	<1	<1					µg/l	A-T-052w
Bis(2-ethylhexyl)phthalate _A	<10	<10	<10	<10					µg/l	A-T-052w
Butylbenzyl phthalate _A	<1	<1	<1	<1					µg/l	A-T-052w
Carbazole _A	<1	<1	<1	<1					µg/l	A-T-052w
Dibenzofuran _A	<1	<1	<1	<1					µg/l	A-T-052w
n-Dibutylphthalate _A	<1	<1	<1	<1					µg/l	A-T-052w
n-Dioctylphthalate _A	<10	<10	<10	<10					µg/l	A-T-052w
n-Nitroso-n-dipropylamine _A	<1	<1	<1	<1					µg/l	A-T-052w
Diethyl phthalate _A	<1	<1	<1	<1					µg/l	A-T-052w
Dimethyl phthalate _A	<1	<1	<1	<1					µg/l	A-T-052w
Hexachlorobenzene _A	<1	<1	<1	<1					µg/l	A-T-052w
Pentachlorophenol _A	<1	<1	<1	<1					µg/l	A-T-052w
Phenol _A	<1	<1	<1	<1					µg/l	A-T-052w
Hexachloroethane _A	<1	<1	<1	<1					µg/l	A-T-052w
Nitrobenzene _A	<1	<1	<1	<1					µg/l	A-T-052w

Envirolab Job Number: 18/06429

Client Project Name: St Johns

Client Project Ref: 42206

Lab Sample ID	18/06429/1	18/06429/2	18/06429/3	18/06429/4					Units	Method ref
Client Sample No										
Client Sample ID	WS10	RBH02	BH04	BH02						
Depth to Top										
Depth To Bottom										
Date Sampled	09-Aug-18	09-Aug-18	09-Aug-18	09-Aug-18						
Sample Type	Water - EW	Water - EW	Water - EW	Water - EW						
Sample Matrix Code	N/A	N/A	N/A	N/A						
Isophorone _A	<1	<1	<1	<1					µg/l	A-T-052w
Hexachlorocyclopentadiene _A	<1	<1	<1	<1					µg/l	A-T-052w
Perylene _A	<1	<1	<1	<1					µg/l	A-T-052w

Envirolab Job Number: 18/06429

Client Project Name: St Johns

Client Project Ref: 42206

Lab Sample ID	18/06429/1	18/06429/2	18/06429/3	18/06429/4					Units	Method ref
Client Sample No										
Client Sample ID	WS10	RBH02	BH04	BH02						
Depth to Top										
Depth To Bottom										
Date Sampled	09-Aug-18	09-Aug-18	09-Aug-18	09-Aug-18						
Sample Type	Water - EW	Water - EW	Water - EW	Water - EW						
Sample Matrix Code	N/A	N/A	N/A	N/A						
VOC (w)										
Dichlorodifluoromethane _A	<1	<1	<1	<1					µg/l	A-T-006w
Chloromethane _A	<10	<10	<10	<10					µg/l	A-T-006w
Vinyl Chloride _A [#]	<1	2	<1	<1					µg/l	A-T-006w
Bromomethane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Chloroethane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Trichlorofluoromethane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
trans 1,2-Dichloroethene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Dichloromethane _A	<5	<5	<5	<5					µg/l	A-T-006w
Carbon Disulphide _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,1-Dichloroethene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,1-Dichloroethane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
cis 1,2-Dichloroethene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Bromochloromethane _A [#]	<5	<5	<5	<5					µg/l	A-T-006w
Chloroform _A [#]	<1	5	1	2					µg/l	A-T-006w
2,2-Dichloropropane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,2-Dichloroethane _A [#]	<2	<2	<2	<2					µg/l	A-T-006w
1,1,1-Trichloroethane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,1-Dichloropropene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Benzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Carbon Tetrachloride _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Dibromomethane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,2-Dichloropropane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Bromodichloromethane _A [#]	<10	<10	<10	<10					µg/l	A-T-006w
Trichloroethene _A [#]	1	<1	<1	<1					µg/l	A-T-006w
cis 1,3-Dichloropropene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
trans 1,3-Dichloropropene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,1,2-Trichloroethane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Toluene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,3-Dichloropropane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Dibromochloromethane _A [#]	<3	<3	<3	<3					µg/l	A-T-006w
1,2-Dibromoethane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Tetrachloroethene _A	<1	<1	<1	<1					µg/l	A-T-006w

