Chapter 16
Hydrology, groundwater and water quality

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16. Hydrology, groundwater and water quality

This chapter describes the potential surface and groundwater hydrology and water quality impacts of the Moorebank Intermodal Terminal (IMT) Project (the Project), in order to address the relevant Commonwealth Department of Environment (DoE)'s Environmental Impact Statement (EIS) Guidelines and the Secretary for the NSW Department of Planning & Environment (NSW DP&E)'s Environmental Assessment Requirements (NSW SEARs) for the Project (refer Table 16.1). Full details of the surface water hydrology and water quality impacts are contained within Technical Paper 6 – *Surface Water Assessment* in Volume 6 of this EIS. Groundwater impacts are not specifically mentioned in the State or Commonwealth requirements for the EIS, but have been qualitatively assessed in this chapter.

Table 16.1 Relevant Commonwealth EIS Guidelines and NSW SEARs

Requirement	Where addressed
Commonwealth EIS Guidelines under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)	
• Water quality management at the proposed action area during and after construction. • Details regarding water supply, waste water management, sewerage management, stormwater management and any other relevant public works. • Full details of risk assessments which have been undertaken regarding potential threats from flood and fire, rehabilitation works, construction and operational storage of flammable and other hazardous materials and strategies to address these risks.	Sections 16.3.1 and 16.4.2 for stormwater and water quality management. In addition, water supply, wastewater and sewage management are covered in Chapter 26 – *Waste and resources* and Chapter 7 – *Project built form and operations*. Sections 16.3.2 and 16.3.3 for flooding impacts. Chapter 14 – *Hazards and risks,* covers threats from both fire and flooding.
• Provide an assessment of the hydrological impacts of the project and the project efforts on flood characteristics on and off the site and the likely impacts of changes to surface water, groundwater and stormwater quality, erosion and sedimentation impacts, on and off site. • Provide an assessment of the likely and potential impacts on all aspects of the environment associated with spills, floods, fire and release of contaminants. The assessment needs to consider all hazardous items that will or could potentially be transported and/or stored at the IMT. Discuss the likelihood of hazardous materials being illegally transported using rail infrastructure and stored at the Moorebank IMT.	Hydrological impacts are covered in sections 16.3.2 and 16.3.3. Water quality impacts are covered in section 16.3.4. Hazards and risks including illegally transported materials are covered in Chapter 14 – *Hazards and risks*; flooding risk is described in sections 16.3.2 and 16.3.3. Spills and contamination, including groundwater impacts, are covered in sections 16.3.4 and 16.3.5 and in Chapter 15 – *Contamination and soils.*
NSW SEARs under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)	
Hydrology – including but not limited to:	
• Changes to the site's hydrology and an assessment of the hydrological impacts of the development and the development effects on flood characteristics on and off the site (in particular Cambridge Avenue), including the consideration of effects associated with climate change, such as changes to rainfall frequency and/or intensity.	Sections 16.3.1 to 16.3.3.
• Surface water and stormwater quality, erosion, spill, and sedimentation impacts, on and off site, and	Section 16.3.4.

Requirement	Where addressed
• Taking into account the Managing Urban Stormwater Soils and Construction, Vol. 1, 2A and 2D (DECC); *National Water Quality Management Strategy; Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC); *Georges River Floodplain Risk Management Study and Plan*; *Anzac Creek Floodplain Risk Management Study and Plan and Floodplain Development Manual* (DIPNR).	Sections 16.1 to 16.4.

16.1 Assessment approach

16.1.1 Surface water

The surface water assessment assessed the following key potential impacts of the Project, both within and outside the Project site:

- potential changes in hydrologic regime, in particular changes in flooding or stormwater runoff quantity; and
- potential impacts on surface water quality, including sedimentation and erosion, stormwater quality and stormwater pollution (including accidental spills).

Potential impacts were considered for both the Early Works and the Full Build (from 2030). The Early Works considered a construction scenario based on assumed worst case disturbance of the local surface water catchments; the Full Build assumed the potential worst case impacts on surface water during Project operations. Assessment of the operational impacts was based on a conceptual stormwater management plan and assumed bridge configurations for the crossing of the Georges River in each of the concept layouts assessed in this EIS (the northern, central and southern rail access options).

