

**BUCKLEY WELLS
LOCOMOTIVE WORKS
BARON STREET, BURY**

**INTERIM
GROUND INVESTIGATION &
RISK ASSESSMENT REPORT**

Date: 25th October 2006

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Document Verification

Job Title	Ground Investigation and Risk Assessment for Buckley Wells Locomotive Works, Baron Street, Bury
Job Number	JB578
Document Title	Contaminated Land Report – INTERIM

Revision	Date	Filename	Contaminated Land Report	
Issue 1	25/10/06	Description	Issue 1	
			Prepared By	Checked By
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		Signature		

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1 INTRODUCTION

1.1 Background

Leyden Kirby Associates Ltd (LKA) has been commissioned by Bury MBC to undertake a geotechnical and environmental ground investigation and risk assessment at the East Lancashire Light Railway (ELLR) depot at Buckley Wells Locomotive Works, Baron Street, Bury. This work is being undertaken to support the future re-development of the site as a visitors centre and the addition of further buildings and track for the use of the ELLR.

This report is provided as an interim for discussion and information purposes and will be updated further to the comments of Bury MBC.

1.2 Site Details

The site is located off Baron Street, approximately 1 km south west of Bury Town Centre. The site is approximately 7.5Ha in area and the site centre is at National Grid Reference 379818 410010 (see Figure 1-1). The site of interest comprises railway workshops, track and sidings, large overgrown areas with invasive species such as Japanese Knotweed and an abandoned allotment in the northwest corner of the site.

The site is bounded to the by residential development and Metrolink lines, to the north by Baron Street and further ELLR Locomotive Sidings and school playing fields to the west.

1.3 Previous Studies

The site has been previously investigated by Campbell Reith Hill (CRH) in a report dated June 1999. Since the production of the CRH report, the UK approach to contaminated land risk assessment has changed, as have the development proposals for the site. Therefore a review of the existing environmental and geotechnical information was required along with further site investigative works as appropriate. CRH split the site up into a number of sectors and these are illustrated on Figure 1-2 which reflect the differing topography and current and recent use of different parts of the site.

1.4 Development Proposals

The development proposals as supplied by Bury MBC are illustrated on Figure 1-3 and includes provision of a new carriage shed, carriage washing plant, new diesel locomotive shed, an extension to the existing locomotive works, a new coaling plant and water tower, a new station, re-routing of track, a new mess room, new car parking, visitors play and activity areas, tree planting, a pedestrian bridge and a turntable.

The site may be zoned according to its proposed use and these zones are illustrated on Figure 1-3 and listed below. Each of these proposed use zones and the new site infrastructure are assessed from an environmental and geotechnical perspective, as appropriate in this report.

1.5 Terms of Reference

The terms of reference required LKA to undertake the following:

- Review existing environmental and geotechnical data;

- Establish the requirement for any supplementary intrusive site works and further risk assessment based upon current development proposals;
- Undertake a review of mining issues;
- Undertake an asbestos survey of the former allotments area;
- Undertake further environmental and geotechnical intrusive site works as appropriate; and,
- Provide a suitable environmental risk assessment and appropriate outline geotechnical proposals based upon the available information and proposed development;

The site is infested with invasive species such Japanese Knotweed and Himalayan Balsam. The control and management of the invasive species at the site is addressed separately to this study.

A former allotment in the northwestern area of the site contained a number of buildings which were observed to contain potential asbestos bearing materials. A survey for asbestos bearing materials has been undertaken by LKA separate to this report.

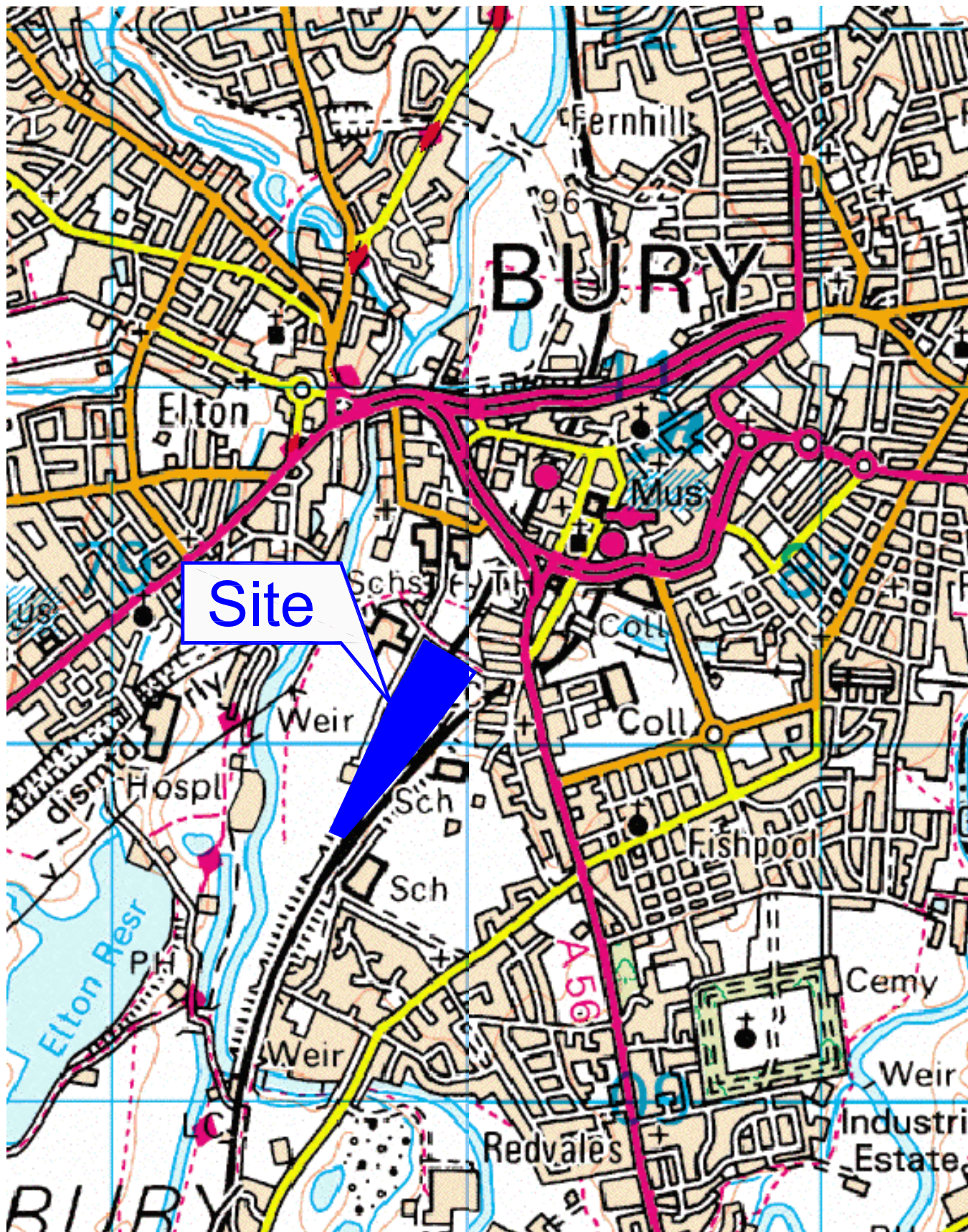
1.6 *Disclaimer*

This report has been prepared by LKA who have exercised such professional skill, care and diligence as may reasonably be expected of a properly qualified and competent consultant experienced in preparing reports of a similar scope.

