CHAPTER 10 Land Use

10.1 Introduction

This chapter outlines the current land use and ownership in and around the areas of construction and operation for the BGC Project. It provides a description of the land use patterns within the overall Project Area, and assesses the potential land use impacts of the project.

10.2 Overview

The land use patterns in and around the Project Area are shown on Figure 10.1, summarised as:

- industrial;
- special uses;
- commercial;
- residential; and
- natural/recreational areas.

These land use patterns are described in the following sections, with detailed descriptions of the specific areas of the BIP and Southlands, and more general descriptions of the broader surrounding areas.

10.2.1 Botany Industrial Park (BIP)

Industry was first established in the East Botany area in the early 1900s. The 1920s and 1930s saw the first establishment of major industries, and manufacturing began at the south end of what is now the BIP in 1942. The 1960s saw the introduction of larger manufacturing plants and the BIP became what is now known as a petrochemical complex.

The BIP was subdivided in 1998–1999, and consists of a number of manufacturing plants operated variously by Orica Australia Pty Ltd, Huntsman Corporation Australia Pty Ltd, and Qenos Pty Ltd, as shown in Figure 2.2.

In addition to the manufacturing operations, there are various services activities within the BIP, as well as areas that are currently unoccupied and/or unused, following the cessation and/or demolition of historical manufacturing plants.
10.2.2 Southlands

Southlands (Block 1 and Block 2) is located just to the south-west of the BIP (refer to Figure 1.2). Although the site has never been developed, it has a long history of disturbance and use from a variety of activities, which have included:

- commercial peat cutting and sand extraction;
- dumping of bottom end furnace ash from coal-fired boilers, mainly from Bunnerong Power Station;
- discharge of paper waste slurries and the storage of waste paper;
- dumping of general refuse due to poorly controlled access in the past.

The only structures on Southlands are associated with the newly installed infrastructure for groundwater remediation, including the groundwater extraction and monitoring wells, and the primary and secondary transfer pipelines.

10.2.3 Surrounding Land Uses

As shown on Figure 10.1, the areas within and around the Project Area largely comprise industrial land uses such as chemical manufacturing and food manufacturing, with residential areas to the north, east and west, and various commercial areas, special uses and recreational areas scattered amongst them.

**Industrial**

The Botany area is one of Sydney’s major port and industrial regions, and a large part of the surrounding area is committed to industrial land uses. The area contains general industrial and mixed industrial zones, including light industrial, commercial and retail land uses.

There are also airport and port related industrial zones, associated with Sydney Airport and Port Botany, described in more detail below.

The industrial land uses can be identified within several industrial clusters:

- **Banksmeadow/Hillsdale/Matraville:** The area surrounding the BIP incorporates industrial land uses such as chemical manufacturing, food manufacturing, container storage and port related facilities. Other than the BIP, current major industrial sites include Nuplex Industries, Pacific National, Kelloggs, Solvay Interox, Amcor Fibre Packaging and Nalco;

- **West Botany:** This area adjoins Sydney Airport to the east and comprises a range of industrial land uses including container parks and motor vehicle repair shops; and

- **Botany/Mascot:** This area comprises a variety of industrial land uses, including new industries generally compatible with residential and open space land uses, such as the Lakes Business Park located along the banks of the Mill Ponds at Lord Street. The Business Park tenants include small to large commercial and light industrial businesses, warehousing and distribution, textile manufacturing and food retailing supplies.
CHAPTER 10 Land Use

Special Uses

There are a number of areas zoned for special purpose land use in the vicinity of the BIP, including:

- Sydney Airport: The airport is NSW’s major domestic and international airport, located about 2.5 km to the west of the BIP. As the major international gateway into Australia, Sydney Airport is Australia’s busiest passenger airport, as well as Australia’s busiest cargo airport, handling 475,000 tonnes of air freight in 2004 (Southern Cross Airports Corporation Holdings Ltd, 2004);

- Port Botany: This is Sydney’s primary port for the handling of containers and bulk liquids, located approximately 1 km to the south of the BIP. Port Botany includes two container terminals to the north (operated by Patrick Stevedores) and south (operated by P&O Ports) side of Brotherson Dock, a number of container parks (Smith Bros, Patrick Port Services and P&O Trans Australia), and a Bulk Liquids Berth from which bulk liquids (LPG, petroleum products, organic chemicals and caustic soda) are transferred to liquid storage facilities operated by other organisations. Sydney Ports Corporation has proposed an expansion of the Port Botany facility, which would consist of a new container terminal facility covering approximately 63 hectares. At the time of writing, this expansion project had not been approved; and

- Botany Freight Rail Line: This is a dedicated freight rail line that operates from Port Botany and links into the metropolitan network, forming the western boundary of the BIP.

There are also various easements for existing services:

- Pipelines under Botany Bay connect the Caltex Oil Refinery at Kurnell with the Caltex terminals at Banksmeadow and Silverwater.

- The Sydney to Newcastle fuel pipeline, which is a buried pipeline located on the southern side of the Foreshore Road reserve, connects the Caltex terminal at Banksmeadow with Newcastle.

- The Sydney Airport jet fuel line is also a buried pipeline, which connects the Caltex terminal at Banksmeadow with Sydney Airport. The pipeline is generally located on the northern side of Foreshore Road, except for a short section near the Caltex terminal where it is located on the southern side of Foreshore Road.

Commercial

Commercial development in the area is primarily located in strip centres, local neighbourhood shopping centres and regional shopping centres.

Strip centres are located along main roads such as Botany Road in Botany and Mascot. These centres tend to offer basic necessities such as butchers, bakeries, newsagents and fast food outlets.

Local neighbourhood shopping centres include Eastlakes and Southpoint Shopping Centres and the regional shopping centre at Westfield Eastgardens (just to the north-west of the BIP).

The Discovery Cove Business Park, a commercial business centre, is located on Botany Road at Banksmeadow, to the south-west of the BIP and south of Southlands. The centre includes a café, commercial office accommodation and truck parking bays.
Residential

Residential areas in the vicinity of the BIP are located to the north, west and east of the site, in the suburbs of Matraville, Hillsdale and Botany.

Botany is located to the west of the BIP, and consists primarily of one- and two-storey detached dwellings. It is bounded by Southern Cross Drive, Wentworth Avenue, Sir Joseph Banks Park and the Banksmeadow/BIP industrial area.

Hillsdale is the closest residential area, located along Denison Street just to the east of the BIP. Hillsdale is part of a relatively large residential area located to the north-east and east of Denison Street, which consists of Hillsdale, Matraville and Maroubra, and extends as far east as the coast.

Residential land uses in the area are complemented by community support services and facilities such as schools, childcare centres, hospitals, libraries, community halls and churches.

There are a number of schools in close proximity to the BIP, including Banksmeadow Primary School to the west and Matraville Primary School to the east. Other schools in the region include JJ Cahill High School, South Sydney High School, Botany Primary School, Pagewood Marist Brothers School, Pagewood Primary School, Our Lady of the Annunciation Primary School and St Agnes Primary School.

Recreational Uses

Open space resources in the vicinity of the BIP provide for:

- recreational opportunities;
- pedestrian and cyclist thoroughfares;
- areas of environmental protection including wetlands, remnant bushland and coastal foreshore zones; and
- the separation of different land uses.

Botany Bay is one of the most important water bodies in the region, both as an ecological habitat and as a recreation resource. The recreational uses of Botany Bay include fishing, boating, swimming and scuba diving.

Penrhyn Estuary, which lies to the south of the BIP, is a small tidal inlet on the northern shores within Botany Bay. The estuary is essentially composed of sand and mudflats. Stormwater from the Botany/Banksmeadow catchment discharges into the upper reaches of the estuary via Springvale and Floodvale Drains. Penrhyn Estuary provides feeding and roosting habitat for migratory and non-migratory shorebird and seabird species. There are signs advising against swimming and fishing in the area, due to known contamination of the sediments.

There is a boat ramp on the southern side of Penrhyn Estuary, off Penrhyn Road. This facility is used by recreational fishers, particularly during the summer months. Users include many formally organised groups as well as individual fishers.
Foreshore Beach, which lies directly south of the BIP, is composed of sands dredged from the entrance of Botany Bay during the Port Botany construction activities in the 1970s and 1980s. Coastal dune vegetation was planted and has colonised the hind dunes of the beach. Foreshore Beach is commonly used for various recreational activities including dog walking, fishing and swimming.

Foreshore Beach users come from within and beyond the Botany and Randwick City local government areas (LGAs). The lack of built concrete structures at Foreshore Beach and its substantial length attracts users to the beach. Unlike the majority of Sydney’s beaches, dog walking is permitted on Foreshore Beach, which makes it appealing to some sections of the community.

The Botany Wetlands, or Mill Ponds, are located just to the north-west of the BIP and comprise a series of artificial lakes or ponds along the upper reaches of the Mill Stream. The wetlands provide roosting and feeding habitat for a small number of shorebird species.

Other recreational areas located in the suburbs surrounding Port Botany include Botany Golf Course, Eastlake Golf Course, The Lakes Golf Course, Bonnie Doon Golf Course, Botany Athletic Centre and Bunnerong Equestrian Park. Small reserves and sports grounds such as tennis courts and rugby fields are scattered throughout the residential areas, usually catering for active recreation activities and children’s playgrounds. In addition, there are several parks and reserves in the area including Sir Joseph Banks Park, Mutch Park, Heffron Park, Garnet Jackson Reserve, Woomera Reserve, Yarra Bay Bicentennial Park and Botany Bay National Park.

10.2.4 Surrounding Zones

The Project Area and surrounds are subject to the planning provisions contained in the Botany Local Environmental Plan 1995 (BLEP). The 4(a) Industrial zoning extends to the north, south, east and some western areas of the BIP. The zones surrounding the industrial zone under the BLEP are illustrated in Figure 10.2. These include:

- **Zone 2(a) – Residential "A"**: Residential area adjacent to the east boundary of the BIP across Denison Street. The primary objective of this zone is to provide for the development and use of dwelling houses as the predominant built form, together with community and service uses of a type and scale appropriate to the enjoyment of such housing;

- **Zone 2(b) – Residential "B"**: Residential area east of the industrial area, adjacent to the 2(a) Residential ‘A’ zone described above. The primary objective of this zone is to provide for the development and use of housing, other than detached housing, in appropriate locations, together with community and service uses of a type and scale appropriate to the enjoyment of such housing;

- **Zone 3(a) – General Business**: Eastgardens Shopping Centre, located due north of the BIP. The primary objective of this zone is to reinforce the historical development of business and shopping locations in the Botany LGA by providing for a full range of retail, business and professional service activities, which provide services and employment opportunities for the community;

- **Zone 5(a) – Special Uses, including railways, main roads and other special uses**: The 5(a) zoning is immediately represented by the railway line running through the Project Area, along the western boundary of the BIP. The primary objective of this zone is to ensure the orderly use of land identified for infrastructure uses, such as Sydney Airport, Port Botany and the Sydenham–Botany goods railway line, or land which is reserved and proposed to be acquired for new or widening of existing arterial roads; and
FIGURE 10-2
Botany Local Environment Plan 1995 Town Planning Zones

LEGEND

1a Non Urban
2a Residential A
2b Residential B
3a Business General
4a Industrial
4b Mixed Industrial
5a Special uses
6a Open Space and Recreation
Interim Development Order

PROJECTION: MGA Zone 56
DATE: 11/11/2004

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• **Zone 6(a) – Open Space and Recreation**: Botany Athletic Centre/Hensley Field, located to the north-east of the BIP. The primary objective of this zone is the provision of different kinds of public open space and recreational land within the LGA to meet the needs of the community.

### 10.2.5 Summary

As shown on Figure 10.2, the Project Area is predominantly zoned for either ‘Industrial Uses’ or ‘Special Uses’, and has been developed according to these zonings. Therefore, the BGC Project generally conforms with land uses and zonings in the Project Area.

### 10.3 Land Use Trends

Reduced availability of land in the Sydney region has put pressure on residential land supplies, resulting in demand for multi-unit housing. Several new residential areas in the area have been created in the past five to 10 years from areas previously used for industrial purposes; for example, multi-unit housing development in Botany (e.g. Banksia/Morgan Street, William Street and the Fairways development) and the Council of the City of Botany Bay’s rezoning of the Mascot Station Precinct (the land bounded by O’Riordan Street, Kent Road, Coward Street and Gardeners Road in Mascot) to 10(a) mixed use residential/commercial, 10(b) mixed use commercial/warehouse, and 3(b) business restricted. The number of residential developments has resulted in an increase in housing density. The increase in medium density housing within the region is being driven by lifestyle considerations associated with the proximity of services, the improvement of infrastructure (e.g. Airport Rail Link and Eastern Distributor) and the availability of large development sites.

The Council of the City of Botany Bay has noted that heavy industry is slowly being replaced by light industrial, high-tech development, commercial and warehouse uses, with a high level of associated office component (CCBB, 2000). This type of development also occurs in Mascot’s industrial zones, north of Sydney Airport.

Local councils are improving the environment of neighbourhoods where residential and industrial land uses coexist, such as in Mascot, Botany and Banksmeadow within Botany Bay LGA, and in Matraville within the Randwick LGA. The coexistence of residential and industrial land uses allows councils to accommodate increased demand for residential development while retaining the supply of industrial land, thus maintaining the region’s significance as an employment base.

Botany Bay is one of 29 sites along the NSW coastline where commercial fishing has recently been banned by NSW Fisheries. The ban is expected to ease pressure on popular recreational angling areas and provide the average enthusiast with better access to fishing.

### 10.4 Assessment of Impacts During Construction

Construction works for the project could have some impacts on surrounding land uses, as a result of construction traffic, noise and dust generated during construction works on the BIP, Southlands and the underground discharge line. However, these would be expected to be minimal, given the nature of the works, the location of the construction sites in the context of the extensive existing industrial activities and road network in the Project Area, and the relatively short timescales involved.
The specific potential impacts have been assessed in the relevant sections of this EIS. Provided that the nominated safeguards and mitigation measures are adopted as part of the Construction Environmental Management Plan (CEMP), the construction works would not have significant impact on surrounding land uses.

### 10.5 Assessment of Impacts During Operation

This EIS has considered all potential impacts for all environmental aspects arising from the operation of BGC Project, as detailed in the relevant sections. Of these, a small number could have the potential to affect land uses in the Project Area, as summarised in Table 10.1. All other issues are considered to have insignificant potential for affecting land use.

#### Table 10.1 Potential issues affecting land use in the Project Area

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Potential impact</th>
<th>Conclusion</th>
<th>Ref. to assessment and relevant mitigation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogeology</td>
<td>Subsidence&lt;br&gt;Reduced use of groundwater&lt;br&gt;Potential for future lifting of groundwater exclusion zone</td>
<td>Minor potential for subsidence, with little impact on local buildings and infrastructure&lt;br&gt;No change to existing restrictions to groundwater use&lt;br&gt;Potential positive benefit of future sustainable use of groundwater, for industry and residents</td>
<td>Chapter 12</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Negative effect of discharge on Botany Bay</td>
<td>GTP design to achieve specified water quality; discharge to stop if any exceedance is identified through monitoring</td>
<td>Chapter 13</td>
</tr>
<tr>
<td>Traffic</td>
<td>Congestion and delay&lt;br&gt;Compromised traffic safety on Foreshore Road</td>
<td>Vehicle numbers insignificant compared to existing traffic flows&lt;br&gt;Infrastructure installed underground, with no obstructions affecting Foreshore Road</td>
<td>Chapters 5 and 16</td>
</tr>
<tr>
<td>Noise</td>
<td>Increased ambient noise levels</td>
<td>Negligible cumulative contribution from plant and pump operations</td>
<td>Chapter 17</td>
</tr>
<tr>
<td>Ecology</td>
<td>Impact on estuarine organisms&lt;br&gt;Impact on Penrhyn Estuary bird life</td>
<td>Potential for some loss of benthos, seagrass and mangroves. Potential improvement in salt marsh.&lt;br&gt;No significant impact predicted</td>
<td>Chapter 20</td>
</tr>
<tr>
<td>Air Quality</td>
<td>Reduced ambient air quality</td>
<td>Low or no cumulative contribution from emissions from GTP operation&lt;br&gt;Emissions to cease immediately in the event of any exceedance</td>
<td>Chapter 22</td>
</tr>
<tr>
<td>Hazard &amp; Risk</td>
<td>Increased risk from accident</td>
<td>Potential risks acceptable within guidelines</td>
<td>Chapter 23</td>
</tr>
<tr>
<td>Health Risk</td>
<td>Negative effect on human health</td>
<td>No significant impact</td>
<td>Chapter 24</td>
</tr>
</tbody>
</table>
The conclusions summarised in Table 10.1 are based on both the assessment of the impacts and the proposed measures to be implemented to address them.

Provided that the nominated safeguards are adopted as part of the design, operation and management of the BGC Project, the project would not have significant impact on surrounding land uses.

10.6 Mitigation Measures

The impacts of construction and operation on land uses would be minimised through the implementation of comprehensive mitigation measures, which are presented in each of the individual chapters (as referred to in Table 10.1) and summarised in Chapter 27.

10.7 Conclusion

The proposed BGC Project is designed to contain and clean up the identified groundwater contamination arising from historical industrial activities in the Project Area. The project is made up of a number of different components that are to be installed and operated in different locations within the Project Area, and these components and locations are generally compatible with the both the existing land uses and the land zoning.

Assessment of the potential impacts from both the construction and operation phases of the project has concluded that, subject to implementation of the specified mitigation and management measures, the project would not affect existing land uses within the Project Area.

In addition, the successful operation of the project could lead to lifting of the current restrictions on use of the groundwater and on recreational activities in and around Foreshore Beach, subject to conditions set and agreement reached with DIPNR, which would have a positive impact on surrounding land uses.
11.1 Introduction

The purpose of this chapter is to identify and assess the potential impacts on geology and soils in the Project Area, arising from the construction and operation of the BGC Project.

The assessment for the Project Area has been based on a number of studies carried out in recent years in the area.

A more detailed assessment has been carried out for the proposed GTP site, located on the BIP, for which the description of the geology and the assessment of sediment, soil and geotechnical issues are based in part on the geotechnical field investigation and contamination assessment undertaken at the GTP site. These reports are Report on Geotechnical Investigation: Orica GTP (Douglas Partners, 2004) and ENV 2949 – Analytical Report (SGS, 2004).

11.2 Methodology

11.2.1 Geotechnical Investigations at the GTP Site

Geotechnical investigations at the GTP site were undertaken to provide information on the subsurface conditions for the design of new foundations for the GTP.

The work comprised nine cone penetration tests (CPTs) to develop the subsoil profile of the site.

In addition, SGS (an independent analytical laboratory) carried out soil sampling at nine nominated locations on the GTP site, as shown in Figure 11.1. Samples were collected at depths of 0.5 m and 1.0 m and analysed to understand the level of contamination. Samples were analysed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, sulphide and total petroleum hydrocarbons (TPH). Soils were also tested for contamination by volatile and semi-volatile CHCs.

Any evidence indicating the presence of Acid Sulphate Soils (ASS) was also noted.

11.2.2 Desk-Top Assessment

The assessment for the other works has largely been based on various other studies carried out in recent years in the area, addressing various geotechnical and soil contamination issues. These include:

- ICI Botany Groundwater Stage 1 Survey (AG Environmental Engineers, 1990)
- ICI Botany Groundwater Stage 2 Survey (Woodward-Clyde, August 1996)
- ICI Botany Groundwater Stage 3 Survey (Woodward-Clyde, August 1998)
- Environmental Impact Assessment Document for Botany Groundwater Remediation Project – Phase 2 (Orica Australia, April 2004)
11.3 Existing Environment

11.3.1 Landscape and Topography

The Project Area is located within an area of former sand dunes and coastal swamps within the Botany Basin. The elevation of the area drops from approximately 20 m above sea level on the north-eastern boundary of the BIP to less than 5 m above sea level on the south-western boundary, and to sea level at Foreshore Beach and Penrhyn Estuary south of the SCA.

Natural drainage of the area is via two drains:

- Springvale Drain, whose catchment drains the low lying areas to the east (including the BIP), including domestic underground stormwater drains from as far afield as Maroubra, for discharge into the eastern side of Penrhyn Estuary; and
- Floodvale Drain, whose catchment includes several kilometres of domestic stormwater drains around east Botany, drains the low lying areas to the west, for discharge into the middle of Penrhyn Estuary.

The shoreline down-gradient of the SCA has been extensively previously modified to accommodate industrial, port and airport facilities, and the identified features have been developed from these works, including:

- Foreshore Beach: A sandy beach approximately 1.6 km long, constructed from sand dredged from Botany Bay in the late 1970s; and
- Penrhyn Estuary: A shallow, intertidal inlet at the south-eastern end of Foreshore Beach, formed in the late 1970s by construction of the existing facilities at Port Botany.

In addition, Bunnerong Canal drains stormwater via Bunnerong Creek from a small catchment that contains portions of the suburbs of Matraville, Malabar, Maroubra and Chifley within the Randwick City Council LGA.

Much of the Project Area has been built upon, with a range of industrial, commercial and infrastructure developments. The two principal undeveloped areas are:

- Botany Golf Course, within Banksmeadow Park, which originally comprised deep gullies, hills and undergrowth and was subsequently improved through deposition of spoil from the construction of Bunnerong Power Station; and
- Southlands, the undeveloped blocks of land just west of the BIP, as previously described.

11.3.2 Regional Geology

The Project Area lies within the Botany Basin, an 80 km² sub unit of the Sydney Basin. The Botany Basin is bounded by Centennial Park to the north, Randwick and Matraville to the east, Alexandria and Rockdale to the west, and the Kurnell Peninsula and part of the Sutherland Shire to the south.
CHAPTER 11 Geology, Soils and Geotechnical

According to the 1:100,000 Sydney Region Geological Map (Geological Survey of New South Wales, 1983) the regional geology around the area consists of bedrock of Triassic Hawkesbury Sandstone overlain by Quaternary sediments. The Hawkesbury Sandstone consists predominantly of crossbedded, medium to coarse quartz sand and resists weathering to crop out as prominent headlands that create Sydney's distinctive steep foreshores and rocky islands. Thin, steeply dipping Jurassic basaltic dykes, trending approximately east–west, have intruded the Hawkesbury Sandstone to the north of Penrhyn Estuary. There are no known geological faults within the Project Area.

Quaternary sediments (up to 80 m thick) have infilled drowned river valleys incised into Hawkesbury Sandstone bedrock. These sediments, otherwise known as the Botany Sands, are composed of predominantly unconsolidated to semi-consolidated permeable sands. These are interspersed with lenses and layers of peat, peaty sands, silts and clay (low permeability), which become more common in the lower part of the sequence. Hard iron cemented sand layers, locally referred to as "Waterloo Rock", are common in the upper layers of the formation.

11.3.3 GTP Site

The GTP site is predominantly covered in asphalt pavement with some areas of concrete hardstanding. The site was previously the location of the Silicates Plant, which was largely demolished in 2000. Concrete footings from that plant are still present on site. Prior to that, the site was used for the air drying of lime, and residues are expected to remain under the old foundations.

Asphaltic concrete pavements cover a large proportion of the site. Grassed and gravel covered areas are located over the western and southern portions of the site. A raised platform area about 1 m high is located in the central portion of the site, and a demountable building and brick substation are located close to the northern boundary of the site. Remains of old footings and steel structures are located within the southern portion of the site. Driveways extend into the site from 10th Avenue and 2nd Street and are connected by an internal asphaltic concrete roadway.

Geology

The geology at the proposed site is as described for the regional geology, underlain by Quaternary age sediments (Botany Sands) which overlie the Hawkesbury Sandstone bedrock at significant depth. The Botany Sands comprise predominantly unconsolidated to semi-consolidated permeable sands, with layers and lenses of alluvial material such as peat, peaty sands, silts and low permeability clays.

Hawkesbury Sandstone is a medium to very coarse grained quartz sandstone with minor laminated mudstone and siltstone lenses. Previous studies suggest that the depth to bedrock at the BIP site ranges between approximately 20 m and 40 m.

The results of the CPTs showed the following typical conditions over the site:

- Filling generally comprised poorly to moderately compacted gravelly sand, clayey sand or sandy clay extending to depths between 0.86 m and 3.46 m.

- Sand/silty sand underlying the filling are assessed to be generally medium dense to dense grading, to very dense at depths between 2.6 m and 4.0 m. Some medium dense to dense layers were encountered within the very dense sand/silty sand profile. There were also thin, hard clay bands at about 7.5 m depth in some locations.
Groundwater levels were measured at depths between 0.8 m and 2.3 m.

**Soil**

Results of the soils testing are presented in Tables 11.1, 11.2 and 11.3. The contaminant concentrations have been compared against appropriate local standards. Where no local standard is applicable, international standards have been applied.

### Table 11.1 Metals, sulphide and moisture content in soil

<table>
<thead>
<tr>
<th>Component</th>
<th>Units</th>
<th>NEPC HIL F (mg/kg)*</th>
<th>S-1</th>
<th>S-2</th>
<th>S-3</th>
<th>S-4</th>
<th>S-5</th>
<th>S-6</th>
<th>S-7</th>
<th>S-8</th>
<th>S-9</th>
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<td>Arsenic</td>
<td>mg/kg</td>
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<td>&lt;3</td>
<td>&lt;3</td>
<td>&lt;3</td>
<td>&lt;3</td>
<td>&lt;3</td>
<td>&lt;3</td>
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</tr>
<tr>
<td>Cadmium</td>
<td>mg/kg</td>
<td>100</td>
<td>&lt;0.5</td>
<td>&lt;0.5</td>
<td>&lt;0.5</td>
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<td>Chromium</td>
<td>mg/kg</td>
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<td>11</td>
<td>13</td>
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<tr>
<td>Copper</td>
<td>mg/kg</td>
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<td>5</td>
<td>11</td>
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<td>Lead</td>
<td>mg/kg</td>
<td>1500</td>
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<td>27</td>
<td>36</td>
<td>28</td>
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<td>Mercury</td>
<td>mg/kg</td>
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<td>0.28</td>
<td>1.1</td>
<td>0.62</td>
<td>0.90</td>
<td>0.40</td>
<td>0.57</td>
<td>0.22</td>
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<tr>
<td>Nickel</td>
<td>mg/kg</td>
<td>3000</td>
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<td>3</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>11</td>
<td>7</td>
<td>7</td>
<td>3</td>
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<tr>
<td>Zinc</td>
<td>mg/kg</td>
<td>35000</td>
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<td>49</td>
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<tr>
<td>Sulphide</td>
<td>% w/w</td>
<td>-</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>0.010</td>
<td>0.007</td>
<td>0.014</td>
<td>0.006</td>
<td>0.010</td>
<td>&lt;0.005</td>
<td>0.014</td>
</tr>
<tr>
<td>Moisture</td>
<td>%</td>
<td>-</td>
<td>16</td>
<td>14</td>
<td>8.8</td>
<td>10</td>
<td>6.2</td>
<td>6.6</td>
<td>8.8</td>
<td>5.9</td>
<td>15</td>
</tr>
</tbody>
</table>


### Table 11.2 Total recoverable petroleum hydrocarbons in soil

<table>
<thead>
<tr>
<th>Component</th>
<th>Units</th>
<th>NSW DEC Threshold Conc (mg/kg)*</th>
<th>S-1</th>
<th>S-2</th>
<th>S-3</th>
<th>S-4</th>
<th>S-5</th>
<th>S-6</th>
<th>S-7</th>
<th>S-8</th>
<th>S-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPH C6-C9</td>
<td>mg/Kg</td>
<td>65</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
</tr>
<tr>
<td>TPH C10-C14</td>
<td>mg/Kg</td>
<td>1000**</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
</tr>
<tr>
<td>TPH C15-C20</td>
<td>mg/Kg</td>
<td>50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>84</td>
<td>55</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
</tr>
<tr>
<td>TPH C21-C30</td>
<td>mg/Kg</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>68</td>
<td>53</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
</tr>
</tbody>
</table>

* NSW DEC (formerly EPA) Service station sites: assessment and remediation 2002, Table 3. Threshold concentrations for sensitive land use: soils.

** Sum of TPH C10 to C40

TPH = Total Petroleum Hydrocarbon
### Table 11.3 Semi-volatile chlorinated hydrocarbons in soil

| Component                        | Units | USEPA Region 9 PRG (mg/kg)* | S-1 | S-2 | S-3 | S-4 | S-5 | S-6 | S-7 | S-8 | S-9 |
|----------------------------------|-------|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Hexachloroethane                 | mg/Kg | 120                         | <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1|
| 1,2,4-Trichlorobenzene           | mg/Kg | 3000                        | <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1|
| Hexachloro-1,3-butadiene         | mg/Kg | -                           | <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1|
| 1,2,4,5-Tetrachlorobenzene       | mg/Kg | 180                         | <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1| <0.1|
| Pentachlorobenzene               | mg/Kg | 490                         | <0.1| <0.1| 0.1  | <0.1| <0.1| <0.1| 0.1  | <0.1| <0.1| <0.1|

* US EPA Region 9 Preliminary remediation Goals 2002, Industrial Soil

#### 11.3.4 The Project Area

**Geology and Soils**

The stratigraphy of the other works areas has been assessed in the studies listed in Section 11.2. These studies indicate that the general stratigraphy across these sites is similar to that for the regional geology described above.

The soils in the Botany area are predominantly derived from aeolian (wind-blown) sand deposits. The natural soil profile is primarily heavily leached infertile grey sand with minimal organic material. This profile has been altered along the north and north-east coast of Botany Bay by land reclamation and filling.

Foreshore Beach is composed of estuarine sands dredged from Botany Bay during the construction of Port Botany and Sydney Airport. Penrhyn Estuary was formed from the reconfiguration of the northern shores of Botany Bay in the late 1970s, as a result of the construction of Port Botany. It is composed of sand (outer Estuary) and mudflats (upper Estuary).

A conceptual geological model of the BIP and Southlands site was developed by Woodward-Clyde as part of the Stage 2 Survey. Figure 11.2 and Figure 11.3 illustrate the geological cross section used as part of the Stage 4 investigation across Southlands and Foreshore Road. The stratigraphy across the BIP site is consistent with Southlands and Foreshore Road.

The BIP and Southlands sites are covered by a layer of surface fill resulting from a range of industrial land uses through previous activities across the area. At the BIP, the surface fill layer ranges from 1 m to 2 m thick and is predominantly composed of medium grained, poorly to well graded, loose, gravelly, silty sand intermixed with building rubble comprising bricks and other waste material, including coal ash (URS, 2001).

On the Southlands site, the surface of Block 1 is composed mostly of boiler ash, with small areas of clay and sand. Block 2 consists of a superficial layer of clayey material. The material beneath this layer is comprised of solid inert fill including bricks, concrete rubble, steel, wood and a variety of other material (Woodward-Clyde, 1996).
Beneath these fill layers the stratigraphy of the Botany Sands has been interpreted as a three layer system (Woodward-Clyde, 1996). Figure 11.3 illustrates these layers:

- Layer 1 is an upper zone of sand with few thin discontinuous peat or clay layers.
- Layer 2 is a middle zone of predominantly sand with intercalated peat, sandy peat and peaty sand.
- Layer 3 is a basal zone of clayey sand and sandy clay with discontinuous layers of gravel, peat and peaty sand.

**Soil Contamination**

A number of soil sampling investigations carried out over the last 10 to 15 years have identified the presence of contaminated soil around the BIP, Southlands and Foreshore Road. Studies have been carried out where required as part of development on the site, rather than as a specific study to assess the nature and extent of potential contamination across the site as whole. The studies completed have determined that the major form of soil contamination relates to volatile and semi-volatile CHCs dissolved in groundwater. The principal dissolved compounds include:

- Ethylene dichloride (EDC);
- Vinyl chloride (VC);
- Carbon tetrachloride (CTC);
- Tetrachloroethene (PCE); and
- Trichloroethene (TCE).

Insoluble components include:

- Hexachlorobenzene (HCB);
- Hexachloroethane (HCE); and
- Hexachlorobutadiene (HCBD).

CHC contamination of soils and groundwater is likely to have occurred via spills, leaks and historical disposal practices in areas where CHCs were manufactured and/or stored (Woodward-Clyde, 1996). In addition to CHC contamination, other contaminants such as mercury and chromium have been detected.

Stage 1 investigations conducted at Southlands similarly indicated the presence of volatile and semi-volatile CHCs and mercury in the soil. Further work was carried out as part of the Stage 2 investigations, with samples taken across Blocks 1 and 2.

The soils on Blocks 1 and 2 contained few volatiles with concentration exceeding 1 mg/kg, except for one sample toward the south of the Block 1 (Woodward-Clyde, 1996). Low levels of semi-volatiles (less than 8 mg/kg) were detected across Block 1, and all concentrations on Block 2 were less than 2 mg/kg. Heavy metals such as mercury and chromium were also detected across both blocks.
Extensive further investigations have been conducted on the BIP in response to the NCUA requirements, to confirm whether inferred DNAPL source areas are actual source areas, and to obtain more data on the distribution of DNAPL in the subsurface (URS, 2004). The results showed a range of results for different CHCs across the investigation areas.

The land used for Foreshore Road was constructed from sediments recovered from Botany Bay during the 1970s, which may have been contaminated prior to reclamation. However, there is no specific data that indicates soil contamination in the area, as soil samples obtained during October 2004 have proven to be uncontaminated.

In addition, the land where the underground discharge pipeline is located has been extensively used for various industrial and commercial activities, and hence may be contaminated from those activities. This is particularly the case where the pipeline route is within the boundaries of the Sydenham–Botany goods railway line.

**Acid Sulphate Soils (ASS)**

The Department of Land & Water Conservation’s *Acid Sulphate Soil Risk Map No.93 (Botany Bay)* (DLWC, 1997) indicates that the BIP and Southlands sites have the classifications presented in Table 11.4.

<table>
<thead>
<tr>
<th>Site</th>
<th>Map Class Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIP</td>
<td>Low Probability (Wa4) Greater than 3 m below the ground surface</td>
</tr>
<tr>
<td></td>
<td>No Known Occurrence</td>
</tr>
<tr>
<td>Southlands</td>
<td>Low Probability (Wa4) Greater than 3 m below the ground surface</td>
</tr>
<tr>
<td></td>
<td>No Known Occurrence</td>
</tr>
<tr>
<td></td>
<td>Disturbed Terrain</td>
</tr>
<tr>
<td>Foreshore Road</td>
<td>Disturbed Terrain</td>
</tr>
<tr>
<td>Discharge Pipeline</td>
<td>Low Probability (Wa4) Greater than 3 m below the ground surface</td>
</tr>
<tr>
<td></td>
<td>Disturbed Terrain</td>
</tr>
</tbody>
</table>

Previous investigations on the BIP site to assess the soils for the presence of ASS or potential ASS (PASS) have been carried out as part of individual developments on the site. The geology across the BIP, Southlands and Foreshore Road sites is such that the stratigraphy of the Botany Sands is fairly uniform, but with localised lenses of peat material interspersed through the layers of sand.

The DLWC’s *ASS Manual* (DLWC, 1998) states that positive results on peaty material, such as that found on the BIP site, may be attributed to high organic sulphur content in the organic matter in the peat, and not to any identifiable pyrite material.

Historical monitoring of groundwater levels around the Orica Botany sites show that levels were lowest during the 1960s and 1970s. Groundwater levels ranged from +1 to –8m AHD around the BIP and Southlands due to excessive groundwater abstraction (Merrick, 2004). If PASS did exist in this area prior to this groundwater lowering, it is most likely that it would have been converted to actual ASS during this period.
Testing of soil and groundwater pH across Southlands and the BIP, carried out as part of the Stage 2 Survey by Woodward-Clyde in 1996, showed soil pH levels ranging from 4.9 to 9.4 and groundwater pH levels ranging from 5.50 to 10.0. Ongoing monitoring and assessment work has shown pH to be generally 4.5–6 in the main contaminant areas. The variation of pH levels around the sites showed that the soil characteristics across the area generally did not indicate the existence of ASS.

However, previous construction works on the BIP, as well as corrosion of existing infrastructure, have shown the presence of ASS at the Qenos Alkathene and Alkatuff Plant sites, which are located within 200 m of the GTP site.

In addition, soils with high acid sulphate potential encountered at Port Botany during works at the hydrocarbon terminal at 39 Friendship Road, are believed to have shown evidence of randomly distributed deposits of soils with very high PASS within the sediments derived from Botany Bay.

In summary, it is likely that there are areas of PASS at different sites within the Project Area.

**Aggressivity of Soils/Groundwater**

The soil testing also included assessment of potential aggressivity/corrosivity towards concrete and steel, based on a selection of the upper sand filling samples taken from the site tested for sulphate, pH and electrical conductivity. The results are presented in Table 11.5. The sulphate content and pH test results indicate that the sand filling soils are non-aggressive when exposed to concrete. The electrical conductivity test results indicate electrical resistivity values of 140 ohms and 180 ohms, indicating a severe exposure classification for steel piled structures.

No steel piles are proposed to be used for the construction of the GTP.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Depth (m)</th>
<th>Sulphate SO₄ (mg/kg)</th>
<th>pH</th>
<th>Conductivity (µS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.2 - 0.3 m</td>
<td>26</td>
<td>8.8</td>
<td>71</td>
</tr>
<tr>
<td>B</td>
<td>0.25 m</td>
<td>32</td>
<td>9.2</td>
<td>55</td>
</tr>
</tbody>
</table>

**11.4 Assessment of Impacts During Construction**

**11.4.1 GTP Construction**

The construction of the GTP would involve a number of different phases with the potential for impacts on soils and geology:

- clearance of the existing concrete slabs and remnant footings, and regrading of the site to required ground level using *in situ* material; and
- installation of site pavements.
The potential impacts are considered in the following sections.

**Soil Contamination**

The soil testing carried out at the proposed GTP site found that concentrations of metals, TPH and CHCs were below appropriate investigation levels. Potential risks to human health during or after construction are therefore considered negligible. This is assessed further in Chapter 24.

It is not anticipated that any soils would be removed from the site during construction. However, if any excess soils are generated during construction, the contamination results indicate that these could be classified as ‘solid waste’ for disposal purposes, if required.

**Foundation Performance**

The results of the investigation indicate that the site is underlain by up to 3.5 m of variable compacted filling which, although appearing uncontrolled, would likely provide suitable support for foundations and pavements.

The preferred option is for the entire site to be subjected to high energy impact compaction, using an impact roller to improve the compaction level of the upper 2 to 3 m. After impact rolling, the surface materials would be graded smooth and the surface layer compacted to minimum 80% density index.

This approach is preferred over the alternative option of removing the filling to 1 m below final surface level, (i.e. to RL 7.2), segregating any organic matters, deleterious substances or oversize material, and then reusing and compacting. This option would generate a quantity of waste material requiring disposal, and could require extensive dewatering due to the presence of groundwater at shallow depths.

Shallow footings, such as strip and pad footings, could then be founded within the compacted filling. An alternative approach would be founding on piles taken to very dense sand at about 4 m depth. Following this approach, given the relatively high water table, grout injected piles or concrete screw piles would be proposed.

Driven piles are not considered suitable for this site because of potential adverse noise or vibration effects. Bored piles would also not be considered favourably, because of the potential contamination in both the surplus soil and water generated during their construction.

**Groundwater**

Groundwater levels were measured at depths between 0.8 m and 2.3 m. However, the proposed use of shallow footings or screw piles would result in minimal disturbance of the groundwater.

**Soil Erosion**

Construction works at the GTP site would involve a limited amount of excavation and site clearing that would disturb soils, with the possibility of soil erosion. These activities include:

- clearance of existing remnant structures (e.g. concrete slab);
- excavation works for foundations;
Geology, Soils and Geotechnical

- movement of construction equipment and other vehicles within the construction zone; and
- stockpiling of materials for site levelling.

The site is served by the stormwater drainage system for the BIP, and therefore has the potential for erosion to eventually discharge to Botany Bay during wet weather events.

The potential for erosion would be reduced by employing effective soil conservation measures during construction.

**Acid Sulphate Soils**

The desk-top assessment suggests that ASS conditions are possibly present at the site for the GTP. These are unlikely to have become acidic due to the presence of lime residues in the shallow soil.

### 11.4.2 Other Construction Activities

The other construction activities would involve various works with the potential to affect soils and geology:

- well installations on the PCA and the BIP, resulting in generation of drilling spoils and slurries;
- pipeline installation on the BIP, resulting in minimal generation of spoil; and
- excavation of underground discharge pipeline, resulting in minimal generation of spoil (as it would be directly reused).

Where excess spoil is generated, this would require appropriate management and disposal, to ensure that no impacts occur if the spoil is contaminated.

As the desk-top assessment suggests that PASS may be present, appropriate assessment and management measures would be required to minimise the potential for impact.

As construction works would involve some site clearing and soil excavation that would disturb soils, appropriate management measures would be implemented to minimise the potential of soil erosion.

### 11.5 Assessment of Impacts During Operation

The full operation of the BGC Project within the Project Area comprises:

- extraction of groundwater at all three containment lines;
- transfer of groundwater to the GTP; and
- treatment, reuse and discharge of treated groundwater.

The potential impacts associated with operation are considered in the following sections.
CHAPTER 11 Geology, Soils and Geotechnical

Contamination
The operation of the extraction wells and pipelines would be designed and managed to minimise the risk of leaks or failure, through the use of design standards and conservative design limits, and the installation of secondary containment systems (for underground pipelines) and leak detection monitors (as described in Chapter 13). In addition, ongoing monitoring and inspection would be carried out to check the integrity of the infrastructure. Major leaks would result in extraction and transfer operations being shut down.

At the GTP itself, the site area would be paved, with a first-flush tank installed to contain any spills, for treatment or discharge. In addition, storage of contaminated groundwater and other chemicals (caustic soda and hydrochloric acid) would be in bunded tanks, to provide containment of spills.

Acid Sulphate Soils
Predicted drawdown of groundwater levels around the groundwater extraction wells due to pumping would range from 1 m to 3 m around the different wells. The maximum drawdown at an external production bore would be 0.4 m. This minimal drawdown effect is not anticipated to affect any localised areas of potential ASS that may exist at the extraction well locations.

11.6 Mitigation Measures

11.6.1 Construction

General
A soil and water management plan (SWMP) would be developed in the detailed design phase to ensure that an adequate standard is applied to erosion and sediment control for the construction activities of the proposed project.

The SWMP would be incorporated in the Construction EMP (CEMP) for the project. All work would be carried out to avoid erosion and sedimentation of the site and surrounding areas. Erosion and sediment control measures would include:

- minimising open areas of excavations;
- using temporary structures to prevent offsite movement of sediment, such as silt fences surrounding stockpiles or in the vicinity of existing stormwater drains;
- maintaining sediment and erosion control measures in an effective condition until the works have been completed;
- ensuring temporary excavations (such as those for the refurbishment of the discharge line) are refilled with excavated soils, which are reinstated to ensure ‘clean’ fill is used at the top layer to avoid potential contamination being discharged to stormwater;
- minimising dust from active earthwork areas and stockpiles using water spray;
Geology, Soils and Geotechnical

- ceasing work, or implementing further suppression measures, if excessive fugitive dust emissions are observed;
- minimising traffic in construction zones and dedicated parking areas; and
- inspecting soil loads on vehicle wheels and undercarriages, and ensuring removal if required.

Erosion and sediment control planning and implementation would apply to all areas that may be disturbed. Regular inspections would occur after heavy rain and during periods of prolonged rainfall.

**Acid Sulphate Soils**

Although the work to date has identified limited potential for acid sulphate soils, an ASS Management Plan would be developed in accordance with the *NSW Acid Sulphate Soil Manual* (DLWC, 1998), to provide an approach for management of any ASS that may be identified during the construction phase.

In addition, ongoing monitoring of groundwater pH as part of the groundwater monitoring regime would be carried out throughout the operation of the GTP. As part of the ASS Management Plan, if this monitoring indicated a significant change in groundwater pH, further investigation would be carried out to determine whether the change was due to ASS.

The ASS Management Plan would include:
- training of construction personnel to remain alert for signs of ASS;
- prompt sampling and analysis to ensure management measures can be implemented appropriately;
- spoil containing ASS to be dosed with lime to neutralise the acidity, before storage pending disposal; and
- temporarily excavated spoil to be dosed with lime to neutralise the acidity before being returned to the hole on completion of the work.

**Contamination**

The objectives for the construction of the GTP would be minimal disturbance of soils, and for no soils to be removed from the site for disposal, notwithstanding that contamination results show the soils would be classified as ‘solid waste’ and suitable for disposal to landfill.

As for the practices agreed with the EPA for the installation of the extraction wells on Foreshore Road, drilling spoil from the well installations would be transferred to Southlands. The materials would be stockpiled in the existing containment structures on Block 2 (constructed of geotextile base and hay bale containment), to be dried, analysed and assessed.

Samples of the dried soils would then be assessed for compliance with landfill requirements in accordance with EPA guidelines (DEC, 2004). Where materials do not meet the criteria, these would be retained in the stockpile for further treatment to render them suitable for landfilling.
Where subsurface contamination is found in excavated soils on the discharge line, the excavated holes would be reinstated to ensure that the contamination remains below the surface, and clean fill would be used on the top layer to prevent contamination of stormwater run-off.

**Foundations**

The geotechnical assessment concluded that the geological conditions at the proposed GTP site do not pose any significant constraints for the use of shallow foundations or screw piles. However, if shallow foundations were to be used, appropriate compaction would be required to provide the compacted fill suitable for shallow foundations.

If concrete screw piles were selected, some form of corrosion protection—such as cathodic protection—would be required, due to the nature of the existing soils and groundwater.

The use of either shallow foundations or screw piling would minimise surplus soil or groundwater generation.

**Groundwater**

The only works that would be expected to affect the groundwater would be the extraction well installation. As described in Chapter 13, drilling slurries and excess groundwater would be collected directly during the installation activities, and transferred to storage on the BIP before treatment.

**11.6.2 Operation**

**General**

An ongoing Soil and Water Management Plan would be maintained for the operational phase of the project, to ensure that a suitable management standard is maintained in the event of spills or leaks from the groundwater extraction and transfer systems.

The development of the Operation SWMP would be based on the Construction SWMP, and would take into account relevant industry guidelines.

**Contamination**

The overall project objective would be to avoid potential contamination of soils from leaks or spills. This would be achieved through various measures, including:

- design of the transfer pipelines (as described in Chapter 5) to minimise the risk of leak or failure, and to ensure containment in underground pipelines;

- installation of pipelines aboveground where possible, to be regularly monitored for leaks by visual inspection, with leak detection in underground pipelines;

- installation of bunds with 110% capacity for storage of materials, such as contaminated groundwater and treatment plant chemicals, providing containment in the event of leaks or spills;
temporary storage of recovered waste EDC liquid from the operation of the SSU in an existing, fully sealed and bunded storage tank at Terminals Pty Ltd’s bulk liquid storage facility; providing containment of any leaks or spills, and

including containment of the recovered waste EDC liquid in a purpose-built isotainer in a fully bunded area on the GTP site.

In the event of major leaks or spills, contamination from the groundwater extraction and transfer systems would be contained through the overall hydraulic containment system.

As noted above, the ASS Management Plan would be maintained through the operational phase of the project to ensure that issues are addressed before potential impacts are realised.

### 11.6.3 Summary of Mitigation Measures

Mitigation measures that would be implemented during pre-construction, construction or operation are summarised in Table 11.6.

<table>
<thead>
<tr>
<th>Table 11.6 Summary of mitigation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safeguard</strong></td>
</tr>
<tr>
<td>General</td>
</tr>
<tr>
<td>Development and implementation of SWMP as part of the EMP</td>
</tr>
<tr>
<td>Development and implementation of ASS Management Plan</td>
</tr>
<tr>
<td>Construction</td>
</tr>
<tr>
<td>Keep open areas of excavations to a minimum</td>
</tr>
<tr>
<td>Install temporary structures to prevent offsite movement of sediment, such as silt fences surrounding stockpiles</td>
</tr>
<tr>
<td>Maintain sediment and erosion control measures in an effective condition until the works have been completed</td>
</tr>
<tr>
<td>Refill temporary excavations to ensure any subsurface contamination is replaced at subsurface level, with clean fill at surface level to avoid contamination of run-off.</td>
</tr>
<tr>
<td>Divert surface water run-off from areas upstream around the site to minimise the volume of water entering construction areas</td>
</tr>
<tr>
<td>Dust minimisation of active earthwork areas and stockpiles using water</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Safeguard</th>
<th>Design</th>
<th>Pre-construction</th>
<th>Construction</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cessation of work, or implementation of further suppression measures, if</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>excessive fugitive dust emissions are observed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimisation of traffic in construction zones and dedicated parking areas</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Inspection of soil loads on vehicle wheels and undercarriages, and</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>removal if required</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preferred option is compaction of entire site to minimise waste generation and dewatering</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Use of shallow foundations or screw piles</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

| Operation                                                                 |        |                  |              |           |
| Design groundwater extraction wells and transfer pipelines to minimise risk of failure or leaks | ✓      |                  |              |           |
| Design and manage the groundwater extraction wells and transfer pipelines to minimise soil erosion | ✓      |                  | ✓            |           |
| Storage of materials such as contaminated groundwater and treatment chemicals in bunded tanks on the GTP site | ✓      |                  | ✓            |           |
| Ongoing monitoring and inspection of wells and pipelines to check for leaks, spills, etc. |        |                  |              | ✓         |

### 11.7 Conclusion

Given the results of the contamination assessment of the site, and provided that the proposed mitigation measures are implemented, no impacts from the BGC Project on the soil or geology in the Project Area would be expected.
GTP Site Geotechnical and Soil Testing Locations

LEGEND
- GTP Site Boundary
- Soil Sample Locations

NOTE:
Soil Sample Locations Based on SOS Sketch
12.1 Introduction

This chapter provides a summary of the hydrogeological assessment conducted for this EIS. Extensive groundwater modelling work has been undertaken to identify the best locations for the groundwater wells, and to calculate the appropriate groundwater extraction rates to achieve the required hydraulic containment whilst minimising potential impacts.

The full report presenting the groundwater modelling and assessment work, *Optimal Groundwater Abstraction Rates for Hydraulic Containment of Contaminant Plumes and Source Areas, Botany NSW* (AccessUTS, 2004), is included as Appendix D. This report has been peer reviewed by Alan Laase, of A. D. Laase Hydrologic Consulting, in Colorado, USA. The peer review is also provided in Appendix D.

12.2 Hydrogeological Setting

This section provides details of the existing hydrogeology and contamination.

12.2.1 Hydrogeology

The description of the hydrogeological setting is based on a range of information sources, particularly the results of previous investigations and reports prepared as part of the ongoing assessment of the Botany groundwater contamination:

- *Orica Botany Environmental Survey Stage 4 – Remediation. GCP Quarterly Groundwater and Surface Water Monitoring Report – March 2004* (URS, March 2004); and

**Geology/Stratigraphy**

The Project Area is located within the Botany Basin, which occupies an area of 80 km² and lies to the south of the City of Sydney. Groundwater in the Botany Basin occurs in unconsolidated sediments of Quaternary age, which overlie a bedrock of Hawkesbury Sandstone. These sediments are known as the Botany Sands Aquifer and are made up of river, beach and dune sands, interbedded with clay and peat lenses. Figure 12.1 illustrates the extent of the aquifer.

The stratigraphy of these sediments is described in Section 11.3, and a typical cross section is illustrated in Figure 11.3.
The aquifer is comprised of three geological layers, which have the following characteristics:

- **Geological Layer 1:** The thickness of this layer ranges from approximately 4 m to over 10 m, with the thickest section along Stephen Road to the west of Southlands and further to the north to the Eastlake Golf Course. Within Southlands, the top 1 to 3 m is made up of fill (predominantly boiler ash), below which is medium to high porosity sand with occasional peat and silt stringers;

- **Geological Layer 2:** This layer is generally 20 m thick, but ranges from less than 10 m near the southern end of the BIP, to over 30 m deep near the northern end of the site. The sand is generally fine to medium grained and more poorly sorted than the sand in Layer 1. Layer 2 contains various thin (up to 0.5 m thick) discontinuous low permeability layers which are composed of peat, peaty clay, peaty sand, clayey sand and silty sand; and

- **Geological Layer 3:** The distribution of this layer is restricted to the deep parts of the Botany Basin and is absent over bedrock highs. Generally this layer is 10 m thick, extending up to 30 m thick in some parts of the basin. The lithology is quite variable and reflects the various depositional environments, which include intercalated sands, clays and peaty material above the bedrock.

The Botany Sands are underlain by impermeable bedrock of Hawkesbury Sandstone.

**Botany Sands Aquifer**

The Botany Sands Aquifer contains a number of hydrostratigraphic units that range from unconfined to fully confined. The Stage 2 Survey (Woodward-Clyde, 1996) reported that there is considerable variation in the groundwater yield from the aquifer, indicating that there are discrete high yielding layers within the sequence. These are interconnected vertically via leakage through the confining peat and clay layers, and laterally by the discontinuous geometry of most of the confining units.

The Stage 2 Survey (Woodward-Clyde, 1996), reported that the 1988 regional water table elevation ranged from 35 m AHD at Centennial Park (northern end of the basin) to 0 m AHD at Botany Bay.

Monitoring of the groundwater flow regime within and surrounding the BIP has been conducted on a number of occasions since the Stage 2 Survey in 1996. The most recent monitoring of groundwater levels across Foreshore Road, Southlands and the BIP was carried out as part of the quarterly monitoring and reporting undertaken under the GCP in March 2004 (URS, March 2004).

The water table elevation measured in a wide number of shallow monitoring wells across the area in March 2004 is shown on Figure 3.1. The groundwater flow direction is generally similar to previous water level monitoring undertaken in 1994, 1996, 1998 and 2000, although the elevations vary between monitoring events due to long term rainfall variations (i.e. drought and wet periods). The groundwater flow directions clearly show the role of both Floodvale and Springvale Drains in capturing shallow groundwater.

Figure 3.2 shows the potentiometric surface for the deep aquifer across the study area. The potentiometric surface represents the total head of groundwater, which is defined by the level to which water from this aquifer would rise in a well. The elevation of the potentiometric surface relative to the water table elevation indicates that the vertical gradient is downwards on the BIP. The vertical gradient progressively moves to an upward direction beyond Southlands as it approaches the discharge zone at Penrhyn Estuary and Botany Bay.
Compaction of Sediments

Compaction of sediments has occurred within the Botany area in the past, due to the long history of significant groundwater use. The lowest recorded water levels occurred around 1969, when there were significantly greater quantities of groundwater extraction for industrial use. Comparison of these historical low levels with recent higher water levels (2000–2002) shows that groundwater levels have historically been between 5 and 13 m lower over the BIP, and 2 to 6 m lower over Southlands.

In the industrial area between Southlands and Botany Road/Foreshore Road, levels have been at least 1 m lower in the past (AccessUTS, 2004).

Groundwater Recharge and Surface Water

The main recharge area from rainfall infiltration is Centennial Park at the northern end of the catchment. Substantial recharge also occurs in green space areas such as parks and golf courses. Groundwater levels are controlled by Alexandra Canal, the Lachlan Lakes and Swamps, Cooks River and Botany Bay. In the vicinity of Southlands, the water table is controlled by Springvale and Floodvale Drains (AccessUTS, 2004).

Springvale and Floodvale Drains collect shallow groundwater flowing through Southlands. This is shown in Figure 3.1, which illustrates the change in water table contours around each drain. Springvale Drain is estimated to intercept groundwater seepage at a depth of 5 to 7 m below ground level (Woodward-Clyde, 1996).

At the foreshore, all groundwater is discharged into Penrhyn Estuary and Botany Bay along the interface between the seawater and groundwater. The interaction of the deep aquifer system with Botany Bay is governed by the presence of a saltwater interface (‘zone of diffusion’), which is a natural phenomenon in coastal aquifers. Due to the difference in the density of seawater (1.025 kg/m³) and the relatively fresh groundwater (1.000 kg/m³), the groundwater discharges into a narrow zone adjacent to the coast.

This mechanism is illustrated in Figure 12.2.

Groundwater Extraction

The Botany Sands Aquifer has been an important source of water for more than a century. During the last 50 years estimates of groundwater extraction have varied from about 20 ML/day to about 55 ML/day. The most recent available record is from 1992, reporting usage around 30 ML/day (Merrick, 1994 – Merrick, N.P., 1994, a Groundwater Flow Model of the Botany Basin. Proceedings of the Water Down Under ‘94 Conference. International Association of Hydrogeologists/Institute of Engineers Australia. Adelaide, 21-25 November 1994. Proceedings Vol. 2A, 113-118.). However, it is likely that usage has declined significantly since then, as many previous industrial users close to Botany Bay have ceased pumping operations.

The estimated distribution of likely existing production bores and an estimate of current extraction rates, as used in the groundwater model, are presented in Figure 12.3. This distribution is based on licensed allocations, historical usage up to 1991 and local knowledge of active users.
Total usage of groundwater during 2000–2002 in the northern part of the Botany Basin is estimated to be about 7,000 ML/year (about 20 ML/day). Current licences exist for approximately 90 bores in the Botany area, but it is thought that only 60% are in use. The current estimate of groundwater extraction in the Botany Sands Aquifer is 20 ML/day (AccessUTS, 2004). It is estimated that 70% of these bores are used for irrigating local parks and golf courses, while the remainder are used by industry.

The industrial users account for approximately 60% of the total water usage, dominated by three operators, as detailed in Table 12.1.

<table>
<thead>
<tr>
<th>Company</th>
<th>Quantity</th>
<th>Borefield Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMCOR</td>
<td>6 ML/day</td>
<td>Snape Park, 3 km north of Botany Mill site</td>
</tr>
<tr>
<td>Solvay Interox</td>
<td>2-2.9 ML/day</td>
<td>Close to Lachlan Swamps</td>
</tr>
<tr>
<td>Qenos</td>
<td>2-3 ML/day</td>
<td>BIP &amp; Hensley Athletic Field</td>
</tr>
</tbody>
</table>

It is understood that the Solvay Interox borefield closed down early in 2004 (D. McKibbin, DIPNR, pers. comm.), and hence the identified quantities are no longer extracted.

The Botany Sands Aquifer is classified as a ‘high risk resource’ by DIPNR, in terms of groundwater quality. A ‘Groundwater Extraction Exclusion Area’ (previously ‘Groundwater Protection Zone 1’), as shown in Figure 2.1, has been declared in response to the detection of contaminants in the groundwater down-gradient from the BIP. This area occupies parts of Botany and Banksmeadow, and groundwater users within the area have been advised by DIPNR not to use the groundwater until further notice. Similarly, issue of any new bore licences for groundwater extraction is restricted, except for cleanup and construction activities.

In order to proactively manage sites around the exclusion area with potential contamination issues, DIPNR also established the ‘Groundwater Embargo Area’ (previously ‘Groundwater Protection Zone 2’). The area incorporates parts of the western half of the Botany Basin Northern Zone, where it is known that industrial activity has occurred. Similar to the exclusion area, the embargo area precludes any new bore licences for the extraction of groundwater from being issued, except for cleanup and construction activities. The intent of the embargo area is to not issue new licences until further assessment of the groundwater system occurs, through the draft Botany Groundwater Strategy (DIPNR, 2004).

Existing Groundwater Monitoring

Monitoring of the groundwater flow regime and groundwater quality is currently being carried out as part of the requirements under the GCP and the VRA. The location of existing monitoring wells around Foreshore Road, Southlands and BIP is shown in Figure 12.4. The groundwater flow regime is monitored annually, whilst chemical monitoring is carried out on a quarterly basis in order to characterise the location of the contaminant plumes and the concentrations of groundwater contaminants.

The results of the monitoring are reported to the EPA for review. The reports are posted on the Orica Botany Groundwater website (www.oricabotanygroundwater.com).
12.2.2 Groundwater Quality

**Regional Groundwater Quality**

The regional water quality in the Botany Sands Aquifer has been reported by a number of authors (Shiel, 1942; Griffin, 1963 and Smart 1974) who indicate that the aquifer contains water with low salinity.

In 2000, the Department of Land and Conservation (DLWC) produced a status report *Botany Sand Beds (GWMA 018) Botany Basin, NSW, Northern, Southern and Western Zones, Status Report No 2* (DLWC, 2000) detailing the quality of the Botany aquifer. In summary, this reported that the aquifer typically contains water with a salinity ranging from 130 to 600 µS/cm (compared with >50,000 µS/cm in Botany Bay) although the salinity is significantly higher close to the margin of Botany Bay. It also reported that the pH is highly variable and ranges from 3.9 to 8.9, but is generally acidic due to peaty sediments. The peaty sediments also give rise to variable sulphate concentrations (5 to >100 mg/L). The aquifer is reported as having negligible levels of nitrate; however, some portions of the aquifer have reported elevated concentrations (up to 87 mg/L), attributed to application of fertiliser or other nutrient-rich waste.

The DLWC report also notes that the Botany aquifer is vulnerable to contamination from overlying urban/industrial development. Areas of the aquifer known to be affected by contamination include the Botany/Banksmeadow area and the industrial areas adjacent to Alexandra Canal.

**Groundwater Contamination**

Assessment of the groundwater contamination in the Project Area has identified three principal plume groups containing one or more overlapping contaminant plumes, known as the Southern Plumes, Central Plume and Northern Plumes. A comprehensive review of the characteristics and inferred source of each of the individual plumes is presented in the March 2004 Quarterly Monitoring Report (URS, March 2004). The principal contaminants that were manufactured in significant quantities are carbon tetrachloride (CTC), tetrachloroethene (PCE), trichloroethene (TCE), vinyl chloride (VC) and 1,2-dichloroethane (EDC). Figures 3.3 to 3.7 illustrate the location and movement of these compounds toward Penrhyn Estuary and Botany Bay.

Monitoring of the movement and contaminant concentrations of these plumes has been carried out regularly in recent years. Surveys were carried out in 1994, 1996, 1998 and 2000, and since the introduction of the VRA in 2000, Orica has submitted annual reports for 2001, 2002 and 2003. The location of the monitoring wells and frequency of monitoring has varied over time according to the spatial and temporal trends that have been observed in the distribution of contaminants since 1994. Most recently, quarterly monitoring has been undertaken under the commitments set out in the GCP (Orica, 2003), with the most recent survey completed in June 2004 (URS, June 2004).

Ongoing monitoring has shown that the groundwater flow regime across Foreshore Road, Southlands and the BIP has remained largely unchanged since detailed monitoring began in 1994. The following summarises the plume characteristics:

- The Southern Plumes comprise three separate plumes (S1, S2 and S3), inferred to be derived from the former Solvents Plant (CTC and PCE) and the former TCE Plant. CTC, PCE, TCE and VC are the dominant contaminants in terms of concentration and distribution. The plumes are currently discharging to Penrhyn Estuary in a zone between Floodvale and Springvale Drains at the eastern
end of the estuary. A comprehensive investigation of the Southern Plumes’ discharge to Penrhyn Estuary was completed in late 2003 (URS, 2004a).

- The Central Plume comprises one plume (C1), which consists predominantly of EDC, with concentrations greater than 5,000 mg/L in the core of the plume, and varying concentrations of 100–1,000 mg/L at the leading edge of the plume. The core of the plume is estimated to be travelling in a southwesterly direction at a rate of 110 m/year to 150 m/year. A review of the historical data since 1999 (URS, 2004b) indicates that the core of the plume (>1000 mg/L) would be likely to reach Foreshore Road between February 2006 and January 2007, if no action were taken.

- The Northern Plumes comprise five separate plumes (N1, N2, N3, N4 and N5), consisting predominantly of EDC, with maximum concentrations between 100 mg/L and 200 mg/L. Plume N4 comprises predominantly CTC and is inferred to be derived from the CTC/PCE storage tanks, which were formerly located in the area now occupied by the Alkatuff Plant. Several other plumes, consisting predominantly of EDC, are inferred to be derived from several, as yet unconfirmed, source areas in the northern part of the site. With the exception of Plume N4, the Northern Plumes are derived from the storage of waste material and not from manufacturing or bulk storage of chemicals. As such, the sources are considered to be diffuse and of limited area, which explains the lower concentration of contaminants in comparison with the Central EDC Plume and the Southern Plumes. Down-gradient of the plant site, the concentration of the contaminants within the Northern Plumes decreases significantly, which suggests attenuation within the aquifer.

The following summarises the movement and contaminant concentrations observed during the most recent monitoring carried out in June 2004 (URS, June 2004):

- inferred contours of the principal contaminants including CTC, PCE and TCE in the Southern Plume (S1, S2 & S3) have remained largely unchanged. However, trend analysis against the historical average indicates that at several locations, including Botany Golf Course, Foreshore Road and Penrhyn Estuary, the Southern Plume may have migrated further toward Botany Bay;

- the Central Plume was observed to have undergone the most significant changes with respect to the concentration and spatial distribution of volatile CHCs. The position of the high concentration ‘toe’ of the plume (>1000 mg/L) is inferred to be approximately 200 m beyond the Southlands boundary. The 100 mg/L EDC contour is inferred to be in the vicinity of the southern margin of Botany Road;

- the Northern Plumes have remained largely unchanged from previous monitoring events. A small increase in the EDC concentration was noted at some sample locations. No significant increases in CTC were recorded. Whilst EDC (Plumes N1, N2 and N3) and CTC (Plume N4) are the main CHCs present in groundwater in the Northern Plumes, other secondary CHCs are present at relatively low concentrations (generally < 0.1 mg/L) including PCE, TCE and their degradation products;

- sampling in Penrhyn Estuary confirmed the trends observed in the baseline study conducted in September 2003 and the March Quarterly Report (URS, March 2004), with volatile CHCs decreasing in a seaward and upward direction. The ANZECC (2000) 95% trigger values (low reliability) were exceeded at the discharge interface (0.1 m depth) at one location adjacent to the shoreline, for PCE, TCE, VC, EDC and chloroform (CFM). Surface water samples collected at the sampling locations at high tide did not exceed the ANZECC (2000) 95% trigger values (low reliability); and
the concentration of EDC, PCE, TCE and VC exceeded the ANZECC (2000) 95% trigger value (low reliability) at the Springvale Drain inlet to Penrhyn Estuary. EDC and VC exceeded the trigger value at the old boat ramp at low tide. The concentration of these and all other volatile CHCs were below the trigger values in all other samples collected from within Penrhyn Estuary.