The methodology primarily involved desktop assessments supplemented by site walkover inspections. The desktop assessments used information and analyses from Liverpool City Council (LCC) and other organisations, including flood and water quality data.

Impacts on the surface water environment were assessed at:

- the regional scale, which addressed the Georges River floodplain and catchment adjacent to the Project site; and
- the local scale, which addressed the surface water environment on the Project site itself.

Regional scale flooding impacts were assessed using a hydraulic model (developed using the one-dimensional hydraulic modelling software package, HEC-RAS) of the Georges River and floodplain system local to the Project site, and simulation of existing conditions and developed scenarios to determine the impact of the Georges River crossing on flood levels and velocities under each of the rail access options. LCC's larger scale MIKE11 hydraulic model of the Georges River was used to verify the HEC-RAS model results. The investigation focused on the 1% annual exceedance probability (AEP) design flood event, as this is the key event for bridge serviceability and for assessing the impacts of the bridge on regional flooding. The 1% AEP design flood event is also the principal flood planning event adopted by LCC and stipulated in the *Georges River Floodplain Risk Management Study and Plan* (Bewsher 2004). The potential impacts of climate change on regional flooding were also assessed both qualitatively and quantitatively, using guidance from the *NSW Government's Floodplain Risk Management Guideline: Practical Considerations of Climate Change* (DECC 2007a).

Local stormwater catchment impacts were assessed in relation to stormwater quantity for the Early Works, construction and operational scenarios. For the operational scenario at Full Build, this involved comparing the predicted runoff from the three concept layout options with the existing rates of runoff at the Project site under the 1%, 2% and 10% AEP design storm events. The potential impacts of climate change on local stormwater catchment flooding were also assessed.

A series of stormwater management features are proposed in order to detain and treat site runoff. These have been incorporated into the concept layouts for the Project, as shown in Figure 7.4 to Figure 7.6 in Chapter 7 – *Project built form and operations*. Specific design criteria have also been detailed (as identified in Appendix B of Technical Paper 6 – *Surface Water Assessment* in Volume 6 of this EIS) to avoid adverse impacts on the local environment.

For the assessment of impacts on surface water quality, existing water quality in the Georges River was assessed based on water quality monitoring undertaken by Parsons Brinckerhoff in 2013–2014. This data is available on the MIC website[1]. Using this data, a baseline water quality standard was established with respect to NSW Office of Water (NOW) water quality objectives and Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines. MUSIC modelling software (Model for Urban Stormwater Improvement Conceptualisation, version 5) was used to determine the likely annual pollutant loads originating from the Project operations through stormwater discharges. Estimated annual loads were compared between the pre-developed Project site and the fully developed Project site, with and without stormwater treatment. MUSIC was then used to analyse the likely reduction of pollutant concentrations following treatment of the stormwater. Calculations were also made to estimate the area of water quality treatment required to meet the water quality management objectives.

16.1.2 Groundwater

A desktop assessment of the existing groundwater environment was undertaken for the area surrounding the Project. This involved a review of the topography and hydrology of the Project site, geology and soils, hydrogeology, groundwater legislation and existing groundwater reports, including:

- GHD (2004) Groundwater Investigation of the North Western Portion of the Moorebank Defence Land;
- HLA Envirosciences (2003) Preliminary Groundwater Study Moorebank Defence Land;
- Earth Tech Engineering (2006) Stage 2 Environmental Investigation Moorebank; and
- Egis Consulting Australia (ECA) (2000) Preliminary Site Investigation.

An investigation of groundwater bores registered as part of the NOW database was also undertaken within a 5 kilometre (km) radius of the Project site to investigate groundwater quality, aquifers present, groundwater receptors and likely groundwater flow directions.

Potential impacts on groundwater were assessed qualitatively.

16.1.3 Cumulative assessment

In accordance with the NSW SEARs, this EIS includes a cumulative assessment of the hydrology impacts of the Project in combination with development of the Sydney Intermodal Terminal Alliance (SIMTA) site and other planned developments within the surrounding region. The findings of the cumulative assessment are provided in Chapter 27 – *Cumulative impacts*.