However, to the extent that the report is based on or relies upon information contained in records, reports or other materials provided to LKA which have not been independently produced or verified, LKA gives no warranty, representation or assurance as to the accuracy or completeness of such information.

This report is issued on the condition that LKA will not be held liable for any loss arising from ground conditions between sampling points (i.e. boreholes/trial pits/hand augers/surface samples) which have not been shown by the sampling points or related testing carried out during the investigation, nor for any loss arising from conditions below the maximum depth of the investigation. Opinions on such conditions, where given, are for general guidance only.

This report is prepared solely for the benefit of Bury MBC. It may not be relied upon by any other party without the prior written consent of LKA. Those using this information in subsequent assessments or evaluations do so at their own risk.



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Site: JB578 Buckley Wells Locomotive Works	
Title:	
Figure 1-1 Site Location Plan	
Date: September 2006	Scale: NTS

LEGEND

SITE BOUNDARY

TP1

TRIAL PIT LOCATIONS

BH-C1

BOREHOLE LOCATIONS

This detailed site plan illustrates the layout of various sectors and features. The plan includes several trial pits (TP1 through TP15) and boreholes (BH-C1 through BH-C5). Key infrastructure includes the Eastern Railway Sector, Carriage Shed, and Ash Embankment. The plan also shows the locations of St. Gabriel's R.C. High School and Bury Grammar School. The site is bounded by Baron Street to the north and Bridge Road to the south. The plan is divided into three main areas: Allotments & Upper Overgrown Area, Lower Overgrown Area, and Ash Embankment. The plan includes numerous elevation points and a legend for site boundaries, trial pit locations, and borehole locations.

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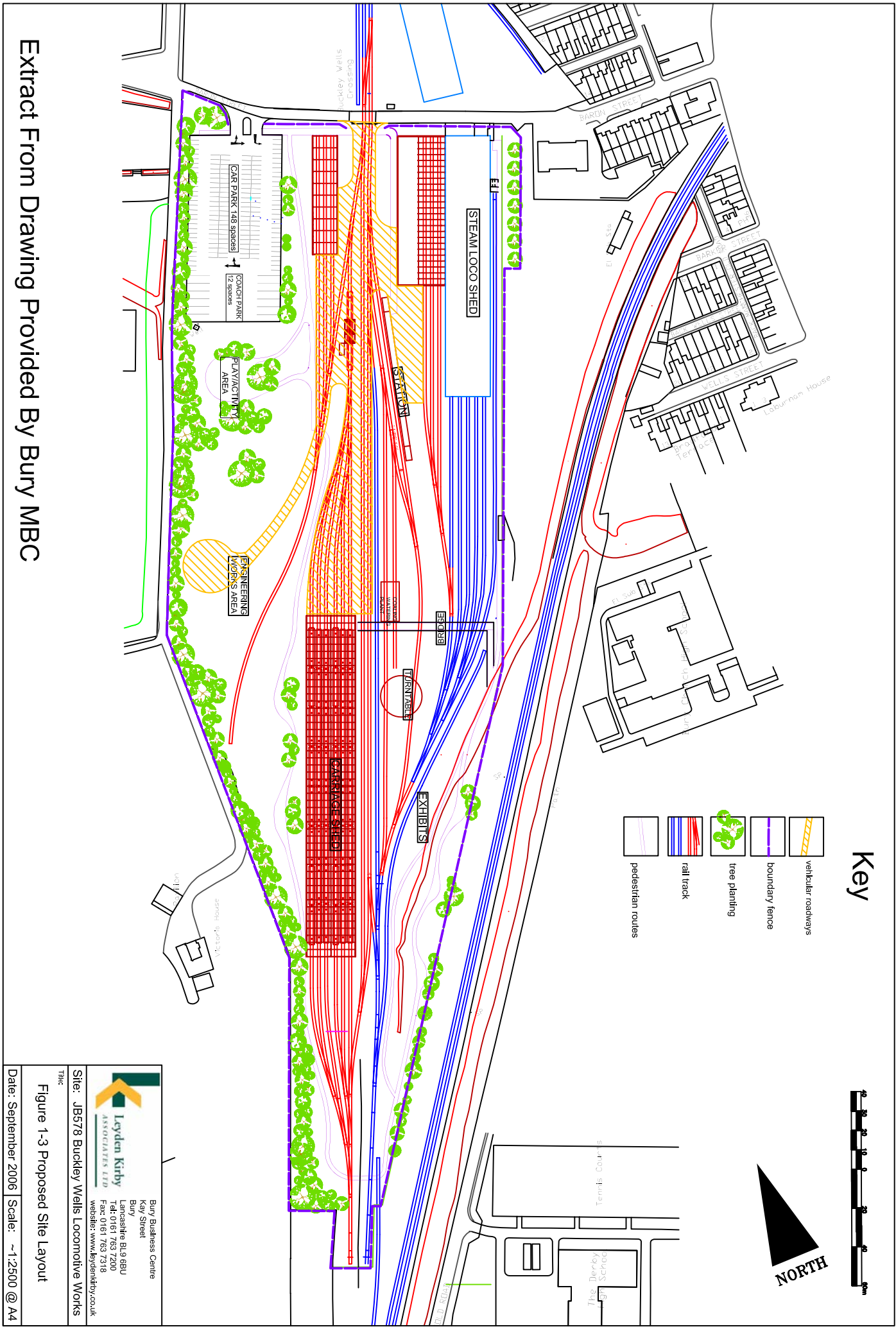
Site: JB578 Buckley Wells Locomotive Works

Title:

Figure 1-2 CRH Site Sectors

Date: September 2006 Scale: NTS

Based upon Campbell Reith Hill Drawing 6955/03



2 REVIEW OF PREVIOUS STUDIES AND EXISTING INFORMATION

2.1 Introduction

A contamination and geotechnical study has previously been undertaken by CRH (ref. PRLk6955-100699, dated June 1999). Bury MBC provided supplementary factual information as part of the tender documentation.

A review of the available information is presented in the following Sections. A copy of the factual information provided by Bury MBC is presented in Appendix A and relevant information from the CRH report is presented in Appendix B.

2.2 Site History

The CRH review only referenced maps at the scales of 6 miles to 1 inch and 1:10000, however these maps along with historical maps published at 1:1250 and 1:2500 scales (printed at 1:2500 and 1:5000 scales) and aerial photographs provided by Bury MBC are summarised below:

2.2.1 1848 OS Mapping, Plotted Scale 1:5,000

The study site is currently occupied by a railway line which runs in a general northeast to southwest direction. The railway line appears to be raised by an embankment. An engine shed is identified adjacent to the track in the northeastern part of the site. The remainder of the study site, either side of the railway line is undeveloped. Coal Pit Lane is located adjacent to the northern site boundary and a small track or pathway diverges from the lane through the western part of the site. The study site is bounded to the east and west by open land.

Development annotated as 'Victoria Gardens' is located 85m due west of the study site. An additional railway line is located 100m due north of the study site and runs in a west to east direction. An unidentified road is located 110m east of the study site and diverges into two separate roads. Much residential development has occurred 110m, 150m, 200m east and 150m southeast of the study site. Two wells are annotated 85m and 140m east-northeast of the study site.

