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# VOLUNTARY MANAGEMENT PROPOSAL PROGRESS REPORT No. 40

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## REVISION 0

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## REVISION HISTORY

| REV | STATUS | DATE | PREPARED | REVIEWED | AUTHORISED |
|---|---|---|---|---|---|
| 0 | Issued | 31 October 2023 | Olga Bukhteeva | Caroline Vernon (WSP) CEnvP SC | James Stening |

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## LIST OF ACRONYMS

| ACRONYM | DEFINITION |
|---|---|
| ADWG | Australian Drinking Water Guidelines |
| AHD | Australian Height Datum |
| ANZG | Australian and New Zealand Governments |
| ARMCANZ | Agriculture and Resource Management Council of Australia and New Zealand |
| BAF | Biological Aerated Filter |
| BGC Project | Botany Groundwater Cleanup Project (hydraulic containment and treatment project as described in the EIS) |
| bgl | Below ground level |
| BIP | Botany Industrial Park |
| BP | Bundle piezometer |
| CFM | Chloroform (trichloromethane) |
| CHC | Chlorinated hydrocarbon |
| CHHRA | Consolidated Human Health Risk Assessment |
| cis-1,2-DCE | cis-1,2-dichloroethene |
| CLC | Community Liaison Committee |
| CoPC | Chemical of potential concern |
| CPRC | Community Participation and Review Committee |
| CTC | Carbon tetrachloride (tetrachloromethane) |
| DNAPL | Dense non-aqueous phase liquid |
| DoD | Department of Defence |
| EDC | Ethylene dichloride (1,2-dichloroethane) |
| EIS | Environmental Impact Statement |
| EP&A Act | Environment Planning and Assessment Act |
| EPA | Environment Protection Authority |
| EPL | Environment Protection Licence |
| GEEA | Groundwater Extraction Exclusion Area |
| GIR | Groundwater Injection and Recovery |
| GRAMP | Groundwater Remediation and Management Plan |
| GTP | Groundwater Treatment Plant |
| HCB | Hexachlorobenzene |
| HCBD | Hexachlorobutadiene |
| HHRA | Human Health Risk Assessment |
| IMC | Independent Monitoring Committee |
| IPART | Independent Pricing and Regulatory Tribunal |
| ISCO | In Situ Chemical Oxidation |
| JBS&G | JBS&G Australia Pty Ltd, an environmental consultancy |
| KBR | Kellogg, Brown and Root Pty Ltd, an engineering contractor |
| KMH | KMH Consulting Pty Ltd, an independent compliance auditor |
| LOR | Laboratory Limit of Reporting |
| MoU | Memorandum of Understanding |
| NCUA | Notice of Clean Up Action |
| NHMRC | National Health and Medical Research Council |
| NRAR | Natural Resources Access Regulator |
| NSW | New South Wales |
| OBLC | Orica Botany Liaison Committee |
| PCA | Primary Containment Area |

| ACRONYM | DEFINITION |
|---|---|
| PCE | Perchlorethylene (tetrachloroethene) |
| PRP | Pollution Reduction Program |
| QRA | Qualitative Risk Assessment |
| RAP | Remedial Action Plan |
| REF | Review of Environmental Factors |
| RO | Reverse osmosis |
| RWG | Regulatory Working Group |
| SCA | Secondary Containment Area |
| SCW | Scheduled Chemical Waste |
| SEPP | State Environmental Planning Policy |
| SESLHD | South-eastern Sydney Local Health District |
| 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-trichlorobenzene |
| 1,2,4,5-TeCB | 1,2,4,5-tetrachlorobenzene |
| TCE | Trichloroethene |
| TfNSW | Transport for NSW |
| TO | Thermal Oxidiser |
| TOC | Total Organic Carbon |
| TWA TLV | Time Weighted Average Threshold Limit Value |
| TWSA | Trade Waste Service Agreement |
| USEPA | United States Environment Protection Agency |
| VC | Vinyl chloride (chloroethene) |
| VMP | Voluntary Management Proposal |
| VOC | Volatile organic compound |
| VSD | Variable speed drive |

## EXECUTIVE SUMMARY

This document is the 40th Progress Report submitted in accordance with the Voluntary Management Proposal (VMP) under the *Contaminated Land Management Act 1997* and includes progress on the revised Groundwater Remediation and Management Plan (GRAMP) (Orica, 2020a). It provides a progress update on groundwater monitoring, Groundwater Treatment Plant (GTP) performance, related environmental management activities and community outreach initiatives. Unless stated otherwise, the reporting interval covered by this report is 1 April 2023 to 30 September 2023, however, if more recent and relevant information is available it is also included.

### Voluntary Management Proposal

A revised VMP was approved by NSW Environment Protection Authority (EPA) on 29 April 2020. This report is the eighth Progress Report prepared under the 2020 VMP.

The August 2023 biennial groundwater and surface water monitoring event was carried out in accordance with the Groundwater Treatment Plant Groundwater and Surface Water Monitoring Program 2020 – 2024 (Golder, 2020).

### Hydraulic Monitoring

Assessment of hydraulic data for the August 2023 monitoring event, with consideration of the six-step evaluation approach adopted by JBS&G (2019), indicates that, although some inconsistencies were noted, hydraulic containment was generally achieved across much of the target capture zone. Periods of elevated groundwater elevations and limited hydraulic capture were influenced by greater than average rainfall in February 2023, compounded by the scheduled GTP maintenance shutdown in March. Improvements in hydraulic containment were evidenced in the latter portion of the monitoring period following increased rates of groundwater extraction and drier conditions limiting aquifer recharge.

Overall, effective hydraulic containment at Botany Industrial Park (BIP), and within the target capture zones of the intermediate and deep aquifers at the Primary Containment Area (PCA) was evidenced by the achievement of target water levels and/or reverse hydraulic gradients immediately downgradient of the containment lines for the monitoring period.

Whilst hydraulic containment at the Secondary Containment Area (SCA) on the basis of target groundwater elevation levels was less clear, analysis of gradient control pairs supports the conclusion that hydraulic containment was still evidenced in key portions of the SCA target capture zone. Reverse hydraulic gradients were achieved in the shallow aquifer within the eastern and central-eastern portions of the SCA, within the intermediate aquifer in the central-eastern portion, and within the deep aquifer in the eastern and central-eastern portions. Broader assessment of water levels across the SCA indicates a flat hydraulic gradient is likely to exist between the SCA and Penrhyn Estuary shoreline.