Further details of the monitoring results are available from the documents available on the Orica Botany Groundwater website at www.oricabotanygroundwater.com.

12.3 Groundwater Extraction Modelling

Orica commissioned the National Centre for Groundwater Management (NCGM) at the University of Technology, Sydney (UTS) to undertake modelling of the groundwater flow regime with the following objectives:

- to determine the optimal volumes of water that need to be extracted from candidate hydraulic containment lines in order to capture the contaminant plumes;
- to determine the optimal spacings of bores along the containment lines; and
- to make an assessment of regional impacts in terms of drawdown, subsidence and saltwater intrusion.

The modelling has been revised and optimised as new information has become available, and the final results of the modelling were presented to Orica in September 2004. The following summarises the modelling methodology and results, as presented in the full modelling report in Appendix D.

12.3.1 The Principle of Hydraulic Containment

Hydraulic controls are often used as a means of managing and controlling situations where reduction in contaminant concentration is the objective. By installing and operating sufficient extraction wells, the groundwater movement is halted, and the contaminated groundwater can be removed for treatment. The groundwater wells within the identified containment lines act as a barrier, stopping continued movement of the contaminant plumes both horizontally and vertically. The principle of hydraulic containment is illustrated in Figure 12.5.

By modelling constraints on pumping rates, the optimum well locations for containing the plumes and removing the groundwater for treatment can be developed.

12.3.2 Modelling Approach

Modelling was carried out to assess groundwater extraction, and to allow the selection of the optimum borehole locations and flow rates. The main stages of the modelling were:

- conceptual model providing a visualisation of groundwater flows through the northern Botany Basin;
- simulation model providing a numeric analysis of flows; and
- optimisation model to identify the optimum number and location of boreholes, along with the optimum extraction rate to provide containment whilst avoiding adverse impacts.
**Conceptual Model**

Appendix D contains a description of the conceptual model for groundwater flows through the northern Botany Basin. This is illustrated in Figure 12.6. The conceptual model has been used as the basis for developing the simulation model.

**Simulation Model**

The simulation model provides a numeric simulation of groundwater extraction, allowing modelling of groundwater flows and extraction from different borehole locations and with different pumping rates.

A number of simulation models for the Botany Sands Aquifer have previously been developed. The various models were found to have limitations, so an updated model was developed by the National Centre for Groundwater Management (NCGM) at UTS using MODFLOW software with the Groundwater Vistas graphics interface. The use of MODFLOW will enable future updates, using groundwater monitoring data, to progress on-going development of the understanding of the groundwater flow regime, and to update the findings. The modelling was conducted according to the Australian groundwater flow modelling guidelines (Middlemis et. al, 2000).

Figure 12.7 shows the extent of previous modelling undertaken in the Botany area. The geographic extent of the area included within the simulation model for this EIS is shown in Figure 12.8.

The model of groundwater flow comprised three layers, representing the shallow (Layer 1), deep (Layer 2) and bottom (Layer 3) aquifers (see Figure 12.6). The bottom aquifer lies between the deep aquifer and the bedrock. The hydraulic conductivity (i.e. rate of groundwater flow) of these three layers is based on previous modelling studies of the aquifer. Layer 2 was subdivided into three sub-layers (A, B and C) so that the depth of the extraction wells could be targeted to encompass the extent of contamination in Layer 2.

The water balance used for the model defines the water inputs and outputs for the model, based on current infiltration, discharge rates and extraction rates. The water balance for current and future extraction rates are detailed in Appendix D.

The modelling was based on a number of constraints, with which the well network design had to comply:

- the locations where the hydraulic containment line could be installed, limited by access and land availability;
- the need to minimise potential for subsidence (Appendix D details the drawdown constraints);
- the need to minimise potential impact on surface water bodies hydraulically connected to the aquifers;
- the need to minimise saltwater intrusion;
- the need to meet the requirements of the draft Botany Groundwater Strategy (DIPNR, 2004); and
- the need to comply with constraints on drawdown levels and individual well pumping rates.
Figure 5.2 illustrates the three specified hydraulic containment lines and the general location for the groundwater extraction wells to form the required hydraulic barriers to the groundwater flow. Figure 12.9 illustrates the locations of the drawdown monitoring sites (these locations were nominated in the model and assigned limitations on drawdown. They were then used to assess the extent of drawdown that is predicted to occur under different pumping scenarios).

The MODFLOW software was used to assess the potential for subsidence resulting from the proposed extraction well network and groundwater extraction rate, modelling three subsidence scenarios (detailed in Appendix D).

Quantitative calibration statistics presented in the groundwater modelling report indicate that the standard deviation for the comparison of 150 modelled sites against observed statistics is 3.2%, compared to a ‘good calibration’ threshold of 10 to 15% defined for the model. As a result, it can be concluded that the model represents an accurate simulation of the behaviour of the Botany aquifer.

Optimisation Model

This final stage of modelling was used to optimise the number of wells, their locations (from a candidate list) and their pumping rates. By modelling different objectives (within the constraints detailed earlier), either the most hydraulically efficient or the most economic way of operating the interception network can be identified. The ‘pump-and-treat’ type remediation proposed for the BGC Project lends itself readily to an optimisation approach.

An optimisation model was developed with OPTIMAQ software created by Merrick (2000, 2001). This software links directly with MODFLOW and uses third party generic optimisation software called GAMS.

A large number of optimisation scenarios were run for various containment lines, various lengths and depths of containment lines, and different degrees of hydraulic gradient reversal. Details of the optimisation phases carried out during the modelling are presented in the full report in Appendix D.

Model Validation

The effectiveness of the hydraulic containment provided by the proposed extraction well locations was validated by modelling the groundwater flow path of individual particles through each layer of the aquifer. The type of modelling used is known as ‘particle tracking’. This approach consists of modelling the flow of hypothetical tracer particles within the groundwater, up-gradient of containment lines and around the edge of the contaminant plumes, and monitoring their progress as they travel through the aquifer. Ideally, all of the particles should be captured by the containment lines of extraction wells.
12.3.3 Modelling Outcomes

Optimum Well Locations and Extraction Rates to Achieve Hydraulic Containment

Table 12.2 describes the extraction rates for the optimal extraction well network, as illustrated on Figure 12.10 for Layer 1.

<table>
<thead>
<tr>
<th>Aquifer Layer</th>
<th>Line A</th>
<th>Core Line 1</th>
<th>Line 2</th>
<th>Line 3</th>
<th>Line 5</th>
<th>Line 6A</th>
<th>Line 6B</th>
<th>Line 6C</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.21</td>
<td>0.21</td>
<td>0.37</td>
<td>0.65</td>
<td>0</td>
<td>0.05</td>
<td>1.48</td>
</tr>
<tr>
<td>2A</td>
<td>0.85</td>
<td>0.69</td>
<td>0.43</td>
<td>0.50</td>
<td>0.35</td>
<td>2.85</td>
<td>1.317</td>
<td>0.49</td>
<td>7.42</td>
</tr>
<tr>
<td>2B</td>
<td>0.25</td>
<td>0.45</td>
<td>0.09</td>
<td>0.51</td>
<td>0.26</td>
<td>0</td>
<td>1.67</td>
<td>0.29</td>
<td>3.81</td>
</tr>
<tr>
<td>2C</td>
<td>0.09</td>
<td>0.36</td>
<td>0.18</td>
<td>0.19</td>
<td>0.23</td>
<td>0</td>
<td>0.33</td>
<td>0.51</td>
<td>2.29</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1.19</td>
<td>1.49</td>
<td>0.70</td>
<td>1.41</td>
<td>1.04</td>
<td>3.22</td>
<td>3.81</td>
<td>1.29</td>
<td>15.00</td>
</tr>
</tbody>
</table>

The total pumping requirement of 15 ML/day is predicted to reduce over time as the water level and, consequently, aquifer recharge from the Springvale and Floodvale Drains also fall. Model sensitivity analysis for the drains suggest that the required extraction rate could be reduced to approximately 12.5 ML/day as the water levels in the drains fall, although the precise timing of this is uncertain.

The final layout of the groundwater extraction well network is shown in Figure 5.2.

Appendix D contains details of the water balance with the groundwater extraction. The main change in the water balance is, as expected, the increase in aquifer discharge to production bores proposed for hydraulic containment of the plumes.

Groundwater Levels and Subsidence

Figure 12.10 also illustrates the predicted groundwater contour levels for Layer 1, based on the proposed rate of groundwater extraction. The full report in Appendix D provides figures showing the results of the predicted drawdown and the simulated groundwater contour levels for each of the five model layers (Layers 1, 2A, 2B, 2C and 3) from the proposed groundwater extraction.

The modelling output shows that the predicted drawdowns in each layer are within tolerances required to minimise potential subsidence. The locations where the predicted drawdowns come closest to historically low water levels are at Botany Road (0.65 m predicted drawdown, compared to 1.0 m historical maximum), and at the southern end of Springvale Drain (0.4 m predicted drawdown, compared to 0.9 m historical maximum).
The local effects of the groundwater extraction would stop the groundwater discharge to Penryhn Estuary down-gradient of the containment lines. This may result in increased saline intrusion along the extent of the secondary containment line on Foreshore Road.

The three subsidence scenarios (detailed in Appendix D) provided the following results:

- **Base Case:** The maximum predicted subsidence is 1.7 cm, associated with the pumping at Botany Industrial Park. Foreshore Road has 1–2 mm subsidence in this case.

- **Likely Case:** The maximum predicted subsidence is 0.9 mm, associated with the pumping at Foreshore Road. Subsidence in the BIP is predicted to be 0.1 mm.

- **Worst Case:** The maximum predicted subsidence is 1.3 cm, which is associated with the pumping at Foreshore Road. The BIP has 1–2 mm subsidence in this case.

This level of subsidence is not considered to be significant and would not have an impact on infrastructure or conventional structures.

The modelled subsidence monitoring locations are illustrated in Figure 12.9. Figure 12.11 illustrates the predicted subsidence for the Likely Case scenario. The predicted subsidence contours associated with the other two scenarios are presented in the full report in Appendix D.

**Model Validation**

The effectiveness of the hydraulic containment provided by the proposed extraction well locations was validated as detailed earlier. Figure 12.12 shows the output of the particle tracking model for the hydraulic containment of groundwater flows in Layer 1. The full report in Appendix D provides similar figures, showing the results of the particle tracking model for each of the five model layers.

In summary, the results show that the groundwater extraction well network would be successful in achieving the NCUA requirement for hydraulic containment of the contaminant plumes.

The report in Appendix D states that there are two areas where the plumes would not initially be contained. These are reported as:

- Layers 1 and 2A, for 40 m along the eastern edge of the Central EDC Plume for half the distance between Line 5 (along 2nd Street) and the BIP boundary; and

- The western lobe of the Northern Plumes is not captured – contaminants will eventually discharge to the Bay through Layer 1 and Layer 2A.

For the first of these, it appears that the particle tracking results were misinterpreted. Prior to optimisation of the extraction well network on BIP in the south-eastern extent of the DNAPL containment line, there was an apparent lack of complete plume capture. However, this was overcome with optimisation of the wells’ positions and pumping rates. Given that this is a minor issue, Orica does not intend to have UTS amend and reissue this report.
On the other hand, the observation about the western margin of the Northern Plumes is correct: it will not be captured by the currently proposed containment line at Foreshore Road. However, there are several reasons why the secondary containment line has been designed as outlined in this EIS:

- The concentrations of contaminants in the western margin of the Northern Plumes are relatively low – if indeed the plumes should ever reach Botany Bay, the resultant concentrations of contaminants in the receiving waters would not be expected to exceed the ANZECC (2000) trigger values (low reliability).

- There is some evidence that the contaminants in the Northern Plumes may be naturally attenuating (i.e. concentrations in the groundwater are reducing through natural processes, possibly including biological degradation, volatilisation and sorption onto organic soil particles).

- The movement of the Northern Plumes is much slower than the Central EDC Plume, probably due to the lower concentrations and the natural attenuation processes described above.

Notwithstanding these factors, Orica will continue to regularly monitor the Northern Plumes’ movement as part of the existing monitoring program. If there is evidence that elevated contaminant concentrations in the Northern Plumes are moving towards the bay, and that the ANZECC (2000) trigger values may be exceeded, then means of containing the contaminants will be investigated and implemented (subject to relevant statutory approvals). This might include extending the Foreshore Road containment line (there is some flexibility in the current design to enable this) or implementing some other means of contaminant containment, such as bioremediation.

It should be noted that the lack of containment in these areas would be only be in the short term, because they are beyond the influence of the hydraulic containment at start-up. Once the hydraulic containment system reaches steady state, all the groundwater that flows beneath the BIP and in the Project Area would be captured by one of the three hydraulic containment lines.

It should also be noted that any contaminants that are located down-gradient of the secondary containment line at Foreshore Road would not be captured. As a result, contaminants within the Southern Plumes that are presently discharging to the intertidal zone of Penrhyn Estuary will continue for a period of time after pumping starts. However, there would be no further movement through the containment line.

### 12.4 Modelling of Groundwater Contamination Variation

#### 12.4.1 Contamination Variation Modelling

Solute transport modelling is also currently being undertaken, to predict the anticipated changes in the concentrations and mass loads of the contaminant plumes over time, during operation of the GTP. This work is ongoing during the preparation of this EIS, and final results will not be available until after submission.

The initial modelling work has been completed, predicting the reduction in contaminant concentration in the groundwater feed to the GTP over time and the reduction in the total contaminant load within the groundwater over time, based on the assumption that there would be no further contaminant contribution from the identified DNAPL sources (i.e. ‘best case’ scenario).
Further modelling work is being undertaken, which incorporates ongoing contributions from identified sources, to produce similar outputs for the ‘worst case’ scenario. The actual scenario would most likely be somewhere between these.

In addition, the outputs from the further modelling will include graphical predictions of the changes in concentrations for the individual contaminant plumes over specific time periods, e.g. 1 year, 5 years, 10 years, etc. These will clearly illustrate the effectiveness of the BGC Project.

This work has not been completed within the timeframe of submission of the EIS, but will be provided by Orica to DEC and DIPNR—and will be made available to the community through the project website—when completed, to present the estimates of changes over time.

This modelling work supports the initial qualitative assessment of the likely changes, based on the position of the various containment lines relative to known or inferred source areas.

Table 12.3 presents an estimate of the mass of volatile CHCs that would be extracted from each of the containment lines at start-up of the GTP in late 2005.

<table>
<thead>
<tr>
<th>Parameter/Contaminant</th>
<th>Units</th>
<th>Primary Pipeline Subtotal</th>
<th>Secondary Pipeline Subtotal</th>
<th>DNAPL Pipeline Subtotal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraction Rate</td>
<td>ML/day</td>
<td>3.4</td>
<td>2.5</td>
<td>9.2</td>
<td>15.0</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane</td>
<td>Mass (kg/day)</td>
<td>6.0</td>
<td>15.6</td>
<td>1.0</td>
<td>22.6</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>Mass (kg/day)</td>
<td>1.8</td>
<td>4.2</td>
<td>2.6</td>
<td>8.6</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>Mass (kg/day)</td>
<td>0.4</td>
<td>0.7</td>
<td>3.9</td>
<td>5.0</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>Mass (kg/day)</td>
<td>1.4</td>
<td>2.4</td>
<td>0.9</td>
<td>4.7</td>
</tr>
<tr>
<td>1,2-Dichloroethene</td>
<td>Mass (kg/day)</td>
<td>1754.3</td>
<td>36.7</td>
<td>571.2</td>
<td>2362</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>Mass (kg/day)</td>
<td>300.9</td>
<td>17.7</td>
<td>2.4</td>
<td>321</td>
</tr>
<tr>
<td>Chloroform</td>
<td>Mass (kg/day)</td>
<td>32.1</td>
<td>19.8</td>
<td>16.7</td>
<td>69</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td>Mass (kg/day)</td>
<td>8.9</td>
<td>8.2</td>
<td>2.7</td>
<td>20</td>
</tr>
<tr>
<td>Methylene Chloride</td>
<td>Mass (kg/day)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Mass (kg/day)</td>
<td>149.6</td>
<td>25.6</td>
<td>5.0</td>
<td>180</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>Mass (kg/day)</td>
<td>1.0</td>
<td>1.2</td>
<td>0.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Mass (kg/day)</td>
<td>33.4</td>
<td>29.0</td>
<td>37.4</td>
<td>100</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>Mass (kg/day)</td>
<td>33.4</td>
<td>5.5</td>
<td>37.1</td>
<td>76</td>
</tr>
<tr>
<td>TOTAL VOLATILE CHCs</td>
<td>Mass (kg/day)</td>
<td>2323.2</td>
<td>166.5</td>
<td>682.1</td>
<td>3172</td>
</tr>
</tbody>
</table>

It is anticipated that it will take some considerable time (at least five years) for noticeable reductions in the rate of contaminant mass removal from the DNAPL containment line on the BIP. This is largely due to the fact that the containment lines are positioned at considerable distances down-gradient of the inferred DNAPL source areas on the BIP, so there is already a significant mass of the contaminants dissolved in the groundwater plumes emanating from these DNAPL source areas.
Furthermore, it will take Orica some time to effectively remove the DNAPL source areas to the maximum extent practicable. The Notice of Clean Up Action requires this to be achieved to the maximum extent practicable by 31 October 2005. Orica is endeavouring to progress this work as effectively as possible; however, there are a number of constraints. First, DNAPL source area containment must be in place to ensure that any contaminants mobilised by the removal of the DNAPL source areas are prevented from migrating beyond the BIP boundary. This contaminant containment cannot be achieved until the DNAPL source areas containment lines and the GTP are fully operational. Second, not all of the DNAPL source areas are accessible (e.g. the source of one of the Northern Plumes—the former CTC/PCE storage tanks—is now located under the Alkatuff reactor section). Third, it is not yet clear whether adequate technologies exist to remove all of the accessible DNAPL source areas.

A program of activities to reduce the contaminant mass of the DNAPL source areas is being developed as part of the GCP. If this program is successful, it could reduce the overall timeframe for DNAPL removal in the Project Area. It would also be instrumental in speeding up the reduction in contaminant mass recovery at the DNAPL containment lines on BIP.

For the Primary Containment Area, designed primarily to capture the Central Plume, it would be expected that there would be a decline in the mass of contaminants captured by the PCA containment in the short term, as the source areas for the plume are located in the BIP up-gradient of the DNAPL extraction wells.

The mass reduction is likely to occur after one to two pore volumes (a pore volume is the volume of groundwater flowing between two lines drawn perpendicular to the groundwater flow) have been removed from the area between the DNAPL containment line and the primary containment line. It is expected that this may require between one and three years, after which time there will be a significant reduction in the mass extracted at the PCA containment line.

As shown in Table 12.3, the mass of EDC estimated to be extracted from the PCA at GTP start-up represents approximately 75% of the total EDC mass. Whilst some of the EDC is derived from sources on Southlands Block 1 (i.e. the Southern Plumes), the majority of this mass of EDC is derived from the Central EDC Plume. It is anticipated that within three years, the mass of CHCs being extracted at the PCA containment line may be reduced from over 2000 kg/day to approximately 500 kg/day, as the core of the plume is removed. Beyond this timeframe the mass is not expected to decline quickly, since the majority of the mass will be derived from capture of groundwater flow passing through Southlands Block 1. This area (Block 1) is inferred to contain significant DNAPL, which is expected to be present for a considerable period of time. As discussed above, the DNAPL source area removal program might take some time for complete and successful implementation, and further time for the dissolved phase contaminants to be flushed out of the aquifer towards the PCA containment line. Particularly in the Southern Plumes, the principal contaminants are significantly less mobile than EDC, tending to be less soluble in the groundwater and more likely to adsorb onto aquifer soil particles. Thus groundwater flushing of the affected areas down-gradient of the DNAPL source areas will require a number of pore volumes of groundwater to flow from the DNAPL source areas through to the down-gradient PCA line of extraction wells.

There is also expected to be a decline over time in the mass of CHCs being extracted at the secondary containment line at Foreshore Road, once the DNAPL source areas are contained at the PCA and DNAPL containment lines. It is expected that the mass will initially increase, due to the high concentration core of the Central Plume arriving at the containment line. Once this has been removed, there would be a considerable decrease in the mass of CHCs at the secondary containment line, as the contaminants are...
extracted from the area between Southlands and Foreshore Road. It is uncertain precisely how long this may take, but it is likely that within five years from start-up, the mass may decline by up to 90% (i.e. by approximately 150 kg/day).

Based on this qualitative assessment, and assuming that the GTP is operational by late 2005, it estimated that by 2010 the mass load will be reduced from approximately 3000 kg/day to below 1200 kg/day.

12.5 Assessment of GTP Construction Impacts

12.5.1 GTP Construction

The depth to groundwater at the site of the GTP is approximately 1.5 m. The construction options would minimise the potential for excavation and dewatering, through the compaction of the existing site area and use of shallow footings such as strip and pad footings. This approach would ensure that there would be no works at or below the level of the groundwater table.

In the event that piling was identified as necessary, appropriate means—such as screw piles—would be used to minimise disturbance of the groundwater.

The management measures detailed in Chapters 11 and 14 would minimise any potential impacts from runoff or erosion, and any chemicals or materials that could cause contamination would be stored in suitably bunded areas to provide containment of any spillages or leaks.

It is anticipated that the existing sanitary facilities on the BIP would be used by construction staff, which are connected to the Sydney Water sewerage system. If these facilities are inadequate for the number of construction workers, temporary sanitary facilities could be provided, which would be connected into the BIP domestic sewer system for discharge and treatment in the Sydney Water sewerage system.

12.5.2 Other Construction Activities

Of the other construction works, only installation of the additional extraction wells in the PCA and for the DNAPL containment line would potentially affect the groundwater, since the DNAPL pipeline installation and the discharge line refurbishment would not involve works at or below the level of the groundwater table.

The installation of the groundwater wells would involve drilling into the groundwater table, to form the wells in which the submersible extraction pumps would be installed. All drilling muds and slurries, and groundwater extracted during commissioning, would be directly removed from the construction sites by a licensed waste contractor, for management as described in Chapters 11 and Section 14 and summarised below:

- drilling muds stored and dried in the containment structures on Southlands, prior to assessment and landfill disposal;
- slurries stored in IBCs in a bunded area on the BIP, to settle out for treatment of sludge with the drilling muds (above) and the groundwater in the SSU; and
extracted groundwater stored in existing tanks in the BIP prior to treatment in the SSU.

The management measures detailed in Chapters 11 and 14 would minimise potential impacts from runoff or erosion. Chemicals or materials that could cause contamination would be stored in suitably bunded areas to provide containment of any spillages or leaks.

These precautions would ensure that no contaminated groundwater or muds/slurries were discharged to the environment or into site drainage systems during construction.

### 12.6 Assessment of Operation Impacts

The principal potential impacts would arise from the operation of the overall BGC Project, with the extraction of 15 ML/day of groundwater along the three containment lines. These potential impacts comprise:

- groundwater recharge from Springvale and Floodvale Drains, reversing the existing situation of groundwater discharge to the drains, and reducing flows and discharges to Penrhyn Estuary and Botany Bay;
- groundwater recharge from Lachlan Swamps, potentially slightly reducing water levels in the swamps;
- reduced groundwater discharge into Penrhyn Estuary and Botany Bay;
- potential saltwater intrusion toward the secondary containment line along Foreshore Road;
- potential subsidence as a result of groundwater extraction; and
- generally reduced groundwater levels.

In addition, there are a number of other potential impacts associated with the groundwater to be considered, including:

- potential for impact on the groundwater from contamination, e.g. from spills at the GTP;
- potential impact of the chemicals used in the bioremediation field trials on Southlands Block 2 (PCA) on the operation of the GTP; and
- overall effectiveness of the proposed hydraulic containment.

#### 12.6.1 Water Balance

**Springvale and Floodvale Drains**

The groundwater extraction would considerably increase the recharge of the aquifer from Springvale and Floodvale Drains. It has been estimated that, currently, 4.3 ML/day flows from the aquifer into the drains, and that this would be reduced to 0.3 ML/day as a result of groundwater pumping.
As a result, it is anticipated that the drains would virtually dry up under low flow conditions, stopping existing fresh water discharges into Penrhyn Estuary and Botany Bay. This would achieve a positive effect, by preventing the potential for ‘short-circuiting’ of the containment lines, and would thereby minimise the risk of ongoing contaminant discharge into the drains and hence into Penrhyn Estuary and Botany Bay.

However, the reduced flow of fresh water could affect the aquatic flora and fauna in the bay (and by association, the avifauna). This is considered further in Chapter 20.

**Lachlan Swamps**

As a result of the cessation of groundwater extraction for industrial use at Solvay Interox, the groundwater recharge from Lachlan Swamps due to the proposed level of extraction is predicted to reduce, by a total of 3%, to 7.6 ML/day. As a result, the water levels in the swamps would not be expected to change, and hence it is considered that there would be no impact on the swamps.

**Penrhyn Estuary and Botany Bay**

The existing rate of groundwater discharge from the aquifer within the groundwater model catchment area to Botany Bay would be reduced from 19 ML/day to 16.2 ML/day; a reduction of 15%. This reduction of the discharge would be concentrated along the length of the secondary containment line on Foreshore Road. As a result, in this area, the groundwater discharge down-gradient of the secondary containment line would be expected to stop completely when the BGC Project is operating at the full proposed extraction rates.

Previous work undertaken by URS (URS, Feb 2004) has characterised the discharge of groundwater from the Southern Plumes to Penrhyn Estuary. Figure 12.13 shows the distribution of pH and the electrical conductivity (EC), which show a distinct trend in a seaward direction from the shoreline. At high tide the pH in pore water increases in an upward and seaward direction from approximately pH 5 to a neutral pH, reflecting seawater. Similarly, electrical conductivity (a measure of salinity) in the shallow sample ports within the intertidal zone increases from approximately 40,000 μS/cm to more than 50,000 μS/cm at high tide.

Overall, the pH and EC distribution highlights the four hydrogeochemical zones that are present between the freshwater terrestrial aquifer and the ocean. Figure 12.2 presents a schematic across the study area showing four distinct zones, which from the terrestrial to seaward direction are:

- freshwater (terrestrial groundwater);
- zone of diffusion;
- mixing zone; and
- seawater.
The freshwater terrestrial aquifer is not well defined within the intertidal zone or adjoining area. The freshwater terrestrial groundwater is represented in up-gradient areas (i.e. Foreshore Road) and generally has a relatively low salinity (EC<5000 µS/cm) and a higher concentration of volatile CHCs (up to 100 mg/L). The pH, EC and volatile CHC concentrations within each of the hydrogeochemical zones are shown on Figure 12.13 (pH and EC only) and summarised in Table 12.4 below.

### Table 12.4 Hydrogeochemical zones: Penrhyn Estuary intertidal discharge zone

<table>
<thead>
<tr>
<th>Zone</th>
<th>pH</th>
<th>Electrical Conductivity (µS/cm)</th>
<th>Total Volatile CHCs (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshwater (Terrestrial Groundwater)</td>
<td>&lt;5</td>
<td>&lt;5000</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Zone of Diffusion</td>
<td>5 to 7</td>
<td>10000 to 40000</td>
<td>10 to 100</td>
</tr>
<tr>
<td>Mixing Zone</td>
<td>6 to 7</td>
<td>&gt;40000</td>
<td>0.1 to 10</td>
</tr>
<tr>
<td>Seawater (Botany Bay)</td>
<td>&gt;7</td>
<td>&gt;50000</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

The boundaries between the various hydrogeochemical zones are not sharp, and are not fixed. The boundaries of the various zones will move laterally and vertically, and are largely dependent on the tidal oscillations.

It is expected that groundwater extraction at Foreshore Road (the secondary containment line) is at risk of causing saltwater intrusion. The implications are that the seawater interface will shift landwards, resulting in a slight increase in pH and EC within the intertidal zone. This will occur as terrestrial groundwater is captured by the hydraulic containment at Foreshore Road, thereby preventing the discharge of groundwater to the estuary. The hydrogeological modelling of the groundwater drawdown caused by pumping along Foreshore Road also suggested that the hydraulic gradients could potentially be reversed all the way from the bay to Foreshore Road. Such gradients would be very low, and the particle tracking analysis concluded that there would be almost no saltwater intrusion.

Potential impacts on flora and fauna from changes to the seawater interface are assessed in further detail in Chapter 20.

Groundwater monitoring, as described in Section 12.7, would be carried out along Foreshore Road to detect saltwater intrusion into the wells. If this did occur, pumping rates would be adjusted to reduce the intrusion of saltwater while maintaining hydraulic containment.

**Groundwater Levels**

The modelling results indicate that groundwater levels would reduce across Foreshore Road, Southlands and the BIP by up to 3 m below existing levels. Lowering of the groundwater table has the potential to expose potential acid sulphate soils to air, allowing them to oxidise into acid sulphate soils (ASS). The predicted lower groundwater levels are higher than the lowest historical groundwater levels recorded in 1969, and consequently the risk of encountering acid sulphate soils during the operation of the GTP is considered to be low.
Predicted drawdown would not be expected to have an impact on the existing groundwater extraction pumping, other than a possible increase in the head requirements of the pumps.

The modelling results also predict decreased evapo-transpiration losses, as a result of reduced groundwater availability to vegetation in the project area, due to the lowered groundwater levels. Given the generally urban nature of the area, no significant impacts would be expected.

**Subsidence**

The predicted level of subsidence associated with the groundwater pumping would not result in significant impacts on commercial or residential structures within the Botany area. Under the most likely case, based on historic water levels in the region, the maximum predicted subsidence would be 0.9 mm on Foreshore Road and 0.1 mm on the BIP, which are both considered minor with regard to movements of roads and conventional building structures.

**Sir Joseph Banks Park**

The modelling predicts a reduction in water levels in the park's ponds of up to 15 cm. This should be considered in the context that the natural exchange of water between the aquifer and the lakes in the project area is dynamic (Merrick, 1994), with fluctuations from +8.6 ML/day (recharge) to –8.6 ML/day (discharge), so that the levels in the ponds naturally fluctuate. Therefore, the predicted changes in water levels are well within the range of long term seasonal fluctuation.

In addition, the ponds do not support significant flora or fauna species and hence no significant impact from such fluctuations would be expected.

**12.6.2 Contaminant Variations**

**Bioremediation Trials**

Under the works carried out for the bioremediation field trials on Southlands Block 2, quantities of emulsified oils and ethanol are being added to the aquifer, to provide a medium for microbial growth and subsequent contaminant degradation. The bioremediation trials are expected to continue until the early part of 2005. It is possible that the chemicals that have been injected into the subsurface may not have been broken down by microbial activity before reaching an extraction well, and hence could be extracted and transferred to the GTP.

It is considered unlikely that the emulsified oil could be captured by the extraction wells, since the oil is immobilised within the aquifer pores. As the emulsified oil will slowly ferment to volatile fatty acids, it is considered more likely that these fatty acids could be transferred to the GTP for treatment, and would be removed.

Ethanol is highly soluble and will migrate with the groundwater, and would not be expected to be present within the capture zone by the time the GTP is operational. Nonetheless, if ethanol is present it would be stripped and oxidised to carbon dioxide and water in the thermal oxidiser.
**Contaminant Variations over Time**

As discussed above, modelling is currently being undertaken to assess the changes in the contaminant concentrations over time, and the outputs of this work will not be available until after submission of this EIS.

However, the preliminary qualitative assessment suggests that the core of the Central EDC Plume (which contains the highest mass load of contaminants within the groundwater) would be removed within the first few years of operation of the GTP, and that the contaminant concentrations—and hence the mass loads within the groundwater extracted and transferred to the GTP—would be expected to reduce over time.

The technology selection and design of the GTP incorporates this anticipated reduction in contaminant loads, and no impact on the continued effective operation of the treatment would be expected. This would be monitored through the operational and emission/discharge monitoring for the GTP, to confirm compliance with the relevant specified standards.

**12.6.3 Containment Failure**

The hydraulic containment of the contaminated groundwater is a proven approach that has been shown to be effective in a range of applications, as the operation of the extraction wells creates a hydraulic gradient that effectively stops the natural groundwater flows.

This has been demonstrated by the ‘particle tracking’ verification, undertaken as part of the groundwater modelling to demonstrate the capture of representative particles placed upstream of the containment lines within each aquifer layer. In all cases of the capture validation, as presented in Appendix D, the modelling of the flow tracer particles showed that in the long term, all groundwater passing beneath the BIP—and hence through the inferred source areas—would be captured by the containment lines.

It is therefore considered very unlikely that the contaminant plumes would not be contained by the operation of the BGC Project.

If, in the unlikely event that the hydraulic containment did not achieve its objective, the following initial qualitative assessment of the potential impact of the Central EDC Plume reaching Penrhyn Estuary/Botany Bay has been undertaken.

With no containment, it is estimated that the core of the Central EDC Plume would reach Penrhyn Estuary and Botany Bay by early 2006 to early 2007.

If incomplete capture were to occur at the secondary containment line on Foreshore Road, some high concentrations of EDC within the Central EDC Plume could potentially discharge to Penrhyn Estuary. The assessment of potential impact on fauna within the estuary is speculative; however, it is unlikely that a large area would be adversely affected, since the incompletely captured groundwater would be attenuated through the zone of diffusion and mixing zone prior to discharge into the estuary. A catastrophic failure of the treatment system, which would result in cessation of pumping, is less likely to occur, but may have a more significant impact, which is largely dependent on the position of the high concentration zone relative to Foreshore Road. Cessation of pumping for less than two weeks is unlikely to have an adverse impact because the contaminated groundwater would be drawn back and extracted when pumping restarted.
CHAPTER 12 Hydrogeology

Based on extrapolation from the current discharge of the Southern Plumes into the estuary, the result may lead to exceedances of ANZECC 2000 trigger values for EDC, TCE and VC within the pore water of the intertidal discharge zone of western arm of Penrhyn Estuary. These exceedances would generally be confined to small areas close to the high tide mark adjacent to the shoreline. The core of the Central EDC Plume would need to pass the containment line if it were to exceed the ANZECC (2000) trigger values within surface water in the estuary.

If incomplete capture of the Southern Plumes were to occur, the impact would be the same as the current situation (as described in Chapter 13), since these plumes have been reported to be discharging into the estuary since the Stage 2 Survey in 1995. An exceedance may be recorded in the pore water within the intertidal zone, near the shoreline, for a number of volatile CHCs, including EDC, PCE, TCE, VC, CTC and chloroform. Based on recent studies, this would not result in an exceedance of ANZECC (2000) guidelines in surface water. The main impact on surface water concentrations in the estuary arises from the surface waters flowing from Springvale Drain.

The specific potential impacts of such discharges on human health have not been fully assessed to date, although Orica is in the process of reviewing the Stage 2 Survey Human Health Risk Assessment. This is being developed in conjunction with the EPA and other regulatory agencies (such as NSW Health). The purpose of this review is to assess the potential health effects of the release of Orica-related contaminants into the estuary. The results of this study are expected to be available in the first half of 2005.

Recent monitoring of the Northern Plumes indicates that the concentrations of contaminants within the source areas are significantly lower than in the Central EDC and Southern Plumes. The contaminants appear to be attenuating, and only relatively low concentrations are detected at Foreshore Road (<10 mg/L). If incomplete capture were to occur, the groundwater would discharge into Botany Bay. Based on the investigation of the Southern Plumes discharge to Penrhyn Estuary (URS, 2004a), the discharge of groundwater is unlikely to cause an exceedance of the ANZECC (2000) guidelines.

12.7 Mitigation and Management Measures

12.7.1 Groundwater Monitoring

The primary management measure for assessing and mitigating potential impacts from the groundwater extraction is through monitoring water levels during the groundwater extraction. As part of the Environmental Management Plan for the BGC Project (see Chapter 28), a comprehensive monitoring program would be developed, using the monitoring wells installed in the containment lines and the existing monitoring locations over the whole area of the Project Area (which have produced the results presented in the quarterly reports).

The program would specify the parameters and frequency of monitoring, procedures for actions to be taken in response to results, and reporting requirements.

For the containment lines, the key monitoring parameters would be:

- water level; and
- electrical conductivity.
These parameters would provide the required information to assess potential impacts, such as saltwater intrusion (for the secondary containment line) and the effectiveness of the hydraulic containment (based on comparison with the predicted drawdown levels within the groundwater model).

The monitoring of electrical conductivity (salinity) along the secondary containment line would be a critical aspect of the monitoring program, to ensure that no saline water was transferred to the GTP. Operational experience would be used to develop appropriate measures to manage the pumping operations in this area, including options such as adjustment of pump flows or intermittent operation of the pumps, to allow the saline interface to retreat toward the shoreline before it adversely affected the GTP. The groundwater extraction model incorporated allowances for project shutdown of up to two weeks without affecting the hydraulic containment of the plumes.

The existing monitoring locations, down-gradient of and in line with the containment lines, would continue to be used to track the contaminant plumes, and hence the effectiveness of the contaminant extraction. It is unlikely that the results from these wells would provide such data until 12 months or more after the BGC Project had become operational, due to the relatively slow rate of groundwater flow (0.3 to 0.4 m/day).

Demonstration of hydraulic containment will be achieved by measuring groundwater levels at the extraction wells and in a network of monitoring wells. Further groundwater modelling will be used to develop the design for the network of monitoring wells, building on the existing networks. These networks will include monitoring wells located between the extraction wells as illustrated in Figure 5.5. Water levels at the extraction wells will be monitored by the GTP PLC to ensure that the desired drawdown is achieved at each extraction well (and will provide pump protection by ensuring the extraction wells are not pumped dry).

The PLC would also monitor all the groundwater extraction flow rates, to provide an instantaneous picture of current operations, and raise alarms in the event of rapid changes to flows.

### 12.7.2 Pumping Rates

The groundwater pumps would be fitted with variable speed drives, so that the extraction rates for the groundwater at each containment line could be varied depending on the variations in the key groundwater parameters.

The predicted groundwater drawdown in the groundwater modelling would be used, in comparison with the actual extraction rates, to trim the initial operation of the overall BGC Project.

Where monitoring results suggest incomplete hydraulic containment, pumping rates could be increased to ensure hydraulic containment. This may have to be balanced with reductions in pumping rates elsewhere, to avoid overloading the GTP or imbalances in drawdown, and this would be subject to careful assessment during commissioning of the containment system.

Conversely, when, as anticipated, the contaminant loads in the groundwater reduce over time, the pumping rates may be reduced in some areas. This is unlikely to occur within the first few years of operation. It is anticipated that, even after a significant reduction in mass is recorded (see Section 12.4.2 above), rate-limited desorption of contaminants from peaty layers will continue for a considerable period of time, resulting in persistent low residual contaminant concentrations (in the order of 1 mg/L) within the aquifer.
12.7.3 Subsidence Monitoring

As noted above, the groundwater model included predictions of subsidence levels based on three scenarios. The Likely Case scenario would result in there being no subsidence impact, with the other scenarios predicting potential subsidence of 1.3- to 1.7 cm at the BIP or on Foreshore Road. Potential subsidence would be monitored by identifying appropriate measurement points in the vicinity of the Worst Case predicted subsidence, installing settlement plates and assessing these over time. This would provide cost-effective monitoring data on potential subsidence from the hydraulic containment.

12.7.4 Contingency Measures

The design of the GTP and the groundwater containment and extraction, as developed from the groundwater modelling, incorporates contingency of around two weeks’ shutdown (e.g. for GTP maintenance), although the design basis has been for 95% availability and one continuous week’s shutdown. This length of shutdown of the BGC Project would not adversely affect the hydraulic containment of the contaminant plumes, due to the relatively slow groundwater velocity (0.3 to 0.4 m/day). Groundwater modelling indicates that any groundwater contaminants that might have migrated beyond the containment line within that period would be drawn back to the extraction wells upon start-up.

The primary contingency measure to cover the very unlikely event of potential long-term shutdown of the GTP project (e.g. due to catastrophic failure of key equipment) is to maintain the Steam Stripping Unit (SSU) in a standby mode, for recommissioning in a controlled and timely manner. The SSU would be used to provide ongoing containment of the highest concentration contaminated groundwater and protection of receiving environments (i.e. Central Plume at Foreshore Road) while GTP operational issues were rectified.

To minimise the risks of significant GTP plant failures and their duration, Orica would adopt a routine inspection and maintenance program for critical equipment. A program for defining and managing required spare parts, including installed and non-installed complete spare equipment, would also be developed to reflect the criticality and availability of different items.

Failures of wells (e.g. through fouling or pump failure) would be likely to occur on an individual basis. The impact of individual wells’ failures would be mitigated by quick repair time and short-term increases in extraction rates from adjacent extraction wells.

Pipeline failures—particularly underground—are likely to be more difficult to repair. However, pipeline failures would be rare, and would be most likely to occur gradually. Leak monitoring (visual inspection of aboveground pipes and leak detection monitoring for the underground pipes) would provide early warning, which would likely be sufficient to marshal and deploy the required materials and resources for timely repairs to be completed.

12.7.5 Summary of Mitigation Measures

Mitigation measures which would be implemented during design, construction and operation phases are summarised in Table 12.5.
Table 12.5 Summary of mitigation measures

<table>
<thead>
<tr>
<th>Safeguards</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure groundwater extraction is designed, and operated based on the results of the groundwater modelling.</td>
<td>✓</td>
</tr>
<tr>
<td>Develop a comprehensive monitoring program, specifying frequency and parameters to provide feedback on operation and effectiveness of containment and extraction—to include monitoring hydraulic parameters on containment lines and chemical parameters on existing monitoring wells.</td>
<td>✓</td>
</tr>
<tr>
<td>Collect drilling muds/slurries/groundwater directly during installation, using licensed waste contractor to transfer wastes to appropriate storage prior to treatment/disposal.</td>
<td>✓</td>
</tr>
<tr>
<td>Install variable speed drives with adjustable kickback on pumps to allow changes to pumping rates.</td>
<td>✓</td>
</tr>
<tr>
<td>Identify appropriate locations and methodologies for monitoring of potential subsidence, for baseline comparison with predictions in modelling.</td>
<td>✓</td>
</tr>
<tr>
<td>Develop appropriate monitoring and management measures to avoid intrusion of saline water into secondary containment line on Foreshore Road.</td>
<td>✓</td>
</tr>
<tr>
<td>Use groundwater modelling drawdown output as initial basis for trimming extraction pumping rates to achieve steady-state operations.</td>
<td>✓</td>
</tr>
<tr>
<td>Vary pumping rates as appropriate to maintain required level of hydraulic containment.</td>
<td>✓</td>
</tr>
<tr>
<td>Regular inspection of containment lines and transfer pipelines, including secondary containment leak detection systems, to ensure no leaks or spills.</td>
<td>✓</td>
</tr>
<tr>
<td>Regular maintenance of groundwater pumps to maintain hydraulic containment.</td>
<td>✓</td>
</tr>
<tr>
<td>Maintain SSU in standby mode once GTP is operational.</td>
<td>✓</td>
</tr>
</tbody>
</table>
12.8 Conclusion

The operation of the BGC Project is designed to alter the existing groundwater flow regime so that the existing contaminated groundwater can be removed for treatment and the Botany Sands Aquifer can be restored over time.

Computer modelling has been used to determine the optimal layout of groundwater extraction wells for the cleanup of the groundwater, within the constraints of the NCUA and the prevailing conditions in and above the aquifer. The results of the modelling have illustrated that the proposed groundwater extraction well network would satisfy the requirements for hydraulic containment of the plumes as described in the NCUA.

The predicted level of subsidence associated with the groundwater pumping is in the order of 0.9 mm, and therefore is unlikely to have significant impacts on commercial or residential structures or public infrastructure within the Botany area.

The operation of the groundwater extraction and transfer via pipelines associated with the GTP operation would be managed, through the monitoring regime proposed, to minimise any potential impacts and to maintain the effectiveness of the hydraulic containment and groundwater treatment. Ongoing monitoring and reporting of groundwater flows and contaminants levels would be continued, in line with the requirement of the GCP and VRA.
Figure 12-5: Principle of Hydraulic Containment

- **Hydraulic Barrier**
- **Groundwater Extraction**
- **Natural Water Table**
- **Shallow Aquifer**
- **Deep Aquifer**
- **Bottom Aquifer**
- **Layer 1**: Gradient Reversal
  - Reversed flow imposed by pumping
- **Layer 2**: No aquifer flow past the hydraulic barrier
- **Layer 3**: Natural aquifer flow

Not to Scale
**FIGURE 12-9**

Monitoring Locations for Modelling Groundwater Drawdown

**MAP DESCRIPTION:**
- **Legend:**
  - Green circle: Production Bore
  - Red plus sign: Drawdown Monitoring Site
  - Purple triangle: Subsidence Monitoring Site

**Map Features:**
- **Location Key:**
  - Solvay Interox Borefield
  - Snape Park Borefield
  - Orica Borefield
  - Botany Industrial Park
  - Southlands Drainage
  - Bay Drainages

**Source:** Access/UTES(2004) Figure 20

**Note:**
1. Solvay borefield shutdown in 2004
2. Size of symbol relative to amount of groundwater extracted

**Not to Scale**

**URS**

This map is subject to CONFIDENTIAL and is the property of URS Australia Pty Ltd.
FIGURE 12-11
Subsidence Modelling - Results of Likely Case Scenario

Maximum predicted subsidence 0.1mm

Maximum predicted subsidence 0.9mm

SOURCE: AccessUTS(2004) Figure 38
FIGURE 12-12
Tracer Particle Modelling - Capture Zones for Tracer Particles in Aquifer Model Layer 1

LEGEND
- Contaminant Plume Contours
  Particles in Aquifer Layer 1
  Particles in Aquifer Layer 2A
  Particles in Aquifer Layer 2B
- Groundwater Extraction Well

- DNAPL Containment Line
- Primary Containment Area
- Full hydraulic containment of central and southern plumes
- Secondary Containment Area
- Long-term slow movement of northern plumes subject to future containment if insufficient natural attenuation
- BIP Location

SOURCE: AccessUS(2004) Figure 27
Not to Scale

PROJECT: 39465 - 033
FILE NAME: Paper 12_10.WOR
DATE: 11/11/2004
PROJECTION: MGA Zone 56
13.1 Introduction

This chapter assesses the water usage and treated water/wastewater management aspects of the BGC Project, focusing on:

- water use during construction and operation;
- treatment of the contaminated groundwater and reuse of the treated groundwater;
- management of wastewater streams generated; and
- discharge of the excess treated groundwater to Botany Bay via Brotherson Dock.

Assessment of the other hydrological and surface water aspects associated with the project is presented in Chapter 14. Hydrogeology and groundwater aspects are assessed in Chapter 12.

13.2 Existing Environment

13.2.1 Groundwater

Groundwater flows, levels and contamination are described in detail in Chapter 12. The objective of this section is to provide the basis of the groundwater treatment and the treated groundwater quality.

The full specification of the contaminated groundwater is presented in Appendix L, based on the extensive groundwater investigation and monitoring works undertaken to characterise the contaminant plumes since 1996. In order to provide the data that formed the design basis of the GTP, analysis results from the March and June Quarterly Monitoring Reports (URS, March & June 2004) have been used to develop typical contaminant concentrations, based on all monitoring wells sampled within the Primary and Secondary Containment Areas and the DNAPL Containment Line, scaled to represent the proposed groundwater extraction rates (as detailed in Chapter 12).

The contaminated groundwater would be continuously extracted from the three containment lines, transferred to the GTP on the BIP, and then combined in the groundwater feed tank to form a homogenous groundwater mixture prior to treatment. The purpose of mixing the three streams within the feed tank is to obtain as consistent a groundwater feed to the GTP and contaminant concentration as possible. It is anticipated that there would be slow variations in the contaminant concentrations of the groundwater feed, through variations in the composition of the groundwater extracted from different areas, the groundwater flows and volumes, and natural degradation of the contaminants. The GTP has been designed to accommodate such variation in the groundwater feed, and to consistently produce the treated groundwater quality specified as well as minimising the emissions to air.

The main components of the design basis for the contaminated groundwater feed are presented in Table 5.9.
13.2.2 Penrhyn Estuary

Penrhyn Estuary is a relatively small waterway that lies at the outlet of both Springvale and Floodvale Drains. The estuary is a man-made system, created as a result of the development of Port Botany in the late 1970s for Sydney Airport and Port Botany. The estuary is characterised by a sandflat area, with two channels from the two inflow points meeting midway within the system to form a single channel. As described in Chapter 20, Springvale Drain has been colonised by mangroves. The fringe of the estuary has some saltmarsh, and some parts of the estuary have seagrass beds (see Chapter 22).

The water quality in this area is primarily affected by inflows from the tide from Botany Bay and by surface water runoff from the Floodvale and Springvale Drain catchments. Groundwater also has an impact on the quality of the inflow.

The monitoring undertaken by Orica has included sampling of both the intertidal groundwater discharge into, and the surface waters of, the estuary. The results are presented in detail in the Quarterly Monitoring Report for June 2004 (URS, June 2004).

The surface monitoring results, as summarised in Table 13.1, show that a number of volatile CHCs are present in surface water, mainly due to the discharge of shallow groundwater to Springvale and Floodvale Drains. The major component of CHC in the surface water is EDC, although a number of other CHCs are present at lower concentrations. Within the estuary, the concentrations of all contaminants are generally an order of magnitude lower at high tide than at low tide. The concentrations of other volatile CHCs in comparison to EDC are low, and in most instances, EDC represents approximately 90% of the total volatile CHC mass.

The transfer of contaminated shallow groundwater via the drains will cease once hydraulic containment is in place.
### 13.2.3 Foreshore Beach

The Foreshore Beach area runs between the Mill Stream outlet to the west and the mouth of Penrhyn Estuary, so water quality in the beach area would be affected by both systems. The water quality is also affected by inputs from the five stormwater outlets along the length of the beach.

### 13.2.4 Botany Bay/Brotherson Dock

The water quality in Botany Bay is affected by a wide variety of factors, with contaminant inflows and outflows dominated by oceanic inflows on the incoming tides, and discharges from the major catchments on the outgoing tides. The tidal range of the bay is essentially the same as the ocean tide.

The major catchments of the bay that are likely to have the most observable impact on water quality are those of the Georges River and the Cooks River (to the south-west and west of the Project Area, respectively). However, while these are considerable sources of contaminants, the wider bay area is considerably well flushed, due to the width and depth of the entrance of Botany Bay. The size of the entrance affords the bay a significant tidal exchange, and allows for the translation of pollutants from the bay to the ocean on each ebb tide.

Brotherson Dock is located at Port Botany and is the principal ship unloading area for both the Patrick Container Terminal (on the north side) and the P&O Container Terminal (on the south side). Water quality in the dock would be affected by both commercial shipping operations and the stormwater runoff from the catchment to the east, which drains into Bunnerong Canal for direct discharge into the dock. However, the dock is open and contiguous with Botany Bay, and therefore would have a tidal exchange that would allow for the flushing of contaminants.

---

**Table 13.1 Surface water quality (mg/L) in Penrhyn Estuary**

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Springvale Drain Outlet – Low Tide (SW031L)</th>
<th>Floodvale Drain Outlet – Low Tide (SW029L)</th>
<th>Old Boat Ramp – Low Tide (SW028L)</th>
<th>New Boat Ramp – Low Tide (SW048L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,1,2-trichloroethane</td>
<td>0.125</td>
<td>0.021</td>
<td>0.007</td>
<td>0.001</td>
</tr>
<tr>
<td>EDC</td>
<td>23.6</td>
<td>4.39</td>
<td>1.01</td>
<td>0.109</td>
</tr>
<tr>
<td>CTC</td>
<td>0.092</td>
<td>0.01</td>
<td>0.002</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.31</td>
<td>0.055</td>
<td>0.021</td>
<td>0.004</td>
</tr>
<tr>
<td>PCE</td>
<td>0.079</td>
<td>0.021</td>
<td>0.002</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TCE</td>
<td>0.34</td>
<td>0.085</td>
<td>0.02</td>
<td>0.006</td>
</tr>
<tr>
<td>Cis-1,2-dichloroethylene</td>
<td>0.504</td>
<td>0.131</td>
<td>0.029</td>
<td>0.01</td>
</tr>
<tr>
<td>VC</td>
<td>1.38</td>
<td>0.338</td>
<td>0.071</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Source: (URS, 2004)
Water quality in Botany Bay was assessed as part of the *Port Botany Expansion EIS* (URS, 2003), through a review of the extensive available data, to establish a baseline dataset of the existing water quality in the vicinity of the proposed port expansion. Data was obtained from sources including:

- the Council of the City of Botany Bay;
- the EPA;
- Sydney Water Corporation;
- the *Proposed Third Runway EIS* (Kinhill, 1990); and
- previous studies of the area for the Penrhyn Road Boat Ramp (JET, 1993).

This data is presented in **Table 13.2**.

**Table 13.2 Summary of Botany Bay water quality**

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Botany Bay Observed Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physico-Chemical</strong></td>
<td></td>
</tr>
<tr>
<td>Conductivity (mS/cm)</td>
<td>49.6 – 54.6</td>
</tr>
<tr>
<td>pH</td>
<td>7 – 8.5</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>Greater than 0 but less than 12</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>0.1 – 14</td>
</tr>
<tr>
<td>Dissolved Oxygen (% saturation)</td>
<td>76 – 118%</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>13.1 – 22.2</td>
</tr>
<tr>
<td><strong>Nutrients</strong></td>
<td></td>
</tr>
<tr>
<td>Total Nitrogen (mg/L)</td>
<td>0.06 – 0.27</td>
</tr>
<tr>
<td>Total Phosphorous as P (mg/L)</td>
<td>0.022 – 0.05</td>
</tr>
<tr>
<td>Chlorophyll-a (µg/L)</td>
<td>5.1 – 12.3</td>
</tr>
<tr>
<td><strong>Hydrocarbons</strong></td>
<td></td>
</tr>
<tr>
<td>Total Petroleum Hydrocarbons (mg/L)</td>
<td>Greater than 0 but less than 2</td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td></td>
</tr>
<tr>
<td>Aluminium (µg/L)</td>
<td>≤ 100</td>
</tr>
<tr>
<td>Cadmium (µg/L)</td>
<td>&lt; 200</td>
</tr>
<tr>
<td>Total Chromium (µg/L)</td>
<td>≤ 100</td>
</tr>
<tr>
<td>Manganese (µg/L)</td>
<td>&lt; 100</td>
</tr>
<tr>
<td>Mercury (µg/L)</td>
<td>≤ 1</td>
</tr>
<tr>
<td>Zinc (µg/L)</td>
<td>&lt; 100</td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td></td>
</tr>
<tr>
<td>Faecal Coliforms (cfu/100 mL)</td>
<td>0 – 42,000,000</td>
</tr>
<tr>
<td>Enterococci (cfu/100 mL)</td>
<td>0 – 980,000</td>
</tr>
</tbody>
</table>

Data Source: Lawson & Treloar, 2003
13.2.5 BIP Water and Wastewater Systems

The BIP is currently connected to the Sydney Water piped supply and sewerage system.

**Water Systems**

The Sydney Water piped supply provides water for process operations across the BIP, for uses such as manufacturing, process cooling and boiler water. This supply is supplemented by groundwater extracted from production wells, and the recycling of process water.

Major water users around the BIP are identified in Table 13.3.

**Table 13.3 Major water users on the BIP**

<table>
<thead>
<tr>
<th>User</th>
<th>Purpose</th>
<th>Source</th>
<th>Usage ML/day</th>
<th>Typical</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orica Chlor-Alkali</td>
<td>Cooling Tower Make Up</td>
<td>Townswater</td>
<td>0.48</td>
<td>0.24-0.84</td>
<td></td>
</tr>
<tr>
<td>Qenos Alkatuff</td>
<td>Cooling Tower Make Up</td>
<td>Townswater</td>
<td>0.48</td>
<td>0.24-0.96</td>
<td></td>
</tr>
<tr>
<td>Qenos Utilities</td>
<td>Cooling Tower Make Up</td>
<td>Extraction bores</td>
<td>1.44</td>
<td>0.96-1.92</td>
<td></td>
</tr>
<tr>
<td>Qenos Utilities</td>
<td>Demineralisation Plant Feed</td>
<td>Townswater</td>
<td>2.4</td>
<td>1.44-3.6</td>
<td></td>
</tr>
<tr>
<td>Qenos Olefines</td>
<td>Cooling Tower Make Up</td>
<td>Townswater</td>
<td>2.4</td>
<td>1.44-3.6</td>
<td></td>
</tr>
<tr>
<td>Qenos E-1000</td>
<td>Cooling Tower Makeup</td>
<td>Townswater</td>
<td>0.48</td>
<td>0.24-0.72</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>7.68</strong></td>
<td><strong>4.56-11.64</strong></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

(i) Maximum usage is based on full manufacturing capacity of the plant.
(ii) Typical usage is based on current manufacturing levels.

**Wastewater Systems**

The trade waste connections to Sydney Water’s sewers provide discharge routes for wastewater generated across the site.

The BIP effluent treatment system is located adjacent to the BIP/SRA boundary at the western end of 8th Avenue. The treatment system consists of sedimentation and pH correction through dosing with carbon dioxide and magnesium hydroxide. Treated trade waste is pumped to the effluent monitoring station and discharge to sewer at 14th Avenue, as shown in Figure 5.11.

The trade waste discharge from the BIP is monitored at 14th Avenue by on-line analysis, with the option to divert the flows to a diversion basin should the results indicate non-compliance with the existing Trade Waste Service Agreement with Sydney Water. The trade waste discharge is analysed on-line and by grab sampling, based on operational standards set in terms of ‘concentration equivalent to the mass standard’ defined in the Trade Waste Service Agreement. Analysis is conducted for pH, Total Oxygen Demand (TOD), BOD, sulphate, ammonia, mercury, CHCs and acid demand. Grab samples are analysed for iron, petroleum hydrocarbons (flammable), petroleum (non-flammable), phenolic compounds, total chlorinated phenolics, total dissolved solids, suspended solids and grease.
The effluent treatment system is owned by Huntsman but operated and managed by Qenos on behalf of the operators of the BIP.

Qenos Olefines has a trade waste connection to Sydney Water sewers separate from the 14th Avenue system.

### 13.3 Construction Water Management

#### 13.3.1 Construction Issues

**Water Use**

During construction, water would be required for uses such as:

- amenities (showers, washing facilities, sanitary facilities) for the construction workforce;
- drilling of wells;
- construction activities, such as local mixing of small amounts of cement; and
- dust suppression of earthworks.

Where construction activities are undertaken on the BIP, water required for construction uses would be available through the existing site connections to the townswater system.

The cleaning of the underground discharge line would require the use of approximately one megalitre of water, as described in Chapter 5.

For all other construction activities to be undertaken away from the BIP, only minor quantities of water would likely be required for construction purposes, and this would be transported to the site in portable containers, as required.

**Wastewater**

Existing sanitary facilities on the BIP would be available for use by construction staff, both for on- and off-site works, because most construction activity is on, or in the vicinity of, the BIP. Such facilities are therefore easily accessible. Some portable amenity blocks would be provided as required for off-site work, and managed by a licensed contractor.

Wastewater generated through cleaning of the underground discharge line is described in Chapter 5.

Wastewater would also be generated during the installation of the groundwater wells on the BIP and the PCA, from drilling slurries and contaminated groundwater during commissioning of the wells and pumps. The drilling slurries would be collected directly by a licensed waste contractor as they were generated, in intermediate bulk containers, and transferred to a secure bunded storage area on the BIP.

At this stage, it is anticipated that the soils would settle out and be combined with the drilling muds stored in the containment structures on Southlands, with the groundwater decanted for treatment.
The contaminated groundwater would similarly be directly collected by a licensed waste contractor in a vacuum truck and transferred to existing bunded storage tanks prior to treatment.

### 13.3.2 Construction Impacts

Due to the limited size and nature of construction activities compared with existing operations at the BIP, no impacts on the existing water supplies or the sanitary wastewater disposal system would be expected. Similarly, through the proposed containment and treatment of the construction wastewaters, no impacts would be expected.

Other potential construction impacts, such as runoff and stormwater management, are assessed in Chapter 14.

### 13.4 Operational Water Management

#### 13.4.1 Water Usage

The GTP has been designed to reuse treated groundwater to meet process requirements for the following process uses:

- process water make-up for the acid absorber, also used for the thermal oxidiser quench, for rapid reduction in the gas temperature;
- process water for preparation of the sodium metabisulphite solution, used in the caustic scrubber for chlorine destruction.

Reuse of treated groundwater would minimise potential additional demand on the existing townswater supply, although a back-up connection to the townswater supply would be installed to maintain the availability of the GTP in the event of a problem with the GTP supply.

Water for staff amenities would be provided through the existing townswater supply.

#### Treated Groundwater

As part of the design of the GTP, following the organics and iron removal treatment stages, the groundwater stream would be split, as follows:

- 10 ML/day would pass to the reverse osmosis (RO) plant for treatment to meet the ANZECC Guideline (2000) for the protection of slightly to moderately disturbed marine ecosystems, the Australian Drinking Water Guidelines, and the BIP process users’ specifications (refer to Table 13.5). This would generate a flow of about 7.5 ML/day of treated groundwater for reuse and about 2.5 ML/day of saline wastewater (equivalent to approximately 25% of the volume treated in the RO plant) for discharge as described below; and
- 5 ML/day excess would bypass the RO unit and combine with the 2.5 ML/day of saline wastewater produced from the RO plant, and would be fed to the organic acid and ammonia removal units. This would produce about 7.5 ML/day of saline wastewater of a quality (as shown in Table 13.5) that
would meet the ANZECC Guideline (2000) trigger values for the protection of slightly to moderately disturbed marine ecosystems. This excess treated groundwater would be discharged to Brotherson Dock.

As additional users for recycled water are found, extra RO capacity would be installed to handle the full 15ML/d capacity. Orica intends to maximise the volume of treated groundwater capable of being reused.

**Treated Groundwater Reuse**

As part of the development of the BGC Project, Orica investigated the potential options to maximise reuse of the treated groundwater, based on:

- proximity of demand;
- available infrastructure; and
- balancing the significant capital and operating cost of treatment and distribution with the sustainability and environmental benefits of reuse.

As a result, Orica has reached agreements with process operators on the BIP for reuse of the treated groundwater, and is currently proposing to initially install sufficient RO capacity and a treated water distribution network for up to 7.5 ML/day. This would replace the existing supply from the Sydney Water townswater system, reducing the current level of demand from the BIP.

The principal users of treated water are identified in **Table 13.4**.

<table>
<thead>
<tr>
<th>User</th>
<th>Purpose</th>
<th>Typical Usage ML/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orica Chlor-Alkali</td>
<td>Cooling Tower Make Up</td>
<td>0.48</td>
</tr>
<tr>
<td>Qenos Alkatuff</td>
<td>Cooling Tower Make Up</td>
<td>0.48</td>
</tr>
<tr>
<td>Qenos Utilities</td>
<td>Demineralisation Plant Feed</td>
<td>2.4</td>
</tr>
<tr>
<td>Qenos Olefines</td>
<td>Cooling Tower Make Up</td>
<td>2.4</td>
</tr>
<tr>
<td>Qenos E1000</td>
<td>Cooling Tower Make Up</td>
<td>0.48</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>6.24</strong></td>
</tr>
</tbody>
</table>

A capacity of about 7.5 ML/day has been installed to cope with peak demand greater than the typical reuse on the BIP shown in **Table 13.4**, as well as use within the GTP itself, for the process requirements detailed above.

The design and layout of the GTP allows for the future expansion of the RO plant, to increase the quantities of treated groundwater that can be reused through the lifetime of the BGC Project. Orica has approval in principle from the NSW Government to recycle the treated water and make it available for sale to other users. Orica would continue to work with relevant authorities and other potential users of the treated groundwater to maximise the level of reuse.
**Excess Reuse Water Discharge**

In the event that the process users on the BIP or other industrial users do not require the treated reuse water, e.g. due to shutdown or process upset, the excess reuse water would be discharged to Brotherson Dock, up to the total flow capacity of the discharge line of 12 ML/day.

In the unlikely event that none of the reuse water was required by the process users on the BIP or by other users, the groundwater extraction rates would be reduced to match the flow capacity of the discharge line, i.e. the maximum 15 ML/day would be reduced to 12 ML/day, to balance the capacity of the discharge line.

Such an event is only likely to be short-term in nature, and the associated reduction in hydraulic containment would be managed to ensure no impacts on hydraulic containment.

**Marine Discharge**

The 2.5 ML/day of RO saline wastewater and the 5 ML/day of treated groundwater bypassing the RO plant would be combined at the GTP and, after removal of organic acids and ammonia, would be discharged through the existing (re-lined) underground discharge pipeline into Bunnerong Canal, which in turn discharges into Brotherson Dock and Botany Bay.

