Site Audit Report
Delineation and Characterisation Sampling and Review of Remedial Options
Former Gasworks Site, Burren Street, Erskineville NSW

14 September 2007

Prepared for:
RailCorp Safety & Environment Group
Environmental Projects Unit
PO Box K349, Haymarket NSW 1238
(Level 1, 18 Lee St, Chippendale NSW 2008)

Report by:
HLA-Envirosciences Pty Limited
ABN: 34 060 204 702
Level 5, 828 Pacific Highway Gordon NSW 2072
PO Box 726 Pymble NSW 2073
Ph: +61 2 8484 8999
Fax: +61 2 8484 8989

HLA Ref: S4015604_SAR_14Sept07

“This page has been left blank intentionally”

DISTRIBUTION

Site Audit Report
Delineation and Characterisation Sampling and Review of Remedial Options
Former Gasworks Site Burren Street, Erskineville NSW
14 September 2007

Copies	Recipient	Copies	Recipient
1 Bound 1 Unbound	**Luke Speechley** **Environmental Projects Officer** **RailCorp Safety & Environment Group** Environmental Projects Unit PO Box K349, Haymarket NSW 1238 (Level 1, 18 Lee St, Chippendale NSW 2008)	1 Hard Copy	HLA ENSR Library
		1 Original	HLA ENSR File

This document was prepared for the sole use of Railcorp and the regulatory agencies that are directly involved in this project, the only intended beneficiaries of our work. No other party should rely on the information contained herein without the prior written consent of HLA-Envirosciences Pty Limited and Railcorp.

By

HLA-Envirosciences Pty Limited
ABN: 34 060 204 702
Level 5, 828 Pacific Highway Gordon NSW 2072
PO Box 726 Pymble NSW 2073

Bill Ryall
Site Auditor (NSW EPA Accredited – 9809)

Technical Peer Reviewer: **Date:**

14 Sept 07

Frank Mohen
NSW/ Sydney Operations Manager

his page has been left blank intentionally"

CONTENTS

TABLES

Body Report

APPENDICES

"This page has been left blank intentionally"

1 INTRODUCTION

1.1 Background

This Site Audit Report relates to the environmental condition of a site, formerly occupied by a manufactured gas plant, located at Burren Street, Erskineville NSW (the Site). The Site is owned by Railcorp and is one of a number of properties which are referred to as being part of the Macdonaldtown Triangle.

This Site Audit Report addresses the environmental condition of the Site and the options for remediation, which have been assessed and presented by CH2MHILL Australia Pty Ltd (CH2MHILL).

This Site Audit Report is the first in a series of Site Audit Reports to be completed on the stages of investigation, remedial planning, remediation and management of the identified soil and groundwater contamination identified on the Site.

Within this Site Audit Report, where a matter has been reviewed that has a significant impact to the investigation of the environmental condition or to the proposed remediation of the Site, it has been addressed in the body of the review as an "Auditor's opinion". The overall conclusions of the Audit are presented in the "Audit Summary Opinion" at the end of the report.

Figures from the CH2MHILL Report relating to the Site are included in Attachment 1 to this Site Audit Report and lists of references, source publications, abbreviations and acronyms are contained at the end of this Site Audit Report.

1.2 Reports reviewed

In completing this Site Audit Report the Auditor reviewed the report "*Delineation and Characterisation Sampling and Review of Remedial Options, Former Macdonaldtown Gasworks, Burren Street, Erskineville, NSW"* by CH2MHILL dated March 2007, herein referred to as "the Report".

1.3 Purpose of the Audit

The purpose of this Site Audit Report was to review the Report to determine whether it substantially met the requirements of relevant guidelines endorsed by NSW Department of Environment and Climate Change (DECC) and to determine whether the investigations completed were sufficient to allow the development of an appropriate remediation action plan (RAP) for the Site.

The Audit is a Statutory Audit under the Contaminated Land Management (CLM) Act (1997) and this Site Audit Report has been completed as part of the ongoing Audit of the Site.

It is proposed to also provide a Site Audit Report following the review of the Remediation Action Plan, when completed, and also to provide Site Audit Reports when reports of achievement of significant milestones are reviewed during the course of the proposed remedial works. At the completion of the remedial works and following review of satisfactory Validation Reports, the Auditor will then provide a Site Audit Report and a Site Audit Statement certifying the suitability of the Site for the proposed use.

2 THE SITE AUDIT PROCESS

The Site Audit process comprises an independent review by a Site Auditor, accredited by the NSW Environment Protection Authority (EPA – now part of the DECC) under the Contaminated Land Management (CLM) Act, of one or more reports of investigation, remediation and validation of a contaminated or potentially contaminated site that have been prepared by an environmental consultant. The audit process and the responsibilities of the Site Auditor are defined in NSW DEC (2006), Contaminated Sites, Guidelines for the NSW Site Auditor Scheme (2nd Edition), which include, firstly, preparation of a Site Audit Report, which summarises the results reported by the consultant for assessment, remediation and/or validation programs, as appropriate, and finally, preparation of a Site Audit Statement, which certifies the suitability of the site for one or more land uses.

This Site Audit has been carried out by Bill Ryall who is a Site Auditor accredited by the NSW Environment Protection Authority (Accreditation No. 9809) and who is an employee of HLA-Envirosciences Pty Ltd (HLA ENSR).

The investigation of the environmental condition of a site and any remediation that is required are carried out by the environmental consultant by reference to guidelines endorsed by the NSW DECC and if the reports prepared by the consultant are in substantial conformance with the guidelines the Site Auditor is entitled to accept the results and conclusions stated therein and to complete the Site Audit Report and to issue a Site Audit Statement and/or to form other opinions based on the results and conclusions stated in the report/s by an environmental consultant.

The Site Auditor does not normally carry out independent sampling or chemical analyses of soil, fill, groundwater or other media on the subject site, but relies on the testing and reporting that has been carried out by the environmental consultant if it has been demonstrated to be of adequate reliability by reference to quality indicators listed in the guidelines endorsed by NSW DECC.

It is expressly recognised that, even when a qualified and experienced environmental consulting firm has substantially followed guidelines endorsed by the NSW DECC, unidentified contamination or sub-surface structures may remain present and that the processes of investigation, remediation and validation are statistically based and that no liability is accepted by the Site Auditor for unidentified contamination or sub-surface structures subsequently found to be present on a site which has been subjected to investigation, remediation and validation processes that are in substantial conformance to guidelines endorsed by the NSW DECC. The audit has not assessed the suitability of any material for disposal from the Site or the geotechnical or engineering suitability of the Site or the use of groundwater for any beneficial purpose.

3 SITE INFORMATION

3.1 Site identification

The Site is located approximately 3km south west of Sydney's central business district, off Burren Street, Erskineville and is identified in the Report as being Part Lot 50 in Deposited Plan 1001467. The Site is zoned Special Uses (Railway) under the City of Sydney Local Environment Plan (LEP) and is owned by Railcorp.

The Report stated that the Site has an area of 7732 m^2 and is triangular in shape, as shown on Figure 2 (Attachment 1).

Auditor's opinion
It is the Auditor's opinion that the Report adequately identified the boundaries of the Site.

3.2 Surrounding land use

The Report stated that the Site is surrounded by the following land uses:

- North – Railcorp-owned land being developed for rail carriage stabling and cleaning operations;
- South – Railcorp-owned land used as railway corridor for the suburban rail network;
- East – Railcorp-owned land used as railway corridor and for suburban rail network; and
- West – Residential properties.

Auditor's opinion
It is the Auditor's opinion that the Report adequately identified the land use surrounding the Site. However, the Auditor considers that the Report should have also provided detail on any relevant local sensitive environments and/or receptors and also provided some discussion on the potential for the surrounding land uses to contain contaminating activities that may have impacted on the Site.

3.3 Site description

The Report provided a description of the Site, based on it's previous use as a gasworks, and the current condition of the Site. The Report stated that the Site previously contained two gasholders, present on the western portion, and that the north-eastern and central portions contained a retort house, tar wells, condensers, coal and shale storage areas and other building structures associated with the operations of the gasworks.

The Report stated that the Site contained remnant structures of the former gasworks, as follows:

- Southern gasholder was stated to be intact with the annulus structure present underground and the structural framework in place approximately 12 metres above the ground surface. The above-ground framework of the northern gasholder was stated to be no longer present, however, the annulus structure remained present underground. Brickwork associated with the northern gasholder was also noted to be present at ground level;
- Two in-ground tar wells covered with concrete circular lids, were noted to be present in the north eastern corner of the Site;

- Various pipework, brick foundations and concrete slabs remained present through the central and north-eastern portions in the vicinity of the former retort house, gas purifier shed, scrubbers and gas meters.

The Report also described the presence of a retaining wall along the northern boundary, a small shed in the south western area and a concrete service trench located along the western boundary. The remainder of the Site was described as being vacant with gravels present on the surface in the central areas of the Site and grasses, trees and shrubs present along the fence lines to the south and west. The Report also noted the presence of minor stockpiles of ballast materials, car tyres and decaying vegetation.

Auditor's opinion

It is the Auditor's opinion that the Report provided an adequate description of the structures known to be present on the Site and of the general layout and condition of the Site at the time the investigation was undertaken. In addition, given the historical operation of the gasworks and the complexity of the structures identified on the Site, the Auditor considers it likely that further remnant gasworks structures may be present buried beneath the surface of the Site. It is expected that, these structures would be exposed and, dependant on their historical significance, removed during the remedial works described in later sections of this SAR.

3.4 Site history

The Report provided a summary of information collated from previous investigations conducted on the Site. The historical information relating to the Site as presented in the Report is summarised as follows:

- Site was acquired in 1888 by the Commissioner for Railways;
- Site operated as a Manufactured Gas Plant (MGP) between 1892 and 1958;
- Operation of the MGP included raw product storage, gas production, waste disposal, filling and storage of liquor wastes;
- Facilities and buildings present on the Site during the operation of the MGP included a retort house, an exhauster, a boiler, condensers, purifier beds, a scrubber, two tar wells, above ground tar tanks, a gas meter, two gasholders, service pipework, raw store areas, compressors and other buildings including offices and washrooms. A railway corridor consisting of three rail lines ran along the south-eastern boundary of the Site and a single rail line ran along the northern boundary of the Site. The historical layout of these facilities is presented on Figure 2 (Attachment 1);
- The MGP consisted of two sperate but parallel works for coal and shale processing with the gas produced from the coal processing stored in the larger southern gasholder (capacity of approximately 3000m^3) while gas produced from the shale processing was stored in the smaller capacity northern gasholder (capacity of approximately 1500 m^3);
- The use of inferior quality coal during the 1950's caused damage to the MGP machinery and as a consequence operations ceased;
- Demolition of the MGP is reported to have commenced in 1958. The review of the aerial photographs indicated that little change appeared to have occurred to the structures at the Site between 1951 and 1961, but in the 1970 photo the majority of the MGP buildings appeared to have been demolished, with the southern gasholder appearing as the only remaining above-ground structure; and

- The southern gasholder is listed on the State Heritage Register and the Sydney Region Environment Plan 26 (SREP 26) as part of the area known as the Eveleigh Railway Workshops. Previous archaeological assessments conducted at the Site did not identify any other items of heritage significance.

Auditor's opinion
It is the Auditor's opinion that the Report provided an adequate summary of the historical use of the Site, the operation of the gasworks and the products produced as a result of the manufacturing processes conducted. The Auditor also considered it useful that the Report identified the items of archaeological significance that were present on the Site.

3.5 Topography and drainage

The Report stated that the Site was generally flat with a gentle grade sloping towards the southeast. The Site was noted to have an embankment which sloped steeply downwards along the western boundary that adjoins the residential properties, particularly in the southern corner where a surface level difference from the top of the embankment to the base of the embankment level which was noted to be at a similar elevation to the rear backyards of the residential properties of approximately 4 metres.

The surface of the Railcorp property located directly to the north of the Site is situated approximately 2 metres above the surface level of the Site due to the presence of a retaining wall and embankment along the northern boundary of the Site.

The Report stated that surface water present on the Site was likely to drain in the direction of the fall of the Site, with the concrete-lined open drain that runs along the western boundary, at the same level as the rear of the residential properties, likely to receive minor surface water flows from the western side of the embankment.

Auditor's opinion
It is the Auditor's opinion that the Report presented a satisfactory understanding of the topography and drainage of the Site for the purposes of the investigation.

3.6 Geology and hydrogeology

The Report stated that the Site is underlain by the Wianamatta Group Ashfield Shale comprising black to dark grey shales and laminate. The Report noted that during previous investigations conducted on the Site shale bedrock was encountered at depths between 7-10 metres below ground surface (mbgs). The shale bedrock is overlain with residual soils and fill materials.

The Report stated that previous investigations conducted on the Site identified the presence of a shallow and a deep groundwater system. The shallow system was stated to be present in the fill materials which overlay the natural residual clay profile and the deeper system was stated to be present in the shale bedrock at approximately 9.5 mbgs under semi-confined conditions. The hydraulic conductivities of the two systems were stated to be highly variable and the hydraulic connection between the shallow and deeper aquifers was stated to be limited. However, the Report also noted that groundwater recharge to the deeper regional aquifer was via infiltration, primarily through residual structural features such as joints and fractures and bedding planes from the fresh bedrock into the overlying weathered rock and soil profile.

The groundwater flow was stated to have been previously determined to be toward the south to southeast for both the shallow and deep aquifers although the Report noted that this flow

direction may be impacted locally due to the presence of underground structures such as the gasholders and tar wells.

Concentrations of polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, xylenes (BTEX), metals and phenols greater than the ANZECC (2000) guidelines were stated to have been detected in both groundwater systems during previous investigations. Despite concentrations of light fraction TPH being noted at greater than the solubility limits at some locations on the Site, previous investigations have not identified the presence of either light non aqueous phase liquids (LNAPLs) or dense non aqueous phase liquids (DNAPLs). It was stated that previous investigations concluded that the contaminated groundwater plumes have migrated from the Site but are limited to surrounding land owned by Railcorp.

Auditor's opinion

It is the Auditor's opinion that the Report presented a satisfactory understanding of the geology and hydrogeology of the Site for the purposes of the investigation.

The Auditor also notes that, given the objectives of the investigation and the results of previous investigations, an assessment of groundwater as part of CH2MHILL's investigation was not considered to be necessary as sufficient information was available regarding groundwater conditions on the Site and on the Railcorp properties. The Auditor understands that the groundwater conditions present beneath the Site and the remedial approach and management options for the groundwater will be addressed within the RAP.

4 QUALITY ASSURANCE/QUALITY CONTROL

4.1 Data Quality Objectives

The Report presented the Data Quality Objectives (DQOs) which were developed to assess the reliability of the results of the investigation program and to ensure they were appropriate to allow remedial options to be developed.

In accordance with NSW DEC (2006), the DQOs adopted by CH2MHILL for the investigation program followed the seven-step iterative DQO process, as follows:

Step 1 State the problem: This step identified the issues which the investigation program was designed to address as follows:

1 "Insufficient information was available to estimate the depth and lateral extent of contaminated fill and natural soils;

2 Insufficient information was available on the contamination characteristics and leachability of the different soil/fill types identified on the Site;

3 Insufficient information was available to allow an assessment of potentially suitable and technically feasible remediation strategies that may be appropriate for contaminated materials at the Site, and to enable development of a Remedial Action Plan."

Step 2 Identify the decisions: The decisions to be made based on the results of the investigation program were stated as follows:

1 "Is there sufficient information on the distribution and characteristics o soil and fill requiring remediation and/or management to allow remedial planning to progress?

2 Do the findings of the investigation provide a higher level of understanding and certainty on contamination source zones and spatial areas?

3 Do the findings of the investigation provide sufficient data that will enable an assessment of remedial screening options for contaminated soils and fills requiring management?

4 Is there sufficient and definitive Site data to enable remedial cost estimates to be developed?"

Step 3 Identify inputs to the decisions: The inputs into the decisions to be made were stated to include the following:

- "Geological data and information relevant to subsurface structures;
- Existing hydrogeological data:
- Concentrations of chemicals in different fill/soil types;
- Observation data for free product, staining, odours and discolouration of the soil media;
- Distribution of impacts both lateral and vertical;
- Contamination impacts below permanent structures, including the Heritage listed Gasholder."

Step 4 Define the study boundaries: The Report divided the study boundaries into spatial and temporal. The spatial boundaries were defined by stating the area of the Site as 7732m^2 and providing the Site description as being Part Lot 50 in DP1001467. The Report stated that the Site had also been divided into "Stratified areas" based on historical activities and the presence of significant sources of contamination. The temporal boundaries were defined by using data from previous investigations between 2000 and 2006.

The Report also described constraints within the study boundaries which included the location of underground services and the presence of items and potential items of archaeological significance, particularly in and around the southern gasholder and former retort house.

Step 5 Develop a Decision Rule: The Report stated two decision rules as follows:

1 "If a review of the data obtained from this and previous investigations indicate a degree of uncertainty on contamination delineation and distribution, then appropriate remedial strategies will be considered to provide management of those uncertainties and limitations;

2 If it is determined that additional information is required to further reduce the uncertainties associated with the distribution and characteristics of soil and fill requiring remediation and/or management, then appropriate recommendations for further technical assessment or investigation will be provided".

Step 6 Specification of the acceptable limits on decision errors: The Report stated that the acceptable error limits were defined by the DQI's of precision, accuracy, representativeness, comparability and completeness. The DQI's for the sampling program were presented in Appendix B of the Report. The Report further stated that decision errors were minimised by completing a "robust QA/QC program" and by completing an investigation that had a "high sampling and analytical density".

Step 7 Optimisation of the design of the collection of data: The Report stated that the previous steps were considered during the design of the investigation program and that this process was further detailed in the scope of work and fieldwork methodology sections of the Report.

Auditor's opinion
The Auditor considers that the DQO process adopted was appropriate given the presence of significant contamination on the Site and was completed in accordance with the requirements set out in NSW DEC (2006) and was appropriate for the purpose of the investigation and to allow remedial options to be developed.

4.2 Field quality control

4.2.1 QA/QC Samples

The assessment of the field QA/QC conducted for the investigation was presented in Appendix B of the Report. Table 1 of Appendix B presented the Data Quality Indicators (DQI's) applied for the field investigation.

The Report stated that the following QA/QC procedures were employed for the sampling conducted during the investigation:

- Use of experienced personnel for the collection of samples;
- Appropriate methodology for the collection and handling of soil samples;

- Preparation and analysis of field inter-laboratory and intra-laboratory duplicate samples;
- Collection and analysis of rinsate blanks during sampling;
- Analysis of laboratory supplied trip blank (water) and trip spike (soil) samples during soil sampling;
- Analysis of laboratory supplied trip blank (water) and trip spike (water) samples during surface water sampling;
- Appropriate documentation; and
- Use of NATA certified laboratories employing appropriate methods to analyse the field samples and LORs appropriate for comparison with assessment criteria.

Intra-laboratory and Inter-laboratory Duplicates

Table 1, below, presents the frequency of field inter-laboratory and intra-laboratory duplicate samples stated in the Report.

Table 1: Frequency of Field Duplicates

Sampling Program	Number of primary samples reported	QA/QC Samples reported
Soil Sampling	136	14 intra-laboratory duplicates, 3 inter-laboratory duplicates
Surface water and groundwater sampling	6	1 intra-laboratory duplicate
Total	142	15 field intra-laboratory duplicates & 4 field inter-laboratory duplicates

It was stated that the frequency of duplicate intra-laboratory duplicate and inter-laboratory duplicate analysis met the requirements specified in the DQIs of 1 in 20 samples in accordance with NEPM (1999).

The Report stated that the results of the Relative Percentage Differences (RPDs) calculations were generally within acceptable limits, with the exception of two primary and duplicate pairs collected from surface fill materials and two primary and duplicate pairs collected from natural clays.

The Report stated that the elevated RPDs were as follows:

- MG05/0.5 and its duplicate pair (Fill material) – Cr, Pb, Ni and TPH (C_{15}-C_{28}) had RPDs which ranged from 56% to 167%;
- TP08/1.0 and its duplicate pair (Fill material) – Cr had an RPD of 97%;
- TP08/2.0 and its duplicate pair (Natural clays) – Cr had an RPD of 59%
- TP15/2.8 and its duplicate pair (Natural clays) – TPH (C_{15}-C_{28}) had an RPD of 91%

The elevated RPDs within the fill materials were stated to be due to the variable and heterogenous nature of the fill materials and as such the exceedances were considered to a reflection of the variability of the concentrations of the contaminants in the material sampled. The Report stated for the samples of the natural clays in which elevated RPDs were calculated,

the concentrations of the analytes in the duplicate samples were "within an order of magnitude of the parent samples".