It is also noted that significant GTP maintenance improvement works have been undertaken following the period throughout August, September and early October

2023. This, as well as a scheduled program of well rehabilitation works targeting extraction wells constrained by biofouling are expected to further improve groundwater extraction rates and associated hydraulic containment into future monitoring periods.

An assessment of long-term water levels for monitoring wells located adjacent to, and at significant distances from, the containment lines indicate that observed drawdowns are similar to those predicted by groundwater modelling (Laase, 2005 and Laase, 2017) and no long-term downward trends, that may be attributable to GTP operation, are evident. The data highlight the relatively localised effects of the hydraulic containment system and its low potential to adversely affect nearby infrastructure and licensed groundwater users.

**Chemical Monitoring**

The August 2023 sampling program represents a biennial monitoring event focused on collecting data critical to the assessment of groundwater and surface water quality with respect to environmental and human health receptors. The assessment includes considerations of:

- Concentrations of groundwater chlorinated hydrocarbons (CHCs) against long-term trends and changes in contaminant distribution (including parametric tests).
- Concentrations of CHCs against assumptions and results considered in the 2022 Consolidated Human Health Risk Assessment (CHHRA) (EnRiskS, 2023).

A parametric test has been used to identify increasing/decreasing trends in contaminant concentrations at sampling locations. The assessment of data trends for monitoring locations indicates that whilst there have been a number of increases (including historical maxima) and decreases in contaminant concentrations, the changes were either relatively small or are consistent with expected plume behaviour as a result of groundwater extraction from the three containment lines.

Review of August 2023 groundwater data confirm the overall decreasing trend in CHC concentrations, particularly in the shallow aquifer. Where CHC increases or historical maximum concentrations were recorded, these were typically at depth and changes were consistent with expected plume behaviour.

No historical maximum concentrations for key contaminants were reported in groundwater samples collected during the August 2023 monitoring round in wells upgradient of the BIP containment line. Historical maximum concentrations were reported in a small number of monitoring locations upgradient of PCA and upgradient of SCA. These were assessed in detail but were not considered to be significant in the context of the overall distribution of contaminants in these areas, with the exception of BP58 and BP72. Increasing CHC trends in the intermediate and deep aquifer at BP58 and BP72 are likely associated with continued migration of the N2 Plume, and/or western expansion of the N3 Plume following changes to the groundwater flow regime.

With the exception of MWF15 and MWF19, monitoring wells located downgradient of the SCA are characterised by stable or decreasing CHC concentration trends. Increasing trends and historical maximum concentrations for some CHCs were reported in the intermediate and deep wells at MWF15, and in the deep well at MWF19. Whilst CHC concentrations at these locations are typically variable, a review of historical data indicates the August 2023 data at MWF15 and MWF19 may be indicative of limited migration of elevated CHC associated with the Central and Northern Plumes past the SCA during periods of limited hydraulic containment. The low or reverse hydraulic gradients typically recorded between the SCA and Penrhyn Estuary are expected to limit further CHC migration downgradient of the SCA, with the potential for attenuation and recapture.

Temporal changes in contaminant distribution have occurred due to plume migration and attenuation processes. However, the overall decreasing trend in CHC concentrations which has been observed since groundwater extraction commenced in 2004/2005 is primarily attributed to the GTP operations. WSP (WSP, 2023) reported that the dissolved phase mass had decreased by approximately 90% since commencement of the GTP. Dissolution of CHCs from dense non-aqueous phase liquid (DNAPL) source zones and back-diffusion of sorbed CHCs will become increasingly dominant mechanisms controlling contaminant distribution.

August 2023 Penrhyn Estuary pore water data are consistent with previous monitoring rounds with the concentrations of key contaminants generally reducing with decreasing depth towards the discharge interface. The concentrations of the key contaminants of concern in pore water are less than the ANZG (2018) Trigger Values for all pore water samples. No historical maximum concentrations for key contaminants were reported in samples collected from Penrhyn Estuary pore water.

Reported CHC concentrations in surface water were generally consistent with, or less than, those reported in previous monitoring events. Key contaminant concentrations were less than the relevant ANZG (2018) Trigger Values at all surface water sampling locations. No historical maximum concentrations for key contaminants in surface water were reported.

**Human Health Risk Assessment**

There are no data presented in the August 2023 monitoring round that affect the conclusions of the 2022 CHHRA (EnRiskS, 2023) in relation to the western margin of the Northern Plumes, the Main Plumes, Penrhyn Estuary and Floodvale and Springvale Drains (i.e., provided groundwater is not extracted and used for any purpose, health risks associated with exposure to CoPC are low and acceptable).

**GTP Operation**

There was a scheduled maintenance shutdown of the GTP and groundwater extraction network from 23 August to 20 October 2023 to install a new quencher and carry out scheduled maintenance items and inspections of critical equipment.

Two wells in the PCA were rehabilitated in August 2023 to improve groundwater ingress into the wells.

On 6 April 2023 control of the GTP's operations and maintenance reverted from Ixom to Orica.

The approximate total volume of groundwater treated since pump and treat activities commenced in 2005, including this period, is 31,492 ML with approximately 817.6 ML treated during this reporting period.

The estimated total mass of chlorinated hydrocarbons destroyed in the thermal oxidiser, including this period, is 1,589 tonnes with approximately 11.1 tonnes destroyed during this reporting period.

**Community Consultation**

One ordinary meeting of the Orica Botany Liaison Committee (OBLC) was held during the reporting period on 11 July 2023. The next scheduled meeting is to be held on 5 December 2023.

Prof. Denis O'Carroll attended the 11 July OBLC meeting to provide his presentation on the Independent Monitoring Committee (IMC) Task (no. 35) to review the updated mass estimate report (WSP, 2023) and comment on its relationship to the Conceptual Site Model (CSM). The follow-up technical meeting with NSW EPA, Department of Water, IMC representative and WSP was held on 28 July 2023 to respond to the questions arising from Prof. O'Carroll's presentation on the updated mass estimate report (WSP, 2023).