The River Irwell and Manchester, Bolton and Bury Canal are present 300m and 380m due west of the study site respectively. A woollen mill is located approximately 270m northeast of the study site. Residential development is identified 280m northeast of the study site. A building annotated as Padiham's and associated well is located 210m southeast of the study site. Healey Woollen Mill is present 300m due south of the study site.

2.2.2 1857 OS Mapping, Original Scale 1:10,560

There are no discernible changes to the study site from previous mapping. The town of Bury is located approximately 1km due north of the study site.

2.2.3 1893 OS Mapping, Plotted Scale 1:5,000

The eastern part of the study site has been further developed for railway land. This area is now mainly occupied by additional railway sidings. The previously identified engine shed in the northeastern part of the study site has been remodelled into a larger building. A carriage shed is identified adjacent to the engine shed and eastern site boundary. A timber yard is located adjacent to the previously identified pathway in the western part of the study site. A

turntable and unidentified rectangular structure associated with the railway line are indicated towards the centre of the study site.

A wagon shed and additional sidings are also present in the surrounding area adjacent to the eastern site boundary. A cricket ground is located southwest of the study site adjacent to the western boundary.

Victoria Rope Works and additional railway sidings are present 5m due north of the study site. These sidings are annotated as Buckley Wells Coal Sidings. A timber yard is annotated 50m east of the study site. Further residential development has occurred 140m north-northeast, 50m northeast, 110m, 130m and 270m due east of the study site. A reservoir which is partially indicated as an area of marsh is located 100m south of the study site. A pond is identified 20m southwest of the study site.

2.2.4 1894 OS Mapping, Original Scale 1:10,560

This edition of mapping refers only to the northeastern part of the study site and surrounding areas to the north and east.

There are no discernible changes to the study site or surrounding areas from previous mapping.

2.2.5 1910 OS Mapping, Plotted Scale 1:5,000

The previously identified railway line running through the study site is now annotated as the L&YR Clifton, Accrington and Colne Line. The previously identified timber yard in the western part of the study site is no longer present although the structures still remain. The previously identified Wagon Shed adjacent to the eastern site boundary is no longer present and has been replaced by further sidings. A football ground is annotated adjacent to the southwestern site boundary. An additional railway line diverges from the main railway approximately 50m south of the site boundary. This line is annotated as the L&YR Bury Loop.

The previously identified Victoria Rope Works north of the study site are now annotated as a timber yard. A tank is identified 75m east of the study site associated with the previously identified timber yard. An iron foundry is identified 55m east of the study site. An additional timber yard is present 180m east-southeast of the study site. The previously identified Victoria Gardens west of the study site is now annotated as Victoria Cottage. The previously identified reservoir south of the study site now has associated tanks.

2.2.6 1910 OS Mapping, Original Scale 1:10,560

This edition of mapping refers only to the northeastern part of the study site and surrounding areas to the north and east.

There are no discernible changes to the study site or surrounding areas from previous mapping.

2.2.7 1930 OS Mapping, Plotted Scale 1:5,000

A refuse heap is indicated running through the western part of the site and appears to indicate that the eastern part of the site is now raised up on an embankment. The previously identified rectangular structure towards the centre of the site is now annotated as a water tank house. A wind pump and well are now present in the western part of the study site.

The previously identified timber yard north of the study site appears to be associated with a saw mill which has been constructed 60m due north of the study site. A petroleum spirit store is identified 60m east of the study site. The previously identified iron foundry east of the study site is no longer present. The previously identified timber yards east and east-

southeast of the study site are no longer present. The previously identified L&YR Bury Loop railway line is now annotated as the LMSR Bury Loop.

An area of rough pasture is identified 10m southwest of the study site. The previously identified pond south of the study site is no longer present however a cutting indicates the former outline. The previously identified football ground and cricket ground adjacent to the western and southwestern site boundaries are now annotated as school playing fields.

2.2.8 1930 OS Mapping, Original Scale 1:10,560

This edition of mapping refers only to the northeastern part of the study site and surrounding areas to the north and east.

There are no discernible changes to the study site or surrounding areas from previous mapping.

2.2.9 1937 OS Mapping, Plotted Scale 1:5,000

The previously identified refuse heap running through the western part of the study site is now indicated as an embankment. A refuse heap is identified adjacent to the western site boundary and is orientated in a northwesterly direction. The previously identified petroleum spirit store east of the study site is no longer annotated although the buildings still remain.

2.2.10 Aerial Photography 1940's, Plotted Scale 1:2,500

There are no discernible changes to the study site or surrounding areas from previous mapping.

2.2.11 1955 OS Mapping, Original Scale 1:10,560

This edition of mapping refers only to the southwestern part of the study site and surrounding areas to the south and west.

There are no discernible changes to the study site or surrounding areas from previous mapping.

2.2.12 1956 OS Mapping, Original Scale 1:10,560

This edition of mapping refers only to the northeastern part of the study site and surrounding areas to the north and west.

There are no discernible changes to the study site or surrounding areas from previous mapping.

2.2.13 1957 / 1958 OS Mapping, Plotted Scale 1:5,000

This edition is a composite of maps from 1957 and 1958.

The western part of the site is now annotated as allotment gardens. St Gabriel's RC High School has been constructed 10m northwest of the study site. Additional playing fields are now annotated adjacent to the northwestern site boundary. The previously identified area of rough pasture southwest of the study site is no longer indicated.

2.2.14 1970 OS Mapping, Plotted Scale 1:5,000

This edition of mapping refers only to the study site and surrounding areas to the north, west and south.

There are no discernible changes to the study site from previous mapping. The previously identified saw mills and timber yard north of the study site are no longer annotated although the buildings remain. The Bury Church School and associated playing fields are located 50m

east of the study site. The Derby School and associated tennis courts and playing field are located 100m, 50m and 130m southeast of the study site.

2.2.15 *Aerial Photography 1979, Plotted Scale 1:2,500*

The previously identified engine shed in the northeastern part of the study site has been demolished. The previously identified saw mills and timber yard buildings north of the study site have been demolished.

2.2.16 *Aerial Photography 1989, Plotted Scale 1:2500*

Many of the previously identified railway sidings in the centre of the study site appear to have been removed and the area is covered with vegetation. The previously identified allotment gardens appear to be confined to the northwestern corner of the study site.

2.2.17 *Aerial Photography 1997, Plotted Scale 1:2500*

There are no discernible changes to the study site from previous mapping. An additional building is located adjacent to the railway sidings approximately 10m north of the study site.

2.2.18 *Aerial Photography 2000, Plotted Scale 1:2500*

There are no discernible changes to the study site or surrounding areas from previous mapping.

2.2.19 *Current OS Mapping, Plotted Scale 1:5,000*

There are no discernible changes to the study site or surrounding areas from previous mapping.

2.3 *Mineral Workings and Waste Disposal*

The site is within an area which is known to have been worked for coal and a review of the coal mining information is presented in Section 6.

The CRH indicates there is one notified landfill within 250m of the site, which is at Bridge Road 240m to the east. The site was licensed to accept construction waste only although a spike survey was undertaken in 1991 which identified some elevated levels of methane. The site has since been re-profiled to make way for the ELLR railway link to Heywood.

Areas of potential infill on historical mapping include a former pond approximately 40m south west of the site and a former reservoir approximately 100m south of the site.