The quality of the discharge would meet the ANZECC Guideline (2000) trigger values for the protection of slightly to moderately disturbed marine ecosystems, as presented in Table 13.5.
## Table 13.5 Treated groundwater discharge quality vs quality parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Re-use Water Quality Specification (mg/L)</th>
<th>Saline Waste Stream Specification (mg/L)</th>
<th>Botany Bay Water Quality, Observed Value (mg/L)</th>
<th>Drinking Water Guideline (mg/L)</th>
<th>ANZECC Marine Guidelines (2000) Trigger value (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.5 - 8.5</td>
<td>6.5 - 9</td>
<td>7 - 8.5</td>
<td>6.5 - 8.5</td>
<td>7 - 8.5</td>
</tr>
<tr>
<td>1,2 Dichloroethane</td>
<td>0.003</td>
<td>0.003</td>
<td>NA</td>
<td>0.003</td>
<td>1.9 (95%)</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>0.003</td>
<td>0.003</td>
<td>NA</td>
<td>0.003</td>
<td>0.24 (95%)</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>0.05</td>
<td>0.05</td>
<td>NA</td>
<td>0.05</td>
<td>NA</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>0.005</td>
<td>0.005</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>0.0003</td>
<td>0.0003</td>
<td>NA</td>
<td>0.0003</td>
<td>NA</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.001</td>
<td>0.001</td>
<td>NA</td>
<td>0.001</td>
<td>0.5 (95%)</td>
</tr>
<tr>
<td>Toulene</td>
<td>0.025</td>
<td>0.025</td>
<td>NA</td>
<td>0.025</td>
<td>0.18 (95%)</td>
</tr>
<tr>
<td>Sodium</td>
<td>20</td>
<td>NA</td>
<td>NA</td>
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<td>Potassium</td>
<td>10</td>
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<td>NA</td>
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<td>Calcium</td>
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<td>7</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Chloride</td>
<td>30</td>
<td>NA</td>
<td>NA</td>
<td>250</td>
<td>NA</td>
</tr>
<tr>
<td>Sulphate</td>
<td>20</td>
<td>NA</td>
<td>NA</td>
<td>250</td>
<td>NA</td>
</tr>
<tr>
<td>Alkalinity as CaCO₃</td>
<td>40</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total Hardness as CaCO₃</td>
<td>60</td>
<td>NA</td>
<td>NA</td>
<td>200</td>
<td>NA</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.0023 (Total)</td>
<td>0.0023 (Total)</td>
<td>NA</td>
<td>0.007</td>
<td>0.0023 (As III), 0.0045 (As V)</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.0002</td>
<td>0.0055</td>
<td>&lt; 0.1 - 0.2</td>
<td>0.002</td>
<td>0.0055</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.001</td>
<td>0.0044</td>
<td>&lt; 0.1 - 0.1</td>
<td>0.05</td>
<td>0.00001-0.0001</td>
</tr>
<tr>
<td>Copper</td>
<td>0.0013</td>
<td>0.0013</td>
<td>NA</td>
<td>1</td>
<td>0.0013 (95%)</td>
</tr>
<tr>
<td>Iron</td>
<td>0.3</td>
<td>0.3</td>
<td>NA</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>
## Parameters of Re-use Water Quality and Water Quality Standards

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Re-use Water Quality Specification (mg/L)</th>
<th>Saline Waste Stream Specification (mg/L)</th>
<th>Botany Bay Water Quality, Observed Value (mg/L)</th>
<th>Drinking Water Guideline (mg/L)</th>
<th>ANZECC Marine Guidelines (2000) Trigger value (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.0044</td>
<td>0.0044</td>
<td>NA</td>
<td>0.01</td>
<td>0.0044 (95%)</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.0004</td>
<td>0.0004</td>
<td>&lt; 0.001 – 0.001</td>
<td>0.001</td>
<td>0.0004 (95%)</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.02</td>
<td>0.07</td>
<td>NA</td>
<td>0.02</td>
<td>0.001 (95%)</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.015</td>
<td>0.015</td>
<td>&lt; 0.1</td>
<td>3</td>
<td>0.015 (95%)</td>
</tr>
<tr>
<td>Ammonia as N</td>
<td>0.5</td>
<td>0.91</td>
<td>NA</td>
<td>0.5</td>
<td>0.91 (95%)</td>
</tr>
<tr>
<td>Total Phosphorous as P</td>
<td>0.1</td>
<td>0.10 (95%)</td>
<td>0.022 - 0.05</td>
<td>NA</td>
<td>0.0325</td>
</tr>
<tr>
<td>BOD</td>
<td>10</td>
<td>10</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>10</td>
<td>15 (95%)</td>
<td>&lt; 1 - 12</td>
<td>NA</td>
<td>0.5 (95%)</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.08</td>
<td>0.08</td>
<td>&lt; 0.1</td>
<td>0.1</td>
<td>0.08 (95%)</td>
</tr>
</tbody>
</table>

### Notes:

(i) Specification for re-use quality
(ii) Specification for saline waste water quality
(iii) Water quality data for Botany Bay from Lawson & Treloar (2003)
(iv) Australian Drinking Water Guidelines (NHMRC/ARMCANZ, 2001). Where both a health and aesthetic guidelines value was provided, the lower value was used.
(v) ANZECC guidelines for analytes are generally for the protection of aquatic ecosystem. The 95% protection level is generally used, because the system is slightly to moderately disturbed. Where chemicals are known to bioaccumulate, the 99% level of protection is applied, and the protection level is parenthesised next to the trigger level.
(vi) NA – data/guideline value not available
(viii) The value given in ANZECC is a trigger value. The value of 15mg/L is chosen to be compatible with the receiving environment, as per (vii).
Water Quality Monitoring

The quality of the treated reuse water and the marine discharge would be optimised by the correct operation of the treatment stages. Failure of any of these treatment stages could result in exceedance of the treated groundwater quality standards (as detailed in Table 13.5). The operation of the groundwater treatment stages would be continuously monitored by the GTP control system to detect any variations in key variables that could have an impact on the final treated water quality.

Monitoring for protection against failure of these systems would include measuring variables such as air and water flows and temperatures in the air stripping system, checking for correct pH adjustment and flows of caustic and flocculant in the iron removal stage, conductivity of the RO product, and other parameters (e.g. reagent flow) in the organic acid and ammonia removal unit. These automatic monitoring systems would be supplemented by regular laboratory analysis of key performance indicators.

In addition, there would be final online pH, CHC content, turbidity and oxygen demand monitoring (with alarm and GTP shutdown in the event of exceedance) of the water, prior to discharge to Brotherson Dock.

In the unlikely event of failure of any of the individual stages, the groundwater treatment system would automatically go into recycle mode, so that the treated groundwater output would be returned to the groundwater feed tank. The groundwater pumping in the containment lines would also be temporarily stopped, so that no further contaminated groundwater would be transferred into the GTP system, until the failure has been identified and corrected. The GTP would be restarted with treated groundwater water (i.e. already meeting the discharge specification), and contaminated groundwater would then be gradually reintroduced to the feed. Performance of the GTP would be monitored, so that any required adjustments could be made to the process until effective groundwater treatment was restored.

13.4.2 Trade and Domestic Waste Discharges

Other than the treated groundwater, the main sources of wastewater generated during the operation of the GTP would be:

- caustic scrubber wastewater, generated from the scrubbing of the remaining acid gases from the off-gas treatment; and

- domestic sewage, produced by the operating staff for the GTP.

The flow of scrubber wastewater would be about 31 kL/day. The wastewater would typically contain sodium chloride, sodium sulphate, caustic soda and sodium metabisulphite, discharged from the scrubber liquor circuit as a continuous purge stream, based on on-line monitoring of the scrubber liquor concentrations.

The scrubber wastewater would be combined with other minor waste streams and monitored for pH, CHCs and flow before discharge to the trade waste sewer. The proposed discharge would be incorporated within the existing Trade Waste Service Agreement for the discharge from the effluent treatment system, in negotiation with Sydney Water.
Domestic sewage from employee facilities (toilets, showers and handbasins) would be connected directly to the existing sewerage system on site, for discharge via a separate sewer connection to the Sydney Water sewer system.

13.4.3 Operation Impacts and Mitigation Measures

Water Use

The GTP would have a positive impact on water use, as the reuse of treated groundwater would reduce demand from the BIP and other industrial users for townswater supply from Sydney Water. In addition, the GTP would largely be self-sufficient in water demand, other than small quantities required for sanitary purposes, thereby minimising additional demand on the capacity of the townswater supply.

Discharge Quality

The GTP has been designed to treat contaminated groundwater to achieve the specified water quality standards detailed in Table 13.5. As a result, the water quality of the treated groundwater for discharge to Brotherson Dock would meet the requirements of the NCUA, which states that “measures implemented under this notice must ensure that any discharge of the substances whether through groundwater or surface water flows into Botany Bay and Penrhyn Estuary achieve protection for slightly to moderately disturbed ecosystems using the Australian and New Zealand Guidelines for Marine and Fresh Water (2000)”.

As part of the monitoring and control system for the GTP, specific parameters related to achieving the required water quality would be monitored, and the discharge prevented and contained within the process in the event of any process failure. Discharge would only resume when the process failure had been rectified, and the monitoring demonstrated that the quality standards were being consistently achieved.

Monitoring of the treated groundwater discharged to Brotherson Dock would be in accordance with the monitoring program proposed and agreed with the EPA (as part of the amendment of the existing Environmental Protection Licence). The monitoring program would be incorporated into the Environmental Management Plan (EMP) to be prepared and implemented for the operation of the GTP. The EMP would detail environmental management procedures, including monitoring of treated water quality, reporting and incident management. Key control measures specified in the EMP would typically include:

- monitoring frequency, parameters and location, for treated groundwater discharge from the GTP;
- monitoring frequency, parameters and location, for the surface waters in the vicinity of the discharge into Brotherson Dock. This monitoring plan could become part of the existing monitoring plan being undertaken by Orica in Penrhyn Estuary and Botany Bay;
- reporting frequency and procedures;
- management, cleanup and reporting procedures in the event of a water pollution incident resulting from the GTP operation; and
- personnel responsible for monitoring and reporting.
**Marine Discharge**

The discharge itself would largely be low salinity water, discharging continuously into the salt water environment of Brotherson Dock. As discussed in Chapter 14, the quantity of this discharge is equivalent to between 0.1% and 1.1% of the 1 in 100 year ARI stormwater flows from the drainage catchment that discharges into Brotherson Dock.

In addition, the volume of the flow compared to the volume of Brotherson Dock (without taking into account mixing within Botany Bay) is insignificant.

Therefore, no impacts associated with the discharge of low salinity water into the dock are considered likely.

**Groundwater Containment**

As shown in Table 13.1, monitoring in Penrhyn Estuary has shown the presence of contaminants from the contaminant plumes in the Project Area, resulting both from water discharge from Floodvale and Springvale Drains (contaminated groundwater currently discharges into the drains), and from groundwater discharge.

Because contaminants located down-gradient of the secondary containment line at Foreshore Road would not be captured, these discharges to the intertidal zone would be expected to continue for a period of time after the start of the hydraulic containment pumping. However, once these have discharged, no further discharges of contaminants into the estuary would be expected, because there would be no further movement past the secondary containment line and no further discharges from the drains (as described in Chapter 12).

Therefore, the existing water quality of Penrhyn Estuary would be expected to improve.

**Operational Management**

The GTP design incorporates bunded tanks for the chemicals used within the process (caustic soda, hydrochloric acid, flocculant, sodium hypochlorite and sodium metabisulphite) and a contaminated groundwater feed tank to contain any leaks or spills and to prevent discharge off-site.

Water collected within the bunds, e.g. from rainwater, would be assessed by site staff to determine the appropriate treatment and disposal option. Contaminated water would be transferred into the GTP for treatment with groundwater, or would undergo further treatment before discharge to the existing BIP trade waste discharge. Clean water would be discharged through the site stormwater management system (as described in Chapter 14).

The design of the transfer pipelines (from the three containment lines) has taken into consideration the need to minimise the risk of leaks. The relevant measures are described in Chapter 5.

**Waste Discharge to the BIP Trade Waste Discharge**

The caustic scrubber waste stream water would be discharged from the scrubber liquor circuit as a continuous purge stream, based on on-line monitoring of the scrubber liquor concentrations. To ensure the quality of these discharges and compliance with the Trade Waste Agreement for the BIP effluent
discharge, monitoring of the discharges would be conducted as follows (according to the testing methods set out by Sydney Water, as appropriate):

- pH, chlorinated hydrocarbons and flowrate for the GTP effluent system;
- continuation of the existing on-line analysis at the BIP trade waste discharge of combined site trade wastewater for BOD, sulphate, ammonia, mercury, CHCs, acid demand, pH and turbidity;
- continued collection of grab composite samples, as per the Sydney Water agreement for suspended solids and grease; and
- additional monthly samples would be taken from the GTP wastewaters and analysed for total CHCs and heavy metals, as well as principal inorganic salts, as an aid to general plant operations. These samples would be taken more frequently at plant start-up, in order to confirm design performance and compliance, and would then reduce as results showed stability of performance.

The BIP trade waste discharge system incorporates the option to divert effluent to the diversion basin if any quality problems should occur, to contain the discharge for further assessment and treatment as necessary.

### 13.5 Summary of Mitigation Measures

Mitigation measures to minimise potential impacts on water quality from the construction and operation of the BGC Project are summarised in Table 13.6.

<table>
<thead>
<tr>
<th>Table 13.6 Summary of mitigation measures to maintain water quality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safeguard</strong></td>
</tr>
<tr>
<td>Technology selection and process design to achieve required standards for treated groundwater, to enable reuse and safe discharge to Botany Bay</td>
</tr>
<tr>
<td>Maximised reuse of treated groundwater, at design stage and ongoing through project timescale, to reduce demand for townswater and make efficient use of groundwater</td>
</tr>
<tr>
<td>Use of existing sanitary facilities on site, for discharge to established sewer system</td>
</tr>
<tr>
<td>Implementation of PLC monitoring of treatment process stages, with recycle in the event of process failure, to prevent exceedance of treated groundwater quality standards</td>
</tr>
<tr>
<td>Undertake monitoring of treated groundwater discharge to prevent exceedance of treated groundwater quality standards</td>
</tr>
</tbody>
</table>
### 13.6 Conclusion

The Groundwater Treatment Plant has been designed to achieve the specified water quality standards to enable reuse of the treated water on both the BIP and by other users, and to ensure that there is no impact from the discharges of excess water to Brotherson Dock.

Wastewaters generated would be suitable for discharge to the existing BIP trade waste discharge system, in compliance with the existing Trade Waste Service Agreement with Sydney Water. The existing comprehensive monitoring program would continue, to ensure that the BIP effluent meets the criteria at all times. If any problems should occur, the flows can be directed back through the GTP or to an existing diversion basin for further treatment and analysis.

It is therefore concluded that, as a result of implementing the GTP operations to achieve the specific water quality standards, the treated groundwater would be suitable for reuse (thereby reducing existing levels of demand on the Sydney Water townswater system) and for discharge of the excess and saline waste stream to Brotherson Dock. In addition, the quality of the wastewaters generated would be such that these could be discharged to the existing trade waste connection with minimum impact on the existing Sydney Water sewer systems.
14.1 Introduction

This chapter addresses the potential surface hydrology and flooding issues related to the BGC Project. The project has the potential to affect surface water quality and the flooding regime at several locations:

- the site of the GTP;
- the site of the other elements of the overall BGC Project, such as the extraction wells and transfer pipelines;
- the point of discharge of treated groundwater into Bunnerong Canal, approximately 1.5 km to the south of the GTP site, and approximately 450 m upstream of Brotherson Dock; and
- indirectly, within Springvale Drain and Floodvale Drain, in the vicinity of the BIP and Southlands.

The BGC Project also involves construction activities on the BIP, on Southlands, and along the route of the discharge line that have the potential to affect the quality of runoff from these areas to existing stormwater systems.

These issues are assessed in the following section, which includes a summary of the detailed hydraulic assessment of the potential for flooding at the discharge to Bunnerong Canal, as presented in Appendix E.

14.2 Existing Environment

14.2.1 Project Area

The majority of the Project Area (excluding the lower section of the discharge pipeline) is located within the catchments of Springvale Drain and Floodvale Drain.

The lower section of the discharge pipeline is considered to be located within the Bunnerong Canal stormwater catchment.

The catchment area of the two drains, as shown in Figure 14.1, is approximately 319 hectares, comprising a mix of industrial, residential and open space (Sinclair Knight, 1992). Springvale and Floodvale Drains were excavated in the mid 19th century to assist in the drainage of Veterans Swamp and surrounding areas.

The northern part of the catchments contains mainly residential land use, with some large open space areas such as Jellicoe Park, Mutch Park and part of the Bonnie Doon Golf Course. The southern part of the catchments contain mainly industrial land use, including the BIP, as well as substantial open areas at Botany Golf Course and Southlands. Southlands is low-lying swampy land that acts as flood storage areas for overflows from the drains.
The total length of Floodvale Drain is around 2.9 km, with a mix of open and closed conduit (open sections on Southlands and upper reaches, closed conduit elsewhere) discharging directly into Penrhyn Estuary just beyond Foreshore Road. Springvale Drain is around 3.9 km long, and is a largely open channel with closed conduit in the lower reaches, discharging into the eastern end of Penrhyn Estuary. The drains flow in a generally north to south direction.

**Flooding**

Limited historical data indicates that the largest rainfall runoff event in recent years in the Springvale Drain catchment occurred in February 1992 (Sinclair Knight, 1992), and resulted in some flooding from overflow of the open channel reaches of both Floodvale and Springvale Drains, affecting areas between the two. Some flooding was reported as a result of this event, particularly in Southlands, which acts as a flood storage area.

A detailed catchment flood study was undertaken of the Springvale Drain and Floodvale Drain systems (Sinclair Knight, 1992), with the following results:

- Some flooding is expected in the northern area of the BIP, between Anderson Street and the Sydenham–Botany goods railway line, for rain events greater than the 1 in 5 year Average Recurrence Interval (ARI).

- The depth of inundation at the Mobil Terminal (to the west of the BIP) ranges from approximately 0.8 m in the 1 in 5 year ARI event, to 1.0 m in the 1 in 100 year ARI event.

- Neither 1st Street on the BIP nor the Sydenham–Botany goods railway line embankment would overtop in the 1 in 100 year ARI event (at approximately RL 7.0 m and RL 6.5 m AHD, respectively).

- The culverts beneath Sydenham–Botany goods railway line provide some control on flows into the downstream area, at the expense of resultant upstream flooding (restricted between 1st Street and the goods railway line embankment).

Hydraulic computer modelling of the Springvale Drain, undertaken for the HCB EIS (URS, 2003), produced flood levels resulting from the 1 in 5, 20 and 100 year ARI events. Modelled flood levels at a point adjacent to the Springvale Drain, approximately 500 m north-west of the proposed GTP site, are summarised in Table 14.1 below.

<table>
<thead>
<tr>
<th></th>
<th>1 in 5 year ARI Event</th>
<th>1 in 20 year ARI Event</th>
<th>1 in 100 year ARI Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL 6.55 m AHD</td>
<td>RL 6.70 m AHD</td>
<td>RL 6.79 m AHD</td>
<td></td>
</tr>
</tbody>
</table>

**Surface Water**

The GTP site is currently largely paved with asphalt, with an unpaved area along the southern end of the site and some grassy areas on the western side. Runoff from the site is primarily stormwater from the paved areas, which discharges into the existing BIP stormwater drainage system. Potential contaminants present in the stormwater runoff would consist primarily of inert suspended solids.
The existing stormwater drainage system for the southern part of the BIP initially discharges to two interceptor pits, from where it is pumped (during dry weather conditions) to the effluent treatment system located just to the south-west of the GTP site. During periods of heavy rain and after the first flush has been captured, the transfer pumps in the interceptor pits are manually switched off, and the stormwater overflows to Springvale Drain, which in turn discharges into Penrhyn Estuary and Botany Bay.

Stormwater from Southlands drains into the two drains for discharge into Penrhyn Estuary and Botany Bay.

### 14.2.2 Bunnerong Canal

The Bunnerong Canal was originally built to service the Bunnerong Power Station, built at Bumborah Point in the 1920s and demolished in the 1980s. The canal remains to drain stormwater via Bunnerong Creek from a small catchment that contains portions of the suburbs of Matraville, Malabar Junction and Chifley within the Randwick City Council LGA. The estimated catchment area that drains to Bunnerong Canal is 386 hectares for major flood flows, and 291 hectares for minor flood flows. The catchment area for minor flood flows is smaller than that for major flows, because the urban stormwater system has a design capacity of 1 in 5 year ARI, which is expected to divert flows up to the 1 in 5 year ARI event away from Bunnerong Canal.

The canal discharges into Botany Bay via Brotherson Dock, which is part of the Port Botany complex. Sydney Ports Corporation currently uses the mouth of the canal as a mooring point for its emergency vessels.

The canal is concrete-lined with a variable width, approximately rectangular with 3.5 m high sides that are near vertical. The canal slope is 0.1%. The canal width decreases downstream, from 26 m wide immediately downstream of Bumborah Point Road to 16 m wide at the outlet to Brotherson Dock.

The canal is tidal in its lower reach, with the tidal influence extending to approximately halfway along the Bunnerong Canal (pers. comm., Sydney Ports, 2004). A site visit by URS engineers also determined that the canal may be subject to siltation, which may affect the capacity in the lower reaches of the canal.

**Flooding**

There is no record of historical flood flows in Bunnerong Canal, and there has not been a systematic flood investigation of the Bunnerong Creek/Bunnerong Canal system (pers. comm., Sydney Water, 2004).

**Surface Water**

The canal catchment comprises a mixture of residential, commercial and industrial areas. Runoff would consist of typical urban stormwater from hard surfaced areas (roads, parking areas and paved surfaces), potentially contaminated with suspended solids, larger solids (rubbish), and oils and greases.

Stormwater runoff discharges directly into Brotherson Dock and hence Botany Bay.
14.3 Hydrology Assessment

14.3.1 GTP Site

The site for the GTP is currently largely paved with asphalt, and is connected to the BIP site stormwater drainage system. The development would therefore not increase the impermeable surface area of the BIP, and the volume of stormwater discharge to the existing drainage system would be very similar to the current volumes.

Based on surveyed level data at the GTP site, the current ground surface level at the site is approximately RL 7.2 m AHD (Douglas Partners, 2004). The ground surface in this area is therefore approximately 0.5 m above the 1 in 100 year ARI flood level for the area. The following can therefore be concluded:

- Flood waters from Springvale Drain, up to the 1 in 100 year ARI event, would have minimal impact on the GTP site.
- The GTP would have negligible effect on current flood levels along Springvale Drain, both upstream and downstream of the site, up to the 1 in 100 year ARI event.
- The GTP would have negligible effect on the existing BIP site stormwater drainage system.

14.3.2 Bunnerong Canal

The operation of the GTP would result in a regular continuous discharge of 7.5 ML/day of treated groundwater, up to a maximum of 12 ML/day (the total capacity of the discharge line) when process users on the BIP and other nearby users were not reusing the treated groundwater. Hydraulic assessment was therefore undertaken using the maximum potential discharge of 12 ML/day, equivalent to 0.14 m$^3$/s.

This additional discharge to Bunnerong Canal has the potential to affect the flood regime, i.e. flood heights and flood velocities, within the canal. An assessment was undertaken to determine whether the proposed additional discharge would affect:

- the ability of the canal to convey stormwater flow;
- the flooding regime of the canal; and
- the likelihood of adding to the sediment transport potential of the canal flow during design flood flows and under dry weather conditions.

The assessment methodology and results of the hydraulic assessment are presented in Appendix E. The assessment reached the following conclusions:

- It was found that the proposed additional inflow from the GTP discharge would result in a less than 0.01 m change in modelled flood levels in Bunnerong Canal and less than 0.01 m/s change in modelled average main channel velocities.
• The modelled increase in flood level in Bunnerong Canal did not lead to overtopping of the canal during standard design ARI flood events.

• The modelled increase in main channel velocity is less than 0.01 m/s, and therefore should not lead to an increased sediment transport potential within Bunnerong Canal during flooding.

• The proposed additional inflow should not increase the sediment transport potential within Bunnerong Canal.

• During dry weather conditions, there would be no significant change to sediment movement in the canal (with an estimated change of only 1.3%).

• As there is no predicted increase in sediment transport potential, the likelihood of mobilisation of any potential contaminants within the sediments is considered negligible.

• It is unlikely that the discharge would affect the Sydney Port emergency vessel moored in the mouth of the canal, because the discharge from the GTP would be minor compared to existing flows, and there is no predicted increase in sediment transport.

• The impact of the proposed inflow on tidal patterns in Brotherson Dock would be negligible, because the overall volume of the receiving water is significantly greater than the inflow.

• The impact on tidal flushing on the interaction of saline tidal water and fresh water discharge is also considered insignificant.

14.3.3 Other Areas

Some of the other areas of the project could be affected by flooding during major storm events; however, given the nature of the activities, no significant impact is expected.

• Transfer pipelines: The aboveground pipelines are installed on low-level pipe racks, and would therefore generally be raised above potential flooding. No impacts would be anticipated for the underground pipelines.

• None of the construction and installation works would affect the existing drainage systems, and there would therefore be no change to the existing flooding regime or drainage.

The extraction wells are designed to only extract water from specific underground levels and would not be affected by surface flooding.
14.4 Surface Water Management

14.4.1 GTP Construction Phase

Construction Phase Impacts

The proposed activities to be undertaken during construction of the GTP, and those extraction wells and pipelines yet to be constructed, are presented in Chapter 5. Such activities have the potential to cause contamination of surface water runoff through various routes, such as:

- oil and grease leaking from construction equipment;
- fuel and oil spills from temporary storage facilities;
- exposed surfaces of soil and fill stockpiles;
- uncontrolled discharge of groundwater during dewatering; and
- dust from the temporary unsealed construction areas and stockpiles.

The potentially contaminated runoff could then discharge into the existing stormwater systems on the BIP or Southlands, or the urban system along the discharge pipeline, and ultimately into Penrhyn Estuary and/or Botany Bay during rainfall periods.

Therefore, control measures would need to be implemented to avoid any surface water impacts.

Construction Phase Mitigation Measures

As described in Chapter 11, the soil and water management plan (SWMP) developed as part of the Environmental Management Plan (EMP) for the construction phase of the project would be based on relevant best practice guidelines such as Landcom’s Managing Urban Stormwater – Soils and Construction (2004).

The objective of the SWMP would be to minimise the potential for sediment and contaminated runoff leaving the construction areas and discharging into the off-site stormwater drainage systems, and hence to Penrhyn Estuary and/or Botany Bay.

A number of basic runoff control principles would be implemented during construction:

- the area of exposed ground surfaces and construction activities would be minimised;
- surfaces would not be left exposed for extended periods and would be resealed as soon as possible;
- erosion and sedimentation control structures would be used to prevent sediment leaving the construction sites. This would, if appropriate, include bunding stockpiles and collection of leachate (e.g. from stockpiles or groundwater collected as a result of dewatering activities) for appropriate treatment and disposal;
sediment and erosion control measures would be installed as a first step, i.e. prior to construction, such as placing silt fencing around stockpiles such that sediment:

- does not spill on the road or pavement;
- is not placed in drainage lines, depressions or watercourses; and
- cannot be washed onto roadways, drainage lines, depressions or watercourses;

sediment and erosion control measures would be maintained in an effective condition until the works had been completed;

where possible, surface water runoff would be diverted from areas upstream around the site to minimise the volume of water entering construction areas;

accidental spills of soil or other materials on the roadway or in gutters would be cleaned up immediately;

groundwater encountered during extraction well installation activities would be directly contained on site as and when generated, and stored in contained areas on the BIP prior to suitable treatment and disposal using licensed waste contractors (as described in Chapter 13);

where excavated soils are to be reused, the excavated layers would be replaced in the same order to ensure that the original top layer is reused as such, to minimise the potential for stormwater contamination;

on-site vehicle movements would be restricted by having a dedicated construction phase car park area;

on-site vehicle activity would be minimised during wet weather or when the site is muddy;

any fuel storage areas would be bunded such that the bunded area will collect minimum 110% of storage capacity; and

all construction activities would cease in the event of flooding.

The discharge of any surface water runoff during construction would be covered by the revised Environment Protection Licence (EPL) for the Orica operations, and therefore the water quality of any runoff would have to be in accordance with the Protection of the Environment Operations Regulations 1998 (POEO Regs).

The SWMP would also identify possible wet weather monitoring requirements and mechanisms to identify and address the cause of any sediment dispersion and runoff incidents.

Given the proposed mitigation measures to be specifically designed to prevent surface water impacts, as implemented through the project-wide SWMP, the impacts on the existing environment would be negligible.
14.4.2 GTP Operation Phase

Operation Phase Impacts

The construction of the GTP would result in the total area of the site being impervious and comprising:

- concrete slab base for the process equipment;
- roofed areas of the GTP, including the control room, reverse osmosis plant and isotainer parking area;
- paved areas for vehicle access to the site; and
- bunded chemical and groundwater feed storage areas.

Contaminants deposited onto these impervious surfaces could be washed off and entrained by stormwater runoff and hence discharged to the site drainage system, except for runoff in bunded areas, which would be contained within the bunds.

Typically, the stormwater that initially runs off an area contains higher contaminant loads and concentrations than stormwater runoff from later in the rainfall event, as the contaminants are washed off within this ‘first flush’ of stormwater. Stormwater runoff from the GTP would originate from the roofs and paved process areas of the plant, so the primary potential stormwater contamination issues would be stormwater runoff contaminated with potential chemical leaks and suspended solids from roadways and working areas outside the roofed areas.

In addition, a number of unlikely events have the potential for the off-site discharge of a number of pollutants. These events include:

- contaminated groundwater spills;
- chemical spills; and
- firewater runoff.

The objectives for managing the above events are to minimise runoff water discharges off-site to:

- ensure that discharges of stormwater from the site are not contaminated; and
- ensure accidental chemical spills are contained on the site.

Operation Phase Mitigation Measures

A Stormwater Management Scheme (SMS) would be prepared for the project, as part of the overall EMP, detailing the specific mitigation measures and procedures to alleviate potential impacts of stormwater from and within the site. This SMS would be consistent with other management approaches for other areas of the BIP.
The SMS would include the following measures for stormwater management at the GTP:

**Stormwater Management**

There are two potential types of stormwater runoff generated at the site:

- clean (free of inert solids/sediment and contaminants); and
- potentially contaminated.

The GTP layout has been developed so that areas generating clean stormwater would drain separately from areas generating potentially contaminated water runoff, as shown in the flow diagram of the stormwater system in Figure 14.2.

Clean stormwater runoff would be expected from the roofed areas of the site, such as the control building, the reverse osmosis units, the air strippers and the isotainer parking area. The clean stormwater from these roofed areas would be collected in roof guttering and connected directly to underground drains directing flow into the existing BIP stormwater system, as shown in Figure 14.2.

Potentially contaminated stormwater could come from the following sources:

- chemical and groundwater feed storage areas;
- non-roofed process areas; and
- site access roadways.

The chemical and groundwater feed storage areas would be externally bunded, with graded sealed surfaces so that any runoff or liquid spills are directed to installed collection sumps. Due to the laboratory turnaround required for CHC analysis, it would not be practical to assess the sump contents and conduct disposal accordingly. Therefore, the precautionary principle would be adopted, and all sump contents would be treated before disposal.

For the non-roofed process areas and site access roadways, a first-flush stormwater pit would be constructed for the GTP site, to be used to capture the ‘first flush’ of water runoff from the entire area generated from a specific design storm event. The first-flush pit would be concreted and lined with an impermeable surface to prevent any infiltration into the groundwater. The volume of the first-flush pit would be sufficient to contain the first 15 mm of rain over the relevant hard surfaced areas of the site.

A typical first-flush system is depicted in Figure 14.3 and this would be designed in accordance with the guidelines in the Environment Protection Manual for Authorised Officers (EPA, 1995). Because high levels of sedimentation within the first-flush pit would reduce its capacity, it would be routinely checked for solids content, and cleaned out by contractors if the storage capacity were reduced by more than 10%.

A pump would be installed in the pit to pump out water as required. As with the bund sumps, the precautionary principle would be adopted and the contents of the first-flush tank treated before disposal.
Chapter 14

Surface Water & Hydrology

Chemical Spills

A number of mitigation measures are proposed to minimise the impact of accidental leaks and spills. These measures would minimise the risk of accidental spills and leaks discharging to the site stormwater system and hence to Springvale Drain. These mitigation measures include:

- bunding of chemical and groundwater feed storage areas (including the recovered waste EDC liquid isotainer parking area);
- drainage of all bunded areas into collection sumps for discharge or treatment;
- the capacity of all bunds (existing and proposed) would comply with relevant Dangerous Goods regulations and EPA requirements, and would be adequate to contain spills and leaks;
- handling, storage and transporting of all Dangerous Goods would be in accordance with prescribed regulations; and
- any spilled or leaked material would be immediately cleaned up and disposed of in the GTP or appropriately disposed of off-site, by a licensed contractor under EPA approval.

Firewater Management

The risk of fire is considered low (as discussed in Chapter 23). However, in the event of a fire, there is the potential for firewater to be contaminated by the contaminants in the groundwater or other chemicals at the plant.

The following mitigation measures would be put in place to avoid contaminated firewater reaching Springvale Drain:

- chemical storage and handling areas would be bunded and drained to collection sumps;
- the first-flush pit could be used as a secondary containment system, if required; and
- the BIP site stormwater collection pits could be used as a secondary containment system, if required.

The collected water would be managed in the same way as contaminated stormwater, and discharged to the BIP effluent treatment system for treatment. Firewater potentially contaminated with CHCs would be transferred to the GTP feedwater tanks.

Other Operational Phase Impacts

No stormwater impacts have been identified from operation of the groundwater wells and transfer pipelines, other than the potential for leaks and discharge into surface water drains. No potential impacts are considered likely from the operation of the discharge pipeline to Bunnerong Canal, because the treated groundwater quality would be equal to or better than the ANZECC 2000 marine guidelines.

The principal mitigation measures for minimising potential leaks from groundwater extraction and transfer are based on equipment design and monitoring, as detailed in Chapter 5. These measures are summarised as:

- compliance with applicable design standards;
• dual-contained piping for underground pipelines (containing contaminated groundwater); and

• use of leak detection systems and inspection.

14.5 Summary of Mitigation Measures

Mitigation measures to minimise potential impact to surface water from the construction and operation of the proposed GTP project are summarised in Table 14.2.

<table>
<thead>
<tr>
<th>Safeguards</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
</tr>
<tr>
<td>Preparation of a Soil &amp; Water Management Plan, to provide the overall construction management approach for preventing off-site discharges of stormwater</td>
<td>✓</td>
</tr>
<tr>
<td>Implementation of erosion controls, as described in Chapter 11, through construction to avoid sediment runoff so no material is discharged off-site</td>
<td>✓</td>
</tr>
<tr>
<td>Immediate cleaning up accidental spills of soil or other materials on the roadway or in gutters</td>
<td>✓</td>
</tr>
<tr>
<td>Bunding of any chemical storage areas such that the bunded area will collect minimum 110% of storage capacity</td>
<td>✓</td>
</tr>
<tr>
<td>Cessation of affected construction activities in the event of flooding</td>
<td></td>
</tr>
<tr>
<td>Preparation of a Stormwater Management Plan to provide the overall operation management approach for preventing off-site discharges of stormwater</td>
<td></td>
</tr>
<tr>
<td>Provision of containment for potentially contaminated stormwater through storage area bunds and first-flush tank to prevent discharge off-site</td>
<td>✓</td>
</tr>
<tr>
<td>Adoption of the precautionary principle for water collected in bunds and first-flush tank, through discharge/disposal via groundwater treatment plant</td>
<td></td>
</tr>
<tr>
<td>All bunds and first-flush pit to be designed and maintained in accordance with relevant Dangerous Goods and EPA guidelines</td>
<td>✓</td>
</tr>
</tbody>
</table>
### Table: Safeguards and Implementation

<table>
<thead>
<tr>
<th>Safeguards</th>
<th>Design</th>
<th>Pre-construction</th>
<th>Construction</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spilled or leaked material to be immediately cleaned up and disposed of in the GTP or appropriately disposed of off-site, by a licensed contractor under EPA approval</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>In the event of a fire, management of firewater to prevent any discharge of contaminated firewater to Springvale Drain</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Design of extraction wells and transfer pipelines according to design guidelines, and regularly inspection to ensure leaks are detected and addressed</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Underground pipelines to be dual-contained and fitted with leak detection systems</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

### 14.6 Conclusion

Based on the results of the flood catchment study of the Springvale Drain system (Sinclair Knight, 1992), the existing ground surface levels at the site and the design of the GTP stormwater system, it can be concluded that:

- flood waters from Springvale Drain, up to the 1 in 100 year ARI event, would have minimal impact on the proposed GTP;
- the proposed GTP would have negligible effect on current flood levels along Springvale Drain, both upstream and downstream of the site, up to the 1 in 100 year ARI event; and
- the proposed GTP would have negligible effect on the existing BIP stormwater drainage system.

For discharge into Bunnerong Canal, the modelling for the project showed changes in modelled flood heights of less than 0.01 m, and did not result in overtopping of the canal. In addition, modelled main channel velocities were found to not change by more than 0.01 m/s. Results suggest that the project should not increase the potential for sediment transport during flooding. The sediment transport potential during dry weather flows was found to be less than the estimated erosion threshold for fine sand.

For both the construction and operational phases of the project, the primary surface water management objectives are to:

- ensure that discharges of stormwater from the site are not contaminated; and
- ensure that accidental chemical spills are contained on the site.

The SWMP would be specifically developed for the construction and operational phases, to minimise contaminated runoff from the site and potential discharge to existing stormwater systems and hence to Penrhyn Estuary.
Potentially contaminated stormwater from the site would be contained within either the containment bunds of the storage area or the first-flush pit system, to prevent discharge during stormwater events. The contained stormwater would be managed on the precautionary principle, and treated before discharge.

Implementation of the proposed mitigation measures would minimise the risk of potentially contaminated water reaching Springvale Drain and having a negative impact on water quality. During dry weather, no uncontrolled discharge would occur from the site. Controlled discharge would only occur following long duration rainfall events, when the first-flush pit reached capacity, and the stormwater would be discharged with the other stormwater flows from the BIP.

The construction of the GTP would not significantly increase the runoff characteristics of the site, and therefore there would be negligible increases in peak discharges and volumes into Springvale Drain downstream.

In addition, the design basis and regular inspection of the extraction and transfer elements of the GTP would ensure no uncontrolled discharge of contaminated groundwater to the environment.

As a result, negligible impacts would be expected on the surface water quality of the stormwater drainage systems in the vicinity of the BGC Project.
GTP Stormwater Flow Diagram

CLEAN STORMWATER

Existing BIP Stormwater System

Springvale Drain

Clean Water Only
(>15mm Rainwater)

STORMWATER

First Flush System

Filter

Holdig Tank and Treatment

GTP Feed Tank or Trade Waste

STORMWATER

Sump
A grating should be provided to retain loose solids.

Minimum distance approximate 1.0m to prevent turbulence washing sediments from pit.

First 15mm of collected stormwater filtered and returned to GTP feed tank.

Stormwater flow to bypass channel to BIP stormwater system.

STORMWATER INLET

OVERFLOW LEVEL

Area of cross section to equal mouth of inlet drain.

STORMWATER SETTLEMENT POND

Design markers indicate where the water has to be pumped down to, to meet the design storage criteria.
15.1 Introduction

This chapter outlines the characteristics of the wastes that may be generated during the site construction works and operation associated with the BGC Project, and describes how the waste would be managed in accordance with the relevant NSW regulations and guidelines.

This chapter deals predominantly with solid waste management. Wastewater management is detailed in Chapter 13.

The NSW Waste Avoidance and Resource Recovery (WARR) Act 2001 sets out a hierarchy of waste and resource management priorities for NSW. In order of importance, these priorities are:

- avoidance of unnecessary resource consumption;
- resource recovery (including reuse, reprocessing, recycling and energy recovery); and
- waste disposal.

The WARR Act also assists in the management of the environmental impacts arising from the generation of waste, which are regulated in accordance with the Protection of the Environment and Operations Act 1997 (POEO Act).


15.2 Existing Environment

Waste generated from Orica’s existing operations are typically recycled or sent to landfill or appropriate treatment and disposal in accordance with Orica’s Safety, Health and Environment (SHE) site procedures titled BP-EP –004 Waste Management and BP-EP-013 Treatment and Disposal. The procedures have a number of requirements, including:

- the maintenance of waste inventories;
- disposal of wastes in accordance with regulatory requirements;
- transportation of wastes;
- storage and handling of wastes; and
- waste documentation.

Several companies are currently involved in the management of waste at the BIP, and are likely to be involved in the management of the wastes generated from the construction and operation associated with the BGC Project.
15.3 Waste Generation

15.3.1 Construction

GTP Site

Activities during the construction of the GTP that would result in the generation of waste include:

- Demolition of the old Silicates Plant: Small amounts of existing concrete footings may have to be removed if they cannot be crushed and reused. It is not expected that in situ soil materials would be removed from the site;
- Construction works: Site works such as construction of foundations, hardstands and drainage would generate small amounts of building waste; and
- Equipment installation: The GTP process equipment would be primarily pre-fabricated off-site, and therefore waste would be generated from packaging and installation practices.

Waste materials expected to be generated during demolition, site preparation and construction of the GTP would include:

- scrap packaging materials including timber, metal and materials such as plastics and cardboard;
- small amounts of building materials such as rubble (concrete) and timber from formwork; and
- general waste generated by the construction workforce.

Extraction Well Installation

Activities and wastes generated during the installation of wells in the primary containment area and the DNAPL containment line include:

- muds and slurries generated from the drilling of the wells;
- amounts of building wastes (concrete and steel parts) generated in the capping and completion of the wells, plus scrap packaging materials; and
- contaminated groundwater generated in the commissioning of the extraction wells.

Pipeline Construction

Activities and wastes generated during the construction of the DNAPL transfer pipeline and the treated groundwater distribution network on the BIP include:

- site works such as construction of foundations and hardstands, generating small quantities of building waste; and
- scrap and packaging wastes generated from the installation of pipelines and connections.
Discharge Pipeline Refurbishment

Activities and wastes generated during the refurbishment of the discharge pipeline include:

- caustic soda currently within the pipeline, flushed through with water and stored in an existing storage tank on the BIP;
- potential waste and/or contaminated soils generated during the excavation of the elbows of the pipeline, which cannot be reused;
- elbows of the existing pipeline removed and replaced with fibreglass, resulting in pieces of scrap metal, plus general waste generated during the sleeving and sealing activities; and
- waste concrete and other construction wastes generated during the installation of the diffuser. No sediment from the base of the canal would be removed.

15.3.2 Operation

The principal solid waste materials generated from operation of the GTP would be the dewatered solid waste and spent activated carbon. Other minor wastes would include scrap metal and oils and greases from maintenance activities, filter cartridges used in the pumps to remove fines from the groundwater, and general wastes from operators working on site.

The only major solid wastes, the dewatered solid waste and spent activated carbon, are described below.

Dewatered Solid Waste

Following air stripping of the VOCs in the groundwater, the next stage of the stripped groundwater treatment process is the precipitation and removal of the iron content. This would be undertaken by precipitation of the iron hydroxide, and removal through a lamella filter to produce an iron hydroxide slurry of 2% solids, containing about 620 kg/day of iron hydroxide.

The organic acid removal stage would use a biological process, which would produce a sludge containing about 430 kg/day of solids at about 1% solids concentration.

These streams would be combined and then passed through a centrifuge dewatering process to increase the solids concentration up to about 18%, to reduce the mass required to go to landfill. The centrate water would be recycled back into the process. The dewatered solid waste which would be a spadeable, soil like consistency would be collected in a covered collection skip.

The estimated annual quantities of dewatered solid waste produced would be about 1900 tonnes, at 18% solids content. This would be disposed of to landfill, in accordance with DEC waste guidelines (DEC, 2004).

Activated Carbon

The activated carbon filter system would be used to remove non-volatile organic compounds from the stripped groundwater. The activated carbon beds would be installed in series to ensure no ‘breakthrough’.
CHAPTER 15 Waste Management

The configuration of the beds would be interchangeable to allow for one unit to be out of service for maintenance/carbon replacement.

Once the operating life of the first carbon bed has been reached, the carbon would be removed for disposal, and replaced by fresh activated carbon.

It is anticipated that the process would generate up to 72 tonnes of spent waste activated carbon per year, requiring regular replacement of the same amount.

Zeolite Waste

If the ammonia polishing technology chosen is the zeolite option (refer to discussion in Chapter 5), this zeolite would need to be replaced periodically, every 18 month to two years. This would equate to about 30 tonnes a year of spent zeolite for disposal. It is proposed that the manufacturer would accept this spent Zeolite for re-manufacture into other products. However, if this could not happen, then the spent material would be sent to landfill, in accordance with DEC guidelines.

15.4 Methods Of Waste Management and Disposal

A comprehensive Waste Management Plan (WMP) would be developed for the BGC Project, to be incorporated in the overall Environmental Management Plan (EMP). The WMP would set out methods for managing waste in accordance with the principles of the WARR Act, 2001, including:

- Waste Avoidance: Avoid generating the waste in the first instance;
- Reuse: Reusing waste within the project or elsewhere within Orica on the BIP, or supplying it to other industrial users in Botany area;
- Recycle: Recovery of waste for recycling off-site, in the same or different form; and
- Disposal, as the final stage following the above waste minimisation and reuse actions.

The WMP would set out measures to minimise the generation of waste and promote the reuse, recycling and reprocessing of both construction and operation waste. The WMP would outline the employees’ and contractors’ requirements for waste disposal, including keeping waste separated for ease of reuse and recycling. All personnel would be advised of the waste management and disposal procedures prior to commencing any work. The achievement of these performance measures would then be reviewed at project site meetings.

Waste generated during the construction or operation of the project that requires disposal to landfill would be classified in accordance with EPA’s Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes (DEC, 2004). These waste streams would be removed from the site by a licensed contractor and disposed of to landfill.

All personnel would be advised of these waste management and disposal procedures prior to starting work. Contractors carrying out site construction works would record the types, quantities and destinations of all waste material taken off site during proposed activities.
15.4.1 Construction Waste

**General Construction Waste**

Management measures and options for minimising construction wastes would include:

**Waste Avoidance**
- Sourcing of materials in the correct quantities and size;
- Ordering pre-cut/pre-fabricated material;
- Materials to be fabricated off-site to reduce waste generation;
- Materials to be imported in bulk to reduce packaging waste;
- Reducing packaging at the source by returning packaging to the supplier where possible, and by purchasing in bulk; and
- Undertaking construction activities in the correct order, to minimise potential rework.

**Waste Reuse**
- Reuse of all fill from earthworks on site where possible, to minimise off-site disposal;
- Crushing and reuse of existing concrete slab as fill, to avoid off-site disposal;
- Reuse timber formwork where possible; and
- Use of iron sheeting as formwork.

**Waste Recycle**
- Separation and storage of construction wastes into recyclable and non-recyclable materials in skips;
- Requesting cardboard or metal drums that can be recycled, instead of plastic; and
- Collection of scrap metals (aluminium, copper, lead, zinc, steel) for recycling off-site.

**Waste Disposal**
- Waste skips to be regularly collected by a licensed waste contractor and transported off-site for disposal to a licensed landfill; and
- Any site waste (e.g. concrete slab) to be tested for contaminants prior to off-site disposal, to ensure that a suitable disposal route is used.

Because the facility will be largely pre-fabricated off-site, and by implementing the above mitigation measures, it is expected that only small amounts of waste would be generated during the construction activities, and that these would be associated with small amounts of domestic waste from construction employees.
It is therefore expected that there would only be small amounts of waste generation from construction of the GTP, and only insignificant impacts on existing landfill capacity or other waste disposal facilities.

**Groundwater Well Installation Wastes**

The installation of the additional groundwater extraction and monitoring wells would generate specific wastes to be managed as follows:

- **drilling muds**, expected to comprise largely the sandy materials of the soil in the area. The management practices used during installation of the wells for the interim works would be similarly followed, with drilling muds collected by a licensed waste contractor in 205 L drums and transported to the existing containment structures on Southlands. These containment structures have been constructed with a geosynthetic liner and hay bales to prevent runoff during stormwater events. The drilling muds would be stockpiled, dried, analysed, assessed, classified and disposed of in accordance with EPA guidelines (DEC, 2004);

- **drilling slurries**, largely groundwater with some soil content. These would be managed in the same way as those generated during the initial installation of the wells for the interim works, through collection in 1 m³ intermediate bulk containers (IBCs) and storage in a dedicated bunded area on the BIP. When the sludge had settled, the groundwater would be treated; and

- **contaminated groundwater**, extracted during commissioning of the extraction wells. This would be collected directly in a vacuum truck and transferred to existing bunded storage tanks on the BIP, before treatment and disposal.

**Excess Caustic Soda**

The caustic soda remaining in the existing pipeline (which would become the treated groundwater discharge line) would be removed by pumping through hot water to push it into an existing bunded storage tank on the BIP. The line would then be ‘pigged’ (using a specific cleaning tool pushed through the pipe) to remove remaining traces of the caustic soda and water. The waste would be treated on site and discharged to sewer in accordance with the existing BIP licence.

**15.4.2 Wastes from Operation**

A number of by-product streams would be produced through operation of the GTP, some of which would be reused, and some treated and disposed of.

As detailed in Chapter 13, the acid produced in the acid absorber would be reused in the GTP, avoiding the requirement for treatment and disposal, and much of the treated groundwater would be reused on the BIP rather than discharged to Bunnerong Canal. In addition, the caustic scrubber wastewater would be discharged to the BIP trade waste discharge under the Trade Waste Service Agreement with Sydney Water.

The management of solid wastes generated from GTP operation is described below.
**Dewatered Solid Waste**

The dewatered solid waste would be produced on a continuous basis and deposited into a collection skip of about 20 m³ capacity for regular collection and disposal. The full skip would be collected by a licensed contractor for disposal to landfill, estimated at two to three skips per week.

The skip would be located undercover on the GTP site, and would be covered for transportation, so that water ingress would be avoided. Any split filter cake material would be cleaned up and replaced in the skip during regular site inspections by shift operators, and the area would discharge to the first-flush pit, to ensure containment of mobilised iron precipitate.

Prior to the construction and operation of the GTP, initial laboratory trials would be undertaken to confirm the quality of the iron precipitate solid and its suitability for landfill disposal, based on the relevant guidelines (DEC, 2004). The output of these trials would include the classification of the waste and confirm the proposed disposal to landfill under the relevant class.

Initial monitoring would be undertaken of the iron solids through the operation of the GTP to confirm their classification and disposal route. Subsequent monitoring would be undertaken, at a frequency to be developed in the WMP, to ensure the waste quality and applicability of the disposal route.

**Activated Carbon**

Once it has reached the end of its operating life, spent activated carbon would be removed directly from the carbon bed by a licensed contractor, for disposal to landfill. There would be no intermediate storage on site.

The estimated ‘operating life’ of the carbon bed would be determined through pilot trials before construction of the GTP, and monitoring during initial operation, based on the guidelines set out in Table A4 of Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes (DEC, 2004) and the gazetted immobilisation approvals for activated carbon in General Approval of the Immobilisation of Contaminants in Waste: Activated Carbon (EPA, 1999).

The purpose of this work would be to assess how long the bed would take to reach the relevant disposal standards, so that the operating life could be defined in the WMP for the GTP. One of the key determinants in the assessment of the activated carbon is the potential for accumulated scheduled chemicals defined by the Chemical Control Order (DEC, 2004b), such as 1,2,4-trichlorobenzene, which has been identified in the groundwater. The testing and development of timing for activated carbon removal and disposal would therefore need to ensure that the scheduled chemical content would be less than the threshold at which the material would be classified as a scheduled chemical waste.

Subsequent monitoring would be undertaken, at a frequency to be developed in the WMP, to ensure the waste quality and applicability of the disposal route. No other management options have been identified for this waste, and the activated carbon stage is a crucial ‘polishing’ step in the treatment process to ensure that the treated groundwater achieves the required standard for process reuse and discharge to Bunnerong Canal.

**Zeolite Waste**

As discussed in Section 15.3.2, the spent zeolite (if that alternative is selected) would preferably be accepted by the supplier for re-manufacturing into other products. If not, then it would then be disposed of to landfill in accordance with the DEC requirements.
**Other Wastes**

Small quantities of solid and liquid wastes, such as oils, greases and spare parts, would be also be generated through maintenance of the GTP and associated extraction wells and pipelines. Such wastes would be recycled where possible, through the existing waste management and recycling procedures at the BIP, or disposed of to landfill as appropriate.

### 15.5 Mitigation Measures

Table 15.1 summarises the measures that would be adopted for waste minimisation and management for the proposed BGC Project.

<table>
<thead>
<tr>
<th>Safeguards</th>
<th>Implementation</th>
<th>Design</th>
<th>Pre-construction</th>
<th>Construction</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop a Waste Management Plan, as part of the Environmental Management Plan for construction and operation of the BGC Project</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reuse <em>in situ</em> soils on site where feasible, so that limited material is removed from the site</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce packaging and return to supplier where practicable</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reuse construction materials such as form work where practicable</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Separate waste so that materials can be sent for recycling where appropriate</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Contaminated groundwaters to be collected during construction activities and treated in the SSU</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Iron filter cake subject to initial lab testing and monitoring during operation to confirm suitability for landfill disposal</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Filter cake collection to be covered, to ensure no ingress of water during site storage and transport for disposal</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Spent activated carbon subject to initial lab testing and monitoring during operation to confirm suitability for landfill disposal</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Procedures for disposal and ongoing monitoring of filter cake waste and spent activated carbon to be developed and incorporated into WMP</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
15.6 Conclusion

A Waste Management Plan would be developed prior to the construction and operation of the GTP to maximise the reduction, recycling and reuse of waste materials during the project. The amount of waste predicted to be generated during the construction of the GTP is small, because the project would only require minor site preparation and the GTP plant would be primarily pre-fabricated offsite.

Other waste materials generated during construction of other parts of the project would be managed in accordance with EPA guidelines and with practices developed and agreed between Orica and the EPA during the initial construction works of the extraction wells and the transfer pipelines.

The principal solid wastes generated by operation of the GTP comprise the spent activated carbon and dewatered solid waste, and laboratory trials and initial monitoring would confirm the management of these wastes to ensure suitability for safe disposal to landfill. Ongoing monitoring of the waste streams would be undertaken according to a program developed in the WMP to ensure ongoing suitability for landfill disposal.
16.1 Introduction

This chapter presents a description of the existing road network and traffic conditions within the Project Area, and assesses potential traffic impacts arising from construction and operation of the BGC Project.

The assessment forms a traffic impact study for the project, based on existing available data on traffic flows and road conditions, and desk-top analysis of potential impacts.

16.2 Existing Road Network and Traffic Conditions

The Project Area is approximately 8 km from the Sydney CBD, and is well serviced by the existing surrounding road network, as shown in Figure 16.1. The major roads in the area are classified as ‘arterial’ and ‘sub-arterial’ roads, both of which have been designed to carry heavy commercial vehicles as well as cars and other vehicles.

The function of these classes of roads can be defined as follows:

- **Arterial roads** predominantly carry through-traffic from one region to another, forming principal avenues of communication for metropolitan traffic movements. They are usually part of the proclaimed road system, including highways and freeways. Freeways are those roads having full access control and grade separated intersections, whose primary function is to serve large traffic volumes. Arterial roads are generally expected to carry in excess of 15,000 vehicles per day.

- **Sub-arterial roads** connect the arterial roads to areas of development or carry traffic directly from one part of a region to another. They may also relieve traffic on arterial roads in exceptional circumstances. Sub-arterial roads are generally expected to carry between 5,000 to 20,000 vehicles per day.

Figure 16.1 shows that the area has a relatively dense network of arterial and sub-arterial roads. Access to the works on the BIP would be through Gate 3, which fronts onto Denison Street, a sub-arterial road. Denison Street connects to Wentworth Avenue, an arterial road, to the north and to Beauchamp Road, a sub-arterial road, to the south. Wentworth Avenue connects to Southern Cross Drive, an arterial road, while Beauchamp Road connects to Botany Road and Foreshore Road (also arterial roads).

It is then possible to connect conveniently to virtually all parts of the Sydney metropolitan area using arterial roads. As the site is highly accessible via the arterial road network, there is little incentive to travel on local roads.

Botany Road connects to Bumborah Point Road in the south, a sub-arterial road that provides access to the BIP from Terminals Pty Ltd’s bulk liquid storage facility at Port Botany.

Southern Cross Drive and Wentworth Avenue to Denison Street would be the designated heavy vehicle route for access to project works on the BIP. There would be no requirement for any heavy vehicles to travel on Botany Road or Foreshore Road.

For the works outside the BIP, access to Southlands would be via McPherson Street, which is a local road fronted by commercial activities and is extensively used by commercial traffic and heavy vehicles.

Virtually all intersections between arterial or sub-arterial roads are controlled by traffic signals.
The main roads in the Project Area are summarised in Table 16.1.

### Table 16.1 Main roads in the Project Area

<table>
<thead>
<tr>
<th>Road</th>
<th>Summary Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Cross Drive</td>
<td>links the BIP with the CBD, eastern and northern suburbs of Sydney.</td>
</tr>
<tr>
<td>Foreshore Road</td>
<td>a divided, arterial road that was developed to connect Port Botany to General Holmes Drive, and which links with Sydney Airport and the southern suburbs.</td>
</tr>
<tr>
<td>Botany Road</td>
<td>merges with Foreshore Road and links the BIP and Port Botany with the CBD and is a major road serving the Banksmeadow/Port Botany area at the south to Redfern at the north. Over most of its length it has four lanes, of which two are typically given over to parking.</td>
</tr>
<tr>
<td>Wentworth Avenue</td>
<td>a divided arterial road that connects Botany Road at Mascot to Bunnerong Road at Pagewood, and has an interchange with Southern Cross Drive, providing east–west access between Southern Cross Drive and Bunnerong Road. It is signposted as a route to Port Botany via Denison Street/Beauchamp Road.</td>
</tr>
<tr>
<td>Denison Street</td>
<td>connects to Wentworth Avenue, with four marked lanes with residential frontage along much of its eastern side and mostly industrial frontage over the rest. The main access to the BIP through Gate 3 is from Denison Street.</td>
</tr>
<tr>
<td>Beauchamp Road</td>
<td>connects Botany Road and Bunnerong Road, a four lane road with industrial frontage (between Denison Street and Botany Road), and mixed low and medium density residential beyond.</td>
</tr>
<tr>
<td>Bumborah Point Road</td>
<td>connects Port Botany to Botany Road and the rest of the road network, providing one of the main routes for vehicle movements to and from Port Botany.</td>
</tr>
</tbody>
</table>

### 16.2.1 Traffic Conditions

The Roads and Traffic Authority (RTA) publishes data on average daily flows on major roads. This information and other available data sources provide an indication of typical traffic conditions in the Project Area, as presented in Table 16.2.
Table 16.2 Annual average daily traffic flows

<table>
<thead>
<tr>
<th>Road</th>
<th>Road Class</th>
<th>Traffic Flows</th>
<th>RTA (i)</th>
<th>Other (ii) (iii)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denison Street (North of Beauchamp Road)</td>
<td>Sub-arterial</td>
<td>n/a</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>Wentworth Avenue (East of Page Street)</td>
<td>Arterial</td>
<td>29,560</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Beauchamp Road (north of Botany Road)</td>
<td>Arterial</td>
<td>17,700</td>
<td>17,796</td>
<td></td>
</tr>
<tr>
<td>Botany Road (west of Beauchamp Road)</td>
<td>Arterial</td>
<td>31,285</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Botany Road (between Beauchamp Road and Bumborah Point Road)</td>
<td>Arterial</td>
<td>19,738</td>
<td>16,237</td>
<td></td>
</tr>
<tr>
<td>Bumborah Point Road</td>
<td>Sub-arterial</td>
<td>n/a</td>
<td>4,740</td>
<td></td>
</tr>
<tr>
<td>Foreshore Road (east of General Holmes Drive)</td>
<td>Arterial</td>
<td>25,170</td>
<td>21,853</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
(i) RTA Traffic Volume Data for Sydney Region, 2000
(ii) EIS for HCB Waste Destruction Facility at Botany, URS, July 2001
(iii) EIS for Port Botany Expansion, URS, Sept 2003 (traffic counts of average weekday traffic).

The information in Table 16.2 indicates that the heaviest flows occur on the arterial roads of Wentworth Avenue, Foreshore Road and Botany Road (west of Beauchamp Road) with flows generally in excess of 20,000 vehicles per day.

Detailed traffic analysis on the roads immediately adjacent to the BIP was undertaken in 1996 (Masson & Wilson, 1996) to examine the specific local traffic conditions and peak period traffic on these roads. Counts were undertaken as part of the assessment at the following locations:

- Denison Street and Wentworth Avenue;
- Denison Street and Beauchamp Road; and
- Denison Street and Gate 3.

The results of these counts are summarised in Table 16.3.
### Table 16.3 Summary of peak hour traffic flows

<table>
<thead>
<tr>
<th>Road</th>
<th>Location</th>
<th>Morning Peak Hour</th>
<th>Afternoon Peak Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wentworth Avenue</td>
<td>West of Denison Street</td>
<td>1,535</td>
<td>1,975</td>
</tr>
<tr>
<td>Beauchamp Road</td>
<td>South of Denison Street</td>
<td>1,070</td>
<td>1,375</td>
</tr>
<tr>
<td>Denison Street</td>
<td>South of Wentworth Avenue</td>
<td>825</td>
<td>1,010</td>
</tr>
<tr>
<td>Denison Street</td>
<td>North of Beauchamp Road</td>
<td>785</td>
<td>965</td>
</tr>
</tbody>
</table>

As this work was carried out in 1996, it is likely that the peak hour traffic numbers have increased, although traffic increases from surrounding activities (such as commercial and residential growth) are likely to have been mitigated to a certain extent by reductions in traffic to and from the BIP itself, as the Vinyl Chloride, Propathene and EDC plants have since closed.

It is unlikely that the traffic patterns would have changed significantly, and the conclusions in that report that were drawn from the available information at that time are therefore considered to still be valid for local traffic. These were that:

- the busiest time on the local road system occurs in the mid afternoon industrial peak, especially on Foreshore Road and the eastern end of Botany Road (i.e. east of the intersection with Foreshore Road);
- afternoon traffic flows drop considerably after 4:00 pm;
- morning peak traffic flows tend to be somewhat heavier between 8:00 am and 9:00 am, compared to those between 7:00 am and 8:00 am;
- traffic flows on Botany Road drop considerably from east to west with those west of Stephen Road typically about half those east of Penrhyn Road;
- the heaviest peak hour flows occur in Wentworth Avenue west of Denison Street in the afternoon, with flows on Beauchamp Road around 30–45% lower in both peaks; and
- Wentworth Avenue has a lower morning peak hour flow, reflecting the impact of the shopping centre, which generates little traffic in the morning peak.

#### 16.2.2 Key Intersection Performance

The performance assessment of major intersections on the road network in the Project Area during morning and afternoon peak periods was based on the results of the traffic and transportation study conducted for the EIS for the proposed Port Botany Expansion (URS, 2003).

The performance criteria for intersections are based on those set out by RTA, as shown in Table 16.4, and these are presented for the key intersections relevant to the GTP development on the BIP in Table 16.5.
### Table 16.4 Performance criteria for intersections

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>Average Delay/Vehicle (sec/vehicle)</th>
<th>Traffic Signals, Roundabouts</th>
<th>Give Way and Stop Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Less than 14</td>
<td>Good operation</td>
<td>Good operation</td>
</tr>
<tr>
<td>B</td>
<td>15 to 28</td>
<td>Good with acceptable delays and spare capacity</td>
<td>Acceptable delays and spare capacity</td>
</tr>
<tr>
<td>C</td>
<td>29 to 42</td>
<td>Satisfactory</td>
<td>Satisfactory, but accident study required</td>
</tr>
<tr>
<td>D</td>
<td>43 to 56</td>
<td>Operating near capacity</td>
<td>Near capacity and accident study required</td>
</tr>
<tr>
<td>E</td>
<td>57 to 70</td>
<td>At capacity. Incidents at signals will cause excessive delays</td>
<td>At capacity; requires other control mode</td>
</tr>
<tr>
<td>F</td>
<td>&gt; 70</td>
<td>Roundabouts required or other control mode</td>
<td>At capacity; requires other control mode</td>
</tr>
</tbody>
</table>


### Table 16.5 Intersection performance in 2002

<table>
<thead>
<tr>
<th>Intersection</th>
<th>AM Peak</th>
<th>PM Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreshore Road and Botany Road</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Botany Road and Beauchamp Road</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Botany Road and Bumborah-Point Road</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

Source: Maunsell Australia, 2002.

The results shown in Table 16.5 indicate that the relevant intersections either have good operation or spare capacity for additional traffic.

