

**INVESTIGATING THE LIMITATIONS OF THE CURRENT
UK WATER PIPE MATERIAL RISK ASSESSMENT GUIDANCE AND
PROCEDURES**

By

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ABSTRACT

Water companies have a statutory duty to supply wholesome water. Developer and/or landowners are responsible for securing the safe development of a site affected by contamination.

Soil and groundwater contamination as a result of historical industrial uses or as a result of a pollution incident such as oil, fuel, solvent or chemical spillages can and have, posed a threat to the drinking water quality and to the structural integrity of pipes used for distributing water.

As part of this research water industry guidance (UKWIR 2010 and Water UK protocol) for the selection of water pipe materials and its application by UK water companies and other key stakeholders, involved in planning, designing and the installation of water pipes and fittings, during the development of land potentially affected by contamination, has been undertaken. This thesis created a database of risk assessments for water pipes submitted to a water company to determine common omissions by developers/SLO (or their consultants) and the water company from the current water industry guidance.

It has illustrated that the majority of water connection applications to the water company fall short of meeting the requirements of the industry guidance through data analysis and case studies.

It is also illustrated that there is variation in the adoption of water industry guidance by water companies across the UK.

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Glossary of Abbreviations

AC	Asbestos cement
AGS	Association of Geotechnical and Geoenvironmental Specialists
AWWA	American Water Works Association
AwwwaRF	AWWA Research Foundation
BRE	Building Research Establishment
BSI	British Standards Institute
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CIRIA	Construction Industry Research and Information Association
CSM	Conceptual Site Model
CIEH	Chartered Institute of Environmental Health
CCW	Consumer Council for Water
C4SL	Category 4 screening levels
CLR11	Contaminated Land Report 11 – EA (2004) Model Procedures for the Management of Contaminated Land Contamination
DEFRA	Department of the Environment, Fisheries and Rural Affairs
DoE	Department of the Environment
DQRA	Detailed Quantitative Risk Assessment
DWI	Drinking Water Inspectorate
DWS	Drinking Water Standards (UK)
DI	Ductile iron
EA	Environmental Agency
EU	European Union
EIC	Environmental Industries Commission
FWR	Foundation for Water Research
GAC	Generic assessment criteria
GQRA	Generic Quantitative Risk Assessment
GRP	Glass reinforced plastic
GI	Ground investigation
GIS	Geographic Information System
HBF	House Builders Federation
HDPE	High-density polyethylene
ICRCL	Inter-Departmental Committee on the Redevelopment of Contaminated Land
LDPE	Low-density polyethylene
MCL	Maximum contaminant limit
MDPE	Medium-density polyethylene
MCERTS	EA Monitoring Certification Scheme
NFB	National Federation of Builders
NHBC	National House Builders Council
OFWAT	The Water Services Regulation Authority
PB	Polybutylene
PRA	Preliminary Risk Assessment
PVC	Polyvinylchloride
PPI	Plastic Pipe Institute
PSRA	Pipe selection risk assessment
PSRAS	Pipe selection risk assessment summary
RA	Risk assessment
R&D66	R&D Publication 66 – NHBC and EA (2008) Guidance for the Safe Development of Housing on Land Affected by Contamination
SGV	Soil guideline values

SLO	Self-lay organisations
SVOC	Semi Volatile Organic Compounds
TCE	Trichloroethylene
TPH	Total petroleum hydrocarbons
UK	United Kingdom
UKWIR	United Kingdom Water Industry Research
UKAS	United Kingdom Accreditation Service
USEPA	United States Environmental Protection Agency
UW	United Utilities Water plc.
VLDPE	Very low-density polyethylene
WC	Water Company
WI	Water Industry
WFR	Water Supply (Water Fittings) Regulations (amended) 1999
WQR	Water Supply (Water Quality) Regulations (amended) 2000
WRAS	Water Regulatory Advisory Scheme
WRc	Water Research Council
WHO	World Health Organisation
VOC	Volatile Organic Compounds

Glossary of Terms

Water mains	Larger water company pipes, which distribute water around the network. They are often, but not always, laid under roads.
Service pipe	General name for the pipes leading between the mains and the property, usually consisting of the communication pipe and the water supply pipe.
Communication pipe	Water company pipes which carry water between the water mains and the boundary of the property.
Supply pipes	Property owner pipes which connect a property to the water mains / communication pipes. The pipe generally runs from the property boundary to the property.
Soil-gas	Gases in the subsurface (term as defined in CIRIA C682: The VOC Handbook (Baker <i>et al.</i> 2009)

Chapter 0 Aims and Objectives

For a new development (requiring a potable water supply) on land potentially affected by contamination, a risk assessment for water pipes is undertaken by the developer/Self Lay Organisation (SLO) or their consultants and is submitted to a water company as part of a water connection application request. The risk assessment (RA) for water pipes (or pipe selection risk assessment (PSRA)) is concerned with demonstrating that pipe materials and/or protection measures that have been specified, in the evaluation and selection process, are suitable. Water industry (WI) guidance (UKWIR2010 and Water UK protocol) has been developed to support this material selection process. This thesis is targeted to ascertain how well the RA for water pipes, implemented by key stakeholders, compares to the recommendations set out in the WI guidance and also to determine WI guidance consistency with the model procedures for the management land contamination.

Aim

The aim of this research is to critically evaluate the effectiveness and the implementation of the current WI guidance for the selection of water pipe materials, to be installed on land potentially affected by contamination. This should have the effect of understanding the risks of contaminated ground to water pipe materials; determining areas of uncertainty and limitations in the PSRA process; and of identifying areas of improvement.

The objectives of this document are to:

1. Explore the factors and effects of ground contamination on the integrity of water pipe materials, through the review of pertinent guidance and research
2. Undertake a critical review of the PSRA process to determine consistency with the model procedures for the management of land contamination (CLR 11 and R&D P66)

3. Consider the views and opinions on the key limitations of the current WI guidance by stakeholders in the land contamination and construction industry community
4. Establish the procedures relating to the selection of water pipe materials, to be installed on land potentially affected by contamination, adopted by water companies in the UK
5. Critically evaluate developer/SLO RA for water pipes and RA supporting information (supporting information to a water connection application) submitted to a WC, by benchmarking for compliance with the requirements set out in the UKWIR 2010 and Water UK protocol and to establish a database. WC recommendations shall also be documented.
6. Establish common omissions and areas of uncertainty in the RA for water pipes by developer/SLO (or their consultants) and in WC recommendations
7. Consider case studies to test the WI guidance and its application by water companies and other key stakeholder (e.g. developers and their consultants), to identify information gaps and areas of uncertainty in the PSRA process. Information that can reduce uncertainty, refine investigations, and demonstrate understanding to the WC shall be identified.
8. Provide recommendations on the way forward to improve the PSRA process, guided by the findings of this research

Chapter 1 Introduction

It has been known for many years that building materials, including pipes used for distributing water, are subject to effects caused by contaminants in the soil and groundwater surrounding the pipe (Crathorne *et al.* 1987). Land may be affected by legacy contamination (as a result of historical industrial uses or from waste disposal activities) or become affected as a result of a pollution incident such as oil, fuel, solvent or chemical spillages. Both drinking water quality and the structural integrity of pipework may be compromised when installed on land affected by contamination.

A staged risk-based approach is adopted in the United Kingdom (UK) for investigating, assessing risk and remediating land affected by contamination and this is embedded in a wide range of legislation that seeks to protect human health and the wider environment. The model framework for applying risk management when dealing with land affected by contamination, is presented in the Environment Agency's (EA) CLR11 publication '*Model Procedures for the Management of Land Contamination*' (EA, 2004). Central to the risk assessment approach is defining the relationship between contaminants, pathways and receptors and the concept of a pollutant linkage (also referred to as a contaminant linkage), when all three elements exist (DEFRA, 2012). In practice, the understanding of the contamination risks presented by land is developed and communicated in the form of a conceptual site model (CSM).

In addition to the CLR11 model procedures, there is an array of other non-statutory technical guidance, national standards guidance and technical guidance document, by not-for-profit organisations (such as NHBC and CIRIA), which are consistent with the model procedures and provide more detailed technical guidance to manage risks by ground contamination to specific receptors (i.e. human health, water environment, ecological systems, buildings and building materials and services) or pathways (e.g. human health inhalation pathway of volatile organic compounds and asbestos or direct contact of property materials to aggressive ground conditions).

Formal contaminated land management guidance on the risk assessment for buildings and services is limited. It may however be expected to follow the overall methodology for assessing potential risks to other receptors from land contamination and/or that used for assessing other specific exposure pathway (Nathanail *et al.* 2007).

In the context of building services and more specifically water distribution pipes, the implementation of risk management when a potential contaminant linkage is identified, is generally concerned with ensuring pipe materials and/or protection measures that have been specified in the evaluation and selection process are suitable (EA, 2000). This material selection process may be applied where a new development is proposed, or where it is suspected that existing services may be at risk.

The risk management procedure, for the selection of water pipe materials and/or protection measures design, will depend on the type and concentrations of contaminants on the site; the type of pipe materials proposed; the requirements for design life; and the requirements of design standards and specifications (EA, 2000).

There has been several guidance documents produced in the UK since the early 1990's, which attempt to provide practical guidance for the selection and installation of suitable water pipe materials in land affected by contamination. The most recent publication is the UK Water Industry Research (UKWIR) '*Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites*' ('UKWIR2010').

UKWIR2010 guidance is intended for use by stakeholders (including developers, SLO, water companies and their consultants) involved in planning, designing and the installation of water mains and/or services in land potentially affected by contamination.

The Water Supply (Water Fittings) Regulations 1999 ('WFR') provides a driver to assess the potential risks posed to a new development (new water main/service connection) by ground contamination. Ground contamination has the potential to effect the structural integrity of the proposed water fittings

and/or the future water quality (by ingress or by permeation of contaminants). A PSRA is generally undertaken by the developer/SLO (or their consultants) and in some instances by the WC, to determine the suitability of pipe materials to be installed. Water companies however are ultimately responsible for the enforcement of the WFR at a local level. Therefore in the context of this thesis the WC should ensure that suitable water fittings are installed as to minimize the risks of permeation by, and deterioration from contact with, contaminants in the ground which may cause contamination of the water supplied by the WC.

In January 2014, Water UK published a protocol document entitled '*Contaminated Land Assessment guidance*' (Lingard *et al.*, 2014) ('Water UK protocol'). This protocol was initially developed in 2011 by United Utilities Plc.(UU) in consultation with the House Builders Federation (HBF) and was subsequently adopted as national guidance by Water UK.

The author was a contributor in the development of the Water UK protocol and coordinated the consultation process. The document acts as supplementary guidance to the UKWIR2010 guidance and provides a protocol template to undertake a PSRA however adopts much of the UKWIR2010 guidance document in principle (Lingard *et al.*, 2014). The development of this supplementary document was instigated due to negative customer (developers, SLO and/or their consultants) contacts received by the WC due to perceived short-comings of the UKWIR2010 and due to difficulties encountered by WC connection engineers and developers/SLO (or their consultants) in applying the UKWIR2010 guidance (this shall be discussed in more detail in a later sections).

The combined use of UKWIR2010/Water UK protocol was adopted by UU and this thesis was conceived to ascertain the effectiveness and implementation of the protocol since its application since 2011. The RA for water pipes (and supporting information to the RA) submitted to the WC, for new developments (new water main/service connections) on land potentially affected by contamination, are considered to be a reflection of both industry and WC implementation of the UKWIR2010/Water UK protocol. A database of water connection PSRA thus was created and data interrogated to see if the requirements of UKWIR2010/Water UK were being met and to identify common data gaps and areas of uncertainty of the PSRA process. With the overall aim

being to ascertain the performance of risk assessment and the risk management procedures implemented; and to determine whether there are any improvements to be made to current guidance to reduce uncertainties during the selection of water pipe materials.

An inconsistent approach to the selection of water pipe materials by UK water companies has been reported in recent publications (discussed in 2.7). To determine the adoption of the UKWIR2010/Water UK protocol by UK water companies a review of pipe materials selection processes of 23 water companies operating in the UK has also been undertaken.

Chapter 2 Literature Review

2.1 Literature Review: Legislative and Regulatory Framework

The primary regulatory driver in the UK (England, Scotland and Wales) for land contamination risk assessment is Part 2A of the Environmental Protection Act 1990 ('Part 2A'). Part 2A works alongside planning rules and the building regulations.

The regulatory framework for water supplies in England and Wales is set out in the Water Industry Act 1991 and 1999 and the Water Act 2003 (DWI, 2009). The Water Act 2014 received Royal Assent on 14 May 2014. The powers and duties associated with the water industry in Scotland are primarily contained within the Water Industry (Scotland) Act 2002.

There are some legislative differences between the four countries in the UK. Environmental and water industry legislation in Northern Ireland (NI) is broadly equivalent to that in England and Wales, although much is NI-specific (Water UK, 2007). The following chapters will generally focus on regimes in England.

2.1.1 Water Industry Act and Water Act

Water companies have a statutory duty to supply wholesome water. Wholesomeness is defined by reference to drinking water quality standards and other requirements set out in the Water Supply (Water Quality) Regulations 2000 (as amended), which apply in England (DWI, 2009). Many essential quality standards (including microbiological, chemical and indicator parameters) protective of human health, are laid down at an EU level in the Drinking Water Directive 1998 (EU, 2014) and in National legislation. The Drinking Water Inspectorate (DWI) is responsible for regulating the quality of drinking water supplies in England. It is the responsibility of the WC to comply with the requirements of the regulations.

Water companies have enforcement powers under the the Water Supply (Water Fittings) Regulations (amended) 1999, which apply in England and Wales. This

allows WC to inspect new and existing water fittings installation to see if they comply with the regulations. Landowners, developers or anyone responsible for the installation of water fittings have a legal duty to ensure the systems comply with the regulations. Responsibilities with regards to the water distribution network are discussed further in section 2.3

The Local Authority (LA) is also required under the Water Industry Act, to monitor the wholesomeness and adequacy of water supplies at a local level. Where a LA has concerns that supplies are harmful or inadequate, they have a responsibility to notify the local WC who has a responsibility to take appropriate action and to rectify the problem.

2.1.2 Part 2A of the Environmental Protection Act

Part 2A is one of the main policy measures used to deal with legacy contamination in the UK (England, Scotland and Wales). The Statutory Guidance ('SG') on the Contaminated Land regime under Part 2A, issued by the Secretary of the State for Environment, Food and Rural Affairs in April 2012, establishes the legal framework for identifying and remediating land that poses a significant risk to health or the environment, where there is no alternative solution (DEFRA, 2012). The SG applies to England.

The recent revision of the SG however, excludes buried services as a property receptor. Therefore land cannot be defined as contaminated land under this regime, based solely on the unacceptable risk (i.e. where significant harm is being caused or there is a significant possibility of such harm) to utility services (DEFRA, 2012).

2.1.3 Planning and Building Control (Town and Country Planning Act, Planning Act, Planning and Compulsory Purchase Act and the Building Act)

The planning policy for England, set out in the National Planning Policy Framework (NPPF), encourages the reuse of land that has been previously developed (brownfield land), provided that it is not of high environmental value (DCLG, 2012). The responsibility for securing the safe development of a site

affected by contamination or land instability rests with the developer and / or landowner.

Building works may require permission under the Building Regulation and / or planning regime (EA, 2010). Approved Document C is a statutory guidance document, which provides the technical guidance that supports Part C of Schedule 1 of the Building Regulations 2010 (and related amendments), and is concerned with the requirements with respect to the resistance of buildings to contaminants and moisture (HM Government, 2013). It provides technical guidance on the assessment and management of risks to building materials and services by land affected by contamination.

Approved Document C states that a particular concern is the effects of hydrocarbons permeating potable water pipes made of polyethylene (PE). The document refers the reader to the '*Foundation for Water Research Report FR0448 Laying potable water pipelines in contaminated ground: guidance, 1994*' on reducing contamination risks to water pipes. The Approved Document C was revised in 2013 however makes no reference to the current water industry guidance UKWIR2010.

2.2 Literature Review: UK Water Industry and Regulation

Private companies deliver water services in England and Wales. At the time of writing there are a total of thirty-two regulated water companies (OFWAT, 2014) (19 regional, 5. local and 8 water supply licensees). Figure 1 presents 21 of the larger regional and local water companies operating areas in England and Wales. Scottish Water and Northern Ireland Water are public sector corporations.

The WI is heavily regulated in the UK on all aspects of service including water resource management and quality, environmental improvement and consumer price control. UK water companies therefore work closely with the government and various authorities such as the Environment Agency (EA), Department for Environment, Food and Rural Affairs (DEFRA), the Drinking Water Inspectorate (DWI), OFWAT (The water Services Regulation Authority) and the Consumer Council for Water (CCW) in England and Wales.

Regulatory bodies in Scotland include the Scottish Environmental Protection Agency (SEPA), the Drinking Water Quality Regulator (DWQR) and the Scottish Public Services Ombudsman and Customer Focus Scotland. In NI these are the Environment and Heritage Service (EHS), the DWI and the CCW.



Key

- AFW – Affinity Water
- BRL – Bristol Water
- CHL – Cholderton & District Water
- DVW – Dee Valley Water
- ESK – Essex & Suffolk (part of Northumbrian Water)
- HPL – Hartlepool (part of Anglian Water)
- PRT – Portsmouth Water
- SBW – Sembcorp Bournemouth Water
- SES – Sutton & East Surrey Water
- SEW – South East Water
- SSC – South Staffs Water

Figure 1 Water Industry (Source:
<http://www.ofwat.gov.uk/industryoverview/today/map/#brl> (Accessed
 August 2014)

2.3 Literature Review: Responsibility of Water Company and Developers / Landowners for Water Pipes

Water companies are responsible for the repair and maintenance of the water mains and communication pipes. Communication pipes carry water between the water mains and the boundary of the domestic property.

Supply pipes connect a property to water mains / communication pipes. These pipes generally run from the property boundary to the property and are the responsibility of the property owner.

Communication pipes and supply pipes are collectively referred to as service pipes (DEFRA, 2013). Figure 2 presents a simple schematic diagram of water pipe responsibilities.

A public consultation was held from 23 May 2013 and 4 July 2013, on the future management of private water supply pipes by Defra and Welsh Government (DEFRA, 2013). A subsequent summary report on the stakeholder views and the enhanced impact assessment of possible ownership policy options was published in July 2014. Defra concluded that despite the recognized benefits for the transfer of private water supply to water companies, no further work is intended due to uncertainties about the range of impact this policy change would have on household water bills (DEFRA, 2013).

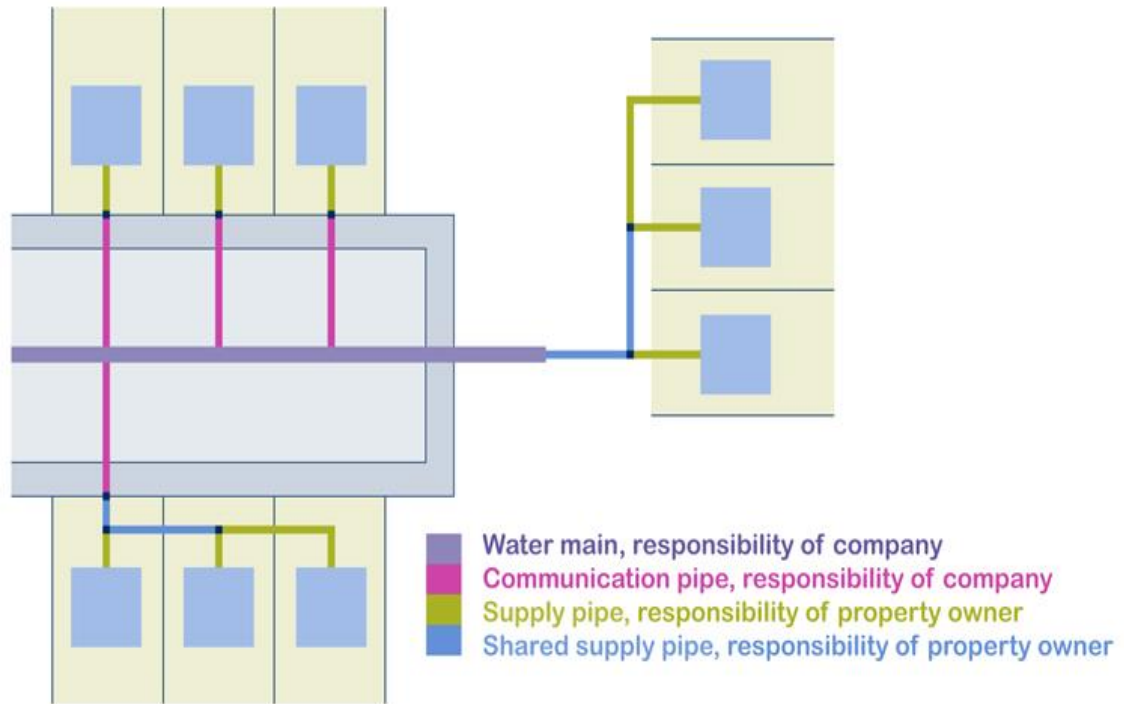


Figure 2 Responsibility for water pipes (Source: <http://www.ofwat.gov.uk/consumerissues/rightsresponsibilities/supplypipes/> (Accessed July 2014))

For a new development, the property may be connected to an existing water main or alternatively may require a new main or an extension to be made to an existing main to provide a water supply.

Developments requiring a new or extended water main for domestic purposes, the developer (or landowner) may request the local statutory water undertaker (the water company) to install the infrastructure (referred to as a main requisition) or alternatively commission an accredited self-lay organization (SLO). The WC however will adopt (take over responsibility) of self-laid mains/communication infrastructure (Water UK, 2015). Supply pipes remain the responsibility of the land- or property-owner post development.

A water connection request by a developer or land-owner is a request to connect a property to an existing main.

In the context of this paper, a water connection application is inclusive of both service connections to existing main and new mains connections.

2.4 Literature Review: WI guidance for the selection of Water Pipes used in land potentially affected by contamination

Since the early 1990's there has been several water industry (WI) guidance documents produced in the UK ('WI guidance'), which attempt to provide practical guidance for the selection and installation of suitable water pipe materials in land affected by contamination. Past and current WI guidance is presented in Table 1

1. The four listed WI guidance documents were published by a for-profit organisation Water Regulatory Advisory Scheme (WRAS) and the following research establishments:

- A member-led organization (UK Water Industry Research (UKWIR)); and
- A not for profit independent charity (Foundation for water research (FWR)).

Table 1 WI guidance for water pipe material selection for use in land affected by contamination

Date	Author/s	Reference
2010	K. Blackmore, B. Briere de l'Isle, D. Garrow, J. Jonsson, M. Norris, J. Turrell, J. Trew, S. Wilcox	Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites. UK Water Industry Research (UKWIR) Report Ref. No. 10/WM/03/21.
2004	R. Morris	Pipe Material Selection and Specification for use in Contaminated Land - Final Project Report. UKWIR Report Ref. No. 04/WM/03/9.
2002	Not known	The Selection of Materials for water Supply to be Laid in Contaminated Land Information and Guidance Note No. 9-04-03. Water regulation Advisory Scheme (WRAS).
1994	J. Stephen and M. Norris	Laying potable water pipelines in contaminated ground - guidance note FR0448. Foundation for Water Research (FWR).

The UKWIR2010 guidance was developed to replace the heavily criticised Water Regulatory Advisory Scheme (WRAS) Information and Guidance Note (the 'WRAS2002'). WRAS2002 was criticised mainly due to the fact that the pipe

selection threshold values presented where protective of human health rather than to water pipe materials (discussed further in section 2.7). WRAS2002 was subsequently withdrawn in January 2010 following the publication of the UKWIR2010 guidance.

The aim of UKWIR2010 is *"to ensure that the correct pipe materials and components are selected to protect the quality of drinking water whilst taking into account the service life of the water distribution system"* (Blackmoore *et al.* 2010, p. 1)

The WRAS2002 guidance recognized limitations in the guidance it provided and referred the reader to anticipated UKWIR project entitled 'Pipe Material Selection and Specification for use in Contaminated Land', which was expected to be published in 2004 ('UKWIR2004').

The UKWIR 2004 guidance does not however appear to have been adopted by the UK water industry, as demonstrated by the continued use of the WRAS2002 (established in Chapter 4). The UKWIR2004 guidance was superseded by the publication of the UKWIR2010 publication.

The WRAS2002 publication reports to be based upon recommendations of the FWR(1994) guidance note. The pipe material selection threshold levels presented in the WRAS2002 are only partially consistent with those presented in FWR(1994), the majority of inorganic contaminants presented where based on those report by FWR(1994); however the threshold levels for organic contaminants and antimony were not and the source of the levels presented in WRAS2002 is not included in the guidance.

The FWR(1994) remains a cited document in the 2013 revision of the Building Regulations, Approved Document C (Resistance to contaminants and moisture) statutory guidance document, as providing guidance on reducing risks of permeation by hydrocarbons to polyethylene water pipes.

The Water UK protocol was published in January 2014 and is a supplementary protocol to UKWIR2010 and provides a template to document information to demonstrate the UKWIR2010 requirements (i.e. Risk Assessment for Water

Pipes) has been met. This RA protocol is therefore intended to be used in the place of the SAR (Site Assessment Report) outlined as required in UKWIR2010. An example of a SAR and extract PSRA protocol is presented as Appendix A and Appendix B, respectively.

2.5 1. Exploring the factors and effects of ground contamination on the integrity of water pipe materials

Before undertaking a critical review of the PSRA process and determining its consistency with the CLR11/R&DP66 model procedures, it was considered appropriate to gain an understanding of the effects of ground contamination on pipe materials used for water supply. To explore the factors and effects a review of historical research and guidance has been undertaken.

Of the literature reviewed, research methods adopted generally include reviews of literature (Vonk and Veenendaal(1983), Flogstad *et al.*(1984), Crathorne *et al.*(1987), Bromhead (1997)), surveys of water quality incidents from WC experiences (Crathorne *et al.*(1987) and Ong *et al.*(2008)) and experimental pipe-bottle tests (Vonk and Veenendaal (1983), Crathorne *et al.*(1987), Ong *et al.*(2008) and Mao *et al.*(2009)) and bent-test (Crathorne *et al.* 1987). More recent experimental research by Ong *et al.*(2008) and Mao *et al.*(2009) also included gravimetric sorption tests and microscopic visualization tests.

As touched on in the introduction formal land contamination technical guidance for the assessment of risk to materials for use in the water distribution network is limited, however those that are available (BRE(1994), EA(2000) and EA(2001), HM Government(2013)) mostly utilise the findings of historical research literature in the guidance they provide.



Figure 3 Pipe-bottle apparatus (Ong *et al.* 2008, Figure 3.1)

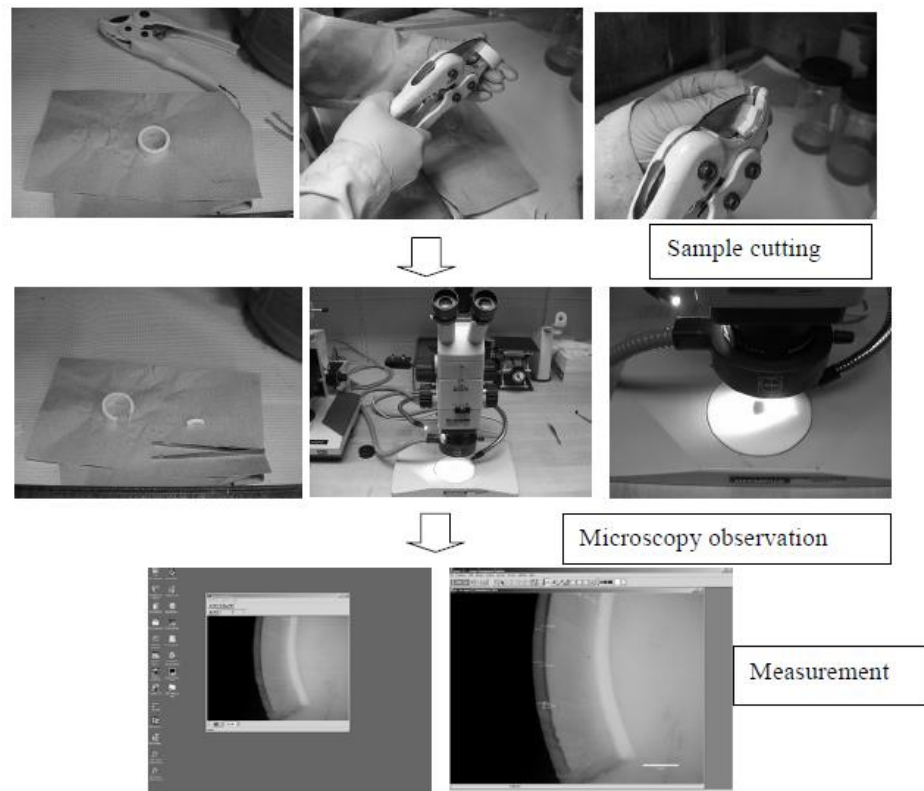


Figure 4 Microscopic visualization procedure 'moving front test' (Ong et al.2008, Figure 5.10)

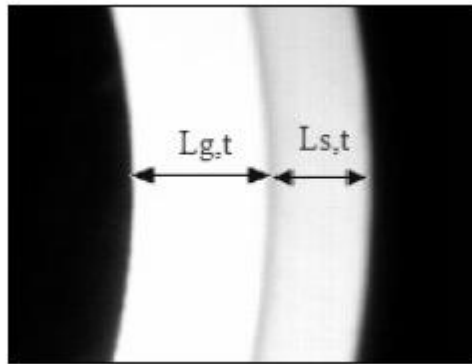


Figure 5 Moving front and definition of $L_{g,t}$ (thickness of the remaining glassy core at time) & $L_{s,t}$ (thickness of the swollen layer at time) (Ong et al.2008, Figure 5.9)

Past research appear mostly to have been instigated by water quality incident experience.

Research by Vonk and Veenendaal (1983) was instigated by an incident of methylbromide contamination of a PE drinking water

A paper by Flogstad *et al.* (1984) recognises the extensive use of plastic pipes for drinking water supply, which has given rise to drinking water taste and odour (T&O) problems in Norway and in several European countries including UK, the Netherlands, Belgium and West Germany attributed to contaminated ground.

More recent research by Ong *et al.* (2008) on behalf of the AWWA Research Foundation, acknowledges the array of historical research and reported case studies around the issue of permeation of organic compounds through plastic pipes however the study was instigated as the researchers recognized that: *"...there is still a lack of understanding of the performance of PE and PVC pipe materials and elastomeric gaskets in hydrocarbon-contaminated soils commonly encountered under field conditions"* (Ong *et al.*, 2008, p. 1).

Types of effects

UKWIR2010 provides guidance for the selection of PE, PVC and metal pipes, therefore these pipe materials will be the focus of the review.

There are no reported effects on barrier pipe (multi-layer PE with aluminum barrier layer) (BP). BP is however required to meet the test method and specification 'Resistance to the permeation of contaminant' set out in WIS 4 32 19; whereby a BP test sample is immersed in petroleum fuel for 72 days following saturation and is to demonstrate that no adverse taste and odour (T&O) or hydrocarbons concentration ($>100\mu\text{g/l}$) in test water sample are encountered. Therefore effects to BP (and subsequent water quality) are highly unlikely in most environmental settings.

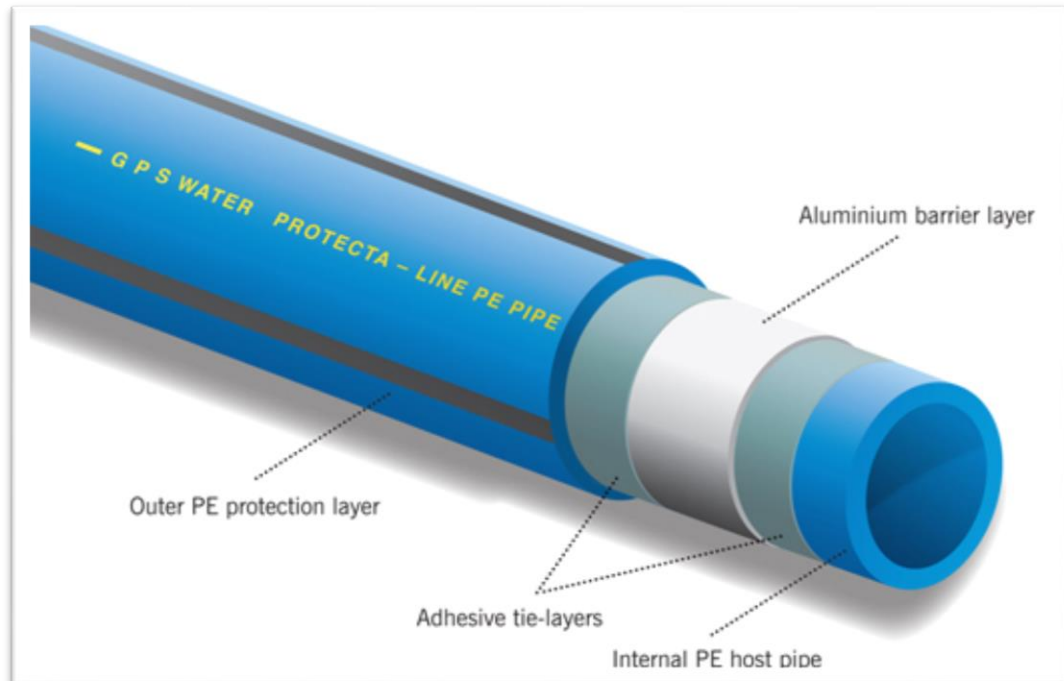


Image source (<http://www.gpsuk.com/range/33/protecta-line.html>) (accessed January 2016)

Plastic pipes:

UKWIR2010 considers three types of effects permeation, swelling and environmental stress cracking (ESC) to PE and PVC pipe materials by organic contaminants. These effects were previously reported on by Crathorne *et al.*(1987). Earlier research by Vonk and Veenendaal (1983), Flogstad *et al.* (1984) and Vonk (1985) recognised permeation and swelling effects.

Permeation is the penetration of a compound through plastic without causing the plastic to fail mechanically (BRE,1994). It is the transport of the contaminant (or compound) from one side the plastic pipe (outer pipe) to the other (inner pipe).

ESC and swelling effects can lead to pipe bursts due to a change in the physical properties and characteristics of the plastic (polymer). Research by Crathorne *et al.*1987 provides the majority of knowledge with regards to mechanical failure of plastic pipes.

Solvation (swelling & dissolution) is when the diffusion of solvent into a polymer results in swelling of the plastic (PE or PVC) (BRE,1994).

ESC (or crazing) is craze/crack growth which is promoted by the combined presence of a surface-active substance and a mechanical stress. Examples of surface-active substances include alcohol, soap and wetting agents, these substances only produce this effect when a stress is present (Crathorne *et al.*1987). It is highlight in the research by Crathorne *et al.*1987 and reported later in technical guidance (BRE,1994 and EA,2000), that the mechanism of ESC is not well understood and that there are no recorded incidents of failure of plastic pipes in the field known to be attributed to ESC.

Polymer characteristics and manufacturing conditions have been observed to have an influence on ESC effects.

Appendix C presents a list of chemicals identified as causing deterioration of plastic (Crathorne *et al.* 1987).

Swelling effects by contaminants is generally discussed, in the research reviewed, in the context of its influence on the mechanism of permeation of PVC pipe materials. Permeation rates through unswollen PVC pipe materials is generally low to negligible (i.e. in the absence of high concentrations of organics which are good solvents or swelling agents for PVC).

Metal pipes:

Corrosion of metal pipe materials is considered the principal risk to metal pipes by UKWIR2010. Metal (such as steel, ductile iron and copper) pipes are considered impermeable to organic compounds and expected to form an effective barrier to permeation (Crathorne *et al.*, 1987).

Contaminants of concern

Contaminants known to cause an effect of PE and PVC are available through the research by Crathorne *et al.*1987 and are presented as Figure 6, Figure 7 and Appendix C. The information can be used to identify risk by contaminant type but does not indicate the effects of concentrations (Bromhead, 1997).

Compounds causing excessive swelling	Compounds causing swelling but to a lesser extent	Compounds which have no or little effect
Chlorinated hydrocarbons*	Benzene	Alcohols
Ketones (particularly low molecular weight compounds such as acetone, methyl ethyl ketone, etc)	Toluene	Aliphatic and alicyclic hydrocarbons
Nitrobenzene	Alkyl benzenes	<i>Solid</i> halogenated benzenes
Aniline		
Esters (for example methyl, ethyl acetate)		

* PVC appears to be more resistant to perchlorinated compounds such as tetrachloroethylene and carbon tetrachloride, and also to compounds containing a trisubstituted carbon atom, for example 1,1,1-trichloroethane.

Figure 6 Organic compounds that cause PVC to swell (Crathorne et al. 1987 reproduced by EA,2000)

Organic compounds in the first column (Figure 7) cause PVC to swell and eventually dissolve (Vonk, 1985). Contaminants identified in the third column (Figure 7) do not cause PVC to soften and therefore do not permeate PVC (EA, 2000). Contaminants identified to cause swelling effects of PE (specifically HDPE) are presented in Appendix C.

Compounds that readily permeate PE	Compounds that permeate PE but relatively slowly	Compounds that do not permeate PE
Benzene	Hexane	Atrazine
Toluene	Octane	Malathion
Xylene	2, 2, 4-Trimethylpentane	Paraquat
Ethylbenzene	Pentachlorobenzene	
Trimethylbenzene	Di-isopropylether	
Propylbenzene	Methyl ethyl ketone	
Chlorobenzene	Ethanol	
Di-, tri-chlorobenzene	Methanol	
Chlorotoluene	Hexanol	
Dichloromethane	Nitrobenzene	
Tetrachloromethane	Chloroanilines	
Trichloroethylene	Aniline	
Tetrachloroethylene	Nitroaniline	
Dichloroethane	Phenol	
Trichloroethane	Chlorophenols	
Tetrachloroethane	Di, tri-chlorophenols	
Dichloropropane	Pentachlorophenol	
Methyl bromide	Pentane	
	Cyclohexane	

Figure 7 Organic compounds that permeate PE (Crathorne et al. 1987 reproduced by EA,2000)

Experimental work has shown that PE is essentially impermeable to compounds of high polarity (EA,2000). PE is readily permeated by compounds of low molecular weight such as benzene, toluene, and tetrachlorethane (Vonk, 1985) but to a lesser extent by more polar compounds such as phenols, aliphatic alcohols and ketones (BRE,1994).

Theory and factors affecting the effects by contaminants

Through the review of literature, and in some cases experiment work, past researchers have identified theoretical mechanisms behind the effects by contaminants on plastic pipe materials and in most instances are in agreement

on the science. Many factors have also been identified which have an influence on the rate of such effects.

The permeation of organic contaminants through plastic pipes is outlined by Vonk and Veenendaal (1983) [and outlined by later researches] to proceed in three phases.

1. Partitioning between ground water or soil-gas and the outer surface of the polymer (pipe)
2. Diffusion of the contaminant through polymer (wall of the pipe)
3. Partitioning of the contaminant between the inner surface of the polymer (pipe) and the water in the pipe.

Both partitioning effects proceed according to Henry's Law. The law of Fick can be used to describe the diffusion phase (Ong *et al.* 2008).

Permeation is therefore not only governed by diffusion but also by how soluble the contaminant is in the polymer (plastic). The following relationship has been described by Crathorne *et al.* 1987:

$$P = DK$$

Where P = permeability coefficient ($\text{m}^2 \text{ day}^{-1}$)

D = diffusion coefficient ($\text{m}^2 \text{ day}^{-1}$)

K = partition coefficient i.e. the equilibrium concentration of the compound in the polymer divided by the concentration outside the polymer" (Crathorne *et al.* 1987, p. 41)

Diffusion coefficient is determined by the rigidity of the polymer chains and the structure of the contaminant. Partition coefficient is determined by the degree of similarity between the contaminant and polymer and is generally greater for compounds of similar polarity to the polymer. In the experimental investigation into permeation, the determination of the constant of Henry's Law and Fick's Law stands at the centre. The partition coefficient and the diffusion coefficient

can be used to calculate the permeability coefficient (Vonk and Veenendaal, 1983)

Different diffusion methods occur in PE and PVC because of fundamental differences in their polymer structures. PVC is an amorphous glassy polymer with very little flexibility of the polymer chain. In contrast PE *"should be considered as a partially crystalline rubberpolymer"* (Vonk and Veenendaal, 1983, p. 64).

Fickian diffusion occurs in both PE and PVC however diffusion coefficients calculated in past experimental research suggests PVC should resist permeation for centuries (Ong *et al.* 2008)

Case-II Transport is demonstrated as the dominant mechanism for organic contaminants that are not inert to the polymer (i.e. permeation by means of softening or swelling of the polymer structure). Vonk and Veenendaal (1983) present the Case-II Transport theory and the moving-front process (zone of swelling progressing through pipe wall) to explain the transport behaviour of organic contaminants in PVC and other glassy polymer matrix interactions.

More recent research by Ong *et al.* 2008 aimed to advance current understanding of the parameters that influence the permeation of plastic pipes under conditions of soil contamination that are typically encountered in the field rather than under test conditions using pure organic compounds in isolation as per earlier research.

The research was not undertaken to demonstrate organic compounds permeate but to predict permeation behavior in real world.

Separate studies were undertaken for PE and PVC pipe materials.

Test conditions to replicate *"subsurface gasoline spills, gasoline-contaminated groundwater and gasoline-contaminated soil with varied levels of contamination"* (Ong *et al.*, 2008, p. 31) were simulated.

The materials used in the PE experimental work included a one-inch (25mm) PE pipe, premium gasoline (benzene, toluene, ethylbenzene and xylene (BTEX)) were to be studied and were roughly 25% by volume of the gasoline) and three types of soil (silica sand, organic topsoil, and sand-topsoil mixture). Variables were controlled, and the surface area of pipe exposed to test conditions calculated (approximately 81.9 cm squared) (Ong *et al.* 2008). Samples were recovered at set intervals and BTEX analysed. Test images are presented as Figure 3.

The data derived was used to estimate diffusion coefficients (D).

–The total mass of contaminant permeating PE pipe (mass/surface area) between sampling periods was estimated based on contaminant concentration in the pipe water, the pipe volume and pipe surface area.

– Using a plot of the cumulative mass permeated per unit area, $Q(\mu\text{g}/\text{cm}^2)$, versus time, the intersect with the time (t) axis of the straight line drawn through the $Q(t)$ at a steady state conditions, is defined as the lag time, T_L . The diffusion coefficient can be estimated using the slope of the permeation curve or by using the lag time method.

The lag time method is an estimation technique based on equation 3.1, which is derived from Fick's diffusion equation. The total quantity of chemical diffusing into a hollow cylinder ($Q(t)$) as a function of time (t), is based on the following assumptions: i) the outer concentration of contaminant remains constant (C_0); ii) the initial concentration of contaminant in the polymer is zero; and iii) the inner concentration is kept zero.

The following equations have been provided by Ong *et al.* 2008 as a method of estimating the diffusion coefficient (Equations 3.1, 3.2, 3.3):

$$\frac{Q(t)}{\pi C_o} = \frac{2(Dt - T_L)}{\ln(a/b)} - 4 \sum_{n=1}^{\infty} \frac{J_o(a\alpha_n)J_o(b\alpha_n)\exp(-D\alpha_n^2 t)}{\alpha_n^2 \{J_o^2(a\alpha_n) - J_o^2(b\alpha_n)\}} \quad (3.1)$$

where a = inner radius (cm)
 b = outer radius (cm)
 D = diffusion coefficient (cm²/s)
 $J_o(x)$ = Bessel function of the first kind of order zero
 α_n = Positive roots of

$$U_o(a\alpha_n) = J_o(a\alpha_n)Y_o(b\alpha_n) - J_o(b\alpha_n)Y_o(a\alpha_n) = 0 \quad (3.2)$$

where $Y_o(x)$ = Bessel function of the second kind of order zero

T_L , the intercept made on the time axis by the asymptote to the plot of the quantity diffused with time, and by setting $Q_t = 0$, equation 3.2 can be simplified to the following equation (Crank, 1975):

$$T_L = \frac{b^2 - a^2 + (a^2 + b^2)\ln(a/b)}{4D\ln(a/b)} \quad (3.3)$$

As suggested by Barrer (1951), this intercept (referred to as the "time lag") provides a means of estimating the diffusion coefficient D of a chemical through a material in the form of a hollow cylinder.

In conclusion the experimental work by Ong *et al.* 2008 demonstrates:

- BTEX rapidly permeate PE pipe, whether in groundwater, in soil pore vapour, or as free product
- Benzene and toluene accounted for the majority of total BTEX that permeated in to water when pipes were exposed to free product or contaminated-water. This may be attributed to the high solubility of benzene in water and the high mass fraction of toluene in the gasoline. At breakthrough, benzene concentration are reported to exceeded or quickly exceeded MCL 5ug/l (note the UKDWS is 1µg/l).

- Breakthrough time and lag time increased with lower BTEX concentration in water, which implies higher bulk contaminant concentration would lead to earlier breakthrough (Figure 9).

See Figure 8 and Figure 9 for the plotted graphs of $Q(\mu\text{g}/\text{cm}^2)$ for the BTEX compounds in PE pipes exposed to pure gasoline and gasoline-contaminated water (at 4 different concentrations).

- Toluene and xylene were the major contributors were pipes were exposed to contaminated-soils in unsaturated conditions (Figure 10). Whilst benzene and ethylbenzene were insignificant. A possible explanation for low permeation of benzene is due to its high soil sorption affinity. Based on this plastic pipes buried in water saturated zone would be more susceptible to benzene permeation than in the vadose(unsaturated) zone.

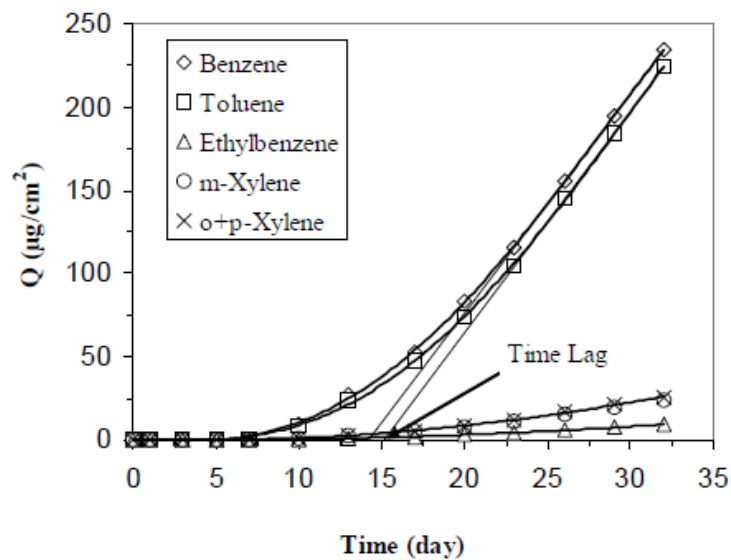


Figure 3.2 Cumulative mass permeated per unit area for BTEX compounds in PE pipe exposed to premium gasoline (Benzene, 19.8 g/L; toluene, 75.9 g/L; ethylbenzene, 14.7 g/L; m-xylene, 33.7 g/L; o+p xylene, 32.5 g/L)

Figure 8 Cumulative mass permeated per unit area for BTEX in PE pipe exposed to pure gasoline (Ong et al. 2008, Figure 3.2)

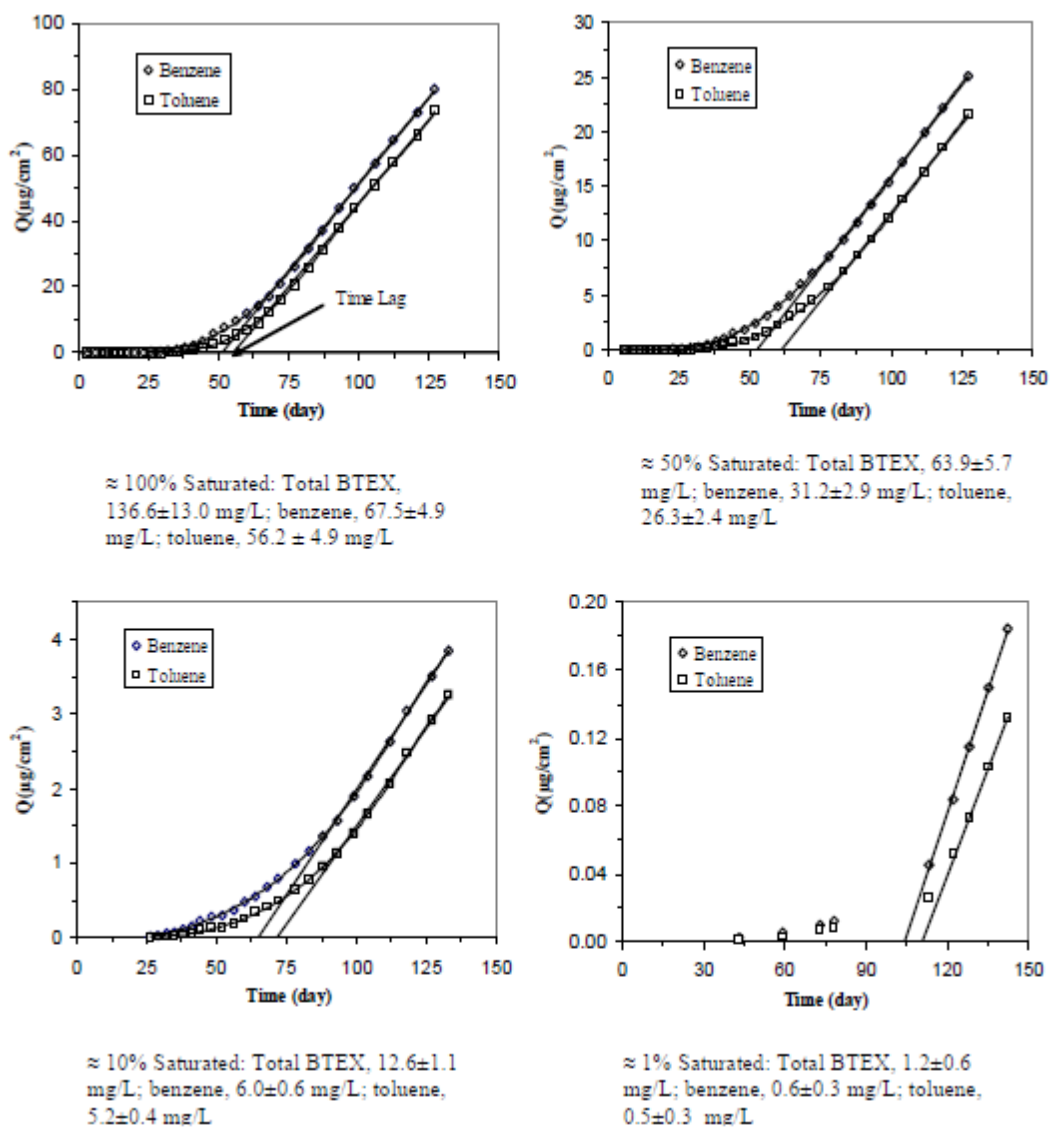


Figure 9 Cumulative mass permeated per unit area for benzene and toluene in PE pipe exposed to gasoline-contaminated water (Ong et al. 2008, Figure 3.2)

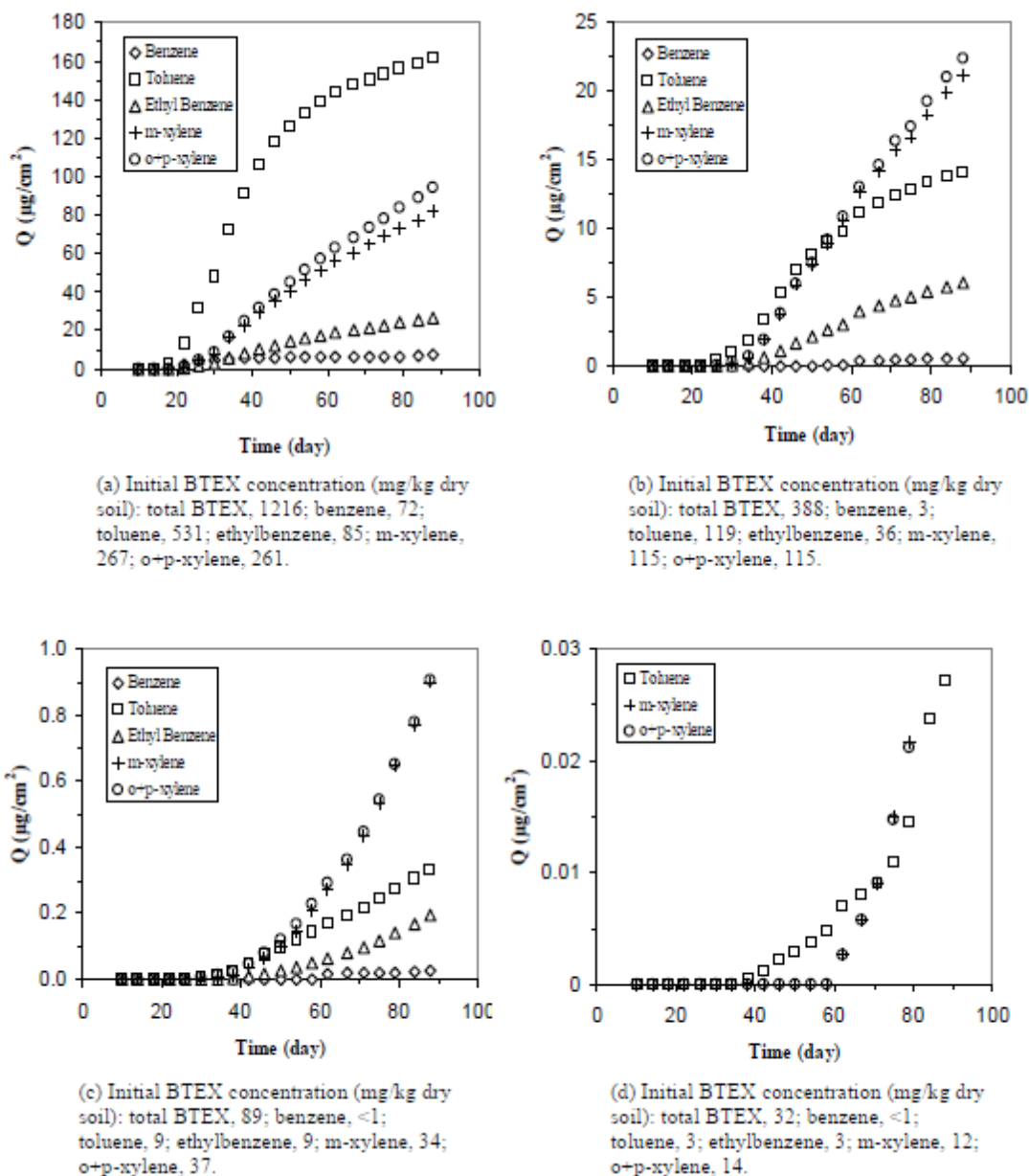


Figure 10 Cumulative mass permeated per unit area for BTEX in PE pipe exposed to gasoline-contaminated soil (Ong et al. 2008, Figure 3.8)

BTEX diffusion coefficients (D) were estimated using the time-lag method (equation 3.3). D were concentrations dependent, with free product calculations greater than that of gasoline-contaminated soils and solutions.