# 1 INTRODUCTION

The NSW Environment Protection Authority (EPA) 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*.

Following effective completion of the principal NCUA actions and consultation with the Community Liaison Committee (CLC) and Orica, NSW EPA determined that the project would be best managed by a Voluntary Management Proposal (VMP) under the *Contaminated Land Management Act 1997*. An initial VMP was approved on 5 November 2010 (Approval No. 20101714), which replaced the NCUA as the regulating tool following the NCUA being revoked on 3 December 2010. A revised VMP was approved on 13 August 2015 (Approval No. 20151711). On 19 May 2020 that VMP was replaced with a revised VMP (Approval No. 20201704).

A revised Groundwater Remediation and Management Plan (GRAMP) (Orica, 2020a) was submitted as an attachment to the 2020 VMP; it outlines the monitoring requirements as per the referenced Groundwater Treatment Plant (GTP) – Groundwater and Surface Water Monitoring Program (Golder, 2017). The GTP monitoring program includes three types of monitoring events: biannual, annual and biennial (in order of sampling program magnitude). In accordance with the review schedule in the VMP, the monitoring program was reviewed and revised in 2020. The 2020-2024 Groundwater and Surface Water Monitoring Program (Golder, 2020) was submitted to NSW EPA in August 2020.

The August 2023 monitoring event is the sixth to be carried out under the 2020-2024 monitoring program (Golder, 2020). As specified in that monitoring program, the August 2023 round is a biennial monitoring event.

This document is the 40$^{th}$ report submitted in accordance with the initial and replacement VMPs and includes progress on the GRAMP (Orica, 2020a). It is the eighth report prepared under the 2020 VMP. It provides a progress update on groundwater, pore water and surface water monitoring, hydraulic monitoring, GTP performance, related environmental management activities and community outreach initiatives. The reporting interval for this report is 1 April 2023 to 30 September 2023, however, if more recent and relevant information is available, it is also included.

Previous reports are available at the relevant section of the website (https://www.orica.com/Locations/Australia--Pacific-and-Indonesia/Australia/Botany-Remediation-Projects/Projects/Groundwater-Cleanup/Publications--Reports---Reviews/progress-reports#.YZWV2NBBw2x) and a distribution list is provided at the beginning of this document.

# 2 COMPLIANCE SUMMARY

## 2.1 Voluntary Management Proposal

The objectives of the 2020 VMP are as follows:

- To protect human health and the environment via hydraulic containment of the chlorinated hydrocarbon contaminant plumes and source areas (as outlined in the GRAMP) (Orica, 2020a). In the case of Penrhyn Estuary and Botany Bay, the hydraulic containment works will prevent contaminant migration to these receptors via groundwater or surface water in order to achieve protection for slightly to moderately disturbed ecosystems using the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018);
- To monitor the nature and extent of the contamination to identify any potential exposures to the contamination that require management; and
- To investigate potential technologies to remediate source zones and plumes.

To achieve these objectives Part 3 of the VMP establishes a clear set of undertakings relating to each of the following components of the project:

- Maintenance and optimisation of hydraulic containment;
- Source area management;
- Contingency measures for the GTP;
- Community consultation;
- Chemical monitoring programs for groundwater and surface water (from which the data are used in assessment of risk to human health and the environment);
- Assessment of risk to human health and the environment (including additional monitoring programs for relevant environmental media); and
- Reporting requirements.

The groundwater contamination issues will require long-term management beyond the expiry date of this VMP. At that time, the objectives and management approach will be reviewed and modified as required.

The 2017-2020 Groundwater and Surface Water Monitoring Program (Golder, 2017) was accepted by NSW EPA in May 2017. It was updated in August 2020. The 2020-2024 Groundwater and Surface Water Monitoring Program (Golder, 2020) was initially adopted for the biannual monitoring event in February 2021 and will be implemented thereafter until the monitoring program is next updated in February 2024.

A summary of the compliance status against VMP requirements is provided below.

| Cond. | Summary of Requirement | Status | Reference Documents / Comments |
|---|---|---|---|
| P1 | Maintain effective hydraulic containment of contaminants of concern at the Primary Containment Area (PCA) Containment Line. | **Ongoing compliance** | Summary of hydraulic containment of PCA provided in Section 3.1 and Attachment A of this report. |
| P1 | Maintain effective hydraulic containment of contaminants of concern at the Secondary Containment Area (SCA) Containment Line. | **Ongoing compliance** | Summary of hydraulic containment of SCA provided in Section 3.1 and Attachment A of this report. |
| P1 | Maintain effective hydraulic containment of contaminants of concern at the Botany Industrial Park (BIP) Containment Line commensurate with the available GTP treatment capacity and operational performance. | **Ongoing compliance** | Summary of hydraulic containment of BIP provided in Section 3.1 and Attachment A of this report. |
| P2 | Conduct ongoing review of developments in remediation technologies and techniques for treatment of Dense Non-Aqueous Phase Liquid (DNAPL), sorbed mass and dissolved phase chlorinated hydrocarbon (CHC) contamination, and their practical applicability to the Botany Groundwater Cleanup Project. | **Work in progress** | On 2 and 3 March 2020 Orica conducted the fifth Botany Groundwater Strategy Review Workshop to discuss remediation strategy with a range of respected overseas and local experts.<br>The inaugural Workshop was held in December 2007, the second in February 2011, the third in February 2014 and the fourth in February 2017. |
| P2 | Convene a Strategy Review Workshop every four years to which it will invite a minimum of three international experts in the field. | **Work in progress** | A workshop was held on 2 and 3 March 2020. A summary report of the outcomes of the review was issued on 30 April 2020. |
| P2 | Provide an annual report to EPA that would assess the practical application and effectiveness of appropriate technologies in relation to the remediation. Every four years, this would also include a detailed summary of the outcomes of the Strategy Review Workshop. | **Ongoing compliance** | The 17th DNAPL and Groundwater Technology Annual Review Report for 2022 was issued on 24 February 2023. |
| P4 | Continue and strengthen community/ stakeholder relationships that help to build awareness and transparency of the contamination, contamination risk, risk management and remediation process. | **Ongoing compliance** | Meeting minutes from the meetings of the Orica Botany Liaison Committee (OBLC), newsletters and newspaper columns are included as part of the community/stakeholder program. |
| P4 | Create a better understanding of public perceptions, information needs and community responses regarding | **Ongoing compliance** | |