Envirolab Job Number: 18/06429

Client Project Name: St Johns

Client Project Ref: 42206

Lab Sample ID	18/06429/1	18/06429/2	18/06429/3	18/06429/4					Units	Method ref
Client Sample No										
Client Sample ID	WS10	RBH02	BH04	BH02						
Depth to Top										
Depth To Bottom										
Date Sampled	09-Aug-18	09-Aug-18	09-Aug-18	09-Aug-18						
Sample Type	Water - EW	Water - EW	Water - EW	Water - EW						
Sample Matrix Code	N/A	N/A	N/A	N/A						
1,1,1,2-Tetrachloroethane _A	<1	<1	<1	<1					µg/l	A-T-006w
Chlorobenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Ethylbenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
m & p Xylene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Bromoform _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Styrene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,1,2,2-Tetrachloroethane _A	<1	<1	<1	<1					µg/l	A-T-006w
o-Xylene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,2,3-Trichloropropane _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Isopropylbenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
Bromobenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
2-Chlorotoluene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
n-propylbenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
4-Chlorotoluene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,2,4-Trimethylbenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
4-Isopropyltoluene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,3,5-Trimethylbenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,2-Dichlorobenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,4-Dichlorobenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
sec-Butylbenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
tert-Butylbenzene _A [#]	<2	<2	<2	<2					µg/l	A-T-006w
1,3-Dichlorobenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
n-butylbenzene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w
1,2-Dibromo-3-chloropropane _A [#]	<2	<2	<2	<2					µg/l	A-T-006w
1,2,4-Trichlorobenzene _A [#]	<3	<3	<3	<3					µg/l	A-T-006w
1,2,3-Trichlorobenzene _A [#]	<3	<3	<3	<3					µg/l	A-T-006w
Hexachlorobutadiene _A [#]	<1	<1	<1	<1					µg/l	A-T-006w

Envirolab Job Number: 18/06429

Client Project Name: St Johns

Client Project Ref: 42206

Lab Sample ID	18/06429/1	18/06429/2	18/06429/3	18/06429/4					Units	Method ref
Client Sample No										
Client Sample ID	WS10	RBH02	BH04	BH02						
Depth to Top										
Depth To Bottom										
Date Sampled	09-Aug-18	09-Aug-18	09-Aug-18	09-Aug-18						
Sample Type	Water - EW	Water - EW	Water - EW	Water - EW						
Sample Matrix Code	N/A	N/A	N/A	N/A						
TPH CWG (w)										
Ali >C5-C6 (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
Ali >C6-C8 (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
Ali >C8-C10 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Ali >C10-C12 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Ali >C12-C16 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Ali >C16-C21 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Ali >C21-C35 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Total Aliphatics >C5-C35 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Aro >C5-C7 (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
Aro >C7-C8 (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
Aro >C8-C10 (w) _A	<5	<5	<5	<5					µg/l	A-T-055w
Aro >C10-C12 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Aro >C12-C16 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Aro >C16-C21 (w) _A [#]	<5	<5	<5	<5					µg/l	A-T-055w
Aro >C21-C35 (w) _A [#]	<10	<10	<10	<10					µg/l	A-T-055w
Total Aromatics >C5-C35 (w) _A	<10	<10	<10	<10					µg/l	A-T-055w
TPH (Ali & Aro >C5-C35) (w) _A	<10	<10	<10	<10					µg/l	A-T-055w
BTEX - Benzene (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
BTEX - Toluene (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
BTEX - Ethyl Benzene (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
BTEX - m & p Xylene (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
BTEX - o Xylene (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w
MTBE (w) _A [#]	<1	<1	<1	<1					µg/l	A-T-022w

REPORT NOTES

General:

This report shall not be reproduced, except in full, without written approval from Envirolab.

All samples contained within this report, and any received with the same delivery, will be disposed of one month after the date of this report.

Analytical results reflect the quality of the sample at the time of analysis only.

Opinions and interpretations expressed are outside the scope of our accreditation.

If results are in italic font they are associated with an AQC failure and there is insufficient sample to repeat the analysis. These are not accredited and are unreliable.

A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.

Soil chemical analysis:

All results are reported as dry weight (<40°C).

For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.

For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any "A" subscripts

All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

TPH analysis of water by method A-T-007:

Free and visible oils are excluded from the sample used for analysis so that the reported result represents the dissolved phase only.

Electrical Conductivity of water by Method A-T-037:

Results greater than 12900µS/cm @ 25°C / 11550µS/cm @ 20°C fall outside the calibration range and as such are unaccredited.

Asbestos:

Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.

Stones etc. are not removed from the sample prior to analysis.

Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

Predominant Matrix Codes:

1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER, 8 = Asbestos bulk ID sample.

Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.

Secondary Matrix Codes:

A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal,

E = contains roots/twigs.

Key:

IS indicates Insufficient Sample for analysis.

US indicates Unsuitable Sample for analysis.

NDP indicates No Determination Possible.

NAD indicates No Asbestos Detected.

N/A indicates Not Applicable.

Superscript # indicates method accredited to ISO 17025.

Superscript "M" indicates method accredited to MCERTS.

Subscript "A" indicates analysis performed on the sample as received.

Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve

Please contact us if you need any further information.