The available information indicates that up to 8m of tipped boiler ash from railway activities was tipped on the CRH named eastern site sector forming an embankment. Mapping indicates tipping commenced in the 1920s and ceased by the mid 1940s. Anecdotal evidence from depot staff indicated that the embankment was formed by the deposit of ash waste from a number of depots in the area and was associated with former sidings, although no sidings are indicated on the embankment area on historical plans or aerial photographs.

2.4 *Made Ground, Geology, Hydrogeology and Hydrology*

Site investigation (see Section 2.5 below) data indicates the site was underlain by up to 11 metres of made ground comprising ash, reworked material containing demolition type rubble or reworked sands and clays. The made ground was deepest in the eastern part of the site which was occupied by the area associated with the railway works and this manifests itself as a 6 metre high embankment dropping down to an area termed as the Lower Overgrown Area by CRH.

British Geological Survey (BGS) data and site investigation information indicates that the drift deposits beneath the site comprise Cohesive Glacial Drift (Boulder Clay), River Terrace Deposits (sands and gravels) and occasional horizons of Alluvium (silts and clays).

Solid strata beneath the site are represented by the Lower Coal Measures Formation (which comprises inter-bedded series of sandstones, mudstone and siltstones) with the Trencherbone Sandstone present beneath the northern third of the site. Two coal seams (Trencherbone and Hell Hole) are indicated to sub-crop beneath the site and the coal measures strata are thought to dip approximately 5 degrees to the south. A review of the coal mining issues is provided in Section 6.

The Environment Agency Groundwater Vulnerability Digital Data and the existing data show the site to be underlain by a minor aquifer (variably permeable), represented by the Coal Measures which underlie the site. As the site is within an urban area a worst-case vulnerability classification (HU) is assumed for the soil classification above the minor aquifer. This represents soils with a high leaching potential with little ability to attenuate diffuse source pollutants and in which non-adsorbed diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater. The Cohesive Glacial Drift is classified as a non-aquifer whereas the River Terrace Deposits (sands and gravels) are classified as a minor aquifer.

The nearest surface water is the River Irwell approximately located approximately 220m west of the study site. CRH assumed that site drainage and surface run-off followed topography westwards towards the River Irwell.

2.5 *Previous Site Investigations*

CRH undertook an intrusive investigation for environmental and geotechnical purposes across the site. This comprised nine cable percussion boreholes and fourteen trial pits. Six of the boreholes were fitted with gas and groundwater monitoring installations.

2.5.1 *Contamination Issues*

CRH detected “limited contamination” across the site although elevated levels (in comparison to the standards and guidelines in use at the time) of arsenic, copper and zinc were encountered in the ash deposits. No evidence of hydrocarbons or asbestos was encountered.

Leachability data did not identify significant levels of available contaminants and groundwater monitoring did not identify any significant impact.

However the limitations with the CRH study, if presented in support of the current development proposals, include the fact that UK standards and guidelines for the assessment of contaminated land have changed radically since the report was issued (explicitly CLR11). The conceptual models must be refined to represent current site proposals and there is insufficient soil sampling data to characterise and assess the suitability of some areas of the site which are now sensitive based upon the new development proposals. Therefore a refined preliminary risk assessment (as far as this study is concerned) is required to take into account the development proposals and the existing CRH site investigation.

LKA would consider that given the historical of the site and the use of electric trains in the Bury area during the tipping of the ash embankment that testing for speciated polyaromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) should be undertaken. These parameters were not tested for by CRH.

Gas monitoring was undertaken on six of the boreholes on two occasions. Methane was detected in BHG4 at concentrations up to 6% by volume. Carbon dioxide was encountered at concentrations up to 5.5% by volume in BHC1A. Negligible flows were detected. The usual requirement for a gas risk assessment through planning is a minimum of six monitoring visits over a minimum three month period, and therefore sufficient information to characterise the gas regime at the site is not available. During a site walkover, LKA were unable to identify any surviving CRH boreholes, therefore further boreholes with gas monitoring installations are required to fully characterise the gas regime at the site.

2.5.2 *Geotechnical Issues*

A significant amount of geotechnical site investigation data is available for the site in the form of in-situ testing and laboratory testing. The aim of the geotechnical works by CRH were to provide information on the depth of the ash embankment and provide information on ground conditions to the west and south of the existing carriage shed for a proposed extension.

The in-situ testing indicated that the load bearing characteristics of the made ground, ash fill and alluvium was low foundations for proposed structures should be taken down to underlying deposits. For heavy loadings piled foundations were considered necessary, although CRH noted that further targeted site investigation was necessary in the location of proposed structures once development proposals had been finalised.

2.6 *Preliminary Contamination Conceptual Model*

In accordance with UK risk assessment methodology a Conceptual Site Model (CSM) and Conceptual Exposure Model (CEM) are required for the site.

The CSM considers parameters such as current and proposed land use, location and extent of contamination, site conditions and likely receptors. The CEM is a subset of the CSM and considers parameters such as pathways and exposure parameters. The CSM and CEM may be combined for clarity in a Contamination Conceptual Model (CCM).

The potential contaminant hazards identified from the history of the study site and surrounding areas and the available site investigation data included heavy metals, TPH, PCBs and PAHs. In addition, due to the presence of infilled ground on and near the site, landfill gases such as methane and carbon dioxide may be present. Although the CRH report did not encounter any evidence of asbestos bearing materials it is considered to present a potential hazard in view of the tipping history of the site and the inclusion of the former allotments area.

The proposed use of the study site is as a tourist attraction and upgrading of the current use as a railway yard and engineering works. Potential receptors with respect to human health therefore include future tourists, site workers, construction workers and nearby residents and workers. No significant risk to controlled waters has been identified during the desk review or demonstrated in the existing analytical data, however depending on the nature and concentration of further contamination that may be detected on site the underlying minor aquifer and the River Irwell may be considered a potential receptor. The fabric of proposed buildings, building materials and services are also considered to be potential receptors as are areas of proposed landscaping.

The pathways by which the receptors could be exposed to the potential hazards present are through dermal contact, inhalation or ingestion of contaminated soils or dust, migration of groundwater into the underlying minor aquifer and nearby River Irwell, vapour migration through the sub-surface geology, sub-surface permeation through, and attack of, building

materials and services, exposure to tainted potable water supplies and uptake through root systems.

For the Buckley Wells site, there are a number of different proposed land use zones across the site; however the pollutant linkages are broadly the same for each zone. Differences may occur in the exposure pathways where site users and workers may spend differing lengths of time and undertake slightly differing activities in each zone.

Table 2-1 below presents the general site contamination conceptual model for the site. The key receptors with respect to human health are considered to be visitors (the 0 to 6 year old female child) in the site visitor facility and full time site workers (16-59 year old female) working within the visitors facility and with the ELLR workshops.