| Cond. | Summary of Requirement | Status | Reference Documents / Comments |
|---|---|---|---|
| | current and emerging Botany Groundwater Cleanup (BGC) Project issues so that these can be anticipated and addressed.<br>Orica will inform the community of developments in the Orica BGC Project through:<br>a) Regular OBLC meetings (nominally three times a year unless otherwise agreed to by OBLC members); and<br>b) Maintenance of an internet website providing information related to the BGC Project, which will provide access to copies of current reports prepared under this VMP. Reports older than three years may be archived from the website and be made available on request. | | a) The OBLC meets nominally three times per year (see Section 6.1)<br>b) https://www.orica.com/Locations/Asia-Pacific/Australia/Botany/Botany-Transformation-Projects/Groundwater-Cleanup#.YZWakdBBw2w |
| P5 | Orica will conduct chemical and hydraulic monitoring of groundwater and chemical monitoring of surface water to measure the effectiveness of hydraulic containment activities, to identify changes in the magnitude and extent of the contamination and to allow for the ongoing assessment of risks to human health and the environment.<br>Orica will conduct groundwater monitoring in accordance with revised *Groundwater Treatment Plant Groundwater and Surface Water Monitoring Program 2020 – 2024* (Golder, 2020), noting that the frequency and scope of the monitoring program will be reviewed periodically. The next scheduled review will occur in May 2024. | **Ongoing compliance** | The current revised monitoring program *Groundwater Treatment Plant Groundwater and Surface Water Monitoring Program 2020 – 2024* (Golder, 2020) was submitted to NSW EPA in August 2020 and has been adopted thereafter.<br>A detailed assessment of hydraulic containment at BIP, PCA and SCA was undertaken by JBS (2012) using the United States Environment Protection Agency approach presented in *A Systematic Approach for the Evaluation of Capture Zones at Pump and Treat Systems* (USEPA, 2008). The assessment was updated by JBS&G and submitted to NSW EPA for review in September 2018. Following comments from NSW EPA, a revised report was prepared and submitted to NSW EPA in November 2019 (JBS&G, 2019). The revised report has been used for assessment of hydraulic containment in the August 2023 monitoring event report (Attachment A). |
| P6 | Orica will implement a suitable monitoring program for the assessment of risk to human health, which is primarily based on groundwater and surface water monitoring. In addition, as described in the GRAMP, there are certain groundwater level and contaminant | **Ongoing compliance** | All reports now submitted to NSW EPA include relevant appraisal of potential risk to human health and hence identify any requirement to update the CHHRA. The CHHRA has been updated and revised a number of times over the years. The latest version of the CHHRA (EnRiskS, 2023) was |

| Cond. | Summary of Requirement | Status | Reference Documents / Comments |
|---|---|---|---|
| | concentration conditions that will trigger the collection of additional soil vapour, flux emission and ambient air data. The trigger values are set out in the Consolidated Human Health Risk Assessment (EnRiskS, 2023) (CHHRA). The scope of this monitoring program will be subject to regular review and possible modification with EPA consent. | | submitted to the NSW EPA on 29 July 2022. This assessment provided an update of the 2017 CHHRA, incorporating data and information relevant to the nature and presence of contamination to February 2022, review and update of information and values used to characterise the toxicity of the chemicals of potential concern and the quantification of risk.<br>The CHHRA has been independently reviewed and the reviewer's correspondence has been forwarded to NSW EPA. |
| P6 | At the end of February every year, should data collected in the previous 12 months determine that risk profiles have changed, an annual Addendum will be issued summarising the changes to the risk profiles outlined in the CHHRA. If the risk profiles have not been altered significantly no addendum will be issued. | **Ongoing compliance** | No addendum was required to be issued in February 2023 as the risk profiles had not been altered significantly.<br>The next review of the risk profiles is scheduled to be completed in February 2024. |
| P6 | Every four years, the entire CHHRA will be revised to take into account more recent consolidated monitoring data and changes to relevant exposure scenarios, toxicological data and risk calculation methods. The next revision will be completed in July 2026. Orica will have this document reviewed by an independent expert. | **Work in progress** | The 2022 revision of the CHHRA was completed in July 2022 and the final version was submitted to NSW EPA in August 2023. An independent expert reviewed the CHHRA and concluded that the CHHRA utilised scientifically valid and robust approaches and assumptions and was completed in accordance with relevant state and national guidance.<br>The next revision will be completed in July 2026. |

## 2.2 Environment Protection Licence No. 2148 (EPL 2148)

The GTP's operational environmental performance is regulated under the *POEO Act* as part of Orica's licence for its activities at Botany Industrial Park via EPL 2148. Orica reports compliance against EPL 2148 requirements via the submission of the annual return to NSW EPA in August each year.

No substantive amendments to EPL 2148 were made during the reporting period.

No technical non-conformances were recorded for the reporting period 1 April 2023 to 30 September 2023.

# 3 AUGUST 2023 MONITORING EVENT

Orica engaged WSP Australia Pty Ltd (WSP) to complete a monitoring event in August 2023 in accordance with the 2020-2024 Groundwater and Surface Water Monitoring Program (Golder, 2020).

The August 2023 monitoring event was a biennial monitoring event and was the 40th monitoring event undertaken in accordance with the requirements of the VMP, which requires Orica to implement a comprehensive monitoring program within the Temporary Water Restrictions Order for the Botany Sands Groundwater Source issued under the *Water Management Act 2000* (the Order), which applies from 23 February 2018 to 30 June 2024 (Area 1 of the Order was previously referred to as the Groundwater Extraction Exclusion Area (GEEA)).

Groundwater level and groundwater and surface water chemical monitoring for volatile CHCs are undertaken biannually to measure effectiveness of containment and for ongoing assessment of potential risks to human health and the environment.

Groundwater, pore water and surface water samples are collected for volatile CHC analysis from the Area 1 of the Order (formerly the GEEA) and Penrhyn Estuary, and surface water samples from Springvale Drain and Floodvale Drain.

