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Orica Botany Groundwater Project

GROUNDWATER CLEANUP PLAN PROGRESS REPORT No. 21

REPORT NO. EN.1591.61.PR030

REVISION 0

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REVISION HISTORY

REV	STATUS	DATE	PREPARED	CHECKED	AUTHORISED
0	Issued to DECC	27/02/09	S Corish	J Stening	G Richardson

DISTRIBUTION

1. Matthew Hart, Contaminated Sites Section, DECC (hard copy with 2 copies of Attachments A).
2. George Gates, DWE (CD Version)
3. Santo Cannata, SESPHU (hard copy)
4. Geoff Richards, NSW Health (hard copy)
5. Paul Shepherd, CoBB (hard copy)
6. John Kent, CLC Chair (hard copy with CD for Attachment A)
7. Prof. Ian Acworth, IMC (hard copy)
8. John McCracken, IMC (hard copy without Attachments A)
9. Prof. Brian Priestly, IMC (hard copy without Attachments A)
10. Dr Mark Hibberd, IMC (hard copy without Attachments A)
11. Chris Clunies-Ross, IMC (hard copy without Attachments A)
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18. Marianne Lloyd-Smith, National Toxics Network (CD version)
19. Botany Central Library, Westfield Eastgardens (two CD versions, with one to be forwarded to Mascot Library, 2 Hatfield Street Mascot)
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LIST OF ACRONYMS

ACRONYM	DEFINITION
ADWG	Australian Drinking Water Guidelines
AHD	Australian Height Datum
ANZECC	Australia and New Zealand Environment and Conservation Council
BEW	Botany Environment Watch
BEREPA	Botany and Eastern Region Environment Protection Agency
BGC Project	Botany Groundwater Cleanup Project (hydraulic containment and treatment project as described in the EIS)
BGL	Below ground level
BGP	Botany Groundwater Project (entire set of activities pertaining to Orica's contamination of the BIP and environs)
BIP	Botany Industrial Park
BP	Bundle piezometer
CFM	Chloroform (trichloromethane)
CHC	Chlorinated hydrocarbon
cis-1,2-DCE	cis-1,2-dichloroethene
CoBB	City of Botany Bay
COPC	Chemical of potential concern
CTC	Carbon tetrachloride (tetrachloromethane)
CLC	Community Liaison Committee
DEAC	Diethyl aluminum chloride
DEC	Department of Environment and Conservation, incorporates the EPA and is now DECC
DECC	Department of Environment and Climate Change, formerly DEC
DIPNR	Department of Infrastructure, Planning and Natural Resources (former NSW Government department, separated into DoP and DNR)
DNAPL	Dense non-aqueous phase liquid
DNR	Department of Natural Resources (formerly part of DIPNR, now part of DWE)
DWE	Department of Water and Energy
DoD	Department of Defence
DoP	Department of Planning (formerly part of DIPNR)
EDC	Ethylene dichloride (1,2-dichloroethane)
EIAD	Environmental Impact Assessment Document
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
EPL	Environmental Protection Licence
EP&A Act	Environment Planning and Assessment Act
GAC	Granular activated carbon
GCP	Groundwater Cleanup Plan
GEEA	Groundwater Extraction Exclusion Area
GTA	General Terms of Approval
GTP	Groundwater Treatment Plant
HCB	Hexachlorobenzene
HCBD	Hexachlorobutadiene
HHRA	Human Health Risk Assessment
IMC	Independent Monitoring Committee

ACRONYM	DEFINITION
ISCO	In Situ Chemical Oxidation
JBS	JBS Environmental Pty Ltd, an environmental consultancy
KBR	Kellogg, Brown and Root Pty Ltd, Engineering Contractor for many sub-projects of the BGP
KMH	KMH Consulting Pty Ltd, independent compliance auditor for the BGP
MoU	Memorandum of Understanding
NCUA	Notice of Clean Up Action
NHMRC	National Health and Medical Research Council
NSW	New South Wales
OEMP	Operational Environmental Management Plan
PCA	Primary Containment Area
PCE	Perchlorethylene (tetrachloroethene)
PFM	Planning Focus Meeting
PHA	Preliminary Hazard Analysis
PVDF	Poly vinylidene fluoride
QRA	Qualitative Risk Assessment
RAP	Remedial Action Plan
REF	Review of Environmental Factors
RO	Reverse osmosis
RTA	Roads and Traffic Authority
RWG	Regulatory Working Group
SCA	Secondary Containment Area
SCW	Scheduled Chemical Waste
SEPP	State Environmental Planning Policy
SESPHU	South East Sydney Public Health Unit
SPC	Sydney Ports Corporation
SSU	Steam Stripping Unit
SWC	Sydney Water Corporation
TBA	To be advised
1,1,2,2-TeCA	1,1,2,2-Tetrachloroethane
1,1,2-TCA	1,1,2-Trichloroethane
1,2,4-TCB	1,2,4-Trichlorbenzene
1,2,4,5-TeCB	1,2,4,5-Tetrachlorobenzene
TCE	Trichloroethene
TO	Thermal Oxidiser
TWA TLV	Time Weighted Average Threshold Limit Value
TWSA	Trade Waste Service Agreement
URS	URS Australia Pty Ltd, Orica's principal environmental consultant on BGP
VC	Vinyl chloride (chloroethene)
VOC	Volatile organic compound
VSD	Variable speed drive

EXECUTIVE SUMMARY

The NSW Environment Protection Authority (EPA), now part of the Department of Environment and Climate Change (DECC), issued Orica Australia Pty Ltd (Orica) with Notice of Clean Up Action (NCUA) No. 1030236 on 26 September 2003, under the Protection of the Environment Operations (POEO) Act 1997.

This document is the twenty-first report submitted in accordance to NCUA Condition 4G. The reporting interval for this report is 30 September 2008, however if more recent and relevant information is available it is also included.

Quarterly Monitoring Event

NCUA Condition 3B(e) requires Orica to implement a comprehensive monitoring program within the defined area (formerly named as the Groundwater Protection

Orica engaged URS to complete a quarterly monitoring event in September 2008 in accordance with an agreed monitoring plan. The conclusions were as follows:

Hydraulic Containment

- The inferred contours and patterns of deep groundwater flow infer that hydraulic containment was achieved around the central part of the Botany Industrial Park (BIP) extraction line (first priority area) during the monitoring period. Containment was not achieved at the northern and southern portions of the BIP containment line during the monitoring period, although the Primary Containment Area (PCA) will effectively capture a large portion of this flow.
- The inferred contours and patterns of deep groundwater flow at the PCA infer that hydraulic containment was achieved during the monitoring period.
- The inferred contours and patterns of shallow and deep groundwater flow at the Secondary Containment Area (SCA) infer that hydraulic containment was achieved during the monitoring period.