The Report stated that the RPD exceedances would not affect the "overall precision of the data".

Auditor's opinion
The Auditor notes that the discussion of the RPD exceedances provided in the Report identified the primary samples but the duplicate samples were not identified. In addition, while the Auditor notes that the borelogs presented in Appendix C of the Report identified five of the primary and duplicate sample pairs, the Report did not identify the remainder of the pairs of primary samples and their corresponding duplicate samples. The Report also did not present the results of the RPDs which were stated to have been calculated between all the pairs of primary and duplicate samples.

The consequence of the above is that the Auditor cannot comment on the discussion of the RPD's provided in the Report and cannot conduct an independent review of the RPDs derived from the analysis of the primary and duplicate samples pairs. However, a limited review of the RPDs for the pairs of primary and duplicate samples identified on the borelogs indicated the RPDs met the DQIs set for the investigation.

However, given the omission of the identification of the remaining pairs of primary and duplicate samples, the Auditor cannot comment on the whether the fieldwork undertaken across the whole Site met the DQIs set for the investigation.

Rinsate Blanks

The Report stated that soil samples were collected from the excavator bucket and from push tube rods at each location and were removed by hand using new set of disposable nitrile gloves. The Report stated that each day, after decontamination, a rinsate blank was collected from the push tube, but that no rinsate blanks were collected from the excavator bucket.

Auditor's opinion
In Table 1 of Appendix B rinsate blanks were stated to have been included as one of the DQI's for the investigation and as summarised above, the Report stated that they were collected during drilling. However, the Auditor notes that neither in Appendix B nor in the main body of the Report were the rinsate blank sample identifications stated nor were their results presented or discussed. The consequence of this is that the Auditor cannot comment on whether rinsate blanks were collected, submitted and analysed by the laboratory nor can the Auditor comment on the results of the rinsate blanks.

Trip Blanks and Trip Spikes

Laboratory-prepared trip blanks and trip spikes were used by CH2MHILL during the soil sampling. The Report stated that the concentrations reported for all trip blanks were less than the laboratory detection limits and that the results for the trip spikes were within the control limits with the exception of one trip spike in which the RPDs for benzene (64.5%) and TPH (C6-C9) (60.4%) were slightly elevated above the DQI limit of 50%.

Auditor's opinion
The Auditor notes that the Report did not identify the number or frequency of the trip blank and trip spike samples used during the sampling program. The Auditor also notes that examination of the final analytical laboratory reports provided in Appendix G of the Report indicated that the trip blanks and trip spikes were clearly labelled as "Trip Blank" or "Trip Spike". Given that these

types of QA/QC samples are employed as one of the methods used to measure the precision and accuracy of the field and laboratory methodologies, the Auditor considers that it is best practice to label these samples as to ensure that their purpose cannot be identified by the laboratory.

4.2.2 Decontamination

The Reports stated that soil samples were collected from the excavator bucket and from push tube rods at each location and were removed by hand using new set of disposable nitrile gloves and that between each sampling location the excavator bucket and push tube rods were washed with a high pressure hose to remove soil material. During the use of a drill rig, the Report stated that the push tube rod was decontaminated at the end of each day by scrubbing in a solution of Decon 90 and tap water and then rinsed using tap water. The Report stated that each day, after decontamination, a rinsate blank was collected from the push tube. It was stated that no rinsate blanks were collected from the excavator bucket.

The Report stated that surface water samples were collected either via disposable Teflon bailers, foot valves or were collected directly into laboratory supplied bottles. Decontamination was stated to have been unnecessary as a new set of disposable nitrile gloves was used at each sampling location.

Auditor's opinion
As stated above, the Report did not identify the rinsate blank samples and did not discuss nor present the analytical results of any rinsate blank samples. The consequence of this is the Auditor cannot comment on the decontamination procedures employed by CH2MHILL during the use of re-useable sampling equipment. However, the Auditor considers that the sampling methodology employed for the soil sampling conducted from the excavator bucket and the surface water sampling was appropriate and did not require decontamination procedures to have been adopted.

4.2.3 Documentation and handling

The Reports stated that the following documentation was produced during the subsurface investigations;

- Visual observations, soil classification and PID readings were recorded on the borelogs presented in Appendix C of the Report; and
- Chain of Custody (COC) documentation recorded sample identifications, name of sampler, type of sample, collection time and date, analyses to be conducted and sample preservation methods.

Auditor's opinion
Review of the COCs and laboratory sample receipt advice forms indicated that the forms were complete and confirmed that the samples were received by the laboratories chilled and intact.

Dates of receipt and completion of chemical analyses were reported by each laboratory, as noted below. Inspection of the laboratory reports sheets indicated that samples were analysed within holding times appropriate for each analyte.

It is the Auditor's opinion that an adequate number of samples were analysed for the purposes of the investigation.

4.3 Laboratory quality control

Analyses for the investigation was performed by ALS Environmental Laboratories Pty Ltd (ALS), Labmark Pty Ltd (Labmark) and AgriQuality Limited (AgriQuality) (PCDDs and PCDFs only). The internal quality control programs employed by the laboratories comprised:

- Method blanks;
- Laboratory duplicates;
- Laboratory control samples;
- Matrix spike recoveries;
- Surrogate recoveries (for organic compounds only);
- Limits of reporting; and
- Extraction and analysis dates.

The assessment of the laboratory quality control as reported by the laboratories and summarised in the Report is as follows:

- All analyses were undertaken using methods registered by NATA;
- All analyses conformed to USEPA or APHA methods as required by NEPC (1999);
- The limits of reporting (LORs) were suitable for the investigation
- Concentrations of analytes in laboratory method blanks were below the laboratory detection limits;
- Results for laboratory control sample recoveries were generally within the control limits for all analytes with the exception of a three control sample recoveries which were for three organic compounds which were just outside the recovery limits. Given the closeness to the stated recovery limits these cases were not considered not to affect the useability of the data;
- The RPDs for laboratory duplicate samples were generally within the control limits for all analytes with the exception of a three laboratory duplicates which had RPDs that were just above the DQIs limits. The RPD exceedances in these cases was considered not to affect the useability of the data; and
- Surrogate and matrix spike recoveries were generally within the control limits for applicable analytes with the exception of matrix spike recoveries in ten pesticide compounds within one batch which were had recoveries less than the lower limits. These lower recoveries for these compounds were not considered to affect the overall accuracy of the data

Analyses for asbestos was stated to have been undertaken by ASET Laboratories Pty Ltd (ASET) who are registered by NATA for the testing for the presence of asbestos fibres.

Auditor's opinion
Following an independent review of the laboratory data reports provided, it is the Auditor's opinion that the QA/QC programs reported by the laboratories were adequate for the purposes of the investigation program.

4.4 Analytical evaluation and data reliability

The Reports provided an assessment of the results of the field and laboratory quality assurance and quality control measures adopted during the works and stated that "Although there were some minor non-conformances, the majority of the PARCC parameters were within the specified DQIs and overall the data is considered to be of sufficient quality to meet the objectives of the program".

Auditor's opinion

As part of this Audit, the quality control meaures adopted by CH2MHILL were compared to relevant guidelines as summarised in the following table.

Table 2: Data Validation Assessment

Item	Objective	Reference	Summary of Results	Compliance
Comparison of field and analytical measurements	Agreement between visual and laboratory results	NA	Visual observations and field screening results generally consistent with analytical data.	Yes
Calibration of field instruments	Meet calibration specifications	AS4482	CH2MHILL supplied calibration details for the PID	Yes
Verification of field procedures	Comply with NEPM	NEPM	General compliance for soil and surface water	Yes
Analysis of 20% field duplicate samples	Less than 30% for inorganic and 50% for organic analyses > analyte conc. 10 x PQL	AS4482/ NEPM	RPDs that were able to be assessed by the Auditor were within the control limits. Identification of pairs of primary and duplicate samples not provided. RPD results not tabulated nor provided in other format. Based on review of Laboratory Reports Auditor considers frequency of inter/intra laboratory duplicates met requirements	Partial Compliance
Chain of Custody Documentation	Completed	NEPM	Completed and signed.	Yes
Sample Analysis and extraction/ holding times	Comply with Table 4 in reference	AS4482	All within guidelines.	Yes

Item	Objective	Reference	Summary of Results	Compliance
Use of NATA certified laboratories	Analytical methods were NATA accredited	NEPM	ALS was used as the primary analytical laboratory. Labmark were employed as the check laboratory. ASET were the laboratory employed for asbestos. AgriQualty were the laboratory employed for PCDDs and PCDFs.	Yes
Limits of Reporting - sensitivity	Less than the Site Acceptance criteria	NEPM, Auditor Guidelines	Acceptable	Yes
Analysis of field blanks, including trip and equipment blanks	No contamination on blanks	NEPM, Auditor Guidelines	Concentrations of chemicals of concern were reported at less than the laboratory LOR for trip blanks. No information provided on the identification or analytical results of rinsate blanks.	Partial Compliance
Analysis of laboratory method blanks	No contamination on blanks	NEPM, Auditor Guidelines	Satisfactory – Appendix G.	Yes
Analysis of laboratory control samples and spike recoveries	Recoveries 70-130% or as specified by laboratory	NEPM, Auditor Guidelines	Satisfactory – Appendix B.	Yes
Analysis of laboratory duplicates	RPDS within $\pm$ 20%	NEPM, Auditor Guidelines	Satisfactory – Appendix B.	Yes
Analysis of surrogates for volatile compounds	As specified by laboratory	NEPM, Auditor Guidelines	Satisfactory – Appendix B.	Yes

It is the Auditor's opinion that the assessment of the precision, accuracy, representativeness, comparability and completeness of the data as indicated by field QA/QC has been compromised due to the following factors:

- The omission of information relating to the identification of all the primary samples and their corresponding field duplicate pairs;
- The omission of the RPD results for all corresponding primary and field duplicate pairs;
- The omission of information relating to the identification of rinsate blank samples and their corresponding results; and
- The omission of information relating to the number or frequency of the trip blanks and trip spike samples used during the sampling program and the inappropriate labelling of trip blanks and trip spikes.

The Auditor considers that the above omissions from the Report affects the Auditor's ability to complete an independent review and assessment of the field QA/QC program and as such this affects the reliance that can be placed by the Auditor on the results of the subsurface investigation.

However, given the presence of high concentrations of contamination on the Site and that large scale remedial activities will be required to be undertaken on the Site, based on the information provided, it is the Auditor's opinion that the omissions identified within the field QA/QC assessment section of the Report, do not reduce the quality and reliability of the data such that it cannot be used for the purposes of the Site investigation program and to allow remedial options to be developed.

In addition, the Auditor requires that detail of the QA/QC program to be applied and reported on during the remediation and validation be included in the RAP so that the Auditor can be confident that the QA/QC measures adopted for both the field and laboratory programs will be sufficiently rigorous to conclude that the results reported for any validation samples can be assessed in terms of the DQIs listed in NSW DEC (2006).

"This page has been left blank intentionally"

5 INVESTIGATION PROGRAM

5.1 Objectives of the investigation program

The Report stated that the objectives of the investigation were to "fill in data gaps and characterise the Site sufficiently to:

- Determine areas, volumes, types of contaminants requiring remediation to meet RailCorp's long term objectives;
- Screen available remedial options and recommend appropriate options to allow long term land use objectives to be met; and
- Provide indicative remedial cost estimates to implement an appropriate remedial strategy, to be provided in a separate letter to this investigation report".

Auditor's opinion
The Auditor considers the objectives to be appropriate, but notes that this SAR addresses the information presented in the Report only and that it is not part of the scope of the Audit to review or comment upon remedial cost estimates provided by CH2MHILL to Railcorp.

5.2 Scope of work

The Report stated that the scope of work completed by CH2MHILL for the investigation was conducted over a number of stages as follows:

- Existing data review – Initial site visits, review of results of previous investigations and tender documentation provided by Railcorp;
- Preliminary site conceptual model – Based on results of the existing data review a preliminary site conceptual model was developed which was stated to have focused on the identification of data gaps;
- Sampling, Analysis and Quality Plan (SAQP) – The SAQP was stated to have been developed based on the information from the data review and the preliminary site conceptual model. The Report also stated that consultation with the Auditor was also undertaken during the finalisation of the SAQP;
- Pre-Site works plan – Site specific Occupational Health and Safety(OH&S) Plans were stated to have been developed prior to the commencement of fieldwork;
- Soil investigation program – The soil investigation program was stated to have been undertaken in two stages. In the first stage, undertaken in August 2006, 32 trenches and test pits were excavated. Based on the results of the first stage of works, the Report stated that further investigations were considered necessary to reduce the level of uncertainty on the extent of the impacted areas. Subsequently, a second stage of works was undertaken in October 2006 in which 16 boreholes were drilled. Soil samples were collected during both stages and submitted to a laboratory for analysis for the chemicals of concern. The adopted analytical program is discussed in further detail in Section 5.9 of this SAR;
- Surface water investigation program – The surface water investigation program was stated to have been conducted to assess the quality of water that had accumulated inside existing structures on the Site. The Report stated that six water samples were collected from the gasholders, tar wells

and the retention pit and were submitted to a laboratory for analysis for the chemicals of concern, as discussed in further detail in Section 5.9 of this SAR;

- Reporting – The results of the investigation program were stated to have been documented in the Report. The Report was stated to have provided information required to develop "conclusive statements and recommendations" for the Site.

Auditor's opinion

The Auditor considers that the scope of work presented in the Report should have included the work completed by CH2MHILL in determining the remedial volume estimates and the screening of remedial options for the Site. However, the Auditor notes that these matters were addressed within the objectives of the investigation program. As such, the Auditor considers that the objectives and scope of work presented in the Report were appropriate given Railcorp's long-term objectives for the Site.

5.3 Existing data review

As stated in the scope of work, the first component of the investigation program undertaken by CH2MHILL was to conduct an initial site visit and to complete a review of existing data from previous investigations conducted on the Site and from tender documentation provided by Railcorp.

The Report provided a summary of the previous contamination and/or archaeological and heritage investigations conducted on the Site between 1999 and 2006 as follows:

- Everleigh Gasworks – Site History, Rail Services Australia, November 1999;
- Phase I and II Environmental Site Assessments, CH2MHILL, June 2000;
- Vegetable, soil and sediment sampling – Letter Report, CH2MHILL, November 2000;
- Soil and Groundwater Investigations of the Former Gasworks Area and Offsite, CH2MHILL, December 2001;
- A Brief History of NSW Railway Gasworks, Australian Railway Historical Society, June 2003;
- Macdonaldtown Station Works – Archaeological Assessment, Banksia Heritage & Archaeology, April 2004;
- Macdonaldtown Triangle (Former Cleaning Sheds) – Delineation and Classification Sampling, GHD, September 2005;
- Macdonaldtown Triangle (Former Gasworks Site) – Human Health and Ecological Risk Assessment, SKM April 2006; and
- Archaeological Assessment and Remediation Management Strategy, Heritage Concepts, November 2006.

As part of the data review, the Report provided a summary of the analytical soil results from the previous investigations in which subsurface investigation, sampling and laboratory analysis had been undertaken. The summary of the previous analytical results were presented in Table 11 and 12 of the Report.

CH2MHILL also undertook an assessment of the reliability of the analytical results presented in the previous investigations. The results of this assessment were stated to have identified minor discrepancies within the QA/QC of the previous investigations including inadequate

documentation of sampling procedures and some field duplicate RPD results not meeting the adopted DQIs, however, the Report stated that 'the data as a whole is considered to be reliable and useable'. The results of the assessment of the previous analytical data sets was presented in Appendix B of the Report.

The Report stated that the results of the data review were compiled into a preliminary conceptual site model which was presented in Appendix D of the Report

Auditor's opinion
The Auditor considers that the summary of the previous investigations completed by CH2MHILL was comprehensive and provided the information necessary to develop an appropriate preliminary conceptual site model for the Site and to identify the data gaps that needed to be addressed within the scope of work for the subsurface investigation on the Site. With respect to the assessment of the quality of the previous analytical data sets, the Auditor agrees that while reliance can be placed on the previous data sets, it is considered that because of the heterogeneity of the identified contamination and the presence of uncontrolled filling on the Site this data should be utilised only for qualitative purposes in determining the volumes requiring remediation.

5.4 Chemicals of concern

Based on the historical use of the Site and the results of the review of the existing data and previous investigations, the Report listed the chemicals of concern on the Site as follows:

- Metals: (Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Lead (Pb), nickel (Ni), zinc (Zn);
- Total Petroleum Hydrocarbons (TPHs);
- Benzene, Ethylbenzene, Toluene and Xylenes (BTEX);
- Polycyclic aromatic hydrocarbons (PAHs);
- Organochlorine Pesticides (OCPs);
- Organophosphorus Pesticides (OPPs);
- Phenolic Compounds (Phenols);
- Cyanides (totals);
- Polychlorinated Biphenyls (PCBs);
- Polychlorinated Dioxins/Polychlorinated Furans (PCDD/F); and
- Asbestos.

Auditor's opinion
The Auditor notes that PCDDs and PCDFs are not listed as chemicals of potential concern in the NSW EPA (2003) *Draft Guidelines for the Assessment of Former Gasworks Sites* or in Turczynowicz (1993) *The Assessment and Management of Gasworks Site*s published by NEHF (Contaminated Site Monograph No 2, pages 261-312). However, the Auditor acknowledges that there is a growing body of literature that shows these compounds are formed during the pyrolisation of coal and are found in gasworks waste, but the levels appear to be low. The Auditor also notes that oil shale have been found to contain low levels of naturally occurring dioxins and furans and it can be expected that residues would contain some detectable levels of these compounds.

It is the Auditor's opinion that the chemicals of concern listed in the Report were appropriate given the history and the results of previous assessments on the Site.

5.5 Areas of concern

Based on the identified chemicals of concern, the previous results and the layout of the gasworks structures on the Site, the Report divided the Site into sub-areas or areas of concern and listed the corresponding chemicals of concern that would be targeted in those sub-areas during the investigation. The identified sub-areas and chemicals of concern presented in the Report were shown on Figure 3 (Attachment 1)and are summarised as follows:

- Gasholders – TPH, PAHs, Phenolics;
- Retort – TPH, BTEX, PAH, Phenolics, PCDD/F;
- Gas Purifiers – TPH, BTEX, PAH, Phenolics, Metals, Cyanides;
- Northeast area of the Site – TPH, BTEX, PAH, Metals;
- South Central area of the Site – TPH, BTEX, PAH, Metals;
- Southwest area of the Site – TPH, BTEX, PAH, Metals;
- Retaining wall – TPH, BTEX, PAH, Metals;
- Western lot – TPH, BTEX, PAH, Phenolics, Metals, Cyanides; and
- General fill and surfaces – TPH, BTEX, PAH, Phenolics, Metals, Cyanides, OCP, OPP, PCB, Asbestos.

Auditor's opinion
The Auditor considers that the division of the Site into sub-areas based on the historical activities and previously identified contamination was appropriate for the purposes of the investigation. It is the Auditor's opinion that the sub-areas and corresponding targeted chemicals of concern as listed in the Report were appropriate given the history and the results of previous assessments on the Site.

The Auditor notes that on Figure 3 of the Report a typographical error in the Key indicated that the area shaded yellow was defined as the Northwest area when it should have been the Northeast area.`

5.6 Site investigation criteria

The Report provided details of the soil and water criteria that were applied during the investigation program and are summarised below.

5.6.1 Soil criteria

The Report stated that the proposed future rail-related use of the Site was consistent with commercial/industrial land use as defined in the NSW DEC (2006) guidelines. As such the commercial/industrial land use criteria as listed in Column 4 of the NSW DEC (2006) guidelines were adopted as the soil investigation criteria for metals, PAHs, OCPs, OPPs, Phenols, Cyanide and PCBS at the Site. The Report also stated that given the proposed land use, phototoxicity was not required to be considered.

With respect to concentrations of TPH and BTEX in soil, the Report stated that whilst the NSW EPA (1994) guidelines were developed for sensitive land use such as residential, however, given that these are the only currently NSW DECC endorsed criteria, these guidelines were adopted as the soil investigation criteria for TPH and BTEX at the Site.

