Controlled Copy ___

Site Audit

2 Christina Road, Villawood

for Orica Australia Pty Ltd
March 2012

J1196.14R-rev0

CMJA

C. M. Jewell & Associates Pty Ltd

Site Audit
2 Christina Road, Villawood

March 2012

J1196.14R-rev0

Controlled Copies 1, 2 and 3 (2 hard copies and 1 CD)	*Mr Ben Dewhurst* Orica Australia Pty Ltd 16-20 Beauchamp Road MATRAVILLE NSW 2036
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5	*Mr John Hunt* Thiess Services Pty Ltd Level 3, 88 Phillip Street PARRAMATTA NSW 2150
6	*Mr Erwin Benker* Director Contaminated Sites NSW Office of Environment & Heritage PO Box A290 SYDNEY SOUTH NSW 1232
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8	CMJA Library

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CHRIS JEWELL
Auditor

Site Audit Report

NSW Site Auditor Scheme
SITE AUDIT STATEMENT

NSW EPA
ENVIRONMENT PROTECTION AUTHORITY

A site audit statement summarises the findings of a site audit. For full details of the site auditor's findings, evaluations and conclusions, refer to the associated site audit report.
This form was approved under the* Contaminated Land Management Act 1997 *on 12 May 2011. For more information about completing this form, go to Part IV.

PART I: Site audit identification

Site audit statement no. SA280/2

This site audit is a **statutory audit**/~~non-statutory audit~~* within the meaning of the *Contaminated Land Management Act 1997*.

Site auditor details (as accredited under the *Contaminated Land Management Act 1997*)

Name: Christopher Jewell Company: C. M. Jewell & Associates Pty Ltd

Address: 1/13 Kalinda Road

BULLABURRA NSW Postcode: 2784

Phone: 02 4759 3251 Fax: 02 4759 3257

Site details

Address: 2 Christina Road,

VILLAWOOD NSW Postcode: 2163

Property description *(attach a list if several properties are included in the site audit)*

The site is identified as Lot 1 in DP634604, in the Parish of Liberty Plains, County of Cumberland.

Local Government Area: Bankstown City Council

Area of site: 126000 m² Current zoning: Industrial (4a)

To the best of my knowledge, the site **is**/~~is not~~* the subject of a declaration, order, agreement, proposal or notice under the *Contaminated Land Management Act 1997* or the *Environmentally Hazardous Chemicals Act 1985*.

Declaration/Order/Agreement/Proposal/Notice* no(s)

Remediation Order No. 23019, Area 3200, issued on 2 November 2005, by the NSW Department of Environment and Conservation (DEC), under s.23 of the Contaminated Land Management Act 1997.

****Strike out as appropriate***

Site audit commissioned by

Name: Mr James Stening

Company: Orica Australia Pty Ltd

Address: 16-20 Beauchamp Road, Matraville, NSW 2036

Phone: 02 9352 2213 **Fax**: 02 9352 2361

Name and phone number of contact person (if different from above)

.....

Purpose of site audit

☐ ~~A. To determine land use suitability *(please specify intended use[s])*~~

.....

OR

☐ ~~B(i) To determine the nature and extent of contamination, and/or~~

☑ B(ii) To determine the appropriateness of an ~~investigation~~/**remedial action**/~~management~~ **plan***, and/or

☑ B(iii) To determine if the land can be made suitable for a particular use or uses by implementation of a specified **remedial action plan**/~~management plan~~* *(please specify intended use[s])*

Industrial and Commercial use

Information sources for site audit

Consultancy(ies) which conducted the site investigation(s) and/or remediation:

AECOM Australia Pty Ltd
Thiess Services Pty Ltd
URS Australia Pty Limited
HLA-Envirosciences Pty Limited
CH2M HILL Australia Pty Ltd
A.D. Laase Hydrologic Consulting

Title(s) of report(s) reviewed:

- Remedial Action Plan, 2 Christina Road, Villawood, NSW, prepared by AECOM Australia Pty Ltd (ref. S4149701), dated 17 March 2011
- Human Health and Environmental Risk Assessment, Orica Villawood, prepared by URS Australia Pty Ltd (ref. 43217484), dated 9 February 2011
- Environmental Assessment, Remediation of Former Orica Villawood Site, 2 Christina Road, Villawood, NSW, prepared by Thiess Services Pty Ltd (ref. 050003), dated February 2011
- Remedial Action Plan Addendum, 2 Christina Road, Villawood, NSW, prepared by AECOM Australia Pty Ltd (ref. S4063810_RAPaddendum_09Jul09_Final), dated 9 July 2009
- Remedial Action Plan, 2 Christina Road, Villawood, NSW, prepared by HLA-Envirosciences Pty Limited (HLA ENSR) (ref. S4066001_FinalDraft_RAP 2Oct07), dated 3 October 2007

Strike out as appropriate

- Validation Report, Pharmaceuticals Site, Christina Road, Villawood, prepared by CH2M HILL Australia Pty Ltd (ref. 359640.T1.01), dated July 2007
- Under Building Investigation, Pharmaceuticals Site Villawood, prepared by CH2M HILL Australia Pty Ltd (ref. 359640.T1.02), dated July 2007
- Groundwater Flow and Contaminant Transport Modelling, Orica Site, 2 Christina Road, Villawood, NSW, prepared by A. D. Laase Hydrologic Consulting, dated June 2007
- Phase 3 Data Gap Investigation, 2 Christina Road, Villawood, NSW, prepared by HLA-Envirosciences Pty Limited (ref. S4075424_RPTFinal_31May07), dated 31 May 2007
- Remedial Technology Assessment (Soil), 2 Christina Road, Villawood, NSW, prepared by HLA-Envirosciences Pty Limited (ref. S4066001_RTA_Final_22Dec06), dated 22 December 2006
- Remedial Technology Assessment (Groundwater), 2 Christina Road, Villawood, NSW, prepared by HLA-Envirosciences Pty Limited (ref. S40660_RPT_Final_22Dec06), dated 22 December 2006
- Phase 2 Remedial Investigation, 2 Christina Road, Villawood, prepared by HLA-Envirosciences Pty Limited (ref. S4060632_RPT_30Aug06), dated 30 August 2006
- Phase 1 Remedial Investigation, Orica Site, 2 Christina Road, Villawood, prepared by HLA-Envirosciences Pty Limited (ref. S4056125_RPTFinal_22Dec05), dated 22 December 2005

Other information reviewed (including previous site audit reports and statements relating to the site):

- Regional geological and topographic mapping
- Regional hydrogeological data

Site audit report

Title: Site Audit – 2 Christina Road, Villawood

Report no. J1196.14R-rev0 Date: 19 March 2012

Strike out as appropriate

PART II: Auditor's findings

Please complete either Section A or Section B, **not** both. *(Strike out the irrelevant section.)*

Use Section A where site investigation and/or remediation has been completed and a conclusion can be drawn on the suitability of land use(s).

Use Section B where the audit is to determine the nature and extent of contamination and/or the appropriateness of an investigation or remedial action or management plan and/or whether the site can be made suitable for a specified land use or uses subject to the successful implementation of a remedial action or management plan.

Section A

☑ **I certify that, in my opinion, the site is SUITABLE for the following use(s)** *(tick all appropriate uses and strike out those not applicable)*:

- ☐ Residential, including substantial vegetable garden and poultry
- ☐ Residential, including substantial vegetable garden, excluding poultry
- ☐ Residential with accessible soil, including garden (minimal home-grown produce contributing less than 10% fruit and vegetable intake), excluding poultry
- ☐ Day care centre, preschool, primary school
- ☐ Residential with minimal opportunity for soil access, including units
- ☐ Secondary school
- ☐ Park, recreational open space, playing field
- ☐ Commercial/industrial
- ☐ Other *(please specify)* .....

subject to compliance with the following environmental management plan *(insert title, date and author of plan)* **in light of contamination remaining on the site:**

.....

.....

.....

OR

☐ **I certify that, in my opinion, the site is NOT SUITABLE for any use due to the risk of harm from contamination.**

Overall comments

.....

.....

.....

.....

Section B

Purpose of the plan[1] which is the subject of the audit: Site Remediation in Compliance with Section 4K, 4L and 4M of Remediation Order No 23019 issued on 2 November 2005.

I certify that, in my opinion:

☑ **the nature and extent of the contamination HAS/~~HAS NOT~~* been appropriately determined**

AND/OR

☑ **the ~~investigation~~/remedial action plan/~~management plan~~* IS/~~IS NOT~~* appropriate for the purpose stated above**

AND/OR

☑ **the site CAN BE MADE SUITABLE for the following uses** *(tick all appropriate uses and strike out those not applicable)*:

- ☐ ~~Residential, including substantial vegetable garden and poultry~~
- ☐ ~~Residential, including substantial vegetable garden, excluding poultry~~
- ☐ ~~Residential with accessible soil, including garden (minimal home-grown produce contributing less than 10% fruit and vegetable intake), excluding poultry~~
- ☐ ~~Day care centre, preschool, primary school~~
- ☐ ~~Residential with minimal opportunity for soil access, including units~~
- ☐ ~~Secondary school~~
- ☐ ~~Park, recreational open space, playing field~~
- ☑ Commercial/industrial
- ☐ ~~Other *(please specify)* .....~~

if the site is remediated/~~managed~~* in accordance with the following remedial action plan/~~management plan~~* *(insert title, date and author of plan)*

Remedial Action Plan – 2 Christina Road, Villawood NSW, prepared by AECOM Australia Pty Ltd (ref. S4149701), dated 17 March 2011

~~subject to compliance with the following condition(s):~~

.....

.....

.....

[1] For simplicity, this statement uses the term 'plan' to refer to both plans and reports.

**** Strike out as appropriate***

Overall comments

Overview

The site at 2 Christina Road, Villawood is contaminated by a wide range of organic chemicals, some of which are present at very high concentrations. Contamination is present in soil beneath the site, groundwater beneath the site, and groundwater off the site.

The distribution of contamination in these media is complex, and reflects the cumulative impact of a number of mechanisms of contamination and site practices acting over a period of many years.

Remediation of site soils is required to make the site suitable for industrial and commercial use.

Although shallow groundwater beneath the site is highly contaminated by some of the organic chemicals identified in site soils, remediation of groundwater contamination is not required to make the site suitable for industrial or commercial use, and the off-site groundwater contamination does not currently present an unacceptable risk to human health or the environment. Remediation of groundwater contamination is not therefore required to manage risk. Because no practicable means of remediating groundwater to meet the policy goals of the NSW EPA has been identified, and such remediation appears impracticable, it is not proposed.

Adequacy of Investigation

I consider the investigations of soil and groundwater contamination beneath the site and off-site areas that have been progressively implemented over a number of years, to be sufficient to define geological and hydrogeological conditions, and the nature and extent of contamination.

These investigations have provided an adequate data set to allow the assessment of human health and environmental risks and to allow an appropriate remedial strategy to be developed.

Adequacy of Human Health and Environmental Risk Assessment

I have reviewed the Human Health and Environmental Risk Assessment carried out by URS. The assessment has been carried out in accordance with national and international guidance approved by the NSW EPA, where applicable, and I consider it appropriate.

In my opinion, the risk assessment adequately identifies and quantifies risks due to chemical contamination on and off the site, and has developed an appropriate set of site-specific risk-based soil concentrations to be used in the development of remediation goals, and risk-based groundwater concentrations to be used to aid the interpretation of future groundwater monitoring data.

Suitability of Remediation Action Plan

I have reviewed the Remedial Action Plan developed by AECOM and consider it to comply with the relevant guidelines, and to be appropriate to guide remediation activities.

The core soil remediation technology proposed, directly-heated ex-situ thermal desorption, is considered to be appropriate for the contaminants of concern, technically feasible, and environmentally justifiable. Implementation of this technology would be in accordance with the remediation policy endorsed by the NSW EPA.

If the site is remediated in accordance with the remedial action plan, and validated in accordance with the validation plan to demonstrate that the remediation goals have been met, then the site will be suitable for industrial and commercial use.

Recommendations

A further site audit will be required at the end of the active remediation process to confirm that the site is suitable for the proposed use.

I strongly recommend that a Site Auditor continue to be involved throughout the remediation process.

The proposed remedial works will not address groundwater contamination beneath the site and off the site. Given the chemical nature of the contaminants present in groundwater, the demonstrated environmental persistence of many of these chemicals and the mechanism of diffusion into, and slow release, from the fine-grained matrix of the residual soils and shales that form the shallow aquifer beneath the site and surrounding area, groundwater contamination is expected to persist for many decades. Management of the groundwater contamination must therefore continue for the foreseeable future.

A long-term environmental management plan setting out requirements for monitoring, data review and reporting, and notification requirements for the owners and occupiers of land that is impacted by the groundwater contamination will be required once active remediation has been completed.

PART III: Auditor's declaration

I am accredited as a site auditor by the NSW Environment Protection Authority under the *Contaminated Land Management Act 1997* (Accreditation No. 9810).

I certify that:

- I have completed the site audit free of any conflicts of interest as defined in the *Contaminated Land Management Act 1997,* and
- with due regard to relevant laws and guidelines, I have examined and am familiar with the reports and information referred to in Part I of this site audit, and
- on the basis of inquiries I have made of those individuals immediately responsible for making those reports and obtaining the information referred to in this statement, those reports and that information are, to the best of my knowledge, true, accurate and complete, and
- this statement is, to the best of my knowledge, true, accurate and complete.

I am aware that there are penalties under the *Contaminated Land Management Act 1997* for wilfully making false or misleading statements.

Signed ..... Date 19 March 2012

PART IV: Explanatory notes

To be complete, a site audit statement form must be issued with all four parts.

How to complete this form

Part I identifies the auditor, the site, the purpose of the audit and the information used by the auditor in making the site audit findings.

Part II contains the auditor's opinion of the suitability of the site for specified uses or of the appropriateness of an investigation, or remedial action or management plan which may enable a particular use. It sets out succinct and definitive information to assist decision-making about the use(s) of the site or a plan or proposal to manage or remediate the site.

The auditor is to complete either Section A or Section B of Part II, **not** both.

In **Section A** the auditor may conclude that the land is *suitable* for a specified use(s) OR *not suitable* for any beneficial use due to the risk of harm from contamination.

By certifying that the site is *suitable*, an auditor declares that, at the time of completion of the site audit, no further remediation or investigation of the site was needed to render the site fit for the specified use(s). Any **condition** imposed should be limited to implementation of an environmental management plan to help ensure the site remains safe for the specified use(s). The plan should be legally enforceable: for example a requirement of a notice under the *Contaminated Land Management Act 1997* (CLM Act) or a development consent condition issued by a planning authority. There should also be appropriate public notification of the plan, e.g. on a certificate issued under s.149 of the *Environmental Planning and Assessment Act 1979*.

Auditors may also include **comments** which are key observations in light of the audit which are not directly related to the suitability of the site for the use(s). These observations may cover aspects relating to the broader environmental context to aid decision-making in relation to the site.

In **Section B** the auditor draws conclusions on the nature and extent of contamination, and/or suitability of plans relating to the investigation, remediation or management of the land, and/or whether land can be made suitable for a particular land use or uses upon implementation of a remedial action or management plan.

By certifying that a site *can be made suitable* for a use or uses if remediated or managed in accordance with a specified plan, the auditor declares that, at the time the audit was completed, there was sufficient information satisfying guidelines made or approved under the CLM Act to determine that implementation of the plan was feasible and would enable the specified use(s) of the site in the future.

For a site that *can be made suitable*, any **conditions** specified by the auditor in Section B should be limited to minor modifications or additions to the specified plan. However, if the auditor considers that further audits of the site (e.g. to validate remediation) are required, the auditor must note this as a condition in the site audit statement.

Auditors may also include **comments** which are observations in light of the audit which provide a more complete understanding of the environmental context to aid decision-making in relation to the site.

In **Part III** the auditor certifies his/her standing as an accredited auditor under the CLM Act and makes other relevant declarations.

Where to send completed forms

In addition to furnishing a copy of the audit statement to the person(s) who commissioned the site audit, statutory site audit statements must be sent to:

Environment Protection Authority, Department of Premier and Cabinet
Contaminated Sites Section
PO Box A290, SYDNEY SOUTH NSW 1232
Fax: (02) 9995 5930
AND
the **local council** for the land which is the subject of the audit.

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TABLES

FIGURES

APPENDICES

ASSOCIATED REPORTS

Remedial Action Plan, 2 Christina Road, Villawood, NSW, prepared by AECOM Australia Pty Ltd (ref. S4149701), dated 17 March 2011

Human Health and Environmental Risk Assessment, Orica Villawood, prepared by URS Australia Pty Ltd (ref. 43217484), dated 9 February 2011

Environmental Assessment – Remediation of Former Orica Villawood Site, 2 Christina Road, Villawood, NSW, prepared by Thiess Services Pty Ltd (ref. 050003), dated February 2011.

Remedial Action Plan Addendum, 2 Christina Road, Villawood, NSW, prepared by AECOM Australia Pty Ltd (ref. S4063810_RAPaddendum_09Jul09_Final), dated 9 July 2009

Remedial Action Plan, 2 Christina Road, Villawood, NSW, prepared by HLA-Envirosciences Pty Limited (ref. S4066001_FinalDraft_RAP 2Oct07), dated 3 October 2007

Validation Report, Pharmaceuticals Site, Christina Road, Villawood, prepared by CH2M HILL Australia Pty Ltd (ref. 3596940.T1.01), dated July 2007

Under Building Investigation, Pharmaceuticals Site Villawood, prepared by CH2M HILL Australia Pty Ltd (ref. 359640.T1.02), dated July 2007

Groundwater Flow and Contaminant Transport Modelling, Orica Site, 2 Christina Road, Villawood, NSW, prepared by A. D. Laase Hydrologic Consulting, dated June 2007

Phase 3 Data Gap Investigation, 2 Christina Road, Villawood, NSW, prepared by HLA-Envirosciences Pty Limited (ref. S4075424_RPTFinal_31May07), dated 31 May 2007

Remedial Technology Assessment (Soil), 2 Christina Road, Villawood, NSW, prepared by HLA-Envirosciences Pty Limited (ref. S4066001_RTA_Final_22Dec06), dated 22 December 2006

Remedial Technology Assessment (Groundwater), 2 Christina Road, Villawood, NSW, prepared by HLA-Envirosciences Pty Limited (ref. S40660_RPT_Final_22Dec06), dated 22 December 2006

Cyanide in Soil and Groundwater Position Letter, Orica Villawood, 2 Christina Road, Villawood, NSW. Sequential Correspondence: HLAO-010, prepared by HLA-Envirosciences Pty Limited, dated 12 December 2006

Phase 2 Remedial Investigation, 2 Christina Road, Villawood, prepared by HLA-Envirosciences Pty Limited (ref. S4060632_RPT_30Aug06), dated 30 August 2006

Phase 1 Remedial Investigation, Orica Site, 2 Christina Road, Villawood, prepared by HLA-Envirosciences Pty Limited (ref. S4056125_RPTFinal_22Dec05), dated 22 December 2005

List of Abbreviations

Measures

µg/L	micrograms per litre
km	kilometre
L	litre
m	metre
m^2	square metre
µS/cm	microsiemens per centimetre
mS/cm	millisiemens per centimetre
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
mm	millimetre

General

AHD	Australian Height Datum
AMG	Australian Map Grid
ANZECC	Australian and New Zealand Environment and Conservation Council
AST	above-ground storage tank
CLM Act	Contaminated Land Management Act
CMJA	C. M. Jewell & Associates Pty Ltd
COPC	contaminants of potential concern
DA	development application
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
DLWC	Department of Land and Water Conservation
DNAPL	dense non-aqueous-phase liquid
DNR	Department of Natural Resources
DP	deposited plan
DQO	data quality objectives
EPA	Environment Protection Authority
ESA	Environmental Site Assessment
GDE	groundwater dependent ecosystems
HDPE	high-density polyethylene
MNA	monitored natural attenuation
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measure
PID	photoionisation detector
PQL	practical quantitation limit
ppmv	parts per million volume
PSH	phase-separated hydrocarbons
QA	quality assurance
QC	quality control
RAP	remediation action plan
RL	relative level
RPD	relative percentage difference
SWL	standing water level
TCLP	Toxicity Characteristics Leaching Procedure
THI	target hazard index
TOC	top of casing
TWA	time weighted average
UCL	upper confidence limit
UST	underground storage tank

Analytes – Organic

BaP	benzo(a)pyrene
BTEX	benzene, toluene, ethylbenzene, xylene
OCP	organochlorine pesticides
OPP	organophosphorus pesticides
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
SVOC	semivolatile organic compounds
TPH	total petroleum hydrocarbons
VHC	volatile halogenated compounds
VOC	volatile organic compounds

Analytes – Inorganic

As	Arsenic
Cd	Cadmium
Cr	Chromium
Cu	Copper
Fe	Iron
Hg	Mercury
Mn	Manganese
Ni	Nickel
Pb	Lead
Zn	zinc

1.0 INTRODUCTION

1.1 Background

1.1.1 Land that is the Subject of Site Audit

This Site Audit Report relates to land located at 2 Christina Road, Villawood, in New South Wales (the site). The location of the site is shown on Figure 1, and its layout is indicated on Figure 2.

As of the date of this report, the description of the site is Lot 1 in DP634604, and the owner is Orica Australia Pty Ltd (Orica).

1.1.2 Statutory Basis of Site Audit

The Site Audit of which this report is a component was requested on 31 March 2006 by Mr James Stening of Orica Australia Pty Ltd, for the purpose of complying with conditions 4D, 4J and 4N of Remediation Order No. 23019, Area 3200, issued on 2 November 2005 by the NSW Environment Protection Authority (EPA), under s.23 of the Contaminated Land Management Act 1997 (CLM Act).

The Auditor has previously carried out a site audit (CMJA report ref. J1196.2R-rev0) of investigation work specifically relating to conditions 4A, 4B and 4C of the abovementioned Remediation Order 23019, Area 3200, issued on 2 November 2005.

The part of the site audit described in this report is a requirement of Section 4N of the Order, as follows:

> Engage a Site Auditor accredited under the CLM Act to review the RAPs referred to in conditions 4K and 4L. Orica must ensure that the Site Auditor comments on whether implementation of the RAPs will make the site suitable for its current and approved use(s) as defined in the CLM Act and to the maximum practicable extent for the proposed use(s) of the land.

The assessment works described and audited within this site audit report are thus s those required by conditions 4K, 4L and 4M of the Remediation Order. The relevant section is reproduced below.

> **4. Action to be taken in remediating contamination on the site**
>
> By this order the EPA directs Orica, being the owner of the premises and, based on information available to date, a person whom the EPA believes to have principal responsibility for the contamination of the premises with the substances referred to above, to do the following:
>
> **Remediation action plan**
>
> K. Prepare a RAP for soil impacted by the site contaminants.
>
> L. Prepare a RAP for groundwater impacted by the site contaminants.
>
> M. The RAPs referred to in Conditions 4K and 4L must include the following:
>
> i. A summary of all investigations carried out in relation to the site contamination, including all investigations carried out in relation to the migration of contamination off the site.
>
> ii. A clear statement of the scope of work to be undertaken.
>
> iii. A re-evaluation of options to prevent the migration of contaminated groundwater off the site, the preferred option and reasons for that preference.
>
> iv. A re-evaluation of options to remediate contaminated site soils that are providing a source of continued groundwater contamination, including reasons for choosing a preferred option.
>
> v. A re-evaluation of options to remediate contaminated groundwater at the site, including reasons for choosing a preferred option.
>
> vi. A re-evaluation of options to remediate contaminated soil and groundwater that has migrated off the site, the preferred option and reasons for that preference.

vii. A review and revision, if required, of the proposed remediation criteria for soil and groundwater referred to in condition 4G(vi) that ensure the remediated site will be suitable for its current and approved use(s) as defined in the CLM Act and to the maximum practicable extent for the proposed use(s) of the land.

viii. If site-specific remediation criteria are proposed, a risk assessment associated with the development of the criteria, being an assessment done in accordance with the NEPM with all site-specific assumptions used in the risk assessment clearly detailed.

ix. Detail of any environmental safeguards required to complete the remediation in an environmentally acceptable manner.

x. Detail of validation and ongoing site monitoring and reporting procedures.

Specifically, the Site Audit relates to the work completed by AECOM Australia Pty Ltd (AECOM) (formerly HLA-Envirosciences Pty Ltd - HLA), on behalf of Orica, and as described in AECOM's Remedial Action Plan dated 2 June 2010.

This Site Audit has been carried out in accordance with the current requirements of the CLM Act. It is a statutory site audit as defined in section 47 of that Act.

The wording of the CLM Act was changed during the course of this audit. However, the audit was completed for the purpose of determining the matters that are listed below (using the terminology and numbering of Section 4 of the Act):

(ii) the nature and extent of any management of actual or possible contamination of the land,

(iv) what management remains necessary before the land is suitable for any specified use or range of uses,

(v) the suitability and appropriateness of a plan of management, a long-term management plan or a voluntary management proposal

The Site Audit Report has been prepared in accordance with the guidelines issued by the NSW EPA, in *Guidelines for the NSW Site Auditor Scheme*, 2nd edition, 2006. It has been prepared by Christopher Jewell, who is a Site Auditor accredited under the NSW Contaminated Land Management Act 1997.

1.1.3 Planning Issues

The proposed remediation of the Villawood site is Category 1 remediation (requiring consent) pursuant to Clause 9 of SEPP55.

The site lies within the Bankstown Council local government area. However, the remediation project was classed as a Major Project pursuant to Schedule 1 of the SEPP (Major Projects) 2005 and Project Approval is therefore being determined by the Minister for Planning and Infrastructure under the transitional arrangements that are in place following repeal of Part 3A of the Environmental Planning and Assessment Act 1979. Director-General's requirements (DGRs) for the project Environmental Assessment (EA) were issued in May 2010.

An EA has been prepared and this site audit is part of the EA process.

1.1.4 Reports Reviewed

This site audit relates primarily to the management works proposed for the site, as described in the following reports:

- Remedial Action Plan, 2 Christina Road, Villawood, NSW, prepared by AECOM Australia Pty Ltd (ref. S4149701), dated 17 March 2011
- Human Health and Environmental Risk Assessment, Orica Villawood, prepared by URS Australia Pty Ltd (ref. 43217484), dated 9 February 2011
- Environmental Assessment, Remediation of Former Orica Villawood Site, 2 Christina Road, Villawood, NSW, prepared by Thiess Services Pty Ltd (ref. 050003), dated February 2011

This document was substantially based upon the investigation, remediation and validation work completed by various consultants involved with the project, as described in the following reports:

- Remedial Action Plan, 2 Christina Road, Villawood, NSW, prepared by AECOM Australia Pty Ltd (ref. S4149701), dated 17 March 2011
- Human Health and Environmental Risk Assessment, Orica Villawood, prepared by URS Australia Pty Ltd (ref. 43217484), dated 9 February 2011
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- Phase 1 Remedial Investigation, Orica Site, 2 Christina Road, Villawood, prepared by HLA-Envirosciences Pty Limited (ref. S4056125_RPTFinal_22Dec05), dated 22 December 2005

Notes:

1. Copies of the reports that the Auditor has specifically relied upon are provided as Appendix B of this report (on CD).
2. Copies of the letter reports and supporting documentation that the Auditor has relied upon are provided as Appendix C of this report.
3. A copy of URS Australia Pty Ltd's (URS) Human Health and Environmental Risk Assessment and a copy of AECOM's Remedial Action Plan is provided (on CD) in Appendix B.
4. Copies of all other relevant documents that were forwarded to the Auditor during the course of this audit are held on file.
5. The Auditor has visited the site on four occasions to observe and verify, as far as practicable, the site conditions and the progress of the work being audited.
6. A compliance checklist has been completed and is held on file.

1.2 Scope and Structure of the Site Audit Report

Section 2 of this report provides a chronological summary of events that relate to the site and are significant to this audit, and it outlines the Auditor's involvement.

Section 3 of this report sets out basic identification and location information concerning the site. An indication of the layout, topography, drainage, geology and hydrogeological setting of the site (or the property if more appropriate) is also provided, together with an overview of its history. Any known or potential contaminant sources are listed, and the associated contaminant groups of concern identified. A list of the individual compounds that make up the contaminant groups is provided as Appendix A. This section also outlines the future use of the site, and provides the associated assessment criteria.

For a more detailed description of the layout, topography, drainage, geology, hydrogeology and history of the site, reference should be made to the associated reports. Copies of these reports are provided (on CD) as Appendix B of this report. It should be noted that throughout this Site Audit Report extensive use has been made of the associated reports. Specifically, sections of those reports have been adopted for use in this report.

Section 4 provides an overview of the investigation, remediation and validation works undertaken on the site by the various consultants, and includes the Auditor's evaluation of the works and of its adherence to NSW EPA guidelines. For a more detailed description of the investigation, remediation and validation works undertaken on the site, reference should be made to the associated reports.

Section 5 of this report describes the investigation work carried out under the Remediation Order.

Note: Sections 4 and 5 of this report also present an audit of the completeness and adequacy of the investigation, remediation and validation works that have been undertaken. The audit was carried out against the criteria established by the NSW EPA publication, *Guidelines for the NSW Site Auditor Scheme*, 2nd edition (2006), but also incorporates the reviewer's own judgement; reference has been made to other guideline publications issued or endorsed by the NSW EPA, including *Guidelines for Consultants Reporting on Contaminated Sites* (1997), *Guidelines for Assessing Service Station Sites* (1994), *Sampling Design Guidelines* (1995) and the *National Environment Protection (Assessment of Site Contamination) Measure* (1999), as appropriate.

Section 6 outlines the 2009 Addendum to HLA's 2007 Remediation Action Plan which contained a revised conceptual site model.

Section 7 presents a summary of the Human Health and Environmental Risk Assessment, and includes the Auditor's review of that document.

Section 8 outlines AECOM's Remediation Action Plan and Section 9 presents the Auditor's assessment of its suitability and appropriateness.

Section 10 outlines the Site Auditor's conclusions, including the compliance to NSW EPA requirements.

The Auditor's assessment of the consultants' use of data quality objectives, data quality indicators and quality assurance/quality controls is provided in Appendix D.

1.3 Limitations and Intellectual Property Matters

This report has been prepared by C. M. Jewell & Associates Pty Ltd for the use of the client identified in Section 1.1 and relevant government agencies (the NSW EPA and Bankstown City Council), for the specific purpose described in that section.

The work has been carried out, and this report prepared, utilising the standards of skill and care normally expected of a site auditor practising in New South Wales under the requirements of the Contaminated Land Management Act 1997. The level of confidence of the conclusions reached is governed, as in all such work, by the scope of the investigation carried out and by the availability and quality of the data. The Auditor has satisfied himself that the available data are adequate to support the conclusions he has reached, and comply with the minimum requirements indicated in the guideline documents specified for the NSW Site Auditor Scheme. Where limitations or uncertainties in conclusions are known, they are identified in this report. However, no liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been assessed or predicted using the site information and analytical data available for review.

Data collected by others have, of necessity, been used to support the conclusions of this report. Those data have been subjected to reasonable scrutiny but have essentially, and necessarily, been used in good faith. Liability cannot be accepted for errors in data collected by others where such errors could not have been detected by reasonable scrutiny of the data and supporting information supplied to or requested by the Auditor.

This report, any original data contained in the report, and its findings and conclusions remain the intellectual property of C. M. Jewell & Associates Pty Ltd. A licence to use the report for the specific purpose identified in Section 1.1 is granted to the persons identified in that section on the condition of receipt of full payment for the services involved in the preparation of the report.

It is recognised that persons other than the client and relevant government agencies may ultimately have access to this report. In this event, it is recommended that this report should not be used by other persons or for other purposes than those identified in this report, without prior reference to the Auditor.

2.0 OVERVIEW OF WORKS COMPLETED AND INVOLVEMENT OF AUDITOR

Table 1 presents a chronological overview of significant events that relate to the site and are significant to this audit, and it outlines the Auditor's involvement.

TABLE 1
Chronological Overview of Significant Events

Date	Activity/Task
Prior to 1953	The site was once part of a larger industrial site acquired by the Commonwealth of Australia in 1941; activities included the manufacturing of munitions, including TNT. Taubmans Pty Limited purchased the site in 1946 and used a range of chemical including chlorobenzene and DDT.
1953 to 2000	Orica (formerly ICANZ) purchased the southern site portion in 1953 and manufactured agricultural and pharmaceutical chemicals until all operations ceased in 2000. *Note:* In 1983 a fire destroyed the former pharmaceutical plant. A new Pharmaceutical Plant was constructed soon after.
Jun 2000	SHE Pacific Pty Limited (SHE) prepared a Site Historic Review as part of the planning for a site assessment. SHE's historic review also identified contaminants, practices and events that it considered had potentially contaminated the site. An overview of SHE's review was provided in HLA's Phase 1 Remedial Investigation, a copy of which is provided in Appendix B.
Nov 2000	URS produced a Stage 1 Phase 2 Environmental Site Assessment detailing the results of its preliminary soil and groundwater investigation and identifying the site contaminants and areas of contamination. An overview of URS's assessment was provided in HLA's Phase 1 Remedial Investigation, a copy of which is provided in Appendix B. Section 4 of this Site Audit Report (SAR) provides details of the results of the assessment together with URS's recommendations for additional site investigation and remediation works.
2001	The majority of the site structures and buildings were demolished and removed.
Mar 2004	CH2M HILL Australia Pty Ltd (CH2M HILL) produced its Additional Stage 2 Environmental Site Assessment to address the conclusions of the previous investigation undertaken by URS in November 2000. An overview of CH2M HILL's assessment was provided in HLA's Phase 1 Remedial Investigation, a copy of which is provided in Appendix B. The results of CH2M HILL's soil and groundwater investigation, along with their conclusions and recommendations for additional work are provided in Section 4 of this SAR.
Apr 2005	CH2M HILL produced its Conceptual Site Model (CSM) the objective of which was to integrate the data obtained from the various CH2M HILL and URS site investigations and thus provide a framework for decision-making with regard to further assessment and required remediation works. An overview of CH2M HILL's CSM was provided in HLA's Phase 1 Remedial Investigation, a copy of which is provided in Appendix B. The Auditor also received a copy of the CSM on 12 March 2006. CH2M HILL's conclusions, objectives and recommendations for future groundwater investigations at the site are outlined in Section 4 of this SAR.
Sep 2005	CH2M HILL produced its Draft Preliminary Voluntary Investigation – Part 1A, presenting the results of off-site workplace vapour testing, a passive soil gas survey (PSGS) trial, monitoring of existing on-site groundwater monitoring wells, on-site and off-site drilling investigations and on-site trenching investigations. An overview of CH2M HILL's investigation was provided in HLA's Phase 1 Remedial Investigation, a copy of which is provided in Appendix B. The Auditor also received a copy of the report on 12 March 2006. Section 4 of this SAR provides a summary of CH2M HILL's investigation results.
2 Nov 2005	Remediation Order Number 23019; Area Number 3220 is issued by the Department of Environment and Conservation (NSW) under s.23 of the CLM Act.

TABLE 1
Chronological Overview of Significant Events

Date	Activity/Task
2 Feb 2006	The Auditor received a copy of HLA's Phase 1 Remedial Investigation dated 22 December 2005, which identified the following objectives. Soil: • Investigation of broad areas known to be most impacted by contamination using test pits and trenches; • Rapid screening methods for identification of Contaminants of Concern (COC); and • Confirmatory analyses at NATA accredited laboratories. Groundwater: • Address critical data gaps, including extent of off-site groundwater contamination using multilevel monitoring wells (bundle piezometers); and • Establish remediation goals based on technical limitations and results of Human Health Risk Assessment. Air Emission Monitoring: • Undertake air emission sampling using flux hood and soil gas sampling methodologies. Section 4 provides a summary of the scope of work carried out to meet the objectives, together with the results of the investigation and HLA's conclusions and recommendations.
2 Mar 2006	The Auditor visited the site.
31 Mar 2006	Chris Jewell was engaged by Orica Australia Pty Ltd as Site Auditor for the site.
11 Apr 2006	The Auditor attended a meeting between with Orica, HLA and NSW EPA; the Auditor also carried out a site visit.
6 Jul 2006	The Auditor attended a health risk assessment workshop meeting between Auditor, NSW EPA, South-South-West Area Health (SSWAH), URS and Orica.
10 Aug 2006	The Auditor received a copy of URS's Human Health and Environmental Risk Assessment (HHERA), dated 8 August 2006.
11 Aug 2006	The Auditor received a copy of HLA's draft Phase 2 Remedial Investigation dated 8 August 2006.
30 Aug 2006	HLA produced its Phase 2 Remedial Investigation the objectives of which were: • to meet the requirements of conditions 4A through 4C of the Remediation Order; • to further delineate identified source areas to assist the preparation of a remedial action plan (RAP); • to further investigate the source location of the B-S1 groundwater plume (Area C); • to investigate potential impacts from the trade waste line; • to investigate identified data gap areas in order to provide an assessment of the nine site areas and to provide information for preparation of the RAP and a HHERA; • to assess groundwater conditions on the eastern site boundary and the eastern extent of off-site impact; • to assess the nature and extent of MCB and DDX contamination in the off-site well BP107; and • to further assess the lateral and vertical extent of identified plumes, both on site and off site. Section 4 provides a summary of the scope of work carried out to meet the objectives, together with the results of the investigation, groundwater modelling, HHERA (conducted by URS), and HLA's conclusions and recommendations.

TABLE 1
Chronological Overview of Significant Events

Date	Activity/Task
1 Sep 2006	Section B Site Audit Statement (SAS) and Site Audit Report (SAR) issued by the Auditor. The Auditor concluded that: in relation to compliance with Sections 4A, 4B and 4C of Remediation Order 23019 issued on 2 November 2005: - the nature and extent of the contamination has been appropriately determined; and - the investigation is not appropriate for the purpose of the plan.
5 Sep 2006	The Auditor received a copy of URS's HHERA dated 31 August 2006.
5 Sep 2006	The Auditor received a copy of HLA's Phase 2 Remedial Investigation dated 30 August 2006.
21 Sep 2006	The Auditor attended a site meeting with Orica, A. D. Laase Hydrologic Consulting Pty Ltd (Laase), URS, and HLA to discuss the outcome of the SAS and SAR.
9 Oct 2006	The Auditor received a copy of HLA's draft Remedial Technology Assessment (RTA) (Soil) dated 9 October 2006 and a copy of HLA's draft RTA (Groundwater) dated 10 October 2006.
15 Dec 2006	The Auditor received an updated version of HLA's draft RTA (Soil) dated 13 December 2006 and an updated version of HLA's draft RTA (Groundwater) dated 12 December 2006.
19 Dec 2006	The Auditor received an updated version of HLA's draft RTA (Groundwater) dated 15 December 2006. The Auditor reviewed HLA's draft RTA (Soil) and considered the document to be comprehensive, adequate, and providing the information needed to carry out the Auditor's limited role under Sections 4.3.1, 4.3.2, 4.3.7 and 4.3.8 of the site auditor guidelines. He advised Orica accordingly in an email dated 19 December 2006. The Auditor reviewed HLA's draft RTA (Groundwater) and made the following comments: 1. Compliance with the RO Whilst the report generally complies with Conditions 4F, 4G and 4I of the RO, it seems that it does not address all of Condition 4G. Specifically: *v. In relation to Schedule X Wastes, demonstrated conformance with approaches to determine air and water emissions standards in the National Management Plans for Schedule X Wastes, or describe alternative approaches.* *vi. Proposed remediation criteria for soil and groundwater that ensure the remediated site will be suitable for its current and approved use(s) as defined in the CLM Act and to the maximum practicable extent for the proposed use(s) of the land.* *vii. Demonstration that the proposed technologies will adequately meet the remediation criteria referred to in condition 4G (vi).* do not appear to be directly addressed. I agree that there is mention, and an explanation, for the absence of remediation criteria, but think that this should be tackled head-on, with reference to the RO conditions, in Section 1 and Section 5. This would provide a basis for the recommendations in Section 6. Other issues Whereas there may be a good argument that plume remediation is not practicable and, on the basis of risk assessment, not required, the same does not necessarily apply to DNAPL source zones. I think a little more discussion of the potential for use of treatment trains of complementary technologies (e.g. combination of an intensive, short-term, area specific technology such as ECH with a long term, less area-specific approach such as bio-augmentation - when things have cooled down) would have been be worthwhile. There are obviously other potential combinations where the limitations of one technology are balanced by the advantages of another. I don't think that this is exclusively the territory of a RAP, and would be useful in this report. Section 2.4.2.1 Organic Carbon There are no site-specific data or *published data for the fraction of organic carbon in the Bringelly Shale.* A literature review of studies on the fate and transport of organics pollutants in shale aquifers indicated that f_{oc} ranged from 0.001 (0.1%) (Barone, 1990) to 0.006 (0.6%) (Lenczewski et al, 2003). This is incorrect – this was previously raised in my review of the groundwater report. The Auditor advised Orica accordingly in an email dated 19 December 2006.