### 16.2.3 BIP Traffic

Another study was undertaken in 1998 (Colston et al, 1998) to assess traffic moving to and from the BIP, and the results are presented in Table 16.6 for the main access gate, Gate 3, from Denison Street.
Table 16.6 shows that about 1100 vehicles entered and left the site via Gate 3 during the 13 hour period recorded. About 85% of all vehicles were cars and small trucks. Over the whole 13 hour period a total of about 160 large rigid trucks and semi-trailers visited the site; an average of about 13 large vehicles per hour. The number of vehicles using Gate 3 peaks in the morning (6.00 am to 8.00 am) and afternoon (3.00 pm to 6.00 pm), mainly as a result of staff arriving and departing in cars. Truck movements were relatively evenly spread through the day, with a peak in the middle of the day. This volume of traffic using Gate 3 was considered to have only a relatively minor impact upon the surrounding road network, when considered in the context of traffic volumes for Denison Street as presented in Tables 16.2 and 16.3. This limited impact on Denison Street would decrease for the broader road network, as traffic spreads out from the BIP. Since this study was undertaken, the Vinyl Chloride, Propathene and EDC plants have closed, and it is therefore likely that the current traffic levels at Gate 3 would be slightly less than the figures presented in Table 16.6.
16.3  Traffic Impacts

16.3.1 Sources of Traffic
The main sources of traffic for the proposed project would be:

- temporary traffic associated with the construction of the GTP on the BIP, including construction staff, material transport and equipment deliveries;
- temporary traffic associated with the installation of the extraction wells and transfer pipeline for the DNAPL containment line on the BIP;
- temporary traffic associated with the installation of the additional extraction wells on Southlands;
- delivery to the BIP of the recovered waste EDC liquid from its storage at Terminals Pty Ltd’s bulk liquid storage facility at Port Botany, over an estimated two to three year timescale; and
- transport of the activated carbon waste and dewatered solid waste generated from the treatment process from the BIP to suitable landfill facilities, throughout the estimated 30 year operational life.

16.3.2 BIP Access
All traffic associated with the construction works carried out on the BIP, and with operation of the GTP, would access the BIP via Gate 3 from Denison Street.

Access to Denison Street would be via Wentworth Avenue and Southern Cross Drive to the north, and Beauchamp Road and Botany Road/Foreshore Road to the south.

Access from Terminals Pty Ltd’s bulk liquid storage facility at Port Botany would be from Bumborah Point Road onto Botany Road.

16.3.3 Construction and Operating Hours

GTP Construction
The estimated construction period for the GTP is around nine months. All work and deliveries would generally be undertaken during the standard construction hours of:

- 7.00 am to 6.00 pm from Monday to Friday; and
- 7.00 am to 1.00 pm on Saturdays.

Works hours will be outlined in the EMP.
**Other Construction Activities**

The other construction activities would be completed within varying timescales within the overall nine month construction timeframe for the GTP. These activities would similarly be undertaken during standard construction hours, except for some limited works to be undertaken at the Bunnerong Canal.

These works, comprising the removal of the existing caustic line pipe spool that crosses the canal and the delivery and installation of the diffuser at the discharge point in the canal, would be undertaken during a period of low traffic flow. The reason for this is that part of the Bumborah Point Road would have to be closed to allow crane and truck access to remove the pipe spool and to place the diffuser into the canal for installation.

**Operations**

The estimated operating period for the GTP is up to 30 years, with extraction, transfer, treatment and discharge activities operating at 95% availability throughout the year.

Within this operating timeframe, it is anticipated that vehicle movements, such as waste removal or material deliveries, would primarily occur during normal working hours, 5.5 days per week, except in the event of emergency operation or maintenance.

### 16.3.4 Construction Traffic

**Construction of the GTP**

The main traffic generated through the construction phase of the GTP would be from equipment and material deliveries, such as:

- **construction materials**—concrete, sand, steel, pipes, valves, bolts/gaskets and electrical cables;
- **construction equipment and machinery**—scaffolding, forklifts and cranes;
- **specific components for the GTP**—the thermal oxidiser, the steam stripper units and the scrubbers—and equipment such as pipe racks, steel framework, piping, pumps, roofing and instrumentation; and
- **movement of construction personnel**, including contractors, site labour force and specialist supervisory personnel.

It is anticipated that very limited traffic would be generated from transport of construction waste for off-site disposal, as the objective would be to reuse material (such as existing concrete slab and soil) on site as part of the construction.

The estimated traffic (passenger cars and trucks) generated during the construction of the GTP is presented in **Table 16.7**.
### Table 16.7 Estimated traffic generation during construction

<table>
<thead>
<tr>
<th>Month</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck (i)</td>
<td>32</td>
<td>119</td>
<td>125</td>
<td>147</td>
<td>172</td>
<td>163</td>
<td>151</td>
<td>149</td>
<td>102</td>
</tr>
<tr>
<td>Daily (ii)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck (i)</td>
<td>1.3</td>
<td>4.8</td>
<td>5.0</td>
<td>5.9</td>
<td>6.9</td>
<td>6.5</td>
<td>6.0</td>
<td>6.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Passenger car (iii)</td>
<td>2.0</td>
<td>12.6</td>
<td>13.0</td>
<td>17.4</td>
<td>20.0</td>
<td>29.2</td>
<td>44.0</td>
<td>56.0</td>
<td>66.0</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>18</td>
<td>18</td>
<td>24</td>
<td>27</td>
<td>36</td>
<td>50</td>
<td>62</td>
<td>70</td>
</tr>
</tbody>
</table>

Notes:
(i) Truck defined as 4m³ or 12t truck.
(ii) Daily vehicle movements are based on an average working day i.e. 25 days per month. A vehicle movement is either an entry to or exit from the site. For example, one delivery to the site is equivalent to 2 movements.
(iii) The passenger car occupancy rate has been estimated to be 2.5 considering some will come by bus (public transport), some will be picked up by company vans, and some will have car sharing.

Construction of the GTP would generate a total of 1160 truck movements and 6505 passenger car movements over the nine month construction period, or a daily average of 4.25 truck movements and 24 passenger car movements.

Table 16-7 shows that the maximum daily traffic generated from the construction of the GTP would be during months 8 and 9. During this time, a worst case and very unlikely scenario would be that all passenger cars and trucks would access the BIP in the peak hour, i.e. 70 vehicles arriving at the BIP in same hour in the morning, and leaving the site in the same hour in the afternoon.

Thus, 70 vehicle movements in the peak hour would be expected to represent the worst case scenario. The increase in traffic generation due to construction of the GTP would represent a very small proportion of peak traffic volumes in the existing traffic flow, as shown in Table 16.8.

### Table 16.8 Additional traffic at peak hours during construction of GTP

<table>
<thead>
<tr>
<th>Road</th>
<th>Location</th>
<th>Existing AM Peak Hour *</th>
<th>Existing PM Peak Hour</th>
<th>Expected Traffic in Peak Hour (Construction)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>am</td>
<td>pm</td>
</tr>
<tr>
<td>Wentworth Ave</td>
<td>West of Denison St</td>
<td>1,535</td>
<td>1,975</td>
<td>70</td>
<td>4.6% 3.6%</td>
</tr>
<tr>
<td>Beauchamp Rd</td>
<td>South of Denison St</td>
<td>1,070</td>
<td>1,375</td>
<td>70</td>
<td>6.5% 5.1%</td>
</tr>
<tr>
<td>Denison St</td>
<td>South of Wentworth Ave</td>
<td>825</td>
<td>1,010</td>
<td>70</td>
<td>8.5% 7%</td>
</tr>
<tr>
<td>Denison St</td>
<td>North of Beauchamp Rd</td>
<td>785</td>
<td>965</td>
<td>70</td>
<td>9% 3.7%</td>
</tr>
</tbody>
</table>

The maximum increase on surrounding roads is expected to occur on Denison Street, north of Beauchamp Road, during the morning peak hour. Since no more than three heavy vehicles are included in this total traffic generation, the impact would be virtually imperceptible and would have no significant impact when compared to the existing traffic flows on Denison Street, Beauchamp Road and Wentworth Avenue. In addition, the peak traffic flows from the construction period would be temporary, lasting only around two months.

All vehicles associated with construction would be accommodated within the BIP, using existing parking areas for both deliveries and workforce parking, so there would be no impact on parking availability in surrounding roads.

The construction and building materials to be delivered to the GTP site would generally be transported by standard articulated and rigid trucks, and the requirement for restricted access oversize or overmass vehicles is considered unlikely, except possibly for the one-off transport of limited large plant items (such as the thermal oxidiser).

The performance of the road system in urban areas is typically dictated by intersection capacity. Estimated delays at intersections during peak periods provide a good indication of future network performance. Given that the traffic increase resulting from the construction of the GTP generally makes up a relatively minor proportion of total traffic on selected roads, and that the associated intersections all have a spare capacity with acceptable delays, it would be unlikely that the limited increase in traffic would significantly influence the performance of those intersections.

As a result, the potential impact of construction of the GTP on the capacity and performance of the existing road system would be minor.

**Other Construction Activities**

The main traffic generated through the construction of other elements of the BGC Project would be minor equipment and material deliveries, such as:

- two drilling rigs and two support vehicles to install the extraction wells on the PCA and the BIP. The same vehicles would be used in the various works;
- limited movement of support vehicles transporting drilling muds/slurries/groundwater between Southlands and the BIP;
- construction equipment and machinery such as scaffolding and cranes for the installation of the DNAPL pipeline on the BIP, and the diffuser in the canal;
- construction equipment and machinery such as excavator, winch truck and air compressor, for the discharge line refurbishment;
- construction materials such as concrete, sand, steel, pipes, valves and electrical cables; and
- construction personnel.
The traffic numbers associated with these activities would be very small. For example, the well installations at Southlands would require access from McPherson Street for drill rig deliveries at the start and removal at the end of the program, and a total of two or three daily movements of support vehicles to the BIP. The construction of the DNAPL pipeline on the BIP would require access from Denison Street for approximately 12 material loads (24 trips in total) during the three-month construction program.

The potential impact of these construction activities on the capacity and performance of the existing road system would be insignificant.

### 16.3.5 Operation Traffic

**Traffic Numbers**

In comparison with the construction phase, the traffic generation during operation of the BGC Project would be limited. Estimated traffic numbers are summarised in Table 16.9.

<table>
<thead>
<tr>
<th>Transportation Purpose</th>
<th>Vehicle Type</th>
<th>Origin or Destination</th>
<th>Estimated Average Vehicle Movements (i) (ii)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deliveries to the Site</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDC Condensate</td>
<td>Isotainer</td>
<td>Terminals at Port Botany</td>
<td>2-4 per month</td>
</tr>
<tr>
<td>GTP process material</td>
<td>Rigid truck</td>
<td>Local area</td>
<td>2-4 per month</td>
</tr>
<tr>
<td><strong>Materials from the Site</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activated Carbon Waste (if not regenerated on site)</td>
<td>Rigid Truck</td>
<td>Landfill or to Regeneration Facility</td>
<td>8 per year</td>
</tr>
<tr>
<td>Spent zeolite (if this option is selected)</td>
<td>Rigid Truck</td>
<td>Landfill or Supplier</td>
<td>4 per year</td>
</tr>
<tr>
<td>Dewatered solid waste</td>
<td>Rigid Truck</td>
<td>Landfill</td>
<td>6 per week</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Services</td>
<td>Rigid Truck</td>
<td>Local area</td>
<td>No additional movements</td>
</tr>
<tr>
<td>Workforce</td>
<td>Passenger Vehicles</td>
<td>Local area</td>
<td>8 per day</td>
</tr>
</tbody>
</table>

Notes:
(i) Daily vehicle movements are based on an average working day, for 365 days a year.
(ii) A vehicle movement is either an entry to or egress from the site. For example, workforce traffic equates to two vehicle movements.
(iii) The car occupancy rate for employees has been estimated to be one, with the total workforce at the GTP on any one shift estimated to be two employees.
(iv) The plant will be staffed on a shift-work basis. At the changeover of shifts, it is possible that employees will all either arrive or leave the site within one hour. The peak hourly vehicle movements of the employees has been calculated accordingly.
Traffic and Transportation

As can be seen from the traffic estimates in Table 16.9, the additional traffic generated would be negligible in comparison with the existing traffic flows around the BIP.

**Traffic Routes**

According to the 1998 *Australian Code for the Transport of Dangerous Goods by Road and Rail* (the ADG Code), the recovered waste EDC liquid stored at Terminals Pty Ltd’s bulk liquid storage facility at Port Botany and transported to the GTP for treatment would be classified as Dangerous Goods Class III and Packaging Group II, meaning that designated roads must be used for its transportation.

Schedule 5 of the Botany Local Environmental Plan 1995 (BLEP) provides a list of designated roads within the Botany Local Government Area, which has been taken into account in the determination of the potential routes for transport of the recovered waste EDC liquid.

As a result, the proposed route for transport of the recovered waste EDC liquid to the GTP would use the following designated roads:

- Bumborah Point Road;
- Botany Road;
- Beauchamp Road; and
- Denison Street.

This route is illustrated in Figure 16.2. No other routes would be used, and the transport would be undertaken by a licensed contractor familiar with the route. These routes would be identified in the EMP.

**16.3.6 Potential Cumulative Traffic**

A number of major developments are proposed in the vicinity of the BIP, which could result in potential cumulative impacts on local traffic and transport networks.

**Port Botany Expansion**

The proposed expansion of Port Botany could result in an additional 3 to 103 daily vehicle movements during construction (for up to four years) and 940 daily movements during operation, which could affect Foreshore Road, Botany Road and Beauchamp Road (URS, 2003).

**Patrick Port Botany Container Terminal Upgrade**

The proposed upgrade of the Patrick Port Botany Container Terminal could result in an additional 110 to 120 daily vehicle movements during construction (for up to two years) and a 3.5% increase in daily movements during operation, which could affect Foreshore Road, Botany Road and Beauchamp Road (URS, 2003).

In addition, the anticipated growth at Sydney Airport, along with commercial and residential developments at Cooks Cove and Green Square, would be expected to result in significantly increased traffic in the general Botany area.
These proposed developments would generate significantly more traffic over a much longer timeframe than the BGC Project. Therefore, it is not considered that the project—with a traffic peak of an additional 156 traffic movements per day during construction for a period of two months, and a maximum peak during operation of 14 movements per day—would contribute significantly to the cumulative impact on local traffic and transport networks.

16.3.7 Other Impacts

The installation of the groundwater extraction wells in the median strip of Foreshore Road will have been completed at the time of submission of this EIS. These wells have been installed underground and are covered at ground level to ensure that there is no obstruction to traffic movement on or around the median strip. The covers have been designed to safely accommodate the weight of heavy traffic, to ensure that there are no safety implications in the event of a heavy vehicle driving over them.

If any maintenance work is required, appropriate safety measures would be implemented to minimise impacts on the flow or safety of traffic on the road (as were carried out during the installation of the wells).

16.4 Mitigation Measures

A Traffic Management Plan (TMP) would be prepared prior to construction based on existing Orica traffic management procedures, and incorporated within the Environmental Management Plan (EMP) for the project. This plan would detail site access routes, time restrictions and mitigation measures that would be implemented during construction works. The measures in the TMP would include:

- designated access through Gate 3 on Denison Street for the BIP;
- designated access from McPherson Street for works on Southlands;
- designated site access routes for construction traffic using the arterial and sub-arterial road system that services the Project Area, primarily from Denison Road north to Wentworth Avenue and joining Southern Cross Drive for the BIP, and via Beauchamp Road or Foreshore Road to access McPherson Street;
- designated site access routes for contractors and employees, using arterial and sub-arterial roads to ensure that the existing local community road amenity is not changed;
- compliance with designated speed limits and load limits specified for heavy vehicle routes and movement around the BIP;
- incorporation of traffic and transport issues within the existing community consultation program, to keep the local communities informed of activities;
- use of existing areas within the BIP as designated car parking, laydown, loading and unloading areas, to ensure no parking on public streets;
- receipt of RTA consent for road closure on Bumborah Point Road, prior to specific canal works commencing, and compliance with all conditions imposed for lane closure, such as appropriate traffic flow management measures;
• implementation of appropriate measures to safely manage pedestrian movements, where discharge line excavation works may affect pathways; and

• any requirement for transportation of large ‘over-sized’ equipment to be undertaken by experienced hauliers, during appropriate times, with suitable signage and escorts, in accordance with RTA Regulations to ensure that the local roads remain safe for other vehicles.

The management measures within the TMP would similarly be incorporated for operational traffic management, to include:

• designated access through Gate 3 on Denison Street;

• designated access from McPherson Street for maintenance works on Southlands;

• designated access routes for transport from the site using the arterial and sub-arterial road system that services the BIP, primarily from Denison Road north to Wentworth Avenue and joining Southern Cross Drive;

• designated site access route for transport of recovered waste EDC liquid from Terminals Pty Ltd’s bulk liquid storage facility at Port Botany to meet the requirements of the BLEP;

• compliance with designated speed limits and load limits specified for heavy vehicle routes and movement around the BIP;

• specific procedures for measures to be implemented when maintenance works are required on the extraction wells and/or pipelines in Foreshore Road, including RTA consent for access, safety barriers and compliance with RTA conditions; and

• GTP site layout to accommodate loading, unloading, manoeuvring, and parking of vehicles.

Proposed mitigation measures for traffic management to be incorporated into the project are shown in Table 16.10.

Table 16.10 Mitigation measures: traffic management

<table>
<thead>
<tr>
<th>Safeguards</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify preferred roads for transporting construction materials, equipment and components.</td>
<td>✓ Pre-construction</td>
</tr>
<tr>
<td>Designate access routes for equipment and material transportation to the construction sites.</td>
<td>✓</td>
</tr>
<tr>
<td>Obtain RTA consent for lane closure on Bumborah Point Road, for works access to Bunnerong Canal</td>
<td>✓</td>
</tr>
<tr>
<td>Compliance with all conditions of RTA approval for lane closure.</td>
<td>✓</td>
</tr>
</tbody>
</table>
Prepare Traffic Management Plan as part of EMP to include:
- designated transport routes and access;
- compliance with existing BIP requirements such as speed limits and load limits;
- specify parking, laydown, loading and unloading areas;
- use of licensed hauliers for oversize equipment, responsible for obtaining RTA permits

Designate access routes for transport of materials to and from the site during operation.

Site layout to include suitable parking, loading and loading areas during operation.

Production wells and pipelines installed on Foreshore Road below ground, with suitable covers flush with ground level to avoid any potential obstructions or safety risks on the median strip.

**16.5 Conclusion**

The traffic associated with the construction and operation of the BGC Project would lead to an imperceptible increase on arterial and sub-arterial roads. Local roads would not be used, and therefore any increases in traffic as a result of the project would not affect local traffic or the availability of parking on local streets.

Where works require lane closure, the works would be carried out with RTA consent and undertaken during periods of low traffic flow to minimise impacts on traffic movements to and from Port Botany.

Transport of recovered waste EDC liquid from Terminals Pty Ltd’s bulk liquid storage facility would be undertaken using designated access routes, in accordance with the Botany Local Environment Plan.
17.1 Introduction

An assessment of the potential noise impacts associated with the BGC Project was undertaken by specialist consultants the Acoustic Group Pty Ltd. This chapter summarises the results of that assessment, with the full acoustic assessment presented in Appendix F.

17.2 Existing Environment

The Botany Banksmeadow industrial precinct has been the subject of a noise policy established by the Council of the City of Botany Bay and the EPA to address night-time noise levels and the potential issue of background noise ‘creep’, by specifying that new plants maintain a level of noise emission significantly less than the ambient background level.

The BIP operates under licence conditions issued by the EPA, with specific conditions governing the cumulative noise impact from the BIP (and hence the proposed site of the GTP). These form part of the BIP Noise Reduction Program that has governed the control and reduction of noise from the existing site operations.

17.2.1 Noise Assessment Criteria

Noise is normally measured in decibels (dB), which is a logarithmic measure of a variation in air pressure (sound waves). Community noise is normally measured using an A weighted scale, noted as dB(A). The A weighting is considered to approximate the frequency response of the human ear. For continuous noise emission from a site, any increase in background (average minimum) noise levels of more than 5 dB(A) is generally taken to be unacceptable.

The GTP would be “scheduled” under the Protection of the Environment Operations Act 1998, and falls under the jurisdiction of the EPA. As the GTP would be located on the BIP, it is governed by stringent noise emission criteria set down by the EPA and in the BIP Noise Reduction program.

In compliance with Orica’s existing EPA licence, noise emissions from the GTP must not exceed an $L_{eq}$ (as defined in the Glossary) sound level contribution of 35 dB(A) at the nearest sensitive receiver boundary (e.g. residential premises) at night. Meeting this requirement would result in a sound level contribution from the GTP significantly lower than the existing ambient background level (typically 48 to 50 dB(A) at night, based on monthly residential boundary monitoring commissioned by the BIP) around the perimeter of the BIP.

While no specific operational noise criteria would apply to the associated off-site infrastructure, such as extraction wells and pipelines, Orica considers these off-site components to be covered by the GTP noise design criteria.

A noise goal for the GTP that is noticeably less than the ambient background noise level at residential boundaries, and both the intrusive goal and the amenity goal obtained from the EPA Industrial Noise Policy (INP), would automatically ensure full compliance with the INP, as required by the DGRs in Appendix C.
As such, standard noise assessment procedures—with respect to measurement of existing ambient sound levels—are not required for the BGC Project, because the design goal that has been specified by the EPA for the BIP renders the conduct of ambient background measurement of no assistance in the acoustical assessment of the GTP. In addition to compliance with external noise emission limits, the BIP Noise Policy specifies that to comply with occupational noise goals, the noise level in working areas not governed by speech communication or annoyance should not exceed 85 dB(A).

To comply with the statutory requirements for occupational noise exposure level, and considering the cumulative effects of additional plant, the general engineering specifications used on the BIP require noise emissions from any individual item to be no greater than 82 dB(A) when measured at a distance of 1 metre from the source.

17.3 Noise Assessment Methodology

17.3.1 Construction Noise

The construction noise criteria set out in the Environmental Noise Control Manual nominate a series of noise goals dependent on the period of construction, with greater noise increases permitted during shorter construction periods. The construction period for the GTP would be greater than 26 weeks, so the $L_{eq}$ criterion for construction of the GTP is background noise +5dB(A).

This criterion would also apply to the construction of off-site infrastructure that is considered part of the overall BGC Project construction works.

17.3.2 Operational Noise

Detailed design of the GTP is yet to be completed. The noise assessment methodology has therefore been developed by ‘working backwards’ from the maximum permitted noise emission levels at residential boundaries. The specification of an effective sound power level for the GTP is consistent with previous BIP projects and has been developed to achieve compliance with the EPA’s noise requirements. This specified sound power level would, in turn, determine the effective noise control required for individual plant items.

The effective sound power level is determined through use of the computer modelling program (ENM), an average source height above ground level, and typical ambient background noise level spectra recorded at a reference sensitive receiver.

In terms of traffic noise, the assessment would be in accordance with the EPA’s Environmental Criteria for Road Traffic Noise (EPA, 1999), which considers noise goals associated with various types of developments or road classifications. Access to the BIP and the GTP site would be via Gate 3 on Denison Street, which is a designated heavy vehicle transport route and carries a significant volume of traffic that is not associated with the BIP.
17.4 Construction Noise Assessment

The EPA generally recommends the following periods for construction activity:

- between 7.00 am and 6.00 pm from Monday to Friday;
- between 7.00 am and 1.00 pm on Saturday, if inaudible at residential premises, or between 8.00 am and 1.00 pm; and
- at no time on Sundays or public holidays (Chapter 171 of the EPA *Noise Control Manual*, 1985)

Monitoring of previous construction activities on the BIP, such as plant maintenance and equipment overhauls, has shown that the noise from these activities is masked by existing general ambient and traffic noise, and complies with EPA construction noise limits.

Subject to time constraints on the project and weather contingencies, there may be a requirement to conduct some construction activities outside normal EPA recommended hours. Such works may typically involve fit-out of buildings, installation of wiring and painting that, in themselves, do not generate audible noise outside the BIP boundary.

Consistent with the BIP Noise Reduction Program, such works could only occur if it is demonstrated that compliance with inaudibility at the site boundary is achieved.

17.4.1 Construction Activities

The construction activities for the GTP are outlined in Chapter 5.

The construction of the BGC Project would generally only involve activities and equipment similar to those that are currently used on the BIP for general construction and maintenance.

Given the location of the GTP in relation to the nearest residential receivers (Reference Locations 9 and 10, as shown in Figure 17.1), there would be a significant degree of distance attenuation of noise impacts to the nearest residential boundary. Potential site boundary noise levels are therefore expected to be similar to existing daytime background levels, and therefore compliant with the EPA’s construction noise criteria applicable to the GTP.

Off-site Infrastructure

The following additional infrastructure is yet to be completed for the operation of the BGC Project:

- installation of additional extraction wells in the PCA;
- installation of DNAPL wells;
- construction of the DNAPL pipeline;
- refurbishment of the underground discharge pipeline for marine discharge that runs from the BIP to Bunnerong Canal; and
- creation of an outlet at this point for the discharge of excess treated water.
The key noise generating activity during installation of the PCA extraction wells would be the operation of the drilling rigs, which would result in a maximum sound level for each rig of 84 dB(A) at a distance of 4 metres. Monitoring of drilling conducted during earlier stages of the BGC Project revealed that there would be no perceptible vibration, either adjacent to the rig or at sensitive receptors (such as residential areas).

The additional PCA wells are located in an industrial zone approximately 30 metres from commercial and industrial businesses on the southern side of McPherson Street, and 400 metres from the nearest residential receivers, off Botany Road in a southwesterly direction. The operation of two drilling rigs simultaneously is calculated to result in a sound level contribution at the boundary of sensitive receivers of less than 43 dB(A), which clearly satisfies the background +5 dB(A) goal.

The installation of the DNAPL extraction wells would involve similar activities to the PCA wells. Construction of the DNAPL pipeline would involve minor clearing and excavation, concrete preparation, welding and other metal works. Construction equipment would include cranes, excavators, welders and forklift trucks.

There are no sensitive receptors close to the DNAPL wells to be installed on the western boundary of the BIP. Installation of these wells and of the DNAPL pipeline would generate a sound level contribution of less than 48 dB(A) at the nearest residence in Denison Street, and less than 42 dB(A) at the nearest residence in Spring Street.

An existing pipeline would be refurbished for use as the marine discharge pipeline. The pipeline would be accessed in sections by excavation at major pipeline elbow locations. These access locations are all located in an industrial setting. The works at each access location would take approximately two weeks and would involve the use of an excavator and a truck mounted compressor. The pipeline does not pass under any residential areas, and the excavation and refurbishment works are not expected to have any noise impact on residential areas.

### 17.4.2 Construction Traffic

The construction of the GTP would involve about six truck movements per day, and worker vehicle movements generated by between 15 and 115 people working on the plant at any time. In the context of existing traffic movements on the BIP, the construction traffic associated with the GTP would represent a small increment in the number of vehicle movements, and would not result in any significant traffic noise impact.

Traffic associated with the construction of off-site infrastructure would similarly be minor, with movements mainly limited to specific construction areas outside the BIP for relatively short periods. Drilling rigs would enter the relevant area by truck and remain until the total number of wells had been installed, with only minor local movements as the rig moves between well locations. Construction of the DNAPL pipeline and the refurbishment of the marine discharge pipeline for the treated water discharge to Bunnerong Canal would involve a minor number of work vehicles.

In terms of traffic noise, vehicles associated with the construction of the GTP and infrastructure would have a negligible impact.
17.4.3 Vibration

The preliminary construction proposal for the GTP at this stage does not envisage piling. Any piles, if required, would be installed by rotary drilling, i.e. concrete screw piles and not hammer driven piles. Previous monitoring conducted on the BIP has not identified vibration impacts from rotary piling, and therefore no potential vibration impacts would be expected at residential boundaries.

17.5 Operation Noise Assessment

17.5.1 General GTP Sound Power Level Assessment

In accordance with the BIP Noise Reduction Program, the noise design goal for the GTP at residential boundaries is not greater than 35 dB(A). Regular monitoring in the vicinity of the BIP has identified appropriate sensitive receiver reference locations along Denison Street (the nearest residential boundary to the GTP) and adjacent areas, as shown in Figure 17.1. Reference location 10 is considered to be the most critical location in relation to the GTP.

As noted above, the operation noise assessment is based on specifying the maximum sound power level for the GTP to achieve compliance with the specified design goal.

Table 17.1 presents the effective sound power level limit required for the GTP to meet the 35 dB(A) criterion at sensitive receptor boundaries. These values are relative to the reference sensitive receiver locations shown in Figure 17.1, based on three different prevailing weather conditions at night:

- neutral (still);
- light NW wind; and
- SW wind at 4 m/s.

<table>
<thead>
<tr>
<th>Reference Location</th>
<th>Effective Sound Power Level dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Neutral</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>9</td>
<td>98</td>
</tr>
<tr>
<td>10</td>
<td>98</td>
</tr>
<tr>
<td>11</td>
<td>99</td>
</tr>
<tr>
<td>14</td>
<td>112</td>
</tr>
<tr>
<td>14a</td>
<td>113</td>
</tr>
<tr>
<td>15</td>
<td>121</td>
</tr>
<tr>
<td>Holloway</td>
<td>119</td>
</tr>
<tr>
<td>Brighton</td>
<td>114</td>
</tr>
</tbody>
</table>
The results in Table 17.1 show that a design sound power level of 96 dB(A) would apply for the GTP in respect of the residential reference location 9 in Figure 17.1.

Based on the information provided in Table 17.1, Orica has specified that the effective sound power level of the GTP would not exceed 96 dB(A).

17.5.2 GTP Equipment Sound Power Level Assessment

The preliminary schedule of plant items for the GTP, as presented in Appendix F, identifies 16 noise producing items, the majority of which are small pumps that would have a noise level significantly lower than the occupational limit of 82 dB(A) at 1 m. Using an appropriate nominal sound power level of 75 dB(A) per small pump/motor, the cumulative sound power level would be 86.5 dB(A), which is less than the target sound power levels identified in Table 17.1.

The two air stripper blowers, which are part of the off-gas oxidation package, were considered to have a sound power level greater than 120 dB(A), which would exceed both the occupational limit and the target sound power levels identified in Table 17.1. The blowers would require appropriate acoustical attenuation to a level sufficient to achieve the occupational noise limits. A level of attenuation to 90 dB(A) maximum external sound power level for each of the two sources would achieve compliance with the overall effective design sound power levels (as specified in Table 17.1).

In the absence of specific noise control procedures at the time of writing this EIS, it has been determined that the design of the two identified equipment items (the air stripper blowers) must achieve the 90 dB(A) external sound power level specification, in accordance with the standard procedure at the BIP.

17.5.3 Pumping and Transfer Activities

A submersible pump that pumps the groundwater into the transfer lines to the plant will be installed at the bottom of each well. Each pump has sufficient capacity to pump the water from its own well back to the plant. There are no additional pumps in the untreated water supply pipelines until they reach the GTP. There are no wells close to residential premises. The transfer lines are fully sealed, and are expected to generate a sound level contribution at the top of each well of less than 45 dB(A) at 1 metre.

The operation of the pumps in the wells in the median strip of Foreshore Road, at Southlands and along the western boundary of the BIP, along with the primary and secondary pipelines and other pipes throughout the BIP for pumping treated water, is not expected to result in audible noise at any residential receivers.

The marine discharge line would be supplied by the treated water distribution pump located on the GTP. The line is underground and passes through the industrial area to Bunnerong Canal. No appreciable noise impact would arise from the use of treated water discharge line.
17.6 Mitigation and Management Measures

In accordance with the BIP policy as applied to previous projects, the following measures would be implemented to minimise construction noise and mitigate against noise impacts:

- construction equipment would be regularly inspected and maintained;
- work would be planned to avoid simultaneous noisy activities;
- equipment of proper size and capacity would be used;
- noise monitoring for work outside the recommended hours;
- noise control measures would be implemented as required around noisy activities, such as metal cutting and grinding; and
- a free call hotline would be maintained to receive and address concerns from the public.

In the absence of specific noise emission levels for the BGC Project, the effective sound power level of the GTP has been derived to ensure compliance with the maximum allowable noise emission of 35 dB(A) at any residential boundary, as set by the BIP Noise Reduction Program. Such a sound power level is considered adequate, subject to implementation of noise control measures on the two principal noisy plant items (the air stripper blowers), to achieve a maximum external sound power level of 90 dB(A).

Once the final specification of the equipment for the GTP is complete, along with relevant noise control measures, an updated noise impact assessment would be carried out to ensure compliance with the maximum allowable noise emission, based on the final site layout and incorporating all noise emission sources.

In addition, all process equipment installed within the GTP would be tested during the commissioning phases to ensure that all equipment operates at the specified sound power levels, before the GTP starts operation, to determine the effective sound power level nominated for the BGC Project and to issue a certificate of compliance.

Existing noise monitoring for the BIP would incorporate monitoring of noise emissions from the BGC Project, once operational, to confirm compliance with the maximum allowable noise emission limit.

It is not anticipated at this stage that piling for foundations would be required; however, if it was required, these would be installed by rotary drilling and not hammer piling. This procedure would minimise any vibration impacts at nearby residential areas during the piling operation and would be monitored to ensure no vibration impacts.

17.7 Conclusions

Subject to the implementation of noise control measures to achieve a maximum external sound power level of 90 dB(A) for the two air stripper blowers, the design sound power level for the BGC Project would comply with the maximum allowable noise contribution of 35 dB(A) at any residential boundary.
Compliance with this objective would also ensure compliance with the BIP occupational noise policy limit of less than 85 dB(A) in working areas.

Given the location of the BGC Project elements, and the existing ambient noise levels, construction activities are not anticipated to create noise impacts.

Similarly, no noise impacts are anticipated as a result of traffic arising from either the construction or the operation of the BGC Project, given the relatively small amount of additional traffic that would be generated, compared with the existing traffic levels on Denison Street and the surrounding road network.
18.1 Background to the Project

The purpose of this chapter is to assess the potential greenhouse gas (GHG) emissions arising from the predicted energy usage of the BGC Project. It presents the measures to be incorporated into the management of the project to minimise energy consumption and GHG emissions. However, such measures are considered in the context of the overall objectives of the project, which are to ensure hydraulic containment of the contaminant plumes and to maximise the efficiency of the thermal oxidiser, to achieve maximum destruction of the volatile contaminants in the groundwater.

18.2 Energy Management and Conservation

The overall design of the BGC Project has been undertaken to minimise energy consumption where possible without compromising the identified containment and treatment objectives. This approach has been incorporated into each stage of development, and into the different elements that make up the BGC Project.

Given the key project objectives, however, Orica’s overall approach to the design and operation of the BGC Project has been to ensure that potential energy efficiencies and greenhouse gas savings from the contaminant destruction are not achieved at the expense of destruction efficiency. This is consistent with the views and concerns of the regulatory agencies (such as the EPA).

18.2.1 Equipment Supply

Where possible, equipment and materials for construction activities would be sourced from local suppliers, to minimise energy consumption associated with transport to the site. Similarly, construction activities would be scheduled and managed to minimise the extent of moving equipment and materials around the construction sites, or the unnecessary duplication of movements.

18.2.2 Construction

During the construction phase, energy consumption would result from a variety of activities including:

- site preparations;
- transport of equipment and materials; and
- equipment installation and commissioning.

The principal source of energy consumption during construction would be heavy equipment, trucks and other vehicles used during equipment transport and construction activities. These activities would consume a combination of diesel fuel, petrol and LPG. Where electrical power is required for the site during construction (e.g. for lighting or power tools), this would be provided from existing connections available on the BIP or from temporary diesel portable generators.
Because the construction activities would not require significant earthworks or the prolonged use of large construction equipment, it is not anticipated that the construction phase would result in significant energy use. However, measures would be employed to minimise fuel and energy use where possible, such as:

- throttling down or switching off idle construction equipment;
- switching off the engines of trucks while they are waiting to access the site and while they are being loaded or unloaded;
- ensuring that equipment is properly maintained for efficient energy consumption;
- using recycled materials (demolition materials, construction materials, paper, glass, etc), where feasible; and
- sourcing materials from local suppliers where appropriate, e.g. concrete and steel works.

These measures would be included in the EMP for the project.

18.2.3 Operation

The operation of the BGC Project would involve a number of energy sources to meet the specific requirements of different parts of the project. These are summarised in the following sections, including the predicted energy consumption and potential management measures to minimise consumption, while meeting the overall project objective of hydraulic containment and destruction of the contaminants.

**Electricity**

Electricity would be used to power a number of aspects of the project, including:

- operation of the extraction pumps in the groundwater wells installed in the three containment lines, to extract and transfer the contaminated groundwater to the GTP;
- operation of the air blowers, pumps and other equipment within the GTP treatment processes;
- operation of the treated water distribution pumps to transfer treated groundwater to other process users on the BIP (and elsewhere in the area, as required);
- operation of the treated water discharge pumps to transfer the excess treated groundwater to Bunnerong Canal; and
- provision of power for miscellaneous aspects, such as the control system and lighting.

The estimated annual electricity consumption for these aspects of the project is presented in Table 18.1, based on a power requirement of 2.3 MVA for the GTP and 0.55 MVA for the extraction well system.
### Table 18.1 Annual electricity consumption

<table>
<thead>
<tr>
<th>Project Element</th>
<th>Annual Electricity Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kWh</td>
</tr>
<tr>
<td>Pumping/Transfer System</td>
<td>4,820,000</td>
</tr>
<tr>
<td>GTP Operation and Treated Water Discharge</td>
<td>20,150,000</td>
</tr>
<tr>
<td>Total</td>
<td>24,970,000</td>
</tr>
</tbody>
</table>

This power will be supplied from existing EnergyAustralia facilities.

The following management measures would be incorporated into the project to maximise the efficient use of electrical power:

- installation of variable speed drives on pumps, to allow for variations in pumping rates;
- regular review of pumping rates required for hydraulic containment to minimise the risk of overpumping and to identify potential reductions in pumping rates;
- engineering design to incorporate energy saving measures, such as specifying high efficiency electric motors and employing waste heat recovery systems where practical;
- monitoring the operation of the GTP to ensure that the plant is operating in line with design parameters; and
- use of energy efficient lighting systems where installed, such as on the GTP.

**Natural Gas**

The operation of the thermal oxidiser would require natural gas as a support fuel to maintain the operating temperature within the oxidiser, thus maintaining the design destruction efficiency and minimising air emissions based on best practice operation.

The natural gas supply required to maintain the design operation of the thermal oxidiser has been estimated to be around 1040 kg/hr during normal operation (with the full contaminant load on the oxidiser) increasing to 1400 kg/hour when the oxidiser is operating on natural gas only (for example, during start-up). These gas flows provide an energy supply of approximately 54–72 GJ/hour (based on typical heating value of natural gas).

The gas would be sourced from the existing gas supply systems on the BIP.

**Diesel Fuel**

Minor use of diesel fuel would be required for the transport of materials during the operation of the GTP, such as the delivery of the recovered waste EDC liquid from Terminals Pty Ltd’s bulk liquid storage facility at Port Botany to the GTP, and ongoing inspection and maintenance activities across the BGC Project for the project lifetime.
The anticipated diesel use from such vehicle movements and maintenance activities is considered to be minor.

18.3 **Greenhouse Gas Emissions**

As a result of the predicted energy consumption, greenhouse gases—predominantly carbon dioxide—would be emitted to atmosphere, both directly, from site activities (e.g. from the use of diesel fuel in vehicles and the oxidation reactions in the thermal oxidiser) and indirectly (e.g. from the use of electricity generated by burning fossil fuels at power stations).

These activities are assessed below, for each of the project stages.

18.3.1 **Supply and Construction**

During the construction phase, GHG emissions would result from the use of fuels during equipment and material supply to the construction sites, operation of construction equipment during construction activities, and from the use of electricity in construction activities.

The major impacts of construction relate to the consumption of non-renewable energy resources and the potential effect on local and regional air quality.

At present, the construction activities—predominantly earthmoving—cannot be undertaken using alternative fuel sources. However, implementation of safeguards would ensure that non-renewable energy sources are used efficiently.

18.3.2 **Operation**

The BGC Project—groundwater extraction, transfer, treatment, discharge—would operate continuously at 95% availability for up to 30 years. The GTP would be managed through an automatic central control system, which would continuously monitor process parameters to ensure that the system is operating efficiently and meeting the design objectives.

In addition, the effectiveness of the hydraulic containment would be monitored through the installed monitoring wells for each containment line, and would be regularly reviewed to assess the ongoing rates of pumping and treatment throughout the life of the project.

**Electricity Consumption**

The amount of indirect GHG emissions resulting from electricity consumption can be calculated through the use of an emissions factor. Under the NSW Greenhouse Gas Abatement Scheme, the *Greenhouse Gas Benchmark Rule (Compliance) No. 1 of 2003* provides an annual greenhouse gas coefficient for power generation in NSW. This is calculated as the average emissions per unit of electricity delivered for all generating systems supplying the notional NSW electricity supply pool, and has been specified as 0.906 tonnes of carbon dioxide equivalent (CO₂-e) per megawatt hour (MWh).
Annual estimated GHG emissions resulting from the electricity usage, as predicted in Table 18.1 for the BGC Project, are presented in Table 18.2.

### Table 18.2 Annual GHG emissions from electricity usage

<table>
<thead>
<tr>
<th>BGC Project Element</th>
<th>Annual GHG Emissions (tonne CO₂-e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumping/Transfer System</td>
<td>4,370</td>
</tr>
<tr>
<td>GTP Operation and Treated Water Discharge</td>
<td>18,260</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22,630</strong></td>
</tr>
</tbody>
</table>

GHG emissions associated with the combustion of natural gas in the thermal oxidiser are accounted as part of the GTP process GHG emissions.

**CHC Destruction and Natural Gas Consumption**

As described in Chapter 5, the thermal oxidiser, which would be used to treat the off-gas stream, would oxidise the CHCs into predominantly carbon dioxide, water and hydrogen chloride.

The thermal oxidiser would also oxidise the natural gas support fuel into carbon dioxide and water.

The assessment of the emissions to air from the operation of the GTP, as presented in Chapter 22, included a determination of the generation of CO₂ emissions during normal operation from the oxidation reactions of both the CHCs and the natural gas. The estimated emission rate of CO₂—including the potential CO₂ stripped from the groundwater—is about is 33,000 tonnes.

During operations such as start-up, when the thermal oxidiser is operating on natural gas only, CO₂ emissions would be higher, estimated at approximately 3.5 tonnes per hour. As the GTP is designed for continuous operation at 95% availability, with a maximum continuous shutdown period of one week per year. Operation at this higher emission rate would be infrequent.

The selection and operation of the thermal oxidiser technology has primarily been based on achieving best practice contaminant destruction and emissions, and energy efficiency options have been incorporated within these objectives.

**GHG Emissions Summary**

Table 18.3 summarises the anticipated annual GHG emissions from the BGC Project.

### Table 18.3 Annual GHG emissions summary

<table>
<thead>
<tr>
<th>BGC Project Element</th>
<th>Annual GHG Emissions(tonne CO₂-e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumping/Transfer System</td>
<td>4,370</td>
</tr>
<tr>
<td>GTP Operation &amp; Treated Water Discharge</td>
<td>18,260</td>
</tr>
<tr>
<td>GTP Process Emissions</td>
<td>33,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>55,630</strong></td>
</tr>
</tbody>
</table>
The above emission estimates should be considered in the context of Orica Group (including its listed subsidiary, Incitec Pivot)’s total annual emissions of GHGs, which globally amount to approximately 6 million tonnes CO₂-e, of which approximately 3.3 million tonnes were emitted in Australia. These emissions include all direct emissions plus emissions from upstream electricity generation.

Mitigation measures proposed as part of the BGC Project are discussed in the following section.

## 18.4 Mitigation Measures

### Existing Mitigation Measures

Orica has been a member of Greenhouse Challenge since 1996 and since this time has achieved significant reductions in greenhouse gas emissions. Since 2000, Orica has reduced its greenhouse gas intensity by 27% per tonne of production and is committed to further reductions in the future. Consequently, the greenhouse gas emissions from the BGC Project could potentially be absorbed in these future emissions reductions.

Examples of works that have resulted in significant reductions in emissions include:

- closure of the old mercury cell chlor-alkali plants at Botany and Yarraville (in Victoria), and their replacement with modern membrane plants;

- continued increases in the efficiency of ammonia plants at Kooragang Island (Newcastle) and Gibson Island (Queensland); and

- general improvements in energy efficiency across the company, which have resulted in an improvement of 18% per tonne of production since 2000.

### Proposed Mitigation Measures

Table 18.4 provides a summary of the proposed mitigation measures for the construction and operation of the BGC Project to minimise energy consumption and the emission of GHGs.

These measures are consistent with the primary objectives of the BGC Project, which are to achieve the hydraulic containment of the contaminated groundwater and to maximise the destruction of contaminants.
Table 18.4 Summary of energy conservation measures

<table>
<thead>
<tr>
<th>Safeguard</th>
<th>Design</th>
<th>Pre-construction</th>
<th>Construction</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throttle down or switch off idle construction equipment.</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Switch off the engines of trucks while they are waiting to access the site and while they are being loaded or unloaded.</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ensure equipment is properly maintained to ensure efficient energy consumption.</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Use recycled materials and recycle materials (demolition materials, construction materials, paper, glass, etc), where feasible.</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Source materials from local suppliers where appropriate i.e. concrete.</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Regularly review pumping rates required for hydraulic containment to minimise the risk of overpumping and identify potential reductions in pumping rates</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>GTP process design would incorporate energy saving measures where appropriate</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Operation of the GTP would be monitored to ensure the plant is operating in line with design parameters</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Energy efficient lighting systems would be employed around the GTP where safe and practical</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

18.5 Conclusion

The construction and operation of the BGC Project would require the use of a number of energy sources to provide power and energy for various elements of the project, resulting in both direct and indirect GHG emissions.

The primary objectives of the project are to achieve the hydraulic containment and to maximise the destruction of the contaminants, and the project design and operation is based on meeting these objectives. Within these constraints, Orica proposes to use best management practice to ensure the most effective use of energy, both from an economic and environmental perspective throughout the construction and operation of the BGC Project.
19.1 Introduction

The purpose of this chapter is to present the results of the visual assessment of the BGC Project, which was undertaken to assess the potential visual impact of the project on people residing, working and travelling through the surrounding area.

The assessment covers the various elements of the overall BGC Project. These include the GTP in the context of the extensive existing industrial development and activities in the Project Area, and the extraction well containment lines and transfer pipelines in the context of their design and adjoining land uses.

The assessment has been based on a combination of desk-top studies and a site visit.

19.2 Site Description

The topography of the Botany area is generally flat and highly urbanised, containing industrial, residential and parkland areas with some commercial facilities. Port Botany and Sydney Airport dominate the industrialised visual environment in the north-eastern shorelines of Botany Bay. The bay, located approximately 1.5 km to the south-west of the GTP, is a significant feature in the area.

19.2.1 GTP Site

The site for the GTP is located within the BIP, which includes a number of large manufacturing plants:

- the BIP Utilities area, just to the west of the GTP site, which includes the coal-fired and gas-fired boiler plant for the site, with two 73 m high and one 48 m high discharge stacks;
- the Alkatuff and Alkathenes manufacturing plant, just to the north of the GTP site, with various chemical plant structures (e.g. columns and flares) up to 25 m high;
- the Olefines manufacturing plant, further to the north of the GTP site, with various chemical plant structures (e.g. furnaces, stacks and flares) from 35 m to 72 m high; and
- the Chlor-Alkali Plant, to the south of the GTP site, with stacks between 15 m and 25 m high.

The BIP itself is located close to other industrial developments such as Rail Access and FreightCorp’s railway facilities, the Mobil Oil Terminal, Kelloggs, BOC, the Caltex Oil Terminal, CTAL and Patrick Container Terminals, Boral, Amcor Fibre Packaging, Bulk Liquids Berth, Metal Recyclers, Nuplex Industries Australia Pty Ltd, Nalco, Solvay Interox and Air Liquide Australia (all within a 2 km radius of the BIP site).

In visual terms, the boundaries of the operating portion of the BIP, with a developed area of approximately 73 hectares, are not distinguishable from the other adjacent industrial properties.

The various operations within the BIP consist of numerous highly visible industrial features, including storage tanks, administration and workshop buildings, distillation columns, cooling towers, processing plants and equipment (both open and closed structures). The highest existing structures are a distillation column and the boilers stacks that stand approximately 73 m above the ground, and which are painted in red and white bands to make them easily visible to aircraft.
Water vapour plumes from the site cooling towers are quite visible on low temperature, high humidity days.

**19.2.2 Other Areas**

The other sites located within the overall Project Area, in which works associated with the project are being undertaken, are briefly described below.

**Southlands**

Southlands is an undeveloped block of land just to the west of the BIP that has previously been used for waste disposal and dumping, and is now overgrown with a variety of exotic flora species. The land is low-lying and some depressions are now permanently filled with water, resulting in a number of ponds, particularly on the eastern side.

Southlands is bisected by Springvale Drain, an open stormwater drain, alongside which is Nant Street, an unsurfaced road that crosses the land. Floodvale Drain, similar to Springvale Drain, abuts the western edge of the area.

The land is fenced around the boundary, and is partially visible from McPherson Street, which runs along the southern end.

**Foreshore Road**

Foreshore Road is a main arterial road in the area, with two lanes of asphalt surface either side of a median strip, which is a mix of paved and unpaved ground, at the same level as the road surface.

Immediately south of Foreshore Road are vegetated dunes that lead down to Foreshore Beach and Botany Bay.

Sir Joseph Banks Park and the Botany Golf Course are situated to the north of Foreshore Road.

The land beyond these open space areas primarily consists of commercial developments and urban roads.

**Bunnerong Canal**

Bunnerong Canal is a concrete lined stormwater channel that was originally constructed for the discharge of cooling water from the old Bunnerong Power Station into Botany Bay. The canal is crossed by Bumborah Point Road, at the same location as the existing discharge pipeline that connects Terminals Pty Ltd’s bulk liquid storage facilities at Port Botany with the BIP.

The canal base is also concrete, but is largely covered with sediment deposited from a combination of stormwater flows and tidal activity.
19.3 GTP Visual Assessment

Since the GTP is the major development to be constructed in the area, the following detailed assessment has focused on this element of the overall BGC Project.

The other project elements, located outside the BIP, have been considered and assessed separately.

19.3.1 GTP Development

The GTP is illustrated in Figure 5.13, which presents a 3D image of the design and layout of the plant. The GTP comprises various industrial structures including storage tanks, pipe rack, treatment vessels/units, site building and exhaust discharge stack.

The tallest component of the plant is the discharge stack, which would be approximately 20 m high from the GTP site ground level. Other structures would include the feed and treated water tanks (around 12 m high), the double bank of air strippers (around 10 m high) and the site control building (around 6 m high).

Construction of the GTP would involve activities and equipment as described in Chapter 5, with crane works that would extend to a height above the discharge stack. Construction would take approximately nine months.

19.4 Visibility

The potential visual impact of the GTP would result from the combination of the following factors:

- visibility of the components of the GTP; and
- visual absorption capacity of the landscape in which these components are placed.

Visibility is a measure of the extent to which the GTP may be visible from surrounding areas, the relative number of viewers, the period of the view, distance of view and context of the view.

The underlying rationale for this aspect of the visual assessment is that:

- if a portion of the GTP is not visible from a particular location, then the potential visual impact is nil; and
- if the number of people who would potentially see the GTP is low then the visual impact would be relatively low, compared to a situation in which a large number of people had the same view.

Distance is a strong influence on potential visual impact, because the proportion of the total view from a particular location that is taken up by the plant decreases with distance. In addition, atmospheric influences would tend to reduce the level of visual contrast between the proposed plant and adjoining landscape, thus reducing the level of visibility.
The visibility assessment that was carried out for the GTP involved:

- determination of the various categories and situations from which the GTP would potentially be visible; and
- a field inspection to determine the extent of visibility.

A summary of the visibility of the GTP is presented in the visibility matrix in Table 19.1. This matrix indicates the locations of nominated view situations identified during the field inspections. Figure 19.1 shows the specific view locations identified during the field inspections.

<table>
<thead>
<tr>
<th>Period of View</th>
<th>Long Distance</th>
<th>Medium Distance</th>
<th>Short Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>M</td>
<td>S</td>
</tr>
<tr>
<td>High number of viewers</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Medium number of viewers</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Low number of viewers</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

19.4.1 Visual Absorption Capacity

Visual absorption capacity is an estimation of the capacity of the landscape to absorb development without creating a significant change in visual character or producing a reduction in scenic quality. The capacity to absorb development is primarily dependent on vegetation cover, landform and existing structures. A major factor influencing visual absorption capacity is the level of visual contrast between the proposed new development and the existing elements in the landscape. If, for example, a visually prominent industrial development already exists, then the capacity of that section of landscape to visually absorb additional industrial structures is higher than that of a similar section of landscape that has a natural, undeveloped visual character.

The capacity of the landscape surrounding the proposed GTP to absorb change was assessed and determined to be moderate to high, based on a combination of the following factors:

- the existing industrial environment of the immediate landscape surrounding the site;
- the existing vertical elements within the surrounding landscape (industrial structures, stacks and chimneys); and
- the existing structural and built elements (power poles, wires and signage) along and surrounding the main road corridors.
19.4.2 Visual Assessment Criteria

The quantitative criteria listed in Table 19.2 have been determined and used in the assessment.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Viewers</strong></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>&gt;1000 people per day</td>
</tr>
<tr>
<td>Medium</td>
<td>100-1000 people per day</td>
</tr>
<tr>
<td>Low</td>
<td>&lt;100 people per day</td>
</tr>
<tr>
<td><strong>View Distance</strong></td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>&gt;500m</td>
</tr>
<tr>
<td>Medium</td>
<td>100-500m</td>
</tr>
<tr>
<td>Short</td>
<td>&lt;100m</td>
</tr>
<tr>
<td><strong>Period of View</strong></td>
<td></td>
</tr>
<tr>
<td>Long term</td>
<td>&gt;120 minutes</td>
</tr>
<tr>
<td>Moderate term</td>
<td>1-120 minutes</td>
</tr>
<tr>
<td>Short term</td>
<td>&lt;1 minute</td>
</tr>
</tbody>
</table>

The resulting visibility matrix, using these assessment criteria and the identified view situations shown in Figure 19.1, is presented in Table 19.3.
### Table 19.3 GTP visibility matrix

<table>
<thead>
<tr>
<th>Viewing Location</th>
<th>Category of Viewers</th>
<th>Context of Potential View</th>
<th>Likely Period of View</th>
<th>Relative No. of Viewers</th>
<th>Distance of View to GTP</th>
<th>Visibility Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location 1</td>
<td>Employees, motorists within car park</td>
<td>View from within existing commercial area/multi-storey car park.</td>
<td>Varies for employees and motorists but generally &lt;2 min</td>
<td>Pedestrians and employees moderate.</td>
<td>1000–1300 m</td>
<td>Low to very low</td>
<td>Generally short-term and indirect views, only from upper sections of multi-storey car park across existing industrial areas</td>
</tr>
<tr>
<td>Location 2</td>
<td>Pedestrians, motorists, residents</td>
<td>View from within and across road corridor</td>
<td>&lt;2 min (pedestrians)</td>
<td>Pedestrians low Residents moderate Motorists high</td>
<td>400–500 m</td>
<td>Nil</td>
<td>Views to GTP generally screened by vegetation along Denison Street and existing structures within the BIP</td>
</tr>
<tr>
<td>Location 3</td>
<td>Pedestrians, motorists and employees at adjacent commercial and industrial properties</td>
<td>View from road corridor and commercial and industrial premises</td>
<td>&lt;2 min (pedestrians)</td>
<td>Pedestrians low Employees low Motorists high</td>
<td>500–600 m</td>
<td>Nil</td>
<td>View to GTP generally blocked by existing buildings and structures within the BIP</td>
</tr>
</tbody>
</table>
## Landscape and Visual View

<table>
<thead>
<tr>
<th>Viewing Location</th>
<th>Category of Viewers</th>
<th>Context of Potential View</th>
<th>Likely Period of View</th>
<th>Relative No. of Viewers</th>
<th>Distance of View to GTP</th>
<th>Visibility Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stephen Road</td>
<td>Motorists, pedestrians employees at adjacent commercial and industrial properties. Residents along Stephen Road</td>
<td>Generally restricted to glimpsed views between existing commercial and industrial development, or views from the rear of existing industrial/commercial development.</td>
<td>&lt;2 min for motorists and pedestrians. Varies for employees. Varies for residents.</td>
<td>Pedestrians low. Employees, residents and motorists moderate.</td>
<td>600–800 m</td>
<td>Low to very low</td>
<td>Views towards the BIP from Stephen Road generally screened by existing buildings, with occasional glimpsed views between buildings. Views toward GTP screened by existing buildings.</td>
</tr>
<tr>
<td><strong>Location 5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brighton Street</td>
<td>Motorists, pedestrians and residents along Brighton Street</td>
<td>Motorists with indirect views from road corridor. Direct views over and beyond the BIP from east facing residences along Brighton Street.</td>
<td>&lt;2 min (motorists). 10 sec (motorists). Varies for residents.</td>
<td>Pedestrians low. Motorists and residents moderate.</td>
<td>1000–1200 m</td>
<td>Low</td>
<td>Generally open and extensive view from residences along east side of Brighton Street over the BIP. GTP site generally screened by existing buildings and industrial infrastructure.</td>
</tr>
</tbody>
</table>
19.4.3 Photographs

The following photographs present an indication of the views toward the GTP site.

Plate 19.1  View west from Denison Street towards the BIP. Views of GTP site screened by existing trees and buildings within site.

Plate 19.2: View east from northern end of Brighton Street towards the BIP. Distant views towards GTP site partially screened by existing trees and buildings within site.

Plate 19.3: View east from northern end of Brighton Street towards the BIP. Distant views towards GTP site partially screened by existing trees and buildings within site.
These photographs clearly demonstrate that the GTP would be virtually screened from view in areas beyond the boundaries of the BIP, by the existing buildings, structures and trees.

### 19.4.4 Summary of Visual Assessment: GTP

Five view locations were identified and assessed as part of the visual assessment process, and included a number of view situations, including views from:

- East Gardens Shopping Centre (commercial area);
- Denison Street (road corridor and residential area);
- Beauchamp Road/Perry Street (road corridor, commercial & industrial premises);
- Stephen Road (road corridor, pedestrian and commercial/industrial areas); and
- Brighton Street (road corridor, pedestrians and residential areas).

The potential extent of visibility of the GTP is generally restricted to the elevated areas east of the site around Brighton Road, and occasional glimpsed views towards the site along Stephen Road. These views would be limited to the upper portions of the GTP structures, with views of lower portions blocked by existing buildings and industrial structures.

Views from residences would be generally restricted to those situated along Brighton Street, with the majority of these views taking in a significant portion of the BIP. Consequently, any view of the GTP site would be in the context of the extensive existing industrial development.

A similarly low level of visibility would apply to the construction and operating phases of the GTP. The construction phase is unlikely to result in any greater visual impact, given the activities involved, the mitigation measures to be implemented (to avoid, for example, dust generation), the low numbers of construction vehicles relative to existing traffic flows, and the short timeframe of the work.

### 19.4.5 Other Operational Visual Impact

Under certain weather conditions (low temperature, high humidity) the operations would have the potential to generate a visible steam plume, around 10 to 15 m above the discharge stack. The height and extent of any such plume would vary with prevailing atmospheric and operating conditions.

Any such plume would only be generated in certain weather conditions, and would be in the context of much larger plumes generated in similar weather conditions from the existing discharge stacks and cooling towers associated with industrial plant within and adjoining the BIP.

It is therefore considered that no significant visual impact would result from such plumes.
19.5 Additional Visual Assessment

The following points summarise the potential visual aspects of the other elements of the BGC Project within the Project Area:

- **Construction Activities**: Construction of the extraction wells on Southlands and the BIP would involve the use of drilling rigs that may be visible from a number of viewpoints. However, these activities would only be short-term, and are in the context of the disturbed nature of Southlands itself and the industrial background of the BIP and other existing industrial facilities. Similarly, the construction of the DNAPL transfer pipeline would be low level and in the context of the existing industrial facilities throughout the BIP. The construction works on the underground discharge line would be minor and very localised, and hence would have no significant visual impact.

- **Extraction Wells**: All of the extraction wells and monitoring wells would be installed underground, and would have no significant visual impact. The wells on Foreshore Road have been connected to underground piping, and hence there would be no visible elements, other than the concrete covers at ground level in the median strip. The wells on Southlands and the BIP would be connected to aboveground piping, installed on low-level pipe racks (see below).

- **Aboveground Transfer Pipelines**: The primary and secondary pipelines have been installed on low-level pipe racks across Southlands, which are visible from McPherson Street but are set in the context of the disturbed nature of Southlands itself and the industrial background of the BIP and other existing industrial facilities. The DNAPL pipeline on the BIP would similarly be installed on low-level pipe racks and would blend in with the existing industrial facilities across the BIP.

- **Underground Transfer Pipelines**: The secondary pipeline would be buried from Foreshore Road to Southlands Block 2. Both the primary pipeline and secondary pipeline are underground where they cross Nant Street, the EnergyAustralia land adjacent to Southlands Block 1 and the Sydenham–Botany goods railway line. These sections of transfer pipeline have no visual impact.

- **Discharge Pipeline**: The majority of the discharge pipeline is installed underground, and once the construction activities of the refurbishment were complete, the only aboveground indication would be the existing markers showing the location of the pipeline easement and the point at which the pipe enters the canal. The discharge point diffuser, installed on the side of Bunnerong Canal and visible from the bridge of Bumborah Point Road, would be similar to the existing pipe crossing at the same point. The treated water discharge would be seen in the context of existing stormwater discharges and tidal movements in the canal.

It is not considered that the other elements of the BGC Project would result in any significant change to the existing visual amenity of the area.

19.6 Conclusion

The visual assessment indicates that the BGC Project would have a low level of visibility across all elements of the project and all the identified view situations.
The potential visual impact would generally be low, due to the combination of the following factors:

- generally high visual absorption capacity of the existing operations within the BIP;
- nature of existing viewers and limited view locations (views generally restricted to within the BIP complex);
- existing trees that screen views towards the Project Area along the Denison Street boundary, and existing industrial structures within the BIP that block views of the proposed development;
- low number of residential properties with direct views to the aboveground development; and
- design of the other elements (underground or low-level) and nature of the existing visual amenity in the affected areas, which have no visual impact.

Overall, the BGC Project would have a low impact on the visual quality of the Project Area.
20.1 Introduction

This chapter describes the existing environments of the overall Project Area and the threatened species, populations and communities present; assesses the impact of the BGC Project; and presents the proposed mitigation measures identified to ameliorate any such potential impacts.

Although much of the Project Area has been subject to a long history of development and industrial use, potential impacts may occur as a result of the anticipated changes in groundwater and surface water flow patterns, particularly in the vicinity of Penrhyn Estuary.

The assessment has been undertaken through desk-top review of the extensive existing information and data about the study area, in particular the studies undertaken as part of the Port Botany Expansion EIS (URS, 2003) and including a desk-top assessment of the impact on invertebrate benthic species and a separate desk-top assessment of the potential impacts on migratory and threatened shorebird communities in Botany Bay.

20.2 The Study Area

The study area associated with the ecological assessment of the BGC Project has been limited to specific areas across the overall Project Area that could be affected by the project’s construction and operation, as illustrated in Figure 20.1. These specific areas and the potential impacts include:

- potential impacts on Lachlan Swamps, to the north and north-west of the BIP, from groundwater recharge;
- potential impacts on Southlands, to the south of the BIP, from the construction of groundwater extraction wells, and operation of the wells and transfer pipelines;
- potential impacts on Foreshore Beach, to the south-west of the BIP, from the changes in groundwater and surface water flows resulting from the operation of the hydraulic containment;
- potential impacts on Penrhyn Estuary, to the south-west of the BIP, from the changes in groundwater and surface water flows resulting from the operation of the hydraulic containment; and
- potential impacts on Brotherson Dock and Botany Bay, to the south of the BIP, from the discharge of the treated groundwater into Bunnerong Canal.

Due to extensive historical development and industrial use, the following areas contain no native vegetation or potential habitats for threatened species and were not assessed in detail:

- the GTP site;
- the extraction wells and pipelines that are not on Southlands; and
- the treated water discharge line refurbishment and works at the discharge point at Bunnerong Canal.
20.3 Methodology

20.3.1 Terrestrial Ecology Study

The terrestrial ecology study focused on Penrhyn Estuary and the eastern end of Foreshore Beach. It also included Southlands Blocks 1 and 2, and Lachlan Swamps.

The study area was limited to those areas that could be affected by the BGC Project, as shown in Figure 20.1.

The assessment was based on literature review of information databases and previous relevant studies, to determine the likely presence of flora and fauna species and their habitats, including:

- the Proposed Third Runway Sydney (Kingsford Smith) Airport Draft EIS (Kinhill, 1990);
- Patrick Port Botany Container Terminal Upgrade EIS (PPK, 2002); and
- the Port Botany Expansion EIS (URS, 2003).

No field surveys were undertaken, or considered to be required as part of this assessment, because it was considered that there was sufficient existing information available to make an assessment of the impacts of the BGC Project.

A desk-top study was conducted by Avifauna Research & Services to assess the potential impacts on migratory and threatened shorebird communities. The full study is presented in Appendix H.

20.3.2 Aquatic Ecology

The aquatic ecology study area focused solely on Penrhyn Estuary and the eastern end of Foreshore Beach. This is the area in which groundwater flows would be contained.

As for terrestrial ecology, the assessment of aquatic ecology included a literature review of information databases and previous relevant studies (as listed in Section 20.3.1) to determine the likely presence of flora and fauna species and their habitats.