Insignificant difference between the D of benzene and toluene were encountered, which conflict with past data by Joo *et al.* 2004 (see Figure 11). This is considered to be due to synergistic effect of permeation (e.g. Joo *et al.* 2004 used individual compounds and Ong *et al.* 2008 study using a mixture of organics). Synergistic effect of permeation were also demonstrated gasoline-contaminated soils.

Table 3.2
Comparison of diffusion coefficients obtained from this study with previous studies

Organic chemical	Materials	Exposure concentration (mg/L)	Diffusion coefficient ($\times 10^{-9}$ cm ² /s)	References
Toluene	HDPE pipe Wall thickness: 3.1 mm	56.2 $\pm$ 4.9	3.4	This study
		26.3 $\pm$ 2.4	3.0	
		5.2 $\pm$ 0.4	2.6	
		0.5 $\pm$ 0.3	1.8	
Toluene	LDPE pipe Wall thickness: 3.5 mm	91 $\pm$ 16	4.7*	Vonk (1985)
		49 $\pm$ 11	3.9*	
		31 $\pm$ 5	3.9*	
		2.9 $\pm$ 1.3	3.5*	
Toluene	HDPE geomembrane Thickness: 2.0 mm	30	3.3	Joo et al. (2004)
Toluene	HDPE geomembrane Thickness: 0.76 mm	100	5.3	Park et al. (1996)
		50	3.6	
		10	3.2	
Toluene	HDPE geomembrane Thickness: 2.0 mm	2	3.0	Sangam and Rowe (2001)
Benzene	HDPE pipe Wall thickness: 3.1 mm	67.5 $\pm$ 4.9	3.6	This study
		31.2 $\pm$ 2.9	3.5	
		6.0 $\pm$ 0.6	2.9	
		0.6 $\pm$ 0.3	1.8	
Benzene	HDPE geomembrane Thickness: 2.0 mm	30	8.5	Joo et al. (2004)
Benzene	HDPE geomembrane Thickness: 2.0 mm	2	3.5	Sangam and Rowe (2001)

* Calculated on the basis of the permeation data in the reference.

Figure 11 Diffusion coefficients for benzene and toluene/PE pipe exposed to gasoline-contaminated water (Ong et al. 2008, Table 3.2)

Pipe size and wall thickness, stagnation and water flow were also identified as factors which can have an effect on permeation by the experimental work by Ong *et al.* 2008. A series of useful equations have been developed by the research to predict the contaminant concentration in the pipe-water at a given bulk concentration in soil-pore water under different site specific scenarios.

Stagnation

A soil-pore water benzene concentration of 1mg/l was calculated to exceed the test MCL of 5µg/l in an 8 hour stagnations (1-inch PE pipe). Therefore, prevention of potential risk of benzene in drinking water should be a priority, if PE are exposed to gasoline-contaminated groundwater. Conversely Ong *et al.* 2008 suggests an alternative pipe material should be considered for concentration 1mg/l or above.

Pipe size and thickness

Small size pipes are more vulnerable to permeation than larger size pipes. It was calculated that a bulk soil-pore water benzene of 10mg/l (after 8 hours stagnation) would result in exceeding MCL of 5µg/l in supply pipes up to 2-inch (0.3-inch ave. wall thickness) but that would not be expected in pipes of a greater size. It was also observed that water mains with a size of 14-inches (355mm) (1.9-inch ave. wall thickness) or larger would not exceed benzene MCL even at an extreme high bulk concentration of 100mg/l.

The aim of the PVC study by Ong *et al.* 2008 was to investigate the permeation of organic contaminants through PVC pipes in extremely aggressive environments, including neat organic solvents, free product gasoline, saturated organic vapours, as well as conditions which reflect real environments, such as aqueous solutions of solvents and of solutions saturated with gasoline. Benzene, toluene and trichloroethylene (TCE) were selected for study.

One-inch PVC pipe and premium gasoline and benzene, toluene and TCE solvents purchased. Gasoline BTEX fraction were determined by GCMS analysis and were roughly 25% by volume of gasoline. Sand silica was purchased. Pipe-bottle tests were conducted to investigate the aim.

Conclusions:

-PVC were found to be an effective barrier to premium gasoline, and therefore to groundwater and soils saturated with gasoline. An explanation for the resistance to permeation is that the activities of the swelling compounds (BTEX) in the premium gasoline were insufficient to soften the PCV materials (activity of approximately 0.25).

-PVC was however observed to be penetrated when exposed to pure solvents (toluene, benzene and TCE) and their saturated vapours. The study also demonstrated in saturated aqueous-solutions of the test solvents, to permeate PVC when at sufficient activity (activity of >0.60). Activity of a compound is generally used rather than the concentration in the prediction of the susceptibility of pipe material to be permeated (in simple terms a pure solvent or fully saturated solution of the solvent would be assigned an activity of '1'). These findings were also reported by Mao *et al.* (2009).

Further experimental work was undertaken to observe the formation and propagation of a moving front due to the softening of PVC by the test solvents. The procedure and sample of microscopy observation is presented as Figure 4.

Many factors have been identified to influence the mechanisms and rate of permeation and/or material deterioration of plastic pipes. A brief summary of the various factors identified during the literature review are presented in Appendix D, but generally include factors such as pipe size, diameter and pipe wall thickness; environment fate-transport (soil sorption); contaminant type and concentration; water flow/stagnation; plastic (polymer) type or matrix and manufacturing process; and availability of contaminants (i.e. in solid, vapour and aqueous phase and non-aqueous phase liquids (NAPL)).

2.6 2. Critical review of the PSRA process to determine consistency with the model procedures for the management of land contamination (CLR 11 and R&D P66)

2.6.1 Approach to critical review

The approach for investigating and assessing risk to water pipe materials (and subsequent water quality) from ground contamination, and based on the ambitions of UKWIR2010 (and subsequent Water UK protocol), follows a risk-based framework. This is in-line with the overall model procedures for the management of land management presented within CLR11 (EA, 2004) and R&D P66 (NHBC/EA, 2008).

The CLR11 model procedures for the management of land potentially affected by contamination comprises up to three tiers of risk assessment assessment: Preliminary Risk Assessment (PRA, Tier 1), Generic Quantitative Risk Assessment (GQRA, Tier 2) and Detailed Quantitative Risk Assessment (DQRA) (Tier 3). These risk assessment tiers present a structured methodology for assessment of land contamination.

The basic risk management process in the model procedures has three main components: risk assessment; options appraisal; and implementation. In other words, establish if there is a risk and if so what further action needs to be taken; evaluate the most feasible risk mitigation/remediation options; and carry out the remediation and demonstrate it is effective).

R&DP66 is guided by CLR11 model procedures however incorporates some alternative terminology:

Phase 1 Hazard identification and assessment which equates to PRA

Phase 2 Risk Estimation and evaluation which equates to GQRA and DQRA

Phase 3 Remediation; design, implementation and verification which equates to options appraisal and implementation.

Formal land contamination management guidance on the RA for utility services is limited. CLR11 refers to technical guidance documents outlined in section 2.5, these guidance documents however refer to WI guidance or research in the guidance they provide for assessing risk. Due to the date of publication of the model procedures and technical guidance reference is not made to the current UKWIR2010/Water UK.

With the above in mind, a critical review of the UKWIR2010/Water UK protocol aligned with model procedures has been undertaken. The structure of this appraisal has been guided by the CLR11 technical guidance (EA,2004) and the R&D P66 (NHBC/EA,2008). This is to determine if the desired risk-based approach to the assessment of risk to water pipes and subsequent pipe selection process is achieved by the procedures of UKWIR2010/Water UK protocol.

2.6.2 Hazard Identification and Assessment

UKWIR2010 recognises a phased approach to the assessment of a site and therefore to the selection of appropriate water pipe materials.

UKWIR2010 presents a site assessment and requirements flow chart (Figure 2.1), an extract of which is presented as Figure 12. Figure 12 has been annotated to identify activities associated with hazard identification and assessment (phase 1) and risk estimation and evaluation (phase 2) RA phases.

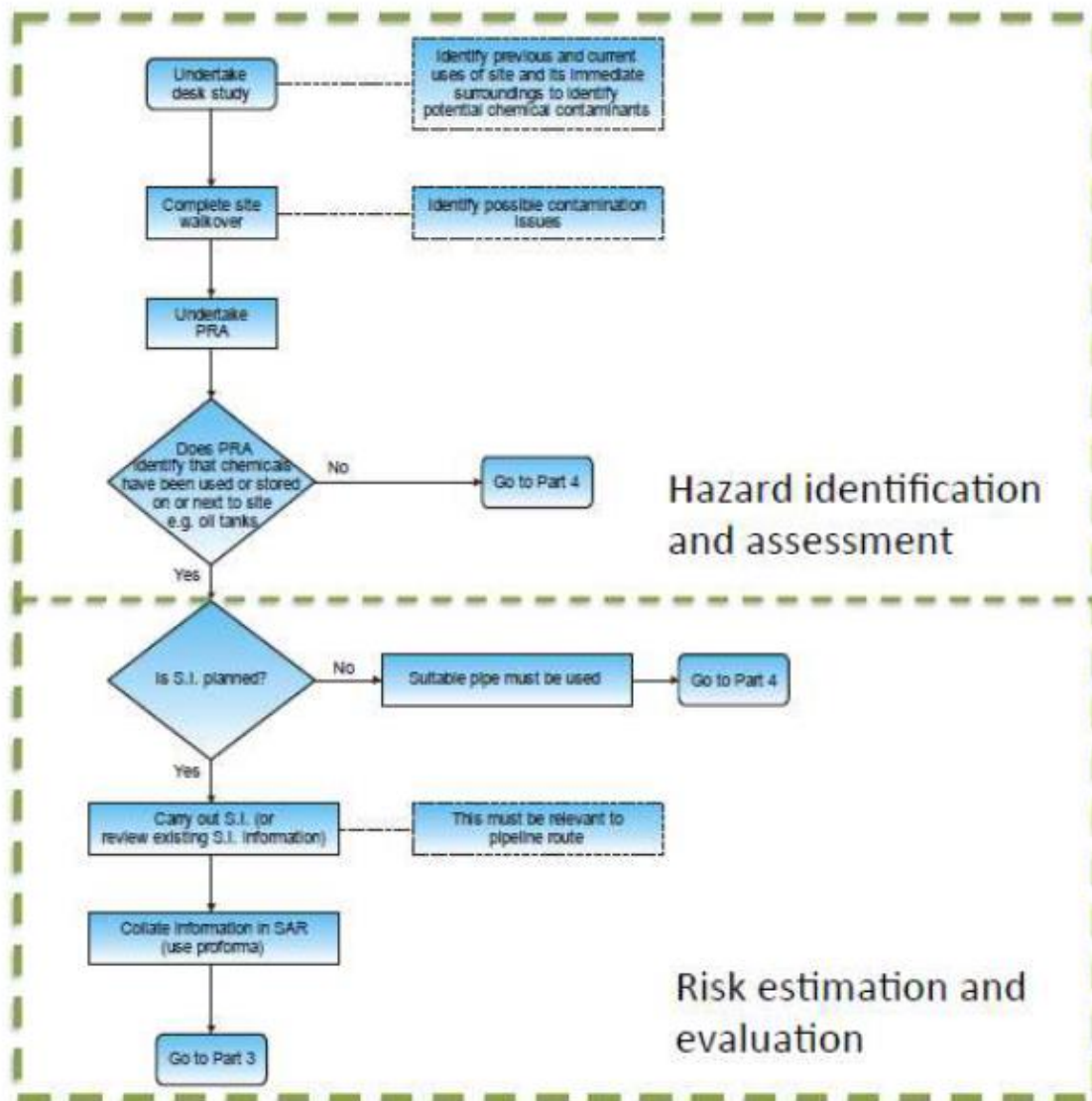


Figure 12 Annotated extract from the UKWIR2010: Site Assessment Process and Requirements Figure (UKWIR 2010 – Figure 2.1) (Blackmore *et al.* 2010)

The requirement to undertake a desk study, site walkover and PRA are outlined as the first stages of a site assessment by UKWIR2010.

UKWIR2010 and earlier WI guidance (outlined in section 2.4) recognise the importance of identifying the historical/current use of a site, to establish potential sources of contaminants of concern (CoC) to pipe materials. Section 1 and 2 of the Water UK protocol allows for this information to be captured (Appendix B).

Interesting however UKWIR2010 describes the PRA as a means of "*identifying the need for a site investigation*" (Blackmore *et al.* 2010, p.10). UKWIR2010 fails to recognise the primary purpose of the PRA as described by the CLR11 technical guidance "*to develop an initial conceptual model of the site and to establish whether or not there are potentially unacceptable risks*" (EA 2004, p. 16).

The definition of a conceptual model as described in the CLR11 is as follows:

"A conceptual model represents the characteristics of the site in a diagrammatic or written form that shows the possible relationships between contaminants, pathways and receptors.

The term pollutant linkage is used to describe a particular combination of contaminant-pathway-receptor" (EA,2004, p. 14).

For a risk to be realised all three elements (a source, a pathway and a receptor) must exist (i.e. if the contaminant source has the potential to affect a receptor via a particular pathway then there is a potential risk).

This omission appears to have been captured by the Water UK protocol which states that the application of the S-P-R concept will be an integral part of any pipeline RA. Water UK goes on to identify the three pathways by which contamination may come in contact with water pipes – direct contact with soil/backfill; an excessive vapour phase or a contaminated-groundwater regime.

Error! Reference source not found. Figure 13 and Figure 14 present generic CSM's that illustrate potential pollutant linkages relevant to plastic pipe materials.

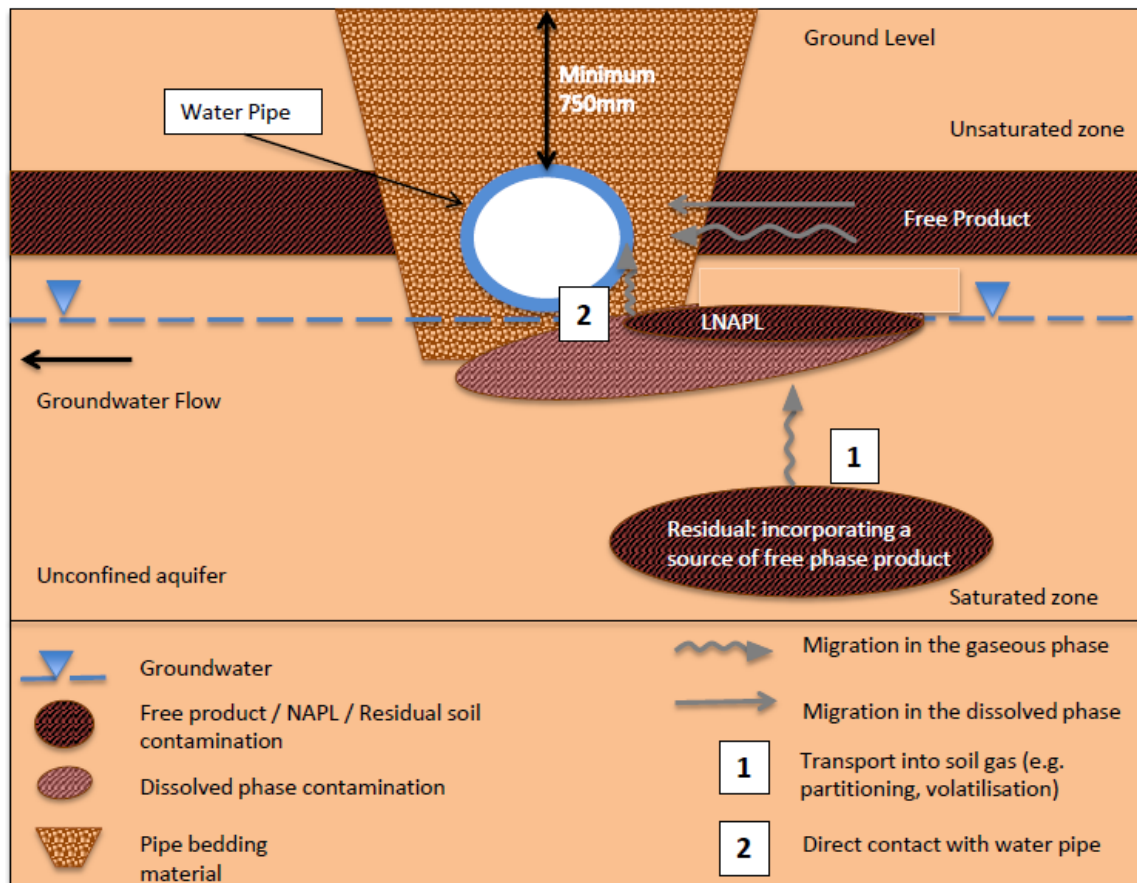


Figure 13 CSM to illustrate potential contaminant linkages relevant to plastic water pipe receptor with a high groundwater level

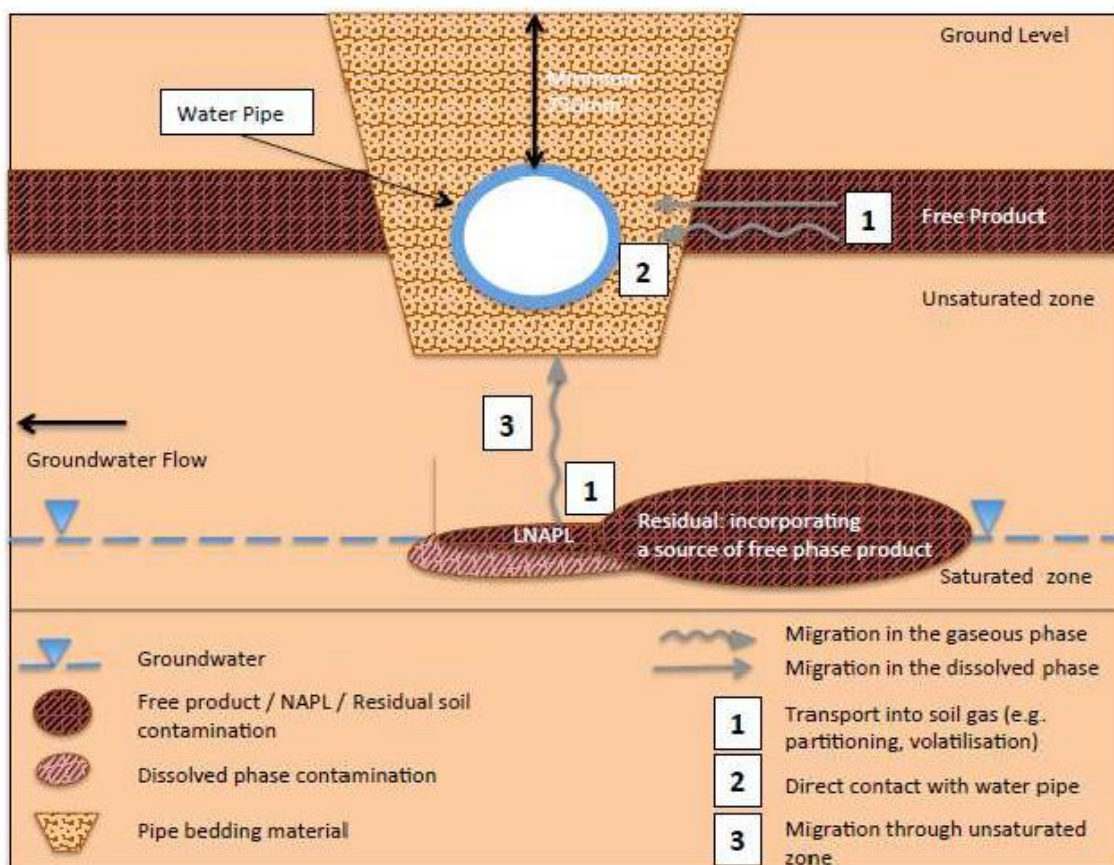


Figure 14 CSM to illustrate potential contaminant linkages relevant to plastic water pipe receptor with a low groundwater level

Figure 13 and Figure 14 illustrate scenarios that may be encountered when undertaking a PSRA. The figure represents a variety of source media (soils, soil-gas, groundwater and NAPL), varying depths to groundwater and potential migration pathways from source through the subsurface to the plastic pipe receptor. The term soil-gas refers to gases in the subsurface, this definition has taken from the *CIRIA C682: The VOC Handbook publication* (Baker et al. 2009).

Potential risks to other pipe materials (i.e. metal pipes) would differ and would be associated with the direct contact of CoC, within various source media (soils, groundwater and NAPL), with pipe materials.

The physical and chemical properties of a contaminant and the ground conditions, such as physical properties of subsurface source media, site geology and/or hydrogeology can have an effect both on the presence and migration of organic compounds (Baker et al. 2009) and therefore needs to be considered during phase 1.

UKWIR2010 only briefly touches on desk-based information that may be relevant to determining potential contaminant migration pathways, with reference to the provision by the developer of *"a separate site map which identifies the proposed topography and presence of groundwater beneath the site and any special features, to include surface water courses and boreholes or soakaways"* (Blackmore et al. 2010, p. 9). An example of desk-based site plans required by the guidance are included in Appendix A – UKWIR2010 Example SAR.

The Water UK protocol requests information relating to groundwater levels at a site in section 3, which relates to information gathered during ground investigation (GI) (Appendix B).

Consideration of the CSM can also help the risk assessor to decide what further action, if any, is appropriate (EA, 2004). This may include, determining there is not a potential risk; identifying data gaps and uncertainties needed to further inform the PRA or to set the objectives for GI and/or more detailed assessment; or it may determine that some form of remedial action is needed (EA, 2004). The CSM is a good communication tool which allows views about the likely risk profile of a site or development. It would appear that the UKWIR2010 SAR / Water UK protocol were developed as a tool to communicate information that will inform the CSM for a new water connection to the WC.

Following the UKWIR2010 site assessment process (presented in Figure 12), to decide whether further site investigation is required or to select a suitable water pipe material the follow decision question is asked:

"Does the PRA identify that chemicals have been used or stored on or next to the site e.g. oil tanks?" (Blackmore et al. 2010, p. 7, Figure 2.1)

A more appropriate decision question, with reference to CLR11 may be:

"Are there potentially unacceptable risks [to proposed pipe material]?" (EA, 2004, p. 17, Figure 2A); or alternatively

Has the preliminary CSM identified possible pollutant (contaminant) linkages (e.g. are direct contact or gaseous/dissolved phase pathways potentially active)?

This question would prompt the risk assessor to consider whether a potential pathway between source (contaminant) and receptor (water pipe) exists, or may exist in the future linking the two, thus allowing the assessor to discount the need for GI or further assessment at an early stage. Within section 2–PRA, of the Water UK protocol, there is the opportunity for the assessor to provide rationale behind intended pipe selection in the absence of GI, in the instance that a contaminative land-use has been identified during the PRA. This approach is consistent with the requirements of CLR11 and R&DP60.

UKWIR2010 considers the following, further action scenarios:

1. No further assessment required, where there is no existing or historical evidence of chemicals on or next to site;
2. Undertake an intrusive GI, where there is evidence that chemicals may have been used or stored on or next to the site; or
3. Select *"suitably specified pipe resistant to permeation and/or chemical attack"* (Blackmore et al. 2010, p.11), where there is evidence that chemicals may have been used or stored, on or next to the site, but no further site investigation is to be carried out. The authors have provided the following example of when this scenario may occur: *"due to the limited extent of the pipeline across brownfield land"* (Blackmore et al. 2010, p.11).

Point 3 could be considered not to be a risk-based approach and to encourage the blanket use of more resistant pipe materials (e.g. barrier pipe (BP) or metal pipe) instead of undertaking GI to demonstrate the lower specification pipes (such as PE) in suitable. This would have a negative impact on future maintenance costs and also negate the need for this WI guidance.

2.6.3 Risk Estimation and Evaluation

Design and Implement Ground Investigation

Investigating contaminant linkages relevant to a water pipe receptor will be an aspect of the overall GI for a development. In practice the GI objectives will be set based on the CSM for the development as a whole. Thus possibly considering contaminant linkages relevant to a range of receptors including human health and other environmental receptors (e.g. controlled waters, property, flora and fauna).

Assessment of risk to property receptors is generally focused around assessing risks to building foundations. With underground services (service routes and bedding material) considered as contaminant preferential pathways rather than receptors. This is demonstrated in later case studies presented in Chapter 6.

UKWIR2010 attempts to provide specific guidance on GI design with the objective to *"obtain representative samples for testing to identify the presence of contamination that could be detrimental to the integrity of the pipe or permeate the pipe and lead to water that is unfit for human consumption"* (Blackmore et al. 2010, p. 11).

The guidance for soil sampling (including sampling locations, depth and frequency) is somewhat confused and impractical, however the reader is referred to BS 10175:2001 (now 2011) for more detailed information. The Water UK protocol, attempts to simplify the sampling and testing requirements as follows:

– *"Samples taken and tested must represent both a) the soil in which the water pipe is to be laid and b) the soil down to at least 500mm below the underside*

of the proposed pipe” (Lingard *et al.* 2014). Clarification is also provided on the normal depth a pipe would be laid (i.e. 0.75 and 1.35m from finished ground level).

The Water UK protocol has not carried through the requirement to extend soil sampling to a minimum distance of 15m on each side of the proposed pipeline, which is a requirement that originates from UKWIR2010. The frequency of sampling is also not specified but reference made to industry standards (such as BS 10175:2011 (BSI, 2011) [now 2013] and CLAIRE/CIEH (2008)) and places the responsibility for determining the location and frequency sampling with the ‘qualified competent person directing the land assessment’. This approach is consistent with the model procedures for land contamination management and also the requirement for a competent person also consistent with the approach adopted by other regulatory authorities (such as the local planning authority under the planning regime).

An exploratory borehole to recover a groundwater sample is advised by UKWIR2010 in instances where groundwater or perched water is present within 1 metre of the base of intended pipe trench (or extended to 2m to take account of rising groundwater levels in winter). The reason: “*to check for the presence of contaminants*” (Blackmore *et al.* 2010, p. 12). However, no further guidance is provided beyond this. Groundwater levels are requested by Water UK protocol, there is no section of the protocol that allow the inclusion of data relating to groundwater chemical data.

A mandatory analytical testing suite to be undertaken is presented by UKWIR2010 (Figure 15). The testing suite is stated to be restricted to contaminants that may permeate or have an impact on pipe material integrity. An extended list of CoC which can impact on the performance of pipe has been identified by UKWIR2010, and analysis required were desk-study points to their potential presence. This however, should be the case for all CoC identified not just the extended suite.

Water UK protocol provides slightly updated Test Groups (Figure 16). The reason for this update was to align with analysis available by commercial

laboratory. It also provides the opportunity for the risk assessor to provide rationale behind the exclusion of test groups (both basic mandatory and extended test groups), thus recognising that only CoC identified during the PRA would be required.

The materials tested should be representative of the materials in which the pipe will be laid whether that be existing ground material, remediated materials or imported materials. This requirements of UKWIR2010/Water UK further demonstrates the aspiration of a phased approach to PSRA.

Quantitative Risk Estimation

UKWIR2010 provides a set of pipe material selection threshold values. Threshold values have been derived for each material (PE and PVC) and chemical groups. The thresholds and chemical groups are indicated on Figure 15. Water UK's updated version is presented as Figure 16, but ultimately continues to adopt thresholds derived by UKWIR2010. Note Water UK national guidance only reports on PE thresholds, as stated previously the Water UK protocol was first developed by UU and this WC does not accept the use of PVC material on its network as it can be susceptible to physical damage during installation and maintenance. This may result in water companies, who use PVC materials, to not adopt the Water UK protocol.

There are no restrictions on the use of BP with reference to the recommendations for UKWIR2010 and corrosion effects are a consideration for metal pipes.

		Pipe material					
		All threshold concentrations are in mg/kg					
	Parameter group	PE	PVC	Barrier pipe (PE-Al-PE)	Wrapped Steel	Wrapped Ductile Iron	Copper
1	Extended VOC suite by purge and trap or head space and GC-MS with TIC	0.5	0.125	Pass	Pass	Pass	Pass
1a	+ BTEX + MTBE	0.1	0.03	Pass	Pass	Pass	Pass
2	SVOCs TIC by purge and trap or head space and GC-MS with TIC (aliphatic and aromatic C5 - C10)	2	1.4	Pass	Pass	Pass	Pass
2e	+ Phenols	2	0.4	Pass	Pass	Pass	Pass
2f	+ Cresols and chlorinated phenols	2	0.04	Pass	Pass	Pass	Pass
3	Mineral oil C11-C20	10	Pass	Pass	Pass	Pass	Pass
4	Mineral oil C21-C40	500	Pass	Pass	Pass	Pass	Pass
5	Corrosive (Conductivity, Redox and pH)	Pass	Pass	Pass	Corrosive if pH < 7 and conductivity > 400µS/cm	Corrosive if pH < 5, Eh not neutral and conductivity > 400µS/cm	Corrosive if pH < 5 or > 8 and Eh positive
Specific suite identified as relevant following Site Investigation							
2a	Ethers	0.5	1	Pass	Pass	Pass	Pass
2b	Nitrobenzene	0.5	0.4	Pass	Pass	Pass	Pass
2c	Ketones	0.5	0.02	Pass	Pass	Pass	Pass
2d	Aldehydes	0.5	0.02	Pass	Pass	Pass	Pass
6	Amines	Fail	Pass	Pass	Pass	Pass	Pass

Figure 15 UKWIR2010 Test Groups and pipe selection threshold concentrations (UKWIR2010, Table 3.1)

1) Testing must be undertaken on the materials within which the pipes are to be laid, whether that be existing ground materials, remediated materials or imported capping materials. Please use the appropriate testing data to complete Table 1 below.

2) If more than one pipe selection is being made, for example, for pipes in different areas of a large site, a completed PSRAS is required for each selection.

What materials have been tested to populate Table 1 below?

☐ Existing ground materials
 ☐ Remediated materials
 ☐ Imported capping materials

All concentrations in mg/kg

Test Group	Testing Required?	PE threshold	Metal Pipes/ Barrier Pipe	Laboratory Detection Limit	Testing UKAS accredited Y/N	Maximum concentration at proposed pipeline depth See Note [2]	Maximum site concentration See Note [3]	Locations and depths where concentrations exceed proposed pipeline threshold
Total VOCs	Where Preliminary Risk Assessment (PRA) has identified land potentially affected by contamination	0.5	Pass					
Total BTEX & MTBE		0.1	Pass					
Total SVOCs (excluding PAHs and those substances marked with an *)		2	Pass					
EC5-EC10 aliphatic and aromatic hydrocarbons		2	Pass					
EC10-EC16 aliphatic and aromatic hydrocarbons		10	Pass					
EC16-EC40 aliphatic and aromatic hydrocarbons		500	Pass					
Phenols* (from SVOC analysis)		2	Pass					
Cresols and chlorinated phenols* (from SVOC analysis)		2	Pass					
Ethers*	Only where identified	0.5	Pass					
Nitrobenzene*		0.5	Pass					
Ketones*		0.5	Pass					
Aldehydes*		0.5	Pass					
Amines		Fail	Pass					
Corrosive	Conductivity, Redox and pH	Pass	See Note [1]					

Note [1] Threshold: For wrapped steel, corrosive if pH<7 and conductivity > 400µS/cm. For wrapped ductile iron corrosive if pH<5, Eh not neutral and conductivity > 400µS/cm. For copper, corrosive if pH<5 or >8 and Eh positive.

Note [2] Water pipes are normally laid at 0.75-1.35m below finished ground level.

Note [3] Also state if liquid free product is present in soil or groundwater.

Figure 16 Water UK Test Groups and pipe selection threshold concentration (Water UK, Table 1)

Various assumptions, considered to be conservative, have been made in the development of these threshold values and an overview is provided in Appendix F of the UKWIR2010 and summarised below. The following has been assumed:

- A linear relationship between the contaminant concentration in external soil (mg/kg) and internal concentration in water supply ($\mu\text{g/l}$);
- A 32mm (diameter) LDPE pipe, with wall thickness of 3.5mm (including an 8 hour water stagnation period (overnight)). This is considered representative of a service pipe; and
- A temperature circa 10 – 15 °C.

The guidance states that three types of effects have been assessed "*permeation, environmental stress cracking (ESC) and swelling*" (Blackmore *et al.* 2010, p.47).

The derived threshold values are based on published laboratory test data and on acceptable drinking water standards (DWS) or taste and odour (T&O) limits.

Although Appendix F of UKWIR2010 provides an overview of assumptions made, in the derivation of the threshold values for PE and PVC pipe materials, it does not provide the physical-chemical properties data of contaminants and/or polymer, or the calculations (or equations) used to derive the values.

UKWIR2010 does not make clear the exposure pathways considered or discuss soil properties but simply state:

"These threshold values have been derived for each material an chemical group using the data available in the published laboratory studies and taking account of acceptable taste and odour limits" (Blackmore *et al.* p. 50); and

"In practice, these studies may not be representative of all site situations and cannot take into account all variations in soil type, backfill materials, and pipe wall thickness. Therefore the UKWIR Project Steering Group has selected a set of threshold values for Table 3.1 [values outlined on Figure 15] which reflects the practical experience of water companies" (Blackmore *et al.* p. 51). The participants of the UKWIR project steering group are discussed in section 2.7.2.

In addition inconsistencies are observed throughout the UKWIR2010 document for example;

- Some of the threshold values presented in Appendix F are not the same as those tabulated in Part 3 (Table 3.1) of the guidance.
- The PVC threshold value for Group 1 VOCs (0.125mg/kg) has been derived based on a T&O detection threshold for Propyzamide (700µg/l). However, propyzamide is recognised as a Group 2 SVOC by the guidance. The use of this T&O threshold is not clearly explained.
- Threshold values are said to be based on a 32mm LDPE, with a wall thickness of 3.5mm. There is no discussion on what has been assumed for PVC pipe material.

The source of the corrosive and conductivity ranges (Group 5), applicable to the assessment of metal pipe materials and to determine the need for metal pipe protection measure, is not provided.

Risk Evaluation

The threshold concentrations, described above, are for comparison with contaminant concentrations of soils and where exceeded represents a contaminant concentration that may compromise pipe material integrity.

This is a fairly practical approach and consistent with the approach used to determine potentially unacceptable risks to other receptors (EA, 2004).

In relation to risks to human health or the environment, risk estimation often involves comparing contaminant concentrations of soils or other media with numerical assessment criteria that, in the context of human health, represent an acceptably 'minimal or low' risk (EA, 2001). Criteria may be generic (i.e. SGV, GAC, C4SL, S4UL) or may be site specific (EA, 2001).

However, the lack of transparency of how the UKWIR2010 generic pipe material selection criteria were derived or what exposure pathways are considered, does not allow the risk assessor to consider the appropriateness of the generic pipe material selection criteria in the context of the development or allow for more detailed quantitative RA. For example, it prevents the consideration of site-specific information, such as individual contaminants properties, specific media, distance of contaminant source to receptor; or development-specific information, such as pipe size (< or >32mm), pipe material type (HDPE, MDPE etc.) or pipe-laying design (backfill material properties, lined trench, trench drainage etc.) in the assessment of risk.

Where an exceedance of the generic pipe material selection criteria for PE and PVC pipe material is encountered, the lack of transparency of how values were derived may also hinder the development of appropriate risk management objectives, restrict feasible remediation/risk management options to less cost effective solutions or result in unnecessary remediation. For example, resulting in the unnecessary use of BP material or metal pipes; the re-routing of the proposed pipe; the use of an impermeable liner or import of clean (suitable for use) pipe bedding; or the complete removal of a contaminant source.

2.6.3.1 Risk Management / Remediation; design, implementation and verification

The focus of the UKWIR2010 is to identify pipe materials that are suitable for use in land affected by contamination. Therefore, the approach to manage unacceptable risks to water pipe materials (and subsequently drinking water quality) is limited to the evaluation and selection of pipe materials.

UKWIR2010 considers BP to provide sufficient protection in all sites affected by contamination. In the case of metal pipes additional protection can be selected (such as PE sleeving and tape wrapping), based on soil contaminant concentrations encountered.

There are no alternative mitigation measures or guidance on implementation or verification provided by UKWIR2010.

The Water UK protocol requests the following protective measures to be provided, where PE or metal pipes are proposed by the developer, and where soil contaminant concentrations are identified above pipe selection threshold values:

- a) a robust risk assessment to show how any contaminants will not significantly impact on proposed water supplies or buried assets over the lifetime of the assets; or
- b) more suitable pipe materials; or
- c) an engineering solution to protect the pipe work backed up by an adequate assessment of the risk.

Liquid free phase product (e.g. oil or free solvent layers) shall not remain in the ground or groundwater in the vicinity of water pipes, whether barrier pipe or any other pipe materials are used.

The Water UK protocol does not however provide guidance on how the 'robust risk assessment' shall be undertaken or how the 'engineered solution' shall be design, assessed and validated to demonstrate water pipe supplies are sufficient protected.

This additional guidance by Water UK however does prompt the exploration of additional risk mitigation options that allow for a degree of professional judgement in the assessment and management of potential unacceptable risk to pipe materials.

It should be noted here that the Water UK highlights the restriction on the presence of liquid free phase product for all pipe materials. Based this requirement, the developer/SLO would be required to demonstrate the absence liquid free phase product where suspected. How this would be achieved is not explained by the protocol.

2.7 3. Consider the views and opinions on the key limitations of the current WI guidance by stakeholders in the land contamination and construction industry community

To consider the views and opinions on the key limitation of WI guidance a review of recent consultations, articles and position statement has been undertaken.

2.7.1 Association of Geotechnical and Geoenvironmental Specialists (AGS) –Position on Guidance on Water Supply materials for Contaminated Land, dated 9th July 2009.

This position statement was issued prior to the publication of the UKWIR2010 guidance and discusses the issues mainly with the use of the WRAS2002 guidance and pipe selection values. It also touches on the inconsistencies between water company procedures.

The AGS members generally agreed that the WRAS guidance (2002) is inappropriate, out of date and should be withdrawn. However, the AGS members observed that some water companies are still using the WRAS guidance.

It goes on to recommend the "*development of scientifically more rigorous guidance for water companies*" along with a "*complete overhaul of thinking behind the guidance to produce a more complete assessment of the risks in line with a source-pathway-receptor concept*" (AGS, 2009, para 20).

2.7.2 UKWIR 2010 – Q&A updates dated November 2010 and May 2011

Appended to UKWIR2010 are the responses to questions raised following the publication of the guidance. Tabulated questions and responses dated November 2010 and May 2011 are presented. Some of the key questions raised and responses by WRc (the project contractor) are summarised below:

1. *Would it be acceptable to not undertake a site investigation and specify the use of barrier pipes (these seem to be suitable for all conditions)?*

"UKWIR steering group decided that barrier pipes would provide sufficient protection" and that "it is therefore reasonable to expect that water companies will accept the use of barrier pipe in all situations as a blanket approach" (Blackmore et al. 2010, Q&A appendix, p. 1)

2. *The responsibility for the selection of supply pipes is confused in the document between the Developer, SLO and Designer*

The responsibility for producing a SAR and selecting the pipes *"rests with the developer and his sub-contracted expert through a competent organisation"* (Blackmore et al. 2010, Q&A appendix, p. 5). It is the responsibility of the WC to give the final approval (Blackmore et al. 2010).

Numerous questions were raised in regards to the *"imposition of a mandatory analytical suite to be undertaken on all samples"* (Blackmore et al. 2010, Q&A appendix, p. 4) and the costs associated with meeting these mandatory requirements. WRc confirmed, *"the mandatory full screening analytical suite should be undertaken on all samples unless earlier studies confirmed these cannot be present"* (Blackmore et al. 2010, Q&A appendix, p. 4).

WRc states that the overall consultation process for the UKWIR guidance was managed by UKWIR, with a representative from every WC invited to sit on the project steering group and to attend workshops. Noting that not all accepted but there was good representation. In addition, WRc confirm that industry groups (HBF, WRAS, NFB and NHBC) were also invited. It is assumed by this response that representatives from these bodies were not in attendance at the steering group/workshops despite invitation.

2.7.3 Boyd, P and Parry, N (2011) – Contaminated Land: A new document on the selection of water pipes for contaminated

land has been produced, but does it address the failings of its predecessor? – AGS Newsletter Issue 62

UKWIR2010 guidance was criticised in this AGS newsletter in May 2011. The article discusses many of the shortcomings of the UKWIR guidance identified during the critical appraisal (section 2.6) relating to the preparation of a CSM, ambiguous ground investigation guidance and onerous mandatory chemical testing requirements. Additional shortcomings identified by the article are summarised below:

- The authors considered the lack of collaboration or consultation with practitioners in the industry has resulted in the guidance document failing to reflect commonly accepted industry practice.
- The responsibility for the selection of supply pipes and for the production of the SAR is not clear and does not consider the need for land contamination expertise or define a required level of competency. The authors considered it was a *"missed opportunity to give some further recognition to the SiLC [such as a Specialist in Land Condition] qualification"* (Boyd and Parry, 2011, para. 4).

The authors conclude that the *"lack of suitable detail, ignorance of current guidance and unwieldy and expensive approach to chemical analysis has made the process of selecting suitable pipe material almost impossible"* (Boyd and Parry, 2011, para 17).

They also note that the following statement would make the whole document redundant: *"barrier pipes should be used for all brownfield sites"* (Boyd and Parry, 2011, para. 16).

The article recommend that the UKWIR2010 guidance goes through a further period of consultation including commercial laboratories, consultants and industry groups (such as EIC, NHBC and AGS).

2.7.4 UUW & subsequent Water UK / HBF Consultation comments and responses

As discussed in the introduction of this paper, the author was a contributor in the development of the Water UK protocol. The author also participated in a consultation which was held in May 2011 during the initial development the Water UK protocol (the protocol was developed initially 2011 by UU Plc and subsequently adopted by Water UK/HBF in January 2014).

The protocol was developed to address some of the shortcomings of the UKWIR2010 and to assist UU Plc. customers (developers, SLO and their consultants) with water connection requests, for developments in land potentially affected by contamination.

A lack of collaboration with industry was identified by Boyd and Parry (2011). To overcome this shortcoming; to gain an insight into development industry stakeholders shared goals; and to gain general feedback on the protocol, an open consultation was held.

A range of stakeholders from various industry groups raised consultation questions. These included SLOs, developers, consultants, AGS and HBF. The author and contributors of the Water UK protocol provided the responses to the consultation comments and made amendments to the protocol where considered appropriate.

In general, comments were received relating to the requirement of a competent person, sampling and testing requirements and the exclusion of greenfield sites potentially affected by contamination by the consultation protocol.

The follow definition of a competent person is provided by the protocol: "*The competent person to be a) a chartered member of an appropriate professional body (such as the Institute of Civil Engineers, the Geological Society of London or the Royal Institute of Chartered Surveyors) with relevant experience of investigating contaminated sites or b) a Specialist in Land Condition (SiLC) with appropriate geo-environmental experience*" (Lingard et al. 2014, p. 3).

Clarification on the role of the competent person was provided by the authors during the consultation:

- The signatory of the PSRA must ensure that all assessments of land have been carried out in accordance with applicable current standards and guidelines by or under the direction of a suitably qualified competent person.
- This is to promote good practice and high professional standards and is no greater than that required by Local Authorities under PPS23 [now NPPF] for planning purposes.
- Where a PRA highlights the need for a GI it is considered the role of the qualified competent person to determine the location and frequency of sampling.

It was clarified that the protocol is considered equally suitable for application to greenfield sites potentially affected by contamination. Amendments were made in the final protocol to clarify this point.

2.7.5 AGS Position Paper 2014 – Potable water supply pipes in land potentially affected by contamination

A position statement was recently issued by AGS following the publication of the Water UK protocol and is in general agreement with the supporting document stating: *"The document makes some reasonable additions/corrections to the UKWIR guidance"* (AGS, 2014, p. 2).

The position statement provides recommendations for AGS members to follow the Water UK guidance for the process of selecting water pipes for use in land potentially affected by contamination. It recommends *"a justifiable risk assessment (in addition to Pipe Selection Risk Assessment Summary – PSRAS)"* (AGS, 2014, p. 3) alongside the pipe selection threshold criteria should be used to provide an appropriate solution.

AGS propose further work should include: "*an appraisal of the threshold values and issues regarding verification/validation process*" (AGS, 2014 p. 3).

The views identified during the review of consultations, articles and position statement on the WI guidance illustrates the perceived limitations of the UKWIR2010 guidance, but also demonstrates the acknowledgement of the progressive improvement of WI guidance, specifically relating to developments of the Water UK protocol.

It is recognised that many of the perspectives discussed are that of the development industry however nuggets of data on the perspective of the WI can be gauged from the consultation responses by WRc (UKWIR project contractor) and Water UK contributors (which included developer/SLO representatives, WI representatives and land contamination professionals).

It is on the basis of this evidence that consideration was given to the review of WC adopted procedures and to the review of developer/SLO (and their consultants) PSRA (and supporting information) undertaken in accordance with UKWIR2010 and supplementary Water UK protocol.

Chapter 3 Methodology

The following approaches have been adopted to meet the objectives of the research.

1. A review of the procedures of UK water companies for water connection applications, for new developments, on land potentially affected by contamination
2. A review of developer/SLO water connection applications - PSRA and supporting information (e.g. land contamination reports) submitted to a WC for new developments on land potentially affected by contamination
3. Detailed case study reviews

Case study 1 – Critical review of PSRA (and supporting information) for a housing development for a former mill complex (print works and dye & bleaching works) - Old Wool Lane

Case study 2 – Critical review of PSRA (and supporting information) for a housing development for a site historically infilled following clay extraction and formerly occupied by a 'workshop' - Elizabeth Street

Case study 3 – Critical review of PSRA (and supporting information) for a housing development for a former gas works - Rigby Road (East Site and West Site)

3.1 A review of UK water company procedures

Water companies have the responsibility to review and approve developer/SLO water connection design proposals (including pipe material selection, size and construction etc.) for new developments. This is a statutory responsibility of the WC, laid out in the WFR, and is an important role in safeguarding water supplies and pursuing efficient water use but most importantly protecting public health by preventing drinking water contamination

A developer/SLO follows the application procedures of the operating WC relevant to the site area.

In order to establish the current procedures adopted by UK water companies for the selection of water pipe materials to be installed during the development of land that may be affected by contamination, an appraisal of the water connection (including both service connections and main requisition) application procedures and guidance of 23 water companies operating in the UK was undertaken.

Data relevant to land contamination management procedures for pipe material selection, that has been adopted by the each WC, has been identified such as:

- WI guidance adopted for service connections
- WI guidance adopted for main requisition

The objective of the literature review is to gain a picture of how water companies were utilising WI pipe selection guidance documents (See Table 1) and other research.

A WC has many other design parameters to consider, to ensure that pipe materials installed meet the requirements set out in the WFR, such as pipe specification is approved DWI, development scale and sufficiency of supply, pressure testing etc. Ensuring suitable pipe material and fittings associated with the sites ground conditions is only part of the design appraisal by a WC. This paper focuses on PSRA requirements.

3.2 A review of submitted developer/SLO water connection applications - PSRA and Supporting Information

To establish the effectiveness of current WI guidance (UKWIR2010 and Water UK protocol) and the implementation or application of the guidance by water companies and developers/SLO a total of 81 developer water connection

applications that were submitted to a WC between 2011 and 2014 have been manually reviewed. The dataset includes proposed developments on sites identified by the developer/SLO as being affected or potentially affected by contamination. The dataset does not represent all developer/SLO applications submitted to the WC during this time period. The dataset represents developer/SLO application submissions that were referred to land contamination management specialist for technical review by the WC.

Developer/SLO connection applications have been sourced from United Utilities plc. UU Plc. originally developed the Water UK protocol in 2011 and therefore is the first WC to implement the combined use of the UKWIR2010 and Water UK protocol. This sourcing of the data allowed for a larger baseline dataset, over the longest possible duration, and it was considered a timeline of progressive improvements in the application of the protocol could be identified. The Water UK document acts as supplementary guidance to the UKWIR2010 guidance document and provides a protocol template to undertake a PSRA however adopts much of the UKWIR2010 guidance document in principle.

It is noted that it is possible that other water companies may have different experiences in the implementation of the Water UK protocol, however this paper aims to identify limitations and potential improvements to the current WI guidance, which will offer improvements nationally and where relevant.

As discussed in section 2.4, the overall aims of the current WI guidance is to provide guidance to ensure the correct pipe materials are selected for water pipes to be laid in land affected or potentially affected by contamination. With the ultimate goal of preventing drinking water quality issues for consumers.

Benchmarking of PSRA to UKWIR2010/Water UK

To undertake a benchmarking exercise a review of PSRA (Water UK protocol template) and supporting information that were submitted to the WC between 2011 and 2014 has been undertaken. A separate review has been undertaken of WC response to each water connection submissions.

A two-staged review of the applications submitted was undertaken and a database developed to transpose data considered relevant to the objectives.

Stage 1 - review of Risk Assessment for Water Pipes (or PSRA)

A matrix was created that tabulated the 'good practice' requirements set out in the Water UK protocol. Information provided to complete each section of the PSRA was reviewed and recorded in the database. Details relating to the preliminary risk assessment (PRA), intrusive ground investigation works (including groundwater information), risk assessor (including professional qualifications) and pipe selection risk assessment summary (PSRAS) (including test groups tested, recorded PE exceedances, material types tested) for each submission where reviewed and transposed.

Section 1: Site Details	Section 1: Site Details	Section 1: Site Details	Section 1: Site Details	Section 2: PRA	Section 2: PRA	Section 3: GI	Section 3: GI	Section 3: GI
Development Name (proposed end-use)	Development Address / OS Grid Reference	Developer Name	Details of the current and historical use of the site and adjacent land	Is the site potentially affected by contamination? (based on DS and / or site walkover findings)? (Y/N)	Rationale for behind intended pipe design in the absence of GI?	Has an intrusive ground investigation been undertaken? (Y/N)	Date GI was undertaken	Notes
St Marys, Oldham	Oldham I 102790 406370	Drumell Construction		Y	N/A	Y	2006-2009	
Berwyn Grove	St Helens	Helena Partnership		Y		Y	26th October 2009	
Bank Moncrea Street	Bolton	Seddon Construction		Y		Y	26th November 2009	
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Land adjacent to 43-50	Vest Drive, Thirlcliffe, Glossop, SK10 4LY	Mansell Construction	Not specified	Y	N/A	Y	Dec-09	
rainford High Technology College	Hammerby, Task Cottage, Higher Lane, St Helens, Merseyside, WA11 0BB	Education & Learning		Y	N/A	Y	Jun-10	
Avondale Drive	Widnes / SU 486 885	Parmer Construction	None provided	Y	N/A	Y	2006, Feb 2010 and Mar	
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Romans Gate - phase 1	Station Road, Blackrod	Walton Homes	site has a previous record of mining or allotment usage. Investigations have located made ground in the strain bar	Y	N/A	Y	Apr-10	
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Former St Anne's Hospital	Over Down, Altrincham / SU 76357 07	PJ Livesey	Not specified	Y	N/A	Y	05.06.11 - 22.06.11	
Closton Vay	Closton Vay, Ellesmere Port	Andrew Property Investments	Not specified	Y	N/A	Y	Feb-11	

Figure 17 Extract of Stage 1 Database – Water UK protocol (PSRA) details

Stage 2 - review of supporting information

A second database has been developed with the objective of enabling an appreciation of the types of information commonly submitted by developer/SLO to support the PSRA.

The developer/SLO applications were manually reviewed and data extracted including the type of information submitted; and comments on the adequacy of the supporting information to the application (e.g. land contamination reports, ground investigation etc.) and if further information or further work was required by the WC either to fulfil the requirements of UKWIR2010/Water UK protocol or to further inform the RA for water pipes.

Microsoft Excel - PipebackfillContaminatingLog_191215_12.xlsx

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Type a question for help

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	New water connections and main replacement applications - Information database																									
2	Water UK protocol requirements:																									
3	Desk Study (Phase 1) minimum:																									
4	PSRA (Phase 2) minimum:																									
5	Signal cables - suitably qualified person minimum:																									
6	Ground investigation (where non-invasive land use identified):																									
7	Testing (e.g. TPA, SIOC, VCC, BTID, WITDI) or Ground (e.g. CPT, microtunnelling, borehole etc.) or Metal pipe (e.g. pH, conductivity & leak):																									
8	Trench, Quality, BOD, MOP's assessment:																									
9	Sufficiency of Testing - 0.75 to 1.0m from finished ground level to nearest pipe:																									
10	Sufficiency of Testing - boring of soils in which pipe is to be laid (existing ground material, remediated materials, or imported materials):																									
11	Sufficiency of Testing - soil close to at least 100mm below underside of the proposed pipe:																									
12	Sufficiency of Testing - in-situ measured depth of pipe ground conditions between surface level and 1.5m below finished ground level shall be taken as a minimum:																									
13	Sufficiency of Testing - groundwater monitoring and sampling, if required (perched or groundwater with 1m of the intended trench (2m maximum for seasonal effect)):																									
14	Sufficiency of Testing - HD (polypropylene) equipment (surveys pipe route for either side of the proposed pipe route):																									
15	Sufficiency of Testing - CLAP/CLAP (2018) used to justify nature of samples taken:																									
16	Sufficiency of Testing - BS7593, CLM and BS7593 Technical Report PS-BS7593 where used for sampling strategy employed:																									
17	Sufficiency of Testing - validation sampling strategy where remediation has been implemented:																									
18	PSRA (Phase 2) (where non-invasive land use identified):																									
19	People columns indicate an element of Subject Interpretation of submission data																									
20	Blue columns indicate transposed factual information collated from developer / GLD submissions																									

STAGE 2 - Supporting Information Data Sheet

STAGE 2 - Support ST

	Application Number / Site No.	Site	Application Date	Site Plan - (pipe route)	Desk Study (Phase 1) report?	Site walkover details?	Phase 2 report?	Combined Phase 1 and Phase 2 report?	Ground Investigation (factual) report?	Site Plan - Exploratory hole locations	PSRA?	Other reports?	Other information provided	Water Company Final Recommendation	No. of sites
21															
22															
23															
40	10	Griffago Oakley	14.07.18	Y	Y		Y	Y (2)	Y	Y	Y	Y	Estimated Report - Initial assessment report. Remediation statement report. Remediation Verification report.	Further information requested from the developer. Ground data in the central area of the site was considered insufficient.	2
42	10	Beverly Green Gr. Havers	05.07.18	Y			Y (2)	Y	Y	Y	Y	Y	Partial Remediation Strategy document.	BP accepted in the absence of chemical data.	3
43	10	Black Minors	05.07.18	Y			Y	Y	Y	Y	Y	Y	BP accepted in the absence of chemical data.	1	

Working Sheet | Other reports | Development - Former | Development - Proposed | Final count | 4

Ready

19/11

Figure 18 Extract of Stage 2 Database – supporting information and WC comments

Figure 17 and Figure 18 above provide an extract of the collated spreadsheet database. Following the completion of the review stage of the exercise, the data was interrogated as required to identify any common omissions from the protocol, the number of submissions that closely followed the protocol and those that did not. The database count sheets are provided as Appendix F.

Supplementary review

Nine separate questions were posed during the data review stage with the objective of gaining a greater insight into the supporting information to the PSRA and in to the WC comments.