TABLE 1
Chronological Overview of Significant Events

Date	Activity/Task
	A revised draft RTA (Groundwater) was forwarded to the Auditor on 22 December 2006. The Auditor reviewed the final draft RTA (Groundwater) and forwarded a letter to Orica dated 22 December 2009 stating the following: I have now viewed the final reports • Remedial Technology Assessment (Groundwater), 2 Christina Road, Villawood NSW, dated 22 December 2006; and • Remedial Technology Assessment (Soil), 2 Christina Road, Villawood NSW, dated 22 December 2006. I consider that the issues that I raised have been adequately addressed in the final reports. I consider that the work described in the reports was adequate in scope and execution, and that the reports are of an appropriate standard, as required by the guidelines relevant to a site audit carried out under the Contaminated Land Management Act. I consider that the reports adequately address Conditions 4E, 4F, 4G, 4H and 4I of Remediation Order 23019 or provide an adequately justified explanation as to why some aspects of these conditions cannot be met at the present time. Subsequently, the Auditor forwarded a letter to NSW EPA, dated 19 February 2007, stating the above in order to satisfy NSW EPA requirements. NSW EPA responded in a letter dated 21 March 2007, accepting the advice outlined in the Auditor's letter and confirming that it satisfied the requirements of Condition 4J of the Remediation Order 23019.
20 Dec 2006	Orica forwarded the Auditor a copy of HLA's letter summarising soil and cyanide results at the site, dated 13 December 2006.
11 Jan 2007	The Auditor received copies of HLA's final Remedial Technology Assessment (Soil) dated 22 December 2006 and its final Remedial Technology Assessment (Groundwater) dated 22 December 2006.
22 Jan 2007	The Auditor received a copy of HLA's letter, dated 17 January 2007, responding to the Auditor's review of the Phase 2 Remedial Investigation and issues with respect to the groundwater flow and solute transport modelling undertaken as part of the study.
16 May 2007	The Auditor attended a meeting with Orica and NSW EPA.
5 Jun 2007	The Auditor received a copy of HLA's Phase 3 Data Gap Investigation (DGI) dated 31 May 2007.
29 Jun 2007	The Auditor received a copy of URS's HHERA dated 22 June 2007.
13 Jul 2007	The Auditor received a copy of Laase's Groundwater Flow and Contaminant Transport Modelling (GFCTM) report dated June 2007.
Jul 2007	CH2M HILL produced its Validation Report and Under Building Investigation for part of the site known as 'The Pharmaceuticals Site'. *Note*: the Auditor did not receive a copy of these reports until 14 April 2010. See Section 4 for further discussion and the Auditor's comments.
16 Jul 2007	The Auditor received a copy of HLA's Draft RAP dated 13 July 2007.
24 Jul 2007	The Auditor carried out an initial review of the Draft RAP, Phase 3 DGI, HHERA and GFCTM reports and advised Orica, NSW EPA and HLA accordingly in a letter dated 24 July 2007. Following is the overview of the Auditor's initial review, a copy of the entire document is provided in Appendix C of this SAR. The draft RAP sets out a clear and comprehensive program for remediation of soil contamination on the Villawood site. The data gaps report and the revised groundwater flow and contaminant transport modelling report have addressed the issues raised in my previous review. The risk assessment report has also addressed the issues raised previously, although seasonal soil vapour data are still being acquired, and some other issues related to vapour risk assessment are apparent. The risk-based soil levels derived by the risk assessment are considered to be robust. Although the groundwater modelling report and risk assessment have demonstrated that active remediation of groundwater contamination is not currently required, in my opinion the draft RAP does not address broader groundwater contamination issues in a manner that complies with the requirements of the remediation order and the

TABLE 1
Chronological Overview of Significant Events

Date	Activity/Task
	NSW Guidelines for the Assessment and Management of Groundwater Contamination. On 17 September 2007, the Auditor received a copy of HLA's revised Section 4 of the Draft RAP. The Auditor reviewed the updated section and considered that as a whole it provided the background information on hydrogeology that was required. He advised Orica and HLA in a facsimile dated 28 September 2007.
2 Oct 2007	The Auditor received a copy of HLA's revised draft RAP dated 21 September 2007. The Auditor reviewed this version of the draft RAP and found that it addressed the major issues previously identified and was suitable for release to contractors preparing the EOI. He advised Orica and HLA accordingly in a facsimile dated 2 October 2007.
5 Oct 2007	The Auditor received a copy of HLA's Final Draft RAP dated October 2007. The Auditor reviewed the Final Draft RAP and noted that from his perspective the document was suitable for release to contractors as part of the EOI process for remedial works. He advised Orica accordingly in a letter dated 16 October 2007.
3 Sep 2008	NSW EPA forwarded a letter to Orica outlining its review of the RAP and supporting documents. The review noted that the RAP needed to address the remediation of DNAPL in the subsurface and should include a proposed groundwater monitoring plan. NSW EPA also reviewed the HHERA in regards to groundwater contamination and raised a range of issues that required re-consideration. The Auditor attended a meeting with Orica and NSW EPA on 12 September 2008 to discuss the removal or treatment of dense non-aqueous phase liquids (DNAPL) at the site. Further to the meeting, NSW EPA forwarded a letter to Orica, dated 7 October 2008, reiterating the need for the RAP include a strategy to eliminate or control the sources of DNAPLs at the site, this letter also included NSW EPA's detailed review of HLA's HHERA (dated 22 June 2007).
16 Sep 2008	The Auditor attended a meeting with Orica and ENSR.
1 Dec 2008	The Auditor attended a meeting with Orica and NSW EPA to present the RAP.
27 Apr 2009	The Auditor received a copy of ENSR's final draft RAP Addendum dated 27 April 2009. The Auditor reviewed the final draft RAP Addendum and found the document to be sound. He advised Orica and AECOM accordingly in an email dated 16 June 2009.
10 Jul 2009	The Auditor received a copy of AECOM's Final RAP Addendum dated 9 July 2009. The Auditor reviewed the Final RAP Addendum and made the following comments in a letter to Orica dated 17 July 2009. I have reviewed the final version of the Remedial Action Plan Addendum for 2 Christina Road, Villawood. I previously reviewed a draft version of this document, and note that my review comments have been incorporated into the final version. I have also read the supporting research papers and other technical material that are included in the technical appendix (Appendix A). I had previously reviewed this material in the course of the Remedial Action Plan development and review. The focus of this addendum, and its main objective, is to re-enunciate the conceptual site model (CSM) that underpins the remedial strategy that has been developed for the site, and to tie the CSM more strongly to both the theoretical framework on which it is based, and the site data. I believe that the CSM is sound, and is founded on an adequate site dataset and effective numerical modelling. Where knowledge gaps exist, they are clearly stated, and in my opinion, variation of assumed parameters within a credible range would not change the interpretation significantly. The knowledge-based referenced in the addendum document is comprehensive. This theoretical framework has been developed over a period of more than 10 years by some of the leading academic researchers in this field, and has been given practical context by agency reviews, case studies and technology evaluations. I think that the theoretical framework has been fairly and appropriately used in the development of the CSM, and is appropriately cited in the addendum document. Specifically, this is the case for the discussion of concentration-gradient driven diffusion between the active fracture flow system and the matrix porosity in the Bringelly Shale and its weathering products.

TABLE 1
Chronological Overview of Significant Events

Date	Activity/Task
	Thus, whilst the conceptual model necessarily incorporates assumptions, and falls short of complete certainty, the assumptions are soundly based. Certainty is never achievable in work of this type, but I note that the Remedial Action Plan Addendum lists specific measures to verify CSM assumptions and assessed parameters during remedial works. This verification process must be kept under ongoing review, so that the model assumptions can be revised, and the remedial program modified, should this prove to be necessary. his could be achieved by regular communication between the remediation consultant and the Site Auditor as remediation proceeds. In conclusion, I endorse the Remedial Action Plan as amended by this addendum document.
22 Feb 2010	The Auditor took part in a conference call with Orica, URS and Thiess to discuss the risk based groundwater criteria.
14 Apr 2010	The Auditor attended a meeting with Orica. The Auditor received copies of CH2M HILL's Validation Report dated July 2007 and Under Building Investigation dated July 2007.
16 Apr 2010	The Auditor received a copy of AECOM's draft Remedial Action Plan (RAP), dated 16 April 2010, for review. The Auditor reviewed the draft RAP and found the document to be suitable, he advised Orica accordingly in an email dated 18 May 2010.
18 May 2010	The Auditor received an email from Environmental Risk Sciences Pty Ltd (ERS) regarding the risk calculations associated with the derivation of the groundwater RBGCs. The Auditor reviewed the calculations and found the approach to be sound and the values suitable for the EMP. He advised ERS and Orica accordingly in emails dated 18 May 2010.
28 Jun 2010	The Auditor received a copy of URS's Final Human Health and Environmental Risk Assessment (HHERA) dated 24 June 2010. The Auditor reviewed the HHERA and requested a meeting take place between Orica, ERS and himself to discuss issues relating to the assessment. Subsequently, the Auditor attended a meeting with Orica and ERS on 28 July 2010 to discuss the HHERA.
26 Aug 2010	The Auditor attended a meeting with Orica and NSW EPA.
27 Aug 2010	The Auditor forwarded a letter to Orica confirming that he had: . . . completed a review of the Human Health and Environmental Risk Assessment, Orica Villawood, prepared by URS Australia Pty Ltd (ref. 43217484, dated 12 August 2010) and the Remedial Action Plan, prepared by AECOM Australia Pty Ltd (ref. S4149701, dated 2 June 2010). Following discussions with URS and AECOM, and incorporation of some minor amendments, I am satisfied that the Remedial Action Plan is suitable and appropriate.
31 Aug 2010	The Auditor received final versions of the RAP (dated 2 June 2010) and the HHERA (dated 12 August 2010).
14 Oct 2010	Orica lodge an Environmental Assessment (EA) for the project with the NSW Department of Planning (DOP) for review. The DOP reviewed the EA and, in a letter to Orica dated 12 November 2010, considered that further information and clarification in relation to the RAP was required before publically exhibiting the project. Subsequently, changes are made to the RAP and HHERA. On 6 December 2010, the Auditor received copies of the amended RAP (dated 3 December 2010) and HHERA (dated 6 December 2010) for review. The Auditor reviewed the documents and considers that the changes to both the HHERA and RAP generally address the issues raised by NSW EPA and DOP. He did however, make the following comment:

TABLE 1
Chronological Overview of Significant Events

Date	Activity/Task
	The only exception is the HHRA Executive Summary: Based on the available data and the assessment presented in this report there are currently no unacceptable risks to human health or the environment associated with the presence of impacted groundwater beneath ***existing down-gradient off-site areas***. However to assist in the evaluation of further monitoring data RBGCs have been calculated for impacted groundwater beneath off-site areas. The RBGCs have been derived for COPC identified in off-site groundwater and are based on the protection of human health, in particular exposures by long-term workers and intrusive workers. The derived RBGCs are considered trigger levels, where exceedance of these levels should prompt the need to conduct further sampling (such as soil gas or indoor air) and assessment. This does not make sense. It should reflect Section 9.1 and indicate that the RBGC are protective for existing exposures (slab-on-ground construction) in downgradient off-site areas. On 10 February 2011, the Auditor received, for his review, an email from Orica containing a review of the revised EA from NSW EPA (dated 31 January 2011) and an updated final draft of the HHERA (dated 9 February 2011). On 17 February 2011, the Auditor received a copy of the updated final RAP (dated 15 February 2011) for his review, which incorporates the comments made by NSW EPA.
13 May 2011	The Auditor received a copy of the final EA (dated February 2011), which included final versions of the RAP (dated 17 March 2011) and the HHERA (dated 9 February 2011).
12 Sep 2011	The Auditor received an email from Orica advising that it had now received the submissions for the EA and requesting a final review of the RAP and HHERA documents, final versions of which were included in the EA (dated February 2011).
15 Mar 2012	The Auditor viewed the site.
19 Mar 2012	Site Audit Statement (SAS) and Site Audit Report (SAR) issued by Auditor. Copies of SAR and SAS forwarded to Orica, NSW EPA and Bankstown City Council (Council). A copy of the SAR was forwarded to AECOM and URS.

Note: Shading indicates work undertaken before the Auditor became involved.

3.0 SITE INFORMATION

Basic identification and location information concerning the site is provided below. An indication of the layout, topography, drainage, geology and hydrogeological setting of the site is also provided, together with an overview of its history.

Any known or potential contaminant sources have been listed, and the associated contaminant groups of concern identified. This section also outlines the future use of the site and provides the associated assessment criteria.

It should be noted that subsections below generally relate to the final versions of reports produced by the consultants, and incorporate any relevant responses to comments raised by the Auditor during the course of the site audit.

3.1 Site Identification and Location

This Site Audit Report (SAR) relates to land located at 2 Christina Road, Villawood, New South Wales (the site). The location of the site is shown on Figure 1. Australian Map Grid Zone 56H co-ordinates of the centre of the site are approximately 314050E and 6249070N.

As of the date of this report, the description of the site is Lot 1 in DP634604, and the owner is Orica Australia Pty Ltd.

The site lies within Bankstown City Council local government area, in the Parish of Liberty Plains, County of Cumberland, and is currently zoned for industrial use.

3.2 Site Setting

The site is located in a predominantly commercial/industrial area, as indicated on Figure 3.

The site is bounded as outlined below.

To the north This area was originally part of the Commonwealth of Australia's explosive factory and was later used as Taubmans paint and resins manufacturing facility. At the date of this report, a paint manufacturer and a storage facility are located to the north of the site.

To the east The land between the eastern boundary and Miller Road was open land until sold by ICIANZ in 1984. This area is currently occupied by a commercial/industrial premises.

To the south The site boundary is Christina Road beyond which are commercial/industrial areas with an open drainage channel. The Main Southern Railway is located further south, to the south of which lies the Leightonfield sidings.

To the west This area was formerly part of the explosives factory. A building occupied by a picture framer and furniture manufacturer is located directly to the west, adjacent to the site, beyond which lies Birmingham Avenue.

3.3 Site Layout, Topography and Drainage

3.3.1 Site Layout

The site is rectangular shape, with an area of approximately 126,000 m^2 (12.6 hectares). At the date of this report, the majority of the site was covered by building slabs, roadways and pavements. An area of the site to the north-west is grassed and is believed to have been extensively filled in the past. The layout of the site is indicated on Figure 2.

3.3.2 Topography

The site is located within the Sydney Basin, within the geomorphic region known as the Cumberland Plain and locally within the Blacktown soil landscape group, which is characterised by gently undulating rises on Wianamatta Group shales with relief ranging up to 30 metres and slopes generally less than 5 per cent (%).

The site slopes from the north-east corner, which is approximately 36 metres above Australian Height Datum (AHD), to the south-west corner, which is approximately 18.5 metres above AHD. The site has been progressively cleared and filled over the years and the highest point of the site is the remnants of a blast mound (approximately 39 metres above AHD) located at the northern boundary of the site.

3.3.3 Drainage

Surface water drainage is expected to be to Byrnes Creek which is located approximately 350 metres downgradient and south-west of the site (to the south of the rail line). Byrnes Creek is essentially a concrete-lined drain and a tributary of Prospect Creek, which is located approximately 4.5 kilometres downstream from the site. In the vicinity of the site, Byrnes Creek receives stormwater discharge from a number of open concrete drains, including one located to the north of the site and another located in the industrial area south of Christina Road. Byrnes Creek has no recreational or ecological value.

Historically, before the early 1970s surface water from the site was collected in open earthen drains and discharged to an open drain to the south of Christina Road. In the early 1970s these drains were replaced with pipe drains, which continued to direct water off site until 1990, at which time surface run-off was segregated into clean stormwater and potentially contaminated run-off. Since then, clean stormwater has been discharged into Byrnes Creek, and run-off from the manufacturing area has been retained for testing before it is discharged.

3.4 Geology

3.4.1 Desktop Review

A review of the Penrith 1:100 000 Geological Series Sheet 9030 (Edition 1) 1991 indicates that the site is underlain by the Bringelly Shale – a member of the mid-Triassic age Wianamatta Group. Underlying the Bringelly Shale is the Ashfield Shale member of the Wianamatta Group, and beneath that the Hawkesbury Sandstone.

The Wianamatta Group and underlying sandstone have been folded and locally faulted by a series of tectonic events that have formed the Sydney Basin, resulting in vertical and sub-vertical joints (two regional sets) and other fractures and, less obviously, low-angle bedding-plane partings and shears.

The terms Bringelly Shale and Ashfield Shale are generic, and a range of lithologies is present within both units.

The Bringelly Shale comprises (in order of abundance) interbedded and interbanded shales, carbonaceous claystone, laminate, sandstone, and, rarely, coal horizons. Regionally, the upper part is deeply weathered, typically resulting in several metres of laterite. The weathered zone grades from residual clay through mottled and leached shales to fresh shale, and may have a thickness of up to 6 metres.

The Ashfield Shale contains four distinct units – a lower unit composed of dark grey to black sideritic claystone and siltstone, overlain by a sandstone-siltstone laminite unit, a second siltstone unit, and an upper sandstone-siltstone laminite that grades into the Minchinbury Sandstone - a unit that, regionally, separates the Ashfield and Bringelly Shales, but is not prominent on site.

3.4.2 Site Investigation Findings

With regard to HLA's investigations of the site, the Auditor noted the site has been progressively cleared and filled over the years, and fill is now the upper stratum across the site, comprising reworked clay varying from shallow to deeper pockets up to 6 metres below ground level (bgl).

The layer of natural clay underlying the fill varies in thickness. It is mottled orange/grey, moist and of moderate to high plasticity. Underlying the residual clay is weathered shale, at depths greater than 1 metre. HLA's investigations identified sub-vertical fractures at approximate 1-metre spacings.

The Auditor notes that organic carbon content within the Ashfield and Bringelly Shales ranges from 0.15% to 4.5% (Herbert 1979).

Copies of HLA's borehole logs are provided within its respective reports, copies of which are provided as Appendix B of this report.

3.5 Hydrogeology

The regional groundwater system is governed by the host geology. The Bringelly and Ashfield Shales have low primary porosity and permeability; the main pathways for the migration of water have thus developed along bedding planes and fractures. The regional groundwater flow directions within the Wianamatta Group are influenced by the topography and surface water features.

The local groundwater flow direction is south-westerly, towards Byrnes Creek. The hydraulic gradient is steeper beneath the higher northern areas – 0.022, compared with 0.010 at the Byrnes Creek floodplain.

Standing water levels measured on site range from 15 metres above AHD (BP114) to 19 metres above AHD (BP103).

HLA reported that the vertical hydraulic gradient is downwards on site, with shallower groundwater at a higher elevation compared to deeper groundwater. Off-site, the vertical hydraulic gradient is upwards with deeper groundwater at a higher elevation compared to shallow groundwater, supporting the assumption of groundwater discharge to Byrnes Creek.

According to HLA, seepage velocities of groundwater on site range from 0.005 metre per day (m/day) to 0.2 m/day.

A more detailed discussion of groundwater characteristics and modelling results is provided later in this report.

3.6 Site History

The site was initially part of land acquired by the Commonwealth of Australia in 1941, and subsequently used for the manufacturing of munitions, including trinitrotoluene (TNT). This facility extended beyond current site boundaries.

In 1946, the site was purchased by Taubmans Pty Limited who manufactured a range of chemicals including monochlorobenzene and dichloro-diphenyl-trichloroethane (DDT) until the southern portion of the facility (the site) was purchased by Imperial Chemical Industries, Australia New Zealand Pty Ltd (ICIANZ) (now known as Orica) in 1953.

During the occupancy by ICIANZ, a large portion of the site was used for the formulation (i.e. mixing) of agricultural chemicals rather than the synthesis of these chemicals.

In 1983 there was a fire in the former pharmaceuticals plant. A new pharmaceutical plant was constructed soon after this event.

In the late 1980s, a site containment system for stormwater, including a first flush system, was installed. This system included the northern and southern reservoirs.

Prior to operations ceasing at the site in 2000, the property was occupied by CropCare Australasia (located across the majority of the site), engaged in the manufacture of agricultural and pool chemicals, and AstraZeneca (located in the south-western portion of the site) engaged in the manufacture of pharmaceuticals.

Most of the site structures and buildings were demolished in 2001.

3.7 Potential Contaminant Sources

On the basis of the findings of site historic review (SHE 2000) and site inspections, URS identified the following historical potential contaminant sources in its HHERA (June 2010). Investigation areas are shown on Figure 2.

Area A

- Presence of boiler ash, which possibly includes heavy metals and polycyclic aromatic hydrocarbons (PAH);
- Effluent Treatment Plant; and
- Past activities by lease holders of the social club.

Area B

- Former empty drum storage area;
- Former equipment graveyard; and
- Presence of demolition waste in fill material.

Area C

- Storage area for empty drums in the northern area of the Pharmaceutical Store (observed in a brief aerial photograph review by URS); and
- Storage of chemicals at the Flammable Drum Store.

Note: URS found the potential for contamination from the Pharmaceutical Plant to be minimal on the basis of Good Manufacturing Practices (GMP) in this part of the site.

Area D

- Chemicals stored in the Pharmaceutical Research and Development Building;
- Location of the former Pharmaceutical Plant which was destroyed by fire;
- Chemicals stored in the CropCare Laboratory Building;
- Interceptor pit on the eastern perimeter of the laboratory building, where wastes may have been discharged in the past; and
- An area between the Main Laboratory and Accounts Building, where grass has been unable to grow and that may have been used for waste disposal in the past. *Note:* URS's

more recent observations at the site suggested that grass cover had been observed in this area.

Area E

- CropCare Finished Goods Warehouse where insecticide dusts were formulated in an old pan mill. DDT was handled in this area of this building.
- Swampy area, west of the Effluent Treatment Plant, where empty drums were stored;
- Effluent Treatment Plant, which removed pesticides;
- Store R14, which was used for the storage of flammable finished goods; and
- Laboratory Retention Store, where old samples were stored.

Area F

- Tetramisole Plant where 1,2-dichloroethane (EDC) and ethylene imine were used. Other potentially contaminating chemicals used in this building included acetone, methanol, toluene, monoethanolamine, diol, thionyl chloride, tars, dimethyl amino pyridine and thiourea;
- Packaging Store (Building 308) where ethylene imine was handled;
- Tank Farm where bulk chemicals were stored;
- Old dust laboratory store which was destroyed by fire;
- Effluent Holding Tank Pit (also referred to as 'BlackTank') which had possible EDC leaks;
- Engineering Huts on the northern boundary of Area F;
- Compressor House where diesel and oils would have been used. It is also reported that ethanol was used in the Compressor House;
- Scrubber, where acids and alkalis were used;
- The Alkyl Ketone Building; where recovered ethanol that included tralkoxydim and tars were handled;
- Stripping Plant which may have had possible leaks; and
- Store No.30 (Store 315) also known as Boiler House, had the potential for contamination from water treatment chemicals, diesel and oils.

Area G

- CropCare No.20, formerly known as the Waste Store which until recently had an earthen floor. Chemical odours have been observed from this building;
- Trade Waste Pit, which fed effluent to the treatment plant;
- Plant No.1 where trinitrotoluene (TNT) was manufactured and chemicals such as mononitrotoluene, acetic acid, PP321 (pyrethroids) and solvents were formulated;
- Bulk Touchdown Area where chemicals were stored in tanks, including cobalt and selenium-based chemicals;
- Herbicide Plant No.2 where solvents, simazine, urea, toluene, 2,4,5-T Butyl ester, 2,4-D (2,4-dichlorophenoxy acetic acid), cypermethrin, diquat dibromide, ethylene glycol, dimethylamine, cyclohexanone, n-butanol, octanol n-methyl-2-pyrrolidone, vapam

(herbicide), chloropropham (carbamate), pendimethylin (herbicide), bensulide (herbicide), monosodium methylarsenate, trifluralin and vernam (thiocarbamate) were handled;

- Tank Farm No.1 where weed killers were stored;
- Tank Farm No.2 where xylene, toluene, and solvesso were stored;
- Plant No.3 where cypermethrins, orchex 796 (thiocarbamates), herbicides and cotoran (urea) were handled;
- Scrubber Area where caustic soda, sodium hypochlorite and phosphoric acid were used;
- Store No.305 where Tandone (carbamate), simazine, and atrazine were used;
- Plant No.4, formerly known as the Sorbies Plant, Chlorea Plant and Store No.305A which was used for the manufacture of herbicides;
- Bipyridyl Tank Farm where diquat dibromide and paraquat dichloride were stored;
- Flammable Liquids Store No.17 (formerly known as Store No.279);
- Filled area to the west of Store No.17;
- Substation which has the potential to have contained transformer oils including PCBs;
- Bunded above ground diesel tank;
- Former Cobex Plant in the area of the above ground storage tank (AST). Chemicals such as dinitriamine, methyl iso amyl ketone, styrene monomer, atlac 382 N,N dimethyl amine, styrene, cobalt naphthalene and hydrocarbons were used; and
- Pilot Laboratory where many different types of chemicals were used.

Area H

- Packaging Store No.5 (formerly known as Store No.205) which was used for the filling of insecticides and fungicides. Chemicals such as formaldehyde, malathion, lindane, imidan, hexachloroethane, EDC, ethylene dibromide, phenyl mercuric chloride, 2-phenylbenzimidazole, phenyl mercuric acetate, carbaryl, chloroform, diphenylamine, dieldrin, diazinon, cyhexatin and DDT were used;
- Buried malathion tank in the north-eastern corner;
- Store No.11 (formerly known as Flammable Solids Store No.296) where weed killers were mixed on the floor;
- Scrubber where sodium hydroxide and sodium hypochlorite were used;
- Drum Store No.7 (formerly known as Store 327) where ethanol and solvents were stored;
- Drum Store No.8 (formerly known as T29) where ethanol and solvents were stored;
- Drum Store No.9 (formerly known as Store 312) where chemicals such as triethanolamine, propylene glycol, thionly chloride, trifluarlin, DDT, diazinon, dinitriamine, cypermethrin, carbon tetrachloride, chloroform, paraquat dichloride, methylene chloride, monoethanolamine, perchloroethylene, permethrin, formothion, endosulfan, epichlorohydrin, ethylene glycol, malathion, hexylene glycol, and tetramisole salt were stored;
- Substation No.2 which may have included polychlorinated biphenyls (PCB) containing transformer oils;

- Plant No.5 (formerly known as DPG Plant 311), which was the insecticide and fungicidal manufacture and filling plant. Chemicals such as diesel distillate, ethanol, n-butanol, isopropanol, butyl cellosolve (a hydrocarbon), propachlor (chloroacetanilide), piromophos-methyl (insecticide), hexaconazole, dicofol (organochlorine (acaricide)), Tetradifon (organochlorine (acaricide)), methylene chloride, permethrin 25:75, Amitraz (Amidine (acaricide)), paraformaldehyde (Fungicide (acaricide)), Manocozeb (Dithiocarbamate), pirimophos ethyl, phenol, propachlor, octanol, propylene glycol, monochloroxylenol, malathion, methanol, methyl ethyl keteone, methylated spirits, permethrin, perchloroethylene, p-chloro-m-xylenol, toluene, xylene, triethanolamine, Shellsol 1687, solvents, diazinon, chloroform, dieldrin, dimethylformamide, diphenylamine, DDT, atrazine, bioresmethrin, carbon tetrachloride, EDC, acetone, acetic acid, cypermethrin, formaldehyde, hexachloroethane, kerosene, ethanol, epichlorohydrin, endrin, endosulfan, and ethylene dibromide were stored;
- Lime Sulphur Pit; and
- Sydney Williamson Hut, where weedkillers were used.

Area I

- Store No.233 was the original mononitrotoluene plant and was later used for animal remedies filling and the manufacture of sheep dip. Chemicals such as TNT, mononitrotoluene, OCPs, chloral, propyl hydroxy benzoate, monochlorobenzene, methyl hydroxy benzoate, edicol tatrazine, toluene and DDT were used.
- Store No.234 was used to isolate DDT and was later used for the formulation of insecticides and fungicides. Chemicals such as n-butanol, trichlorofon, chloral, isopropanol, methanol, methyl hydroxy benzoate, Imidan, hexachloroethane, solvents, mononitrotoluene, methylated spirits, monomchloroxtlenol, chlorofenzon, malation, dimethoate (OPP), n-menthyl-2-pyrolidone, lindane, kerosene, methyl ethyl ketone, perchloroethylene, p-chloro-m-xylenol, solvents, formothion, propylene glycol, sodium benzoate, diazinon, DDT, cyclohexanone, cresylic acid, dieldrin, carbon tetrachloride, acetic acid, chloroform, ethanol, formaldehyde, ethylene glycol, ethylene dichloride, paraformaldehyde, epichlorohydrin, endrin, endolsufan, diphenylamine, tetramisole, ethylene dibromide, toluene, xylene, trichlorofon were used;
- Monochlorobenzene UST;
- Floor washings from monochlorobenzene production;
- Former Levamisole Plant were toluene was used;
- Former tank farm where toluene, xylene, kerosene, methylated spirits, benzene, solvents, mineral oil, chloroform, endosulfan, ethanol, malathion were stored;
- Equipment washdown area, which recently included two 44 gallon drums;
- Igloo Workshop where lubricating oils, oil, transformer oils (potentially containing PCB), methylated spirits and diesel were used;
- Garage where cleaning solvents, lubricating oils and diesel distillate were used;
- Electrical workshop where instrument liquids (potentially containing mercury) were handled;
- Cooling tower, where water treatment chemicals were handled;
- Two USTs, one located north-west of the workshop and one south of the workshop; and
- HV Substation No.9, which as the potential to have oil contamination.

The Auditor considered this to be an acceptable assessment of potential contaminant sources likely to be present on such a site on the basis of its former industrial use.

3.8 Contaminant Groups of Concern

On the basis of the identified potential sources of contaminants, the initial investigations targeted a wide range of organic and inorganic contaminants that could result from the storage, mixing, processing and manufacture of chemicals.

NSW EPA's 2005 Remediation Order identified the primary contaminants of concern for the site as:

- total petroleum hydrocarbons (TPH)
- benzene
- DDT and its degradation products DDD and DDE (DDX)
- 1,2-dichloroethane (EDC)
- trichloroethene (TCE)
- chlorobenzene (MCB)
- 1,4-dichlorobenzene (1,4-DCB)
- hexachlorobenzene (HCB)
- lindane (a-BHC)
- polycyclic aromatic hydrocarbons (PAH), including benzo(a)pyrene (BaP); and
- cyanide

Note: AECOM's Phase 1 and 2 remedial investigations undertaken across the site did not identify any significant cyanide sources in soil and the analysis of groundwater samples collected from the well network generally reported non-detectable cyanide concentrations. Consequently, AECOM did not consider cyanide to be a contaminant of potential concern (COPC) at the site.

Based on previous investigations, URS identified COPC in a number of areas on and off the site in their HHERA (URS 2010). The COPC identified by URS reflect the characteristics of the source zones and groundwater plumes relevant to those areas. Section 6.3 of this report presents a summary of COPC in soil and air at the site.

The individual compounds that make up the PAH contaminant group are listed in Appendix A.

The Auditor considered the above to be an acceptable assessment of the contaminants of concern.

3.9 Proposed Development

At this stage, the future landuse of the site has not been determined. However, based on the predominantly commercial / industrial landuse in the area surrounding the site, the Auditor anticipates a commercial/industrial landuse for the site.

3.10 Assessment Criteria

3.10.1 Soils

Site specific risk-based criteria have been developed by URS. These are discussed in Section 7 of this report.

3.10.2 Groundwater

Human health and environmental risks were assessed by forward modelling of the risks associated with measured concentrations of contaminants in groundwater. As discussed in Section 7 of this report, these risks were found to be acceptable.

URS also derived risk based groundwater concentrations (RBGCs) for impacts identified in off-site groundwater. It is expected that the RBGCs will be utilised as trigger levels for the collection of additional data and further assessment in off-site areas.

RBGCs for off-site groundwater impacts are discussed further and presented in Section 7 of this report.

4.0 PREVIOUS INVESTIGATIONS

This section provides:

- An overview of the investigations conducted on the site prior to the issuing of the Remediation Order, prior to HLA's Remedial Investigations (Phase 1 and 2) and prior to the Auditor's involvement. The Auditor has read but did not review in detail key parts of the reports outlined below; summaries are derived from HLA's Phase 1 Report and included here as background information only.
- An overview and the Auditor's evaluation of the remediation and validation works and under building investigation of the portion of the site known as the 'Pharmaceutical Site' conducted prior to the issuing of the Remediation Order, prior to HLA's Remedial Investigations (Phase 1 and 2) and prior to the Auditor's involvement.

4.1 Site Historic Review (SHE, 2000)

SHE Pacific Pty Limited (SHE) conducted review of available site historical information to assist in the planning for a site assessment. The review included interviews with present and former site employees, research into production processes undertaken at the site, historic uses of each of the site buildings, and an aerial photography review. SHE then identified contaminants, practices and events that it considered had potentially contaminated the site.

An overview of SHE's review was provided in HLA's Phase 1 Remedial Investigation dated 22 December 2005, a copy of which is provided in Appendix B.

4.2 Stage 1 Phase 2 Environmental Site Assessment (URS, 2000)

In 2000, URS Australia Pty Limited (URS) carried out Stage 1 Phase 2 Environmental Site Assessment (ESA) which involved a Stage 1 investigation to identify the main site contaminants and areas of concern, and a detailed soil and groundwater investigation to assess the nature and extent of any soil and groundwater contamination. The areas of concern and the main site contaminants are summarised below. The areas identified as areas of contamination are shown on Figure 2; whilst monitoring well locations are shown on Figure 5.

- **Area A:** The main contaminants of concern were identified as DDT and its breakdown products DDE and DDD (combined as DDX). DDX concentrations exceeding the adopted criterion were present within the surface soils.
- **Area B:** The contaminants of concern were identified as DDX, although no concentrations were reported to exceed the adopted criteria.
- **Area C:** DDX concentrations exceeded the adopted criteria in one sampling location (CSB04), within the surface soils.
- **Area D:** A maximum DDX concentration of 8.6 mg/kg was reported within this area; this did not exceed the adopted criterion.
- **Area E:** 1,2,4-trimethylbenzene (1,2,4-TMB) concentrations exceeded the adopted criterion within the surface soils at ESB08, north of Store R14. This was considered to be related to a surface spill of 'Solvesso', a solvent stored in this building.
- **Area F:** TPH C_6-C_9 and EDC concentrations exceeded the adopted criteria at depth at FSB13 (1.1 to 1.4 metres), located beneath the former IHPT tank farm. EDC spills were known to have occurred in the past. A maximum DDX concentration of 88.8 mg/kg was reported within Area F.

- **Area G:** TPH C_6-C_9 and ethylbenzene concentrations exceeded the criteria at surface and at depth at GSB27. DDX, TPH C_{10}-C_{36} and 1,2,4-TMB were detected at surface and at depth at GSB01 (north of Store No. 17) and were considered to be the result of spills of solvents such as Solvesso and other hydrocarbons stored in the building.
- **Area H:** Test pits were excavated in the north-east corner of this area in an unsuccessful attempt to locate a process vessel. Fill material impacted by mercury, TPH C_6-C_{36}, PAH, HCB, DDX and 1,2,4-TMB was identified.
- **Area I:** The identified contaminants of concern included DDX, TPH, 1,2,4-TMB, benzo(a)pyrene (BaP), chlorobenzene and 1,4-DCB.

  MW05: Groundwater at this location was impacted with TPH C_6-C_9 (346 micrograms per litre – µg/L), TPH C_{10}-C_{36} (215 µg/L), DDT (10 µg/L), EDC (13,100 µg/L) and chlorobenzene (307 µg/L).

  MW06: Groundwater at this location was impacted with TPH C_6-C_9 (11,400 µg/L), benzene (300 µg/L), EDC (9 µg/L), 1,4-DCB (18 µg/L), and chlorobenzene (5780 µg/L). Chloroform was detected at concentrations that exceeded the Drinking Water Quality Guidelines.

  MW08: Groundwater at this location was impacted with TPH C_6-C_9 (135 µg/L).

On the basis of the above findings, URS recommended additional site investigation works to delineate the source and extent of the impacted soils and groundwater. URS also recommended a site-specific risk assessment, with the following objectives:

- to identify the requirement to undertake remediation;
- to develop remediation goals for individual contaminants of concern; and
- to allow assessment of remediation technologies.

4.3 Additional Stage 2 ESA (CH2M HILL, 2004)

The CH2M HILL Australia Pty Ltd (CH2M HILL) investigation involved the drilling of fifty-eight boreholes, ten of which were converted to groundwater monitoring wells, and the collection and analysis of soil and groundwater samples. Soil samples were also collected from five trenches excavated across Area B. The locations of the groundwater sampling locations are shown on Figure 5; whilst soil sampling locations are shown on Figure 6.

Results – Soils

The higher OCP levels reported during this investigation were detected in the south-eastern corner of the site. These results were considered to correspond to 'the distribution of fill material' on the site and to areas down-gradient of locations 'where OCPs were manufactured or handled'.

CH2M HILL stated:

> The distribution of TPH C_6-C_9 and TPH C_{10}-C_{36} concentrations in soil above the adopted criteria was considered to be consistent with the distribution of OCPs with the exception of the former Tetramisole Plant in Area I. The TPH C_{10}-C_{36} impacted soils in this part of the site were noted to be wider than the distribution of TPH C_6-C_9.

The distribution of benzene, toluene, ethylbenzene and total xylenes (BTEX) across the site was noted to correlate with the distribution of TPH C_6-C_9, with the exception of an area to the east of the Drummed Waste Store at the eastern end of Area B.

Elevated concentrations of other volatile organic compounds (VOC) were reported adjacent to the following former site structures:

- Store R14 (Area E);
- IHPT Tank Farm (Area F);
- Store No. 17 (Area G);
- Solids Store No. 11 (Area H);
- Flammable Drum Store No. 8 (Area H);
- Store No. 233 (Area I);
- Former Fleet Compound; and
- Tank Farm (Area I).

Results – Groundwater

HLA summarised CH2M HILL's groundwater analytical results as follows:

- Benzene concentrations exceeded the ANZECC (2000) high reliability trigger value at MW06.
- Chlorobenzene concentrations exceeded the ANZECC (2000) low reliability trigger value at MW5, MW06, MW14 and MW17 across the south-eastern portion of the site.
- Tetrachloroethene (PCE) and EDC were detected at MW06 on the southern boundary. The EDC levels exceeded the ANZECC (2000) low reliability trigger value at MW06.
- TCE concentrations exceeded the relevant groundwater guideline at MW06, and MW14 and MW17 in the southern portion of the site.

CH2M HILL concluded that, on the basis of the available data, it was not possible

> to adequately determine whether the site posed a SRoH [significant risk of harm, the terminology used in a previous version of the Act] pursuant to s9 of the Contaminated Land Management Act (1997).

Recommendations for additional works included further detailed assessment for contaminants of concern in:

- areas immediately adjacent to former above and underground structures;
- areas that were not known to CH2M HILL at the time of the investigation but which have subsequently been identified by past and present Orica personnel;
- areas which the current Pharmaceuticals Site Remediation Project is demonstrating as susceptible to containing contamination (e.g. garden beds, landscaped features, etc.); and
- to further assess the identified impacts to confirm their distribution.

A groundwater monitoring program was also recommended, involving:

- installation of additional monitoring wells in off-site locations to assess whether the identified on-site impacts have migrated off-site;
- installation of monitoring wells to delineate the extent of the groundwater impacts identified; and
- continued monitoring of the groundwater passing through the site on an estimated six-monthly basis to assess the distribution of the identified impacts.

4.4 Conceptual Site Model (CH2M HILL, 2005)

The objective of CH2M HILL's Conceptual Site Model (CSM) was to integrate the data obtained from the various CH2M HILL and URS site investigations and thus provide a framework for decision-making with regard to further assessment and required remediation works.

The CSM concluded that:

- Additional data were required to assess the hydrogeological characteristics of the site geology, including potential lateral and vertical flow direction(s), lateral and vertical hydraulic gradient, hydraulic conductivity, etc. due to the complexity of the fractured shale bedrock aquifer;
- The groundwater quality down gradient of some inferred secondary source zones (Areas B, G, H, F and I) had not been adequately characterised;
- Chemicals with the potential to form DNAPL (Compounds - VHC) have been historically used at the site and are present within the dissolved phase in the groundwater (B-S1, B-S2, B-S3 and B-N1). It was concluded that the plumes required further delineation both laterally and vertically;
- Off-site wells were required to confirm that volatile halogenated compounds (VHC) impacted groundwater was migrating from the site;
- The site contains many, varied secondary sources zones, presently only a few have been confirmed (such as, the former ETP and the former trade waste lines);
- The site contains various inferred contaminant migration pathways and transport mechanisms that need further investigation before being either determined as significant or not. These include man-made conduits (trade waste lines, deeper sewer lines), perched water/s and saturated bedrock aquifer flow; and
- The primary potential on-site and off-site human and environmental receptors of predominantly groundwater contamination are inferred to include service trenches, buildings and waterways (both the concrete canal to the south, south-west and west of the site and Prospect Creek) these receptors require further assessment.

Key objectives for future groundwater investigations at the site were as follows.

On-site

- Determine where DNAPLs are located (vertically and horizontally within the site geology);
- determine and identify impacted groundwater plumes, inferred sources and migration pathways;
- further refine the CSM; and
- assess the fate and transport of identified on-site impacted groundwater and DNAPL.

Off-site

- Determine whether impacted groundwater and/or DNAPL is migrating from the site from the southern and western boundaries;
- further refine the CSM;
- assess the fate and transport of identified off-site impacted groundwater and/or DNAPL;
- identify the potential beneficial receptors down gradient of the site; and
- delineate any observed off-site impacted groundwater and DNAPL.

The key recommendations for groundwater investigations at the site were as follows:

Part A

- Installation of nested monitoring wells at off-site, down gradient locations;
- undertake 'on-site Passive Soil Gas Sampling (PSGS) within 'key' inferred source zones and along inferred potential migration pathways'; and
- install nest monitoring wells within the area known to contain DNAPL.

Part B

- Excavate investigative trenches to the top of the groundwater table within the inferred source areas and/or migration pathways based on the results of 'Part A'. These works needed to be undertaken in a manner that is appropriate, advantageous and safe with respect to creating an artificial DNAPL migration pathway;
- install nested monitoring wells on-site based on the results of 'Part A' and trenching results targeting inferred source zones and potential migration pathways;
- install 'deeper' monitoring wells within the nested on-site and off-site wells where investigation of the deeper aquifer is considered warranted;
- carry out soil, rock and groundwater sampling and analysis for the site contaminants of concern; and
- carry out hydrogeological and geophysical testing to estimate the aquifer properties.

4.5 Draft Preliminary Voluntary Investigation – Part 1A (CH2M HILL, 2005)

CH2M HILL's draft report presented the results of off-site workplace vapour testing, a PSGS trial, monitoring of existing on-site groundwater monitoring wells, on-site and off-site drilling investigations and on-site trenching investigations. Locations of trench sampling points are shown on Figure 6.

HLA provided the following summary of results.

- The workplace vapour testing indicated that all contaminant of concern concentrations were below the National Occupational Health and Safety Commission Time Weighted Average criteria in all locations tested.
- The PSGS was concluded to have collected insufficient evidence to support the continued use of PSGS as an investigation screening tool for DNAPL, groundwater plumes and secondary source zones on the site.
- No detailed interpretation of the data obtained during the sampling of on-site groundwater monitoring wells or the drilling and sampling of the new off-site monitoring wells was provided in the draft report.
- The results reported from the excavation of six trenches indicated:
    - **Area I** – MCB and DDX concentrations at IT101 at a depth of 3.5 metres indicated 'that a DNAPL is likely to have migrated along the sampled sub-vertical fracture at some point (which supports the CSM)';
    - **Area F** – EDC concentrations were reported above the adopted criteria in the two trenches (ITF01 and ITF02) with concentrations ranging between 0.8 and 71.5 mg/kg. The report concluded that the EDC impact suggested that the 'trenches had been excavated into the capillary fringe and the EDC concentrations detected within the matrix were a result of matrix diffusion effects from infiltration pore water or DNAPL (supporting the CSM)'; and

- **Area G** – 'a white crystalline material' was observed at trench ITG02 and was considered to comprise pesticides. A water sample from the pipe accidentally broken in this trench exceeded the site criteria for total cyanide, 1,3,5-TMB, vinyl chloride, naphthalene and Bis(2-chloroethyl). A seepage water sample from the trench IT/G01A indicated that isopropylbenzene, 1,2,3-trichlorobenzene, naphthalene and DDX concentrations were above the site criteria.

4.6 Validation Report – Pharmaceuticals Site (CH2M HILL, 2007)

From November 2003 to December 2004, CH2M HILL conducted remediation and validation on the Pharmaceuticals Site in accordance with the requirements of the following report.

- Remediation Action Plan, Pharmaceuticals Site, Christina Road, Villawood, prepared by CH2M HILL Australia Pty Ltd (ref. 312264.T5.003), dated October 2003.

The Validation report also included a groundwater investigation incorporating an on-site and limited off-site assessment to identify potential sources and or migration pathways, delineate impacts identified during previous investigations and to provide data for the assessment of risks to human health and/or the environment.