The Report stated that there are no published criteria for PCDD/Fs in NSW. Given that the inclusion of PCDD/Fs in the analytical program was primarily to determine remedial options

available to manage these types of contaminants if they persist at the Site, rather than assess their potential risk to human health or the environment, the Report stated that the preliminary remediation goal (PRG) from the USEPA Approach for Addressing Dioxin in soil at CERCLA and RCRA Sites, 1998 was adopted, for the purposes of comparison, as the soil investigation criteria for PCDD/Fs at the Site.

The adopted soil investigation criteria for asbestos on the Site was presented in Table 6.2 of the Report as "no detection of fibres in the surface soils" and "no visible fragments in the surface soils". The Report referenced the Australian Contaminated Land Consultants Association, Asbestos in Soils – Code of Practice, 2002 Tier 1 HIL guideline where no detection refers to 95% probability that there are no fibres in surface soils (less than 5 fibres detected).

The Report also stated that the statistical methodology applied during the investigation for the comparison of soil analytical results to the adopted soil investigation criteria was based on the methods referred in the NSW EPA (1995) and NEPM (1999) including the use of the 95% upper confidence limit of the arithmetic mean of the concentrations of chemicals of concern, the identification of "hotspots" which are classified as containing concentrations greater than 250% of the criteria and the calculation of standard deviations to a value of 50% of the criteria.

Auditor's opinion
The Auditor considers that the soil investigation criteria adopted by CH2MHILL for the investigation program were suitable given the proposed commercial/industrial land use. The Auditor also considers that the statistical analysis described in the Report, are appropriate only when applied to a set of soil analytical results that are from a similar lithology or strata on the Site. The Auditor notes that this section of the Report did not detail how the statistical analysis would be applied, however, this was addressed in later sections of the Report.

The Auditor also notes that NSW DEC (2006) provides general guidance relating to asbestos in soil and that the criteria presented in the Australian Contaminated Land Consultants Association, Asbestos in Soils – Code of Practice, 2002 has not been endorsed by NSW DECC. However, the adoption of the "no detection of fibres in the surface soils" and "no visible fragments in the surface soils" criteria is accepted by the Auditor, as a conservative measure, for the investigation program.

5.6.2 Water criteria

The Report stated that the results of the surface water samples collected would be compared to investigation criteria derived from the ANZECC (2000) guidelines. Alexandra Canal was identified as the nearest receptor of surface water and potentially of groundwater from the Site and it was stated that as this system was not under tidal influence that it would be a freshwater environment. Based on this premise, the ANZECC (2000) high reliability trigger values for a Slightly – Moderately Disturbed system were adopted as the water investigation criteria for selected Metals, Benzene, Xylenes, PAHs, Phenol, Cyanide and selected OCPs and OPPs at the Site. With respect to TPH, the Report stated that the laboratory Limit of Reporting (LOR) for TPH of 100 µg/L would be applied as "an initial screen to evaluate the protection of environmental values at the Site".

Auditor's opinion
The Auditor agrees with the application of the ANZECC (2000) guidelines for the assessment of surface water at the Site as presented in the Report and agrees with the approach presented for assessing TPH concentrations.

5.7 Sampling program

The sampling program conducted on the Site involved the soil investigation program and the surface water investigation program. The details as presented in the Report are summarised below.

5.7.1 Soil investigation program

The Report stated that the soil investigation was conducted in two stages, as described in Section 5.2 of this SAR. The Report stated that the adopted sampling strategy was a combination of stratified sampling which involved the division of the Site into sub-areas and then judgemental sampling within each sub-area in which the location of sampling points were selected based on the results of previous investigations and historical uses of each of the sub-areas. The sub-areas were stated to be the Gasholders, Retort, Gas Purifier, Northeast area, South Central area, Southwest area, Retaining wall and the Western Lot. These sub-areas were shown on Figure 3 (Attachment 1).

The Report stated that the location of the sampling points were determined based on satisfying the requirements of the DQOs and access restrictions on the Site such as the location of underground services.

During the first stage of the investigation, 32 trenches and testpits were excavated across the Site. The Report stated that this approach provided a greater understanding of the subsurface conditions and during the second stage of the investigation, 16 boreholes were drilled across the Site. The number of soil sampling locations in each sub-area on the Site was presented in Table 4.1 of the Report and the soil sampling locations were shown on Figure 3 (Attachment 1).

Auditor's opinion
The Auditor notes that the locations in which excavation and drilling were undertaken on the Site was limited by the presence of items of archaeological significance and heritage listed items such as the southern gasholder.

5.7.2 Surface water investigation program

The Report stated that samples were collected from water present in the former gasworks structures on the Site. Given that the water in these structures will be required to be removed prior to the remedial works, the Report stated that the water sampling was undertaken to determine appropriate options for water management. Water samples were collected from inside the brick annulus of the southern and northern gasholders, the two tar wells, the retention pit at the southern side of the southern gasholder and from the base of the southern gasholder.

5.8 Sampling methodology

The sampling activities undertaken by CH2MHILL during the investigation program were stated to be have been completed in accordance with the SAQP (CH2MHILL, July 2006) developed prior to the commencement of the investigation and CH2MHILL's Standard Operating Procedures that were stated to have been developed following specific industry standards and protocols. The sampling methodologies adopted during the investigation program, as described in the Report, are addressed in detail below.

5.8.1 Soil sampling

Soil sampling was stated to have undertaken during the two stages of the investigation program. During the first stage, test pits and trenches were excavated using an excavator and soil samples were stated to have been collected directly from the undisturbed bulk of material in the centre of the excavator bucket. It was stated that the second stage of the investigation involved the drilling of boreholes using a push-tube rig and soil samples were collected directly from the push-tube. The Report stated that during both stages of the investigation that the depth of sampling was determined based on the depth to fill, natural soil and bedrock, the depth to groundwater and the potential source of the contamination. The Report stated that at each sampling location the soil profile was logged and the borelogs were presented in Appendix C of the Report.

Field screening was stated to have been conducted at each sampling location using a photo-ionisation detector (PID) and by undertaking a visual assessment of the material sampled. It was stated that the PID was used to screen the samples for the presence of volatile compounds and that the visual assessment was undertaken to identify soil and waste types based on their physical appearance. The identification of soil types was stated to have been undertaken in accordance with Table 7.1 of the Report which provided a list of physical characteristics of soil and waste types expected on the Site. The Report stated that the results of the field screening would assist in the selection of samples representative of Site conditions for laboratory analysis. The results of the PID screening and visual assessment were included on the borelogs in Appendix C and the PID calibration records were presented in Appendix E of the Report.

The Report stated that the soil samples were collected from the excavator bucket and from the push tube rods at each location by hand using new set of disposable nitrile gloves and that between each sampling location the excavator bucket and push-tube rods were washed with a high pressure hose to remove soil material. During the second stage of the investigation, the Report stated that the push-tube rod was decontaminated at the end of each day by scrubbing in a solution of Decon 90 and tap water and then rinsed using tap water. The Report stated that each day, after decontamination, a rinsate blank was collected from the push tube. It was stated that no rinsate blanks were collected from the excavator bucket.

During sample collection, in order to minimise the loss of volatiles, the Report stated that samples were not mixed or homogenised. The soil samples were stated to have been placed directly into laboratory-supplied, acid-rinsed 250 mL glass jars, labelled and placed in an ice-chilled cooler box for dispatch to a NATA registered laboratory under chain of custody procedures.

Inter-laboratory and intra-laboratory duplicates were stated to have been collected during each sampling event. The frequency of the collection of field quality samples was stated to have been undertaken in accordance with the SAQP (CH2MHILL, July 2006).

5.8.2 Surface water sampling

Sampling of the accumulated surface water in the former gasworks structures on the Site was stated to have been undertaken at five locations. Samples were stated to have been collected using a disposable teflon bailer or were collected directly into laboratory supplied bottles. The Report stated that the water sample from the southern gasholder was collected using a foot valve mechanism to ensure water from the bottom of the structure was collected.

The Report stated that samples were placed into laboratory-supplied preserved bottles and vials, labelled and placed in an ice-chilled cooler box for dispatch to a NATA registered

laboratory under chain of custody procedures. Decontamination was stated to have been unnecessary as a new set of disposable nitrile gloves was used at each sampling location.

Inter-laboratory and intra-laboratory duplicates were stated to have been collected during each sampling event by alternatively filling the primary then the duplicate bottles. The frequency of the collection of field quality samples was stated to have been undertaken in accordance with NEPM (1999) and AS 4482.1 – 1997.

Auditor's opinion
Overall, the Auditor considers that the sampling methodologies employed by CH2MHILL during the investigation were satisfactory for the purpose of the investigation.

The Auditor notes that while the Report stated that the adopted sampling procedures were conducted in accordance with CH2MHILL's Standard Operating Procedures, this document was not provided to the Auditor and as such the Auditor cannot provide comment on this document and whether or not the sampling procedures described in the Report were conducted in accordance with this document.

5.9 Analytical program

Primary and intra-laboratory duplicate samples collected during the investigation program were submitted to ALS Environmental Laboratories Pty Ltd (ALS) and the inter-laboratory duplicate samples were submitted to Labmark Pty Ltd (Labmark). Asbestos analysis was completed by ASET Laboratories Pty Ltd (ASET). The Report also stated that one sample of tar material was submitted to AgriQuality Limited (AgriQuality) located in Wellington New Zealand for analysis for PCDDs and PCDFs.

The Report also presented a summary of the analytical methods, holding times and laboratory limits of reporting (LORs) applied by the laboratories for the investigation program.

The Report stated that soil samples including field quality control samples were variably analysed for the following:

- Metals (Totals - As, Cd, Cr, Cu, Hg, Pb, Ni, Zn);
- TPHs;
- BTEX;
- PAHs;
- OCPs;
- OPPs;
- Phenols;
- Cyanides (totals);
- PCBs; and
- Asbestos.

In addition, selected samples were also submitted for Toxicity Characteristics Leaching Procedure (TCLP) analysis and for neutral leachate analysis. Leachate analysis was variably conducted for the following:

- Selected metals (As, Cd, Pb, Ni, Hg);
- B(a)P;

- TPHs; and
- BTEX.

The Report stated that water samples, including field quality control samples, were variably analysed for the following:

- Metals (Dissolved - As, Cd, Cr, Cu, Hg, Pb, Ni, Zn);
- TPHs;
- BTEX;
- PAHs;
- OCPs;
- OPPs;
- Phenols; and
- PCBs.

Auditor's opinion

Given the historical use of the Site, the results of the previous assessments, the observations made during the works and the objectives of the works, it is the Auditor's opinion that the analytical program, methods used by the laboratories and LORs employed were acceptable for the purpose of the investigation program.

"This page has been left blank intentionally"

6 RESULTS

The results of the sampling program were presented in the Report based on the adopted sampling strategy which divided the Site into sub-areas. The sampling locations completed in each sub area have been presented in the Table 3 below and the results of the soil and surface water sampling program are summarised in the sections below.

Table 3: Sub-Area Sampling Locations

Sub-Area of the Site	Trench/Test Pits	Boreholes	Surface Water
Gasholders Northern Gasholder Southern Gasholder	MG02, MG03, MG04, MG05, MG07	Angled boreholes – BHC, BHC1, BHD Angled boreholes – BHA, BHA1, BHA2, BHB	W01 W05, W06
Retort	MG06, MG08, MG09A, MG09A1, MG09B, MG09C, MG10A, TP15, TP15A	BHG, BHC2, BH12A	W02, W03
Gas Purifier	MG11	BHB, BHE, BHF	
Northeast	MG10, MG10B, TP05, TP06, TP07, TP08, TP09, TP16	BH14A	
South Central	TP03, TP04, TP11		
Southwest	TP01, TP02, RP, MG01	BHA, BHA1	W04
Retaining Wall	TP10, TP12, TP18		
Western Lot	TP13, TP14		

6.1 Subsurface conditions

The Report stated that the excavation and drilling works completed on the Site during the sampling program provided a "better understanding" of the subsurface conditions than had been reported previously. A summary of the observations made by CH2MHILL during the intrusive works including the observed contamination, the subsurface structures and the fill and natural soil materials encountered on the Site, is presented below.

6.1.1 Soil stratigraphy

The Report provided a detailed description of the fill and natural soil types encountered on the Site which were presented graphically on cross-sections on Figures 5 and 6 of the Report (Attachment 1) and are summarised below.

Fill Materials

The Report identified five different fill materials on the Site as follows:

- Ash and coke gravels – present at surface generally across majority of Site and was noted to depths of 0.5mbgs in the north-east, south-central, retort and western lot sub-areas;

- Reworked clays – present as general filling materials between 0.5 mbgs to 1.5 mbgs across majority of Site;
- Sands and Gravels – present as general filling materials between 0.5 mbgs to 1.5 mbgs across North-east, south-central and gas purifier sub areas;
- Gravelly Sand and Clay with Minor Ash – present at surface to approximately 3.5 mbgs predominately in south-west sub area as general filling;
- Gravel, Sand and Demolition Waste – present in embankment areas along the northern boundary of the Site and inside annulus of northern gasholder.

The Report stated that the deepest filling was in the south-west sub area to depths of 3.5 mbgs.

Natural Soil

The Report stated that the natural soil materials identified at the Site were as follows:

- Silty Clay – present across the majority of the Site between 1.5 mbgs to 2.5 mbgs and was stated to be moderately to highly plastic and contained the perched groundwater system;
- Red/Grey Mottled Clay – present across majority of the Site between 2.5 mbgs to 4.0-6.0 mbgs and was stated to be moderately to highly plastic and stiff to very stiff;
- Weathered shale – present underlying the clays and was stated to grade from extremely weathered to moderately weathered at depths up to 10 mbgs. At depths below 6.0mbgs fracturing was noted and it was stated that has created prominent iron stone gravels and iron staining.

6.1.2 Subsurface structures

Northern Gasholder

The Report stated that the sub-surface structures encountered and the contamination observed during the trenching and drilling work conducted in and around the northern gasholder were as follows:

- The top of the brick annulus and a part of the northern sidewall (MG05) was stated to have been exposed. The circumference of the annulus was surveyed and determined to be approximately 20 metres which was stated to be the same as the southern gasholder;
- Tar and oil was observed to be seeping from the brickwork at approximately 2 mbgs;
- Two test pits (MG03 and MG04) excavated within the annulus exposed a variety of building and demolition waste materials that included fibro cement sheeting which, laboratory analysis confirmed, contained asbestos;
- The brick annulus was stated to contain a large volume of water. The Report stated that this may be due to the annulus walls having low permeability such that any surface water entering the annulus was being stored. The water level within the annulus was stated to be 0.4 mbgs whereas the groundwater level in the nearest well MW06s was stated to be 2.0 mbgs. The Report stated that the positive head of water within the annulus would provide a source of recharge to the shallow groundwater system in this area of the Site;

- The angled borehole completed at BHC was stated to have intersected the base of the annulus at 6 mbgs. This was stated to be contrary to the historical information which indicated that the gasholders were constructed to approximately 3 mbgs. It was noted that at 6 mbgs at this location, the sample collected contained tar and oily material and bricks and that similar material was also sampled at BHD at 6.0 mbgs. This tar material was stated to be a relatively fluid and was termed "free tar"; and
- Pipework containing free tar materials was stated to have been uncovered at trench location MG02 on the south-eastern side of the annulus and a sample of this material was collected for laboratory analysis (MG02/PIPE).

Southern Gasholder

The Report stated that the subsurface structures encountered and the contamination observed during the trenching and drilling work conducted in and around the southern gasholder were as follows:

- Brick annulus was stated to be completely full of water and similar to the northern gasholder, the Report stated that the positive head of water within the annulus would provide a source of recharge to the shallow groundwater system in this area of the Site;
- Angled boreholes, BHA, BHA1 and BHB were stated to have been positioned so as to clear the base of the annulus at approximately 6.5 mbgs. The drilling confirmed that the gasholder was no deeper than 6.5 mbgs;
- Samples collected from borehole locations BHA, BHA1 and BHB, between 6.0 mbgs and to refusal at 10 mbgs, beneath the gasholder, were stated to contain dark stains and were highly odorous. This material was stated to appear to have been impacted by tar but did not contain the "free tar" that was noted in the material beneath the northern gasholder. This material was described as containing "dark stained impacts".

Retention Pit

The Report stated that the subsurface structures encountered and the contamination observed during the trenching conducted in and around the retention pit were as follows:

- Retention pit was stated to be a brick pit built approximately 2 mbgs and located adjacent to the southern gasholder;
- Two pipes containing water and an oily/tarry material were stated to be connected to the pit. During excavation works the Report stated that the pipes were broken and the pit was "flooded with water";
- A sample of the residual material, labelled as "RP", present in the pipes was collected for laboratory analysis.

Tar Wells

The Report stated that the subsurface structures encountered and the contamination observed during the trenching and drilling work conducted in and around the tar pits were as follows:

- Two tar wells were stated to be located approximately 5 m to the north-east of the northern gasholder;
- Both wells were stated to have a diameter of 4 m and be covered with concrete lids. The lids were subsequently removed using an excavator;
- The wells were stated to contain water which was underlain by tarry liquid materials which were described as black, highly odorous and contained a mixture of free tar and gravels. The Report stated that the excavator was

used to collect a sample of this material from one of the tar wells, labelled as "Tar Well #2";

- During the excavation of a trench (MG06) adjacent to one of the tar wells free tar material was noted to be seeping from the wall of the well into the surrounding soil materials;
- Free tar was also noted to have been observed at borehole location BHG, adjacent to the wells, at depths to 7 mbgs.

Retort
The Report stated that the subsurface structures encountered and the contamination observed during the trenching and drilling work conducted in and around the retort house were as follows:

- Trenches completed across the footprint of the former Retort House were stated to have uncovered an completed brick base floor;
- Brick floor of the retort house was stated to be considered to have potential heritage significance and as such excavation works were limited;
- The lateral extent of the brickworks was stated to be in general alignment with the former historical layout of the retort house;
- At test pit location TP15 the brick floor was stated to have been discontinuous and the test pit was able to be advanced beneath the floor. The Report stated that a brick footing was encountered and that free tar material was present on both the footing and in the surrounding soils;
- Pipework containing free tar materials was stated to have been uncovered at trench location MG09B and a sample of this material was collected for laboratory analysis (MG09B/PIPE).

6.1.3 Observed subsurface contamination

As stated above, the fill and natural soil materials in a number of areas on the Site were observed to be contaminated by tar. CH2MHILL categorised these contaminated materials as follows:

- Free Tar – stated to consist of black, low viscosity, highly odorous material as noted to be associated with a number of the former gasworks structures present in the subsurface at the Site; and
- Dark Stained Impacts – stated to consist of highly odorous dark brown to black stained soils and weather shales, as noted beneath the southern gasholder.

6.2 Soil results

6.2.1 Field screening analysis

The Report stated that the PID readings at each sample location "appeared to correlate well with the analytical results", with samples which had higher PID readings also having higher concentrations of contaminants, particularly volatile compounds such as BTEX and light fraction TPH. The PID was stated to be "an effective tool for field screening to identify the location and depth of contamination".

Auditor's opinion

While reasonable correlation between the PID readings and the concentrations of volatile compounds reported by the laboratory was noted, particularly where free tar was present, the Auditor also notes that the number of locations in which volatile compounds, such as BTEX and light fraction TPH, were detected in the soil at concentrations greater than the site criteria was limited.

Given that the primary source of the contamination on the Site is the presence of dense non-aqueous phase liquids such as liquid tars or "free tars", it is the Auditor's opinion that the application of the PID as an effective field screening tool, particularly during remediation works, would be limited to the areas in which light fraction TPH, BTEX and PAHs such as Naphthalene were associated with "free tars" or "tarry materials".

The Auditor considers that the Report has not adequately demonstrated the correlation of the PID results to the analytical results such that the effectiveness of the PID as a tool for field screening during remediation can be stated. If the PID is proposed to be used as a screening tool for the remediation, then the Auditor requires that adequate demonstration and establishment of its effectiveness be provided within the RAP.

In addition, the Auditor considers that while the PID readings were presented on the borelogs, it would have been useful, for the purposes of comparison, to include the PID readings on the analytical tables within the Report.

6.2.2 Soil analytical results

The results of the soil sampling completed by CH2MHILL during the investigation were presented in the Report and are summarised below.