Interpretation of chemical data is limited to significant changes in water quality that are identified during monitoring rounds. Parametric tests are used to identify increasing/decreasing trends in contaminant concentrations at sampling locations. Measured concentrations are also compared against those considered in the Consolidated Human Health Risk Assessment (CHHRA) (EnRiskS, 2023).

Hydraulic containment at the SCA, PCA and BIP is assessed every six months.

Results and discussions are provided in the WSP report *Groundwater Treatment Plant – August 2023 Biennial Groundwater and Surface Water Monitoring Report*. This report is bound separately as Attachment A. The remainder of this section has been extracted from the WSP report to summarise the monitoring event findings.

## 3.1 Hydraulic Monitoring

A detailed assessment of hydraulic containment at BIP, PCA and SCA was undertaken by JBS (2012) using the United States Environment Protection Agency approach presented in A Systematic Approach for the Evaluation of Capture Zones at Pump and Treat Systems (USEPA, 2008). The assessment was updated in 2019 (JBS&G, 2019) incorporating more recent data and modelled capture targets. This monitoring report uses the updated (2019) version as the basis for assessment of hydraulic containment performance.

The JBS&G (2019) evaluation uses multiple lines of evidence within the six ‘steps’ framework to assess hydraulic containment. It concludes that the remediation objective of the BGC Project (i.e. “*to achieve protection for slightly to moderately disturbed ecosystems using the Australian and New Zealand Guidelines for Marine and Fresh Water (ANZG, 2018)*” in surface water at Penrhyn Estuary is being achieved. It provides a framework for assessment of key metrics for evaluation of the success of hydraulic containment during ongoing monitoring.

Assessment of hydraulic data for the August 2023 monitoring event, with consideration of the six-step evaluation approach adopted by JBS&G (2019), indicates that, although some inconsistencies were noted, hydraulic containment was generally achieved across much of the target capture zone.

Although lower than the preceding monitoring period, averaged groundwater elevations were generally higher than the longer-term averages, attributed to higher-than-average rainfall in February 2023, preceding the scheduled GTP maintenance shutdown in late February and March. Drier conditions and improved groundwater extraction rates following the GTP shutdown maintenance activities resulted in improvement in hydraulic containment in the latter portion of the period.

Overall, effective hydraulic containment at BIP, and within the target capture zones of the intermediate and deep aquifers at PCA was evidenced by the achievement of target water levels and/or reverse hydraulic gradients immediately downgradient of the containment lines for the monitoring period.

Whilst hydraulic containment SCA on the basis of target groundwater elevation levels was less clear, analysis of gradient control pairs supports the conclusion that hydraulic containment was still evidenced in key portions of the SCA target capture zone. Reverse hydraulic gradients were achieved in the shallow aquifer within the eastern and central-eastern portions of the SCA, within the intermediate aquifer in the central-eastern portion, and within the deep aquifer in the eastern and central-eastern portions. Broader assessment of water levels across the SCA indicates a flat hydraulic gradient is likely to exist between the SCA and Penrhyn Estuary shoreline.

It is also noted that significant GTP maintenance improvement works have been undertaken following the period throughout August, September and early October 2023. This, as well as a scheduled program of well rehabilitation works targeting extraction wells constrained by biofouling are expected to further improve groundwater extraction rates and associated hydraulic containment into future monitoring periods.

An assessment of long-term water levels for monitoring wells located adjacent to, and at significant distances from, the containment lines indicate that observed drawdowns are similar to those predicted by groundwater modelling (Laase, 2005 and Laase, 2017) and no long-term downward trends, that may be attributable to GTP operation, are evident. The data highlight the relatively localised effects of the hydraulic containment system and its low potential to adversely affect nearby infrastructure and licensed groundwater users.

### 3.2 Chemical Monitoring

The August 2023 sampling program represents a biennial groundwater chemical monitoring event focused on assessing major changes to plumes, chemical changes in areas where plume migration is expected to occur, as well as detailed assessment of data with respect to the assumptions made in the updated 2022 Consolidated Human Health Risk Assessment (CHHRA) (EnRiskS, 2023).

A parametric test was used to identify increasing/decreasing trends in contaminant concentrations at sampling locations. The assessment of data trends indicated that whilst there have been increases (including some localised historical maxima) and decreases in contaminant concentrations, the changes are consistent with expected plume behaviour as a result of groundwater extraction from the three containment lines.

Additional chemical monitoring was conducted during this monitoring round. These additional results will be reported separately but will be included for the future interpretation of plume dynamics and contaminant distribution.

### *3.2.1 Groundwater - Upgradient of the BIP Containment Line*

Overall, there has been a decreasing trend in volatile chlorinated hydrocarbon (CHC) concentrations at BIP since the commencement of groundwater extraction. The change is most apparent in the long-term trend data, however, the decreases are also notable with respect to the four-year (short-term) parametric tests. No historical maximum concentrations were reported for the monitoring locations upgradient of BIP containment line in August 2023.

### *3.2.2 Upgradient of the PCA Containment Line*

Review of available groundwater data collected in August 2023 indicates that there has been a continued and consistent decreasing trend in CHC concentrations at the former Southlands area, particularly in the shallow portion of the aquifer. The change is most significant with respect to the long-term trend; however, the decreases are still apparent with respect to the four-year (short-term) parametric test presented in this report.

Where CHC increases have been reported, the concentrations are similar to or less than historical maxima reported in adjacent ports, or an artefact of limited monitoring history and unlikely to represent a significant change in contaminant distribution. It is noted that several monitoring locations were recently decommissioned or destroyed to enable site development works on the former Southlands Block 1.

Whilst the absence of these wells represents a short-term data gap, CHC trends in this area have been well established through the evaluation of historical data and an appropriate chemical and hydraulic monitoring network is intended to be reinstated following completion of these works. In recent monitoring events, changes in CHC distribution across this area have been attributable to vertical redistribution of the contaminant mass or changes in groundwater flow direction from the operation of the PCA containment line affecting the C1, S1 and S2 Plumes' orientation and flow direction, or DNAPL dissolution due to the proximity of the S1 source area.