Specialist aquatic ecologists, The Ecology Lab, conducted an assessment of potential impacts on the ecology of Penrhyn Estuary and Foreshore Beach. The aims of the study were to:

- identify and review existing information on the habitats and biota that may be affected;
- summarise the BGC Project with respect to potential effects on aquatic ecology of the study area;
- assess impacts of the BGC Project on the aquatic ecology of Penrhyn Estuary and subtidal and intertidal habitats near Foreshore Beach, including the populations of invertebrates living in subtidal and intertidal habitats;
define testable predictions about changes likely to occur to habitats and biota, and
suggest measures that could be taken to mitigate the identified impacts.

The complete study is presented in Appendix H.

20.4 Existing Environment

20.4.1 Botany Wetlands

The Botany wetlands are located on the northern shore of Botany Bay, and run in an arc to the north and west of the BIP. The wetlands are considered nationally important wetlands, and have been listed by the Federal Department of the Environment and Heritage in the Directory of Important Wetlands in Australia (Environment Australia, 2001).

The wetlands include the Lachlan Swamps, Mill Pond, Mill Stream and Engine Pond, and consist of a chain of 11 ponds, the larger of which are open water with fringing vegetation. They are maintained by surface runoff and the underground Botany aquifer. Historically the wetlands were a water supply for Sydney and nearby industrial areas. There are numerous banks and structures in the complex, most of which no longer function.

Areas of marsh and teatree (several species) and broad-leaved paperbark (Melaleuca quinquenervia) swamp also occur. Common sedges include tall spike rush (Eleocharis sphacelata), club-rush (Bolboschoenus caldwellii) and marsh club-rush (Bolboschoenus fluviatilis), jointed twig-rush (Baumea articulata) and soft twig-rush (Baumea rubiginosa).

There has been considerable disturbance to both the physical integrity and the water quality of the wetlands over time. The wetlands form the lower part of a trunk drainage system in a 20 km² urbanised catchment, and consequently have high silt and other pollutant loadings from urban runoff. The invasive weed water primrose (Ludwigia peruviana) dominates about 20 hectares of the wetlands, and other aquatic and terrestrial weeds are abundant.

Lachlan Swamp is characteristically known to include the catchment section between The Lakes and Eastlake Golf Courses (SMEC, 1992). Flora and fauna in this area have largely been modified or removed for development. Some remnants of the endangered ecological community, Eastern Suburbs Banksia Scrub (ESBS), has been reported to occur, in poor condition, in the Bonnie Doon, Eastlake and The Lakes Golf Course areas (Sauvetere, 1997).

20.4.2 BIP

The GTP would be situated within the footprint of the former silicates plant on the BIP. Both the specific GTP site, and the BIP as a whole, have been subject to extensive use and disturbance, primarily for industrial activities, for more than 60 years. In addition, the GTP site is currently largely paved with asphalt, with the remaining area consisting of building rubble following the substantial demolition of the Silicates Plant previously located at the site.
The additional BGC Project works proposed on the BIP (the installation of the DNAPL containment line extraction wells and transfer pipeline) would also be undertaken on areas that have been subject to extensive historical use and disturbance, as well as containing existing developments (such as the paved 1st Street and 2nd Street, where the wells are to be installed).

Given this, these areas are considered to contain no vegetation of conservation value and are not likely to have any habitats suitable for threatened species. Therefore, no potential impact on flora and fauna would be expected.

### 20.4.3 Southlands

Extraction wells and pipelines to the GTP would be constructed on Southlands, adjacent to the BIP. Southlands is predominantly a levelled site, which contains little original vegetation or surface features. It occupies alluvial terrain that was originally loose sand, root-bound soil and humus (BEC, 1997). Southlands has been subject to extensive previous use for peat cutting, dumping of solid wastes, discharge of paper waste slurry, and storage of waste paper.

The site is often boggy, with swampy areas in the north-west corner and in the eastern half of Block 1, as well as a number of permanent water ponds (resulting from the previous peat cutting activities) that fluctuate depending on the level of rainfall. The ponds are surrounded by rubble mounds overgrown with exotic weeds, but also have extensive beds of reeds and bulrushes (BEC, 1997).

Southlands is dominated by exotic weed species, including pampas grass (*Cortaderia sellona*), lantana (*Lantana camara*), castor oil plant (*Ricinus communis*), and green cestrum (*Cestrum parqui*).

Previous field surveys have shown that 34 out of 38 vascular plant species identified on the site do not naturally occur in NSW, and have concluded that “the site contains no conservationally significant flora species or vegetation types, as the site was previously cleared of all native flora and is predominantly inhabited by species that do not naturally occur in NSW” (Dames & Moore, 1996).

The site provides a range of habitat features of potential value for some native fauna; in particular, the varied substrate of rock, rubble, building materials and soil provides potential refuge and foraging substrates for a variety of native reptiles and amphibians.

However, the poor water quality discharging into Springvale and Floodvale Drains (particularly from the contaminated groundwater) is considered to reduce the potential for amphibians to inhabit these areas (Dames & Moore, 1996). This is discussed further in Section 20.5.

### 20.4.4 Penrhyn Estuary

Hydraulic containment would reduce groundwater input to Penrhyn Estuary. The estuary is a small tidal inlet to the north of Brotherson Dock. It was formed from the reconfiguration of the northern shores of the Bay in the late 1970s, as a result of the construction of Port Botany.

Penrhyn Estuary is essentially comprised of an inner estuary and an outer estuary. The inner estuary comprises a small shallow lagoon (approximately 1.4 m deep). Floodvale and Springvale Drains flow into the estuary from the industrial and residential catchments of Banksmeadow and Matraville, forming two distinct deltas. As well as conveying stormwater after rainfall, these drains carry a base flow of shallow
contaminated groundwater. Sand and mud flats cover most of the shore and in some areas there are oysters on the mud flats. There is a derelict boat ramp on the eastern side of the inner estuary, with some rock rubble at the base of the ramp.

Towards the back of Springvale Drain, there are areas of mangroves ranging from juvenile seedlings to mature mangrove trees. Saltmarsh plants, *Sarcornia* spp and *Suaeda* are abundant on the shore fringing the more stable rush grass *Juncus kraussii* and *Isolepis nodosus*. No seagrasses were recorded in the inner estuary (URS, 2003).

The inner and outer estuaries are connected via a narrow channel that has reduced in width in recent years due to the accretion of sand from Botany Bay. The outer estuary comprises four habitats:

- sand and silty intertidal flats on both sides of the estuary;
- unvegetated subtidal habitats ranging from sand in the shallows to dark silty mud in deeper areas, to at least –3 m, which is the lowest tidal level;
- vegetated subtidal habitats, including seagrass and some algae, occurring from the low tide mark around the edges of the estuary (seagrass beds (*Zostera capricornii*) approximately 0.2 hectares in area); and
- artificial substratum, including the new boat ramp and jetty on the eastern side of the outer estuary and a derelict rock groyne and wharf pilings at the western end of the estuary (areas of seagrass (*Zostera capricornii*) surround these rocky structures).

The two drains that flow into Penrhyn Estuary (Floodvale Drain and Springvale Drain) have freshwater habitat in their upper catchments. These drains are highly disturbed by surrounding development and contaminants from industry and their value as freshwater habitat is considered to be very limited.

### 20.4.5 Foreshore Beach

The eastern end of Foreshore Beach, near Penrhyn Estuary, would suffer reduction in groundwater flows due to hydraulic containment. Foreshore Beach is composed of estuarine sands dredged from Botany Bay during previous Port Botany and Sydney Airport construction activities. The beach is currently eroding towards its eastern end, with sand migrating to the west and depositing at the mouth of the Mill Stream. There are no mangroves growing along the beach.

### 20.4.6 Brotherson Dock/Botany Bay

Brotherson Dock and Botany Bay would receive treated water from the GTP via the marine discharge point in Bunnerong Canal. Botany Bay contains a diverse array of aquatic habitats across the area that may be affected by the BGC Project, including:

- the water column;
- unvegetated soft sediments;
- hard substrata;
algae; seagrass; and saltmarshes and mangroves.

The bay has been declared a recreational fishing haven by NSW Fisheries and is currently one of the most popular fishing areas in NSW.

20.4.7 Other Aquatic Habitats of Significance in Botany Bay

There are several other important habitats on the southern side of the bay, including Towra Point Aquatic Reserve (a marine protected area and RAMSAR wetland) and Silver Beach, to the east of Towra Point. Other areas of interest include Lady Robinsons Beach and Cape Banks Scientific Marine Research Area.

These areas are all a significant distance (more than 6 km) from the BGC Project, and any activities associated with it, and hence no impacts are considered likely to occur.

20.5 Terrestrial Flora

20.5.1 Vegetation Communities

Three vegetation communities have previously been identified during field surveys in the study area (URS, 2003).

Planted Shrubland

This shrubland community occurs on marine sands and was recorded in the hind dunes along Foreshore Beach, the Mill Stream and Penrhyn Estuary. The community is dominated by Banksia integrifolia to approximately 7 m in height, a sparse to moderately dense and wind-pruned shrub stratum to 4 m in height, and a sparse groundcover to 0.5 m in height comprising herbs and grasses. Fore dune vegetation, comprising grasses and herbs to 30 cm in height, is also included in this plant community, occurring along Foreshore Beach and Penrhyn Estuary above the high water mark.

Sarcocornia quinqueflora/Suaeda australis (Saltmarsh)

This saltmarsh community, covering approximately 1.15 hectares, occurs on marine sands as well as alluvial deposits (muds) as a narrow fringe above the mangroves in the mid to upper intertidal zone of Penrhyn Estuary, on both the eastern and western sides of the channels entering the estuary. The community comprises a patchy herland to 0.5 m in height dominated by Sarcocornia quinqueflora and Suaeda australis and a dense rush meadow on the western side of the creek channel composed of Juncus krausii and Isolepis nodosa to 1 m in height. The rush meadow occupies most of the saltmarsh area. Scattered grey mangrove seedlings and shrubs to 1 m in height were recorded in the marsh zone. Small grassland patches were also recorded in the upper marsh zone on both sides of the creek channels.
**Avicennia marina (Grey Mangrove)**

This grey mangrove community is generally confined to the lower intertidal zone on both sides of the eastern channel entering Penrhyn Estuary, and has been frequently recorded encroaching into the saltmarsh zone. The community receives daily tidal inundation and varies in structure from low shrubland of scattered seedlings (frequently recorded in the marsh zone) to dense pockets of mature shrubs 2 to 3 m in height. Scattered grey mangrove seedlings and shrubs to 1 m in height were often recorded in the marsh zone.

**20.5.2 Floristics of the Study Area**

Previous studies have shown the floristic species diversity in the study area to be low, due to the disturbed nature of the site (URS, 2003). This is particularly true for the planted shrubland community along Foreshore Beach and the Mill Stream, which is disturbed by humans walking through and using the areas of shrubland. Rubbish is dumped in this area and there are problems with erosion.

In some places there are heavy infestations of the exotic shrub Bitou Bush (*Chrysanthemoides monilifera*).

**20.5.3 Conservation Significance**

**Vegetation Communities**

The Eastern Suburbs Banksia Scrub (ESBS) in the Sydney Basin Bioregion is listed as an endangered ecological community under both the TSC Act and the EPBC Act. While some shrubs and small trees characteristic of ESBS occur (as dominants) within the planted shrubland of Foreshore Beach, the shrubland is not considered to constitute ESBS as per the NSW Scientific Committee Final Determination (2002) for this plant community. None of the study area is mapped as ESBS by the NSW NPWS. A small remnant of ESBS occurs in Sir Joseph Banks Park, north of Foreshore Road. This remnant is not considered any further in this EIS, as it would not be affected by the BGC Project.

The planted shrubland community that occurs along the hind dunes of Foreshore Beach, along the Mill Stream and along Penrhyn Road foreshore, is of low to moderate conservation value. While this community was planted, some of the plantings are considered to be indigenous to the locality (characteristic of the remnant Coastal Dune Heath plant community) and thus the community would be expected to possess local conservation value. In many places, the study area has become infested with dense thickets of the exotic shrub Bitou Bush (*Chrysanthemoides monilifera*) and Lantana, particularly along the Penrhyn Estuary foreshore.

The saltmarsh community at Penrhyn Estuary is of high conservation value. This plant community colonised Penrhyn Estuary after the northern foreshore of Botany Bay was reshaped in the late 1970s. It remains the only saltmarsh on the northern shoreline of Botany Bay, following the destruction of two saltmarsh areas as part of the construction of the Parallel Runway in the mid-1990s. Saltmarsh is of high ecological significance to fish and migratory shorebirds.
The mangrove community at Penrhyn Estuary is of low to moderate conservation value. The present landward encroachment of mangroves into the mid/upper tidal marsh zone at Penrhyn Estuary would reduce the amount of saltmarsh area on the site over time. Mangroves are opportunistic colonisers of newly accreted sediment and thus increased land clearing and urbanisation in the catchment over the years—which has no doubt led to increased sedimentation and elevated nutrient levels at the estuary—appears to have promoted the expansion and productivity of mangroves.

Mangroves are proliferating in large numbers on the mudflats at Penrhyn Estuary. This, in turn, increases the number of seedlings germinating in the marsh zone, and so a proliferation of mangroves on the mudflats in intertidal areas would eventually be detrimental to the saltmarsh at Penrhyn Estuary unless active mangrove removal and control is carried out.

Flora Species

Based on NSW NPWS and EPBC database searches, 13 species of threatened flora listed under the TSC and/or EPBC Act have been recorded within the vicinity of the study area. Of the 11 flora species in the vicinity of the Project Area listed as having conservation significance, four are listed as Endangered and seven as Vulnerable under the TSC Act, and three are listed as Endangered and six as Vulnerable under the EPBC Act. The status and habitat details of these species are described in Appendix H.

The discussion presented in Appendix H illustrates that no plants listed under the TSC or EPBC Acts and previously recorded in the locality would be expected to occur within the study area, and therefore have not been considered further in this assessment.

20.6 Fauna

Desk-top studies were undertaken to determine the likelihood of threatened species, populations and ecological communities existing within the study area and, specifically, to assess amphibian (i.e. green and golden bell frog) habitats on Southlands and shorebird habitat in Penrhyn Estuary and Foreshore Beach and elsewhere in Botany Bay.

20.6.1 Conservation Significance

Threatened Fauna Species

Eighty-six species of terrestrial fauna listed as having conservation significance under the TSC and/or EPBC Act have been previously recorded in the vicinity of the study area or have been predicted to occur within the study area.

Of the 86 listed species, 24 species of resident and migratory shorebirds and seabirds, listed under the TSC Act and/or the EPBC Act, are known to occur or have previously been recorded at Penrhyn Estuary. Of these 24 species, seven are listed as Vulnerable and one (the Little Tern) as Endangered under the TSC Act; 22 are listed under international agreements (JAMBA and CAMBA) and 23 under the Bonn Convention of Migratory Animals.
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The species assessed as having a moderate or high likelihood of occurrence are summarised in Table 20.1. One of the species, the green and golden bell frog, was recorded in a survey on Southlands a number of years ago, but it is considered to have a low likelihood of occurrence in the general area, according to relevant databases. The status and habitat details of all species, including those with a low likelihood of occurrence, are presented in Appendix H. The study area does not represent suitable habitat for species with a low likelihood of occurrence, and these species are not considered further in this EIS.

### Table 20.1 Significant fauna species recorded in the vicinity of the study area

<table>
<thead>
<tr>
<th>Species</th>
<th>Conservation status</th>
<th>Habitat requirements</th>
<th>Likelihood of occurrence and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actitis hypoleucus</td>
<td>M, J, C</td>
<td>Sleep-sided muddy or rocky margins of various water bodies, whether saline, fresh or brackish. In coastal sites it is typically found on the margins of salt or brackish watercourses, tending to occur in the upper rather than the lower parts of estuaries.</td>
<td>Moderate Occurs most years in very low numbers in Botany Bay and presently roosts on a wooden jetty at Shell Point. The last sighting of the species at Penrhyn Estuary was a single sighting recorded by the NSW Wader Study Group in 1994.</td>
</tr>
<tr>
<td>Arenaria interpres</td>
<td>M, J, C</td>
<td>Occur mainly on rocky coasts, sometimes on ocean beaches, seldom on estuarine mudflats. In northern Australia, prefers coasts with wide intertidal mudflats.</td>
<td>Moderate Presently feeds and roosts on rock platforms at Boat Harbour and also roosts on wooden barges at Shell Point. This species is seldom seen on estuarine mudflats although may occasionally forage at Penrhyn Estuary. More often on rocky platforms and ocean beaches.</td>
</tr>
<tr>
<td>Calidris acuminata</td>
<td>M, J, C</td>
<td>Saltmarsh and intertidal mudflats but seems to prefer non-tidal wetlands, especially freshly exposed mudflats around drying lakes and swamps. May be found over a wide range of salinities, from freshwater wetlands through to hyper-saline inland lakes. Generally roosts and often feeds amongst low vegetation. Occasionally visits mangroves, beaches and rocky shores.</td>
<td>High Typically feeds and roosts in saltmarsh at the Barton Park (Eve Street) wetland and may occasionally forage and roost in the upper reaches of Penrhyn Estuary in mudflats and saltmarsh. Has been recorded at Penrhyn Estuary in 1995, 1996 (68 individuals) and 1997 (32 individuals).</td>
</tr>
<tr>
<td>Calidris alba</td>
<td>V, M, J, C</td>
<td>Sandy ocean beaches, where it feeds in the wave washed zone at low tide. At high tide roosts on beaches or on nearby rocky reefs. Favours beaches near estuaries rather than long stretches of uninterrupted beach. Sometimes roosts or shelters in estuaries but seldom feeds there.</td>
<td>High Occasionally seen in Botany Bay. Typically feeds in the wave zone of ocean beaches at Boat Harbour and will generally flee to the northern shores of the bay (Penrhyn Estuary) during rough weather for shelter and feeding.</td>
</tr>
</tbody>
</table>
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<table>
<thead>
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<tbody>
<tr>
<td>Calidris canutus red knot</td>
<td>M, J, C</td>
<td>Forages on intertidal sand and mudflats in estuaries. Usually roosts at high tide on beaches and other open sites.</td>
<td>High Presently feeds on intertidal sand and mudflats at Penrhyn Estuary and at Rocky Point and roosts at Penrhyn Estuary (typically in association with Godwits). Six individuals have been recorded feeding at Woolooware Shorebird Lagoon on the southern shores of the Bay on bivalve molluscs (pers. comm., Phil Straw). Up to about 200 individuals may be present in the Bay currently.</td>
</tr>
<tr>
<td>Calidris ferruginea curlew sandpiper</td>
<td>M, J, C</td>
<td>Forages on intertidal sand and mudflats in estuaries. At high tide roosts on beaches or rock platforms, or continues to feed in saltmarshes and backwaters. Frequents muddy margins of shallow inland wetlands.</td>
<td>High Presently feeds and roosts at Penrhyn Estuary on intertidal mudflats (feeding) and sandflats at the mouth of the estuary and on the north side of the channel (roosts).</td>
</tr>
<tr>
<td>Calidris ruficollis red-necked stint</td>
<td>M, J, C</td>
<td>Most numerous on intertidal sand and mudflats in estuaries. Frequents saltmarsh, ocean beaches and rocky shores. Inland, mostly numerous on the muddy margins of saline lakes, although often occurs at freshwater wetlands as well.</td>
<td>High Presently feeds and roosts at Penrhyn Estuary and occasionally at Boat Harbour and Spit Island. The species also roosts on barges at Shell Point which demonstrates the general lack of adequate high tide roosts for shorebirds utilising the Bay. Straw (1996) notes that the birds roosting at Boat Harbour are likely a result of the displacement of these birds from Penrhyn Estuary due to disturbance in the area.</td>
</tr>
<tr>
<td>Calidris tenuirostris great knot</td>
<td>V¹, M, J, C</td>
<td>Forages on intertidal sand and mudflats in estuaries. Usually roosts at high tide on beaches and other open sites.</td>
<td>High Occasionally recorded feeding on mudflats at Penrhyn Estuary, particularly since it was displaced from its preferred habitat at the former Pilots Embayment, which was lost due to the Parallel Runway construction.</td>
</tr>
<tr>
<td>Charadrius bicinctus double-banded plover</td>
<td>M</td>
<td>Mainly found on intertidal sand and mudflats in estuaries, often preferring sites near saltmarsh or other low, moist vegetation, where the birds roost and feed at high tide. Also feeds and roosts on ocean beaches and rocky shores. Inland, inhabits the margins of both saline and freshwater wetlands.</td>
<td>High Presently feeds on intertidal sand flats at Penrhyn Estuary. The species also roosts at Penrhyn Estuary, Boat Harbour and reportedly, at present, Molineux Point and on the end of the parallel runway. This species is thus quite vulnerable to disturbance due to fishermen, dogs and beach walkers given its key habitat at Penrhyn Estuary and Boat Harbour. This species used to feed at the former stockpile site and northern sections of Foreshore Beach, which were both lost due to the parallel runway construction, and has thus experienced a critical decline in their Bay habitat. Based on counts since the 1970s, Botany Bay is one of the three most important estuaries for the species in NSW (along with the Hunter and Shoalhaven Rivers).</td>
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## Flora and Fauna

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<tr>
<td>Charadrius leschenaultii greater sand plover</td>
<td>V1, M, J, C</td>
<td>Forages on intertidal sand and mudflats in estuaries, and roosts during high tide on sand beaches or rocky shores.</td>
<td>High Occasional visitor to Penrhyn Estuary and Boat Harbour (often in association with the Lesser Sand Plover) where it feeds on intertidal sand flats. Only one or two individuals are recorded in the Bay on an occasional basis (this is significant given the NSW estimated population for this species is only 80 birds, with the majority occurring in the Clarence and Richmond estuaries).</td>
</tr>
<tr>
<td>Charadrius mongolus lesser sand plover</td>
<td>V1, M, J, C</td>
<td>Feeds on intertidal sand and mudflats in estuaries, roosting on sandy beaches or rocky shores at high tide, and sometimes feeding at these sites.</td>
<td>High Roosts every year on intertidal sand flats at Boat Harbour (up to about 10 individuals) and feeds at Penrhyn Estuary and possibly elsewhere in the Bay.</td>
</tr>
<tr>
<td>Haematopus longirostris pied oystercatcher</td>
<td>V1</td>
<td>Favours ocean beaches and estuarine sand and mudflats.</td>
<td>High Presently occurs in relatively large numbers (up to 60 individuals) at Sandringham Bay where it feeds and roosts, and at Penrhyn Estuary where it feeds on intertidal sandflats. Presently five or six pairs nest at Wooloware Shorebird Lagoon, Towra Spit Island and at the airport. The volume of pedestrian traffic and shoreline steepness of Foreshore Beach would be expected to preclude the use of this area by the species for its life cycle requirements, particularly nesting activity.</td>
</tr>
<tr>
<td>Limicola falcinellus broad-billed sandpiper</td>
<td>V1, M, J, C</td>
<td>Favours intertidal sand and mudflats in estuaries.</td>
<td>Moderate Up to 17 individuals of this species were recorded on the northern shores of Botany Bay in 1953 (Straw 1996) and mostly single individuals have been recorded in the Bay on an occasional basis since the mid-1970s (northern shoreline). This species may occasionally feed and roost at Penrhyn Estuary.</td>
</tr>
<tr>
<td>Limosa lapponica bar-tailed godwit</td>
<td>M, J, C</td>
<td>Intertidal sand and mudflats in estuaries. Also forages at times in saltmarsh, mangroves and ocean beaches. Usually roosts at high tide on beaches and other open sites.</td>
<td>High Presently feeds on intertidal sandflats at Penrhyn Estuary and at Rocky Point in the Bay and roosts on beaches at Penrhyn Estuary and Sandringham Bay.</td>
</tr>
<tr>
<td>Limosa limosa black-tailed godwit</td>
<td>M, J, C</td>
<td>Forages on intertidal sand and mudflats in estuaries, roosting at high tide in a variety of open sites. Also occurs on the muddy margins of inland wetlands.</td>
<td>Moderate Feeds on intertidal mudflats and on muddy margins of wetlands. Occurs in very small numbers (one or two individuals) in the Parramatta River Estuary at Homebush Bay and may occasionally forage and roost at Penrhyn Estuary, although no recent sightings of this species have been recorded at Botany.</td>
</tr>
<tr>
<td>Numenius madagascariensis eastern curlew</td>
<td>M, J, C</td>
<td>Intertidal sand and mudflats in estuaries, particularly where there are extensive seagrass beds and stands of mangroves. Usually roosts at high tide on beaches or in saltmarshes.</td>
<td>Moderate Presently feeds over much of the intertidal mudflats of the southern parts of the Bay, including Woolooware, Quibray, Weeney and Stinkpot Bays and Towra Point. Preferred roost sites on the southern shores of the Bay include sand spits and shoals and wooden poles of oyster leases. The species does not normally use the northern shoreline of the Bay to feed or roost, but may do so on occasion.</td>
</tr>
</tbody>
</table>
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### Species

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<tbody>
<tr>
<td>Numenius phaeopus</td>
<td>M, J, C</td>
<td>Typically forages on intertidal mudflats near mangroves or along the banks of tidal creeks and rivers. Also often forages on intertidal rock shelves. Roosts in mangroves or other shoreline trees, or on beaches or rocky shores.</td>
<td>Moderate Presently feeds on exposed mudflats near and under mangrove trees at Towra Point Aquatic Reserve and roosts in mangrove trees at Woolooware, Weeney and Stinkpot Bays. This species may occasionally feed at Penrhyn Estuary.</td>
</tr>
<tr>
<td>Pluvialis fulva</td>
<td>M, J, C</td>
<td>Occurs mainly on estuarine sand and mudflats and nearby saltmarsh and short, moist pasture. Typically roosts at high tide in saltmarsh and pasture, and often feeds in these areas as well. At some sites, feeds on rocky intertidal areas, roosting at high tide on sandy beaches or rocks. Occasionally visits coastal freshwater wetlands.</td>
<td>High Regularly feeds on intertidal mudflats at Penrhyn Estuary and roosts in saltmarsh at Penrhyn and on wooden barges at Shell Point (up to six birds use the barges on the southern side). Straw (1996) notes that a small number of birds also feed and roost at Boat Harbour which may be the result of disturbance to the birds at Penrhyn Estuary. Key feeding habitat of the species at the mouth of the Mill Stream and Runway Beach have been lost due to the Parallel Runway construction and may explain, in part, the marked decline in numbers of this species in the Bay since the mid-1980s. The erosion of intertidal sands off Towra Beach and increased 4WD usage of the Boat Harbour area may similarly explain the marked decline in usage of the southern part of the Bay by the species.</td>
</tr>
<tr>
<td>Pluvialis squatarola</td>
<td>M, J, C</td>
<td>Forages on intertidal sand and mudflats, and roosts at high tide usually on beaches.</td>
<td>High Occasionally recorded feeding on intertidal sand and mudflats at Penrhyn Estuary, Quibray Bay and west of Taren Point. One known roost of the species in the Bay is on the sandy points on either side of the channel at Penrhyn Estuary. The species was historically recorded from the original mouth of the Cooks River.</td>
</tr>
<tr>
<td>Sterna albifrons</td>
<td>E, M, J, C</td>
<td>Nests only on or near the coast of NSW, although in other parts of the world they may be found nesting beside rivers and lakes far from the sea. Some breeding sites in NSW are within estuaries or harbours. Other nesting sites are in dunes behind ocean beaches, but most are on sand spits or sand islands where rivers, creeks or lakes enter the sea.</td>
<td>Moderate Forages at the mouth of Penrhyn Estuary for small fish and also roosts at the Estuary. This species has successfully nested in recent years on Towra Spit Island but was unsuccessful in the 2001/02 season due to the presence of foxes (pers. comm., Geoff Ross). The species aborted nesting on Towra Spit in 2001/02 and fled to Molineux Point to nest. NPWS notes that upwards of 60 pairs of the bird nested on Spit Island during the past 10 years (pers. comm., Geoff Ross). The species returned to Towra Spit in 2002/03 for nesting and had a successful breeding season.</td>
</tr>
<tr>
<td>Tringa brevipes</td>
<td>M, J, C</td>
<td>Typically found in estuaries with extensive mangroves and intertidal mudflats, although it also inhabits rocky shores along the coast. Often roosts in mangroves at high tide, or on rocks in preference to beaches.</td>
<td>Moderate Presently feeds on exposed mudflats on the southern part of the Bay and has been recorded resting at a number of locations including the groynes at Kurnell, the old rocky wharf at the mouth of Quibray Bay, in mature spreading mangroves and on platforms in mangroves at Quibray Bay. May occasionally feed in small numbers at Penrhyn Estuary.</td>
</tr>
</tbody>
</table>
## Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Conservation status</th>
<th>Habitat requirements</th>
<th>Likelihood of occurrence and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tringa nebularia (common) greenshank</td>
<td>M, J, C</td>
<td>Occurs in all types of wetlands. Usually found beside shallow waters generally either saline, brackish or fresh, including intertidal sand and mudflats, saltmarsh, mangroves and freshwater wetlands.</td>
<td>Moderate: Recorded on the mangrove lined shores of Woolooware Bay and used to favour the pond at the Woolooware Shorebird lagoon site (H1 site). May be an occasional visitor to Penrhyn Estuary.</td>
</tr>
<tr>
<td>Tringa stagnatilis (marsh) sandpiper</td>
<td>M, J, C</td>
<td>Saline or freshwater wetlands, both coastal and inland. Common on intertidal mudflats in northern Australia. Typical of pools in saltmarshes. Often occurs at artificial wetlands such as sewage treatment works and saltworks.</td>
<td>Moderate: Presently feeds and roosts in the Hawkesbury Swamps and at the waterbird refuge at Homebush and Newington Wetlands in the Parramatta River Estuary in relatively low numbers (up to 17 birds have been recorded in the Hawkesbury Swamps). No recent records exist for this species in the Bay. One historical record for this species in the Bay was identified (in 1983 at the old mouth of the Cooks River). This species may feed on estuarine mudflats at Penrhyn on an occasional basis.</td>
</tr>
<tr>
<td>Xenus cinereus (terek) sandpiper</td>
<td>V, M, J, C</td>
<td>Forages on intertidal sand mudflats, often near mangroves or in tidal creeks. Occasionally forages on sandy ocean beach or rocky shores. Typically roosts on or among mangroves, but also on open beaches.</td>
<td>Moderate: Presently feeds on intertidal mudflats between Taren Point and Woolooware Bay on the southern shores of the Bay and roosts on a disused jetty at Shell Point. This species may occasionally forage at Penrhyn Estuary (although no recent records exist of this species on the northern shores of the Bay).</td>
</tr>
<tr>
<td>Litoria aurea (green and golden bell) frog</td>
<td>E, V</td>
<td>Aquatic, found among vegetation within or at the edges of permanent water– streams, swamps, lagoons, farm dams and ornamental ponds. Often found under debris on low, often flooded river flats.</td>
<td>Low: Although there have been records of (L.) aurea on Southlands, there is no permanent population on the site. The GTP and pipeline sites do not provide suitable habitat.</td>
</tr>
</tbody>
</table>

* Conservation Status is as follows:
- E = Endangered
- V = Vulnerable
- 1 = listing under TSC Act 1995
- P = Protected under NSW National Parks and Wildlife Act 1974
- J = Listed under JAMBA agreement
- C = Listed under CAMBA agreement.

### Taren Point Shorebird Community

The Taren Point Shorebird Community is listed as an endangered ecological community under the TSC Act. This community of shorebirds uniquely occur on the relict marginal shoal of the Georges River that occurs between Taren Point and Shell Point in Botany Bay. The bird community is dominated by shorebird species from the order Charadriiformes (NSW Scientific Community, 1998).

The assemblage of shorebird species that make up the Taren Point Shorebird Community have been addressed individually in this assessment. The community as a whole was not addressed, as the BGC Project would not affect this area or other migratory shorebird habitats elsewhere within Botany Bay.
**Litoria aurea (Green and Golden Bell Frog)**

The green and golden bell frog (*Litoria aurea*) is a threatened species that was once widespread throughout Botany Swamps, including Veteran’s Swamp, which was drained and filled and is now known as Southlands (part of the BCG Project area).

Since the 1960s, the distribution of the species has declined and it now occurs only in isolated pockets within its former range (Pike and White, 1996). Remnants of the Botany Swamps population have been located, since 1990, at Eastlake Golf Course and Rosebery (White and Pyke, 1996). There has been one unconfirmed record, in 1992, of the species in Springvale Drain that runs through Southlands (pers. comm., R. Evans, Orica).

A survey on Southlands in autumn 1997 located five juvenile green and golden bell frogs in an ephemeral puddle on Block 2 (White, 1997). However, further intensive surveys carried out on the same site during warmer weather failed to locate any individuals of the species. White (1997) concluded that, “it can be confidently concluded that there are no permanent colonies of these frogs on Southlands”. There is therefore no evidence of a viable local population on Southlands.

The ponds on Southlands are filled with a mix of rainwater and contaminated groundwater and also contain the exotic mosquito fish, *Gambusia holbrooki*, a known predator of frog eggs and tadpoles; particularly of tree frogs. White (1997) considers that the presence of the mosquito fish is a key reason for the green and golden bell frog not residing permanently on Southlands.

**20.6.2 Eight Part Tests**

The seven shorebird and one seabird species listed under the TSC Act that are considered as regular or occasional visitors to Penrhyn Estuary were assessed under Section 5A of the EP&A Act. Eight Part Tests concluded that no significant impact on shorebirds at Penrhyn Estuary is likely, given that the BGC Project represents long-term protection of shorebirds and their habitat from contaminated groundwater and the long-term reduction of existing contamination levels of shorebird habitat. The saltmarsh and tidal flats used by shorebirds will be monitored and managed throughout the period of the BGC Project.

A Section 5A assessment for the seven shorebirds, one seabird species and the green and golden bell frog are provided in Appendix H.

**20.6.3 EPBC Referral**

An assessment of the impact on migratory and threatened shorebird communities in Botany Bay (Appendix H) concluded that no species listed under international agreements would be significantly affected to an extent that would warrant a referral to the Department of Environment and Heritage with regard to species listed under the EPBC Act.
20.6.4 Shorebird Habitat

The importance of Botany Bay for migratory shorebirds has been significantly reduced in recent decades due to habitat loss and habitat disturbance (relative to other NSW estuaries). Although Botany Bay still has extensive shorebird habitats, these are chiefly confined to mangrove-fringed soft mudflats on the southern shores of the bay between Taren Point and Bonna Point at Kurnell. These mudflats provide suitable habitat for grey-tailed tattlers, whimbrel, eastern curlew and a few terek sandpipers. Their numbers in these locations have remained relatively stable. One species, the bar-tailed godwit, has been able to adapt to changes in conditions in the bay and its overall numbers have remained relatively stable.

Shorebirds that once used feeding habitat at Runway Beach, the Pilots Embayment, the entrance to the Mill Stream and Foreshore Beach, were displaced as a result of the construction of the Parallel Runway (Kinhill, 1990). After the construction of the runway, most of the shorebirds that returned to the northern portion of the Bay were concentrated in a much reduced area, restricted to Penrhyn Estuary and a small section of beach west of the Penrhyn Road boat ramp (Straw, 1996).

Shorebird habitat within the study area is described below.

- Penrhyn Estuary is essentially the only habitat remaining for shorebirds formerly abundant in the northern part of the bay. The estuary provides important feeding and roosting habitat for non-migratory and migratory shorebirds listed under the TSC and EPBC Acts. Feeding habitat is restricted to the exposed mudflats that extend from the mouths of Floodvale and Springvale Drains to a narrow neck in the estuary (about 1.5 hectares) and an area of sand flats along the southern shore of the estuary (Figure 20.2). Penrhyn Estuary is now the most important site in Botany Bay for shorebird species such as the red-necked stint, curlew sandpiper, red knot, pacific golden plover, double-banded plover and sharp-tailed sandpiper that are now sparse or absent from other parts of the bay. While the estuary provides an important ecological habitat for migratory shorebirds, water quality within the estuary is poor due to historical contamination from industrial land uses in the surrounding catchment.

- Foreshore Beach was created during dredging works for Sydney Airport and Port Botany in the 1970s, replacing the former Botany Beach. This resulted in the loss of a large proportion of the intertidal flats that existed at the time. Wave action has eroded Foreshore Beach, steepening the profile and deepening the immediate foreshore and, coupled with frequent disturbance from people and unleashed dogs that walk the beach, has essentially precluded the use of the remaining beach as feeding habitat for shorebirds.

- Saltmarsh, mud flat and sand flat habitats at the mouth of the Mill Stream that previously provided valuable feeding and roosting habitats for shorebirds were lost during the construction of the Parallel Runway. The Mill Stream does not, at present, provide feeding or roosting habitat for shorebirds (Straw, 1996).

20.7 Aquatic Ecology

During previous investigations in Penrhyn Estuary, 10 small seagrass beds composed of Zostera capricornii have been identified growing on the fringes of the outer estuary (The Ecology Lab, 2003). Four beds occur in the vicinity of the new boat ramp off Penrhyn Road, ranging in size from 48 to 300 m², with a total area of approximately 559 m². They are composed of sparse to moderately dense Zostera mixed with Halophila and, in some places, the algae Caulerpa filiformis.
Six beds of *Zostera* were mapped off the north-western shore of the outer estuary, between the derelict groyne and jetty and the channel between the inner and outer estuary. The largest of these beds is located 70 to 90 m offshore, with smaller patches present closer to the shore in water depths of approximately 0.5 m. Their total area is approximately 1,046 m² (The Ecology Lab, 2003).

During recent studies in Penrhyn Estuary, The Ecology Lab has recorded the presence of a bed of *Zostera* growing intertidally on the eastern side of the inner estuary, to the north of the old boat ramp. This bed occurs amongst mangrove seedlings and pneumatophores and is relatively sparse.

Mapping of seagrass off Foreshore Beach, from the entrance of the Mill Stream to Penrhyn Estuary, was undertaken as part of the *Port Botany Expansion EIS* (URS, 2003), as shown in Figure 20.2. The total area of seagrass in the study area was estimated to be about 9.7 hectares. The majority of this area was composed of *Zostera capricornii*. Three small patches of *Posidonia* were also present. *Halophila ovalis* was frequently present mixed with *Zostera* in the main bed, and *Caulerpa filiformis* and *Caulerpa taxifolia* were also present toward the southern end of the main bed.

Seagrasses are flowering plants adapted for subaquatic environments, and are protected in NSW under the *Fisheries Management Act* 1994. The most common seagrass in the study area is *Zostera capricornii*, while two species of *Halophila* are present but less common. A small patch of *Posidonia australis* occurs off the northern end of Foreshore Beach, away from the study area. The ecological functions of seagrass include a significant contribution to the productivity of the ecosystem (King, 1981; Zieman and Wetzel, 1980), stabilising sediments (Keough and Jenkins, 1995), providing food and habitat for fish and invertebrates (Zieman and Wetzel 1980; Bell et al 1987) and providing ‘nursery habitats’ for recreationally and commercially important species of fish and invertebrates such as prawns and crabs (Pollard 1984; Bell and Pollard 1989; Larkum and West 1990; Smith and Pollard 1999).

### 20.8 Assessment of Impacts

#### 20.8.1 Lachlan Swamps/Botany Wetlands

No works are to be undertaken in the vicinity of the ponds that make up the Lachlan Swamps/Botany wetlands. The hydrogeological modelling undertaken to assess the groundwater changes that would result from the operation of the BGC Project (i.e. the hydraulic containment and extraction of the contaminated groundwater) has predicted that the existing recharge levels would only reduce by around 3%, and would therefore not significantly affect existing water levels.

As a consequence, it is considered unlikely that there would be any impact on the flora and fauna of the wetlands from the BGC Project.

#### 20.8.2 Southlands

Given the existing disturbed nature of Southlands, with exotic flora species dominating the site and no critical habitats, threatened species, populations or ecological communities present or likely to occur on the site, no significant impacts on flora and fauna arising from the construction and operation activities of the BGC Project on Southlands have been identified.
As described elsewhere in this EIS, specific mitigation measures would be implemented to minimise the potential for impact, including:

- containment and management of drilling muds in specific containment structures;
- removal of contaminated groundwater during construction to contained storage and treatment in the GTP;
- design and construction of extraction wells and transfer pipelines to minimise potential for leaks, and
- regular inspection and maintenance.

These measures would also minimise the potential for runoff or spillage into the drains that discharge into Penrhyn Estuary.

**20.8.3 Penrhyn Estuary/Foreshore Beach**

**Aquatic Ecology**

Penrhyn Estuary and the south-eastern end of Foreshore Beach are part of an estuarine ecosystem that includes fringing saltmarsh and mangrove habitats, subtidal seagrass beds, and intertidal and subtidal sand and mudflats that support invertebrates living at the surface or within the upper layers of sediment (benthos). The assessment of the impacts on aquatic ecology encompassed the Penrhyn Estuary and the south-eastern end of Foreshore Beach as a whole.

The assessment of impacts on aquatic ecology considered two alternative conditions:

1. **Do nothing**: No interception of groundwater; hence no remediation, and plumes of contaminated groundwater migrate to Botany Bay.

2. **Complete interception**: All contaminated groundwater is intercepted, treated to remove CHCs and appropriately used or disposed of. In this case, no groundwater would enter Penrhyn Estuary or the south-eastern end of Foreshore Beach upon commencement of full hydraulic containment. The expected physical effects of this hydraulic containment include:
   - no groundwater discharge into Springvale and Floodvale Drains, resulting in no surface water flow into the drains during dry weather;
   - no discharge of groundwater into the intertidal and subtidal zone along the extent of the secondary containment line; and
   - saltwater intrusion in groundwater at depth toward Foreshore Road, with associated increases in pH and conductivity.

Within this scenario, consideration has been given to:

- **High Level Response**: Response to groundwater interception at the high end of the response spectrum; and
- **Low Level Response**: The response at the low end of the response spectrum.
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There are no known studies in the scientific literature that are sufficiently similar to the BGC Project, and set in similar physical and ecological settings, that would inform predictions of the impacts of the proposed groundwater interception. As a result, the assessment of impacts is largely qualitative.

‘Do Nothing’ Option

If nothing is done to intercept the flow of CHCs to Botany Bay, there will be a risk of mortality to intertidal and subtidal benthos due to toxic effects of the CHCs. Although the specific levels of acute toxicity to high concentrations of CHCs are not known for the benthos, a precautionary approach would indicate that the risk is high. Similarly, seagrass, saltmarshes and invertebrates would also suffer mortality due to exposure to CHCs in the levels indicated in the Central Plume (maximum EDC level in the Central Plume is predicted to be in the order of 5000 mg/L). Overall, the estuarine ecosystem may degrade significantly, with potential long-term residual effects, but it is not possible to quantify the magnitude of effects or their duration beyond the period of flow of contaminated groundwater into the bay. Recovery time for the ecosystem would be linked to the severity of the response by various ecosystem components and the time required for the plume to dissipate into the waters of Botany Bay.

The discharge of treated water into Brotherson Dock would cause a slight reduction in salinity there, which is not expected to have significant effects on aquatic biota. Therefore, the assessment of impacts of the BGC Project focus on the effects of groundwater interception on aquatic habitats and biota in Penrhyn Estuary and the south-eastern end of Foreshore Beach.

Complete Interception—High Level Response scenario

In the ‘High Level Response’ to the groundwater interception, intertidal benthos are predicted to reduce in abundance and species richness, assuming that long-term reduction in sediment water content during low tide would cause mortality. Effects would be greater during spring low tides, due to increased evaporation of residual saline pore water. While some types of intertidal benthos are resistant to desiccation, being protected by shells (e.g. gastropods and bivalves) or hard body coverings (e.g. crabs and amphipods), these types of benthos are less common in the estuary than the soft-bodied animals such as polychaetes that may have a greater response to desiccation. Effects on subtidal benthos are expected to be less extreme, because sediments are not predicted to dry during low tides; however, subtidal benthos would be exposed to more variable salinity.

The long-term response to the interaction of new factors (increase in salinity during low tide, decrease in dissolved nutrients and particulate organic matter input) with current conditions (presence of metals such as Hg and Cr in sediment) is unknown. Saltmarsh habitats would become more saline, potentially killing some plants or altering the assemblage in favour of salinity tolerant species. In the short-term, fish would continue to bioaccumulate metals in benthic food items at the same or lower levels as at present, but in the longer term would shift to other, more abundant food sources. The direct effects of withdrawal of groundwater on seagrass beds are unknown, but the beds in outer Penrhyn Estuary and off Foreshore Beach are subtidal, patchy in nature and provide relatively low quality habitat due to their short, sparse morphology compared to seagrasses elsewhere in Botany Bay. The single intertidal bed in the inner estuary is short and sparse, and may be at risk due to desiccation.
Complete Interception—Low Level Response scenario

The 'Low Level Response' to groundwater interception predicts a smaller magnitude of response by invertebrates and saltmarsh plants, with reduced flow-on effects to fish and shorebirds. In this scenario, abundance of intertidal benthos may reduce only slightly, but may become dominated by smaller bodied meiofauna that are too small for shorebirds to eat. The altered intertidal community may display a spatial shift with the centre of their population displaced towards the subtidal zone. Subtidal benthic communities may respond by altering community structure in favour of assemblages adapted to increased salinity, decreased dissolved nutrients and decreased amount of particulate organic matter entering the estuary. This shift may also be accompanied by a reduction in overall abundance, with flow-on effects to fish and shorebirds are previously described.

In the context of the effects on Botany Bay, Penrhyn Estuary represents a relatively small area. The loss of some benthos, seagrasses and mangroves is not likely to have a major effect on the productivity or diversity of the large bay ecosystem. Impacts on shorebirds that feed and roost in the estuary may be of greater significance, due to the protected status of some of the species and due to the dwindling habitat in the Sydney region. Similarly, impacts on saltmarshes would be significant because these habitats are decreasing in Botany Bay and the Sydney region generally. However, as elsewhere in the region, the increase in the extent of mangrove in Penrhyn Estuary threatens saltmarsh habitats there. Removal of groundwater may actually create conditions more favourable to the expansion of saltmarsh over mangrove habitat.

Cumulative Impacts

As the BGC Project would result in a reduction in water-borne contaminants in Penrhyn Estuary and Botany Bay, and no change in existing levels of sediment contamination, the cumulative effects of the project with respect to levels of contamination is likely to reduce future levels of contamination in Penrhyn Estuary and Botany Bay. The proposed port expansion would have negligible effects on groundwater, and hence there would be no cumulative effects on groundwater.

It is recommended that a program of monitoring be developed in negotiation with the relevant government agencies and initiated as soon as possible, to enable the effects of groundwater interception to be measured. This program may involve habitat mapping and surveys of benthos, shorebirds and fish, using—wherever appropriate—control locations to provide a measure of natural variability.

Shorebird Habitat

Since the 1940s, the gradual loss of shorebird habitat has resulted in a substantial decline in the numbers of shorebirds found in the northern part of Botany Bay. Penrhyn Estuary now provides the only shorebird feeding habitat and roosting sites in the north of the Bay. Although shorebird habitat exists along the southern shores of the bay, it is not suitable for most of the shorebirds found at Penrhyn Estuary. The most productive shorebird feeding habitat appears to be the silts in the delta area formed by Springvale and Floodvale Creeks.

Shorebirds feed almost exclusively on invertebrates found in the substrate of wetlands, especially coastal estuaries. These habitats provide exposed mudflats in a relatively sheltered environment. Estuarine habitats are complex and rely on river flows, daily tidal cycles, groundwater runoff and the presence of organic material, which support invertebrate populations. Although groundwater plays an important role in the formation and health of some saltmarsh plant communities, it is not known how important groundwater is to maintaining invertebrate populations on the tidal mudflats, given that frequent freshwater flows occur at Penrhyn Estuary from surface runoff of local catchments.
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A reduction in groundwater flows into Penrhyn Estuary is likely to result in a change in species composition and numbers of some invertebrates. However, it is known that shorebirds are readily able to switch prey, due to their migratory nature, feeding in a variety of habitats from freshwater bogs to hypersaline salt pans, and can adjust to a wide variety of invertebrate prey.

Foreshore Beach currently provides very little shorebird feeding habitat. However, the proposed port expansion would result in a modification of the beach and protection from wave action. This is likely to increase the area of shorebird feeding habitat if the slope of the beach is lowered. This would also be compatible with the BGC Project, providing a wider area of tidal flats and minimising the effect of groundwater interception.

**Availability of Prey**

Studies of invertebrate populations at Penrhyn Estuary (The Ecology Lab, 2004) indicated that characteristics indicative of this community include reduced species richness, community structure dominated by a few taxa, a paucity of small crustaceans such as amphipods, dominance of a few families of polychaete worms, and dominance by species with small body size and short life spans that retain (by various means) offspring in the immediate vicinity of parents or within the parental habitat.

The current population of shorebirds at Penrhyn Estuary has developed in the presence of the current levels of contaminants in the estuary, as well as a level of toxins in the tissues of their prey. Any changes to invertebrate populations could influence the species diversity and population density of shorebirds.

Improvement in the level of contaminants in the mudflats at Penrhyn Estuary, through the prevention of further contamination of the estuary, should in the long-term provide a healthier environment for shorebirds by improving the diversity and health of their invertebrate prey. The effect of groundwater interception on invertebrates is largely unknown (The Ecology Lab, 2004), but may result in a change in species composition. Any such changes may require a switch in prey species by shorebirds. Provided that the density of available prey is not reduced overall, most shorebird species should be able to adapt to these changes.

**Changes to Invertebrate Populations**

Invertebrate populations appear to be under stress from the current state of the tidal flats at Penrhyn Estuary, including high levels of contaminants. However, it would be logical to assume that the shorebird species composition and numbers at Penrhyn Estuary are as a result of the current degraded state. Any improvement would presumably result in an increased shorebird population and increased health of the birds.

Any change to invertebrate populations at Penrhyn Estuary is likely to affect shorebird populations. An overall reduction in numbers of invertebrates may result in a decline in the numbers of shorebirds, while the change in invertebrate species composition may affect one or two species of shorebirds that feed on these—although it is known that most shorebirds are able to readily switch prey.

**Changes in Groundwater Flows**

The effects of changes to groundwater flows into the estuary as a result of the BGC Project are not likely to have any direct impacts on shorebirds, since these species may frequent a range of habitats with varying salinity levels in the space of a day. Any impact on shorebirds is likely to be as a result of changes in vegetation composition and prey availability, addressed above.
Changes in Saltmarsh Communities

Shorebirds at Penrhyn Estuary spend most of the time during high tide roosting on sand spits or saltmarsh habitat while waiting for the tide to recede. Roost sites used by shorebirds at Penrhyn Estuary include saltmarsh during neap tides, and sand spits or beaches during spring high tides. Saltmarsh, in particular *Sarcocornia* sp., provides protection from adverse weather for some of the small shorebirds while enabling them to watch over the top of the vegetation for potential predators. However, key saltmarsh roost sites used by shorebirds, such as the Pacific golden plover, have been lost at Penrhyn Estuary due to invasion by mangroves, and these birds have been forced to roost elsewhere. Some species of shorebirds, notably the sharp-tailed sandpiper, feed on invertebrates including insects and benthic animals found in saltmarshes at Penrhyn Estuary.

*Sarcocornia* exists in a wide variety of wetland habitats ranging from daily inundated estuaries to rarely flooded saltmarshes in coastal, as well as inland, wetlands.

Changes in flows of groundwater at Penrhyn Estuary will change the nature of the saltmarsh community and may result in some sections dying. However, saltmarsh species are likely to adapt to a new regime of flooding. If appropriate soils are available, a healthy saltmarsh is likely to result, although these may be perched at different levels to the existing saltmarsh.

Flooded saltmarsh habitats are used by many shorebird species at night; however, flooding conditions do not occur at Penrhyn Estuary, and shorebirds abandon the site at night to roost elsewhere.

Likelihood of Impact

As the BGC Project would result in reduced water-borne contaminants in Penrhyn Estuary and Botany Bay, and no change in existing levels of sediment contamination, the cumulative effects of the BGC Project are expected to reduce the levels of contamination in Penrhyn Estuary and Botany Bay. The BGC Project represents greater potential changes to the groundwater levels than those associated with the port expansion, and hence the cumulative effects are considered negligible in comparison.

In the context of the effects on Botany Bay, Penrhyn Estuary represents a relatively small area. The loss of some benthos, seagrasses and mangroves is not likely to have a major effect on the productivity or diversity of the large bay ecosystem. Impacts on saltmarshes would be significant because these habitats are decreasing in Botany Bay and the Sydney region generally. However, as elsewhere in the region, the increase in the extent of mangrove in Penrhyn Estuary threatens saltmarsh habitats there. Removal of groundwater may actually create conditions more favourable to the expansion of saltmarsh over mangrove habitat.

Assessments of the potential impacts of the BGC Project conclude that no threatened species, populations or ecological communities of birds are likely to be significantly affected as listed under the TSC Act. There is therefore no requirement for an SIS under the EP&A Act. No species listed under international agreements would be affected to an extent that would warrant a referral to the Department of Environment and Heritage with regard to species listed under the EPBC Act. Little is known about the influence on invertebrates as a result of alterations to groundwater flows, and therefore indirect impacts on shorebird populations; however, it is likely that species diversity and abundance will change with changes in salinity. Any changes to the number of invertebrates or species composition of invertebrates at Penrhyn Estuary may have an effect on shorebirds in the estuary; however, it is known that shorebirds are readily able to switch prey due to their migratory nature.
Invertebrate populations are currently under severe stress as a result of contaminants in the mudflats at Penrhyn Estuary. The groundwater interception would reduce the risk of further contamination and risk to the estuary and its fauna and flora, allowing the levels of contaminants to decline over time.

Roost sites used by shorebirds are usually areas that have an open aspect to allow an all-round view for potential predators, either saltmarsh habitat with low vegetation or open sand spits or beaches. The level at which saltmarsh grows depends on a number of factors, including tide heights and freshwater runoff (including groundwater flows). Cessation of groundwater flows may result in a change in saltmarsh distribution, influenced by tide heights alone.

The proposed expansion of Port Botany would, to some extent, override the effect of groundwater interception, because that proposal includes the establishment of additional saltmarsh habitat, much larger than that currently existing. If the port expansion proceeds, the remediation measures planned by Sydney Ports Corporation would potentially complement those of Orica in providing an improved roosting and foraging habitat for migratory and non-migratory shorebirds within the estuary. Should the port expansion project proceed, Orica would liaise with Sydney Ports Corporation to determine any necessary changes to the habitat enhancement plans due to the hydraulic containment. The planted shrubland community above the high tide mark along Foreshore Beach and along the Penrhyn Road foreshore would not be affected by the reduced groundwater flow down-gradient of the secondary containment line, because it is not dependent on the groundwater as a water supply. Hence no impact would be anticipated on this plant community.

Regular monitoring of the estuary would be necessary to determine whether any changes in the nature of the foreshore have occurred as a result of the BGC Project. Although it is likely that invertebrate populations and saltmarsh would adjust, it may be advantageous to carry out landscaping, including the addition of appropriate soils, to enhance and expand the area of saltmarsh and therefore shorebird habitat. Recent successes in the establishment or enhancement of saltmarshes in Sydney have clearly demonstrated the feasibility of managing saltmarsh in modified habitat.

Ongoing management of the estuary may be necessary to prevent invasion of shorebird habitat by mangroves, including the ‘weeding out’ of mangrove seedlings on an annual basis.

20.8.4 Brotherson Dock/Botany Bay

No impacts are considered likely on the aquatic habitats or flora and fauna of Brotherson Dock/Botany Bay from the BGC Project, because there would be no significant change in the water quality of the dock resulting from the discharge of treated water and salty wastewater to Bunnerong Canal. Appendix E discusses the hydraulic impact of the treated water and salty wastewater discharge from the GTP on Bunnerong Canal, and concludes that the volume of the discharge would be minor compared to the volume of the canal for a range of flow tidal and flood conditions. Consequently, it is considered that the discharge from the GTP to the canal would not affect the tidal flushing regime or water quality of Bunnerong Canal. The Brotherson Dock tidal flushing regime and water quality would be even less likely to be affected, due to the large volume of water in the Dock.

In addition, the discharge from the GTP to Bunnerong Canal would be treated to achieve quality standards based on the ANZECC Guideline (2000) trigger values for the protection of slightly to moderately disturbed ecosystems.
As described in Chapter 14, the discharge into Bunnerong Canal would not mobilise the existing sediments within the canal, and hence there would be no sediment discharge or associated impact in the dock.

The treated water and salty wastewater discharge from the GTP would be continuously monitored, and would not be discharged if the quality standards were not achieved, to avoid potential impact on the aquatic environments of the Bay.

### 20.9 Management and Mitigation Measures

#### 20.9.1 Management Measures

Although no impact on flora and fauna is expected from the construction and operation of the BGC Project, monitoring of treated water (to be discharged at Brotherson Dock) and monitoring of the groundwater table would be undertaken. A detailed monitoring program would be described in the environmental management plan.

#### 20.9.2 Summary of Mitigation Measures

Table 20.2 lists the measures that would be adopted to assist in minimising the impacts of the BGC Project on flora and fauna in the subject area.

<table>
<thead>
<tr>
<th>Safeguard</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
</tr>
<tr>
<td>Develop and implement a program of monitoring, in negotiation with the relevant government agencies to enable the effects of groundwater interception to be measured.</td>
<td>✓</td>
</tr>
<tr>
<td>If required, undertake landscaping works, including the addition of appropriate soils, to enhance and expand the area of saltmarsh shorebird habitat should monitoring indicate significant change directly associated with the groundwater interception.</td>
<td></td>
</tr>
<tr>
<td>If required, ongoing management of the estuary to prevent invasion of shorebird habitat by mangroves including the 'weeding' of mangrove seedlings on an annual basis.</td>
<td></td>
</tr>
</tbody>
</table>
20.10 Conclusion

The GTP site contains no vegetation. The secondary and DNAPL extraction wells, DNAPL pipeline and that part of the secondary pipeline (not on Southlands) and the reuse or discharge pipelines would be installed on Orica owned or licensed land, or along the existing easements, where the land is largely cleared. No threatened species or populations or ecological communities are likely to occur in these areas.

Assessments of the potential impacts of the BGC Project conclude that no threatened species, populations or ecological communities of birds are likely to be significantly affected as listed under the TSC Act. There is therefore no requirement for an SIS under the EP&A Act. No species listed under international agreements would be affected to an extent that would warrant a referral to the Department of Environment and Heritage with regard to species listed under the EPBC Act. Orica has considered it prudent to refer the BGC Project and seek confirmation.

In the context of the effects on Botany Bay, Penrhyn Estuary represents a relatively small area. The loss of some benthos, seagrasses and mangroves is not likely to have a major effect on the productivity or diversity of the large bay ecosystem. Impacts on saltmarshes would be significant because these habitats are decreasing in Botany Bay and the Sydney region generally. However, as elsewhere in the region, the increase in the extent of mangrove in Penrhyn Estuary threatens saltmarsh habitats there. Removal of groundwater may actually create conditions more favourable to the expansion of saltmarsh over mangrove habitat.

Any changes to the number of invertebrates or species composition of invertebrates at Penrhyn Estuary may have an effect on shorebirds in the estuary; however, it is known that shorebirds are readily able to switch prey due to their migratory nature. Invertebrate populations are currently under severe stress as a result of contaminants in the mudflats at Penrhyn Estuary. The groundwater interception would reduce the risk of further contamination and risk to the estuary and its fauna and flora, allowing the levels of contaminants to decline over time.

It is expected that the aquatic flora and fauna would not be affected by the discharged treated water at Brotherson Bay, because the treated water would meet the marine water quality guidelines specified in the ANZECC 2000.
21.1 Introduction

This chapter presents a summary of the assessment of the potential impacts on sites of Aboriginal or non-Indigenous heritage, on and in the Project Area of the BGC Project.

The National Parks and Wildlife Act 1974 (NP&W Act) and the New South Wales Heritage Act 1977 (Heritage Act) provide for the protection of items and places of Indigenous and non-Indigenous heritage significance, respectively. Assessment of development sites to determine the presence and significance of heritage items, prior to development approval, is required under these Acts.

Given that the Project Area has been extensively disturbed over many years, through previous construction, building and industrial operations, it was concluded that field works would not be required. This assessment has therefore been based on desk-top studies, using available information from a range of sources. These include previous relevant EIS documents (URS, 2001) and public databases maintained by the Council of the City of Botany Bay (CCBB), Australian Heritage Commission (AHC), National Trust (NT), and National Park and Wildlife Service (NPWS).

21.2 The Existing Environment

21.2.1 Aboriginal Heritage

“Aboriginal places” and “Aboriginal relics” are protected under the NP&W Act. A search for Aboriginal sites within the Project Area was undertaken using the NPWS Aboriginal Sites Register, as well as through review of other relevant studies in the area. These searches showed no evidence of any known Aboriginal sites located within the Project Area.

Any such sites would most likely have been affected, damaged or destroyed by previous construction and industrial activities, such as:

- construction and demolition of the former Silicates Plant at the GTP site, with subsequent levelling and paving with asphalt;
- peat cutting and sand extraction on Southlands (within the PCA), with subsequent waste disposal and storage;
- extensive rework and levelling in the 1960s on the BIP (in relation to the DNAPL wells and pipelines), with subsequent further rework as part of the construction and demolition of other plants; and
- previous installation of the underground discharge pipeline on the discharge pipeline route, as well as construction of various roads, buildings and other infrastructure.
CHAPTER 21 Archaeology and Heritage

21.2.2 Non-Indigenous Heritage

Heritage items are part of the natural and built environment and are protected under the Heritage Act. A review of relevant heritage inventories was undertaken to identify potential heritage items located in the vicinity of the GTP on the BIP and associated facilities in the vicinity.

The inventories reviewed include:

- Australian Heritage Commission’s Register of National Estate;
- National Trust;
- NSW Heritage Office; and
- Botany Bay Local Environmental Plan (BLEP) 1995 – Part 4 Heritage Provisions, and heritage register.

The results from the review found two listed heritage items under Schedule 3 (Heritage items and heritage conservation areas) of the BLEP:

- Orica’s Main Administration Building, located in the southern corner of the BIP; and
- a mature Ficus tree, located adjacent to this building.

The location of these items is shown on Figure 21.1.

No other listed heritage items were identified in the vicinity of the Project Area.

21.3 Assessment of Impacts

Given that the Project Area has been significantly previously disturbed, with no current or past evidence of any Aboriginal relics or Aboriginal places, and that the specific sites of construction works have similarly been subject to extensive construction and demolition activities, the likelihood of encountering any relics is considered very low. Therefore, no impacts on Aboriginal heritage are considered likely.

As shown on Figure 21.1, the two identified listed heritage items are at least 250 m from the proposed construction activities for the discharge pipeline (the element of the BGC Project that is nearest to the items). No construction activities would be undertaken in the vicinity of these items. Similarly, no operational activities would be undertaken in the vicinity of these items.

As a result, no impacts on these items are considered likely.

21.4 Management and Mitigation Measures

All staff and others (e.g. contract employees) involved in the BGC Project would be advised of their obligations under the Heritage Act and the NP&W Act. In the unlikely event that unrecorded surface or subsurface relics or artefacts were found during development related activities, work would cease immediately in the vicinity and the Heritage Council and/or the NPWS would be contacted immediately for further directions to ensure appropriate preservation/management.
A summary of the proposed mitigation to be implemented for the BGC Project and incorporated within the Environmental Management Plan is presented in Table 21.1.

### Table 21.1 Cultural heritage: summary of mitigation measures

<table>
<thead>
<tr>
<th>Safeguard</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
</tr>
<tr>
<td>Ensure that site inductions are provided to all site personnel to increase awareness of identification and protection of archaeological artefacts</td>
<td>✓</td>
</tr>
<tr>
<td>Cease work and advise Heritage Council and/or the NPWS in the event that unrecorded surface or sub-surface relics or artefacts are found</td>
<td></td>
</tr>
<tr>
<td>Ensure protection of the listed heritage items by avoiding any construction works and minimising traffic movements in the vicinity</td>
<td></td>
</tr>
</tbody>
</table>

### 21.5 Conclusion

Based on the results of the relevant database searches and reviews of previous studies, and the assessment of existing environment and proposed activities, it can be concluded that any impacts on Aboriginal or non-Indigenous heritage items from the BGC Project would be very unlikely.
22.1 Introduction

The operation of the BGC Project would result in emissions to air of the final off-gas, after treatment in the various off-gas treatment stages of the GTP.

The removal and treatment of the volatile CHCs from the contaminated groundwater is based on world’s best practice technologies and process standards, comprising:

- air stripping to remove the CHCs;
- thermal oxidation to destroy the CHCs through reaction at high temperature;
- acid absorption and caustic scrubbing to remove any acid gases; and
- final emission to atmosphere through the process stack.

As well as the point source emissions from the process stack, other potential discharges to air include particulate emissions during all construction activities, dust, and fugitive emissions during the extraction, transfer and treatment of the groundwater.

The air quality assessment summarised in this chapter is based on the full assessment report, *Air Quality Impact Assessment for a Groundwater Treatment Plant Proposed by Orica Australia Ltd., Botany* (PAE, 2004) as presented in Appendix G.

The outputs from the air quality assessment have also been assessed as part of the Human Health Risk Assessment summarised in Chapter 24, with the full report *Human Health Risk Assessment* (URS, 2004) presented in Appendix J.