Table 4: Summary of Soil Analytical Results

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
Gasholder Area – Table 1 of the Report			
5 Trenches/Test Pits: MG02, MG03, MG04, MG05, MG07 3 Boreholes: BHC, BHC1, BHD Auditor notes that also included in Table 1 of the Report were boreholes completed in south-west area but adjacent to southern gasholder - BHA, BHA1, BHA2	**Fill Material – 7 Samples** 7 - TPH, BTEX 6 – PAHs, Metals 5 – Phenols 3 – OCPs, OPPs, PCBs 3 - Asbestos **Natural Soil – 17 Samples** 17 – PAHs 16 – TPH, BTEX 15 – Phenols 2 – Metals, OCPs, OPPs, PCBs	**Fill Material** MG02/0.2 MG02/1.8 MG03/0.1 MG04/0.5 MG04/1.5 MG05/0.5 MG07/1.0 **Natural Soil** MG02/4.7 MG05/1.8 MG05/5.0 MG07/4.0 BHA/7.0 BHA/10.2 BHA1/7.0 BHA1/10.2 BHA2/7.0 BHA2/10.0 BHB/6.0 BHB/9.0	**TPH C6-C9:** Concentrations greater than assessment criteria at: MG02/0.2 (72) MG02/1.8 (189) MG05/1.8 (118) MG05/5.0 (92) BHC/6.0 (559) Remaining samples <LORs to 9 therefore less than assessment criteria **TPH C10-C36:** Concentrations greater than assessment criteria at: MG02/1.8 (36 140) MG03/0.1 (2750) MG04/0.5 (1860) MG05/0.5 (13 340) MG05/1.8 (3140) MG05/5.0 (1420) BHC/6.0 (8760) Remaining samples <LORs to 490 therefore less than assessment criteria

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
		BHC/6.0 BHC1/8.0 BHD/7.0 BHD/8.4	**BTEX:** Concentrations of **Benzene** greater than assessment criteria at: MG02/0.2 (4.2) MG02/1.8 (3) BHA1/7.0 (1.6) BHA1/10.2 (1.4) BHB/6.0 (2) BHC/6.0 (6.4) BHD/7.0 (5.4) BHD/8.4 (7.5) Remaining samples <LORs to 0.9 therefore less than assessment criteria. Concentrations of **Total Xylenes** greater than assessment criteria at: MG02/0.2 (29.6) MG02/1.8 (165.8) MG05/1.8 (80.4) MG05/5.0 (35) BHC/6.0 (246.7) Remaining samples <LORs to 1.6 therefore less than assessment criteria Concentrations of **Ethylbenzene:** <LOR to 40.8 therefore all samples less than assessment criteria. Concentrations of **Toluene:** <LOR to 38.7 therefore all samples less than assessment criteria. **PAHs:** Concentrations of **B(a)P** greater than assessment criteria at: MG02/1.8 (178) MG03/0.1 (10.4) MG04/0.5 (6) BHC/6.0 (17.6) Remaining samples <LORs to 2.2 therefore less than assessment criteria Concentrations of **Total PAHs** greater than assessment criteria at: MG02/0.2 (149.5) MG02/1.8 (5301.9) MG03/0.1 (115.3) MG05/1.8 (289) BHC/6.0 (1906.4) Remaining samples <LORs to 68.1 therefore less than assessment criteria **Pb:** Concentrations greater than assessment criteria at MG04/0.5 (2140) Remaining samples: <LOR to 744 therefore less than assessment criteria **As, Cd, Cr, Cu, Ni, Hg, Zn:** Concentrations were either <LORs or were less than assessment criteria **Phenols:** <LOR to 11.4 therefore all samples less than assessment criteria. **PCBs, OPPs, OCPs:** All < LORs

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
			therefore less than assessment criteria **Asbestos:** Chrysotile & Amosite detected in: MG04/1.5 – Fibro fragment Chrysotile & Crocidolite detected in: MG04/1.5 – Soil mix Not detected in: MG03/0.1 – Soil mix
Retort Area – Table 2 in the Report			
8 Trenches/Test Pits: MG06, MG08, MG09A, MG09A1, MG09B, MG09C, MG10A, TP15, TP15A, 3 Boreholes: BHG, BHC2, BH12A	**Fill Material – 11 Samples** 10 - TPH, BTEX 9 – PAHs 8 - Metals 4 – Phenols 3 – OCPs, OPPs 2 - PCBs 1 – Cyanide 2 - Asbestos **Natural Soil – 20 Samples** 20 – PAHs, TPH, BTEX 14 – Phenols 7 – Metals 6 – Cyanide 4 - OCPs, OPPs 2 – PCBs	**Fill Material** MG06/1.0 MG08/0.3 MG08/1.5 MG08/2.1 MG09A1/0.7 MG09B/0.3 MG09B/0.6 MG09C/0.3 MG09C/1.9 MG10A/0.7 TP15/0.3 **Natural Soil** BH12A/4.2 BH12A/6.0 BHC2/6.0 BHG/6.0 BHG/7.2 BHG/8.1 MG06/2.0 MG06/4.7 MG08/4.0 MG09A1/3.6 MG09A1/4.8 MG09B/2.5 MG09C/3.8 MG10A/2.8 MG10A/4.0 TP15/2.8 TP15/4.1 TP15A/6.0 TP15A/7.0	**TPH C6-C9:** Concentrations greater than assessment criteria at: MG08/2.1 (97) BH12A/4.2 (228) TP15/4.1 (107) TP15A/6.0 (65) Remaining samples <LORs to 56 therefore less than assessment criteria **TPH C10-C36:** Concentrations greater than assessment criteria at: MG06/1.0 (1370) MG08/1.5 (435100) MG08/2.1 (2790) MG09A/0.7 (3520) MG09B/0.3 (20700) MG09C/0.3 (1200) MG10A/0.7 (234950) BH12A/4.2 (5350) MG06/2.0 (1700) MG10A/2.8 (4070) TP15/2.8 (2090) Remaining samples <LORs to 760 therefore less than assessment criteria **BTEX:** Concentrations of **Benzene** greater than assessment criteria at: MG09A1/0.7(1.7) BH12A/4.2 (20) BHG/6.0 (2.4) MG10A/2.8 (1.1) TP15/2.8 (1.8) TP15/4.1 (2.7) Remaining samples <LORs to 0.5 therefore less than assessment criteria. Concentrations of **Total Xylenes** greater than assessment criteria at: BH12A/4.2 (94.9) TP15/2.8 (56.2) Remaining samples <LORs to 24.8 therefore less than assessment criteria Concentrations of **Ethylbenzene:** <LOR to 17.5 therefore all samples less than assessment criteria. Concentrations of **Toluene:** <LOR to 53 therefore all samples less than assessment criteria.

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
			PAHs: Concentrations of **B(a)P** greater than assessment criteria at: MG08/1.5(444) MG08/2.1(6.9) MG09A1/0.7(8.2) MG09C/0.3(5) MG10A/0.7(339) BH12A/4.2(13.9) MG10A/2.8 (6.3) TP15/2.8 (10.8) Remaining samples <LORs to 2.2 therefore less than assessment criteria Concentrations of **Total PAHs** greater than assessment criteria at: MG06/1.0(135.5) MG08/1.5(15237.6) MG08/2.1(321.2) MG09A1/0.7(416.6) MG10A/0.7(4578.2) BH12A/4.2(515.6) MG06/2.0(103.5) MG10A/2.8 (206.9) TP15/2.8 (426.2) Remaining samples <LORs to 74.1 therefore less than assessment criteria **As, Cd, Cr, Cu, Pb, Ni, Hg, Zn:** Concentrations were either <LORs or were less than assessment criteria **Cyanide:** Concentrations were either <LORs or were less than assessment criteria **Phenols:** Concentrations <LOR to 16.6 therefore all samples less than assessment criteria. **PCBs, OPPs, OCPs:** Concentrations were either < LORs or were less than assessment criteria **Asbestos** – Chrysotile detected in: MG09B–fragment Not detected in: MG10A/0.7– Soil mix
Gas Purifier Area – Table 3 in the Report			
1 Trenches: MG11 3 Boreholes: BHB, BHE, BHF	**Fill Material – 4 Samples** 4 - TPH, BTEX, PAHs 3 – Phenols 2 – Metals. Cyanide 1– OCPs, OPPs PCBs **Natural Soil – 6 Samples** 6 – PAHs, TPH, BTEX, Phenols 5 – Cyanide 1 – Metals	**Fill Material** MG11/0.2 MG11/2.0 BHE/2.2 BHF/1.0 **Natural Soil** MG11/4.0 BHE/3.5 BHE/8.4 BHF/3.6 BHF/7.0 BHF/8.5	**TPH C6-C9:** Concentrations greater than assessment criteria at: BHE/2.2 (155) Remaining samples <LORs to 22 therefore less than assessment criteria **TPH C10-C36:** Concentrations greater than assessment criteria at: MG11/0.2(6210) MG11/2.0(7750) BHF/1.0(1150) BHF/8.5(1260) Remaining samples <LORs to 460 therefore less than assessment criteria

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
			BTEX: Concentrations of **Benzene** greater than assessment criteria at: BHE/8.4(1.6) Remaining samples <LORs to 0.8 therefore less than assessment criteria. Concentrations of **Total Xylenes** <LOR to 17 therefore all samples less than assessment criteria. Concentrations of **Ethylbenzene:** <LOR to 16.1 therefore all samples less than assessment criteria. Concentrations of **Toluene:** <LOR to 0.4 therefore all samples less than assessment criteria. **PAHs:** Concentrations of **B(a)P** greater than assessment criteria at: MG11/0.2 (42) MG11/2.0(48.8) BHF/1.0(6.4) Remaining samples <LORs to 1.1 therefore less than assessment criteria Concentrations of **Total PAHs** greater than assessment criteria at: BHF/8.5(134.6) Remaining samples <LORs to 89.5 therefore less than assessment criteria **As, Cd, Cr, Cu, Pb, Ni, Hg, Zn:** Concentrations were either <LORs or were less than assessment criteria **Cyanide:** Concentrations were either <LORs or were less than assessment criteria **Phenols:** Concentrations <LOR therefore all samples less than assessment criteria. **PCBs, OPPs, OCPs:** Concentrations were either < LORs or were less than assessment criteria
Northeast Area – Table 4 in the Report			
1 Trenches/Test Pits: MG10, MG10B, TP05, TP06, TP07, TP08, TP09, TP16 1 Boreholes: BH14A	**Fill Material – 18 Samples** 18 – PAHs 15 - TPH, BTEX 12 – Phenols 10 - Metals 5 – PCBs, OCPs, OPPs 6- Asbestos **Natural Soil – 8 Samples** 8 – PAHs, TPH, BTEX, 3 – Phenols, Metals	**Fill Material** MG10/0.2 TP05/0.25 TP05/0.5 TP05/1.5 TP06/0.25 TP06/0.5 TP06/1.0 TP07/0.5 TP07/1.5 TP08/0.25 TP08/0.5 TP08/1.0 TP09/0.5 TP16/0.3 TP16/1.0 BH14A/1.4 MG10B/1.8	**TPH C6-C9:** Concentrations greater than assessment criteria at: TP16/1.0 (166) Remaining samples <LORs to 13 therefore less than assessment criteria **TPH C10-C36:** Concentrations greater than assessment criteria at: MG10/0.2(1940) TP16/0.3(1280) TP16/1.0(7640) Remaining samples <LORs to 520 therefore less than assessment criteria **BTEX:** Concentrations of **Benzene** greater than assessment criteria at: TP16/0.3(1.2) TP16/1.0(3.1) Remaining samples <LORs to 0.4 therefore less than assessment

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
		Natural Soil TP05/2.0 TP06/2.5 TP07/2.0 TP08/2.0 TP09/2.5 TP16/3.5 BH14A/2.4 MG10B/3.0	criteria. Concentrations of **Total Xylenes** greater than assessment criteria at: TP16/1.0(61.20) Remaining samples <LOR to 5.6 therefore all samples less than assessment criteria. Concentrations of **Ethylbenzene:** <LOR to 6.4 therefore all samples less than assessment criteria. Concentrations of **Toluene:** <LOR to 3.7 therefore all samples less than assessment criteria. **PAHs:** Concentrations of **B(a)P** greater than assessment criteria at: TP05/0.25 (158) TP06/0.25 (55) TP08/0.25 (8.2) TP09/0.5(5.4) TP16/0.36(6.9) TP16/1.0(39.4) Remaining samples <LORs to 1.8 therefore less than assessment criteria Concentrations of **Total PAHs** greater than assessment criteria at: TP05/0.25 (4300.9) TP06/0.25 (690.2) TP16/1.0(425.1) Remaining samples <LORs to 79.4 therefore less than assessment criteria **As, Cd, Cr, Cu, Pb, Ni, Hg, Zn:** Concentrations were either <LORs or were less than assessment criteria **Phenols, PCBs, OPPs, OCPs:** Concentrations were either < LORs or were less than assessment criteria **Asbestos:** Not detected in samples analysed
South Central Area – Table 5 in the Report			
3 Trenches/Test Pits: TP03, TP04, TP11	**Fill Material – 6 Samples** 6– PAHs, TPH, BTEX 4 - Metals 3 –OCPs, OPPs 2 – Phenols, PCBs 3 - Asbestos **Natural Soil – 4 Samples** 4 – PAHs, TPH, BTEX,	**Fill Material** TP03/0.5 TP03/1.0 TP04/0.5 TP04/0.7 TP11/0.2 TP11/1.0 **Natural Soil** TP03/2.0 TP03/4.0 TP04/3.0 TP11/3.5	**TPH C6-C9:** Concentrations <LOR therefore less than assessment criteria **TPH C10-C36:** Concentrations greater than assessment criteria at: TP11/0.2(1410) Remaining samples <LORs therefore less than assessment criteria **BTEX:** Concentrations <LOR therefore less than assessment criteria **PAHs:** Concentrations of **B(a)P** greater than assessment criteria at: TP11/0.2 (6.2) Remaining samples <LOR therefore less than assessment criteria Concentrations of **Total PAHs** 8 to 63.8 therefore less than assessment criteria. **As, Cd, Cr, Cu, Pb, Ni, Hg, Zn:**

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
			Concentrations were either <LORs or were less than assessment criteria **Phenols, PCBs, OPPs, OCPs:** Concentrations were either < LORs or were less than assessment criteria **Asbestos:** Not detected in samples analysed
Southwest Area – Table 6 in the Report			
4 Trenches/Test Pits: TP01, TP02, RP, MG01 2 Boreholes: BHA, BHA1	**Fill Material – 9 Samples** 9– PAHs, TPH, BTEX 3 – Metals, Phenols, PCBs, OCPs, OPPs 1 – Cyanide 4 - Asbestos **Natural Soil – 4 Samples** 4– PAHs, TPH, BTEX 1 – Metals, Phenols, OCPs, OPPs.	**Fill Material** MG01/1.8 MG01/2.8 RP/2.0 TP01/0.25 TP01/1.0 TP01/1.5 TP01/3.0 TP02/1.0 TP02/3.0 **Natural Soil** MG01/5.0 TP01/4.5 TP02/4.5 BHA/5.0	**TPH C6-C9:** Concentrations <LOR to 120 therefore less than assessment criteria **TPH C10-C36:** Concentrations greater than assessment criteria at: RP/2.0 (1730) Remaining samples <LORs to 520 therefore less than assessment criteria **BTEX:** Concentrations <LOR therefore less than assessment criteria **PAHs:** Concentrations of **B(a)P** greater than assessment criteria at: RP/2.0 (12.8) Remaining samples <LOR to 3.5 therefore less than assessment criteria Concentrations of **Total PAHs** greater than assessment criteria at: RP/2.0 (118.2) Remaining samples <LOR to 39.2 therefore less than assessment criteria **Cyanide:** Concentration <LORs therefore less than assessment criteria **As, Cd, Cr, Cu, Pb, Ni, Hg, Zn:** Concentrations were either <LORs or were less than assessment criteria **Phenols, PCBs, OPPs, OCPs:** Concentrations were either < LORs or were less than assessment criteria **Asbestos** – Chrysotile and amosite detected in: MG01/0.2–fibro fragment Not detected in remaining samples analysed
Retaining Wall Area – Table 7 in the Report			
3 Trenches/Test Pits: TP10, TP12, TP18	**Fill Material – 5 Samples** 5– Metals, PAHs, TPH, BTEX 4 – Phenols 3 - PCBs, OCPs, OPPs 1 – Cyanide 2 - Asbestos **Natural Soil – 3 Samples** 3– Metals PAHs, TPH, BTEX .	**Fill Material** TP10/1.0 TP10/2.0 TP12/0.25 TP12/0.5 TP18/1.2 **Natural Soil** TP10/4.0 TP18/3.2 TP18/4.4	**TPH C6-C9:** Concentrations <LOR therefore less than assessment criteria **TPH C10-C36:** Concentrations greater than assessment criteria at: TP12/0.25 (2320) Remaining samples <LOR therefore less than assessment criteria **BTEX:** Concentrations <LOR therefore less than assessment criteria **PAHs:** Concentrations of **B(a)P** greater than assessment criteria at: TP12/0.25 (9.6)

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
			Remaining samples <LOR to 1 therefore less than assessment criteria Concentrations of **Total PAHs** greater than assessment criteria at: TP12/0.25 (117.4) Remaining samples <LOR to 17 therefore less than assessment criteria **As, Cd, Cr, Cu, Pb, Ni, Hg, Zn:** Concentrations were either <LORs or were less than assessment criteria **Phenols, PCBs, OPPs, OCPs:** Concentrations were either < LORs or were less than assessment criteria **Asbestos:** Chrysotile detected in: TP12/0.25 – Soil Mix Not detected in TP10/0.25
Western Lot Area – Table 8 in the Report			
2 Test Pits: TP13, TP14	**Fill Material – 3 Samples** 3–PAHs, TPH, BTEX 2 – Phenols Metals 2 - Asbestos **Natural Soil – 4 Samples** 4– PAHs, TPH, BTEX 2 - Metals 1 - Phenols	**Fill Material** TP13/0.25 TP14/0.25 TP14/0.5 **Natural Soil** TP13/1.0 TP13/1.5 TP14/1.0 TP14/1.5	**TPH C6-C9:** Concentrations <LOR therefore less than assessment criteria **TPH C10-C36:** Concentrations greater than assessment criteria at: TP13/0.25 (8870) TP14/0.25 (3500) Remaining samples <LOR therefore less than assessment criteria **BTEX:** Concentrations <LOR therefore less than assessment criteria **PAHs:** Concentrations of **B(a)P** greater than assessment criteria at: TP13/0.25 (45.5) TP14/0.25 (7.4) Remaining samples <LOR therefore less than assessment criteria Concentrations of **Total PAHs** greater than assessment criteria at: TP13/0.25 (512) Remaining samples <LOR to 95.2 therefore less than assessment criteria **As, Cd, Cr, Cu, Pb, Ni, Hg, Zn:** Concentrations were either <LORs or were less than assessment criteria **Phenols:** Concentrations were either < LORs or were less than assessment criteria **Asbestos:** Not detected in samples analysed.

6.2.3 Coal tar analytical results

Samples of coal tar were stated to have been collected from one of the tar wells and from pipes uncovered during excavation works at sampling locations RP in the South-West Area and MG09B located in the Retort Area. The analytical program and results for the three samples of coal tar as presented in Table 9 of the Report are summarised in the table below.

Table 5: Summary of Coal Tar Analytical Results

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (mg/kg)
Retort Area 2 Samples - TAR WELL #2 MG09B/PIPE South-West Area – 1 Sample RP/PIPE Other – Tar Sample – Sample stated to be collected from the Site, specific sample location not stated in Report	**Coal Tar – 4 Samples** 3- PAHs, TPH, BTEX 1 – PCDD/F	TAR WELL #2 MG09B/PIPE RP/PIPE Tar	**TPH C6-C9:** Concentrations greater than assessment criteria at: TAR WELL #2 (6690) MG09B/PIPE (3770) RP/PIPE (70) **TPH C10-C36:** Concentrations greater than assessment criteria at: TAR WELL #2 (98 700) MG09B/PIPE (1 180 000) RP/PIPE (24 660) **BTEX:** Concentrations of **Benzene** greater than assessment criteria at: TAR WELL #2 (814) MG09B/PIPE (576) RP/PIPE (2) Concentrations of **Ethylbenzene** greater than assessment criteria at: TAR WELL #2 (254) MG09B/PIPE (156) Remaining sample concentration of 1.1 therefore less than assessment criteria Concentrations of **Toluene** greater than assessment criteria at: TAR WELL #2 (1 680) MG09B/PIPE (1 210) Remaining sample concentration of 3.6 therefore less than assessment criteria Concentrations of **Total Xylenes** greater than assessment criteria at: TAR WELL #2 (3 170) MG09B/PIPE (1 516) RP/PIPE (47.4) **PAHs:** Concentrations of **B(a)P** greater than assessment criteria at: TAR WELL #2 (164) MG09B/PIPE (595) RP/PIPE (491) Concentrations of **Total PAHs** greater than assessment criteria at: TAR WELL #2 (25 557.6) MG09B/PIPE (26 805.3) RP/PIPE (20 889.8) **PCDD/F** – Concentrations reported in sample “Tar” was reported at 1.1pg/g

Based on the analytical results, the Report stated that the sample MG09B was considered to be 100% tar.