Note: This Validation report refers only to the Pharmaceuticals Site, which incorporates all of Area A, most of Area C (with the exception of the north-east portion), the south-west corner of Area B, and the western end of Area D.

4.6.1 Objectives and Scope of Work

The objectives of CH2M HILL's validation report were to:

- Identify whether the site soil validation results confirm that remediation was conducted in accordance with relevant guidance, and whether the data indicates that the site is suitable for the proposed commercial/industrial land uses, with the exception of the area located immediately beneath the Pharmaceuticals Building footprint, as this portion of the site has been investigated and assessed in CH2M HILL's Under Building Investigation (July 2007).
- Present the results from the Additional Groundwater Investigation Part 2 (conducted in November 2004) which incorporated an on-site and limited off-site assessment of groundwater quality to achieve the following:
  - Identify probable sources and/or migration pathways of identified groundwater contamination within the site; and
  - Provide supplemental fate and transport information and a reassessment of the risk of harm from identified groundwater contamination plumes at the site.

  Due to the observation of DNAPL within the site during the investigation fieldworks, the objectives of the investigation were refined to provide further fate and transport information in regards to known groundwater impacts.

Scope of Work – Remediation and Validation Works

CH2M HILL's scope for remediation and validation works is summarised as:

- Excavation of impacted materials from Validation Areas (VA) 1 to 7, 7A, 8, 9, 10, 12, Social Club (SC), Trade Waste (TW) and Finished Goods (FG).

  A total of 9990 m^3 of impacted fill, clay, weathered shale and shale was excavated from areas identified as being impacted with contaminants of concern (predominately DDX)

and was transported and stored within the NSW EPA-licensed secure storage facility located on the Orica site.

- Investigation of VA 11, 13, 14, 15, Car Park (CP) and Fish Pond (FP).
- Validation of the remaining soil through sampling and laboratory analysis for the chemicals of concern following removal of the impacted material.
- Reinstatement of remediated areas using validated virgin excavated natural material (VENM).

Figure 7 shows validation areas within the Pharmaceuticals site.

Scope of Work – Additional Groundwater Investigation Part 2

CH2M HILL incorporated the following work into the additional groundwater investigation:

- Desktop work including compilation of a Summary Sampling, Analysis and Quality Plan (SSAQP), review of plans for onsite and off-site services locations, a search of DIPNR records for groundwater boreholes within a 2-kilometre radius of the site, preparation of a health and safety plan and work method statement.
- Decommissioning of the Orica site groundwater well MW07.
- Installation of angled groundwater monitoring wells (MW41 and MW42) beneath Christina Road to determine whether service trenches were acting as preferential pathways for contaminated groundwater migrating off site;
- Installation of four nested wells (MW43A/B/C, MW44A/B/C, MW46A/B/C and MW53A/B/C) to provide data on the vertical distribution of previously identified groundwater impacts.
- Installation of seven additional monitoring wells (MW45, and MW47 to MW52) downgradient of inferred source zones to delineate previously identified groundwater impacts;
- Sampling and analysis of groundwater from 48 monitoring wells;
- Excavation of a 5-metre long trench adjacent to the former trade waste line to a depth of 5.7 metres bgs to assess whether the trade waste line was a potential source of identified EDC impacts previously identified in groundwater downgradient from this location;
- Excavation of 5 test pits (TP12 to TP16) adjacent to Christina Road to assess whether service trenches along the sites southern boundary are providing preferential pathways for impacted groundwater. Trenches were excavated until groundwater was observed (approximately 5 to 6 metres bgs). Groundwater seeping into the excavation was analysed;
- An assessment of accessible service pits and trenches along Christina Road. The investigation comprised a vapour assessment using a PID to measure organic vapours to determine whether service trenches have been providing preferential pathways for the migration of impacted groundwater; and
- A visual assessment of the former trade waste line under the Pharmaceuticals Building using a closed circuit television (CCTV) camera.

Figure 5 shows groundwater monitoring well locations within the Pharmaceuticals site.

4.6.2 Results

Results – Remediation and Validation Works

The following conclusions were reached by CH2M HILL following the validation of the soil remediation:

- The Pharmaceuticals site has been validated for the contaminants of concern identified in soil on the site with the exception of the soil located immediately beneath the Pharmaceuticals Building footprint (this portion of the site has been investigated and assessed in the CH2M HILL's Under Building Investigation, dated July 2007), and some residual impact in VA4 and VATW.
- The Pharmaceutical site, excluding the area immediately underneath the Pharmaceutical Building footprint, is considered suitable for commercial land uses.

Results – Additional Groundwater Investigation Part 2

The following conclusions were reached by CH2M HILL following the groundwater investigation:

- Results from the trench excavated adjacent to the former trade waste line indicated that no impacts are present at that location;
- The CCTV assessment indicated that breaks in the trade waste line are present beneath the Pharmaceuticals Building, which may be providing a source for the impacts detected in groundwater down gradient of this location;
- The vapour assessment along Christina Road indicated that no evidence was found to suggest that the service trenches along Christina Road are providing a preferential pathway for impacted groundwater;
- Groundwater monitoring indicated that impacted groundwater is present in three areas on the Pharmaceuticals site with EDC impacts detected on the northern boundary; EDC, TCE and MCB impacts detected on the southern boundary; and EDC, BTEX, TCE, MCB and OCP impacts detected on the western boundary, down gradient of the former ETP; and
- Groundwater monitoring indicated that free cyanide concentrations are below the LOR of 10 mg/L at all wells and total cyanide concentrations above the site criteria were only detected at five wells (MW26, MW29, MW30, MW50 and MW53A).

4.6.3 CH2M HILL's Recommendations

Recommendations – Remediation and Validation Works

Whilst CH2M HILL considered the Pharmaceutical site, excluding the area immediately underneath the Pharmaceutical Building footprint, suitable for commercial/industrial landuses, it recommended that site management instruments be implemented to minimise exposure to VOC impact in soils at depth within VA4 and VATW.

Recommendations – Additional Groundwater Investigation Part 2

Due to the limited historical data set and observed variability in the results between rounds, CH2M HILL noted that continued monitoring would be required to assess the full extent of cyanide concentrations across the Pharmaceuticals site.

4.6.4 Auditor's Comments

In the Auditor's opinion, the remediation and validation works were carried out in compliance with then-applicable legislation and guidelines, and generally in accordance with the RAP.

The validation data were of appropriate quality, and support the conclusions reached.

The groundwater sampling and analysis program completed by CH2M HILL in 2004 has also been reviewed. The Auditor is satisfied that the groundwater monitoring wells, including angled and nested wells, were appropriately designed and installed.

The low-flow purging and sampling protocol used was appropriate for the conditions, and an adequate quality assurance / quality control program was used to demonstrate compliance with the DQOs.

The data support the conclusions reached by CH2M HILL.

4.7 Under Building Investigation – Pharmaceuticals Site (CH2M HILL, 2007)

Note: The Under Building Investigation relates to the Pharmaceuticals Building which is located on the Pharmaceuticals Site, which incorporates all of Area A, most of Area C (with the exception of the north-east portion), the south-west corner of Area B, and the western end of Area D).

4.7.1 Objectives and Scope of Work

In November 2004, CH2M HILL conducted an investigation to assess whether soil beneath the Pharmaceuticals Building had been impacted by previous site activities.

The scope of work for the investigation was:

- to document the site description and site history with regards to potentially contaminating activities;
- to complete underground service searches for infrastructure, including an on-site survey by a licensed pipe and cable locater to identify existing underground services;
- to prepare a SSAQP using the Data Quality Objectives (DQO) process, prior to undertaking intrusive site investigation works;
- to complete a soil investigation in accordance with the SSAQP, this included analysis of a total of 33 surface samples and 38 deeper soil samples identified for contaminants of concern;
- the preparation of a report that documents the contamination status of the soil beneath the Pharmaceuticals Building; assesses the suitability of the site for continuing commercial/industrial landuse; and addresses the issue of DDX validation underneath the Pharmaceuticals Building.

Figure 6 shows the soil sampling locations within the Pharmaceuticals site.

4.7.2 Results

The results of CH2M HILLs investigation indicated that some impacted fill material was used during the construction of the Pharmaceuticals Building, with elevated DDX concentrations detected in fill material at three locations beneath the concrete slab.

4.7.3 CH2M HILL's Recommendations

Based on the findings of the investigation, CH2M HILL concluded that if the Pharmaceutical Warehouse (Modules 1 and 2) is to be used for commercial/industrial purposes, the area around locations PBSB10, PBSB14 and PBSB18 should be excavated, remediated and validated to a maximum depth of approximately 1 metre below ground level.

4.7.4 Auditor's Comments

The Auditor considers that the data support CH2M HILL's conclusions, but the extent of the remedial area may be different than indicated on CH2M HILL's Figure 4, and will need to be defined by validation sampling to be carried out as part of the overall site remediation works.

4.8 Auditor's Evaluation of Adherence to NSW EPA Guidelines

4.8.1 Data Quality Objectives (DQOs)

CH2M HILL appropriately adopted the DQO process endorsed by NSW EPA (2006).

4.8.2 QA/QC Evaluation

The field and laboratory quality assurance / quality control (QA/QC) measures presented by CH2M HILL in its associated reports have been reviewed and, overall, are considered to comply with NSW EPA guidelines and to be adequate to ensure the integrity of the data set used to assess the site.

The QA/QC criteria list examined in this review included:

- Precision
- Accuracy
- Sensitivity
- Representativeness
- Comparability
- Completeness
- Holding times
- Blanks

Data Quality Indicators (DQIs)

The data quality indicators (DQIs) presented by CH2M HILL have also been reviewed.

The Auditor considers that appropriate DQIs were used adequately to assess field procedures and analytical results. The DQIs are considered to comply with NSW EPA guidelines and to be adequate to ensure the integrity of the data set used to assess the site.

A copy of the Auditor's assessment of QA/QC measures presented by CH2M HILL (including CH2M HILL's use of DQIs) is provided within Appendix D of this Site Audit Report.

4.8.3 Summary

The Auditor considers that the overall quality of data and their presentation are of an adequate standard to support the conclusions he has reached.

5.0 SUMMARY OF INVESTIGATIONS CARRIED OUT TO COMPLY WITH REMEDIATION ORDER

This section provides:

- An overview of HLA's Remedial Investigations (Phase 1 and Phase 2) which were previously summarised and evaluated by the Auditor in Site Audit – 2 Christina Road, Villawood - Section 4D Audit (ref. J1196.2R-rev0, August 2006).
- An overview and the Auditor's evaluation of Laase's Groundwater Flow and Contaminant Transport Modelling (2007).
- An overview and the Auditor's evaluation of HLA's Phase 3 Data Gap Investigation (2007).

5.1 Phase 1 Remedial Investigation (HLA, 2005)

HLA's investigation involved the excavation of 46 test pits (TP1 to TP46) across the site to further delineate identified areas of concern and the installation of 14 bundled piezometers (BP101 to BP114) in on-site and off-site locations to further delineate the vertical and horizontal nature of the identified groundwater plumes. A study was also undertaken to assess the likely fate and transport of contaminated groundwater at the site.

HLA's groundwater sampling locations are shown on Figure 5; whilst soil sampling locations are shown on Figure 6.

HLA drew the following conclusions from the results of the Phase 1 Remedial Investigation.

- The main contaminants from on-site sources and the off-site migration of dissolved phase plumes include MCB, EDC, TCE, and DDX;
- DNAPL is inferred to exist at depths up to 20 m based on the dissolved phase concentrations recorded for MCB at BP106. High concentrations of DDX compounds significantly above the solubility were reported at this location, which is likely to be related to solid phase material;
- Up to eight separate dissolved phase plumes have been identified at this stage, however, the source of several of these has not been identified and requires further investigation. In some instances what has been inferred to be a single plume may include multiple entry points of DNAPL into the subsurface;
- [Data from] The new bundle piezometers installed down gradient of the rail line suggest that the dissolved phase plumes are being significantly attenuated;
- DNAPL source areas other than those already identified as specific point sources (BN-1 and BW-1) will be difficult to characterise and may also provide some pathways for DNAPL mobilisation and therefore future characterisation of source zones should be limited to vadose zone;
- The limitations of DNAPL source zone characterisation and remediation are related to the process of contaminant diffusion into the rock matrix and the inherent limitations that this poses for groundwater remediation.
- Remediation of the diffused contaminant mass in a short time frame is technically impossible. The process and kinetics are such that it cannot be accelerated with currently available technology;
- Orica has commissioned a number of soil remediation bench scale trials, predominantly focused on DDX. None of the trials has been identified as being highly successful and likely to be used for site remediation. A review of alternative technologies conducted by Orica has identified a number of technologies, with a thermal-based technology being the most likely option; and
- A preliminary screening of remediation technologies for both DNAPL sources and dissolved phase contamination was undertaken and has highlighted the wide range of the physical and chemical properties of the main contaminants. Whilst some technologies are unlikely to be effective, none have been deleted from the proposed technology assessment as required by the RO.

HLA made the following recommendations.

- Prepare a detailed scope of work for the Phase II Remedial Investigation for concurrence by the Site Auditor;
- Additional characterisation of several plumes and in particular the confirmation of source areas is required and will require the installation of additional monitoring wells and/or bundle piezometers. These include, but are not limited to, the following locations:
- A groundwater sampling location between the existing wells MW13 and MW14 on the southern boundary of the site and an additional well up gradient to confirm the source of contamination detected in off-site wells OS03A;
- An additional groundwater sampling location up gradient of BP114 to confirm the possible source of the BW-1 Plume;
- An additional well near the inferred source of the BN-1 Plume;
- Additional off-site bundle piezometers along the southern side of the rail corridor to confirm attenuation of dissolved phase plumes;
- Re-sampling of selected existing wells and piezometers which characterise the various plumes;
- Conduct additional investigations to delineate the extent of source areas in the vadose zone. Delineation of DNAPL in the saturated zone is difficult, likely to be inconclusive and has the potential to remobilise DNAPL along boreholes;
- Conduct additional soil investigations in areas where data are sparse, in particular the north-west portion of the site; and
- Revise the list of analytes to include additional analytes that will assist in the assessment of treatment technologies.

Auditor's Comments

The Auditor considered HLA's Stage 1 report to be an excellent summary of work undertaken previously by other consultants. The data gap analysis was considered appropriate, and the work carried out during this stage filled some of these gaps. The use of bundled piezometers was considered very useful in providing depth-stratified information on geochemistry and contamination. The visual presentation of data is of a high standard.

Dr Reynolds' review of DNAPL physics and transport is considered authoritative.

Conclusions and recommendations are generally supported by the site data. Conclusions regarding DNAPL and dissolved phase fate and transport reflect the current consensus in the scientific literature, but are generic and not supported by site-specific data. The extrapolation of generic interpretations to the site is plausible, but not proven.

5.2 Phase 2 Remedial Investigation (HLA, 2006)

The objectives of HLA's Phase 2 Remedial Investigation were to:

Soil

- meet the requirements of conditions 4A through 4C of the Remediation Order;
- further delineate identified source areas to assist the preparation of a remedial action plan (RAP);
- further investigate the source location of the B-S1 groundwater plume (Area C);
- investigate potential impacts from the trade waste line; and
- investigate identified data gap areas to provide an assessment for each of the nine site areas and to provide an adequate data set for the preparation of the RAP and human health and environmental risk assessment (HHERA).

A total of 46 testpits (TP47 to TP92) were excavated across the site to assess the site based on the above objectives. Air emission testing from site soils was also undertaken for input into the original HHERA (URS, 2007).

Groundwater

- assess groundwater conditions on the eastern site boundary and the eastern extent of off-site impact;
- assess the nature and extent of MCB and DDX contamination in the off-site well BP107; and
- further assess the lateral and vertical extent of identified plumes, both on site and off site.

The groundwater investigation works generally involved the installation of bundle piezometers with sampling ports placed at 2-metre intervals to vertically characterize groundwater conditions. A total of 16 bundle piezometers (BP201 to BP216) and one shallow/deep monitoring well pair (MW217A/B) were installed as part of the Phase 2 works.

HLA's groundwater sampling locations are shown on Figure 5; whilst soil sampling locations are shown on Figure 6.

HLA results established that the significant contaminants associated with both on-site sources and the off-site migration of dissolved-phase plumes are MCB, EDC and DDX.

Eleven Impacted Soil Zones (ISZ) were identified at the site, relating to manufacturing plants and leakages from the trade waste line. The locations of the ISZ are shown on Figure 4 of this report.

In groundwater, five dissolved-phase plumes were identified, of which several are likely to be sourced from multiple entry points. The locations of the plumes are identified on Figure 4.

High concentrations of dissolved-phase groundwater contamination south of Christina Road (off site) have been attributed to migration via the former open stormwater system and subsequent local infiltration. However, with the exception of two areas of isolated DDX contamination, dissolved-phase contamination does not extend beyond the railway line.

Soil

Contaminant concentrations exceeding the adopted criteria were detected as follows:

- EDC in Area F;
- MBC in Areas B and I; and
- DDX in Area B.

Fragments of potentially asbestos-containing materials were noted in fill material in Area B. Analysis of three fragments confirmed the presence of asbestos.

Analysis of soil samples for cyanide in both Phase 1 and 2 investigations detected generally low concentrations, indicating that cyanide is not a contaminant of concern on the site.

Groundwater

DNAPL was recovered from a depth of 6 metres at BP106 (in the south-eastern site portion). MCB concentrations recorded at this location exceed the aqueous solubility of this material by more than 60%, and indicate that DNAPL is present at depths of up to 20 metres. High concentrations of DDX

compounds above the aqueous solubility were detected in BP106, and attributed to the presence of solid-phase material in the sample.

Analytical results for samples collected from the two additional wells to the east of Plume 1 (BP201 and 202) did not identify contamination, and therefore the eastern boundary of this plume is considered to be delineated.

Seepage water was noted in five of the test pits; low concentrations of DDX and some VHC compounds were detected in two water samples.

HLA developed a conceptual site model based on consolidated data for soil and groundwater. HLA identified the contaminants within each ISZ and plume, and named the associated site area. Conclusions were then made relating to the necessity for remediation of each ISZ and plume, and to whether the remediation recommendations in the Site Management Plan (SMP) needed revision.

The truncation of the dissolved-phase plumes near the railway line suggests plume attenuation. HLA considered a number of potential plume attenuation mechanisms, including biodegradation, adsorption and matrix diffusion, and concluded that the most likely mechanism was diffusion from the fracture porosity into the primary porosity.

A précis of Dr David Reynolds' earlier review of the literature and experience concerning DNAPL fate and transport in fractured media provided perspective on the migration and attenuation of the dissolved-phase plumes, and discussed the limitations for groundwater remediation.

HLA concluded that remediation of the plumes in the short term was technically impossible.

Groundwater Modelling

Flow modelling was carried out using MODFLOW, and transport modelling was carried out using MT3D-MS, although the multi-species capability was not used. Automatic calibration was carried out using PEST with user-defined pilot points.

HLA's conclusions, based on the modelling conducted, are summarised as follows.

- A recharge rate of 2% (22 millimetres per year) was identified as the most representative recharge scenario.
- Four calibrated regional models replicated groundwater conditions at the site – potentiometric patterns and plume flow paths.
- Matrix diffusion influences contaminant migration from the site.
- Cross-sectional flow modelling confirmed that the groundwater beneath the site discharged to Byrnes Creek (except when the horizontal to vertical anisotropy ratio is 100:1 or greater, which is considered unlikely).
- Cross-sectional flow and transport modelling results indicate that contamination at depths greater than -10 metres AHD will not migrate 'significant distances' within 100 years. Flow model sensitivity analysis indicated that for hydraulic conductivity values of 10^{-2} m/day at depths below 0 metre AHD, migration to Byrnes Creek will take more than 200 years. In addition, owing to retardation, migration to the creek may be even slower.
- Of the transport processes – organic carbon fraction, matrix diffusion and biodegradation – matrix diffusion is considered to be the dominant process affecting contaminant transport at Villawood.

- Transport modelling simulating matrix diffusion predicted a rapid plume expansion followed by a decrease in migration rates. Once the slow migration period is reached, concentrations and extent remain static. The Villawood plumes are therefore static and no longer expanding.

Human Health and Environmental Risk Assessment

The objectives of the risk assessment conducted by URS Australia Pty Ltd (URS) were to:

- Provide a quantitative assessment of potential risks to human health associated with the presence of site related chemicals in soil and groundwater beneath the site and in offsite areas;
- Provide a qualitative assessment of potential risk to the environment associated with the presence of site related chemicals in soils and groundwater, particularly within off site areas; and
- Develop risk-based soil, groundwater and/or vapour concentrations that can be used at a screening level for further investigation or as remediation end-points (if required).

The risk assessment identified soil contaminants at sufficiently high levels in some areas of the site to present a risk to human health under commercial land use. The primary exposure mechanisms are incidental ingestion and dermal contact.

It was considered that the exposure assessment of volatile contaminants of concern via inhalation indicates a low risk, particularly for off-site areas.

URS stated that there is uncertainty in the available data for off-site areas where ambient data is not consistent with soil gas and flux emission data collected both on and off-site. Thus further assessment of air concentrations is warranted.

Risks to the environment were assessed as negligible, given the commercial land use and the hydrogeological conditions. Management of surface water and perched groundwater is necessary to mitigate contaminant discharge.

HLA's summary of the risk assessment states:

> There is uncertainty in the available data for off-site areas where ambient data is not consistent with soil gas and flux emission data collected both on and off-site. Thus further assessment of air concentrations is warranted.

Risks to the environment were assessed as negligible, given the commercial land use and the hydrogeological condition. Management of surface water and perched groundwater is necessary to mitigate contaminant discharge.

Risk-Based Soil Concentrations

The results of the risk assessment informed the development of criteria for the protection of human health under a commercial/industrial land use. These are applicable to the site only, and were designed to be applied to the screening of data for investigations and remediation.

The values developed by HLA are presented in Table 2.

TABLE 2
Risk-Based Soil Concentrations
(HLA, 2006)

Contaminant	Value (mg/kg)
1,2-Dichloroethane (EDC)	226
Vinyl chloride	13
Benzene	21.4
PAH (B(a)P equivalent)	16
Hexachlorobenzene (HCB)	18
Chloroform	77
Carbon tetrachloride	5.8
Trichloroethene (TCE)	154
Tetrachloroethene (PCE)	603
Chlorobenzene (MCB)	535
Toluene	177
Ethylbenzene	127
Xylenes	595
1,4-Dichlorobenzene	165
a-HCH (a-BHC)	2000
b-HCH (b-BHC)	5
d-HCH (d-BHC)	5
g-HCH (g-BHC or lindane)	2000
Dieldrin	25
DDX (DDT and its degradation products DDD and DDE)	200
Endosulfan II	1500
Mercury (inorganic)	100

HLA's Recommendations

HLA's recommendation for the remediation of all groundwater plumes involves the excavation of the impacted soils and in some cases further delineation works to identify the volumes of soil for removal. The modelling indicated that the plumes had stabilised and that groundwater remediation would be difficult to impossible in the short term. Further, it was considered that the plumes were not impacting on Byrnes Creek.

HLA concluded that it was necessary to remediate most of the impacted soil zones, and that the remediation program outlined in the site management plan did not require revision, with the following exceptions.

- ISZ 10 may not require remediation, owing to 'the absence of other RBSC [risk-based soil contamination]'.
- ISZ 6 remediation is dependent on the results of validation testing conducted by CH2M HILL.
- ISZ 4 remediation is dependent on the results of a review into the viability of remedial technologies for this zone.

HLA stated:

> Based on the assessment of the consolidated historic and HLA RI (Phase 1 and 2) analytical data, remediation of ISZs will be required to facilitate a commercial/industrial redevelopment at the site. These works will also ensure that identified DNAPL sources are remediated to the maximum extent practicable to mitigate ongoing impacts to groundwater.

Based on the findings of this Phase 2 RI, it is recommended that:

- A targeted RIFS [Remedial Investigation/Feasibility Study] be undertaken to:
  - Assess specific remediation requirements relating to the remediation of DNAPL within identified ISZ 1b/Plume 1. These works will serve to characterize the presence of DNAPL in this are to the MPDoRE and provide the operational detail required during the preparation of the RAP;
  - Assess groundwater data gap in north east portion of site; and
  - Assess the most optimal remediation technology, as part of the remedial technology review process. This will include bulk testing of DDX impacted soils within identified ISZ 1a to assess representative DDX concentrations following excavation and stockpiling activities.
- Further assessment of air concentration be undertaken to address uncertainties as recommended in the HHERA. This related to inconsistencies between the ambient data obtained from off-site areas and soil gas and flux emission data collected both off-site and on-site.

Auditor's Comments

In his previous review of this document, the Auditor considered that:

1. A generally adequate and sufficiently detailed description of the geological and hydrogeological conditions on and in the vicinity of the site is contained in the report. However, some information required to support the assessment of fate and transport of contaminated groundwater has not been provided, and some data were erroneous at the time when that assessment was made.
2. A sufficiently detailed description of the sampling and analysis plan and methodology used in carrying out the investigation has been provided, and that the methodology was suitable and appropriate to meet the objectives of the investigation.
3. Contaminated groundwater plumes, sources and migration pathways have been delineated to the maximum extent practicable, commensurate with what is necessary to evaluate the risk of harm to human health and the environment posed by the contamination.
4. Delineation of DNAPL distribution in a fractured rock system is not a realistic possibility.
5. Adsorbed-phase source zones (impacted soil zones) have generally been adequately delineated, laterally and vertically, with sampling of sufficient density. The exceptions to the general statement are ISZ 1 (a and b), and ISZ 6 and 10, where additional investigation is required.
6. The approach adopted by HLA for modelling the fate and transport of contaminants in groundwater is generally appropriate, and the modelling itself has been carried out well. However, the following issues of concern have been noted:
   - The unacceptability of a flow model calibration that is known to have unquantifiable errors relating to gross errors in survey data
   - Lack of data (that could have been obtained relatively easily) on:
     - matrix porosity of the various lithologies making up the Ashfield and Bringelly Shales
     - measurements of organic carbon content and/or use of available, and pre-existing, regional data
     - measurements of concentrations of contaminants in matrix pores, and measurements of diffusion rates in a particular matrix
     - groundwater flux to surface watercourses

7. The approach adopted by URS for assessment of actual and potential on- and off-site impacts on human health and the environment was considered to be generally appropriate. However, two specific issues were noted:
    - the use of flux emissions data in preference to soil gas data in the quantification of potential inhalation exposures, rather than use of both data sets in parallel
    - acceptable risk levels for non-threshold effects required clarification.

The Auditor considered that there are sufficient data to support the recommendations for remediation of eight of the eleven identified impacted soil zones, and that the data are sufficient and suitable for the preparation of remedial action plans.

Additional sampling may be required to support the preparation of remedial action plans for the other three zones. The Auditor supported HLA's recommendations regarding removal of sources of groundwater contamination.

The Auditor considered that HLA's reasoning with regard to plume stability and retardation is credible, and there is a strong consensus that active remediation of a dual porosity system would require an extremely long time. However, due to lack of some site-specific data and modelling problems, the case regarding plume stability has not been made with adequate robustness.

The Auditor recommended that:

1. all groundwater measurement points relevant to the flow and transport modelling be resurveyed
2. the flow model calibration be rerun with resurveyed groundwater level data
3. additional field data relevant to the contaminant transport modelling, as outlined in Section 5.2 of this report, be collected
4. the contaminant transport modelling be reviewed and, if necessary, re-run.

5.3 Phase 3 Data Gap Investigation (HLA, 2007)

5.3.1 Objectives and Scope of Work

The objectives of the soil investigation component of the Phase 3 Data Gap Investigation (DGI) were to:

- address the Site Auditor's request for additional investigation for ISZ 1a and also evaluate bulk DDX concentrations for remedial operation purposes;
- gather sufficient data to allow delineation of the extent of remediation required within ISZ 1b (MCB impacts) as part of the RAP preparation process and address the Site Auditor's additional investigation requirements for this area; and
- gather sufficient data to allow delineation of the extent of remediation required with ISZ 2, 7 and 8; and upgradient of Plume 4.

The objectives of the groundwater investigation component of the Phase 3 DGI were to:

- further delineate selected plumes at the site as requested by the NSW EPA and the Site Auditor; and
- confirm various on-site and off-site groundwater contaminant concentrations exceeding ANZECC 2000 water quality guidelines.

The scope of works comprised the following.

- Excavation of 23 trenches across Areas B, H and I to facilitate the collection of soil samples;
- laboratory analysis of selected soil samples for OPCs and VHCs;
- installation and sampling of four off-site groundwater monitoring wells to address identified data gaps;
- collection of water samples from all off-site bundled piezometers (selected ports)/monitoring wells, and selected on-site bundled piezometers/monitoring wells to verify the 2006 results;
- laboratory analysis of groundwater samples for OCPs (either ultra trace or standard detections analysis) and VHCs (standard detection analysis);
- re-surveying of all onsite monitoring wells and completion of a full groundwater level monitoring round;
- matrix porosity testing on existing rock cores currently stored at the site;
- a conductivity and pH survey of Byrnes Creek from Miller Road to Leightonfield Station to identify potential zones of groundwater seepage; and
- consolidation of the historic and HLA Phase 1 and Phase 2 remedial investigations soil and groundwater analytical data sets to define identified soil and groundwater source areas and associated groundwater plumes (if present).

5.3.2 Conclusions and Recommendations

Soil

Because of the complexity of the contaminants reported at the site and their distribution, a HHERA was conducted by HLA to develop site-specific RBSC. Soil analytical results obtained during the Phase 3 DGI (as well as historic data) were assessed against these criteria.

Based on the findings of the Phase 3 DGI, HLA drew the following conclusions.

- Plume 4 source area (Area B). The investigation did not identify a significant source area in soils which is likely to have produced the groundwater impacts previously identified within Plume 4. Consequently, HLA considered the impacted groundwater at Plume 4 to be the result of a localised source likely to be present in the vicinity of MW48 and, as such, recommended that the RAP include further trenching works in this area to locate potential source materials.
- ISZ 1a. The horizontal and vertical nature of DDX impacts in this area were further delineated to assist with preparation of the RAP. The vertical migration of DDX into underlying natural clays and weathered shales previously reported in the TP2 area (HLA, 2005) were also further characterised with the sampling and analysis undertaken at TP106. HLA concluded that, based on the interpretation of historic site aerial photographs, the significant mobilisation of DDX from the surface into underlying natural clays and weathered shales was considered to be the result of historic surface (mono)chlorobenzene (MCB) spills associated with the former MCB tank and tankfarm area which was located in the upgradient area.
- ISZ 1a. HLA's testing of homogenised, bulk soil samples collected from surface fill materials, where relatively high DDX impacts have been reported in the past, indicated that DDX concentrations are in the range of 20 to 50,000 mg/kg. HLA concluded that this analytical data was indicative of contaminant levels requiring treatment during remedial works.

- ISZ 1b. The horizontal and vertical nature of MCB impacts in this area were further delineated to assist with prepared of the RAP. HLA found that, the results of the Phase 3 DGI and previous investigations indicated that MCB concentrations exceeded the RBSC at five sampling locations within the ISZ and that, based on the vertical distribution of MCB within the ISZ, it appeared that the contamination had migrated to greater depths with increasing distance away from (south) of the former MCB tank area. Consequently, HLA concluded that higher MCB concentrations are likely to be present in the upper portion of the underlying weathered shale.
- ISZ 2. Based on soil analytical results obtained from TP111 indicating that the eastern extent of this ISZ had been suitably delineated, HLA concluded that no further delineation of ISZ 2 was required.
- ISZ 7. Based on soil analytical results obtained from TP112 indicating that the western extent of this ISZ had been suitably delineated, HLA concluded that no further delineation of ISZ 7 was required.
- ISZ 8. Based on soil analytical results obtained from TP113 indicating that the southern extent of this ISZ had been suitably delineated, HLA concluded that no further delineation of ISZ 8 was required.

Groundwater

Groundwater analytical results obtained during HLA's investigation were assessed against the ANZECC 2000 guidelines for fresh and marine water quality, which provided trigger values for chemicals within water at Byrnes Creek channel. HLA noted that the current data set indicates that contaminated groundwater from the site is not discharging to Brynes Creek channel and therefore the criteria are considered to be conservative.

Also, based on the findings of the groundwater modelling report (Laase, 2006), it was concluded that the groundwater plumes are static and are unlikely to migrate to Byrnes Creed due to the effects of retardation, matrix diffusion and biodegradation. Based on these factors and the site's continued commercial land use, the (preliminary) HHERA (URS 2006) concluded that groundwater did not present an unacceptable risk to human health or the environment and, consequently, only soil RBSC were derived for the site.

Based on the findings of the Phase 3 DGI, HLA made the following conclusions.

- Groundwater results from the DGI generally support the results of previous investigations across the site.
- The downgradient extent of Plumes 1 and 2 has been delineated along Christina Road and south of the railway easement. HLA concluded that no further delineation of Plumes 1 and 2 is required.
- The DDX concentration in groundwater reported at the newly-installed MW304 (Plume 3) is of a similar order of magnitude to the adopted guidelines.

5.3.3 Auditor's Evaluation of Adherence to NSW EPA Guidelines

Data Quality Objectives (DQOs)

HLA appropriately adopted the data quality objectives (DQO) process endorsed by NSW EPA (2006).

A detailed DQO checklist is included as Appendix D of this site audit report.

Data Quality Indicators (DQIs)

Appropriate data quality indicators (DQIs) were used to assess field procedures and analytical results.

The DQIs presented by HLA have been reviewed and are considered to comply with NSW EPA guidelines and to be adequate to ensure the integrity of the data set used to assess the site.

This part of the auditing checklist is included as Appendix D.

QA/QC Evaluation

The field and laboratory QA/QC measures presented have been reviewed and are considered to comply with NSW EPA guidelines and to be adequate to ensure the integrity of the data set used to assess the site.

Specifically, a detailed QA/QC checklist is provided in Appendix D.

The QA/QC criteria list examined in this review included:

- Precision
- Accuracy
- Sensitivity
- Representativeness
- Comparability
- Completeness
- Holding times
- Blanks

HLA adopted and described an appropriate sampling plan, sample handling, and sample collection and transport processes.

The Auditor considers that the overall quality of data and their presentation are of an adequate standard to support the conclusions he has reached.

5.3.4 Auditor's Conclusions and Recommendations – Phase 3 Report

The Auditor noted that some significant variations in concentration between consecutive sampling rounds were observed:

- in the EDC plumes (Plume 2 and Plume 5) – both increases (51 to 196%) and decreases (69 to 190%)
- in individual wells; in MCB Plume 1 – decreases of 53 to 167%; and
- in DDX Plumes 1 and 5 – both increases (54 to 200%) and decreases (57 to 200%) in individual wells.

He considered that it would be important to recognise this variability when comparing calculated risk levels with risk targets.

The Auditor observed that:

- Valid porosity and permeability data were obtained for the single sandstone core submitted for laboratory testing, but the two shale cores submitted for porosity and permeability analysis disintegrated during testing.
- Shallow groundwater inflow to Byrnes Creek was confirmed, and inflow locations mapped, but HLA did not comment on the significance of these measurements.
- Organic carbon measurements were not reported in the DGI.
- Following discussions with HLA and a detailed submission from HLA's advisor on matrix diffusion issues, Dr Reynolds, the Auditor agreed that the practical difficulties and extended time frame involved in obtaining matrix diffusion data by laboratory measurement were unlikely to be justified by the utility of the information derived.

Overall, the Auditor considered that the issues that he had raised in relation to groundwater have been substantially but not completely addressed.

5.4 Groundwater Flow and Contaminant Transport Modelling (Laase, 2007)

5.4.1 Objectives and Scope of Work

The objectives of the groundwater flow and contaminant transport modelling were to develop a better understanding of groundwater movement and contaminant migration in the fractures and block matrix of the shale underlying the site. *Note:* Laase (2006) presented the initial modelling study, which was revised to account for issues raised by the Auditor.

Laase's modelling included the development of four regional flow models calibrated to differing recharge scenarios. In addition, 36 cross-sectional flow models having differing recharge, hydraulic conductivity and anisotropy ratios were developed and analysed to develop a better understanding of the groundwater flow. A three-dimensional contaminant transport model based on the regional flow model was also configured, calibrated and used to evaluate future plume movement of dissolved phase contamination originating at the site. Sensitivity analysis was performed using the transport model to evaluate how parameter uncertainty could affect model predictions, specifically whether or not the plume would reach Byrnes Creek within 100 years of present day.

5.4.2 Conclusions

Laase drew the following conclusions based on the results of the modelling study.

- Based on approximating Byrnes Creek daily discharge volumes and more closely replicating plume flow paths, recharge scenario 2, corresponding to a parkland recharge rate of 5% annual precipitation (55 mm/year), is likely to be the most representative of the four recharge scenarios.
- Cross-sectional flow modelling demonstrates that, except for when the horizontal to vertical anisotropy ratio is 100:1 or greater, all groundwater beneath the site ultimately discharges to Byrnes Creek. Given that many of the fractures are oriented nearly vertically, it is unlikely that horizontal to vertical hydraulic conductivity ratios would exceed 100:1.
- Cross-sectional flow modelling suggests that contamination, if present at depths greater than –10 metres AHD, will not migrate significant distances within 100 years. Flow model sensitivity analysis shows that even for hydraulic conductivity values as high as 10^{-2} m/day at depths below 0 metres AHD, groundwater travel times to Byrnes Creek will be in excess of 200 years. Because of plume attenuation, primarily through matrix diffusion, contaminant migration to Byrnes Creek will be even slower.

- Three-dimensional contaminant transport modelling simulating matrix diffusion effects predicts relatively rapid plume expansion followed by a decrease in plume migration rates. Once the 'slow' migration period is reached, plume concentrations and extent become relatively static. It is believed that the plumes originating from the site are no longer rapidly expanding and are now relatively static with respect to concentrations and extent.
- Sensitivity analysis shows that while varying transport input parameters produces plumes of different configurations than the calibrated plumes, none of these plumes reaches Byrnes Creek within 100 years of present day. Thus, it is unlikely that, even considering the uncertainties, dissolved contaminants from the site (EDC being the most mobile) will reach Byrnes Creek within 100 years of present day.
- While the modelling results alone demonstrate that it is unlikely that groundwater contamination will reach Byrnes Creek within the next 100 years, it is important to note that the observed plume configurations support this conclusion. Although site groundwater velocities have been calculated to be as high as 200 metres per year (m/year) (HLA 2006), the plumes have migrated less than 100 metres. Clearly, the plumes are being significantly attenuated, which has been replicated by the transport model.

5.4.3 Auditor's Conclusions and Recommendations – Modelling Report

The Auditor reviewed the revised groundwater modelling report.

He considered that differences from the August 2006 report were subtle but it was noted that the cross-sectional contaminant transport modelling has been omitted. The following observations were made:

- The flow calibration was re-run with the revised survey data, correcting previous errors. Calibrated hydraulic conductivity distributions are similar, but with a small overall reduction in absolute values for equivalent recharge scenarios.
- The 5% recharge scenario is now considered to provide the best fit. Previously, the 2% scenario was favoured.
- The calibration residuals are slightly tighter, but more than anything else, recalibration has removed a substantial source of unquantifiable uncertainty associated with the erroneous survey data.
- In relation to transport parameters, additional data constitute a single organic carbon measurement and a single matrix porosity determination. These data do, however, support assumptions previously made.
- In the revised calibration the mass transfer rate has been reduced by two orders of magnitude, and the reaction rate has been increased from 150 to 200 per day.
- The core prediction of the transport modelling, that none of the plumes will reach Byrnes Creek within 100 years, remains unchanged from the initial modelling.
- An additional program of sensitivity analysis has been carried out. The sensitivity analysis indicates that this prediction is relatively insensitive to changes in transport parameter, and adds substantially to the robustness of the prediction.

In key assumptions related to the significance of matrix diffusion relative to other attenuation mechanisms, reliance was still placed almost entirely on the professional judgement of the modeller and HLA's expert, Dr Reynolds, but in the Auditor's opinion there was no alternative to this, and the approach was not inconsistent with international practice.

The Auditor concluded that although it had not been possible to follow through on all the matters raised in his initial review of the model, it had been possible to remove some sources of potential error, and to increase the overall confidence level of the predications by sensitivity analysis.

He recommended that work proceed on the basis that the model's predictions are sound.

6.0 ADDENDUM TO THE REMEDIAL ACTION PLAN (AECOM, 2009)

In 2009, AECOM produced an addendum to the Remedial Action Plan (RAP) produced by HLA in October 2007. *Note:* HLA's RAP (2007) was subsequently superceded by AECOM's RAP dated 17 March 2011.

The Addendum to the RAP included an updated conceptual site model (CSM) to better explain the nature and extent of groundwater contamination, mechanism for migration off-site and potential for further discharge to Byrnes Creek.

The following paragraphs provide a summary of the key aspects of the CSM, in particular, issues that are of concern with respect to the potential for further migration and exposure of environmental receptors.

- The geological profile on-site and off-site comprises fill materials, residual clay on-site, alluvial clay off-site and basal variably weathered Bringelly Shale. These materials are all considered to have low primary permeability. The less weathered shales may have some secondary (fracture) permeability.
- The largest reservoir of contamination is likely to be distributed in the clay (shallow) and in the rock matrix deeper shale.
- Contamination has been identified in soil materials on the site due to historical operations at the site. Based on the available information, the most significant soil impacts have been identified as ISZ which are located across the site and characterised by a range of contaminants consistent with historical operations in different areas of the site. The ISZ are shown on Figure 4.
- Dense non-aqueous phase liquid (DNAPL) has been identified on the site adjacent to former storage tanks and infrastructure. In addition, DNAPL was likely to have migrated off-site via former open surface water drains on the southern side of Christina Road, particularly near MWOS10 as indicated by the high concentrations of dissolved phase contamination. Geometry of the groundwater plumes, flow direction and groundwater modelling suggests rapid migration via surface flow in a south-west direction on site, then a more westerly direction off-site, aligning with the former No.9 branch drain. Rapid migration in the subsurface through unidentified preferential pathways (e.g. fractures, bedding planes, etc.) is not supported by the available data.
- Shallow vertical ingress of contamination is the predominant migration pathway, with deeper DNAPL migration controlled by flow down vertical fractures and then by lateral diffusion into the bedrock matrix.
- Historically, five dissolved phase groundwater plumes have been identified and delineated. Three plumes extend off-site. The distribution of Plumes 1 and 2 was predominantly formed by the flow of dissolved and separate-phase source material over the surface of the land in drains and swales, followed by downward migration from the drains' bases into the underlying clay and weathered shale matrix. Plume 3 has migrated from the former Effluent Treatment Plant area. Off-site monitoring points within and south of Christina Road indicate that no contamination has reached Byrnes Creek and groundwater plumes are stable.

  An important aspect of the revised CSM presented in the RAP Addendum was a clearer exposition of the process of diffusion of the contaminants of concern from the fractures that form the secondary permeability of the Bringelly Shale into the low-permeability high-porosity matrix. The diffusion process is driven by concentration gradients. The entry gradient is high, resulting in relatively rapid inward diffusion. However, the exit

gradient is low, and will remain low, resulting in slow and protracted outward diffusion. This fundamentally limits the practicability of remediation of groundwater contamination.