1 http://www.micl.com.au/environment/monitoring-results/water-quality.aspx

16.2 Existing environment

16.2.1 Regional surface water environment

The Project site is located within the Georges River catchment, with the majority of the Project site draining into the Georges River, which forms the western boundary of the site. Land use within the catchment varies, and includes residential, industrial, agricultural, mining and Defence activities, and protected areas such as drinking water catchments and conservation areas. The Georges River extends approximately 60 km south-west of Sydney, with the Project site located in the upper section of what is referred to as the mid Georges River.

The catchment area upstream of the Project site is largely undeveloped; however, downstream the catchment is increasingly developed, extending out to the river mouth at Botany Bay. The section of river adjacent to the Project site (refer to Photo 16.1) is not subject to tidal influences, because the Liverpool Weir, located approximately 2 km downstream (to the north of the Project site), governs minimum water levels. Flooding in this reach of the river is therefore a fluvial process, i.e. it is caused by the catchment's runoff response to rainfall.

Photo 16.1 View of Georges River adjacent to Project site (facing north, downstream)

The Project site is generally flat to gently undulating, with vegetated banks on both sides of the river. The eastern floodplain of the river (part of the Project site) has a terraced area at a relatively low elevation. East of this terraced area, the ground levels rise steadily up to the main IMT site.

A small portion of the south-eastern part of the Project site drains to Anzac Creek, which is an ephemeral (i.e. temporary) tributary of the Georges River with a catchment of 10.6 square kilometres. The creek flows in a north-easterly direction and ultimately drains to Lake Moore on the Georges River, some 3 km downstream of the Project site. In the south-west corner of the Project site a number of linked ponds within the existing Royal Australian Engineers (RAE) Golf Course form the headwaters of Anzac Creek. From these ponds, the creek flows east under Moorebank Avenue via culverts (refer Figure 16.1).

The area has historically been subject to flooding from the Georges River. Regionally, flood records date back as far as the 1860s. The most recent major flood occurred in 1988, and was estimated to have an annual exceedance probability (AEP) of 5%. This flood resulted in inundation of more than 1,000 properties along the Georges River. The existing flood risk extent at the Project site is detailed in Figure 16.2.

Georges River flood risk

The January 2011 LCC flood risk map (shown on Figure 16.2) indicates that the Project site is most at risk of flooding from the Georges River in the lower terrace area of the eastern floodplain of the river. Peak 1% AEP flood levels range from 11.7 to 10.4 metres above Australian height datum (AHD) along the western boundary of the site.

LCC flood data was used to assess existing flood risk zones within the Project site, as summarised in Table 16.2.

Table 16.2 Project site flood risk zones

Flood risk category	Category definition	Project area affected (ha)	Percentage of Project site affected
High flood risk	Areas within 1% AEP flood extent and subject to high hydraulic hazard or evacuation difficulties.	23.6	12%
Medium flood risk	Areas within 1% AEP flood extent and not subject to high hydraulic hazard or evacuation difficulties.	25.5	13%
Low flood risk	All other flood liable land (i.e. within the probable maximum flood (PMF) extent).	56.8	29%
No flood risk	All other areas (i.e. all areas outside the PMF extent).	90.9	46%

Source: Table 2.1 in Technical Paper 6 – *Surface Water Assessment* (Volume 6)

Notes: ha = hectares

Figure 16.1 shows these existing flood risk zones for the Project site based on LCC's flood modelling results from the *Upper Georges River Flood Study* (Department of Land and Water Conservation and Liverpool City Council, 2000) and the modelling of Anzac Creek completed for the *Anzac Creek Floodplain Risk Management Study and Plan* (BMT WBM 2008). This study predicted that the critical storm duration for flooding at the Project site is 36 hours for the 1% AEP flood event. Thus, flooding from a critical storm would persist for a relatively long duration in the medium and high flood risk zones within the Project site, although the proximity of the river would allow visual warning of rising flood levels. In extreme flood events, the existing Project site could be evacuated via the areas of the Project site that lie outside the PMF extent, as there is direct access to Moorebank Avenue, which remains flood free under this maximum event.