6.2.4 Leachate analytical results

The Report stated that TCLP analysis and neutral leachate analysis were conducted on selected soil samples from the Site. The Report stated that TCLP analysis was conducted on 11 samples for the purposes of providing preliminary waste classification for incorporation into remedial options screening and that neutral leach analysis was conducted on three samples for the purpose of providing a preliminary assessment of the potential for the contaminants of concern to leach under "neutral water infiltration".

The results of the TCLP analysis and the neutral leach analysis were presented on Table 13 and Table 14, respectively, of the Report and have been summarised below.

Table 6: Summary of TCLP and Neutral Leach results

Sub-Area	Analytical Program	Sample ID Depth (mbgs) Material Description	Analytical Results (ug/L)
Gasholder Area			
	TCLP –As, Cd, Pb, Ni, B(a)P	MG02/1.8 Silty Clay with free tar	TCLP - Concentrations of **As, Cd, Pb, Ni, B(a)P** <LORs
	TCLP – Pb, Ni, Hg, B(a)P	MG04/0.5 Fill from inside northern gasholder	TCLP – Concentration of **Pb** - 5 Concentrations of**, Ni, Hg, B(a)P** <LORs
	TCLP – BTEX Neutral Leach - BTEX	BHD/8.4 Weathered Shale with dark staining	TCLP – Concentration of **Benzene** – 0.012 **Xylenes** – 0.009 Concentrations of**, Toluene, Ethylbenzene** <LORs Neutral Leach – Concentration of **Benzene** – 0.01 **Xylenes** – 0.005 Concentrations of **Toluene, Ethylbenzene** <LORs
Gas Purifier Area			
	TCLP – BTEX, TPH, PAHs Neutral Leach – TPH, PAHs	BHF/8.5 Weathered Shale with free tar	TCLP – Concentration of **Benzene** – 0.001 **Toluene** – 0.002 **Ethylbenzene** – 0.106 **Xylenes** – 0.648 **TPH C6-C9** – 0.6 **TPH C10-C14** – 0.6 **TPH C15-C28** – 0.5 **Various PAH compounds** – <LOR to 0.1018(Naphthalene)

Sub-Area	Analytical Program	Sample ID Depth (mbgs) Material Description	Analytical Results (ug/L)
			Concentrations of **B(a)P** <LOR Neutral Leach Concentrations of **TPH C10-C14** – 6.99 **TPH C15-C28** – 0.6 **Various PAH compounds** – 0.0005 B(a)P to 3.13 (Naphthalene)
	TCLP –Pb, B(a)P	MG11/2.0 Fill material with free tar	TCLP - Concentrations of **Pb**, **B(a)P** <LOR
Retort Area			
	TCLP –As, Cd, Pb, Ni, B(a)P	MG10A/0.7 Fill with ash and coke	TCLP - Concentrations of **As, Cd, Pb, Ni, B(a)P** <LORs
	TCLP – Pb, B(a)P	MG06/2.0 Natural Soil with free tar	TCLP - Concentrations of **Pb**, **B(a)P** <LOR
Retaining Wall Area			
	TCLP - Pb, Ni, B(a)P	TP10/2.0 Fill materials	TCLP - Concentrations of **Pb, Ni, B(a)P** <LORs
Southwest Area			
	TCLP –B(a)P	MG01/1.8 Fill materials	TCLP - Concentrations of **B(a)P** <LOR
	TCLP – BTEX Neutral Leach - BTEX	BHA1/7.0 Weathered Shale with dark staining	TCLP and Neutral Leach - Concentrations of **BTEX** <LOR
Northeast Area			
	TCLP –B(a)P	TP06/0.25 Fill with ash and coke	TCLP - Concentrations of **B(a)P** <LOR

6.2.5 Surface water analytical results

The results of the surface water sampling completed by CH2MHILL during the investigation were presented in Table 15 of the Report and are summarised below.

Table 7: Summary of Surface Water Analytical Results

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (ug/L)
Gasholder Area			
MG04 – Inside Northern Gasholder	1 - PAHs, TPH, BTEX	W01	**TPH C6-C9:** Concentration - 40 **TPH C10-C36: Concentration – 480** **BTEX:** Concentrations of **Benzene** – 12 Concentrations of **Xylenes** – 9 Concentrations of **Toluene**, **Ethylbenzene**

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (ug/L)
			<LORs. **PAHs**: Concentrations of **Acenaphthene** – 3.7 **Fluorene** – 1.3 **Naphthalene** – 38.5 **Phenanthrene** – 1.2 Remaining compounds concentrations <LORs
Inside Annulus of Southern Gasholder	1 – Phenols, Metals, PAHs, TPH, BTEX	W05	**TPH/BTEX/Phenols/PAHs :** Concentration <LOR **Metals**: Concentrations of As, Cd, Cr, Cu, Ni <LORs Pb – 3 Zn - 16
Base of Southern Gasholder	1 – Phenols, Metals, PAHs, TPH, BTEX	W06	**TPH C6-C9:** Concentration <LOR **TPH C10-C36: Concentration –** 420 **BTEX:** Concentrations <LORs. **PAHs**: Concentrations <LORs. **Phenols**: Concentrations 63.5. **Metals**: Concentrations of As, Cd – 1 Cr – 8 Cu – 7 Pb – 107 Ni – 4 Zn - 277
Retort Area			
Tar Well #1 Tar Well #2	2- PAHs, TPH, BTEX	W02 W03	**TPH C6-C9:** Concentration – 100(W02) to 7240(W03) **TPH C10-C36:** Concentration **-** 3470 (W02) to 214400(W03) **BTEX:** Concentrations of **Benzene**: <LOR(W02) to 1360(W03) Concentrations of **Xylenes**: 66(W02) to 1903(W03) Concentrations of **Toluene**: <LOR(W02) to 1260(W03) Concentrations of **Ethylbenzene**: <LOR (W02) to 160(W03) **PAHs**: Concentrations of **Acenaphthene** – 5(W02) to 215(W03) **Fluorene** – 4.3(W02) to 750(W03) **Naphthalene** – 230(W02) to 20900(W03) **Phenanthrene** – 6.8(W02) to 1520(W03) Remaining PAH compounds concentrations <LORs to 482

Sub-Area Sample Locations	Analytical Program	Sample ID Depth (mbgs)	Analytical Results (ug/L)
South west Area RP	1 – Phenols, Metals, PAHs, TPH, BTEX	W04	**TPH C6-C9:** Concentration <LOR **TPH C10-C36:** Concentration – 1560 **BTEX:** Concentrations <LORs. **PAHs**: Concentrations <LORs to 23.6 **Phenols**: Concentrations 3.8. **Metals**: Concentrations of As - 8 Cd – 1 Cr – 7 Cu – 43 Pb – 87 Ni – 16 Zn - 302

"This page has been left blank intentionally"

7 CONSULTANT'S DISCUSSION OF RESULTS

Based on the results of the subsurface investigations, the Report provided a discussion on the nature and extent of the identified contamination at the Site and, given the proposed use of the Site, the extent to which remediation and/or management of the contamination would be required and estimates on the volumes of materials that will require remediation. These matters,as presented in the Report, are summarised below.

Auditor's opinion
The Auditor notes that while the Report stated that it was likely that the extent of the areas nominated for remediation would not be "confined to one identified impacted area or a defined hotspot", the "Remediation/Management" sections of the Report listed the individual sampling locations and depths requiring remediation and/or management for each sub-area of the Site. It is the Auditor's opinion that in providing such lists the Report contradicts the earlier statements made in relation to the uncertainty of the extent of the contamination and also contradicted the main discussions provided within the Report in relation to the delineation of the extent of the contamination in each sub-area of the Site. However, the Auditor notes that that in later sections of the Report, the remedial objectives, approach and options that are presented recognise the scale of contamination present on the Site and the scale of remediation that will be required to ensure the Site is suitable for the proposed use.

The Auditor considers that the discussion of the results of the subsurface investigation and the delineation of the contamination for each sub-area on the Site presented in the Report adequately reflected the results of the investigation and was appropriate for the purposes of estimating the remediation required and to present the remedial options for the Site.

7.1 Former gasworks area

The Report stated that the results of the subsurface investigations in the Gasholder Area, the Retort Area and the Gas Purifiers Area indicated "extensive impact" with high concentrations of PAHs, TPHs, Benzene and Xylenes in the fill materials and natural soils, particularly surrounding former infrastructure. A summary of the delineation and characterisation of the identified contamination in each sub area is provided below.

7.1.1 Gasholder area

Based on the results of the subsurface investigation in the Gasholder Area of the Site the Report stated the following:

- Free tar was observed at the base of the Northern Gasholder and was observed to be seeping from the brick annulus wall during the excavation of trenches adjacent to the annulus wall. No free tar was observed beneath the Southern Gasholder. The vertical extent of contamination beneath the Northern and Southern Gasholder was stated to be between 8 to10 mbgs. The lateral extent was estimated to up to 5 m laterally from the annuli and the depth of contamination outside of the annuli was estimated between 4 to 15 mbgs;
- The potential for benzene and other organic compounds to leach was stated to be greater in materials sampled from beneath the northern gasholder than from materials beneath the southern gasholder;
- Free tar was also noted to be present where pipework was uncovered and it was stated the impacts from leaking pipes were assumed to be localised to the soils immediately surrounding the pipework. It was stated that the extent

of the contamination from the pipework was dependant upon determining the location of the network of underground pipework, which was stated to be unknown; and

- The contamination associated with the northern gasholder was observed to be significantly greater than the contamination associated with the southern gasholder. The Report stated that during operation of the gasworks it was likely that both gasholders would have been maintained and cleaned regularly to prevent the accumulation of tarry waste at the base. However, during the plant shut down and demolition of the northern gasholder, the Report stated that tarry wastes may have been dumped inside the northern gasholder providing a source of tar in this area of the Site regardless of historical operation and maintenance procedures. The southern gasholder was stated to have been retained for temporary storage of gas and as such may have still been regularly cleaned and maintained beyond the ceasing of gasworks operations on the Site. The Report stated that this situation may have contributed to the observed differences in impact between the two gasholders; and
- Fill materials present inside the northern gasholder were noted to comprise sandy gravely fill with a large component of building demolition waste materials. It was noted that the fill materials present at depths greater than 4.0 mbgs towards the base of the gasholder were impacted by free tar. Concentrations of TPH and B(a)P greater than the site criteria were noted in the fill materials present at shallow depths inside the annulus and fragments of bonded sheeting containing asbestos were noted throughout the fill materials.

Auditor's opinion

The Auditor notes that, due to its heritage status, the investigations conducted on the southern gasholder were limited to three angled boreholes conducted from approximately 5 m, laterally, to the south of the gasholder structure and were completed to underneath the edge of the gasholder structure. The Auditor also notes that, unlike the investigations conducted at the northern gasholder, no trenches were able to be completed adjacent to the southern gasholder and no subsurface investigations were conducted within the annulus of southern gasholder.

The Auditor considers, based on the results of the limited investigation and the likely extended operation of the southern gasholder as compared to the northern gasholder, that it maybe likely, as suggested in the Report, that the contamination at the northern gasholder is significantly greater than that at the southern gasholder. However, the Auditor also considers that the information provided in relation to the historical operation, maintenance, cleaning and the decommissioning of the gasholders, was not adequately supported or referenced. The consequence of this is that this information cannot be relied upon in determining the extent of contamination associated with the southern gasholder.

Given the above, it is the Auditor's opinion that any assumptions on the nature and extent of the contamination present in the southern gasholder should, as a conservative measure, be based on the results of the limited investigation in this area and with consideration to the nature and extent of the contamination identified at the northern gasholder and other associated structures.

7.1.2 Retort area

Based on the results of the subsurface investigation in the Retort Area of the Site the Report stated the following:

- Tar wells were stated to be the major structures in this area of the Site and were constructed to at least 3 mbgs. One well was observed to contain a significant volume of free tar and it was assumed that the other well also contained a similar volume;
- Free tar was observed in surface fill materials and in the reworked and natural clays underlying and surrounding the tar wells to depths of between 4.5 to 6 mbgs. At 7.2 mbgs beneath the tar wells concentrations of contaminants were noted to be less than the site criteria and at 8.1 mbgs concentrations of contaminants were noted to be less than detection limits. It was stated that impacts may potentially extent to at least between 8 to 10 mbgs in this area of the Site;
- Free tar was also noted to be associated with brick footings and underground pipework with this area of the Site. It was stated that the contamination associated with the brickwork could not be delineated due to the heritage status of the brickwork which was likely to have been the floor of the former retort house. The vertical extent of free tar in this area was stated to be approximately 4 mbgs with localised pockets that may be present to depths between 5 to 6 mbgs. The lateral extent was stated to be expected to extend across the footprint of the retort house and for approximately 5m to the north below the Retaining Wall Area. The lateral extent was also stated to potentially be affected by the extensive underground tar laidened pipework system present in this area.

7.1.3 Gas purifiers area

Based on the results of the subsurface investigation in the Gas Purifiers Area of the Site the Report stated the following:

- No prominent structures or significant sources of contamination were noted in this area of the Site;
- Free tar observed in the sand and gravel fill material to depths of 2.0 mbgs and in weathered shales at 8.5 mbgs;
- Vertical extent of impact in this area was stated to be unlikely to exceed 4 mbgs although migration through soil pores and fractures may have resulted in impacts to depths of at least 10 mbgs. Lateral extent of impact was stated to be across the sub-area as presented on Figure 7 of the Report; and
- Source of contamination at depth was stated to be due to a prominent vertical fracture or from the lateral leakage of tars from the gasholder structures.

7.2 Northeast and South central areas

Based on the results of the subsurface investigation in the Northeast and South Central Areas of the Site the Report stated the following:

- The primary source of contamination across these areas of the Site was stated to be the surface layer of ash and coke gravels. The vertical extent was stated to be approximately 0.5-1.0 mbgs within the reworked clay materials. The lateral extent was broadly defined across these areas;
- Leachate analysis conducted on the ash fill indicated that B(a)P had a low propensity to leach under acidic conditions. Based on this it was stated that

contaminants including B(a)P under neutral conditions, such as infiltrating water, would not leach; and

- Free tar was noted to be present at one location (TP16) at a depth of 1 mbgs and concentrations of benzene greater than the site criteria were noted in silty clays at two locations (BH14 and MW04s) at a depth of 1 mbgs. It was noted, given the heterogenous nature of the subsurface materials in these areas of the Site, that additional "hotspots" of contamination may be present and that their potential extent could not be defined.

Auditor's opinion

While it may be likely that compounds present in the ash fill, such as B(a)P, which do not appear to leach significantly under the acidic conditions of a standard TCLP analysis and would behave similarly under neutral conditions, the Auditor considers that without conducting the appropriate analysis conclusions regarding the potential for these compounds to leach under neutral conditions should not be drawn. However, the Auditor noted that the contamination associated with the ash and coke gravels is of limited vertical extent, which may indicate that the contaminants of concern have a low leachability in their current condition and location.

7.3 Southwest area

Based on the results of the subsurface investigation in the Southwest Area of the Site the Report stated the following:

- Significant filling was stated to have occurred in this area of the Site particularly in the south;
- Primary source of contamination across this area of the Site was stated to be the surface layer of ash and coke gravels. The vertical extent was stated to be approximately 0.5 mbgs. The lateral extent was broadly defined across these areas;
- Fill materials underlying the surface layer were stated to consist of concentrations of contaminants that generally met the site criteria;
- Concentrations of total PAHs, B(a)P and TPH greater than the site criteria were noted to present at one location (MW13s) at a depth of 1.0 mbgs. The lateral and vertical extent of this "hotspot" was considered to be limited based on the data collected at surrounding sample locations;
- Concentrations of B(a)P greater than the site criteria were also noted to be present at the Retention Pit sampling location (RP). Free tar was noted to be present within the pipework at this location. The extent of the contamination was stated to be dependant on the depth of the pit and connecting pipework and due to the pit's potential heritage significance deeper sampling was not able to be undertaken. Based on the results from the pit and surrounding sampling locations the vertical extent of the contamination at this location was estimated to be limited to 4 mbgs due to the underlying clays and that the lateral extent was estimated to extend across an approximately 2m radius from the pit.

7.4 Retaining wall area

Based on the results of the subsurface investigation in the Retaining Wall Area of the Site the Report stated the following:

- The retaining wall was stated to be located along the northern boundary of the Site and was stated to be approximately 3 to 5 m in width and 170 m in length;
- Materials used behind the retaining wall were stated to comprise of sandy gravely fill with some building demolition wastes. These materials were noted to be similar to those found within the northern gasholder;
- Concentrations of benzene greater than the site criteria were noted in ashy fill material present at the surface in two locations along the retaining wall (TP44 and TP3);
- Fragments of sheeting containing asbestos were noted throughout the fill materials in the wall;
- At the locations sampled, no impacts were identified in the natural soils beneath the retaining wall and it was therefore considered that the vertical extent of the fill materials to be only the thickness of the retaining wall;
- It was state the material within the retaining wall was unsuitable for use at the Site and that it required remediation or management.

7.5 Western lot area

Based on the results of the subsurface investigation in the Western Lot Area of the Site the Report stated the following:

- The only identified contamination across this area of the Site was stated to be the surface layer of ash and coke gravels. The vertical extent was stated to be approximately 0.5 mbgs. The lateral extent was broadly defined across these areas.

7.6 Remediation volume estimates

Based on the estimated extent of the contamination, presented in the Report, as summarised above, estimates of the volumes of materials that would require remediation were prepared. The estimates were stated to be calculated based on a remediation approach that would be "driven by the removal of free tar impacted fill and natural soil". It was considered that this approach would "remove the source areas and reduce the mass contamination" thereby "enabling the long term objectives for the Site to be met" and would ensure that "any remaining materials do not pose an unacceptable risk to the identified receptors".

The Report provided detail on the nominal measurements and assumptions used to calculate the remediation volume estimates for each sub-area of the Site that was identified as requiring remediation. The assumptions used in the volume estimate calculations included the following:

- The lateral extent of contamination was estimated to be half the distance between a location in which the contamination was identified and the nearest location in which no free tar was observed and/or where concentrations of contaminants either met or were less than the site criteria;
- The extent of free tar material present in the northern gasholder was stated to be unknown. It was assumed that the base 2.0 m of the gasholder was impacted with free tar;
- Demolition waste in the northern gasholder was assumed to have a porosity of 50%;

- No volume estimates were provided for southern gasholder due to it heritage status;
- The extent of underground pipework was stated to be unknown. An estimate of 50 tonnes of pipework was applied;
- Nominal depth of 4 mbgs was applied as the depth of impact across the majority of the former gasworks area, excluding the northern gasholder, the tar wells and part of the gas purifier areas which were given a nominal depth of 8-10 mbgs;
- Nominal depth of 0.5 mbgs for the presence of ash and coke gravels requiring remediation was applied over the entire Site;
- The NSW DEC "General approval for the immobilisation of coals tars" would not be able to be applied to the "free tar materials" without treatment but may apply to the "tarry impacted materials"; and
- NSW DEC "General approval for the immobilisation of ash" would apply to the ash and coke gravel materials identified across the Site.

The Report also stated that inherent uncertainty was present in the estimates provided due to the heterogenous nature of filling materials and the irregular distribution of contaminants across the Site. However, the Report stated that by using visible free tar impacts as an indicator for remediation that the uncertainty was reduced. The Report also stated that given the correlation between PID screening measurements and analytical results during the investigations on the Site, that during the remedial works, the PID would be a "valuable screening technique" during remedial excavations to "determine extent to which chasing out would occur" and "to lower volume uncertainty".

The remediation areas and the estimates on the excavation depths were presented on Figure 7 in the Report (Attachment A) and the calculated volume estimates and potential waste classifications were presented on Table 12.1 of the Report. A summary of these estimates is provided in the table below.