It is not the intension of this research to assess the quality of land contamination assessments or critique individual consultancies but to identify information that reduces uncertainties and further informs the RA for water pipes. With this in mind the following questions where posed and data transposed into the database:

1.Application date

The developer application date was recorded as to provide a timeline for submissions and to enable any time sensitive characteristics of submission to be recorded (e.g. to determine if compliance with the requirements of Water UK protocol improves as the guidance becomes more embedded in the ways of working for both WC and developer/SLO).

2.Types of contaminative land-use

The historical and/or current contaminative land-use of the site (pre-development) and of its surroundings was recorded. This data can be used to determine the types of sites which required more or less attention by the water company. This data can also build a picture of the types of land uses and associated contaminants of concern (CoC) which are most commonly demonstrated to pose a potential risk to pipe materials and/or where protective measures are required. Also to determine if CoC to water pipes and associated to identified land uses have been considered in RA for water pipes.

3.Proposed use

The data was to gain an insight into the proposed development as a whole. An appreciation of the proposed use and layout of the development is required to determine the likely route and depth of proposed water pipe and its proximity

with historical/current contaminative uses and to determine the adequacy of GI and testing (where applicable).

4. Report titles, author, date

This data has been noted for completeness. From this data it may be possible to get a feel for the perceived quality of the supporting information. The data will provide insight in to the developer/SLO, their clients and consultants involved in the development project.

The dates of reports and GI reports submitted have been recorded to provide a time reference from the point of undertaking investigation works and submitting an application to the WC for a connection request.

As previously stated however it is not the intension of this thesis to critique individual consultancies.

5. Types of supporting information

The types of information submitted to support the RA for water pipes has been recorded in the database. The content of the supporting information has been appraised and data considered relevant to the assessment of risk to water pipes extracted. Information types to be considered include, but are not restricted to, pipeline design plans/drawings, land contaminations reports, factual GI report, GI data (including exploratory hole plans, logs and chemical data) or other supporting information (e.g. Envirocheck or Groundsure reports etc.). The phase of investigation submitted shall also be noted and appraised (e.g. Phase 1 desk study/preliminary risk assessment, Phase 2 quantitative risk assessment; remediation strategy or verification report.)

The data can be used to ascertain the complexity of the proposed developments with relation to land contamination, for example where there is the need for a more detailed land contamination RA or remediation for the proposed development for planning purposes, this may warrant more scrutiny by the WC.

This data can be used to interpret whether the Water UK protocol is sufficient in its content to capture all information that is relevant to the assessment of

risk to water pipe materials. It can also be used to interpret whether it is advantageous to a developer/SLO to submitted additional information to that required by the Water UK protocol.

.6.Ground Investigation

Where a GI was undertaken to inform the RA for water pipes this has been reviewed. It has been documented whether groundwater levels and testing was undertaken during the investigation for the site and if this data was considered by the risk assessor.

Reference will be made to the Stage 1 review and WC comments, as required, to determine if the GI data used in the assessment of risk to pipe materials is sufficient to meet the requirements of UKWIK2010/Water UK. Data relating to the type of materials included in the risk assessment (i.e. existing ground material, remediated materials or imported materials) has been considered.

7.Proposed Pipe Material

The water pipe materials intended for use on the proposed development shall be recorded. A record as to whether the Developer/SLO pipe material design was accepted by the WC shall be identified.

The rationale behind the intended pipe selected by the developer/SLO shall be reviewed along with proposals for protective measures.

8.Remediation

Supporting information has been appraised to identify proposals for remediation, which may have been disclosed in Section 4 of the RA for Water Pipes and recorded in the Stage 1 database.

9.Comment from water company

Responses made to the applicant were reviewed, it was noted if the RA for water pipes and supporting information was accepted by the WC, or if more information was required by the WC to meet the requirements of Water UK/UKWIR, other WC policies or to reduce uncertainties & to further inform the

RA for water pipes. The number of submissions by the developer has been recorded in the database.

The following has been recorded if observed:

A simple yes / no category were developed to demonstrate the progress of the application and liaison between the Developer/SLO and the WC. The databases allows for the documentation of specific details.

- Was the RA for water pipes and supporting information, submitted with the application, accepted by the WC? (yes / no)

- Was additional information requested by the WC to support the application / RA? (yes / no)

If yes, what additional information was requested by the WC following the initial developer application?

- Was more information provided by the Developer/SLO following request by WC? (yes/no)

If yes, what information was provided?

If no, how were the uncertainties raised by the WC addressed?

It was noted what pipe material had been proposed by the Developer/SLO and what pipe material required by the WC

The UKWIR2010/Water UK requirements have been considered during the data interrogation stage to determine if the requested information is in additional to the requirements of the WI guidance

This data can be used to identify areas of improvement in the current Water UK protocol to provide clarification on the supporting information commonly required by WC to support the Developer/SLO applications and RA, thus seeking to improve the efficiency of application process and to reduce the number of adverse comments.

Not all of the questions have been included within the results or discussion within this research as a focus has been placed only on information felt appropriate and relevant to the aim of the project. However, full electronic database can be made available upon request (extract is present as Figure 17 and Figure 18) to interpret and interrogate for other purposes in the future or to inform the basis of ongoing benchmarking of report submissions and to encourage performance improvement of water companies and developers/SLO (and their consultants). Database interrogation count sheets have been appended.

3.3 Detailed case study reviews

Following on from the database interrogation exercise which aims to identify common omissions from the protocol and common uncertainties within the RA procedures, three case studies have been undertaken. The latest three submissions recorded in the database were chosen.

The case studies have been reviewed for consistency with the UKWIR2010/Water UK protocol but also a detailed review undertaken of the PSRA and supporting information submitted to the WC.

Each case study is structured to present an overview of the pipe design proposal and RA conclusions by the developer and the final WC decision on pipeline design and specification.

An independent detailed appraisal of the supporting factual information to the developer's PSRA has been undertaken with the overall aim of the appraisal being to develop a CSM of the site to establish whether or not there are potentially any unacceptable risks posed ground contamination to the proposed future water supply pipe material (and subsequently drinking water quality) and to identify areas of uncertainty with respect to the site information provided to inform the CSM. The outcomes of the appraisal are compared to original developer and WC recommendations.

A validation exercise has been undertaken for each case study.

1. A search and review of other publically available sources of information has been drawn on to supplement the case study appraisal. The case studies have been prepared with reference to sources such as:

- British Geological Survey (BGS) website: Geology of Britain Viewer
- Environment Agency website: What's in your backyard?
- Department of Environment (DoE) Industry Profiles
- Local Authority Planning pages - to determine planning status of the development, if planning Conditions relating to land contamination management had been applied or if there was any further information available for the development that had not been submitted in support of the planning permission for the development.

2. WC GIS mapping was reviewed to confirm that the pipe materials installed by the developer is consistent with that requested by WC during application process. WC GIS mapping is updated based on SLO/Developer as-built information upon adoption by WC.

3. Each case study was followed up with an interview with the WC connection engineer to discuss the case and to confirm the validation exercise undertaken.

Chapter 4 Water Company Procedures

It was identified early in the project that it would be beneficial to establish the procedures currently adopted by UK water companies for the selection of water pipe materials, to be installed during the development of land, which may be affected by contamination. Procedures for service connections and new main requisitions have been appraised.

This chapter provides a brief summary of the procedures and guidance developed/adopted by 21 of the larger water companies operating in UK (see Figure 1). The procedures adopted by Scottish Water and NI Water, are also included in the review.

The aim of the web-based literature review was to ascertain whether the current guidance (UKWIR2010/Water UK), historical pipe selection guidance (Table 2) or other guidance/research has been adopted.

4.1 4. Establish the procedures relating to the selection of water pipe material, to be installed on land potentially affected by contamination, adopted by water companies in the UK

Nine of the twenty-three water companies have adopted in principle, the guidance outlined in the UKWIR2010 for service connection applications. Whereas the number increases to twelve for new mains application procedures. The supplementary Water UK protocol has been adopted by three of nine; and by four of the twelve water companies for their service connection and new mains application procedures, respectively.

Four of the twenty-three water companies continue to refer to the procedures and threshold values, of the now withdrawn WRAS2002 for service connection applications. Two water companies out of those four adopt an alternative approach for mains connections. One WC providing its own company specific

RA procedures and set of organic contaminant trigger values (WC no.5) the other requires the use of UKWIR2010/Water UK

Although acknowledging the potential effects to pipe materials laid in 'contaminated' sites, seven of the twenty-three water companies provide no guidance in relation to service pipe material selection practices adopted but simply request soils reports to be submitted as part of the application process, where considered appropriate or where contamination is anticipated. Two of the seven request the developer/SLO to meet the requirements UKWIR2010 guidance for new main applications (WC. No.15 and 17).

Two water companies provide company specific pipe material selection guidance and threshold values for water connection applications. One states their values are based on 'available research data'; the other states the source of their threshold values (threshold values sourced from Wilson and Norris (1992) WRc report to DoE, Crathorne *et al.* 1987, Veenendaal *et al.* 1983). One WC providing its own company specific RA procedures and set of organic contaminant trigger values (WC no.5) for new main application only.

A single WC provides no guidance or requirements relating to land contamination and pipe material selection.

Table 2 and Table 3 provide a summary of the WI guidance adopted by the twenty-three water companies operating in the UK for service connection and new main applications, respectively. WC procedures datasheet is presented as Appendix E.

Table 2 Summary of WI guidance adopted UK water companies for the selection of pipe materials to be used on potentially contaminated sites – Service Connections applications (pipe size generally 25 – 32mm)

WC No.	WI Guidance
4 14 20	UKWIR2010 & Water UK protocol
1 2 12 21 22 23	UKWIR2010
5 10 11 18	WRAS 2002
6	Other 1 – company specific procedures & pipe selection threshold values (source of values provided)
19	Other 2 – company specific procedures & pipe selection threshold values (source of values not provided)
7 8 9 13 15 16 17	Other 3– none or limited guidance, implications of ground contamination recognized, no reference to WI guidance/thresholds adopted.
3	No guidance

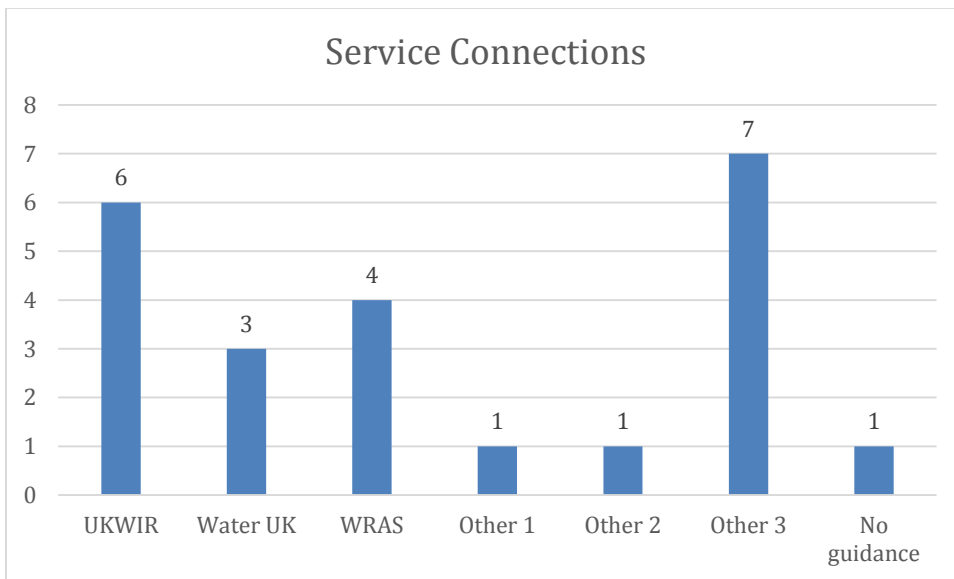


Figure 19 WI guidance adopted by UK water companies for the selection of pipe materials for service connections

Table 3 Summary of WI guidance adopted UK water companies for the selection of pipe materials to be used on potentially contaminated sites – New main supply applications (pipe size generally > 32mm)

WC No.	WI Guidance
4 11 14 20	UKWIR2010 & Water UK protocol
1 2 12 15 17 21 22 23	UKWIR2010
10 18	WRAS 2002
6	Other 1 – company specific procedures & pipe selection threshold values (source of values provided)
5 19	Other 2 – company specific procedures & pipe selection threshold values (source of values not provided)
7 8 9 13 16	Other 3– none or limited guidance, implications of ground contamination recognized, no reference to WI guidance/thresholds adopted.
3	No guidance

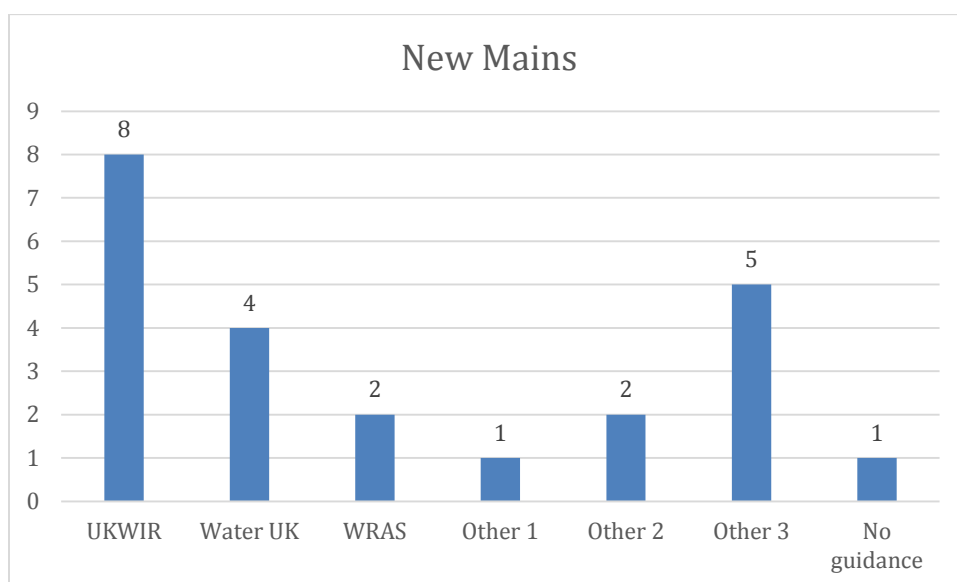


Figure 20 WI guidance adopted by UK water companies for the selection of pipe materials for new mains connections

The majority of water companies adopt a consistent approach for the selection of service pipes and mains pipes however, 17% of water companies (4 out of 23) differ in their approach. Out of the 4 that differ in their approach 3 requested the use of UKWIR2010 (1 included the use of Water UK) for new

mains whereas either provided limited guidance for service connection (i.e. simply requested the submission of soils report) (x2) or referred to the use of WRAS2002 (x1). 1 of the 4 water companies had developed company specific pipe selection procedure for contaminated sites (WC no.5) for new mains however continued to request the use of WRAS2002 for service connections.

With reference to section 2.4 the data demonstrates that UKWIR2004 guidance does not appear to have been adopted for use by any of the 23 water companies thus therefore resulting in the continued use of WRAS2002. WRAS2002 has continued to be adopted as best practice by 18% and 9% of water companies for service connection and new mains requests, respectively. This is despite its withdrawal in 2010.

The reason for the greater use of the WRAS2002 for service connection procedures cannot be explain by the data however it is likely that these water companies have neglected to update their pipe material selection process for service connections. As identified in section 2.3 the WC take over responsibility of mains/communication infrastructure (will adopt) and so are more likely to develop their processes to ensure that suitable pipe materials (based on ground conditions, maintenance needs and network) are installed by the developer's SLO. Also WC in some circumstances will undertake the design/installation of mains infrastructure (rather than the SLO) and therefore likely to ensure processes are up to date for this reason.

The guidance provided by UKWIR2010 for the selection of mains pipe materials is followed by 52% of water companies. With less than 20% of the water companies also adopting the combined use of UKWIR2010/Water UK protocol to guide the selection of water pipe materials. It should be noted however that the WC review was undertaken in June 2014 therefore only 5 months following the publication of the Water UK guidance and therefore may be the reason why few have adopted the Water UK protocol. The uptake of the use of the current guidance for service connection procedures is slightly less at 39%.

A fairly substantial proportion (31% (service connection) and 22% (new mains)) of water companies, although recognising the effects by contamination to pipe material, provided limited guidance or failed to provide reference to WI

guidance that they adopt for PSRA (presented as 'Other 3' on Figure 19 and 20).. In these cases the WC general request the developer/SLO to submit 'soils reports' with their application. This may be an acceptable approach taken by a WC where they undertake their own assessment of materials suitability for the infrastructure they will adopt and therefore be responsible for in the future (i.e. for new mains). However, in the case of supply pipe selection, which remain the responsibility of the developer (and subsequently the future property owner), this lack of transparency by the WC for how they determine materials to be connected the distribution network, to be suitable, may not be considered a reasonable approach by the WC. In the majority of these cases however, for service connections (4 out of the total 7 WC's), the WC appear to simply state that where the developer suspects contamination that BP or other suitable metal pipe metal should be used.

The data demonstrates the observations made by AGS (section 2.7) that there is an inconsistent approach by UK water companies for the selection of pipe material to be installed in land potentially affected by contamination.

The next chapter aims to critically evaluate the implementation of the WI guidance (UKWIR2010/Water UK) by developers/ SLO and by a WC.

Chapter 5 Implementation of Water Industry guidance

5.1 5. Critically evaluate developer/SLO RA for water pipes and RA supporting information (supporting information to a water connection application) submitted to a WC, by benchmarking for compliance with the requirements set out in the UKWIR 2010 and Water UK protocol and to establish a database. Water company recommendations shall also be documented.

The database of 81 water connection applications for developments on land affected or potentially affected by contamination, forms the cornerstone of this thesis and is critical to the identified objectives. When assessing the results of the review of developer/SLO RA for water pipes (Water UK protocol) and the supporting information submitted, it is necessary to provide some structure as to more readily relate to the primary objectives of the research and as such the findings have been subdivided into:

1. Types of land contamination RA reporting submitted in support of developer/SLO applications (in support of RA for water pipes)
2. Types of contaminative land-uses
3. Types of developments
4. Test Groups used in the assessment of risk to water pipes
5. Proportion of submissions providing rationale for the exclusion of Test Groups
6. Types of materials tested & appropriateness of material type included in assessment
7. Proportion of submissions which would require groundwater testing to be undertaken based on the requirements set out in the UKWIR2010/Water UK (assumes groundwater levels <3.5m below surface level have the potential to intersect pipe route)
8. Types of pipe materials specified by developer
9. Types of pipe material specified by WC
10. Quantity of submissions resulting in the specification of barrier pipe
11. Proportion of risk assessments complete by- or under the direction of 'suitably qualified competent person'
12. Types of Qualifications of person completing or directing the RA for water pipes

13. Proportion of submissions considered to have insufficient supporting information by the WC
14. Proportion of pipe material design proposals that were accepted by the WC
15. Types of information that was requested by WC to reduce uncertainties

A description of the results is presented and further supplemented within the discussion of results in the following sections and within Chapter 7.

TYPE OF LAND CONTAMINATION RISK ASSESSMENT REPORTING SUBMITTED IN SUPPORT OF DEVELOPER/SLO APPLICATION

The Water UK protocol requests "*As a minimum a desk study (preliminary risk assessment) shall be provided with the RA*" (Lingard *et al.* 2014, pg.1). It also states that for land which may be affected by contamination that appropriate testing of the material in which the pipes are to be laid shall be undertaken. The submissions reviewed are those which have been identified by the developer/SLO as sites potentially affected by contamination and therefore it would be anticipated that, as a minimum, supporting information to the RA for water pipes (or Pipe Selection Risk Assessment (PSRA) or (Water UK protocol)), would consist of a desk study (preliminary risk assessment (PRA) (Phase 1 report) and factual ground investigation (GI) information (including exploratory hole location plan, borehole logs and chemical laboratory) or a Phase 2 report with this factual information appended (or a combined phase 1 and 2 report with factual information appended). By totalling the number of each report type recorded on the datasheet, a picture can be built of the types of information more regularly submitted or of regular omissions. In addition a crude result can be derived to illustrate the number of submissions which meet the minimum requirements of the Water UK protocol with regards to the provision of supporting information.

It should be noted here, that the Water UK protocol although outlining the requirement for appropriate testing to be undertaken on material within which the proposed pipes are to be laid, it does not necessarily make clear that the factual information is to be provided as supporting information. For the purposes of this appraisal it is assumed that provision of supporting factual information is inferred.

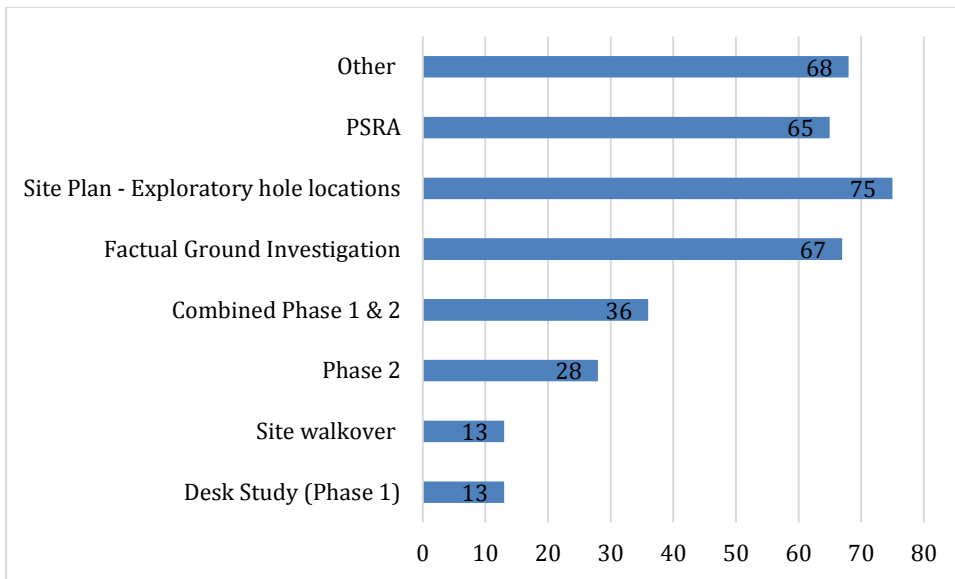


Figure 21 Report types and number of report

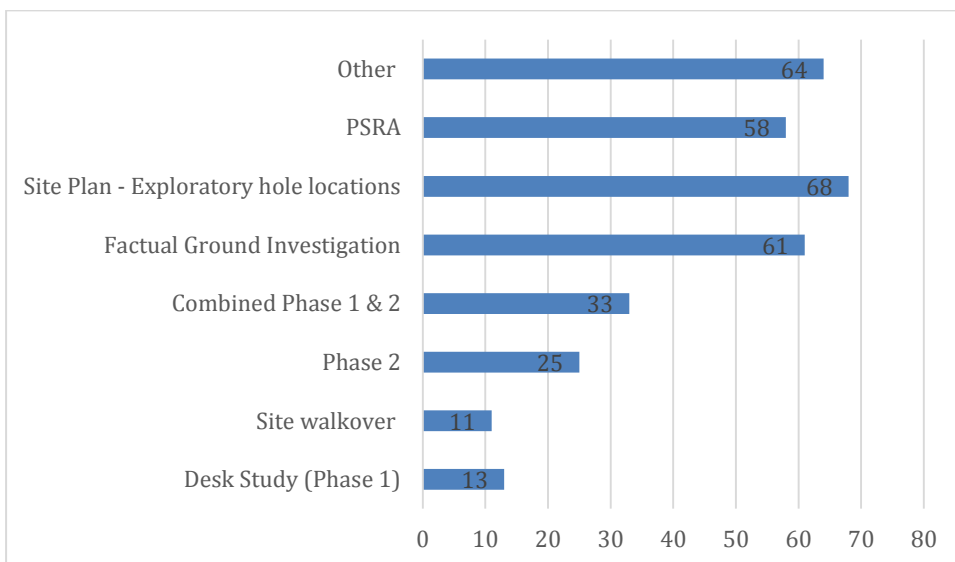


Figure 22 Report types and number of reports (excluding 7 submissions without Water UK PSRA)

It has been identified from the dataset of the 81 developer/SLO submissions that a total of 65 included a PSRA (**Figure 21**). The majority that were absent of a PSRA were submissions received by the WC in early 2011 (between May 2011 to August 2011). These omissions are therefore likely attributed to a period of transition from the use of the previous WRAS guidance to the UKWIR2010/Water UK protocol. The receipt of 7 PSRA following the former WRAS guidance (i.e. utilising the WRAS pipe selection threshold values) by the WC during this time period is further evidence to suggest this is a valid conclusion for the omission of

an appropriate PSRA. **Figure 22** presents report types and number of reports for submissions inclusive of a Water UK PSRA.

A review of the types of reports submitted to the WC suggests 36 of the submissions achieved the minimum requirements with the provision of a Water UK PSRA (a total of 58 submissions utilised the Water UK protocol) and supporting information consisting of an individual phase 1 report and phase 2 report or a combined phase 1/phase 2 report. With an exploratory borehole location plan and factual ground investigation information provided for each reporting scenario.

In 2 other cases a combined phase 1/phase 2 report was provided however only raw laboratory chemical data was provided (i.e. absent of exploratory borehole logs and therefore factual ground strata descriptions, installation details and groundwater strikes/monitoring level etc.). These submissions could also be considered to meet the minimum requirements of the Water UK protocol if the developer's (or their consultant's) interpretation of the ground conditions, presented in the report, is considered sufficient or acceptable by the water company.

A further 6 submissions (of the total 58) which provided a Water UK PSRA were supported by a Phase 2 report (including exploratory hole location plan and factual ground investigation information). In some cases, the Phase 2 reports provide an overview of Phase 1 findings and therefore it is possible to gain an understanding of former and current uses of the site proposed for development and which have instigated the need for phase 2 investigation works. This was the case for all 6 submissions. One developer (Site 75 on the datasheet) also provided a letter report which presented an overview of the phase 1 and phase 2 investigations undertaken for the proposed development.

A single site was submitted with a remediation verification report (including an overview of the site setting (i.e. former contaminative uses and findings of previous investigation phases), exploratory hole location plan and raw laboratory chemical data (Site 79 on the datasheet). It was however absent of exploratory hole logs however an interpretation of ground conditions were described with the report. This submission could also be considered to meet the minimum requirements of the Water UK protocol if the developer's (or their consultant's) interpretation of the ground conditions, presented in the report, is considered sufficient or acceptable by the WC.

The datasheet identifies 7 PSRA submissions to be supported by factual ground information (including exploratory hole plan). However, 'Other' report types in addition to the factual ground investigation were provided to the WC to support PSRA for 4 of the 7 developments. These 'Other' report type includes a letter report (Site 28 a letter report including PSRA, historical mapping and additional chemical laboratory data and Site 49 a letter report supporting the PSRA and additional chemical laboratory data), a Geoenvironmental Appraisal report (this report provided an overview of the site's historical use) and a Remediation Completion Report (including site investigation overview and remediation validation reporting). 3 submissions did not provide any supporting information relating to the sites former or current contaminative land use. One of the letter reports were received following a request for further information by the WC.

An exploratory hole plan and raw laboratory chemical data were provided as supporting information to 1 PSRA submissions. 4 PSRA submissions were supported by raw laboratory chemical data only. 1 PSRA submission was supported by a sampling plan and partial Remediation Statement report (including remediation validation raw laboratory chemical data).

Based on the above extrapolation of data it could be interpreted that the supporting information of 9 of the 58 PSRA (16%) utilising Water UK protocol did not meet the requirements of the Water UK protocol due to shortcomings in supporting information relating to a sites former/current contaminative land-use or in the provision of ground investigation information which allows insight in to the anticipated ground conditions of the development area (i.e. to allow a full understanding of the PRA and CSM for the site).

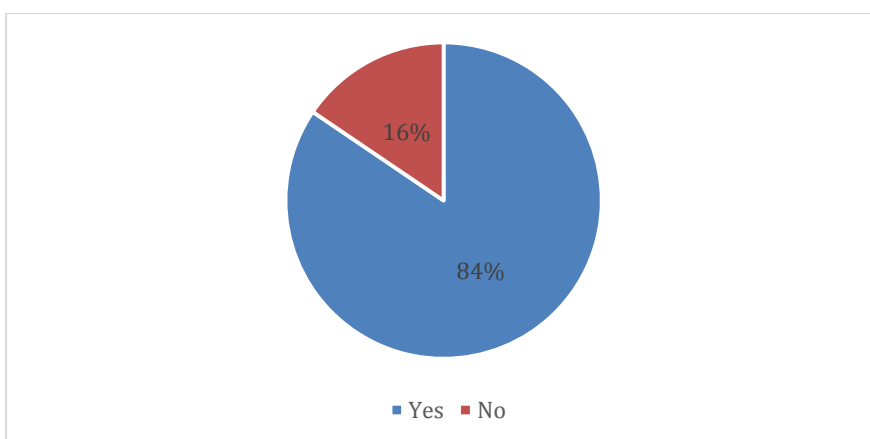


Figure 23 Provision of supporting information - Proportion of submissions considered to meet the minimum requirements of the Water UK protocol (Yes) and proportion which fall short of requirements (No)

Following a closer inspection of the dataset it would appear that information was provided as a second (10) or even third (1) submission, possibly as a request for further information by the WC. The following have been identified and excluded to give a closer reflections of the quality of initial water connection applications:

- 5 individual phase 1/phase 2 reports and 3 combined report (inc. GI) were received in second or third submission
- 1 combined reports (exc. GI)
- 1 'Other' report type (a letter report including PSRA, historical mapping and addition chemical laboratory data (Site 28)

Based on the above extrapolation of data 20 of the 58 PSRA (34%) fell short of meeting the Water UK protocol's supporting information requirements, based on the content of the initial submission pack to the WC.

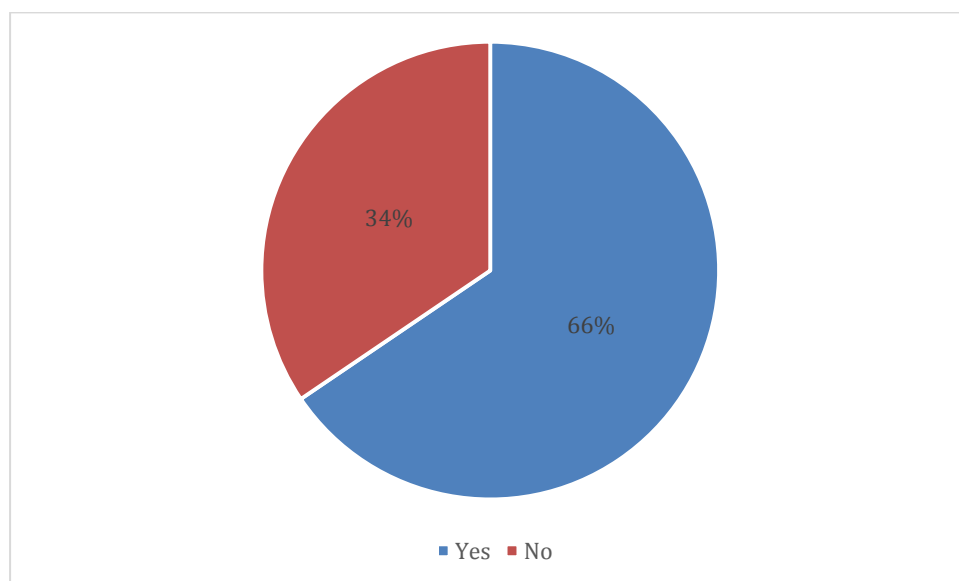


Figure 24 Provision of supporting information - Proportion of submissions considered to meet the minimum requirements of the Water UK protocol (Yes) and proportion which fall short of requirements (No) – excluding documents received following request for information by WC.

7 PSRA following the former WRAS were received by the WC and 16 were received absent of a completed PSRA. Supporting investigation reports and data was however submitted by developers/SLO. The water companies approach to the review of such submissions shall be explored later in the chapter.

To gain a picture of the 'Other' types of supporting information used by a developer/SLO in the assessment of the potential risks to water pipes and for the selection of suitable pipe materials, the types of 'Other' supporting information were recorded during the review of the 81 submissions (presented in **Table 4**). This data may have been appended to, provided in addition to or in place of the phase 1, phase 2 and/or factual GI reports.

Table 4 Types of 'Other' supporting information submitted to inform the Water UK PSRA

Types of 'Other' supporting information	Number
Landmark Envirocheck (historical mapping)	12
Groundsure (historical mapping)	4
Site check (historical mapping)	2
LA correspondence (planning)	4
Walkover photographs	2
Environmental Statement (likely to be supporting information to EIA process)	2
Outline Remediation Strategy / Statement	16
Validation Report Proposal	2
Remediation Validation / Verification Report / Completion Report	8
Letter Report	14
Consultants email	8
Laboratory data	25
Geoenvironmental appraisal	3
EA Landfill search	2
Trench Photographs	1
Coal Authority Report	3
Site inspection report	1
Earthworks Specification	1
Enabling works and Material Management Plan	1
Topographical Survey	3
Groundwater contours / cross sections	1
Geotechnical Desk Study	1

TYPES OF CONTAMINATIVE LAND-USE & DEVELOPMENTS

49 different types of contaminative land-uses were identified in the dataset.

Table 5 presents the number and types for contaminative land uses identified by developers/SLO (or in some cases by author through review of supporting information) during PRA. All 81 submissions were reviewed some submissions recorded numerous contaminative uses for a single site, all uses identified have been included in the land-use count.

The contaminative uses were not specified for 8 sites. In the absence of information relating to the potential sources of contamination (e.g. contaminative uses), the formulation of a PRA and CSM of the site and establishing whether or not there are potentially unacceptable risks by contamination to water pipes, is not possible. It would also be difficult to determine potential contaminants of concern (CoC) at a site and therefore to determine sufficiency of investigation and testing relating to assessment and selection of appropriate pipe materials. With this in mind, it would be anticipated that these 8 submissions would be considered to contain insufficient information with regards to meeting the minimum requirements

of the UKWIR/Water UK requirements. It would be anticipated that these submissions would receive adverse comments by the WC and the additional information would be requested from the developer/SLO, possibly in the form of the provision of a PRA or alternatively in the absence of a PRA request all contaminant test groups be undertaken due to the absence of evidence to discount the presence of CoC to pipe material (i.e. CoC identified in the WI guidance). WC consultation data shall be interrogated in a later section.

Supporting information accompanying the 8 submissions included phase 2 report (3) (nb. these 3 submissions were absent of a Water UK PRSA and therefore excluded from report type data interrogation), factual ground investigation report only (1) and raw chemical laboratory data (4). The land-use data are consistent with the findings of the 'supporting reporting types' data interrogated in the previous section. With exception of 4 submissions where the former/current contaminative use have been determined either through the site name (e.g. Site 61 Pemberton Colliery), WC knowledge of the area (e.g. Site 41 Hardman Fold is a known landfill site) or limited details included in the PSRA (Site 72 states a former agricultural use and Site 55 a history of residential use).

Table 5 Potentially contaminative land-uses identified during PRA

Contaminative Land-uses	Number
Recreational	1
Residential	8
Allotment	2
Manufacturers	1
Industrial	15
Agricultural	4
Disused land	17
Not specified	8
Social Club and car park	2
Hospital	3
Dye works	1
College	1
Primary School	1
Made ground / demolition arisings	6
Church	2
Depot	5
Timber yard	2
Railway	6
Landfill	6
Power Station	1
Chemical Works	1
Asbestos & Cement Works	1
Petrol Station	1
Tar Works	1
Landfill	5
Mill	9
Iron Works	2
Colliery	3
Engineering works	2
Waste / Water Treatment Works	2
Substation	4
Domestic garages	1
Boiler house	3
Gas Works	2
Brick Works	3
In-filled Ground	4
Fuel tank	2
Distillery	1
Airport	1
Oil Works	1
Garage / Vehicle Yard / Repair	3
Tramway	1
RAF Facility	1
Tannery	1
Alkali Works	1
Diary (associated tanks)	1
Royal Ordnance Factory	1
Garden centre	1
Printing Works	1

The types of proposed development was recorded during the review of the water connection submissions, it was found that by far that the most common type of development in United Utilities operational area between 2011 and 2014 was for residential properties, which accounted for 82% of applications. Other development types included residential/light commercial/retail mixed uses and retail and leisure developments (including business park, hostel, and college extensions) which accounted for 12% of the submissions and waste transfer/recycling/treatment facilities accounting for the remaining 6%. The developments were on sites with a range of contaminative uses as presented in **Table 5**.

As stated previously the dataset does not account for all development submissions to the WC but those identified as sites on land potentially affected by contamination and referred by the WC to land contamination management specialists for review.

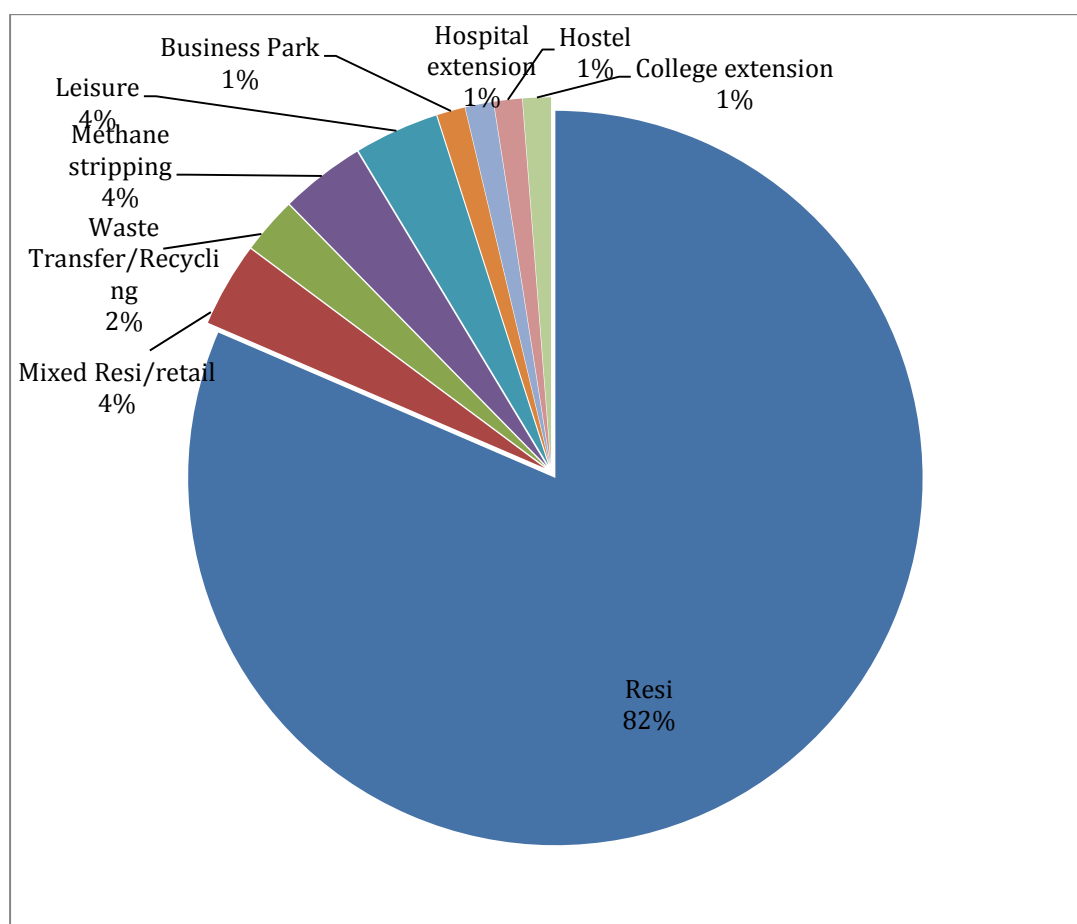


Figure 25 Proportion of proposed development types

TESTING REQUIREMENTS AND SUFFICIENT OF TESTING

Test Groups

There is a mandatory testing suite requirement of the UKWIR2010/Water UK protocol. The exclusion of testing is acceptable where rationale to exclusion can be provided, for example the outcome of the PRA confirms no evidence of the presence of a certain contaminant. **Figure 26** presents an extract of Table 1 of the Water UK protocol, which outlines the Test Groups required by the guidance.

The dataset of developer/SLO submissions have been reviewed and the test groups undertaken for the assessment of risk to water pipe materials has been identified. An appraisal of completed Water UK PSRAS (Table 1) has been undertaken during the stage 1 review. The Test Group identification used to populate the datasheet is presented in **Figure 26**, below.

Test Group	Testing Required?	Datasheet ID
Total VOCs Total BTEX & MTBE Total SVOCs (excluding PAHs and those substances marked with an *)	Where Preliminary Risk Assessment (PRA) has identified land potentially affected by contamination	Basic (B)
EC5-EC10 aliphatic and aromatic hydrocarbons		
EC10-EC16 aliphatic and aromatic hydrocarbons		
EC16-EC40 aliphatic and aromatic hydrocarbons		
Phenols* (from SVOC analysis)		
Cresols and chlorinated phenols* (from SVOC analysis)	Only where identified	Extended (E)
Ethers*		
Nitrobenzene*		
Ketones*		
Aldehydes*	Conductivity, Redox and pH	Metal Pipes (MP)
Amines		
Corrosive		
'Other' test groups than those outlined in Water UK protocol (this may include PSRA based on a selection of determinands outlined in Test Group B or E)		Other (O)
'Incomplete' Table 1 of Water UK protocol		Incomplete (I)

Figure 26 Annotated extract from the Water UK Pipe Selection Risk Assessment Summary (PSRAS) (Water UK - Table 1 including Datasheet Test Group ID.

The dataset of 81 developer/SLO submissions has been reviewed. To allow for a systematic review, the following data cleansing activities have been undertaken:

- 23 submissions were received by the WC absent of Water UK PSRA. These have been excluded from Stage 1 review and benchmarking exercise.
- 2 Water UK PRSA documents that were recovered from the WC archives were corrupt and therefore could not be reviewed. The 2 submissions have therefore been excluded from the Stage 1 review (Site 33 and Site 34, have been excluded from stage 1 review however supporting information and submission details can be viewed on datasheet)
- 3 developer/SLO submissions include PSRA protocol updates. The updated PSRA protocols were either from a voluntary update by the developer/SLO as more investigation information became available for the site (applicable to Site 74/74a) or at the request of the WC due to data omissions (applicable to Site 65/65a-c and Site 57/57a). The latest version of the PSRA protocol, by the developer, has been included in the Stage 1 review and benchmarking exercise.
- 1 developer/SLO submission included 2 separate PSRA, one for Area 1 of the site and one for Area 2 (Site 50/50a). These PSRAs have been benchmarked separately.

The dataset shows that out of the 57 developer/SLO Water UK PSRA 9 reported on the basic (B) test group, none undertook the extended (E) or metal pipe (MP) test groups. 42 PSRA report on other (O) testing suites and in the remaining 6 PSRA, Table 1 - PSRAS was not populated (I). The proportion of test groups used in the assessment of risk to pipe materials is presented in **Figure 27**. **Table 6** presents a summary of common omissions from the mandatory testing suite requirement of the UKWIR2010/Water UK protocol. The most common omission of the basic test group generally being cresols and chlorinated phenols (absent from 48 out of 57 PSRA (84%) submissions), Total SVOCs (absent from 47 out of 57 PSRA (82%) submissions), and Total VOCs (absent from 41 out of 57 PSRA (72%) submissions).

Total BTEX & MTBE was undertaken in 67%, EC5-EC10, EC10-EC16 aliphatic and aromatic hydrocarbons in 68%, EC16-EC40 aliphatic and aromatic hydrocarbons in 70% and phenols in 63% of PSRAS.

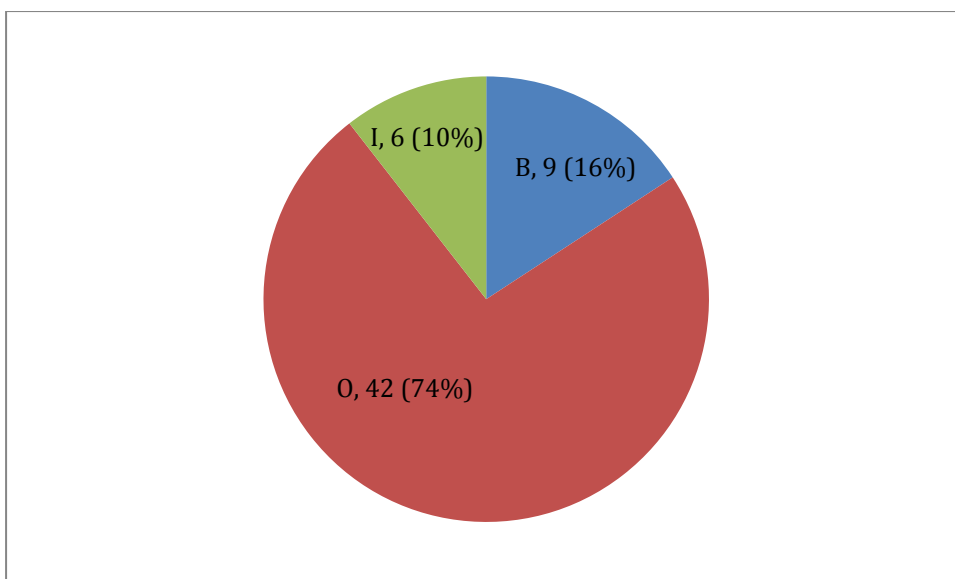


Figure 27 Proportion of the Test Groups used to assess risk to pipe material

Table 6 Common determinand omissions from Table 1 - PSRAS (omissions of CoC identified by UKWIR2010/Water UK)

Test Group	Testing Required?	Number Tested (out of 57 PSRA submissions)	Number of Test Omissions (out of 57 PSRA submissions)
Total VOCs	Where Preliminary Risk Assessment (PRA) has identified land potentially affected by contamination	16	41
Total BTEX & MTBE		38	19
Total SVOCs (excluding PAHs and those substances marked with an *)		10	47
EC5-EC10 aliphatic and aromatic hydrocarbons		39	18
EC10-EC16 aliphatic and aromatic hydrocarbons		39	18
EC16-EC40 aliphatic and aromatic hydrocarbons		40	17
Phenols* (from SVOC analysis)		36	21
Cresols and chlorinated phenols* (from SVOC analysis)		9	48
Ethers*	Only where identified	0	57
Nitrobenzene*		1	56
Ketones*		0	57
Aldehydes*		0	57
Amines		0	57
Corrosive	Conductivity, Redox and pH	0	57

Rationale for the exclusion of test group determinands was provided for 25% of PSRA. **Table 7** presents the rationale provided by developer/SLO. Contaminative land-use data has been reviewed and transposed into **Table 7** this allows the comparison of the rationale for exclusion of test group CoC against contaminative land-uses identified in developer/SLO PRA or supporting information. An assessment of the CoC associated with the various contaminative land-uses can be made and rationale accepted or challenged by the WC.

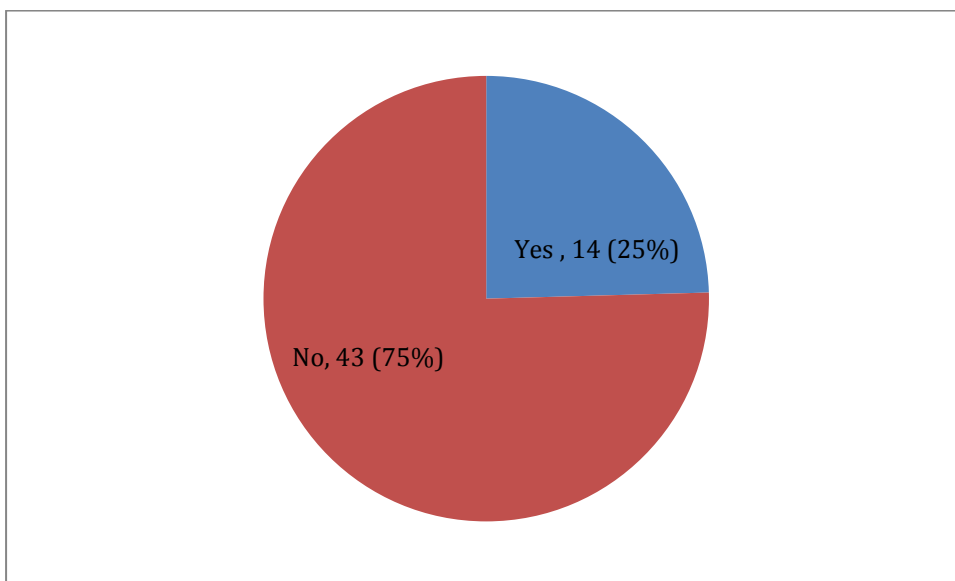


Figure 28 Proportion PSRA submissions providing rationale for the exclusion of test group determinands

Table 7 Rationale for the exclusion of test group determinands (CoC identified by UKWIR2010/WaterUK)

Site Datasheet ID	Submission date	Rationale for test group determinand exclusion	Contaminative land-uses
19	06.07.11	"Not TESTED NO SOURCE"	Disused (former care home. Fill on site is colliery spoil type material
20	06.07.11	"Not TESTED NO SOURCE"	Former landfill
22	17.07.11	SI enclosed. "We are unable to fill in the current Risk Assessment form regarding contamination as this is a new form only brought out this year (the SI was undertaken in 2009) which requests for testing of contaminants which we had no reason to test for at the time. The tests we did undertake, however, found no elevated levels of contaminants and no remedial measures required. We therefore feel that although not in line with the current requirements for contamination testing, the report adequately demonstrates that there is no contamination on site and no remedial measures for water mains therefore required."	Disused (formally garage and an electricity substation before demolition). Sewage works (off-site) [undertook PAH analysis only]
65	05.09.12	Not tested, BTEX, MTBE, VOC, SVOC, Ethers, Nitrobenzene, Ketones, Aldehydes and Amines as the Preliminary Conceptual Site Model did not identify these contaminants as potentially present. See Section 5.0 of Sirius Geoenvironmental Appraisal.	Former landfill
68	18.10.12	Desk Study Report does not indicate the likely presence of VOCs, BTEX & MTBE, SVOCs, EC5-EC10 and EC10-EC16 hydrocarbons, phenols, cresol and chlorinated phenols	Agricultural land with depot NW. Alkali works and railway (off-site)
71	03.06.13	PRA identified a potential risk of heavy metals, PAHs and asbestos containing material. Soils were tested for these contaminants during the investigation. PRA did not identify a risk of VOC/SVOCs (with the exception of PAHs), petroleum hydrocarbons, BTEX, MTBE, phenols, cresols, chlorinated phenols, ethers, nitrobenzene, ketones, aldehydes and amines. Furthermore PID testing undertaken on the soils did not detect any	Church. Residential setting

Site Datasheet ID	Submission date	Rationale for test group determinand exclusion	Contaminative land-uses
		volatile contaminants. Soils were therefore not tested for these contaminants during the investigation. See supporting document: 'Preliminary Risk Assessment and Ground Investigation Report' ref: LKC-12-1045-01, date Nov 2012.	
72	04.06.13	The site history indicates no contaminative uses & there were no visual or olfactory evidence during GI	Undeveloped agricultural fields [undertook TPH CWG and BTEX testing]
73	30.07.13	Extended suite tests were not tested as they were not identified on site.	Disused (former manor house). Surrounding land - industrial setting
74a	24.01.14	Desk Study did not identify them as potential CoC and no evidence of their presence during ground investigation	Disused (former hospital) [undertook TPH CWG and BTEX testing]
75	02.06.14	Any groups not tested were deemed unnecessary due to sites previous / end use.	Disused (former agricultural use and recorded infilled pond) [undertook BTEX only]
77	16.06.14	Compliance report validation and completion report completed by BAE System in line with the approved Buckshaw Village remediation programme.	Remediated Royal Ordnance Factory [Table 1 incomplete (I)]
78	07.07.14	Desk Study and site walkover revealed limited possibility for the land to be contaminated. Reference is made to combined P1 and P2 report	Disused (former garden centre) [Table 1 incomplete (I)]
79	28.08.14	No source for extended. No conductivity and redox (not required for PE pipe material)	Gas works
80	08.09.14	VOC and SVOC and Extended suite excluded - no evidence to point to their presence.	Mill complex with infill filtration tanks (builders waste) <i>Nb. a review of supporting reports suggests filter tanks may be associated with historical print works (1898) / Dye & Bleaching Works</i>

Site Datasheet ID	Submission date	Rationale for test group determinand exclusion	Contaminative land-uses
			(1910) on adjoining land. [undertook TPH CWG and BTEX testing]

Material Tested

The WI guidance requires testing to be undertaken on materials within which the pipes are to be laid whether that is existing ground material (EGM), remediated materials (RM) or imported materials (IM). Table 1 of the Water UK protocol requests this information as part of the PSRAS.

It was found that by far, test results of EGM, was most commonly used in PSRAS, and was utilised in 82% of assessments. **Figure 29** illustrates the proportion of each material type tested and used in RA. 6 PSRA were submitted absent of complete Table 1 PSRAS (referenced as 'Not Specified' and 'N/A - no testing' on **Figure 29**.

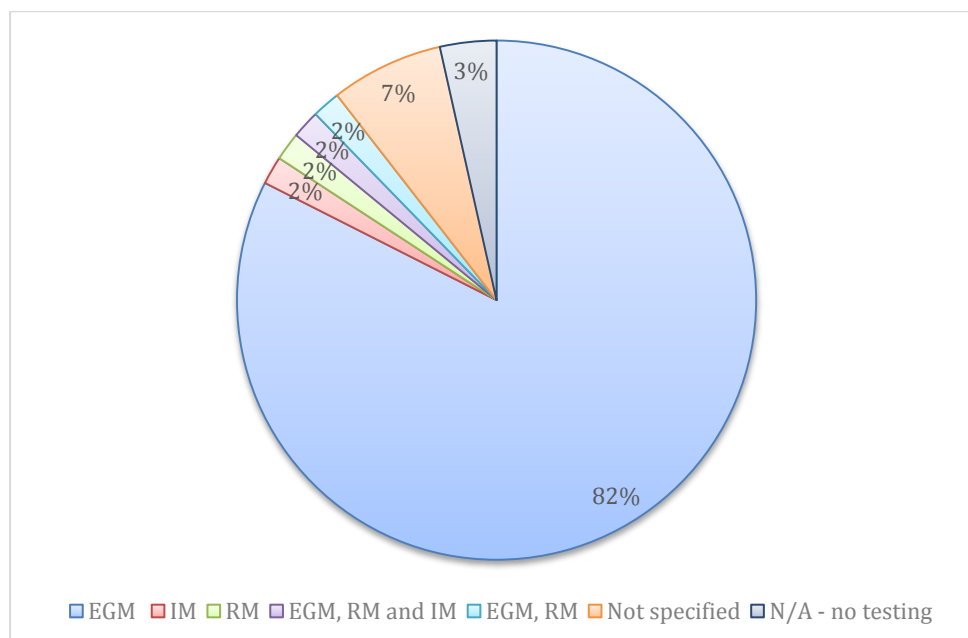


Figure 29 Proportion of Material Types used to assess risk to pipe material

Groundwater monitoring and testing

Section 3 of the Water UK protocol asks *"At what level has groundwater been encountered?"*. The Water UK protocol provides the follow guidance under the title 'Sufficiency of Testing' *"Where appropriate (see UKWIR Guidance) groundwater sampling and groundwater monitoring will also be necessary."* (Lingard *et al.* 2014, p3). As discussed in section 2.6 UKWIR2010 states that if groundwater or perched water is present with 1m of the base of the intended pipe trench, a water sample should be taken and tested for the mandatory test groups to check for the presence of contaminants. It also states that depth of sampling may be extended to 2m to take account of rising groundwater levels in winter.