- Contaminant transport modelling (Laase 2007) supports the observation that the groundwater contaminant plumes are stable due to matrix diffusion and to some extent biodegradation. Hence, even though groundwater could reach Byrnes Creek, the contaminants could not.

  The Auditor has reviewed the CSM and the technical discussion that underlies it, and considers that these are sound.

  The Auditor accepts that the only remedial technologies that might be capable of dealing with the contaminants diffused into the rock matrix at depth within a reasonable time-frame are:

  - very energy intensive, and
  - very expensive.

  The use of such technologies would only be justified to mitigate a current and demonstrated human health or environmental risk.

7.0 HUMAN HEALTH AND ENVIRONMENTAL RISK ASSESSMENT (URS, 9 FEBRUARY 2011)

7.1 Summary

URS undertook an assessment of potential risks to human health and the environment associated with the presence of site-related chemicals in soil and groundwater beneath the site and in off-site areas; and developed risk-based soil, groundwater and/or vapour concentrations that could be used at a screening level for further investigation or as remediation end-points (if needed).

The risks associated with these exposures were quantified using assumptions related to how people could be exposed and the data collected from the site that are representative of concentrations in air, soil and groundwater relevant to the assessment of human exposure.

The assessment focused on the ISZ on the site and inferred groundwater plumes that are present on the site and extend down-gradient beneath off-site areas. The ISZ are shown on Figure 4 of this report.

Human Health

The HHERA identified the potential for soil contaminants to be present at sufficiently high concentrations in some areas of the site (associated with ISZ 1a, 1b, 2, 4, 5, 7, 8, 9 and 10) to present an unacceptable risk to human health under a commercial/industrial land use. The prime exposure pathways for concern are ingestion and dermal contact with soil.

URS found that inhalation generally makes a minor contribution to the overall risk with the calculated risk associated with inhalation exposures being less than the adopted target for all areas except ISZ 5 where the presence of 1,2,3-trichloropropane dominates the calculated risk. URS recommended that the presence of this chemical in this area required further assessment.

Assessment of exposure to volatile chemicals of potential concern (COPC) via inhalation in areas located above groundwater plumes in areas on the site (where no source zones are present) and off site indicates risks to be low and essentially negligible. This assessment was based on measured data and URS recommended that further data should be collected to assist in the assessment of variability, particularly in off-site areas. *Note:* On the basis of the assessment of inhalation risks, risk-based vapour concentrations were not been derived.

Total petroleum hydrocarbons (TPH) were not identified as a COPC, however, the characterisation of TPH was limited to a small number of samples. URS noted that additional assessment of the nature of the TPH would be warranted to ensure that the COPC list adequately addresses health risks.

Environment

URS assessed the environmental risks as negligible given the commercial land use and the hydrogeological conditions. It was noted that contaminated perched groundwater is expected to be removed and surface water managed under the proposed remediation of the site to ensure contaminant discharge via surface water and buried stormwater lines does not occur. Consequently, risk-based groundwater concentrations based on the protection of the environment were not derived by URS.

7.2 Methodology

The approach taken by URS to the assessment of human health risks was generally in accordance with the protocols and guidelines recommended by enHealth (*Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards,* 2002). These guidelines draw on and are supplemented by those provided by ANZECC and NHMRC and are detailed in the following documents:

- The NEPC Schedule B(4) 1999, *Guideline on Health Risk Assessment Methodology*;
- CSMS 1991, 1993, 1996 and 1998, and enHealth 2002, *The Health Risk Assessment and Management of Contaminated Sites*; and
- ANZECC/NHMRC 1992, *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites.*

Additional guidance was obtained from the following documents, as required:

- USEPA 1989, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual*. Interim Final;
- USEPA 2001, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*; and

The Auditor notes that the enHealth, NEPC and ANZECC/NHMRC (1992) documents are approved by the NSW EPA under the provisions of s105 of the Contaminated Land Management Act 1997.

The ANZECC and NHMRC document provides only general guidance for the completion of these tasks, and so the more detailed protocols and guidelines developed by the US EPA (1989 and 2001) were used to provide supplementary guidance.

The various guideline documents describe the standard approach to risk assessment, under which the conduct of an HHERA can be divided into four prime tasks.

1. *Issue Identification* – involving a review of the available data to identify key issues and chemicals of potential concern (COPC) that warrant more detailed assessment within the HHERA.
2. *Exposure Assessment* – involving identification of:
    - the population that may be exposed to COPC;
    - the activities by which exposure may take place for each population; and
    - parameters which define activity (such as time spent indoors) and physiological exposure parameters (such as body weight and inhalation rate), together defining a set of *exposure scenarios*;

    and involving quantification of:

    - the chemical concentration at the point of exposure; and
    - the chemical intake of each of the identified exposed populations, for each relevant exposure scenario.
3. *Hazard/Toxicity Assessment* – involving the definition of the dose/response relationships (threshold or non-threshold) relevant to each of the COPC for the exposed populations, and the identification of appropriate toxicity values.
4. *Risk Characterisation* – the final stage, involving the calculation of *hazard quotients* that compare assessed and acceptable intakes for each threshold COPC, and *cancer risks* for non-threshold COPC. Hazard quotients and cancer risks are then summed across all COPC to derive estimates of total risk.

7.3 Contaminants of Potential Concern

Based on previous investigations, the HHERA identified chemicals of potential concern (COPC) in a number of areas on and off the site. The COPC identified by URS reflect the characteristics of the source zones and groundwater plumes relevant.

A summary of the COPC identified in soil and air at the site is provided in Table 3 below.

TABLE 3
Summary of COPC Identified in Soil and Air

COPC	On Site											Off Site		
	ISZ 1a, 1b and 2	ISZ 3	ISZ 4	ISZ 5	ISZ 6	ISZ 7	ISZ 8	ISZ 9	ISZ 10	Plume 2 (and 1)	Plume 3 and 4	Plume 3	Plume 2	Plume 1
hexachlorobenzene (HCB)	●		●	●	●	●	●							
1,2-dichloroethane (EDC)	●❍	●❍	●❍	●❍			●❍			❍	❍	❍	❍	
vinyl chloride	●❍		❍	❍			❍							
chloroform	●❍		●❍	●❍			●❍							
carbon tetrachloride	●						●			❍				
trichloroethene (TCE)	●❍	●	●❍	●❍			●❍			❍	❍	❍	❍	
tetrachloroethene (PCE)	❍			❍			●❍	●❍						
1,1,2-trichloroethane				❍			❍	●		❍			❍	❍
chlorobenzene	●❍	❍	❍	●❍			❍			❍				
benzene	●❍		●❍				●❍	●❍	●					
toluene	●❍	❍	❍	❍			●❍			❍			❍	
ethylbenzene	●		❍	●										
xylenes	●		❍	●			●		●					
PAHs (BaP equivalent)	●			●	●		●	●	●					
1,4-dichlorobenzene	●			●			●							
1,2,3-trichloropropane				●❍						❍			❍	
bis(2-chloroethyl)ether				●										
α-HCH	●		●	●	●	●	●	●	●					
β-HCH	●	●	●	●	●	●	●	●	●					
δ-HHC	●		●	●	●		●							
γ-HCH (lindane)	●	●	●	●	●	●	●	●	●					
DDX	●	●	●	●	●	●	●	●	●					
dieldrin							●	●						
endosulfan II								●						
pentachlorophenol							●							
cis-1,2-dichloroethene	❍						❍							
1,1,1,2-tetrachloroethane				❍										
1,1-dichloroethene				❍										
1,2-dichloropropane				❍										
trimethylbenzene	❍		❍				❍							
naphthalene										❍			❍	
mercury			●				●							

Notes: ● COPC identified in soil based in maximum concentrations reported in area
❍ COPC identified in air, namely soil gas and flux emissions in areas overlying source zones and/or groundwater plumes

7.4 Exposure Pathways

Based on the use of the site and surrounding area, and the nature and extent of impacts identified in soils and groundwater, URS considered the following exposure pathways, summarised in Table 4, to be complete and to warrant further assessment for the key receptor groups identified.

Because exposures by visitors would be lower than those of long-term workers due to their short duration (time spent on site), URS did not undertake quantification of risks to visitors. As the assessment area, including site areas, is and will be used for commercial/industrial purposes only and does not include recreation areas, only adults were considered relevant to the assessment.

TABLE 4
Summary of Key Exposure Pathways

Receptor	Exposure Pathway	Activity
Adult workers – on site and off site	Inhalation of volatile chemicals (indoors, outdoors).	Working on the site following redevelopment. Working in areas located off-site and down-gradient.
Adult workers – on site	Ingestion of soil. Dermal contact with soils.	Working on the site following redevelopment.
Intrusive workers (i.e. workers entering excavations)	Inhalation of volatile chemicals (in excavations) on site and off site. Ingestion of soil on site. Dermal contact with soils on site.	Undertaking intrusive activities on the site following redevelopment or undertaking intrusive activities in areas off site above impacted groundwater. Activities include the maintenance of services that could be undertaken by workers who might be unaware of the presence of impacts in soil or groundwater. This does not include construction workers on the site who would be required to work under a relevant occupation health and safety plan or workers involved in significant major excavation works such as maintenance of major water drainage or sewer lines where such works would require intrusive activities to be undertaken in accordance with relevant occupational health and safety plans. Deep works in off-site areas have been considered. However, exposure to shallow groundwater is only expected to occur infrequently in such workers.
Intrusive workers – deep works off site	Ingestion of shallow groundwater off site. Dermal contact with shallow groundwater off site.	

7.5 Toxicity Assessment

URS identified toxicity values relevant to long-term threshold and non-threshold effects, as recommended by the relevant enHealth (2002) and NEPC (1999) guidance.

The complication of values used by URS is shown in Table 5 below, which is Table 4.1 of the URS report.

TABLE 5
Compilation of Values Used by URS

Chemical	Non-Cancer Toxicity Endpoint	Animal Carcinogen and IARC Classification	Genotoxic	Oral Slope Factor $(mg/kg/day)^{-1}$	Oral TDI (mg/kg/day)	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Inhalation TC (or equivalent) (mg/m^3)	TWA [6] (mg/m^3)	Potential for Background Intake
hexachlorobenzene (HCB)	Liver	Yes, NG	No	T	0.00016 [1]	T	O	0.002[7]	Negligible
1,2-dichloroethane (EDC)	Liver	Yes, M, G	Yes	0.012[1],[3]	NT	(0.5 to 2.8)x10^{-6} [2] 2.8x10^{-6} proposed	NT	40	NA
vinyl chloride	Liver	Yes, G	Yes	1.2[1] adulthood 2.3[1] lifetime	NT	4.4x10^{-6} adulthood 8.8x10^{-6} lifetime [4]	NT	13	NA
1,1-dichloroethene	CNS, liver	Limited data	No	T	0.046 [1]	T	0.2 [2]	20	Negligible
1,1-dichloroethane	CNS	Limited data	No	T	0.1 [4]*	T	0.5 [4]*	412	Negligible
chloroform	Liver, kidney, CNS	Yes, P, C	No	T	0.013 [1]	4.2x10^{-7} [2*]	0.14 [2]	10	Yes (50%)
carbon tetrachloride	Liver, kidney	Yes, P, C	No	T	0.00142 [1]	T	0.0061 [2]	0.63	Yes (65%)
trichloroethene (TCE)	CNS, liver	Yes, P, C, MG	Equivocal	T	0.00146 [1]	4.3x10^{-7} [2]	NT	54	Yes, low
tetrachloroethene (PCE)	Liver, kidney, CNS	Yes, P, C, MG	No	T	0.014 [3]	T	0.2 [2]	335	Yes (34%)
cis-1,2-dichloroethene	Liver	Insufficient data	Equivocal	T	0.01 [4]*	T	O	793	Negligible
1,1,2-trichloroethane (1,1,2-TCA)	Liver, immune	Yes, C	No	T	0.004 [5]	T	O	55	Negligible
1,1,1-trichloethane	CNS	Limited data	No	T	0.6[1]	T	2[1]	555	Negligible
chlorobenzene	Liver, kidney, CNS	No	No	T	0.086[1],[3]	T	0.5[2]	46	Yes, low
benzene	Immune	Yes, G	Yes	0.035[1]	NT	6x10^{-6} [2]	NT	3.2	NA
toluene	Kidney	No	No	T	0.22 [1],[3]	T	0.26 [2]	191	Yes (10%)
ethylbenzene	kidney, liver	Possible?	No	T	0.097 [1],[3]	T	22 [2]	434	Negligible
xylenes	CNS	No	No	T	0.179 [1],[3]	T	0.87 [2]	350	Yes (2%)
PAHs – benzo(a)pyrene equivalent		Yes, G	Yes	0.5 [1]	NT	8.7x10^{-2} [2]	NT	NA	NA
1,2-dichlorobenzene (and 1,3-)	Liver, kidney, CNS	No	No	T	0.43[1],[3]	T	0.6[8]	150	Negligible
1,4-dichlorobenzene	Liver, kidney	Yes	No	T	0.0107 [3]	T	1 [2]	150	Yes, low
1,2,3-trichloropropane	Stomach, liver	Yes, G	Yes	7[4]*	NT	O	NT	60	NA
α-HCH (α-BHC)	CNS, liver, kidney	Equivocal	No	T	0.008[5]	T	0.00025[8]	0.1 (lindane)	Yes, low

TABLE 5
Compilation of Values Used by URS

Chemical	Non-Cancer Toxicity Endpoint	Animal Carcinogen and IARC Classification	Genotoxic	Oral Slope Factor $(mg/kg/day)^{-1}$	Oral TDI (mg/kg/day)	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Inhalation TC (or equivalent) (mg/m^3)	TWA [6] (mg/m^3)	Potential for Background Intake
β- and δ-HCH (β- and δ-BHC)	Liver, kidney	Possible	No	T	0.00002[8]	T	0.00025 (α-HCH)	0.1 (lindane)	Yes, low
γ-HCH (γ-BHC, or lindane)	CNS, liver, kidney	Yes	No	T	0.003[3]*	T	0.00014[8]	0.1	Yes, low
dieldrin	CNS	Yes	No	T	0.0001[1],[3]	T	O	0.25	Yes, low
DDX (sum of DDT, DDE and DDD)	CNS, liver	Yes	No	T	0.002[3]*	T	O	1[7]	Yes, low
endosulfan II	Kidney	No	No	T	0.006[1]	T	O	0.1	Yes (10%)
pentachlorophenol	Liver	Yes	No	T	0.003[3]	T	O	0.5	Yes, low
1,1,1,2-tetrachloroethane	CNS, liver	Limited data	No	T	0.03[4]	T	O	6.9	Negligible
1,2-dichloropropane	CNS, liver, kidney	Limited data	Equivocal	T	0.014[1]	T	0.004[4]	347	Yes (10%)
1,2,4- and 1,3,5-trimethylbenzene	CNS, respiratory	Insufficient data	Insufficient	T	0.05 [4]**	T	0.006 [4]**	125[7]	Yes (50%)
naphthalene	Haemic, respiratory	Yes, possible	No	T	0.02 [4]	T	0.003 [4]	52 [9]	Low (5%)
mercury (inorganic)	Kidney	No	No	T	0.00071[1]	T	Not assessed	Not assessed	Yes (50%)

Notes:
[1] Derived from WHO Drinking Water Guidelines (1993, 1996, 1998 and 2004) including rolling revision to TCE (2005)
[2] Derived from WHO Air Quality Guidelines (2000, 2000b or CICAD 58 (2004) for chloroform). Where range is presented, the most conservative value (higher unit risk and lower ADI) has been adopted.
[3] Derived from NHMRC Australian Drinking Water Guidelines (1996 and draft 2002)
[3]* ADI recommended by the Office of Chemical Safety as part of Therapeutic Goods Administration (2006)
[4] Derived by USEPA (IRIS evaluations, current 2006)
[4]* Derived from USEPA (evaluation presented within HEAST and referenced in RAIS database)
[4]** Derived from provisional peer reviewed data available from USEPA and referenced by OEHHA and Region IX PRGs (2004)
[5] Derived by ATSDR based on chronic exposures
[6] Occupational data available from NOHSC except where noted, TWA values based on 8-hour average
[7]* Data available from NIOSH
[8] Value derived from review undertaken by RIVM (2001)
O Inhalation exposure evaluated using oral data as no relevant chronic inhalation data available
T Threshold approach adopted, hence no oral slope factor or inhalation unit risk considered relevant
NT Non-threshold approach adopted
NA Not available
CNS Central nervous system
TDI Tolerable daily intake
TC Threshold concentration
TWA Time-weighted average

7.6 Risk Characterisation

URS carried out an assessment addressing potential worst-case exposure to COPC calculated for a reasonable maximum exposure (RME) scenario estimated by using intake variables and chemical concentrations that define the highest exposure that is reasonably likely to occur in the area assessed. The RME is likely to provide a conservative or overestimate of total exposure and therefore health risk. This approach follows ANZECC/NHMRC guidance (1992) supplemented by USEPA guidance (USEPA 1989).

On-Site Risks

URS's assessment indicated that there is potential for unacceptable risks to be associated with many of the source zones identified. The prime exposure pathways for concern are ingestion and dermal contact with soil. Inhalation generally presents a minor contribution to the risk with the calculated risk associated with inhalation exposures being less than the adopted target for all areas with the exception of ISZ 5, where the presence of 1,2,3-trichloropropane dominates the calculated non-threshold risk.

As URS's assessment was based on the maximum concentrations present in soil within the site areas, the assessment provides a guide to those source zones and COPC that would require particular consideration in the further management and development of the site. The assessment generated an overestimate of risks for a worker who would spend time across many areas of the site as the average exposure concentration will be substantially less than that used in URS's assessment.

Table 6 presents a summary of outcome of the risk characterisation presented for key areas of the site. The prime COPC driving the calculated risk are also presented.

TABLE 6
Summary of Key Risk Issues on Site

Key Area on Site	Calculated Risk		
	Commercial / Industrial Workers	Intrusive Workers	Comments and Prime COPC
ISZ 1a, 1b and 2	X	X	Ingestion and dermal contact with DDX in soil
ISZ 3	✓	✓	
ISZ 4	X	X	Ingestion and dermal contact with DDX in soil
ISZ 5	X	✓	Ingestion and dermal contact with β-BHC and DDX in soil Inhalation for 1,2,3-trichloropropane
ISZ 6	✓	✓	
ISZ 10	X	✓	Ingestion and dermal contact with β-BHC and DDX in soil beneath pharmaceutical building
ISZ 7	X	X	Ingestion and dermal contact with β-BHC in soil
ISZ 8	X	X	Ingestion and dermal contact with β- and δ-BHC, dieldrin and DDX in soil
ISZ 9	X	X	Ingestion and dermal contact with β-BHC and dieldrin and DDX in soil
On Site Plumes			
Groundwater Plume 3	✓	✓	
Groundwater Plumes 4 and 5	✓	✓	
Groundwater Plume 2 (and 1)	✓	✓	

Notes: ✓ acceptable or less than or equal to target
X greater than target and requires management

Off-Site Risks

URS's assessment of inhalation exposure off-site indicated a low and essentially negligible risk for off-site (slab-on-grade) commercial premises that might be located above inferred groundwater Plumes 1, 2 or 3. In addition, risks to off-site workers undertaking intrusive works (including deep works that could intersect shallow groundwater) are considered to be low and manageable. URS stated that this conclusion is also valid for visitors to areas surrounding the site.

URS's assessment of the area relied directly on measured soil gas, sub-slab soil gas and ambient air data. URS concluded that whilst a number of sampling events were conducted in the off-site areas, it would be appropriate that additional data be collected to enable an assessment of variability over different ambient conditions and following remediation of the site.

7.7 Environmental Risk

URS found that investigations carried out at the site indicated a low potential for contamination associated with the site to adversely affect off-site environmental receptors. URS based its conclusion on the following assumptions.

- Given the industrial land use, consideration of on-site terrestrial environmental receptors would not normally be considered relevant. However, site management and remediation might need to be cognisant of the regenerated bush land located on the north-western boundary of the site.
- The current understanding is that the existing groundwater plumes are stable due to matrix diffusion and, to a lesser degree, biodegradation. Hence, groundwater plumes will not reach or discharge to Byrnes Creek.
- The proposed removal of contaminated perched groundwater and management of surface water will be carried out as described within the RAP.

On the basis of the above, URS considered that environmental issues associated with on-site soil or groundwater do not need to be further considered in the derivation of risk-based concentrations.

7.8 Risk-Based Remediation Criteria

Risk Management Measures – Soils

URS calculated risk-based soil concentrations (RBSC) for each ISZ where the potential for elevated risk has been identified (ISZ 1a, 1b, 2, 4, 5, 7, 8, 9 and 10). In addition, risk-based site-wide criteria (RBSWC) were derived that could be applied in any area on the site. Table 7 provides a summary of the derived risk-based soil concentrations for the site which will be adopted as 'remediation goals' during the remediation works.

TABLE 7
Risk Based Soil Concentrations (mg/kg)

COPC	RBSC for Key Source Zones On Site							RBSWC for Whole Site
	ISZ 1a/1b**	ISZ 4*^	ISZ 5**	ISZ 7	ISZ 8**	ISZ 9	ISZ 10##	
Hexachlorobenzene (HBC)***	10	15	5	30	15			5[C]
1,2-dichloroethane (EDC)	55	700	30		10			700[A]
Vinyl chloride	10							10[A]
Chloroform	80	5	5		45			80[A]
Carbon tetrachloride	10							10[A]
Trichloroethene (TCE)	400	100	5		15			400[A]
Tetrachloroethene (PCE)					650	5		5[B]
1,1,2-trichloroethane			10					10[A]
Chlorobenzene	2500		600					2500[A]
Benzene	5	10			25	10	5	5[B]
Toluene	200				200			200[A]
Ethylbenzene	200		150					200[A]
Xylenes	200		800				200	800[A]
PAHs (BaP equivalent)	24		36		40	40	40	10[D]
1,4-dichlorobenzene	40		15		200			15[B]
a-HCH (a-BHC) ***	1.5	5	2	600	500	500	150	30[D]
b-HCH (b-BHC) ***	2.7	15	8	20	8	20	23	15[D]
d-HCH (d-BHC) ***	1.2	2	4		5			1.2[C]
g-HCH (g-BHC or lindane) ***	12	50	8	1000	400	500	150	15[D]
Dieldrin***					50	50		15[D]
DDX (sum of DDT, DDE and DDD) ***	2300	1800	1900	900	400	800	2000	2000[D]
Endosulfan II						1200		100[D]
Pentachlorophenol					15			10[D]
Mercury (as total inorganic)		120			75			75[C]

Notes: ^ Impacted soil has been remediated (CH2M HILL, 2007), with impacted soil located within the onsite shed. The RBSC relate to the excavated and stored materials.

* Higher RSBCs might be allowable for volatile chemicals within this ISZ, however if these were to be identified, verification would need to include soil gas or flux emission sampling.

** Presence of a number of volatile COPC in soils in these ISZ. Note further characterisation of key contaminant areas within ISZ 1a, 1b and 2 suggest concentrations of BHC are generally less than derived criteria, with elevated concentrations associated with an isolated area. Such issues are expected to be addressed within the RAP.

*** Chemicals defined as Scheduled Chemicals (as per Schedule A, EPA NSW Scheduled Chemical Waste Chemical Control Order 2004 – CCO). Remediation of these chemicals might also require consideration of other criteria to address requirements as outlined in the CCO.

Presence of 1,2,3-trichloropropane in ISZ 5 requires further investigation. RBSC presented is preliminary only and subject to the outcome of further sampling and analysis of soil, groundwater and soil gas in the area.

RBSCs presented for ISZ 10 are only relevant if the existing Pharmaceuticals Building is removed. White the building remains, as is proposed, risks are negligible and no remediation is required.

A RBSWC for volatiles based on the maximum RBSC as available data suggests vapour inhalation exposures are not significant and other exposures (ingestion and dermal contact) do not contribute significantly to the total risk (for all key chemicals).

[B] RBSWC for volatiles based on the lower RBSC as the vapour pathways is not significant but other exposures (ingestion and dermal contact) do contribute significantly to the total risk (for all key chemicals). Hence to ensure the total risk remains acceptable, the lower RBSC has been adopted.

[C] RBSWC based on the lowest RBSC.

[D] RBSWC derived to ensure a balance of total risk such that it remains acceptable (for all key chemicals), and the extent of remediation (based on available data).

Shaded Site-wise criteria recommended for use in the remediation and management of the site.

Risk Management Measures – Groundwater

URS derived risk based groundwater concentrations (RBGCs) for impacts identified in off-site groundwater. It is noted that based on assessment of the risks associated with contaminant concentrations in groundwater as indicated by the currently available data there are no unacceptable risks to human health or the environment in any of the off-site areas. However, it is expected that the RBGCs will be utilised as trigger levels for the assessment of additional data collected during future assessment and monitoring in off-site areas.

Exceedances of trigger levels would indicate a need for further and more specific investigation.

As there is no complete exposure pathway relevant for the discharge of any groundwater to a receiving environment, the RBGCs were derived for the protection of human health only. Hence, the RBGCs have been derived to be protective of all existing exposures off-site and as such the receptors and exposure pathways considered complete are the same, and have been quantified on the basis of the same exposure parameters, as identified in the assessment of risk in off-site areas. The key difference in the derivation of RBGCs is that the risk assessment approach has been used to derive a source concentration that is protective of human health.

Table 8 presents a summary of the RBGCs derived for the off-site areas. RBGCs have been derived for COPC identified in off-site groundwater. The calculated risks from the RBGCs meet the target risk levels defined for both long-term on-site workers and intrusive workers.

TABLE 8
Calculated RBGCs for Off-Site Areas (mg/L)

COPC	Calculated RBGC
Hexachlorobenzene (HBC)	0.06
1,2-dichloroethane (EDC)	120
Vinyl chloride	6
Chloroform	100
Trichloroethene (TCE)	200
Tetrachloroethene (PCE)	30
1,1,2-trichloroethane	3.5
Chlorobenzene	200
Benzene	50
Toluene	6
a-HCH (a-BHC)	44
b-HCH (b-BHC)	0.11
d-HCH (d-BHC)	0.11
g-HCH (g-BHC or lindane)	16
Dieldrin	0.33
DDX (sum of DDT, DDE and DDD)	0.3

Risk Management Measures – Surface Water

All seepage water collected within excavated areas on the site will be treated onsite in a waste treatment plant to a standard suitable for discharge to sewer or for beneficial reuse during the excavation, remediation and reinstatement works, where possible.

Surface waters captured on building roofs at the site will be considered to be free from contamination and will be discharged directly to the stormwater system during remediation works. Surface water collected from within and adjacent to remediation areas, and the soil treatment area, including stockpiling areas, will be recovered and captured in the sites stormwater pits, which are sealed from the external stormwater system.

Testing of this water will be conducted and if this testing indicates that it is contaminated it will be directed to the water treatment plant for treatment.

No other surface waters are proposed to be recovered during the works.

A Trade Waste Licence will be obtained from Sydney Water for the disposal of treated waters into the sewerage system. Site water will not be discharged from the site unless tested and in full compliance with the water quality criteria specified in the licence. All discharges will be documented in terms of quantity and quality, and compliance with the licence criteria will be recorded

7.9 Uncertainty Assessment

URS carried out an assessment of the uncertainty associated with its assessment of risk.

The uncertainties URS identified relate to:

- Sampling and analysis

  In addition to data and method uncertainties that are inherent in the risk assessment process (as applied to any contaminated site), which were listed and discussed by URS in Section 10 of the HHERA, the following areas might warrant further consideration to reduce uncertainty in the available data.

  - Characterisation of TPH which can be undertaken by reviewing the relevant chromatograms. Whilst it is considered that the assessment of individual COPC identified will adequately address risk issues and define remediation requirements, there remains uncertainty as to the nature of the TPH contamination. Limited data is available and no further evaluation has been undertaken to date.
  - Air data collected from a number of sampling programs show variability in chemicals detected as well as concentrations reported. For on-site areas sufficient data is available to enable risk issues to be identified for the purpose of remediation. Further sampling of soil gas in off-site areas, where remediation is not expected, might be required to further assess the potential variability. Given the number of off-site vapour sampling rounds conducted, it is expected that an additional two or three sampling rounds (addressing other seasons) might be required to adequately address the variability.

- Receptor exposure assessment

  The risk assessment included assumptions about general characteristics and patterns of human exposure relevant to the site and surrounding area. The assumptions used were conservative and developed to provide an estimate of maximum possible exposures rather than the actual exposures. The approach used is expected to overestimate the risks. The assessment was completed using upper-bound concentrations reported within soil, groundwater and air reports and might therefore overestimate the potential for exposure to the COPC in the areas assessed.

- Toxicological assessment

  The approach for evaluating risks to mixtures of chemicals assumes dose additivity and does not account for potential synergism, antagonism or differences in target organ specificity and mechanisms of action. In general, the additivity approach has the effect of overestimating the risks. This is because chemicals that have no additive effects are included together as well as chemicals that might have additive effect.

7.10 Auditor's Review

7.10.1 Approach and Methodology

Human Health Risk Assessment (HHRA)

The approach and methodology for the HHRA follow the normal practice used in New South Wales, and the guidelines approved the NSW EPA.

This three-step approach, combining the four tasks of Data Evaluation, Exposure Assessment, Toxicity Assessment and Risk Characterisation, is considered appropriate for the site and its specific contamination issues.

Environmental Risk Assessment (ERA)

The ERA was conducted as a qualitative assessment focused on the aquatic environment of Byrnes Creek.

Given the highly urbanized nature of the environment of the Villawood site and the absence of other aquatic or terrestrial receptor environments, this is considered to be appropriate.

7.10.2 Contaminants of Potential Concern

URS used the conceptual site model developed by AECOM (2009, see Table 1) which was later incorporated into the final RAP (2011), as the basis for its issue identification and data review.

Chemicals of potential concern (COPC) were identified by comparing maximum concentrations reported for the site with screening criteria obtained where possible from Australian sources and were necessary from US sources. URS appears to have used all the available data and this approach is considered appropriate.

The Auditor considers that, based on his reviews of the original reports, the data set for the site as a whole is of adequate quantity and quality for risk assessment purposes, although the soil vapour data set is sparse.

7.10.3 Exposure Assessment

URS has appropriately identified the receptor groups of concern at this site; together with the relevant exposure activities.

The exposure parameters utilised for each receptor group are consistent with Australian guidance when available, and otherwise with appropriate US guidance.

The judgments used to estimate exposure point concentrations for each COPC in each relevant medium in each zone are considered appropriate. These are:

- Soil – maximum concentration of COPC in 0 to 1-metre depth intervals in the relevant zone.
- Offsite Shallow Groundwater – maximum concentration of COPC in shallow groundwater in relevant plume.
- Air – surface flux emissions where available, otherwise maximum measured soil vapour concentration.
- Excavations – measured soil gas concentration or groundwater concentration for wet excavations.

Vapour transport modelling procedures have been reviewed and are considered adequate.

The equations used to calculate chemical intake have been reviewed. These are standard equations and are considered appropriate.

7.10.4 Toxicity Assessment

The dose-response relationship (threshold / non-threshold) applied to each COPC has been checked and is considered appropriate.

The Auditor notes that as is normal practice in Australia (but not the US) non-genotoxic carcinogens are treated as threshold chemicals.

The hierarchy of sources used to obtain toxicity values used by URS is in accordance with EPA guidelines.

Toxicity values used have been checked and are considered appropriate.

7.10.5 Risk Characterisation

The target risk values adopted by URS

1×10^{-5}	calculated incremental risk for non-threshold chemicals
1.0	hazard index for threshold chemicals

are widely used in Australia and are considered by the Auditor to be appropriate for this site.

The workplace exposure standards also included by URS are useful for comparison but are not considered relevant for the assessment of risk on this site.

The characterisation and assessment of risk for each key area (ISZ and areas over groundwater plumes) of the site, has been reviewed by the Auditor and is considered to be soundly based upon the data sets and methodology previously outlined in this section.

7.10.6 Environmental Risk

The assessment of environmental risk essentially considers risk to the aquatic environment of Byrnes Creek and is based upon the modelling carried out by Laase (2007). This modelling was reviewed by the Auditor and the conclusions of both the modelling and this risk assessment are supported as being based upon a sound approach, and being the best estimate possible given the unresolvable data and off-site access constraints.

7.10.7 Risk-Based Remediation Criteria

The process used by URS to derive RBSC and RBSWC has been reviewed. Although complex and not necessarily intuitive, the reasoning underlying the process is considered to be sound. The focus on the chemicals that contribute most to risks in a particular area is appropriate.

The process used to derive risk-based groundwater criteria (RBGC) has also been assessed. It is noted that exposure modelling in this process incorporates two estimation steps,

- Calculation of sub-slab vapour concentrations from group water concentration using a ration derived from site data, and
- Modelling the intrusion of sub-slab vapour into indoor air space.

The only exposure pathways considered are inhalation of indoor air and inhalation exposures to workers in excavations but this is appropriate as these are the only complete pathways identified.

Clearly this process has its limitations – these are discussed in detail in Section 7.10.8. In particular, the Auditor notes that this process is only valid for buildings with slab-on-grade construction and is not valid for buildings with basements, particularly wet basements.

The RBGC are considered by the Auditor to be valid screening or trigger criteria provided that their inherent limitations are recognised.

7.10.8 Uncertainty Assessment

URS has provided an uncertainty assessment in which uncertainties in toxicological assessment are treated generically, while exposure-assessment uncertainties are considered on a site-specific basis.

The generic treatment of toxicological uncertainty is considered appropriate, because the toxicological data set is common to most risk assessments carried out in New South Wales.

The Auditor notes that in this assessment, as in most Australian assessments, a slope-factor is not used for non-genotoxic carcinogens.

The treatment of exposure uncertainty is valid, but brief, and it does not address all uncertainties of concern. In particular, the uncertainties associated with vapour intrusion modelling are not discussed. The Auditor considers that because (for on-site exposures) exposures via the inhalation pathway make a minor contribution to total exposures, this does not affect the validity of the assessment.

For off-site exposures it is noted that uncertainties due to variation in depth to groundwater, variably in the soil profile, the potential localised presence of high-conductivity vertical pathways, differences in standards of building construction and the condition of slabs all exist.

As indicated previously, the derived RBGC are not valid for buildings with basements, although there is no indication that such buildings currently exist in the impacted area.

Risk assessment checklists are provided in Appendix E of this report.

8.0 REMEDIAL ACTION PLAN (AECOM, 2011)

8.1 Remediation Scope and Methodology

AECOM's Remediation Action Plan (RAP) was prepared to meet the requirements of Remediation Order No. 23019, Area 3200, issued by the NSW EPA on 2 November 2005. *Note:* AECOM's RAP supercedes and replaces the original version of the RAP prepared by HLA (dated 3 October 2007).

The RAP outlines the rationale for remediation works and the proposed methods of excavation of contaminated soils and the on-site ex-situ treatment of these soils for reuse on site.

Based on the findings of groundwater modelling (Laase, 2007), it was concluded that the groundwater contamination at the site is static and is unlikely to migrate to Byrnes Creek due to the effects of retardation, matrix diffusion and biodegradation. Based on these factors and the site's continued commercial/industrial land use, the HHERA (URS 2010) concluded that groundwater did not present an unacceptable risk to human health or the environment. Consequently, AECOM did not consider remediation of the site's groundwater to be required. Therefore, AECOM's primary driver for the remediation works is the risk to human health from contaminants of concern identified within the site soils. Excavation and treatment of soils, which do not meet the remediation goals, will adopt a conservative strategy for the remediation of the site with the benefit of also removing impacted soils which have the potential to impact the shallow groundwater system.

Based on AECOM's review of the findings of a Remedial Technology Assessment (RTA) carried out by HLA in 2006 (which reviewed possible remedial options for the site), a range of remedial options and technologies were considered. AECOM included in its RAP a discussion that addressed the advantages and disadvantages of each.

As a result of the findings and further evaluation, AECOM recommended ex-situ Direct Thermal Desorption (DTD) as the preferred remediation technology.

Because the DTD process is an ex-situ treatment method, excavation of the remediation areas will be required prior to treatment. The excavated materials will be assessed upon excavation and sampled for classification. Excavated materials requiring treatment will be transported from the remediation area to a Feed Soil Building (FSB), where they will be readied for treatment in the adjoining DTD Plant. The FSB will be equipped with an Emission Control System (ECS) to control and regulate emissions from the material handling processes prior to treatment. After treatment, the material will be validated and temporarily stockpiled adjacent to the FSB. Once treatment of each of the remediation areas has been completed and the areas have been suitably validated, the treated material will be reused as backfill material at the site.

AECOM's RAP sets out specific information relating to the project tasks, individual plant, site facilities and treatment processes. General operations involving the remedial works are described in the following sections.

- Progressive excavation of contaminated soils from the first remediation area.
- Proof of performance testing period for the DTD Plant and associated ECS for the FSB.
- Screening of oversize excavated materials.
- Transport of the excavated materials from the remediation area to:
    - the FSB if the initial testing finds that the excavated materials require remedial treatment; or
    - a second stockpile if initial testing indicates that the excavated materials are suitable for reuse without remedial treatment; or
    - an off-site licensed waste facility where excavated materials are considered unsuitable for remedial treatment but are suitable for disposal/recycling at such as facility.

- Treatment of soils within the DTD Plant.
- Progressive validation of the treated soils and placement in temporary stockpile areas.
- Progressive validation of the remediation areas (against the remediation goals) after the excavation and removal of the contaminated materials.
- Dismantling and reestablishment of remediation area for each stage of excavation works.
- Backfilling of the validated remediation areas after completion of the excavation and remedial treatment works.
- Final reinstatement and finishing of the remediation areas.
- All necessary OH&S, environmental protection works and monitoring.

8.2 Preliminaries and Regulatory Compliance

Prior to establishment at the site, preliminary activities including all plans, programs, licenses, certificates and other documents necessary for the commencement of work will be completed.

Site facilities required for the remediation works will be established in compliance with relevant regulations. The facilities, which will be connected to appropriate utilities where required, include:

- FSB and the DTD Plant;
- site offices located adjacent to Gate 1;
- air lock and wheel wash zones at the entrance and FSB exit point;
- ECS for the FSB;
- stores, work sheds, lunchrooms and changing areas for the use of subcontractors and consultants;
- temporary site sheds, first aid and emergency facilities, bathroom facilities and decontamination units;
- internal haulage roads; and
- any additional site facilities to facilitate work in other areas of the site, or in areas requiring additional safety measures.

Entry to the site will be strictly controlled throughout the course of the remediation works. Security fencing will be established around the soil treatment area (STA) and additional fencing will be erected where necessary to secure portions of the site. OHS signage will be installed at the site entrance detailing directions to key areas and after-hours contact details.

8.3 Excavation Works

The RAP appropriately identifies works associated with the excavation of the identified remediation areas, including:

- all stages of the establishment and disestablishment;
- control and minimisation of emissions from the excavation area;
- control and treatment of water from the remedial excavations;
- excavation of remedial areas; and
- loading of excavated materials for transport to the soil treatment area.

At the date of AECOM's RAP, the staging of the main excavation works within the remediation areas had not been determined, although it is likely that the remediation works will start with the excavation and removal of the TWL.

8.4 Materials Handling

The RAP appropriately specifies the proposed materials handling procedures designed to provide 'cradle-to-grave' control and management of excavated materials at all times necessary to ensure that each remediation area is suitable for the proposed land use.

The RAP provides a waste classification of in-situ soils that are identified as requiring excavation and removal.

The RAP references the EPA (2008) *Waste Classification Guidelines* and notes that materials considered unsuitable for off-site disposal or re-use on-site will be transported to the FSB for further processing. The Auditor notes that these guidelines were reissued in 2009, and the version that is current at the time of remediation must be used.

8.5 Treatment Operations

As the materials excavated from the remediation areas will have different treatment requirements in terms of their workability, management, range of contaminants of concern present and contaminant concentrations, the RAP describes the methodologies to be employed for preparing and treating the excavated materials for beneficial reuse on-site, and stockpiling of surplus materials.

8.6 Management of Water

A water management program will be implemented at the site to minimise the volume of contaminated water generated, and to manage the water in the most efficient manner possible in compliance with regulatory requirements.

AECOM describes the likely types of water to be encountered on site during remediation as:

- Clean water – water that is not contaminated. Clean water is likely to collect in areas of the site that remain undisturbed by site works, such as in areas upgradient of site works and water collected from the roof of the FSB.
- Contaminated water – water that is considered to be impacted and which requires recovery, treatment and recycling or disposal. Contaminated water will likely be encountered from seepage associated with rainfall events, within the materials at the base of the remedial excavations, within the treatment area bunds and the truck washes.
- Grey water – water on-site which has been untreated or has been treated and which is acceptable for being recycled on-site in truck wheel wash facilities or for dust suppression.
- Sewer quality water – is defined as water that has been either treated or untreated and which meets the Trade Waste Criteria, as detailed in the Sydney Water Trade Waste License.

Water recycling will be undertaken on-site where possible but it may be necessary to discharge site water into the sewerage system. A Trade Waste License will be obtained (or modified) for the site from Sydney Water prior to the commencement of site works. Detailed records of the quantity and quality of all water recycled and discharged from the site will be kept and made available to the regulatory authorities as required.

8.7 Removal and Disposal of Materials from the Site

AECOM anticipates that the off-site disposal of materials may be necessary during the course of the remediation works to remove foreign materials such as crushed drums, steel reinforcement, scrap steel, pipework and timber. These materials (if they do not require treatment in the DTD plant) and low-level

contaminated clothing and PPE from site workers, will be transported off-site for disposal at an appropriately licensed landfill or recycling facility.

The RAP details the procedures to be adopted for the disposal of materials from the site, which may also include bonded asbestos containing materials (BACM) which may be present in the form of stormwater pipes and drains as well as fragments. AECOM's procedure for off-site waste disposal is described as follows.

- Material requiring off-site disposal will be stockpiled separately in the central stockpile area and will be tracked using the materials tracking system.
- The liquid or non-liquid material will be classified in accordance with the NSW EPA's *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes* (2004).
- Notification of the waste facility organized to receive the waste to confirm that the facility is licensed to accept the material.
- If the waste facility is licensed to accept the class of waste, the material will be transported under the appropriate license to the designated receiving facility. Every load of waste removed from the site will be recorded.
- A copy of the waste depot weighbridge docket will be collected and retained for each load of waste delivered.

If BACM materials are encountered during excavation works they will be collected and disposed of by a licensed asbestos removal contractor in accordance with the requirements of the NSW WorkCover NSW Occupational Health and Safety Regulation Act (2001) and the requirements of the NSW Occupational Health and Safety Commission Asbestos Code of Practice and Guidance Notes.

8.8 Placement of Reinstatement Materials

At the conclusion of the excavation and validation works, treated and validated soil material stockpiled within the STA will be beneficially reused within remediation areas to restore the land to original levels. AECOM's RAP outlines the processes and methodologies involved in the reinstatement of the remediation areas.