Table 8: Summary of Volume Estimates and Waste Classifications

Remediation Area	Impacted Area and Material Type	Estimated Volume (m^3)	Potential Waste Classification
Tar Wells	Base annulus and immediate area Free Tar Impacts	1000	Hazardous
	Tar well contents Tar	100	Hazardous (Liquid)
Northern Gasholder	Base annulus and immediate area Free Tar Impacts	2100	Hazardous
	Gasholder contents Impacted water Tar	 640 320	Hazardous (Liquid)
	Buried wastes inside annulus Demolition materials	1900	Asbestos/Industrial

Remediation Area	Impacted Area and Material Type	Estimated Volume (m^3)	Potential Waste Classification
Tar Impacted Soils	Shallow Fill and natural clays	9225	Industrial(1)
	Deeper Natural clays and weathered shales	2375	Industrial(1)
	TP16 Hotspot Fill and natural clays	115	Industrial(1)
Site Surfaces	Ash and coke gravels	2950	Solid(1)
Retaining Wall	Gravel sand and demolition waste	1765	Solid
Hotspots	BH14 Fill and natural clays	100	Solid
	MW13s Fill (southwest site area)	140	Solid
	MW04s Fill and natural clays	100	Solid
Pipework	Varying across site Tar and scrap metal	unknown	Hazardous/Solid

Notes: (1) Classification either after treatment and/or application of appropriate NSW DEC General Approval for Immobilisation

Auditor's opinion

The Auditor considers that the volume estimates presented in the Report appear to be consistent with the assumptions adopted in the Report. The Auditor also considers that the uncertainty associated with the estimated volumes was consistent with the assumptions adopted in the Report.

With regard to the southern gasholder, the Auditor understands, given its heritage status, that no remedial activities will be conducted in or directly surrounding the structure. Consequently, no volume estimates were required to be provided for this area of the Site, but the Auditor notes that it is likely that free tar and associated contamination would be present in and directly surrounding the southern gasholder and will remain on the Site after remediation. Potentially, the remaining contamination will provide an ongoing source of contamination to both soil and groundwater on the Site.

The Auditor notes that it is difficult to derive accurate estimates of volumes of material requiring remediation when the contamination has developed in a heterogenous manner. It is the Auditor's opinion that an adequate level of uncertainty is required to be applied to estimates of volumes of materials requiring remediation at the Site.

Based on the results of the investigation it is the Auditor's opinion that the application of the PID as a field screening tool during remediation has not been adequately demonstrated and that it maybe likely that the "chasing out" of contamination will have to be determined based on a combination of visual observation, PID readings and laboratory analysis. This matter is required to be addressed further in the RAP to be developed for the Site.

"This page has been left blank intentionally"

8 REMEDIAL OPTIONS

Remedial options for the Site were presented within the Report. It was stated that as part of the scope of work for the investigations conducted on the Site, CH2MHILL were required to consider the remedial options and management strategies that may apply to the Site. The Report stated that the list of preferred remedial options were determined based on the remediation objectives for the Site, the management considerations during remediation and a set of evaluation criteria. These matters are addressed below.

8.1 Remediation objectives

The Report stated that the remediation objectives for the Site were to remediate:

- "..to a standard suitable for proposed commercial industrial land use;
- ..to a level that mitigates risks to human health and the environment; and
- ..the contamination sources on the Site to the extent where the SRoH declaration can be removed".

Auditor's opinion
The Auditor considers the remediation objectives presented to be appropriate for the purpose of determining a list of preferred remedial options and remedial estimates, given the scale of contamination present on the Site and Railcorp's long term objectives for the Site. Depending on the remedial option adopted the Auditor considers that adjustments to the remediation objectives may be required during the development of the RAP for the Site.

In addition, an important objective for the remedial works is the requirement to deliver an improvement in the quality of groundwater and a reduction in the dimension of the contaminated groundwater plume. This matter is required to be addressed during the development of the RAP for the Site.

8.2 Management during remediation

Given the nature and extent of contamination on the Site, it's location and historical significance, the Report presented a number of factors that would require management during the planning and implementation of the remediation works. These factors were stated as follows:

- Groundwater and surface water – Given the depth required for source removal, the Report anticipated that significant volumes of contaminated water present both within the structures present on the Site and at depth, will require management and potential treatment and/or offsite disposal;
- Odours – The Report highlighted that the residential properties present adjacent to the western boundary of the Site will require protection from potential exposure to odours emitted during remediation works. It was considered that pre-remedial work would be necessary to provide for controls of odour emissions and that management measures such as capturing and treating vapours and/or odour masking agents would be required.
- Archaeological and heritage matters – The Report presented the findings of a report prepared by Heritage Concepts Pty Ltd which documented the items of archaeological and heritage importance and provided recommendations on the management of these items during remediation. The Report listed the following considerations:
    - The retention and preservation of the southern gasholder

- Completion of an archival photographic record to document all existing items prior to remediation
- During remediation works, archaeological monitoring and recording should be undertaken to monitor the discovery of any unknown items of potential historical significance
- The retention, in-situ, of any significant elements of the gasworks and completion of an assessment of the historical significance and degree of contamination of those elements
- Any items of archaeological significance uncovered during site remediation should be retained, protected and interpreted with appropriate signage post-remediation
- The protection and interpretation of all remaining gasworks elements should be incorporated into the final design of the Site.

The Report stated that the heritage considerations were subject to an evaluation of the degree of contamination and potential human health risks compared to the heritage significance of an item.

8.3 Evaluation criteria

The criteria used to evaluate the remedial options for the Site and to determine the preferred option were presented in the Report. The criteria used to assess each remedial option included the effectiveness of the remedial option to achieve the objectives of the remediation, the timeframe required, likelihood of community and regulatory acceptance, flexibility of the remedial option to fit in with other aspects of the redevelopment of the Site including potential changes during re-development, ability to re-use contaminated materials, indicative cost of the remedial option and the potential ongoing requirements for management and/or maintenance after remediation.

8.4 List of remedial options

The Report stated that based on commercially available technologies a “long list of remedial options” was initially put together. This list was then stated to have been subject to a “fatal flaw analysis” to assess which of the options could be applied to the remediation of the Site, with the options identified as having a “fatal flaw” or unlikely to meet the remediation objectives, removed from the list. The long list of remedial options and details on the fatal flaw analysis were included in Appendix F of the Report.

The resultant, shorter, list of remedial options that remained after the fatal flaw analysis and that were considered to be potentially applicable to the Site were then presented in detail within the Report and have been summarised below.

8.4.1 No action

The Report stated that this option would not address the SRoH issues or make the Site suitable for the proposed land use.

Auditor’s opinion
Given that the “No Action” option does not satisfy any of the remediation objectives, the Auditor considers that it should not have been included in the short list of remedial options for the Site.

8.4.2 Institutional controls

The Report stated that intuitional controls such as a Site Management Plan and access restrictions would need to be applied as a component of the remedial strategy for the Site where the presence of residual contamination may require management after remediation. The Report stated that such controls would be required particularly in areas where the presence of heritage items will prevent remedial works being undertaken.

8.4.3 In situ physical/chemical treatment

The Report provided detail on two technologies, in-situ chemical oxidation and in-situ soil vapour extraction, which were stated to be suitable for application after the removal or pre-treatment of source materials. It was stated that both technologies could be used to treat residual BTEX contamination at depths at which excavation may be limited by physical or economic constraints. In situ chemical oxidation was also stated to potentially be able to address groundwater impacts in the bedrock over the long term by treating leaching BTEX compounds. However, the effectiveness of this technology was stated to be limited by the presence of other oxidant-consuming materials such as organic matter often associated with gasworks sites.

Pilot tests were recommended as being required prior to further consideration of these technologies.

8.4.4 In situ thermal treatment

The Report stated that in situ thermal treatment could be applied in combination with in situ soil vapour extraction to increase the effectiveness of the volatile extraction over a shorter time period. It was stated that this option would be applicable after source removal at the limit of excavation depth or in the vicinity of the retained gasholder. The effectiveness of this option was considered to potentially be limited by the groundwater present in the bedrock.

8.4.5 Ex situ biological treatment

The Report provided detail on three treatment options, biopiles, composting and landfarming which were classified as being ex situ biological treatment which would assist in remediating some organic contaminants. It was stated that this type of treatment would likely result in high fugitive and odorous emissions and is not suitable for grossly impacted materials such as free tar. This type of treatment was also stated to historically have not been particularly effective for heavy multi–ring organic compounds, such as those present in tars, but could be effective in reducing the more volatile compounds. Given the constraints at the Site it was stated that this type of treatment would require the establishment of an alternate treatment site.

8.4.6 Ex situ physical/chemical treatment

The Report provided detail on solidification/stabilisation/immobilisation and chemical extraction treatment methodologies.

Solidification/stabilisation/immobilisation processes were stated to be appropriate for materials such as free tar and materials containing tar and/or moderate concentrations of organic contaminants. It was stated that this treatment option could be used in conjunction with NSW DECC's general immobilisation approvals for coal tar wastes 2005/14 from former gasworks sites and which requires treatment of such waste materials with calcium or magnesium based cements and 1999/05 for ash and coke impacted material where PAH contamination can be

demonstrated to be immobile with ash and coke materials. The Report also stated that this treatment of ash and coke materials may enable these materials to be retained on Site, in combination with a physical barrier and an appropriate management plan.

Chemical extraction technologies were stated to potentially be applicable only for old service lines and that pipework containing residual tar and would require treatment of the resulting solution containing the contaminants as well as treatment and disposal of the chemically treated pipework.

8.4.7 Ex situ thermal treatment

The Report provided detail on incineration and co-burning and thermal desorption treatment methodologies. Both technologies were stated to be applicable for high-organic content materials, such as free tar wastes. It was stated that incineration and co-burning would allow material to be pre-treated to improve handling and transport and also would allow materials to either be stabilised or be subject to other off site treatments to reduce the mass of soil material and oversize materials. However, it was stated that there may be issues gaining the necessary approvals for this type of treatment. For thermal desorption it was stated that an alternative treatment site would be required and that there may be issues relating to the availability and commissioning of a treatment unit.

8.4.8 Containment

The Report stated that capping and or the establishment of a containment area may be applicable given the presence of "relatively shallow impacts of non-leaching materials and/or materials that meet land use criteria". The areas of the Site to which this applies were stated to be the Northeast, South Central, Southwest, Western lot and sections of the Retaining wall areas. It was also stated that this option would require a long-term management plan.

Auditor's opinion
The Auditor considers that if any containment were to be considered for the Site, including a capping system or cell, then appropriate justification of this option, including the location of the containment, the structure and engineering properties of the containment, the nature, including leachability of the materials to be contained, the management of the containment over time and monitoring of media in which contaminants may potentially migrate, would need to be provided within the RAP for the Site.

8.4.9 Disposal

The Report stated that given the presence of highly impacted materials on the Site and the preliminary waste classifications conducted, off-site disposal of these materials from the Site would only be applicable in combination with other technologies.

Auditor's opinion
The Auditor also notes that some disposal to an off-site location may be possible through the application of the NSW DECC's immobilisation approvals.

8.4.10 Reuse and recycle

The Report sated that oversize materials and fill material meeting land use criteria and /or that are approved for immobilisation under NSW DECC immobilisation approvals may be able to be removed to a recycling facility or may be used to backfill excavated sections of the Site. It was stated that this option may apply to the demolition waste materials inside the northern gasholder

and the retaining wall, with consideration given to disposal requirements for asbestos containing materials.

Auditor's opinion

The Auditor considers that the preferred remedial options presented in the Report provided an adequate preliminary analysis of the applicability of individual remedial methodologies that may be applied in the remediation of the Site and the management options that may also be required post-remediation of the Site.

Given the nature and extent of the contamination on the Site, the physical constraints of the Site and the remedial objectives it is the Auditor's opinion that a combination of remedial and management options will need to be applied as part of the overall remedial strategy for the Site that will be presented in the RAP.

The Auditor requires the RAP to address requirements for management and monitoring of groundwater quality as a component of the option or options adopted for remediating the Site. In addition, the Auditor requires that the RAP address in detail the requirement for pos-remediation management of contaminated soil that will remain on the Site.

"This page has been left blank intentionally"

9 INVESTIGATION CONCLUSIONS

The conclusions of the Report were presented so as to address the DQOs for the investigation. Based on the results of the investigation the Report concluded the following:

- The investigation identified the contamination sources on the Site as follows:
  - Tar wells
  - Network of underground pipes
  - Base annulus of northern gasholder
  - Tar present in soil pores and fractures
  - Base annulus of southern gasholder as a secondary source
  - Demolition wastes containing asbestos sheeting
  - Ash and coke fill materials present across the majority of the Site within the surface a shallow subsurface materials
- The investigation identified the exposure scenarios for the Site as follows:
  - Construction and maintenance Railcorp employees and contractors who may be exposed to impacted soil (including dusts), water and vapours
  - Residents of surrounding properties who may be exposed to impacted dust, water and vapours
  - Users of groundwater extracted down-gradient of the Site;
  - Hypogean ecosystems may be exposed to impacted waters
  - Ecosystems of receiving waters (Alexandra Canal) may be exposed to impacted waters
- The results obtained from the delineation investigation was “sufficient to understand the degree of Site contamination and distribution of contaminants” and “to identify and characterise different fill and natural soil types..” enabling the application of “…appropriate statistical analysis to be undertaken to assess material suitability for the proposed land use”;
- The vertical extent of contamination was stated to have been delineated in all sub-areas of the Site;
- The lateral extent of contamination was stated to have been delineated due to the sampling density and “high level of understanding of the historical layout”. It was stated that the previous uncertainty surrounding the lateral extent of the source areas on the Site (tar wells, underground pipework, base annulus of the northern and southern gasholder) had been significantly reduced as a result of the delineation investigation;
- The results of the delineation investigation were stated to have identified that remediation of the contamination sources will adequately reduce the risks associated with the Site;
- The results of the delineation investigation were stated to enable a robust and definitive RAP to be developed to address the remediation of the Site and that given Railcorp’s long-term objectives for the Site, that the remediation strategy for the Site needs to be directed at removing or reducing, to the extent practicable, the contamination source areas present

on the Site and that this approach will likely result in a reduction of the exposure pathways to site users and environmental receptors;

- It was concluded that the RAP should be developed based on the remedial options presented in the Report and it was considered that the "selection of a suitable remedial option and assessment of its feasibility would provide for the appropriate management of areas that show minor impacts in the deep weathered zones of bedrock shales, particularly once source zones have been remediated";
- The Report also stated that to assess the effectiveness of the remediation in reducing the risks on the Site, ongoing groundwater monitoring will be required post-remediation, to monitor the status of natural attenuation of the contamination plume in both the shallow groundwater and deeper bedrock groundwater systems on and off the Site; and
- "Sound estimates on remedial volumes" were stated to have been able to be undertaken as part of this investigation due to the "high level of understanding of contamination distribution, both laterally and vertically and of subsurface conditions particularly subsurface structures and contents remaining at the Site".

10 AUDIT CONCLUSIONS

It is the Auditor's opinion that the investigation program undertaken by CH2MHILL was conducted in general accordance with relevant guidelines endorsed by NSW DECC and that the scope of work completed was appropriate to meet the objectives of the investigation. Where requirements of guidelines endorsed by DECC were not addressed appropriately, the Auditor is satisfied these did not adversely impact the outcome of the investigation program.

The Auditor notes that one of the objectives of CH2MHILL's investigation was to provide to Railcorp, under separate cover to the Report, indicative remedial cost estimates. The Auditor notes that it is not part of the scope of the Audit to undertake review or provide comment on such matters and this objective has not been addressed within this SAR.

10.1 Delineation and characterisation of contamination

The Auditor considers that the subsurface investigations conducted by CH2MHILL were appropriate given the results of the previous investigations and the requirement to address the data gaps present on the Site. The Auditor acknowledges that in some locations, particularly in the vicinity of the former gasworks structures that items of historical significance uncovered during the investigation or items already heritage listed, restricted the extent of the investigations. Similarly, the extent of some sub-surface structures such as the pipework, which was stated to be likely to be extensive, was not able to be determined.

Despite these limitations, the Auditor considers that, in general, the discussion of the results of the previous investigations, the results of the subsurface investigation and the delineation of the contamination for each sub-area on the Site were appropriate for the purposes of estimating the extent of remediation required and to present the remedial options for the Site.

The Auditor notes that, given the objectives of the investigation and the results of previous investigations, an assessment of groundwater as part of the investigation was not considered to be necessary as it was considered that sufficient information was available regarding groundwater conditions on the Site and on the Railcorp properties. The Auditor understands that the groundwater conditions present beneath the Site and the remedial approach and management options for the groundwater on the Site will be addressed within the RAP.

In addition, given the noted deficiencies in the presentation of the assessment of the field and laboratory QA/QC within the Report, the Auditor also requires that the RAP provide detail on the DQO approach relating to field and laboratory QA/QC during the remediation works and validation program and how the assessment of the reliability of the results will be presented in the validation report.

10.2 Remedial volume estimates

The Auditor considers that the volume estimates presented in the Report appear to be consistent with the assumptions adopted in the Report. The Auditor also considers that the uncertainty associated with the estimated volumes was consistent with the assumptions adopted in the Report.

With regard to the southern gasholder, the Auditor understands, given its heritage status, that no remedial activities will be conducted in or directly surrounding the structure. Consequently, no volume estimates were required to be provided for this area of the Site, but the Auditor notes that it is likely that a free tar and associated contamination would be present in and directly surrounding the southern gasholder and will remain on the Site after remediation. Potentially,

the remaining contamination will provide an ongoing source of contamination to both soil and groundwater on the Site.

The Auditor notes that it is difficult to derive accurate estimates of volumes of material requiring remediation when the contamination has developed in a heterogenous manner. It is the Auditor's opinion that an adequate level of uncertainty is required to be applied to estimates of volumes of materials requiring remediation at the Site.

10.3 Remedial options

The Auditor considers that the preferred remedial options presented in the Report provided an adequate preliminary analysis of the applicability of individual remedial methodologies that may be applied in the remediation of the Site and the management options that may also be required post-remediation of the Site.

Given the nature and extent of the contamination on the Site, the physical constraints of the Site and the remedial objectives it is the Auditor's opinion that a combination of remedial and management options will need to be applied as part of the overall remedial strategy for the Site. The Auditor requires that further detail and discussion on the remedial options and strategy for the Site can be provided within the RAP.

10.4 Audit summary

In consideration of the results presented within the Report, the Auditor concurs with the conclusions made within the Report that, in order to meet Railcorp's long term objectives for the Site, the remediation strategy for the Site needs to be directed at removing or reducing, to the extent practicable, the contamination source areas present on the Site. The Auditor agrees that this approach will likely result in a reduction of the exposure pathways to site users and environmental receptors.

However, it is the Auditor's opinion, that given the nature and extent of the contamination and the heritage and physical constraints on the Site, complete removal of source material on the Site is unlikely to be able to be achieved and that management strategies, including development of a site management plan including groundwater monitoring, will form a significant component of the remedial strategy for the Site. The Auditor requires that the detail on such strategies be provided within the RAP.

This Site Audit addresses the requirements that are required to be fulfilled for the Audit process. However, these requirements are separate to requirements that are expected to be required by regulatory authorities. Given that some of the remedial options presented are likely to require the approval and/or input of relevant regulatory authorities, it is the Auditor's opinion that in determining the remedial options and in developing the RAP for the Site, that full consideration is given to the requirements of relevant regulatory authorities that these requirements be addressed within the RAP.

11 REFERENCES

ANZECC, 1992. Australian Water Quality Guidelines for Fresh and Marine Waters. Australian and New Zealand Environment and Conservation Council.

ANZECC/ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resourced Management Council of Australia and New Zealand.

ANZECC/NHMRC, 1992. Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites. Australian and New Zealand Environment and Conservation Council and National Health and Medical Research Council.

Australian Standard AS 4482.1-1997. Guide to sampling and investigation of potentially contaminated soil: Part 2: Non-volatile and semi-volatile substances. Standards Australia.

Australian Standard AS 4482.1-1999. Guide to sampling and investigation of potentially contaminated soil: Part 2: Volatile substances. Standards Australia.

CH2MHILL, 2006. Sampling, Analysis and Quality Plan, Delineation and Characterisation – Macdonaldtown Former Gasworks Site – Draft. July 2006. CH2MHILL Australia Pty Ltd

Imray, P and G Neville, 1993. Approaches to the Assessment and Management of Asbestos Contaminated Soils. Second National Workshop on the health risk Assessment and management of Contaminated Sites, South Australian Health Commission.

MHSPE, 1994. Environmental Quality Objectives in the Netherlands. Ministry of Housing, Spatial Planning and the Environment.

NEHF, 1998. Health-Based Soil Investigation Levels. National Environmental Health Forum Monographs. Soil Series No 2. National Environmental Health Forum.