With the above requirement in mind a crude assessment of sites where groundwater sampling and testing may be applicable based on groundwater levels, has been undertaken. It has been assumes groundwater levels <3.5m have the potential to intersect the pipe route (i.e. assuming pipe to be installed between surface level and 1.5mbgl in the absence of proposed pipe depth) and therefore groundwater sampling and testing may have been required.

It should be noted that only sites where there is the potential for groundwater to be affected by contamination would require groundwater sampling and testing. Therefore the requirement to undertake testing cannot be determined solely by groundwater levels.

The dataset shows that out of the 57 developer/SLO WaterUK PSRA, 36 recorded groundwater levels less than or equal to 3.5mbgl (31 were recorded <2.5mbgl, where seasonal effects are not considered), groundwater was recorded as 'not encountered' during GI works for 11 submission and 9 did not specify a groundwater level. A single site recorded levels >3.5m bgl (recorded at 4.2m bgl).

Based on the dataset it would be anticipated that water sampling test data would be provided to support the assessment of risk to water pipes for approximately 60% to 80% of water connection submissions. A high level totalling of supporting information reports, which include chemical data for groundwater, has been undertaken. 18% (10 out of 57) of submissions have been identified to include groundwater data.

There is however no area of the Water UK protocol template which allows the developer/SLO to make reference to groundwater testing undertaken or to provide details on the outcome of such testing. The WC would be required to review supporting information to determine if testing has been undertaken and the contaminant concentrations encountered. No groundwater threshold levels are provided by the WI guidance.

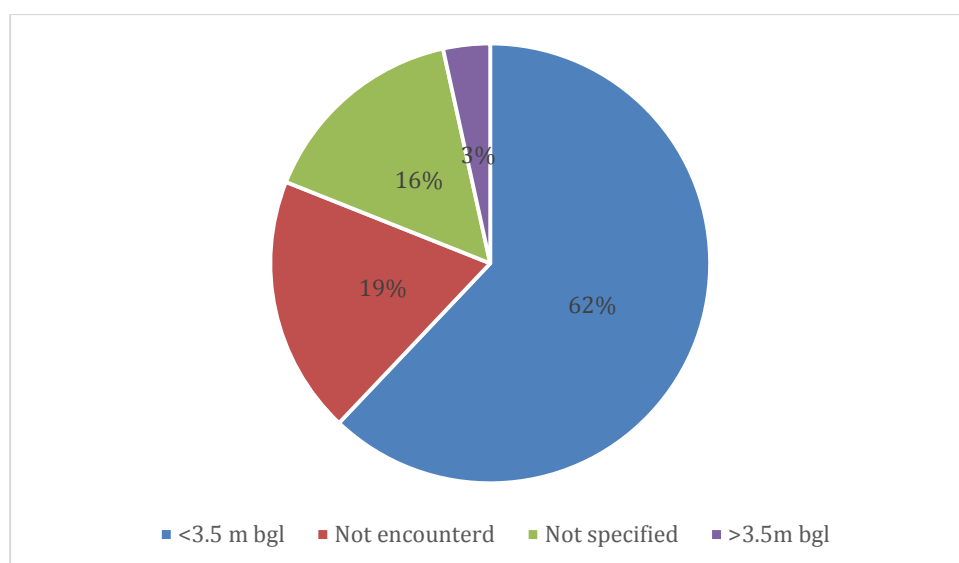


Figure 30 Proportion of the groundwater levels recorded in RA for water pipes submitted to the water company

REMEDICATION

Section 4 of the protocol gives the risk assessor the opportunity to consider if the data used in the Table 1 is appropriate for the assessment of risk to the proposed pipe material, for example if remediation is proposed is the use of EGM data (from previous GI) suitable or would data relating to RM or IM, for example, be appropriate. Data provided has been assessed and an overview of risk assessor responses counted and tabulated below **Table 8**

Table 8 Remediation information provided by risk assessor as part of PSRA

Has the PSRAS been undertaken using appropriate data following remediation?	Number
Yes	15(26%)
No	9(16%)
Not specified	24(42%)

States as N/A risk assessor [assume data used in RA is applicable to the material pipe is to laid, for example remediation is not proposed]	9(16%)
---	--------

The 9 PSRA, considered by the risk assessor to have not been undertaken using appropriate data following remediation, utilised EGM data recovered in advance of remediation works in the PSRAS. In each of these cases the WC accepted the use EGM in the absence of RM data.

Just under half of the submissions (42%) did not specify whether the RA had been undertaken using appropriate data following remediation.

PIPE MATERIAL

Developer/SLO pipe material proposal:

Of the 57 developer/SLO Water UK PSRA 62% proposed the use of PE, 19% BP, 4% combined use of BP and PE, 4% PVC and 11% did not specify a proposed pipe material as part of the PSRA

WC recommendation:

Roughly a quarter of submissions either required PE (19%), BP (26%), a combined uses of BP/PE (25%) or further information was requested of the developer/SLO prior to confirming the final determination of pipe materials (30%). An overview of pipe material data is presented in **Table 9**

Table 9 Types of pipe materials proposed by developer/SLO compared to those recommended by the WC

Pipe material	Proposed by Developer	Recommended by WC
PE	36	11
BP	11	15~
BP/PE mix	2	14
PVC	2	0
Not specified	6*	17*(RFI)#

Notes:

~4x submissions BP originally recommended by WC. Specification changed to PE following the receipt of additional information.

*Pipe material selection not determined in the Developer/SLO PSRA.

*(RFI) Not specified by WC generally due to insufficient information. WC requested additional information (Request for Information (RFI)).

#5x RFI submissions (outstanding information), 9x RFI - BP accepted in absence of data, 2x RFI - PE following receipt of additional information, 1xRFI PE accepted in error.

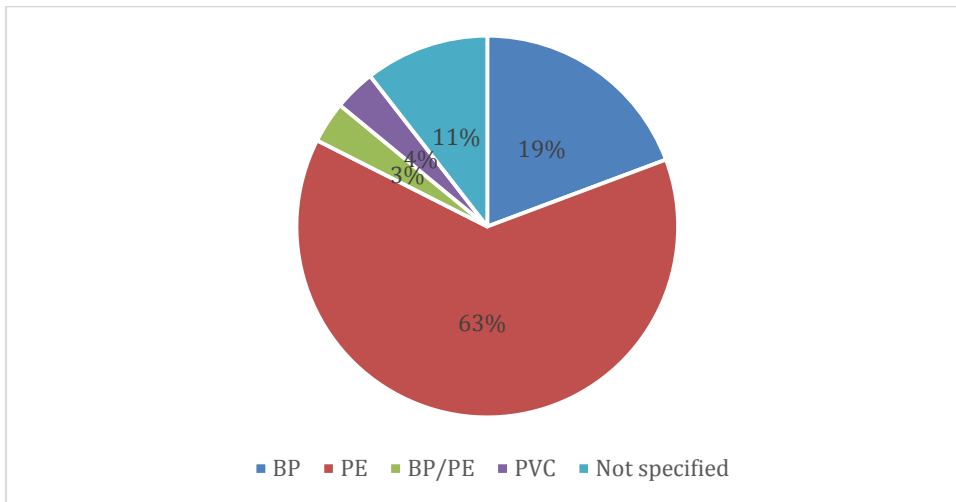


Figure 31 Proportion of pipe material types proposed by developer/SLO in PRSA

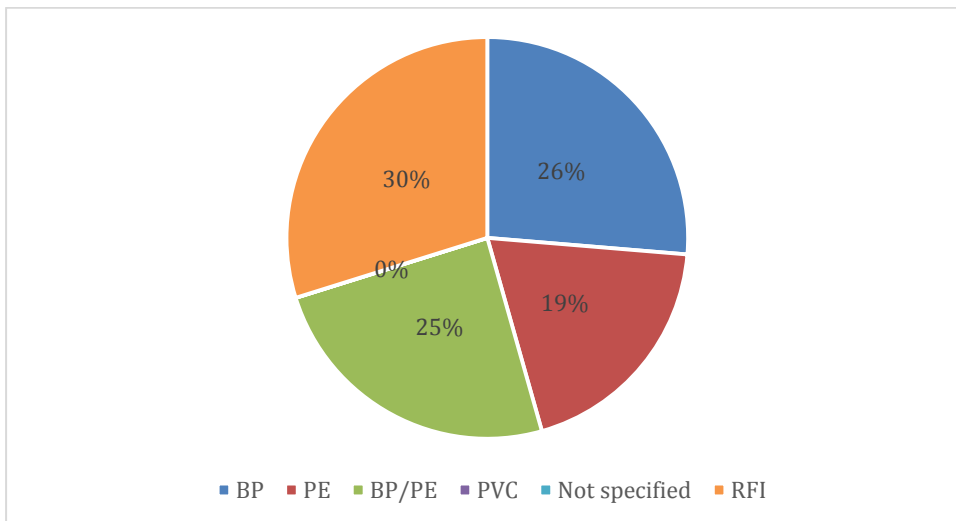


Figure 32 Proportion of pipe materials and information requests (RFI) by WC post review of developer/SLO PSRA

SIGNATORIES OF THE RISK ASSESSOR OR PERSON DIRECTING THE RA FOR WATER PIPES

A requirement of the Water UK protocol is that the risk assessment for water pipe materials should be undertaken *"by or under the direction of a suitably qualified competent person"* and that the competent person is required to be *"a) a chartered member of an appropriate professional body (such as the Institution of Civil Engineers, the Geological Society of London or the Royal Institution of Chartered Surveyors) with relevant experience of investigating contaminated sites or b) a Specialist in Land Condition (SiLC) with appropriate geo-environmental experience"* (Lingard et al. 2014 p.2).

The protocol states that signatories (or competent person) is to ensure that all assessments of land condition have been carried out in accordance with applicable current standards and guidelines. As part of the stage 1 review the specified qualifications of the person named as directing the PSRA have been collated.

Data to demonstrate that the PRSA has been completed by- or under the direction of a suitably qualified competent person is absent in 70% of submissions. The dataset demonstrates that only 26% of submissions were undertaken by- or under the direction of a Chartered Professional and 4% by- or under the direction of a Chartered Professional and SiLC (refer to **Figure 33**).

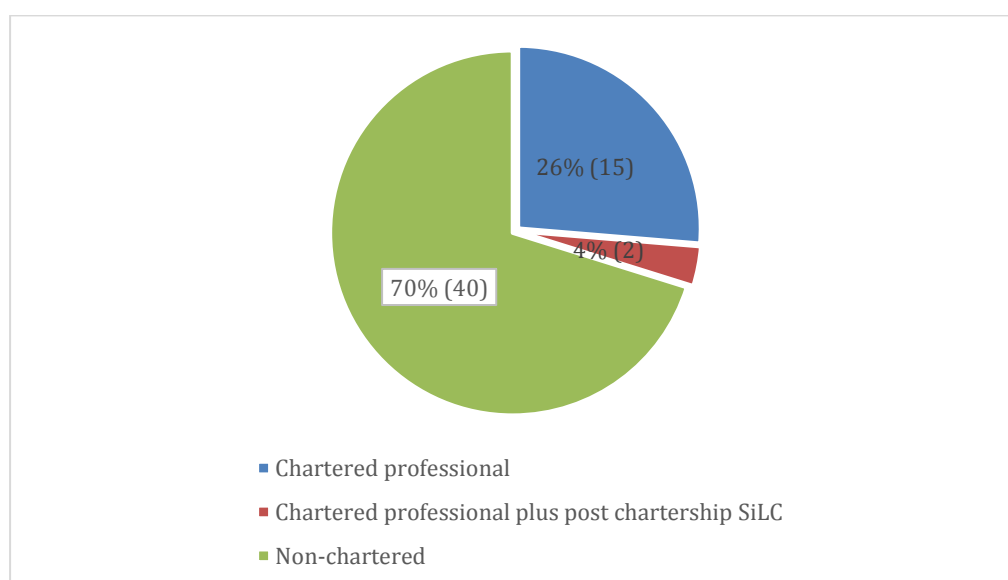


Figure 33 Proportion of PSRA completed by- or under the direction of Chartered Professional, Chartered Profession & SiLC or non-chartered assessor.

Table 10 presents the types of professional chartership and professional institutions that were identified in the dataset. Other evidence that was provided to demonstrate the risk assessor's competence is presented in **Table 11**, this evidence includes academic qualifications and years of experience in the land contamination industry. With the requirement of the Water UK in mind this evidence in isolation (e.g. absent of chartered status) would not be sufficient. No details were provided to demonstrate competence of the risk assessor in 27 submissions.

It would be therefore be anticipated that at least 70% of submission would have been considered insufficient by the WC.

Table 10 Types of chartership and Institutions of risk assessors

Professional Qualification	Number
Specialist in Land Condition (SiLC)	2
Chartered Geologist (CGeol)	8
Chartered Scientist (CSci)	4
Chartered Engineer (CEng)	6
European Geologist (EurGeol)	2
Member of the Institute of Structural Engineers (MIStructE)	7
Member Chartered Institute of Water and Environmental Management (MCIWEM)	1
Member Institute of Environmental Sciences(MIES (or MIEnvSc))	3
Member Institute of Civil Engineers (MICE)	1
Member Royal Society of Chemists (MRSC)	1
Fellow Geological Society (FGS) (with chartered status)	4

Table 11 Types of other evidence presented to demonstrate risk assessors competence (non-chartered assessors)

Professional Qualification	Number
FGS (without chartered status) - entry requirements of a degree or equivalent in geology (or related subject) or have no less than 6yrs relevant experience)	4
AIEMA (entry examination to demonstrate a broad understanding of environmental issues. No professional experience is required)	2
Academic qualification (including BSc, MSc, MEng, HNC, PGDip, MESci)	13
Years experiences (generally >10 years' experience on assessment, investigation, remediation)	7

PROPORTION OF SUBMISSIONS CONSIDERED AS HAVING INSUFFICIENT SUPPORTING INFORMATION BY THE WATER COMPANY & THE TYPE OF ADDITIONAL INFORMATION REQUESTED.

During the water connection application process, the WC has the opportunity to review the developer/SLO application and pipe design details. In the context of land contamination, the WC has the opportunity to review the developer/SLO PSRA and supporting information and consider whether they meet the requirements of the UKWIR2010/Water UK guidance, to seek to ensure the correct pipe materials that are selected for use, based on the site specific conditions. The WC (generally a connections engineer/designer) is required to bear in mind the requirements of the WI guidance in their review of the developers/SLO pipe design. The WC has the opportunity to accept the design; or to request further information from the developer/SLO to address areas of uncertainty; or to specify a particular pipe specification considered suitable. This section is presented to illustrate the percentage of submissions which are considered to have insufficient information for the assessment of risk to water pipe materials and also to illustrate the design outcomes of the developer/SLO and WC consultations.

A review of the supporting information of all submissions in the database has been undertaken. However, to keep consistent with the stage 1 review and

benchmarking, data has been interrogated separately for the available 57 Water UK PSRA submissions. As previously identified Site 50 was received with 2 separate PSRA for different areas of the development (Area 1 and Area 2), the consultation outcomes have been reviewed separately for Site 50, thus resulting in a dataset of 82 submissions.

It should be noted that the dataset is of submissions that have been referred to land contamination specialist by the water company's connections engineer/designer, therefore represent the more complex submissions with respect to land contamination management.

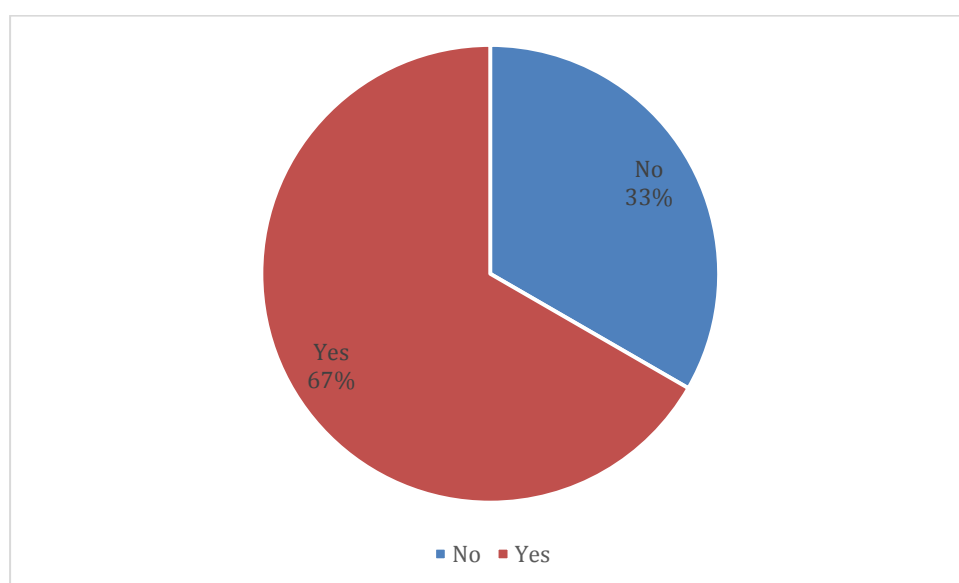


Figure 34 Proportion of PSRA where further information was requested by the WC

Of the 57 PSRA submissions, 67% were assessed as requiring additional information to be provided by the developer/SLO to support the RA or to justify the pipe material selected. Inclusive of all 82 submissions, 65% were assessed insufficient of information.

From this initial assessment, it is necessary to further interrogate the results to ascertain if a conclusion can be reached as to why more than half of the submissions were found to be insufficient of information. This can be achieved by considering the types of information requested by the WC. As part of the review cross reference can be made to the stage 1 review and benchmarking exercise to identify information requested that may be additional to that of the UKWIR2010/Water UK minimum requirements or to identify if some of the identified shortcomings

/submission omissions, in previous sections, are consistent with the adverse comments by the WC.

Table 12 provides an overview and breakdown of information requested by WC following the initial water connection submission by the developer. The number represents the number of submissions in which the data was requested. For completeness a full dataset interrogation has been undertaken and a separate data appraisal for the 57 PSRA submissions to allow comparison with the stage 1 review and benchmarking (presented in brackets in **Table 12**).

The most common adverse comment (or information request) made by the WC is generally related to the requirement for ground investigation (GI) data and chemical testing, and more specifically GI data of the material in which the pipes are to be laid (i.e. at the proposed line and depth of the proposed pipe) (48). Other more common requests include the requirement for test group data (generally relating to the absence of VOC/SVOC testing or a request for testing in-line with Table 1 CoC) (35) PRA (including supporting appendices e.g. historical maps) (20), details on remediation works and remediation validation information (19) and completed/updated RA for water pipes (18). Less frequent requests were made for GI exploratory plans (8), risk assessor qualifications/signature (8), groundwater data (levels and testing) (6) and requests for imported material data (2).

Table 12 Types of further information requested by the WC

Types further information	Number (number of requests out of 57 PSRA submissions)
Complete or updated RA for Water Pipes	18 (13)
DS / PRA data (including supporting mapping)	21 (17)
Ground Investigation (& chemical data) - line and depth of pipe	48 (33)
Test Group	35 (28)
Test of import material	2 (2)
Plan (generally exploratory holes plans)	8 (4)
Risk Assessor qualifications	8 (8)
Groundwater level &/or data	6 (5)
Remediation / Validation data	19 (14)

Figure 35 presents the proportion of Water UK PSRA submissions where additional supporting information was provided either voluntarily or at the request of the WC. With additional data being provided by the developer for over half (76%) of the submissions considered insufficient of information by the WC. For the remaining submissions data was either not provided or outstanding information (24%).

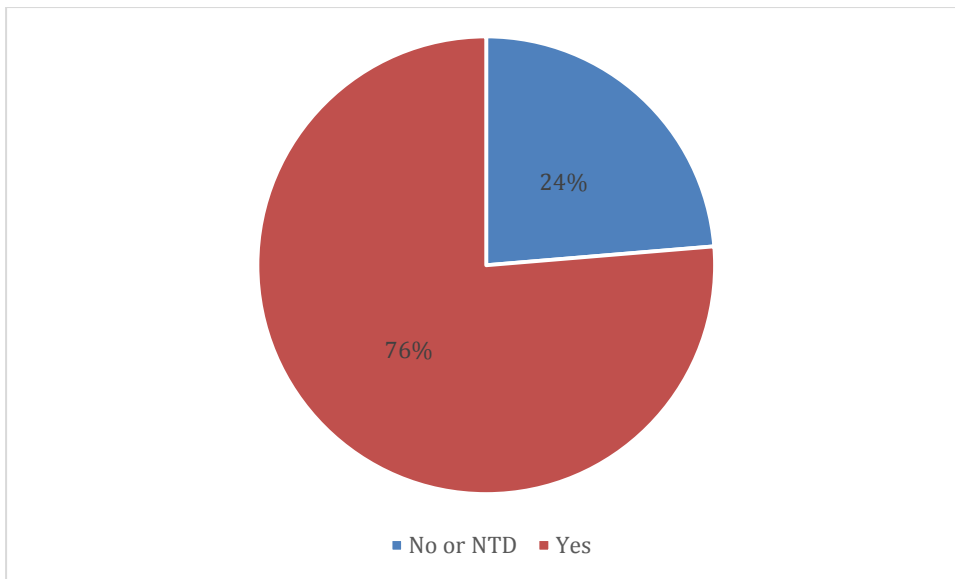


Figure 35 Proportion of PSRA where additional supporting information was provided by the developer/SLO following additional information request by WC (Yes-Information provided, No or Not to date (NTD))

A review has been undertaken of the final recommendations of the WC to determine how RA uncertainties were resolved in the absence of the provision of the additional information requested by the WC. BP was accepted as default position in the majority of cases, where data has been requested by the WC (PSRA dataset 67%, all submissions 84%). The remaining appear to be ongoing consultations due to the absence of requested data.

An assessment has also been made of the proportion of developer/SLO pipe materials selection proposals that have been accepted by the WC. Where the developer/SLO has not provided a pipe material proposal this is included as 'not specified' in **Figure 36** Developer's pipe material proposals were assessed to have not been accepted ('NA') for 37% of submissions (with 30% requiring a greater specification of pipe), 44% were accepted (11% of which were accepted following the receipt of additional information) and 9% were rejected followed by a request for further information to support pipe material specification ('RFI'). This data demonstrates that only a small portion (11%) of developer proposals have been accepted following the receipt of additional information. It should be noted here however that the aim of the WI guidance is to ensure that the correct materials are selected for water pipes in brownfield site, therefore the provision of additional site information would act to provide lines of evidence to demonstrate the appropriate pipe materials are selected for a site and therefore may not result in a more favourable result (i.e. lower pipe specification) for the developer.

For completeness an assessment of all submissions and supporting information has been undertaken (i.e. including submissions absent of Water UK PSRA and therefore excluded from the stage 1 review and benchmarking exercise). A breakdown of the assessment results are presented in **Table 13**

The proportion of developer/SLO pipe materials selection proposals that have been accepted or not accepted (NA) by the WC, for the 57 PSRA submissions is presented in **Figure 36**.

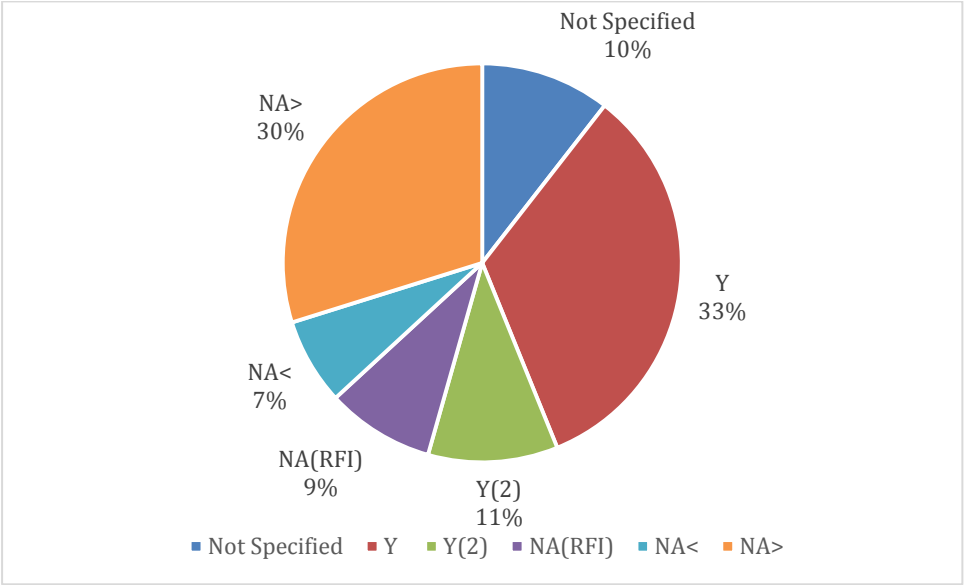


Figure 36 Proportion of developer/SLO pipe materials selection proposals that have been accepted or not accepted (NA) by the WC

Table 13 Number of developer pipe material design proposals accepted and not accepted by WC

Developer pipe material design proposal	Number (number of requests out of 57 PSRA submissions)
Not Specified	23(6)
Not accepted (lower spec of pipe required by WC) (NA<)	4(4)
Not accepted (higher spec of pipe required by WC) (NA>)	22(17)
Accepted (Y)	22(19)
Accepted following receipt of additional information (Y(2))	6(6)
Not accepted - request for addition information (NA(RFI))	5(5)

5.2 6. Establish the common omission and areas of uncertainty in the RA for water pipes by developers/SLO (or their consultants) and in water company recommendations

Supporting information

The results indicate that based on the types of reports submitted as supporting information to the PSRA, as part of the initial submission by developer, that the majority of submissions meet the minimum requirements of the Water UK protocol with approximately 34% (20 of 58) falling short of the requirements due to the absence of information relating to the site's former/current contaminative land-uses and/or of factual ground data (e.g. exploratory BH logs), which provide supporting information to the PRA/CSM for a development (new water connection).

The supporting information dataset shows that for 11 of the 20 submissions, that further information was submitted at a later date by the developer, following a request for further information by the WC.

The collated data presented does not however demonstrate the content of the supporting documents and whether the site investigations and assessments undertaken in support of the PSRA, meet all the requirements of the UKWIR 2010/Water UK protocol.

Further information was requested by the WC for more than half of submissions (67%), which suggests the content of the information provided falls short of the requirements by UKWIR2010/Water UK (**Figure 34**).

Sufficiency of Testing

The benchmarked PSRA submissions demonstrate that very few meet the WI mandatory testing requirements. Only 16% providing PSRA which includes the basic test groups. No PSRA included the extended test groups.

A very small proportion of the PSRA submissions provided rationale for test group exclusion (25% (14 out of 57 PSRA)). **Table 7** presents the rationale provided by developer/SLO for the exclusion of test groups aligned to contaminative land-use data. Based on the contaminative land-uses identified it would be anticipated that at least 11 of the 14 submissions would be challenged (sites 19, 20, 22, 65, 68, 75, 77, 79, 80). With cross reference to WC response data, further test data was requested for 6 out of 14. The rationale was accepted for the remaining however for 2 submissions further PRA information was requested to support rationale provided (site 73 and 78).

The most common testing omissions were cresols, chlorinated phenols (provided in only 9 of 57) closely followed by SVOC (provided in 10 out of 57) and VOC (provided in 16 out of 57) analysis. There were omissions in the provisions of the other basic test groups but to a lesser extent.

Test groups VOC/SVOCs were identified as a common omission by WC and often requested to support the developers PSRA. Additional chemical test data to meet the requirements of the WI guidance was requested in approximately 28 of 57 PSRA submissions (**Table 12**).

The most common uncertainty/information request by the WC is related to GI data and specifically uncertainty due to the absence of data in the line and depth of the proposed pipe and insufficient chemical data. Further information in the form of GI was requested in 33 out of 57 PSRA submissions.

The extended test group contaminants have not been considered in any PSRA. Land-uses known as possible sources of such CoC include pharmaceutical, dye and

printing works, chemical industries and coal tars. Based on the land-use data presented within **Table 5** at least 4 land-uses have been identified which pose a potential source of extended test group contaminants – print works, tar works, dye works and gas works. Other more general description such as 'industrial', 'manufacturers', 'chemical works' could also be considered as potential sources in the absence of more detailed information.

There has been no challenge by the WC for the absence of extended test group contaminants in the consultations reviewed.

The requirement to consider groundwater contamination in the assessment of risk to water pipes appears to be overlooked by both developer/SLO and WC. Information on groundwater levels is a requirement of the Water UK protocol and for the majority (84%) of PSRA water levels are provided. The protocol however falls short on requesting information relating to groundwater contaminant concentrations (as required to meet the requirements set out in UKWIR2010). . Based on a crude assessment of groundwater levels presented in PSRA it would be anticipated that groundwater data would be required for between 60-80% of submissions. A review of supporting information dataset suggests approximately 18% of submission have been provided with groundwater data however there is little evidence which suggest the data has been reviewed as part of the PSRA.

This shortfall of information to inform PSRA does not appear to have been considered in the majority of cases by the WC, with groundwater data being considered insufficient in only 5 out of 57 submissions (**Table 12**).

During the stage 1 PSRA benchmarking exercise, it proved difficult to grasp the remediation proposed or undertaken for each submission. 82% of PSRAS were completed using EGM data (**Figure 29**). Just under half the 57 PSRA (42%) did not specify whether the PSRAS had been completed using appropriate data after remediation thus resulting in uncertainty of ground conditions in which the pipe will be laid. There is little to no evidence within the dataset to suggest the PSRA are updated/refined by developers/SLO following the completion of any proposed land remediation.

9 submission (16%) of submissions stated that the data included in the PSRAS was not appropriate data following remediation. The WC accepted the use of EGM data in the absence of RM data in each of these cases.

Signatories

There are a limited number of submitted PSRA that were demonstrated to have been undertaken by- or under the direction of a suitably qualified competent person (30%). Of the 70% submitted without this requirement less than 20% were challenged by the WC. It isn't possible to demonstrate the benefits this Water UK requirement has on the PSRA process based on the results however the requirement for 'suitably qualified competent person' shall be considered in chapter 6.

Water Company

There are clear consistencies in the type of information requested by WC and these requests are generally consistent with the omissions in data identified in the stage 1 benchmarking review (i.e. shortfall of information to inform developer/SLO PSRA). The dataset also demonstrates where the WC consistently falls short of recognising the requirements of the WI guidance. The requirement for groundwater testing, signatories and recognising the need for extended test groups is a common omission by the WC.

Chapter 6 Case Studies

6.1 7. Consider case studies to test the WI guidance and its application by water companies and other key stakeholders (e.g. developers and their consultants), to identify information gaps and areas of uncertainty in the PSRA process.

To gain an insight into the implementation of the guidance by water companies and other key stakeholders (e.g. developers and their consultants), the author has undertaken a review of a number of water connection applications to a WC, for new developments on land potentially affected by contamination. The extrapolated data of key omissions from the 'good practice' UKWIR2010/Water UK guidance has been interrogated discussed in Chapter 5.

In order to test the WI guidance further and to identify areas of uncertainty or possible deficiencies in the PSRA process three case studies have been undertaken. Each case study is structured to present an overview of the pipe design proposal and RA conclusions by the developer and the final WC decision on pipeline design and specification.

The author has undertaken detailed appraisal of the supporting factual information to the developer's PSRA. With the overall aim of the appraisal being to develop a CSM of the site to establish whether or not there are potentially any unacceptable risks posed by either historical or current use of the land and surrounding area to the proposed future water supply pipe material (and subsequently drinking water quality) and to identify areas of uncertainty with respect to the site information provided to inform the CSM. Only key elements of each of the study site have been included to illustrate the PSRA process and key outcomes of each case study.

Each case study has been undertaken following the UKWIR 2010 guidance and the Water UK protocol template.

6.2 Case Study 1 Old Wool Road

The water connection application for the housing development was received with a Water UK PSRA and supporting information of a combined phase 1/phase 2 report (including historical mapping, GI factual report, chemical data and exploratory hole). The submission appears consistent with the supporting information requirements of the Water UK protocol.

Overview of site details presented in the PSRA undertaken by developer/SLO and/or their consultants

Land potentially affected by contamination has been identified by desk study/site walkover.

An intrusive GI has been undertaken dated Feb 2012.

Groundwater has been encountered at 2.0m below ground level.

The exclusion of VOC, SVOC, ethers, nitrobenzene, ketones, aldehydes and amines from analytical testing suite. The rationale for their exclusion is that there is *'No evidence to point to their presence on site'*.

No remediation undertaken to date.

PSRAS (Table 1) has not been completed using appropriate data after remediation.

The following was stated by the developer/SLO for details of remediation that may affect intended pipe selection:

Further ground investigations required in the mill area of the site prior to finalising formal remediation strategy. Areas of the site previously investigated are to be remediated by the excavation of the area and removal of the buried tanks, sorting of the made ground material and subsequent capping with 600mm clean inert material.

Figure 37 Extract from developers GI,2012 report

The person directing the PSRA has been named and stated to be a Chartered Engineer (CEng) with the Institute of Structural Engineers (M.I.Struct.E).

To support the intended use of PE pipe material the developer concluded '*The Phase 1 and Phase 2 works have not identified any evidence of contamination by determines listed in Table 1 within the ground*'.

The developer also provided a completed PSRAS, presented in **Figure 38**, populated with EGM GI data

No exceedances of the PE threshold were identified on the developer's PSRAS.

PE pipe materials are proposed.

All concentrations in mg/kg								
Test Group	Testing Required?	PE threshold	Metal Pipes/ Barrier Pipe	Laboratory Detection Limit	Testing UKAS accredited Y/N	Maximum concentration at proposed pipeline depth See Note [2]	Maximum site concentration See Note [3]	Locations and depths where concentrations exceed proposed pipeline threshold
Total VOCs	Where Preliminary Risk Assessment (PRA) has identified land potentially affected by contamination	0.5	Pass			Not identified by initial risk assess		
Total BTEX & MTBE		0.1	Pass	0.01	Y	0.055	0.055	None
Total SVOCs (excluding PAHs and those substances marked with an *)		2	Pass			Not identified by initial risk assess		
EC5-EC10 aliphatic and aromatic hydrocarbons		2	Pass	0.01	Y	<0.01	<0.01	None
EC10-EC16 aliphatic and aromatic hydrocarbons		10	Pass	1.0	Y	<1.0	<1.0	None
EC16-EC40 aliphatic and aromatic hydrocarbons		500	Pass	1.0	Y	<1.0	<1.0	None
Phenols* (from SVOC analysis)		2	Pass			Not identified by initial risk assess		
Cresols and chlorinated phenols* (from SVOC analysis)	Only where identified	2	Pass			ditto		
Ethers*		0.5	Pass			Not identified by initial risk assess		
Nitrobenzene*		0.5	Pass			ditto		
Ketones*		0.5	Pass			ditto		
Aldehydes*		0.5	Pass			ditto		
Amines		Fail	Pass			ditto		
Corrosive	Conductivity, Redox and pH	Pass	See Note [1]			ditto		

Figure 38 Extract of developer's PSRAS

Water Company recommendations

This water connection application was submitted to the WC on the 18/12/2012.

WC connection engineer referred this submission to specialist for review stating: "can you advise which pipe material to use. The developers risk assessment states PE, but after reading the report my opinion is BP"

Specialist recommendation:

PE pipe material is not considered suitable for the proposed development. Further consideration of free product is required before defaulting to BP, additional protection measures may be required. The following information (data gaps) were requested:

- VOC/SVOC analysis
- Groundwater quality chemical analysis
- Remediation Strategy
- Verification Report

This application was however resubmitted by SLO energetics on the 08/09/2014 the SLO proposal of PE was accepted by the WC.

Follow-up interview with connection engineer

An interview with the WC connection engineer was undertaken in January 2016 to discuss the outcome of this application and discuss the inconsistency in the database information.

The connection engineer stated they had not recognised that an initial application for the development had been submitted by the developer in 2012. They had reviewed the PSRA when it was submitted by SLO in support of the application in 2014. The connection engineer stated that they had accepted the recommendation of the PSRA due to fact that the PSRA had been completed by- or under the direction of a chartered professional. The connection engineer stated that although they recognised the risk assessor to hold chartered status that they did not have an appreciation of what the professional prefix stated in the PSRA was.

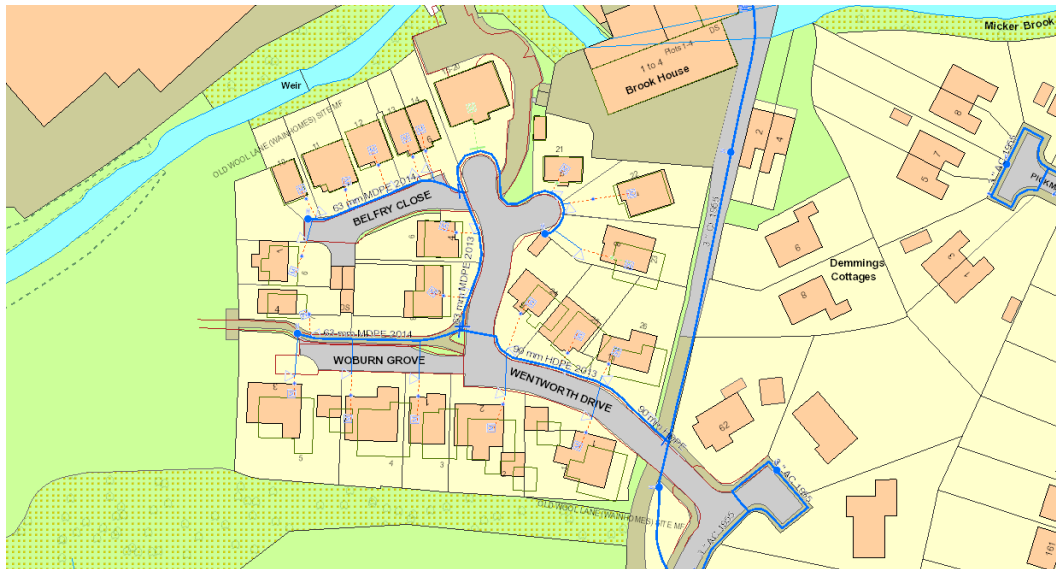


Figure 39 GIS utility mapping - Old Wool Road - Clean water asset map information (Key: Green assets indicate 'proposed' BP installations across the development [Accessed November 2015])

6.2.1 Case Study 1: Introduction

An appraisal has been undertaken of the supporting information. Other publically available sources of information has been drawn on primarily to validate the content of the developers supporting information and supplement the case study appraisal, as required. This appraisal has been prepared with reference to the following sources of information:

- GI, 2012 (draft Ground Investigation Report dated February 2012 'GI, 2012' represents combined phase1/2 report
- BGS website: Geology of Britain Viewer. Available at: <http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html>. [Accessed: 20 August 2014]
- EA website: What's in your backyard? Available at: <http://www.environment-agency.gov.uk/homeandleisure/37793.aspx>. [Accessed: 20 August 2014]

- Department of Environment Industry Profiles (DoE) (1995). Textile works and dye works [on-line]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/314253/scho0195bjlf-e-e.pdf [Accessed: 20 August 2014]
- DoE (1995). Chemical works: coatings (paints and printing inks) manufacturing works [on-line]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/290802/scho0195bjjy-e-e.pdf [Accessed: 20 August 2014]
- DoE (1995). Engineering works: electrical and electronic equipment manufacturing works [on-line]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/314089/scho0195bjkn-e-e.pdf [Accessed: 20 August 2014]
- Local Authority Planning pages website (Stockport Council) [on-line]. Supporting documentation for the proposed development submitted as part of the planning permission application for the scheme [Accessed: 20 August 2014]

6.2.2 Case Study 1: PRA

Site Setting

The site is a proposed residential development in England. A site location plan and existing [at time of writing] site layout (industrial estate N, recreational land S,SW) plan are presented as **Figure 40**



Figure 40 Site Location and existing layout plan (GI, 2012) (Aerial photography supplied by Getmapping PLC. © Copyright Getmapping PLC 2003. All rights Reserved)

Table 14 present a summary of desk study findings for the site following a review of historical mapping and additional sources of available information. The summary is consistent with the findings of the developer's GI,2012 report.

Table 14 Summary of desk study findings

Factor	Findings
Historical use	Site undeveloped until 1898. River meanders within western portion of the site. By 1961 channel has been straightened to run along the northern boundary of the site. The central and western portions of the site were occupied by filter beds and a possible lagoon (1898 – circa 1974). Two footbridges (1898 / 1910) from site to adjacent river bank, adjoining the site to an off-site print works (1898) / Dye & Bleaching Works (1910). Two small buildings occupied the central portion (1898). The site expanded and by 1961, the current site layout was present with buildings to the east. The site was occupied by an "Electronic Engineering works" and a "Print Ink Factory". Two large building occupy site to the east (since 1961).
Use of surrounding land	Land to the north, northwest (adjacent river bank) was occupied by a "Print works" (1898). The area is now referred to as an industrial estate / business park. A recreational golf course occupies land to the south and extensive residential housing to the east, southeast.

Factor	Findings
Geology (hydrogeology)	Superficial deposits comprise glacial till (unproductive aquifer) and alluvium (secondary A aquifer) associated with river to the north. Solid geology comprises of the Chester Pebble Bed Formation, which typically comprises pebbly sandstone (principal aquifer). Made ground is anticipated due to the sites past industrial use.
Hydrology	A river bounds the site to the north and has a water level at approximately 2.5m (GI, 2012).

Note:

1. Based on Ordnance Survey maps scale 1:10,000 and 1:10,560, dated 1897 to 2001 (GI, 2012)
2. BGS and EA website [Accessed August 2014]. Note the additional sources of information are consisted with that reported by the developer in the GI report 2012.

Table 15 Potential contaminants of concern

Land used	PCoC
Previous industrial use (on- and off-site) (refer to Table 14) Landfilling (infilling of historical on-site filter beds, lagoons and watercourse)	Hydrocarbon fuel, coal tar, lubricants, oils, metals, sulphates, chlorides, chlorinated solvents, non-chlorinated solvents, polyaromatic hydrocarbons (PAH), BTEX, polychlorinated biphenyls (PCB), acids and alkalis

Note:

1. Not all CoC listed are known to affect pipe material integrity or to permeate plastic pipe.
2. Historic site users have been identified as providing potential sources of contamination, DoE Industry profiles (1995) used to highlight PCoC.

A site walkover plan was provided, which identifies several potential fuel storage areas. **Figure 41**

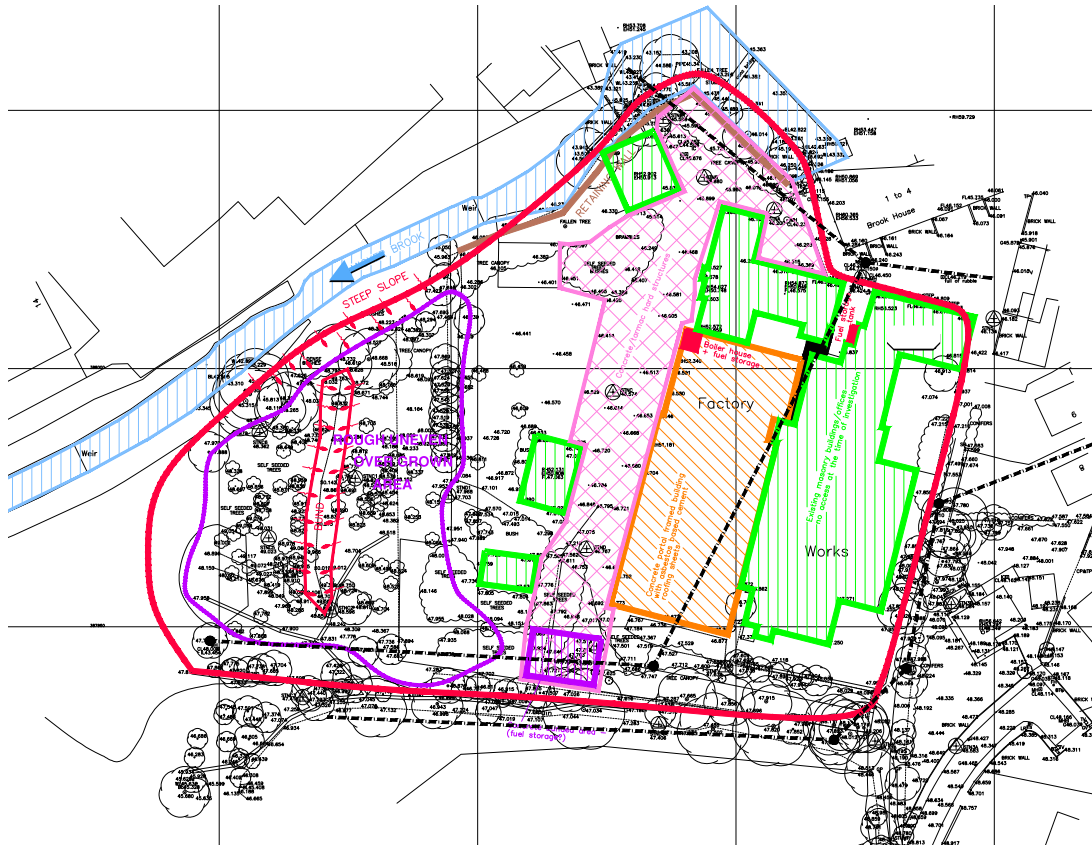


Figure 41 Site Layout and potential areas of concern (Appendix G – Walkover Survey Plan (GI, 2012))

The developer has identified several potential contaminant linkages based on the results of the DS and site walkover, which warranted further investigation. The PRA identifies the potential for contaminated soils and groundwater associated with on- and off-site sources, including fuel storage areas and previous industrial use.

The preliminary CSM undertaken by the developer considers the scheme as a whole and does not consider potential risk to water supply pipes as part of site assessment.

6.2.3 Case Study 1: GI

The site has undergone an intrusive GI. It is stated in the developer's report the "On the basis that the majority of the site is considered to have been subject

to industrial usage, the investigation locations have been spread over the whole site in accordance with the recommendation laid down in BS 10175: 2011 "Investigation Of Potentially Contaminated Site"". The initial GI strategy is also detailed in the GI report and is presented in **Figure 42**.

Exploratory Hole No.	Target	Purpose
WS1 – WS4	Inside open building areas	To determine the general nature of underlying soils and geology including: 1. Nature, distribution and thickness of made ground 2. Nature, degree and extent of potential contamination 3. Content of unacceptable material eg biodegradable matter etc. 4. Suitability of the ground for the founding of structures 5. Engineering properties of the ground
WS5 & WS6	Shallow ground conditions below bunded area	
TP1 – TP15	Investigate general ground conditions at shallow depth across site area	
BH1 – BH7A	General exploration of deeper ground conditions and environmental conditions	
BH1- BH4 BH6 & BH7	Gas monitoring wells installed	Installation of gas wells in deeper made ground in order to: 1. Monitor for hazardous gasses 2. Determine ground water levels 3. Obtain representative ground water samples (where possible)

Figure 42 Extract from developer's GI report – Initial Ground Investigation Strategy (GI, 2012)

The sampling strategy and testing programme design is not clearly defined in the developer's GI report however, in general consisted of the recovery and analysis of made ground and natural ground soil samples. PAH (USEAP 16), phenols; TPH CWG and BTEX.

No SVOC/VOC analysis or extended test group CoC were undertaken. The former uses of the site (Table 14) and the review of DoE Industry profiles would suggest that such contaminants may be present.

No leachate or groundwater analysis appears to have been undertaken by the developer.

Chemical laboratory data is available on selected samples ranging in depth 0.2m to 3.8m bgl.

Exploratory hole location plans are presented as **Figure 43**.

N.B. Exploratory holes marked in red represent historical holes. This data was not made available to the WC.

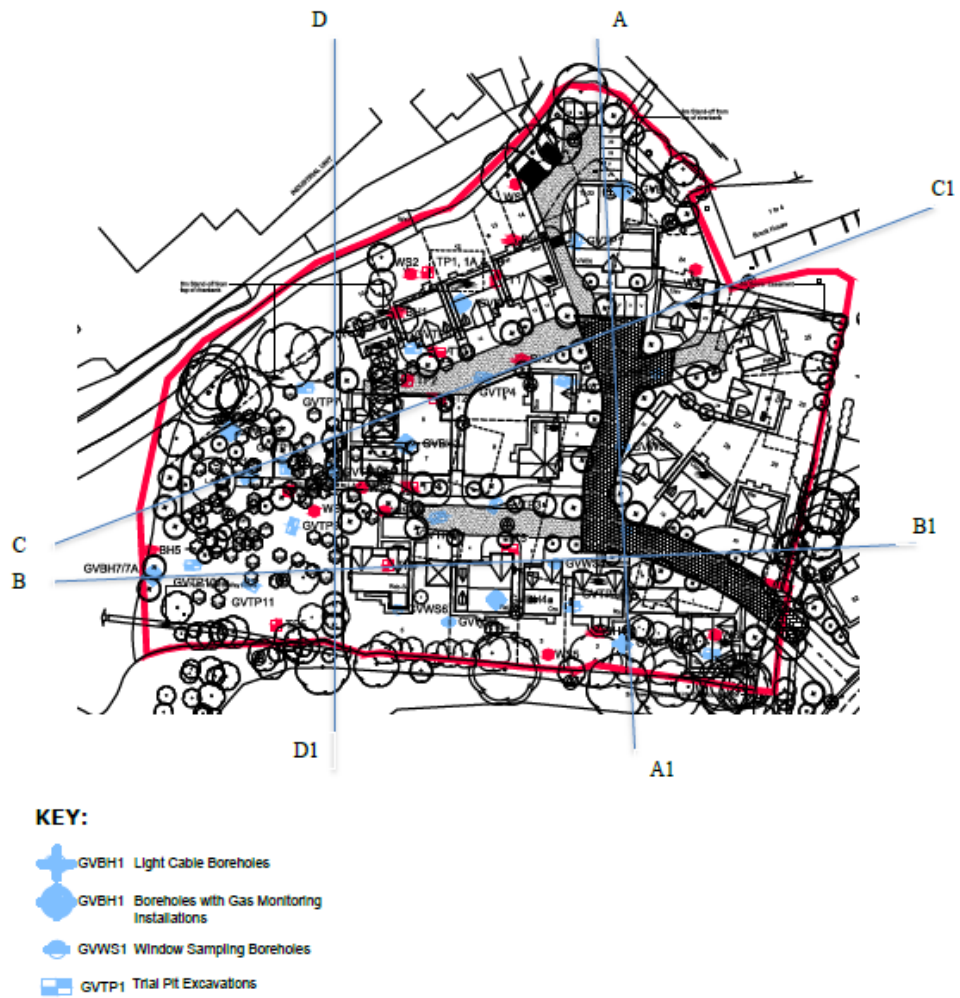


Figure 43 Exploratory hole location plan, section lines and proposed development layout (base drawing is taken from Appendix F – Ground Investigation Location Plan and proposed site layout (GI, 2012))

6.2.4 Case Study 1: Findings of the GI

Ground Conditions

Table 16 presents a summary of the typical stratigraphy based on the GI data.

Table 16 Summary of site stratigraphy

Material Description (Geological Unit)	Range of thickness of stratum (m)
Made ground	0.3 to 6.7
Glacial Till and Alluvium (interbedded clays, sands and gravels)	>0.2 to >8.95 (Base not proven in all location)
Chester Pebble Bed Formation, which typically comprises pebbly sandstone	>0.2 (Base not proven)

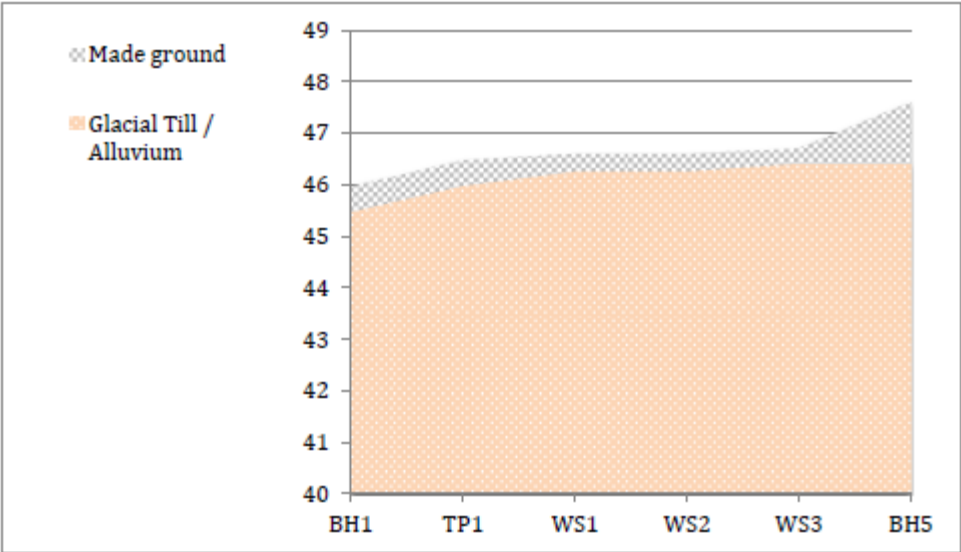
Geological cross-sections (Figure 45-48) have been developed to provide a good understanding of the subsurface geology prior to development and along the route of proposed water pipes. **Figure 43** identifies the representative cross-sections.

Water pipes are normally laid between 0.75m and 1.35m from the finished ground level to crown of pipe. The Site final finish level has not been provided on the site layout plans for the scheme.

Therefore, the ground conditions between surface level and 1.5m shall be considered as a minimum.

In addition, ground elevations (meters above ordnance datum (mAOD)) and exploratory hole coordinates were absent for BH logs. Elevations have been taken from a topographical survey plan available on planning pages [on-line].