Chemical Monitoring Results

- Concentrations reported for offsite monitoring wells were similar to those previously reported with the exception of wells located at the leading edge of the Central Plume (which is continuing to slowly migrate towards the SCA) and sampling locations in the dune areas in Penrhyn Estuary;
- In general, volatile chlorinated hydrocarbon (CHC) concentrations in pore water within Penrhyn Estuary are similar to or lower than historical concentrations;
- The concentrations of volatile CHCs in all surface water sampling locations were less than the respective ANZECC (2000) Trigger Values. This is consistent with the monitoring rounds performed since the GTP commenced steady operation indicating the remediation is having a significant effect on the surface water quality in the estuary; and

- Based on the data collected to December 2008, the conclusions presented within the Human Health Risk Assessment (URS 2005b) associated with exposures within the inner and outer estuary remain unchanged.

Residential Monitoring

Based on the sampling program provided by Orica, URS sampled 17 residential bores in the GEEA (in response to requests from residents) on 3 to 5 November 2008.

Volatile CHCs were detected in groundwater collected from 10 of the 17 residential bores sampled during this round (8 of the bores with detections were in Spring and Collins streets, Pagewood).

The source of contamination under the Collins and Spring Streets area is considered to be unrelated to BIP.

Groundwater Treatment Plant Operation

A summary of the Groundwater Treatment Plant (GTP) operational performance for 1 October to 31 December 2008 is provided below:

Average volumetric rate of groundwater treated 1 October 2008 to 31 December 2008	4.70 ML/day
Total volume of groundwater treated since pump and treat activities commenced in 2005 (at 31 December 2008).	4.85 GL
Total mass of CHCs destroyed in the thermal oxidizer	642 tonnes

Thermal Oxidiser and Dioxin Air Emissions

A routine quarterly sampling event took place in December 2008. All parameters, including dioxins, were within specification.

GTP Scheduled Shutdown

The GTP annual shutdown commenced on 14 November 2008 and the plant was restarted in the first weekend in December. Over 450 jobs were executed without any environmental incidents.

Groundwater Modelling Assessment

Al Laase from A D Laase Hydrologic (Colorado, USA,) has been engaged to perform the groundwater modelling assessment in order to determine the maximum sustainable extraction volume. A scoping meeting was held on 24 February 2008 to determine the most appropriate approach. Orica has obtained the support of the CLC in involving Ian Acworth form the IMC in this process.

Conclusions

Following the annual shutdown in November-December of 2008, the GTP experienced some temporary capacity limitations following some unexpected fouling of the stripped water treatment plant pre-filters. At the time of writing, these issues had been largely resolved and daily average capacities were again approaching pre-shutdown figures.

The dramatic improvements to the surface water quality of Penrhyn Estuary resulting from the operation of the containment network are still evident in this quarter and are likely to improve even further as extraction gradually increases on the BIP containment line. Meanwhile, as expected, chemical concentrations in most groundwater monitoring locations remain largely unchanged from quarter to quarter.

1 INTRODUCTION

The NSW Environment Protection Authority (EPA), now part of the Department of Environment and Climate Change (DECC), issued Orica Australia Pty Ltd (Orica) with Notice of Clean Up Action (NCUA) No. 1030236 on 26 September 2003, under the Protection of the Environment Operations (POEO) Act 1997. Since then the DECC has issued three variation notices as follows:

Notice under Protection of the Environment Act 1997	Date Issued
Notice of Cleanup Action (NCUA) No. 1030236	26 September 2003
Variation NCUA No. 1033107	17 February 2004
Variation NCUA No. 1042957	7 December 2004
Variation NCUA No. 1052882	2 February 2006

Condition 3 of the NCUA requires Orica to submit a Groundwater Cleanup Plan (GCP) by 31 October 2004 for consideration by the EPA. Condition 3 defines the issues to be addressed in the GCP within timeframes defined in Condition 4. Condition 3(e) defines requirements for a comprehensive monitoring plan, the results of which were to be reported to the EPA (under Condition 4G) on a quarterly basis.

This document is the twenty-first report submitted in accordance to NCUA Condition 4G. The reporting interval for this report is 30 September 2008, however if more recent and relevant information is available it is also included.

Progress Report No	Date	Comment
1	Wednesday 25 February 2004	Submitted on schedule
2	Monday 17 May 2004	Submitted on schedule
3	Friday 20 August, 2004	Submitted on schedule
4	Thursday 18 November 2004	Submitted on schedule
5	Wednesday 16 February 2005	Submitted on schedule
6	Tuesday 17 May 2005	Submitted on schedule
7	Monday 15 August 2005	Submitted on schedule
8	Wednesday 30 November 2005	Submitted on schedule
9	Tuesday 28 February 2006	Submitted on schedule
10	Wednesday 31 May 2006	Submitted on schedule
11	Thursday 31 August 2006	Submitted on schedule
12	Thursday 30 November 2006	Submitted on schedule
13	Wednesday 28 February 2007	Submitted on schedule
14	Thursday 31 May 2007	Submitted on schedule
15	Friday 31 August 2007	Submitted on schedule
16	Friday 30 November 2007	Submitted on schedule
17	Friday 29 February 2008	Submitted on schedule
18	Friday 30 May 2008	Submitted on schedule
19	Friday 29 August 2008	Submitted on schedule
20	Friday 28 November 2008	Submitted on schedule
21	**Friday 27 February 2009**	**Current Report**

Previous reports are available at the relevant section of the website oricabotanytransformation.com and a distribution list is provided at the beginning of this document.

2 COMPLIANCE SUMMARY

2.1 Notice of Clean Up Action (NCUA)

A summary of the compliance status against current NCUA (including variation notices) condition requirements is provided below. DECC has advised that the regulation of the Botany Groundwater Cleanup (BGC) Project is currently being reviewed to take into account cleanup progress and recent developments. Orica has made a submission to DECC to outline a proposed way forward.