NEPC, 1999a. Guideline on the Investigation Levels for Soil and Groundwater. Schedule B(1). National Environmental Protection Measure. National Environmental Protection Council.

NEPC, 1999b. Guideline on Data Collection, Sample Design and Reporting. Schedule B(2). National Environmental Protection Measure. National Environmental Protection Council.

NEPC 1999c. Guideline on Laboratory Analysis of Potentially Contaminated Soils. Schedule B(3). National Environmental Protection Measure. National Environmental Protection Council.

NEPC, 1999d. Guideline on Health Risk Assessment Methodology. Schedule B(4). National Environmental Protection Measure. National Environmental Protection Council.

NSW DEC, 2007. Guidelines for the Assessment and Management of Groundwater Contamination. NSW Department of Environment and Conservation

NSW DEC, 2006. Guidelines for the NSW Site Auditor Scheme (2nd edition). NSW Department of Environment and Conservation.

NSW DEC, 2004. Environmental Guidelines: Assessment, Classification & Management of Liquid & Non-liquid Wastes. NSW Department of Environment and Conservation

NSW EPA, 1994. Contaminated Sites: Guidelines for Assessing Service Station Sites. NSW Environment Protection Authority.

NSW EPA, 1995. Contaminated Sites: Sampling Design Guidelines. NSW Environment Protection Authority.

NSW EPA, 1996. Environmental Guidelines: Solid Waste Landfills. NSW Environment Protection Authority.

NSW EPA, 1997. Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites. NSW Environment Protection Authority.

12 GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ACM. Asbestos containing material(s).
ANZECC. Australian and New Zealand Environment and Conservation Council.
AHD. Australian Height Datum.
APHA. American Public Health Association.
ASS. Acid Sulfate Soil.
B(a)P. Benzo(a)pyrene (a PAH).
BTEX. Benzene, toluene, ethylbenzene and xylenes.
CCA. Copper chrome arsenate.
DQOs. Data Quality Objectives.
DQIs. Data Quality Indicators.
EPA. New South Wales Environment Protection Authority.
EMP. Environmental Management Plan.
HASP. Health and Safety Plan.
HRA. Health Risk Assessment.
NEHF. National Environmental Health Forum.
NEPC. National Environmental Protection Measure.
NSW DEC. New South Wales Department of Environment and Conservation
NSW DECC. New South Wales Department of Environment and Climate Change
NSW EPA. New South Wales Environment Protection Authority.
OCPs. Organochlorine pesticides.
OH&S. Occupational Health & Safety.
OPPs. Organophosphorus pesticides.
PAHs. Polynuclear Aromatic Hydrocarbons.
PCBs. Polychlorinated biphenyls.
PID. Photoionisation detector.
PQL. Practical quantitation level.
PSH. Phase Separated Hydrocarbon.
QA. Quality Assurance.
QC. Quality Control.
RAP. Remedial Action Plan.
RPD. Relative Percent Difference.
SAP. Sampling and Analytical Plan.
SMP. Soil or Site Management Plan
SVOCs. Semi-volatile Organic Compounds.
SWL. Standing Water level.
UCL. Upper Confidence Limit (on mean).
USEPA. United States Environment Protection Agency.
UST. Underground Storage Tank.
VENM. Virgin excavated natural material.
VOC. Volatile Organic Compound.

Terms relating to chemical analysis methods:
AES. Atomic emission spectrometry.
CV-AAS. Cold vapour atomic absorption spectrometry
GC/ECD. Gas chromatography/electron capture detector.
GC/FID. Gas chromatography/flame ionisation detector.
GC/NPD. Gas chromatography/nitrogen/phosphorus detector.
CG/MS. Gas chromatography/mass spectrometry.
GC/PID. Gas chromatography/photoionisation detector.
ICP Inductively coupled plasma.
OES. Optical emission spectrometry.

P&T. Purge and trap.

Units:
ha. hectare.
km. kilometre.
m. metre.
mbgs. metres below ground surface
mg/kg. milligrams/kilogram.
ppm. parts per million.
mg/L. milligrams/litre.
μg/L. micrograms/litre.
t. tonne.

Attachment A: Figures from CH2MHill Report

"This page has been left blank intentionally"

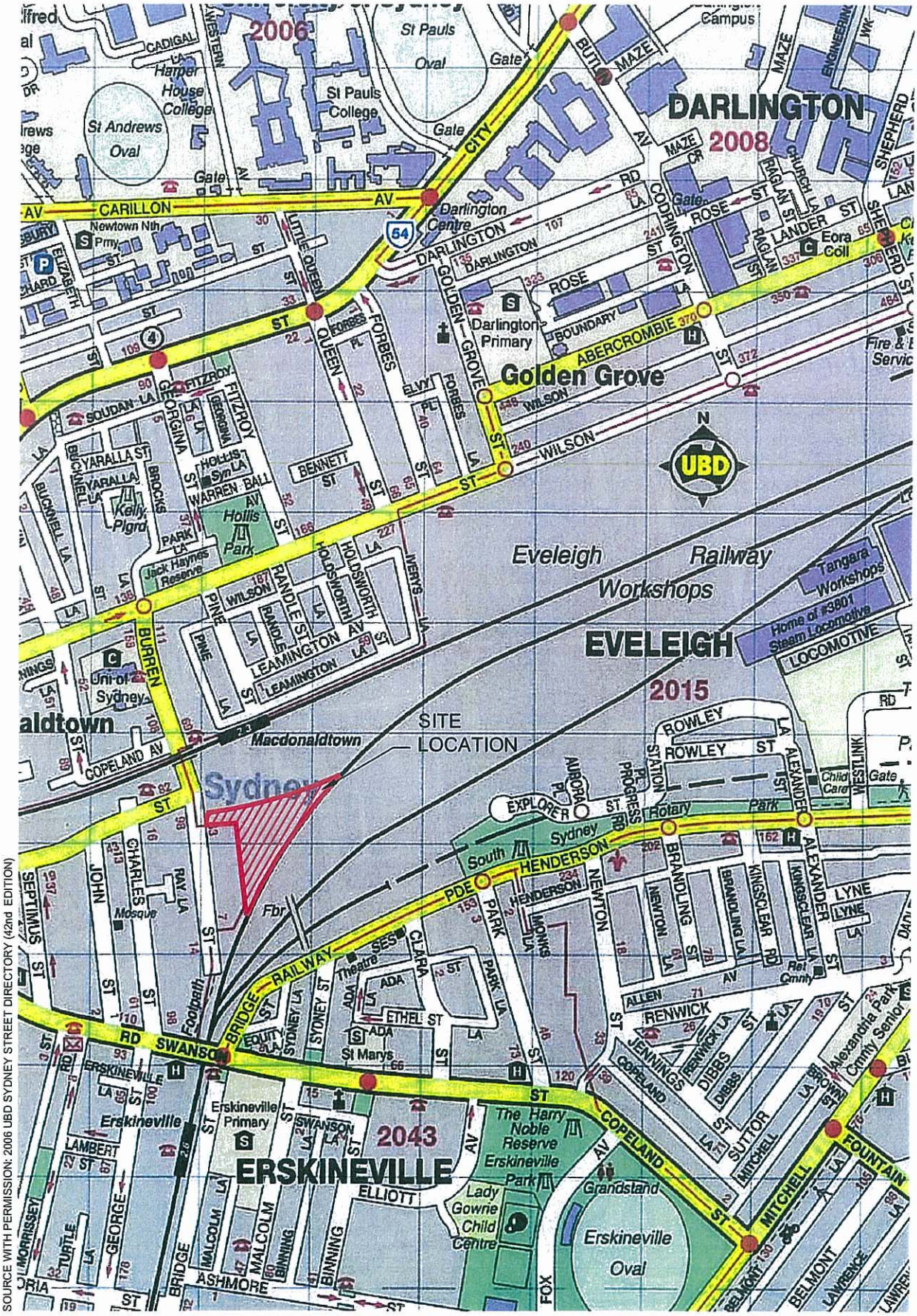


Figure 1
Site Location

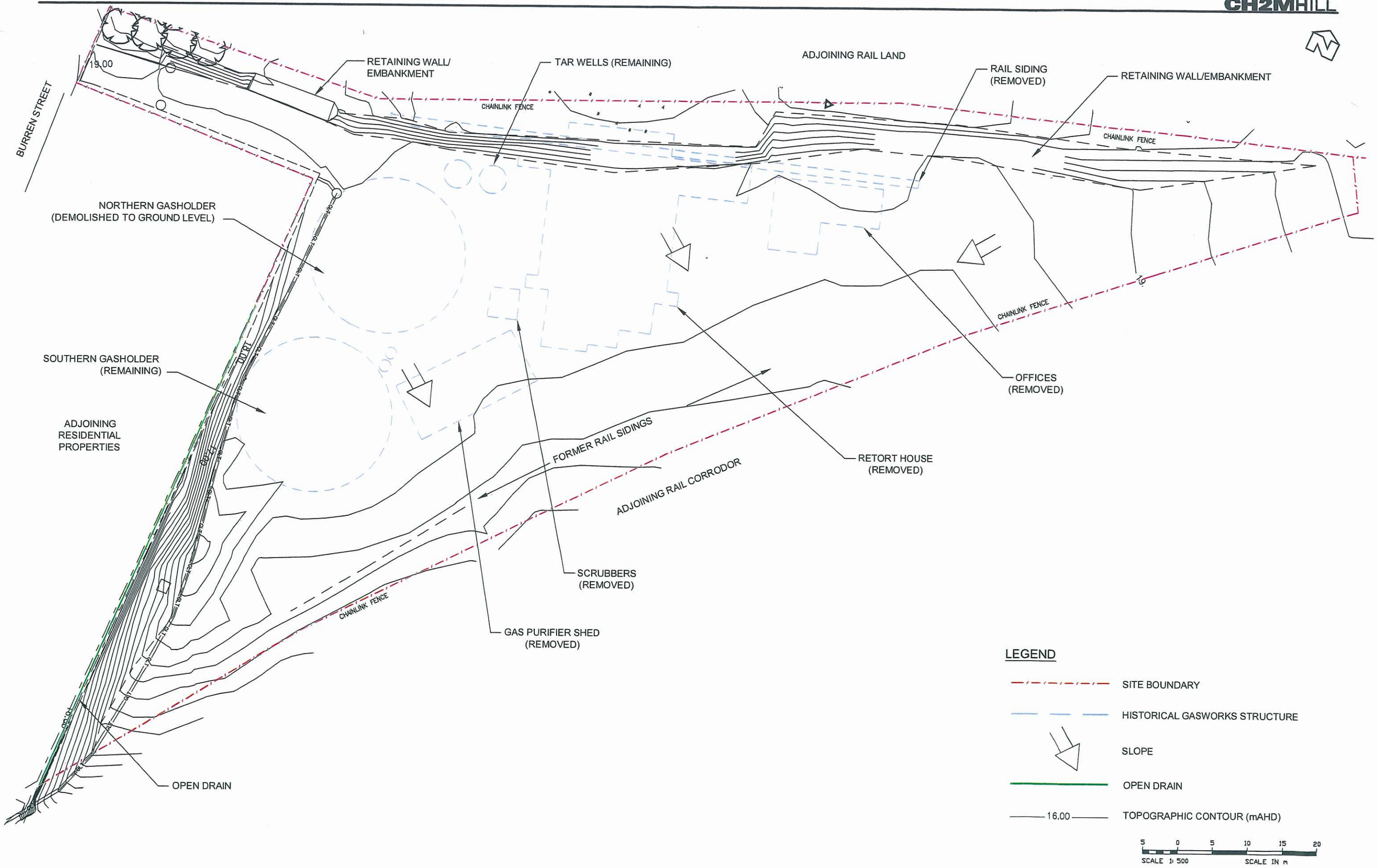
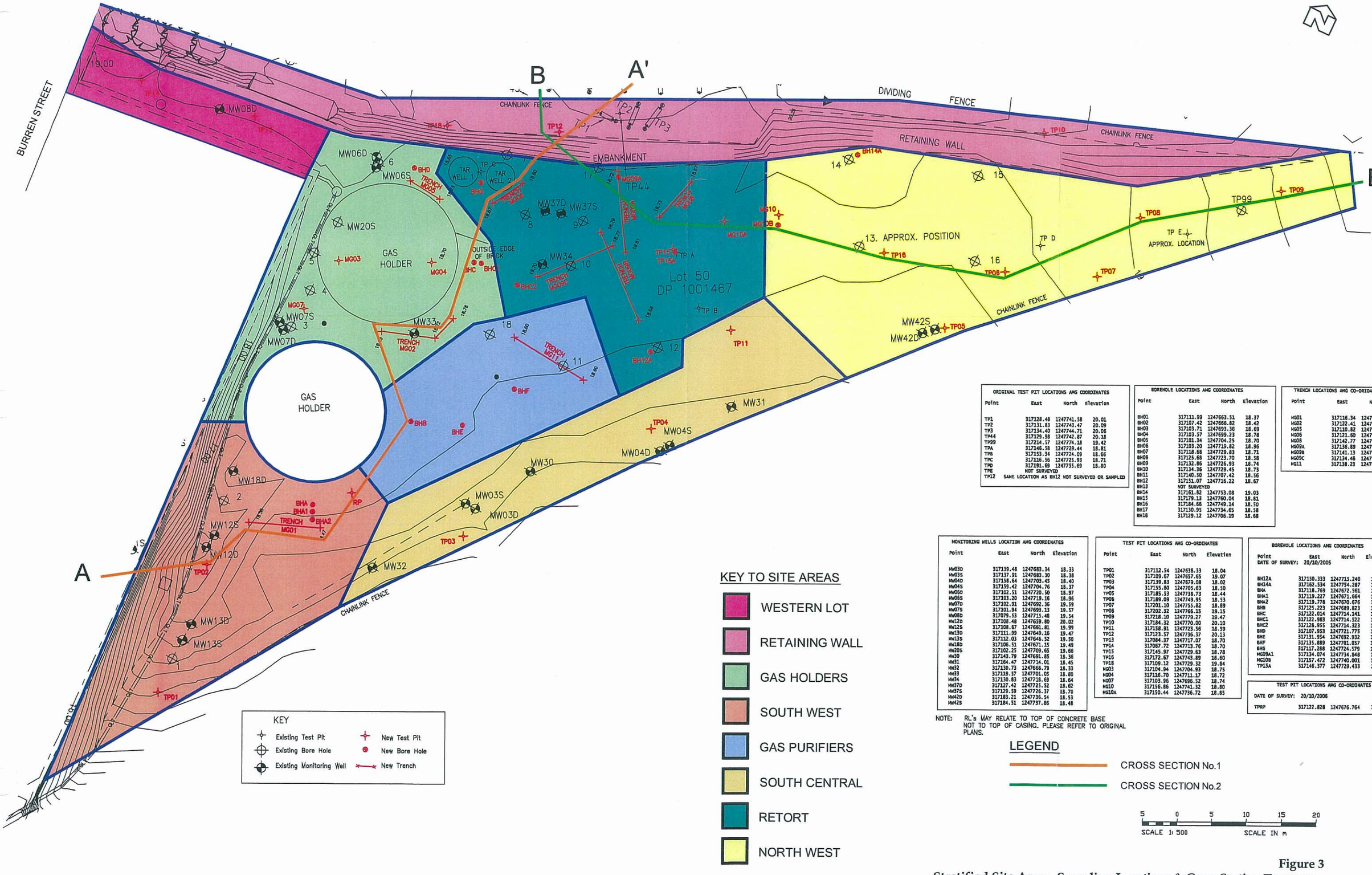


Figure 2
Current & Historical Site Layout



KEY

Existing Test Pit	New Test Pit
Existing Bore Hole	New Bore Hole
Existing Monitoring Well	New Trench

KEY TO SITE AREAS

- WESTERN LOT
- RETAINING WALL
- GAS HOLDERS
- SOUTH WEST
- GAS PURIFIERS
- SOUTH CENTRAL
- RETORT
- NORTH WEST

ORIGINAL TEST PIT LOCATIONS AMG COORDINATES

Point	East	North	Elevation
TP1	317128.48	1247741.58	20.01
TP2	317131.83	1247743.47	20.09
TP3	317134.40	1247744.71	20.06
TP44	317129.98	1247742.87	20.18
TP99	317214.37	1247774.18	19.42
TPA	317146.58	1247729.44	18.81
TPB	317153.34	1247724.09	18.66
TPC	317136.56	1247725.93	18.71
TPD	317191.69	1247733.69	18.80
TPE	NOT SURVEYED		
TP12	SAME LOCATION AS BH12 NOT SURVEYED OR SAMPLED		

BOREHOLE LOCATIONS AMG COORDINATES

Point	East	North	Elevation
BH01	317111.99	1247663.51	18.37
BH02	317107.42	1247666.82	18.42
BH03	317103.71	1247693.36	18.69
BH04	317103.37	1247699.23	18.78
BH05	317101.34	1247704.25	18.70
BH06	317103.20	1247719.82	18.96
BH07	317118.68	1247728.83	18.71
BH08	317123.68	1247723.70	18.58
BH09	317132.86	1247726.93	18.74
BH10	317134.36	1247729.45	18.73
BH11	317140.50	1247707.42	18.56
BH12	317151.07	1247716.22	18.67
BH13	NOT SURVEYED		
BH14	317161.82	1247753.08	19.03
BH15	317179.13	1247760.04	18.81
BH16	317184.66	1247749.14	18.50
BH17	317130.95	1247734.65	18.58
BH18	317129.12	1247706.19	18.68

TRENCH LOCATIONS AMG CO-ORDINATES

Point	East	North
MG01	317116.34	1247667.86
MG02	317122.41	1247701.92
MG05	317130.82	1247719.75
MG06	317121.60	1247725.15
MG08	317142.77	1247736.07
MG09A	317136.89	1247730.65
MG09B	317141.13	1247722.61
MG09C	317134.46	1247721.27
MG11	317138.23	1247707.26

MONITORING WELLS LOCATION AMG COORDINATES

Point	East	North	Elevation
MW03D	317139.48	1247683.34	18.33
MW03S	317137.91	1247683.30	18.38
MW04D	317158.64	1247703.45	18.40
MW04S	317159.42	1247704.76	18.37
MW06D	317102.51	1247720.50	18.97
MW06S	317103.20	1247719.16	18.96
MW07D	317102.91	1247692.36	19.59
MW07S	317101.94	1247693.13	19.57
MW08D	317079.53	1247715.48	19.54
MW12D	317108.48	1247659.80	20.02
MW12S	317108.67	1247681.81	19.99
MW13D	317111.99	1247649.16	19.47
MW13S	317112.03	1247646.52	19.50
MW18D	317106.51	1247671.15	19.48
MW20S	317102.25	1247709.65	19.66
MW30	317143.79	1247691.85	18.36
MW31	317164.47	1247714.01	18.45
MW32	317130.73	1247668.79	18.33
MW33	317139.57	1247701.05	18.80
MW34	317130.83	1247718.69	18.64
MW37D	317127.42	1247725.52	18.62
MW37S	317129.59	1247726.37	18.70
MW42D	317183.21	1247736.54	18.53
MW42S	317184.51	1247737.86	18.48

TEST PIT LOCATIONS AMG CO-ORDINATES

Point	East	North	Elevation
TP01	317112.54	1247638.33	18.04
TP02	317109.67	1247657.65	19.07
TP03	317139.83	1247679.08	18.02
TP04	317155.80	1247705.63	18.50
TP05	317185.53	1247738.73	18.44
TP06	317189.09	1247749.95	18.53
TP07	317201.10	1247755.82	18.89
TP08	317202.32	1247766.15	19.15
TP09	317218.10	1247779.27	19.47
TP10	317184.32	1247770.00	20.10
TP11	317158.91	1247723.56	18.59
TP12	317123.57	1247736.37	20.13
TP13	317084.37	1247717.07	18.70
TP14	317067.72	1247713.76	18.70
TP15	317145.97	1247729.63	18.78
TP16	317172.67	1247743.89	18.60
TP18	317109.12	1247729.32	19.84
MG03	317104.94	1247704.93	18.75
MG04	317116.70	1247711.17	18.72
MG07	317103.86	1247696.52	18.74
MG10	317156.86	1247741.32	18.80
MG10A	317150.44	1247736.72	18.85

BOREHOLE LOCATIONS AMG COORDINATES

Point	East	North	Elevation
DATE OF SURVEY: 20/10/2006			
BH12A	317150.333	1247715.240	18.63
BH14A	317162.534	1247754.287	18.89
BHA	317118.769	1247672.561	18.46
BHA1	317119.227	1247671.664	18.41
BHA2	317119.778	1247670.576	18.48
BHB	317125.223	1247689.823	18.49
BHC	317122.014	1247714.141	18.78
BHC1	317122.983	1247714.322	18.75
BHC2	317128.555	1247714.323	18.66
BHD	317107.853	1247721.775	18.86
BHE	317131.954	1247692.932	18.50
BHF	317131.889	1247701.057	18.56
BHG	317117.288	1247724.579	18.61
MG09A1	317134.074	1247734.848	18.44
MG10B	317157.472	1247740.001	18.82
TP15A	317146.377	1247729.433	18.80

TEST PIT LOCATIONS AMG CO-ORDINATES

DATE OF SURVEY: 20/10/2006			
TPRP	317122.828	1247676.764	18.37

NOTE: RL's MAY RELATE TO TOP OF CONCRETE BASE NOT TO TOP OF CASING. PLEASE REFER TO ORIGINAL PLANS.