### *3.2.3 Upgradient of the SCA Containment Line*

Review of groundwater CHC data indicates that the trends in off-site groundwater CHC concentrations continue to be characterised by a decrease in CHCs, particularly within the shallow portion of the aquifer. At locations of increasing CHC concentrations, the observed increases are mostly at depth or are relatively low concentrations and are consistent with expected plume migration or the effects of groundwater extraction at the PCA and the SCA.

Increasing CHC trends observed in the intermediate and deep aquifer of the leading edge of the Northern Plumes in the vicinity of BP58 and BP72 is likely associated with continued migration of the N2 Plume, and or western expansion of the N3 Plume following changes to the groundwater flow regime. The increases at depth in these areas are in contrast to the stable or decreasing trends at shallower depths. It should also be noted that the relative concentrations of volatile CHCs in the Northern Plumes are significantly lower than those reported for the Central and Southern Plumes.

### *3.2.4 Downgradient of the SCA Containment Line*

With the exception of MWF15 and MWF19, monitoring wells located downgradient of the SCA are characterised by stable or decreasing CHC concentration trends. The overall decreasing trends in CHC concentrations in the vicinity of SCA are further evidenced through the evaluation of CHC concentrations at SCA monitoring and extraction wells.

Increasing CHC trends and historical maximum concentration of 1,2-dichloroethane (EDC) were recorded for the intermediate and deep wells at MWF15. It is inferred that elevated EDC associated with the Central Plume may have migrated beyond the SCA during historical intermittent periods of limited hydraulic containment. It is noted that hydraulic containment in the deep aquifer within the eastern portion of SCA has been significantly improved since the installation of replacement deep extraction well EWF28D and new deep extraction well EWF25D in August 2020, with potential for recapture due to flat or reverse hydraulic gradients. All other groundwater, pore water and surface water monitoring locations downgradient of MWF15 were characterised by stable or decreasing CHC concentration trends.

Increasing CHC concentrations for most CHCs and a historical maximum EDC concentration were also recorded in the deep well at MWF19. Whilst CHC concentrations at this location historically fluctuate, the trend is consistent with limited migration of the Northern Plumes (or western periphery of the Central plumes) past the SCA during historical periods of incomplete hydraulic capture. Expected improvements in hydraulic containment within the western portion of the SCA, and the very low hydraulic gradients between the SCA and Penrhyn Estuary provide opportunities for recapture. CHCs were not detected in Penrhyn Estuary surface water samples located downgradient of MWF19.

Continued monitoring of these locations in consideration of the downgradient pore water and surface water monitoring networks is required to ensure the remedy objectives of the BCG at Penrhyn Estuary continue to be met.

### *3.2.5 Semi-Volatile CHCs*

Except for hexachlorobutadiene (HCBD) at BP61, all locations where semi-volatile CHCs were detected were on BIP or the former Southlands, close to DNAPL source areas, and upgradient of the PCA. Relatively high concentrations (>0.1 mg/L) of semi-volatile CHCs were detected at BP46, BP48, and WG255, consistent with or less than those reported in previous biennial monitoring events. HCBD was the only semi-volatile CHC to be detected in groundwater downgradient of the PCA. The reported concentrations are consistent with or less than those reported in previous biennial monitoring events for locations with a historical dataset.

### *3.2.6 Regional Contaminant Distribution*

While biannual and annual chemical monitoring programs are focussed on collecting data critical to environmental and human health receptors and assessing chemical changes in areas where relatively rapid plume migration is occurring, the biennial program (August 2023) is designed to enable identification of major changes to plume geochemistry and distribution.

A recent revision of the estimates of CHC contaminant mass at Orica Botany (WSP, 2023) was fundamentally underpinned by the development of a three-dimensional geological model using the Leapfrog subsurface modelling software. Lithological data from 343 historical borehole logs and 102 Cone Penetration Testing (CPT) logs were converted to a digital format to develop a comprehensive geological model. This model was coupled with the modelling of groundwater analytical data to enable estimation of dissolved phase and adsorbed mass in differing lithological units (primarily based on the 2021 biennial sampling data).

The Leapfrog model has also subsequently been utilised to characterise the vertical and lateral distribution of key CHCs in consideration of the August 2023 CHC analytical data. Additionally, Leapfrog has been used to support updates to the Botany numerical groundwater model including 3D modelling of the 2005 and 2013 analytical data and continues to provide valuable insights into the evolving changes of CHC distribution over time.

The August 2023 biennial sampling event has confirmed the historical trend of decreasing dissolved phase concentration throughout much of the aquifer, primarily due to GTP operation. However, there are long-term increases in CHC concentrations in specific areas, including:

- In the deep aquifer on the south-western leading edge of the Northern Plumes, at the northern boundary of the Botany Golf Course, which are inferred to be related to migration of the N1 or N2 Plumes and/or western expansion of the N3 Plume due to changes in the flow regime due to groundwater extraction.

- At Southlands where groundwater extraction at the PCA is drawing the Southern Plumes to the west and is primarily related to trichloroethene (TCE) increases.

- At depth for a limited number of chemicals downgradient of the PCA in the vicinity of Botany Road and are limited to a few discrete vertical intervals and could potentially be related to increasing rates of biodegradation.

- At several locations downgradient of the SCA containment line and are likely related to incomplete capture of the contaminant plume.

Persistent elevated concentrations of EDC (exceeding 10 mg/L or even 100 mg/L) are present within the Central Plume downgradient of the PCA containment line in the area between Botany Road and the SCA. Long-term monitoring has shown that EDC concentrations at most locations have typically decreased by several orders of magnitude from the historical maximums typically reported in the period between 2005 and 2009. The portions of the aquifer with elevated concentrations of EDC are generally restricted to discrete vertical intervals and appear to correlate with low permeability layers within the aquifer which would indicate that the persistence is related to diffused mass in these layers.

Temporal changes in contaminant distribution have occurred due to plume migration and attenuation processes. However, the overall decreasing trend in CHC concentrations which has been observed since groundwater extraction commenced in 2004/2005 is primarily attributed to the GTP operations. WSP (WSP, 2023) reported that the dissolved phase mass had decreased by approximately 90% since commencement of the GTP.