Cond.	Summary of Requirement	Status	Reference Documents / Comments
3A	Commence preparation of GCP by 30/09/2003	**Achieved.**	Commenced on 26/09/2003
3B	Prepare and submit GCP by 31/10/2003 covering matters listed	**Achieved.**	GCP submitted 31/10/2003. EPA authorisation of GCP on 17/02/2004 by Variation Notice No.1033107.
4A	Commence implementation of GCP by 16/03/2004	**Achieved.**	Work commenced immediately after submission of GCP, in anticipation of its approval.
4B	Commence containment works within primary containment area within 14 days of receipt of all approvals and complete such work within 90 days.	**Achieved.**	Extraction commenced 28/10/2004. Orica letter of 29/10/2004, DECC letter 10/11/2004.
4BA	At least once every 3 months during GCP implementation report on effectiveness of hydraulic containment works.	**Ongoing compliance**.	Most recent data provided in Section 3.1 of this report.
4C	Complete identification of the locations of the DNAPL sources by 31 May 2004.	**Ongoing compliance.**	Significant DNAPL investigations completed to date and discussed in previous GCP Progress reports. No further work in this reporting period.
4D	Complete containment of DNAPL sources by 30/11/2004.	**Achieved**	Orica submission regarding compliance submitted 30/11/2004. DEC letter of 06/01/2005 has stated in–principle acceptance and requested further information. Orica submitted requested information on 27/01/2005. DEC provided letter of compliance on 07/09/2005.
4D	Remove DNAPL sources to the maximum extent practicable by 31 October 2005.	**Achieved**	Progress included in Section 4.3 of this report.
4E	Reduce the concentrations within the primary containment area to the maximum extent practicable by 31/10/2005, with an 80% target on July 2002 levels.	**Achieved**	Letter of compliance (to maximum extent practicable requirements of the Condition) received on 1 February 2006.
4F	Establish a secondary containment area by 31/10/2004.	**Achieved**.	Commenced extraction 29/10/2004. Orica letter of 29/10/2004, DEC letter of 10/11/2004 (confirmed in DEC letter of 06/01/2005).
4G	Implement monitoring program and report at the end of February, May, August and November of each year.	Ongoing compliance.	Summary of monitoring program results for this reporting period provided in Section 3 of this report. Details are provided in Attachment A.

Cond.	Summary of Requirement	Status	Reference Documents / Comments
5	Remedial measures to ensure groundwater and surface water flows into Botany Bay and Penrhyn Estuary achieve ANZECC Guidelines for slightly to moderately disturbed ecosystems.	Work in progress.	Discussion on latest findings provided in Section 3 and Attachment A of this report.
6	Emission controls from works and measures required by the NCUA strictly controlled through adoption of best practice. Works and operations to be carried out in a controlled and competent manner.	Ongoing monitoring being performed.	A discussion on GTP emission compliance provided in Section 5 of this report.
7	Orica to make all reasonable attempts to obtain consent for work on premises not occupied by Orica and related companies. Notify EPA within 7 days if refusal to grant access.	**Ongoing compliance**.	Ongoing access to third party premises sought as required.
7A	Updating of GCP to take account of developments.	**Ongoing compliance**.	The GCP remains relevant in terms of the overall groundwater containment and remedial strategy. The strategy is currently under review (see Section 4.3). The Groundwater and Surface Water Monitoring Plan was agreed for 2006 and a revised Plan was submitted and agreed with former DEC (now DECC) for 2007. In June 2008 Orica, in conjunction with its consultants, submitted a proposal for monitoring from late 2008 to 2010. DECC has agreed to the revised program.
7B	Orica to monitor groundwater in any other area likely to have been, or to be, impacted by the contaminants.	**Ongoing compliance**.	The most recent residential bore monitoring round took place in early November 2008 and results are presented in Section 4.2.
7C	7B monitoring is to: a) Determine the spatial distribution of the contaminants; and b) Monitor changes in the spatial contamination and distribution of the contaminants.	**Ongoing compliance**.	Refer to comments on 7B.
7D	Monitoring results to be provided to the EPA as soon as possible after results become available to Orica.	**Ongoing compliance**.	Important results are provided to DECC as soon as possible. The quarterly progress reports are the primary mode of reporting monitoring data.
7E	Orica must consider best practice technology in the remediation of DNAPL and groundwater containing dissolved phase contamination.	**Ongoing compliance**.	DNAPL overseas mission completed in April 2005. Orica representatives have attended Battelle conference on “Remediation of Chlorinated and Recalcitrant Compounds” in Monterey, California in May 2008. Orica held a workshop at Botany in

Cond.	Summary of Requirement	Status	Reference Documents / Comments
			December 2007 to discuss remediation strategy with a range of respected overseas and local experts. A submission and presentation was made to the DECC and the Botany Groundwater Community Liaison Committee (CLC) in September 2008. A community workshop is to be held on 31 March 2009.
7F	Orica must provide an annual written report to DECC on actions required by 7E. First report to be provided no later than 28 February 2006.	**Ongoing compliance**.	Annual detailed update provided in Attachment B of this report.
7G	Orica must review the need to revise the HHRA in light of relevant monitoring data.	**Ongoing compliance**.	See 7H
7H	All reports submitted to DECC must include an assessment of the potential risk to human health.	**Ongoing compliance**.	All reports now submitted to DECC include relevant appraisal of potential risk to human health and hence identify any requirement to update the Consolidated HHRA.
7I	By 30 April 2006, Orica must prepare and submit to DEC, a monitoring plan for all necessary input parameters to the HHRA.	**Achieved**.	Plan submitted on 30 April 2006.
7J	Orica must provide copies of reports issued under 7F and 7H to DWE, SESPHU, NSW Health, and City of Botany Bay (CoBB) Council within 7 days of submission to DECC.	**Ongoing compliance**.	Ongoing compliance
7K	Orica must inform the community of developments by: a) A community forum agreed to by the DECC. b) Provision of a quarterly newsletter to people residing within a 1 km radius of BIP. c) Maintenance of a website in which copies of relevant reports are posted.	**Ongoing compliance**.	a) The CLC meets quarterly b) See Section 6.1. c) www.oricabotanytransformation.com
8	Works and measures under voluntary agreement must not compromise the efficacy of measures under the notice.	**Ongoing compliance**.	Orica has since discontinued bioremediation trials because sufficient data had been obtained to assess the efficacy of bioremediation, and the PCA interim hydraulic containment was interfering with the flow of groundwater through the trials area. Orica proposed and DECC agreed to defer installation of a zero valent iron permeable reactive barrier wall.
8A	Provide additional information as detailed to DEC by 16/03/2004.	**Achieved**.	Issued by Orica 16/03/2004, received by DEC 17/03/2004 due to courier error. Additional information on PCA extraction design progressively provided in accordance with Orica's response of 16/03/2004.