LEGEND

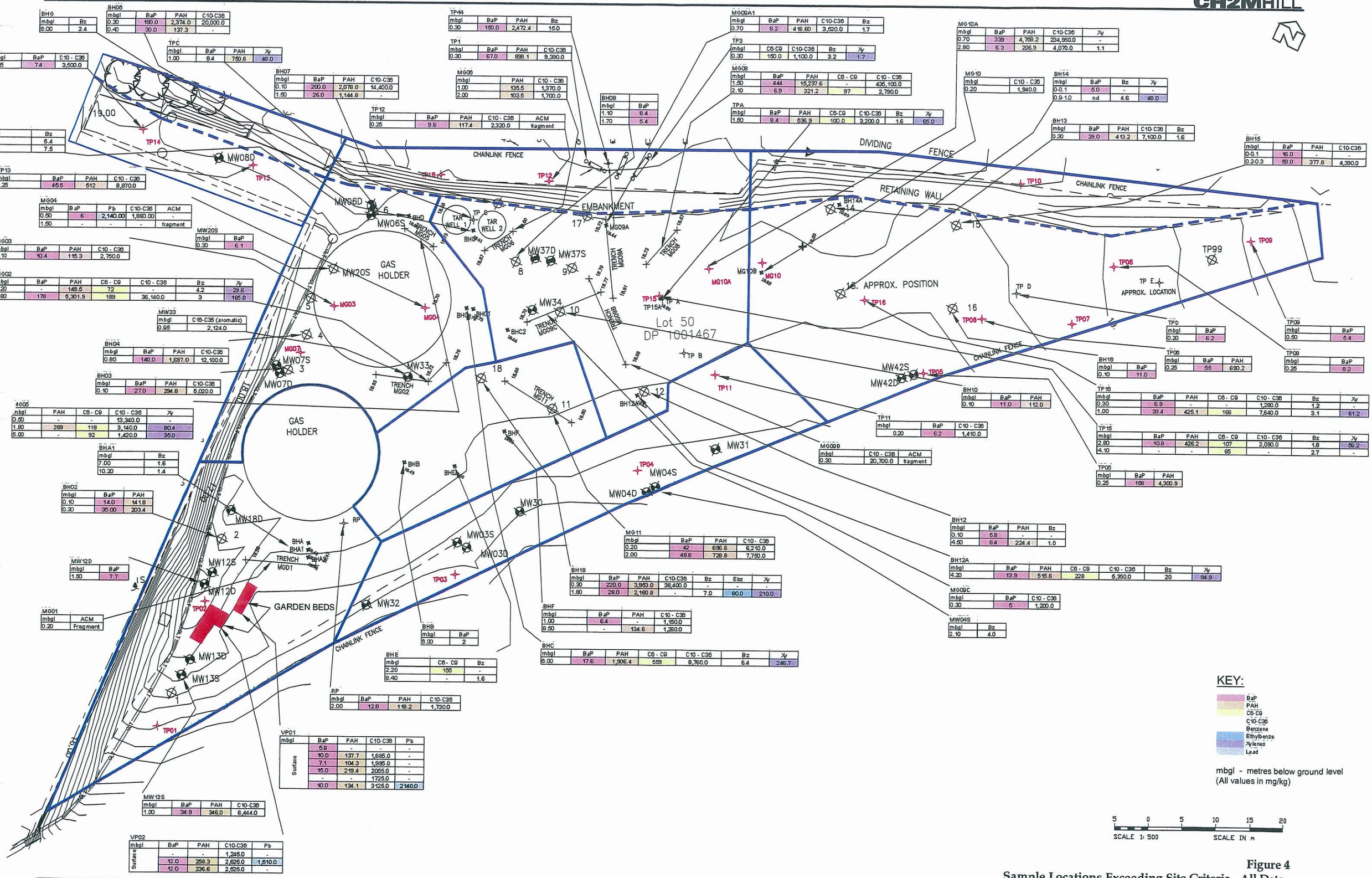
- CROSS SECTION No.1
- CROSS SECTION No.2

5 0 5 10 15 20
SCALE 1: 500 SCALE IN m

Figure 3
Stratified Site Areas, Sampling Locations & Cross Section Transects

Rail Corporation NSW
Delineation Investigation
Former Macdonaldtown Gasworks

CH2MHILL



BH6	
mbgl	Bz
6.00	2.4

BH06			
mbgl	BaP	PAH	C10-C36
0.30	190.0	2,374.0	20,000.0
0.40	30.0	137.3	-

TPC			
mbgl	BaP	PAH	Xy
1.00	8.4	760.6	48.0

BH07			
mbgl	BaP	PAH	C10-C36
0.10	200.0	2,078.0	14,400.0
1.50	26.0	1,144.8	-

TP44			
mbgl	BaP	PAH	Bz
0.30	150.0	2,472.4	15.0

TP1			
mbgl	BaP	PAH	C10-C36
0.30	67.0	899.1	9,390.0

MG06		
mbgl	PAH	C10 - C36
1.00	135.5	1,370.0
2.00	103.5	1,700.0

BH09	
mbgl	BaP
1.10	8.4
1.70	5.4

TP12				
mbgl	BaP	PAH	C10 - C36	ACM
0.25	9.6	117.4	2,320.0	fragment

MG09A1				
mbgl	BaP	PAH	C10-C36	Bz
0.70	8.2	416.60	3,520.0	1.7

TP3					
mbgl	C6-C9	C10-C36	Bz	Xy	
0.30	150.0	1,100.0	3.2	1.7	

MG08				
mbgl	BaP	PAH	C6 - C9	C10 - C36
1.50	444	15,237.6	-	435,100.0
2.10	6.9	321.2	97	2,790.0

TPA							
mbgl	BaP	PAH	C6-C9	C10-C36	Bz	Xy	
1.60	8.4	536.9	100.0	3,200.0	1.6	65.0	

MG10A				
mbgl	BaP	PAH	C10-C36	Xy
0.70	339	4,768.2	234,950.0	-
2.80	6.3	206.9	4,070.0	1.1

MG10	
mbgl	C10 - C36
0.20	1,940.0

BH14				
mbgl	BaP	Bz	Xy	
0-0.1	5.0	-	-	
0.9-1.0	nd	4.6	48.0	

BH13					
mbgl	BaP	PAH	C10-C36	Bz	
0.30	39.0	413.2	7,100.0	1.6	

BH15			
mbgl	BaP	PAH	C10-C36
0-0.1	16.0	-	-
0.2-0.3	69.0	377.6	4,390.0

BHD	
mbgl	Bz
7.00	5.4
8.40	7.5

TP13			
mbgl	BaP	PAH	C10 - C36
0.25	45.5	512	8,870.0

MG04					
mbgl	BaP	Pb	C10-C36	ACM	
0.50	6	2,140.00	1,980.00	-	
1.50	-	-	-	fragment	

MW20S	
mbgl	BaP
0.30	6.1

MG03			
mbgl	BaP	PAH	C10 - C36
0.10	10.4	115.3	2,750.0

MG02						
mbgl	BaP	PAH	C6 - C9	C10 - C36	Bz	Xy
0.20	-	149.5	72	-	4.2	29.6
1.80	178	5,301.9	189	36,140.0	3	165.8

MW33	
mbgl	C16-C35 (aromatic)
0.95	2,124.0

BH04			
mbgl	BaP	PAH	C10-C36
0.80	140.0	1,697.0	12,100.0

BH03			
mbgl	BaP	PAH	C10-C36
0.10	27.0	294.8	5,020.0

MG05				
mbgl	PAH	C6 - C9	C10 - C36	Xy
0.50	-	-	13,340.0	-
1.80	269	118	3,140.0	80.4
5.00	-	92	1,420.0	35.0

BHA1	
mbgl	Bz
7.00	1.6
10.20	1.4

BH02		
mbgl	BaP	PAH
0.10	14.0	141.8
0.30	35.00	203.4

MW12D	
mbgl	BaP
1.50	7.7

MG01	
mbgl	ACM
0.20	Fragment

BHB	
mbgl	BaP
6.00	2

BHE			
mbgl	C6 - C9	Bz	
2.20	155	-	
8.40	-	1.6	

RP			
mbgl	BaP	PAH	C10-C36
2.00	12.8	118.2	1,730.0

VP01					
mbgl	BaP	PAH	C10-C36	Pb	
Surface	5.9	-	-	-	
	10.0	137.7	1,685.0	-	
	7.1	104.3	1,995.0	-	
	15.0	219.4	2055.0	-	
	-	-	1725.0	-	
	10.0	134.1	3125.0	2140.0	

MW13S			
mbgl	BaP	PAH	C10-C36
1.00	34.9	346.0	6,444.0

VP02				
mbgl	BaP	PAH	C10-C36	Pb
Surface	-	-	1,245.0	-
	12.0	258.3	2,625.0	1,510.0
	12.0	236.6	2,525.0	-

BH18						
mbgl	BaP	PAH	C10-C36	Bz	Etbz	Xy
0.30	220.0	3,953.0	38,400.0	-	-	-
1.80	28.0	2,160.8	-	7.0	80.0	210.0

BHF			
mbgl	BaP	PAH	C10 - C36
1.00	6.4	-	1,150.0
8.50	-	134.6	1,280.0

BHC							
mbgl	BaP	PAH	C6 - C9	C10 - C36	Bz	Xy	
6.00	17.6	1,906.4	569	8,760.0	6.4	246.7	

MG11			
mbgl	BaP	PAH	C10 - C36
0.20	42	696.6	6,210.0
2.00	48.9	729.8	7,790.0

BH10			
mbgl	BaP	PAH	
0.10	11.0	112.0	

TP11		
mbgl	BaP	C10 - C36
0.20	6.2	1,410.0

MG09B		
mbgl	C10 - C36	ACM
0.30	20,700.0	fragment

BH12			
mbgl	BaP	PAH	Bz
0.10	5.8	-	-
4.50	8.4	224.4	1.0

BH12A							
mbgl	BaP	PAH	C6 - C9	C10 - C36	Bz	Xy	
4.20	13.9	515.6	228	5,350.0	20	94.9	

MG09C		
mbgl	BaP	C10 - C36
0.30	5	1,200.0

MW04S	
mbgl	Bz
2.10	4.0

TP16						
mbgl	BaP	PAH	C6 - C9	C10 - C36	Bz	Xy
0.30	5.9	-	-	1,280.0	1.2	-
1.00	39.4	425.1	166	7,640.0	3.1	61.2

TP15						
mbgl	BaP	PAH	C6 - C9	C10 - C36	Bz	Xy
2.80	10.8	426.2	107	2,090.0	1.8	55.2
4.10	-	-	65	-	2.7	-

TP05		
mbgl	BaP	PAH
0.25	168	4,300.9

TPD	
mbgl	BaP
0.20	6.2

TP09	
mbgl	BaP
0.50	5.4

TP08		
mbgl	BaP	PAH
0.25	55	680.2

TP08	
mbgl	BaP
0.25	9.2

BH16		
mbgl	BaP	
0.10	11.0	

KEY:

- BaP
- PAH
- C6-C9
- C10-C36
- Benzene
- Ethylbenze
- Xylenes
- Lead

mbgl - metres below ground level
(All values in mg/kg)

SCALE 1: 500 — SCALE IN m (5 0 5 10 15 20)

Figure 4
Sample Locations Exceeding Site Criteria - All Data

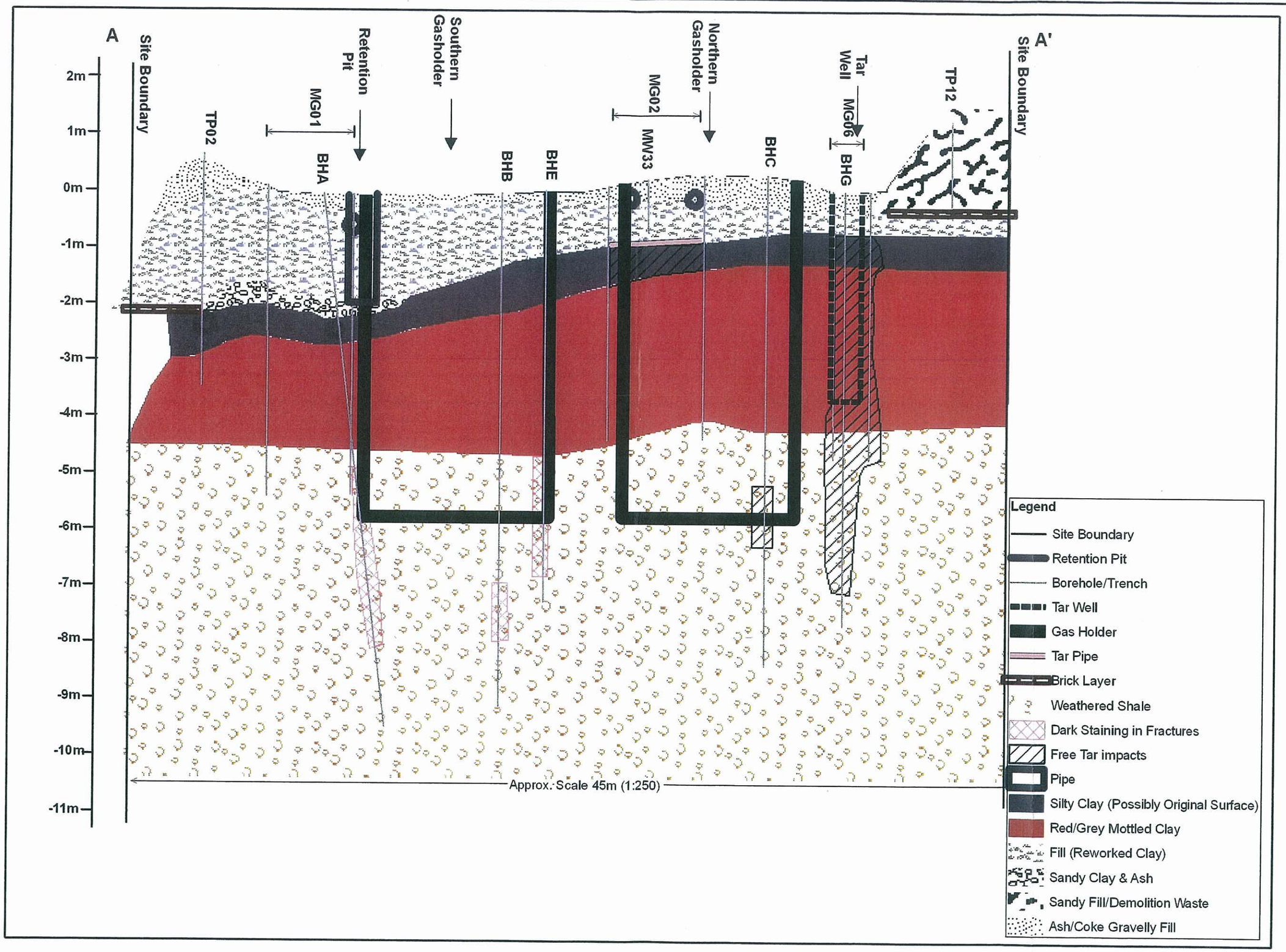


Figure 5 Cross Section Plan No. 1

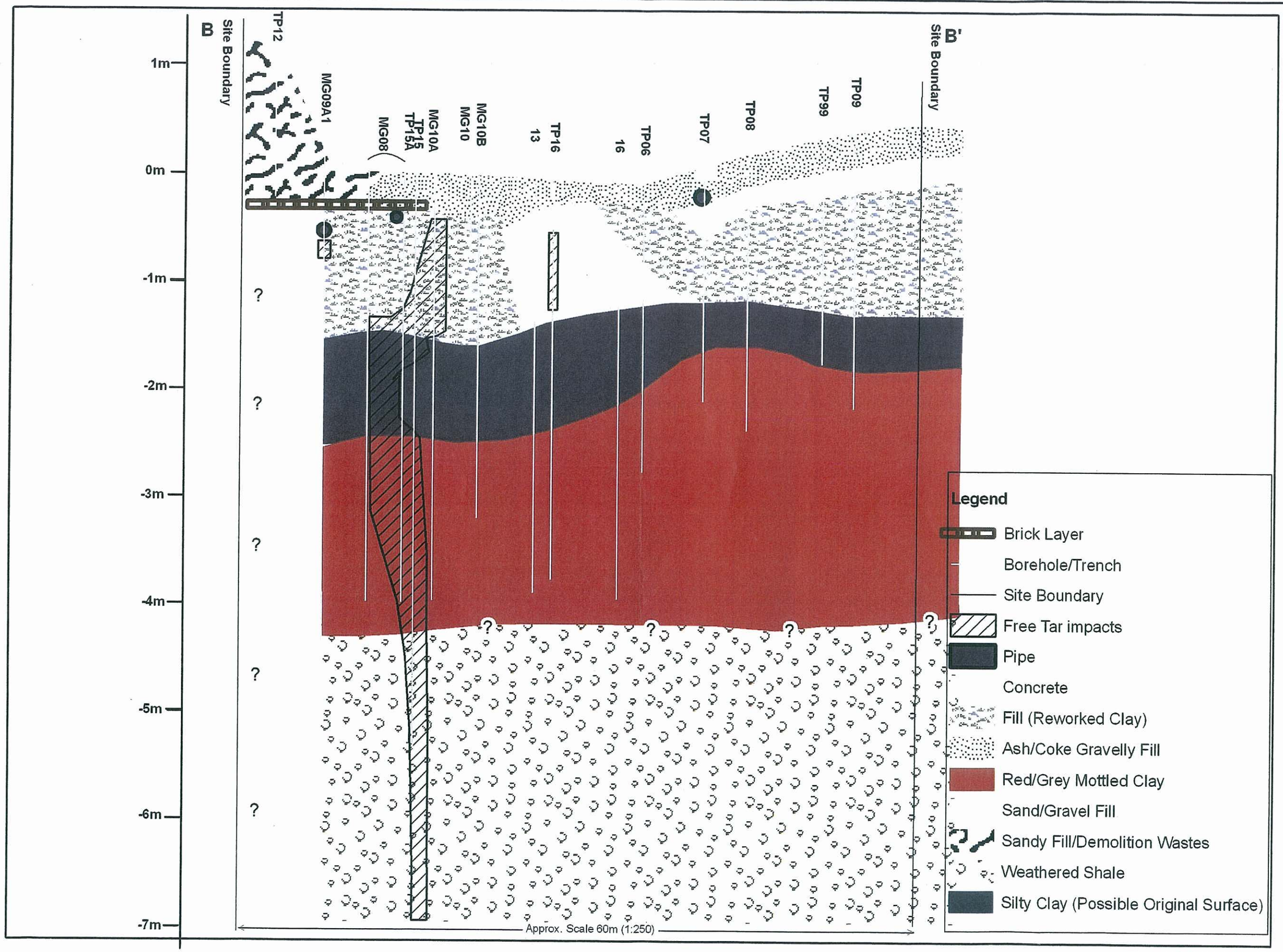


Figure 6 Cross Section Plan No. 2

LEGEND

- ASH & COKE GRAVEL FILL (0.5m)
- CONTAMINATION HOTSPOTS (1-2m)
- GRAVELLY SAND & DEMOLITION WASTES (VARYING DEPTH)
- TAR IMPACTED SOIL (AT LEAST 4m)
- FREE TAR/PRIMARY SOURCE (8-10m)
- TAR PIPE (DEPTH m)
- CAST IRON PIPE (DEPTH m)

5 0 5 10 15 20
SCALE 1: 500 SCALE IN m

Figure 7
Remediation Areas
& Excavation Depth Estimates