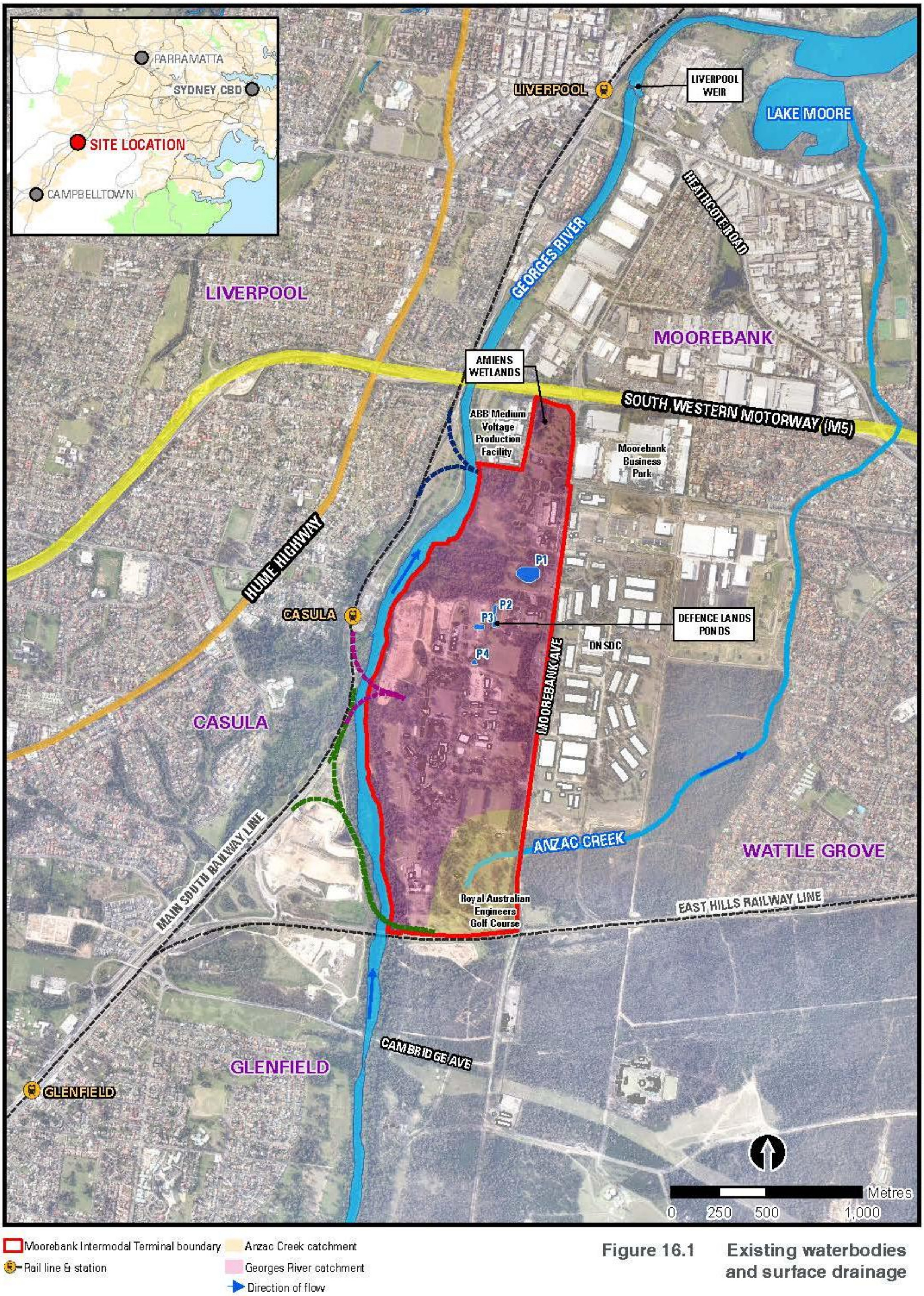

Figure 16.1 Existing waterbodies and surface drainage

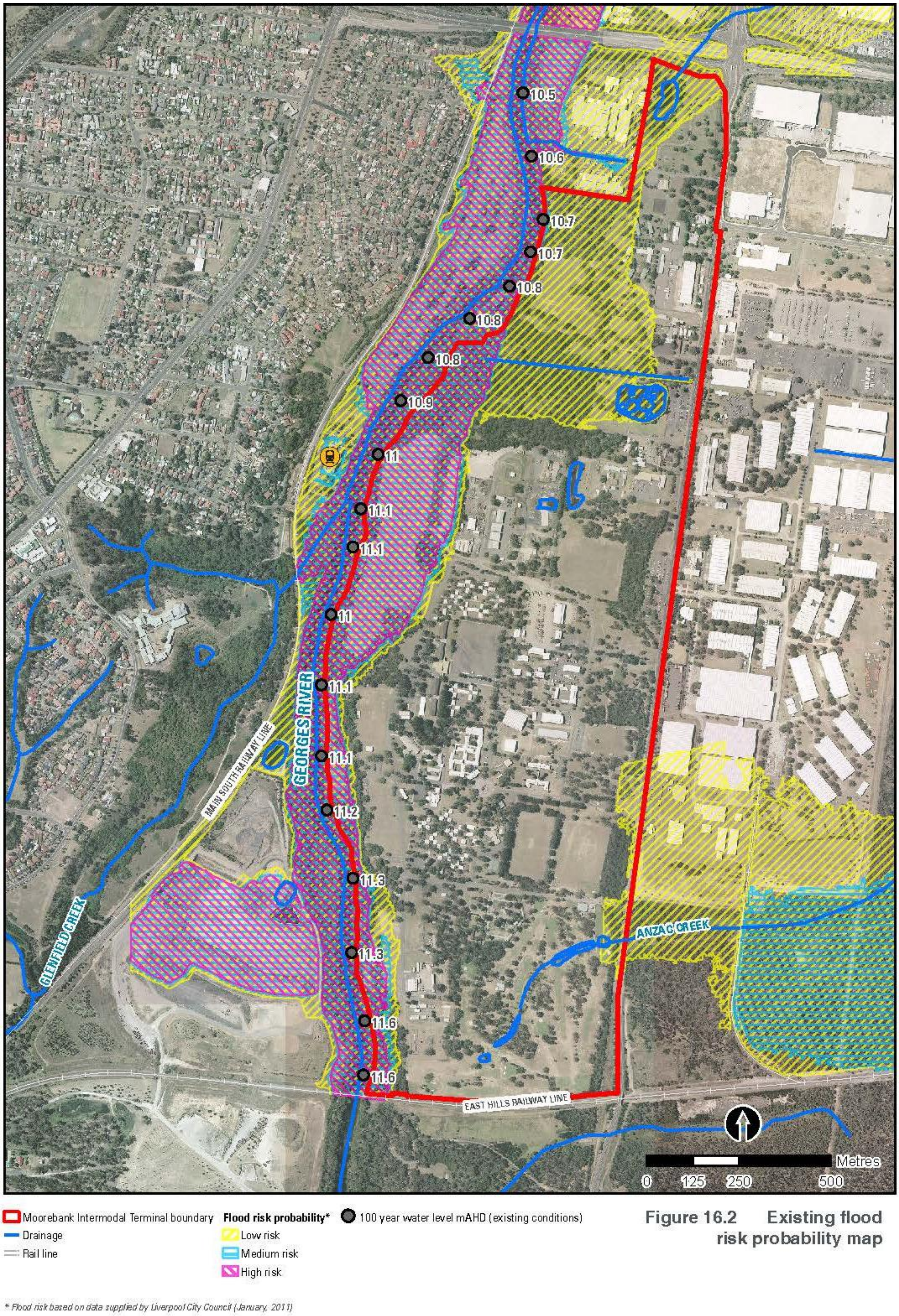

Figure 16.2 Existing flood risk probability map

Anzac Creek flood risk

The Project site is at the headwaters of Anzac Creek. The *Anzac Creek Floodplain Risk Management Study and Plan* (BMT WBM 2008) identifies that flooding is generally confined within the main channel of Anzac Creek, upstream of the M5 Motorway. Effective conveyance of flood discharges in the main channel means that there is very little floodplain inundation, even up to the 1% AEP flood event. Existing culverts through the M5 Motorway embankment are considered adequate to convey the 1% AEP floodwaters to the downstream reaches of the Anzac Creek catchment, without causing substantial backwater accumulation (assuming no culverts are blocked).