2.2 Environmental Protection Licence No. 2148 (EPL2148)

Orica reports compliance against EPL2148 requirements via the submission of the annual return in September each year. The following matters in this reporting period are noted in relation to the licence conditions and GTP:

- Orica obtained NATA accreditation for the GTP Laboratory in January 2009.
- A number of technical matters in relation to monitoring at the GTP stack have been addressed through licence modifications and some further changes are scheduled for the next licence review.
- An analytical scan of the GTP feedwater, discharge to Bunnerong Canal and discharge to sewer for semi-volatile compounds was conducted (in response to a request from DECC following advice to the Community Liaison Committee (CLC) from Independent Monitoring Committee (IMC) member John McCracken). Results will be provided to DECC shortly.
- An update on the ammonia pollution reduction program was submitted to DECC on 12 December 2008.
- Orica received a penalty infringement notice on 5 January 2009 for an exceedance of the total solid particulate limit for the GTP stack. This single exceedance was reported to DECC with results from monitoring during treatment of the diethyl aluminium chloride (DEAC) contaminated waste.
- In December 2008 DECC initiated changes to the waste licensing aspects of EPL2148 to ensure consistency following the recent review of waste classifications under the *Protection of the Environment Operations Act, 1997*. DECC and Orica have discussed the need for further variations to ensure that activities permitted prior to the definition changes are still captured in EPL2148.
- Orica received feedback from DECC on the 2007/8 annual return (as submitted in September 2008) on 22 January 2009. DECC has asked Orica to review the minor temperature exceedances in discharge water from the GTP and Orica has subsequently provided some options to DECC for consideration.

It is also noted that EPL2148 requires the ongoing necessity for independent compliance audits to be reviewed by DECC in consultation with the IMC. This will be included in the agenda for the March CLC meeting.

In addition Orica is currently working with DWE and DECC to secure the following approvals for the Groundwater Injection and Recovery (GIR, formerly Temporary Aquifer Storage and Recovery [TASR]) proposal:

- Bore licences from DWE for the injection of contaminated groundwater; and
- A modification to EPL2148 to permit the injection of contaminated groundwater.

Orica has identified an opportunity to treat contaminated stormwater, liquids and activated carbon from Store G & H of the HCB Waste Repackaging operation at the GTP. These proposals were presented to the February 2009 Community

Participation and Review Committee meeting and will be presented to the CLC in March. Orica will submit this proposal to DECC and Department of Planning (DoP).

2.3 Other Licences and Statutory Approvals

A summary of recent compliance activity regarding other approvals relevant to the project is provided in the table below.

Licence / Statutory Approval	Comments
Conditions under Part V of the Water Act	• Groundwater and surface water monitoring conducted during this reporting period was undertaken in accordance with the program developed in response to condition E12.2.3 of EPL2148. A summary of the results is provided in Section 3 of this report. • Orica submitted production bore applications to DWE in mid 2008 and awaits a response.
Conditions from Department of Planning	• These conditions require that Orica maintain a register of accidents, incidents and potential incidents with actual or potential significant off-site impacts on people, property, or the biophysical environment. Orica maintains an incident register for the GTP in the internal Safety Health and Environment Incident Management database. • The DoP conditions require preparation of Hazard Audits. The first GTP hazard audit was conducted in November 2008 and the report submitted in December 2008.

3 QUARTERLY MONITORING EVENT

NCUA Condition 3B(e) requires Orica to implement a comprehensive monitoring program within the defined area (formerly named as the Groundwater Protection Zone 1 by the then DIPNR (subsequently DNR and now part of DWE), and now referred to as the Groundwater Exclusion Extraction Area [GEEA]) to:

- monitor changes in concentrations of the substances in the contaminant plumes;
- monitor changes in the spatial distribution of contaminant plumes in the sub-surface;
- gauge groundwater levels to assess effectiveness of hydraulic containment; and
- monitor concentrations in groundwater and surface water discharges to Botany Bay and Penrhyn Estuary for comparison against the Australian and New Zealand Guidelines for Marine and Fresh Water (ANZECC, 2000) trigger values for protection of slightly to moderately disturbed ecosystems.

Orica and DEC (now DECC) subsequently agreed the content and scope of the *GTP Groundwater and Surface Water Monitoring Plan* (URS, 2005a). On an annual basis DECC and Orica meet to discuss the effectiveness of the monitoring program and revise monitoring requirements as appropriate.

Orica engaged URS to complete a quarterly monitoring event in September 2008 in accordance with the agreed monitoring plan. Results and discussions were provided in the URS report *Groundwater Treatment Plant (GTP) Quarterly Groundwater and Surface Water Monitoring Report, December 2008*. This report is bound separately as Attachment A. The remainder of this section has effectively been transcribed from the URS report.

3.1 Hydraulic Containment

General

- The slow migration of groundwater and the potential for increased pumping to recapture groundwater mean that hydraulic containment can still be maintained through extended periods of no, or low, groundwater extraction.
    - Implementation of hydraulic containment has altered the natural groundwater flow regime with flow now characterised by flow drawn towards the three containment lines;
    - Large areas of very low hydraulic gradients have developed due to hydraulic containment. These areas represent zones of very slow groundwater flow and as a result contaminant concentrations in these areas are likely to remain relatively constant for the medium to long term;
    - While the observed pattern of groundwater flow in December 2008 is clearly different to that observed during the baseline monitoring in October 2004 it is very similar to that presented in recent monitoring reports; and
    - Water levels at regional monitoring wells show no discernible water level impact due to hydraulic containment thus indicating a limited potential to affect infrastructure and groundwater users.

BIP Containment Line

- The primary purpose of the BIP containment line is to contain contaminated groundwater migrating from source areas located on BIP. If groundwater extraction is temporarily reduced due to periodic GTP capacity limitations, this reduction occurs at sections of the BIP containment line based on a predetermined order of priorities; and
- The inferred contours and patterns of deep groundwater flow infer that hydraulic containment was achieved around the central part of the extraction line (first priority area) during the monitoring period. Containment was not achieved at the northern and southern portions of the BIP containment line during the monitoring period, although the PCA will effectively capture a large portion of this flow.