The remediated materials will be transported from their respective stockpile areas to the remediation areas. The materials will be placed and compacted in successive layers for the full width and length of the excavation. The compacted layer thickness will not exceed 300 mm and fill will be compacted to produce a field dry density of at least 98%. At the time of compaction of each layer, the moisture content of the material will be such that the specified compaction is achieved. Where necessary, water will be sprayed on the material by water cart in sufficient quantity to ensure that the appropriate moisture content is achieved for each layer.

Compaction testing will be conducted for each layer, by a qualified geotechnical engineer using NATA-certified methods, to confirm that the desired compaction standard is achieved.

The excavation will be reinstated to levels that are consistent with the area surrounding each remediation area.

8.9 Validation

All soil materials to be retained on-site must satisfy the remediation goals detailed in Section 7.1 of the RAP.

AECOM recognises that the requirements of the *Guidelines for the NSW Site Auditor Scheme* (EPA, 2006) will be implemented for continued commercial/industrial land use. Where material appears, because of aesthetic issues, to be incompatible with the requirements of the nominated land use, guidance will be sought from Orica and the Auditor concerning an appropriate location for the ongoing management of the offensive material.

Validation data will be assessed in accordance with the National Environment Protection (Assessment of Site Contamination) Measure (NEPM) (1999).

Materials that will require validation sampling during the remediation works will be as follows:

- Residual, unexcavated material beneath the trade waste line, comprising the base and walls of the final excavation.
- Residual, unexcavated material within the remediation areas, comprising the base and walls of the final excavated surface.
- Excavated and treated material which has been treated via the DTD plant.

As treatment and stockpiling will be undertaken on appropriately sealed hardstand areas, soil beneath the concrete slabs is unlikely to be impacted by the stockpiling activities and consequently validation testing of these areas once the concrete slabs are removed is not proposed. However, before removal of concrete slabs is commenced, an inspection of these will be undertaken to identify the presence of contamination. If this inspection indicates the visual presence of any contamination relating to treatment operations, validation of the soil beneath the concrete slabs will be undertaken.

The RAP outlines sampling procedures to be implemented should such material require validation for onsite beneficial reuse. All materials excavated for onsite beneficial reuse must be inspected for asbestos containing materials and signs of visual or olfactory contamination by a qualified environmental scientist/engineer with experience working on contaminated sites. Samples are to be taken, at frequencies outlined in the RAP, and analysed against the RBSWC which have been derived to allow for the excavation, validation and movement of materials across the site. All materials validated for onsite beneficial reuse are to be tracked using the materials tracking system.

It has been noted that residual PAH impacts are present in the vicinity of sample location VA12/94 (CH2M Hill, 2007) due to excavation works not being undertaken because of the proximity of the site boundary. Consequently, to assess the significance of the reported PAH impacts AECOM recommend that additional delineation testing of the surface soils be undertaken in this area. The findings of these works and any required remediation works will be detailed in the validation report.

Sampling fieldwork will be conducted in accordance with written standard operating procedures, copies of which will be maintained in a register on site during the remedial work to ensure that representative samples of materials are collected and the sampling methodology remains consistent throughout the duration of the remedial works.

Analytical testing will be undertaken by laboratories using NATA-registered methods and in accordance with the NEPM (1999).

9.0 AUDITOR'S ASSESSMENT OF SUITABILITY OF REMEDIATION ACTION PLAN

9.1 Remediation Goals

AECOM adopted the URS risk-based site-wide criteria (RBSWC) as soil remediation goals for the site. As discussed in Section 8 of this report, these criteria were developed using a site-specific risk assessment approach that is considered to be appropriate by the Auditor. The RBSWC were agreed to by the Auditor.

The URS HHERA concluded that the currently-measured concentrations of COPC in groundwater did not present an unacceptable risk to human health for industrial / commercial developments on or off the site. It was also concluded that groundwater contamination did not present a risk to Byrnes Creek, the only identified ecological receptor of concern.

On this basis, it was concluded that active groundwater remediation is not required, although there is a need for ongoing groundwater monitoring. The Auditor supports this conclusion because it reflects the outcome of the HHERA.

Therefore, remediation goals for the site relate only to site soils. The Auditor considers that it is appropriate that the remediation goals be based upon the risk assessment, and therefore considers that these goals are appropriate.

9.2 Mitigation of Risk to Human Health and the Environment

As outlined previously in this section, human health risks due to COPC in site soils in Remediation Areas 1a, 8, 1b, 5, 7 and 9, and previously-stockpiled soil originating from the site and the Chester Hill site will be excavated and treated using a directly-heated thermal desorption (DTD) plant to reduce the concentrations of COPC to concentrations below the site remediation goals.

The Auditor considers that:

- The remediation strategy set out by AECOM in the RAP is capable of meeting the site remediation goals, i.e. it is technically feasible.
- The remediation strategy in general, and the DTD technology for soil remediation in particular is considered to be environmentally justifiable because although it is a relatively high-energy process, the treated soils will be suitable for re-use on site, avoiding any requirement for road transport and offsite disposal. The DTD technology was selected following a detailed remedial technology assessment; all other technologies that ranked high in this assessment were also high-energy processes.
- The remediation strategy involves treatment of the contaminated soils on site, and reuse of the treated soils on site. This combination ranks at the top of the preferred order of remediation and management approaches set out in ANZECC (1992) and currently approved by the NSW EPA.
- The Auditor is carrying out a site audit of the implementation of DTD for the treatment of soil contaminated by chlorinated hydrocarbons on another site in the Sydney Metropolitan Area, and has gained confidence in that process.
- Air emissions from the DTD process are not anticipated to result in unacceptable human health or environmental risks, and the plant will be subject to an Environment Protection Licence (EPL) under the POEO Act.

9.3 Regulatory Compliance

The remediation of the Villawood site is Category 1 remediation (requiring consent) pursuant to Clause 9 of SEPP55.

The remediation project was classed as a Major Project pursuant to Schedule 1 of the SEPP (Major Projects) 2005 and Project Approval is being determined by the Minister for Planning and Infrastructure under the transitional arrangements that are in place following repeal of Part 3A of the Environmental Planning and Assessment Act 1979. Director-General's requirements (DGRs) for the project Environmental Assessment (EA) were issued in May 2010.

An EA has been prepared and this site audit is part of the EA process. In the Auditor's opinion, the specific DGRs applying to the RAP have been met.

The site is currently subject to an EPL covering some assessment, remediation and assessmental activities. Following grant of Project Approval, application for a new EPL to cover the DTD process will be required.

Because the site hosts materials that are classified as scheduled chemical wastes (SCW), within the SCW chemical control order (CCO) issued pursuant to the NSW Environmentally Hazardous Chemicals Act 1985, that CCO applies to the proposed remediation.

The requirements of the Stockholm Convention concerning organochlorine pesticides (OCP) and hexachlorobenzene (HCB) apply to the site and the remedial works.

The Australian National Organochlorine Pesticides Waste Management Plan does not apply to OCP-contaminated soil but may apply to any other OCP residues that may be encountered in the remediation process.

These specific regulatory issues are addressed in Appendix E of the RAP, which the Auditor considers to be appropriate.

9.4 Potential Contaminant Migration

The RAP adequately addresses potential contaminant migration during remediation by air and dust emissions from contaminated soil during excavation and handling, and by transport in surface water runoff.

Potential contaminant migration in groundwater is discussed in Section 9.5 below.

Air emissions from the DTD plant will be regulated under the EPL.

9.5 Groundwater Issues

As discussed previously in this report, the groundwater contaminant plumes have been shown to have dimensions and concentrations that are effectively stable with time, both onsite and off-site. The demonstrated capacity of the COPC for diffusion into the matrix of the Bringelly Shale, and the reservoir of contamination currently stored there, will buffer that stability in the future.

The modelling carried out by Laase (2007) demonstrated that dissolved phase contaminants in groundwater ill not discharge to the only environmental receptor of concern, Byrnes Creek.

On this basis, the Auditor has concluded that groundwater contamination issues can be appropriately addressed by:

- A long-term groundwater monitoring plan.
- Appropriate notification of the groundwater contamination issue to the owners and occupiers of land located above the groundwater plumes.

9.6 Aesthetic Issues

Following remediation, the site will be used for industrial and commercial purposes only.

Visual aesthetic issues will not be of concern on a commercial site.

Odour issues will be addressed during remediation. Treated soil will not be odorous.

9.7 Chemical Mixtures

Chemical mixtures are a significant concern on this site. The risk assessment has addressed this issue to the extent possible, but it is not possible to fully assess risks due to complex mixtures of chemicals as present on this site.

The DTD process will adequately deal with the mixtures present in soil requiring treatment.

Any residual mixtures will be addressed in the site condition audit to be completed following remediation and validation.

9.8 Short-Term and Long-Term Management

Section 21 of the RAP adequately addresses the requirement for short-term environmental management during remediation.

Long-term environmental management of some contaminated soil and the groundwater contamination plumes present beneath the site and off-site will be required. An appropriate long-term Environmental Management Plan will be prepared following completion of remediation and validation.

9.9 EPA Guideline Requirements

The Auditor has checked the RAP against the requirements for a remedial action plan listed in the NSW EPA's *Guidelines for Consultants Reporting on Contaminated Sites* (1997). In the Auditor's opinion, the RAP and the EA of which it is a component:

- has set appropriate remediation goals;
- documents in detail the procedures and plans to be implemented to reduce risk due to contamination to a level that is acceptable for industrial and commercial use;
- has established the environmental safeguards required to complete the remediation in an environmentally-acceptable manner with the exception of detailed measures concerning the operation of the DTD plan that will be the subject of an EPL.

Because the RAP has been prepared to support an application for project (planning) approval for the remediation works, and because an EPL application will not be submitted until project approval is granted, the necessary approvals and licences are not available at this time.

The Auditor has checked and is satisfied that the requirements of the checklist in *'Guidelines for Consultants Reporting on Contaminated Sites'* have been met by the RAP and, where a summary is provided in the RAP, by the supporting documentation.

The RAP relies upon the HHERA prepared by URS. The Auditor has checked and is satisfied that the HHERA is in accordance with Schedule B4 of the NEPM (1999) and with the relevant guidelines made or approved by the EPA, specifically enHealth (2002) and that the methodology of the HHERA and the reasons underlying the many choices of approach, method and data necessary to carry out a risk assessment are clearly explained in the HHERA document.

The RAP and HHERA rely upon many site investigation reports. Relevant reports have been summarised in this site audit report. These reports have been progressively reviewed by the Auditor over a period spanning a number of years.

In the Auditor's opinion, this body of reports provides data that is reliable and representative of the condition of the site. The reliability and fitness for the purposes of the RAP and HHERA of the field sampling procedures and laboratory programs have been checked by the Auditor.

As discussed in Section 8, the strategy outlined in the RAP and EA is consistent with the ANZECC remediation policy approved by the NSW EPA, and is the most preferred option (on-site treatment so that the contaminant is either destroyed or the associated hazard is reduced to an acceptable level) under that policy.

9.10 Validation

The validation plan set out in Section 19 of the RAP has been reviewed by the Auditor.

The Auditor is satisfied that if validation sampling and analysis is carried out in accordance with the validation plan then the requirements for validation sampling and reporting set out in *'Guidelines for Consultants Reporting on Contaminated Sites'* will be met.

The Auditor is satisfied that the validation plan demonstrates an adequate appreciation of the issues that are likely to arise during validation of remediation this site. The data quality objectives are considered appropriate, and the processes specified for achieving these objectives, including sampling methodology, analytical methodology, the use of appropriate quality control sampling and data quality indicators, and the decision processes are adequate and appropriate.

The Auditor emphasises that due to the complexity of this site, appropriate validation will be more than usually dependent upon the experience, observations and decisions of the validation team. Consultation with the Auditor will be necessary prior to and during implementation of the validation plan, as foreshadowed in the plan.

10.0 AUDITOR'S CONCLUSIONS AND RECOMMENDATIONS

The Auditor's opinion and reasoning concerning the individual components of the complex assessment, remediation and validation process that is described in the RAP is set out in the preceding sections of this site audit report.

This final section provides a very brief summary of the Auditor's opinions. Reference to the body of the report should be made for the reasons underlying these opinions.

10.1 Overview

The site at 2 Christina Road, Villawood is contaminated by a wide range of organic chemicals, some of which are present at very high concentrations. Contamination is present in soil beneath the site, groundwater beneath the site, and groundwater off the site.

The distribution of contamination in these media is complex, and reflects the cumulative impact of a number of mechanisms of contamination and site practices acting over a period of many years.

Remediation of site soils is required to make the site suitable for industrial and commercial use.

Although shallow groundwater beneath the site is highly contaminated by some of the organic chemicals identified in site soils, remediation of groundwater contamination is not required to make the site suitable for industrial or commercial use, and the off-site groundwater contamination does not currently present an unacceptable risk to human health or the environment. Remediation of groundwater contamination is not therefore required to manage risk. Because no practicable means of remediating groundwater to meet the policy goals of the NSW EPA has been identified, and such remediation appears impracticable, it is not proposed.

10.2 Adequacy of Investigation

The investigations of soil and groundwater contamination beneath the site and off-site areas that have been progressively implemented over a number of years, are considered by the Auditor to be sufficient to define geological and hydrogeological conditions, and the nature and extent of contamination.

These investigations have provided an adequate data set to allow the assessment of human health and environmental risks and to allow an appropriate remedial strategy to be developed.

10.3 Adequacy of Human Health and Environmental Risk Assessment

The Human Health and Environmental Risk Assessment carried out by URS has been reviewed by the Auditor. The assessment has been carried out in accordance with national and international guidance approved by the NSW EPA, where applicable, and are considered appropriate by the Auditor.

In the Auditor's opinion, the risk assessment adequately identifies and quantifies risks due to chemical contamination on and off the site, and has developed an appropriate set of site-specific risk-based soil concentrations to be used in the development of remediation goals, and risk-based groundwater concentrations to be used to aid the interpretation of future groundwater monitoring data.

10.4 Suitability of Remediation Action Plan

The Remedial Action Plan developed by AECOM has been reviewed by the Auditor and is considered to comply with the relevant guidelines, and to be appropriate to guide remediation activities.

The core soil remediation technology proposed, directly-heated ex-situ thermal desorption, is considered to be appropriate for the contaminants of concern, technically feasible, and environmentally justifiable.

Implementation of this technology would be in accordance with the remediation policy endorsed by the NSW EPA.

If the site is remediated in accordance with the remedial action plan, and validated in accordance with the validation plan to demonstrate that the remediation goals have been met, then the site will be suitable for industrial and commercial use.

10.5 Recommendations

A further site audit will be required at the end of the active remediation process to confirm that the site is suitable for the proposed use.

It is strongly recommended that a Site Auditor continue to be involved throughout the remediation process.

The proposed remedial works will not address groundwater contamination beneath the site and off the site. Given the chemical nature of the contaminants present in groundwater, the demonstrated environmental persistence of many of these chemicals and the mechanisms of diffusion into, and slow release from, the fine-grained matrix of the residual soils and shales that form the shallow aquifer beneath the site and surrounding area, groundwater contamination is expected to persist for many decades. Management of the groundwater contamination must therefore continue for the foreseeable future.

A long-term environmental management plan setting out requirements for monitoring, data review and reporting, and notification requirements for the owners and occupiers of land that is impacted by the groundwater contamination will be required once active remediation has been completed.

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Important Information About Your Site Audit Report

These notes will help you to interpret your Site Audit report. They are based on guidelines prepared by the NSW Department of Environment and Conservation.

Introduction to the NSW Site Auditor Scheme

Objectives

The objectives of the NSW Site Auditor Scheme are to:

- ensure that public health and the environment are protected through proper management of contaminated sites, particularly during changes of land use
- improve access to technical advice on contaminated sites for planning authorities and the community by establishing a pool of accredited site auditors
- provide greater certainty for planning authorities and the community through the independent review by those auditors of contaminated site assessment and remediation reports, and reports that validate the successful completion of the assessment of remediation.

Background

In Australia, the use of accredited auditors to review work conducted by contaminated site consultants was first introduced in Victoria in 1989 through the Victorian EPA's Environmental Auditor (Contaminated Land) Scheme.

In 1998, NSW commenced its own Site Auditor Scheme under the *Contaminated Land Management Act 1997* (CLM Act). The scheme is administered by the Department of Environment and Conservation (DEC).

The CLM Act empowers DEC to accredit individuals as site auditors and to establish guidelines for them.

The Contaminated Land Management Regulation 1998 (CLM Regulation) specifies some of the procedural requirements of the scheme.

Site Audits in Relation to Contaminated Sites

Site auditors review the work of contaminated site consultants. The CLM Act calls these reviews 'site audits' and defines a site audit as an independent review:

a) that relates to investigation or remediation carried out (whether under the CLM Act or otherwise) in respect of the actual or possible contamination of land, and

b) that is conducted for the purpose of determining any one or more of the following matters:

   i) the nature and extent of any contamination of the land

   ii) the nature and extent of the investigation or remediation

   iii) whether the land is suitable for any specified use or range of uses

   iv) what investigation or remediation remains necessary before land is suitable for any specified use or range of uses

   v) the suitability and appropriateness of a plan of remediation, a long-term management plan, a voluntary investigation proposal or a remediation proposal.

The main products of a site audit are a 'site audit statement' and a 'site audit report'.

A **site audit statement** is the written opinion by a site auditor, on a DEC-approved form, of the essential findings of a site audit. It includes, where relevant, the auditor's conclusions regarding the suitability of the site for its current or proposed use.

Before issuing a site audit statement, the site auditor must prepare and finalise a detailed **site audit report**. The report must be clearly expressed and presented and contain the information, discussion and rationale that support the conclusions in the site audit statement.

In some circumstances a site audit is required by law. These audits are known as '**statutory site audits**' and may be carried out only by site auditors accredited under the CLM Act. A statutory site audit is one that is required by:

- a regulatory instrument issued under the CLM Act, including DEC agreements issued by DEC to voluntary proposals.
- the *Environmental Planning and Assessment Act 1979*, including an environmental planning instrument or development consent condition
- any other Act.

Role of Site Auditors

The services of a site auditor can be used by anyone who needs an independent and authoritative review of information relating to possible or actual contamination of a site. The review may involve independent expert technical advice or 'sign-off' of contaminated site assessment, remediation or

validation work conducted by a contaminated site consultant.

Site Assessment and Audit Process

The usual stages in the assessment, remediation and validation of a contaminated site, and in the audit of those activities, are as follows:

Consultant is Commissioned to Assess Contamination

In most cases, a site owner or developer engages a contaminated site consultant to assess a site for contamination and, where required, to develop a remediation plan, implement the plan and validate the remediation.

The contaminated site consultant designs and undertakes the site assessment and, where required, all remediation and validation activities to achieve the objectives specified by the owner or developer.

Site Auditor Reviews the Consultant's Work

The site owner or developer commissions the site auditor to review the consultant's work. The auditor prepares a site audit report and a site audit statement at the conclusion of the review, which are given to the owner or developer.

Where the local planning authority or DEC uses its legal powers to require the carrying out of a site audit, the site owner or developer must commission a site auditor accredited under the CLM Act to perform this task. This is known as a 'statutory' audit. The CLM Act requires that an auditor must notify DEC when he or she has been commissioned by anyone other than DEC to perform a statutory site audit. The auditor is also required to furnish the local authority and DEC with a copy of the completed site audit statement.

In some cases, the site owner or developer may wish to have a site audit undertaken although it is not a legal requirement. The audit is termed 'non-statutory'. If their intention is to obtain a site audit statement, they must commission a site auditor accredited under the CLM Act to perform this task. This is because only a site auditor so accredited can issue a site audit statement and they are obliged to issue one at the end of any site audit. For non-statutory audits, the site auditor must give a copy of the site audit report to the local authority or DEC, or both, on request.

As required by the CLM Act, DEC maintains a record of all statutory site audit statements issued in relation to land that is the subject of a regulatory instrument under the CLM Act. Copies are available for public inspection through DEC's website at www.environment.nsw.gov.au. If the local council receives a copy of a site audit statement, it must list the statement on any certificate it issues under section 149 of the *Environmental Planning and Assessment Act 1979* in relation to the land concerned.

Limitations of Your Site Audit Report

The following notes have been added by the Auditor who prepared this report, to highlight some important limitations on the use of this report.

This report has been prepared by C. M. Jewell & Associates Pty Ltd for the use of the client who commissioned it, and relevant government agencies, for the specific purpose described in the report.

Consistently with the objectives of the NSW Site Auditor Scheme, it may be appropriate for others to rely upon this report in some circumstances.

However, the original purpose of this report and the site conditions prevailing at the time the report was prepared – as described in the report – should be considered first.

If you are not the person for whom the report was prepared, or you wish to use it for a different purpose to that for which it was prepared, or site conditions appear to differ from those described in this report, or a significant period of time has elapsed since the report was prepared, then PLEASE CONSULT THE SITE AUDITOR BEFORE RELYING UPON THE REPORT.

It is also important to recognise that a site audit is primarily a review of work carried out by other companies and individuals.

The site auditor has checked data and interpretations, ascertained whether or not appropriate guidelines have been followed, and satisfied himself that the available data are adequate to support the conclusions he has reached.

However, all environmental sampling programs have an inherent degree of uncertainty. Even when sampling fully complies with guidelines, it is possible for areas of contamination to remain undetected, but be revealed by more extensive excavations during site redevelopment. This risk is usually quantified using statistical confidence limits.

The site audit report identifies data limitations and uncertainties where these are recognised, but users must accept the finite and unavoidable risk that some contamination may remain undetected during even a diligent site assessment and audit process.

If there is a need to copy this report, it must be reproduced in full. No reliance whatsoever should be placed upon partial copies of a site audit report.

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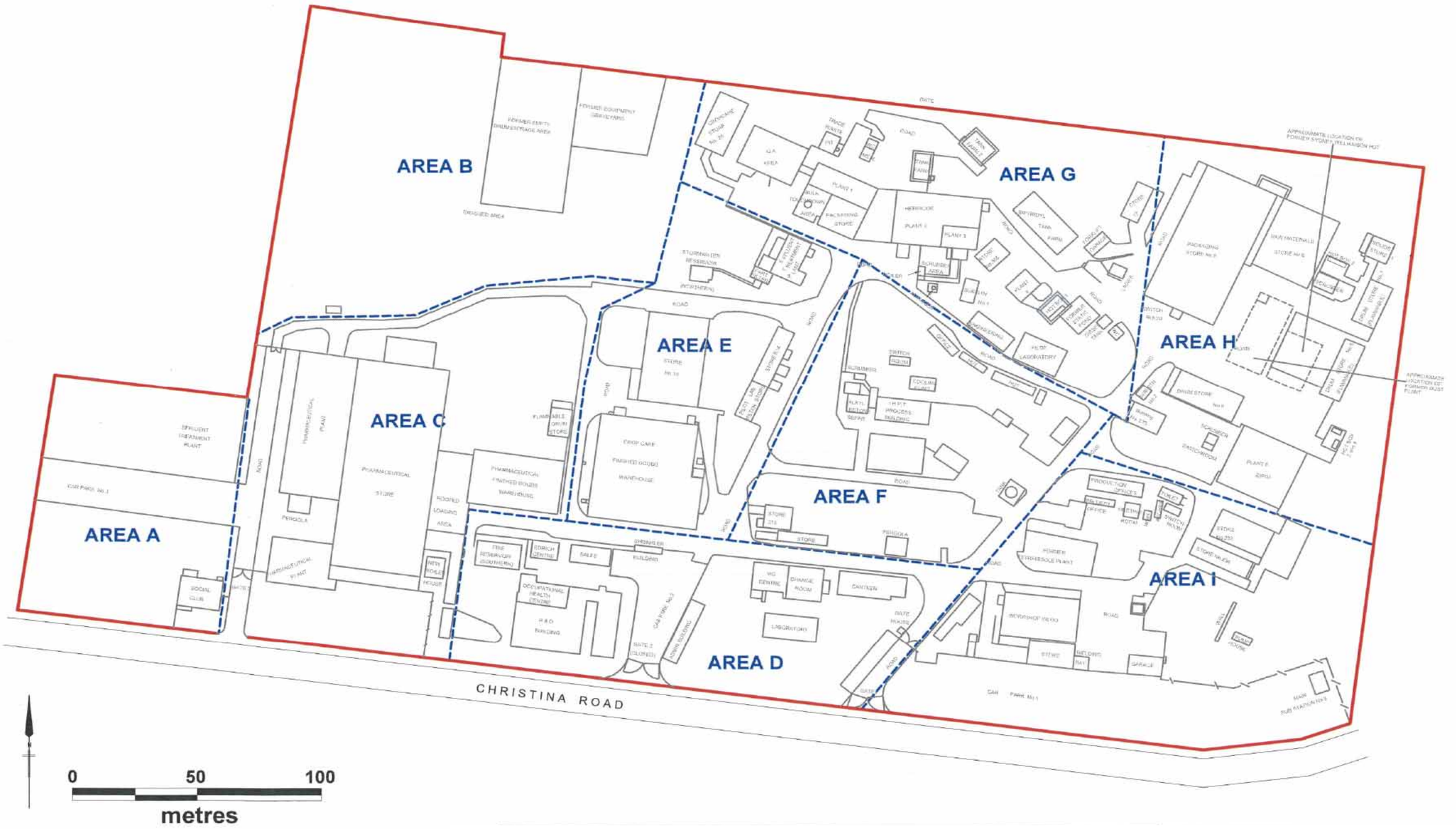
Report Ref: J1196.14R
Rev: 0
Rev Date: 30-Mar-10
Author: NAA

Figure 1

Site Location



Source: URS 2010

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Author: NAA

Figure 2
Site Layout and Investigation Areas

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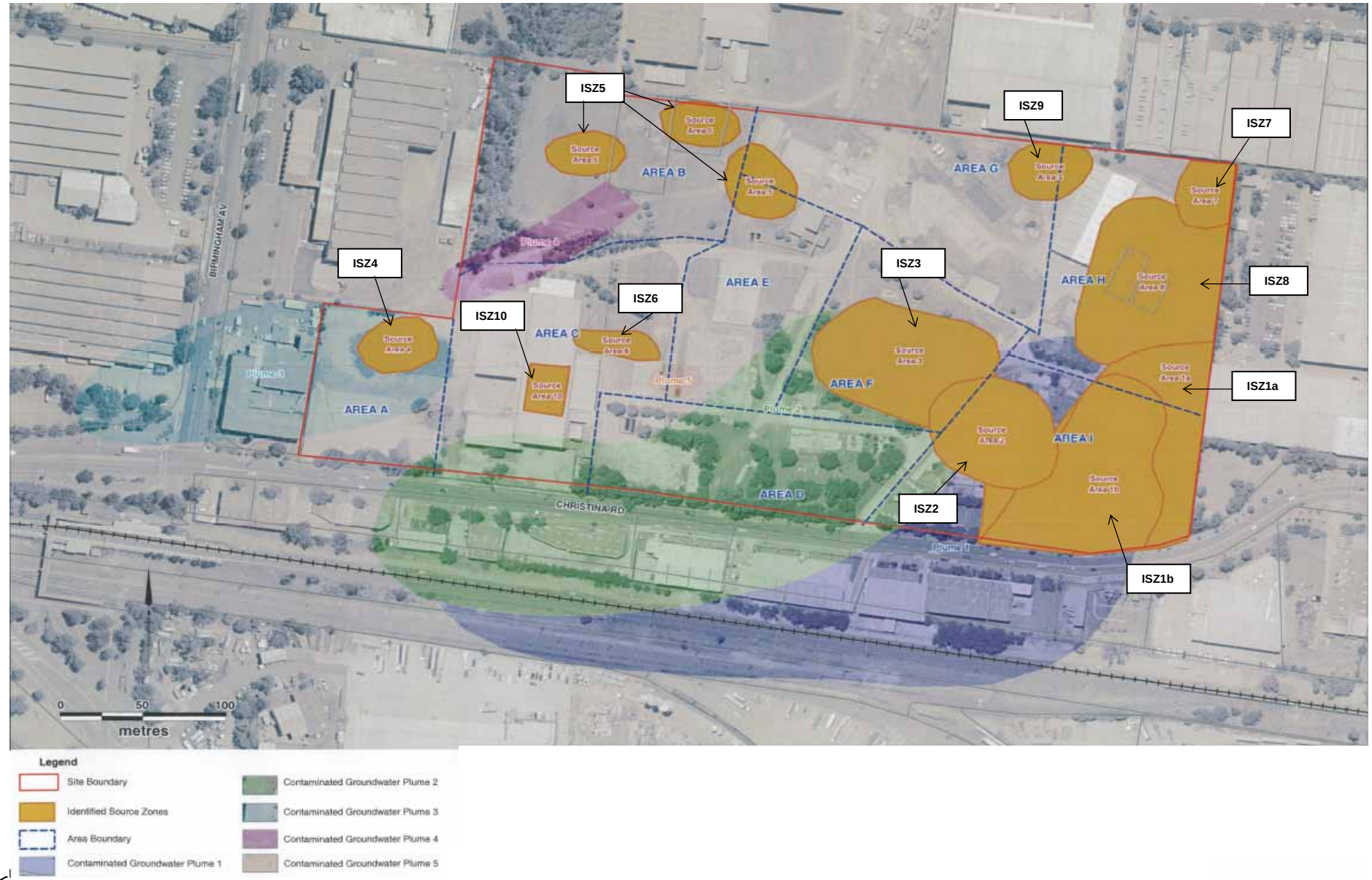
Author: NAA

Figure 3

Site Setting



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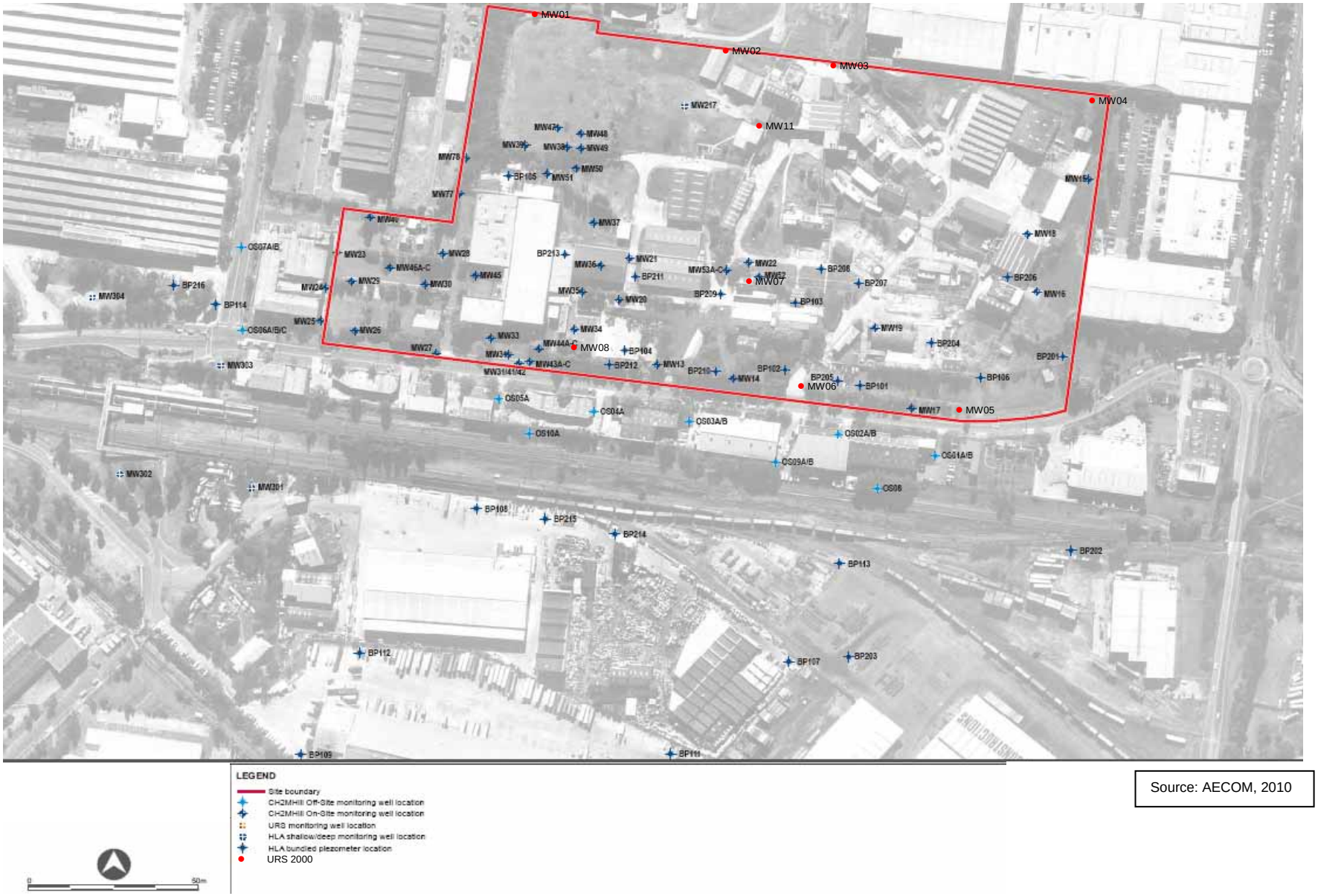
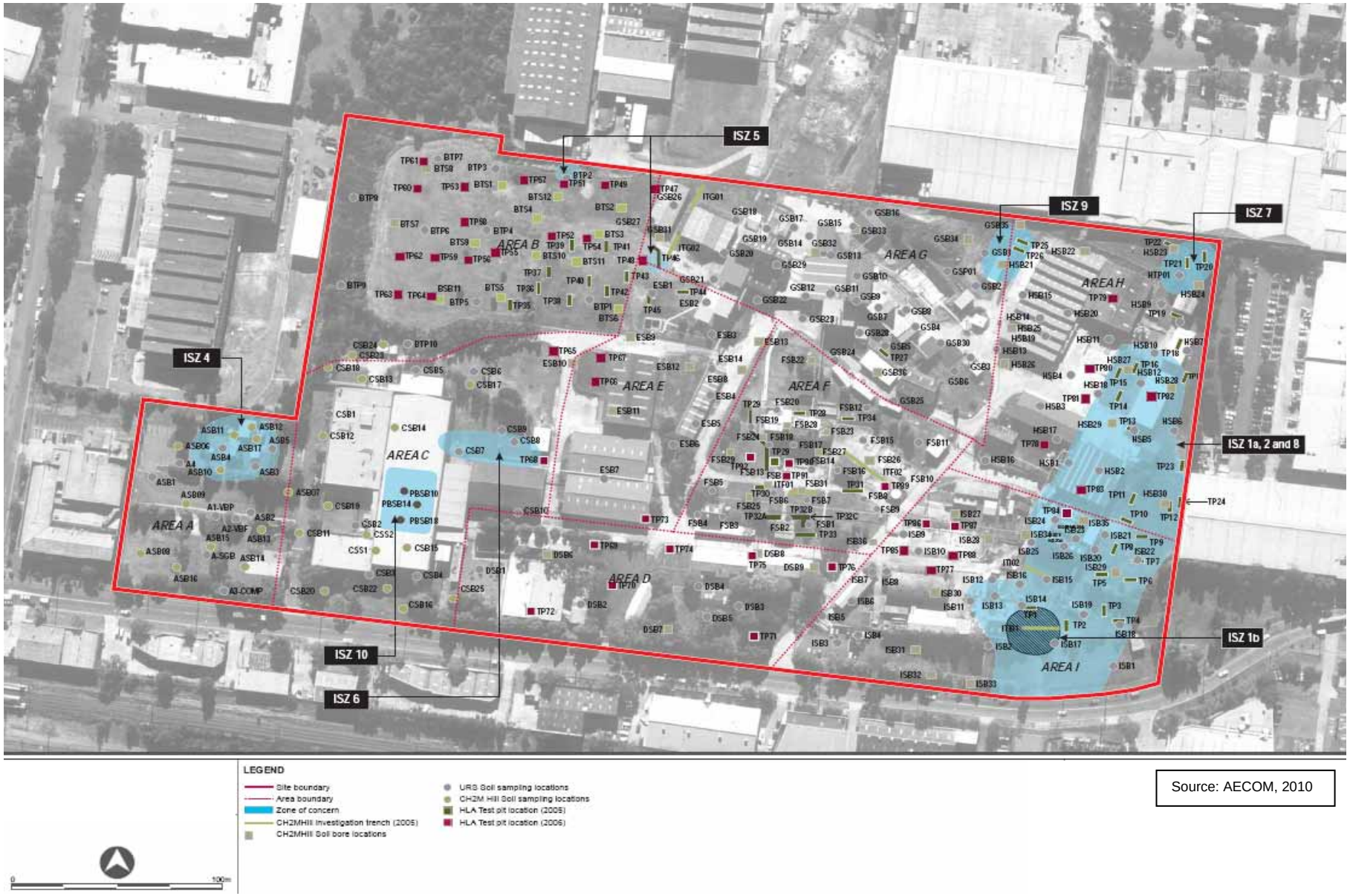
Report Ref: J1196.14R
Rev: 0
Rev Date: 30-Mar-10
Author: NAA

Figure 4
Locations of Dissolved Phase Plumes
and Identified Source Zones (ISZ)



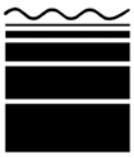
Source: AECOM, 2010



Source: AECOM, 2010

Figure 7

Validation Areas within the Pharmaceuticals Site



APPENDIX A
Contaminant Groups

Individual Species Making up Contaminant Groups

TOTAL PETROLEUM HYDROCARBONS

C_6-C_9 fraction
C_{10}-C_{14} fraction
C_{15}-C_{28} fraction
C_{29}-C_{36} fraction

MONOCYCLIC AROMATIC HYDROCARBONS

Benzene
Toluene
Chlorobenzene
Ethylbenzene
meta- & para-xylene
ortho-xylene
Styrene
Isopropylbenzene
n-propylbenzene
1,3,5-trimethylbenzene
tert-butylbenzene
1,2,4-trimethylbenzene
sec-butylbenzene

POLYCYCLIC AROMATIC HYDROCARBONS

Naphthalene
Acenaphthylene
Acenaphthene
Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benzo(a)anthracene
Chrysene
Benzo(b) & (k) fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-c,d)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

HALOGENATED ALIPHATIC HYDROCARBONS

ALKANES

Chloromethane
Dichloromethane
Carbon tetrachloride (tetrachloromethane)
Dichlorodifluoromethane
Trichlorofluoromethane
Bromomethane
Dibromomethane
Bromochloromethane
Chloroethane
1,1-dichloroethane (1,1-DCA)
1,2-dichloroethane (EDC)
1,1,1-trichloroethane (1,1,1-TCA)
1,1,2-trichloroethane (1,1,2 TCA)
1,1,1,2-tetrachloroethane
1,1,2,2-tetrachloroethane
Hexachloroethane
1,2-dibromoethane
1,2-dichloropropane
2,2-dichloropropane
1,3-dichloropropane
1,2,3-trichloropropane
1,2-dibromo-3-chloropropane

TRIHALOMETHANES

Trichloromethane (Chloroform)
Bromodichloromethane
Dibromochloromethane
Tribromomethane (Bromoform)

ALKENES

Vinyl chloride (chloroethene)
1,1-dichloroethene (1,1-DCE)
Cis-1,2-dichloroethene (Cis 1,2-DCE)
Trans-1,2-dichloroethene (trans 1,2-DCE)
Trichloroethene (TCE)
Tetrachloroethene (PCE)
1,1-dichloropropene
Cis-1,3-dichloropropene
Trans-1,3-dichloropropene
Hexachloropropene (Hexachloropropylene)
Hexachlorocyclopentadiene
Hexachlorobutadiene

HALOGENATED AROMATIC HYDROCARBONS

Chlorobenzene
Bromobenzene
2-chlorotoluene
4-chlorotoluene
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
1,2,4-trichlorobenzene
1,2,3-trichlorobenzene
Pentachlorobenzene
Hexachlorobenzene

HEAVY METALS

Arsenic (As)
Cadmium (Cd)
Chromium (Cr)
Copper (Cu)
Lead (Pb)
Mercury (Hg)
Nickel (Ni)
Zinc (Zn)

SEMI VOLATILE ORGANIC COMPOUNDS

PHENOLS

Phenol
2-chlorophenol
2-methylphenol
3- & 4-methylphenol
2-nitrophenol
2,4-dimethylphenol
2,4-dichlorophenol
2,6-dichlorophenol
4-chloro-3-methylphenol
2,4,5-trichlorophenol
2,4,6-trichlorophenol
Pentachlorophenol

PHTHALATE ESTERS
Dimethyl phthalate
Diethyl phthalate
Di-n-butyl phthalate
Butyl benzyl phthalate
Bis(2-ethylhexyl)phthalate
Di-n-octyl phthalate

NITROSAMINES
N-nitrosomethylethylamine
N-nitrosodiethylamine
N-nitrosopyrrolidine
N-nitrosomorpholine
N-nitrosodi-n-propylamine
N-nitrosodibutylamine
N-nitrosodiphenylamine & Diphenylamine
Diallate
Methapyrilene

NITROAROMATICS AND CYCLIC KETONES
2-picoline
Acetophenone
Nitrobenzene
Isophorone
2,6-dinitrotoluene
2,4-dinitrotoluene
1-naphthylamine
4-nitroquinoline-N-oxide
5-nitro-o-toluidine
Azobenzene
1.3.5-Trinitrobenzene
Phenacetin
4-aminobiphenyl
Pentachloronitrobenzene
Pronamide
Dimethylaminoazobenzene
Chlorobenzilate

HALOETHERS
Bis(2-chloroethyl)ether
Bis(2-chloroethoxy) methane
4-chlorophenyl phenyl ether
4-bromophenyl phenyl ether

CHLORINATED HYDROCARBONS
Polychlorinated benzenes
Hexachlorinated alkanes and alkenes

ANILINES AND BENZIDINES
Aniline
4-chloroaniline
2-nitroaniline
3-nitroaniline
Dibenzofuran
4-nitroaniline
Carbazole
3.3’-dichlorobenzidine

ORGANOCHLORINE PESTICIDES

Hexachlorobenzene (HCB)
α-Benzene hexachloride (α-BHC)
β-Benzene hexachloride (β-BHC)
δ-Benzene hexachloride (δ-BHC)
γ-BHC (Lindane)
Heptachlor
Heptachlor epoxide
Aldrin
Dieldrin
Endrin
Alpha-chlordane
Trans-chlordane
Cis-chlordane
Gamma-chlordane
Oxychlordane
Trans nonachlor
DDD
DDE
DDT
α-Endosulfan/Endosulfan-1
β-Endosulfan/Endosulfan-2
Endosulfan sulfate
Methoxychlor
Endrin aldehyde
Endrin ketone

ORGANOPHOSPHORUS PESTICIDES

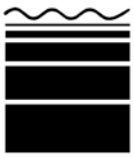
Dichlorvos
Mevinphos
Ethoprop
Phorate
Demeton-S-methyl
Diazinon
Disulfoton
Ronnel
Chlorpyrifos-methyl
Chlorpyrifos
Merphos
Parathion-methyl
Fenthion
Malathion
Fenitrothion
Prothiofos
Stirophos
Ethion
Bolstar
Fensulfothion
Azinphos-methyl
Coumaphos

POLYCHLORINATED BIPHENYLS

Arochlor 1016
Arochlor 1221
Arochlor 1232
Arochlor 1242
Arochlor 1248
Arochlor 1254
Arochlor 1260
Arochlor 1262
Arochlor 1268

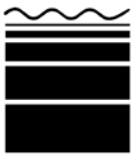
ASBESTOS

Amosite
Crocidolite
Crysotile



APPENDIX B

Copies of Associated Reports that the Auditor has Specifically Relied Upon (on CD)



APPENDIX C

Copies of Relevant Communications and Letter Reports

13475

C.M. Jewell & Associates Pty Ltd

A.C.N. 056 283 295 A.B.N. 54 056 283 295

Water and Environmental Management

1/13 Kalinda Road, Bullaburra, NSW 2784, Australia
P.O. Box 10, Wentworth Falls, NSW 2782
Phone: (02) 4759 3251 Fax: (02) 4759 3257
Email: postie@cm-jewell.com.au

Ref: J1196.5L
22 December 2006

Orica Australia Pty Ltd
16-20 Beauchamp Road
MATRAVILLE NSW 2036

Attention: Mr James Stening

Dear James

Statutory Site Audit - 2 Christina Road, Villawood
Remedial Technology Assessment

I have previously reviewed drafts of two reports prepared by HLA-Envirosciences Pty Ltd, presenting the results of remedial technology assessments for soil and groundwater at the Orica Villawood site.