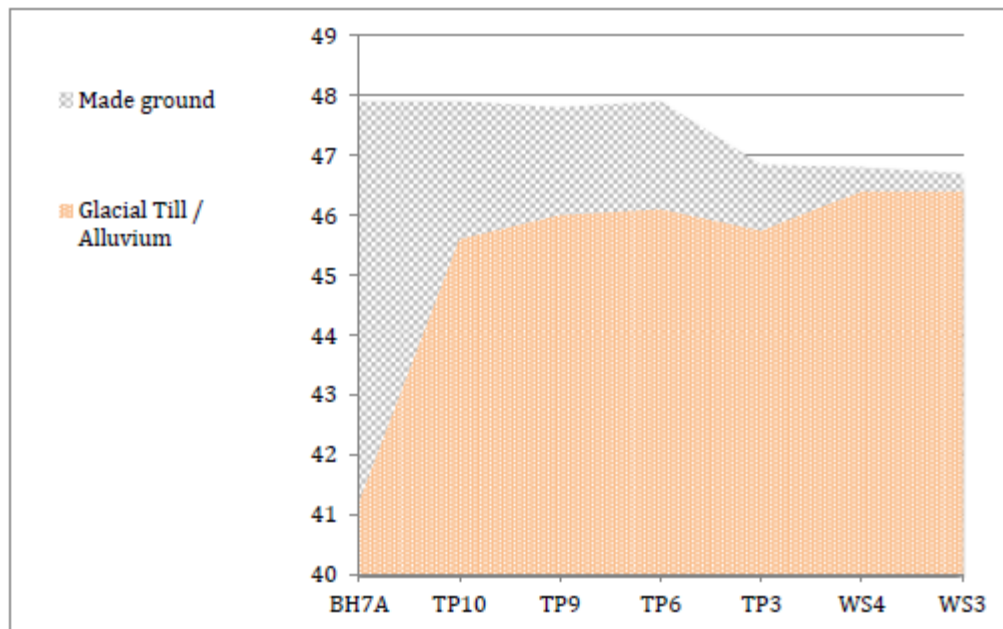
Material	Description
Made Ground	Concrete GL - 0.18 (WS1, WS2, WS3, TP1). Generally soil ash, brick, stone fill.
Superficial deposits	Interbedded SAND and GRAVEL, and firm sandy CLAY



Note: Vertical axis values represent elevations (mAOD)

Figure 44 Geological cross-section A-A1

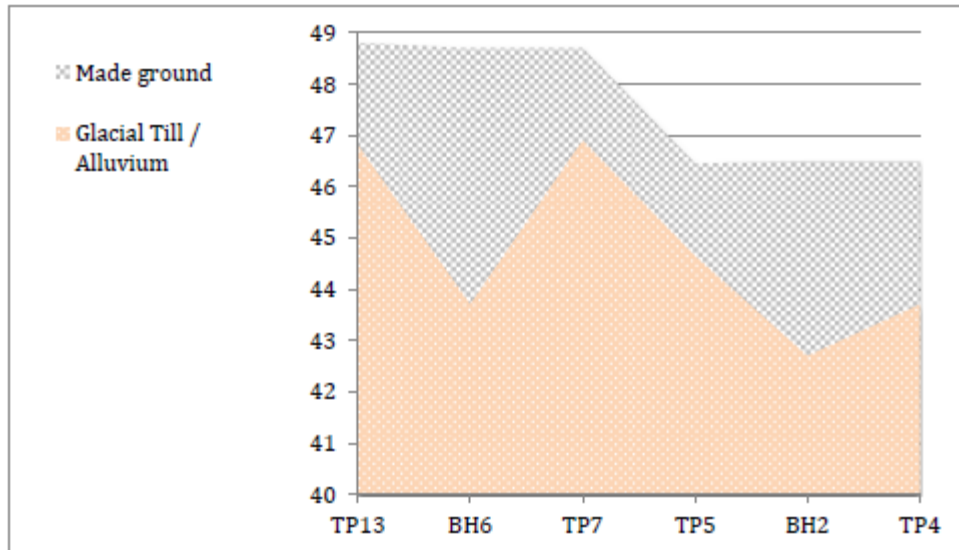
Material	Description
Made Ground	Concrete and stone fill (WS3 & WS4). Generally black soil fill with occasional clay, brick, tarmac and concrete. Fragments of metal, bottles and pipes (TP9) Patches of blue, purple, red and green chemical waste (TP9). Obstruction encountered at 1.8m bgl (TP9)
Superficial deposits	Interbedded coarse SAND and sandy CLAY



Note: Vertical axis values represent elevations (mAOD)

Figure 45 Geological cross-section B-B1

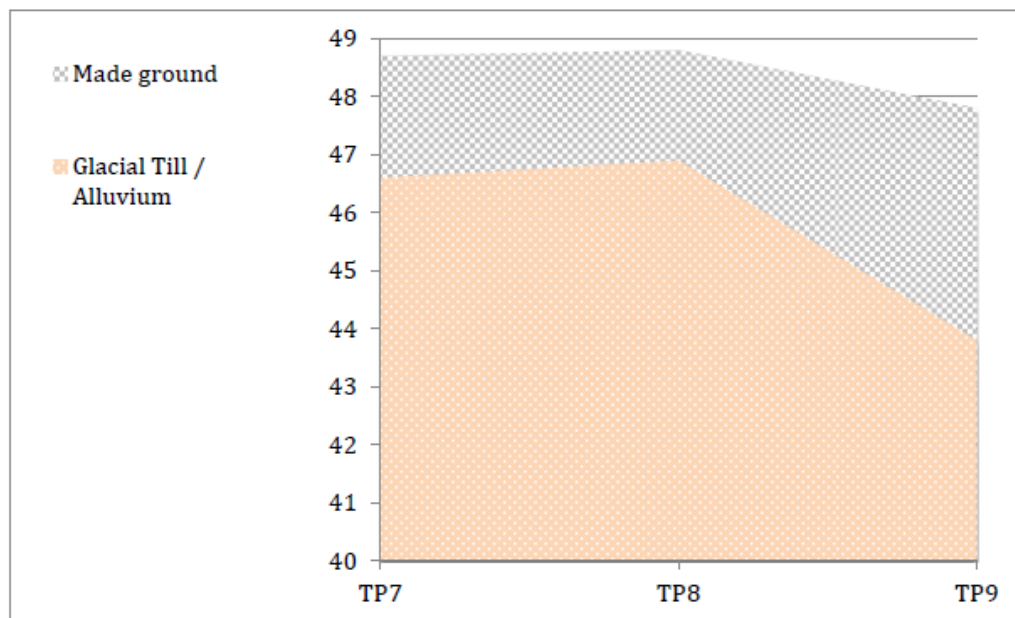
Material	Description
Made Ground	Generally black soil fill with occasional ash, brick, concrete, sandstone, plastic, copper wire, rubber (TP5) Rubber tyre, metal, brick foundation (TP13) Patches of red/purple chemical waste (TP5, TP4)
Superficial deposits	Interbedded dense SAND and GRAVEL and stiff sandy CLAY



Note: Vertical axis values represent elevations (mAOD)

Figure 46 Geological cross-section C-C1

Material	Description
Made Ground	Generally black soil fill with occasional clay, brick, tarmac and concrete. Fragments of metal, bottles and pipes (TP9) Patches of blue, purple, red and green chemical waste. Obstruction encountered at 1.8m bgl (TP9)
Superficial deposits	Medium SAND (TP7), stiff CLAY (TP8)



Note: Vertical axis values represent elevations (mAOD)

Figure 47 Geological cross-section D-D1

Based on the available existing ground condition data it appears the proposed water pipes would be laid within made ground and natural superficial strata. However, the developer's PSRA and GI,2012 suggestion site remediation is proposed that could affect existing site conditions.

6.2.5 Case Study 1: GQRA

Chemical test data presented in the GI report have been reviewed and used to complete a PSRAS. **Table 17** presents author's updated PSRAS.

The PSRAS, based on the available data, identified all test groups (where testing is available) to exceed the PE threshold. This significantly contradicts

the developer's PSRAS (presented as **Figure 38**), where no contaminant concentrations which recorded to have exceeded

Table 17 Updated PRSA (Case Study 1)

All concentrations in mg/kg								
Test Group	Testing Required?	PE threshold	Metal Pipes/ Barrier Pipe	Laboratory Detection Limit	Testing UKAS accredited Y/N	Maximum concentration at proposed pipeline depth See Note [2]	Maximum site concentration See Note [3]	Locations and depths where concentrations exceed proposed pipeline threshold
Total VOCs	Where Preliminary Risk Assessment (PRSA) has identified a level potentially affected by contamination	0.5	Pass	0.1	Y	2.2 (TP4@0.25) Naphthalene	130 (DH7@1-1.45) Naphthalene	13 (DH13@0.2), 0.6 (DH17@0.2), 1.4 (DH14@1-1.45), 2.1 (DH14@0.2), 1.6 (TP3@0.3), 2.2 (TP4@0.25) Naphthalene only in absence of VOC Analysis
Total BTEX & MTBE		0.1	Pass	0.001	Y	0.561 (DH11@0.5)	0.561 (DH11@0.5) (Sum Benzene 0.55 & Toluene 0.011)	see max column
Total SVOCs (excluding PAHs and those substances marked with an *)		2	Pass	N/A	N/A	Not tested	Not tested	Not tested
EC5-EC10 aliphatic and aromatic hydrocarbons		2	Pass	0.01	N	21.4 (DH13@0.5)	21.4 (DH13@0.5)	4.2 (DH11@0.5)
EC10-EC16 aliphatic and aromatic hydrocarbons		10	Pass	1	N	405 (DH13@0.5)	405 (DH13@0.5)	30 (DH13@0.7), 14 (DH14@0.2)
EC16-EC40 aliphatic and aromatic hydrocarbons		500	Pass	1	N	1374 (DH13@0.7)	1374 (DH13@0.7)	see max column
Phenols* (from SVOC analysis)		2	Pass	1	Y	0 (TP5@0.1)	0 (TP5@0.1)	see max column
Cresols and chlorinated phenols* (from SVOC analysis)		2	Pass	N/A	N/A	Not tested	Not tested	Not tested
Ethene*	Only where identified	0.5	Pass					
Nitrobenzene*		0.5	Pass					
Ketones*		0.5	Pass					
Aldehydes*		0.5	Pass					
Amines		Fail	Pass					
Corrosive	Conductivity, Redox and pH	Pass	See Note [1]				N/A	N/A - PE proposed

6.2.6 Case Study 1: Discussion

Sources of contamination

The GI report has identified made ground associated with the former use of the site as a works (print works / electrical engineering works) to the east, and as former filter beds to the central and western site area.

As the GI report has identified, it is likely that the former on-site filter beds are associated with the industrial surroundings, including discharge from the bleach and dye works identified to occupy the adjacent site. This is further highlighted by the trial pit logs, which indicate 'chemical waste' located in TP04 (0.70 – 2.80m bgl +), TP5 (GL- 0.3mbgl, and TP09 (GL – 1.80m bgl +).

Based on the former use of the site and the potential CoC associated with such land-uses, both the basic and extended test group analysis would be required with reference to the requirements UKWIR2010/Water UK guidance.

The extended test groups are potential CoC associated with dyeing works and dye manufacture (e.g. methylethylketone(MEK), formaldehyde, acetone etc.)

The WC specialist, following the first application in 2012, had queried the absence VOC/SVOC testing and advised such testing should be requested to inform the PSRA. The need for the extended test suite was not recognised by the WC. No shortcomings were identified as part of the later submission.

The developer has considered the exclusion of VOC/SVOC extended analytical testing suite. The rationale for their exclusion is that there is '*No evidence to point to their presence on site*'. However, the evidence presented in the desk-based review (PRA) for the site suggests otherwise.

RA for water pipes

The PSRAS provided to the WC, by the developer, has been completed incorrectly. **Figure 38** presents developer PSRAS. **Table 17** presents updated PSRAS. The developer's risk assessor identified no contaminant concentrations above PE threshold whereas all test group CoC tested exceeded the threshold.

The RA has been undertaken incorrectly despite the assessor being a chartered professional as required by the guidance. The assessor is identified as a CEng with the Institute of Structural Engineers and therefore may not necessarily have relevant experience of investigating land contamination. As a chartered professional however, knowing your knowledge limitations is a key component of professional ethics. During the case study follow-up interview it was clear that the water connection engineer did not fully appreciate what the professional prefix 'M.I.Struct.E' referred.

Furthermore, the developer's PSRSA states groundwater has been encountered at 2.0m below ground level. The minimum depth encountered with the GI,2012 was 0.76m bgl (BH4) at this depth shallow groundwater will likely intercept the proposed pipework depth. No groundwater quality chemical analysis has been presented. Based on the requirements of UKWIR2010/Water UK groundwater testing would be required to demonstrate absence of CoC to water pipe materials.

Sampling and testing of groundwater is provided as a further works recommendation within the developer's GI report (GI, 2012) this however has not been clearly communicated to the WC as part of the water connection application.

Based on the evidence presented by the developer potentially unacceptable risks to the proposed PE have been established. There is insufficient evidence presented that would justify discounting contaminated linkages identified. The contaminated linkages illustrated in Figure 13 are potentially applicable in this site scenario.

PE has been recognised as not suitable for use at the site by the WC in the earlier submission however when submitted by the SLO in 2014, the PSRA was accepted by WC due to the PSRA being completed by a Chartered Professional.

Following the requirement set out in the Water UK protocol which states "Liquid free phase product (e.g. oil or free solvent layers) shall not remain in the ground or groundwater in the vicinity of water pipes, whether barrier pipe or any other pipe materials are used". It could be argued in this case that there is insufficient information to warrant the default position of barrier pipe. Based on the supporting information provided both qualitative and quantitative information, the presence of free phase product (e.g. oil or free solvent layers) cannot be discounted in the soil or groundwater.

Further GI and remediation was identified as required by the developer at the site. The ground data used in the assessment of risk to water pipes therefore may not be representative of the final ground conditions following remedial works.

Due to the existing ground conditions at this site the WC's acceptance of PE is not appropriate and even a default use of BP would be questionable. It may have been appropriate in this case for the WC to either;

1. Request a refined RA utilizing remediation validation data and based on final levels to allow the use of PE; or

2. Request a RA to demonstrate the absence free phase product through validation data to allow the use of BP (or PE).

6.3 Case Study 2 Elizabeth Street

The WC received a water connection application for a new housing development. The developer proposed the use of BP materials on the site.

Figure 48 presents developer/SLO water pipe design proposal.



Figure 48 Developer/SLO Water Pipe Design Proposal (drawing Ref - CU-ES-01)

The developer provided a Water UK PSRA however each section of the RA was mostly absent of information and referred the reader to supporting reports “see Geotechnical Survey”.

Supporting information provided as part of the application included:
Geoenvironmental Investigation and Risk Assessment report, 29 June 2007
(Combined Phase 1/Phase 2 report including factual ground investigation data,

exploratory borehole location plan, coal authority report and local authority landfill search correspondence).

Pipe design drawing Ref - CU-ES-01

Overview of site details presented in the PSRA undertaken by developer/SLO and/or their consultants

The developer does confirm that land potentially affected by contamination has been identified by desk study / site walkover and that site investigation was undertaken on the 29/06/07. It should be noted however that the protocol declaration was completed and the application submitted to WC in November 2013.

A Technical Director of an Environmental Consultancy, stated to hold the following qualifications - PhD, BSc. MEnvSc CSci, was named as the person directing the risk assessment of water. The risk assessment was stated to have been performed on the 29/06/07 (note: the date of the performed risk assessment is consistent with the date of the Combined Phase 1/Phase 2 report however the named risk assessor is not the author of the Combined report).

The RA Declaration was signed by a representative from a Construction company and dated 13/11/13. No job title or qualifications were specified.

The following statement was included in Section 6 of the protocol "Proven barrier against all recognised brownfield contaminants". Section 6 Additional Information of the protocol allows the risk assessor to provide additional details to support the intended pipe selection.

The developer submitted a supporting Combined Phase 1/Phase 2. Limited information was presented within the PSRA and the developer did not complete the PSRAS (Table 1 of the Water UK protocol)).

Water Company recommendations

The application was referred by the WC connections engineer to a specialist consultant to determine if any measures are required in addition to the use of BP because of the "high levels of contamination".

Specialist recommendation:

PE pipe material is not considered suitable for the proposed development as numerous hydrocarbon exceedances were observed. The specialist noted the absence of VOC/SVOC testing, which cannot be discounted based on the sites former use as a landfill. No further information however was requested of the developer.

BP within inert service corridors was the final recommendation of the WC.

6.3.1 Case Study 2: Introduction

An appraisal has been undertaken of the Combined Report (2007) and other publically available sources of information has been drawn on to supplement the site appraisal including:

- Manchester City Council Planning Permission search website [on-line]. Available at https://www.manchester.gov.uk/info/200074/planning/5865/planning_permission [Accessed: 07 November 2015]. Supporting documentation for the proposed development submitted as part of the planning permission application (reference 084498/FO/2007/N1) for the scheme.

Legal and Planning Status - Additional source of information

Conditional planning permission has been granted for the proposed housing development.

The development application was validated on the 17th October 2007 however planning decision date was recorded to be on 25 August 2010.

It should be noted here that the planning permission is stated to expire on 25 August 2013 the water connection application was submitted in December 2014.

Land contamination management documentation available on the planning pages is the Combined Report, 2007 which was provided as supporting

information to the WC. No other land contamination reports are available on the planning pages.

The planning permission for the development is subject to 19 Conditions, one of which is associated with land contamination management. An extracts of the planning condition is presented below:

Condition 6 a and b *(Extract from local planning decision notice, 2010)*

6) a) Before the development hereby approved commences, a report (the Preliminary Risk Assessment Desk Study) to identify and evaluate all potential sources and impacts of any ground contamination, groundwater contamination and/or ground gas relevant to the site shall be submitted to and approved in writing by the City Council as local planning authority. The Preliminary Risk Assessment shall conform to City Council's current guidance document (Planning Guidance in Relation to Ground Contamination).

The Desk Study shall be prepared by a suitably qualified person whose competence to carry out the Desk Study has been approved in writing by the City Council as local planning authority (an "Expert").

In the event of the Preliminary Risk Assessment Desk Study identifying risks which in the written opinion of the Local Planning Authority require further investigation, the development shall not commence until a scheme for the investigation of the site and the identification of remediation measures (the Site Investigation Proposal Scheme) has been submitted to and approved in writing by the City Council as local planning authority.

The measures for investigating the site identified in the Site Investigation Proposal Scheme shall be carried out, by an Expert before development commences and the Expert shall prepare a report prepared outlining what measures, if any, are required to remediate the land (the Site Investigation Report and/or Remediation Strategy) which shall be submitted to and approved in writing by the City Council as local planning authority.

b) When the development commences, the development shall be carried out in accordance with the previously agreed Remediation Strategy. Site Investigation Report and a Completion/Verification Report shall be submitted to and approved in writing by the City Council as local planning authority.

In the event that ground contamination, groundwater contamination and/or ground gas, not previously identified, are found to be present on the site at any time before the development is occupied, then development shall cease and/or the development shall not be occupied until, an Expert has prepared a report outlining what measures, if any, are required to remediate the land (the Revised Remediation Strategy Site Investigation Report) which shall be submitted to

and approved in writing by the City Council as local planning authority and the development shall be carried out in accordance with the Revised Remediation Strategy Site Investigation Report, which shall take precedence over any Remediation Strategy Site Investigation Report or earlier Revised Remediation Strategy Investigation Report.

There is no correspondence on the planning pages which suggest that the pre-commencement land contamination risk assessment requirements, required to satisfy Condition 6a) and b), have been undertaken by the developer (or their consultants) to discharge the Conditions.

6.3.2 Case Study 2: PRA

Site Setting

Proposed residential development in Cheetham Hill, Manchester, England.

Site historically used for clay extractions and subsequently infilled (Landfill).

The walkover was undertaken in March 2007. The site is reported as a derelict parcel of land occupied by a security bund of soil and hardcore material (northeastern boundary), with overgrown scrub vegetation and concrete hardstanding associated with relict structures. Fly tipping was observed.

The consultant's report identifies the potential for organic contaminants of concern as polycyclic aromatic hydrocarbons (PAH) and petroleum hydrocarbons to be present based on the site and its surroundings former industrial uses. In particular, contamination possible due the site being

previously infilled (with unknown material) and the unknown nature of the on-site workshops

The Consultant's report specifically considers the potential risk of tainted water supply by organic contaminants.

Potential pollutant linkage 6 refers to the contaminants permeating potable water pipes and consumption by the future residents of the tainted water supply. This linkage is also considered possible.

Figure 49 Extract from developer's Combined Phase 1/Phase 2 report– Preliminary CSM – Pollutant linkage associated with water supply identified

The preliminary CSM undertaken by the developer's consultant considers the scheme as a whole but also considers potential risks to potable water supply. Unfortunately, due to the date the RA has been completed reference has been made to the former WRAS guidance rather than UKWIR2010/Water UK.

6.3.3 Case Study 2: GI and findings

Investigation Design

The site has undergone an intrusive ground investigation *"in order to investigate the potential pollutant linkages identified in the preliminary contamination conceptual model"* (Combined Report 2007 p. 12). The investigation was undertaken in April 2007.

The sampling strategy is stated to have been undertaken in accordance with BS 10175, which is consistent with the requirement of the UKWIR2010/Water UK. A grid spacing of 15 – 20m between sampling points was undertaken. The exploratory positions are presented on **Figure 50**. The report identifies areas of targeted investigation as presented in **Figure 51**.

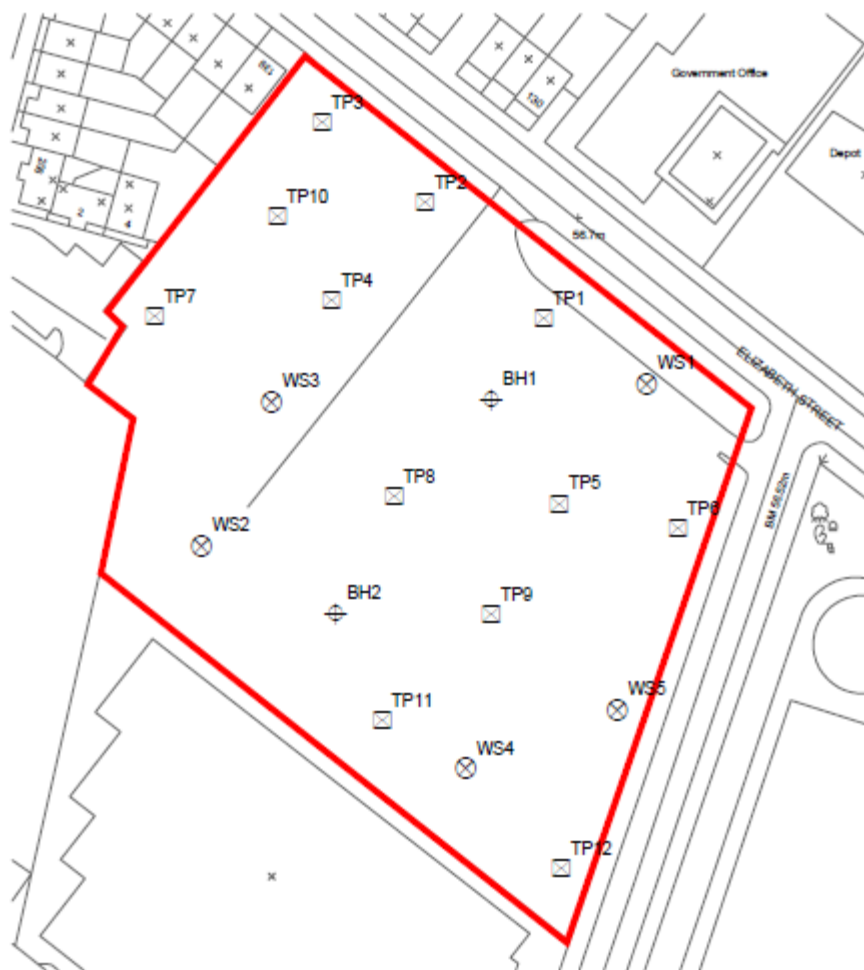


Figure 50 Exploratory hole location plan (Combined Report 2007)

Present/Formal Land Use	Borehole/Trial Pit Reference
Former terraced houses in northwestern corner	TP2, TP3
Tipped Area	BH1, BH2, WS2, WS3, WS4, WS5, TP5, TP6, TP8, TP9, TP11, TP12
Workshops	WS3, TP4, TP7, TP10

Table 6-1. BH and TP locations targeted to potential point sources of contamination

Figure 51 Extract from Combined Report 2007 presenting the Consultants targeted sampling strategy

The testing is absent of total SVOC/VOC, phenols, and cresols and chlorinated phenols. TPH CWG, PAH, BTEX/MTBE analysis has been undertaken at exploratory location and sample depth presented in **Figure 52**.

Sample Identity	Depth (m)
BH 1	0.70
BH 1	4.00
BH 2	0.60
TP 1	0.50
TP 2	0.30
TP 3	0.10
TP 4	0.40
TP 5	0.60
TP 6	0.35
TP 6	0.90
TP 7	0.40
TP 7	1.20
TP 8	0.60
TP 9	0.55
TP 10	0.20
TP 11	0.40
TP 12	0.20
WS 1	0.40 - 0.50
WS 1	2.50
WS 2	0.50
WS 3	0.30 - 0.40
WS 3	2.20 - 2.30
WS 4	0.40 - 0.50
WS 4	3.00 - 3.20
WS 5	0.50 - 0.60

Figure 52 Extract from Combined Report 2007 sampling and chemical analysis depths.

Groundwater testing was undertaken. The testing included TPH, BTEX and PAHs.

Made ground associated with the former use of the site as a clay/landfill and evidence of imported fill/made ground was recorded in the majority of the exploratory holes to a maximum depth of 7.4m bgl. Hydrocarbon odours were recorded in the exploratory locations presented as **Figure 53**.

Borehole/Trial Pit Reference	Depth olfactory evidence of hydrocarbons noted (m)
WS2	Various depths throughout
WS3	2.0-2.5
WS4	2.7-4.0
WS5	0.5-0.9
BH1	0.5-3.7
BH2	1.4-2.7 and 4.1-6.2
TP5	0.7-1.4
TP6	0.15-0.6 and 0.8-1.1
TP7	0.8-1.6 and 1.6-2.4
TP8	0.8-1.6
TP9	1.6-2.7
TP11	0.1-0.6 and 1.0-2.5
TP12	1.3-2.1

Figure 53 Extract from Combined Report 2007 presenting a summary of the depths of visual/olfactory evidence of hydrocarbon contamination

Groundwater levels encountered at a minimum depth of 4.2m bgl which is consisted with the levels stated in PSRA.

6.3.4 Case Study 2: GQRA

The consultant's report identifies organic contaminants above the pipe line assessment criteria. The WRAS criterion however was used in the assessment of risk. The pollutant linkage identified during PRA has been demonstrated a valid (presented as **Figure 54**) through GI and RA. A recommendation for the installation of a protective water supply pipe and sterile trenches was also specified.

Pollutant linkage 6 relates to the potential for contaminants on site to permeate potable water supply pipes and for contaminants to affect those installing the pipes. Levels of heavy metals, PAHs and petroleum hydrocarbons are above the pipe line assessment criteria set by United Utilities¹². Therefore, protective water supply pipes and sterile trenches will be required where pipes are to be installed in the made ground.

Figure 54 Extract from developer's Combined Phase 1/Phase 2 report– Generic CSM – Pollutant linkage associated with water supply identified

6.3.5 Case Study 2: Discussion

Timeline

The investigation was undertaken in April 2007 this is 7 years prior to the water connection application. The WC (or their specialist) did not question the date of the supporting investigation and RA works in comparison to the application date. UKWIR2010 guidance recommends that site assessment produced more than 3 years prior to submission should be redone

Due to the site being a disused parcel of land prior to its proposed development and evidence of fly tipping identified during the consultant's site walkover in 2007, should the WC have requested the RA be revisited and evidence of the sites condition at time of submission [November 2013] be demonstrated by the developer? This may have been in the form of more recent site walkover survey with photographic evidence or alternatively trench inspection prior to installation.

The supporting information RA report consider the risk of tainted water supply by ground contamination and considers this potential pollutant linkage in the GI design. Due to the date of the report the WRAS guidance was referenced. It may have been advisable that the WC request the developer to provide an update PSRA following current guidance for completeness.

It does however appear that the WC has undertaken this appraisal on behalf of the developer by referring the application to a land contamination specialist for review prior to acceptance of the pipe design proposal for BP. This approach could be considered a pragmatic approach by the WC however it could also be considered as an inconsistent approach as for other application cases the developer has been asked to provide additional information or to provide an updated Water UK PSRA [evidence identified during database development and discussed in Chapter 5, Table 12].

Further research in to the progress of the case study with the WC connection engineer and through the review recent utility records [accessed November 2015] indicates that this development did not progress beyond the planning stages. The referral of the application to a specialist would have been at the

cost of the WC, and not reimbursable by connection fees, a check of report dates and reference to the planning permission which had expired may have prevented this additional spend.

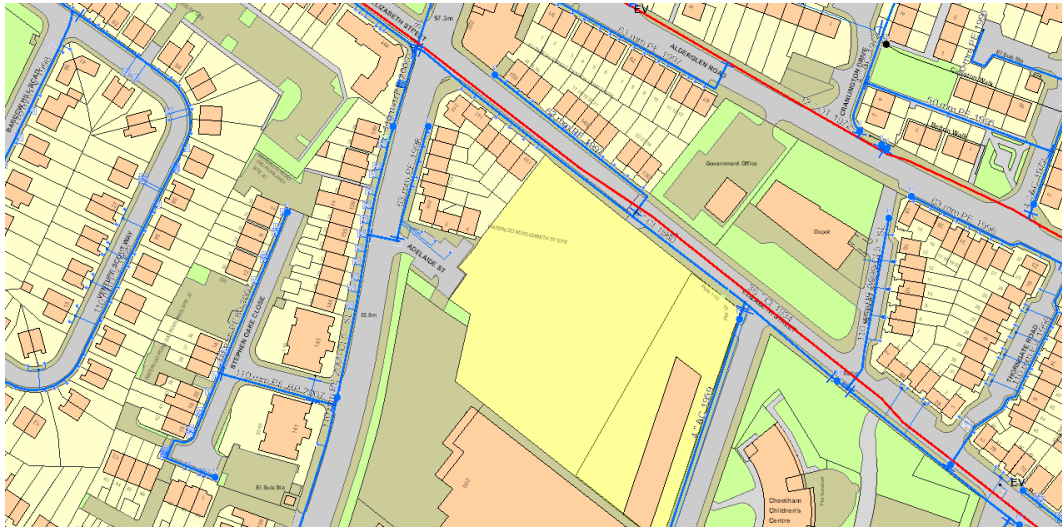


Figure 55 GIS mapping - Elizabeth Street site – Clean water asset map information (Key: yellow indicates no clean water asset records)

6.4 Case Study 3 Rigby Road (East Site and West Site)

The WC received a water connection application for a new predominately residential housing development with limited commercial properties and areas of public open space) on a site formerly used as a gas works. The Site consists of two development areas the East-Site and the West-Site. The developer proposed the use of PE materials on the site(s).

The developer provided a PSRA (signed by a C.Geol) and supporting information of a Verification report (Verification Report for Remediation Enabling Works, Phase 1 East Site, Phase 1 & 2 West Site, Site Reference No.582, dated 29/11/2013 ' VR ') for remediation. Appended to the VR was a factual report dated 2013.

Remediation scope:

-supplementary GI (to assess existing ground materials);

- made ground turnover
- removal of obstructions, structures and redundant services;
- treatment/removal of contamination hotspots identified during previous investigations, during supplementary GI and during made ground turnover.

The VR, 2013 states the primary objective of the remediation works is as follows (Verification Report 2013, p.1):

The primary objective of the remediation works is to reduce the risks posed by contaminated and to future site users and the environment to an acceptable level. This report provides comprehensive detail of the works undertaken, demonstrating compliance using appropriate lines of evidence, to render the site suitable for use of residential properties with gardens.

The PSRA is not specifically considered in the remediation strategy for the scheme or by the VR or the Factual report 2013.

Overview of site details presented in the RA for Water Pipes undertaken by developer and / or their consultants

The PSRA was completed by- or under the direction of a Chartered Geologist (C.Geol).

All sections of the protocol were completed. The following was confirmed as part of the application:

Both site areas has have had a history of contaminative uses. This includes the former use as a Gas Works.

The site has been remediated as appropriate for its endues as housing – this includes the removal of any free product tanks, below ground structures and hotspots of contamination, processing (removal of oversized, soft and hard material) and re-engineering of made ground soils insitu, and site subsequently covered by a 800mm clean cover (including 200mm capillary break layer and 600mm clean cover

GI was completed in August 2013 with on-going site validation testing

Groundwater was encountered at 0.5 to 3.0m below ground level

Section 3 'Intrusive Site Investigation' section of the Water UK protocol asks the risk assessor to provide rationale behind the use of PE where the intrusive site investigation has identified concentrations above the PE threshold in Table 1 PSRAS. The risk assessors states:

The site has been remediated and then a cover layer placed over the remediated materials. The cover layer comprises a 200mm capillary break over a minimum 600mm clean cover.

Assessment of the proposed pipe level indicates that the majority of pipes will be within the cover layer materials with only localised pipes extending beneath this into the remediated soils. However, assessment of all soils, including those within 500mm of the underside of the pipe indicates that some soils fail the PE threshold.

In order to ensure that these do not impact to the PE pipe it is proposed to install the pipes within clean service corridors, with the clean materials placed to a minimum depth of 500mm beneath the underside of the pipe.

PSRAS was populated indicating all basic test group CoC were undertaken. The risk assessor states that no source of extended testing suite was identified & therefore not tested and metal pipes are not proposed therefore metal pipe (MP) testing was not undertaken.

EGM, RM and IM (capping materials) were tested to populate Table 1 PSRAS. Refer to **Figure 56**.

Table 1 - Pipe Selection Risk Assessment Summary (PSRAS)								
1) Testing must be undertaken on the materials within which the pipes are to be laid, whether that be existing ground materials, remediated materials or imported capping materials. Please use the appropriate testing data to complete Table 1 below.								
2) If more than one pipe selection is being made, for example, for pipes in different areas of a large site, a completed PSRAS is required for each selection.								
What materials have been tested to populate Table 1 below?				☒ Existing ground materials ☒ Remediated materials ☒ Imported capping materials				
All concentrations in mg/kg								
Test Group	Testing Required?	PE threshold	Metal Pipes/ Barrier Pipe	Laboratory Detection Limit	Testing UKAS accredited Y/N	Maximum concentration at proposed pipeline depth See Note [2]	Maximum site concentration See Note [3]	Locations and depths where concentrations exceed proposed pipeline threshold
Total VOCs	Where Preliminary Risk Assessment (PRA) has identified and potentially affected by contamination	0.5	Pass	0.3	Y	29	29	O10 - 1.25m
Total BTEX & MTBE		0.1	Pass	0.01	Y	0.11	0.11	O9/1 1.0
Total SVOCs (excluding PAHs and those substances marked with an *)		2	Pass	0.1	Y	29	29	O10 - 1.25m
EC5-EC10 aliphatic and aromatic hydrocarbons		2	Pass	0.01	Y	<0.01	<0.01	NA
EC10-EC16 aliphatic and aromatic hydrocarbons		10	Pass	0.1	Y	20	20	W11/1 0.5
EC16-EC40 aliphatic and aromatic hydrocarbons		500	Pass	0.1	Y	683	683	V11 0.9
Phenols* (from SVOC analysis)		2	Pass	0.2	Y	11.8	11.8	T16/1 0.8
Cresols and chlorinated phenols* (from SVOC analysis)		2	Pass	0.3	Y	11.8	11.8	T16/1 0.8
Ethers*	Only where identified	0.5	Pass	N/A	N/A	N/A	N/A	N/A
Nitrobenzene*		0.5	Pass	N/A	N/A	N/A	N/A	N/A
Ketones*		0.5	Pass	N/A	N/A	N/A	N/A	N/A
Aldehydes*		0.5	Pass	N/A	N/A	N/A	N/A	N/A
Amines		Fail	Pass	N/A	N/A	N/A	N/A	N/A
Corrosive	Conductivity, Redox and pH	Pass	See Note [1]	N/A	N/A	N/A	N/A	N/A

Figure 56 Extract of Developer's completed PSRAS

WC recommendations

The WC accepted the developer's proposal and considered the installation of PE materials acceptable within clean service corridors compliant with the PE

threshold values, with clean materials placed to a minimum depth of 500mm beneath the underside of the pipe.

The WC however noted areas of the site which could not be remediated due to geotechnical access constraints. This information was presented in the supporting information to the application and not outlined in the PSRA. This includes all features within 1m of the site boundary and within 1m of the Seaside's Way Retaining wall (East Site). The WC recommended the use of BP in areas where a clean service corridor is not possible (i.e. within 1m of the site boundary and/or within 1m of the Seaside's Way).

The WC states if clean pipe corridors are not utilised for potable water PE supply pipes at the site, BP will be required to protect against any future impact to the pipe material.

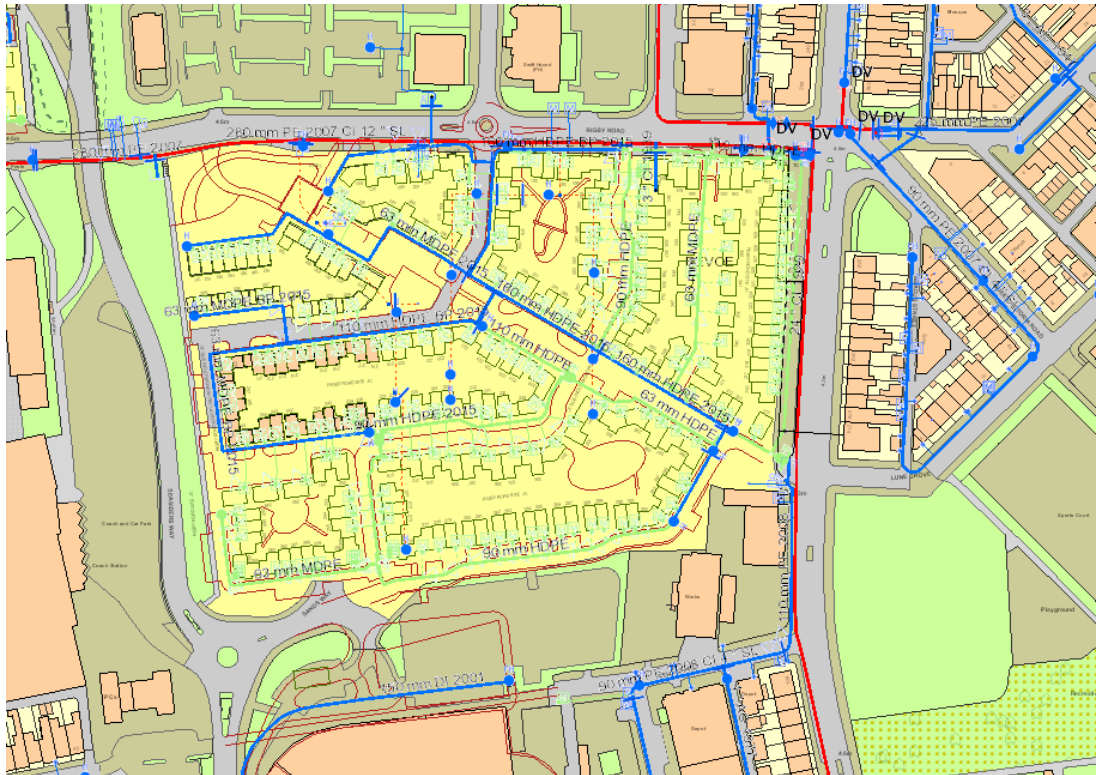


Figure 57 GIS mapping – Rigby Road East – Clean water asset map information (Key: Blue assets are installed asset, green assets are proposed assets following WC consultation) [GIS accessed November 2015]

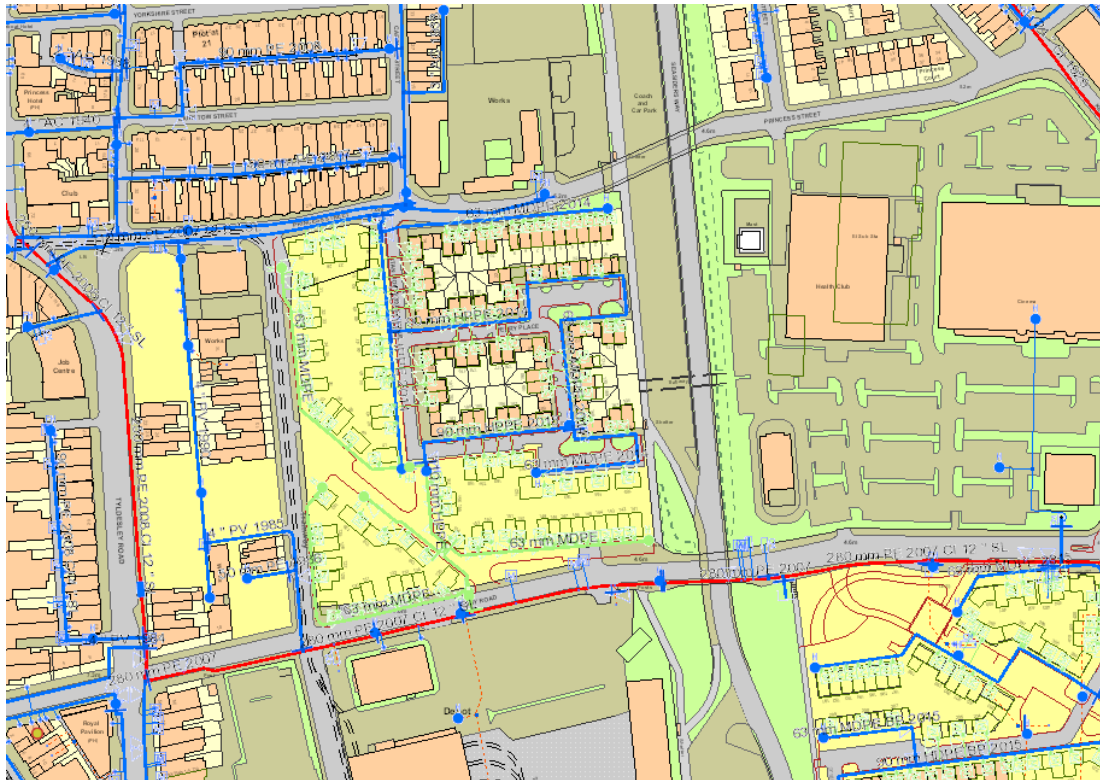


Figure 58 GIS mapping – Rigby Road West – Clean water asset map information (Key: Blue assets are installed asset, green assets are proposed assets following WC consultation) [GIS accessed November 2015]

6.4.1 Case Study 3: PRA

A section of the VR,2013 provides an overview of the original site conditions which would likely have been utilized by the WC in the absence of a desk study report (or PRA).

Site Setting

The development comprises of two sites (East-Site and West-Site):

The site history of the East Site:

- Railway land with engine shed
- Laundry
- Engineering works
- Waste treatment works

- Waste transfer station
- Sewage pumping station
- Illuminations depot
- Above and below ground tanks
- Petrol Station
- Electrical substation

The site history of the West Site:

- Location of Gas Works (2 pre-1860s gas holders, oxide purifiers and condensers and 2 further gas holders constructed later that remained on site)
- Tramway depot
- Unspecified works
- Garage
- Residential housing

East-Site

Made ground up to 5m thick below hardstanding, underlain by alluvial silt/clay encountered up to 5.6m thick. These are underlain by Glacial Till (clay) and a Solid geology of Mudstone is anticipated

West-Site

Made ground (comprising demolition rubble, ash and clinker with inclusions of tar waste lime, coal, metal and timber) up to 6.05m thick, underlain by alluvial deposits or peats encountered up to 4.9m thick. These are underlain by Glacial Till (clay) and a Solid geology of Mudstone is anticipated based on geological mapping.

Perched groundwater is stated to have been encountered within made ground and confined in the sand and gravel bands within the Glacial Till.

The information summarized above was provided within the verification and factual report. No supporting information such as historical mapping or previous investigation factual information was provided to help validated the summary. The WC did not challenge this and accepted the developer's (or their consultant's) overview.

6.4.2 Case Study 3: GI

Intrusive GI

Factual Report, 2013 provides supplementary GI works undertaken to meet the requirements set out in the Remediation Strategy report [report was not provided to the WC]. The objective of the GI is stated to be to determine the chemical suitability and depth of existing made ground materials

The GI is stated to have been undertaken in advance of any remedial works, complete in March 2013.

In a section title 'Site Information' it can be interpreted that the GI was undertaken in advance of the demolition and remediation of existing below ground gas holders present on the West-Site.

The GI was undertaken following the demolition of the illumination/council depot buildings of the East-Site. Car parks were present to the south and west of the East-Site.

Investigation Design and sampling strategy

Each site was divided into a grid of 20m by 20m squares

A trial pit was excavated within the centre of each square but not in areas classified by previous assessment as 'contaminated' [this previous reporting was not provided to WC]

A total of 114 trial pits were excavated as part of the supplementary GI.

A total 203 samples were recovered.

The contaminants testing included (and where based on the Remediation Strategy requirements [the remediation strategy report has not been made available to the WC]):

- Asbestos (screen)
- Phenol
- Free cyanide
- Total cyanide
- Arsenic
- Lead
- Nickel
- Zinc
- Speciated TPH
- Speciated PAH
- Volatile Organic Compounds (VOC's) consisting of:
 - Chlorophenol,
 - 2,4-Dimethylphenol,
 - 2-Methylnaphthalene
 - 1,2-Dichloroethane (DCE)
 - 1,2,4-Trimethylbenzene
 - 1,3,5-Trimethylbenzene
 - sec-Butylbenzene
 - n-Butylbenzene
 - Isopropyltoluene

Figure 59 Extract of Chemical Testing suite parameters of supplementary GI (Factual Report, 2013).

The exploratory positions are presented on **Figure 60** and **Figure 61**. There are exploratory gaps in coverage either due to known contaminant hotspot or the presence of a structure (i.e. gas holders).

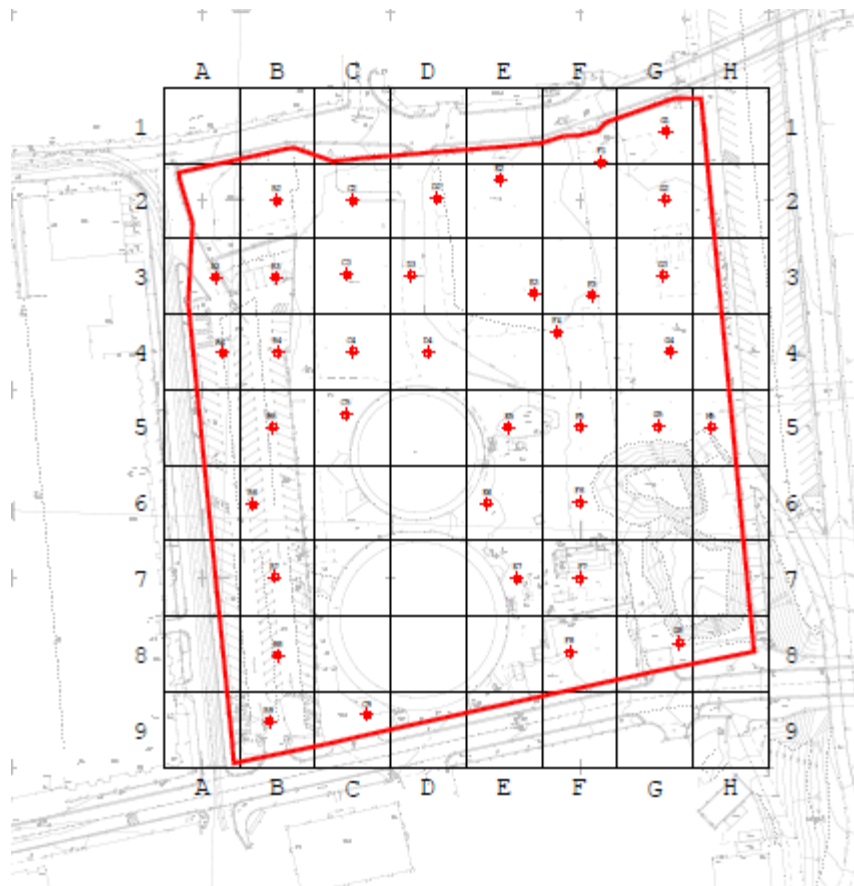


Figure 60 Exploratory hole location plan - West Site (Factual Report 2013)

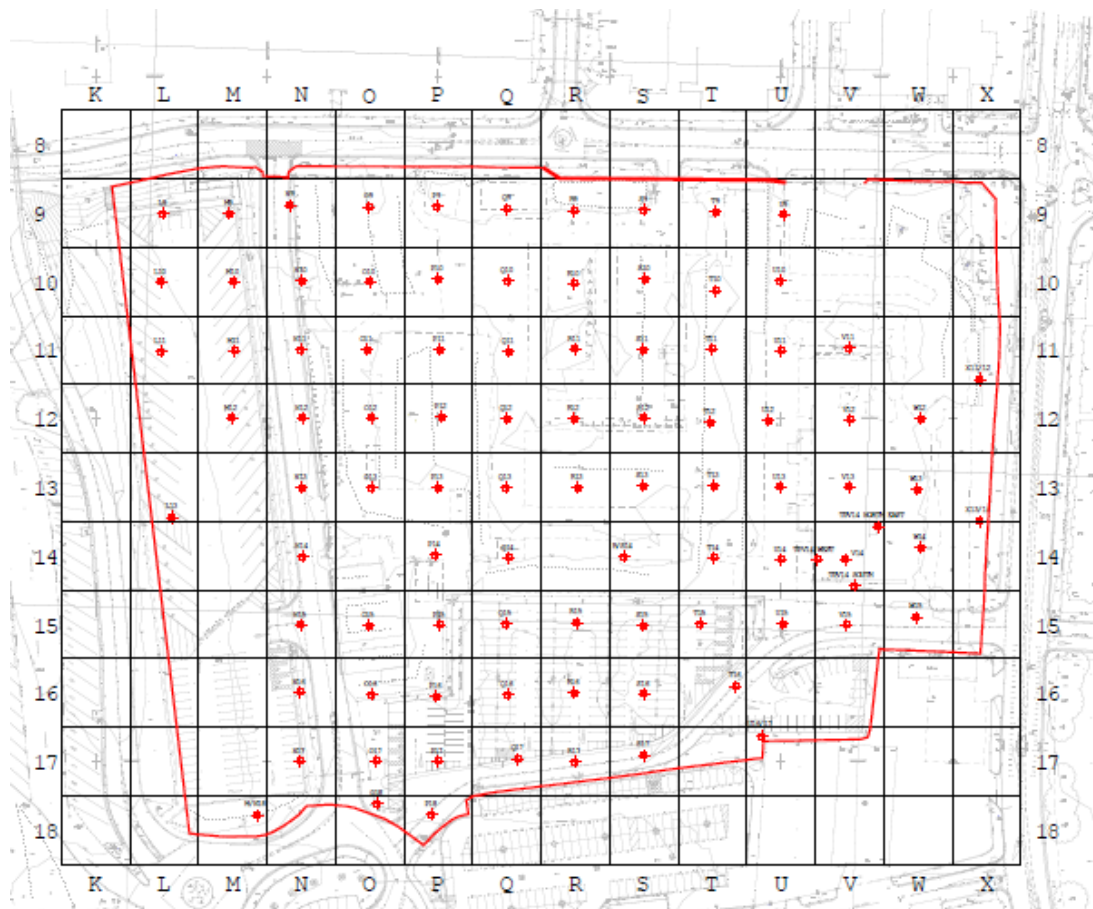


Figure 61 Exploratory hole location plan - East Site (Factual Report 2013)

6.4.3 Case Study 3: Findings of the GI

A number of areas are reported as exceeding the remedial targets for a number of CoC. These CoC related to the scheme as a whole and not necessarily CoC for water pipe materials.

Only raw chemical laboratory results were appended. The factual report was absent of factual exploratory hole records including description of strata encountered, groundwater conditions and installation details

A summary of the findings was provided by the author of the Factual Report 2013.

Further hotspots of contamination are recorded to have been encountered (note previous identified hotspots details were not provided to WC). A summary of the hotspot areas were summarized and an extract from the Factual report presented as **Figure 62**

Table 6 Observed Contamination

Investigation Position	Nature of Impact	Depth Encountered	Sample Taken
TPC9	Strong coal tar odour	2.8-3.4m bgl	Sample taken at 2.80m bgl which passed remediation criteria B.
TPF3	Pockets of hydrocarbon and odour	2-2.6m bgl	No sample taken. Failure of Naphthalene in sample at 1.60m bgl. Recommend to include strata in remediation works.
TPF7	Hydrocarbon odour	1.1-1.4m bgl	No sample taken. Sample taken in strata above at 0.75 to 1.10m bgl. Failure of Naphthalene. Recommend to include strata in remediation works.
TPH5	Hydrocarbon odour in gravel	0.46-0.51m bgl	Sample taken at 0.45m bgl which passed remediation criteria B.
TPN10	Hydrocarbon odour	0.55-0.90m bgl	Sample at 0.50m bgl which passed remediation criteria B.
TPY16	Hydrocarbon odour	1.2-1.5m bgl	Sample taken at 0.80m and 1.45m bgl which passed remediation criteria B.
TPV11	Hydrocarbon odour present	0.8-1.1m bgl	Sample taken at 0.90m bgl which passed remediation criteria B.
TPV13	Hydrocarbon odour	1.45-1.55m bgl	No sample taken. Sample taken at 0.75m bgl which passed remediation criteria. Recommend to include strata in remediation works.
TPV14	Slight hydrocarbon odour	0.25-0.85m bgl	No sample taken. Recommend to include strata in remediation works.
TPV14 South	Hydrocarbon Odour	1.7-1.8m bgl	No sample taken. Recommend to include strata in remediation works.
TPV14 North East	Hydrocarbon odour, possibly diesel	0.5-0.8m bgl	No sample taken. Recommend to include strata in remediation works.
TPV14 West	Slight odour from east side of pit	0.8-1.5m bgl	No sample taken. Recommend to include strata in remediation works.
TPW12	Hydrocarbon Odour	0.20-1.10m bgl	Samples at 0.70m and 1.10m bgl which passed remediation criteria B.

Figure 62 Extract from Factual 2013 report - contamination observations during GI.

The WC did not challenge the absence of supporting factual ground data or request contamination hotspot.

No information of groundwater levels was presented in the Verification or Factual report. The levels presented in the developer's PSRA are assume to remain relevant (0.5 to 3.0m bgl).

6.4.4 Case Study 3: GQRA

Chemical test data presented in the factual report 2013 has been reviewed against the content of the developer's PSRAS (presented **Figure 56**). The data presented in the developer's PSRAS is consistent with the data presented in the report

GI was recovered in advance of proposed remediation works (i.e. structure removal (e.g. gas holder tanks) and hotspot removal/treatment). This was used to populate the PSRAS.

Concentrations of total VOC/SVOC, TPH EC10-16, TPH EC16-40, phenols and cresols and chlorinated phenols were recorded in excess of the PE threshold values.

The risk assessor offers the following additional supporting information to support the intended use of PE pipe materials:

The contaminant assessment and testing included is applicable to the existing soil profile. It is proposed to install the pipes within clean corridors compliant with the PE threshold values.

Figure 63 Extract from Section 6 - Additional Information of the Developer's RA for water pipes dated 01.08.14

Chemical laboratory data (absent of sampling plan) was appended to the developer's PSRA. This data is stated to represent '6F2 imported materials'. This data was not included on the PSRAS (Table 1) however a scanned copy of the data was provided which included the developer's manual data screen against UKWIR2010/Water UK PE threshold values. BTEX/MTBE and TPH CWG were the only determinands tested. 4 out of the 8 samples presented TPH aliphatic/aromatic EC10-16 and EC16-40 concentrations above PE threshold. The source of the IM was not provided.

6.4.5 Case Study 3: Discussion/Conclusion

The developer proposed the use of PE across the subject area with the installation of a clean corridor compliant with the PE threshold values. The WC has accepted the developer's proposal in principal however has requested the use of BP in areas where a clean service corridor is not possible.

RA for Water Pipes - data gaps and areas of uncertainty

The PSRAS states it has been undertaken by assessing EGM, RM and IM, which does not appear the case following a review of the PSRA and supporting data. The PSRAS is based on data recovered in advance of remediation works (i.e. structure removal (e.g. gas holder tanks) and hotspot removal/treatment). The developer does provided IM data however this data was not included in the PSRAS (Table 1). Contaminant concentrations were recorded above PE threshold in 4 out of the 8 IM samples. Therefore, the use of PE pipes may not be suitable for use if installed in this material. It was not however entirely clear where the developer intended to use the IM. The RA does however state that the clean service corridor would be compliant with PE threshold. Validation data for the services corridor has not been provided by the developer or requested by the WC.