PCA Containment Line

- The primary purposes of the PCA are mass removal of the central 1,2-dichloroethane (EDC) plume in the deep aquifer, and hydraulic containment on Block 2, Southlands;
- The inferred contours and patterns of deep groundwater flow at the PCA infer that hydraulic containment was achieved during the monitoring period; and
- It is important to note that consistent pumping will be required during the next monitoring period (January to March 2008) to ensure that the effects of the shutdown and slightly inconsistent pumping in December 2008 are negated; and
- The interpreted contours and groundwater flow lines show that although drawdown has been recorded, it cannot be conclusively determined that shallow groundwater is being contained at the PCA. However, the very low hydraulic gradient in the shallow aquifer at McPherson Street indicates that the rate of migration of shallow groundwater has been significantly reduced and the majority of the contaminant mass is located in the deep aquifer. Orica has engaged URS to install additional offsite shallow groundwater monitoring bores to provide further information.

SCA Containment Line

- The primary purpose of the SCA is to minimise migration of groundwater contamination to Botany Bay (recognising that there was already contamination in areas downgradient and to the east of the containment line before groundwater extraction commenced);
- The inferred contours and patterns of shallow and deep groundwater flow at the SCA infer that hydraulic containment was achieved during the monitoring period; and
- Results of salinity monitoring downgradient of the SCA indicate similar levels to those observed during previous monitoring rounds.

3.2 Chemical Monitoring Results

Onsite Monitoring Wells

- The December 2008 sampling period represents a quarterly monitoring event. As such, it is focussed on collecting data from offsite locations that are critical to environmental and human health receptors. No samples were collected from onsite sampling locations (i.e. on BIP or Southlands).

Offsite Monitoring Wells

- Concentrations reported for offsite monitoring wells were similar to those previously reported with the exception of wells located at the leading edge of the Central Plume (which is continuing to slowly migrate towards the SCA) and sampling locations in the dune areas in Penrhyn Estuary;
- The increase and reported maximum observed for EDC at WG154S is considered to be significant. This increase is consistent with short- and long-term historical trends. It is noted that contamination from this location will be captured at the SCA and will not discharge into Penrhyn Estuary;
- The increases observed for EDC and TCE at BP01 (2 m and 6 m ports, respectively) and PCE and CTC at MWF15I are considered to be significant. The increases are consistent with historical trends and concentrations are considered to be representative of groundwater that migrated downgradient of Foreshore Road prior to the commencement of hydraulic containment at the SCA; and
- The reported maximum concentrations at BP115 (5.25 m port) may not be representative of actual concentrations at this location and depth as it is suspected that the samples at the 5.25 m port and the 6.5 m port may have been interchanged. The March 2009 sampling round will be used to confirm the concentrations and trends at these ports.

Penrhyn Estuary

- In general, volatile CHC concentrations in pore water within Penrhyn Estuary are similar to or lower than historical concentrations; and
- Maximum concentrations for EDC, TCE and CFM in BP71A (1.0 m port), located on the western side of Penrhyn Estuary, and EDC and TCE (2 m and 6 m ports, respectively) were noted. However, these concentrations were below the respective ANZECC (2000) Trigger Values.

Surface Water

- The concentrations of volatile CHCs in all surface water sampling locations were less than the respective ANZECC (2000) Trigger Values. This is consistent with the monitoring rounds performed since the GTP commenced steady operation indicating the remediation is having a significant effect on the surface water quality in the estuary; and
- Surface water samples collected from the pond within the Botany Golf Course showed no detection of CHCs above the limits of reporting.

Implications for Human Health Risk Assessment

- There are no additional data presented in the December 2008 round of sampling with respect to the Western Margin of the Northern Plumes that affect the conclusions of the Human Health Risk Assessment (HHRA) (URS, 2005b) and Addendum (URS, 2006)). That is, the groundwater contamination within the Northern Plumes near the western margin is not considered to pose an unacceptable risk to human health, assuming that groundwater is not extracted and used;
- There are no additional data presented in the December 2008 Quarterly Monitoring Report that alter the conclusions of the HHRA (URS, 2005b) with respect to existing commercial/industrial workers in areas above the main plumes. That is, the groundwater contamination within the main plumes is not considered to pose an unacceptable risk to human health, assuming that groundwater is not extracted and used untreated; and
- Based on the data collected to December 2008 (and considering the additional review of data presented in the June 2007 (URS, 2007) and September 2008 (URS, 2008) monitoring reports), the conclusions presented within the HHRA associated with exposures within the inner and outer estuary remain unchanged. That is, given the conservative nature of the range of assumptions and the safety factors applied to toxicity values, the risks to human health for all exposure scenarios are considered to be low. However, the assessment has identified worst-case exposure scenarios (particularly within the inner estuary) where the calculated risks exceed the target values. It is noted that the potential for exposure within the inner estuary is effectively eliminated by access restrictions associated with the Port Botany expansion works.

3.3 Recommendations

On the basis of the results of the December 2008 program, URS made the following recommendations:

Hydraulic Monitoring

- Repair of faulty and damaged loggers and transducers identified in this monitoring period;
- Given the very similar water levels historically reported at WG75I and WG75D replacement of the faulty logger at WG75D is not required and the well should be removed from the hydraulic monitoring program;
- The logger installed at WG216S (dry) should be transferred to WG216I to assess the relative response of the shallow and deep aquifer east of the BIP to hydraulic containment. Similarly a logger should be considered for installation at WG215I;
- Monitoring well MWB10S should be replaced and additional shallow groundwater monitoring wells should be installed downgradient of the PCA as part of the continuing effort to assess shallow groundwater containment at the PCA;

- In view of the gradually increasing drawdown in the shallow aquifer at PCA as a result of increased pumping in the deep aquifer, the current pumping regime should be continued and enhanced (where possible);
- To allow more efficient allocation of resources and ensure ongoing timely delivery of reports it is proposed to modify the monitoring period for hydraulic data such that the hydrographs represent the period up to submission of the previous monitoring report; and
- As GTP capacity increases, additional pumping should be concentrated at the southern end of the BIP containment line to maximise contaminant mass removal and maximise the remedial effects on Springvale Drain.