I provided comment on those drafts to Orica and HLA Envirosciences.

I have now viewed the final reports

- Remedial Technology Assessment (Groundwater), 2 Christina Road, Villawood NSW, dated 22 December 2006; and
- Remedial Technology Assessment (Soil), 2 Christina Road, Villawood NSW, dated 22 December 2006.

I consider that the issues that I raised have been adequately addressed in the final reports.

I consider that the work described in the reports was adequate in scope and execution, and that the reports are of an appropriate standard, as required by the guidelines relevant to a site audit carried out under the Contaminated Land Management Act.

I consider that the reports adequately address Conditions 4E, 4F, 4G, 4H and 4I of Remediation Order 23019 or provide an adequately justified explanation as to why some aspects of these conditions cannot be met at the present time.

For and on behalf of
C. M. JEWELL & ASSOCIATES PTY LTD

CHRIS JEWELL

Orica Australia Pty Ltd
ACN 004 117 828
1 Nicholson Street Melbourne
PO Box 4311 Melbourne Victoria 3001 Australia
Tel + 61 3 9665 7111
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22 December 2006

DOCUMENT CONTROL		
Control No:	18752 + 18753	
Date received:	11/1/07	
Job No:	1196	
Routing:	CMJ	SF
	FILE	

Dr Erwin Benker
Contaminated Sites
Department of Environment and Conservation
59-61 Goulburn Street
SYDNEY NSW 2000

Reference No.: **EN1660-LT-44-006**
Subject: **Orica Villawood Site – Remedial Technology Assessments**

Dear Erwin

Orica Australia Pty Limited (Orica) is pleased to provide you with the Remedial Technology Assessments (RTAs) for soil and groundwater for the Orica site at 2 Christina Road, Villawood. The reports have been prepared to meet the requirements of Conditions 4E to 4I of the Remediation Order No 23019, Area 3200, issued to Orica on 2 November 2005.

It should be noted that separate RTA reports for soil and groundwater have been prepared for the Villawood site, as required by Conditions 4E and 4F. Groundwater impacts at the site have been identified at depth within the bedrock and therefore require separate consideration due to the inherently complex nature of any proposed remediation strategy.

Also enclosed is a copy of the Site Auditor's report of his review of the RTA, as required under Condition 4J.

We trust the enclosed reports provide a robust assessment of the suitability of available technologies in remediating contamination issues at the site. Once you have reviewed the reports, we would welcome the opportunity to meet to discuss the findings in more detail.

If you require any additional information please do not hesitate to contact the undersigned.

Yours sincerely

per **Bill Crowe**
Manager, Legacy Sites

Copies: Chris Jewell (CM Jewell & Associates Pty Ltd)
James Stening (Orica Australia Pty Ltd)

13938

C.M. Jewell & Associates Pty Ltd

A.C.N. 056 283 295 A.B.N. 54 056 283 295

Water and Environmental Management

1/13 Kalinda Road, Bullaburra, NSW 2784, Australia
P.O. Box 10, Wentworth Falls, NSW 2782
Phone: (02) 4759 3251 Fax: (02) 4759 3257
Email: postie@cm-jewell.com.au

Ref: J1196.6L
19 February 2007

NSW Department of Environment and Conservation
PO Box A290
SYDNEY SOUTH NSW 1232

Attention: Mr Erwin Benker

Dear Erwin

Statutory Site Audit - 2 Christina Road, Villawood - Remedial Technology Assessment

I am writing in relation to the Remedial Technology Assessments carried out by HLA-Envirosciences in respect of the Orica Villawood site. I understand that these reports were forwarded to you in December 2006, accompanied by a letter from myself to Orica, which stated:

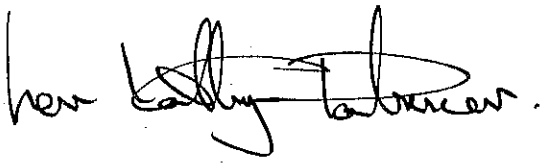
> I have previously reviewed drafts of two reports prepared by HLA-Envirosciences Pty Ltd, presenting the results of remedial technology assessments for soil and groundwater at the Orica Villawood site.
>
> I provided comment on those drafts to Orica and HLA Envirosciences.
>
> I have now viewed the final reports
>
> - Remedial Technology Assessment (Groundwater), 2 Christina Road, Villawood NSW, dated 22 December 2006; and
> - Remedial Technology Assessment (Soil), 2 Christina Road, Villawood NSW, dated 22 December 2006.
>
> I consider that the issues that I raised have been adequately addressed in the final reports.
>
> I consider that the work described in the reports was adequate in scope and execution, and that the reports are of an appropriate standard, as required by the guidelines relevant to a site audit carried out under the Contaminated Land Management Act.
>
> I consider that the reports adequately address Conditions 4E, 4F, 4G, 4H and 4I of Remediation Order 23019 or provide an adequately justified explanation as to why some aspects of these conditions cannot be met at the present time.

To close the loop on this, could you please confirm that this letter satisfies DEC requirements, and that DEC does not expect a full site audit report on the Remedial Technology Assessment from me at this stage.

As you are aware, a site audit report and site audit statement were prepared in relation to the Phase 1 and Phase 2 remedial investigations. It is likely that this report will be revised and reissued once the additional work requested by DEC and myself has been carried out.

I intend to prepare a site audit report and site audit statement on the remedial action plan, once that has been developed.

For and on behalf of
C. M. JEWELL & ASSOCIATES PTY LTD



CHRIS JEWELL

DOCUMENT CONTROL		
Control No:	19243	
Date received:	26-3-07	
Job No:	1196	
Routing:	CMJ	
	FILE	

Our reference : DOC07/10401
Carolyn Alford – 02 9995 5732

Mr C Jewell
C.M Jewell & Associates Pty Ltd
PO Box 10
WENTWORTH FALLS NSW 2782

Dear Mr Jewell

Re: Review of Remedial Technology Assessments under Remediation Order No.23019

I refer to your letter of 19 February 2007 (ref: J1196.6L) regarding your review of the Remedial Technology Assessments carried out by HLA Environmental for the Orica Villawood site at 2 Christina Road, Villawood. This review is required under condition 4(J) of the remediation order No. 23019, that has been served on the site under s.23 of the *Contaminated Land Management Act* 1997 (CLM Act).

Your letter outlines that you have reviewed the soil and groundwater Remedial Technology Assessments and your review comments have been addressed and incorporated into the final reports. We understand that you consider the work as adequate in scope and execution to address the conditions of the remediation order outlined in conditions 4E, 4F, 4G, 4H and 4I.

DEC accepts the advice outlined in your letter and confirms that this satisfies the requirements of condition 4J of the remediation order. We do not require a full site audit report on the Remedial Technology Assessments, but confirm that a site audit report and site audit statement will be required for your review of the Remedial Action Plans, as per conditions 4K and 4L of the remediation order.

Should you require any further clarification regarding the above matter please contact Carolyn Alford on (02) 9995 5732.

Yours sincerely

21/3/2007

NIALL JOHNSTON
A/Manager Contaminated Sites

PO Box A290, Sydney South NSW 1232
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A.C.N. 056 283 295 A.B.N. 54 056 283 295

Water and Environmental Management

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Ref: J1196.9L
24 July 2007

Orica Australia Pty Ltd
1 Nicholson Street
MELBOURNE Vic 3000

Attention: Mr Ben Dewhurst

RE: Draft Remedial Action Plan, 2 Christina Road, Villawood

Dear Ben

As agreed with Dr Erwin Benker of the NSW Department of Environment and Climate Change (DECC) and discussed with Orica last week, this letter provides my initial review of the draft Remedial Action Plan (RAP) for the Orica site at 2 Christina Road, Villawood, prepared by HLA-Enviros ciences Pty Ltd and dated 13 July 2007, together with my initial review of three supporting documents:

- Phase 3 Data Gap Investigation, 2 Christina Road, Villawood, NSW, Ref: S4075424_RPTFinal_31 May 2007 (DGI), prepared by HLA-Enviros ciences Pty Limited (HLA) and dated 31 May 2007.
- Groundwater Flow and Contamination Transport Modelling, Orica Site, 2 Christina Road, Villawood, NSW (Modelling Report), prepared by A. D. Laase Hydrologic Consulting and dated June 2007.
- Human Health and Environmental Risk Assessment, Orica Villawood Site, Ref: 43217484 (Risk Assessment), prepared by URS Australia Pty Ltd (URS) and dated 22 June 2007.

1.0 OVERVIEW

In preparing this review I have considered the guidelines made or endorsed by the EPA, including, particularly:

- *Guidelines for the NSW Site Auditor Scheme*, 2nd edition (2006) and
- *Guidelines for the Assessment and Management of Groundwater Contamination* (2007).

The draft RAP sets out a clear and comprehensive program for remediation of soil contamination on the Villawood site. The data gaps report and the revised groundwater flow and contaminant transport modelling report have addressed the issues raised in my previous review. The risk assessment report has also addressed the issues raised previously, although seasonal soil vapour data are still being acquired, and some other issues related to vapour risk assessment are apparent.

The risk-based soil levels derived by the risk assessment are considered to be robust.

Although the groundwater modelling report and risk assessment have demonstrated that active remediation of groundwater contamination is not currently required, in my opinion the draft RAP does not address broader groundwater contamination issues in a manner that complies with the requirements of the remediation order and the NSW Guidelines for the Assessment and Management of Groundwater Contamination.

2.0 ISSUES PREVIOUSLY RAISED BY THE AUDITOR

I have previously made the following comments on earlier reports prepared by HLA. The comments were made in the report: Site Audit, 2 Christina Road, Villawood – Section 4D Audit (J1196.2R-rev0) August 2006, and in a subsequent letter reviewing the remedial technology assessments.

Soil Issues

Adsorbed-phase source zones (impacted soil zones – ISZ) have generally been adequately delineated, laterally and vertically, with sampling of sufficient density. The exceptions to the general statement are ISZ 1 (a and b), and ISZ 6 and 10, where additional investigation is required.

I therefore considered that there were sufficient data to support the recommendations for remediation of eight of the eleven identified impacted soil zones, and that the data are sufficient and suitable for the preparation of remedial action plans.

Additional sampling was required, to support the preparation of remedial action plans for the other three zones. I supported HLA's recommendations regarding removal of sources of groundwater contamination.

Groundwater Issues

The approach adopted by HLA for modelling the fate and transport of contaminants in groundwater is generally appropriate, and the modelling itself has been carried out well. However, the following issues of concern were noted:

- The unacceptability of a flow model calibration that is known to have unquantifiable errors relating to gross errors in survey data.
- Lack of data (that could have been obtained relatively easily) on:
    - matrix porosity of the various lithologies making up the Ashfield and Bringelly Shales;
    - measurements of organic carbon content and/or use of available, and pre-existing, regional data;
    - measurements of concentrations of contaminants in matrix pores, and measurements of diffusion rates in a particular matrix; and
    - groundwater flux to surface watercourses.

I considered that HLA's reasoning with regard to plume stability and retardation was credible, and that there is a strong consensus that active remediation of a dual porosity system would take an extremely long time. However, due to lack of some site-specific data and modelling problems, the case regarding plume stability had not been made with adequate robustness.

I recommended:

- that all groundwater measurement points relevant to the flow and transport modelling be resurveyed;

- that the flow model calibration be re-run with re-surveyed groundwater level data;
- that additional field data relevant to the contaminant transport modelling be collected, specifically:
    - matrix porosity of the various lithologies making up the Ashfield and Bringelly Shales,
    - measurements of organic carbon content and/or use of available, and pre-existing, regional data,
    - measurements of concentrations of contaminants in matrix pores, and measurements of diffusion rates in a particular matrix, and
    - groundwater flux to surface watercourses; and
- that the contaminant transport modelling be reviewed and, if necessary, re-run.

Vapour Issues

I considered that the approach adopted by URS for assessment of actual and potential on- and off-site impacts on human health and the environment was generally appropriate. However, two specific issues were noted:

- the use of flux emissions data in preference to soil gas data in the quantification of potential inhalation exposures, rather than the use of both data sets in parallel; and
- the need for clarification of acceptable (target) risk levels for non-threshold effects.

Remedial Technology Selection

I reviewed the following reports:

- Remedial Technology Assessment (Groundwater), 2 Christina Road, Villawood NSW, dated 22 December 2006; and
- Remedial Technology Assessment (Soil), 2 Christina Road, Villawood NSW, dated 22 December 2006.

I considered that the reports either adequately addressed Conditions 4E, 4F, 4G, 4H and 4I of Remediation Order 23019 or adequately explained why some aspects of these conditions could not be met at that time.

The data gaps investigation was subsequently undertaken to address identified data gaps and issues raised by me and the DEC, and to provide a suitable data set to facilitate preparation of the Remedial Action Plan.

3.0 REVIEW OF REPORTS SUBMITTED IN SUPPORT OF THE RAP

3.1 Phase 3 Data Gaps Investigation Report

The data gaps investigation (DGI) included both soil and groundwater components.

Soil Investigations

The objectives of the soil investigation component of the DGI were:

- to address the Site Auditor's request for additional investigation for ISZ 1a and also to evaluate bulk DDX concentrations for remedial operational purposes;

- to gather sufficient data to allow delineation of the extent of remediation required within ISZ 1b (MCB impacts) as part of the RAP preparation process and to address the Site Auditor's additional investigation requirements for this area; and
- to gather sufficient data to allow delineation of the extent of remediation required within ISZ 2, 7, and 8 and upgradient of Plume 4.

The scope of work for the soil component of the DGI included the following:

- excavation of 23 trenches across Areas B, H and I to facilitate the collection of soil samples; and
- laboratory analysis of selected soil samples for organochlorine pesticides (OCPs) and volatile halogenated compounds (VHCs).

Based on the findings of this Phase 3 Soil DGI, conclusions were drawn by HLA with regard to each of the main areas of impact, as outlined below.

Assessment of Plume 4 Source Area (Area B)

The DGI has not identified a significant source area in soils which is likely to have produced the groundwater impacts previously identified within Plume 4. Consequently, the impacted groundwater at Plume 4 is considered to be the result of a localised source likely to be present in the vicinity of MW48. HLA stated that it was likely that the RAP to be prepared for the Site will include further trenching works in this area to locate potential source materials.

Impacted Soil Zone 1a

- The horizontal and vertical nature of DDX (sum of DDE, DDD and DDT) impacts in this area has been further delineated to assist with the preparation of the RAP. The vertical migration of DDX into the underlying natural clays and weather shales previously reported in the TP2 area (HLA, 2005) has also been further characterised with the sampling and analysis undertaken at TP106. Based on the interpretation of historic site aerial photographs, the significant mobilisation of DDX from the surface into the underlying natural clays and weathered shales is considered to be the result of historic surface (mono)chlorobenzene (MCB) spills associated with the former MCB tank and tankfarm area which was located in the upgradient area.
- The testing of homogenised, bulk soil samples collected from surface fill materials, where relatively high DDX impacts have been reported in the past, indicates that DDX concentrations are in the range of 20-50,000 mg/kg. This analytical data is indicative of contaminant levels which will require treatment during the remediation works.

Impacted Soil Zone 1b

- The horizontal and vertical nature of MCB impacts in this area has been further delineated to assist with the preparation of the RAP. The results of the Phase 3 DGI and previous investigations indicate that MCB concentrations exceed the risk-based soil concentrations (RBSC) at 5 sampling locations within ISZ.
- Based on the vertical distribution of MCB within the ISZ, it would appear that the contamination has migrated to greater depths with increasing distance away from (south) of the former MCB tank area. Consequently, higher MCB concentrations are likely to be present in the upper portion of the underlying weathered shale.

Impacted Soil Zone 2

The soil analytical results obtained from TP111 appear to indicate that the eastern extent of this ISZ has been suitably delineated. No further delineation of ISZ 2 is required.

Impacted Soil Zone 7

The soil analytical results obtained from TP112 appear to indicate that the western extent of this ISZ has been suitably delineated. No further delineation of ISZ 7 is required.

Impacted Soil Zone 8

The soil analytical results obtained from TP113 appear to indicate that the southern extent of this ISZ has been suitably delineated. No further delineation of ISZ 8 is required.

I consider that the scope of work was adequate to address the issues that I had raised, and that the additional investigations were appropriately carried out. I am satisfied that my concerns in relation to soil contamination have been appropriately addressed.

Groundwater Investigations

The objectives of the groundwater investigation component of the DGI were:

- to further delineate selected plumes at the site as requested by the NSW Department of Environment and Climate Change (DECC, formerly the Environment Protection Authority, EPA, and the NSW Department of Environment and Conservation, DEC) and the Site Auditor;
- to confirm various on-site and off-site groundwater contaminant concentrations exceeding Australian and New Zealand Environment Conservation Council (ANZECC, 2000) water quality guidelines; and
- to address the issues raised by the Auditor in relation to the lack of data to support some groundwater modelling assumptions.

The scope of work for the groundwater component of the DGI included the following:

- installation and sampling of four off-site groundwater monitoring wells to address identified data gaps;
- collection of water samples from all off-site bundle piezometers (selected ports)/monitoring wells, and selected on-site bundle piezometers/monitoring wells to verify the 2006 results;
- laboratory analysis of groundwater samples for OCPs (either ultra trace or standard detections analysis) and VHCs (standard detections analysis);
- re-surveying of all on-site monitoring wells and completion of a full groundwater level monitoring round;
- matrix porosity testing on existing rock cores currently stored at the site;
- a conductivity and pH survey of Byrnes Creek from Miller Road to Leightonfield station to identify potential zones of groundwater seepage; and
- consolidation of the historic and HLA Phase 1 and 2 RI soil and groundwater analytical data sets to define identified soil and groundwater source areas and associated groundwater plumes (if present).

Based on the findings of the groundwater DGI, HLA concluded:

- that groundwater results from the DGI generally support previous investigation results obtained across the site;
- that the downgradient extent of Plumes 1 and 2 have been delineated along Christina Road and south of the railway easement, and no further delineation of Plumes 1 and 2 is required; and
- that the DDX concentration in groundwater reported at the newly installed MW304 (Plume 3) is of a similar order of magnitude to the adopted guideline level.

I note as follows.

- Some significant variations in concentration between consecutive sampling rounds were observed:

- in the EDC Plumes (Plume 2 and Plume 5) – both increases (51 to 196%) and decreases (69 to 190%) in individual wells;
- in MCB Plume 1 – decreases of 53 to 167%; and
- in DDX Plumes 1 and 5 – both increases (54 to 200%) and decreases (57 to 200%) in individual wells.

It is important to recognise this variability when comparing calculated risk levels with risk targets.

- Valid porosity and permeability data were obtained for the single sandstone core submitted for laboratory testing, but the two shale cores submitted for porosity and permeability analysis disintegrated during testing.
- Shallow groundwater inflow to Byrnes Creek was confirmed, and inflow locations mapped. HLA did not comment on the significance of these measurements.
- Organic carbon measurements are not reported in the DGI.
- Following discussions with HLA and a detailed submission from HLA's advisor on matrix diffusion issues, Dr Reynolds, I agreed that the practical difficulties and extended time frame involved in obtaining matrix diffusion data by laboratory measurement were unlikely to be justified by the utility of the information derived.

I consider that the issues that I had raised in relation to groundwater have been substantially but not completely addressed.

3.2 Groundwater Modelling Report

The revised groundwater modelling report has been reviewed. Differences from the August 2006 report are subtle but it is noted that the cross-sectional contaminant transport modelling has been omitted.

The flow calibration was re-run with the revised survey data, correcting previous errors. Calibrated hydraulic conductivity distributions are similar, but with a small overall reduction in absolute values for equivalent recharge scenarios.

The 5% recharge scenario is now considered to provide the best fit. Previously the 2% scenario was favoured.

The calibration residuals are slightly tighter, but more than anything else, recalibration has removed a substantial source of unquantifiable uncertainty associated with the erroneous survey data.

In relation to transport parameters, additional data constitute a single organic carbon measurement and a single matrix porosity determination. These data do, however, support assumptions previously made.

I note that in the revised calibration the mass transfer rate has been reduced by two orders of magnitude, and the reaction rate has been increased from 150 to 200 per day.

The core prediction of the transport modelling, that none of the plumes will reach Byrnes Creek within 100 years, remains unchanged from the initial modelling.

An additional program of sensitivity analysis has been carried out. The sensitivity analysis indicates that this prediction is relatively insensitive to changes in transport parameter, and adds substantially to the robustness of the prediction.

In key assumptions related to the significance of matrix diffusion relative to other attenuation mechanisms, reliance is still placed almost entirely on the professional judgement of the modeller and HLA's expert, Dr Reynolds, but that is the way it has to be, and the approach is not inconsistent with international practice.

In summary, although it has not been possible to follow through on all the matters raised in my initial review of the model, it has been possible to remove some sources of potential error, and to increase the overall confidence level of the predications by sensitivity analysis.

At this stage the modelling is about as good as it is going to get, and we should proceed on the basis that the model's predictions are sound.

3.3 Risk Assessment Report

An initial review of the risk assessment undertaken by URS has been carried out.

The methodology for exposure assessment via the ingestion and dermal absorption pathways is quite standard and has been agreed to at earlier stages of this project. Toxicity values are those previously agreed upon by the NSW DECC and NSW Health.

The target risks used for risk characterisation (1×10^{-5} combined non-threshold risk and a hazard index of 1.0 summed across all contaminants of potential concern (COPC) and all exposure pathways for threshold risks) were also agreed upon in advance.

I have no questions concerning risks calculated for the ingestion and dermal absorption exposure pathways.

I do question the use of hazard indices calculated from time weighted average (TWA) exposure standards, as an alternative to the use of inhalation-route toxicity data, in the calculation of risks for the inhalation exposure pathway.

It is acknowledged that both approaches have been used in parallel.

It is my understanding that TWA standards can only be appropriately used to evaluate risks if all the following circumstances apply.

- The contaminant of concern (COC) that is the source of the vapour risk is present on the site as a result of activities that are similar to the ongoing commercial/industrial use of the site. For example, there may be a vapour risk due to the presence of benzene contamination of groundwater beneath the workshop of a service station, but products containing benzene are routinely used on the site.
- The owners/managers of the site are aware of the risk and undertake to manage it as part of their own occupational health and safety program.
- Workers on the site are educated as to the nature of the risk and any necessary control measures.

This reflects the difference between voluntarily assumed and involuntary risks and the fact that TWAs are occupational standards that assume awareness and competence in the management of occupational risks, as required by health and safety legislation.

We are considering the management of risks in the long term, in relation to property that is to be sold to unknown future owners, and used for unknown commercial and industrial purposes.

Toxicity values can change with time, as more research data become available. It is a legal requirement for employers to keep up to date with changes in toxicity data for chemicals used in their workplace, and to maintain effective measures to manage exposure within acceptable levels. However, it is unreasonable to apply the same standards – enforced by very severe penalties – in relation to chemicals associated with a prior use of the site, with which the current owner has no experience.

Therefore it is appropriate to apply 'community' rather than 'workplace' standards in these circumstances.

I note the use of the United States Environmental Protection Agency (US EPA) Farmer model for the calculation of exposures via the vapour migration pathway, and also note that a description of the modelling process is provided in Appendix D.

In my experience, when sensitivity analysis is carried out by varying model input parameters within credible ranges, there may be quite significant variations in calculated exposures (certainly ±100%)

The URS risk assessment does not provide a sensitivity analysis for vapour risk modelling.

I note that for ISZ 1a, 1b, 2, 3 and 9, inhalation-pathway risks form a minor component of total risk, and for ISZ 6, 7 and 10 this pathway is not considered complete.

For ISZ 4 and ISZ 8 the inhalation pathway contributes a significant portion of the calculated non-threshold risk, but threshold risks dominate the overall risk profile.

In ISZ 5, vapour risks (due to 1,2,3-trichloropropane) dominate the non-threshold risks but threshold risks via the ingestion and dermal pathways exceed the target hazard index by a factor of 3.

Above the groundwater plumes, the inhalation pathway is the only relevant exposure route, and calculated non-threshold risks of 8×10^{-6} above Plume 2 on and off site are within 20% of the target risk of 1×10^{-5}.

I consider that it is not reasonable to conclude on the basis of the calculated exposure data that inhalation risks above the on-site and off-site portions of Plume 2 are 'low and essentially negligible', without undertaking further detailed sensitivity analysis.

I agree that calculations based on measured data do indicate a low risk, but note URS's qualification that more data acquired under a range of seasonal and atmospheric conditions are still required.

On the basis of this review, I consider that the RBSC calculated by URS are robust and incorporate an appropriate measure of conservatism.

The RBSC are thus appropriate for use as remediation goals.

4.0 CRITIQUE OF THE RAP

I note the absence of an executive summary – a requirement of 'Guidelines for Consultants Reporting on Contaminated Sites'. However, I am not an enthusiast for executive summaries – particularly for complex reports such as this, which already summarise other reports.

Summaries of summaries inevitably exclude detail and qualifying statements that are essential for a full appreciation of the issues, and can be misleading.

4.1 Section 1: Introduction

Condition M of the Remediation Order (RO) is reproduced in Section 1.1 on Page 2 of the RAP. Condition M (subconditions M(I) to M(X)) defines the scope of the RAP. In Section 1.4 (Scope) it is indicated that, on the basis of the findings of the groundwater modelling study and the human health and environmental risk assessment, 'remediation of the site's groundwater is not considered to be required'.

Consequently, the RAP does not address Conditions M(III) and M(V), or the groundwater component of Conditions M(IV), M(VI) and M(X).

As I understand it, HLA's view is that as the groundwater modelling study and risk assessment have shown that active remediation of groundwater contamination is not necessary to manage human health and environmental risks, no further consideration of groundwater contamination is required. HLA therefore believes that there is no need to directly address the parts of Condition M that relate to groundwater.

However, a broader view of NSW policy in relation to groundwater contamination, as set out in Section 3 of *Guidelines for the Assessment and Management of Groundwater Contamination* (2007) (the Groundwater Guidelines), indicates that mitigation of human health and environmental risk by active clean-up forms only part of the management strategy for groundwater contamination.

In my opinion, even if it is accepted that active clean-up of groundwater contamination at this site is not necessary to protect the relevant environmental values of groundwater, and to protect human and ecological health, it is necessary, in addressing Condition M of the RO, to demonstrate why it is considered impractical to clean up the contamination so that natural background water quality is restored, as indicated in Section 4 of the Groundwater Guidelines. In my opinion this is also likely to be an issue in the community consultation process.

Although the groundwater modelling report indicates that the plumes are now relatively static, and the risk assessment indicates that human health risks due to groundwater contamination (essentially via the vapour transport pathway) are currently acceptable, both of these opinions are necessarily qualified, as previously discussed in Section 3 of this review.

The groundwater modelling considered a broad picture, and whilst it is calibrated against the available data, and has adequate discretisation, it is an equivalent porous medium model and cannot (nor can it reasonably be expected to) model transport at the level of individual fracture systems.

The model used average values of recharge, and did not consider extreme recharge events.

Because of these and numerous other limitations, the predictions of the modelling (whilst providing a sound basis for future management of groundwater contamination) cannot be relied upon absolutely. They must be supported by ongoing monitoring of groundwater, and by contingency planning for the event that the plumes migrate faster than predicted.

This requirement is consistent with the policy set out in Section 3 of the Groundwater Guidelines, and in particular Section 3.6, which, it is noted, applies to natural containment as well as induced containment.

The groundwater modelling report does not indicate how long the groundwater contamination will persist, but on the basis of the discussion of aquifer and contaminant characteristics that is provided in the modelling and risk assessment reports, and the wider technical literature, it is expected that contamination will persist for a long time.

Therefore monitoring will need to be long-term.

Condition M(X) of the RO calls for details of ongoing site monitoring and reporting procedures, but these are omitted from the RAP.

The risk assessment indicates that vapour risks above the off-site portion of the plumes are currently acceptable. Some issues in relation to that conclusion were raised in Section 3 of this review.

However, even though it was agreed that these risks are currently acceptable, they could rise to unacceptable levels in the event of significant changes such as roadworks, basement construction or major drainage works.

Again, as indicated in Section 3 of the groundwater guidelines, effective management will require notification and advice to potentially impacted parties such as Bankstown Council, utility owners and adjacent landowners, and a mechanism for regularly updating this advice into the future. It would be appropriate to discuss this issue in the RAP.

The possibility of transient spikes in groundwater concentration following soil remediation should be considered. Such spikes are not uncommon, particularly if remediation coincides with a period of high rainfall recharge.

In considering a broader management strategy for groundwater contamination, the need for administrative controls on future groundwater use should be assessed. Given the likely longevity of the contamination, it would be appropriate to think outside the current groundwater use paradigm of:

low yield + poor quality = no use

As examples:

- Demands to improve energy efficiency and reduce CO_2 emissions are likely to result in increased use of groundwater heat pumps in air-conditioning systems.
- Restrictions on the use of mains water for filling and maintaining domestic swimming pools have recently caused a proliferation of low-yield, marginal-salinity domestic bores to be drilled in metropolitan Melbourne, where bore licence applications (predominantly for the low-yield Silurian siltstones) have increased from 12 per year to 250 per month (information from EPA Victoria).

4.2 Section 2: Assessment and Approval Process

Section 2 is considered appropriate for the draft RAP. However, following review of the draft by DECC it would be appropriate to add a subsection (2.2) detailing proposed DECC regulation of the remediation and validation process, and a further subsection (2.3) outlining regulation of long-term monitoring, reporting and notification requirements.

4.3 Section 3: Site Identification and History

Sections 3.1 and 3.2 provide an adequate summary of site identification details and history. Section 3.3 provides a summary of site investigations that achieves compliance with Section M(I) of the RO.

To be consistent with the title of Section 3, and to accommodate the extended scope outlined below, subsection 3.4 could sensibly be expanded to a full report section, becoming Section 4.

Subsection 3.4 currently provides an adequate summary of site topography and regional geology. The discussion of local geology could usefully be expanded to include more site-specific detail, to support an expanded Section 3.6.

Section 3.4 lacks an adequate summary of site and regional drainage issues. This is required in order to assist the reader's understanding of a number of remediation matters.

Section 3.5 provides an exceptionally clear and comprehensive summary of soil conditions and soil contamination issues.

Section 3.6 is really inadequate as a summary of groundwater conditions and should be substantially expanded.

This would also be an appropriate place to provide the detailed discussion of remediation policy issues and remedial options required by Sections M(III), M(IV), M(V) and M(VI) of the RO, as outlined in Section 4.1 of this review.

4.4 Section 4: Remediation Goals

As discussed in Section 3 of this review, the derivation of soil remediation goals (risk-based soil concentrations – RBSC) on an individual zone basis through a risk assessment process is considered appropriate.

The derivation of RBSC, and the target risks used in this derivation, are in accordance with normal practice: the margins applied to threshold and non-threshold risk targets to allow for additional exposure via the inhalation pathway appear to be adequate.

I am not entirely convinced that the potential for leaching to groundwater should not have been a factor in the determination of soil remediation goals.

I note that risk-based groundwater concentrations (RBGC) have not been calculated and understand that the chain of reasoning underlying this decision was as follows(although this is not explicitly stated in the RAP).

1. On the basis of the groundwater modelling, exposure pathways (other than the vapour pathway) for groundwater contaminants were assessed to be incomplete.
2. During the risk assessment process, both threshold and non-threshold risks via the vapour pathway were calculated to be below target levels.
3. On the basis of 1) and 2) above, no remediation of groundwater contamination was considered to be necessary.
4. Therefore there was no need to calculate RBGC.

I question the validity of this reasoning, and consider that it should at least be fully justified, and possibly amended. My reasoning is as follows.

1. If it is accepted that, as part of a broader groundwater contamination management strategy, long-term groundwater monitoring is required, then it is appropriate to establish decision criteria to be used in the assessment of monitoring data.
2. Unless RBGC are established for that purpose at this stage, it would be necessary to re-run the risk assessment modelling whenever (or if ever) groundwater monitoring indicated concentrations of COC greater than those used in the current risk assessment. That would be tedious.

3. As the vapour-pathway non-threshold risk associated with Plume 2 is currently 80% of the target risk (for Plume 1 20% of target risk), the margin is quite small.
4. It would be sensible to use RBGC to establish a hierarchy of response to an increasing concentration trend in monitoring data. Typically this might involve

   a) increasing monitoring frequency,

   b) administrative controls, and

   c) re-appraisal of the need for active controls.

In summary, Section 4 should be expanded to include a subsection dealing with RBGC.

4.5 Section 5: Extent of Remediation

The discussion in relation to potential impacts of soil contamination on the shallow groundwater systems is noted and substantially supported.

However, I also note that if the requirement for a broader groundwater management strategy extending beyond active remediation is accepted, then removal of soils that have the potential to impact the shallow groundwater system becomes a more important consideration.

I note that the further investigation of the Plume 4 source area that was foreshadowed in the data gaps investigation report does not appear to have been included in the RAP.

With this qualification, the remainder of Section 5 is considered to be an adequate and appropriate statement of remediation requirements.

4.6 Section 6: Remedial Options

I have previously reviewed the technology assessment, and accept HLA's reasoning and concur with the choice of soil remediation technology.

4.7 Section 7: Remediation Works Overview

This section provides an adequate overview for the purpose of the RAP.

4.8 Section 8: Public Consultation Strategy

The approach to public consultation that is outlined is considered reasonable and appropriate.

It is worth noting that this RAP will form the foundation for the public consultation process.

It might be better received if it contained a more detailed treatment of groundwater and air quality management issues, which I think may be the likely focus of any public concern.

4.9 Section 9: Preliminaries

Considered to be adequate and appropriate.

4.10 Section 10: Excavation Works

Considered to be adequate and appropriate.

4.11 Section 11: Material Handling

This provides a good overview of this complex aspect of the proposed soil remediation works.

4.12 Section 12: Treatment Operations

This section is considered to provide a good overview of the treatment process. All the abbreviations that are used (heavily) in this Section – for example FSB, ECS, STA – should be included in the glossary as well as being defined in the text.

4.13 Section 13: Management of Water

Considered to be adequate and appropriate.

4.14 Section 14: Removal and Disposal of Materials from the Site

This section could appropriately include reference to the need to classify waste materials that are to be removed from the site in accordance with the recommendations in *Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes*, and a statement as to how this will be achieved.

4.15 Section 15: Validation Plan

This section is considered to contain an adequately detailed description of this vital aspect of site remediation.

The quite intensive involvement of the Site Auditor set out in this section is noted. There will be a need for prior liaison with the Site Auditor to ensure that this can be managed effectively.

Validation sampling frequencies, as specified, are considered to be appropriate.

Section 15.6 is not clear; it could be read as meaning 3 discrete samples obtained from the conveyor + 1 composite collected from stockpile = 4 per 24 hours, or as meaning just one composite per 24 hours.

The cost of re-treating off-spec material may well justify one sample per 8 hours.

Analytical methods, sampling methodology and QA/QC are adequately specified.

The data quality objectives paragraph at the head of Section 15.2 needs to be substantially expanded, and should comply with Appendix IV of *Guidelines for the NSW Site Auditor Scheme* (DEC 2006).

Data quality indicators are appropriately described.

4.16 Section 16: Placement of Reinstatement Materials

It should be noted that achieving adequate compaction of thermally treated soils is often difficult.

It would be appropriate to provide within this section a full geotechnical specification for the placement and compaction of treated materials.

I appreciate that it is hard to define the exact end-use of different areas of the site at this stage, and therefore hard to specify compaction requirements. However, it is clearly undesirable for the remediated areas to be re-excavated and re-compacted prior to site development, and therefore a specification should be developed that is adequate for most foreseeable industrial uses, if not for unusually demanding uses.

4.17 Section 17: Environmental Management Plan

This section is generally considered to be adequate and appropriate.

It may be desirable to expand subsection 17.5, Air Quality Management, to provide greater community reassurance, and to specify community and regulatory reporting requirements, or at least to note that these will be specified within the DECC licence.

4.18 Section 18: Occupational Health and Safety

This section is considered to be a comprehensive specification for the occupational health and safety plan that will be developed at a later time.

4.19 Section 19: Contingency and Emergency Response

This section is generally appropriate.

Subsection 19.1.2 could reasonably consider how variations in the quantity of material requiring treatment will impact on the project schedule set out in Section 7.3.

4.20 Section 20: Conclusion

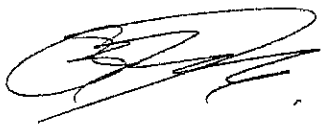
As indicated in Section 4.1 of this review, the RAP should have an additional section or sections dealing with long-term monitoring of groundwater (post completion of soil remediation), together with discussion of appropriate long-term administrative and regulatory provisions, and contingency measures.

5.0 CLOSURE

This letter has set out the results of my initial review of the draft RAP and supporting documents. Following DECC review and Auditor review of any proposed changes to the draft RAP, these comments will be incorporated into a Site Audit Report, and a Site Audit Statement will be issued. The formal comment required by DECC under Condition N of the Remediation Order will be provided at that stage.

This communication has been provided as interim advice only. Where applicable, the information provided is consistent with NSW EPA (DEC) guidelines and policies. The advice does not constitute a site audit report or site audit statement and does not pre-empt the conclusions which will be drawn at the end of the audit process. A site audit report and site audit statement will be issued when the audit process has been completed.

For and on behalf of
C. M. JEWELL & ASSOCIATES PTY LTD



CHRIS JEWELL

Site Auditor accredited under the
Contaminated Land Management Act 1997

C. M. Jewell & Associates Pty Ltd
Water and Environmental Management

CMJA

Phone 02 4759 3251 *International* 61 2 4759 3251
Fax 02 4759 3257 *International* 61 2 4759 3257

FAX

Ref:	J1196.10F	**Date:**	28 September 2007
To:	Orica Australia Pty Ltd	**c.c.**	HLA-Environmental
Attention:	Ben Dewhurst ✓	**Attention:**	Andrew Rolfe ✓
Fax no:	9352 2361	**Fax no:**	8484 8989
From:	Chris Jewell	**Total pages including this page:**	

Orica Villawood Site

Section 4 – RAP

FAXED 14755

Dear Andrew/Ben

My comments on Section 4 follow. The section as a whole provides the background information on hydrogeology that is required.

The use of 'upper' and 'lower' is ambiguous – I understand what is meant, but it reads as though the Upper Bringelly Shale and Lower Ashfield Shale stratigraphic units are being discussed, when we are dealing with the Lower Bringelly Shale and Upper Ashfield Shale.

Perhaps rewrite as 'Groundwater flow in the upper aquifer (Lower Bringelly Shale) is . . . . . .' and 'Groundwater flow in the lower aquifer (Upper Ashfield Shale) is . . . . . .'

Section 1.3, 3rd Paragraph

. . . the variability reflects the range of lithologies present within the bedded shale.

Section 1.4, 1st Paragraph

The bulk hydraulic conductivity

Section 16 – Table

When discussing impacts on Byrnes Creek (all plumes) it would be better to state 'Plume X is not considered to impact Byrnes Creek', as this is partly a judgement call.

'Plume 5 is restricted to the site and is not predicted to migrate off-site'.

Section 1.7

1. Should be RBGC not RBSC.
2. Active groundwater remediation is not considered to be required, although long-term management of the contaminated groundwater will be necessary.

P.O. Box 10, Wentworth Falls, NSW 2782, Australia
1/13 Kalinda Road, Bullaburra, NSW 2784, Australia
Email postie@cm-jewell.com.au
ABN 54 056 283 295

Our email has been down since Tuesday morning and Telstra are still trying to restore it.

If you have sent anything through by email this week, please resend to ccmj1@bigpond.net.au.

This communication has been provided as interim advice only. Where applicable, the information provided is consistent with NSW EPA guidelines and policies. The advice does not constitute a site audit report or site audit statement and does not pre-empt the conclusions which will be drawn at the end of the audit process. A site audit report and site audit statement will be issued when the audit process has been completed.

For and on behalf of
C. M. JEWELL & ASSOCIATES PTY LTD

CHRIS JEWELL
Site Auditor accredited under the
Contaminated Land Management Act 1997

14826

C.M. Jewell & Associates Pty Ltd

A.C.N. 056 283 295 A.B.N. 54 056 283 295

Water and Environmental Management

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Phone: (02) 4759 3251 Fax: (02) 4759 3257
Email: postie@cm-jewell.com.au

Ref: J1196.11L
16 October 2007

Orica Australia Ltd
16-20 Beauchamp Road
MATRAVILLE NSW 2036

Attention: Mr Ben Dewhurst

Dear Ben

Remedial Action Plan - Orica Site, Villawood

As the Site Auditor appointed in respect of the site at 2 Christina Road, Villawood, I confirm that I have reviewed the Remedial Action Plan, 2 Christina Road, Villawood NSW, ref. S4066001_Final_RAP_2Oct07, dated October 2007, prepared by HLA-Envirosciences Pty Limited (HLA ENSR).

I confirm that from my perspective this document is suitable for release to contractors as part of the EOI process for remedial works.

I note that DECC is carrying out a separate review of some aspects of the RAP.

This communication has been provided as interim advice only. Where applicable, the information provided is consistent with NSW EPA (DEC) guidelines and policies. The advice does not constitute a site audit report or site audit statement and does not pre-empt the conclusions which will be drawn at the end of the audit process. A site audit report and site audit statement will be issued when the audit process has been completed.

For and on behalf of
C. M. JEWELL & ASSOCIATES PTY LTD

CHRIS JEWELL

Site Auditor accredited under the
Contaminated Land Management Act 1997

DOCUMENT CONTROL		
Control No:	21534	
Date received:	31-7-08	
Job No:	1196	
Routing:	cmj	
	FILE	✓

Subject: **Review of RAP for Orica Villawood - 2 Christina Road**
Date sent: **Thu, 31 Jul 2008 10:42:49 +1000**
From: **"Manuel Ulli" <Ulli.Manuel@environment.nsw.gov.au>**
To: **<chris@cm-jewell.com.au>**

Chris

I'm the project office for the above site since Carolyn Alford has left Consites.