Pollutant Linkage No.	Hazards				Pathway	Receptor
	Ground Gas	Asbestos	Heavy Metals	Organic Compounds incl. PCBs, pesticides and herbicides		
1	x	?	?	?	Dermal Contact, ingestion and inhalation of contaminated soil and dust	Future tourists and current and future site workers
2	x	?	?	?	Dermal Contact, ingestion and inhalation of contaminated soil and dust	Future site construction workers
3	x	?	?	?	Ingestion and inhalation of contaminated soil and dust	Nearby residents and workers
4	?	x	x	?	Vapour Migration	Site users, current and future site workers and buildings
5	x	x	?	?	Groundwater migration	Minor Aquifer and River Irwell
6	?	x	?	?	Contact with potential hazards	Current and proposed Site Buildings
7	x	x	?	?	Ingestion of tainted water supply	Future tourists and site workers
8	x	x	?	?	Uptake of contaminants	Future landscaping

Table 2-1: General Preliminary Contamination Conceptual Model for the Buckley Wells Site
(Key: ? – pollutant linkage possible; x – pollutant linkage unlikely)

3 GROUND INVESTIGATION

3.1 Site Investigation Design and Methodology

In order to investigate the engineering properties of the ground and the potential pollutant linkages identified in the preliminary conceptual model, intrusive investigations were undertaken between 9th and 19th December 2005. A further phase of rotary boreholes was undertaken on 26th April 2006 as part of the coal mining assessment.

The site investigation rationale is listed in Table 3-1 below.

Location / Zone or Proposed Use	Sampling Locations (relevant CRH locations)	Reason
Proposed car park / former allotments area	TP6 & TP7 (TP1)	Identify any contamination and gain CBR values for pavement design
Proposed play / activity area	TP1 to TP5 (TP3)	Identify any contamination
Proposed pedestrian routes and proposed landscaping)	HA1 to HA14 (BH-C5, TP10, BH-C4, BH-C2, TP14, BH-C3 TP7)	Identify any contamination
Proposed exhibits area	TP8 to TP12	Identify any contamination
Carriage / steam shed extension	BH3 & BH4 (BH-G1 & TP15)	Identify ground conditions for foundation design and any ground gas risk
New roadways and track bed	TP-G3 to TP-G6 (TP2, TP10 to TP14)	Identify CBR values for pavement design
New shed (northern site boundary)	BH1 and BH2 (TP4)	Identify ground conditions for foundation design and any ground gas risk
New station and platform	BH5 (BH-G2)	Identify ground conditions for foundation design
Engineering works area	TP-G1 & TP-G2 (TP6)	Identify CBR values for pavement design
New Carriage Shed	CP2, CP3, BH7 R2 (TP8, TP9, BH-C2, BH-C4)	Identify ground conditions for foundation design and any ground gas risk
Relocation of turntable	BH6 (TP12)	Identify ground conditions for foundation design
New Bridge	CP1 & CP2 (TP14)	Identify ground conditions for foundation design

Table 3-1: Site investigation rationale, Buckley Wells.

All the borehole sample descriptions undertaken by LKA (except for the rotary boreholes) were carried out in accordance with BS5930 by suitably qualified and experienced members of staff. Trial pit logs, window sample borehole logs, hand auger logs, cable percussive borehole logs and rotary borehole logs for the site are presented in Appendices C to G respectively.

The location of each sampling location is illustrated on Figure 3-1. Figure 3-2 illustrates the LKA sampling locations with an overlay of the CRH sampling locations. Borehole and trial pit logs from the CRH investigation are presented in Appendices H and I respectively.

3.2 Sample Collection and Analysis - Contamination

Soil samples of approximately 250g were recovered in amber jars. All the samples were labelled and stored in cool boxes prior to being collected by courier for delivery to the laboratory. Samples were sent to STL Midlands in Coventry. Samples were tracked using appropriate Chain of Custody forms provided by the analytical laboratory.

In total 32 representative soil samples taken during the site investigation were selected for chemical contamination analysis. A summary of the analytical suite is given in Table 3-2 below:

Analysis	No of Samples
Heavy metals including Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Zinc	32
USEPA priority 16	32
TPH Screen (C6-C10, C10-C20, C20-C40)	12
TPH CWG	15
PCB	3
Asbestos	3
Water soluble sulphate	3
Pesticide Screen	1
pH	21

Table 3-2: Summary of contamination testing, Buckley Wells.

Many of the tests are UKAS or MCERTS accredited and further details are given in the Certificate of Analysis presented in Appendix J. A summary of the results is given in Section 4.

Additionally, the CRH investigation comprised 39 soil samples, tested for all or a combination of a range of contaminants including heavy metals, boron, cyanide, TPH screen, total PAH, phenols, sulphides, sulphur, thiocyanate, BTEX, chlorinated solvents herbicides and asbestos.

CRH undertook leachate testing on 12 samples for heavy metals and 12 groundwater samples for including heavy metals, boron, cyanide, TPH screen, total PAH, phenols, sulphides, sulphur and thiocyanate. Copies of the Certificates of Analysis from the CRH investigation are presented in Appendix K.

3.3 Sample Collection and Analysis – Geotechnical

Bulk samples for geotechnical analysis were recovered from the trial pits and boreholes with undisturbed U100 samples recovered from clay deposits in the cable percussion boreholes.

A summary of the geotechnical testing undertaken is given in Table 3-3 below:

Test	No. of Samples
Moisture Content	10
Atterberg (plasticity) Limits	4
Particle Size Distribution (PSD)	2
Triaxial	1
pH and soluble sulphate to BS1377	12
Bulk density	12
Hand vane (shear strength)	1
California Bearing Ration (CBR)	8

Table 3-3: Summary of geotechnical testing undertaken by LKA, Buckley Wells

The testing was undertaken by Ian Farmer Associates Ltd in accordance with BS1377. Copies of the Certificates of Analysis are presented in Appendix L.

Additionally, geotechnical testing was undertaken as part of the CRH investigation. The tests are summarised in Table 3-4 below and copies of the certificate of analysis are presented in Appendix M.

Test	No. of Samples
Moisture Content	26
Atterberg (plasticity)Limits	26
Particle Size Distribution (PSD)	34
Triaxial	16
pH and soluble sulphate to BS1377	9 (soils) 8 (groundwater)
California Bearing Raito (CBR)	1
Shear Box	2
Consolidation Test	4
Calorific value	3

Table 3-4: Summary of geotechnical testing undertaken by CRH, Buckley Wells

3.4 *In Situ Geotechnical Testing*

In-situ geotechnical tests were performed in the window sample and cable percussion boreholes. A total of 39 standard penetration tests (SPTs) and 1 shear vane test were performed on the underlying sub-soils.

The CRH investigation comprised 66 SPTs in the cable percussion boreholes and 13 shear vanes in the trial pits.

The results are illustrated on the soil profile logs and are assessed in Section 7 according to the appropriate development proposals.