Chemical Monitoring

- It is recommended that SW066, collected from the pond at the Botany Golf Course, be removed from the sampling program following no detections of volatile CHCs in the September 2008 and December 2008 sampling rounds;
- It is recommended that BP44, BP66, BP108 and BP109 be deleted from the monitoring program.

4 OTHER ENVIRONMENTAL ACTIVITIES

Other groundwater and surface water monitoring and data acquisition activities that have been undertaken in this reporting period pursuant to, or that have relevance to, the agreed monitoring plan and conditions of the NCUA are detailed below.

4.1 Air Monitoring and Human Health Risk Assessment

It was reported in Progress Report No. 6 that the draft *Consolidated Human Health Risk Assessment 2005* (URS, 2005b) was prepared by URS and submitted to the DEC on 31 March 2005 with copies provided also to NSW Health and Prof. Brian Priestly (Monash University) from the Australian Centre for Human Health Risk Assessment for independent review. Following a request from the DEC, the draft report was released publicly.

Prof. Priestly completed the independent review and provided comments in a letter to the DEC on 11 May 2005. Generally the comments were overwhelmingly positive and strongly supported the findings of the risk assessment.

Since 1995 air emission monitoring has conducted on a nominally 15-month cycle (targeting different seasons every year). Sampling locations are on and off the BIP and are usually adjacent to shallow groundwater-monitoring points. Some air monitoring locations – such as the Car Park Waste Encapsulation – are not directly relevant to the Botany Groundwater Project. Sampling was last performed in March 2008 and the next round is scheduled for June 2009.

4.2 Residential Monitoring

Based on the sampling program provided by Orica, URS sampled 17 residential bores in the GEEA (in response to requests from residents) on Monday 3 November, Tuesday 4 November and Wednesday 5 November 2008.

Volatile CHCs were detected in groundwater collected from 10 of the 17 residential bores sampled during this round (8 of the bores with detections were in Spring and Collins Streets, Pagewood).

The most pervasive contaminants present in the sampled bores are TCE and PCE. These compounds are used as industrial and commercial solvents for the cleaning of dirt, grease, resins, glues and clothing.

Trends in concentrations of TCE and PCE in bores sampled along Collins and Spring Streets indicate that the contaminants appear to be migrating to the south (following the general groundwater flow direction) based on the generally decreasing concentrations measured in bores in the properties on these streets.

The source of contamination under the Collins and Spring Streets area is considered to be unrelated to BIP.

4.3 DNAPL Source Area Depletion Projects

In accordance with Condition 7E of the NCUA, Orica is required to stay abreast of relevant DNAPL remedial technologies and apply them as practicable. Orica is required to submit an annual report pursuant to this condition at the end of February. The 2009 report is provided in Attachment B.

4.4 Groundwater Injection and Recovery

In January 2009, DECC provided feedback on the proposed Groundwater Injection and Recovery (GIR) project. Formerly referred to as Temporary Aquifer Storage and Recovery (TASR), GIR proposes to reinject extracted groundwater into the aquifer upgradient of the containment lines on BIP if the GTP is unable to treat groundwater for an extended period of time (i.e., several months). Orica is currently in discussion with DECC and DWE to arrange licences required to proceed with a trial of this proposal. A trial injection is planned for late in March 2009, and the results will be provided to DECC and DWE for discussion prior to licensing for and implementation of the full-scale system.

5 GROUNDWATER TREATMENT PLANT OPERATION

5.1 GTP Performance

A summary of the GTP operational performance for 1 October to 31 December 2008 is provided below:

Average volumetric rate of groundwater treated 1 October 2008 to 31 December 2008	4.70 ML/day
Total volume of groundwater treated since pump and treat activities commenced in 2005 (at 31 December 2008).	4.85 GL
Total mass of CHCs destroyed in the thermal oxidiser	642 tonnes

5.2 Air Strippers

Previous GCP Progress Reports indicated the air stripping system was suffering from biological fouling caused by the growth of a filamentous fungus within the stripping cabinets. Under the GTP's original operating regime, the groundwater entering the air strippers was acidified to prevent the build-up of inorganic precipitants such as aluminium and iron. However, it was found that these acidic conditions encouraged growth of the filamentous fungus.

It has been previously reported that Orica had successfully trialled dosing with chlorine dioxide, a disinfectant routinely used in water treatment. Scale up of the process is been investigated.

Regardless, the air strippers continue to operate effectively, requiring only routine cleaning.

5.3 Stripped Water Treatment Plant (SWTP)

The co-current Biological Aerated Filters (BAFs) installed in the first half of 2008 continue to work well in reducing concentrations of organics in the stripped water and increasing RO unit run times.

Following the annual shutdown in November 2008, the pre-filters located between the Actiflo coagulation/precipitation system and the BAFs have experienced ongoing fouling. This resulted in reduced SWTP capacity during December and January.

Trials of cleaning of the filters have occurred to minimise the impacts of fouling. At the time of writing, capacity was again improving.

5.4 Thermal Oxidiser and Dioxin Air Emissions

A routine quarterly stack emissions sampling event took place in December 2008. All parameters, including dioxins, were within specification.

5.5 Thermal Oxidiser and Dioxin Air Emissions

A routine quarterly sampling event took place in December 2008. All parameters, including dioxins, were within specification.

5.6 GTP Scheduled Shutdown

The GTP annual shutdown commenced on 14 November 2008 and the plant was restarted in the first weekend in December. Over 450 jobs were executed without any environmental incidents.

The jobs undertaken have been divided into improvement, repair and preventative categories, with the percentage in each group noted below:

- Repair: 32% of tasks – This is where equipment that is showing signs of poor performance needs maintenance. Sometimes this can only be done when the plant is off-line. An example of type of work is the thermal oxidiser refractory repair. Limited inspection while the thermal oxidiser was operating indicated that some of the refractory (internal brickwork) was likely to be in need of repair. Detailed inspection and repair works could only be done while the plant was shutdown.

- Preventative: 53% of tasks – This is work that is done to ensure that equipment does not stop working due to normal wear and tear of components. For example, caustic pump inspection and oil change. The internal components of this important pump may work correctly for a number of years. To ensure that the pump doesn't breakdown while the plant is operating, it is opened and checked to see whether any of the components are showing wear and needs replacement.

- Improvement: 15% of tasks – As understanding of better ways to operate the plant develops with time and experience, equipment needs to be changed to take advantage of this new knowledge. Sometimes these changes can only occur when the plant is offline. For example, valves on the inlet to the pre-filters were upgraded to allow easier manual operation by the process operators.