Up to the end of September 2023, GTP performance data indicate that approximately 31,492 ML of groundwater had been extracted from the aquifer since GTP operations commenced with approximately 1,590 tonnes of CHCs treated. This mass exceeds the pre-containment dissolved CHC mass estimate of 1,500 tonnes (URS, 2007), which implies that dissolution of CHCs from DNAPL source zones and back-diffusion of sorbed CHCs will become increasingly dominant mechanisms controlling contaminant distribution in the lower Area 1 of the Order (formerly the GEEA). This is supported by GTP data which have clearly demonstrated diminishing influent concentration to the GTP, which is almost two orders of magnitude lower than when operations commenced.

### *3.2.7 Penrhyn Estuary Pore Water*

In general, the August 2023 Penrhyn Estuary pore water data were consistent with previous monitoring rounds with the concentrations of key contaminants generally decreasing with decreasing depth towards the discharge interface.

The concentrations of the key contaminants of concern in pore water are less than the ANZG (2018) Trigger Values for all pore water samples.

No historical maximum concentrations for key contaminants were reported in samples collected from Penrhyn Estuary pore water.

#### *3.2.8 Surface Water*

Reported CHC concentrations in surface water were generally consistent with, or less than, those reported in previous monitoring events. Key contaminant concentrations were less than the relevant ANZG (2018) Trigger Values at all surface water sampling locations.

No historical maximum concentrations for key contaminants in surface water were reported.

### 3.3 Implications for Human Health Risk Assessment

A review of Springvale Drain surface water data collected in accordance with EnRiskS (EnRiskS, 2023) did not indicate potential issues during the monitoring period with respect to workplace inhalation exposures adjacent to Springvale Drain. It is noted that water levels at MWB03S, which is located close to Springvale Drain where it flows under McPherson Street, exceeded the risk review trigger level for a cumulative period of 74 days during the monitoring period, which is less than the period recommended in 2022 CHHRA (EnRiskS, 2023) as a trigger for further assessment. The elevated groundwater levels are expected to have primarily resulted from the GTP maintenance shutdown in March 2023, as well as significant rainfall in the preceding month. Key contaminant concentrations were also less than the relevant ANZG (2018) Trigger Values and less than those considered in the CHHRA (EnRiskS, 2023) at all surface water sampling locations.

There are no data presented in the August 2023 monitoring round that affect the conclusions of the CHHRA (EnRiskS, 2023) in relation to the western margin of the Northern Plumes, the Main Plumes, Penrhyn Estuary and Floodvale and Springvale Drains (i.e., provided groundwater is not extracted and used for any purpose, health risks associated with exposure to CoPC are low and acceptable).

# 4 GROUNDWATER TREATMENT PLANT ACTIVITIES

## 4.1 GTP Performance

Overall, the GTP continues to operate effectively. There was one planned shutdown of the GTP during the reporting period from 23rd August until 20th October 2023 for six-monthly Safety Instrumented Function (SIF, or automated process safety trip) testing and installation of a new quencher. The opportunity was taken to carry out some maintenance items and inspections of critical equipment.

There were no process trips during the reporting period.

Two wells in the Primary Containment Area were rehabilitated in August 2023 to improve groundwater ingress into the wells.

Operations have not been adversely affected by COVID-19.

A summary of indicative GTP operational performance figures for 1 April 2023 to 30 September 2023 is provided below:

| | |
|---|---|
| Average volumetric rate of groundwater treated (1 April 2023 to 30 September 2023) | 4.5 ML/d[1] |
| Approximate total volume of groundwater treated since pump and treat activities commenced in 2005 (at 30 September 2023) | 31,492 ML |
| Volume of groundwater treated during the period 1 April 2023 to 30 September 2023 | 817.6 ML |
| Estimated total mass of CHCs destroyed in the thermal oxidiser (at 30 September 2023) | 1,589.4 tonnes |
| Estimated mass of CHCs destroyed in the thermal oxidiser during the period 1 April 2023 to 30 September 2023 | 11.1 tonnes |

In the past several years, GTP operations – and the volumes of groundwater treated in it – have been relatively steady. As the mass of dissolved-phase CHCs in the aquifer has been depleted, the average concentration of groundwater being pumped to the GTP has decreased. The daily mass of CHCs destroyed has gradually declined due to the reduction in CHC concentrations in extracted groundwater; it was approximately 77 kg per day during the reporting period (taking into account the GTP shutdowns).

On 6 April 2023 control of the GTP's operations and maintenance reverted from Ixom to Orica.

[1] Excluding the offline time for the September 2023 shutdown, the average volumetric rate of groundwater treated during the reporting period was 5.7 ML/d.

The annual return for EPL 2148 was submitted in August 2023.

The annual Network Operator Compliance Report and Retail Supplier Compliance Report were submitted to the Independent Pricing and Regulatory Tribunal (IPART) in August 2023.

### 4.2 Thermal Oxidiser and Dioxin Air Emissions

Stack emissions testing was undertaken in May and August 2023, with all results below the relevant licence limits.

## 5 STRATEGY REVIEW WORKSHOP

Condition P2 of the 2020 VMP states that Orica will:

- "Conduct ongoing review of developments in remediation technologies and techniques for treatment of Dense Non-Aqueous Phase Liquid (DNAPL), sorbed mass and dissolved phase CHC contamination, and their practical applicability to the Botany Groundwater Cleanup Project.
- Convene a Strategy Review Workshop every four years to which it will invite a minimum of three international experts in the field. The EPA will be consulted on the selection of the experts prior to the experts being engaged. The review process will involve consideration by the experts of the annual reports prepared by Orica (see bullet point below) and worldwide developments in technology in order to assess whether any current or emerging technologies (including developments in technology and its applications) are likely (individually or in combination) to provide a practicable solution and justify the conduct of field trials of those technologies. Appropriate representatives of the Independent Monitoring Committee (IMC) (as agreed with the Orica Botany Liaison Committee (OBLC) – refer P4) and the EPA will be invited to attend the workshop. The outcome of the Remediation Strategy Review Workshop will be considered in determining whether field trials of one or more remediation technologies should be conducted.
- Provide an annual report to the EPA that would assess the practical application and effectiveness of appropriate technologies in relation to the remediation. Every four years, this would also include a detailed summary of the outcomes of the Strategy Review Workshop (refer R3)."