22.2 Assessment Criteria

For an industrial development such as the GTP, there are three main types of relevant air quality criteria:

- Emission Standards, which are the maximum allowable pollutant emission concentrations (stack concentrations) specified for particular types of equipment;
- Air Impact Assessment Criteria, which are designed for use in air dispersion modelling studies and air quality impact assessments for new or modified emission sources; and
- Ambient Air Quality Standards, which set standards against which ambient air quality monitoring results may be assessed.

In general, emission standards and ambient air quality design criteria are used to evaluate the expected impact of air emissions on air quality and the effectiveness of plant design and any associated mitigation measures. The main objective of these criteria is to ensure that the resulting local and regional ambient air quality meets the relevant ambient air quality standards.
22.2.1 Emission Standards

The NSW Clean Air (Plant and Equipment) Regulation 1997 (CAPER) sets emission concentration limits for air impurities from stationary plant and equipment. These regulations have been carried over directly into the Protection of the Environment Operations Act 1997 (POE Act) and associated Regulations, and are in the process of undergoing a comprehensive review by the NSW DEC.

Concentration limits prescribed by CAPER relevant to the GTP operations are presented in Table 22.1.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Applicable Standards</th>
<th>CAPER Limit Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate</td>
<td>Any trade, industry, process, industrial plant or fuel burning equipment excluding boilers and incinerators. Boilers or incinerators emitting solid particles (@7% O₂ for Group C).</td>
<td>100 mg/m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 mg/m³</td>
</tr>
<tr>
<td>Smoke</td>
<td>All fuel burning equipment or industrial plant where fuel being used is other than coal.</td>
<td>20% opacity</td>
</tr>
<tr>
<td>Oxides of nitrogen</td>
<td>Any trade industry or process emitting oxides of nitrogen (with noted exceptions).</td>
<td>2,000 mg/m³</td>
</tr>
</tbody>
</table>

Notes:
(i) Group C = All installations on scheduled premises, for which an application for approval pursuant to Section 16 of the Clean Air Act was made on or after 1 September 1977.

22.2.2 Ambient Air Quality Standards

In Action for Air – the NSW Government’s 25-year Air Quality Management Plan (EPA, 1998) the DEC adopted a number of regional ambient air quality goals for a range of air pollutants.

In June 1998 the National Environment Protection Council (NEPC) also released a National Environment Protection Measure (NEPM) for Ambient Air Quality, setting out national standards and goals for six common ambient air pollutants (known as the "criteria" air pollutants). These are sulphur dioxide, particulate matter as PM₁₀¹, carbon monoxide, lead, ozone and nitrogen dioxide.

In May 2003 the NEPC also released a Variation to the Ambient Air Quality NEPM, which introduced advisory reporting standards for PM₂.⁵². These advisory reporting standards have been designed to assist in gathering sufficient data nationally on fine particles, with the information used to inform the planned 2005 review process for the Ambient Air Quality NEPM.

¹ Particulate matter up to 10 microns in diameter
² Particulate matter up to 2.5 microns in diameter
The standards and goals set out in the NEPM for Ambient Air Quality are designed for use in assessing regional air quality and are not intended for use as site boundary or atmospheric dispersion modelling criteria.

The relevant ambient air quality standards for the air pollutants predicted to be emitted from the GTP are presented in Table 22.2.

### Table 22.2 Ambient air quality guidelines

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Regulatory Agency</th>
<th>Pollutant Concentration</th>
<th>Averaging Period#</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ppm)</td>
<td>(µg/m³, 0°C)</td>
</tr>
<tr>
<td><strong>SO₂</strong></td>
<td>NEPC (NEPM)</td>
<td>0.20*</td>
<td>572*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.08*</td>
<td>229*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.02</td>
<td>57</td>
</tr>
<tr>
<td><strong>NO₂</strong></td>
<td>NEPC (NEPM)</td>
<td>0.12*</td>
<td>246*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.03</td>
<td>62</td>
</tr>
<tr>
<td><strong>Total Suspended Particulate Matter – TSP</strong></td>
<td>NSW DEC</td>
<td>-</td>
<td>90</td>
</tr>
<tr>
<td><strong>Suspended Particulate Matter - PM₁₀</strong></td>
<td>NEPC and NSW DEC</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>NSW DEC</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td><strong>Suspended Particulate Matter - PM₂.₅</strong></td>
<td>NEPC</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>NEPC</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td><strong>O₃</strong></td>
<td>NEPC (NEPM)</td>
<td>0.10*</td>
<td>214*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.08*</td>
<td>171*</td>
</tr>
<tr>
<td><strong>CO</strong></td>
<td>NEPC (NEPM)</td>
<td>9*</td>
<td>11,250*</td>
</tr>
</tbody>
</table>

Notes:
* Goal includes a maximum number of allowable exceedances of 1 day per year.
# Averaging period refers to a time period over which the measurement is collected and then averaged for reporting.

### Sulphur Dioxide

Sulphur dioxide (SO₂) is a colourless, pungent, irritating and reactive gas, which is soluble in water.

Natural sources of SO₂ include volcanic and geothermal activity and bacterial and algal processes. The main human activities that produce SO₂ include fossil fuel-based power generation and processing mineral ores containing sulphur. In urban areas, vehicles contribute about 10% of ambient SO₂ levels.
**Oxides of Nitrogen**

Oxides of nitrogen (NO\textsubscript{x}) are formed by the direct combination of oxygen and nitrogen during a variety of thermal processes. Oxides include nitrogen dioxide (NO\textsubscript{2}), nitric oxide (NO) and nitrous oxide (N\textsubscript{2}O).

NO\textsubscript{2} is of greatest significance in terms of potential human health effects and it is this compound that is the focus of ambient quality guidelines and standards. NO emitted into the air, however, reacts with oxygen in the atmosphere to form NO\textsubscript{2}, so emission limits normally relate to total NO\textsubscript{x} emissions, expressed as NO\textsubscript{2}.

NO\textsubscript{2} is a reddish-brown gas with an acrid odour detectable at 0.12 ppm. Natural sources of NO\textsubscript{2} include the biological cycling of nitrogen and thermal processes in the atmosphere, for example lightning. The principal sources of NO\textsubscript{2} from human activities include internal combustion engines (with vehicles being the major source of NO\textsubscript{2} in the urban environment) and thermal power generating stations.

**Particulate Matter**

Suspended particulate matter is dust or aerosol suspended in the atmosphere, with a diameter up to about 10 to 20 microns (µm).

Inhalable particulate refers to that portion of total suspended particulate matter (TSP) that penetrates the upper respiratory tract. The indicator ‘PM\textsubscript{10}’ refers to that fraction of TSP with an aerodynamic diameter smaller than 10 µm. These particles have been recognised as being of concern in terms of potential human health impacts. Recent research, however, has indicated that particles with a diameter less than 2.5 µm (PM\textsubscript{2.5}) may pose a greater risk.

The dust deposition rate is measured as the amount of dust deposited on a horizontal surface as a result of gravitational settling over a specified time period. There are no ambient air quality guidelines for deposited dust in NSW, other than the design criteria shown in Table 22.2 for particulate matter.

**Ozone**

Ozone (O\textsubscript{3}) is a by-product of the chemical reaction that produces photochemical smog in the atmosphere. Ozone is often used as the indicator pollutant for monitoring photochemical smog. While ozone in the upper atmosphere is beneficial to life, by shielding the earth from the sun’s ultraviolet radiation, high concentrations of ozone at ground level are a major health and environmental concern. At elevated concentrations, ozone causes health problems by damaging lung tissue and reducing lung function.

**Carbon Monoxide**

Carbon monoxide (CO) is a colourless, odourless gas produced by the incomplete combustion of carbon in fuels. Major CO sources include transportation activities, as well as incinerators and industrial sources. When CO enters the bloodstream it reduces the delivery of oxygen to organs and tissues.
22.2.3 Air Toxics Assessment Criteria

As well as the six criteria air pollutants specified in the NEPM for Ambient Air Quality, concerns about air quality are also focused on a number of air pollutants which, although found in relatively small concentrations, have the potential to adversely affect human health and the environment through long-term exposure. These substances have been given a variety of names, but are typically referred to as ‘air toxics’ in NSW.

**Volatile Organic Compounds (VOCs)**

‘Total VOCs’ is the term for a grouping of a wide range of organic chemical compounds, which is used to simplify reporting when these are present in ambient air or emissions. The main VOC compound of the dilute stack emissions from the GTP is expected to be EDC, which makes up around 76% of the total VOCs in the feed to the thermal oxidiser.

The National Environment Protection Council released the *National Environment Protection (Ambient Air Toxics) Measure* in April 2004. This document specifies investigation levels for ambient monitoring of benzene, formaldehyde, benzo(a)pyrene, toluene and xylenes. Of these compounds, only benzene and toluene have been identified in the contaminated groundwater and could be discharged from the GTP. The current investigation levels for these compounds are listed in Table 22.3.

The NEPM (Air Toxics) notes that, for toluene, the annual average and 24 hour monitoring investigation levels have been derived independently for different (chronic and acute) health endpoints. In addition, the 24 hour monitoring investigation level has been derived from health based guidelines of 4 ppm for a six hour averaging period.

**Table 22.3 NEPM (Air Toxics) monitoring investigation levels: benzene and toluene**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Period</th>
<th>Monitoring Investigation Level</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ppm) (µg/m³)</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>Annual (i)</td>
<td>0.003 9.6</td>
<td>8-year goal is to gather sufficient data nationally to facilitate development of a standard.</td>
</tr>
<tr>
<td>Toluene</td>
<td>24 hours (ii)</td>
<td>1.0 3770</td>
<td>8-year goal is to gather sufficient data nationally to facilitate development of a standard.</td>
</tr>
<tr>
<td></td>
<td>Annual (i)</td>
<td>0.1 377</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
(i) For the purposes of this Measure the annual average concentrations in Column 3 are the arithmetic mean concentrations of 24-hour monitoring results.
(ii) For the purposes of this Measure monitoring over a 24 hour period is to be conducted from midnight to midnight.

In addition, the guidance document *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2001a) includes impact assessment criteria for a number of other VOCs identified in the contaminated groundwater, as presented in Table 22.4.
Table 22.4 Impact assessment criteria for VOCs

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Ground Level Concentration (ppm)</th>
<th>(µg/m³, 0°C)</th>
<th>Averaging Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>0.033</td>
<td>100</td>
<td>3 minutes</td>
</tr>
<tr>
<td>EDC</td>
<td>1.7</td>
<td>6,700</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>0.033</td>
<td>100</td>
<td>3 minutes</td>
</tr>
<tr>
<td>1,1,2 Trichloroethane</td>
<td>0.33</td>
<td>1,500</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.33</td>
<td>1,590</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>0.17</td>
<td>1,100</td>
<td>3 minutes</td>
</tr>
</tbody>
</table>

Given these different sets of criteria, the air quality impact assessment of VOC emissions has been based on two approaches:

- comparison of emissions and ground level concentrations against assessment criteria (as available) based on dispersion modelling, for screening assessment of the expected VOC emissions; and
- use of the output from the dispersion modelling in the health risk assessment (as presented in Chapter 24) to assess potential adverse acute and chronic (long-term) health impacts, based on accepted assessment methodologies and criteria.

**Dioxins and Furans**

Dioxins and furans are chemically classified as halogenated aromatic hydrocarbons, and belong to a family of chemicals with related properties and toxicity. There are 75 different dioxins, or polychlorinated dibenzodioxins (PCDDs), and 135 different furans, or polychlorinated dibenzofurans (PCDFs). Each different form is known as a ‘congener’ and the most potent member of this family is 2,3,7,8-tetrachlorodibenzo-p-dioxin (or TCDD), which is often referred to simply as ‘dioxin’ and is the reference for a number of compounds which are similar structurally and have dioxin-like toxicity.

In general, the compounds have low water solubility and low vapour pressure; many are very stable and tend to bioaccumulate.

Dioxin-like compounds are not all equally toxic; therefore, the health risk of each congener is assessed by rating their toxicity relative to TCDD, which is assigned a value of 1, to establish toxic equivalency factors. The total toxic equivalency (TEQ) of a group of dioxins and furans is then determined from the sum of all individual congeners, multiplied by their individual toxic equivalency factors. In this chapter the term ‘dioxin TEQ’ is used to cover all dioxins and furans.

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3 Of the 75 PCDD congeners, seven are considered toxic; of the 135 PCDF congeners, 10 are considered toxic. It is these toxic congeners for which toxic equivalency factors are established to determine the TEQ.
CHAPTER 22

Air Quality Assessment

The only potential source of dioxin is the operation of the thermal oxidiser, and the design and operation of the equipment for the GTP is specifically designed to minimise their potential formation, meeting the requirements of the NCUA to "ensure that any air emissions to the environment from works and measures required by this notice are strictly controlled through the adoption of best practice, including the adoption of specific measures to minimise air emissions".

Due to the toxic nature of dioxins, there are no specific ambient air quality criteria, as the use of ambient dioxin goals would consider acute exposure only, not addressing potential chronic and carcinogenic impacts.

Therefore, the air quality assessment considered potential dioxin emissions in order to provide results for the health risk assessment, as presented in Chapter 24, to ensure that all potential impacts associated with their emission are considered and assessed in full.

22.2.4 Air Impact Assessment Criteria

As noted, the guidance document Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW (EPA, 2001a) lists a range of impact assessment criteria for the criteria pollutants, as well as other toxic and odorous air pollutants. The impact assessment criteria set for those pollutants (other than the VOCs discussed above) relevant to activities at the GTP are shown in Tables 22.5 and 22.6.

Table 22.5 Impact Assessment Criteria for Dust Deposition

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Period</th>
<th>Maximum Increase in Deposited Dust Level</th>
<th>Maximum Total Deposited Dust Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposited Dust</td>
<td>Annual</td>
<td>2 g/m²/month</td>
<td>4 g/m²/month</td>
</tr>
</tbody>
</table>

Table 22.6 Impact Assessment Criteria for Air Pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Ground Level Concentration (ppm)</th>
<th>(µg/m³, 0°C)</th>
<th>Averaging Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur Dioxide</td>
<td>0.25 715</td>
<td></td>
<td>10 minutes</td>
</tr>
<tr>
<td></td>
<td>0.20 572</td>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td>0.08 228</td>
<td></td>
<td>24 hours</td>
</tr>
<tr>
<td></td>
<td>0.02 57</td>
<td></td>
<td>annual</td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>0.12 246</td>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td>0.03 62</td>
<td></td>
<td>annual</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>- 50</td>
<td></td>
<td>24 hour</td>
</tr>
<tr>
<td></td>
<td>- 30</td>
<td></td>
<td>annual</td>
</tr>
<tr>
<td>Ozone</td>
<td>0.10 214</td>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td>0.08 171</td>
<td></td>
<td>4 hours</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>87 100,000</td>
<td></td>
<td>15 minutes</td>
</tr>
<tr>
<td></td>
<td>25 30,000</td>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td>9 10,000</td>
<td></td>
<td>8 hours</td>
</tr>
</tbody>
</table>
22.2.5 Assessment of Odours

The assessment guidance (EPA, 2001a) specifies ground level concentration criteria for a number of odorous air pollutants. This is supported by additional guidance in the Draft Policy: Assessment and Management of Odour from Stationary Sources in NSW (EPA, 2001b), which outlines the EPA’s proposed approach for the assessment of odour emissions, using a three-level system of odour impact assessment:

- Level 1: Simple screening exercise to identify the potentially affected zone and site suitability for a proposed facility or expansion of an existing facility;
- Level 2: Simple dispersion modelling procedure, to be undertaken as a minimum for any odour-emitting development for which an EIS or DEC licence is required. Failure to meet the design odour criteria, however, means that a more detailed and refined Level 3 assessment is required; and
- Level 3: A more refined, comprehensive dispersion modelling assessment, including the use of hourly averaged site-specific meteorological data and a robust emissions data set.

The assessment of H₂S emissions from the GTP undertaken as part of this study represents a Level 3 impact assessment.

22.3 Existing Environment

22.3.1 Climate & Meteorology

The climate in the local area can be described as warm and temperate, and is typified by warm to hot summers and cool to mild winters. The coastal nature of the site means that it experiences stronger sea breeze effects and smaller seasonal and daily temperature ranges than more inland areas of Sydney.

Climate data for the air quality assessment is based on data collected by the Bureau of Meteorology (BoM) at Sydney Airport (located approximately 2 km west to north-west of the site). Long-term wind speed and wind direction information recorded at Sydney Airport was also obtained from the BoM in the form of wind roses (a graph showing the proportion of time that wind comes from each direction).

**Temperature & Humidity**

The annual maximum mean daily temperature is 22°C and the annual mean daily minimum temperature is 13°C. January and February are generally the warmest months, with both having mean temperatures of 22°C and 25°C for 9.00 am and 3.00 pm respectively. July experiences the coldest mean temperatures of 10.5°C at 9.00 am and 16°C at 3.00 pm.

The mean relative humidity recorded over 15 years is 69% at 9.00 am and 57% at 3.00 pm. Afternoon humidity levels peak during late summer/autumn and are at their lowest in August.
Rainfall, Evaporation and Cloud Cover

The Project Area experiences a mild seasonal variation in rainfall, with most of the rain falling in the late summer and autumn months. The average annual rainfall is 1094 mm, with an average of 129 raindays per year. Highest falls occur in March and June, each recording a mean of 120 mm and 119 mm/month respectively. Lowest falls occur in September, with a mean of 61 mm. The mean daily evaporation peaks in December at 7.4 mm.

The maximum number of clear days occurs in August, while the maximum number of cloudy days occurs in January.

Wind Speed and Direction

Based on the wind roses prepared by the BoM, which are based on the data collected at Sydney Airport in general:

- in spring, winds in the morning blow predominantly from the northwesterly to southerly sector, while winds in the afternoon are dominated by moderate to strong northeasterly to southerly winds;
- in summer, southerly winds are predominant, with northeasterly winds also occurring frequently during the afternoon;
- during autumn, southerly winds dominate in the afternoon, while in the morning, westerly and northwesterly winds are predominant; and
- in winter, winds from the north-western sector dominate in the mornings.

Mixing Height

Weather conditions at the GTP site can lead to the formation of two different types of temperature inversion, which can lead to air pollution episodes. These are:

- radiation or surface inversions that form overnight through rapid cooling of the ground and surface air layers; and
- subsidence inversions that form at various heights above the ground, due to subsiding air associated with the anticyclone.

Radiation inversions are usually short-lived and rarely persist beyond midday. Subsidence inversions may persist for up to six days while the anticyclone is in the vicinity. Short periods of severe air pollution can occur with radiation inversions, but the worst pollution results from subsidence inversions.

Analysis of weather conditions at the GTP site has been carried out to identify the frequency of inversion effects and hence the frequencies of different mixing heights at the site. The results of this analysis are presented in Appendix G.
Atmospheric Stability

Atmospheric stability affects the atmosphere’s ability to mix and disperse a plume. This is measured by the Pasquill Stability Classes, ranging from A to F. Stability Class A indicates unstable, highly dispersive conditions. Stability Class F indicates highly stable, poorly dispersive conditions.

At the GTP site, the most frequently occurring conditions are stable and poorly dispersive (Stability Class F), which occur 35% of the time. Stability Classes A and B, which denote unstable, well-mixed, convective conditions (normally associated with hot sunny afternoons) occur 17% of the time. Neutral conditions (Stability Class D) occur 21% of the time.

Katabatic Air Drainage and Air Recirculation

In the Sydney region, katabatic winds (where colder, denser air flows down slopes) occur overnight, draining cold air from the mountains down to the coast and out to sea. This results in air pollutants being transported offshore. A sea breeze, usually from the north-east, then develops in the late morning to midafternoon, which transports these air pollutants back across Sydney, typically arriving in the Liverpool area at about 3.00 pm, and at Campbelltown at about 6.00 pm.

A horizontal air flow, circulating in a clockwise direction, can also occur when low-level northeasterly gradient winds combining with sea breezes are blocked by the shape of the land and are redirected.

22.3.2 Existing Air Quality

Air quality in the vicinity of the GTP site is likely to be significantly influenced by the existing emission sources in the Project Area. It would also be affected by emissions from Sydney Airport, located 2 km to the west and north-west, and emissions from vehicles using the major roads in the area, such as Southern Cross Drive, Bunnerong Road and Anzac Parade.

No ambient air quality monitoring has been undertaken in the immediate vicinity of the site. This assessment of existing air quality in and around the site has been based on data collected by the EPA’s ambient air quality monitoring network in the Sydney metropolitan region.

The nearest EPA ambient air monitoring station is the Randwick air quality monitoring site, located in a residential area on the corner of Avoca and Bundock Streets, approximately 3 km north-east of the site. The monitoring site measures:

- NO, NO₂ and NO₃;
- SO₂;
- O₃; and
- fine particles as PM₁₀.

The following summaries of the existing air quality in the area are based on the air quality data collected at this monitoring station in 2001 and 2002, as well as from the State of the Environment Report (DEC, 2003). In each case, the most conservative data were chosen.
**Sulphur Dioxide**

Overall, maximum hourly ambient SO$_2$ concentrations in the Sydney region are low, at less than 25% of the AAQ NEPM standard of 572 µg/m$^3$ (0.20 ppm) (DEC, 2003).

SO$_2$ monitoring data from the Randwick monitoring station, presented in Table 22.7, shows that ambient SO$_2$ concentrations in the area were well below guideline levels during both 2001 and 2002.

<table>
<thead>
<tr>
<th>Monthly Average Daily Maximum 1 Hour Values (pphm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
</tr>
<tr>
<td>2002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1 Hour Maximum Values (pphm)</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>2002</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>24 Hour Maximum Values (pphm)</th>
</tr>
</thead>
<tbody>
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<td>2001</td>
</tr>
<tr>
<td>2002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of events above NEPM Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
</tr>
<tr>
<td>2002</td>
</tr>
</tbody>
</table>

NR = Not Reported
pphm = parts per hundred million

**Oxides of Nitrogen**

For the Sydney region, previously common exceedances of the 1-hour average AAQ NEPM standard of 246 µg/m$^3$ (0.12 ppm), particularly during the winter months in early 1980s, are now rare. For the last three years the highest value recorded in the Sydney region was 164 µg/m$^3$ (0.08 ppm) (DEC, 2003).

NO$_2$ monitoring data from the Randwick monitoring station, presented in Table 22.8, shows that 1-hour average NO$_2$ concentrations in the vicinity of the monitoring station during 2001 and 2002 were well below the 1-hour NEPM Standard for NO$_2$ of 246 µg/m$^3$ (12 pphm).
### Table 22.8 Ambient NO₂ concentrations at DEC’s Randwick monitoring site

<table>
<thead>
<tr>
<th>Site</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
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</thead>
<tbody>
<tr>
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<td>3.3</td>
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<td>1.6</td>
<td>2.4</td>
</tr>
<tr>
<td>1 Hour Maximum Values (pphm)</td>
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<td>4.4</td>
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<td>Number of events above NEPM Standard</td>
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<td>1</td>
<td>2</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

### Suspended Particulates (PM₁₀)

High levels of particle pollution recorded in NSW are generally attributable to bushfires (DEC, 2003).

Table 22.9 summarises the ambient concentrations of PM₁₀ measured by the Randwick monitoring station as 24-hour averages, using a Tapered Element Oscillating Microbalance (TEOM-PM₁₀). Against the 24 hours NEPM standard for PM₁₀ of 50 µg/m³, the goal of no more than five exceedances a year is exceeded, with a total of seven exceedances recorded during the year.

<table>
<thead>
<tr>
<th>Site</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum 24-Hour Values (µg/m³)</td>
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<td>NR</td>
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<tr>
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<td>26</td>
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<td>26</td>
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<td>2</td>
<td>4</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

NR = Not Reported

### Ozone

In the Sydney and Illawarra regions, ozone concentrations can be expected to exceed the NEPM standards on days that have suitable meteorological conditions (DEC, 2003).

Ambient ozone concentrations measured at the Randwick monitoring station, as summarised in Table 22.10, show that ozone concentrations peak during the summer months and are at their lowest during winter. Elevated O₃ concentrations were measured in November and December during both years, with exceedances of both the 1-hour (0.10 ppm) and 4-hour (0.08 ppm) NEPM Standards.
### Table 22.10  Ambient O₃ concentrations at DEC’s Randwick monitoring site

<table>
<thead>
<tr>
<th>Site</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
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<tr>
<td>Monthly Average 1-Hour Values (pphm)</td>
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<td>Maximum 1-Hour Values (pphm)</td>
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</tbody>
</table>

NR = Not Reported

### Carbon Monoxide

CO monitoring, undertaken by the EPA at a number of locations in NSW (including five sites in the Sydney region), indicates that levels are generally low and have fallen over the last two decades, and hence that CO is not a pollutant of regional concern (EPA, 2003). The Sydney CBD site is the only one where elevated levels of carbon monoxide are detected (EPA, 2003).

### Other Contaminants

No deposited dust monitoring has been carried out in the vicinity of the site. Dust deposition would only be expected to be a potential issue for the GTP as a result of construction activities. Once commissioned, the GTP would not result in emissions of the larger deposited particulate size fractions, because the only predicted particulate emissions are PM₁₀, as described above.

For odours, an odour complaint record is maintained for the existing operations at the site. The records for past 20 months show that since January 2003, 26 odour complaints were received by the Orica Botany Site Environment Manager, of which only seven were attributed to site operations.

These results suggest that while activities at the GTP site may give rise to off-site odours, there are other sources of odour in the vicinity of the GTP that can affect the amenity of nearby residential areas.
22.3.3 Data Update: Randwick Monitoring Station

As noted in the tables above, there are some gaps in the available data from the Randwick monitoring station (e.g. due to equipment downtime or failure). However, the data set needed to be completed for the purposes of the air quality modelling detailed below. These gaps have been filled as follows:

- gaps of less than three hours were replaced with the concentration recorded in the previous hour; and
- larger gaps were replaced with concentrations recorded during the same hours on the previous day.

Summaries of the key statistics for the modelling background pollutant data files are presented in Table 22.11.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NO₂</th>
<th>PM₁₀</th>
<th>SO₂</th>
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<td>Complete Data Set</td>
<td>Raw Data</td>
</tr>
<tr>
<td>Number of Records</td>
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<td>8,068</td>
</tr>
<tr>
<td>Percent Complete</td>
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<td>(µg/m³)</td>
<td>(µg/m³)</td>
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<td>52.8</td>
<td>53.2</td>
<td>29.5</td>
</tr>
</tbody>
</table>

22.4 Construction Assessment

The only potentially significant emissions to air associated with the construction phase of the GTP would be dust emissions from soil excavation and handling activities. Other emissions may include exhaust emissions from vehicles used in the construction activities, but these are considered to be negligible in the context of the existing traffic levels in the area (as discussed in Chapter 16).

**Groundwater Treatment Plant**

An investigation into the soil quality at the GTP site has been undertaken, and no significant areas of soil contamination were identified (as detailed in Chapter 11). Any dust emissions generated by soil excavation and handling activities would therefore not be expected to contain significant traces of contaminants.
The location of the GTP is within the BIP (away from the boundaries), which means that there would be little potential for emissions to give rise to nuisance impacts off-site, provided that the works were undertaken with appropriate dust mitigation measures, as described in the proposed Environment Management Plan (EMP).

The GTP site is relatively small, and access to the site is by an existing sealed road network. Therefore, dust emissions from wind erosion and vehicle emissions are expected to be negligible.

**Extraction Well Installation**

The extraction wells yet to be installed include additional wells in the primary containment line in Southlands, and the DNAPL line on the BIP. No specific contamination assessment has been undertaken in these areas, but the drilling installation process would not be expected to generate significant dust or particulate emissions, as these would be prevented by the use of drilling muds/slurries in the process.

The excavated solid materials from the wells, largely composed of sand, would be stockpiled on the existing containment structures on Southlands Block 2 (developed for the excavations from the installation of the secondary containment wells). Given the location of the containment structures on the block (well inside the boundaries, away from the surrounding commercial activities) and the nature of the sand material, no significant dust emissions or impact would be expected.

There may be fugitive emissions of VOCs from the sands deposited in the containment structures, or from the drilling slurries stored in intermediate bulk containers (IBCs) on the BIP itself, but these would be expected to be minor and short-term.

**Discharge Line Refurbishment**

No contamination assessment has been undertaken of the areas to be excavated as part of the discharge line refurbishment. However, the construction activities would be limited to minor excavation of small areas to access the pipeline elbows, and hence potential dust emissions are considered to be minor and effectively controlled through the general construction measures outlined below.

**General Mitigation Measures**

As part of the Environment Management Plan (EMP) for the project, a range of dust mitigation measures would be implemented during construction, including:

- access to the GTP site would be via existing sealed roadways;
- areas of disturbed soils would be minimised during the construction period;
- water may be used to suppress dust emissions during dry windy periods as required, such as light water sprays and/or covering of stockpiles with tarpaulins or geotextiles; and
- separate stockpiling of soils on different work sites is to be kept to a minimum (with a single stockpile of drilling mud/sands from extraction wells).
22.5 Operation Assessment

22.5.1 Approach

Maximum Emission Limits

As part of the process selection and design of the GTP and its operations, Orica determined the maximum emission rates for the final emissions from the discharge stack, which have been provided to the equipment suppliers as the minimum design specifications for the plant.

The development of these maximum emission rates has incorporated Orica’s responsibility under the NCUA to ensure that “any emissions to the environment from works and measures required by this [clean up] notice must be strictly controlled through the adoption of best practice, including the adoption of specific measures to minimise air emissions.”

In order to identify and incorporate best practice emission limits, Orica carried out a systematic and comprehensive review of relevant international regulations, starting with the existing EPA limits set out in the Clean Air Plant and Equipment Regulations 1997. From this starting point, the Options Paper on the Clean Air Plant and Equipment Regulations, titled Clearing the Air (EPA, 2003), was also reviewed, as well as standards and limits from:

- the US Environmental Protection Authority; and
- the Japanese Ministry of the Environment.

These various standards are presented in Table 22.12, alongside the maximum emission limits adopted for the GTP.
## Table 22.12  Comparison of proposed maximum emission limits for GTP

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NOₓ</td>
<td>2000 mg/m³</td>
<td>350 mg/m³ @ 3% O₂</td>
<td>194 mg/m³ @ 11% O₂</td>
<td>400 mg/m³ @ 11% O₂</td>
<td>(a)</td>
<td></td>
<td>60-400 mg/m³ (c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO₂</td>
<td>200 mg/m³ @ 6% O₂</td>
<td></td>
<td>133 mg/m³ @ 11% O₂</td>
<td>200 mg/m³ @ 11% O₂</td>
<td>(a)</td>
<td>Load based</td>
<td>100 mg/m³ @ 11% O₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO₃</td>
<td>100 mg/m³</td>
<td></td>
<td></td>
<td>(a)</td>
<td>-</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>100 ppm @ 7% O₂</td>
<td>69 mg/m³ @ 11% O₂</td>
<td>100 mg/m³ @ 11% O₂</td>
<td>(a)</td>
<td>-</td>
<td>100 mg/m³ @ 11% O₂</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particulates</td>
<td>100 mg/m³ @ 7% O₂</td>
<td>69 mg/m³ @ 11% O₂</td>
<td>100 mg/m³ @ 11% O₂</td>
<td>30 mg/m³ @ 11% O₂</td>
<td>(a)</td>
<td></td>
<td>20-700 mg/m³ (c)</td>
</tr>
<tr>
<td></td>
<td>(69 mg/m³ @ 11% O₂)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCl</td>
<td>100 mg/m³</td>
<td></td>
<td></td>
<td>60 mg/m³ @ 11% O₂</td>
<td>(a)</td>
<td></td>
<td>80-700 mg/m³</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl₂</td>
<td>200 mg/m³</td>
<td></td>
<td></td>
<td>(a)</td>
<td>30 mg/m³</td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dioxins/</td>
<td>0.1 ng/m³ @ 11% O₂</td>
<td>0.1 ng/m³ @ 6% O₂</td>
<td>0.1 ng/m³ @ 11% O₂</td>
<td>0.1 ng/m³ @ 11% O₂</td>
<td>(b)</td>
<td>0.1-5 ng/m³ (d)</td>
<td>0.1 ng/m³ @ 11% O₂</td>
</tr>
<tr>
<td>Furans</td>
<td>(a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOCs</td>
<td>20 ppm @ 7% O₂</td>
<td>14 mg/m³ @ 11% O₂</td>
<td>20 mg/m³ @ 11% O₂ (g)</td>
<td>50-600 mg/m³ (e)</td>
<td>(a)</td>
<td></td>
<td>10 mg/m³ @ 11% O₂ (g)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂S</td>
<td>5 mg/m³</td>
<td></td>
<td></td>
<td>(a)</td>
<td>-</td>
<td></td>
<td>2 mg/m³ @ 11% O₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>10 ppm (f)</td>
<td>-</td>
<td>10 ppm @ 11% O₂, &lt; 50 g/hr</td>
<td></td>
</tr>
<tr>
<td>Monomer (VCM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Notes:**

a) Depends on state; typically load based limits.

b) No limit for vapour thermal oxidisers. Liquid and solid limit is 0.5 ng/m³ @ 11% O₂.

c) Generally only specified for >0.2 t/hr; depends on capacity and location.

d) Depends on waste destruction load: <0.2 t/hr no limit specified, <2 t/hr 5 mg/m³, <4 t/hr 1 ng/m³, >4 t/hr 0.1 ng/m³.

e) Depends on specific compound and other circumstances: Benzene 50-600 mg/m³, Trichloroethylene 150-300 mg/m³, Tetrachloroethylene 150-300 mg/m³.

f) Southern California EPA, also maximum of 50 g/h

g) Expressed as TOC (Total Organic Carbon)

h) The proposed limit is 100 mg/m³ @ 11% O₂ for total SO₂ and SO₃. Due to the caustic scrubber, emissions of SO₃ are expected to be negligible.

i) All proposed limits are dry and per normal m³ (273K and 1 atm). Test methods, averaging periods and percentile will be agreed with the EPA. It is proposed that typically a one hour averaging period be employed, and that for continuous monitoring the 90 percentile apply and for manual monitoring the 100 percentile apply.
The basis for each of the proposed maximum emission limits for the GTP is summarised as follows:

- For NO\textsubscript{x} the proposed limit is a significant improvement on the existing EPA limit of 2,000 mg/m\textsuperscript{3} and meets the European Directive.

- For SO\textsubscript{2} and SO\textsubscript{3} there is no current limit for SO\textsubscript{2} in NSW, but there is a limit of 100 mg/m\textsuperscript{3} for SO\textsubscript{3}. The proposed limit of 100 mg/m\textsuperscript{3} for SO\textsubscript{2} and SO\textsubscript{3} is lower than the proposed value in the *Clearing the Air* Options Paper. The proposed value is lower than the European Directive. Note that due to the caustic scrubber, emissions of SO\textsubscript{3} are expected to be negligible and the assessment has been undertaken on the basis that all SO\textsubscript{2}/SO\textsubscript{3} would be present in the form of SO\textsubscript{2}.

- The CO limit proposed for “engines” in the *Clearing the Air* Options Paper has been selected. The value chosen represents an improvement over previous submissions and on the approved value for a biomedical incinerator in Western Australia, and matches the European Directive.

- The VOC limit proposed in the *Clearing the Air* Options Paper for “engines” has been taken as the basis, and is an improvement on the European Directive.

- For particulates (as PM\textsubscript{10}) the limit proposed is a significant reduction compared to the existing NSW limit, and is equivalent to the lowest Japanese value and lower than the European Directive.

- For H\textsubscript{2}S the proposed limit of 2 mg/m\textsuperscript{3} is lower than the existing NSW limit, to ensure that under worst case operation sensitive community groups would not be affected.

- For HCl the proposed limit matches the value recently approved for the Chlor-Alkali facility at Botany, and is lower than the European Directive.

- For Cl\textsubscript{2} the limit proposed is a significant reduction on existing NSW limit, and is equivalent to the Japanese value.

- For VCM the limit proposed meets the information supplied by the EPA for the operation of the SSU, and is based on the Southern Californian EPA requirements.

- For dioxins and furans the proposed maximum emission limit for the GTP meets or exceeds limits identified.

The very low emission limits proposed can be achieved in this project because of the dilute off-gas stream, the absence of solids and the light hydrocarbons to be treated. The air emissions from the GTP will meet these proposed limits.

Stack concentrations are often expressed at a given percentage of oxygen to correct for any dilution prior to the stack. In Table 22.12, all values have been converted to a standard value of 11% oxygen to allow direct comparison, and converted to milligrams per normal (0°C and 101.325 kPa) dry cubic metre.

**Mass Emission Rates**

Using these maximum emission limits, coupled with the process data for the GTP design (exhaust temperature, exhaust flow rate, etc), an inventory of emissions was compiled to develop the maximum pollutant emission rates for the GTP, as shown in Table 22.13.
Table 22.13 Predicted stack and emission data for the GTP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMG Coordinates</td>
<td>(335,400 mE, 6,241,400 mN)</td>
</tr>
<tr>
<td>Stack Diameter</td>
<td>1.36 m</td>
</tr>
<tr>
<td>Stack Height</td>
<td>20 m</td>
</tr>
<tr>
<td>Gas Temperature</td>
<td>67°C</td>
</tr>
<tr>
<td>Gas Flowrate</td>
<td>12.8 Nm$^3$/s</td>
</tr>
<tr>
<td>Efflux Velocity</td>
<td>15 m/s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pollutant Emissions</th>
<th>Concentration (i)</th>
<th>Emission Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxides of Nitrogen</td>
<td>400 mg/m$^3$</td>
<td>10.1 kg/hr</td>
</tr>
<tr>
<td>Sulphur Dioxide</td>
<td>100 mg/m$^3$</td>
<td>2.5 kg/hr</td>
</tr>
<tr>
<td>Particulate Matter (as PM$_{10}$)</td>
<td>20 mg/m$^3$</td>
<td>0.5 kg/hr</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>100 mg/m$^3$</td>
<td>2.5 kg/hr</td>
</tr>
<tr>
<td>Volatile Organic Compounds</td>
<td>10 mg/m$^3$</td>
<td>0.25 kg/hr</td>
</tr>
<tr>
<td>Chlorine</td>
<td>14 mg/m$^3$</td>
<td>0.75 kg/hr</td>
</tr>
<tr>
<td>Hydrogen Chloride</td>
<td>30 mg/m$^3$</td>
<td>0.75 kg/hr</td>
</tr>
<tr>
<td>Hydrogen Sulphide</td>
<td>2 mg/m$^3$</td>
<td>0.05 kg/hr</td>
</tr>
<tr>
<td>Dioxins (TEQ)</td>
<td>0.1 ng/m$^3$</td>
<td>2.5 x10$^{-9}$ kg/hr</td>
</tr>
</tbody>
</table>

Notes:
(i) Concentrations specified at 11% O$_2$, 0°C, dry gas basis

Using this combination of maximum emission limits and rates, the air quality impact assessment provides a conservative, worst-case assessment of the potential air quality impacts, as these represent the ‘worst case’ emissions from the GTP. It should be noted that any variation from these parameters in the final design that increase height, temperature or velocity in the stack would improve dispersion and lead to lower ground level concentrations.

For VOCs, the emission concentrations and emission rates for the individual components are based on the composition of VOCs specified within the contaminated groundwater feed (as presented in Appendix L) with equivalent destruction efficiency of the thermal oxidiser for destruction of each compound.

For dioxins/furans, the maximum emission limit of 0.1 ng/m$^3$ is not used as a criterion to assess the acceptability of potential dioxin emissions. Due to the toxic nature of dioxins, there are no specific ambient air quality criteria, as the use of ambient dioxin goals would consider acute exposure only, and would not address potential chronic and carcinogenic impacts. Instead, the results of the dispersion modelling (undertaken using the maximum emission limit) have been incorporated within the health risk assessment (Chapter 24) to consider the potential acute and chronic impacts from the emissions.

A summary of the current emissions from the existing sources within the BIP is provided in the full report in Appendix G.
22.5.2 Assessment Methodology

Cumulative Impacts

In quantitatively assessing air quality impacts from a proposed development at an existing industrial site, there are three components that need to be addressed:

- air emissions from the proposed new development itself;
- air emissions from the plant and equipment already operating at the site; and
- background pollutant concentrations from other emission sources in the regional airshed (other industries, vehicles, domestic sources, natural sources, etc).

The cumulative impacts of these three contributing sources need to be assessed on a pollutant-by-pollutant basis.

The approach used in this assessment has been to include emission data for all existing air emission sources within the BIP in the air dispersion modelling study, through the compilation of a detailed emissions inventory for the existing plants at the BIP.

The assessment has also used regional background pollutant data collected at the Randwick monitoring station, to provide a thorough assessment of cumulative impacts. Hourly background NOx, PM10 and SO2 concentration data files were compiled from data collected at this monitoring station during 200/2001. For the other pollutants, either a 'typical Sydney' background level has been estimated, based on publicly available information or, if appropriate, ambient concentrations have been assumed to be negligible.

The potential emissions from the SSU, operated under the revised EPL from the EPA as the interim treatment measure, have not been incorporated within this assessment, as the two plants (SSU and GTP) would not be operated at the same time. The SSU would be operated until the GTP was commissioned and fully operational, at which time the extracted groundwater would be transferred to the GTP for treatment and the SSU would cease operation. The operation of the SSU would be managed during the commissioning period for the GTP, to limit simultaneous operation of the plants.

Dispersion Modelling

In order to understand the transportation of contaminants discharged into the air, a computer atmospheric dispersion model was employed for this assessment. Modern air dispersion models calculate the pollutant concentration downwind of a source using information on the:

- contaminant emission rate;
- characteristics of the emission source;
- local topography;
- meteorology of the area; and
- ambient or background concentrations of the pollutant.
Models can be set up to estimate downwind concentrations of contaminants over varying average periods, either short-term (e.g. three minutes) or long-term (e.g. annual).

In consultation with the EPA, the CALPUFF air dispersion model was used for this assessment. As the GTP site is located close to the NSW coastline, the potential exists for shoreline fumigation conditions to occur which would affect the dispersion of emissions from tall sources such as the 73 m tall Qenos Site Utilities boiler stacks and the 35 m tall Qenos Olefines cracker furnace stacks on the BIP. The use of the CALPUFF model is considered to be appropriate for these conditions, and was agreed with the EPA.

The modelling has been undertaken using meteorological data for 2001, which was the more conservative data set available and was deemed appropriate for the model complexity. The data was generated using both the meteorological pre-processor (CALMET) and The Air Pollution Model (TAPM), which is a three dimensional meteorological and air pollution model produced by the CSIRO Division of Atmospheric Research. CALPUFF was then used to calculate the dispersion of the plumes within this three-dimensional meteorological field.

The impact of air flowing over buildings and reducing plume dispersion has been included in the modelling for a number of buildings and structures in the vicinity of stack discharges. These include the Qenos Olefines cracker furnaces on the BIP, a warehouse located north of the GTP site, and two cooling towers and the decommissioned cells building near the Chlorine Plant.

**Normal Operation Modelling Scenarios**

In order to be able to assess the incremental impact of the GTP, as well as the cumulative impacts, under the full range of potential operating scenarios at the site, a range of emission scenarios have been assessed:

- Scenario 1: Normal plant operation, with the GTP stack emitting on its own;
- Scenario 2: Normal operation of the BIP, with existing plants operating at current typical discharge concentrations without the GTP, including background levels; and
- Scenario 3: Normal plant operation, with the GTP stacks emitting with the rest of the BIP plants operating at typical loads and including background levels.

No assessment of emissions to air from the GTP during maintenance has been carried out as part of this assessment. In the event of maintenance activities that may affect any part of the treatment stages of the GTP, the entire plant would be shut down and there would therefore be no emissions to atmosphere.

**Abnormal Operation Modelling Scenarios**

Two potential abnormal operating scenarios have been identified, based on an unlikely combination of factors, both with an estimated risk of occurrence of once in 50,000 years. These have been assessed for completeness through this assessment and to provide data for assessment within the health risk assessment. These scenarios are:

- Scenario A – Incorrect thermal oxidiser temperature: Failure of temperature control leading to lower than optimal temperature in the oxidiser, in turn leading to a higher dioxin emission level, up to 0.5 ng/m³; and
Scenario B – Uncontrolled air emission: Failure of temperature and automatic shutdown controls, coupled with operator inaction, leading to minimal effective destruction efficiency of the thermal oxidiser and emission of untreated off-gas.

**Sensitive Receptors**

Table 22.14 sets out the 14 receptor locations used in the computer model to assess predicted pollutant concentrations at the nearest sensitive locations around the GTP site. These represent specific points all around the site for assessment purposes, indicative of the surrounding commercial and residential areas.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Receptor Name</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Botany Golf Course</td>
<td>outdoor activities</td>
</tr>
<tr>
<td>2</td>
<td>Banksmeadow Primary School</td>
<td>young children</td>
</tr>
<tr>
<td>3</td>
<td>Garnet Jackson Reserve</td>
<td>outdoor activities</td>
</tr>
<tr>
<td>4</td>
<td>Pagewood Primary School</td>
<td>young children</td>
</tr>
<tr>
<td>5</td>
<td>Botany Athletic Centre</td>
<td>outdoor activities</td>
</tr>
<tr>
<td>6</td>
<td>Denison Street North</td>
<td>Representative residential</td>
</tr>
<tr>
<td>7</td>
<td>Denison Street South</td>
<td>Representative residential</td>
</tr>
<tr>
<td>8</td>
<td>Guides Hall</td>
<td>young people</td>
</tr>
<tr>
<td>9</td>
<td>Retirement Village</td>
<td>older people</td>
</tr>
<tr>
<td>10</td>
<td>Our Lady of the Annunciation School</td>
<td>young people</td>
</tr>
<tr>
<td>11</td>
<td>Marist Brothers High School</td>
<td>young people</td>
</tr>
<tr>
<td>12</td>
<td>Childcare Centre</td>
<td>young children</td>
</tr>
<tr>
<td>13</td>
<td>St Agnes Primary School</td>
<td>young people</td>
</tr>
<tr>
<td>14</td>
<td>South Sydney High School</td>
<td>young people</td>
</tr>
</tbody>
</table>

The location of these receptors is shown on Figure 22.1.

While these 14 receptors have been selected for detailed analysis, where maximum ground level concentrations are reported in this study, those maxima are the highest concentrations predicted over the entire 9 km by 10 km modelling grid. Therefore, the potential for air quality impacts at other sensitive locations in the modelling area has not been excluded, and this has been identified in the reporting of the modelling results.

**22.5.3 Impact Assessment**

The predicted ground level concentrations for the contaminants discharged from the GTP stack are presented in the following sections, and assessed against the relevant air quality criteria presented in Section 22.2, for the maximum predicted concentrations and the range of concentrations at the 14 receptor locations.
**Oxides of Nitrogen**

The assessment of NO_x impacts was carried out in two stages.

The first stage adopted a very conservative assumption, that all the NO_x emissions would be NO_2. The results of this first conservative stage, with the predicted concentrations for the operating scenarios, are presented in Table 22.15.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Maximum Ground Level NO_x Predictions (µg/m³)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Hour Averages</td>
</tr>
<tr>
<td>Scenario 1 – GTP Emissions Only</td>
<td>236</td>
</tr>
<tr>
<td>Scenario 3 – GTP &amp; BIP Emissions</td>
<td>791</td>
</tr>
<tr>
<td>Criteria</td>
<td>246</td>
</tr>
</tbody>
</table>

Notes:

* No background NO_2 concentrations included.

Since the emissions from the GTP and other existing BIP sources have been modelled based on total NO_x emission rates, the ground level concentrations shown in Table 22-15 are also expressed as total NO_x. Of the NO_x compounds, however, it is NO_2 that is of greatest significance in terms of potential human health effects, and it is this compound that is the focus of ambient quality guidelines and standards.

The NO_x modelling results show that maximum 1-hour average ground level NO_x concentrations for the GTP operating on its own are below the assessment criterion for NO_2 of 246 µg/m³. Downwind NO_2 concentrations would therefore also be below the assessment criterion. The maximum 1-hour NO_x concentrations predicted for the other operating scenarios modelled, however, exceed the NO_2 guideline and further analysis is required.

As shown more fully in the report (Appendix G), the addition of the GTP does not affect the maximum predicted 1-hour average NO_x concentration, with 791 µg/m³ predicted for the current BIP emission scenario as well as the future BIP plus GTP emissions scenario. This is because the worst case 1-hour prediction occurs at a time and at a location when the ground level NO_x concentration is solely influenced by existing emission sources at the BIP. This type of situation will occur if the wind direction associated with the worst case conditions does not result in the plume from the GTP overlapping with the plumes from the existing sources. This is demonstrated in Figure 22.2, which presents the maximum predicted 1-hour average NO_x concentrations predicted by the modelling for cumulative modelling scenario. This figure shows that the maximum ground level NO_x concentrations are predicted to occur in the vicinity of the ground flares at the north-western end of the site. These low level releases would be expected to give rise to maximum predictions close to the source under light wind or calm conditions, when the emissions from the GTP may not be blowing towards this part of the site.
Consequently, further analysis was undertaken to take into account the conversion of NO\textsubscript{x} to NO\textsubscript{2}. At the point of discharge, the NO\textsubscript{2}:NO\textsubscript{x} ratio for combustion gas emissions is normally in the range of around 5–10%, with the majority of the NO\textsubscript{x} being in the form of NO. NO emitted into the air, however, reacts in the atmosphere to form additional NO\textsubscript{2}, which means that the NO\textsubscript{2}:NO\textsubscript{x} ratio in the plume would increase as it travels downwind.

Because the first stage work was very conservative in its assumptions, the second stage incorporated a conversion based on the US EPA’s Ozone Limiting Method (OLM), since there is no methodology specified by the NSW EPA Guidelines (EPA, 2001a). The OLM analysis involves analysis of the 1-hour model predictions using concurrent hourly records of ambient O\textsubscript{3} levels and background NO\textsubscript{2} concentrations for the area, and was undertaken for the 14 sensitive receivers only.

Table 22.16 presents the results as the highest and lowest predicted concentrations at the sensitive receivers for the combination of GTP, existing BIP operations and existing background concentrations.

The results show two key conclusions:

- No exceedances of either the long-term (annual average) or short term (1-hour average) NO\textsubscript{x} assessment criteria are predicted at the sensitive receivers for any of the operating scenarios.

- Ambient concentrations are dominated by the existing ambient levels, with the contribution from the GTP being virtually negligible (as shown by the very minor changes (if any) between highest and lowest concentrations at the receivers when background levels are included).

### Table 22.16  Summary of NO\textsubscript{2} ground level concentrations at sensitive receivers

<table>
<thead>
<tr>
<th>Concentration Range at Receivers</th>
<th>Assessment Criteria (µg/m\textsuperscript{3})</th>
<th>Ground Level Concentration – GTP Emissions (µg/m\textsuperscript{3})</th>
<th>Ground Level Concentration – GTP &amp; BIP Emissions (µg/m\textsuperscript{3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max NO\textsubscript{2} 1-Hour Average (excluding background levels)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest</td>
<td>246</td>
<td>53 (Denison Street north)</td>
<td>97 (Denison Street south)</td>
</tr>
<tr>
<td>Lowest</td>
<td></td>
<td>16 (Banksmeadow School)</td>
<td>42 (South Sydney High)</td>
</tr>
<tr>
<td>Max NO\textsubscript{2} 1-Hour Average (including background levels)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest</td>
<td>246</td>
<td>132 (all locations)</td>
<td>144 (Garnet Jackson Reserve)</td>
</tr>
<tr>
<td>Lowest</td>
<td></td>
<td>132 (all locations)</td>
<td>132 (locations 1, 4-14)</td>
</tr>
<tr>
<td>Max NO\textsubscript{2} Annual Average (excluding background levels)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest</td>
<td>62</td>
<td>1.2 (Denison Street south)</td>
<td>4 (locations 3-6)</td>
</tr>
<tr>
<td>Lowest</td>
<td></td>
<td>0.1 (Banksmeadow School)</td>
<td>1 (locations 8-9, 13-14)</td>
</tr>
<tr>
<td>Max NO\textsubscript{2} Annual Average (including background levels)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest</td>
<td>62</td>
<td>24 (locations 4-7)</td>
<td>27 (locations 3-6)</td>
</tr>
<tr>
<td>Lowest</td>
<td></td>
<td>23 (locations 1-3, 8-14)</td>
<td>24 (locations 8-9, 13-14)</td>
</tr>
</tbody>
</table>
**SO₂**

SO₂/SO₃ emissions from the GTP are estimated at 2.5 kg/hr with a maximum emission concentration of 100 mg/Nm³ (at 11% O₂). Due to the caustic scrubber, emissions of SO₃ are expected to be negligible and this assessment has therefore been undertaken on the basis that all SO₂/SO₃ would be present in the form of SO₂.

Table 22.17 shows the maximum predicted SO₂ ground level concentrations.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Maximum Ground Level SO₂ Predictions (µg/m³)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Hour Average</td>
</tr>
<tr>
<td>Scenario 1 – GTP Emissions Only</td>
<td>125</td>
</tr>
<tr>
<td>Scenario 3 – GTP &amp; BIP Emissions</td>
<td>469</td>
</tr>
<tr>
<td>Criteria</td>
<td>572</td>
</tr>
</tbody>
</table>

Notes:
* Hourly varying background SO₂ concentrations included.

Table 22.18 presents the results as the highest and lowest predicted concentrations for the sensitive receivers for the combination of GTP, existing BIP operations and existing background concentrations.

<table>
<thead>
<tr>
<th>Concentration Range at Receivers</th>
<th>Assessment Criteria (µg/m³)</th>
<th>Ground Level Concentration – GTP Emissions (µg/m³)</th>
<th>Ground Level Concentration – GTP &amp; BIP Emissions (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max SO₂ 1-Hour Average (including background levels)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest</td>
<td>572</td>
<td>106 (Guides Hall)</td>
<td>247 (Guides Hall)</td>
</tr>
<tr>
<td>Lowest</td>
<td>104 (all other locations)</td>
<td>104 (locations 1-3, 6, 9-14)</td>
<td></td>
</tr>
<tr>
<td><strong>Max SO₂ Annual Average (including background levels)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest</td>
<td>57</td>
<td>4 (locations 4-7, 12)</td>
<td>6 (Denison Street north &amp; south))</td>
</tr>
<tr>
<td>Lowest</td>
<td>3 (locations 1-3, 8-11, 13-14)</td>
<td>4 (locations 1-2, 9-11, 13-14)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 22.3 shows the contour plans of the distribution of the predicted maximum 1-hour average SO₂ concentrations for the combined GTP and BIP operations, including background concentrations (i.e. Scenario 3).
The results show the following:

- The maximum ground level SO₂ concentrations predicted are below the assessment criteria for SO₂ for all operating scenarios modelled and for all averaging periods investigated.

- The contribution of emissions from the GTP to off-site SO₂ levels at the sensitive receivers is minor, ranging from 7 to 16 µg/m³ as a 1-hour average, less than 3% of the 1-hour SO₂ guideline.

- Although the short-term (10-minute and 1-hour) maximum ground level predictions are close to the criteria for the combined operations, the longer term predictions (24-hour and annual averages) are well below the criteria, indicating that peak levels are predicted to occur only infrequently.

**PM₁₀**

PM₁₀ emissions from the GTP are estimated at 0.5 kg/hr, with a maximum emission concentration of 20 mg/Nm³. **Table 22.19** shows the maximum predicted PM₁₀ ground level concentrations.

**Table 22.19** Maximum predicted ground level PM₁₀ concentrations

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Maximum Ground Level PM₁₀ Predictions (µg/m³)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24 Hour Average</td>
</tr>
<tr>
<td>Scenario 1 – GTP Emissions Only</td>
<td>36</td>
</tr>
<tr>
<td>Scenario 3. –GTP &amp; BIP Emissions</td>
<td>37</td>
</tr>
<tr>
<td>Criteria</td>
<td>50</td>
</tr>
</tbody>
</table>

Notes:
- * Hourly varying background PM₁₀ concentrations included.

**Table 22.20** presents the results as the highest and lowest predicted concentrations for the sensitive receivers for the combination of GTP, existing BIP operations and existing background concentrations.

**Table 22.20** Summary of PM₁₀ ground level concentrations at sensitive receivers

<table>
<thead>
<tr>
<th>Concentration Range at Receivers</th>
<th>Assessment Criteria (µg/m³)</th>
<th>Ground Level Concentration - GTP Emissions (µg/m³)</th>
<th>Ground Level Concentration - GTP &amp; BIP Emissions (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max PM₁₀ 24-Hour Average (including background levels)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>50</td>
<td>36 (locations 6-8, 11-12)</td>
<td>36 (locations 5-8, 10-14)</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>35 (all other locations)</td>
<td>35 (all other locations)</td>
</tr>
<tr>
<td>Max PM₁₀ Annual Average (including background levels)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>30</td>
<td>19 (locations 4-7, 10, 12-13)</td>
<td>19 (locations 1, 3-8, 10-13)</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>18 (all other locations)</td>
<td>18 (all other locations)</td>
</tr>
</tbody>
</table>
Figure 22.4 shows the contour plans of the distribution of the predicted maximum 24-hour average PM$_{10}$ concentrations for the combined GTP and BIP operations, including background concentrations (i.e. Scenario 3).

The results show two key conclusions:

- No exceedances of either the long-term (annual average) or short term (24-hour average) PM$_{10}$ assessment criteria are predicted at the sensitive receivers for any of the operating scenarios.

- Ambient concentrations are dominated by the existing ambient levels, with the contribution from the GTP being virtually negligible (as shown by the very minor changes (if any) between highest and lowest concentrations at the receivers when background levels are included).

**CO**

The proposed CO emissions from the GTP are estimated at 2.5 kg/hr with a maximum emission concentration of 100 mg/Nm$^3$.

The results of the modelling are summarised in Table 22.21.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Maximum Ground Level CO Predictions (µg/m$^3$)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Hour Average</td>
</tr>
<tr>
<td>Scenario 1 – GTP Emissions Only</td>
<td>58</td>
</tr>
<tr>
<td>Scenario 3 – GTP &amp; BIP Emissions</td>
<td>111</td>
</tr>
<tr>
<td>Criteria</td>
<td>30,000</td>
</tr>
</tbody>
</table>

The results show no exceedances of the CO assessment criteria predicted, with the maximum predicted concentration being 0.37% of the assessment criteria for the 1-hour average. As these levels would not have a significant impact on existing off-site CO levels, CO emissions have not been considered further.

**HCl/Cl$_2$**

There are no other significant HCl/Cl$_2$ emission sources identified in the surrounding area; consequently, the modelling has included the emissions from the GTP and BIP operations only.
Table 22.22 summarises the results of the modelling. Three-minute average predictions (converted from the 1-hour average predictions given by the model) were used in the assessment to enable direct comparison against the relevant assessment criteria.

### Table 22.22 Maximum predicted ground level Cl₂ and HCl concentrations

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Maximum (99.9 percentile) Ground Level Cl₂ and HCl 3-Minute Average Predictions (µg/m³)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cl₂</td>
</tr>
<tr>
<td>Scenario 1 – GTP Emissions Only</td>
<td>15</td>
</tr>
<tr>
<td>Scenario 3 – GTP &amp; BIP Emissions</td>
<td>15</td>
</tr>
<tr>
<td>Criteria</td>
<td>100</td>
</tr>
</tbody>
</table>

Existing emissions of Cl₂ at the BIP are extremely low, so the modelling predictions indicate a relatively large increase in maximum ground level concentrations, although this maximum represents only 15% of the criterion.

Similarly, existing emissions of HCl at the GTP site are extremely low, so the modelling predictions indicate an increase of 20% in maximum ground level concentrations, although this maximum represents only 5% of the criterion.

**H₂S**

There are no other significant H₂S emission sources identified in the surrounding area; consequently, the modelling has included the H₂S emissions from the GTP only.

Table 22.23 presents the results as the highest and lowest predicted concentrations at the sensitive receivers for the operation of the GTP. The values shown are averages for the “nose response time” as defined by the Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW (EPA, 2001a).

### Table 22.23 Maximum predicted ground level H₂S concentrations

<table>
<thead>
<tr>
<th>Concentration Range at Receivers</th>
<th>Maximum Ground Level H₂S Predictions (in µg/m³, 99th Percentiles, Nose Response Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1.2 (Denison Street south)</td>
</tr>
<tr>
<td>Low</td>
<td>0.1 (Banksmeadow Primary School)</td>
</tr>
<tr>
<td>Criteria</td>
<td>1.38</td>
</tr>
</tbody>
</table>

The results show no exceedances of the assessment criteria predicted at the sensitive receivers, with all results well below the odour threshold of 6.3 µg/m³ (0.0045 ppm).
VOCs

The proposed emissions of total VOCs from the GTP have been estimated at 0.25 kg/hr based on the best practice technology assessment undertaken. The mass emission rates of the individual VOCs have been calculated based on the combination of the total VOC emission rate and the VOC composition of the feed to the thermal oxidiser (based on the composition of the contaminated groundwater).

This approach assumes that the thermal oxidiser operates at the same destruction efficiency for all VOC compounds.

The maximum VOC mass emission rates are summarised in Table 22.24, along with the associated maximum predicted ground level concentrations for each compound.

The assessment has focused on the top 10 VOCs in the groundwater, which account for 99.1% of the total VOCs present. Emissions of phenol have also been included because, while this compound only comprises 0.001% of the total VOCs emitted, as it has the lowest assessment criterion of all those compounds and therefore shows the impact that might be typical of a compound with very low threshold. Using these 11 compounds as representative indicators, provided that they show compliance with the assessment criteria, the remaining 0.9% of the VOCs can also be confidently assumed to meet their relevant assessment criteria (where available).

Three-minute average predictions were used in the assessment to enable direct comparison against the relevant assessment criteria, converted from the 1-hour average predictions from the model.

Table 22.24 shows that the maximum predicted ground level concentrations are all significantly less than the relevant assessment criteria, with the most significant emission being VC, at only 0.13% of its criterion. Based on this screening approach, it may be concluded that no impacts on local air quality would be expected as a result of the VOC emissions from the GTP.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Emission Rate (kg/hr)</th>
<th>Maximum 3-Minute Average Ground Level Concentration (µg/m³)</th>
<th>Assessment Criteria (µg/m³)</th>
<th>Percentage of Assessment Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDC</td>
<td>0.16</td>
<td>3.72</td>
<td>6,700</td>
<td>0.06%</td>
</tr>
<tr>
<td>VC</td>
<td>0.007</td>
<td>0.13</td>
<td>100</td>
<td>0.13%</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>0.008</td>
<td>0.16</td>
<td>NA</td>
<td>-</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.001</td>
<td>0.02</td>
<td>100</td>
<td>0.02%</td>
</tr>
<tr>
<td>1,1,2 Trichloroethane</td>
<td>0.001</td>
<td>0.02</td>
<td>1,500</td>
<td>0.001%</td>
</tr>
<tr>
<td>1,1,2,2 Tetrachloroethane</td>
<td>0.001</td>
<td>0.03</td>
<td>NA</td>
<td>-</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.006</td>
<td>0.11</td>
<td>1,590</td>
<td>0.01%</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>0.018</td>
<td>0.35</td>
<td>1,100</td>
<td>0.03%</td>
</tr>
<tr>
<td>cis-1,2 Dichloroethylene</td>
<td>0.001</td>
<td>0.03</td>
<td>NA</td>
<td>-</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>0.015</td>
<td>0.30</td>
<td>NA</td>
<td>-</td>
</tr>
<tr>
<td>Phenol</td>
<td>2.6 x 10⁻⁶</td>
<td>5.1 x 10⁻⁵</td>
<td>36</td>
<td>0.0001%</td>
</tr>
</tbody>
</table>

NA: None available.
Notwithstanding these results, further analysis of the potential for adverse health impacts of VOC emissions from the GTP has been undertaken in the health risk assessment (HRA), as presented in Chapter 24.

**Dioxins and Furans**

The proposed dioxin emissions (as TEQ) from the GTP have been based on world’s best practice emission level of 0.1 ng/m³ (as previously discussed, and presented in context above).

The maximum concentrations predicted by the modelling at the sensitive receptors are shown in Table 22.25. The annual average predictions are not compared to any ambient air quality criteria set for dioxin TEQ, because such ambient dioxin goals would consider acute exposure only, not incorporating potential chronic or carcinogenic impacts.

The results are presented as health impacts for dioxin exposures related to chronic, long-term exposures, for the purpose of assessment of the potential human health risk associated with these emissions, as undertaken in the HRA in Chapter 24.