The main focus of this year's shutdown was the thermal oxidiser and quench tower (where approximately 43% of the total tasks were conducted). No significant works were conducted on the SWTP, the blowers or the air strippers.

The breakdown of tasks for 2008 (shown above) is similar to that for the 2007 shutdown, in which 55% of tasks were preventative, 31% were repairs and 14% were improvement tasks.

Three first aid injuries occurred during the shutdown and Orica has identified improvement opportunities (including a requirement for all contractors to be on time in order to participate in the daily safety talks and a refresher training for supervisors and operational staff on Unsafe Acts Prevention) that will be implemented next year.

5.7 Beneficial Reuse of Treated Water

The GTP began supplying the Orica ChlorAlkali Plant with treated water in December 2006. Qenos is regularly receiving treated water for use in cooling towers. Solvay Interox continues to receive and utilise treated water.

In this reporting period, Orica commenced an investigation in order to determine the maximum sustainable volume of groundwater the aquifer could provide to the GTP from the existing groundwater extraction network and assess the impacts that this extraction will have on the built and natural environments (e.g., subsidence). The additional extraction above and beyond what is required for containment alone will provide significant benefits to the project including:

1. The potential to maximise contaminant removal;

2. Further long-term improvement to the surface water quality of Penrhyn Estuary and Springvale Drain and subsequent improvements to the ambient air quality in the vicinity of the drain; and

3. Maximizing the use of recycled water in lieu of towns water for industrial purposes on and adjacent to the BIP.

Consistent with these objectives, Orica has submitted licence applications to the DWE requesting allowances for increased extraction above and beyond what is required for containment alone. Orica has committed to providing supplementary information in support of the application. This included:

1. An assessment of the maximum sustainable yield of the existing containment system;

2. Determination of the likelihood of subsidence;

3. An assessment of impacts on other industrial groundwater users;

4. An assessment of impacts on surface water bodies; and

5. A description of the environmental benefits with supporting evidence where available.

- **Groundwater Modelling Assessment**

Al Laase from A D Laase Hydrologic (Colorado, USA) has been engaged to perform the groundwater modelling assessment in order to determine the maximum sustainable extraction volume. A scoping meeting was held on 24 February 2008 to determine the most appropriate approach. Orica has obtained the support of the CLC in involving Ian Acworth form the IMC in this process.

- **Subsidence Assessment**

Pell Sullivan Meynink (PSM) have been engaged to determine safe extraction limits that do not present any subsidence risk.

- **Reporting**

The results of the assessment will be compiled into a report and provided to DWE as a supplement to the licence application. Should the report suggest that the sustainable yield (with due consideration of possible impacts and environmental benefits) is greater than formerly assumed, it is Orica's intention that this report would form the basis for an increase in requested extraction allocation through a revision of the licence application.

6 COMMUNITY CONSULTATION

This section provides a consolidated update in response to Condition 7K of the NCUA, which specifies how Orica must inform the community of developments in the remediation of groundwater, and provides information regarding the wider consultation activities that are undertaken by Orica to obtain community feedback regarding the BGC Project. Orica supports a two-way communication process with the local community and this section incorporates feedback received from the community during the reporting period.

6.1 Community Liaison Committee

The Community Liaison Committee (CLC) for the BGC Project was established in 1996 and meets the requirements for a community forum in accordance with Part a of Condition 7K of the NCUA. The CLC provides an opportunity for representatives of the local community to voice their concerns and questions, and provide feedback to Orica about the BGC Project.

CLC Meetings

A quarterly CLC meeting was held on 16 December 2008. Presentations were made by the DECC and Orica on progress of the BGC Project. The following table summarises key matters raised by members of the CLC at the December 2008 meeting, and actions taken or planned as a result (please note that this information has been summarised from draft minutes not yet endorsed by the CLC).

Matter Raised by CLC	Action Taken or Planned
Need for community reminder that bore water cannot be used for residential purposes.	DWE to report back to the CLC on ongoing communication regarding the ban on bore water use by residents within the GEEA.
Request for results of bore water testing by CoBB at Hensley Athletics Field.	CoBB to provide feedback to CLC following testing.
Request for more information on the Remediation Strategy Review	Initial feedback provided to the CLC by DECC. A community workshop on the outcomes of the Strategy Review and DNAPL technology investigations is to be held on 31 March 2009. Dr Bernie Keuper and Prof Ian Acworth will attend this workshop.
Former ChlorAlkali Plant and the Human Health and Environmental Risk Assessment (HHERA).	Orica provided an update and DECC provided feedback on the former ChlorAlkali Plant mercury investigations.
Request for the GTP Hazard audit results to be presented to the CLC	Presentation planned for March CLC meeting.
Request for the conceptual site model prepared for the BGC Project to be placed on project website.	The full Conceptual Site Model report has been uploaded to the website.
Botany Environment Watch (BEW) tabled a document expressing concerns regarding use of the GTP to treat other wastes and providing increased consultation.	DECC to consider and respond to the BEW document.
DEAC contaminated waste treatment at the GTP – strong feedback	Orica provided a detailed presentation to the CLC on the DEAC contaminated waste, including monitoring results,

Matter Raised by CLC	Action Taken or Planned
received regarding the failure to notify the CLC in advance of the waste treatment	and other waste at the Orica site.
Communication processes with the CLC	Draft protocols for notification and communication with the CLC on matters of CLC interest between meetings were tabled and discussed. Matter to be further discussed at the March CLC meeting.
CLC access to details on Orica's Trade Waste Agreement with Sydney Water	Orica has included the web address to its Trade Waste Agreement in the December CLC minutes.
Request for further information on DECC's planned review of the regulatory approach for the BGC Project	Item to be further discussed at the March CLC meeting. To assist in the discussion on the regulatory review the following is to be undertaken: • DECC to provide briefing paper as background to the CLC; • Gary Blaschke (Botany Bay and Catchment Alliance) to seek advice from the Environmental Defenders Office; and • Orica to contribute information to the discussion.
Southlands community workshop	Orica held a community workshop to discuss the Southlands RAP and the HHRA on 27 January 2009. Community representatives requested the opportunity to further discuss traffic concerns and the management of flood waters with relevant government agencies.
Community research	Representatives from University of Technology attended the CLC meeting to explain their research project on community views on communication during remediation projects.