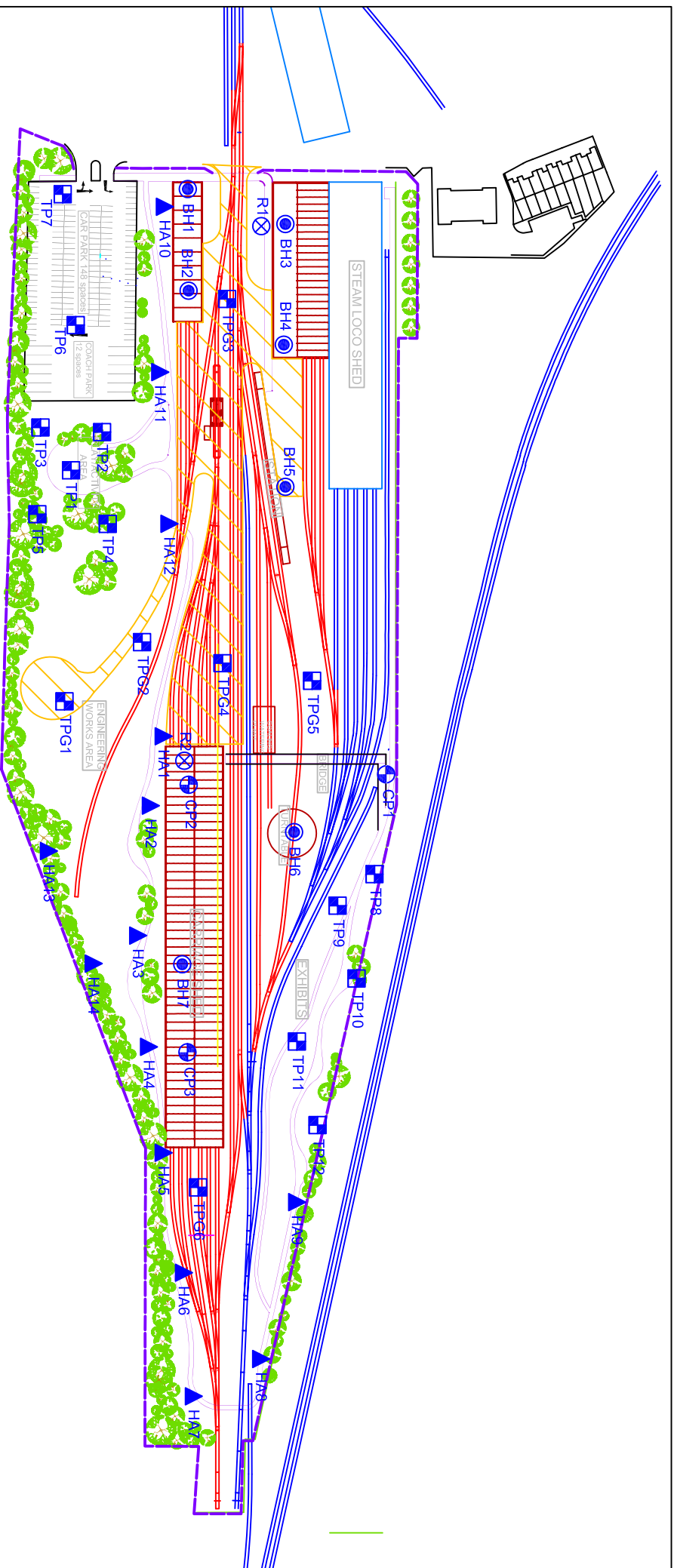
3.5 *Gas Monitoring*

Boreholes BH1, BH3, BH4, BH7 and CP2 and CP3 were instrumented with gas monitoring standpipes and were subsequently monitored on ten occasions between 4th January 2006 and 29th March 2006.

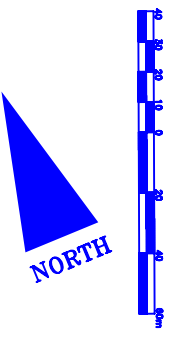
In addition, boreholes CRH C1A, C3, C4, C5, G1 and G4 were instrumented with gas monitoring standpipes and were monitored on two occasions on 3rd and 11th March 1999. Additionally three gresham tube samples for laboratory analysis were taken.

The gas monitoring results from the LKA and CRH investigations are presented in full in Appendix N.

The location of the gas monitoring locations in this study was dependant on the location of proposed buildings and structures, therefore the ground gas issues at the site is addressed in Section 7 relevant to the appropriate areas of proposed development.



- Key to LKA Sampling Locations**
- Window Sample Borehole
 - ▲ Hand Auger
 - Trial Pit
 - ⊗ Rotary Borehole
 - ⊕ Cable Percussion Borehole



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Title:

Figure 3-1 LKA Sampling Locations

Date: September 2006 | Scale: ~1:2500 @ A4

LEGEND

SITE BOUNDARY

TP1

TRIAL PIT LOCATIONS

BH-C1

BORING LOCATIONS

Key to LKA Sampling Locations

- Window Sample Borehole
- Hand Auger
- Trial Pit
- Rotary Borehole
- Cable Percussion Borehole

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Title:

Figure 3-2 LKA & CRH Sampling Locations

Date: September 2006

Scale: ~1:2500 @ A4

4 CONTAMINATION ANALYSIS

4.1 Soils Analysis

The results of the solid soil samples collected from the upper metre across the site show that arsenic concentrations varied between 3.6 and 130 milligrams per kilogram (mg/kg); cadmium concentrations varied between <0.5 and 17mg/kg, chromium concentrations varied between 5.1 and 32mg/kg; lead concentrations varied between 6 and 2300mg/kg; mercury concentrations varied between <0.1 and 8.9mg/kg; selenium concentrations varied between <0.1 and 2.1mg/kg. Nickel concentrations varied between 2.3 and 83mg/kg. In addition, copper concentrations varied between 4.4 and 770mg/kg and zinc concentrations varied from 4.7 to 490mg/kg.

Concentrations of phenols varied between 0.96 and 6.9mg/kg, total cyanide concentrations varied between <0.1 and 0.85mg/kg and sulphide concentrations varied between <5 and 96mg/kg.

Total PAH and USEPA PAH 16 values ranged between <1 and 860mg/kg. LKA considers that the main drivers for PAHs on the Buckley Wells site are naphthalene and benzo(a)pyrene. Naphthalene results ranged between <1 and 14mg/kg and benzo(a)pyrene results ranged between <1 and 22mg/kg.

Speciated TPH screening values ranged between <10 and 5,016mg/kg and TPH CWG values (TPH Risk) varied between <40 and 930mg/kg.

Concentrations of VOCs, SVOCs and pesticides were all below the relevant analytical limit of detection. Concentrations of PCBs ranged between <0.1 and 0.21mg/kg

The water-soluble sulphate results were encountered between <0.05 and 0.2. The pH of the soil samples ranged between 4.4 and 7.9.

No asbestos fibres were detected in any of the soils samples.

4.2 Groundwater and Leachate Analysis

The results of the leachate and groundwater samples collected by CRH were generally at or below the analytical limits of detection. The pH of the samples ranged from 6.4 to 6.7 and sulphate concentration ranged between 0.02 and 0.23 grams per litre (g/l).

5 CONTAMINATION RISK ASSESSMENT

5.1 Introduction

The following risk assessment is a Tier 2 risk assessment as defined in the Government's approach to environmental risk assessment and management (DETR 2000) which advocates a tiered risk assessment system. Tier 1 involves basic risk screening of the contamination problems associated with the site which can be performed using desk based data. Section 2 produced a Tier 1 assessment in the form of a preliminary conceptual model which has identified the potential pollutant linkages requiring further assessment across the various proposed zones of the site.

A Tier 2 risk assessment is generally described as a generic quantitative risk assessment and involves the comparison of the analytical results from the site investigation with generic guideline values derived for soil or relevant water quality guidelines for either the groundwater or surface water results.

For the human health risk assessment, under the recently released documents (CLR7-10) Soil Guideline Values (SGVs) derived from the CLEA model are provided to compare with concentration data from an appropriately designed site investigation. Unfortunately, however, there are only a select number of SGVs currently available and therefore, where necessary, the SNIFFER model may be used to derive site specific assessment criteria (SSACs).