I understand that you did review (and provided comments to) the Draft RAP, dated 13 July 2007, together with supporting documents, including:

- Phase 3 Data Gap Investigation, HLA, dated 31 may 2007;
- Groundwater Flow and Contamination Transport Modelling, Laase, June 2007;
- Human Health and Environmental Risk Assessment, URS, 22 June 2007.

In reviewing the RAP for the above site, dated 3 October 2007, I've noticed that your comments, including the comments re the above supporting documents, have not been fully addressed. My question is, Chris, whether you had a look at the previous RAP and if yes, wether your comments have been taken on board by Orica/HLA.

Regards
Ulli Manuel

Department of Environment and Climate Change
Tel. 61-2- 9995 5611 Fax 61-2- 9995 5999
E-mail: ulli.manuel@environment.nsw.gov.au

From: **"Chris Jewell" <chris@cm-jewell.com.au>**
To: **"Manuel Ulli" <Ulli.Manuel@environment.nsw.gov.au>**
Date sent: **Thu, 07 Aug 2008 08:39:28 +1000**
Subject: **Re: Review of RAP for Orica Villawood - 2 Christina Road**
Send reply to: **chris@cm-jewell.com.au**
Priority: **normal**

Ulli,

Sorry for the delay in replying to your email, it has been a while since I looked at these reports.

As you know, I completed a detailed review of the draft RAP in July last year. When the "final" RAP (in reality a final draft) was provided in October, I did not carry out such a detailed review, but did review the document to check whether the issues raised in my previous review had been addressed. I was satisfied that, in large part, although not completely, they had been.

In October 2007 I provided a letter indicating that from my perspective, the document was suitable for release to contractors as part of the Expression of Interest process for remedial work. In so doing, I implied that I was satisfied with the overall approach and that I did not anticipate that there would be changes of such magnitude as to require contractors to reconsider their choice of remedial technology or their decision to participate. That is not the same as agreeing to every detail of the RAP or even agreeing that there would not need to be changes that would affect the cost - an Expression of Interest is not a priced tender.

At meetings in the early part of 2007 it was agreed that DECC and the Auditor would independently review the RAP in parallel, with DECC focussing on a detailed review of the risk assessment, which would therefore be reviewed only in general terms by the Auditor. DECC's review was to be considered by the Auditor prior to the issue of a Section B site audit statement. Clearly, and appropriately, DECC and the Auditor have somewhat different perspectives, and it is important that the finalised audit and RAP reflect both, and that ultimately we have a consistent approach.

Thus I have held off from finalising my review in anticipation of DECC's input.

I will be out of the office from later this morning until 18th August.

Chris.

Subject: **Review of RAP for Orica Villawood - 2 Christina Road**
Date sent: **Thu, 31 Jul 2008 10:42:49 +1000**
From: **"Manuel Ulli" <Ulli.Manuel@environment.nsw.gov.au>**
To: **<chris@cm-jewell.com.au>**

Chris

I'm the project office for the above site since Carolyn Alford has left Consites.

I understand that you did review (and provided comments to) the Draft RAP, dated 13 July 2007, together with supporting documents, including:

- Phase 3 Data Gap Investigation, HLA, dated 31 may 2007;

Our reference : DOC08/45352#FIL08/937
Contact : Ulli Manuel – 02 9995 5611

Mr Bill Crowe
Manager Legacy Sites
Orica Australia Pty Ltd
PO Box 4311
MELBOURNE, VICTORIA 3001

Dear Mr Crowe

REMEDIAL ACTION PLAN FOR FORMER ORICA SITE AT 2 CHRISTINA ROAD, VILLAWOOD, NSW

I refer to a recent discussion we had with Chris Jewell on 12 September 2008 at the Department of Environment and Climate Change's offices regarding our letter sent to you on 3 September 2008.

In our letter we advised that groundwater remedial works are required to remove or treat dense non-aqueous phase liquids (DNAPL) as these would otherwise provide an ongoing source for groundwater contamination.

At this stage the proposed remedial strategy outlined in the Remediation Action Plan, prepared by HLA-Envirosciences Pty Ltd, and dated 3 October 2007, is not proposing any measures to remediate DNAPL.

Based on the NSW DECC *Guidelines for the Assessment and Management of Groundwater Contamination* 2007, sources of groundwater contamination need to be eliminated or controlled (refer to Section 3.5 of the guidelines). DNAPLs and chemicals held in the matrix of the rock may act as an ongoing source for groundwater contamination via dissolution and back-diffusion. Therefore, the RAP should include a strategy to eliminate or control these sources. With respect to back-diffusion from the rock matrix, for instance, a reduction of the concentrations in groundwater would increase diffusion and allow an assessment of diffusion resistance, which may then be used to demonstrate a case for impracticability.

Chris Jewell also advised us in the meeting that you are requesting clarification about our concerns relating to the Human Health and Environmental Risk Assessment (HHERA - HLA, 22 June 2007). Please find attached our detailed review comments.

PO Box A290, Sydney South NSW 1232
59-61 Goulburn St, Sydney NSW 2000
Tel: (02) 9995 5614 Fax: (02) 9995 5930
ABN 30 841 387 271
www.environment.nsw.gov.au

Should you require any further clarification regarding the above please contact Ulli Manuel on (02) 9995 5611.

Yours sincerely

7/10/08

Dr ERWIN BENKER
Acting Unit Head (Metro Sites)

Attachment: HHRA Comments

Cc Chris Jewell

Attachment

Orica Villawood HHRA

Summary

Onsite
The HHRA found that the risks to on site workers are unacceptably high in Identified Source Zones (ISZ) 1a, 1b, 2, 4, 5, 7, 8, 9 and 10. The source zones 1a, 1b, 2 and 8 pose the highest risks – of the order of 200 times acceptable levels. Remediation of these areas is therefore required.

The proposed risk based soil concentrations to enable remediation plans to be developed are not acceptable given the scenario does not include consideration of the ongoing movement of the more hydrophilic compounds remaining in the soils from the soil into the groundwater. This aspect needs to be considered and added into the scenario from which the proposed soil concentrations are calculated.

Groundwater plumes and offsite locations
The HHRA is not sufficient in its current form to demonstrate with confidence that the risks posed by the groundwater plumes to offsite receptors are acceptable.

There are a range of issues that need clarification. The most important of these are:

- the adequacy of chemical and hydrological assessment of the old drainage lines for potential to short circuit the normal flow patterns of groundwater towards Byrnes Creek
- the potential for risks in Byrnes Creek if the contaminated groundwater reaches the creek given the potential for the drainage lines to short circuit the overall regional flow, and
- whether off site intrusive workers undertaking works in the off site areas near the southwestern corner of the site really are unable to interact with the groundwater given the relatively shallow depth of the groundwater.

Detailed Comments

1. *Risk Based Soil Concentrations*

The risk based soil concentrations do not include any consideration of whether the contaminant levels proposed to remain post remediation would have the potential to be a source to groundwater. Some of the values recommended are substantially higher than the relevant NEPM HIL – eg DDTs 1000mg/kg NEPM HIL for industrial land while this HHRA recommends values of up to 2300mg/kg in some locations. As a consequence it is important that all the potential risks are suitably evaluated before these values can be accepted.

The regional screening values developed across the regions in the USEPA suggest that soil needs to have hundreds to million times lower concentrations in it for various of these chemicals to prevent the soil being an ongoing source to groundwater (eg DDTs USEPA screening level for groundwater protection is 0.06mg/kg compared to 2300mg/kg noted above). These calculations are designed for areas where groundwater is a source of drinking water. This is not the case at the Orica site at Villawood so these values are not directly applicable. The calculations, however, could be adapted by using ecosystem protection guidelines or some multiple of these values as the endpoint for the calculation. These calculations are based on the characteristics of the chemical and the soil in which it

is found and this information should be available so it should be possible to do the calculations.

The other aspects of the calculations of risk based soil concentrations appear to be appropriately conservative to protect human health if the area is be used for industrial purposes.

2. *Byrnes Creek*

On page 8-1 and 8-2 the report states that

- the groundwater does discharge to the creek,
- the contaminant plumes have not progressed to the creek yet, and
- given the lack of breakdown products found in the plume, it is unlikely that the chemicals will disappear via degradation.
- The possibility of drainage lines short circuiting the local groundwater flow patterns for either the regional groundwater or the perched groundwater in filled areas is also mentioned on numerous occasions in the text but no information is supplied as evidence of whether or not this is being found to occur.

So it would appear possible that contaminated water may be currently reaching Byrnes Creek via the stormwater system or that it will reach Byrnes Creek within approximately 5-20 years depending on the plume (if no short circuiting is occurring). In this HHRA, however, no assessment of the potential for impacts on human health or ecological health has been undertaken for exposure via surface waters in Byrnes Creek currently or in the future.

At a minimum, the risks posed when the front of plume 3 reaches Byrnes Creek should be assessed for the trespasser exposure scenario developed for the Chester Hill site and then included in this report.

Also its probably not appropriate to describe Byrnes Creek as having no recreational or ecological value given that it's a waterway according to S120 of the POEO Act. It could be said that the waterway is significantly degraded and its value, therefore, limited but its important to note that it still requires protection from further degradation according to NSW legislation.

3. *Off Site Intrusive workers*

An assumption is made that intrusive workers in off site areas would not be exposed to contaminated groundwater or soils and so risks don't need to be assessed. Given that the depth to groundwater in the southwestern corner of the site is approximately 2m and that there are extensive services under Birmingham Ave and in that corner of Christina Rd, some further evidence is required that such workers are not going to interact with contaminated soil or contaminated groundwater. The services on Birmingham Ave are in the path of plume 3. Evidence, like depth to groundwater in all the wells in this area of the site and these off site areas, should be included in the final report.

Other issues to be resolved

1. *Off Site soil*

The report states that soil off site is not contaminated by Orica chemicals except where it is in contact with the contaminated groundwater. It is not clear whether the sampling targeted areas most likely to have been contaminated like the drainage lines/stormwater system. It is acknowledged that there are only limited locations where chemicals relevant to the Orica Villawood contamination could have contaminated off site soils. Clarification should be provided on whether those areas were the areas targeted for checking whether soils off site were contaminated.

2. *Groundwater data*

It would be useful to include summary tables of contaminant levels in the groundwater as well as the soil and the soil gas/air in the report to assist understanding of the full situation at the site. This would also allow a better determination of the appropriateness of the risk assessment.

3. *Ambient air data in off site buildings*

The text states that the ambient air data collected inside the buildings off site does not show a good relationship with the contaminants in the groundwater in plume 1 and plume 2. The argument is made that the main chemicals found in the plumes are not found in the ambient air results. This discussion is quite confusing because its clear from Table 3-23 and 3-25 that both 1,2-dichloroethane and chlorobenzene have been found inside these buildings. They were not found in the 2007 round of analysis but were found in the 2005 round. The discussion about the relevance of these results and what they say about these off site locations needs to be further clarified. The small dataset (2 rounds of sampling) limits the confidence in any of the data and, as a result, all the data available should be considered.

The units for results listed in these 2 tables (3-23 and 3-25) should be changed from mg/m3 to ug/m3 to bring them into line with all the other tables in the report.

4. *Site History description*

The site history description includes a note that area D has an area where grass won't grow. Area D doesn't have any inferred source zones in it which would imply that it is fairly uncontaminated. Information should be provided indicating whether the phytotoxic area has been appropriately sampled, how big it is and what action is being taken to ensure plants can grow there in the future.

5. *Plume 3,4,5*

Very few specific measurements have been undertaken in the areas of plumes 4 and 5 and risks in these locations are assessed using the data available for plume 3. Given that plume 4 is moving off site and no action is proposed to remediate the plume, further work is necessary to fully assess this plume.

Specific Editorial and Technical Comments

1. *Screening process for soil gas*

On page 3-17 the process of screening soil gas data to determine COPCs is described. A screening step is a normal part of a risk assessment so it is not necessary to provide the justification in the text on this page. This section should be rewritten so that it reflects the same sort of description as for the soil screening values.

2. *Lack of QA for air analyses*

Some results especially for soil gas and other air analyses are labelled in the report as somewhat unreliable because of a lack of information about the QA or the lack of a QA assessment. This applies to studies completed in 2006 as well as those from earlier times. If work has been completed as recently as 2006 without the inclusion of a QA assessment then this is inappropriate. Such sampling should be redone with appropriate QA.

3. *TPH*

Total petroleum hydrocarbons were not considered as a chemical of potential concern (COPC) because the high results for this analysis in the initial screening were thought to be due to the presence of chemicals like DDTs in the samples which cross-react in the TPH analysis rather than the presence of actual petroleum hydrocarbons. In the executive summary the need to confirm this assumption is highlighted. The report does not include any information indicating that this confirmation step has been undertaken.

4. *Risk Calculations*

Page 3-26 – the maximum benzene concentration in soil gas listed in Table 3-14 is 640000ug/m3 – the value listed in the risk calculations appendix for this location is 64000ug/m3 so the risk calculated is 10 times too low.

5. *Screening Health Guidelines – soil gas*

- Text says uses WHO guidelines are primary source which is in line with NEPM but then the tables show the Region 9 PRG value for 1,2-dichloroethane (which has a WHO guideline). As a result it becomes a COPC when it may not need too;
- some of the region 9 PRGs are listed incorrectly which in some cases means a chemical has been misclassified as not being a COPC (eg table 3.12 – methylene chloride listed screening value is 313000 but the region 9 value is 4.1 which means the screening value should be 410 – given results this means it should be a COPC);
- some chemicals are listed as PRGs but they can't be found in the source table (table 3.12 - isopropyltoluene);
- some chemicals are listed as not having a PRG and so a surrogate chemical is used as a basis for a screening value but no indication is given of what chemical is used as the surrogate (eg table 3.13 – 2-propanol);
- some chemicals are listed as not having a PRG and so a surrogate chemical has been used as basis for screening value but they are listed in the PRGs – changes classification in some cases (eg table 3.13 bromodichloromethane and dibromochloromethane – PRGs are 0.11 and 0.08ug/m3 – there is a note indicating that a different approach was adopted for these trihalomethanes but little detail is provided hence the query);

6. *Screening Health Guidelines – soil*

- Tetrachloroethene – region 9 PRG is listed as 1.3 mg/kg but in Table 3-1 its listed as 3.4mg/kg
- Butyl benzyl phthalate – region 9 PRG is listed as 100000mg/kg but in Table 3-1 its listed as 10000mg/kg
- Anthracene - region 9 PRG is listed as 100000mg/kg but in Table 3-1 its listed as 10000mg/kg
- Tin - region 9 PRG is listed as 100000mg/kg but in Table 3-1 its listed as 10000mg/kg

7. *Chemical Specific data for vapour modelling*

The values listed are quite different to those listed on RAIS for some chemicals. The toxicity summary appendix indicates the values were sourced from a range of references including RAIS. The RAIS database is regularly reviewed while some of the other references have not been updated for some time. Some information should be provided as to why the older references are to be preferred for these physico-chemical data. Particularly, water solubility and Koc values used in this assessment are different to those listed in RAIS. The values should be checked and models rerun as appropriate.
(for example

1) the water solubility listed for 1,2-dichloroethane is 8690mg/L while for vinyl chloride the value listed is 2760mg/L. The RAIS entries are 5100 and 8800mg/L respectively
2) the Koc for trichloroethene is listed as 166 while in RAIS the listed value is 67 and for benzene the listed value is 58.9 while in RAIS its listed as 165)

8. *Editorial comments*

Page 3-35 – in the first section on this page the text would seem to imply that the source zone being referred to is ISZ4 not ISZ2?

Table 3-18 – W is used to indicate a note in 2 different ways but only 1 is defined in the Notes.

Page 2-6 and 2-7 - Trifluarlin – is this meant to be trifluralin?

Page 2-6 - What is meant by hormone weed killers?

To: "Benker Erwin" <Erwin.Benker@environment.nsw.gov.au>, "Manuel Ulli" <Ulli.Manuel@environment.nsw.gov.au>
Copies to: Jackie_Wright@URSCorp.com, Frank.Mohen@aecom.com, Brad.Eismen@aecom.com, chris@cm-jewell.com.au, bill.crowe@orica.com, james.stening@orica.com, james.fairweather@orica.com
Subject: DECC Presentation Minutes - Orica Villawood Site - December 1 2008
From: ben.dewhurst@orica.com
Date sent: Tue, 16 Dec 2008 10:03:28 +1100

MINUTES
VILLAWOOD RAP PRESENTATION - DECC
1000 - 1200 MONDAY 1 DECEMBER 2008

Attendees

DECC: Ulli Manuel, Erwin Benker
CMJ&A: Chris Jewell
Orica: Bill Crowe, James Stening, Ben Dewhurst
ENSR: Frank Mohen, Brad Eismen
URS: Jackie Wright

Introduction (BC)

- Orica's approach has been consistent since the development of the groundwater model 2-3 years earlier and through the development of the Remediation Action Plan (RAP).
- Remedial approach has been discussed (Govt briefing days) during this time.
- RAP has been with the DECC for 15 months.
- Discussion on potential Direct Thermal Desorption plants (DTD) and timing.
- Potential for new use of part of the site to create up to 100 jobs to the area in 12 - 18 months, but the opportunity could be lost if remediation is delayed excessively.
- Believe the RAP is consistent with Groundwater guidelines and hope to demonstrate this today, and reach a consensus on the forward plan.

Key Points from Presentation

- Overview on supporting documentation which focussed on the modelling and risk assessment.
- Plume configuration follows historical drainage line along Christina Road which provides the curved plume shape (this is due to the drain being a historical source and not due to the drain acting as a preferred flow path).
- Recent groundwater monitoring data supports the current groundwater model and plume configuration.
- Discussion on DNAPL sources/migration and matrix diffusion.
- Chris Jewell added comment on formation and DNAPL migration, with vertical migration occurring via microfractures in the clay. Clay in the weathered zone maintains the same geological features as the parent bedrock so secondary porosity in the clay is the primary migratory pathway.
- A very high percentage of the DNAPL on site has been inferred to have either dissolved into solution or has been forward diffused into the matrix.
- The source of DNAPL in off site areas is not due to migration from a point source(s), but from historical migration along the surface of the open drain on Christina Road. Therefore, DNAPL migration has been predominantly vertical until dissolution and matrix diffusion create a steady state.
- Groundwater from the site eventually discharges into Byrnes Creek. However, due to matrix diffusion, dissolved phase migration will be significantly retarded and contamination from the site is not considered likely to reach Byrnes Creek.
- Vertical discretisation discussed, with current well network utilising bundle piezometers to

assess the vertical distribution of contamination.

- HHERA discussion was not technical and focussed on the vapour inhalation pathway of off-site intrusive workers. Direct contact has not been considered due to the depth of groundwater of 3-4 metres (2.3 m minimum) below ground level (needs to be articulated more in HHERA).
- Discussion on potential short circuiting of contamination via drainage lines. These drainage lines will only influence shallow/perched contaminated groundwater which will be removed as part of the soil earthworks. This needs to be discussed in the RAP.
- Comment on small area of site where grass would not grow, as discussed in the HHERA. This area has been inspected and grass is now abundant in this area.

DECC Comments

- Erwin Benker requested more detail on the correlation between concentrations detected in the shallow groundwater vs deep groundwater. Need to discuss implications of removal of shallow contamination on the deeper groundwater. Also, the removal of impacted perched groundwater during soil earthworks on the site is essentially remediating a groundwater source and this can be outlined in the RAP along with the implications of this removal on the deeper groundwater.
- Erwin Benker commented on the low yield which supports our argument but hasn't been articulated in supporting documentation.
- Erwin Benker suggested more clarity could be provided in the Conceptual Site Model with regards to plume migration both laterally and vertically.
- DECC requested that the EMP for the site be prepared and issued with the updated RAP, to provide a complete package for the ongoing management of the residual site issues following remediation.
- Potential for chemical oxidation discussed with Erwin. ENSR briefly discussed why this would not be effective.
- DECC would accept that consideration of off-site intrusive worker risk is not required if contaminated groundwater is >2 m below grade. In response to a question on future regulation to control this issue for any major development, DECC will advise council who have Planning responsibility.
- DDX RBC vs NEPM guidelines needs to be addressed in the HHERA. The current RBC is well above the NEPM guideline. This will need to be checked and well justified as DDX is classified as scheduled chemical waste.
- Erwin believed that if the discussion topics could be clearly articulated in the RAP and future management of risks could be demonstrated in the Site Management Plan, then demonstration of clean up to the extent practical would be demonstrated.

Actions

1) Prepare Site Conceptual Model that clearly demonstrates the geological factors determining plume configuration and contaminant migration. Needs to support the model and the statement that contamination will not reach Byrnes Creek. Key points to clarify are:
- Where is bulk of contaminant located - in clay (shallow) vs deep matrix
- Demonstrate the correlation of deep impact with shallow impact. i.e demonstrate that there are no other pathways at depth other than from shallow vertical ingress.
- Demonstrate with data that wells are low yield and extraction is impractical
- Articulate argument that addition of chemical oxidant will not ultimately be effective
- Articulate that plumes are stable, but even though groundwater may reach Byrnes Creek, contaminants will not.

2) Prepare Site Management Plan which clearly outlines monitoring requirements, responsibilities and contingencies to manage future risks and demonstrates the assumptions made in the RAP.
3) Revise RAP responding to DECCs comments above and include a summary of key points in the Site Conceptual Model which are relevant to RAP.
4) Revise HHERA to include points discussed in the presentation. JW will discuss technical issues with Therese Manning.

Regards,

Ben Dewhurst
Environmental Projects Manager

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Matraville, NSW, 2036
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Email: ben.dewhurst@orica.com

(16715)

C.M. Jewell & Associates Pty Ltd

A.C.N. 056 283 295 A.B.N. 54 056 283 295

Water and Environmental Management

1/13 Kallinda Road, Bullaburra, NSW 2784, Australia
P.O. Box 10, Wentworth Falls, NSW 2782
Phone: (02) 4759 3251 Fax: (02) 4759 3257
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Ref: J1196.12L
17 July 2009

Orica Australia Ltd
16-20 Beauchamp Road
MATRAVILLE NSW 2036

Attention: Mr Ben Dewhurst

Dear Ben

Remedial Action Plan Addendum
2 Christina Road, Villawood
Final Document Dated 9 July 2009

I have reviewed the final version of the Remedial Action Plan Addendum for 2 Christina Road, Villawood. I previously reviewed a draft version of this document, and note that my review comments have been incorporated into the final version.

I have also read the supporting research papers and other technical material that are included in the technical appendix (Appendix A). I had previously reviewed this material in the course of the Remedial Action Plan development and review.

The focus of this addendum, and its main objective, is to re-enunciate the conceptual site model (CSM) that underpins the remedial strategy that has been developed for the site, and to tie the CSM more strongly to both the theoretical framework on which it is based, and the site data.

I believe that the CSM is sound, and is founded on an adequate site dataset and effective numerical modelling. Where knowledge gaps exist, they are clearly stated, and in my opinion, variation of assumed parameters within a credible range would not change the interpretation significantly.

The knowledge-base referenced in the addendum document is comprehensive. This theoretical framework has been developed over a period of more than 10 years by some of the leading academic researchers in this field, and has been given practical context by agency reviews, case studies and technology evaluations.

I think that the theoretical framework has been fairly and appropriately used in the development of the CSM, and is appropriately cited in the addendum document. Specifically, this is the case for the discussion of concentration-gradient driven diffusion between the active fracture flow system and the matrix porosity in the Bringelly Shale and its weathering products.

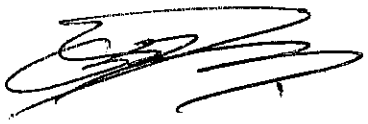
Thus, whilst the conceptual model necessarily incorporates assumptions, and falls short of complete certainty, the assumptions are soundly based.

Certainty is never achievable in work of this type, but I note that the Remedial Action Plan Addendum lists specific measures to verify CSM assumptions and assessed parameters during remedial works. This verification process must be kept under ongoing review, so that the model assumptions can be revised, and the remedial program modified, should this prove to be necessary. This could be achieved by regular communication between the remediation consultant and the Site Auditor as remediation proceeds.

In conclusion, I endorse the Remedial Action Plan as amended by this addendum document.

This communication has been provided as interim advice only. Where applicable, the information provided is consistent with NSW EPA (DEC) guidelines and policies. The advice does not constitute a site audit report or site audit statement and does not pre-empt the conclusions which will be drawn at the end of the audit process. A site audit report and site audit statement will be issued when the audit process has been completed.

For and on behalf of
C. M. JEWELL & ASSOCIATES PTY LTD



CHRIS JEWELL

Site Auditor accredited under the
Contaminated Land Management Act 1997

Our reference: DOC10/13689
Contact: Deanne Pitts, (02) 9995 5739

Ms Ann-Maree Cuthers
Senior Environmental Planning Officer
Mining and Industry
Department of Planning
PO Box 39
SYDNEY NSW 2001

EMAIL & STANDARD POST

Dear Ms Cuthers

Proposed remediation of contaminated soils - Orica Australia Pty Ltd
2 Christina Rd, Villawood NSW 2163 - MP09_0147

I refer to your request received on 4 March 2010 for the Department of Environment, Climate Change and Water's ("DECCW") requirements for the Environmental Assessment ("EA") in regard to the above proposal.

Please note that, although the Environment Protection Authority ("EPA") is now a part of the DECCW, certain statutory functions and powers continue to be exercised in the name of the EPA.

DECCW has considered the details of the proposal as provided by the Department of Planning ("DoP") and has identified the information required to be included in the EA to assess the project (Attachment A). The proponent should ensure that the EA is sufficiently comprehensive and detailed to allow the DECCW to determine the extent of the impact(s) of the proposal.

The proponent should be aware that any commitments made in the EA may be formalised as approval conditions. Consequently, pollution control measures should not be proposed if they are impractical, unrealistic or beyond the financial viability of the development. It is important that all conclusions are supported by adequate data.

Due to the complexity of this proposal, DECCW recommends that the proponent consults with the DECCW during the assessment period.

Based upon the information provided to DECCW, the proponent will need to apply to the EPA to vary Environment Protection Licence No. 2149 in regard to carrying out scheduled activities. The proponent will need to make a separate application to DECCW to obtain this variation if planning project approval is given.

DECCW would also like to advise that the site is currently subject to a Management Order No. 23019 under the *Contaminated Lands Management Act 1997.*

DECCW requests that the proponent provides five copies of the EA for assessment. These documents should be sent to the Manager Waste Operations, PO Box A290, Sydney South NSW 1232.

PO Box A290 Sydney South NSW 1232
59-61 Goulburn St Sydney NSW 2000
Tel: (02) 9995 5000 Fax: (02) 9995 5999
TTY (02) 9211 4723
ABN 30 841 387 271
www.environment.nsw.gov.au

If you have any queries regarding this matter, please contact Deanne Pitts on 9995 5739.

Yours sincerely

26/3/10

JULIE CURREY
Unit Head Waste Operations
Environment Protection and Regulation

Encl. Attachment A - DECCW DGRs

ATTACHMENT A: ENVIRONMENTAL ASSESSMENT REQUIREMENTS FOR THE REMEDIATION OF CONTAMINATED SOILS AT 2 CHRISTINA RD, VILLAWOOD NSW

PROPONENT: ORICA AUSTRALIA PTY LTD

MARCH 2010

ENVIRONMENTAL IMPACTS OF THE PROJECT

The following environmental impacts of the project need to be assessed, quantified and reported on:

1. Air
2. Noise and vibration
3. Water
4. Waste and chemicals
5. Threatened Species
6. Aboriginal Cultural Heritage
7. Other site specific issues
8. References

General

The EA must include:

- An executive summary;
- A description of the overall remediation strategy for the site, including the:
  - objectives of the remediation strategy;
  - proposed staging of the strategy; and
  - relationship between the various stages of the strategy;
- A detailed description of the project, including the:
  - need for the project;
  - alternatives considered;
  - Remedial Action Plan, validation and ongoing site monitoring for the project prepared in accordance with the NSW EPA *Guidelines for Consultants Reporting on Contaminated Sites 1997* and to the satisfaction of the NSW EPA accredited Site Auditor and DECCW. This should include, but is not limited to:
    - Details of the proposed remediation process;
    - Justification of all proposed remediation criteria; and
    - Details of compliance with the *Contaminated Land Management Act 1997* and Management Order No. 23019 (dated 2/11/05).
  - Final landform following remediation and the suitability of fill material;
  - On going management of the site following remediation works;

- Risk assessment of the potential environmental impacts of the project, identifying the key issues for further assessment;
- A detailed assessment of the key issues specified below, and any other significant issues identified in the risk assessment (see above), which includes:
    - a description of the existing environment, using sufficient baseline data;
    - an assessment of the potential impacts of all stages of the project, including any cumulative issues arising from other sites in the area; and
    - a description of the measures that would be implemented to avoid, minimise, mitigate, rehabilitate/remediate, monitor and/or offset the potential impacts of the project, including detailed contingency plans for managing any potentially significant risks to the environment.
- A statement of commitments, outlining all the proposed environmental management and monitoring measures;
- A conclusion justifying the project on economic, social and environmental grounds, taking into consideration whether the project is consistent with the objects of the *Environmental Planning & Assessment Act 1979*;
- A signed statement from the author of the Environmental Assessment, certifying that the information contained within the document is neither false nor misleading; and
- Detailed descriptions and specifications of the:
    - Emission Control System (ECS) in the Pre-Treatment Building (PTB);
    - The Water Treatment Plant; and
    - The DTD Plant.

1. Air Environmental Assessment Requirements

The EA must:

- Identify all sources of air emissions from the development;

Note: emissions can be classed as either:

- *point (e.g. emissions from stack or vent) or*
- *fugitive (from wind erosion, leakages or spillages, associated with loading or unloading, conveyors, storage facilities, plant and yard operation, vehicle movements (dust from road, exhausts, loss from load), land clearing and construction works).*

- Provide details of the project that are essential for predicting and assessing air impacts including:
    - the quantities and physio-chemical parameters (eg concentration, moisture content, bulk density, particle sizes etc) of materials to be used, transported, produced or stored;
    - an outline of procedures for handling, transport, production and storage; and
    - the management of solid, liquid and gaseous waste streams with potential for significant air impacts.

- Include clear diagrams illustrating;
    - the physical layout of the plant and pollution control equipment; and
    - the material and air flows through the plant and any pollution control equipment, including structures or enclosures for controlling air and odour emissions.
- Establish existing background levels of the key air pollutants in the ambient air at potentially affected sensitive receptor locations;
- Detail how background levels and emissions from other potential sources of the key air pollutants have been cumulatively assessed at sensitive receptor locations;
- Details how fugitive emissions of potentially contaminated material will, essentially, be eliminated;
- Provide details of an appropriate odour impact assessment and detail how potentially offensive odour will be eliminated at any sensitive receptor locations; and
- Provide details of trials to verify (before treating or disturbing contaminated materials) that the process will not create fugitive emissions and that point emissions will meet predicted levels.

Baseline conditions

The EA must provide a description of existing air quality and meteorology, using existing information and site representative ambient monitoring data. This description must include the following:

- A description of the topography and surrounding land uses;
- Details of the exact locations of dwellings, schools and hospitals;
- A perspective view of the study area such as the terrain file used in dispersion models (where appropriate); and
- A description of surrounding buildings that may effect plume dispersion.

The EA needs to include site representative data on the following meteorological parameters:

- temperature and humidity;
- rainfall, evaporation and cloud cover;
- wind speed and direction;
- atmospheric stability class;
- mixing height (the height that emissions will be ultimately mixed in the atmosphere);
- katabatic air drainage; and
- air re-circulation.

Assess impacts

The EA must demonstrate that Proponent has:

- Conducted an air quality and odour impact assessment in accordance with the requirements of the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, August 2005* and with regard to *Assessment and Management of Odour from Stationary Sources in NSW (EPA, 2001)*, and *Technical Notes: Draft Policy: Assessment and Management of Odour from Stationary Sources in NSW (EPA, 2001)*;

- Conducted a health risk assessment acceptable to the NSW Department of Health;
- Identified all pollutants of concern and estimate emissions by quantity (and size for particles), source and discharge point;
- Estimated the resulting ground level concentrations of all pollutants. Where necessary (e.g. potentially significant impacts and complex terrain effects), used an appropriate dispersion model to estimate ambient pollutant concentrations. Discussed choice of model and parameters with DECCW;
- Described the effects and significance of pollutant concentration on the environment, human health, amenity and regional ambient air quality standards or goals;
- Described the contribution that the development will make to regional and global pollution, particularly in sensitive locations; and
- For potentially odorous emissions provided the emission rates in terms of odour units (determined by techniques compatible with EPA / DECCW procedures).

  Note: Use sampling and analysis techniques for individual or complex odours and for point or diffuse sources, as appropriate.

  Note: With dust, it may be possible to use data from existing similar activities to generate emission rates.

The proponent must refer to:

- *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2005);
- *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW* (EPA, 2005);
- *Assessment and Management of Odour from Stationary Sources in NSW* (EPA, 2001);
- *Technical Notes: Draft Policy: Assessment and Management of Odour from Stationary Sources in NSW (EPA, 2001); and*
- *Load Calculation Protocol for use by holders of NSW Environment Protection Licences when calculating Assessable Pollutant Loads* (EPA, 1999).

Management and mitigation measures

The EA must:

- Outline specifications of pollution control equipment (including manufacturer's performance guarantees where available) and management protocols for both point and fugitive emissions. Where possible, this should include cleaner production processes.

2. Noise & Vibration Environmental Assessment Requirements

The EA must:

- Identify, assess and model all noise sources from the remediation project (including both construction and operation phases). Detail all potentially noisy activities including ancillary activities including transport;

- Specify the times of operation for all phases of the project and for all noise producing activities; and
- For projects with a significant potential off site traffic noise impact, provide details of road alignment (include gradients, road surface, topography, bridges, culverts etc), and land use along the proposed road and measurement locations – diagrams should be to a scale sufficient to delineate individual residential blocks.

The location

The EA must:

- Identify any noise sensitive locations likely to be affected by activities at the project site, such as residential properties, schools, churches, and hospitals; and
- Identify the land use zoning of the site and the immediate vicinity and the potentially affected areas.

Note: Typically the noise assessment report should include a map of the locality showing any identified noise sensitive locations in relation to the site.

Baseline conditions

The EA must demonstrate how the proponent will:

- Determine the existing background (LA90) and ambient industrial (LAeq) noise levels in accordance with the NSW Industrial Noise Policy. The determination of 'existing industrial noise level' shall consider known or reasonably foreseeable changes likely to occur to existing industrial noise levels during the project timeline (other than the project under consideration); and
- Determine the existing road traffic noise levels in accordance with the NSW Environmental Criteria for Road Traffic Noise, where road traffic noise impacts may occur.
- The noise impact assessment report should provide details of all monitoring of existing ambient noise levels including:
    - Details of equipment used for the measurements;
    - A brief description of where the equipment was positioned;
    - A statement justifying the choice of monitoring site, including the procedure used to choose the site, having regards to the definition of 'noise sensitive location(s)' and 'most affected location(s)' described in Section 3.1.2 of the NSW Industrial Noise Policy;
    - Details of the exact location of the monitoring site and a description of land uses in the surrounding areas;
    - A description of the dominant and background noise sources at the site;
    - Day, evening and night assessment background levels for each day of the monitoring period;
    - The final RBL value;
    - Graphs of the measured noise levels for each day should be provided;
    - A record of periods of affected data (due to adverse weather and extraneous noise), methods used to exclude invalid data and a statement indicating the need for any re-monitoring under Step 1 in Section B1.3 of the NSW Industrial Noise Policy; and

- Determination of LAeq noise levels from existing industry.

Assess environmental impacts

The EA must demonstrate how the Proponent will:

- Determine the INP project specific noise levels for the site. For each identified potentially affected receiver, this should include:
  - determination of the intrusive criterion for each identified potentially affected receiver;
  - selection and justification of the appropriate amenity category for each identified potentially affected receiver;
  - determination of the amenity criterion for each receiver; and
  - determination of the appropriate sleep disturbance limit.

  Note: Maximum noise levels during night-time period (10pm-7am) should be assessed to analyse possible affects on sleep. Where LA1(1min) noise levels from the site are less than 15 dB above the background LA90 noise level, sleep disturbance impacts are unlikely. Where this is not the case, further analysis is required.

  Additional guidance is provided in the INP Policy Application Notes at www.environment.nsw.gov/noise/applicnotesindustnoise.htm

- Determine expected noise level and noise character (eg: tonality, impulsiveness, vibration, etc) likely to be generated from noise sources during:
  - site establishment;
  - construction;
  - operational phases;
  - transport, including traffic noise generated by the proposal; and
  - other services.

  Note: The noise impact assessment report should include noise source data for each source in 1/1 or 1/3 octave band frequencies including methods or references used to determine noise source levels.

The EA must demonstrate how the Proponent will:

- Determine the noise & vibration levels likely to be received at the most sensitive locations (these may vary for different activities at each phase of the development). Potential impacts should be determined for any identified significant adverse meteorological conditions. Predicted noise levels under calm conditions may also aid in quantifying the extent of impact where this is not the most adverse condition. $L_{Aeq,15minute}$ and $L_{Aeq,period}$ predicted noise levels should be provided.
- Potential vibration impacts should be assessed using the DECCW guideline titled: "Environmental Noise Management – Assessing Vibration: a technical guideline". http://www.environment.nsw.gov.au/noise/vibrationguide.htm
- The noise impact assessment report should include:

- A plan showing the assumed location of each noise source for each prediction scenario;
- A list of the number and type of noise sources used in each prediction scenario to simulate all potential significant operating conditions on the site;
- Any assumptions made in the predictions in terms of source heights, directivity effects, shielding from topography, buildings or barriers, etc;
- Methods used to predict noise impacts including identification of any noise models used. Where modelling approaches other than the use of the ENM or SoundPlan computer models are adopted, the approach should be appropriately justified and validated;
- An assessment of appropriate weather conditions for the noise predictions including references to any weather data used to justify the assumed conditions;
- The predicted noise impacts from each noise source as well as the combined noise level for each prediction scenario under any identified significant adverse weather conditions as well as calm conditions where appropriate;
- For developments where a significant level of noise impact is likely to occur, noise contours for the key prediction scenarios should be derived; and
- An assessment of the need to include modification factors as detailed in Section 4 of the NSW Industrial Noise Policy.

- The noise impact assessment report should discuss the findings from the predictive modelling and, where relevant noise criteria have not been met, recommend additional mitigation measures; and should include details of any mitigation proposed including the attenuation that will be achieved and the revised noise impact predictions following mitigation.

- Where relevant noise/vibration criteria cannot be met after application of all feasible and reasonable mitigation measures the residual level of noise impact needs to be quantified by identifying:
  - locations where the noise level exceeds the criteria and extent of exceedence;
  - numbers of people (or areas) affected;
  - times when criteria will be exceeded;
  - likely impact on activities (speech, sleep, relaxation, listening, etc);
  - change on ambient conditions; and
  - the result of any community consultation or negotiated agreement.
- For the assessment of existing and future traffic noise, details of data for the road should be included such as assumed traffic volume; percentage heavy vehicles by time of day; and details of the calculation process. These details should be consistent with any traffic study carried out in the EA. Alternatively, measured noise levels can be used provided the traffic volume during the period of measurement is demonstrated to be typical of normal volumes etc

Management and mitigation of environmental impacts

The EA must demonstrate how the Proponent will:

- Determine the most appropriate noise mitigation measures and expected noise reduction including noise controls and management of impacts for both construction and operational noise. This will include selecting quiet equipment and construction methods, noise barriers or

acoustic screens, location of stockpiles, temporary offices, compounds and vehicle routes, scheduling of activities, etc. In particular, the EA must address:

- Specific noise mitigation measures for the DTD Plant, including consideration of physical barriers to reduce noise emissions from the site; and
- Specific noise mitigation measures for the DTD Plant Stack, including consideration of a muffler device on the Stack to reduce noise emissions.

- For traffic noise impacts, provide a description of the ameliorative measures considered (if required), reasons for inclusion or exclusion, and procedures for calculation of noise levels including ameliorative measures. Also include, where necessary, a discussion of any potential problems associated with the proposed ameliorative measures, such as overshadowing effects from barriers. Appropriate ameliorative measures may include:

  - Use of alternative transportation modes, alternative routes, or other methods of avoiding the new road usage;
  - Control of traffic (eg: limiting times of access or speed limitations);
  - Resurfacing of the road using a quiet surface;
  - Use of (additional) noise barriers or bunds;
  - Treatment of the façade to reduce internal noise levels buildings where the night-time criteria is a major concern;
  - More stringent limits for noise emission from vehicles (i.e. using specially designed "quiet" trucks and/or trucks to use air bag suspension);
  - Driver education;
  - Appropriate truck routes;
  - Limit usage of exhaust breaks;
  - Use of premium mufflers on trucks;
  - Reducing speed limits for trucks;
  - Ongoing community liaison and monitoring of complaints; and
  - Phasing in the increased road use.

3. Water Environmental Assessment Requirements

Groundwater

DECCW is concerned about groundwater contamination which may be disturbed by the remediation and remain at the site after the remediation. The EA needs to address:

- An accurate representation of the extent and nature of the plumes underneath the site including details of location and extent of Dense Non Aqueous Phase Liquids (DNAPLs);
- How groundwater in the surrounding area will be monitored;
- How contaminated groundwater that is encountered during excavation will be treated and disposed of;
- Remediation of contaminated groundwater at the site and provision of justification for otherwise;

- Details of any contaminated soil management arrangements; and
- Details of the installation, operation and maintenance of the sediment and erosion controls associated with the construction works.

In development of the EA and carrying out the works, the proponent should also refer to DECCW's *Guidelines for the Assessment and Management of Groundwater Contamination* 2007.

Surface Water

- A detailed Surface Water Management Plan must be developed that includes:
    - All erosion and sediment controls to be used during excavation, stockpiling and backfilling;
    - Details of how surface water from "clean" areas will be directed and stored away from surface water from contaminated areas; and
    - Details of how the contaminated water will be treated and its final disposal location i.e. sewer or liquid waste treatment facility.

    Note: A trade waste agreement with Sydney Water may be need be sought for any waste going to sewer

In development of the EA and carrying out the works, the proponent should also refer to the Department of Housing Document titled "*Managing Urban Stormwater: Soils and Construction*".

4. Waste & Chemicals Environmental Assessment Requirements

Statutory Requirements Under the Environmentally Hazardous Chemicals Act 1985

The EA must demonstrate how the Proponent will manage all materials and wastes containing scheduled chemical waste, dioxin and/or polychlorinated biphenyls (PCBs) in accordance with the applicable Chemical Control Order, National Management Plan or in accordance with a licence under the Environmentally Hazardous Chemicals Act 1985.