CLC Newsletter

Orica produces a quarterly CLC Newsletter distributed by letterbox drop to approximately 5,500 homes and businesses within the Botany, Banksmeadow, Hillsdale, Matraville and Pagewood areas. This distribution area encompasses the 1 km radius from the Orica premises at Botany as required under Part b of Condition 7K of the NCUA.

CLC Newsletter No. 31 was distributed in December 2008 after being reviewed by the CLC. It included updates on groundwater treatment and containment, the September 2008 CLC meeting and the treatment of DEAC contaminated waste.

6.2 Independent Monitoring Committee

As detailed in previous reports, the IMC is a panel of experts, which has been established in consultation with the CLC to report to the CLC with appraisals of the operations of the GTP. The IMC contracts with Orica are to be extended for a year in accordance with the contract wording. Dr Hibberd's contract requires additional wording to reflect this.

At the December 2008 CLC meeting, the CLC supported Orica's suggestion of seeking the assistance of Prof Acworth in its project to review the maximum volume

of groundwater which could be sustainably extracted. The table below lists recently completed and current IMC tasks.

Task #	IMC Task Description	Status
21	Orica to share the requirements of its Environment Protection Licence, Trade Waste Service Agreement and Ammonia Pollution Reduction Program for the GTP, along with recent results for each, with Dr John McCracken in order to better describe the inputs and outputs from the GTP treatment process. Dr John McCracken to provide feedback to the CLC following review of this information.	DECC sent a letter to Orica on 12/09/08 requesting sampling of feed and product water and scanning for semi-volatile compounds. Sampling and analysis are complete. Results to be reported to DECC and the CLC.
23	Prof Acworth to be invited to attend a community workshop on Orica's Strategy Review and DNAPL technology investigations.	Prof Acworth has been invited to the workshop scheduled for 31 March 2009.

6.3 Communication Tools

Community Workshops

A Southlands workshop was held 27 January to discuss the RAP and the HHRA. A workshop report will be uploaded to the project website.

Orica has arranged a BGC Project Remediation Strategy Review/DNAPL technology investigations workshop for 31 March 2009.

Orica plans to hold further community workshops on Water Recycling initiatives as those plans develop further over time.

Newspaper Columns

Three newspaper columns were published in the *Southern Courier* since the last quarterly Progress Report. A column was also published in the *St George and Sutherland Shire Leader*. The columns incorporate information on a range of Orica projects. Reporting on the BGC Project was as follows:

- *Column 85: 15 (Courier) and 23 (Leader) December 2008:* Groundwater treatment, particularly the maintenance works and repairs completed during the annual shutdown of the GTP.
- *Column 86: 27 January 2009:* GTP Treated Water Recycling update, results from the November 2008 residential bore monitoring event.
- *Column 87: 24 February 2009:* Invite to the BGC Project Strategy Review Workshop and feedback from the Southlands Remediation and Development Project workshop held on 27 January 2009. Discussion on the proposal to use the GTP to treat waste water and regenerate filter carbon from HCB stores.

Website

The website is an important tool which provides immediate access to information about the BGC Project and supports Orica's commitment to open and transparent communication. Maintenance of the website is now a requirement under Part c of Condition 7K.

The following material has been posted on the website during the reporting period:

- Groundwater Cleanup Plan Progress Report No.20;
- Recent newspaper columns;
- The December CLC newsletter;
- The Briefing Paper, and all presentations to the CLC December 2008 meeting;
- The Site Conceptual Model (URS 2007b)

There were 1,345 visits to the Botany Transformation Projects website from 17 December to 22 February 2009 and 21 % of the page views in this period were of the BGC Project pages.

The webpage for the Former ChlorAlkali Plant Mercury Investigations went live on 13 February 2009.

1800 Number
Orica continues to operate the free-call number – 1800 025 138. Some of calls during this reporting period related to the boundary of the GEEA and the rainwater tank rebate program.

Enquiries placed through the 1800 line are generally responded to within 24 hours.

E-mail Feedback
Several e-mails were received in this reporting period from browsers of the Botany Transformation Projects website. These included requests for information about the groundwater contamination, technical details relating to operations of the GTP operations and the mercury soil-washing trials. Two emails related specifically to the functionality of the website (difficulties accessing archived files). Orica also received emails from UTS who are undertaking a research project on community views on remediation projects.

There were no emails received via the CLC feedback facility in this reporting period.

Provision of Reports (Part d of Condition 7K)
Part d of Condition 7K requires Orica to provide the community forum (i.e. the CLC) and the local libraries in the local government areas of Botany Bay and Randwick with copies of reports provided to the EPA under the NCUA. Quarterly reports are regularly provided to the CLC and these libraries.

7 REFERENCES

ANZECC/ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

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URS (2005a) Orica Botany Environmental Survey, Stage 4 – Remediation. *Groundwater Treatment Plant – Groundwater and Surface Water Monitoring Plan*. Document Number R013_A. 17 May 2005.

URS (2005b) Orica Botany Environmental Projects. *Consolidated Human Health Risk Assessment 2005.* Document Number R022_D. August 2005.

URS (2006) Orica Botany Environmental Projects. *Addendum to Consolidated Human Health Risk.* Doc. No. R022_D, August 2005.

URS (2007a) Orica Botany Environmental Survey, Stage 4 – *Remediation. Groundwater Treatment Plant (GTP) Quarterly Groundwater and Surface Water Monitoring Report - June 2007*. Doc. No. R03, 31 August 2007.

URS (2007b) *Conceptual Site Model, Botany*, 23 November 2007

URS (2008a) Orica Botany Environmental Survey, Stage 4 – *Remediation. Groundwater Treatment Plant (GTP) Quarterly Groundwater and Surface Water Monitoring Report - September 2008*, 30 November 2009.

URS (2008b) *Proposed Amendment to the GTP Groundwater and Surface Water Monitoring Program, 2008-2010*. WCIE 4396. 6 June 2008.

ATTACHMENT A – QUARTERLY MONITORING REPORT – FEBRUARY 2009.

Groundwater Treatment Plant (GTP) Quarterly Groundwater and Surface Water Monitoring Report, February 2009, URS Australia Pty Ltd, *Separately bound report.*

ATTACHMENT B – DNAPL AND GROUNDWATER REMEDIATION TECHNOLOGY ANNUAL REVIEW - FEBRUARY 2009