Furthermore, following discussion with Bury MBC it was decided it may be appropriate to compare the contaminant concentrations with site specific values (SSVs) produced in the ATRisk Soil database. These are Tier 2 concentrations developed with recourse to the CLEA methodology but with more sensitive exposure pathways to ensure a suitable factor of conservatism. The database also includes parks, playing fields and open spaces SSVs which may be appropriate for this assessment.

The Tier 2 values are dependent on the land-use of the proposed development. The Buckley Wells site will be used include workshops for the ELLR and for tourists and visitors. Appropriate land use scenarios depending on the proposed site use are outlined in Table 5-1 below. A list of appropriate Tier 2 values is presented in Appendix O.

Location / Zone or Proposed Use	Key Receptor(s)	Tier 2 land use scenario
Proposed car park / former allotments area	Site visitors Site Worker Landscaping	ATRisk SSV Open Spaces Commercial/Industrial SGV & ATRisk SSV ICRCL 59/83
Proposed play / activity area	Site visitors Site Worker Landscaping	ATRisk SSV Open Spaces Commercial/Industrial SGV ICRCL 59/83
Proposed pedestrian routes and proposed landscaping)	Site visitors Site Worker Landscaping	ATRisk SSV Open Spaces Commercial/Industrial SGV ICRCL 59/83
Proposed exhibits area	Site visitors Site Worker Landscaping	ATRisk SSV Open Spaces Commercial/Industrial SGV ICRCL 59/83
Site Wide	Site worker (ELLR) Site Worker (tourist guide & maintenance)	Commercial/Industrial SGV AT Risk SSV Playing fields

Table 5-1: Tier 2 assessment criteria, Buckley Wells.

The Sections below will assess the Tier 1 identified potential pollutant linkages using the relevant Tier 2 values for the various proposed land uses of the site. Statistical tests as outlined in CLR7 were undertaken in the analytical results for each zone (where sufficient sample numbers were available). The tests comprise a Mean Value Test where the 95% percentile of the sample data is calculated for comparison against the appropriate Tier 2 value and a Maximum Value Test which establishes if the sample data belongs to a normal distribution curve and allows identification of any statistical outliers in the dataset. The data generated is summarised in Appendix P.

An evaluation can then be made on whether the potential pollutant linkages will be complete following the proposed redevelopment or whether they can be discounted.

5.2 Proposed Car Park / Former Allotments Area

A summary of the minimum and maximum contaminant values is outlined in the CLR7 spreadsheet for this area of the site in Appendix P. Pollutant Linkages 1 and 8 from the Tier 1 risk assessment are considered appropriate for this area of the site.

For pollutant linkage 1 no detectable levels of asbestos, pesticides, PCBs or VOCs were encountered. Comparison of the site contamination data with the Tier 2 values for the commercial and industrial land use indicates that for the site workers no elevated levels of contamination are present. This includes total and speciated TPH and PAH concentrations.

For site visitors, the ATRisk soil open space land use SSVs have been applied and again no elevated levels of contamination were detected. Therefore in this area of the site pollutant linkages 1 is considered incomplete.

For pollutant linkage 8, slightly elevated levels of copper were encountered. This linkage is therefore considered complete in this area of the site; however it may be appropriate to consider the former use as an allotment and to take advice from a landscape architect on whether specific planting is required due to the copper contamination.

5.3 *Proposed Play / Activity Area*

Pollutant Linkages 1 and 8 from the Tier 1 risk assessment are considered appropriate for this area of the site. This area of the site is considered to be the most sensitive due to the possibility of site visitors, particularly the critical receptor of a 0 to 6 year old female child, playing in this area and coming into contact with contaminated soils. Nevertheless, it is considered the ATRisk soil SSV for open space is appropriate as the exposure pathways concentrate on the receptor being on site for 78 days per year which is considered to be conservative for a visitor attraction.

The statistical tests indicate that no elevated levels of contaminants are present in this area and the laboratory data also indicates that heavy Metals, PCB, PAHs, Total TPH and TPH CWG concentrations were below the relevant Tier 2 values

Therefore pollutant linkages 1 and 8 are considered incomplete in this area of the site.

5.4 *Proposed Pedestrian Routes and Proposed Landscaping*

Pollutant Linkages 1 and 8 from the Tier 1 risk assessment are considered appropriate for this area of the site.

Concentrations of herbicides, PCBs, pesticides, halocarbons, asbestos and BTEX compounds were below the limit of detection. Heavy metals, Total TPH and TPH CWG concentrations were below the relevant Tier 2 values.

For pollutant linkage 1, the statistical tests and analytical data indicate that for the site worker no elevated contaminant levels were detected, while for the site visitor elevated levels of benzo(a)pyrene were present.

Therefore with respect to benzo(a)pyrene in this area pollutant linkage 1 is considered complete and a either remedial measures or further assessment in a refined Tier 3 risk assessment is required.

For pollutant linkage 8 elevated levels of copper were encountered. This linkage is therefore considered complete alongside pedestrian walkways and the proposed landscaped areas sampled. There appears to be no distinction in copper concentrations between ashy and non-ashy made ground and therefore the site should be addressed as a whole. Therefore either remedial actions should be undertaken in these areas or consultation should be undertaken with a landscape architect to produce a specific planting scheme with respect to the copper contamination.

5.5 *Proposed Exhibits Area*

Pollutant Linkages 1 and 8 from the Tier 1 risk assessment are considered appropriate for this area of the site.

For pollutant linkage 1, the statistical tests and analytical data do not indicate any elevated levels of contamination and the heavy metals, PAHs, total TPH and TPH CWG analyses were all below the relevant Tier 2 values.

PCBs were below the limit of detection of 0.1mg/kg in TP8 and present at 0.21mg/kg in TP10. No Tier 2 SSV, SGV or TOX report exists for total PCB however LKA consider the use of the Dutch Action Level of 1mg/kg is appropriate as a screening value.

LKA recognise the Dutch List exposure parameters used to derive action levels differ from those outlined in the CLEA model, nevertheless LKA consider a maximum site wide value of 0.21mg/kg is 5 times lower than the action level and as a qualitative basis is not significant.

With respect to pollutant linkage 8, elevated levels of copper and zinc were encountered. This linkage is therefore considered complete in this area of the site.

5.6 Site Wide

For the site as a whole, all pollutant linkages are considered relevant.

The site wide land use scenario has been considered applicable to site workers such as maintenance workers or gardeners involved with the tourist facility and ELLR site workers.

For the maintenance workers and ELLR workers the statistical tests indicate that for pollutant linkage 1, no elevated levels of contamination is present.

Pollutant linkage 2 is concerned with the future construction workers coming into contact with contaminated soils. This linkage is considered complete as a precautionary measure due to levels of contaminants in the made ground. This linkage may be broken by the adoption of standard health and safety procedures.

Pollutant Linkage 3 is concerned with contamination on site having an impact on adjacent residents. No evidence of any mobile contamination was encountered during the site works and the contaminant concentrations in the near surface soils are not considered to constitute a significant risk to neighbouring receptors. Therefore pollutant linkage 3 is considered incomplete.