The fifth Botany Groundwater Strategy Review Workshop was held on 2 and 3 March 2020. A report on the Workshop was issued to the EPA on 30 April 2020.

Updates on work arising from the 2017 Workshop actions (Orica, 2017) were presented to the 2020 Workshop participants (Orica, 2020b). In particular, Geosyntec Consultants issued a report and gave a presentation on the outcomes of their column studies and related DNAPL characterisation and contaminant mass transport work. Their work included assessment of additional groundwater data from the March and September 2019 monitoring events. The report indicated there is clear evidence of natural attenuation in the aquifer due to biological and abiotic degradation processes, and sorption and diffusion into low-permeability layers, which varies both laterally and vertically in the aquifer beneath and downgradient of the BIP.

Over the two days of the 2020 Workshop presentations were made by:

- Orica personnel and environmental consultants to provide background to the Orica Botany Groundwater Project and updates since the previous workshop;
- A representative from NSW EPA to provide the Regulator's perspective; and
- The three international experts to provide their views on the current remediation strategy and achievements of the BGC Project to date, observations from comparable sites overseas, updates on available and

emerging cleanup technologies, and views on whether any changes to the strategy would be warranted.

Attendees of the Workshop then participated in a facilitated discussion of recent developments and application of cleanup technologies, and what – if any – could be the best alternative strategies for long-term management and remediation.

The primary conclusions for the 2020 Workshop are:

- The existing remedial strategy (hydraulic containment effected through large-scale 'pump and treat' of groundwater) is appropriate, effective and concluded to remain the most viable option for containment and source reduction through the foreseeable future;
- No recent remediation technology developments, or complementary technologies, are identified at this time that would merit exploration of their applicability to the BGC Project; and
- The review of source zone remediation options indicates uncertain performance relative to the current situation and high cost.

Notwithstanding the above outcomes, it was also noted that:

- Flushing and mass extraction alone (i.e., without natural attenuation) will not likely achieve remediation end goals in the short or medium term;
- In situ degradation is contributing to faster decay of the plumes and sources; while
- The mechanisms of 'back-diffusion' and desorption create secondary sources which impact long-term persistence of plumes and plume response to GTP pumping.

Accordingly, a series of actions were captured in the context of moving towards an enhanced project direction aimed to:

- Optimise GTP performance in key areas of the plumes where practical and cost beneficial;
- Continue to investigate and enumerate existing back-diffusion/desorption and natural attenuative processes with the goal of defining a transition condition that could allow for cessation of operating the GTP;
- Continue to evaluate options to enhance natural attenuative processes to accelerate the rate of cleanup progress; and
- Continue to evaluate timing, metrics and potential effects on the receiving environment of shutting down the 'pump and treat' system

while maintaining the 'pump and treat' system for the medium to long term.

A special meeting was held on 4 March 2020 to allow community members of the OBLC to discuss the outcomes of the Strategy Review Workshop with the three international experts, IMC hydrogeologist Dr Denis O'Carroll and James Stening.

The sixth Botany Groundwater Strategy Review Workshop will be held in March 2024.

# 6 COMMUNITY CONSULTATION

This section provides an update in response to Condition P4 of the VMP, which specifies how Orica must inform the community of developments in the BGC Project. It provides information regarding the consultation activities undertaken by Orica to share information and obtain community feedback on the BGC Project.

## 6.1 Orica Botany Liaison Committee (OBLC)

One ordinary meeting of the Orica Botany Liaison Committee (OBLC) was held during the reporting period on 11 July 2023. The next scheduled meeting is to be held on 5 December 2023.

## 6.2 Independent Monitoring Committee (IMC)

- IMC Task no. 35 for Prof Denis O'Carroll, IMC hydrogeologist to review the updated mass estimate report and comment on its relationship to the Conceptual Site Model (CSM), has been completed.

Prof O'Carroll's presentation was recorded at the July meeting and was uploaded to the Orica website together with a follow-up technical meeting minutes that was an action from the July OBLC meeting.

## 6.3 Communication Tools

The following table provides an overview of activity this reporting period (or more recently) for the routine BGC Project communication tools used by Orica.

| Communication Tool | Activity This Reporting Period Related to the BGC Project |
|---|---|
| BGC Project pages on https://www.orica.com/Locations/Asia-Pacific/Australia/Botany/Botany-Transformation-Projects/Groundwater-Cleanup#.X8QZoGgzYuU | Information uploaded:<br>• July 2023 OBLC meeting agenda and briefing paper.<br>• July 2023 OBLC meeting minutes and presentations.<br>• March 2023 OBLC meeting minutes and presentations.<br>• April 2023 Orica VMP Progress Report no. 39. |
| Local newspapers | Column published in the *St George Leader* 5 July 2023[2], and emailed to Orica's database of subscribers. |

[2] The *Southern Courier* and *St George Leader* are now only published online. As the *Southern Courier* is only available through paid subscription, column advertisements for the BGC Project are now only published in the *St George Leader* and is also distributed via Orica's database of subscribers.

| Communication Tool | Activity This Reporting Period Related to the BGC Project |
|---|---|
| Email enquiries | No feedback received specific to the BGC Project. |
| Feedback facility on the Orica website | No feedback received specific to the BGC Project. |
| 1800 Number Calls | No feedback received specific to the BGC Project. |
| Site tours | 1 September 2023 – Chemical Engineering students from Sydney University visited the Botany Industrial Site and Groundwater Treatment Plant.<br><br>29 September 2023 – Students and Professionals from UTS, undertaking the Contaminated Site Assessment Remediation and Management (CSARM) course, visited the Botany Industrial Site and Groundwater Treatment Plant. |

### 6.4 Community Investment

The successful recipient of the Orica Botany Community Investment Program for 2023 is the Windgap Foundation, receiving $9,000 towards a twelve-week Fitness and Wellness Program and the purchase of health and wellbeing items to promote health and wellness of adults living with intellectual disabilities.

## 7 REFERENCES

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## ATTACHMENT A – BIENNIAL MONITORING REPORT – AUGUST 2023

Groundwater Treatment Plant – August 2023 Biennial Groundwater and Surface Water Monitoring Report. WSP Australia Pty Ltd. 31 October 2023. *Separately provided report.*