In addition no post-remediation validation data was provided by the developer or requested by the WC. It should be noted that the VR was completed to demonstrate the objectives of the site remediation strategy had been achieved. The remediation acceptance criteria were not provided as part of the supporting information. Based on the information contained within the VR the remediation acceptance criteria for the site is not likely to have included acceptance values protective of a PE water pipe receptor.

The PSRA does not considered possible pollutant linkage associated with shallow groundwater at levels that could intercept proposed pipe depth (0.5m to 3.0m bgl was reporting on the Water UK protocol). Lines of evidence to demonstrate the absence of this linkage was not considered by the WC either. Based on the WI guidance and based on the sites former use as a gas works, groundwater sampling and testing would be required to demonstrate the groundwater at the site was not impacted by Water UK test group CoC.

Alternatively, a developer design proposal which prevented groundwater interception or the use of BP may have been appropriate.

There are a few gaps in the supporting information provided for example the special ground data gaps (e.g. position of below ground structures, absence of figures and appendices to both the VR and Factual Report. The absence of certain figures and ground condition data would make the validation of the PSRA difficult for the WC. For example the absent of a figure relating to the phases of remediation and the absence of ground strata descriptions of the factual report.

PRSAS (table 1) is fully populated in regards to basic mandatory test groups. A closer inspection of the supporting data shows a limited number of number VOC/SVOC compounds have been reports. 9 individual compounds rather than the full target compounds listed in US EPA Method 8270D (or similar) (SVOCs by GCMS) and US EPA Method 8260C (or similar) (VOCs by head space or purge & trap). This testing falls short of the WI testing requirements which requests a method and associated compounds.

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Chapter 7 Discussion of results/data

UKWIR2010 was developed to provide guidance to stakeholders involved in the planning, designing and the installation of water mains/service connections in land potentially affected by contamination. The Water UK protocol was developed to provide a RA for water pipes and to provide guidance on the supporting information requirements to inform the RA/CSM for new water connections. With the overall aim of UKWIR2010/Water UK best practice guidance to ensure that suitable water pipe materials are selected based on the condition of the land in which it will be laid. It is from these core documents that much of the project are based, to ascertain the effectiveness of the guidance and its implementation by developers/SLO (or their consultants) and the WC.

This research has been formulated to allow the evaluation of procedures adopted by UK water companies but also to allow the critique of the implementation of the PSRA process by developers/SLO and by the WC on a project/development level. The key findings of which are discussed in the following subsections:

UK Water Company Procedures

The data presented and discussed in Chapter 4 has identified inconsistencies in the guidance adopted by UK water companies. The data demonstrates the observations made by AGS (section 2.7). Only 52% of water companies were identified to follow the guidance provided by UKWIR2010 for the selection of mains pipe materials. The uptake of the use of the UKWIR2010 for service connection procedures was slightly less at 39%.

The withdrawn guidance WRAS2002 has continued to be adopted as best practice by 18% and 9% of water companies for service connection and new mains requests, respectively. The data does not provide an explanation for why some water companies are still using old guidance or guidance which has been withdrawn for many years, this however may be because some water companies, do not consider the UKWIR2010/Water UK suitable for use. It may

simply be due to the fact that water companies are unaware of the publication of the newer guidance.

Water companies in the UK (excluding Scottish Water and NI Water) are private companies (see section 2.2) therefore it may be the case that the water companies have not invested in the update of developer guidance on their websites in-line with WI publications. The data also identified 17% of water companies appeared to adopted a different approach for the selection of mains (>32mm) and services (<32mm) pipes. In general these water companies refer developers/SLO to the current WI guidance for the selection of new mains and either provide limited/no guidance for service connections or refer the developer/SLO to withdrawn WRAS2002. A suggested reason for this (see section 4.1) is that a WC is more likely to keep processes for mains infrastructure design/installation up-to date. WC undertake the design/installation of mains (rather than SLO) in some cases and also will adopt responsibility of mains infrastructure following installation, which is not the case for supply pipes.

The combined use of UKWIR2010/Water UK protocol was identified to have been adopted by less than 20% of the water companies reviewed (section 4.1). This limited uptake in the use of the Water UK protocol is likely to be attributed to the fact that the Water UK protocol was published in January 2014 only 5 months prior to the WC review which has been undertaken as part of this research. Another possible suggested reason is the Water UK excludes the option to select PVC pipe materials. As discussed previously, the Water UK protocol was initially developed by United Utilities plc. This company does not accepted the use of PVC pipe materials within its distribution network thus the option to select PVC material is excluded from the protocol (i.e. the PVC threshold values are excluded from Water UK PSRAS (Table 1)), the requirement not to use PVC pipe materials may not be a policy of other UK water companies. An oversight of Water UK protocol but one that could be rectified by a revision of the protocol.

Implementation of WI guidance

This research was conceived to ascertain the effectiveness and implementation of the UKWIR2010/Water UK protocol.

The database of developer/SLO PSRA submissions created as the cornerstone of this project identified a number of common omissions when benchmarked to the requirements of the UKWIR2010/Water UK protocol.

The results presented demonstrate trends and patterns in the PSRA's and the supporting information submitted to the WC for review and also in WC response to the submissions, since the combined use of UKWIR2010/Water UK protocol, by United Utilities plc. in 2011. It is not uncommon for the PSRA to fall short of the requirements of the UKWIR2010/Water UK protocol.

Further information was requested of the developer/SLO by the WC in 67% of submissions (**Figure 34**). The information requested was consistent with the requirements of the UKWIR2010/Water UK protocol and so avoidable if the 'best practice' guidance was followed. However, there are aspects of the 'good practice' guidance that the WC fell short on applying during the water connection application process.

The most common further information request made by the WC was the requirement for GI data, specifically related to the need for data of the material in which the pipes are to be laid (i.e. at the proposed line and depth of the proposed pipe) and for the provision of test group data (generally relating to the absence of VOC/SVOC testing or a request for testing in-line with Table 1 CoC) (**Table 12**).

The sufficiency of GI coverage (i.e. in line and depth of proposed pipe) is an omission not easily identified through the review of completed PSRA (Water UK Protocol). A review of supporting information (e.g. factual GI data, exploratory hole plan and pipe design proposal) by WC is required to allow the WC to determine the sufficiency of GI coverage. It is therefore essential that supporting factual information is provided as part of the submission.

The short-fall in the provision of mandatory test group analysis (CoC to pipe materials), identified by the WC, is consistent with the omissions established as part of the stage 1 PSRA benchmarking (see **Table 6**). The WC however failed to identify cases where current/historical contaminative land-uses presented a source of the 'extended' test group contaminants (see section 5.2

and Case Study 1: Discussion). No PSRA included the extended test groups. We cannot be certain on the reason for this oversight by the WC however this is likely due to a lack of knowledge on the types of contaminative land-uses/sources of such contaminants and therefore the WC did not recognise the potential risks that required further consideration in the PSRA. This may also be the reason for the omission by the developer/SLO in their PSRA, however it would be anticipated, based on the requirement for RA to be undertaken by- or under the direction of a 'competent person' would bring relevant experience and knowledge to identify contaminative land-uses/sources of the 'extended' test group contaminants.

The developer/SLO PSRA in 70% of submissions were not completed by or under the direction of a 'suitably qualified competent person' (**Figure 33**). This was not a requirement that was consistently implemented by the WC, with risk assessor qualifications queried on only 14% of submissions (**Table 12**). The requirement for a 'suitably qualified competent person' was introduced by the Water UK protocol. This requirement was queried by a range of key stakeholders during the Water UK consultation, and a definition requested (see section 2.7.4). It was apparent by the comments received during the consultation that the need for a chartered professional/SiLC is questionable by some and considered onerous and possibly even 'jobs for the boys'. However, the rationale provided for the requirement - to promote good practice and high professional standards - is a good aspiration to hold and the fact that the requirement is no greater than that required by other regulators such Local Authorities for planning purposes confirms that this is a reasonable requirement by the Water UK protocol.

This requirement falls-short however, in the instance that the 'competent person' is not fully aware of the requirements of UKWIR2010/Water UK but also where the WC (or connection engineer) reviewing the PSRA for compliance, is unaware of what an 'appropriate professional body' or 'relevant experience' is. This was demonstrated in Case Study 1, the PSRA was completed incorrectly by a chartered engineer with the Institute of Structural Engineers (M.I.Struct.E), this professional may not have a full understanding of the WI guidance or have the relevant experience in land contamination management based on the affiliated professional body detailed. In the follow-up interview

with the connection engineer, they stated they acknowledged the professional status and thus accepted the recommendations made by the assumed competent person. The WC was unaware of what the prefix 'M.I.Struct.E' referred.

Ideally the WC should be able to step back from scrutinising individual PSRA and supporting information for compliance with the WI guidance and rely on the expertise of industry specialists/professionals, and be assured that the work has been carried out in accordance with applicable standards and guidelines, when the signatories (or competent person) meets the requirement.

The upskilling of both WC personnel and professionals in the construction/developer industry, to the requirements of UKWIR2010/Water UK, and the regulatory regime (section2.1) which drives the guidance would go a long way in improving standards of PSRA.

Groundwater levels are requested in Section 3 of PSRA (Water UK protocol). The UKWIR2010 recommends groundwater/perched water samples be recovered and mandatory test groups undertaken, where present within 1m of the base of pipe trench. The data demonstrates that as few as 18% of submissions have been identified to include groundwater data. The groundwater level recorded in developer/SLO PSRA suggestion the provision of groundwater data were required to inform the RA/CSM in between 60% to 80% of water connection submissions (**Figure 30**).

No further guidance beyond this recommendation is provided by baseline UKWIR2010 guidance. No groundwater threshold values are provided, for example, to assist in determining if the groundwater contaminant concentrations encountered at a site have the potential to impact water pipe materials. This is most likely to be the reason why this requirement is not followed up by the WC connection engineers as they are unlikely to know how to interpret the results even if received. It is clear from the case studies (Case Study 1 and 2) that risk assessors have also failed identify groundwater as a potential source and the subsequent potential contaminant linkage associated with groundwater levels which intercept the route of the pipeline.

The reason for why developer/SLO fail to fulfil all of the requirements of the UKWIR2010/Water UK and for the shortcomings of the WC during the water connection application process, cannot be confirmed by the dataset however it may be due to the lack awareness of the requirements by developer/SLO and the WC.

Key omissions by the developer/SLO however may be due to time and cost constraints associated with meeting the WI guidance requirements (e.g. costs and time associated with undertaking GI and chemical testing or costs associated with employing a suitability qualified competent risk assessor) or simply due to the assessment of risk to a water pipe receptor being considered as an afterthought and therefore not considered as part of the site assessments as a whole (i.e. not considered as part of GI design for the development) and missed from the scope. In the knowledge that the use of BP is accepted by the WC when a PSRA falls short of the requirements; or that BP may still be required, based on the ground conditions encountered during investigation, the developer/SLO may not feel there is an incentive to meet the requirements of the WI guidance and simply default to the use of BP.

In view of the common omissions in GI and the provision of test group data, the cost difference between PE and BP pipe types and of soils and groundwater chemical analysis (consistent with the test group requirements of Water UK requirements) have been considered. The rates associated which each are presented in the Tables below and have been sourced from commercial providers (sourced January 2016).

Based on the rates provided, BP is approximately 4x more expensive than PE. However, when considering the cost for testing required to demonstrate the suitability of PE materials, it would likely to be more cost effective to default to the use BP. For example, assuming a 20m length of 32mm PE plus 3 soils samples recovered in line a depth of pipe for basic test group and a single groundwater sample, the cost would be approximately £460. Whereas the cost for the length of BP with no testing would be approximately £45.

Note this is a crude assessment and does not include the cost for GI plant mobilisation or suitably qualified competent person fees, fittings or other preliminaries.

Size(mm)	Material	Rate (£) per metre
25	PE80 (SDR 11)	0.33
32	PE80 (SDR 11)	0.53
63	PE80 (SDR 11)	2.09
90	PE100 (SDR 17)	2.81
110	PE100 (SDR 17)	4.08
160	PE100 (SDR 17)	8.27
250	PE100 (SDR 17)	19.92
315	PE100 (SDR 17)	29.91

SDR (Standard Dimension Ratio) – calculate wall thickness (size(mm) divided by SDR)

Size(mm)	Material	Rate (£) per metre
25	PE80 (SDR 11) BP	1.40
32	PE80 (SDR 11) BP	2.28
63	PE80 (SDR 11) BP	7.84
90	PE100 (SDR 17) BP	5.68
110	PE100 (SDR 17) BP	8.19
160	PE100 (SDR 17) BP	14.29
250	PE100 (SDR 17) BP	71.77
315	PE100 (SDR 17) BP	110.72

SDR (Standard Dimension Ratio) – calculate wall thickness (size(mm) divided by SDR)

Test Group	Media	Rate (£) per test
Basic suite	Soil	110
Extended	Soils	125
Basic suite	Groundwater	120
Extended	Groundwater	60

The costs associated with meeting the requirements of UKWIR2010/Water UK may be a reason for the shortcomings of PSRA however with early consideration of the WI guidance much of the information would be gathered as part of the site assessment as a whole, as would likely be required to assess risks to other receptors, to meet planning conditions for example.

UKWIR2010 considered the use BP as acceptable in the absence of GI. Based on the test method and specification that BP is required to meet by the water industry standard (WIS) (see section 2.5) permeation effects to BP are highly unlikely in most environmental settings.

The Water UK guidance does not appear accept the blanket use of BP. From liaison with WC connection engineers as part of the case study review interviews, the default use of BP is not considered favourable by water companies due to the higher installation and general/future maintenance (restrictions on 'squeeze-off' clamping) costs associated. Squeeze-off clamping is used by WC, on PE materials, in routine or emergency situations to stop/reduce water flow – this method is quick and saves time and costs that would be encountered with other methods of isolation. BP can be squeezed-off however the squeeze-off/re-rounding procedures are more onerous than that of PE and BP is more prone to damage.

Baseline UKWIR2010

It is apparent from the stakeholder views presented in section 2.7, and the author's critique of the UKWIR2010 guidance in section 2.6 that the baseline guidance has its failings. This is further emphasised by the publication of supplementary guidance by Water UK but also by the array of WC specific policies and guidance for the selection of water pipes for potentially contaminated sites (section 4.1).

Several limitations in the current baseline UKWIR2010 guidance has been identified, including:

-An ambition of UKWIR2010 is to provide a staged approach to the PSRA, based on contamination status of the site. UKWIR2010, however fail to recognise the centrality of the CSM to the qualitative and the quantitative assessment of potentially unacceptable risks to water pipe receptors by ground contamination. This shortfall however appears to have been captured to a certain extent by the Water UK protocol.

To help illustrate the potential contaminant linkages relevant to plastic water pipe receptors, a set of generic CSM have been developed and are presented as Figure 13 and Figure 14.

–UKWIR2010 provides a set of pipe material selection threshold values for PE and PVC pipe materials. The guidance states that three types of effects have been assessed "*permeation, environmental stress cracking (ESC) and swelling*". The guidance does not provide the physical-chemical properties data of contaminants and/or polymer, media assessed or the calculations (or equations) used to derive the values. There are various other limitations observed by the author and have been discussed in section 2.6 however, the lack of transparency of how UKWIR2010 generic pipe selection threshold values were derived or of what exposure pathways are considered, is a key failing of the UKWIR2010 guidance. The absence of this background data does not allow the risk assessor to consider the appropriateness of the generic values in the context of the development.

This point is further demonstrated by each of the case studies, where the developer/SLO and the WC has failed to recognise potential contaminant linkages relevant to the proposed pipe for example case study 1 and case study 2, the pollutant linkage associated with shallow groundwater (potentially contaminated) at levels that could intercept proposed pipe depth is not considered; case study 3 the WC recommends the use of BP and an inert service trench, BP is an effective barrier in land affected by contamination therefore the need for the additional trench requirements is questionable. This may be attributed to a lack of understanding of the factors affecting the performance of plastic materials in ground that is affected by organic contamination; or of the exposure pathways being assessed.

The work by Ong *et al.* (2008) has taken steps to provide data to help predict permeation behaviour for a range of permeation scenarios (section 2.5). This work has also resulted in the development of calculations that can be used to estimate contaminant concentration in the environment that would impact on water quality under various site specific conditions, such as estimating the impact following periods of stagnation or considering water flow and/or with

different pipe sizes. The study focused on hydrocarbon contaminants- premium gasoline (BTEX) and pure solvents of benzene, toluene and TCE.

Ong *et al.* also established contaminant concentrations (of benzene) in groundwater that would result in drinking water quality (in-pipe) being in excess of quality standards [US EPA MCL of 5µg/l (note the UKDWS is 1µg/l)], when exposed. The research covered a range of pipe sizes, thicknesses and conditions of stagnation/water flow – a key finding being that plastic pipes greater than 355mm (wall thickness of approx. 48mm) would not be affected by benzene concentrations up to 100mg/l. The study demonstrated smaller size pipes to be more vulnerable to permeation than larger size pipes. A soil-pore water benzene concentration as low as 1mg/l was calculated to cause in-pipe water to exceed the test MCL of 5µg/l in an 8-hour stagnation (1-inch(25.4mm) PE pipe). It is noted that this study utilised pipe materials and water quality standards relevant to the US and therefore is not directly comparable to the UK however, this research provides some insight into benzene concentrations in groundwater that may be problematic to PE service pipes, in fact the UKDWS are more stringent than that of the US EPA MCL and therefore in-pipe drinking water quality standards may be breached from lower groundwater concentrations of benzene e.g. <1mg/l (for 25mm pipe). The research by Ong *et al* (2008) concluded that for practical purposes, there are no level contamination at which PE pipe is resistant to gasoline or chlorinated solvents.

This research was not consulted during the development of the UKWIR2010. It is the author's opinion, that if consulted, the research by Ong *et al.* (2008) would have been valuable in the development of the UKWIR2010 guidance.

Chapter 8 Conclusions

The aim of this research is to critically evaluate the effectiveness and the implementation of the current WI guidance for the selection of water pipe materials, to be installed on land potentially affected by contamination. This should have the effect of understanding the risks of contaminated ground to water pipe materials; determining areas of uncertainty and limitations in the PSRA process; and of identifying areas of improvement.

This research is unique in that the implementation of PSRA guidance by developer/SLO and WC has been evaluated. Previous research in this area has focused on experimental research in to effects of land contamination on water pipe materials and of pollution incident studies and their impacts on water supply pipes (section 2.5). It is envisaged that the findings of this research will make a positive contribution by enhancing understanding and awareness of the developer/construction industry and the water industry stakeholders to the requirements of current PSRA guidance; but also by providing recommendation for improvements of PSRA.

Each of the eight objectives which were formulated to inform the aim and have been previously discussed and the results presented where appropriate. The outcomes of these can be considered with the aim of the report in mind and the research has identified consistent omissions in data required by the UKWIR2010/Water UK guidance for the assessment of risk to water pipe material (and subsequent water quality). These are omissions by the developer/SLO (or their consultants) and by the WC in their response to developer/SLO pipe selection proposals (section 5.2, Chapter 7). Inconsistencies in the WI guidance adopted by the UK water industry as a whole (Chapter 4) has also been identified.

There are clear failings on both sides by developers/SLO(or their consultants) and by the WC in the application of the guidance. It has been demonstrated that developer/SLO PSRA often fall-short of meeting requirements of the WI guidance and although the majority of shortcomings/omissions are identified

by the WC, the practice of defaulting to the use of BP in the absence of data or where there uncertainty is not uncommon (section 5.1).

Stakeholder views (section 2.7) suggests that the combined use of UKWIR2010 and supplementary Water UK guidance does offer some improvements to the PSRA process however there are still fundamental issues with the baseline UKWIR2010 guidance that need to be resolved to improve confidence in the process. Transparency for how existing pipe selection thresholds have been derived or the development of new thresholds (considering the findings of the recent research by Ong *et al.* 2008), which includes thresholds values for groundwater, would bring great benefit. Knowledge of how the numbers have been derived will improve understanding of the risks being assessed and the effects which are being mitigated.

This thesis has clearly identified areas of uncertainty and limitations of the current PSRA process, which have been considered to inform the final objective:

8.1 8. Provide recommendations on the way forward to improve the PSRA process, guided by the findings of this research

The findings of the research has identified limitations and highlighted potential areas of improvement to the PSRA process, these have been identified as follows:

1. Suggested interim Water UK protocol updates:

In the short-term the protocol and its introductory guidance should be updated to request:

- Supporting site assessment information (including appendices) should be provided as a minimum, with an indication of the assessment activities undertaken and of those proposed (e.g. remediation or enabling works that would change the conditions of the site prior to the installation of pipes). A summary list of supporting documents and drawings shall be provided.

- The provision of details relating to planning such as planning application reference and submission date; and an indication of any Conditions relating to land contamination management.

There should be greater emphasis on the requirement to determine groundwater levels and to recover water quality samples in the instances of a high water table (at a level that would intercept proposed pipe depth) and where a potential source of groundwater contamination has been identified. The protocol should be updated to allow groundwater data to be referenced/summarised. At present there is no area of the Water UK protocol template which allows the developer/SLO to make reference to groundwater testing undertaken or to provide details on the outcome of such testing. The WC is required to review supporting information to determine if testing has been undertaken and to interpret [in the absence of guidance by UKWIR2010/Water UK] the contaminant concentrations encountered.

Table 1 of the PSRA (Water UK protocol) to be revised to include PVC thresholds and thus make the protocol applicable for use by water companies that allow the use of PVC pipes in their network.

The generic CSM (Figure 13 and Figure 14), developed as part of this research, to be included in the introductory guidance of the Water UK protocol to help illustrate the potential contaminant linkages relevant to plastic water pipe receptors and should be consider by risk assessor.

The author being a contributor to the original HBF/Water UK protocol shall share research findings with protocol working group to take these data-support improvements forward through protocol updates.

2. Education and Awareness

The reasons for omissions by developers/SLO (or their consultants) to the UKWIR2010/Water UK requirements and the shortcomings of the WC when checking for compliance during water connection consultation, cannot be determined solely on the results discussed. A reason however may simply be due to a lack of understanding of the potential risks to water pipe materials, by environmental media affected by contamination; or due to a lack awareness of

the UKWIR2010/Water UK requirements. With this in mind a proposed way forward would be to promote improved performance.

This can be achieved by sharing the findings of this research with key stakeholders including:

- the WC and WI bodies such as Water UK and UKWIR; and
- the developer/SLO/construction/land contamination community

This may be in the form of attending/presenting at seminars, workshops, working groups and through publications.

The results, specifically the results of the stage 1 and stage 2 database reviews, shall be shared with the WC (United Utilities being the source of research data) with the objective to help improve water connection consultation performance. The WC may wish to share results of the common omissions with external customers/stakeholders (developer/SLO) to promote improved industry performance moving forward within their operating area.

Food-for-thought sessions can also be held with WC connection engineers to upskill the workforce and to encourage a consistent approach to the implementation of the current WI guidance.

The Land contamination AGS working group has shown a keen interest in the findings of this research. The author has been invited to attend and present research findings to the working group. The group provides advice and feedback to other organisations, committees (e.g. BSI) and government bodies on documentation and policy. The group works as a subsidiary of the Environmental Committee of the Construction Industry Council (CIC) and keeps their members informed of developments to do with contaminated land and the environment. Group members include numerous consultants and representatives of NHBC, BSI and SiLC. A message to be encouraged would be that land contamination professionals should seek to adapt land contamination risk assessment and reporting, to consider the potential risk to water pipe materials as part of overall site assessment (consider water pipe as a receptor in PRA and ground investigation design).

The role of the suitably qualified competent person, that is required to undertake or oversee the PSRA, which was absent in 70% of submission (**Figure 33**), would be another key point to raise with the group. The AGS working group and its members are closely involved with the National Quality Mark Scheme initiative, which is being rolled out in England to increase confidence and improve quality of submissions made under regulatory regimes, particularly planning applications. The principles of this scheme could be expanded to include WI guidance requirements for PSRA (as required to meet the Water Supply (Water Fittings) Regulations). Water companies are responsible for reviewing PSRA for compliance with WI guidance and therefore would benefit greatly from taking a more active role in industry groups such as this to raise standards.

3. Consideration of further research

Broaden evidence base

It is recognised that there are some limitations to this research due to the focus on developer/SLO PSRA and WC responses from a single WC in the north-west of England. There would be benefits to expanding the database nationally to minimize the influence of regionality (including WC culture and policy); WC and developer/SLO character, experience and resources.

Supplementary research

Organic contaminant permeation effects to BP are highly unlikely in most environmental settings, the main objection to the default use of BP in the absence of data in-line with the UKWIR/Water UK requirements, is due to future maintenance costs associated. With this in mind further research to investigate and optimise maintenance procedures for BP would be beneficial, for example to minimize damage by squeeze-off and negative impact on the short- and long-term performance of BP. If BP maintenance became more favorable to a WC and the default use of BP was acceptable to a WC, this will remove the need for costly soils and groundwater testing that is required by the developer/SLO to demonstrate PE is suitable.

Revisit UKWIR2010 guidance

There is the potential for the under- or over-specification of water pipe design on sites potentially affected by contamination. This has an impact not only on developers and water companies relating to installation and maintenance costs but also financial and health implications to future landowners (property owner and water consumers).

The current WI guidance would benefit from a review, ideally by the water industry and other industry groups (such as CIRIA, AGS, NHBC, HBF, SLO) involved in design and installation and by pipe material manufacturers.

Area of focus as identified by the findings of the research:

- The methodology and input parameters used to derive the UKWIR2010 pipe selection threshold values, should be made available by UKWIR/WRc. These values may be revised where required or as more data becomes available. Alternatively, consideration to the development for new thresholds through experimental research, considering the work by Ong *et al.* 2008 should be made.

- Manufacturers to provide more information relating their products resistance to ground contamination, including further research with commonly used pipe materials to derive data to predict deterioration or permeation effects of various contaminant concentrations and media.

- The practical measures and protection measures (in addition to pipe material selection) (e.g. use of trench drains, impermeable inert backfill etc.) presented in FWR 1994 and EA,2001 guidance should be revisited. The outcome would include the provision of guidance on practical measures, outline design/specification and verification requirements.

- UKWIR2010 to refer to the use of supplementary Water UK protocol in place of the SAR currently required by guidance.

When approached ahead of the development of the supplementary Water UK protocol, UKWIR who acknowledged there are issues with the baseline guidance, advised there are no planned updates to the baseline guidance as budget had been spent. UKWIR Research Programme runs on annual cycles, taking suggestions from WI members to build a programme of research projects therefore, now 5 years on, UKWIR2010 may reconsider this position.

CIRIA [providing good practice guidance for the construction industry] and NHBC [providing research and guidance reports to support house-builders sector] has expressed an interest in working collaboratively with WI bodies, and potentially contributing funding, for the review and update/provision of new guidance for the selection and installation of water pipes in land potentially affected by contamination. With this in mind the way forward will be to identify potential research partners and develop an outline research proposal to determine the appetite of the water and developer/construction industry to resolve the PSRA limitations identified as part of this research.

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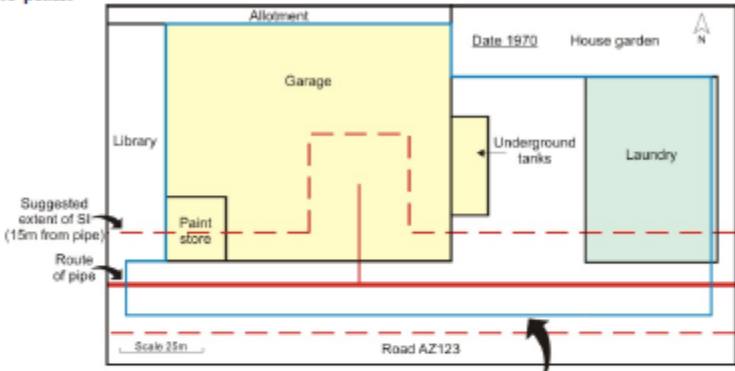
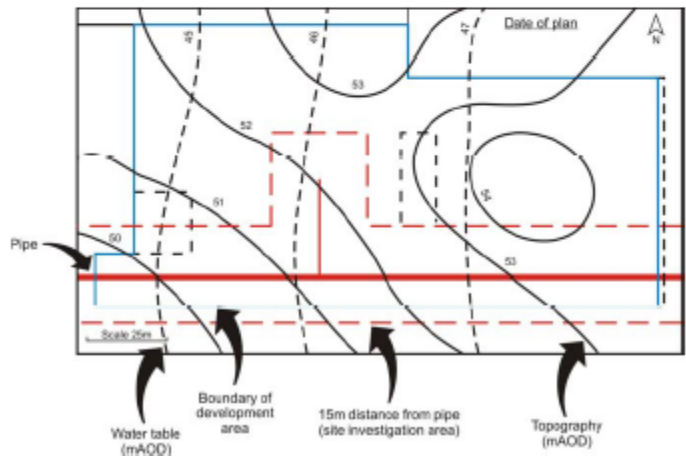
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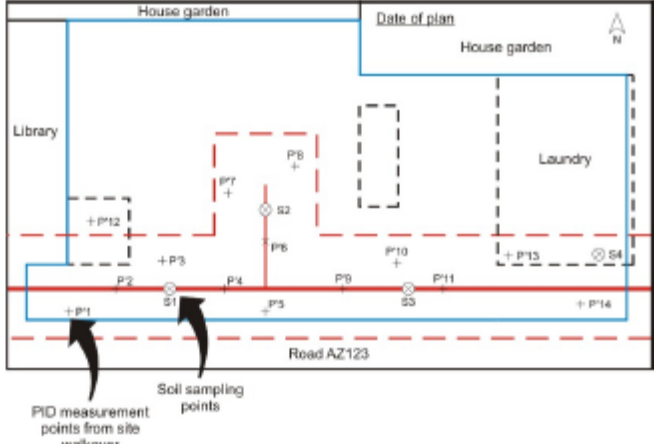
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Chapter 9 Appendices

Appendix A - UKWIR2010 Example SAR

Information	Specific details to be included
Site Details	Name of Site Developer Site plans  NGRXXXXYY Ordinance Survey Grid Reference Building (historic use) Building (current use which potentially use or store chemicals) Compilation of historic information Review of current use of site Site walkover survey Relevant photographs 

Information	Specific details to be included																																																																																																																																																			
Sampling & Analysis Plans	A completed sampling and analysis plan (see example in Appendix B) Plan showing the location of all sampling points 																																																																																																																																																			
Results	Tabulated results from any on site photo-ionisation detector (PID) measurements. Analytical data for soil samples (as per Table 2.1) <table><tr><td colspan="7">Laboratory Name:</td></tr><tr><td colspan="7">Unique Job reference numbers:</td></tr><tr><td colspan="7">Date analysis:</td></tr><tr><th>Group No.</th><th>Parameter group</th><th>Units</th><th>Detection Limit</th><th>Sample code 1</th><th>Sample code 2</th><th>Sample code 3</th></tr><tr><td>1</td><td>Extended VOC suite (with TIC)</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>1a</td><td>• BTEX + MTBE</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>2</td><td>Extended SVOC suite (with TIC)</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>2a</td><td>• Phenols</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>2f</td><td>• Cresols and chlorinated phenols</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>3</td><td>Mineral Oil C11-C20</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>4</td><td>Mineral Oil C21-C40</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td>Corrosive (Conductivity, Redox and pH)</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>Conductivity</td><td>µS/cm</td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>Redox potential</td><td>Volt</td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>pH</td><td>-</td><td></td><td></td><td></td><td></td></tr><tr><td colspan="7">Specific suite if identified relevant:</td></tr><tr><td>2a</td><td>• Ethane</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>2b</td><td>• Nitrobenzene</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>2c</td><td>• Ketones</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>2d</td><td>• Aldehydes</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr><tr><td>6</td><td>Amines</td><td>mg/kg</td><td></td><td></td><td></td><td></td></tr></table>	Laboratory Name:							Unique Job reference numbers:							Date analysis:							Group No.	Parameter group	Units	Detection Limit	Sample code 1	Sample code 2	Sample code 3	1	Extended VOC suite (with TIC)	mg/kg					1a	• BTEX + MTBE	mg/kg					2	Extended SVOC suite (with TIC)	mg/kg					2a	• Phenols	mg/kg					2f	• Cresols and chlorinated phenols	mg/kg					3	Mineral Oil C11-C20	mg/kg					4	Mineral Oil C21-C40						5	Corrosive (Conductivity, Redox and pH)							Conductivity	µS/cm						Redox potential	Volt						pH	-					Specific suite if identified relevant:							2a	• Ethane	mg/kg					2b	• Nitrobenzene	mg/kg					2c	• Ketones	mg/kg					2d	• Aldehydes	mg/kg					6	Amines	mg/kg				
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Pipe selection	There should be a value for each of the contaminant parameters (even if it is a less than value). If not, undertake further analysis. Identify those pipe materials which can be used i.e. where the contaminants present meet the threshold values in Table 3.1 List all suitable pipe materials (example as per Table 3.2) <table border="1"> <thead> <tr> <th rowspan="2">Parameter group</th><th colspan="7">Pipe material</th></tr> <tr> <th>PE</th><th>PVC</th><th>Galvanneal (PE or PE)</th><th>Alloyed Steel</th><th>Uncoated Steel</th><th>Copper</th></tr> </thead> <tbody> <tr> <td>1 Extended VOC suite (with TIC)</td><td>✓</td><td>✓</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>1a • BTEX + MTBE</td><td>✓</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>2 SVOCs TIC by purge and trap or head space and GC/MS with TIC (Aliphatic and Aromatic C2 - C10)</td><td>✓</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>2a • Phenols</td><td>✓</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>2b • Cresols and chlorinated phenols</td><td>✓</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>3 Mineral oil C11-C20</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>4 Mineral oil C21-C40</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>5 Corrosive (Conductivity, Redox and pH)</td><td>Pass</td><td>Pass</td><td>Pass</td><td>✓</td><td>✗</td><td>✓</td></tr> <tr> <td colspan="8">Specific suite identified as relevant following the investigation</td></tr> <tr> <td>2a Ethers</td><td>✓</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>2b Nitrobenzene</td><td>✓</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>2c Ketones</td><td>✓</td><td>✗</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>2d Aldehydes</td><td>✓</td><td>✓</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>6 Amines</td><td>✗</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td><td>Pass</td></tr> <tr> <td>Pipes that pass chemical thresholds</td><td>✗</td><td>✗</td><td>✓</td><td>✓</td><td>✗</td><td>✓</td></tr> <tr> <td>Preferred selection</td><td></td><td></td><td>✓</td><td></td><td></td><td></td></tr> </tbody> </table> If a metal pipe has been selected, choose suitable protection systems.	Parameter group	Pipe material							PE	PVC	Galvanneal (PE or PE)	Alloyed Steel	Uncoated Steel	Copper	1 Extended VOC suite (with TIC)	✓	✓	✓	Pass	Pass	Pass	1a • BTEX + MTBE	✓	✓	Pass	Pass	Pass	Pass	2 SVOCs TIC by purge and trap or head space and GC/MS with TIC (Aliphatic and Aromatic C2 - C10)	✓	✓	Pass	Pass	Pass	Pass	2a • Phenols	✓	✓	Pass	Pass	Pass	Pass	2b • Cresols and chlorinated phenols	✓	✓	Pass	Pass	Pass	Pass	3 Mineral oil C11-C20	✓	Pass	Pass	Pass	Pass	Pass	4 Mineral oil C21-C40	✓	Pass	Pass	Pass	Pass	Pass	5 Corrosive (Conductivity, Redox and pH)	Pass	Pass	Pass	✓	✗	✓	Specific suite identified as relevant following the investigation								2a Ethers	✓	✓	Pass	Pass	Pass	Pass	2b Nitrobenzene	✓	✓	Pass	Pass	Pass	Pass	2c Ketones	✓	✗	Pass	Pass	Pass	Pass	2d Aldehydes	✓	✓	Pass	Pass	Pass	Pass	6 Amines	✗	Pass	Pass	Pass	Pass	Pass	Pipes that pass chemical thresholds	✗	✗	✓	✓	✗	✓	Preferred selection			✓			
Parameter group	Pipe material																																																																																																																															
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Preferred selection			✓																																																																																																																													

Information	Specific details to be included
	Of the suitable pipe materials identified in Table 3.2, consult the Water Company to ensure compatibility with any preferred materials. List any preferred materials and sizes. Record the chosen pipe material using all the information above.
Specification of pipes	Record details of any restrictions relating to Part 4.
Checklists	Completed checklist

Appendix B – Water UK RA for water pipes protocol

Section 1: Development Details	
Development Name <i>(if it has one)</i>	
Development Address	
OS Grid Reference <i>(mid point)</i>	
Developers Name	
Water company reference number	
Please provide details below of the current and historical use of the site and adjacent sites. <i>If your supporting information has details of the current and historical site use, please reference below the relevant sections of your report.</i>	

Section 2: Preliminary Risk Assessment	
Has your desk study and site walkover identified any land potentially affected by contamination?	☐ Yes ☐ No
If the site is potentially affected by contamination but you have not completed any intrusive site investigation please provide details below of the rationale behind the intended pipe selection. <i>If your supporting information has details of the rationale behind the intended pipe selection, please reference below the relevant sections of your report.</i>	
Section 3: Intrusive Site Investigation	
Have you completed any intrusive site investigation?	☐ Yes ☐ No
Date(s) when the site investigation(s) undertaken	
At what level has groundwater been encountered?	☐ metres below ground level or ☐ Not encountered
Table 1 (Pipeline Selection Risk Assessment Summary (PSRAS)) below classifies testing required where the preliminary risk assessment has identified land potentially affected by contamination. Please provide details below of any test groups which have not been tested and the rationale for not testing. <i>If your supporting information has details of the rationale behind not testing any particular test groups, please reference below the relevant sections of your report.</i>	

If the intrusive site investigation has identified concentrations above the PE threshold (see PSRAS) and your intended pipe selection is PE please provide details below of the rationale behind the intended pipe selection. <i>If your supporting information has details of the rationale behind the intended pipe selection, please reference below the relevant sections of your report.</i>

Section 4: Site Remediation	
Please provide details below of any site remediation (which may include a change in site levels) already completed. <i>If your supporting information has details of the site remediation already completed, please reference below the relevant sections of your report.</i>	
Has the PSRAS (Table 1) been completed using appropriate data after remediation?	☐ Yes ☐ No ☐ N/A
Please provide details below of any proposed site remediation and an analysis of whether this will affect your intended pipe selection. <i>If your supporting information has details of any proposed site remediation and whether this will affect your</i>	

Section 6: Additional Information

Please use the section below to provide any additional details to support your intended pipe selection.

If your supporting information has additional information to support your intended pipe selection, please reference below the relevant sections of your report.

Section 7: Risk Assessor

Name and relevant qualifications of person directing the risk assessment for water pipes

Name and address of risk assessor's company

Date risk assessment performed

Section 8: Declaration

I confirm I have completed this form and provided supporting information in accordance with 'UKWIR Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites' and the water company's Supplementary Guidance. I also confirm that if any further site investigation is needed and carried out, I will be required to submit an additional Risk Assessment for Water Pipes with the relevant supporting information. I understand that failure to supply any of the required information may delay my application being processed.

Name

Company

Phone Number

Date

Table 1 - Pipe Selection Risk Assessment Summary (PSRAS)

- 1) Testing must be undertaken on the materials within which the pipes are to be laid, whether that be existing ground materials, remediated materials or imported capping materials. Please use the appropriate testing data to complete Table 1 below.
- 2) If more than one pipe selection is being made, for example, for pipes in different areas of a large site, a completed PSRAS is required for each selection.

What materials have been tested to populate Table 1 below?

☐ Existing ground materials ☐ Remediated materials ☐ Imported capping materials

All concentrations in mg/kg

Test Group	Testing Required?	PE threshold	Metal Pipes/ Barrier Pipe	Laboratory Detection Limit	Testing UKAS accredited Y/N	Maximum concentration at proposed pipeline depth See Note [2]	Maximum site concentration See Note [3]	Locations and depths where concentrations exceed proposed pipeline threshold
Total VOCs	Where Preliminary Risk Assessment (PRA) has identified and potentially affected by contamination	0.5	Pass					
Total BTEX & MTBE		0.1	Pass					
Total SVOCs (excluding PAHs and those substances marked with an *)		2	Pass					
EC5-EC10 aliphatic and aromatic hydrocarbons		2	Pass					
EC10-EC18 aliphatic and aromatic hydrocarbons		10	Pass					
EC18-EC40 aliphatic and aromatic hydrocarbons		500	Pass					
Phenols* (from SVOC analysis)	Only where identified	2	Pass					
Cresols and chlorinated phenols* (from SVOC analysis)		2	Pass					
Ethers*		0.5	Pass					
Nitrobenzene*		0.5	Pass					
Ketones*		0.5	Pass					
Aldehydes*		0.5	Pass					
Amines		Fail	Pass					
Corrosive	Conductivity, Redox and pH	Pass	See Note [1]					

Note [1] Threshold: For wrapped steel, corrosive if pH<7 and conductivity > 400µS/cm. For wrapped ductile iron corrosive if pH<5, Eh not neutral and conductivity > 400µS/cm.

For copper, corrosive if pH<5 or >8 and Eh positive.

Note [2] Water pipes are normally laid at 0.75-1.35m below finished ground level.

Note [3] Also state if liquid free product is present in soil or groundwater.

Appendix C - Chemical causing degradation of MDPE* (Crathorne et al. 1987 (reproduced in BRE, 1994)

- * Many of the data have been extrapolated from experiments on low-density (LDPE) and high-density (HDPE) polyethylenes. Extrapolation is thought to be valid for swelling agents and chemicals causing degradation, but it may not be so for ESC agents
- † No entry in this column indicates that no information was available
- ‡ Environmental stress cracking
- ✓ Indicates effect causing deterioration

Substance	Concentration [†] (%)	Effect		
		Swelling	ESC [‡]	Degradation
Acetaldehyde	100		✓	
Acetic acid	10		✓	
	100		✓	
Acetic anhydride	100		✓	
Acetonitrile	—		✓	
Acetophenone	100		✓	
Acrylic emulsion	Wide range		✓	
Aliphatic hydrocarbons		✓		
Allyl chloride	100	✓		
Ammonia (liquid)	—	✓		
Amyl acetate	100	✓		
Amyl alcohol	10	✓		
Amyl chloride	All	✓		
Aniline	100	✓		
Aqua regia	100			✓
Aromatic hydrocarbons	100	✓		
Benzaldehyde	Saturated	✓		
Benzene	100	✓		
Benzene sulphonie acid	100		✓	
Benzoyl chloride	100	✓		
Benzyl acetate	—		✓	
Benzyl alcohol	—		✓	
Bromine (liquid)	100			✓
(vapour)	High			✓
(aqueous solution)	Saturated			✓
Bromochloromethane	100	✓		
Butadiene	100	✓		
Butanediol	100		✓	
Butane (liquid)	100	✓	✓	
Butanol	100		✓	
Butyl acetate	100		✓	
Butyl alcohol	100		✓	
Butyl chloride	—	✓		
Butyraldehyde	—	✓		
Butyric acid	20		✓	
Carbon disulphide	100	✓		
Carbon tetrachloride	100	✓		
Chloral hydrate	100	✓		
Chlorine gas	—	✓		✓
Chlorobenzene	100	✓		
Chloroform	100	✓		
Chloromethane	100	✓		
Chlorosulphonic acid	100			✓
Chromic acid	Saturated			✓

Substance	Concentration [†] (%)	Effect		
		Swelling	ESC [‡]	Degradation
Citric acid	—		✓	
Cresols	100	✓		
Crotonaldehyde	100		✓	
Cyclohexane	100	✓		
Cyclohexanol	100	✓	✓	
Cyclohexanone	100	✓		
Decahydronaphthalene (Decalin)	100	✓		
Detergents	—		✓	
Diamyl ether	—	✓	✓	
Dibutyl ether	100	✓		
Dibutyl phthalate	100	✓		
<i>o</i> -Dichlorobenzene	—	✓		
<i>p</i> -Dichlorobenzene	—	✓		
Dichloroethane	100	✓		
Dichloroethylene	100	✓		
1,2-Dichloropropane	—	✓		
Diethyl ether	100	✓		
Diethyl ketone	—		✓	
Diethylene glycol	100		✓	
Diglycolic acid	100		✓	
Dimethylamine	—	✓		
Dimethyl formamide	100	✓		
Dinonyl phthalate	100	✓		
Dioctyl phthalate	100	✓		
Dioxane	—	✓	✓	
Diphenyl ether	100	✓		
Dodecanoic acid (Lauric)	—		✓	
Dodecanol	—		✓	
Emulsifiers	—		✓	
Ethane	—		✓	
Ethyl acetate	—	✓	✓	
Ethyl acrylate	100	✓	✓	
Ethyl alcohol	100		✓	
Ethyl benzene	100	✓		
Ethyl butyrate	100	✓		
Ethyl chloride	100	✓		
Ethylene chloride	100	✓		
Ethylene dichloride	100	✓		
Ethylene glycol	100		✓	
Ethylene oxide	—	✓		
Fatty acids (>C ₆)	—		✓	
Fluorine	100			✓
Formaldehyde	40		✓	
Formic acid	—		✓	
Furfural	100	✓		

Substance	Concentration [†] (%)	Effect		
		Swelling	ESC [‡]	Degradation
Furfuryl alcohol	100	✓		
Gallic acid	—		✓	
Glycolic acid	30		✓	
Glycerol monobenzyl ether	—		✓	
Heptane	—	✓		
Hexamine	100		✓	
Hydrazine	100		✓	
Hydrazine hydrate	—		✓	
Hydrogen peroxide	—	✓		
Hypochlorous acid	—	✓		
Iodine (solution in potassium iodide)	—			✓
Isooctane	—	✓	✓	
Isopropanol	—		✓	
Isopropyl ether	100	✓		
Lactic acid	—		✓	
Latex	—		✓	
Mesityl oxide	—		✓	
Methyl acetate	—	✓		
Methyl acrylate	—	✓		
Methyl alcohol	—		✓	
Methyl bromide	—	✓		
Methyl cyclohexane	—	✓		
Methylene chloride	—	✓		
Methyl ethyl ketone	—	✓		
Methyl methacrylate	—		✓	
4-Methyl pentan-2-one	—	✓		
Methyl sulphonic acid	—		✓	
Naphtha	—	✓		
Nicotine	—		✓	
Nicotinic acid	—		✓	
Nitric acid	Above 25			✓
Nitrobenzene	—	✓		
Nitroglycerine	—	✓		
Nitropropane	—	✓		
<i>o</i> -Nitrotoluene	100	✓		
Octane	—	✓		
Octanol	—		✓	
Oleic acid	—		✓	
Oleum	—			✓
Orthophosphoric acid	—		✓	✓
Oxalic acid	—		✓	
Ozone	—			✓
Palmitic acid	—		✓	
Pentane	—	✓		
Perchloric acid	70			✓
Petroleum ether	—	✓		

Substance	Concentration [†] (%)	Effect		
		Swelling	ESC [‡]	Degradation
Phosphoric acid	Concentrated			✓
Phosphorous oxychloride	—			✓
Phosphorous trichloride	—			✓
Picric acid	Above 10		✓	
Polyglycol ethers	—		✓	
Potassium hydroxide	Concentrated		✓	
Propane	—	✓		
Propargyl alcohol	—		✓	
Propyl alcohol	100		✓	
Propylene glycol	—		✓	
Propylene oxide	—	✓		
Pseudocumene	—	✓		
Silicone fluids	—		✓	
Soap solutions	—		✓	
Sodium hydroxide	Concentrated		✓	
Sodium peroxide	Saturated			✓
Stearic acid	100		✓	
Sulphur trioxide	—			✓
Sulphuric acid	Above 90			✓
Sulphuric acid fuming	—			✓
Sulphuryl chloride	—			✓
Tannic acid	—		✓	
Tetrabromomethane	100	✓		
Tetrachloroethane	100	✓		
Tetrahydrofuran	100	✓		
Tetraline	—	✓		
Thionyl chloride	—	✓		✓
Thiophene	100	✓		
Toluene	100	✓		
Trichloroacetic acid	100	✓		
Trichlorobenzene	—	✓		
Trichloroethylene	—	✓		
Trichloroethane	—	✓		
Tricresyl phosphate	—	✓		
Triethanolamine	—	✓		
Turpentine	—	✓		
Urea	—		✓	
Vinyl acetate	—	✓	✓	
Xylene	—	✓		
Xylenol	—	✓	✓	

Substance	Concentration [†] (%)	Effect		
		Swelling	ESC [‡]	Degradation
Oils and fuels	—			
Animal oils	—	✓		
Vegetable oils	—	✓		
(castor, cedar, cinnamon, lemon eila, coconut, peppermint, pine)				
Fuel oil	—	✓		
Kerosene	—	✓		
Lubricating oil	—	✓		
Mineral oil	—	✓		
Paraffin oil	—	✓		
Petrol	—	✓		
Silicone oil	—		✓	
Transformer oil	—	✓		

Appendix D - Key literature: summary of research method and outcomes

Reference	Key Factor of Research			
	Contaminant	Material Type	Type of Effect	Research Method and Outcomes
Vonk and Veenendaal, 1983.	Methylbromide, toluene	Plastic – PE, PVC	Permeation Swelling	Literature review and experimental work. - Theory of permeation – Henry's law and two laws of Fick's - Theory of swelling – Case II and moving front process and Fick's Law (PVC) - Introduces the constants of Henry's law (solubility coefficient) and Fick's law (diffusion coefficient). The lag-time process is identified as a commonly used technique to determine these constants. Factors considered: - Pipe thickness (i.e. Δthickness = Δtime to permeate through polymer) - Type of contaminant and concentration - Polymer structure (i.e. differences between PE and PVC) - Vapour and aqueous phases (permeation greater in vapour phase)
Flogstad et al. 1984.	Solvent residues (from pipe manufacture)	Plastic – PE, PVC	Permeation Swelling	Literature review and overview of taste and odour incidents -Focuses contaminants originating from plastic pipe material and gas permeation Factors considered: - Raw polymer materials and manufacturing process causing taste and odour - Ground temperature - Polymer structure (i.e. differences between LDPE, HDPE, PVC) - Water contact time (e.g. stagnation and pipe volume)
Crathorne et al. 1987.	Organic and inorganic contaminants	Metal (ductile iron, copper) Cementitious (asbestos cement, concrete) Plastic (MDPE, uPVC, GRP)	Deterioration Effects: -Solvation (swelling and dissolution) -Environmental Stress cracking (ESC) -Chemical degradation	Literature Review and surveys (site assessment procedures in UK, Netherlands and US and of incidents in UK and US). Theory and mechanisms of various effects discussed: - Permeation – Fick's law and free-volume theory (or moving front) - Solvation – Solubility parameter and the Flory-Huggins constant concept can be used to predict the likelihood of pipe failure. Limitation due to limited data polymers used for pipes or relating to contaminated soil (i.e. only commercial solvent data available).