> *Note: The proposed treatment of scheduled chemicals including DDTs using direct thermal desorption is deemed "processing" in accordance with the Scheduled Chemical Waste Chemical Control Order 2004 made under the Environmentally Hazardous Chemicals Act 1985 and must be done in accordance with an EPA licence.*

Prior to the issue of any variation of the existing Environmental Protection Licence and Environmentally Hazardous Chemicals Act Licence to permit the proposed works, the proponent must provide the EPA with sufficient and appropriate documentation for a technology assessment to be undertaken by the EPA, in accordance with the following:

- 'National Protocol - Approval/Licensing of Trials of Technologies for the Treatment/Disposal of Schedule X Wastes - July 1994'; and
- 'National Protocol for Approval/Licensing of Commercial Scale Facilities for the Treatment/Disposal of Schedule X Wastes - July 1994'.

The applicant will be expected to operate in accordance with the procedures outlined in the technology assessment documents provided to the EPA, unless otherwise agreed by the EPA.

Assessment of technologies for treatment of Schedule X Wastes

Note: Technologies for treating or destroying scheduled chemicals are initially assessed in accordance with the 'National Protocols for Approval/Licensing of Trials of Technologies for the Treatment/Disposal of Schedule X Wastes 1994' developed as part of the National Strategy for the Management of Scheduled Waste. If trial data demonstrates the technology can meet specified environmental outcomes for a particular feedstock, the proponent can apply to proceed with commercial-scale treatment. In this case, the proposal would be assessed against the 'National Protocol for Approval/Licensing of Commercial-Scale Facilities for the Treatment/Disposal of Schedule X Wastes 1994'.

Assessment in accordance with such protocols requires a technology that:

- is a viable option meeting best practice standards;
- will not create any additional problematic waste streams;
- will minimise any transfer of POPs or other contaminants of concern to the environment; and
- will meet the strictest air emission criteria.

Within the technology assessment application, the applicant must develop a Commissioning and Proof of Performance Program (CPoP) to demonstrate the technology's capability to meet best practice emission and treatment levels. The CPoP must include the proposed staging of treatment consistent with the requirements of the 'National Protocols'. Consideration should also be given to the Basel General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs) and Stockholm BAT BEP guidance.

Note: Assessment in accordance with the 'National Protocols' involves applying for a technology assessment under the Environmentally Hazardous Chemicals Act 1985 and paying the assessment fee.

Treatment limits

The EA must demonstrate how the Proponent will:

- Process all Scheduled Chemical Waste, dioxin waste and/or Polychlorinated Biphenyls Waste (PCBs), and any wastes generated by the treatment process until the materials/wastes meet:
  - a statistical average dioxin, furan and dioxin like PCB WHO-TEQ of less than 1ug/kg^{-1} (1000 ppt) determined with a methodology acceptable to the EPA;
  - an aggregate concentration of scheduled chemical waste constituents of less than 2mg/kg;
  - a polychlorinated biphenyl concentration of less than 2mg/kg;
  - the requirements that apply in accordance with the Organochlorine Pesticide Waste Management Plan 1999; and
  - best practice limits as demonstrated within the Commissioning and Proof of Performance Program for other principal contaminants of concern.

Excavation, handling, pre-treatment and storage

The EA must demonstrate how the Proponent will:

- Demonstrate how excavation, handling, pre-treatment, storage and other activities involving materials and wastes containing scheduled chemical waste, dioxin, polychlorinated biphenyls (PCBs) and other principal contaminants of concern is conducted in accordance with best practice measures to minimise loss to the environment, exposure to humans and maximise destruction through the proposed treatment plant. In the EA, the applicant should demonstrate how this will be achieved.
- In addition to the NSW statutory requirements, the proponent should consider the USEPA Best Management Practices (BMPs) for Soils Treatment Technologies - Suggested Operational Guidelines to Prevent Cross-Media Transfer of Contaminants During Cleanup Activities - EPA530-R-97-007. DECCW can provide the proponent with all the application forms, protocols and guidelines covered in relation to the EHC Act and technology assessment.

In development of the EA and carrying out the works, the proponent should also refer to the following guidelines: The former EPA guidelines titled *Assessment, Classification & Management of Liquid & Non-liquid Wastes.*

Risk assessment

The EA needs to include risk assessment details covering exposure by inhalation and ingestion of contaminated soil if there is to be any loss of dust from the site during the rehabilitation process. The risk assessment should also focus on inhalation of volatilised chemicals that are released whenever the soil is worked – i.e. when excavated; when prepared for treatment; when treated; when stored prior to treatment; when moved from storage shed. .

Ambient monitoring using summa canisters for VOCs and high volume air sampling for SVOCs should be undertaken.

Other waste

If any waste (including "clean" and contaminated soil not suitable for treatment in the DTD Plant) is proposed to leave the site, the EA must:

- Identify and characterise the waste leaving the site;
- Proposed quantities of the waste; and
- Disposal location for the waste.

In addition, if waste leaving the site has the potential to be classified as "hazardous" under DECCW's *Waste Classification Guidelines 2008*, the EA must outline:

- How the waste will be handled and managed onsite and during transport to a lawful facility;
- How the waste will be treated or immobilised to render it suitable for transport and disposal;
- That the proponent is aware of DECCW's requirements with respect to notification and tracking of the waste; and
- All procedures and protocols to be implemented to ensure that any hazardous waste leaving the site is transported and disposed of lawfully and does not pose a risk to human health or the environment.

5. Impacts on threatened species and their habitat

DECCW acknowledges that the site is highly disturbed and therefore the presence of threatened species is unlikely. Nonetheless, the EA should, if applicable, include a brief field survey of the site. If any TS are identified then likely impacts on threatened species and their habitat need to be assessed, evaluated and reported on. The EA must describe the actions that will be taken to avoid or mitigate impacts or compensate for unavoidable impacts of the project on threatened species and their habitat. This should include an assessment of the effectiveness and reliability of the measures and any residual impacts after these measures are implemented.

6. Impacts on Aboriginal cultural heritage values

DECCW acknowledges that the site is highly disturbed and therefore the presence of Aboriginal cultural heritage artefacts is unlikely. Nonetheless, the EA should if applicable:

- Address and document the information requirements set out in the draft *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* involving surveys and consultation with the Aboriginal community;
- Identify the nature and extent of impacts on Aboriginal cultural heritage values across the project area;
- Describe the actions that will be taken to avoid or mitigate impacts or compensate to prevent unavoidable impacts of the project on Aboriginal cultural heritage values. This should include an assessment of the effectiveness and reliability of the measures and any residual impacts after these measures are implemented; and
- Demonstrate that effective community consultation with Aboriginal communities has been undertaken in determining and assessing impacts, developing options and making final recommendations.

7. Other site specific issues

The proponent should address all requirements listed in Sections 1-6 above (where applicable) in respect of the proposal.

If not already addressed in Sections 1-6, DECCW requires the following specific issues to be addressed in the Environmental Assessment:

Excavation works

The EA must specifically state whether excavation of materials at the site will be wholly completed within a building or out in the open.

If all excavation works are to be conducted within a building(s), the EA must provide:

- The size and specifications of the building;
- Mitigation measures associated with the building to address air quality, noise and odour emissions; and
- Details of how the building will be relocated around the site to different excavation areas.

If excavation works are proposed to be conducted out in the open, the EA must provide specific and extensive details of how dust, noise and odour emissions will be managed at the site, to the satisfaction of DECCW.

Stockpile management

- The EA should outline how stockpiles of material (both "clean", contaminated and post-treatment) will be handled and managed at the site, including:
  - Labelling of stockpiles for identification, ensuring that all material is clearly identified and stockpiled separately from other types of material;
  - Proposed height limits for all materials to reduce the potential for dust and odour;
  - Timeframes for moving stockpiles of pre-treated contaminated material to the PTB to ensure that it is completed quickly to minimise dust and odour issues;
  - Procedures for minimising the movement of contaminated material around the site and double handling;
  - Measures to minimise contaminants leaching from stockpiles into the surrounding environment, such as sediment fencing, geofabric liners etc; and
  - How the post-treatment stockpiles will be stabilised and stored prior to backfilling at the site.

Hazards

- The EA must include a Preliminary Hazard Analysis (PHA) of the treatment facility including a detailed assessment of the potential off-site risks.

Visual

- The EA must include an assessment of the visual impact of the treatment facility (height, scale and lighting) on the local and regional area, particularly on any adjoining land owners and significant vantage points in the public domain.

Sampling

- The EA must include details of sampling methodology and regime used at the site to ensure:
  - Appropriate characterisation of site areas;
  - Appropriate handling and management; and
  - Frequency and timeframes for sampling to minimise extended stockpiling of contaminated material.

Contingency plans

- The EA must outline contingency plans for any event that affects contaminated soil treatment operations at the site, particularly in relation to the DTD Plant.

Traffic

- The EA must consider the impacts of extra traffic and truck movements as a result of the project including:
  - details of the traffic that would be generated by the project;
  - transport routes;

- traffic management procedures for onsite traffic; and
- navigation and safety impacts on other road users as a result of the transport of any contaminated material.

8. References

The environmental assessment of the key issues listed above must take into account relevant guidelines, policies, and plans. While not exhaustive, the following attachment contains a list of some of the guidelines, policies, and plans that may be relevant to the environmental assessment of this project.

Guidelines, Policies and Plans

Aspect	Policy /Methodology
Risk	
	AS/NZS 4360 Risk Management (Standards Australia)
	HB 203:2006 Environmental Risk Management – Principals and Process
Contamination	
	Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (ANZECC & NHMRC)
	National Environment Protection (Assessment of Site Contamination) Measure (NEPC)
	EnHealth – Environmental Health Risk Assessment – Guidelines for assessing human health risks from environmental hazards
	Managing Land Contamination - Planning Guidelines SEPP 55 – Remediation of Land (DUAP and EPA)
	Contaminated Sites: Sampling Design Guidelines (NSW EPA)
	Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites (NSW EPA)
	Contaminated Sites: Guidelines for the NSW Auditor Scheme (NSW EPA)
	Contaminated Sites: Guidelines on Significant Risk of Harm from Contaminated Land and Duty to Report (NSW EPA)
	Guidelines for the Assessment and Management of Groundwater Contamination (DECC)
Traffic and Transport	
	Guide to Traffic Generating Development (RTA)
	RTAs Road Design Guide (RTA)
Air Quality	
	Technical Framework: Assessment and Management of Odour from Stationary Sources in NSW (DEC)
	Technical Notes: Assessment and Management of Odour from Stationary Sources in NSW (DEC)
	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC)

	Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (DEC)
	Protection of the Environment Operations (Clean Air) Regulation
Soil and Water	
Soil	Managing Urban Stormwater: Soils & Construction (Landcom)
Surface Water	Managing Urban Stormwater: Treatment Techniques (EPA)
	Managing Urban Stormwater: Source Control. Draft (EPA)
	Managing Urban Stormwater: Harvesting and Reuse (DEC)
	National Water Quality Management Strategy - Guidelines For Water Recycling: Managing Health And Environmental Risks (Phase1) (EPHC, NRMMC & AHMC)
	National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ);
	National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ);
	Using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC);
	Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC)
	Storing and Handling Liquids: Environmental Protection - Participants Manual (DECC)
	Environmental Compliance Report: Liquid Chemical Storage, Handling and Spill Management - Part B Review of Best Practice and Regulation (DEC)
Health	
	Environmental Health Risk Assessment Guidelines for Assessing Human Health Risks from Environmental Hazards (Department of Health and Ageing and enHealth Council)
Flora and Fauna	
	Policy & Guidelines - Aquatic Habitat Management and Fish Conservation (NSW Fisheries)
	Primefacts. Mangroves (DPI)
	Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities. Working Draft (DEC)
	Draft Guidelines for Threatened Species Assessment under Part 3A of the *Environmental Planning and Assessment Act 1979* (DEC)
Hazards	
	Multi-Level Risk Assessment (DUAP)
	Hazardous Industry Planning Advisory Paper No 6 - Guidelines for Hazard Analysis
Noise	
	Industrial Noise Policy (DEC)
	Environmental Criteria for Road Traffic Noise (DEC)
	Environmental Noise Control Manual (DEC)

Waste	
	Waste Classification Guidelines 2008 (DECC)
	Environmental guidelines: Solid Waste Landfills (NSW EPA)

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C.M. Jewell & Associates Pty Ltd

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Water and Environmental Management

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Ref: J1196.15L
27 August 2010

Orica Australia Pty Ltd
16-20 Beauchamp Road
MATRAVILLE NSW 2036

Attention: Mr Ben Dewhurst

Dear Ben

Site Audit - 2 Christina Road, Villawood

This is to confirm that I have completed review of the Human Health and Environmental Risk Assessment, Orica Villawood, prepared by URS Australia Pty Ltd (ref. 43217484, dated 12 August 2010) and the Remedial Action Plan, prepared by AECOM Australia Pty Ltd (ref. S4149701, dated 2 June 2010).

Following discussions with URS and AECOM, and incorporation of some minor amendments, I am satisfied that the Remedial Action Plan is suitable and appropriate.

The Site Audit Report is in preparation and should be available in approximately four weeks time.

This communication has been provided as interim advice only. Where applicable, the information provided is consistent with NSW EPA (DEC) guidelines and policies. The advice does not constitute a site audit report or site audit statement and does not pre-empt the conclusions which will be drawn at the end of the audit process. A site audit report and site audit statement will be issued when the audit process has been completed.

For and on behalf of
C. M. JEWELL & ASSOCIATES PTY LTD

CHRIS JEWELL

Site Auditor accredited under the
Contaminated Land Management Act 1997

1196

Villawood ben.dewhurst@orica.com

To:	**chris@cm-jewell.com.au**
Subject:	**Villawood**
From:	**ben.dewhurst@orica.com**
Date sent:	**Tue, 19 Oct 2010 09:12:33 +1100**

Chris,

We had a meeting between DECCW and Orica regarding the HHERA and RAP documents. I have attached the DECCW comments and the proposed revisions (RAP) below.

We have been asked to include a scenario for basements in the areas above the off site groundwater plumes (which is highly disappointing given this was not requested following the 2007 version which was issued to DECCW). We only have sub slab and shallow soil gas data so it may need an additional investigation at depth to enable this so it might not be able to be included in the current document given the timing of the EA issue (this week.).

DECCW Comments

- Remediation areas in the RAP are different to the risk areas within the HHERA – would be appropriate if they were realigned to enable transparent communication with stakeholders.
  - The RAP has blue shaded areas in the figures (s4.6) – are these the areas to be excavated? No where in the report does it actually say that.
  - In area 1b the explanation for the max depth of excavation is not sufficient and the only contaminant mentioned for this area is monochlorobenzene but there are also very high levels of DDX at depth (pg 50)
  - Areas of open excavation are to be limited at any one time, it is expected that all open excavations will be covered at the end of each day with tarpaulins and whenever not being actively excavated – this will be a requirement in the licence so would be good to include in the RAP
  - Regardless of criteria, if contamination remains at depth below proposed excavation depths soil (material above unweathered rock) is to be removed and treated to the extent practicable – which needs to be appropriately justifiable.
  - All crystalline DDT will be removed. It is expected that this material will be chased out.
  - Treatment goals need to be as close as possible to the CCOs
  - RAP section 12.2 does not mention that an EPL exists or is needed (pg 63)
  - Technology Assessment – As discussed, specific requirements for a technology assessment will need to be discussed with Andrew Hawkins (9995 5793).
  - Off site areas – could basements be part of any proposed redevelopment? If so then risk assessment needs to have a scenario added. How deep is groundwater on that side of the road? Would normal construction intersect groundwater? If so, then risk assessment needs to have a different intrusive worker scenario. *Not necessarily a requirement for the EA.*
  - Some issues with vapour intrusion both on and off site need to be further discussed with Jackie Wright to clarify size of dilution.
  - Validation of area 4 and 6 –the HHERA says that the information available does not allow confirmation that the contaminated material in these areas was removed in early works but the RAP assumes that all the contaminated materials in these areas have been removed –this needs to be clarified

Revisions to the RAP

Remediation areas as indicated in the RAP are not consistent with the ISZs in the HHERA document.

Although we have correctly identified which ISZs require remediation based on the risk approach adopted in the HHERA, we haven't provided enough detail explaining the decision process. See below:

Sections 4.6.1, 4.6.2 and 4.6.9

Although we provide mention of this in Section 8.2, the areas 1a, 1b and 8 have been combined in the RAP with limited explanation as to why. The reasons for doing so are based on the data but the wording needs to clarify the decision. We need to add a paragraph at the start of Section 4.6 to clarify why we have combined these ISZs.

Section 4.6.3

In Section 8.1, we indicate that ISZ 2 doesnt warrant remediation, which isnt clear in Section 4.6.3. I think the paragraph from Section 8.1 can also be reiterated in Section 4.6.3.

We also include ISZ 2 in the combined area Figures F4 and F7 (Soil Zones 1a, 1b, 8 and 2).

Section 4.6.6 Impacted Soil Zone 5

In the HHERA, ISZ 5 has three areas, but the RAP only specifies two that require remediation. While this is correct, more detail needs to be included as to why the third area has been excluded.

The HHERA does not provide detail on what areas will be excavated. Jackie will be adding words to the HHERA that feed into that decision process, which should also provide more clarity between the documents.

Section 4.6.5 Impacted Soil Zone 4

We need to state that this area does not form part of the RAP given remediation activities have been undertaken.

In this section, (although we provide an overview in Section 4.6.14) we dont actually state any detail on remediation activities (volumes or whether validation data indicated that the areas were remediated). According to the CH2 report, 3057 m3 of material was removed from RAP Area 4 (combined CH2 validation areas 3 and 4) to the extent practicable (excavation undertaken to shale bedrock at a maximum depth of 4 mbgl) with excavated material stored in the SSF. Sampling of the walls and base of the excavations was undertaken to validate the remaining material for the CoC and the excavation was backfilled using validated VENM.

Section 4.6.7 Impacted Soil Zone 6

We need to state that this area does not form part of the RAP given remediation activities have been undertaken.

In this section, (although we provide an overview in Section 4.6.14) we dont actually state any detail on remediation activities (volumes or whether validation data indicated that the areas were remediated). According to the CH2 report, 700 m3 of material was removed from RAP Area 6 (combined CH2 Finished Goods and Trade Waste areas) to the extent practicable (excavation undertaken to shale bedrock at a maximum depth of 1 mbgl) with excavated material stored in the SSF. Sampling of the walls and base of the excavations was undertaken to validate the remaining material for the CoC and the excavation was backfilled using validated VENM.

Defining Excavation Areas

We need to add a comment that the areas shaded blue in the RAP figures are the areas which are planned for excavation. Although this may seem obvious, it requires a comment nonetheless.

Depth of Excavations

Although we have indicated an approximate depth of excavation in each area (Section 8), the potential exists for contaminants to remain at depths below those estimates. Although we have indicated that we will be validating to the RBSWC, we need to specify that we will continue to excavate beyond the depths estimated to the extent practicable if necessary. We need to be specific that all DDT crystals

will be removed.

Extent of Depth of Area 1b

Even though the comment "Continued excavation further into the weathered shales beyond 4.0 m bgl at this location was not possible using a 20T excavator due to the presence of 'very, very hard' shales (refer to the Trench Logs, HLA 2006a)." indicates that the extent practicable is the*very very hard shales,* we need to include more evidence. Adding reference to borehole log BP106 which is located in the centre of the area will provide further justification that the shale is the extent practicable (4.0 m), not the reach of the excavator, as DECCW believe this is the current argument.Please expand the text to reiterate that the shale is the extent practicable.

Section 8.3

Table indicates that MCB is the main CoC, however we should also include DDX which has been identified at a depth of 3.5 mbgl.

Section 12.2

We need to include reference to existing EPL. We dont comment that an EPL will be required for the remediation works. Also include most recent EPL in relevant Appendix.

Regards,

Ben Dewhurst
Environmental Projects Manager

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APPENDIX D

Auditor's Assessment of the Consultants' Use of Data Quality Objectives, Data Quality Indicators, Quality Assurance/Quality Control

7.0 DATA QUALITY OBJECTIVES CHECKLIST

The Guidelines for the NSW Site Auditor Scheme (2nd edition, April 2006) state that site auditors must check that a consultant has properly addressed and adopted Data Quality Objectives (DQOs) for the investigation or validation program (as outlined in the checklist below), and that the consultant's report includes the following:

- *a statement of pre-determined DQOs for field and laboratory procedures, including quantitative DQOs;*
- *a plan to achieve pre-determined DQOs; and*
- *procedures to be undertaken if the data do not meet the expected DQOs.*

Generally, the DQOs should include, or address, the following:

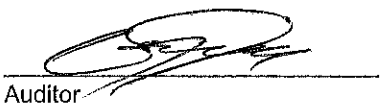
DQO Steps and Outputs		Comments
Note: The timing for the various stages of the project must be clearly understood by all parties prior to commencing any work on the project. The DQO process must be commenced before any investigative work begins on the project.		
A concise description of the problem.	✓	
A list of the planning team members and a decision maker.	✓	
A summary of available resources and relevant deadlines for the study.	✓	
A conceptual model of the site based on information prior to the commencement of the investigation/validation.	✓	
A decision statement that links the principal study question to actions that will solve the problem.	✓	
A list of informational inputs needed to resolve the decision statement.	✓	
A list of environmental variables or characteristics to be measured.	✓	
Information required to allow informed decisions to be made to address the decision statements.	✓	
Identification of the media (fill, soil, groundwater) to be investigated/ validated.	✓	
Identification of the criteria for each medium.	✓	
Identification of the analytical methods required for chemicals of concern relative to the site criteria.	X	Not appropriate at this time
Identification of defined concentrations for field screening (and a response if reached).	X	
Any other information required to make decisions.	✓	
A detailed description of the spatial and temporal boundaries of the problem.	✓	
Identification of any practical constraints that may interfere with the study.	✓	
Definition of acceptable limits for: chemicals of concern detected in field blanks; recoveries of laboratory spike additions; and RPDs of matrix spike and matrix spike duplicates.	✓	
Identification of the statistical parameters of interest that characterise the population (e.g. 95% UCL).	✓	
A statement that the criteria exceed the laboratory reporting limits.	✓	
Any contingency measures.	✓	
Justification of decision error rates based on a consideration of the consequences of making an incorrect decision.	✓	
Was data collection optimised?	X	N/A
Was a sampling analytical and quality plan (SAQP) developed and provided?	X	N/A

Adequacy

Are the DQOs, as outlined above, provided by the consultant adequate for the purpose of this audit?
DQOs are provided in the validation plan for work to be carried out under the RAP.

Yes	No
✓	

If no, provide comments above as appropriate.



Auditor

19/3/12

Date

8.0 REPORTING OF FIELD AND LABORATORY QUALITY ASSURANCE AND QUALITY CONTROL

*This section is based on Appendix V of the Guidelines for the NSW Site Auditor Scheme (2006). It contains the essential issues **'which must be included in the quality assurance program'** conducted by a contaminated site consultant during site assessment and remediation processes.*

Item		Comments
Does the consultant's site assessment report include a QA/QC narrative describing all information relevant to the site assessment?		Supporting Reports
Does the consultant's sampling program include assessment of all relevant environmental media, including: Soil		
Dust		
Surface water		
Groundwater		
Air		
Sediments		
Biota		
Is the sampling strategy clearly defined and justified on the basis of project objectives, site conditions and history?		
Sampling strategy is: ☐ Systematic ☐ Random ☐ Stratified ☐ Judgemental ☑ Combination		
Was the sampling strategy appropriate for the conditions at the site and the nature of the contamination?		Supporting Reports
Is the rationale for the strategy described in the consultant's report?		
Does the rationale include: Sampling pattern		
Sampling density		
Estimated size of residual hotspots that may remain undetected		
Sampling depths		
Analytes		
Analytical methods		
Were all samples analysed for all analytes of concern?		
Justification of decisions concerning samples to be analysed and samples not to be analysed		
Does the number of sample locations comply with EPA sampling design guidelines?		
Are divergences from guidelines adequately justified?		
Is overall coverage of site adequate?		
Are the sampling locations shown on a scaled site sampling plan?		
Are sample depths stated?		
Are borehole/test pit logs provided?		
Was sampling investigation depth sufficient?		
Was fill material adequately investigated?		
Was number of depth samples sufficient to give adequate coverage of profile?		
Are sample collection, handling and transportation procedures documented and appropriate to meet the project DQOs?		
Was sampling representative of site conditions, based on the selection of appropriate number of sampling points and of samples from each relevant strata and material types stated in a site sampling plan to meet the project DQOs?		
Are sampling procedures adequately described?		
Are sampling procedures adequate and appropriate for the site?		
Was composite sampling used?		
Were composite samples laterally adjacent?		
Were composites from the same depth interval?		
Were samples for analysis for volatile analytes composited?		

8.0 REPORTING OF FIELD AND LABORATORY QUALITY ASSURANCE AND QUALITY CONTROL

Adequate description of investigation methods?		Supporting Reports
Sampling equipment description (including drilling plant)		
Has an assessment of the reliability of field procedures been undertaken by the consultant by using the Data Quality Indicators (DQI) (precision, accuracy, representativeness, completeness and comparability)?		
Were the appropriate media sampled according to SAQP?		
Have all media identified in SAQP been sampled?		
Are SOPs appropriate and complied with?		
Have all critical locations been sampled?		
Have all required samples been collected (from grid and at depth)?		
Was an experienced sampler used on each occasion?		
Is the documentation correct?		
Have the same SOPs been used on each occasion?		
Have comparisons been made regarding climatic conditions (temperature, rainfall, wind, etc.)?		
Were the applicability and limitations of field methodology discussed appropriately in the consultant's report?		
Has the consultant ensured adequate calibration of instruments?		
[EPA] Has the consultant's report adequately assessed the significance of the results of field screening methods compared with the results of laboratory analyses, for example that the results reported for field screening using a photo-ionisation detector are compatible with the results reported by the laboratory for volatile organic compounds?		
[CMJ] Have the results of screening methods and laboratory analyses been compared and discussed (including an explanation of non-compatibility)?		
[CMJ] Where not compatible, has the consultant's report adequately explained this?		
Are the applicability and limitations of any screening methodology used by the laboratory appropriately discussed in the consultant's report?		
Is screening method performance known and expressed as a multiple of specific analytical method performance?		
Has a field QA/QC plan been included in the consultant's report?		
Does the report include details of the sampling team?		
Does the report include details of sampling method(s), including the actual methods employed for obtaining samples, sample devices and equipment, type(s) of sample containers and seal used, order and degree of filling, preservation, labelling, logging, custody?		
Does the report include details of evidence of appropriate decontamination procedures carried out between sampling events?		
Does the report include details of logs for each sample collected showing time, location, initials of sampler, duplicate locations, duplicate type, chemical analyses to be performed, site observations and weather conditions?		
Does the report include details of chain-of-custody documentation fully identifying for each sample:		
Name of sampler		
Nature of sample		
Collection date		
Analyses to be performed		
Sample preservation method		
Departure time from the site		
Dispatch courier(s)		
Condition of samples at dispatch		
Does the report include details of sample splitting techniques?		
Does the report include details of a statement of duplicate frequency for intra-laboratory and inter-laboratory duplicate samples and duplicate sample results?		
Does the report include details of background sample results		
Does the plan include details of rinsate sample results?		

8.0 REPORTING OF FIELD AND LABORATORY QUALITY ASSURANCE AND QUALITY CONTROL

Does the report include details of laboratory-prepared trip spike results for volatile analytes?		
Does the report include details of trip blank results?		
Does the report include details of field instrument calibrations on-site (when used)?		
Does the consultant's field QA/QC program include replicate samples split in the field and submitted to two separate laboratories in accordance with the requirements of the National Environment Protection (Assessment of Site Contamination) Measure 1999?		
Has an assessment of the reliability of analytical results has been undertaken by the consultant by using the Data Quality Indicators (DQI) (precision, accuracy, representativeness, completeness and comparability)?		
Have all samples been analysed according to SAQP?		
Analysis of: Intra-laboratory and inter-laboratory duplicates with RPDs		
Field duplicates with RPDs		
Laboratory-prepared volatile trip spikes		
Analysis of: Field blanks		
Rinsate blanks		
Reagent blanks		
Method blanks		
Matrix spikes		
Lab duplicates		
Matrix spike duplicates		
Surrogate spikes		
Reference materials (CRM)		
Laboratory control samples		Supporting Reports
Laboratory-prepared spikes		
Have all critical samples been analysed according to the SAQP?		
Have all analytes been analysed according to the SAQP?		
Have appropriate methods and PQLs been used?		
Is sample documentation complete?		
Have sample holding times been complied with?		
Have the same analytical methods been used (including extraction and clean-up)?		
Sample PQLs (justify/quantify if different)		
Same laboratories (justify/quantify if different)		
Same units (justify/quantify if different)		
Are the analytical methods used for site validation of appropriate precision and accuracy?		
Are the sensitivity and selectivity of the analytical methods appropriate for the assessment of the risk?		
Do the precision and accuracy criteria set out in the consultant's QA/QC plan, for a given method and matrix, meet the performance expected of the reference method?		
Has the consultant included in their reports written documentation on quality of data supplied by the analytical laboratory which meets the objectives of the testing laboratory's quality plan for at least 95% of test results?		
Names of the accredited laboratories used and relevant details of their accreditation for each analytical method.		
A statement that laboratories were accredited for all analyses by the National Association of Testing Authorities (NATA) or an equivalent (government-endorsed provider of accreditation for laboratories).		
A statement that sample analyses use appropriate methodologies for each potential contaminant in the matrix.		

8.0 REPORTING OF FIELD AND LABORATORY QUALITY ASSURANCE AND QUALITY CONTROL

A statement that Practical Quantitation Limits are appropriate for the chemicals of concern for use in the assessment of risk.		
A copy of signed chain-of-custody forms acknowledging receipt date and time, conditions of samples on receipt and identity of samples included in shipments.		
Record of holding times and a comparison with method specifications.		
Analytical methods used.		
Laboratory accreditation for analytical methods used.		
Laboratory performance in inter-laboratory trials for the analytical methods used, where available.		
Acceptance limit(s) for each QC test, such as duplicate relative percentage differences (RPDs) and recoveries for laboratory quality control analyses.		
Where used, the origin of certified reference material (CRM), its batch number and the concentrations of the chemicals of potential concern.		
Results for blind duplicate samples collected from the field.		
Description of surrogates and spikes used		
Per cent recoveries of spikes and surrogates		
Instrument detection limit		
Method detection limits		
Matrix or practical quantification limits		Supporting Reports
Standard solution results		
Reference (CRM) sample results		
Daily check sample results		
Laboratory (reagent/method) blank results		
Laboratory standard charts		
The laboratory specifying compliance with the requirements of the NEPM and equivalence with the reference method or non-standard methods.		
Does the consultant's site assessment report address all the QA/QC checklist items in the Guidelines for Consultants Reporting on Contaminated Sites (EPA 1997) related to field quality assurance and quality control, laboratory QA/QC and data evaluation QA/QC reporting?		
QC results relevant to the sample analysis.		
For each sample, the highest measurement result wherever replicate measurements are taken (or all measurement results for each sample).		
Results for all data tabulated separately according to each type of soil, fill materials, groundwaters, surface waters and sediments, with appropriate statistical analysis according to the National Environmental Protection (Assessment of Site Contamination) Measure 1999 requirements.		
Is a QA/QC narrative that substantially complies with DEC (2006) and EPA (1997) guidelines included in the report?		

9.0 AUDITOR'S REVIEW OF FIELD AND LABORATORY QUALITY ASSURANCE AND QUALITY CONTROL

Adequacy

Is the QA/QC information, as outlined above, provided by the consultant, adequate for the purpose of this audit?

Yes	No
✓	

If no, provide comments as appropriate.

Supporting Reports

Adequacy of Fieldwork and Methods

In addition to the QA/QC information provided by the consultant, are the QA/QC samples obtained by the consultant and their associated laboratory results, adequate for the purpose of this audit?

Yes	No
✓	

If no, provide comments as appropriate.

Supporting Reports

Adequacy of Laboratory

In addition to the QA/QC information provided by the consultant, are the laboratory QA/QC procedures sufficient to ensure that the laboratory results are adequate for the purpose of this audit?

Yes	No
✓	

If no, provide comments as appropriate.

Supporting Reports

Data Usability

In summary, are the field and laboratory analytical data provided of adequate quality for the purpose of this audit?

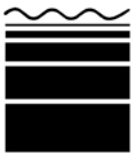
Yes	No
✓	

Comment further as necessary.

Supporting Reports

Auditor

19/3/12
Date



APPENDIX E

Risk Assessment Checklists

APPENDIX E

Risk Assessment Checklist

The Guidelines for the NSW Site Auditor Scheme (2nd edition, April 2006) state that the following checklist must be used by an auditor to review any human health risk assessments undertaken by a consultant. Where the auditor's check reveals that the consultant's risk assessment has omitted one or more of the points specified in the checklist, the auditor must document this in the site audit report and take this into account in reaching their site audit conclusions.

Title of Report: 2 Christina Road, Villawood - Section 4N Audit

Report Number: J1196.14R-rev0

Item	C = Compliance P = Partial Compliance N = Non-compliance NA = Not Applicable	Comments
Hazard Identification		
Have all appropriate sources of information regarding chemicals of potential concern been identified and appraised	**C**	Extensive site history review and sampling programs.
Has justification been given for the selection of the chemicals of potential concern?	**C**	Sections 3.3 to 3.7 and included tables.
Has justification been given for the omission of chemicals from the analysis?	**C**	Sections 3.3 to 3.6
Toxicological Information		
Have all relevant toxicological facts been checked for accuracy and currency?	**C**	Section 4.2 and Appendix D
Has the adequacy of the available toxicological database been commented on?	**C**	Appendix D
Have the effects on each body system (for example renal, hepatic, cardiovascular and developmental) and the types of effects (for example genotoxic and carcinogenic) been summarised?	**C**	Appendix D
Have all relevant allergic/idiosyncratic toxicological effects been noted?	**C**	
Have the critical toxic effects been identified?	**C**	
Has the experimental basis of the toxicological reference dose or potency factor, where applicable, been discussed and the uncertainties noted?	**C**	
Have the NHMRC (where applicable) or World Health Organisation (WHO) toxicological assessments been considered as the primary toxicological resource?	**C**	Section 4.1.3
Where relevant, have differences between, for example, WHO and US Environmental Protection Agency (USEPA) toxicological assessments been discussed?	**C**	Appendix D
Has the dose-response relationship for chemicals of potential concern been discussed?	**C**	Sections 4.1.1 and 4.1.2, and Appendix D

APPENDIX E

Risk Assessment Checklist

Item	C = Compliance P = Partial Compliance N = Non-compliance NA = Not Applicable	Comments
Has the data been presented in a form amenable to efficient interpretation and review?	**C**	Clear tables
Exposure Assessment		
Has the potentially exposed population been identified?	**C**	Section 5.2
Have potentially exposed, unusually susceptible sub-populations been identified?	**C**	For example, brothel in industrial area.
Have the estimates of chemical exposure for each exposure route and chemical of potential concern been quantified and tabulated?	**C**	Tables 5.2 and 5.3
In cases of presumed insignificant risk, has the risk been demonstrated to be small?	**C**	
Has the relative significance of each exposure pathway, based on the risk analysis, been discussed?	**C**	Sections 5.2 and 6.3
Equations		
Have all equations used in the risk assessment been presented in the report?	**C**	Section 5.3, Appendix F
Are all equations consistent?	**C**	
Have all parameters in each equation been clearly defined?	**C**	
Have the correct units been allocated to each parameter?	**C**	
Are all equations dimensionally correct?	**C**	
Have all unit conversion factors, where applicable, been included in the equations?	**C**	
Has all pertinent information been provided to enable calculations to be checked through in a step-wise process?	**C**	
Data Evaluation		
What were the data collection objectives and are they consistent with the requirements of the risk assessment?	**C**	Initial objectives, site characterisation, later objectives specifically risk focussed.
Have the laboratories that did the chemical analyses been noted, and do they have NATA accreditation (or equivalent) to perform each particular chemical analysis?	**C**	HLA/AECOM reports
Has laboratory QA/QC been reported and analysed?	**C**	HLA/AECOM reports
Has field QA/QC been reported and analysed?	**C**	HLA/AECOM reports
Where appropriate, has the size of any ‘hot spot’ detected by the sampling pattern been stated?	**NA**	

APPENDIX E

Risk Assessment Checklist

Item	C = Compliance P = Partial Compliance N = Non-compliance NA = Not Applicable	Comments
Have statements of the accuracy of the laboratory data for each contaminant been made?	**C**	HLA/AECOM reports
Assessment and Report Presentation		
Have all tables and figures been referred to correctly in the text of the report?	**C**	
Has information from other sites been excluded from the report?	**C**	
Has information from previous reports on the site been appropriately selected and incorporated into this report?	**C**	
Have all assumptions and default data been identified and justified?	**C**	
Has the analysis been based on an up-to-date literature appraisal?	**C**	
Have all conclusions been justified?	**C**	
If toxicological data and the exposure scenario lead to the conclusion that a high concentration of contaminant is permissible, does the result violate ecological, aesthetic, land-use or physical principles?	**C**	RBSC and RSGC have been calculated. The values presented are justified by the data for a specific exposure setting.
Has a risk management decision been made during the course of the risk assessment and, if so, how might that have influenced the calculation of risk?	**C**	Risk management considerations relate to the industrial / commercial proposed land use and are reasonable.
Has a detailed uncertainty discussion been included in the report?	**C**	Section 10
Has information been presented coherently and in an appropriate sequence to enable efficient appraisal of the report?	**C**	

APPENDIX E

Risk Assessment Checklist

Uncertainty Assessment			
Assumption	**Effect on Exposure**		
	Potential Magnitude for Over-Estimation of Exposure	**Potential Magnitude for Under-Estimation of Exposure**	**Potential Magnitude for Over- or Under-Estimation of Exposure**
Exposure Assessment ***Environmental Sampling and Analysis*** Sufficient samples may not have been taken to characterise the media being evaluated (soil vapour only).			Low
The data collected for groundwater and air from the Orica Villawood site has been based on the knowledge of the site hydrogeological conditions (both on and off site) and former site activities. The selection of analytes has been based on knowledge of former site activities and hence has focussed on chemicals which were known to have been formerly used at the site. There is the potential for chemicals to be present on the site which have not been characterised based on omission from site history records. *The soil and air concentrations utilised in this risk assessment have been collected by HLA, CH2M HILL and URS, however, there is uncertainty in the sampling protocols and collection methods utilised by CH2M HILL as the data has not been formally reported. The HLA soil gas and flux emissions data has not been assessed with respect to quality assurance. The data collected by URS has been reported and assessed in the relevant reports (URS 2007 and 2009).* *The assessment of risk presented in the HHERA has used maximum concentrations reported to be conservative. In the absence of necessary information the assumptions which have been documented in this report in relation to the adoption of air concentrations reported are conservative.* *No specific data gaps have been identified, however, the following area that might warrant further consideration to reduce uncertainty in the available data:* *Air data collected from a number of sampling programs show variability in chemicals detected as well as concentrations reported. For on-site areas sufficient data is available to enable risk issues to be identified for the purpose of remediation. Further sampling of soil gas in off-site areas, where remediation is not expected might be required to further assess the potential variability. Given the number of off-site vapour sampling rounds conducted, it is expected that an additional two or three sampling rounds (addressing other seasons) might be required to adequately address the variability.*	Low	Low Low-moderate	Low-moderate

APPENDIX E

Risk Assessment Checklist

Uncertainty Assessment			
Assumption	**Effect on Exposure**		
	Potential Magnitude for Over-Estimation of Exposure	**Potential Magnitude for Under-Estimation of Exposure**	**Potential Magnitude for Over- or Under-Estimation of Exposure**
Exposure Parameter Estimation *The standard assumptions regarding body weight, period exposed, life expectancy, population characteristics, and lifestyle may not be representative of any actual exposure situation.*			Low
This risk assessment includes assumptions about general characteristics and patterns of human exposure relevant to the Orica Villawood site and surrounding area. The assumptions used are conservative and developed to provide an estimate of reasonable maximum exposures rather than the actual exposures.	Low		
The assessment has been completed using upper bound concentrations reported within soil, groundwater and air reports.	Low		
Given the uncertainty in the estimate of intake via dermal exposure, intake has been calculated using the method of Hawley (1985), SEDISOIL (1996) and CSOIL (2001), as well as the standard USEPA method.	-	-	-
It should be noted that comparison chemicals with the exception of PAHs using the USEPA approach which uses chemical specific absorption (based on a 24 hour exposure) which results in a more conservative calculated risk. It should be noted that PAHs are not a significant COPC at the Orica Villawood site. In general, the calculated risks presented by both approaches (with the exception of PAHs) are consistent and the outcomes and conclusions of the risk assessment are also consistent with the adoption of either approach.			Low
The assessment of exposure by workers in off-site areas above Plumes 1 and 2 has considered workers may spend longer periods of time (each day) at the premises. If exposures were assumed to occur above Plume 2 (where higher risks have been calculated), for 24 hours per day, 365 days per year for a 5 year period, then inhalation risks would be higher.		Low	
Toxicological Assessment ***Interspecies variability*** - extrapolation from laboratory animals (rates in the case of (-BHC) to humans.			Moderate
Uncertainty associated with differences between animal and human exposure routes.			Moderate

APPENDIX E

Risk Assessment Checklist

Uncertainty Assessment			
Assumption	**Effect on Exposure**		
	Potential Magnitude for Over-Estimation of Exposure	**Potential Magnitude for Under-Estimation of Exposure**	**Potential Magnitude for Over- or Under-Estimation of Exposure**
Intraspecies variability - extrapolation from short term subchronic studies to chronic exposures.			Low
Use of linearised multistage model for slope factor determination (US EPA data).	Low		
In order to adjust for these uncertainties, ADIs and RfDs incorporate safety factors that may vary from 10 to 1000. The US EPA assumes that humans are as sensitive to carcinogens as the most sensitive animal species. The policy decision, while designed to minimise the potential for underestimating risk, introduces the potential to over-estimate carcinogenic risk. It also does not allow for the possibility that humans may be more sensitive than the most sensitive animal species. The model used by the US EPA to determine slope factors is a linearised multistage model, which provides a conservative estimate of cancer risk at low doses and is likely to overestimate the actual slope factor. It is assumed in this approach that a genotoxic mechanism applies, however, most carcinogens do not actually cause cancer by this mechanism. *The result is that the use of slope factors has the general effect of overestimating the incremental cancer risks.*	*Low*		
The approach for evaluating risks to mixtures of chemicals assumes dose additively and does not account for potential synergism, antagonism or differences in target organ specificity and mechanism of action. In general, the additively approach has the effect of over-estimating the risks. This is because chemicals that have no additive effects are included together as well as chemicals that may have additive effects.	*Low*		

[1] As a general guideline, assumptions marked as "low" may affect estimates of exposure by less than one order of magnitude; assumptions marked "moderate" may affect estimates of exposure by between one and two orders of magnitude; and assumptions marked "high" may affect estimates of exposure by more than two orders of magnitude. (Adapted from US EPA, 1989.)