**Table 22.25  Summary of annual average ground level dioxin concentrations at sensitive receivers**

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Maximum Annual Average Ground Level Dioxin Predictions (ng/m³)</th>
<th>Maximum Annual Deposition (µg/m²/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum predicted across grid</td>
<td>1.54 x 10⁻⁶</td>
<td>3.8 x 10⁻⁶</td>
</tr>
<tr>
<td>1: Botany Golf Course</td>
<td>7.31 x 10⁻⁸</td>
<td>1.9 x 10⁻⁷</td>
</tr>
<tr>
<td>2: Banksmeadow Primary School</td>
<td>7.36 x 10⁻⁸</td>
<td>9.0 x 10⁻⁸</td>
</tr>
<tr>
<td>3: Garnet Jackson Reserve</td>
<td>4.09 x 10⁻⁷</td>
<td>6.8 x 10⁻⁷</td>
</tr>
<tr>
<td>4: Pagewood Primary School</td>
<td>3.58 x 10⁻⁷</td>
<td>8.0 x 10⁻⁷</td>
</tr>
<tr>
<td>5: Botany Athletic Centre</td>
<td>4.90 x 10⁻⁷</td>
<td>7.4 x 10⁻⁷</td>
</tr>
<tr>
<td>6: Denison Street north</td>
<td>7.04 x 10⁻⁷</td>
<td>6.9 x 10⁻⁷</td>
</tr>
<tr>
<td>7: Denison Street south</td>
<td>8.60 x 10⁻⁷</td>
<td>9.4 x 10⁻⁷</td>
</tr>
<tr>
<td>8: Guides Hall</td>
<td>3.34 x 10⁻⁷</td>
<td>3.8 x 10⁻⁷</td>
</tr>
<tr>
<td>9: Retirement Village</td>
<td>3.34 x 10⁻⁷</td>
<td>6.8 x 10⁻⁷</td>
</tr>
<tr>
<td>10: Our Lady of the Annunciation School</td>
<td>3.34 x 10⁻⁷</td>
<td>1.0 x 10⁻⁶</td>
</tr>
<tr>
<td>11: Marist Brothers High School</td>
<td>3.34 x 10⁻⁷</td>
<td>8.9 x 10⁻⁷</td>
</tr>
<tr>
<td>12: Childcare Centre</td>
<td>3.34 x 10⁻⁷</td>
<td>1.4 x 10⁻⁶</td>
</tr>
<tr>
<td>13: St Agnes Primary School</td>
<td>3.34 x 10⁻⁷</td>
<td>1.0 x 10⁻⁶</td>
</tr>
<tr>
<td>14: South Sydney High School</td>
<td>3.34 x 10⁻⁷</td>
<td>6.5 x 10⁻⁷</td>
</tr>
</tbody>
</table>
Air Quality Assessment

CHAPTER 22

**Odour**

The raw groundwater is quite odorous, due to the presence of sulphur compounds and organic acids. As previously described, it is expected that the off-gas treatment (thermal oxidation plus scrubbing) will remove sulphur compounds below the odour threshold.

The organic acids will not be stripped out of the groundwater into the off-gas stream by the air strippers to any significant extent. Any low levels entering the off-gas treatment would be substantially destroyed and removed, leading to the negligible risk of odour.

The stripped water treatment units would be designed to minimise the risk of fugitive emission and odour. The odorous compounds would be partially captured by the activated carbon, with the remainder destroyed in the organic acid removal unit.

In addition, both the reuse water and the marine discharge water will meet the Australian Drinking Water Guidelines for odour.

**Fugitives**

Potential sources of fugitive emissions to air during process operations include:

- pump packing and seals;
- air vents on transfer pipelines;
- flanges on transfer pipelines and other process equipment on the site;
- seals on process equipment, such as air strippers; and
- leaks in off-gas handling equipment.

During process operation, such fugitive emissions would comprise the VOCs within the groundwater and off-gas streams, but these would be expected to be in very small quantities, because the equipment selection and design has been based on minimising such emissions. In addition, the concentration of the VOCs in the groundwater is generally very low.

For example, the three transfer pipelines include air vents on the high points, which will be isolated during normal operation and will only operate during recommissioning after pipeline maintenance, and only for a very short time to discharge trapped air.

**Abnormal Operating Conditions**

Assessment of the two identified abnormal operating scenarios has been undertaken, with results presented below. Each scenario has an estimated frequency of one in 50,000 years.

- Scenario A: As there are no significant process changes, the maximum downwind dioxin concentrations have been estimated by taking the results shown in Table 22.25, and incorporating them (in proportion to the base case) into the health risk assessment in Chapter 24.
Scenario B: Further modelling was undertaken to obtain the estimates of maximum downwind VOC concentrations, as shown in Table 22.26. Because these represent atypical conditions, the assessment criteria are not applicable, and the results have been incorporated in the health risk assessment in Chapter 24.

**Table 22.26 Maximum predicted ground level VOC concentrations under abnormal operating conditions (Scenario B)**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Emission Rate (kg/hr)</th>
<th>Maximum 3-Minute Average Ground Level Concentration (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDC</td>
<td>105.8</td>
<td>6,426</td>
</tr>
<tr>
<td>VC</td>
<td>3.7</td>
<td>227</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>4.5</td>
<td>274</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.5</td>
<td>31</td>
</tr>
<tr>
<td>1,1,2 Trichloroethane</td>
<td>0.5</td>
<td>31</td>
</tr>
<tr>
<td>1,1,2,2 Tetrachloroethane</td>
<td>0.9</td>
<td>55</td>
</tr>
<tr>
<td>Chloroform</td>
<td>3.1</td>
<td>190</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>9.9</td>
<td>599</td>
</tr>
<tr>
<td>cis-1,2 Dichloroethene</td>
<td>0.8</td>
<td>49</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>8.5</td>
<td>516</td>
</tr>
</tbody>
</table>

For Scenario B, further modelling was undertaken to assess the potential elevated emissions of H₂S that would occur if the thermal oxidiser did not destroy the contaminants in the feed gases. Because these represent atypical conditions, the assessment criterion is not applicable, and the maximum ground level concentrations have been compared against the odour threshold for H₂S and other health effects thresholds. The results in Table 22.27 show that odours would be likely to be detectable at the receptors under worst case meteorological conditions, but that the concentrations are much lower than the levels at which adverse health effects could occur.

**Table 22.27 Maximum predicted 3-minute average ground level H₂S concentrations under abnormal operating conditions (Scenario B)**

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Maximum Ground Level H₂S Predictions (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Botany Golf Course</td>
<td>50</td>
</tr>
<tr>
<td>2: Banksmeadow Primary School</td>
<td>24</td>
</tr>
<tr>
<td>3: Garnet Jackson Reserve</td>
<td>44</td>
</tr>
<tr>
<td>4: Pagewood Primary School</td>
<td>54</td>
</tr>
<tr>
<td>5: Botany Athletic Centre</td>
<td>56</td>
</tr>
<tr>
<td>6: Denison Street north</td>
<td>71</td>
</tr>
<tr>
<td>7: Denison Street south</td>
<td>73</td>
</tr>
<tr>
<td>8: Guides Hall</td>
<td>51</td>
</tr>
<tr>
<td>9: Retirement Village</td>
<td>32</td>
</tr>
</tbody>
</table>
### Air Quality Assessment

#### CHAPTER 22

**Receptor Maximum Ground Level H₂S Predictions (µg/m³)**

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Maximum Ground Level H₂S Predictions (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10: Our Lady of the Annunciation School</td>
<td>39</td>
</tr>
<tr>
<td>11: Marist Brothers High School</td>
<td>42</td>
</tr>
<tr>
<td>12: Childcare Centre</td>
<td>48</td>
</tr>
<tr>
<td>13: St Agnes Primary School</td>
<td>39</td>
</tr>
<tr>
<td>14: South Sydney High School</td>
<td>33</td>
</tr>
</tbody>
</table>

**Concentrations causing health effects**

| Odour Threshold (0.0045 ppm) | 6.3  |
| Eye Irritation (30 ppm)      | 42,000 |
| Irritation of the eyes and respiratory tract, leading to nausea, vomiting and headaches (50 – 500 ppm) | 70,000 – 700,000 |
| Olfactory (sense of smell) fatigue occurs (150 to 200 ppm) | 210,000 – 280,000 |
| Pulmonary oedema and unconsciousness after prolonged exposure (250 to 600 ppm) | 350,000 – 840,000 |
| Unconsciousness, stopped breathing, and death after a few breaths due to paralysis of the respiratory centre (1000 to 2000 ppm) | 1,400,000 – 2,800,000 |

**Annual Emission Loads**

Based on continuous operation of the GTP, emitting at the maximum emission rates detailed in Table 22.13, the annual emission loads for the various pollutants would be as listed in Table 22.28. In order to provide context for the proposed emissions in terms of the total site emissions from the whole BIP, the annual emission loads reported to the National Pollutant Inventory for the existing Orica, Huntsman and Qenos operations at the site are included for comparison.

**Table 22.28 Annual emission loads**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Annual Emissions from GTP (kg/annum)</th>
<th>Total Emissions from BIP in 2002/3 [from NPI website] (kg/annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stack</td>
<td>Fugitive</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>21,926</td>
<td>101,500</td>
</tr>
<tr>
<td>Chlorine (Cl₂)</td>
<td>6,579</td>
<td>1,500</td>
</tr>
<tr>
<td>Dioxins (TEQ)</td>
<td>2.19 x 10⁻⁵</td>
<td>7.46 x 10⁻⁵</td>
</tr>
<tr>
<td>Fine Particles (PM₁₀)</td>
<td>4,389</td>
<td>13,781</td>
</tr>
<tr>
<td>Hydrogen Chloride (HCl)</td>
<td>6,579</td>
<td>16,051</td>
</tr>
<tr>
<td>Hydrogen Sulfide (H₂S)</td>
<td>438</td>
<td>-</td>
</tr>
<tr>
<td>Oxides of Nitrogen (NOₓ)</td>
<td>87,696</td>
<td>549,200</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO₂)</td>
<td>21,926</td>
<td>430,731</td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOCs)</td>
<td>2,190</td>
<td>7,285</td>
</tr>
</tbody>
</table>
22.5.4 Mitigation/Management Measures

Mitigation Measures

As discussed in Section 23.4, the CEMP for the construction of the GTP would include a range of dust mitigation measures aimed at reducing the potential for any off-site dust emissions during the construction phases.

As described in Section 5.8, the operation and control of the GTP would be designed to continuously monitor performance parameters, in order to ensure the efficiency of the groundwater treatment processes, and to adjust the operation of the off-gas treatment to maintain the specified emission levels. The monitoring would include process parameters within the GTP, as well as emissions from the stack.

The monitoring would be linked to the GTP control system, which would activate suitable actions in response to excursions from normal operating conditions, such as alarms to initiate further response in the event of continued excursion, followed by automated shut-down of the GTP for critical excursions. Shutdown would result in stopping all groundwater feed, stopping flow through the GTP, stopping off-gas transfer to the thermal oxidiser, and thus stopping emissions to atmosphere.

Mitigation measures for potential fugitive emissions that would be incorporated within the design include the requirement for all contaminated groundwater piping to have minimal flanging, to reduce potential fugitive emissions, and for the EDC pump (to transfer the recovered waste EDC liquid from the isotainer) to be a fully sealed unit to reduce potential EDC fugitive emissions.

Monitoring

Monitoring of air emissions from the GTP would be carried out to demonstrate compliance with assessment criteria and to minimise the potential for any adverse impacts on ambient air quality. The monitoring program would include:

- continuous monitoring of temperature and CO at the exit of the thermal oxidiser;
- continuous monitoring of gas and liquid flow rates, levels and temperatures within the quench scrubbing system to ensure the efficient operation of the unit;
- continuous monitoring of VOC concentrations in the emissions to air, and monitoring that includes speciation of the VC and EDC concentrations;
- continuous monitoring of HCl, oxygen, moisture content, temperature and gas flows discharged to atmosphere from the stack;
- manual sampling and analysis of NOx, PM10, SO2 and H2S concentrations in the exhaust gases upon commissioning of the unit and at agreed intervals thereafter;
- manual sampling and analysis of dioxin and furan concentrations in the exhaust gases upon commissioning of the unit and then at quarterly intervals. Subsequent frequency of monitoring would be agreed with the EPA, dependent on the results; and
• manual sampling of pumps and flanges using a LDAR (Leak Detection and Repair) Protocol for Equipment Leak Estimation Estimate (US EPA, 1995) system to measure and minimise fugitive emissions from all elements of the process.

The NOX, PM10, SO2 and H2S monitoring program would include measurement of the exhaust gas temperature, flow rate, oxygen and moisture content to calculate pollutant emission rates and corrected concentrations.

### 22.5.5 Summary of Mitigation Measures

Mitigation measures that would be implemented during pre-construction, construction or operation are summarised in Table 22.29.

<table>
<thead>
<tr>
<th>Table 22.29</th>
<th>Summary of mitigation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safeguard</strong></td>
<td><strong>Design</strong></td>
</tr>
<tr>
<td><strong>Construction</strong></td>
<td></td>
</tr>
<tr>
<td>Access to the construction sites via existing sealed roadways</td>
<td>✓</td>
</tr>
<tr>
<td>Areas of disturbed soils would be minimised during the construction period</td>
<td>✓</td>
</tr>
<tr>
<td>Water may be used to suppress dust emissions during dry windy periods (as required)</td>
<td>✓</td>
</tr>
<tr>
<td>Stockpiling of soils on separate sites to be kept to a minimum</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td></td>
</tr>
<tr>
<td>A program of continuous monitoring of emissions to air to ensure the efficiency of the GTP and to prevent any discharges to air beyond normal operating conditions</td>
<td>✓</td>
</tr>
<tr>
<td>Operation and control systems of the GTP would shut down the GTP in the event of abnormal operation</td>
<td>✓</td>
</tr>
<tr>
<td>Implementation of LDAR System, for monitoring and minimising fugitive emissions.</td>
<td></td>
</tr>
</tbody>
</table>

### 22.6 Conclusions

The proposed GTP operation would be designed to meet the specified air quality emission guidelines set down by the EPA. In order to assess the impact of the GTP operation on ambient air quality, a detailed atmospheric dispersion modelling study has been undertaken for the construction and operation of the GTP.
CHAPTER 22 Air Quality Assessment

There is a significant buffer distance between the GTP site and nearby sensitive receptors and residential areas, so dust emissions from the construction phase would not be expected to result in off-site nuisance impacts. Similarly, potential dust emissions from other construction activities would be minor, and unlikely to cause off-site impacts. Dust mitigation measures would be specified in the EMP for the project to minimise the potential for any emissions from excavation and soil handling activities.

The results of the modelling predict that the specified maximum emissions to air from the GTP would not be expected to have a significant impact on air quality in the surrounding area. The assessment of potential air quality impacts has been based on the minimum performance specifications, and they therefore represent potential worst case impacts. The air emission limits proposed clearly demonstrate best practice. Dioxin emissions have been considered and modelled, but because the effects of concern are not acute, consideration of potential chronic effects is undertaken in the health risk assessment in Chapter 24. This is similarly the case for the VOC emissions, which have also been considered in the context of assessment criteria.

The key results show:

- No exceedances of the long-term (annual average) or short term (1-hour average) NOx assessment criteria are predicted for any of the operating scenarios modelled.
- Maximum predicted ground level SO2 concentrations are below the assessment criteria set for SO2 for all operating scenarios modelled and for all averaging periods investigated.
- The maximum ground level Cl2 and HCl concentrations are very low, at 14% and 5% of the guidelines, respectively.
- Maximum predicted ground level VOC concentrations are all far below relevant assessment criteria, with the most significant emission being VC, at only 0.13% of its criterion.
- There is the potential for odour impact, but no health impacts, from the assessment of the two very low frequency abnormal operating scenarios. However, further assessment of these scenarios is included in the health risk assessment in Chapter 24.

The operation of the GTP would be monitored for a range of process parameters to ensure efficient operation of the process and the off-gas treatment train, and this would be supplemented by a combination of continuous monitoring and manual sampling of the final emissions to confirm compliance with the specified emission levels.

This monitoring would include continuous monitoring of VOC emissions, with speciation of two principal VOCs within the emissions, EDC and VC, setting a new standard for process monitoring from industrial operations.

The monitoring would be linked with the GTP control system, to ensure that corrective action is taken in the event of excursions from normal operation, with the ultimate response being to shut down the GTP and stop all treatment operations and associated emissions to air.
FIGURE 22-2
Maximum Predicted 1-Hour NOx Concentrations - Combined GTP & BIP Emissions

LEGEND

- GTP Site
- BIP Site

1-Hour NOx Concentration Contours (µg/m³)


PROJECT: 3H489 - 002
FILE NAME: Figure 22.2 NQMI
DATE: 11/11/2004
PROJECTION: MGA Zone 56
FIGURE 22-3
Maximum Predicted 1-Hour SO₂ Concentrations - Combined GTP & BiP Emissions

LEGEND
- GTP Site
- BiP Site

1-Hour SO₂ Concentration Contours (µg/m³)


PROJECT: 3M4898-002
FILE NAME: Figure 22.3.WCP
DATE: 11/11/2004
PROJECTION: MGA Zone 56

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23.1 Introduction

23.1.1 Risk Assessment in Land Use Planning

The NSW Government has recognised that the risks associated with the storage and handling of hazardous materials can never be eliminated entirely. The Government and industry have a responsibility to ensure that these risks are properly managed and that they are negligible compared to the risks faced during the course of everyday life.

DIPNR (as the Department of Urban Affairs and Planning (DUAP) in 1992) developed a rigorous assessment process in connection with approvals for potentially hazardous industries. This process follows a number of steps/stages that provide assurances that the risks imposed by a development upon surrounding land uses would be within acceptable limits, and that this would continue to be the case throughout the life of the development.

As part of the approval process for potentially hazardous industries, it is necessary to determine whether a Preliminary Hazard Analysis (PHA), as defined by State Environmental Planning Policy No.33 – Hazardous and Offensive Development (SEPP 33), is required to be conducted at the development application stage. This policy requires rigorous scrutiny of any proposed activity that has the potential to conflict with surrounding land uses, in terms of risks to people, property or the environment.

Other studies that might be required for approval to be granted include Hazard and Operability Studies (HAZOP), Fire Safety Studies, Final Hazard Analysis (FHA), Construction Safety Studies, development and review of Emergency Plans, and independent Hazard Audits.

When a PHA is undertaken, the results normally include a quantified level of risk. These risks can be compared with the criteria for acceptable risk presented in DIPNR’s Hazardous Industry Planning Advisory Paper No. 4, ‘Risk Criteria for Land Use Safety Planning’ (HIPAP 4) (DUAP, 1992). In cases where the risks imposed exceed the specified criteria, additional controls may be put in place that would reduce the risk to acceptable levels. Such controls could be a combination of technical controls (engineering hardware), operational controls (management systems and operating controls) and locational controls (e.g. removing the risk source to a more remote location).

23.1.2 PHA Screening

As part of the screening process, SEPP 33 requires a summary of the potentially hazardous materials for a proposed development to be compiled and evaluated. The material summary for the BGC Project is presented in Table 23.1.
### Table 23.1 SEPP 33 material summary

<table>
<thead>
<tr>
<th>Material</th>
<th>Dangerous Goods Class(i)</th>
<th>Quantity</th>
<th>Exceeds SEPP 33 Criterion?</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 wt% hydrochloric acid</td>
<td>Corrosive - 8 (PG II)</td>
<td>40 m³</td>
<td>Yes</td>
<td>On the GTP site</td>
</tr>
<tr>
<td>46 wt% caustic soda</td>
<td>Corrosive - 8 (PG II)</td>
<td>30 m³</td>
<td>Yes</td>
<td>On the GTP site</td>
</tr>
<tr>
<td>Recovered waste EDC liquid (Isotainer)</td>
<td>Flammable liquid - 3, toxic - 6.1 (PG II)</td>
<td>20 tonnes</td>
<td>Yes (for toxic criterion)</td>
<td>On the GTP site</td>
</tr>
<tr>
<td>Groundwater</td>
<td></td>
<td>15 ML/day</td>
<td>NA</td>
<td>Piped to and on the GTP site</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Flammable gas - 2.1</td>
<td>Negligible</td>
<td>No</td>
<td>In piping to the thermal oxidiser only</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Non-flammable, non-toxic gas - 2.2</td>
<td>Negligible</td>
<td>No</td>
<td>In piping</td>
</tr>
<tr>
<td>Sodium metabisulphite (33 wt%)</td>
<td>Corrosive - 8 (PG III)</td>
<td>4.5 m³</td>
<td>No</td>
<td>On the GTP site</td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>Corrosive - 8 (PG II)</td>
<td>5 m³</td>
<td>No</td>
<td>On the GTP site</td>
</tr>
<tr>
<td>Various water treatment chemicals</td>
<td>Corrosive - 8</td>
<td>Low</td>
<td>No</td>
<td>On the GTP site and/or brought on-site for equipment cleaning and then removed</td>
</tr>
<tr>
<td>Flocculant</td>
<td></td>
<td>6 m³</td>
<td>NA</td>
<td>On the GTP site</td>
</tr>
<tr>
<td>Salty waste water</td>
<td></td>
<td>Negligible</td>
<td>NA</td>
<td>Pipeline from GTP to Brotherson Dock</td>
</tr>
<tr>
<td>Steam</td>
<td></td>
<td>Minor</td>
<td>NA</td>
<td>On the GTP plot</td>
</tr>
</tbody>
</table>


As the nature and quantities of some of the materials for the GTP operations exceed the SEPP 33 screening thresholds, the GTP is considered a ‘potentially hazardous facility’ in terms of SEPP 33, and a PHA is therefore required.

The primary purpose of the PHA is to ensure that the design and location of the GTP is appropriate for a facility of this type in terms of the risks imposed upon surrounding land uses by its operations, including the transport of recovered waste EDC liquid, the extraction and transfer of groundwater by pipelines to the GTP and the reuse or discharge of treated water. The following sections summarise the works and results of the PHA prepared for the BGC Project.

The full PHA report is presented in Appendix I.
23.2 Objectives of the Preliminary Hazard Analysis

The general objectives of a PHA are to develop an understanding of the hazards and risks associated with an operation at a site and to model the consequences, calculate the risk and ensure that the level of risk is as low as reasonably practical and meets community standards.

The specific aims of the PHA study for the proposed BGC Project were to:

- address the Director-General’s requirements for the PHA (as presented in Appendix C);
- identify the credible, potential hazardous events associated with the GTP and associated operations;
- evaluate the level of risk associated with the identified potential hazardous events from the GTP and associated operations to surrounding land users, including other BIP companies and their operations, and to compare the calculated risk levels with the risk criteria published by DIPNR in HIPAP 4 (DUAP, 1992);
- review the adequacy of the existing safeguards; and
- present recommendations to ensure that the GTP and associated operations are operated and maintained at acceptable levels of safety, and that effective safety management systems are used.

23.3 Preliminary Hazard Analysis Methodology

23.3.1 Scope

The PHA assesses the credible, potential hazardous events and corresponding risks associated with the GTP and associated operations.

The assessment covers:

- the GTP process operations;
- material storage;
- pumping and transport of groundwater through pipelines to the GTP as part of its operations;
- pumping and transport of treated water through pipelines from the GTP as part of its operations;
- road transport of recovered waste EDC liquid from storage at Terminals Pty Ltd’s bulk liquid storage facility at Port Botany for destruction in the GTP as part of its operations; and
- pumping and transport of salty waste water (water treatment by-product) via a discharge pipeline from the GTP to a stormwater channel discharging to Brotherson Dock.

It does not include any aspects of the storage and handling of recovered waste EDC liquid at Terminals Pty Ltd’s facility, because the facility is owned by a third party and is covered by its own planning approvals and licence, which include storage and handling of waste CHCs such as the recovered waste EDC liquid.
CHAPTER 23 Preliminary Hazard Analysis

As with most PHAs, limited detailed design information is currently available. Correspondingly, some of the analysis in the assessment was based on assumed conditions. The assumptions made in the analysis would be reviewed throughout the project design stage and updated in the Final Hazard Analysis, which would be prepared if required as a Condition of Approval of the Activity.

23.3.2 PHA Boundary

Because the GTP would be considered as part of Orica’s existing operations on the BIP, for the purposes of the assessment of the GTP and its operations, there are in effect two boundaries to be considered:

- the boundaries between Orica and neighbouring industrial land users, the nearest being other companies/facilities within the BIP; and
- the boundary with residential land users outside the BIP.

Where associated operations required for the BGC Project—such as wells, pipelines and road transport—are located outside the BIP, then the relevant boundaries for risk assessment are the land users adjacent to, and nearby, these operations.

23.3.3 Methodology

In accordance with the approach recommended by DIPNR in HIPAP 6 (Guidelines for Hazard Analysis, Hazardous Industry Planning Advisory Paper No. 6, 1992, DIPNR), the underlying methodology of the PHA is risk-based; that is, the risk of a particular potentially hazardous event is assessed as the outcome of its consequences and likelihood.

The PHA has been conducted as follows:

- the design and location of the GTP and associated operations were reviewed to identify credible, potential hazardous events;
- the consequence of each potential hazardous event was estimated;
- if required by the consequence results, the frequency (likelihood) of the potentially hazardous event was estimated
- the risk results were quantified by combining the frequency and consequence for each event to identify the total (cumulative) risk as appropriate; and
- the risks associated with the GTP and associated operations were compared to the criteria in HIPAP 4 (DUAP, 1992).
23.3.4 Risk Criteria

The risk criteria applying to new developments in NSW are summarised in *Risk Criteria for Land Use Safety Planning*, (DUAP, 1992). Criteria are defined for:

- individual fatality risk;
- injury risk levels;
- irritation risk levels;
- risk of property damage and accident propagation;
- societal risk; and
- biophysical environment risk

The PHA has compared the risks associated with the GTP and associated operations to the HIPAP 4 criteria, and the results are presented in Section 23.7.

23.4 Hazard Identification

23.4.1 Hazardous Materials

The key hazardous materials identified for the BGC Project are summarised below. Other non-hazardous materials are also included for information.

*Groundwater*

Over 99% of the groundwater, by weight, is water. The principal identified chemicals of concern, and their typical concentrations, are:

- EDC (less than 0.02%);
- TCE (less than 0.001%);
- CTC (less than 0.002%);
- PCE (less than 0.002%), and
- VC (less than 0.001%).

The groundwater is not classified as a Dangerous Good under the National Road Transport Commission’s *Australian Code for the Transport of Dangerous Goods by Road and Rail* (6th Edn) (NRTC, 1998). The Orica Material Safety Data Sheet for this material classifies it as non-hazardous, according to the criteria of the National Occupational Health and Safety Commission (NOHC).

The full design composition of the groundwater feed to the GTP is presented in Appendix L.
CHAPTER 23 Preliminary Hazard Analysis

Recovered Waste EDC Liquid

The operation of the GTP would also include treatment of the recovered waste EDC liquid produced by the SSU, as one of the short-term measures being implemented by Orica before the construction and operation of the GTP. The principal contaminant in the recovered waste liquid is EDC, at approximately 95% by weight.

As described in Chapter 5, the recovered waste EDC liquid would be stored in the existing EDC storage tanks at Terminals Pty Ltd’s bulk liquid storage facility at Port Botany, and subsequently transported to the GTP once it is in operation for treatment.

Hydrogen Chloride & Chlorine

Hydrogen chloride (HCl) and chlorine (Cl₂) would be produced in the thermal oxidation unit and would be present in the exit stream passed to the acid scrubber. They are corrosive gases which can affect people, property and the environment. Chlorine would be present at much lower concentrations than hydrogen chloride.

Natural Gas

The thermal oxidation unit would burn natural gas for additional heat input. This gas is the same as that used in domestic situations, e.g. household water heaters and stoves.

Natural gas is a flammable gas and releases can lead to fires and/or explosions if ignition occurs. It is not toxic, but it is an asphyxiant.

Corrosives

The two corrosive fluids that would be handled and/or stored at the GTP in bulk would be hydrochloric acid (5 wt%) and caustic soda (sodium hydroxide; 46 wt%). Other corrosive chemicals that would be stored and used at the GTP include:

- sodium metabisulphite solution, for use as a reducing agent in the caustic scrubber (total storage 4.5m³ as 33% solution; annual use 18 tonne as 100%); and
- sodium hypochlorite solution, for ammonia removal (total storage 5m³ as 12% solution; annual use 220 tonne as 100%)
- small quantities of miscellaneous chemicals, which may be stored on a temporary or permanent basis for GTP maintenance, especially for the treated water equipment.

Releases of these materials can affect those who come into contact with the liquid and/or vapour above the liquid, as well as potentially affecting the environment if allowed to flow to soil and/or waterways.

Nitrogen

Nitrogen is non-toxic (it is the major constituent of air) but it presents the hazard of asphyxiation to on-site personnel who may enter equipment containing nitrogen or a reduced oxygen content due to dilution by nitrogen.
Oxides of Sulphur and Nitrogen

Oxides of sulphur and nitrogen (SOx and NOx) are formed in the thermal oxidation unit as by-products of combustion. The potential impact of operating emission of these materials is considered as part of the air quality assessment in Chapter 22.

Marine Discharge Water

This is the salty waste stream produced as part of the water treatment process. It contains the chlorides removed from the main treated water stream in order to meet the specifications for supply of treated water to other users. It is not a Dangerous Good or a Hazardous Material. The expected effects of discharge of this material are discussed in Chapter 13.

Steam

Medium pressure (around 1000 kPag) steam is produced in the waste heat boiler, which is part of the thermal oxidation unit. Its associated hazards—high temperature and pressure—would only have local effects.

23.4.2 Potential Hazardous Incidents

In accordance with the requirements of DIPNR’s Guidelines for Hazard Analysis (HIPAP 6, 1992), it is necessary to identify hazardous events that could be caused by the GTP and it associated operations. As recommended in HIPAP 6, the PHA focuses on atypical and abnormal events and conditions. It is not intended to apply to continuous or normal operating emissions to air or water. The latter are discussed elsewhere in the EIS (see Chapters 22 and 13, respectively).

Hazardous events are those that could cause injury or fatalities to people, or damage to property or the biophysical environment. They include:

- fires causing damage by heat radiation;
- explosions causing damage by overpressure; and
- toxic or environmentally hazardous materials escaping to the air, waterways or the ground.

Potential hazardous events for the GTP and associated operations were identified through:

- hazard studies involving design and operating personnel;
- operational experience;
- literature reviews;
- checklists; and
- historical incident reviews.
In keeping with the principles of PHAs, credible, hazardous events with the potential for off-site effects have been identified. “[S]lips, trips and falls” type events are not included, nor are non-credible situations such as an aircraft crash occurring at the same time as an earthquake.

The large majority of the identified specific release scenarios of hazardous materials are caused by generic equipment failures, e.g. failures of vessels, pipes, etc. Information about these failures is taken from data collected on previous industrial events. These are supplemented by information about process incidents caused by other abnormal modes of operation, control system failure and human error.

The credible, significant incidents identified are summarised in the Table 4 in the full PHA report in Appendix I. Those events with the potential for significant consequences are summarised in Table 23.2, on the following pages. These events have also been included in the quantified risk assessment for the BGC Project.

Where abnormal events are assessed as having potentially chronic effects, these are discussed in the Human Health Risk Assessment (Chapter 24). The PHA itself only discusses acute effects.
### Table 23.2 Summary hazard identification

<table>
<thead>
<tr>
<th>Item No.*</th>
<th>Event</th>
<th>Causes</th>
<th>Possible Consequences</th>
<th>Prevention/Protection</th>
<th>Evaluated in EIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Emissions of dioxin from the thermal oxidiser</td>
<td>Thermal oxidiser does not perform to specification under all required conditions</td>
<td>Dioxins may be produced with impact to people and fauna.</td>
<td>Control and Monitoring System will shut down the plant under abnormal conditions, i.e. stop the air stripper and shut down the feed to the thermal oxidiser. Regular testing will occur to prove good operation (note: risks assessed in Health Risk Assessment, Chapter 24)</td>
<td>Chapter 24</td>
</tr>
<tr>
<td>9</td>
<td>Piping from the stripper to the thermal oxidiser fails</td>
<td>Pipes can fail due to a number of reasons, e.g. design and manufacturing errors, corrosion and impact</td>
<td>Loss of containment of air stream containing the groundwater impurities. Potential to impact people and the environment</td>
<td>Design and maintenance procedures Pipe protection from traffic</td>
<td>Section 23.6.1</td>
</tr>
<tr>
<td>10</td>
<td>Natural gas jet fire impinging on stored EDC, other plant and/or people</td>
<td>Rupture of natural gas line or leak from valves which is ignited</td>
<td>EDC fire; possible Boiling Liquid Expanding Vapour Explosion (BLEVE) of the EDC isotainer; plant damage, injury to people, environmental impacts</td>
<td>‘Dematched’ site reduces chances of ignition (i.e. no matches or lighters) Design and maintenance procedures for the natural gas supply line Fire protection equipment for emergency response Isolation of the natural gas line at the plant battery limit</td>
<td>Section 23.6.2</td>
</tr>
<tr>
<td>11</td>
<td>Natural gas supply line failure</td>
<td>Mechanical impact Corrosion Weld defect Gasket leak</td>
<td>Release of natural gas to atmosphere; fire, Unconfined Vapour Cloud Explosion (UVCE) if ignited</td>
<td>Dematched site reduces chances of ignition Emergency isolation valve (EIV) on feed line to plant plus manual isolations Design and maintenance procedures for the natural gas supply line Fire protection equipment for emergency response</td>
<td>Section 23.6.3</td>
</tr>
</tbody>
</table>

* from PHA Table 4 (Appendix I)

1 For an explanation of the BLEVE event, see Section 23.6.2
## Preliminary Hazard Analysis

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Event</th>
<th>Causes</th>
<th>Possible Consequences</th>
<th>Prevention/Protection</th>
<th>Evaluated in EIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Gas burner management system fails unsafely causing explosion inside the thermal oxidiser</td>
<td>Non-compliance with gas supplier requirements, Component failures</td>
<td>Fatalities or injuries to operators; plant damage</td>
<td>The thermal oxidiser burner management system is to comply with the AGL requirements</td>
<td>Section 23.6.4</td>
</tr>
<tr>
<td>13</td>
<td>The thermal oxidiser does not operate correctly</td>
<td>Burner problems, poor gas quality, burner management system faulty, air flow problems, feed flow problems</td>
<td>Off-gas is not in specification, Potential chronic and acute effects on people and the environment</td>
<td>Air stripping should not continue if the thermal oxidiser is not operating correctly, e.g., correct temperature or fan stopped. Alarms and trips are proposed to be used to avoid incorrect operation (note: chronic effects assessed in Health Risk Assessment, Chapter 24)</td>
<td>Section 23.6.1, Chapter 24</td>
</tr>
<tr>
<td>15</td>
<td>Undetected release of EDC from stack</td>
<td>Hole in thermal oxidiser feed/product heat exchanger allowing untreated vapour into the thermal oxidiser exhaust, Nozzle re-injecting recovered waste EDC liquid malfunctions and the liquid is not fully atomised</td>
<td>Environmental impact, Effect on people</td>
<td>Online stack monitoring of EDC, Nozzle is self-cleaning. Nozzle back pressure will be monitored to check for normal operation. Regular visual observation and routine maintenance (note: chronic effects assessed in Health Risk Assessment, Chapter 24)</td>
<td>Section 23.6.1, Section 23.6.1</td>
</tr>
<tr>
<td>16</td>
<td>Inadequate scrubbing</td>
<td>Circulation pump failure, Flooding of scrubber, Inadequate level of circulating absorbent chemicals, Loss of liquid from scrubber</td>
<td>Atmospheric emissions to environment exceed licence requirements, Environmental impact, effect on people</td>
<td>Plant shutdown due to alarms and trips on the scrubbing towers, e.g., differential pressure for flooding, correct reflux flow rates, pump operation, sump level, circulating liquid composition, Online HCl measurement</td>
<td>Section 23.6.5</td>
</tr>
<tr>
<td>17</td>
<td>Failure of scrubbers</td>
<td>Inadequate operation of quench resulting in high temperature exit gas to the acid scrubber</td>
<td>High temperature leads to failure of the acid scrubber resulting in release of toxic gases</td>
<td>Trip protection for quench failure</td>
<td>Section 23.6.5</td>
</tr>
<tr>
<td>Item No.</td>
<td>Event</td>
<td>Causes</td>
<td>Possible Consequences</td>
<td>Prevention/Protection</td>
<td>Evaluated in EIS</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>--------</td>
<td>-----------------------</td>
<td>-----------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>18</td>
<td>Loss of containment from the recovered waste EDC liquid storage or delivery system to thermal oxidiser</td>
<td>Mechanical failures, Human error</td>
<td>Bund fire if ignited leading to damage to the groundwater treatment plant, injury to people, toxic combustion products, BLEVE of the isotainer is a possibility</td>
<td>Dematched site reduces chances of ignition, Isotainers are of robust design and are used for transporting millions of tonnes of Dangerous Goods each day throughout the world, Hazardous area design and precautions, Fire fighting equipment and procedures, Location is adequately protected from vehicle impact, Isotainer is insulated, Sloped bund floor (away from the isotainer)</td>
<td>Section 23.6.2</td>
</tr>
<tr>
<td>19</td>
<td>Corrosion of pipe fittings</td>
<td>Wet EDC hydrolyses in storage creating acidic chlorides</td>
<td>Corrosion of pipes result in leaks or damage to plant or isotainer</td>
<td>Spill containment, Appropriate materials of construction for EDC containing equipment</td>
<td>Section 23.6.2</td>
</tr>
<tr>
<td>20</td>
<td>Boiling Liquid Expanding Vapour Explosion (BLEVE)</td>
<td>Pool fire in bund engulfs EDC Isotainer, Transport truck fire</td>
<td>Fireball, Possible fatalities and damage to surrounding area</td>
<td>As per Item Number 18</td>
<td>Section 23.6.2</td>
</tr>
<tr>
<td>21</td>
<td>Exposure to recovered waste EDC liquid in the EDC Isotainer</td>
<td>Recovered waste EDC liquid containing VCM leaks from hose when disconnected from isotainer</td>
<td>Personnel injury from toxic fumes, prolonged/frequent exposure could cause chronic problems, e.g. cancer, from VCM</td>
<td>Personal Protective Equipment (PPE), First Aid, Dry break coupling to be provided at hose connection from isotainer to unloading pump</td>
<td>Section 23.6.2</td>
</tr>
<tr>
<td>26</td>
<td>Sabotage/terrorism</td>
<td>Disgruntled employee or intruder</td>
<td>Possible release of groundwater, EDC, HCl or caustic soda with consequences as above, EDC releases have the potential to impact on adjacent residential areas, Consequences of EDC releases analysed as per Item Nos 18 to 21</td>
<td>The groundwater treatment plant is to be located on the BIP, with existing security measures</td>
<td>Section 23.6.2</td>
</tr>
<tr>
<td>Item No.*</td>
<td>Event</td>
<td>Causes</td>
<td>Possible Consequences</td>
<td>Prevention/Protection</td>
<td>Evaluated in EIS</td>
</tr>
<tr>
<td>----------</td>
<td>-------</td>
<td>--------</td>
<td>-----------------------</td>
<td>-----------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>27</td>
<td>Incident on adjacent plants</td>
<td>Emergency situations resulting in fires, explosions or toxic releases</td>
<td>Fires and explosions have the potential to propagate the incident on the groundwater treatment plant. Toxic gases may be drawn into the air intake to the strippers. The consequences of propagation events in the GTP are as per the above GTP scenarios</td>
<td>'Dematched' site reduces chances of ignition Emergency response actions to shutdown the groundwater treatment plant will deal with the emergency at the adjacent plant</td>
<td>Section 23.6.2</td>
</tr>
</tbody>
</table>
23.5 Summary of Consequence Analysis

**GTP**

The PHA initially assessed each credible, significant hazardous event (i.e. scenario) associated with the GTP operations for its consequential impacts. If it is shown that the GTP does not impose unacceptable consequences at the site boundary then, by default, the corresponding risk is broadly acceptable. If, however, the consequential impact at the nearest site boundary exceeds values normally associated with irritation, injury and fatality then the scenarios are evaluated for their contribution to off-site risk.

The GTP location is a significant distance from the nearest residential area (approximately 325 m away), so many incidents would have consequences that would not reach this far, and hence would have no effects on residential areas.

In addition to off-site residential risk, there is also risk to Orica’s industrial neighbours on the BIP. This risk was estimated in the PHA and compared to the relevant risk criteria set out in HIPAP 4 (DUAP, 1992). Table 23.3 details the neighbouring facilities and the distances involved.

<table>
<thead>
<tr>
<th>Direction</th>
<th>Company/Area</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>Qenos (Alkatuff)</td>
<td>25 m (from scrubbers)</td>
</tr>
<tr>
<td>East</td>
<td>Huntsman (drum, IBC storage area)</td>
<td>40 m (from the thermal oxidiser)</td>
</tr>
<tr>
<td>South</td>
<td>Huntsman (ethylene oxide and surfactants)</td>
<td>70 m (from the thermal oxidiser)</td>
</tr>
<tr>
<td>West</td>
<td>Qenos (Site Utilities)</td>
<td>50 m (from the thermal oxidiser)</td>
</tr>
</tbody>
</table>

The consequence calculations for this PHA were carried out using commercially available risk software, as detailed in the full PHA report in Appendix I. The following summarises the consequence modelling work. The scenarios modelled for the PHA, as presented in Table 23.2, were chosen based on the potential for a release from a pipe and/or vessel to cause adverse effect both on-site and off-site (fatality, injury or irritation).

For each scenario in Table 23.2, the amount of material released was calculated based on the type of release and initial state of the material.

Outcomes for various types of release cases were modelled as presented in Table 23.4. For each flammable material release case, probabilities of immediate ignition (leading to jet or pool fires), delayed ignition (leading to flash fires or explosions) and safe dispersal are calculated, depending upon the material's specific characteristics, as summarised in Section 23.3. For each toxic release case, the vapour release was modelled using gas dispersion modelling to calculate the ground level concentration of the toxic material at various distances. The consequence at a particular location is then obtained from the results.
### Table 23.4 Possible release cases

<table>
<thead>
<tr>
<th>Type of Release</th>
<th>Subsequent Event (i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas release</td>
<td>Flash fire/explosion</td>
</tr>
<tr>
<td></td>
<td>Jet fire</td>
</tr>
<tr>
<td></td>
<td>Toxic impact</td>
</tr>
<tr>
<td>Instantaneous gas release</td>
<td>Flash fire/explosion</td>
</tr>
<tr>
<td></td>
<td>Toxic impact</td>
</tr>
<tr>
<td>Liquid release</td>
<td>Flash fire/explosion</td>
</tr>
<tr>
<td></td>
<td>Pool fire</td>
</tr>
<tr>
<td></td>
<td>Toxic impact</td>
</tr>
<tr>
<td>Instantaneous liquid release</td>
<td>Flash fire/explosion</td>
</tr>
<tr>
<td></td>
<td>Pool fire</td>
</tr>
<tr>
<td></td>
<td>Toxic impact</td>
</tr>
<tr>
<td>Pressurised liquefied gas release</td>
<td>Flash fire/explosion</td>
</tr>
<tr>
<td>Note: The GTP is not proposed to store</td>
<td>Jet fire</td>
</tr>
<tr>
<td>pressurised liquefied gases, so incidents of</td>
<td>Pool fire</td>
</tr>
<tr>
<td>this type cannot occur.</td>
<td>Toxic impact</td>
</tr>
<tr>
<td>Instantaneous pressurised liquefied gas</td>
<td>Flash fire/explosion</td>
</tr>
<tr>
<td>Note: The GTP is not proposed to store</td>
<td>Jet fire</td>
</tr>
<tr>
<td>liquefied gases, so incidents of this type</td>
<td>Pool fire</td>
</tr>
<tr>
<td>cannot occur</td>
<td>Toxic impact</td>
</tr>
<tr>
<td>BLEVE</td>
<td>Fireball</td>
</tr>
</tbody>
</table>

Notes:
(i) Safe dispersal is another possible outcome for each.

### Associated Operations

A different approach was required for analysing risks for the GTP’s associated operations.

Transport risks of the recovered waste EDC liquid are discussed in Section 23.7.6.

In assessing pipeline and pumping risks it is important to note that the materials handled (groundwater, salty waste water) are non-hazardous. Therefore, risks associated with potential releases were confined to potential effects on the biophysical environment. These are discussed in Section 23.8. Any risks associated with these operations would be managed as an integral part of Orica’s Safety Management System, which is described in detail in the full PHA report attached as Appendix I and would be included in the BGC Project EMP.
23.6 Consequence Analysis

As the materials of concern at the GTP are flammable and/or toxic, consequence modelling involves the simulation of various types of fires, explosions and atmospheric dispersion of toxic materials.

Where the consequential impacts from larger release cases are shown to be negligible, then the smaller release cases are not included in the modelling, because they would not contribute to the risk being assessed.

In assessing the consequences of releases, criteria need to be established to determine the severity of particular scenarios and therefore whether further analysis is required.

Consequence Criteria

The consequence criteria used to screen these scenarios are listed in Table 23.5 below.

<table>
<thead>
<tr>
<th>Event</th>
<th>Consequence Level</th>
<th>Criterion</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire - heat radiation</td>
<td>4.7 kW/m²</td>
<td>Injury to people after 30 seconds of exposure</td>
<td>HIPAP 4</td>
</tr>
<tr>
<td>Fire - heat radiation</td>
<td>23 kW/m²</td>
<td>Property damage to neighbouring industrial installations or public buildings</td>
<td>HIPAP 4</td>
</tr>
<tr>
<td>Explosion - overpressure</td>
<td>7 kPa</td>
<td>Injury to people and damage to residential areas</td>
<td>HIPAP 4</td>
</tr>
<tr>
<td>Explosion - overpressure</td>
<td>14 kPa</td>
<td>Property damage to neighbouring industrial installations or public buildings</td>
<td>HIPAP 4</td>
</tr>
<tr>
<td>Toxic exposure</td>
<td>Irritation</td>
<td>EDC - 50 ppm, VC – 500 ppm, HCl – 3 ppm, Chlorine – 1 ppm</td>
<td>ERPG–1 (i)</td>
</tr>
<tr>
<td>Toxic exposure</td>
<td>Injury</td>
<td>EDC - 200 ppm, VC – 5000 ppm, HCl – 20 ppm, Chlorine – 3 ppm</td>
<td>ERPG–2 (ii)</td>
</tr>
</tbody>
</table>

Note: Emergency Response Planning Guidelines (ERPGs) are values intended to provide estimates of toxic gas concentration ranges above which one could reasonably anticipate observing adverse health effects.

(i) ERPG–1 is defined as the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odour. It is suggested that this is a reasonably conservative interpretation of the toxic irritation definition in HIPAP 4.

(ii) ERPG–2 is defined as the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual’s ability to take protective action. It is suggested that this is a reasonably conservative interpretation of the toxic injury definition in HIPAP 4.
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If the off-site consequence levels exceeded the injury criteria, then a probability of fatality (probit) equation was used to determine whether there was a chance of fatality due to the particular event.

Table 23.6 below summarises the consequence results, which are discussed in detail below. Where a consequence is possible, it is evaluated further in Section 23.7.

**Table 23.6 Summary of consequences of scenarios modelled**

<table>
<thead>
<tr>
<th>Equipment Item</th>
<th>Material Released</th>
<th>On-site Fatality</th>
<th>Off-site Fatality</th>
<th>Off-site Injury/Property Damage</th>
<th>Off-site Irritation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipes or vessels from the air stripper to the plant exhaust vent</td>
<td>EDC in air, HCl in air</td>
<td>No, No</td>
<td>NA, NA</td>
<td>No, Possible</td>
<td>No, Possible</td>
</tr>
<tr>
<td>Recovered waste EDC liquid Isotainer and transfer system including connecting piping and hose</td>
<td>EDC in air, EDC</td>
<td>No, Possible (BLEVE case)</td>
<td>NA, No</td>
<td>No, No</td>
<td>No, No</td>
</tr>
<tr>
<td>Natural gas line</td>
<td>Natural gas (methane)</td>
<td>No</td>
<td>No, No</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Thermal oxidiser explosion</td>
<td>Natural gas (methane)</td>
<td>No</td>
<td>No, No</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Caustic scrubber (loss of reflux flow)</td>
<td>HCl in air</td>
<td>No</td>
<td>NA, No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Note: In this context, ‘on-site’ means adjacent industrial plants on the BIP; ‘off-site’ means residential areas.

### 23.6.1 Pipe or Vessel Failures

**Causes**

The contaminated groundwater is to be pumped to the air stripper. A fan on the inlet to the thermal oxidiser draws air through the air stripper, which contacts the groundwater to remove (‘strip’) the volatile contaminants. The suction side of the fan is under vacuum. If any pipe or vessel on the fan suction fails whilst the fan is running, then air will be drawn in through the holes. Hence, the impurities will not be released and a plume will not form.

In the event of major plant disturbances, such as the total pipe failures on the discharge of the fan (releasing the entire flow rate of untreated gas to the thermal oxidiser), or total pipe failures of the piping after the thermal oxidiser (releasing the entire flow rate of combusted gas), it is assumed that the automatic plant system would detect such conditions (i.e. no flow through the plant) and automatically shut down the process, including the fan before the thermal oxidiser. Therefore, a maximum release duration of one minute is considered appropriate. For other release cases, durations of up to 20 minutes have been selected based, on the estimated time to detect and respond to the incident.
**Consequences**

**Holes in Piping and Vessels**

For potential releases from holes in piping and vessels, the released stream is modelled as air and the concentrations of the components of interest are estimated based on the concentration at the point of release. Dispersion modelling of this stream under appropriate wind conditions shows that the ground level ERPG-1 EDC concentration (50 ppm) for a release from a 50 mm hole in the thermal oxidiser feed pipe travels no further than approximately 10 m from the point of release, for a release duration of 20 minutes. Similarly, for the thermal oxidiser exit stream, dispersion modelling shows that the ERPG-1 HCl concentration (3 ppm) for a release from a 50 mm piping hole (at 5 kPag) travels no further than approximately 55 m from the point of release for a release duration of 20 minutes.

The calculations show that, for the scenarios considered, the concentrations of concern (ERPG-1) can only occur close to the release and do not travel far enough to affect neighbouring plants or residences. Based on these results, further assessment of releases from potential holes (50 mm and smaller) in the thermal oxidiser feed and exit piping was not considered warranted, i.e. there would be no fatalities, injuries or irritation effects either on-site or off-site.

**Total Inlet and Exit Pipe Failure**

For total inlet and exit pipe failures, dispersion modelling of the full flow stream at various weather/wind conditions suggests that the potential off-site impact (i.e. at 325 m or further) would be limited to specific combinations of wind/weather patterns. Injury risk is predicted for HCl only, and irritation is only expected for the more stable wind/weather patterns for both EDC and HCl. The risk of an EDC and/or HCl impact on off-site personnel is assessed further in Section 23.7 below.

**Thermal Oxidiser Exit Pipe Failure**

For a 20 minute release from the thermal oxidiser feed pipe, the concentration required for a probability of fatality of 1% is around 4500 ppm. As the concentration of EDC in the thermal oxidiser feed stream is substantially less than this (no more than 660 ppm), no fatalities would be expected either on-site or off-site from piping failures, i.e. there is no fatality risk from these dilute emissions.

It should be noted that the ‘worst case’ failure of thermal oxidiser combustion (Item 13 in Table 23.2) and ‘worst case’ bypassing of feed gas around the thermal oxidiser due to a hole in the feed heat exchanger (Item 15 in Table 23.2) can be regarded as similar release cases to total feed pipe failure, i.e. the gas leaving the thermal oxidiser has the same composition as the gas entering. However, in these cases the release would be more dispersed than for a feed pipe failure, since it would vented via the 20 m high vent stack, so the ground level concentrations would be lower and therefore would have no adverse consequences.

For a one minute release from a total failure of the thermal oxidiser discharge piping, the concentration of HCl in air required to effect a probability of fatality of 1% is 23,700 ppm. For a five minute release, the corresponding concentration is 4740 ppm. For a 20 minute release, the concentration decreases to 1185 ppm. As the concentration of HCl in the thermal oxidiser exit stream is 1550 ppm, and full flow release durations will be limited to approximately one minute, then given the dispersion and consequent dilution, no fatalities from the thermal oxidiser exit piping failures either on-site or off-site would be expected, i.e. there is no fatality risk from these HCl emissions.
23.6.2 Recovered Waste EDC Liquid Isotainer Events

Cause

Releases of recovered waste EDC liquid from the isotainer (e.g. due to vessel or pipe failure or operator error) would form pools in the bunded area where the isotainer is kept, since the boiling point of EDC is 83°C. Over time, some EDC would evaporate and hence a toxic plume would be generated. If the pools are ignited, however, a pool fire would result. As the BIP is ‘dematched’ (i.e. no matches or lighters are permitted on-site) and there are special controls over ignition sources around the isotainer (e.g. for welding and electrical equipment), there is a significantly reduced probability of ignition.

Prolonged pool fires could result in a Boiling Liquid Expanding Vapour Explosion (BLEVE). In this event, the heat from the pool fire raises the temperature—and hence the pressure—of the isotainer contents. The isotainer safety relief valve would lift, allowing material to escape. The isotainer wall’s mechanical integrity would reduce over time, particularly if flames affect the vessel wall when no liquid EDC is present to help cool the vessel. At some point (historically, the fire has to last for more than 10 minutes for a BLEVE to occur), the vessel wall fails and a vessel rupture occurs. The released material vaporises instantaneously, ignites and forms a fireball. Such an event would generate three significant consequential effects:

- radiant heat from the fireball;
- explosion overpressures from the release of stored energy; and
- potential formation of projectiles from equipment fragments.

BLEVE models estimate radiant heat only, because the distance to significant radiant heat levels is greater than the distance to significant levels of overpressure.

In addition, releases from the EDC isotainer and connecting transfer system could result in the formation of pool fires of varying size. Total vessel failure would release the entire isotainer contents (approximately 20 tonnes) into the bunded area. Releases from transfer system failures would involve smaller quantities (if detected and stopped before complete loss of vessel contents) and correspondingly smaller pool fires if ignited. As the radiant heat from a pool fire is dependent on the size of the pool and hence limited by the bund design, two pool fire scenarios have been considered:

- the entire bund full of the recovered waste EDC liquid; and
- a 3 m equivalent diameter pool for smaller releases.

If equivalent pools of EDC are formed in the EDC isotainer bund, as per the above pool fire analysis, but are not ignited, evaporation of the EDC and subsequent atmospheric dispersion needs to be modelled to determine whether it could cause significant concentrations of EDC off-site. A 20 minute evaporation period is assumed as representative, and within this time emergency response action would be taken to mitigate the EDC evaporation and/or dispersal.
Consequences

BLEVE

The results from the BLEVE simulation show that the predicted fireball radius would be approximately 81 m. Therefore, the radiant heat levels from a potential EDC isotainer BLEVE would not cause any significant impact off-site, but may affect personnel involved in operating the GTP and adjacent plants on the BIP, i.e. on-site fatality may occur. The risk of this occurring is assessed further in Section 23.7.

Pool Fires

Given the location of the GTP and the size of the bunded area, the results show that the radiant heat levels from potential pool fires would not cause any significant impact to personnel involved in operating the adjacent plants on the BIP or off-site.

Toxic EDC Releases

Dispersion modelling of the EDC evaporation plume from a pool of EDC in the isotainer bund under various weather/wind conditions predicted no injury risk or off-site fatalities. The dispersion models also show that the EDC concentration drops below 4500 ppm (the estimated value for 1% fatality for a 20 minute exposure duration) within 25 m under the various wind/weather combinations. Hence, neither off-site nor on-site fatalities are expected from this scenario.

23.6.3 Natural Gas Line Failures

Cause

Failures associated with the natural gas feed line to the thermal oxidiser would release natural gas to the atmosphere and, if ignited, this could form a jet fire, a flash fire and/or an explosion.

Consequence

The analysis of the potential jet fires from the natural gas feed line to the thermal oxidiser showed no adverse radiant heat levels off-site or on adjacent operating plants.

The analysis of the potential vapour cloud explosions and flash fires from the natural gas pipe failures showed a relatively small vapour cloud size with limited consequential impacts if ignited. The 20 minute release duration would have no significant impact on the release.

Given these results for the natural gas vapour cloud explosions and flash fires, no adverse impacts would be imposed off-site or at neighbouring plants.
23.6.4 Thermal Oxidiser Explosion

**Cause**

An internal thermal oxidiser explosion would be possible if the burner management system failed. This would involve a flammable gas build-up within the thermal oxidiser whilst it is off-line and the introduction of a source of ignition. This is a known hazard with burners and boilers, and the control and start-up systems include robust, proven and regularly tested prevention measures such as automatic purging of the internal space prior to ignition.

For an internal thermal oxidiser explosion to occur, the gas inside the unit must be in the flammable range, i.e. between the lower and upper explosion limits. For the modelling, the entire volume of the thermal oxidiser was assumed to contain flammable gas. For some internal explosions, this will be a conservative assumption.

Internal explosions have the potential to cause harm through overpressures and possibly projectile formation from equipment fragments.

**Consequence**

Using a modelling scenario of an internal explosion of 200 m$^3$ (i.e. the internal volume of the unit), the overpressure level (a measure of the increased pressure emanating from the source of an explosion) was determined for various distances from the thermal oxidiser internal explosion scenario. These levels are shown in Table 23.7.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Overpressure (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10 m</td>
<td>70</td>
</tr>
<tr>
<td>14 m</td>
<td>35</td>
</tr>
<tr>
<td>19 m</td>
<td>21</td>
</tr>
<tr>
<td>25 m</td>
<td>14</td>
</tr>
<tr>
<td>42 m</td>
<td>7</td>
</tr>
<tr>
<td>80 m</td>
<td>3.5</td>
</tr>
</tbody>
</table>

At a distance of 42 m from the explosion, the overpressure would be 7 kPa. This would cause some building damage, but only a 10% probability of injury and zero probability of fatalities.

At 80 m from the explosion, the overpressure would be 3.5 kPa. At this level, there is very low probability of injury. Given the site layout and the location of the thermal oxidiser (approximately 50 m from neighbouring industrial BIP facilities and 325 m from the nearest residence), no fatalities or significant effects from this explosion scenario would be expected on adjacent plants or off-site.

At 325 m from the explosion, there is a much lower than 5% chance of injury.

23.6.5 Caustic Scrubber Failure

**Cause**

Failure of the caustic scrubber to absorb the HCl carryover from the acid absorber may be due to loss of reflux flow, and failure of the control system to trip the plant.
As a result, the discharge to atmosphere from the GTP stack would be vented with HCl mist. The exhaust vent height is 20 m.

**Consequence**

Dispersion modelling of this stream being vented under representative weather/wind conditions showed that the ERPG–1 HCl concentration (3 ppm) would not form at ground level because of the elevated point of dispersal. The ERPG–1 concentration would exist approximately 400 m downwind of the plant vent only at heights greater than 15 m above the ground.

Consequently, there would not be any off-site or on-site impacts from this scenario.

### 23.6.6 ‘Domino’ Events

A potentially hazardous event within a plant can cause further incidents in the same plant or, in some cases, in other plants. With any large site, there is a potential for a severe incident in one area to cause a secondary, ‘knock-on’ incident in another area. The secondary event is called a ‘domino’ event.

From the analysis conducted above, radiant heat and overpressures from potential hazardous events would not be sufficient to cause a domino event at nearby adjacent operating plants. For the BLEVE case, the duration is approximately 11 seconds; ‘knock-on’ to other piping and vessel failures within this timeframe is considered unlikely.

Projectiles from the BLEVE could cause a domino event, although the low likelihood of one in ten million (1 x 10^-7) per year for the BLEVE event (see Section 23.7.1) is further reduced when the probability of an equipment fragment hitting a selected target and damaging it sufficiently to cause a hazardous incident is considered. Therefore, the risk of a domino event occurring is considered broadly acceptable. Emissions of gas streams would not cause any significant domino events.

It is also possible that an event in the neighbouring plants could cause a domino event in the GTP operations, but as shown above, the consequences of many of these potential hazardous events associated with the GTP operations will not have any off-site impact. Nonetheless, the risk of these events is estimated in Section 23.7 below.

The BIP is close to Sydney Airport and there is a potential for aircraft impact. In 1990, the Australian Centre of Advanced Risk and Reliability Engineering Ltd (ACARRE) considered the risks associated with increased operations at Sydney Airport due to the third runway. The result from the ACARRE study was used to determine the risk from aircraft crashes with a potential for domino effects at the Botany site (SHE Pacific, 2000), and concluded that there was a low level of risk for such an incident.

Earthquake events could also cause plant damage sufficient to cause a release. Frequencies and consequences of these events were also estimated (SHE Pacific, 2000), and it was concluded that there was a low level of risk for such an incident.

No other external events were considered to pose any significant risk to the GTP or its associated operations.
23.7 Risk Analysis

The risks associated with the BGC Project have been estimated in the following sections for comparison with the DIPNR risk criteria presented in HIPAP 4.

By convention in Australia, mitigation factors are not taken into account in the estimation of individual fatality risk. An individual is considered to be located permanently at a particular location, and no scope for shelter or escape is factored into the calculations. The risk results are essentially the risk at a location, not necessarily to a particular individual, and are therefore considered highly conservative.

A summary of all the risk results and comparison with risk criteria is presented in Table 23.8.

Table 23.8 Comparison of results against DIPNR risk criteria (from HIPAP 4)

<table>
<thead>
<tr>
<th>Description</th>
<th>Assessed Risk</th>
<th>Risk Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality risk to sensitive users, including hospitals, schools, aged care</td>
<td>Negligible</td>
<td>One in two million (0.5 x 10^{-6}) per year</td>
</tr>
<tr>
<td>Fatality risk to residential areas and hotels</td>
<td>Negligible</td>
<td>One in a million (1 x 10^{-6}) per year</td>
</tr>
<tr>
<td>Fatality risk to commercial areas, including offices, retail centres, warehouses</td>
<td>Negligible</td>
<td>Five in a million (5 x 10^{-6}) per year</td>
</tr>
<tr>
<td>Fatality risk to sporting complexes and active open spaces</td>
<td>Negligible</td>
<td>Ten in a million (10 x 10^{-6}) per year</td>
</tr>
<tr>
<td>Fatality risk to be contained within the boundary of an industrial site</td>
<td>Less than one in ten million (1 x 10^{-7}) per year – complies</td>
<td>Fifty in a million (50 x 10^{-6}) per year</td>
</tr>
<tr>
<td>Injury risk – Incident heat flux radiation at residential areas should not exceed 4.7 kW/m² at frequencies of more than 50 chances in a million per year, or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year</td>
<td>Negligible</td>
<td>Fifty in a million (50 x 10^{-6}) per year</td>
</tr>
<tr>
<td>Injury risk – Frequency at which toxic concentrations in residential areas should not exceed a level which would be seriously injurious to sensitive members of the community following a relatively short period of exposure</td>
<td>One in a million (1 x 10^{-6}) per year – complies</td>
<td>Ten in a million (10 x 10^{-6}) per year</td>
</tr>
<tr>
<td>Irritation risk – Frequency at which toxic concentrations in residential areas should not cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community</td>
<td>Less than twenty one in a million (21 x10^{-6}) per year (toxic releases plus toxic combustion products) – complies</td>
<td>Fifty in a million (50 x 10^{-6}) per year</td>
</tr>
<tr>
<td>Property damage risk – Incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed 23 kW/m² at frequencies of more than 50 chances in a million per year</td>
<td>Negligible</td>
<td>Fifty in a million (50 x 10^{-6}) per year</td>
</tr>
</tbody>
</table>
## 23.7.1 Individual Fatality & Societal Risk

### Off-site

From the consequence analysis in Section 23.6, there are no identified events that have the potential to cause off-site fatality. Therefore, the risk to sensitive land users, residential areas, commercial areas, sporting areas and open spaces is lower than the HIPAP 4 criteria. Correspondingly, societal risk is also negligible.

### On-site

From the consequence analysis in Section 23.6, the one event that may possibly lead to fatalities on the BIP is a BLEVE of the recovered waste EDC liquid Isotainer. As the likelihood of this event is taken as one in ten million (1 x 10⁻⁷) per year, even given a 100% chance of fatality (conservative), then the corresponding industrial risk to other BIP users is below 50 chances in a million (50 x 10⁻⁶) per year. Therefore, the fatality risk to both the BIP and neighbouring industries is lower than the HIPAP 4 criterion.

## 23.7.2 Injury Risk

### Off-site

From the consequence analysis in Section 23.6, and using the ERPG–2 value for injury risk due to exposure to HCl (which is conservative, given the duration of exposure expected), severe failures of the piping and equipment downstream of the thermal oxidiser have the potential for off-site injury for three specific wind/weather conditions.
CHAPTER 23 Preliminary Hazard Analysis

Given the likelihood of these failures occurring, and the probability of the three specific wind/weather conditions existing and blowing from an arc from north-west to south-west (i.e. a 90° arc such that the wind is blowing in the direction of the residential area along Denison Street), the likelihood of injury from HCl emissions is one in a million \(1 \times 10^{-6}\) per year. This is lower than the HIPAP 4 criterion for toxic injuries to people in residential areas of no more than 10 in a million \(10 \times 10^{-6}\) per year.

**On-site**

There is no on-site criterion for injury risk in HIPAP 4.

### 23.7.3 Irritation Risk

**Off-site**

From the consequence analysis in Section 23.6, and using the ERPG-1 value for irritation risk due to exposure to HCl (which is conservative, given the duration of exposure expected), the total failures associated with the piping and equipment downstream of the thermal oxidiser have the potential for off-site irritation for five specific wind/weather conditions.

Off-site irritation is also possible from severe failures of the piping entering the thermal oxidiser (i.e. EDC releases) for two wind/weather conditions, and from a plume emanating from a bund of EDC (release from the Isotainer and transfer system) for one wind/weather condition only.

The likelihood of these failures occurring is estimated as 20 in a million \(20 \times 10^{-6}\) per year.

This value is below the HIPAP 4 criterion for residential irritation likelihood of no more than 50 in a million \(50 \times 10^{-6}\) per year (without taking into consideration the probability of the relevant wind/weather conditions existing, such that the wind blows in the direction of Denison Street).

**On-site**

There is no on-site criterion for injury risk in HIPAP 4.