Reference	Key Factor of Research			
	Contaminant	Material Type	Type of Effect	Research Method and Outcomes
		Other (rubber gaskets)	-Corrosion -Leaching Water Quality Effects: -Permeation	-ESC effects are not well understood. Limited data on the effects of surface-active contaminants and experimental bent strip test only using undiluted substances. No records of failures in the field. -Chemical degradation – polymer chain scission and crosslinking reaction mechanisms and unzipping reactions (uPVC). -Anodic dissolution, cathodic processes and galvanic corrosion mechanisms. Limitation to the use of corrosive indicators and corrosive protection should be considered as general practice for iron pipes.
Park et al. 1996	Methylchloride, toluene, trichloroethylene	Polyethylene (thermoplastic geomembranes – HDPE, VLDPE, PVC)	Permeation	Literature review and experimental work. - Transport theories of aqueous organic compounds (Transient Mass Flux and Steady-state Mass Flux and Permeability) Factors considered: - Transport of aqueous organic compounds - Membrane thickness - Partition coefficient effect - Contaminant concentration - Material type (i.e. HDPE, VLDPE and PVC)
Young et al. 1996.	Range	N/A	N/A – taste and odour thresholds	Experimental work to determine taste and odour thresholds and compared with health-based limit established by the USEPA and WHO drinking water guidelines. Outcome: - 59 T&O threshold values - T&O can be detected at concentration below health-based limits - T&O in water alone cannot warn against concentrations above health-based limits.
Bromhead, 1997	Organic contaminants specifically benzene, tetrachloroethene and trichloroethene	Plastic (PE, PB and PVC)	Permeation Swelling	Literature review, incident and manufacturer survey. Theories / mechanisms of permeation (Fick's Law of diffusion & lag-time process), swelling (solubility parameter and Flory-Huggins concept and crosslink effect) Factors considered: -Soil properties -Rate of Flow of water (stagnation) -Pipe manufacturers information

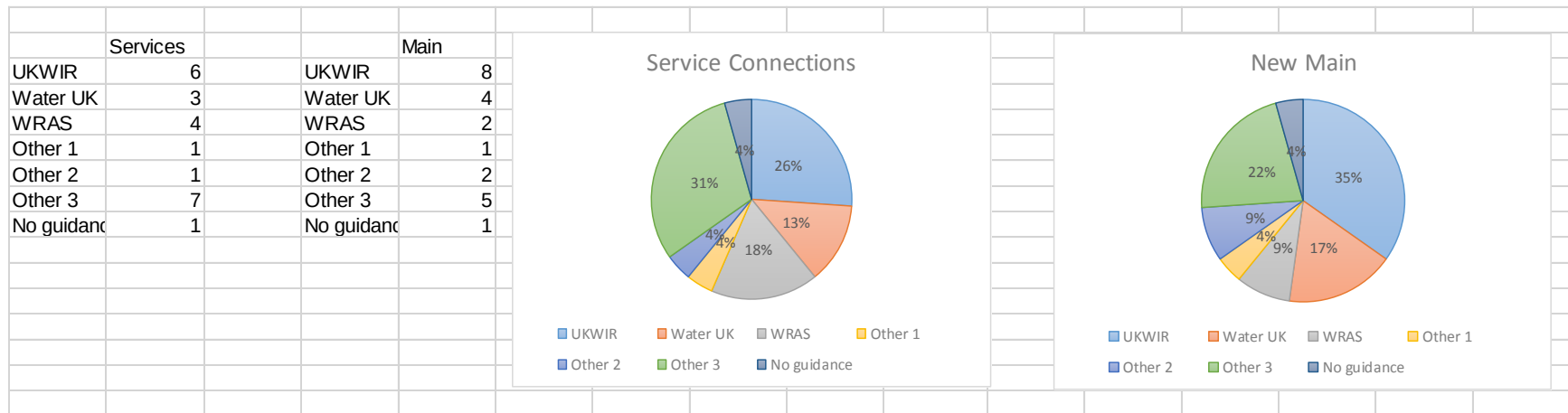
Reference	Key Factor of Research			
	Contaminant	Material Type	Type of Effect	Research Method and Outcomes
				-Water Quality Standards -Climate / ground temperature -Pipe Diameter (pipe thickness) - Medium e.g. vapour and aqueous phases (permeation greater in vapour phase)
Mao et al. 2009.	Benzene, toluene and trichloroethylene	PVC	Permeation Swelling	Experiment work: Visualization test, gravimetric sorption test, pipe bottle tests Factors considered: - Vapour and aqueous phases - Contaminant concentration (e.g. a range of contaminant concentrations were investigated and effects compared with those encountered with saturate vapour and aqueous solution) -Exposure time -Polymer matrix
Ong et al. 2008.	Petroleum-based hydrocarbons	PVC, PE and other elastometric gaskets	Permeation	Survey of types of service and main pipes materials used in the US. Experimental work as per Mao et al. 2009 Factors considered: - Soil properties - Rate of Flow of water (stagnation) - Saturated and unsaturated soil conditions (experimental work undertaken to replicated pipe exposure to free product, gasoline-contaminated soils (unsaturated) and gasoline-contaminated groundwater (saturated)) - Pipe size

Appendix E – UK Water Company Procedures datasheet

No.	Water Company	Website links [Accessed June 2014]	Services								Main							
			UKWIR/ Water UK	UKWIR2010	UKWIR2004	WRAS2002	Other1	Other2	Other3	No guidance	UKWIR/ Water UK	UKWIR2010	UKWIR2004	WRAS2002	Other1	Other2	Other3	No guidance
1	Sembcorp Bournemouth Water Ltd.	http://www.sembcorp.co.uk/developers/water-mains/how-to-apply.aspx		1								1						
2	Bristol Water	http://www.bristolwater.co.uk/developments/		1								1						
3	Cholderton and District Water	http://www.choldertonwater.co.uk/								1								1
4	Dee Valley Water	http://www.deevalleywater.co.uk/article.php?id=146	1								1							
5	Essex and Suffolk Water	https://www.eswater.co.uk/business/dev-water-mains-and-services.aspx				1										1		
6	Hartlepool Water (Part of the Anglian Water Group)	http://www.hartlepoolwater.co.uk/developers/planning-for-development.aspx					1								1			
7	Portsmouth Water	http://www.portsmouthwater.co.uk/customer_services/default.aspx?id=8662							1								1	
8	South East Water (Mid Kent)	http://www.southeastwater.co.uk/your-business/developer-services/new-water-connections-how-to-apply/new-connection-checklist#.VAyqoCiErTR							1								1	

9	South Staffordshire Water	South Staffs Water - New Connections Application							1								1	
10	Sutton and East Surrey Water	http://www.waterplc.com/pages/business/services-for-developers/getting-connected/				1								1				
11	Affinity Water (formerly Veolia Water Central)	https://www.affinitywater.co.uk/developer-services.aspx				1					1							
12	Anglian Water	http://www.anglianwater.co.uk/developers/waterservices.aspx		1								1						
13	Dwr Cymru (Welsh Water)	http://www.dwrcymru.com/en/Developer-Services.aspx							1								1	
14	Northumbrian Water	https://www.nwl.co.uk/developers.aspx	1								1							
15	Scottish Water	http://www.scottishwater.co.uk/business/connections/connecting-your-property/connections-applications-forms							1			1						
16	Seven Trent water	http://www.stwater.co.uk/developers/							1								1	
17	South West Water (SWW)	http://www.southwestwater.co.uk/index.cfm?articleid=1540							1			1						
18	Southern Water	http://www.southernwater.co.uk/property-and-developers/developers-and-housebuilders/water-connections/water-main-reg/				1								1				
19	Names: Thames Water	http://www.thameswater.co.uk/developers/1328.htm						1									1	

20	United Utilities	http://www.unitedutilities.com/pipeline-land-assessment.aspx	1								1							
21	Wessex Water	http://www.wessexwater.co.uk/developers/threecol.aspx?id=372&linkidentifier=id&itemid=372 [Accessed June 2014]		1								1						
22	Yorkshire Water	http://www.yorkshirewater.com/extra-services/developer-services/new-water-connections/apply-for-a-water-connection.aspx		1								1						
23	Northern Ireland Water	http://www.niwater.com/water/		1								1						
			3	6	0	4	1	1	7	1	4	8	0	2	1	2	5	1



Appendix F – PSRA datasheet – Stage 1 and Stage 2

New water connections and main requisition applications - information database**Water UK protocol requirements:**

Desk Study (PRA), minimum
 PSRA (Phase 1), minimum
 Signatories - suitability qualified person, minimum
 Ground Investigation (where contaminative land use identified)
 Testing (Basic (e.g. TPH, SVOC, VOC, BTEX/MTBE) or Extended (e.g. Ether, nitrobenzene, ketones etc.)) or Metal pipes (e.g. pH, conductivity & redox)
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 Sufficiency of Testing - 0.75 to 1.35m from finished ground level to crown of pipe
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 Sufficiency of Testing - PID employed to supplement (Screen pipe route 15m either side of the proposed pipe route)
 Sufficiency of Testing - CL:AIRE/CIEH 2008 used to justify number of samples tested
 Sufficiency of Testing - BS10175, CLR4 and R&D Technical Report P5-066/TR referenced for sampling strategy employed
 Sufficiency of Testing - validation sampling assessed where remediation has been implemented
 PSRA (Phase 2) (where contaminative land use identified)

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Blue column indicate transposed factual information collated from developer / SLO submissions

STAGE 2 - Author Review - Overview of identified contaminative land-uses, proposed land use & Developer/SLO submission history

Application Number / Site No.	Site	Application Date	Proposed Development	Contaminative Land-use(s) (current and historical, on-site and adjacent land)	Developer / SLO Supporting Information
1	Field lane, Fazakerley	12/05/2011	Residential resettlement centre with soft landscaping communal area	Historically the site and its surrounds have been used for recreational use	BSP Consulting Field Lane, Fazakerley Combined Phase I Desk Study & Phase II Exploratory Investigation, January 2008. KGA Partnership Annotated Site Plan Drawing No. 2889-M-08 (submitted with application).
2	Quinn Radiators, Spinning Jenny Way, Leigh, WN74PE	01/06/2011	Retail - leisure development	Currently occupied by Quinn radiators, a former manufacturing works. Historically Albian Iron Works (1907/1908) (W), Engineering Work (1928/29) (W).	Particle Size Distribution Lab Report, dated November 2009 Phase 1 Geoenvironmental Desk Study, dated June 2009 Phase 2 Geoenvironmental and Geotechnical Report, November 2009 Exploratory hole location plan
3	Salford Reds Stadium	20/05/2011	Leisure development	Industrial and residential area. A section of the proposed pipe may pass through unconsolidated landfill material. Saltey Brook and Manchester ship canal is located to the south.	Site Plan annotated with proposed water main layout across the site from existing connection on A57 Liverpool Road. SKM Land Remediation - GeoEnvironmental Investigation December 2009.
4	Ince Marshes, Frodsham	06/06/2011	Waste transfer facility	Currently in agricultural use. The site is road and rail access in close proximity to the site. The site is reclaimed marshland of the mersey estuary. The site is bound to the north by Manchester Ship Canal. A fertiliser plant (S) and former power station now glass manufacturing plant (S).	RSK Group Plc Environmental Site Investigation Resource Recovery Park & Power Station Ince Marshes, Cheshire Report Ref:16321-R2 RSK Environment Ltd Environmental Statement Section 6 Geology Ref: RSK/HE/P40142/04/Section 6 Rev06 WSP Group Base Infrastructure Services Layout WSP/1772/GA/BASE/100
5	Mercer Av. Kirkby	16/05/2011	Residential development and associated infrastructure	Open land with evidence of the previously demolished structures.	Initial application - developer provides provides assessment based on withdrawn WRAS guidance. Further information provided by developer upon water company request. Phase 2 Report Exploratory hole location plan Raw chemical data
6	Derby Rd, Widnes	16/05/2011	Residential, retail, light commercial development	Historic brick works (1907)/ chemical works (1927), Asbestos & Cement works (1957) more recently Former Marley Eternit factory (demolished). Area 1 - formerly occupied by despatch building - bitumen storage tank, reservoir and associated pump house, solvent/paint storage & dipping tanks - 2 abstraction BHs. Area 2 - security lodge. Area 3 - former garage & workshop, sewage pump station. Area 4 effluent treatment plant - hydrochloric acid (to be decommissioned)	Proposed water design for Self Lay Water Mains Dwg No. 3691-300-RevB 02/03/11 Energetics, Site Plan of housing arrangements annotated with proposed 110mm & 90mm HPPE, 63mm MDPE, water main layout for plots 1 to 106. - REC GeoEnvironmental Site Assessment June 2009, including Remedial Remedial Strategy - REC Feb 2011 Verification Reports Areas 1-11 - Halton BC letter 21/02/11 referring to an REC Addendum report - REC Validation Report Hydrocarbon Impacted Areas (Report Ref: 43284p3r0) January 2011 (second submission) No developer Water Pipe Section RA was submitted
7	Hillingdon Av. Halewood	09/05/2011	Residential housing	Not specified	Consultants letter including lab results, and exploratory hole location plan
8	Carrswood Wythenshawe	30.05.11	Residential	Developer discription undeveloped 1876-1959. Social club and car park land use	Letter report (including site history overview, pipe selection risk assessment (based on WRAS guidance threshold values), exploratory hole location plan and laboratory data)
9	Edge Lane, Liverpool	12.04.11	Retail - leisure development including car parking and underground car parking.	Limited historical information provided by the developer. A petrol station was identified.	Initial submission: Desk study (Phase 1) Upon water company request: Pipe Layout drawing Development phase plan drawing Phase 2 report (inc. factual GI data and exploratory hole plan) No pipe selection RA undertaken by developer
10	John St, Carlisle	14.04.11	Hostel, essentially a building surrounded by hardstand.	Not provided	No specific risk assessment . No exploratory hole logs The following information was provided: proposed pipe layout drawing Phase 2 risk assessment report SI data provided (which provides data from only 2 samples below 0.5m)
11	Hayes Road, Cadishead	06.06.11	Housing and associated public open space	Development area was previously occupied by British Tar Products & Clariant. A car park is located to the north west of the site and a disused railway to the north east and a canal to the south east.	Proposed water design network for Hayes Road, Cadishead Dwg No. 264591-W PH1 with Phase 2 indicated by freehand in highlighter pen. Wardell Armstrong Clariant Works, Hayes Road, Manchester Remediation Validation Report October 2007
12	Spencer Street	07/06/2011	112 residential dwellings	Two historical mill complexes and a series of reservoirs which have since been infilled. Site can be split into Area A to E. A - later became industrial works with former colliery W & SW, B - distriution warehous (1980). Iron works loacted adjacent to Area C, Area D and E predominately residential with some industrial encroachment. On-site in-filled reservoirs recorded as historical landfills (Area A, C and B)	Enicia Supplementary Geoenvironmental Appraisal (Report No. 20050/2) February 2011; Enicia Quantitative Risk Assessment (Report No. 20050/4) February 2011; Enicia Outline Remedial Strategy (Report No. 20050/5) February 2011
13	Norlands Lane, Widnes	07/06/2011	24no, 2/3 storey residential properties with rear gardens and associated hardstanding car parking.	Historical use as farmland. Current use is as rough pasture open space with 3no. Topsoil stockpiles (source of stockpile material was not provided). Surrounding land predominantley residential since the 1950's. Site history obtain from phase 2 report, no supporting OS mapping was provided in the developer report.	Phase 2 Site Investigation Report (combined phase 1 and phase 2 report) Betts Associates for Bellway Homes dated 2010 Exploratory Hole Location Plan Exploratory hole logs Chemical laboratory data (stockpile and TP samples) Water Pipe Selection Assessment (in accordance with WRAS guidance)
14	Chapelford Phase 11	21/06/2011	Village development (including low rise residential structures, gardens, infrastructure and public open space.	Currently open space following the demolition of foemer warehouse (associated with RAF facility dated 1960-2004). A number of small stockpiles were observed during fieldwork associated with temporary works of phase 10 development to the north. Standing water was observed. No support OS mapping was provided as part of the connection submission.	Hydrock Ground Investigation at Phase 11, Chapelford Urban Village, Warrington Report (Ref. R/101113/11/002) November 2010. Water Supply Layout plan

New water connections and main requisition applications - information database**Water UK protocol requirements:**

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Blue column indicate transposed factual information collated from developer / SLO submissions

STAGE 2 - Author Review - Overview of identified contaminative land-uses, proposed land use & Developer/SLO submission history

Application Number / Site No.	Site	Application Date	Proposed Development	Contaminative Land-use(s) (current and historical, on-site and adjacent land)	Developer / SLO Supporting Information
15	The Manor House Site, Sefton Lane, Maghull	27/06/2011	Residential	Site previously occupied by recreation buildings. A paper works, industrial site and historical landfill were identified within 200m of the site. (reported in the developers phase 2 report)	Leyden Kirby Associates Ltd Report (Ref. CL-602-CL1130-02 28th November 2008) Executive Summary Leyden Kirby Associates Ltd Report (Ref. CL-602-CL1130-02 28th November 2008) Conclusions and Recommendations Leyden Kirby Associates Ltd Report (Ref. CL-602-CL1130-02 28th November 2008) Appendix B Analytical Results Leyden Kirby Associates Ltd Report (Ref. CL-602-CL1130-02 28th November 2008) Figure 3.1 Sampling Location Plan Additional information submitted following request by WC: Leyden Kirby Associates Ltd. Phase 1 Desk Study - PRA, Dated 29th June 2007 Leyden Kirby GI and Assessment Report, dated 28 November 2008
16	Mulberry Road Rock Ferry Birkenhead	08/06/2011	Residential	The site is currently occupied (prior to residential development) by buildings annotated as a depot (west) and a works (east). The surrounding land where formally occupied by a saw mill and welding factory & depot before being redeveloped to residential housing.	Leyden Kirby Associates Ltd Ground Investigation and Risk Assessment Report (Combined Phase 1 and Phase 2) Land at Mulberry Road, Birkenhead – October 2008. Pipeline Route Layout Plan
17	St Catherine's Hospital, Church Road, Tranmere	07/07/2011	Hospital extension	Limited historical information provided. Developer describes current use as a hospital with limited soft landscaping areas. The surrounding area appears mostly residential.	Northwest HSE Report of a ground investigation at St Catherine's Hospital Birkenhead (Ref F15453) July 2009 Notes to accompany PSRAS for St Catherine's Health Centre (attached to application) Gifford Geotechnical and Contaminated Land Interpretive Report (Report No. 14861-GE-003 April 2009) Water supply connection drawing (identifying 3 separate water connect points)
18	St Marys Oldham	04.07.11	93no. Traditional 2/3 storey family properties	Site previously occupied by apartment blocks. The site was discribed by the developer as a disccused rough grassland area divided into three plots by two roads which transect the site. Two tarmac car parks occupy the west of the site. A gravel surfaced area was identified in the northeastern portion of the site and assumed to be utilised for parking by a local school. A garage and electricity substation is located along the northern site boundary. The is located in a mainly residential setting.	Proposed pipe route plan (including exploratory hole locations and PE threshold TPH exceedance locations). Pipe Selection Risk Assessment summary (completed by Matt Gardener CGeol, SILC, dated 21/06/11) GCM Site Investigation factual report dated 1999, 2002 (inc. exploratory hole plan, logs, and chemical data (metals, phenol, total PAH only) Sirius Site Investigation factual report dated 2006 (inc. exploratory hole plan, logs, chemical data (metals, Speciated PAH 16, TPH CWG - totals and leachate data) Sirius Geoenvironmental appraisal (combined phase 1 and 2) (no historical mapping included) Mouchel Parkman Human Health Risk Assessment dated October 2009 (includes historical GI assessment and completion of Supplementary GI inc. plan, logs, chemical data (metals, TPH CWG, 16PAH - total and leachate) Capita Symonds Geoenvironmental Audit Report (historical plus Supplementary GI inc plan, logs and chemical data (metals and PAHs only) , dated July 2010 Capita Symonds Ground Remediation Statement, dated July 2010 Capita Symonds Remediation verification Report - Hotspot Management report dated 24 June 2011
19	Berwyn Grove, St Helens	06.07.11	Residential	Limited historical site information provided by the developer as part of connection submission. The following statement was provided "The site is brownfield as it was previously a care home, no obvious source of organic contamination desk study and no evidence of such in GI, fill on site is colliery spoil type material".	This application was first received 09.06.11 with a completed RA for water pipes dated 08.06.11. BP was proposed due to elevated PAHs. Supporting email correspondence was provided stating the PRA has identified no risks of contamination. The WC reject the June 11 submission. Next submission 06.07.11: RA for Water Pipes, dated 08.06.11 Section 9 Remediation (Ref: GRMPS311/F.1); GRM Development Solution Limited Exploratory Hole Location Plan Figure 2 (Ref: PS311); GRM Development Solution Limited Trial Pit Logs (TP1-TP9); Second submission (further info request from water company): GRM Development Solution Limited Site Appraisal dated December 2010 (Ref: GRMPS311/F.1). Third submission (further info request from water company): Email received with application, dated 16 August 2011 (Subject: FW: Berwyn Grove, Padstow Close, Vernon Street & Back Minorca Street).
20	Back Minorca Street	06.07.11	Residential	Limited historical site information provided by the developer as part of connection submission. The following statement was provided "Site is brownfield due to being a former land fill".	1. - Email received with application, dated 06 July 2011; - GRM Phase II Site Appraisal Report (GRMPS361/F.1): - RA for Water Pipe, dated 21.06.11 2. GRM Letter Report dated 13th April 2011 (GRMPS361/F.1) 3. -Email received with application, dated 16 August 2011 (Subject: FW: Berwyn Grove, Padstow Close, Vernon Street & Back Minorca Street).
21	Beswick Phase 2, Bell Crescent	12/07/2011	Residential	Developer consultants stated a residential site use from late 19th century to 2010, when existing housing as demolished. Following the review of historical mapping, the majority of the site has a historical residential landuse however a portion of the site to the east was historically occupied by a dye works & reservoir (1893), replaced by a church (1908), replaced by a depot (1956) then redeveloped as a police station (1977 to 2010). Land south of the site had a historical industrial use being occupied by mineral and cattle depot and rail and various engineering works.	Water Pipe Material Risk Assessment (withdrawn WRAS threshold values used) dated 09.05.11 Proposed Pipe Route Layout Drawing (PE and BP mix proposed). Eastwood&Partners Geotechnical & Geoenvironmental Site Investigation Phase 2, Bell Crescent Manchester, dated Nov 2010 (enclosed GI factual report and Envirocheck report)
22	West Drive, Tintwistle	15/07/2011	Residential	Site formally occupied by garage and a electricity substation before demolition. Site is located in a residential setting with a water treatment works located north and a sewage treatment works located to the southeast. Two historical landfill sites have been identified within 200m of the site.	BSL Desk Study Assessment Report (Ref JD/C1550/1850) dated Aug 2009 BSL Geo-Environmental Assessment Report (DNC/C1550/1850) dated Dec 2009 Water Pipe Risk Assessment Completed by E.Hackney Beng, Ceng, M(StructE) Proposed pipe route drawing

New water connections and main requisition applications - information database**Water UK protocol requirements:**

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STAGE 2 - Author Review - Overview of identified contaminative land-uses, proposed land use & Developer/SLO submission history

Application Number / Site No.	Site	Application Date	Proposed Development	Contaminative Land-use(s) (current and historical, on-site and adjacent land)	Developer / SLO Supporting Information
23	Rainford High Tech College, Higher Lane, St Helens, Merseyside, WA11 8NY	18/07/2011	Technology college extension	Current use as a Technology college	Pipe Material Selection Risk Assessment (risk assessor T. Godfrey (HNC) Building Services Engineering Gifford (Sept 2010) Geotechnical & Contaminated Land Interpretative Report Ref no. 16122-GE002 (including factual ground investigation factual report) Correspondance St Helens Council dated 30.09.10 re. P/2010/0592 Technical Review of Interpretative Report Relating to Rainford High Tech College Supplementary chemical lab data (HDP1-4) dated Aug 2011 (SVOC, TPH CWG, VOC) Service Trench photographs Water pipe route plan
24	Avondale Drive, Widnes	19.07.11	Residential	Former primary school (based on developers assessment, no supporting historical mapping provided)	Brownfield Solutions Limited Geo-Environmental Assessment Report Avondale Drive, Widnes Ref: JMJ/C1151/296 December 2006; Coppers Letter Report – Land at Avondale Drive, Widnes Ref: 5144MC100218L February 2010; Coopers Remediation Statement Ref: 5144HBC110505L May 2011-07-28. Email response dated 01 August 2011 (received follow request for further ground investigation by WC) Proposed Water Design for Self Lay Water Main Drawing 4368_400_RevB Submission 1: Email received with application, dated 12 July 2011; Risk assessment for water pipes, dated 11 July 11 (using WRAS); Tameside Metropolitan Borough Council Planning Permission, dated 26th January 2011; GRM Development Solution Limited Site Appraisal (Ref: GRM/P51959F-1), dated January 2011. Submission 2: Email received, dated 05 August 2011 (developer email following request for further information by WC)
25	Padstow Close , Hattersley	15/07/2011	New build - eight bungalows	Domestic garages including hard and soft landscaping (based on consultants description, no supporting historical mapping was provided)	Submission 1: REFA Consulting Engineers Letter Report Ref: REF/EJ07055, January 2008; REFA Consulting Engineers Letter Report Ref: REF/EJ07055 June 2011 Submission 2 (following request for further information by WC): REFA Consulting Engineers Ground Investigation Report No. 07055, April 2010 Proposed Water Design for Self Lay Water Mains, Dwg No. 4211_400_RevB, June 2011. Water Pipe Selection Risk Assessment dated 16.09.11
26	Station Road, Blackrod, Bolton	22/07/2011	Residential	The site has a historical use as allotment land. Widespread commercial and industrial activity has taken place in the immediate vicinity of the site (inc. railway land/station, cotton mill, timber yard). A historical landfill has been identified within 150m of the site.	Submission 1: REFA Consulting Engineers Letter Report Ref: REF/EJ07055, January 2008; REFA Consulting Engineers Letter Report Ref: REF/EJ07055 June 2011 Submission 2 (following request for further information by WC): REFA Consulting Engineers Ground Investigation Report No. 07055, April 2010 Proposed Water Design for Self Lay Water Mains, Dwg No. 4211_400_RevB, June 2011. Water Pipe Selection Risk Assessment dated 16.09.11
27	Mottram Moor, Hyde	26/07/2011	Residential	No historical site information was provided to the WC by the developer. A phase 2 report was provided and presence of made ground was identified as a potential source of contamination.	Wormseye Electronic Report Ref: GGC/mottram rd junction pub/SK14 6LA. (phase 2)
28	Former St Annes Hospital, Altrincham	27/07/2011	Refurbish existing hospital building into residential apartment block & construction of new apartment block.	Historical use as a hospital. A boiler house and heating oil tanks have been recorded to have been present at the site.	Strata Surveys Limited Ground Investigation Report, July 2011 (Report No.15139); Proposed site plan and water pipe distribution for residential development at the former St Annes Hospital, Bowden Road, Altrincham. Dwg No. 085-00-1001C P.J. Livesey Group Ltd; Risk assessment for water pipes, dated 14 July 11. Strata Surveys Limited Ground Investigation Report, July 2011 (Report No.15139); Reports submitted following the request for further information by the WC (PRA, lab chemical data and Remediation Verification Report); Strata Surveys Limited supplementary report New water service connection risk assessment report (inc historical mapping and additional chemical testing) Ref. JMT/L15139 3000811 dated 30th August 2011 Risk Assessment for Water Pipes, dated 1st September 2011.
29	Cloister Way, Ellesmere Port	29/07/2011	Residential	Based upon the historical records for the site, the proposed development is situated on the site of a former gas works.	Tier Consult Environmental Phase II Geotechnical Appraisal of Land at Cloister Way, Ellesmere Port Ref T/11/930/GA, Feb 2011 Sitecheck Report dated 02-02-2011 Proposed route of pipework, Portal Construction NW Ltd Dwg No. 10/HTL/PL/03 (sketch plan) Risk Assessment for water pipes dated 13-07-2011. Further information provided following request from WC: Risk Assessment for water pipes dated 24-08-2011, including supplementary chemical data.
30	Turves Road, Cheadle Hulme	05/08/2011	Residential properties with associated infrastructure and gardens	Current use as British Legion clud with associated soft and hard landscaping. Site had a former use as a brick works (1907-1935) (no historical mapping has been submitted to support the application	Email dated 02 August 2011-08-09 Shepherd Gilmour Geo-Environmental Desk Study April 2010 (Ref S0057 DH ME1114) Shepherd Gilmour Generic Quantitative Risk Assessment June 2010 (Ref S0107 CM (ME1117)
31	Spinney Walk, Castlefield	09/08/2011	Residential	Limited information provide with regards to current and historical use of the site (industrial). Developer reports state that the former site usage may give rise to ground contamination	Spinney Walk, Castlefields002.pdf (containing Water Pipe Selection RA, water supply route sketch excludes raw ground data and exploratory hole plan) Submitted following request for further information by the WC: Sutcliffe Phase 1 Desk Study: Spinney Walk, Castlefield (Ref: 25016L.G); Sutcliffe Phase 2 Geotechnical and Environmental Assessment: Spinney Walk, Castlefield (Ref: 25016L.G).
32	Storrington Avenue, Croxteth	08/08/2011	Residential	Historically the site has been developed with several terraced residential properties from c.1955 to c.1971. After which 2 no. high rise blocks of flats were constructed and later demolished prior to c.2004. The high rise development included an electrical sub-station (ESS) on site. The primary sources of ground contamination on site were identified as made ground including significant demolition rubble and potential Polychlorinated Biphenyls (PCB's) associated with the former ESS. An existing ESS also bounds the site to the northeast.	Whitby Bird Limited, Report on a Site Investigation at Storrington Avenue, Croxteth Ref No. C10900A, March 2007; SWF Heswall Limited, Phase II Ground Investigation Report Proposed Site Redevelopment Storrington Heys, Liverpool, Project No. RE04/2161, July 2004; United Utilities Scale Drawing, Storrington Avenue proposed water pipe location, 27-Jul-2011. DK-Architects Proposed Site Plan, Drawing No. 937.101.03 December 2010. Submitted following the request for further information by the WC: - Arc Environmental Final Remediation Statement Summary Sheets, Project 11-029, Storrington Heys, Storrington Avenue, Croxteth, Liverpool.

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33	New Street, St Helens	19/08/2011	Residential	Areas (now demolished) and infilled watercourse to the east, the site has large	Smith Grant LLP Environmental Consultancy Stage 1 & 2 Geo-environmental Investigation and Assessment for Barratt Homes, Report No. R1497-R01-v3, November 2010 Proposed Water Construction Drawing, Dwg No. PND/2956/01W, August 2011 Risk Assessment for Water Pipes (not signed or dated).
34	Margaret Street, Liverpool	17/08/2011	Residential	Former high school. Now derelict land.	Contamination Summary Statement Site Assessment Report MU 2998 Margaret Street, Liverpool. Phase 1: Risk Assessment for Water Pipes (dated 4th August 2011); Stage 1 & 2 Geo-environmental investigation and assessment: Land at Margaret Street, Liverpool November 2010 (Ref: R1513-R01-V2).
35	Ruscombe Road, West Derby Liverpool	12/08/2011	Residential	Historical records show that other than some terraced residential properties (demolished), the site has remained undeveloped open land (based upon the historical publication data summary provided in the report).	Risk Assessment for water pipes (RA) SAL laboratory data, Ref 50539/RGB/1236 SP Energy Networks, Water Network Design for Ruscombe Road Liverpool, Dwg No. CC0230755-W. Submitted following request for further information by WC: Curtins Consulting Phase 1 Detailed Desk Top Study, Ruscombe Road and Murcote Road, Liverpool, Report No.50645/RGB/1212, dated 06-10-2010 Curtins Consulting Phase 2 Intrusive Investigation, Ruscombe Road and Murcote Road, Liverpool, Report No.50645/RGB/1237, dated 12-11-2010 Curtins Consulting Phase 2 Intrusive Investigation Addendum Report, Ruscombe Road and Murcote Road, Liverpool, Report No.50645/RGB/1471, dated 11-03-2011.
36	Groveside Park off Liverpool Road Burnley	23/08/2011	Residential	Land use - residential / industrial mix. Former mill	Worms Eye Electronic Report: Desk Study Ref: GGC/BB12 6HH/07 Worms Eye Electronic Report: Intrusive Report Ref: GGC/BB12 6HH/Int rpt.07/08 Worms Eye Electronic Report: Remediation Statement Ref: GGC/Imperial Mill/BB12 6HH/Int08 Information submitted following request for further info from WC: - Email response dated 14th September 2011 (Subject: Groveside Park off Liverpool Road Burnley).
37	Wood Lane, Croxteth Stat	26/08/2011	Residential	disused land	Lovell Partnerships Ground Investigation Report for Wood Lane, Netherley, Liverpool February 2011 (Report No. 10LPL006/GI) Betts Associates – Supporting Information for Drinking Water Pipeline Selection Following submitted following a request for further information by the WC: - DK-Architects Proposed Site Plan, Drawing No. 884.003.2.J November 2010 - Risk Assessment for Water Pipes (RA) (Betts Geo-environmental 14/7/11). - Appendices provided by email dated 01_09_11
38	Loushers Lane, Warrington	26/08/2011	178no. 2-storey private residential houses	On-site (brewery/distillery, railway, steam laundry, infilled canal). Surrounding land (brewery, brickworks, residential / school). Buildings currently on site (SW) are reported to be associated with former distillery. Fuel tanks reported to have been present to the S but since removed. Distillery tank bases still present. A fire reported to have destroyed warehouse & liquor tanks (2 million litres of alcoholic beverages reported to have been lost during fire). Surrounding land currently occupied by industrial (N) and residential (E,S,W) uses.	CD submitted with application (Ref 4730 The Heath Loushers Lane, Warrington) Betts Associates – Supporting Information for Drinking Water Pipeline Selection Following request for further information by the WC: Pipeline Selection Risk Assessment Summary, signed and dated 17/08/2011 Laboratory chemical test data for import materials May-June from Donor sites A B Sal, RefJ241.pdf Laboratory chemical test data for Initial Donor site D Site, RefG_J_Distillery, YourSal, RefJ23.pdf Proposed Water Design for Self Lay Water Mains, Dwg No.4730 400 RevB, dated 16.08.11
39	Lydiate Lane, Thornton	25/08/2011	13no. 4 bed 2-storey detached houses	Prior to development the site was occupied by a 1970's construction church building and hall building. A boiler room and fuel tank was located to the east of the church building and reported to be in a poor condition (no staining observed). The site was predominately of hard standing cover. Surrounding land predominately occupied by residential setting (based on Desk Study report, no support historical mapping provided).	Risk Assessment for Water Pipes (RA), dated 19-08-2011 Betts Associates Geo-Environmental Phase 1 Desk Study Report for Lydiate Lane, Thornton Report No. 10ELA007/DS dated October 2010 Elan Homes Proposed Services drawing Dwg No. LL-SERV-001. Following submitted following request for factual ground investigation data & validation testing (following the proposed surface scrape/site clearance and of the imported backfill materials) & missing PSRAS Table 1 by WC: Table 1 of PSRAS, dated 22-08-2011 Betts Associates Geo-Environmental Phase 2 Ground Investigation Report at Lydiate Lane, Thornton Report No. 10ELA007/GI dated November 2010 Betts Associates Geo-Environmental Supporting Information for Drinking Water Pipeline Selection, Water Street/Lydiate Lane, Thornton
40	Northumberland Street, Liverpool	07/09/2011	Residential	Long history as as residential history. Light industrial / commercial use on the eastern end of Northumberland street historically timber yards, saw mill, railway and dock goods warehouses presently car show rooms. No supporting historical maps submitted with applications.	Risk Assessment for Water Pipes (RA), dated 31-08-2011 Resource & Environmental Consultants (REC) Ltd. Supplementary Intrusive Investigation, Northumberland Street Liverpool, Ref:04c43779, dated 12-08-2011 REC Remediation Strategy, Proposed Residential Development Northumberland Street Liverpool, Ref:43779p3r0, dated January 2011 REC Phase I Geo-environmental Site Assessment, Northumberland Street Liverpool Ref:43779p1r0, dated October 2010 REC Phase II Geo-environmental Site Investigation, Northumberland Street Liverpool Ref:43779p2r0, dated November 2010 Site development plan with proposed water connection locations, email dated 07/09/2011.
41	Hardman Fold Methane Stripping	02/09/2011	Methane stripping facility	Not provided by developer. Hardman Fold Landfill	Risk Assessment for Water Pipes (RA) (Signed Michael Kelly – (Risk Assessor) – GMDWA dated 12 08 11); SAL Report (Ref: 219556-1 dated 02 December 2010); Hytech-Water Limited Pink Bank Lane MSP Site Layout (Ref: 7048-01-15a issue A, dated 05/05/10).
42	Cringle Road Manchester	02/09/2011	Methane stripping facility	Not provided by developer.	Risk Assessment for Water Pipes (RA) (Signed Michael Kelly – GMDWA dated 15 08 11); SAL Report (Ref: 219556-1 dated 02 December 2010); Hytech-Water Limited Cringle Road MSP Site Layout (Ref: 7046-01-08b issue A, dated 07/05/10)

New water connections and main requisition applications - information database**Water UK protocol requirements:**

Desk Study (PRA), minimum
 PSRA (Phase 1), minimum
 Signatories - suitability qualified person, minimum
 Ground Investigation (where contaminative land use identified)
 Testing (Basic (e.g. TPH, SVOC, VOC, BTEX/MTBE) or Extended (e.g. Ether, nitrobenzene, ketones etc.)) or Metal pipes (e.g. pH, conductivity & redox)
 Testing - Quality UKAS / MCERT's accredited
 Sufficiency of Testing - 0.75 to 1.35m from finished ground level to crown of pipe
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 Sufficiency of Testing - PID employed to supplement (Screen pipe route 15m either side of the proposed pipe route)
 Sufficiency of Testing - CL:AIRE/CIEH 2008 used to justify number of samples tested
 Sufficiency of Testing - BS10175, CLR4 and R&D Technical Report P5-066/TR referenced for sampling strategy employed
 Sufficiency of Testing - validation sampling assessed where remediation has been implemented
 PSRA (Phase 2) (where contaminative land use identified)

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Blue column indicate transposed factual information collated from developer / SLO submissions

STAGE 2 - Author Review - Overview of identified contaminative land-uses, proposed land use & Developer/SLO submission history

Application Number / Site No.	Site	Application Date	Proposed Development	Contaminative Land-use(s) (current and historical, on-site and adjacent land)	Developer / SLO Supporting Information
43	Pinkbank Lane, East Road	02/09/2011	Methane stripping facility	Not provided by developer.	Risk Assessment for Water Pipes (RA) (Signed Michael Kelly (Risk Assessor) – GMWDA dated 15 08 11); SAL Report (Ref: 219556-1 dated 02 December 2010); Hytech-Water Limited Pink Bank Lane MSP Site Layout (Ref: 7047-1-09a issue A, dated 05/05/10)
44	Estuary Science Park, Estuary Boulevard	09/09/2011	Business Park Development	The site was formerly occupied by Liverpool Airport with a runway (probable taxi area) intersecting the site boundary to the west and open land between runways on the remainder of the site.	Risk Assessment for Water Pipes (RA) (Signed Chris Bolan (Risk Assessor) – CC Geotechnical Ltd dated 08 08 11); CCG Combined Phase I / Phase II Geoenvironmental Report for Estuary Business Park, Speke, Liverpool January 2011 (Ref: CCG-C-10-6172); Email from Chris Bolan Subject: UU Estuary Business park (dated 17 August 2011)
45	Penpoll Industrial Est Phase 1A, Bootle	13/09/2011	Mixed residential and retail development	Industrial and trading estate. Historically the site was exploited for clay extraction, tin smelting works and oil works.	Entec UK Limited, Verification Report and Health & Safety File, Penpoll Site Hawthorne Road, January 2011 Entec UK Limited, Final Remediation Strategy and Design, Former Penpoll Industrial Estate, Hawthorne Road, 23-03-2010 AMEC Environment & Infrastructure UL Limited, Build Phase Remediation Strategy, Former Penpoll Industrial Estate, Hawthorne Road, August 2011 Entec UK Limited, Preliminary Geo-Environmental Assessment Final Report, Former Penpoll Industrial Estate, Hawthorne Road, November 2009 Pipeline Risk Assessment, signed and dated 18-08-2011 AMEC Dwg No. 4889_400_Rev B, Proposed Water Design for Self Lay Water Mains, Bellway Homes (North West), dated 30-08-2011
46	Halewood District Centre, Leathers Lane	14/09/2011	Residential	Predominately a residential setting setting.	Risk Assessment for Water Pipes (RA) (Signed Kathryn Ellis (Risk Assessor) – WYG Environmental dated 05 09 11); WYG Environment Geo-environmental Ground Investigation Interpretative Report Halewood District Centre March (Ref: A064885-1); Mayfield Section 38 Works Adoption Plan Rev P2 (annotated with proposed route of mains/services) dated 21.04.11.
47	Chadwick Fields, Coronation Road, Middlesbrough	30/09/2011	Housing	Consultants PRA states "no evidence of any diesel tanks or oil heating tanks were noted on the historical plans or from walkover". Derelict day care nursery	Risk Assessment for Water Pipes (RA) (Signed James Thorburn (Risk Assessor) – Strata Surveys Ltd dated 21 09 11); Strata Surveys Limited Preliminary Risk Assessment & Ground Investigation Report July 2008 (Ref: 14329); Strata Surveys Limited Letter Report (Re.: New 25mm water services connection – Chadwick Fields – UUW ref: 4100664478) dated 30th August 2011.
48	Whitefield In, Boundary Ln & Redrock St, Liverpool	14/10/2011	Residential housing	Not provided by developer.	Risk Assessment for Water Pipes (RA) (Signed David Bowen (Risk Assessor) – Sutcliffe Projects Ltd dated 23 09 11) - incomplete; Sub Soil Surveys Limited Report on Ground Investigation May 2010 (Report No 2010/42-001-CON-Rev0); Sub Soil Surveys Limited Phase 2 Supplementary Report March 2011 (Report No 2011/500-002-CON-Rev0).
49	Hartley Lane, Rochdale	29/11/2011	Residential	Former school with associated boiler house (qualitative information by email from Developer's consultant)	Risk Assessment for Water Pipes form, completed by Adam Czarniecki of McAuliffe Environmental Laboratory test results (EnviroLab 11/04/11 and 20/04/11); Exploratory hole location plan Proposed development plan and route of main over-lay; Exploratory hole logs for Window sample boreholes, cable percussion boreholes and trial pits; Geotechnical results (Geotest); Geo-environmental desk study report (Aecom Environment June 2010) and Letter dated 24/11/11 from Adam Czarniecki (McAuliffe Environmental) to Rachel Yates (UU Water Connections)
50	Rossfield Road, Ellesmere Port Area 1 & 2	31-11-11	Residential housing	Site has been a vehicle storage yard since the 1970's	Submission 1: 2x Pipe Material Selection Risk Assessment (Area 1 & 2), dated Nov 2011 (including Site Plan - Site Walkover features & annotated with ground strata log details) Proposed pipe route sketch and exploratory hole plan and Submission 2 12.12.11 (following requested for further information by WC): Geoenvironmental Appraisal, February 2010 (excluding appendices) Raw chemical data
50a	as above				
51	Granby Street, Toxteth	17.11.2011	Residential	Currently discussed parcel of land with exception of a row of victoria terrace housing and recently constructed substation within the SW corner. Site historically was occupied with residential housing (since demolished). Mostly - a residential setting in the surrounding with possibility of some light industry such as repair works.	Geoenvironmental Appraisal Report, dated October 2007 PSRAS dated 08.11.11. Pipe location and general arrangement plan
52	Land off Portland Drive, Congleton	23.12.2011	Residential	Currently and historically a agricultural field (specified by developer)	Risk Assessment for Water Pipes form, completed by Tony Higgins of Ben Bailey Homes (no qualifications provided); and Geo-Environmental Investigation and Assessment Report, Capita Symonds Structures, reference ss015738/GEIA, October 2006
53	Former Greenway Garage, Frodsham Road	07.02.2012	Residential	Garage, motorcycle sales and repair centre and a showroom (specified by developer)	Risk Assessment for Water Pipes (RA) (dated 01 02 12 NOT SIGNED); Lees Roxburgh Limited Greenbank Garage, Frodsham Road, Alvanley Geoenvironmental Assessment August 2011 (Ref: 5390/R1). Email from Paul Pedley Subject: Former Greenbank Garage, Frodsham Road, Alvanley: Site Inspection Reports 5390/5.1 (dated 06 February 2012) TFA Architects Annotated Service Plan (AR1014PL01REV-8) annotated 08 02 12

New water connections and main requisition applications - information database**Water UK protocol requirements:**

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STAGE 2 - Author Review - Overview of identified contaminative land-uses, proposed land use & Developer/SLO submission history

Application Number / Site No.	Site	Application Date	Proposed Development	Contaminative Land-use(s) (current and historical, on-site and adjacent land)	Developer / SLO Supporting Information
54	Mellor Street, Rochdale	16.02.2012	Residential and locally commercial end use	Cotton Mill in the N, central, Sw areas of the site. Historical tramway and depot occupied area along eastern boundary in the centre to S of the site. Surrounding land use including industrial uses (N, E, S) and residential (W).	Risk Assessment for Water Pipes (WSP) (no signature); Mellor Street, Rochdale Addendum to Earthworks Specification (WSP); Former Stotts Mill, Mellor Street, Rochdale – May 2009 Additional Investigation; and SP Energy Networks Water Network Design for Alexander Drew, Rochdale. Additional Information (provided following initial submission): WSP Geoenvironmental Assessment, Former Stotts Mill, Mellor Street, Rochdale, July 2006 (Envirocheck and factual GI, June 06 appended) WSP Letter Report, Former Stotts Mill - Additional Site Investigation, dated July 2009
55	Grasscroft, Oldham	12/03/2012	Residential	No supporting information provided by the developer. Developer states a residential history	Email dated 21/01/12 from Carl Watson (DEVELOPER) to Rachel Yates and Karen Hanley (WC). Risk Assessment for Water Pipes form, completed by Sarah Griggs of GCM Consulting Engineers, dated 21.02.12. Further site investigation report for the proposed residential development at Oldham Road, Grasscroft, dated August 2011. Additional Information (following request for further information by WC): Email dated 08/06/12 from Carl Watson to Rachel Yates. Revised Risk Assessment for Water Pipes form, completed by Martin Griggs of GCM Consulting Engineers, dated 08.06.12. Draft pipeline location plan (N4100076214/R), dated 26/03/12
56	Chapelford Phase 13	23/03/2012	Residential	RAF constructed 1960. Phase 13 development area was an area of open space at the base with a refueling point located to the NE. RAF facility was demolished between 2002 and 2008	Land parcel query drawing (highlighting previous development phases, the Phase 13 area and future Phase 13b) Exploratory hole location plan (including proposed pipe route sketch) (Developer notes on sketch states 'pipeline in natural soils' 7 sections in 'pipeline in till') Pipe Material Selection Assessment (UKWIR/Water UK) - BP proposed although values included fall below threshold) Ground Investigation Phase 13 & 14, Chapelford urban Village, Warrington, dated September 2010 (R/10113/1314/002) (Combined phase 1 and phase 2)
57	Thelwall Lane, Warrington	27/03/2012	Residential	Former hind/tannery factor from 1896. Factory indicated as an Abrasive Wheel factory from 1939. Demolition remains of factory present at time of initial investigations. Surrounding land generally occupied by industrial land uses, a historical landfill is indicated to occupy land directly to the north (specified in consultants report)	Initial Submission: Pipe Material Selection Risk Assessment dated 8.3.12 (based on existing ground material data) REC Contamination Assessment report dated sept 2010 (Combined Phase 1 & 2, inc. GI factual data) REC Remediation Strategy, Earthworks and Materials Management Plan Report, dated Sept 2011. Pipe layout plan Supporting Information following request for further information by WC: Pipe Material Selection Risk Assessment dated 18.4.12 (REC Ltd letter report, Water Pipeline RA, Former Eagle Ottawa and Hydrocarbon Hopspot Delineation Letter Report)
57a	as above				
58	Edwards Lane, Hunts Cross (Phase 6 & 7)	01/05/2012	Residential	No supporting information provided by the developer	Risk Assessment of Water Pipes (RA) (incomplete) Partial Remediation Statement Chemical data (no exploratory hole logs provided) Water Pipe Material Design drawing
59	Whitshire Street, Salford	01/05/2012	Residential	Supporting Consultant (Encia) of Developer email states site historical residential use	Submission 1: Risk Assessment of Water Pipes (RA) dated 18/04/12; Encia Geoenvironmental Appraisal of land off Wiltshire Street, Avenue (Ref: 201081, dated December 2011); Supporting e-mail for Risk Assessment (Dated 19/04/12); Proposed Water Design for self lay water mains drawing. Submission 2 (20/06/12) Urban Regen, Proposed Methodology for the Installation & Validation of Clean Corridors for New Water Mains;
60	Norris Green Phase 5, Liverpool	15/05/2012	Residential	A historically occupied by residential properties	Geoenvironmental Ground Investigation Report (Phase 2 and 3 of development), date October 2007
61	Pemberton Colliery, Foundry Lane, Wigan	26/06/2012	Residential	No supporting information provided by the developer. Site called former colliery	Water pipe Selection Risk Assessment dated 26.04.15 Exploratory Hole location plan (including topographical survey levels - existing and proposed) Chemical test data (PAH, BTEX, MTBE, TPH CWG - 0.5 to 4m bgl sampled 18.04.15 Exploratory hole logs dated 15.04.15
62	Bromborough Pool, Wirral	03/07/2012	Residential	Formerly occupied by residential housing and former allotments. Surroundings occupied by residential properties and commercial/leisure amenities.	Initial Submission: Risk Assessment for Water Pipes (RA) (dated 14 06 12 signed William Baldwin) Pipe Layout Design Plan Submitted following request for further information by WC: Sutcliffe Investigations Phase I Desk Study Bromborough Pool Village, Wirral June 2011 (Ref: LG25105 Rev 0). Sutcliffe Investigations Phase II Geotechnical and Environmental Assessment March 2012 (Ref: LG25105 Rev A). Sutcliffe Investigations Remediation / Validation proposals March 2012 (Ref: 25105LG Rev 0).
63	Huyton Waste Recycling Centre	20/07/2012	Waste Recycling facility	No supporting information provided by the developer	Wilson Road, Risk Assessment for Water Pipes, dated 08.03.12 Sheppard Gilmour Infra Ltd Letter, Re: Huyton, Wilson Road, Domestic Waste Recycling Facility Supplementary Water Supply to Rainwater Harvesting Facility, dated 12 July 2012, Ref: C959/SBS/J/V01.49 Drawing – Proposed Services within the site, Ref: C959-224 Huyton, Wilson Road, Table 1 – Pipe Selection Risk Assessment Summary Soil Sample Analysis, Ref: EFS/125309 (Ver. 2) dated 02 July 2012

New water connections and main requisition applications - information database**Water UK protocol requirements:**

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 Sufficiency of Testing - validation sampling assessed where remediation has been implemented
 PSRA (Phase 2) (where contaminative land use identified)

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STAGE 2 - Author Review - Overview of identified contaminative land-uses, proposed land use & Developer/SLO submission history

Application Number / Site No.	Site	Application Date	Proposed Development	Contaminative Land-use(s) (current and historical, on-site and adjacent land)	Developer / SLO Supporting Information
64	Norris Green Phase 1C, Liverpool	26/07/2012	Residential	Residential use since 1938. Minimal made ground encountered during GI (depth 0.8m)	Pipe Materials Selection Risk Assessment, dated 28.05.12 (supporting cover letter outlining minimal remediation proposed - as per phase 1a and 1b) Geoenvironmental Appraisal Report (combined phase 1 and 2), Jan 2012 Pipe layout plan Initial Submission 24.09.15
65	Town Lane, Southport	05/09/2012	Residential	Former landfill site	Risk Assessment for Water Pipes form, completed by G Halliday of the Sirius Group (29/02/12); Sirius Group, Geoenvironmental Appraisal of Land Adjacent to Southport Hospital, Southport, February 2012. Proposed Water layout/Site Plan (Keepmoat Homes) Water Mains Records (United Utilities) Second submission (following request for further information by WC 12.09.12): Outline Remediation Strategy, Sirius May 2012. External Works Drawing Ref: QD500-04-01 (cut and fill plan) Arcadis Geotechnical & Environmental Site Assessment, August 2010 Ref: 961030001_01. Risk Assessment for Water Pipes form, completed by R Battick of the Sirius Group (18/09/12). Third submission (following request for updated RA by WC) Risk Assessment for Water Pipes form, completed by R Battick of the Sirius Group (22/10/12) Fourth submission (following request for updated RA by WC) Risk Assessment for Water Pipes form, completed by R Battick of the Sirius Group (28/11/12)
65a					
65b					
65c					
66	Acre Mill, Rawtenstall	27/09/2012	Residential	Formerly occupied by Acres Mill (Cotton Mill) and associated reservoir. Mill buildings located to the west and the reservoir to east of the site. Existing terrace housing are located to the north and the remainder of the site is currently grass covered open space. The western area of the site is covered by demolition rubble since 2011. (no supporting historical mapping provided)	Envia Supplementary Geoenvironmental Appraisal May 2012 (including Exploratory Hole plan and Factual GI); Water Supply Material Selection Risk Assessment dated August 2012 Pipe layout plan
67	Blackpool Road, Newton	16/10/2012	Residential	Historically residential use	Desk Top Study/Preliminary Site Investigation Phase 1 Land Quality Assessment, Hermolle Associates, 3/02/12 Proposed External Works Specification layout. Pipe Material Selection Risk Assessment (incomplete) Site and Pipe Layout Plan, dated Feb 2012
68	Jersey Way Middlewich	18/10/2012	Housing development comprising 83 new residential dwellings	Undeveloped agricultural land with stream running through the centre (1800-1980s). By 1985 a depot was present in the northwest corner. A railway line and Alkali work (no longer present 1949) were identified to occupy surrounding land (description taken from Phase 2 report)	Initial Submission: Risk Assessment for Water Pipes (RA) V1, 22.05.2012; and Brownfield Solutions Limited, Drawing: Exploratory Hole Location Plan, Aug 2011. DGL Associates Limited, Drawing: Site Layout Indicative Landscape Scheme (No. 1213SMH/JWM-PL01) - details proposed pipeline route and dimensions CD containing Brownfield Solutions Limited, Geo-Environmental Assessment Report, September 2011
69	Browside Road, Dearham	19/10/2012	Residential	Colliery spoil and made ground (3.6m bgl) (based on developer assessment report, no supporting mapping)	Initial submission: Risk Assessment for Water Pipes dated 14.02.2012; Aptus Utilities, Drawing: Proposed Water Design (AP0240-WD-Rev01), 10.10.2012; Integra Consulting, Drawing: Exploratory Hole Location Plan, Jan 2012; ALcontrol Laboratories, Certificate of Analysis, Dearham (Rep No: 115318), 11.02.2012; and ALcontrol Laboratories, Certificate of Analysis, Dearham (Rep No: 164830). Second submission: Phase 1, Integra Consulting, dated Jan 2010 Phase 2, Integra Consulting, dated Jan 2012 Geotechnical Desk Study Jan 2012 Exploratory hold plan - site layout and topographical over lay
70	Stretton Dairy, Malpas	21.11.2012	Residential	Use as a dairy since the early 1990's, consists large industrial building, 2 tanks and a possible admin building. Surrounding land is mostly made up of farmland (text taken from developers phase 2 report)	Phase II Ground Investigation Report At Former Stretton Dairy, Stretton, Bett Associates, Ref: 09RED002/GI, July 2011; Risk Assessment for Water Pipes (RA) 24.10.2012 (v1 May 2011); Water Network Design for Stretton Dairy, Malpas, SP Energy Networks, Drawing No: QAS69226-W
71	Ashfield, Liverpool	03/06/2013	Residential (9 town houses with drive and landscaping)	Church building previously occupied the majority of the site. The surrounding land is generally occupied by residential	Risk Assessment for Water Pipes (RA) (Signed Catherine Baranek (Risk Assessor) - LK Consult Limited dated 31 05 13); LK Consult Ltd Preliminary Risk Assessment and Ground Investigation Report, November 2012 (Ref: LKC-12-1045 - Land at former St Thomas' Church, Ashfield, Liverpool).
72	Tarporley Road, Tarvin	04/06/2013	Residential	Undeveloped agricultural fields	Risk Assessment for Water Pipes (RA) (Signed Paula Gallagher (Risk Assessor) - WSP Environmental Ltd dated 29 04 13). WSP Environmental Ltd Ground Investigation Exploratory Hole Logs and laboratory screened data, September 2012 (Job No: 30977 - Tarporley Road - Tarvin, for Taylor Wimpey North West).
73	Milne St, Chadderton	30.07.2013	Residential houses with gardens and parking	Area of open space surrounded by residential housing. The site was historically occupied by a manor house which was demolished circa 2009. surrounding land historically occupied by cotton mills, reservoirs, iron works, railway lines, ponds, infilled areas - landfills.	RA for Water Pipes, 29.07.2013 (signed William Baldwin (Sutcliffe Projects), BEng (Hons) CEng MStrucIE AIEMA) Phase 1 Desk Study, Milne Street, Chadderton, April 2012 (provide upon request by Water Company); Phase 2 Report, Milne Street, Chadderton, April 2012; and Final Analytical Report, EnviroLab, 10 July 2013 Drawing - Service Connection Concept Drawing (by Water company)
74	Booths Hall Hospital	24.01.2014	Residential	Current derelict land formally occupied by infirmery / hospital demolished in 2010	2x Water Supply Risk Assessments dated Jan 13 and Dec 2013 Coopers, Site Investigation Report for Land at the Former Booth Hall Children's Hospital, Charlestown Road, Blackley, Manchester. Ref: 5541si. August 2012 Lithos Consulting, Remediation Strategy for Land at Booth Hall Children's Hospital, Blackley, Manchester. Ref: 16111/A. March 2013 Proposed Water Construction Drawing, Booth Hall, Moston, Manchester. Drawing No. PND 4480 / 01W.
74a					

New water connections and main requisition applications - information database

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 Testing (Basic (e.g. TPH, SVOC, VOC, BTEX/MTBE) or Extended (e.g. Ether, nitrobenzene, ketones etc.)) or Metal pipes (e.g. pH, conductivity & redox)
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 Sufficiency of Testing - validation sampling assessed where remediation has been implemented
 PSRA (Phase 2) (where contaminative land use identified)

Purple columns indicate an element of Author interpretation of submission data

Blue column indicate transposed factual information collated from developer / SLO submissions

STAGE 2 - Author Review - Overview of identified contaminative land-uses, proposed land use & Developer/SLO submission history

Application Number / Site No.	Site	Application Date	Proposed Development	Contaminative Land-use(s) (current and historical, on-site and adjacent land)	Developer / SLO Supporting Information
75	106 houses, Cottam / Haydock East	02/06/2014	Residential 104 dwellings	Land mostly undeveloped with historical use as farmland. Ponds and later marsh land was recorded in the footprint of the proposed development (absent post 1960). Much of the surrounding area is occupied by residential properties. A historical clay pit is recorded approx. 200m NW, which was reported to be infilled with surplus construction arisings (peats and alluvial deposits) in 1997.	Risk Assessment for Water Pipe Selection dated 20/12/2013 SI- Atkins, Homes & Communities Agency, Supplementary Ground Investigation at Cottam K, Factual and Interpretative Report, July 2011 - Site Survey Drawing, Cottam K, Cottam Way, Preston, Drawing No. SDL 1974/1 - Atkins Letter Report, Re: Cottam K1/K2 Site - Proposed Development, 30 March 2009 - Curtins Letter Report, Re: Residential Development, Cottam, Site K, Preston - Trial Pit Investigation, Ref EB1042A/RA/3253, 7 October 2013 - Proposed Water Construction Drawing, Cottam Hall Site K, Preston, PR4 GNX, Drawing No. PND 4412/01W - Atkins, Homes & Communities Agency, Environmental Impact Assessment Environmental Statement, Cottam Hall, Cottam, Preston, February 2012 Planning decision notice 06/2013/0148 - 104 residential dwellings
76	Buckshaw Village, Chorley - Persimmon Homes (Spine Road)	26/05/2014	Residential (main installation along Spine Road to service new residential development)	The main is to be installed along Spine Road which located in a residential and industrial development village. Royal Ordnance Factory (ROF) occupied the land directly adjacent to Spine Road between 1937 until its closure 2008. ROF has been remediated for use for residential housing	Risk Assessment for Water Pipes - Spine Road (21.05.14) Capita Buckshaw Village Supplementary Site Investigation, ref CS074081-SS1, dated May 2014 BAE Systems Environmental Completion Report, Option Land Area, Group 1 Chorley, Ref B0191-00-R8_A, dated December 2013
77	Buckshaw Village, Chorley - Redrow (Group 1)	16/06/2014	Residential (main requisition for new residential housing estate)	Development is located on remediated land formerly occupied by Royal Ordnance Factory (ROF) between 1937 until closure 2008.	Risk Assessment for Water Pipe - Group 1 (03.06.14) BAE Systems Environmental Completion Report, Option Land Area, Group 1 Chorley, Ref B0191-00-R8_A, dated December 2013
78	Westfield Nurseries, Lytham	01/07/2014	Residential	Historically the site formed part of a garden centre and horticultural nursery, prior to this the site was greenfield (confirmed in consultants letter)	E-mail sent by Ian Ramsbottom (Consultant) Re: Area of diesel dated 01.07.14 & attached Analytical lab data Report, SAL, 25 June 2014 Water Construction Plan, Westfield Nurseries, Lytham, Drawing No. PND/4719/01W Site Plan - Water Supply Layout plan. Submission 2: Risk Assessment for Water Pipes (signed I. Ramsbottom - WSP, dated 19.08.13) - Combined phase 1 and phase 2, dated Jan 2013 referenced in PSRA but not provided). Submission 3: - Desk Study and Ground Investigation Report, Kensington Developments Ltd, Westfield Nurseries, Whitehall Road, January 2013. LE11688-001.
79	Rigby Road, Blackpool	28/08/2014	Residential housing development	Former gas works	Risk Assessment for Water Pipes (RA) (Signed Anthony Simmons - Fairhurst, dated 01/08/2014); Marcus Worthington & Co Ltd, 7621-West Site Phase I, 117 Plots Rigby Road Blackpool, Proposed East Water Design Drawing (Dwg No.7621_400_East Site_Rev A, dated 31/07/2014). VHE Construction plc, Rigby Road Development Corridor, Verification Report for Remediation Enabling Works, Phase 1 East Site, Phase 1 & 2 West Site, Site Reference No.582, dated 29/11/2013
80	Old Wool Lane, Cheadle	08/09/2014 (18/12/2012)	Residential housing development	Former industrial mill complex with infilled water filtration tanks (infilled with builders waste)	Risk Assessment for Water Pipes (signed R.E Fry - R.E Fry Associates Ltd.) dated 03.12.12 Ground Investigation Report, dated February 2012 Pipeline route drawing
81	Elizabeth St, Cheetham Hill, Salford	16/12/2014	Residential development comprising 51 houses and private gardens	Current land use consists of some residential dwellings and warehouses. Infilled clay extraction pits across the majority of the site. Nearest landfill site located within 70m (demolition waste from WW2 waste), a garage depot 60m a historical printing works, engineering works and substation identified within 200m of the site (based LK interpretation).	Leyden Kirby Associates Ltd, Geoenvironmental Investigation and Risk Assessment, June 2007 (Ref: CL1099-02) Drawing - Ref. CU-ES-01 Proposed Water Supply Layout Design Risk Assessment for Water Pipes (RA) (Risk Assessor: Signed Dr P Quimby (Technical Director) - Leyden Kirby Associates Ltd dated 29/06/07. Declaration: Signed Munib Ahmed - Waterloo Construction Ltd, dated 13/11/13).