Pollutant Linkage 4 refers to the potential for migration of ground gas into the proposed site buildings. The gas monitoring indicates that methane was detected in one location across the site (CRH BH-G4) at a maximum concentration of 6.6% by volume. The maximum carbon dioxide concentration of 5.5% was detected in CRH BH-C1A although flow rates were generally negligible. This may indicate that gas is being generated at very low rates and any migration would be by diffusion rather than pressure driven into buildings and services.

This linkage is generally considered complete although this is dependant on the location and nature of the proposed site buildings. The gas regime relevant to each proposed enclosed structure is outlined in Section 7.

For pollutant linkage 5, no evidence of free phase or mobile contamination has been encountered during the site works. Leachability testing on the selected soil samples and testing of groundwaters recovered from boreholes across the site did not indicate any elevated concentrations when compared to appropriate Environmental Quality Standards as advocated by Environment Agency guidance on the pollution of Controlled Waters for Part IIA.

Additionally, the site is underlain by stiff glacial clay which will allow a level of protection and attenuation against the downward migration of any mobile contamination towards the underlying aquifer.

The River Irwell is approximately 280m west of the site and it is considered unlikely that any leachable or mobile contamination sourced from the site would be able to reach and adversely affect this receptor. The River Irwell is a substantial fast flowing river where dilution of any contaminated water entering the river would be significant.

A former abattoir and landfill site is present on the bank of the River Irwell on a similar northing to the site. This site is known to contain animal wastes and seepages have occurred to the River. Anecdotal evidence from the Environment Agency in 2005 indicated they suspect any contamination from this landfill site entering the River Irwell would be sufficiently diluted and as the Buckley Wells is demonstrably much less contaminated and much further away from the river than this landfill site, LKA would conclude that the site would not constitute a significant risk to the River Irwell.

Therefore pollutant linkage 5 is considered incomplete.

Pollutant Linkage 6 is concerned with ground gas and chemical attack on proposed buildings. The ground gas issue has been assessed above. The water soluble sulphate results indicate the site falls within Class AC-1s and therefore no specific precautions are required with respect to sulphate resistant concrete.

Pollutant linkage 7 refers to potential impact of contamination on potable water supply pipes. The levels of contamination in the made ground at the site are above United Utilities pipe risk assessment trigger concentrations. If potable water supply pipes are to be placed in the made ground then it is likely that consideration will be required in respect of using protective pipes and sterile backfilled trenches. Therefore this linkage is considered complete if the potable pipes are to be installed in the made ground.

Pollutant linkage 8 refers to the potential impact ground contamination may have upon areas of proposed landscaping. As indicated in the above Sections, the concentrations of copper and zinc in the soil are above the concentrations considered to be phytotoxic in guidance given in document ICRCL 59/83. Although this document has been withdrawn with respect to human health, it still provides a useful Tier 2 guidance value for assessing potential effects on plant and trees.

This linkage is considered complete in proposed landscaping areas; however LKA note that the Tier 2 levels are highly conservative in that they assume an acid soil and more susceptible plants. An inspection of the site that vegetation (albeit mainly invasive species) is growing successfully and LKA would consider that advice is sought from a landscape architect.

5.7 *Refined Contamination Conceptual Model*

Based upon the above information the Preliminary Contamination Conceptual Model for the site may be refined to reflect actual site conditions. This is provided in Table 5-2 below:

Pollutant Linkage No.	Hazards				Pathway	Receptor
	Ground Gas	Asbestos	Heavy Metals	Organic Compounds incl. PCBs		
1	x	x	x	✓ (site visitor along pedestrian walkways)	Dermal Contact, ingestion and inhalation of contaminated soil and dust	Future tourists and current and future site workers
2	x	x	✓ (in made ground)	✓ (in made ground)	Dermal Contact, ingestion and inhalation of contaminated soil and dust	Future site construction workers
3	x	x	x	x	Ingestion and inhalation of contaminated soil and dust	Nearby residents and workers
4	✓ (depending on location on site)	x	x	?	Vapour Migration	Site users, current and future site workers and buildings
5	x	x	x	x	Groundwater migration	Minor Aquifer and River Irwell
6	✓ (depending on location on site)	x	x	x	Contact with potential hazards	Current and proposed Site Buildings
7	x	x	✓	✓	Ingestion of tainted water supply	Future tourists and site workers
8	x	x	✓	x	Uptake of contaminants	Future landscaping

Table 5-2: Refined Contamination Conceptual Model for the Buckley Wells Site

(Key: ✓ – pollutant linkage likely; pollutant linkage possible, x – pollutant linkage unlikely)

In summary, pollutant linkage 1 is considered complete with respect to benzo(a)pyrene along the pedestrian routes.

Pollutant linkage 2 should be considered complete during the redevelopment works in areas of made ground.

Pollutant linkage 4 and 6 is considered complete in certain areas of the site depending on the nature of the proposed building and the gas regime. This is assessed in Section 7.

Pollutant linkage 7 is considered complete should any potable water supply pipes be installed in the made ground.

Pollutant linkage 8 is considered complete across the site due to elevated levels of copper and zinc which have the potential to affect proposed landscaping areas.

6 COAL MINING ISSUES

A review of coal mining issues and its potential impact on development was required as part of the geo-environmental assessment works at the above site. The CRH report comprised a desk-based review of the existing coal mining information and trial pits were subsequently undertaken in the vicinity of the shafts near to the existing carriage shed.

LKA supplemented the above information with a further Coal Authority report and reference to 1st Edition (dated 1857) and 2nd Edition (dated 1910 and 1930) geological mapping.

Copies of the above are reproduced in Appendix Q.

6.1 *Information Review*

Section 4.3 of the CRH report explains that an examination of Coal Authority records attributes the location of the shafts to the Dicconsons Coal Survey Data Maps published in the 1850's. The report confirms they were not indicated on later Ordnance Survey Mapping.

Site investigation information included within the Campbell Reith Hill report shows that mudstone was recorded in borehole G1, located near shaft 003, at a depth of 13.8m. Borehole C1 and trial pits TP1, 2 & 4 were excavated in the vicinity of the shafts. No evidence of coal or detritus associated with previous mining appears to have been recorded. However, it is possible the shafts may have been used for ventilation and not for raising coal.

Section 4.5 of CRH report indicates that given the age of the shafts and past development of the site the shafts may have collapsed and self-stabilised or have been infilled. CRH indicate that further development however, may result in stability problems due to new loadings.

First edition Geological Mapping does not indicate either shaft but describes Coal Pit Lane along the northerly site boundary, some 20m from the indicated shafts. The mapping shows the railway and an Engine Shed on the site.

Second edition geological mapping shows that the site is located between the conjectured positions of two faults. The conjectured locations of the outcrop at rockhead of the Trencherbone, Hell Hole Mine, Five Quarters and Doe coal seams are indicated to be in the vicinity of the site. No details of mining or other geological information is indicated within the vicinity of the site. A level tunnel from a shaft at Fletcher Fold some 1.2km south east of Buckley Wells records strata dipping in a south westerly direction at gradients from 1 in 5 to 1 in 6.

The Coal Authority report indicates there are no records available for past underground mining beneath the Buckley Wells site although coal is believed to exist at or close to the surface. The report adds that it may have been worked at some time in the past. Two mine openings are indicated at the northerly area of the site. No further information or whether the shafts are infilled is available.

6.2 *Interim Coal Mining Review Conclusions*

Based upon the available information Leyden Kirby Associates (LKA) concluded the following :