### 23.7.4 Property Damage

Given the explosion overpressure and radiant heat analyses in Section 23.6, the risk of property damage due to a domino event is negligible, i.e. the predicted explosion overpressures at the neighbouring facilities are less than 14 kPa and the predicted radiant heat at the neighbouring facilities is less than 23 kW/m² (the latter takes into consideration the likelihood of an EDC isotainer BLEVE being approximately one in 10 million \(1 \times 10^{-7}\) per year).

### 23.7.5 Cumulative Risk

Cumulative risk within the Botany/Randwick Industrial Area (which includes what is now the BIP) was considered by DIPNR as part of a quantitative risk assessment (QRA) published in 1985, and updated in 1999. Subsequent to this, an overview report on the Botany/Randwick Industrial Area was issued by DIPNR in 2001.
The calculated risk levels presented in the PHA for the BGC Project would have only a minor impact on the cumulative risk results previously calculated for the Botany/Randwick Industrial Area. This is due to the relatively few potentially hazardous events that could significantly affect off-site risk.

### 23.7.6 Transport Risk

It is proposed to transport an isotainer containing recovered waste EDC liquid from Terminals Pty Ltd’s bulk liquid waste storage facility at Port Botany to the GTP, on average, once every two weeks, following a route from Terminals Pty Ltd to Bumborah Point Road, left onto Botany Road, right into Beauchamp Road, left into Denison Street, and left into the BIP at Gate 3 (as shown on Figure 16.2).

In 1995, a transport risk assessment was carried out for EDC product transport movements in the opposite direction, i.e. from the BIP to Terminals Pty Ltd (ICI Engineering, 1995). This transport risk assessment reviewed the risk associated with 2500 road tankers (i.e. not isotainers, which are more robustly designed) per year, a figure that significantly exceeds the proposed GTP EDC isotainer movements of approximately 25 per year.

The 1995 transport risk assessment included potential hazardous events associated with loading and unloading activities, as well as incidents along the transport route. Both fires and toxicity impacts were considered.

The results of the 1995 transport risk assessment found that the risk associated with the movement of EDC by 2500 road tankers per year was broadly considered acceptable. Given that the GTP transport of EDC involves significantly fewer movements by the same route, albeit in the opposite direction, it is concluded that the EDC transport for the BGC Project is also broadly acceptable.

### 23.7.7 Risk from Combustion Products

There would be a potential risk for those attending a fire emergency (and possibly for those off-site) of effects from toxic products of combustion from an EDC fire, e.g. carbon oxides, HCl and smoke, as well as vaporised (i.e. not combusted) EDC.

Potential irritation impacts from toxic products of combustion from a fire would generally be insignificant. The hot products of combustion would rise from a fire, as they typically would have a temperature in the range of 800 to 1200°C and a density a quarter that of air (Lees, 1996).

Hence, a buoyant plume would be formed and the combustion products dispersed according to the prevailing wind/weather conditions. Modelling for various combinations of weather/wind conditions and fire temperatures showed that the plume from an EDC bund fire would rise to at least 100 m, and would then disperse passively in the downwind direction.

As a result, no effect at ground level would be expected under most weather conditions.

However, in the event of a temperature inversion, in which reverse atmospheric currents can occur (i.e. air slumps to the ground, as opposed to air eddies that rise), the combustion products can return to the ground, and emergency response may be required to clear/control the area. Given the low likelihood of EDC releases calculated in this PHA (approximately seven in a million \(7 \times 10^{-6}\) per year), the probability of ignition of flammable liquids (less than 10%), and the probability of a temperature inversion occurring in
the Sydney area (less than 19%), the risk of irritation from products of combustion is assessed as less than one in a million \((1 \times 10^{-6})\) per year. This can be added to the risks of irritation from other toxic releases, assessed in Section 23.7.3 as 20 in a million \((20 \times 10^{-6})\) per year, for a total of less than 21 in a million \((21 \times 10^{-6})\) per year. This is less than the HIPAP 4 irritation risk criterion of 50 in a million \((50 \times 10^{-6})\) per year.

23.8 Risk to the Biophysical Environment

The main concern about risk to the biophysical environment is generally in relation to the effects on whole systems or populations, and it is difficult to envisage an incident scenario at the GTP or from its associated operations that would threaten a whole system or population. For the BGC Project, the risk to people in the vicinity is the main concern, and this has been the principal focus of the PHA.

However, the PHA also considered risks to the biophysical environment due to loss of containment events, as summarised below.

23.8.1 Emission to Atmosphere

The likelihood of unplanned releases of gas and products of combustion were estimated as part of the risk assessment and shown to be low. For any release of the process air stream, the contaminant concentrations are low and hence significant environmental impact would not be expected.

The GTP design incorporates a range of measures to avoid impacts from potential process failures, including process monitoring and emissions monitoring, with shutdown of the GTP in the event of failure detection.

Assessment of the impacts of air emissions has been undertaken as a separate study, presented in Chapter 22 and Appendix G.

23.8.2 Material Discharge to Soil or Water

As with emissions to atmosphere, no incident scenarios were identified in which significant environmental impact would be expected, given the design and management measures that would be implemented for the BGC Project to prevent/contain discharges. These measures include containment, adherence to GTP design standards, monitoring and automatic water recycling in the event of system failures.

23.9 Conclusions

The risk associated with GTP operations to the BIP and environs has been assessed and compared against the DIPNR risk criteria through the PHA, presented in Appendix I.

The results of the PHA show that the level of risk complies with DIPNR guidelines for tolerable fatality, injury, irritation and societal risk. Also, transport risk, risks to biophysical environment, the risk of domino events and the impact on cumulative risk in the Port Botany/Randwick area from releases are broadly acceptable. These conclusions apply to risks both on-site (i.e. neighbouring industrial facilities) and off-site (e.g. residential areas and other sensitive receivers).
The primary reason for the low risk levels associated with the operation of the GTP is that significant consequential impacts from potential hazardous events do not reach the nearest site boundary or that, for the neighbouring industrial facilities, their likelihood is acceptably low.

For the pumping wells and pipeline operations associated with the BGC Project, the primary reason for the negligible risk levels is that the materials handled are non-hazardous. Nevertheless, as described in detail in the PHA, the design minimises the chances of leaks from these systems.

As with most PHAs, limited detailed design information is currently available. Correspondingly, some of the analysis in this report is based on assumed conditions. The assumptions made in this analysis are to be reviewed throughout the project design stage via the HAZOP methodology and updated in the Final Hazard Analysis, which would be prepared if required as a Condition of Approval of the Activity.

Compliance with the Orica Safety Management System (as detailed in the full PHA report) is required for all Orica plants and facilities. This, and the implementation of the BGC Project EMP, would keep operating risks low.
24.1 Introduction

This chapter presents an overview of the health risk assessment that has been undertaken to assess the potential impacts associated with the BGC Project. This chapter uses several everyday words that have specific technical meanings in the context of a human health risk assessment. Definitions of these terms, and full details of the human health risk assessment (HHRA), are presented in Appendix J.

24.1.1 Aim of HHRA

The aim of the health risk assessment was to identify, characterise and evaluate the potential risks to human health associated with the BGC Project and its operations. In undertaking this process, the health risk assessment has followed national guidance provided in *Environmental Health Risk Assessment – Guidelines for Assessing Human Health Risk from Environmental Hazards* (enHealth, 2002). It has been undertaken in consultation with the NSW Department of Environment and Conservation (DEC) and the NSW Department of Health.

By nature, a health risk assessment is technical, as it provides a systematic review of many aspects of the proposal, surrounding areas and key aspects associated with chemicals which require evaluation. The level of detail presented within the Appendix is necessary to ensure that the health risk assessment follows the required guidance and provides sufficient detail and justifications for the evaluation undertaken and to support the conclusions presented. In doing so, the health risk assessment presents an assessment that is specific to the technology proposed for the BGC Project and specific to the location of the GTP.

24.1.2 HHRA Limitations

The health risk assessment provides an evaluation of risk to human health associated with the BGC Project. The assessment does not evaluate or review community health status or issues. Health of individuals in the community is dependent on many factors. These include age, family history (genetic make-up) and lifestyle choices such as sports, diet and smoking.

Environmental issues in the surrounding community will involve daily exposure to a range of chemicals and sources including motor vehicles, trucks, emissions from many different industries in the local area as well as within the Sydney basin, household chemical products (such as insecticides, cleaning products) and other sources which include household furnishings and common household products (eg. shampoos, cosmetics).

As the GTP is not yet built or operating, exposures to emissions from the GTP do not currently exist and therefore any impacts cannot be measured. On this basis, the assessment has followed regulatory guidance and industry best practice in evaluating risks to human health that may be associated with the GTP. The assessment provides a tool for use in the evaluation of the BGC Project. It is an assessment of the incremental health risk that would arise from implementation of the BGC Project, with a focus on the GTP.
24.1.3 Key Findings

Following this approach, risks to human health associated with the GTP—both on and off the BIP—have been evaluated. The level of risk associated with exposure to chemicals which may be emitted from the GTP have been calculated, and are considered to be low and representative of negligible or ‘zero’ risk to human health.

24.2 Approach to Health Risk Assessment

The health risk assessment has been undertaken in consultation with DEC and NSW Health, following an approach that is consistent with health risk assessments undertaken for other aspects of the Orica site, as well as many other environmental exposures in NSW and Australia.

The approach has followed guidance provided by enHealth (2002), which also references the following:

- National Environmental Protection Measure (1999);
- ANZECC/NH&MRC guidance (1992);
- protocols and guidelines recommended by ANZECC and NH&MRC and detailed in the documents *The Health Risk Assessment and Management of Contaminated Sites* (CSMS 1991, 1993, 1996, 1998; enHealth 2002b); and
- World Health Organisation (WHO).

Where specific detail has not been provided by these documents, supplementary guidance has been provided from the United States Environment Protection Agency (US EPA and associated agencies).

More specifically, the conduct of the health risk assessment requires four key steps. These are:

1. **Issue Identification** – This involves a review of the BGC Project, and studies to evaluate potential emissions to air, water and soil both on and off the site. The review process aims to select key issues and chemicals associated with the GTP that require further assessment.

2. **Exposure Assessment** – The assessment of exposure requires an evaluation of who might be exposed to the key chemicals and how. In addition, where exposures are identified, they are quantified.

3. **Toxicity Assessment** – The assessment of toxicity involves an assessment of the health effects that may be associated with the key chemicals, the mechanisms for exposure and health effects, and an assessment of relevant data that can be used to quantify toxicity that is not harmful to all individuals, on and off the site.

4. **Risk Characterisation** – This aspect of the assessment provides an estimation of risks to human health by combining/comparing the exposure assessment and toxicity assessment. The characterisation of risk also involves a review of the risks calculated and an evaluation of the acceptability of risk.
Chapter 24: Health Risk Assessment

The following sections present an overview of these key steps, which have been undertaken in the health risk assessment for the BGC Project.

### 24.3 Issue Identification

This aspect of the health risk assessment has been undertaken to identify issues associated with the BGC Project, from construction through to all aspects of the operation of the GTP, that have the potential to result in emissions to air, water or soils that anyone on or off the site may come into contact with on a daily basis. This has involved a review of the BGC Project’s processes, management and control practices. It has also included a review of studies undertaken as part of this EIS that provide detail about emissions and discharges to the receiving environment during all phases of the BGC Project.

Issues identified include:

- emissions and exposures associated with construction of the GTP;
- emissions during normal operation; and
- emissions during possible worst case scenarios of the process.

The review has focused on identifying issues that require detailed evaluation or quantification in the health risk assessment. In particular, these are emissions or exposures that cannot be managed on the GTP site (under an appropriate health and safety plan, implementation of controls or through routine inspection and maintenance) and which have the potential to result in exposure of workers elsewhere on the BIP or in the surrounding community over a long period of time.

Following this process, the project phases and a set of worst case hypothetical scenarios were identified. Table 24.1 presents a summary of these phases, scenarios and the potential exposures that have been reviewed. The table identifies the key issues and chemicals of potential concern. Chemicals of concern are those which have the potential to be present at concentrations high enough to pose a risk to human health or to constitute a nuisance (e.g. odours). These were then further assessed.

Table 24.1: Identification of potential issues

<table>
<thead>
<tr>
<th>Potential Issues</th>
<th>Potential exposures and management measures</th>
<th>Key issues and chemicals identified for further assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction of GTP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure to chemicals in soil and groundwater on site where GTP is to be constructed.</td>
<td>Any exposure to chemicals identified in groundwater managed under health and safety plan for the site.</td>
<td>None identified.</td>
</tr>
<tr>
<td>Emissions to air during construction.</td>
<td>Products of fuel combustion and dust emissions. All these are to be managed and controlled on site.</td>
<td>None identified.</td>
</tr>
<tr>
<td><strong>Normal Operation of GTP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraction and handling of contaminated groundwater.</td>
<td>Sealed system, with fugitive emissions to be managed and expected to be low.</td>
<td>None identified.</td>
</tr>
</tbody>
</table>
## Potential Issues

| Storage, handling and use of process chemicals. | Compliance with relevant Australian Standards and on-site health and safety plans. | None identified. |
| Impacts to stormwater drainage system. | Control using bunding and on-site stormwater management system to minimise impacts. | None identified. |
| Impacts to wastewater and other process wastes. | Discharges to sewer in accordance with Trade Waste Service Agreement. Other waste discharges to meet EPA guidelines. | None identified. |
| Treated water reuse within the BIP or nearby or discharge via Bunnerong Canal to Brotherson Dock and Botany Bay. | Quality of treated water to meet Australian Drinking Water Guidelines and ANZECC Water Quality Guidelines for the protection of marine waters. In addition, expected quality of water (not diluted in bay) reviewed against human health based levels relevant for recreational contact. Concentrations less than the recreational levels. | None identified. |
| Emissions to air from thermal oxidiser. | Air Quality Impact Assessment indicated compliance with regulatory requirements. | None identified (refer to Chapter 22). |

### Potential Worst Case Scenarios

| Identification and evaluation of hazards and failure scenarios. | Preliminary hazard analysis provided review in accordance with DIPNR guidance. Indicated risks comply with relevant guidance. | None identified (refer to Chapter 23). |
| Worst case scenarios for emissions to air (frequency of failure for both scenarios estimated to be once per 50,000 years, as calculated in the PHA, prepared in accordance with DIPNR’s guidelines). | Increased emission of dioxin associated with undetected failure in oxidiser and continuous temperature controls, and all other indicators. This may go unnoticed between dioxin measurements. For the purpose of this assessment a 12 months worst case scenario has been assumed. | Potential for exposure via many routes for: |
| | | - HCBD |
| | | - Dioxins |
| | | - Mercury |
## CHAPTER 24 Health Risk Assessment

### Potential Issues

<table>
<thead>
<tr>
<th>Potential Issues</th>
<th>Potential exposures and management measures</th>
<th>Key issues and chemicals identified for further assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No destruction of chemicals in the thermal oxidiser. Significant failure event which may occur for a maximum time period of 12 hours (this is based on the maximum period between shift changes and assumes that through the period of one shift any unusual operation goes unnoticed). Increased emissions modelled with maximum ground level concentrations compared with relevant acute exposure criteria. Potential increased emission of persistent and bioaccumulative chemicals should be evaluated.</td>
<td>No chemicals of potential concern identified for exposure via inhalation</td>
</tr>
<tr>
<td></td>
<td>Potential for exposure via many routes for:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HCBD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Dioxins</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Mercury</td>
<td></td>
</tr>
</tbody>
</table>

On the basis of the evaluation, the key issues requiring detailed assessment are:

- inhalation exposure to chemicals identified in air following normal emissions from the thermal oxidiser;
- multiple pathway exposure to persistent and bioaccumulative chemicals, which may be emitted to air during normal operation of the thermal oxidiser;
- multiple pathway exposure associated with potential worst case operating scenarios (i.e. all controls fail, as described in detail in the report in Appendix J) that may give rise to increased dioxin emissions for up to 12 months (this has an estimated 1 in 50,000 year likelihood of occurring); and
- multiple pathway exposure to persistent and bioaccumulative chemicals that may be emitted to air following a worst case release where no destruction occurs in the thermal oxidiser for up to 12 hours (this has an estimated 1 in 50,000 year likelihood of occurring, as described in detail in the report in Appendix J).

### 24.4 Exposure Assessment

#### 24.4.1 Identification of Exposures

The exposure assessment aims to further review the key issues and chemicals identified for the BGC Project, and to identify individuals or groups who may be exposed, and how the exposure may occur. As noted, key issues identified in the health risk assessment are associated with emissions to air during normal operations and potential worst case operating scenarios. As these emissions are to air, there is the potential for exposure on the BIP as well as off-site. Hence there is the potential for workers (on and off-site), residents and anyone undertaking recreational activities (including golfing, athletics and all activities in the estuary and beach areas) to be exposed to chemicals emitted to air from the GTP. All these groups have been evaluated in the health risk assessment.
The chemicals that have been identified for further assessment include a range of chemicals for which inhalation is considered to be the most relevant pathway for exposure. These chemicals are chloroform, carbon tetrachloride (CTC), ethylene dichloride (EDC), vinyl chloride (VC), trichloroethylene (TCE) and tetrachloroethylene (PCE). A number of other chemicals have also been identified. These are chemicals which are considered (by the United Nations) to be persistent and bioaccumulative in the environment. This means that there is the potential for these chemicals to remain in the environment for a long period of time and to accumulate in other media (such as soils and water) and organisms (such as plants and fish). These chemicals include dioxins, mercury and hexachlorobutadiene (HCBD).

These processes are illustrated in Figure 24.1. (Not all pathways illustrated will be of relevance to the assessment at the Project Area).
Following a review of the areas surrounding the BIP and potential emissions of persistent and bioaccumulative chemicals from the GTP, the pathways that have been identified for detailed assessment are:

- inhalation of chemicals in air by all groups in the area surrounding the BIP (residents, workers and recreational groups);
- direct contact (ingestion and dermal (skin) contact) by residents with soils that may accumulate levels of persistent and bioaccumulative chemicals;
- ingestion of homegrown produce (fruit and vegetable crops) by residents, which may be grown in soils that may accumulate levels of persistent and bioaccumulative chemicals through the deposition of GTP atmospheric emissions; and
- ingestion of persistent and bioaccumulative organic chemicals by infants during breastfeeding.

The assessment of exposure to persistent and bioaccumulative chemicals has focused on residents, since they are more likely to spend long periods of time in the area, undertake activities involving contact with potentially affected soils (such as gardening or outdoor play), and grow and eat crops grown in potentially affected soils.

24.4.2 Quantification of Exposure

The quantification of exposure requires a number of inputs and assumptions. These are:

- values that describe physical and activity specific variables for residents (adults, children and infants), workers and recreational users in the area. These values include body weight, inhalation rate at home or exercising, how much soil may be eaten (ingested), how much of the body gets dirty, how much fruit and vegetable product is grown and eaten from home gardens, how many hours are spent at home (or in the area) and for how many years. The values selected are representative of maximum exposures and have been reviewed and agreed with the DEC and NSW Health prior to use.

- Concentrations of chemicals in air. This value has been obtained from the air dispersion modelling undertaken in the Air Quality chapter (Chapter 22). As discussed, the concentration of chemicals in air derived from the GTP will decrease with distance from the BIP, due to natural processes of mixing or dispersion with the atmosphere. To provide a conservative assessment of potential exposure, the maximum predicted concentration at ground level (known as the maximum ground level, or MGL, concentration) has been used in the health risk assessment. This concentration would occur on the BIP, but not in residential areas; however, as a conservative approach, this concentration has also been used in the assessment of maximum exposure by residents and recreational users in the area. This is expected to overestimate risk. Further detailed assessment of exposure at specific locations (discrete receptors as modelled in the Chapter 22) has also been undertaken.

- Concentration of persistent and bioaccumulative chemicals in soil. This has been estimated using a soil accumulation model (Stevens, 1991) that predicts the concentration in soil based on the deposition rate and chemical specific parameters such as the half-life of the chemical in soils. The deposition rate used in the assessment has been obtained from air dispersion modelling, with the maximum deposition value from the model used in the assessment. The maximum deposition rate
occurs on the BIP; however, to be conservative, the assessment of maximum exposure by residents has also used this value. This is expected to overestimate risk. Further detailed assessment of exposure at specific locations (residential and schools identified as discrete receptors, as discussed in Chapter 22) has also been undertaken.

- Concentration of persistent and bioaccumulative chemicals in fruit and vegetables. This has been estimated using a plant model (Stevens, 1991) that predicts the concentration in edible fruit and vegetables on the basis of deposition onto leaves of the plant (and absorption) as well as uptake by roots from chemicals accumulated in soils through the deposition of GTP atmospheric emissions. This has been undertaken using the maximum deposition rate and soil concentrations estimated as above.

- Concentration of persistent and bioaccumulative chemicals in breast milk. This has been undertaken using a model (USEPA, 1998) that is based on the mother’s intake of chemicals from all sources (inhalation, soils, fruit and vegetables and other background intakes) and accumulation of the chemical in milk fat. The milk is then ingested by the infant. This assessment has used the maximum concentrations and maternal intakes estimated for inhalation of chemicals in air, soil concentrations and fruit and vegetable consumption, and is therefore expected to conservatively overestimate risk.

Using exposure variables and concentrations in air, soil, plant and breast milk, the amount of each chemical entering the body each day (referred to as a daily chemical intake) associated with emissions from the GTP has been estimated for residents, workers or recreational users in the area. This is the maximum intake associated with emissions from the GTP that may occur every day for a lifetime (or for up to a year, for the worst case 1 in 50,000 year scenario).

The daily chemical intake calculated for each chemical (for all pathways of exposure) for each group is then compared with the relevant toxicity value for the chemical to determine a risk.

### 24.5 Toxicity Assessment

The objective of the toxicity assessment is to identify toxicity values for the key chemicals that can be used to quantify potential risks to human health associated with calculated daily chemical intake. Toxicity can be defined as “the quality or degree of being poisonous or harmful to plant, animal or human life” (NEPM, 1999).

Each of the key chemicals identified in the health risk assessment has been reviewed with respect to potential health effects that may be associated with exposure by inhalation, oral or dermal exposures. This review has been undertaken in accordance with the guidelines provided by enHealth (2002), which draw on the approach used by the WHO and NHMRC in assigning toxicity values to chemicals. The approach adopted distinguished between chemicals on the basis of their “dose-response relationship”. This is the relationship that is assumed for the chemical on the basis of its intake or dose and the resultant health effect response.

*Figure 24.2* illustrates (using hypothetical curves) the two types of dose-response that are considered in the assessment of toxicity for chemicals.
Non-Threshold Response

Non-threshold dose response assumes that any amount of exposure to the chemical has the potential to result in an increased risk (as illustrated in Figure 24.2). These chemicals are typically carcinogens, whose toxicity values are referred to as ‘cancer risk slope factors’. The NHMRC and WHO assign slope factors to chemicals identified as ‘genotoxic’ carcinogens, with other carcinogens evaluated on the basis of a threshold response relationship (see below). A ‘slope factor’ is an upper bound estimate of the probability of a response occurring following the intake of a chemical over a lifetime via a specific exposure pathway (such as ingestion or inhalation). Therefore, the higher the slope factor, the higher the risk that may be associated with a given exposure. On the basis of the review of chemicals identified in the assessment for the BGC Project, non-threshold dose-response chemicals have been identified as EDC, vinyl chloride and TCE.

Threshold Response

This relationship assumes that there is a level of exposure below which there is no risk of an adverse health effect (illustrated as a ‘safe level’ in Figure 24.2). This is in contrast to the non-threshold relationship, where there is an increased risk associated with any exposure. The NHMRC and WHO identify threshold chemicals as those that are not suspected of exhibiting carcinogenic effects (non-carcinogens) or those which exhibit non-genotoxic carcinogenicity. Toxicity factors for these chemicals are referred to as an acceptable daily intake (ADI) by the WHO. Other terms are used by different agencies for different exposures such as ingestion or inhalation. The lower the ADI, the more toxic the chemical, and the lower the concentration above which there exists a potential for an adverse health effect. On the basis of the review of chemicals identified in the assessment for the BGC Project, threshold dose-response chemicals have been identified as dioxins, mercury, HCBD, chloroform, carbon tetrachloride and PCE.
Toxicity Values

Toxicity values used to quantify potential exposures to the non-threshold and threshold chemicals have been determined using guidance from enHealth (2002). The values selected for use have been determined in consultation with DEC and NSW Health, and are considered current and sufficiently conservative to be protective of exposures to all individuals.

24.6 Risk Characterisation

Risk characterisation is the final step in the health risk assessment. It involves the combination of the exposure assessment and the toxicity assessment to provide a quantitative assessment of non-threshold carcinogenic risk and threshold health effects. The following description presents the general approach to calculating risk for both non-threshold chemicals and threshold chemicals, and the levels of risk that have been adopted as representing acceptable and negligible or ‘zero’ risk.

24.6.1 Non-Threshold Risk

Non-threshold carcinogenic risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential non-threshold carcinogen. The numerical estimate of excess lifetime cancer risk is calculated as follows:

\[
\text{Carcinogenic Risk} = \text{Daily Chemical Intake} \times \text{Cancer Slope Factor}
\]

The total non-threshold carcinogenic risk is the sum of the risks for each chemical for each pathway.

Adopted Risk Targets

Based on available guidance from WHO, NHMRC and the USEPA with respect to incremental lifetime cancer risks, the following is considered representative of current practice in NSW:

- Calculated incremental risks below 1 in a million \( (1 \times 10^{-6}) \) would be considered to be negligible and effectively ‘zero’.
- Calculated incremental risks between 1 in a million and 1 in 100 thousand \( (1 \times 10^{-5}) \) would be considered acceptable.
- Calculated risks greater than 1 in 10 thousand \( (1 \times 10^{-4}) \) would be considered to warrant some form of action or management to reduce the risk.

These levels are extremely low when compared to the background incidence of cancer in NSW society. The background incidence is in the order of 1 in 4 to 1 in 3 (Fitzgerald, 1993). This means that for a population of one million, around 250,000 individuals are expected to contract cancer over a lifetime. An additional risk of one in a million predicts that one additional individual in a group of a million may develop cancer.
24.6.2 Hazard Index for Threshold Risk

The potential for adverse threshold effects resulting from exposure to a chemical has been evaluated by comparing an exposure level, expressed as a daily chemical intake, with the adjusted acceptable daily intake (ADI minus background intake). The resulting ratio is referred to by the USEPA as the hazard quotient (USEPA, 1989) and is derived by the following formula:

$$\text{Hazard Quotient} = \frac{\text{(Daily Chemical Intake from GTP)}}{\text{(ADI)} - \text{(Background Intake)}}$$

To assess the overall potential for adverse health effects posed by simultaneous exposure to multiple chemicals, the hazard quotients for each chemical and exposure pathway have been summed. The resulting sum is referred to by the USEPA as the hazard index (HI). The hazard index does not represent a statistical probability of an effect occurring.

The evaluation of risk associated with threshold chemicals involves a comparison of the total daily intake with the adjusted ADI. The adjusted ADI is that which has been adjusted for background intake from all other sources (food, water and urban air) so that the calculated hazard index compares the chemical intake derived from the GTP with the ADI allowable from sources other than background. Background intakes for evaluated threshold chemicals have been determined from available data from Australian sources for food and water, with air data typically from industrial areas.

**Adopted Targets**

If the total daily chemical intake from the BGC Project exceeds the adjusted ADI (i.e. if the hazard index exceeds one), then this would indicate potentially unacceptable chemical intakes from the GTP. Hence, acceptable levels of exposure are associated with a hazard index of less than one.

Accordingly, if the hazard index is less than one, cumulative exposure to the site chemicals is judged unlikely to result in an adverse effect and is considered to be acceptable.

24.6.3 Risk Calculations

Non-threshold risks and threshold hazard quotients were estimated for potential exposure (reasonable maximum exposures and maximum emissions) associated with normal operation of the GTP and for the worst case scenarios evaluated.

Tables 24.1 and 24.3 present the health risks calculated for residents, workers and recreational users in the area, based on maximum exposure and maximum concentrations during normal operations and worst case scenarios.

The tables indicate that risks associated with maximum potential exposures to emissions from the GTP during normal and worst case scenarios are low, and less than the level adopted as representative of negligible or ‘zero’ risks. As these risks are based on maximum emissions and maximum predicted concentrations (and deposition rates), they are considered to be a conservative overestimation of risks in areas surrounding the BIP.
**Table 24.2 Summary of risks: maximum exposure to maximum concentrations associated with normal operation of the GTP**

| Receptors and Chemicals | Background Intake | Target Risk Levels | Adults | | Children | | Infants |
|-------------------------|-------------------|--------------------|--------|---------|--------|---------|
|                         |                   | Non-threshold       |        | Non-threshold |        | Non-threshold |
|                         |                   | incremental risk    |        | incremental risk |        | incremental risk |
|                         |                   | 1x10⁻⁵             |        | 1x10⁻⁵         |        | 1x10⁻⁵          |
|                         |                   | 1x10⁻⁹             |        | 1x10⁻⁹         |        | 1x10⁻⁹          |
| **Residential Exposure**|                   |                    |        |                    |        |                    |
| Carbon tetrachloride    | 65%               | 65%                | 0.007  | 0.02               |
| Chloroform              | 50%               | 50%                | 2 x 10⁻⁹| 4 x 10⁻¹⁰        |
| EDC                     | NA                | NA                 | 0.00007| 0.0002             |
| Vinyl Chloride          | NA                | NA                 | 5 x 10⁻⁷| 8 x 10⁻⁹         |
| TCE                     | NA                | NA                 | 3 x 10⁻⁹| 8 x 10⁻¹⁰        |
| PCE                     | 34%               | 34%                | 0.00008| 0.0002             |
| Dioxins**               | 54%               | 54%                | 0.001  | 0.003              |
| Mercury**               | 80%               | 80%                | 0.00004| 0.0001             |
| HCBD**                  | 60%               | 60%                | 0.0001 | 0.0003             |
| **TOTAL**               | 5 x 10⁻⁷          |                    | 0.009  | 8 x 10⁻⁹         |
| **CONCLUSION**          |                    |                    | Negligible | Acceptable   |
|                         |                    |                    | Negligible | Acceptable   |
|                         |                    |                    |                    |                    |
| **Recreational Exposure**|                   |                    |        |                    |        |                    |
| Carbon tetrachloride    | 65%               | 65%                | 0.0009 | 0.001              |
| Chloroform              | 50%               | 50%                | 3 x 10⁻¹⁰| 5 x 10⁻¹¹        |
| EDC                     | NA                | NA                 | 0.00009| 0.00001            |
| Vinyl Chloride          | NA                | NA                 | 6 x 10⁻⁸| 1 x 10⁻⁸         |
| TCE                     | NA                | NA                 | 7 x 10⁻¹⁰| 1 x 10⁻¹⁰        |
| PCE                     | 34%               | 34%                | 4 x 10⁻¹⁰| 8 x 10⁻¹¹        |
| Dioxins                 | 54%               | 54%                | 0.00008| 0.0001             |
| **TOTAL**               | 6 x 10⁻⁸          |                    | 0.001  | 1 x 10⁻⁹         |
| **CONCLUSION**          |                    |                    | Negligible | Acceptable   |
|                         |                    |                    | Negligible | Acceptable   |
|                         |                    |                    |                    |                    |
| **Worker Exposure***    |                   |                    |        |                    |        |                    |
| Carbon tetrachloride    | 33%               | 33%                | 0.002  |                    |
| Chloroform              | 50%               | 50%                | 3 x 10⁻¹⁰| 0.00002            |
| EDC                     | NA                | NA                 | 6 x 10⁻⁸|                    |
| Vinyl Chloride          | NA                | NA                 | 7 x 10⁻¹⁰|                    |
| TCE                     | NA                | NA                 | 4 x 10⁻¹⁰|                    |
|                         |                    |                    | Not applicable | since children and infants are not workers. |
### Target Risk Levels

<table>
<thead>
<tr>
<th>Receptors and Chemicals</th>
<th>Background Intake</th>
<th>Adults</th>
<th>Children</th>
<th>Infants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acceptable</td>
<td>Non-threshold incremental risk</td>
<td>Threshold HQ</td>
<td>Non-threshold incremental risk</td>
</tr>
<tr>
<td></td>
<td>Negligible</td>
<td>$1 \times 10^{-3}$</td>
<td>$1 \times 10^{-5}$</td>
<td>1</td>
</tr>
<tr>
<td>PCE</td>
<td>34%</td>
<td>0.00003</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dioxins</td>
<td>54%</td>
<td>0.0002</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6 x $10^{-8}$</td>
<td>0.003</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**CONCLUSION**

- Not applicable, since children and infants are not workers.

* Highest level of risk estimated from exercising and golfing activities for adult.
** Chemicals evaluated for multiple pathway exposure, other chemicals evaluated for inhalation only
*** Worker exposures based on a 10-hour shift.

NA – Not assessed as chemical has been evaluated on the basis of threshold Hazard Index. No non-threshold chemicals identified as key chemicals for relevant receptor and pathway.

HQ – Hazard Quotient

Calculated exposures by an infant and calculated risks are higher than for a child due to the low body weight of an infant (intake is based on an intake of chemical per unit of body weight) and the calculated concentration of chemicals in breast milk which is conservative.
## Table 24.3 Summary of risk associated with potential worst case scenarios – maximum exposure by residents

<table>
<thead>
<tr>
<th>Receptor and Chemicals</th>
<th>Target Risk Levels</th>
<th>Background Intake</th>
<th>Adults</th>
<th>Children</th>
<th>Infants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-threshold incremental risk</td>
<td>Threshold HQ or HI</td>
<td>Non-threshold incremental risk</td>
</tr>
<tr>
<td><strong>Increased Dioxin Emission over 12 months</strong></td>
<td></td>
<td></td>
<td>1x10^5</td>
<td>1</td>
<td>1x10^4</td>
</tr>
<tr>
<td>Other COPC normal operation</td>
<td></td>
<td></td>
<td>5 x 10^{-7}</td>
<td>0.008</td>
<td>8 x 10^{-5}</td>
</tr>
<tr>
<td>Dioxins**</td>
<td>54%</td>
<td></td>
<td>0.003</td>
<td>0.01</td>
<td>0.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>5 x 10^{-7}</td>
<td>0.01</td>
<td>8 x 10^{-4}</td>
<td>0.03</td>
<td>NA</td>
</tr>
<tr>
<td><strong>CONCLUSION</strong></td>
<td></td>
<td></td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>

| **Accidental Release – No Destruction** |                     |                   | Acceptable | Acceptable | Acceptable | Acceptable |
| Dioxins**               | 54%                |                   | 0.00009 | 0.0002 | 0.006 |
| Mercury**               | 80%                |                   | 0.000005 | 0.000001 | 0.0002 |
| HCBD**                  | 60%                |                   | 0.008 | 0.02 | 0.2 |
| TOTAL                   | NA                 |                   | 0.008 | NA | 0.02 | NA | 0.2 |

** Chemicals evaluated for multiple pathway exposure, other chemicals evaluated for inhalation only

NA – Not assessed as chemical has been evaluated on the basis of threshold Hazard Index. No non-threshold chemicals identified as key chemicals for relevant receptor and pathway.

HQ – Hazard Quotient

Calculated exposures by an infant and calculated risks are higher than for a child due to the low body weight of an infant (intake is based on an intake of chemical per unit of body weight) and the calculated concentration of chemicals in breast milk which is conservative.
Figure 24.3 presents a graph of the conservatively calculated intake of persistent and bioaccumulative chemicals by residents during normal operation of the BGC Project (assuming maximum exposure and concentrations). The graph illustrates the background intake (such as food, water and urban air) assumed for HCBD, mercury and dioxins, as well as the estimated intake for adults, children and infants associated with exposure from the BGC Project. This figure indicates the negligible contribution of exposures associated with the operation of the GTP, compared to the background intake (from food, water and urban/industrial air) and the adopted acceptable daily intake (ADI). In other words, residents’ existing intake of persistent and bioaccumulative chemicals (based on the conservative assumptions detailed in Appendix J) is of an acceptable level. The incremental impact of the BGC Project would not significantly change this situation for any residents, including infants.

**Figure 24.3 Intake of persistent and bioaccumulative chemicals by residents during normal operation of GTP**

As an example of the very conservative approach adopted in the estimation of chemical intakes, a child aged between 0 and five years is assumed to:

- be at home 24 hours a day, every day of the year;
- eat 100 mg of soil and 70.7 g of homegrown fruit and vegetables a day;
- cover their hands, legs and feet in soil every day; and
- not wash for 24 hours.
A further evaluation of risk was also undertaken for the normal operations of the BGC Project, for a number of specific locations surrounding the BIP. Recreational areas have been evaluated on the basis of recreational inhalation exposure scenarios. Other areas, which include residential areas and schools, have been evaluated on the basis of residential-type exposure scenarios, which include inhalation and multiple pathway assessment. It is considered reasonable to assume that a child attending school in the local area may also live near the school, and residential exposures that assume that a child (or adult) spends all day, every day of the year at or near the school are therefore considered relevant.

The calculated total risk to human health associated with normal operation of the BGC Project is presented in Figure 24.4 (non-threshold risk) and in Figure 24.5 (threshold hazard index) for these specific areas, along with the maximum risk level calculated for residential and worker exposures, based on maximum concentrations. The maximum risk calculated is considered to be conservative for all areas on and off the BIP.

* 1E-5 = 1 x 10^{-5} = 0.00001 or 1 in 100 thousand; 1E-10 = 1 x 10^{-10} = 0.0000000001 or 1 in 10 billion

** Areas assessed on the basis of recreational exposure. Other areas assessed on the basis of residential exposure.

Figure 24.4 Calculated total non-threshold risk associated with normal operation of GTP
These figures illustrate that the contribution of intake for all key chemicals in areas surrounding the GTP (during normal operations) is associated with risks that are less than the risk levels adopted as representative of acceptable (non-threshold risk of 1 in 100 thousand – 1 x 10⁻⁵ – and threshold HI of 1) and negligible (non-threshold risk of 1 in a million – 1 x 10⁻⁶) values.

Because of the low to very low concentrations of other chemical emissions predicted from the BGC Project (under the normal operations and worst case scenarios), the cumulative impact of such chemicals on the estimated reasonable maximum risk for all receptor groups is also expected to be negligible.

Consideration of potential exposures associated with a range of scenarios, such as a resident who lives near the BIP, works on the BIP and uses the athletics field, has been undertaken in the health risk assessment. In addition, consideration of cumulative risks associated with exposures associated with emissions from the GTP, as well as other exposures derived from contamination identified in groundwater (such as extraction and use of groundwater by residents), has been undertaken in the health risk assessment. The evaluation of combined exposures as well as cumulative exposures indicates that risks to human health remain low and indicative of negligible or ‘zero’ risks.
24.7 Summary of Management Measures

Operation of the GTP, under normal and worst case operating scenarios, would result in negligible risk of human health impacts. As such, specific mitigation measures are not deemed necessary.

This low level of risk would be achieved because operation of the BGC Project would:

- have extensive automatic control and monitoring;
- have an independent high integrity safety system;
- be permanently manned by trained and skilled operators;
- be mechanically robust;
- incorporate inherent safety through small inventories of hazardous materials and low concentrations generally throughout the plant;
- meet best practice, strict, internationally accepted emission standards; and
- use proven equipment from reputable suppliers.

The construction and operation of the GTP would be undertaken using an appropriate occupational health and safety plan for construction workers and long-term employees at the GTP. The plan would require the preparation of safe work method statements to address specific activities. In addition, all operational procedures and controls noted in the Preliminary Hazard Analysis would be implemented.

24.8 Conclusions

Risks to human health associated with the construction and operation of the GTP have been evaluated using a systematic approach as outlined in guidance provided by enHealth (2002). This includes the identification of key issues, evaluation and quantification of exposure, evaluation and quantification of hazards or chemical toxicity and the characterisation of risk.

The assessment undertaken and presented in detail in Appendix J indicates that incremental risk to the health of residents, recreational users of areas surrounding the BIP and workers from the operation of the GTP is negligible.

Operational conditions assessed for normal and worst case scenario releases have been based on estimated emissions from the GTP. These emissions are expected to be conservative and, once operational, should be monitored and re-evaluated against the assumptions used in the health risk assessment.
25.1 Introduction

The Botany Bay Planning Region incorporates the Local Government Areas (LGAs) of Sutherland, Kogarah, Hurstville, Bankstown, Canterbury, Marrickville, Rockdale, South Sydney, Randwick and Botany Bay. Three of the major employment-generating activities in the Sydney metropolitan area and NSW are located in the Botany Bay Planning Region (DIPNR, 1992). These are the Sydney International and Domestic Airports, Port Botany and the Botany Industrial Park (BIP), of which Orica is a part.

25.2 Existing Socio-Economic Environment

25.2.1 Population

The BIP is located within the Botany Bay LGA, close to the Randwick LGA. According to the Australian Bureau of Statistics latest Census (ABS, 2001), the population of the Botany Bay LGA in 2001 was 35,897; an increase of 3.5% since the previous census in 1996. Similarly, the population of Randwick LGA in 2001 was 121,497; an increase of 2.2% since 1996.

The two LGAs form less than 4% of the 3,997,321 total population of the Sydney area, which in contrast grew by 6.8% over the same period.

Population density in the two LGAs, at 1,624 per km\(^2\) in the Botany Bay LGA and 3,338 per km\(^2\) in the Randwick LGA, is much greater than the 329 per square kilometre average across Sydney as a whole.

There are no major age distribution differences between the Botany Bay LGA, Sydney and NSW as a whole, as shown in Table 25.1 (ABS, 2001). More than half of the population residing in the Botany area is between the ages of 20-54 which is typical for the rest of Sydney and NSW.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Botany Bay LGA</th>
<th>Sydney</th>
<th>NSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–4</td>
<td>6.4%</td>
<td>6.7%</td>
<td>6.7%</td>
</tr>
<tr>
<td>5–14</td>
<td>11.9%</td>
<td>13.5%</td>
<td>14.1%</td>
</tr>
<tr>
<td>15–19</td>
<td>6.3%</td>
<td>6.9%</td>
<td>6.9%</td>
</tr>
<tr>
<td>20–54</td>
<td>52.1%</td>
<td>52.2%</td>
<td>49.8%</td>
</tr>
<tr>
<td>55–64</td>
<td>10.1%</td>
<td>8.8%</td>
<td>9.4%</td>
</tr>
<tr>
<td>65 and over</td>
<td>13.2%</td>
<td>11.9%</td>
<td>13.1%</td>
</tr>
</tbody>
</table>

More than 50% of the population of Botany Bay LGA were born overseas, which is reflected in the fact that nearly 53% of the population are from a non-English speaking background. These figures compare with less than 40% and less than 35% respectively, for Sydney as a whole.
25.2.2 Employment

The workforce in the Botany Bay LGA is approximately 47% of the total population, with an unemployment rate of 6% in 2001, down from 8.9% in 1996. This is very similar to the unemployment rate for Sydney as a whole, at 6.1%, and reflects the generally buoyant economy in Sydney and Australia as a whole.

The main employment sectors in the LGA are wholesale and retail trade (21%), manufacturing (13%), property and business services (11%), transport and storage (10%), health and community services (8%), and hospitality services (6.5%). These figures confirm the general trend in the region toward less employment in the manufacturing sector (down from 17% in 1996), with increases in the service industry, particularly in financial, property, business, recreational and personal services.

Unsurprisingly, given the presence of Sydney Airport and Port Botany, the Botany Bay LGA has the highest percentage of employment in the transport and storage industry sectors for any LGA across Sydney.

Employment by occupation is generally well spread across the occupation classifications, with minor changes since 1996—intermediate clerical, sales and service workers (19%), intermediate production and transport workers (12%), tradesperson and related workers (12%), labourers and related workers (11%) and professionals (13%).

The weekly median household income in the Botany Bay LGA is between $800 and $999, which is just less than that for Sydney as a whole, at between $1,000 and $1199 (ABS, 2001).

25.2.3 Ethnicity

The proportion of Australian-born people in the Botany Bay LGA is around 48%, which compares to 61% for Sydney as a whole, and is much lower than the 70% across NSW. This is reflected in the fact that the Botany Bay area has one of the most ethnically diverse populations in Sydney, with over 31 language groups other than English identified in the 2001 census.

The most common countries of origin outside Australia are:

- Greece;
- United Kingdom;
- Indonesia;
- New Zealand;
- The Philippines; and
- China.

The Indigenous population represents 1.6% of Botany Bay LGA’s population, compared to an Indigenous population of 0.97% and 1.9% for Sydney and New South Wales, respectively.
25.2.4 Housing

The 2001 census identified a total of 13,762 private dwellings in the Botany Bay LGA, 55% of which are houses (either separate or semi-detached/terraced/townhouse). Units make up 38% of the total housing stock, with various other dwellings (such as a house or flat attached to a shop) making up the remainder.

Of these, 54% were reported as owned or being purchased, 37% being rented, and the remainder as other tenure types (such as rent-free occupation or dwellings occupied under a life tenure scheme).

25.3 Project Components

The capital cost of the BGC Project is expected to be approximately $102 million, for all elements including the installation of the extraction wells, transfer pipelines and treatment plant. The breakdown of this cost is shown in Table 25.2.

<table>
<thead>
<tr>
<th>Project Element</th>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTP</td>
<td>Equipment (overseas)</td>
<td>$16 million</td>
</tr>
<tr>
<td></td>
<td>Equipment (local)</td>
<td>$22 million</td>
</tr>
<tr>
<td></td>
<td>Labour &amp; Materials (local)</td>
<td>$15 million</td>
</tr>
<tr>
<td></td>
<td>GTP Infrastructure labour and materials (local)</td>
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<td></td>
<td>Engineering (local)</td>
<td>$12 million</td>
</tr>
<tr>
<td>Associated Infrastructure</td>
<td>Treated water distribution pipelines and discharge pipeline refurbishment (local)</td>
<td>$5 million</td>
</tr>
<tr>
<td></td>
<td>DNAPL pipeline and extraction wells (local)</td>
<td>$7 million</td>
</tr>
<tr>
<td></td>
<td>Steam Stripping Unit</td>
<td>$8 million</td>
</tr>
<tr>
<td></td>
<td>Primary and Secondary pipelines and extraction wells (local)</td>
<td>$12 million</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>$102 million</td>
</tr>
</tbody>
</table>

During the construction phase, estimated to be completed in nine months, a construction team varying in numbers from an initial 28 to a peak of 115 would be employed, made up of a labour force, a contractors management team and a BGC Project design team.

Once constructed, it is estimated that the BGC Project would operate for up to 30 years, and would be permanently staffed by two operators per shift throughout the proposed operating hours of 24 hours a day, seven days a week, for up to 365 days a year. There may be one to two weeks during which the GTP would be shut down for planned maintenance.
A team of 10 skilled process operators would be employed on the GTP, with additional engineering contractor personnel engaged to carry out the maintenance activities.

### 25.4 Assessment of Costs/Benefits

As a treatment plant specifically designed to effectively treat the contaminated groundwater, the BGC Project would not generate revenue, and the costs of its construction and operation would be borne by Orica through its other existing and future commercial activities.

However, there would be significant social benefits from the BGC Project. Stopping and treating the contaminant plumes would be expected to significantly reduce the local community’s concerns about the potential ecological and human health impacts of discharge of contaminated groundwater into Botany Bay, and in future, the successful operation of the BGC Project could lead to lifting of the current restrictions on use of the groundwater and on recreational activities in and around Foreshore Beach, subject to conditions set and agreement reached with DIPNR.

In addition, the containment and treatment of the contaminant plumes would avoid a much larger economic and social cost that would be expected to be incurred if the plumes did eventually (as discussed in Chapter 12) discharge into the Bay. These costs would arise from potential ecological impacts, impacts on commercial activities within Botany Bay, potential human health impacts, and impacts on recreational activities. A specific cost estimate has not been prepared, due to the extensive uncertainties associated with the potential impacts of uncontrolled discharge.

There would also be some relatively minor economic benefits from the temporary construction jobs and permanent employment of staff for the plant.

#### 25.4.1 Construction Phase

The construction and commissioning phase of the GTP is expected to require an increasing workforce, with peak requirement of 115 staff in months 7 and 8 of the nine month construction program. This is equivalent to 53 full-time positions over a year.

The construction team would consist of a combination of contract labour force (labourers, drivers, mechanical and electrical fitters), a contractor management team (project managers, engineers) and a project design team (engineers, design specialists). Construction activities would also generate indirect jobs from the purchase of construction materials, transportation of materials and procurement of services. The payroll and contractors fees from the construction would then be filtered through the economy by induced effects, i.e. effects attributable to expenditure arising from income received during the construction.

The Botany region has a long history of industrial development, and as a result there is an available pool of skilled workers with the skills and experience necessary for the construction of this type of development. Given the relatively short-term nature of the construction phase, the employment opportunities would be predominantly open to contract staff and tradespeople with prior industry experience. It would therefore be expected that the majority of the construction personnel would be sourced from within the region.
In summary, the construction phase of the BGC Project would be expected to have the following short-
term direct economic impacts:

- an injection of capital investment spending of up to $64 million into the region, consisting of
  construction phase wages and the purchase of local materials and services used during the
  construction phase;

- the creation of 53 full-time equivalent jobs (with a peak of 115 jobs for two months) over the nine
  month construction period as a result of construction activities in the local economy; and

- the provision of salaries and wages to local labour with the potential to increase household spending
  and demand for goods and services in the local area.

25.4.2 Operational Phase

The key benefit of the BGC Project would be the containment and treatment of the contaminant plumes,
and hence the avoidance of extensive potential impacts and associated costs.

In addition, there would be a number of relatively minor direct impacts on the local economy during the
operating life of the BGC Project, arising from the expected operating expenditure. These additional direct
economic impacts on the local economy include:

- creation of 10 permanent jobs, expected to be recruited locally, for the full-time operation of the
  treatment plant, with the additional wages and salaries injected into the local economy;

- associated operating expenditure on minor maintenance and equipment/materials purchases would
  be expected to increase demand for local suppliers and contractors over the operating phase of the
  project; and

- local service suppliers and contractors would benefit during the major plant maintenance activities
  and overhauls undertaken for the GTP approximately every 10 to 15 years, when up to 10 additional
  contractors could be working on the site.

There would also be additional social benefits arising from the reuse of the treated groundwater by users
on the BIP, and other nearby users. This reuse would supplant existing use of townswater from the
Sydney Water supply and result in potentially significant long-term reductions in demand on the already
stressed water resources. This would be of immense benefit in periods of drought.

25.5 Conclusion

Orica has been required to implement the proposed BGC project, for containment, extraction and
treatment of the contaminated groundwater, through the NCUA issued by the EPA.

The key benefit of the BGC Project would be the cleanup of the contamination, removing the current risk
of contaminant discharge into Botany Bay with the associated extensive potential negative impacts on
commercial, recreational and ecological activities within the bay.
The BGC Project has been designed to achieve this objective, as well as ensuring that there would be no other issues that could cause significant or permanent detrimental social impacts.

The BGC Project would also be expected to provide relatively minor economic benefits in terms of employment and indirect output generation at the local and regional level. Expenditure on local and imported capital (including natural resources and labour) would generate income for staff employed by the development (direct impacts) and in some additional sectors of the economy that comprise the local and regional economy (indirect impacts).

In summary, the BGC Project would have the significant positive benefit of avoiding the discharge of the contaminant plumes into Penrhyn Estuary, in turn avoiding the significant potential impacts on the commercial, recreational and ecological activities within the area. As an additional benefit, the quality of the treated groundwater would be such that it could be reused by existing operations on the BIP and by other nearby users, thereby reducing the current demand on the townswater supply from Sydney Water, a particular benefit in the current drought conditions.
26.1 Introduction

The concept of cumulative environmental impacts recognises that human activity and developments can combine and interact with each other to cause aggregate effects that may be different in nature or extent from the effects of the individual activities. Cumulative impacts include those that the BGC Project may have on existing land use and facilities already in operation in the vicinity of the site, and on other developments also in the planning stage in the vicinity of the site.

This chapter assesses potential cumulative impacts by considering the overall impact of the BGC Project in the context of the existing and known major proposed developments in the area.

26.2 Existing Developments

The existing developments in the Botany area considered of the greatest significance in assessing the potential cumulative impacts of the BGC Project are:

- the various manufacturing operations across the BIP, as identified in Chapter 2;
- the additional manufacturing operations in the vicinity of the BIP, as identified in Chapter 10;
- the operations of Sydney Airport, to the west of the BIP; and
- the operations of Port Botany, to the south of the BIP.

The transport activities associated with these operations, and with the other commercial and residential areas in the vicinity of the site, are also considered for assessment of potential cumulative impacts.

All of these existing developments and activities have been considered during the preparation of the EIS, and have been included in the assessment studies undertaken. The principal cumulative impacts associated with these activities and that of the BGC Project have been identified and considered as follows:

- hydrogeology – incorporating existing extraction of groundwater by other users, in Chapter 12;
- water use – incorporating the positive impacts of reuse of the treated groundwater, in Chapter 13;
- hydrology – incorporating existing stormwater discharges through Bunnerong Canal, in Chapter 14;
- traffic and transportation – incorporating existing traffic flows on surrounding roads, in Chapter 16;
- noise – incorporating existing ambient noise levels from the BIP operations and surrounding activities, in Chapter 17;
- flora and fauna – incorporating existing impacts on ecological habitats and species from surrounding activities, in Chapter 20;
- air quality – incorporating existing air quality and ambient pollutant concentrations, as well as process emissions from the BIP, in Chapter 22;
CHAPTER 26 Cumulative Impacts

- hazard and risk assessment – incorporating existing hazards and risks, and relevant management measures, in Chapter 23; and


By these means, the potential cumulative impacts of existing developments in the Botany area and the development of the BGC Project have been assessed as part of the environmental impact assessment contained in this EIS.

Specific cumulative impact issues that have been highlighted during community consultation are considered in more detail below for completeness.

26.2.1 Air Quality

The assessment of air quality impacts has taken account of prevailing background air quality parameters. Although no ambient air quality monitoring has been undertaken in the immediate vicinity of the BIP, the assessment of existing air quality in and around the BIP has been based on data collected by the EPA’s ambient air quality monitoring network in the Sydney metropolitan region; in particular, the Randwick air quality monitoring site. This is located in a residential area on the corner of Avoca and Bundock Streets, approximately 3 km north-east of the site. The monitoring site measures:

- oxides of nitrogen (NO, NO\(_2\) and NO\(_x\));
- sulphur dioxide (SO\(_2\));
- ozone (O\(_3\)); and
- fine particulate emissions.

The air quality assessment included cumulative impacts from all emissions to air from GTP related contaminants on the BIP (where licence and operating emission data is available to Orica) to predict contaminant ground level concentrations at receptor locations. The assessment model did not include specific data from other industrial sources in the Botany industrial area, due to practical issues of availability of complete and verifiable dataset.

Dioxins and furans, whilst prevalent in the environment from a variety of sources, including:

- uncontrolled combustion processes, including bushfires;
- ferrous and non-ferrous metals production;
- power generation and heating; and
- emissions from transportation, including motor vehicles,

are not routinely monitored and no local background air quality data was available for consideration of cumulative impact.
For dioxins/furans, the maximum stack emission limit of 0.1 ng/m$^3$ is not used as a criterion to assess the acceptability of potential emissions. Due to the toxic nature of dioxins and furans, there are no specific ambient air quality criteria, as the use of ambient dioxin goals would consider acute exposure only, and would not address potential chronic and carcinogenic impacts. Instead, the results of the dispersion modelling (undertaken using the maximum emission limit) have been incorporated within the health risk assessment (discussed in Chapter 24, and summarised below) to consider the potential acute and chronic impacts from dioxin/furan emissions.

### 26.2.2 Health Risk Assessment

**General Approach and Community Health**

The health risk assessment provides an evaluation of risks to human health associated with the GTP. The assessment does not evaluate or review community health status or issues. The health of individuals in the community is dependent on many factors. These include age, family history (genetic make-up) and lifestyle choices such as sports, diet and consumption of drugs (notably tobacco products and alcohol).

Environmental issues in the surrounding community involve daily exposure to a range of chemicals and sources including motor vehicles, trucks, emissions from many different industries in the local area as well as within the Sydney basin, household chemical products, household furnishings and common household consumer products (e.g. shampoos, cosmetics).

As the GTP is not yet built or operating, exposures to emissions from the GTP do not exist and therefore any impacts cannot be measured. On this basis, the assessment undertaken has followed regulatory guidance and industry best practice in evaluating risks to human health that may be associated with the GTP. The assessment provides a tool for use in the evaluation of the BGC Project. It is an assessment of the incremental health risk that would arise from implementation of the BGC Project, with a focus on the GTP.

**Persistent and Bioaccumulative Chemicals**

Cumulative health risk assessment was completed for persistent and bioaccumulative chemicals associated with the GTP operation (mercury, hexachlorobutadiene [HCBD], dioxins and furans).

For non-bioaccumulative chemicals, inhalation was the only exposure pathway considered. For mercury and HCBD, the assessment included multiple pathway exposures specific to the Botany groundwater context.

The health risk assessment concluded that there are negligible incremental risk due to mercury and HCBD emissions from the GTP at all modelled receptor locations.

Dioxins and furan exposures are discussed in more detail below.

**Dioxins and Furans**

Dioxin exposures have been extensively reviewed by the Department of the Environment and Heritage (DEH, 2004). A review of the potential intake of dioxins from all sources indicates that dioxin intake (based on upper bound estimates) may conservatively represent between 22% and 54% (adults and
young children respectively) of the tolerable monthly intake. These data are considered to be conservative, as they are based on upper bound estimates. Given that no other significant localised sources of dioxin emissions have been identified in the BIP, the upper bound estimate of 54% provided by the DEH was adopted for background human health risk.

The health risk assessment concluded that there are negligible incremental risks due to dioxin and furan emissions from the GTP at all modelled receptor locations.

26.3 Proposed Developments

The major proposed developments in the area identified through review of public information and consultation with the Council of the City of Botany Bay (CCBB) and DIPNR comprise:

- the Clean Fuels project, proposed in 2004, at the Caltex Refinery on the Kurnell Peninsula, approximately 8 km south-east of the BIP;
- the Port Botany expansion, proposed in 2003, at Port Botany, approximately 2 km south of the BIP;
- the Patrick Port Botany container terminal upgrade, also proposed in 2003, at Port Botany south of the BIP;
- the Botany freight rail line duplication, final stage proposed in 2003, including the line that runs alongside the BIP; and
- an expansion of Sydney Airport, through anticipated growth in passenger traffic up to 2020, framed in the master plan process prepared in 2003.

No other major potential developments have been identified in the area to date that may produce cumulative impacts with the BGC Project. The previous proposal by Orica for the HCB Waste Destruction Facility on the BIP has been withdrawn.

The potential impacts from these proposed projects have been reviewed, where possible, and considered as part of the assessment within this EIS.

Any future proposed developments, in addition to those identified, would be required to address the cumulative impacts of their developments with the impacts of the other existing and currently proposed developments in the area, and would be considered by the relevant approval authority in that context.

Overall, the potential for cumulative impacts from the identified developments and the BGC Project is considered to be minimal, given the nature of the different projects (the other proposed projects in the area are largely infrastructure projects). The key potential cumulative impacts associated with the multiple developments are considered to be:

- traffic;
- noise;
- flora and fauna; and
- air quality.
CHAPTER 26 Cumulative Impacts

These are considered in detail below.

Each of the identified projects would have its own identified safeguards to mitigate individual impacts relating to these issues, both proposed by the proponent and as required by the consent authority. This would ensure that adverse cumulative impacts would be minimised.

No additional potential cumulative impacts for the other issues assessed in this EIS are considered significant, for the following summarised reasons:

- **Land use:** The other proposed developments would generally not change existing land uses, as they are extensions of existing activities.

- **Geology and soils:** There would be no interaction between the lands affected by the proposed developments, as they are all on land previously developed and disturbed.

- **Hydrogeology:** The other proposed developments would not affect the existing hydrogeological regime in the Project Area.

- **Water quality:** There would be no interactions between the proposed projects that would cause a significant impact on water quality, because all projects are committed to measures to maintain the water quality of Botany Bay.

- **Hydrology:** There would be no interactions between the BGC Project and the others that would cause a significant impact on hydrology.

- **Waste management:** The nature of the proposed projects, and the relatively minor quantities of waste that would be generated by them, would not significantly affect existing waste management facilities.

- **Energy and greenhouse:** The energy demand and greenhouse gas emissions from the BGC Project would be a relatively minor contribution to the potential overall increase from the other proposed projects (particularly from associated impacts, such as increases in vehicle traffic).

- **Landscape and visual:** The nature of the BGC Project and existing land uses is such that it would have a minor contribution to potential visual impacts, if any.

- **Archaeology and heritage:** The BGC Project entails no potential contribution to impacts on archaeological or heritage items in the area.

- **Hazard assessment:** The nature of the other proposed projects is such that there would be no significant interaction that would increase potential hazards or risks in the Botany/Randwick Industrial Area.

- **Health risk:** Similarly, the nature of the other proposed projects is such that there would be no significant interaction that would increase potential health risks.
26.3.1 Traffic

As detailed in Chapter 16, the peak traffic generated by the BGC Project would be an estimated 70 vehicles per day (private vehicles for workers and trucks) during months 7 and 8 of the construction phase.

This peak traffic is only a fraction of the existing traffic levels on Denison Street, and would be an insignificant contribution to the predicted traffic increases from the other identified developments. In addition, these peak flows would only be short-term in nature.

All the other traffic vehicle numbers generated by the construction of wells and pipelines and by the full operation of the GTP are less than the 70 peak, and would therefore represent an even smaller contribution to the predicted traffic increases.

Therefore, the potential cumulative impact on future traffic flows from the BGC Project is considered insignificant in comparison with the other proposed developments in the area.

As detailed in Chapter 17, the wells and pipelines installed on Foreshore Road are underground, with covers set at the existing ground level, designed to safely carry the weight of heavy traffic. There would be no impact on the existing use of the road, and no safety implications.

26.3.2 Noise Impact

As detailed in Chapter 17, the BGC Project would include equipment sound power level specifications to achieve compliance with the BIP Noise Reduction Program. As a result, the major potential cumulative noise impacts from the BGC Project would be those associated with traffic (resulting from construction of the GTP and associated elements), and with the operation and maintenance of the GTP.

For traffic noise, given that the potential cumulative impact on future traffic flows from the BGC Project is considered insignificant, it is concluded that any potential cumulative noise impact from additional traffic would similarly be insignificant.

For potential noise from the operation of the pumps, as detailed in Chapter 17, the use of submersible pumps, installed below ground level with the top of the wells covered, would mean that noise emissions from operation of the pumps would be insignificant, particularly in the context of the surrounding ambient noise levels.

Therefore, it is concluded that any potential cumulative noise impact from pumping would be insignificant.

26.3.3 Flora and Fauna

As detailed in Chapter 20, the operation of the BGC Project would result in a reduction in the discharge of groundwater, and a cessation of dry weather surface water discharge from the Springvale and Floodvale Drains, into Penrhyn Estuary. The potential impacts from these predicted changes in water flows have been assessed, and the findings are presented in Chapter 20.
CHAPTER 26 Cumulative Impacts

The Port Botany Expansion EIS (URS, 2003) identified a potential impact on the shorebird habitat of Penrhyn Estuary from that development, and proposed a number of measures for habitat enhancement in this area. The objective was to improve the shorebird habitat so as to provide for the continued use of the estuary by shorebirds and potentially to increase the number of shorebirds using the area following the expansion works. The proposed habitat enhancement would involve the creation of an additional 11 hectares of tidal flats and up to five hectares of additional saltmarsh habitat.

The predicted changes to the groundwater and surface water flows from the BGC Project could affect this proposed habitat enhancement. The change in groundwater flows should be considered in the implementation of the rehabilitation program proposed by Sydney Ports Corporation. If the port expansion proceeds, the remediation measures planned by Sydney Ports Corporation would complement those of Orica in providing an improved roosting and foraging habitat for migratory and non-migratory shorebirds within the estuary.

The potential cumulative impacts of the BGC Project on the Port Botany expansion enhancement works have been assessed as part of the ecological assessment in Chapter 20.

26.3.4 Air Quality

As detailed in Chapter 22, the air quality assessment incorporated existing emissions from industrial operations on the BIP, as well as contributions to air quality from other general operation and traffic movements, through the use of local ambient air quality data. The additional proposed infrastructure developments in the area would be expected to lead to increased impacts on air quality from increased vehicle traffic, potentially resulting in increased NO\textsubscript{x}, carbon monoxide, PM\textsubscript{10} and sulphur dioxide concentrations in the area.

It is not considered that the emissions from the GTP would contribute to such future potentially increased emissions, because the predicted emissions from the plant are insignificant in comparison with the current existing background levels (as shown in Table 22.13).

26.4 Conclusion

The potential cumulative impacts of the BGC Project with existing developments in the Botany area have been considered in conjunction with potential project impacts, within the relevant chapters of this EIS. The impacts identified during the construction and operational phases would be managed through the Environmental Management Plans to be prepared for the BGC Project.

Other proposed major developments in the area have been identified and the potential cumulative impacts of significance considered. No significant cumulative impacts have been identified, and therefore the potential for cumulative impacts of the BGC Project with other developments in the area is considered to be low.

Any future proposed developments, in addition to those identified, would be required to address the cumulative impacts of their developments with the impacts of the other existing and currently proposed developments in the area, and would be considered by the relevant approval authority in that context.