Site	Phase1?	Site walkover	Phase2?	Combined P1 /P2?	GI factual?	Site Plan - Exploratory hole	PSRA?	sort without (0=WRAS)	Other reports?
74a					1	1	1	1	1
75			1			1	1	1	1
76					1	1	1	1	1
77						1	1	1	1
78					1	1	1	1	1
79						1	1	1	1
80		1			1	1	1	1	1
81		1			1	1	1	1	1

USED IN REPORT	WRAS PRSA							
	Desk Study (Phase 1)	Site walkover	Phase 2	Combined Phase 1 & 2	Factual Ground Investigation	Site Plan - Exploratory hole locations	PSRA	Other
	13	13	28	36	67	75	65	68
USED IN REPORT (exclude WRAS PRSA)	WRAS							
	Desk Study (F Site walkover)	Phase 2	Combined P	Factual C	Site Plan - Explora	PSRA	Other	
	13	11	25	33	61	68	58	64

1-Yes

Submission no.

1	
2	
3	

RA submission 2
Incomplete RA
Updated with additional information
Updated with subsequent submission
Two submissions for single scheme / duplicate

[illegible]

		NUMBER OF LANDUSES																											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		
LANDUSE COUNT		1	8	2	3	10	4	17	8	2	3	1	1	2	6	2	5	2	6	6	1	1	1	1	5	8			
Appraisal Number /	Site	Recreational	Residential	Aktoiment	Manufacturers	Industrial	Agricultural	Disused land	Not specified	Social Club and car park	Hospital	Dye works	College	Primary School	Made ground / excavation arbitres	Church	Depot	Timber yard	Railway	Landfill	Power Station	Chemical Works	Asbestos & Cement Works	Petrol Station	Tar Works	Landfill	MR		
53	Former Greenway Garage, Frobban Road																												
54	Melur Street, Rochdale					1											1										1		
55	Grasscroft, Oldham		1														1										1		
56	Chapelton Phase 13								1																				
57	Thelwell Lane, Warrington							1																					
57a								1																					
58	Edwards Lane, Harts Cross (Phase 6 & 7)								1																				
59	Whitbyre Street, Salford		1																										
60	Norris Green Phase 5, Liverpool		1																										
61	Pemberton Colliery, Foundry Lane, Wigan																												
62	Bromborough Pool, Wirral		1		1																								
63	Hayton Waste Recycling Centre									1																			
64	Norris Green Phase 1C, Liverpool		1																										
65	Town Lane, Southport																			1									
65a																													
65b																													
65c																													
66	Acro Mill, Raistrickall							1																			1		
67	Blackpool Road, Newton		1																										
68	Jersey Way Middlewich							1									1		1										
69	Browside Road, Deansham														1														
70	Stenton Dairy, Melpas																												
71	Ashfield, Liverpool		1														1												
72	Tappesley Road, Tarvin							1									1												
73	Millie St, Chadderton					1																				1	1		
74	Booths Hall Hospital							1			1																		
74a																													
75	105 Peases, Cotton / Raydock East							1	1						1														
76	Buckshaw Village, Chelley - Parsonson House, Spine					1																							
77	Buckshaw Village, Chelley - Redrow Group 1)																												
78	Westfield Nurseries, Lytham																												
79	Highy Road, Blackpool																												
80	Old Wood Lane, Chaeade																										1		
81	Elizabeth St, Cheetham Hill, Salford					1									1			1			1								

[illegible]

NUMBER OF LANDUSES		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
LANDUSE COUNT		2	3			4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Application Number	Site	Iron Works	Colliery	Engineering works	Waste / Water Treatment Works	Substation	Domestic garages	Boiler house	Gas Works	Brick Works	Infilled Ground	Fuel tank	Distillery	Airport	Oil Works	Garage / Vehicle Yard / Repair	Tramway	RAF Facility	Tannery	Abattoir	Dairy (associated tanks)	Royal Ordnance Factory	Garden centre	Printing Works
53	Former Greenway Garage, Frodsham Road															1								
54	Melior Street, Rixdale																	1						
55	Grasscroft, Odham																							
56	Chapelford Phase 1.3																		1					
57	Thelwell Lane, Warrington																				1			
57a																								
58	Edwards Lane, Hurts Cross (Phase 6 & 7)																							
59	Whitbyre Street, Salford																							
60	Norris Green Phase 5, Liverpool																							
61	Pemberton Colliery, Foundry Lane, Wigan			1																				
62	Bromborough Post, Wirral																							
63	Haydon Waste Recycling Centre																							
64	Norris Green Phase 1C, Liverpool																							
65	Town Lane, Southport																							
65a																								
65b																								
65c																								
66	Acres Mill, Rawtenstall																							
67	Blackpool Road, Newton																							
68	Jersey Way Middlewich																				1			
69	Browside Road, Oxenham			1																				
70	Streton Dairy, Malpas																							
71	Amfield, Liverpool																					1		
72	Tappery Road, Tarvin																							
73	Mine St, Chaddockton	1								1		1												
74	Booths Hall Hospital																							
74a																								
75	106 Houses, Cotesan / Haydon East																							
76	Browside Village, Worsley - Persimmon Homes (Spartan)												1											
77	Buckshaw Village, Chorley - Robson Group (1)																						1	
78	Woodfield Nurseries, Lytham																							1
79	Rigby Road, Blackpool									1														
80	Old Wood Lane, Cheshire																							
81	Elizabeth St, Chester Hill, Salford			1			1					1												

Application Number / Site No.	Site	Resi	Mixed Resi/retail	Waste Transfer/ Recycling	Methane stripping	Leisure	Business Park	Hospital extension	Hostel	College extension
1	Field lane, Fazakerley	1								
2	Quinn Radiators, Spinning Jenny Way, Leigh, W17 4DE					1				
3	Salford Reds Stadium					1				
4	Ince Marshes, Frodsham			1						
5	Mercer Av. Kirkby	1								
6	Derby Rd, Widnes		1							
7	Hillingdon Av. Halewood	1								
8	Carrswood Wythenshawe	1								
9	Edge Lane, Liverpool					1				
10	John St, Carlisle								1	
11	Hayes Road, Cadishead	1								
12	Spencer Street	1								
13	Norlands Lane, Widnes	1								
14	Chapelford Phase 11	1								
15	The Manor House Site, Sefton Lane, Maghull	1								
16	Mulberry Road Rock Ferry Birkenhead	1								
17	St Catherine's Hospital, Church Road, Tranmere							1		
18	St Marys Oldham	1								
19	Berwyn Grove, St Helens	1								
20	Back Minorca Street	1								
21	Beswick Phase 2, Bell Crescent	1								
22	West Drive, Tintwistle	1								
23	Rainford High Tech College, Higher Lane, St Helens, Merseyside, WA11 8NY									
24	Avondale Drive, Widnes	1								
25	Padstow Close , Hattersley	1								
26	Station Road, Blackrod, Bolton	1								
27	Mottram Moor, Hyde	1								
28	Former St Annes Hospital, Altrincham	1								
29	Cloister Way, Ellesmere Port	1								
30	Turves Road, Cheadle Hulme	1								
31	Spinney Walk, Castlefield	1								
32	Storrington Avenue, Croxteth	1								
33	New Street, St Helens	1								
34	Margaret Street, Liverpool	1								
35	Ruscombe Road, West Derby Liverpool	1								
36	Groveside Park off Liverpool Road Burnley	1								
37	Wood Lane, Croxteth Stat	1								
38	Loushers Lane, Warrington	1								
39	Lydiat Lane, Thornton	1								
40	Northumberland Street, Liverpool	1								
41	Hardman Fold Methane Stripping				1					
42	Cringle Road Manchester				1					
43	Pinkbank Lane, East Road				1					
44	Estuary Science Park, Estuary Boulevard						1			

Application Number / Site No.	Site	Resi	Mixed Resi/retail	Waste Transfer/ Recycling	Methane stripping	Leisure	Business Park	Hospital extension	Hostel	College extension
45	Penpoll Industrial Est Phase 1A, Bootle		1							
46	Halewood District Centre, Leathers Lane	1								
47	Chadwick Fields, Coronation Road, Middlesbrough	1								
48	Whitefield In, Boundary Ln & Redrock St, Liverpool	1								
49	Hartley Lane, Rochdale	1								
50	Rossfield Road, Ellesmere Port Area 1 & 2	1								
50a										
51	Granby Street, Toxteth	1								
52	Land off Portland Drive, Congleton	1								
53	Former Greenway Garage, Frodsham Road	1								
54	Mellor Street, Rochdale		1							
55	Grasscroft, Oldham	1								
56	Chapelford Phase 13	1								
57	Thelwall Lane, Warrington	1								
57a										
58	Edwards Lane, Hunts Cross (Phase 6 & 7)	1								
59	Whitshire Street, Salford	1								
60	Norris Green Phase 5, Liverpool	1								
61	Pemberton Colliery, Foundry Lane, Wigan	1								
62	Bromborough Pool, Wirral	1								
63	Huyton Waste Recycling Centre			1						
64	Norris Green Phase 1C, Liverpool	1								
65	Town Lane, Southport	1								
65a										
65b										
65c										
66	Acre Mill, Rawtenstall	1								
67	Blackpool Road, Newton	1								
68	Jersey Way Middlesbrough	1								
69	Browside Road, Dearham	1								
70	Stretton Dairy, Malpas	1								
71	Ashfield, Liverpool	1								
72	Tarporley Road, Tarvin	1								
73	Milne St, Chadderton	1								
74	Booths Hall Hospital	1								
74a										
75	106 houses, Cottam / Haydock East	1								
76	Buckshaw Village, Chorley - Persimmon Homes (Spine Road)	1								
77	Buckshaw Village, Chorley - Redrow (Group 1)	1								
78	Westfield Nurseries, Lytham	1								
79	Rigby Road, Blackpool	1								
80	Old Wool Lane, Cheadle	1								
81	Elizabeth St, Cheetham Hill, Salford	1								
		66	3	2	3	3	1	1	1	1

Application Number		Section 3:GI	Calc	Calc	Section 3:GI	Section 3:GI
	PRSA?	Has Table 1 PSRA summary been	Chart REF.	Count	Rationale provided for discounted contaminants Test	Rationale for test group exclusion
1	N	N/A	N/A	1	N/A	N/A
2	N	N/A	N/A	1	N/A	N/A
3	Y (WRAS)	1 N/A	N/A	1	N/A	N/A
4	N	N/A	N/A	1	N/A	N/A
5	Y (WRAS)	1 N/A	N/A	1	N/A	N/A
6	N	N/A	N/A	1	N/A	N/A
7	N	N/A	N/A	1	N/A	N/A
8	Y (WRAS)	1 N/A	N/A	1	N/A	N/A
9	N	N/A	N/A	1	N/A	N/A
10	N	N/A	N/A	1	N/A	N/A
11	N	N/A	N/A	1	N/A	N/A
12	N	N/A	N/A	1	N/A	N/A
13	Y (WRAS)	1 N/A	N/A	1	N/A	N/A
14	Y - (WRAS (included in Phase 2 report))	1 N/A	N/A	1	N/A	N/A
15	N	N/A	N/A	1	N/A	N/A
16	N	N/A	N/A	1	N/A	N/A
17	N	N/A	N/A	1	N/A	N/A
18	Y	1 Y	O	1	N	
19	Y	1 N	O	1	Y	"Not TESTED NO SOURCE"
20	Y	1 N	O	1	Y	"Not TESTED NO SOURCE"
21	Y(WRAS)	1 N/A	N/A	1	N/A	N/A
22	Y	1 N	O	1	Y	I also enclose a copy of the SI which includes the
23	Y	1 Y	O	1	N	
24	Y	1 Y	O	1	N	
25	Y WRAS	1 N/A	N/A	1	N/A	N/A
26	Y	1 Y	O	1	N	Not specified
27	N	N/A	N/A	1	N/A	N/A
28	Y	1 Y	B	1	N	N/A
29	Y(x2 - updated to inc. additional data	1 Y	B	1	N	N/A
30	Y	1 Y	B	1	N	N/A
31	Y	1 Y	O	1	N	
32	N	N/A	N/A	1	N/A	N/A
33	Y	?				
34	Y	?				
35	Y	1 Y	O	1	N	
36	N	N/A	N/A	1	N/A	N/A
37	Y	1 Y	O	1	N	
38	Y	1 Y	O	1	N	
39	Y(Table 1 - sub 2)	1 Y	O	1	N	
40	Y	1 Y	O	1	N	
41	Y	1 Y	O	1	N	
42	Y	1 Y	O	1	N	
43	Y	1 Y	O	1	N	
44	Y	1 Y	O	1	N	
45	Y	1 Y	O	1	N	
46	Y	1 Y	O	1	N	
47	Y	1 N	O	1	N	
48	Y (incomplete)	1 N	O - INCOMPLETE TABLE 1	1	N	
49	Y	1 Y	O	1	N	
50	Y	1 Y	O	1	N	
50a	-	1 Y	O	1	N	
51	Y	1 Y	O	1	N	
52	Y	1 Y	O	1	N	
53	Y	1 Y	O	1	N	
54	Y	1 Y	B	1	N	N/A
55	Y(2)	1 Y	O	1	N	
56	Y	1 Y	O	1	N	

Application Number		Section 3:GI	Calc	Calc	Section 3:GI	Section 3:GI
	PRSA?	Has Table 1 PSRA summary been	Chart REF.	Count	Rationale provided for discounted contaminants Test	Rationale for test group exclusion
57	Y	1 Y	B	1 N		N/A
57a	-		see 57			
58	Y(incomplete)	1 N	O - INCOMPLETE TABLE 1	1 N		N/A
59	Y	1 Y	O	1 N		
60	N	N/A	N/A	1 N/A		N/A
61	Y	1 Y	O	1 N		
62	Y	1 Y	O	1 N		
63	Y	1 Y	O	1 N		
64	Y	1 Y	O	1 N		
65	Y(x4)	1 Y	O	1 Y		Not tested, BTEX, MTBE, VOC, SVOC, Ethers,
65a	-		See 65			
65b	-		See 65			
65c	-		See 65			
66	Y	1 Y	B	1 N		N/A
67	Y (incomplete)	1 N	O - INCOMPLETE TABLE 1	1 N		
68	Y	1 N	O	1 Y		Desk Study Report does not indicate the likely
69	Y	1 Y	O	1 N		
70	Y	1 Y	O	1 N		
71	Y	1 Y	O	1 Y		PRA identified a potential risk of heavy metals, PAHs
72	Y	1 Y	O	1 Y		The site history indicates no contaminative uses &
73	Y	1 Y	B	1 Y		Extended suite tests were not tested as they were not
74	-	Y	see 74a			
74a	Y	1 Y	O	1 Y		Desk Study did not identify them as potential CoC and
	Y	1 Y	O	1 Y		Any groups not tested were deemed unnecessary
75	Y	1 Y	B	1 N		N/A
76	Y	1 Partially	O - INCOMPLETE TABLE 1	1 Y		Compliance report validation and completion
77	Y (2)	1 N	O - INCOMPLETE TABLE 1	1 Y		Desk Study and site walkover revealed limited
78	Y (P1,P2,P3)	1 Y	B	1 Y		No source for extended. No conductivity and redox
79	Y	1 Y	O	1 Y		Extended suite excluded - no evidence to point to
80	Y	1 N	O - INCOMPLETE TABLE 1	1 N		Not specified
81						

Total RA	64
minus 7 WRAS	57
Count	57

No Table 1 (I)	O	B	N/A
6	42	9	23

No PSRA submitted by developer or PSRA submitted following former WRAS guidance N/A

Applicat#	PSRA?	Table 1	FILTER	Count	Total VOCs	Total BTEX/MTBE	Total SVOCs	EC5-10	EC10-16	EC16-40	Phenols	Cresols & Chlorinated phenols	Ethers	Nitrobenzene	Aldehydes*	Amines	Corrosive
18	1	Y	O	1			1		1	1	1	1					
19	1	N	O	1													
20	1	N	O	1													
21	1	N/A	N/A														
22	1	N	O	1													
23	1	Y	O	1			1		1	1	1	1					
24	1	Y	O	1									1				
25	1	N/A	N/A														
26	1	Y	O	1													
27		N/A	N/A														
28	1	Y	B	1	1		1	1	1	1	1	1					1
29	1	Y	B	1	1		1	1	1	1	1	1					1
30	1	Y	B	1	1		1	1	1	1	1	1					1
31	1	Y	O	1			1		1	1	1	1					
32		N/A	N/A														
33	1	?															
34	1	?															
35	1	Y	O	1			1		1	1	1	1					
36		N/A	N/A														
37	1	Y	O	1			1		1	1	1	1					
38	1	Y	O	1			1		1	1	1	1					
39	1	Y	O	1			1		1	1	1	1					
40	1	Y	O	1			1		1	1	1	1					
41	1	Y	O	1			1		1	1	1	1					
42	1	Y	O	1			1		1	1	1	1					
43	1	Y	O	1			1		1	1	1	1					
44	1	Y	O	1			1		1	1	1	1					
45	1	Y	O	1			1		1	1	1	1					
46	1	Y	O	1			1		1	1	1	1					
47	1	N	O	1					1	1	1	1					
48	1	N	O - INCOMPLETE	1													
49	1	Y	O	1			1		1	1	1	1					
50	1	Y	O	1			1		1	1	1	1					
50a	1	Y	O	1			1		1	1	1	1					
51	1	Y	O	1			1		1	1	1	1					
52	1	Y	O	1			1		1	1	1	1					
53	1	Y	O	1			1		1	1	1	1					
54	1	Y	B	1	1		1	1	1	1	1	1					1
55	1	Y	O	1		1											1
56	1	Y	O	1													
57	1	Y	B O - INCOMPLETE	1	1		1	1	1	1	1	1					1
58	1	N	O - INCOMPLETE	1													
59	1	Y	O	1	1												
60		N/A	N/A														
61	1	Y	O	1													
62	1	Y	O	1			1		1	1	1	1					
63	1	Y	O	1	1		1	1	1	1	1	1					1
64	1	Y	O	1	1		1		1	1	1	1					
65	1	Y	O	1					1	1	1	1					
66	1	Y	B O - INCOMPLETE	1	1		1	1	1	1	1	1					1
67	1	N	O - INCOMPLETE	1													
68	1	N	O	1			1										
69	1	Y	O	1					1	1	1						
70	1	Y	O	1			1		1	1	1						
71	1	Y	O	1													
72	1	Y	O	1			1		1	1	1						
73	1	Y	B	1	1		1	1	1	1	1	1					1
74	Y																
74a	1	Y	O	1			1		1	1	1	1					
75	1	Y	O	1			1										
76	1	Y	B O - INCOMPLETE	1	1		1	1	1	1	1	1					1
77	1	Partially	O - INCOMPLETE	1													
78	1	N	O - INCOMPLETE	1													
79	1	Y	B	1	1		1	1	1	1	1	1					1
80	1	Y	O	1			1		1	1	1	1					
81	1		O - INCOMPLETE	1													

1 - tested 57 16 38 10 39 39 40 36 9 0 1 0 0

		16	38	10	39	39	40	36	9	0	1	0	0	0
B	9	9	9	9	9	9	9	9	9					
O	42	7	29	1	30	30	31	27			1			
I	6													
TOTAL	57													
No. Omissions		41	19	47	18	18	17	21	48	57	56	57	57	57
No. Tested		16	38	10	39	39	40	36	9	0	1	0	0	0

SORT	Number / Site No.	Additional Has groundwater testing been undertaken?	Section 3:GI Has groundwater level been	Section 3:GI Groundwater level (m)					
					<2.5	<3.5	Not Encountered	Not specified	>3.5
1	18		Y	3 to 5		1			
1	19		Y	1.4-1.9		1			
1	20		Y	1.2-3.0		1			
1	22		Y	Strike at 1.5m bgl rose to 0.5m bgl in one location					
1	23		Y	1.3		1			
1	24		Y	seepage at 0.7m bgl		1			
1	26		Y	5					1
1	28		N	No groundwater encountered				1	
1	29	Y - Mineral oil 290mg/l	Y	0.5 (localised)		1			
1	30	Y - Table 1 CoC < LOD	Y	2.4		1			
1	31		Not specified	N/A					1
1	35	Y - Table 1 CoC < LOD (WS1)	Y	2.3			1		
1	37		Y	<1.0		1			
1	38	Y <LOD	Y	<1.0		1			
1	39		Y	0.9		1			
1	40		Y	Not encountered				1	
1	41		N	Not specified					1
1	42		N	Not specified					1
1	43		N	Not specified					1
1	44		N	Not encountered				1	
1	45		Y	2.5		1			
1	46	Y - EPH C10-C40 2050ug/l	Y	2.2		1			
1	47		Y	1.88		1			
1	48		N	Not specified					1
1	49		Y	1.5 (area of ruptured drain)		1			
1	50		stated - N/A	stated - N/A				1 (assume not encountered)	
1	50a		stated - N/A	stated - N/A				1 (assume not encountered)	
1	51		Y	2.3 to 6.30		1			
1	52		Not specified	Not specified					1
1	53		Y	1.7		1			
1	54		Y	0.5 to 3.75		1			
1	55		Not encountered	Not encountered				1	
1	56		Y	1.1 to 2.85		1			
1	57	Y - <LOD	Y	>2.0			1		
1	57a								
1	58		Not specified	Not specified					1
1	59		Y	0/5 - 1.5		1			
1	61		Y	0.5 - 10.7		1			
1	62		Not specified	Not specified					1
1	63		Y	0.46, 2.67, 2.94		1			
1	64		Not encountered	Not encountered				1	
1	65	Y (<LOD)	Y	1			1		
1	65a								
1	65b								
1	65c								
1	66		Not encountered	Not encountered				1	
1	67		Y	1.2		1			
1	68		Y	1.4-3.0		1			
1	69		Not specified	Not specified					1
1	70		Y	0.48 - 2.71		1			
1	71		Y	0.7		1			
1	72		Y	0.4-1.6		1			
1	73		Y	3.5			1		
1	74	Y (<LOD + 26ug/l C16-21)	Y	Perched		1			
1	74a	Y	Y	1.8		1			
1	75		Not encountered	Not encountered				1	

1	76		Not encountered in trial pits	Not encountered in trial pits			1		
1	77		Not encountered	Not encountered			1		
1	78		Y	0.4 to 7.3	1	1			
1	79		Y	0.5 - 3.0	1	1			
1	80		Y	2	1	1			
1		Y (<LOD + Naphthalene 81.76ng/l)	See Geotechnical Survey	See Geotechnica l Survey (4.2)					1
Y - 10									
Y					31	36	11	9	2
N					58				
total									

<3.5 m bgl	36
Not encountered	11
Not specified	9
>3.5m bgl	2

Stage 1 review - Material Tested

Application Number / Site No.	PSRA? (1,Y)	sort without WRAS(=0)	Table 1	Calc-count
			What materials have been tested to populate Table 1 below? EGM, RM, IM	
	1		N/A	
	2		N/A	
	3	1	0 N/A	
	4		N/A	
	5	1	0 N/A	
	6		N/A	
	7		N/A	
	8	1	0 N/A	
	9		N/A	
	10		N/A	
	11		N/A	
	12		N/A	
	13	1	0 N/A	
	14	1	0 N/A	
	15		N/A	
	16		N/A	
	17		N/A	
	18	1	EGM	1
	19	1	N/A - no testing	1
	20	1	N/A - no testing	1
	21	1	0 N/A	
	22	1	Not complete	1
	23	1	EGM	1
	24	1	EGM	1
	25	1	0 N/A	
	26	1	EGM	1
	27		N/A	
	28	1	EGM	1
	29	1	EGM	1
	30	1	EGM	1
	31	1	EGM	1
	32		N/A	
	33	1		
	34	1		
	35	1	EGM	1
	36		N/A	
	37	1	EGM	1
	38	1	EGM	1
	39	1	EGM	1
	40	1	EGM	1
	41	1	EGM	1
	42	1	EGM	1
	43	1	EGM	1
	44	1	EGM	1
	45	1	IM	1
	46	1	EGM	1
	47	1	EGM	1
	48	1		
	49	1	EGM	1
50a	50	1	EGM	1
			EGM	1
	51	1	Not specified (EGM assumed)	1
	52	1	EGM	1
	53	1	EGM	1
	54	1	EGM	1
	55	1	EGM	1
	56	1	EGM	1
57a	57		EGM (updated RA)	
		1	EGM, RM	1

Stage 1 review - Material Tested

65a 65b 65c	58	1	Not complete	1
	59	1	EGM	1
	60		N/A	
	61	1	EGM	1
	62	1	EGM	1
	63	1	EGM	1
	64	1	EGM	1
	65	1	EGM	1
74a	66	1	EGM	1
	67	1	Not complete	1
	68	1	EGM	1
	69	1	EGM	1
	70	1	EGM	1
	71	1	EGM	1
	72	1	EGM	1
	73	1	EGM	1
	74		EGM	1
		1	EGM	1
	75	1	EGM	1
	76	1	EGM	1
	77	1	RM	1
	78	1	Not complete	1
	79	1	EGM, RM and IM	1
	80	1	EGM	1
			Not specified (refers reader to Geotechnical Survey - EGM)	
	81	1		1
COUNT SUMMARY				
EGM (45 (plus 2 assumed)				47
IM				1
RM				1
EGM, RM and IM				1
EGM, RM				1
Not specified				4
N/A - no testing				2
TOTAL PSRA				57

1- PSRA	Application Number / Site No.	Completed? Section 4: Remediation	Remediation details	PSRA? Section 4: Remediation	Proposed? Section 4: Remediation	Section 4: Remediation
		Has remediation already been complete (which may include change in site levels)?		Has the PSRAS been undertaken using appropriate data following remediation?	Is remediation proposed that may have a potential affect on PSRA?	Details of proposed site remediation
1	18	Y	N/A	Y	N	None provided - supporting reporting provided
1	19	Y		Y	Y	
1	20	Y		Y	Y	
1	22	N	N/A	Not specified	N	N/A
1	23	N	N/A	Not specified	N	N/A
1	24	N		Not specified	Y	None provided
1	26	Y	Removal of topsoil and made ground from site	Y	N	
1	28	N	N/A	Y	N	N/A
1	29	N	N/A	Not specified	N	None proposed
1	30	N	N/A	Not specified	N	N/A
1	31	N	N/A	Not specified	N	N/A
1	35	N	N	not specified	not specified	
1	37	N		not specified	not specified	
1	38	N		Not specified	Y	Import of >1.5m cover for flood alleviation requirements
1	39	N		Not specified	N	N/A
1	40	N	Not specified	N	Y	Not specified
1	41	not specified	Not specified	Not specified	Not specified	Not specified
1	42	not specified	Not specified	Not specified	Not specified	Not specified
1	43	not specified	Not specified	Not specified	Not specified	Not specified
1	44	Not specified	Not specified	Not specified	Not specified	Not specified
1	45	Y	Not specified	Y	Y	Not specified
1	46	N	N/A	N/A	N	N/A
1	47	Y	"the access road and the underlying ash fill has been stripped down to natural clay"	Not specified	N	
1	48	Not specified		Not specified	Not specified	
1	49	N	N/A	Y	N	N/A
1	50	N	N/A	N	Y	Not specified
1	50a	N	N/A	N	Y	Not specified
1	51	N	N/A	Not specified	N	N/A
1	52	N	N/A	N/A	N	N/A
1	53	N	N/A	N/A	N	N/A
1	54	Not specified	N/A	Not specified	Not specified	N/A
1	55	N	N/A	not specified	Y	Not provided
1	56	N		Y	N	
1	57	Y	Not specified	Y	Y	N/A
1	58	Y	Not specified	N	Not specified	N/A
1	59	N	N/A	Not specified	Y	Not specified
1	61	Y	Not specified	Y	N	N/A
1	62	N	N/A	N	Y	Contaminant removal and 600mm validated cover layer (inc. 150mm imported topsoil, 300mm clean subsoil, 150mm drainage layer, geomembrane)
1	63	Y	Level changes	N	N	N/A
1	64	N	N/A	Y	Y	N/A
1	65	N	None	N/A	Y	See section of 10.5 of Geoenvironmental Appraisal. Summary = Proposed to install 600mm thick capping layer in garden areas with 200mm capillary break.
1	66	N	N/A	N	Y	Asbestos removal in vicinity of TP12 and TP13. Some import of clean fill proposed.
1	67	N	N/A	Not specified	N	N/A
1	68	N		Not specified	Y	Not specified
1	69	Not specified	Not specified	Not specified	Not specified	Not specified
1	70	Y	Not specified	Y	Y	Not specified
1	71	N/A	N/A	N/A	N	No remediation proposed that will affect the intended pipe selection.
1	72	N	N/A	N/A	Not specified	No remediation has been complete but the site redevelopment will involve some cut and fill to level the site
1	73	Not specified	N/A	N/A	N	Not provided
1	74	No remediation has been completed to date to our knowledge.	PE suitable for majority of the site with exception of the northern most area which will require remediation due to spillages associated with historical above ground fuel storage tank. Earthworks and remediation works are to be undertaken be a follow on contractor.	N	N	Not provided
1	74a	N	Remediation works are currently on-going; the risk assessment will be reviewed upon completion.	N	Y	Refers to Remediation Strategy. Localised hydrocarbon will be remediated to target levels designated as protective of human health
1	75	Not specified	Not specified	N/A	Not specified	Not specified
1	76	Y	All structures have been demolished and a sitewide superficial strip has been completed prior to our investigation.	Y	N	No remediation proposed
1	77	Y	See Site Remediation Completion Report attached	Y	N	All site remediation has been completed in line with the Completion report
1	78	Not specified	Not specified	N/A	Not specified	Not specified
1	79	Y	The site has been remediated with a cover layer placed over the remediated materials. Comprising a 200mm break layer and minimum 600mm clean cover. Assessment of the proposed pipe level indicates that the majority of pipes will be within the cover layer with only localised pipes extending beneath within remediated soils. Assessment of soils including those extending 500mm of the underside of the pipe indicate that some soils fail the PE threshold. A clean service corridor is proposed to a minimum depth of 500mm beneath the underside of the pipe.	Y	Y	Remediated appropriate to its end-use as housing. This includes the removal of any free phase products, tanks, below ground structures and hotspots of contamination, together with the excavation, processing (to remove oversized materials) and then reengineering in-situ of all made ground soils. The site has also had an 800mm clean cover system placed over it comprising a 200mm capillary break layer and a 600mm clean cover. Reader is referred to VR

		Completed? Section 4: Remediation	PSRA? Section 4: Remediation		Proposed? Section 4: Remediation	Section 4: Remediation
1- PSRA	Application Number / Site No.	Has remediation already been complete (which may include change in site levels)?	Remediation details	Has the PSRAS been undertaken using appropriate data following remediation?	Is remediation proposed that may have a potential affect on PSRA?	Details of proposed site remediation
1	80	N	No remediation undertaken to date	N	Not specified	Further GI required in the mill area of the site prior to finalising formal remediation strategy . Area of the site previously investigated are to be remediated by excavation of the area and removal of the buried tanks, sorting of the made ground and subsequent capping with 600mm clean inert material.
1	81	Reader is referred to Geotechnical Survey	Reader is referred to Geotechnical Survey	Not specified	Reader is referred to Geotechnical Survey	Reader is referred to Geotechnical Survey

Has the PSRAS been undertaken using appropriate data following remediation?

No	9	16%
Yes	15	26%
Not specified	24	42%
N/A	9	16%

SORT	Application No.	Site	PSRA?	COUNT	DEVELOPER	WC	COUNT
0	1	Field lane, Fazakerley	N	1	Not Specified	PE	-
0	2	Quinn Radiators, Spinning Jenny Way, Leigh, V	N	1	Not Specified	BP	-
0	3	Salford Reds Stadium	Y (WRAS)	1	BP	BP	Y
0	4	Ince Marshes, Frodsham	N	1	Not Specified	RFI	-
0	5	Mercer Av. Kirkby	Y (WRAS)	1	Not Specified	BP	-
0	6	Derby Rd, Widnes	N	1	Not Specified	BP/PE	-
0	7	Hillingdon Av. Halewood	N	1	Not Specified	PE	-
0	8	Carrswood Wythenshawe	Y (WRAS)	1	PE	PE	Y
0	9	Edge Lane, Liverpool	N	1	PE	BP	N>
0	10	John St, Carlisle	N	1	Not Specified	RFI (BP in absence)	-
0	11	Hayes Road, Cadishead	N	1	Not Specified	RFI (BP in absence)	-
0	12	Spencer Street	N	1	Not Specified	BP	-
0	13	Norlands Lane, Widnes	Y (WRAS)	1	Not Specified	PE	-
0	14	Chapelford Phase 11	Y - (WRAS)	1	Not Specified	BP	-
0	15	The Manor House Site, Sefton Lane, Maghull	N	1	Not Specified	RFI (submission 1) / PE accepted upon receipt of	-
0	16	Mulberry Road Rock Ferry Birkenhead	N	1	Not Specified	BP	-
0	17	St Catherine's Hospital, Church Road, Tranmer	N	1	PE	BP (RFI for 2 other connection ar	N>
1	18	St Marys Oldham	Y	1	Not Specified	RFI (BP in absence)	-
1	19	Berwyn Grove, St Helens	Y	1	PVC or PE	BP	N>
1	20	Back Minorca Street	Y	1	PVC	BP	N>
0	21	Beswick Phase 2, Bell Crescent	Y(WRAS)	1	PE	BP/PE	N>
1	22	West Drive, Tintwistle	Y	1	PE	BP	N>
1	23	Rainford High Tech College, Higher Lane, St H	Y	1	BP/PE	BP/PE	Y
1	24	Avondale Drive, Widnes	Y	1	PE	RFI (BP in absence)	N>(RFI)
0	25	Padstow Close , Hattersley	Y WRAS	1	Not Specified	PE	-
1	26	Station Road, Blackrod, Bolton	Y	1	PE	RFI	N(RFI)
0	27	Mottram Moor, Hyde	N	1	BP	BP	Y
1	28	Former St Annes Hospital, Altrincham	Y	1	PE	RFI (PE following receipt of addit	Y(2)
1	29	Cloister Way, Ellesmere Port	Y(x2 - updated	1	Not Specified	BP	-
1	30	Turves Road , Cheadle Hulme	Y	1	PE	BP	N>
1	31	Spinney Walk, Castlefield	Y	1	Not Specified	BP	-
0	32	Storrington Avenue, Croxteth	N	1	Not Specified	RFI (submission 1) / PE accepted upon receipt of	-
0	33	New Street, St Helens	Y	1	PE	BP	N>
0	34	Margaret Street, Liverpool	Y	1	PE	BP	N>
1	35	Ruscombe Road, West Derby Liverpool	Y	1	PE	BP/PE	N>
0	36	Groveside Park off Liverpool Road Burnley	N	1	Not Specified	RFI	-
1	37	Wood Lane, Croxteth Stat	Y	1	PE	PE	Y
1	38	Loushers Lane, Warrington	Y	1	PE	PE	Y
1	39	Lydiat Lane, Thornton	able 1 - su	1	PE	RFI (BP in absence)	N>(RFI)
1	40	Northumberland Street, Liverpool	Y	1	PE	BP/PE	N>
1	41	Hardman Fold Methane Stripping	Y	1	Not Specified	RFI (BP in absence)	-
1	42	Cringle Road Manchester	Y	1	Not Specified	RFI (BP in absence)	-
1	43	Pinkbank Lane, East Road	Y	1	Not Specified	RFI (BP in absence)	-
1	44	Estuary Science Park, Estuary Boulevard	Y	1	PE	RFI	N(RFI)
1	45	Penpoll Industrial Est Phase 1A, Bootle	Y	1	PVC	BP	N>
1	46	Halewood District Centre, Leathers Lane	Y	1	PE	BP	N>
1	47	Chadwick Fields, Coronation Road, Middelwich	Y	1	PE	PE	Y
1	48	Whitefield In, Boundary Ln & Redrock St, Liver	Y (incomplete	1	PE	RFI	N(RFI)
1	49	Hartley Lane, Rochdale	Y	1	PE	BP (PE accepted following receipt	Y(2)
1	50	Rossfield Road, Ellesmere Port Area 1 & 2	Y	1	BP	BP	Y

SORT	Application No.	Site	PSRA?	COUNT	DEVELOPER	WC	COUNT
1	50a	Area 2	-	1	BP	BP	Y
1	51	Granby Street, Toxteth	Y	1	PE	RFI	N(RFI)
1	52	Land off Portland Drive, Congleton	Y	1	PE	PE	Y
1	53	Former Greenway Garage, Frodsham Road	Y	1	PE	RFI	N(RFI)
1	54	Mellor Street, Rochdale	Y	1	BP/PE	BP/PE	Y
1	55	Grasscroft, Oldham	Y(2)	1	BP	BP/PE	N>
1	56	Chapelford Phase 13	Y	1	BP	PE	N<
1	57	Thelwall Lane, Warrington	Y	1	PE	RFI (PE following receipt of addit	Y(2)
	57a		-	1	0	0	0
1	58	Edwards Lane, Hunts Cross (Phase 6 & 7)	Y(incomplete)	1	BP	RFI (BP in absence)	Y
1	59	Whitshire Street, Salford	Y	1	PE	BP/PE	N>
0	60	Norris Green Phase 5, Liverpool	N	1	Not Specified	BP	-
1	61	Pemberton Colliery, Foundry Lane, Wigan	Y	1	PE	PE	Y
1	62	Bromborough Pool, Wirral	Y	1	PE	BP/PE	N>
1	63	Huyton Waste Recycling Centre	Y	1	BP	BP/PE	N<
1	64	Norris Green Phase 1C, Liverpool	Y	1	PE	PE	Y
1	65	Town Lane, Southport	Y(x4)	1	BP	RFI (BP in absence)	Y(RFI)
	65a		-	1	0	0	0
	65b		-	1	0	0	0
	65c		-	1	0	0	0
1	66	Acre Mill, Rawtenstall	Y	1	PE	BP/PE	N>
1	67	Blackpool Road, Newton	Y (incomplete)	1	PE	PE	Y
1	68	Jersey Way Middlewich	Y	1	PE	BP (PE accepted following receipt	Y(2)
1	69	Browside Road, Dearham	Y	1	PE	BP (PE accepted following receipt	Y(2)
1	70	Stretton Dairy, Malpas	Y	1	PE	BP (PE accepted following receipt	Y(2)
1	71	Ashfield, Liverpool	Y	1	PE	PE	Y
1	72	Tarporley Road, Tarvin	Y	1	PE	PE	Y
1	73	Milne St, Chadderton	Y	1	BP	RFI (BP in absence)	Y(RFI)
1	74	Booths Hall Hospital	-	1	0	0	0
1	74a		Y	1	BP	BP/PE	N<
1	75	106 houses, Cottam / Haydock East	Y	1	BP	BP/PE	N<
1	76	Buckshaw Village, Chorley - Persimmon Home	Y	1	PE	PE	Y
1	77	Buckshaw Village, Chorley - Redrow (Group 1)	Y	1	PE	BP/PE	N>
1	78	Westfield Nurseries, Lytham	Y (2)	1	PE	BP/PE	N>
1	79	Rigby Road, Blackpool	Y	1	PE	BP/PE	N>
1	80	Old Wool Lane, Cheadle	Y	1	PE	RFI (PE accepted in error)	Y(RFI)
1	81	Elizabeth St, Cheetham Hill, Salford	Y	1	BP	BP	Y

COUNT	
Water Cor	Developer
BP	15
PE	11
BP/PE	14
PVC	0
Not specified	6
RFI	17

* BP originally recommended by WC. Specification change to PE following the receipt of additional information

** 5x RFI (outstanding information), 9x RFI - BP accepted in absence of data, 2x RFI - PE following receipt 1x accepted PE in error

Application No.	PSRA?	COUNT	COUNT	No. of submissions	Further Information Requested by Water Company (Y/N)	PSRA	DS / PRA	GI - chemical data / line and depth	GI - Testing Group excluded	IM	GW	missing data	Plan	Quals	RS / VR	Was further information provided?	COUNT	Types of information returned	Status of application
0	1	N	1	1	N														
0	2	N	1	1	Y			1								N	1		on-going
0	3	Y (WRAS)	1	Y	Y										1	N	1		on-going
0	4	N	1	2	Y	1					1	1				Y		Exploratory hole location plan	on-going
0	5	Y (WRAS)	1	2	Y	1		1	1		1	1				Y		Phase 2 report Exploratory hole logs Chemical data (the data provided was for materials recovered between 0.1 and 0.3m bgl which are too shallow. Also the data was not Validation Report - hydrocarbon impacted areas, Jan 2011)	complete
0	6	N	1	2	Y				1						1	Y		Complete	Complete
0	7	N	1	2	N		1	1								Y		Consultants letter including lab results, and exploratory hole location	Complete
0	8	Y (WRAS)	1	Y	N														
0	9	N	1	N>	Y			1	1							Y		Phase 2 including ground investigation data	on-going
0	10	N	1	1	Y	1		1			1					N	1		On-going
0	11	N	1	1	Y						1				1	N	1		on-going
0	12	N	1	1	N										1	N			On-going
0	13	Y (WRAS)	1	1	N														
0	14	Y - (WRAS)	1	1	N			1											
0	15	N	1	2	Y	1	1	1				1 (factual data)				Y		PRA report dated June 2007 Ground Investigation & Assessment	on-going
0	16	N	1	1	N			1											
0	17	N	1	N>	Y			1								N	1		on-going
1	18	Y	1	2	Y			1	1						1	Y		Factual ground investigation data	on-going
1	19	Y	1	N>	Y		1	1								Y		Combined Phase 1 & 2 report (2) Developer email dated 22.08.11	complete
1	20	Y	1	N>	Y	1		1	1							Y		Letter Report - however this did not provide the information requested by	Complete
0	21	Y (WRAS)	1	N>	Y	1		1	1							Y		Email correspondence L&P Consulting providing the qualitative	complete
1	22	Y	1	N>	Y		1	1				1 (DS mapping)				Y		DS appendices	complete
1	23	Y	1	Y	Y			1	1							Y		Additional ground investigation as requested by W/C	Complete
1	24	Y	1	N>(RFI)	Y			1			1					Y		Email correspondence - solution of clean trench in absence of additional	on-going
0	25	Y WRAS	1	2	Y		1	1	1				1			Y		email response dated 05.08.15 providing qualitative explanation and	complete
1	26	Y	1	N(RFI)	Y			1	1						1	Y		Phase 2 plus GI factual information.	on-going
0	27	N	1	Y	Y		1	1	1							N	1		Complete
1	28	Y	1	Y(2)	Y		1	1	1						1	Y		Letter Report - supplementary report with historical mapping and additional	Complete
1	29	Y(x2 - updated)	1	2	Y			1	1							Y		Updated Rfior water pipes dated 24-08-2011, including supplementary	Complete
1	30	Y	1	N>	Y			1								N	1		
1	31	Y	1	2	Y		1	1								Y		Phase 1 Desk Study Phase 2 Geotechnical and	Complete
0	32	N	1	2	Y			1	1							Y		Remediation Statement (inc. additional ground data)	complete
0	33	Y	1	N>	N														
0	34	Y	1	N>	N			1											
1	35	Y	1	N>	Y	1	1					1 (logs)	1	1		Y		Curtins Consulting Phase 1 Detailed Desk Top Study, Ruscombe Road	?
0	36	N	1	2	Y						1		1		1	Y		Email response dated 14th September 2011 (Subject: Groveside)	on-going
1	37	Y	1	Y	Y			1	1							Y		Exploratory borehole logs and chemical data. Plus developer	complete
1	38	Y	1	Y	Y				1	1					1	Y		Laboratory chemical data for mounted backfill materials	complete
1	39	Table 1 - su	1	N>(RFI)	Y			1	1		1				1	Y		Phase 2 plus GI factual information. Letter report - to qualitatively mitigate	Complete
1	40	Y	1	N>	N														
1	41	Y	1	1	Y		1	1	1					1	1	N	1		complete
1	42	Y	1	1	Y		1	1	1					1	1	N	1		complete
1	43	Y	1	1	Y		1	1	1					1	1	N	1		complt
1	44	Y	1	N(RFI)	Y			1	1							N	1		

RFI by WC	
No	19
Yes	38

No	28
Yes	54

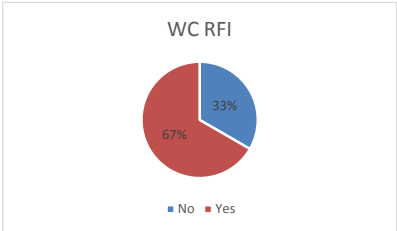
Proportion of developers pipe selection proposals accepted

Not Specified	6
Y	19
Y(2)	6
NA(RFI)	5
NA<	4
NA>	17

57

57

82 (supporting info Site 50 counted once)



23

22

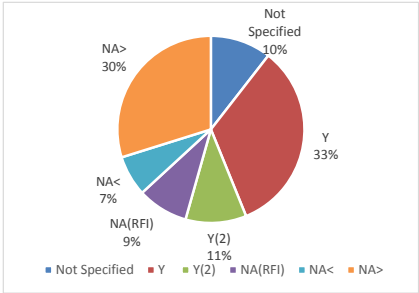
6

5

4

22

82

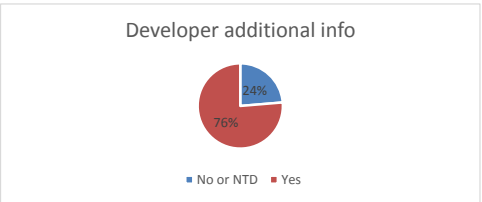


Developers additional info	38
No or NTD	9
Yes	29
No or NTD	16
Yes	38

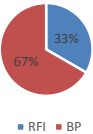
WC approach in absence of additional data

RFI	3
BP	6

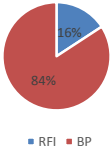
RFI	3
BP	16
	19



Approach in absence of data (57 PRSA)



Approach in absence of data (82 full)



SORT	Applicatio n Number	PSRA?	Non- chartered	Chartered	Not specified	Section 7: Risk Assessor Risk Assessor Signatory -	Section 7: RISK Assessor
						Qualifications /	Date
1	18	Y		1*		CGeol, SiLC	21.06.11
		Y	1			BSc PGDip FGS > 10 years experience in contaminated land assessments	21.06.11
1	19	Y	1			BSc PGDip FGS > 10 years experience in contaminated land assessments	21.06.11
1	20	Y	1			BSc PGDip FGS > 10 years experience in contaminated land assessments	21.06.11
1	22	Y		1		CEng, CGeol, MIStructE	Not specified
1	23	Y	1			HNC	31.05.15
1	24	Y	1			MEng (Hons)	13.06.11
1	26	Y		1		BSc(Hons), C.Eng., MIStruct.E	16.09.11
1	28	Y	1			BSc(Hons)	01.09.11
		Y(x2 - updated to inc. additional data	1				
1	29	Y				BSc, MSc, FGS	24.08.11
1	30	Y			1	Not specified	19/07/2011
1	31	Y	1			BSc(Hons)	21.06.15
	33	Y					04.08.11
	34	Y					
1	35	Y			1	Not specified	
1	37	Y			1	Not specified	14/07/2011
1	38	Y			1	Not specified	17.08.11
1	39	Table 1sub2)			1	None provided	19/08/2011
1	40	Y			1	None provided	31.08.11
1	41	Y			1	Not provided	12.08.11
1	42	Y			1	Not provided	15.08.11
1	43	Y			1	Not provided	15.08.11
1	44	Y			1	not provided	
1	45	Y		1*		MCIWEM, MRSC, SiLC	
1	46	Y			1	Not provided	
1	47	Y			1	Not provided	21.09.11
		Y(incompl ete)			1	Not provided	23/09/2011
1	49	Y		1		FGC CGeol	25/10/2011
1	50	Y			1	Not provided	03/11/2011
1 50a		-			1	Not provided	03/11/2011
1	51	Y			1	Not provided	08/11/2011
1	52	Y			1	Not provided	Not provided
1	53	Y			1	Not provided	Not provided
1	54	Y			1	Not provided	Not provided
1	55	Y(2)		1		BSc CEng MIStructE	08/06/2012
1	56	Y		1		CGeol	10/02/2012
1	57	Y		1		BSc MIES AIEMA FGS	Not specified
57a		-				BSc	18/04/2012
		Y(incompl ete)			1	Not specified	21/03/2012
1	58	Y	1			BSc Geology 13 yrs post graduate experience	18/04/2012
1	61	Y		1		CEng	26/04/2012
1	62	Y			1	Signed but Not specified	14/06/2012
1	63	Y			1	No signature	Not specified
		Y	1			Not provided (stated 14 years experience in brownfield investigation and remediation)	28/05/2012
1	64	Y				None specified	29/02/2012
1	65	Y(x4)			1		18/09/2012
65a		-					22/10/2012
65b		-					28/11/2012
65c		-					
1	66	Y	1			BSc geology 14 yrs post graduate experience	11.07.15
		Y(incompl ete)		1		MICE MIStructE	11/01/2012
1	67						

SORT	Application Number	PSRA?	Non-chartered	Chartered	Not specified	Section 7: Risk Assessor Risk Assessor Signatory - Qualifications /	Section 7: RISK Assessor Date
1	68	Y		1		CGeol, Csci, EurGeol, FGS	22.05.2012
1	69	Y			1	Not specified	10.10.12
1	70	Y			1	N	24/10/2012
1	71	Y			1	Not specified.	31/05/2013
1	72	Y			1	Not specified.	29.04.13
1	73	Y		1		BEng (Hons) CEng MIStructE AIEMA	12.07.13
	74	-				BSc, MSc, Cgeol, Csci, MIEEnvSc, FGS, EurGeol	29/01/2013
		Y		1			
1 74a						MSc CGeol	15/11/2013
1	75	Y	1			Kristopher Rodway BSc (Hons) FGS	20/12/2013
		Y	1			Jonathan Aykroyd MESci FGS	
1	76						21/05/2014
		Y	1			Originator - Sharon Bateman BSc Authorised - Duncan Fairwood MSc BSc FGS	
1	77						01/12/2013
		Y(2)		1		BSc(Hons), MSc Environmental Science, CSci, MIEEnvSc	19/08/2013
1	78	Y		1		CGeol	01/08/2014
1	80	Y		1		BSc CEng M.I.Struct.E	03/12/2012
1	81	Y		1		PhD, BSc. MIEEnvSc CSci	29/06/2007
Count			13	17	27		

Chartered	15
Chartered	2
Non-chartered	40

76 Jonathan Aykroyd MESci FGS	1	1																x (uni)
77 Originator - Sharon Bateman BScAuthorised - Duncan Fairwood MSc BSc FGS	1		1											1				1
78 BSc(Hons), MSc Environmental Science, CSci, MIEnvSc																		
79 CGeol				1														
80 BSc CEng M.I.Struct.E						1		1										
81 PhD, BSc. MIEnvSc CSci								1						1				
COUNT	13	4	7	8	2	6	7	4	1	1	1	2	1	4	2	2	2	0