Only a minor proportion of the existing Project site (approximately 9%) lies within – and drains to – the Anzac Creek catchment. Under existing conditions, the flood risk to the Project site from Anzac Creek is negligible.

16.2.2 Local surface water environment

Stormwater drainage

Stormwater on the existing Project site is generally conveyed via pits, pipes and open channels in a north-westerly direction across the site and discharged into the Georges River. Only one of the existing stormwater pipe networks discharges elsewhere (into Anzac Creek).

The Project site contains two open channels; one is a vegetated open channel in the north of the Project site adjacent to the ABB site, and the other is an open concrete-lined trapezoidal channel that flows westward through the Project site from the lowest point in Moorebank Avenue to the Georges River (see Figure 16.1). In November 2010, a site inspection of the two open channels revealed both channels to be in poor condition, with the presence of thick vegetation and significant erosion.

Discharges within the RAE Golf Course, in the south-east corner of the Project site, drain by open channels to road culverts underneath Moorebank Avenue, which then discharge into Anzac Creek. Based on the local topography, a number of land areas surrounding the Project site partially drain into the Project site through open channels, box culverts, natural drainage lines and overland flows during differing rainfall events. These land areas include:

- Defence National Storage and Distribution Centre (DNSDC) site, east of the Project site;
- M5 Motorway, north of the Project site;
- Moorebank Business Park, north-east of the Project site; and
- ABB site, north of the Project site.

Existing waterbodies

There are several waterbodies adjacent to and within the Project site that provide either a stormwater treatment function or are used for onsite activities, as described below and shown on Figure 16.1:

- *Georges River* – At the regional level the Georges River is the main receiving waterway for discharge from the Project site.
- *Amiens wetland* – The Amiens site is located in the north-eastern corner of the Project site and has an approximate local catchment area of 5.9 ha, which drains north towards the Amiens wetland waterbody. The wetland acts as an outlet controlled detention basin for the M5 Motorway and adjacent catchment, which means that if water levels in the Georges River are elevated, the basin will not release water until the levels are below the outlet pipe levels. Waters are discharged from the Amiens wetland via a piped connection to the Georges River.
- *Anzac Creek and water bodies* – The densely vegetated and linked permanent waterbodies that form the headwaters of Anzac Creek provide some degree of detention and water quality treatment for stormwater flows from the local catchment draining to Anzac Creek. However, Anzac Creek is heavily degraded and is generally in poor condition. It is predominantly in a low flow state with sluggish to minimal water movement, dependent on local rainfall (Hyder Consulting 2011).
- *Defence land ponds* – The main IMT site contains four small waterbodies that are most likely used for attenuation and/or water quality treatment. Discharge from these ponds overtops the pond outlets and flows through informal overland channels into the Georges River.

Surface water within the Project site and surrounding local catchment predominantly drains to one of these water bodies, before discharging to the Georges River. The Amiens wetland and Defence land ponds provide a limited stormwater treatment function through the retention of some nutrients, sediment and other pollutants. However, discharge of stormwater from the Project site to the Georges River and Anzac Creek is currently largely unmanaged.

Applicable water quality guidelines

Environmental values are defined in *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DEC 2006b) as values or uses of water that the community believes are important for a healthy ecosystem – for public benefit, welfare, safety or health. For the Georges River catchment, there are four main sub-catchment categories, each with a set of environmental values that describe the water quality goals relevant to each sub-catchment. The *Independent Inquiry into the Georges River – Botany Bay System* (Healthy Rivers Commission 2001) determined that the Project is located within a sub-catchment classified as a 'waterway affected by urban development'; therefore, the environmental values for this category were applied to the assessment.

There are two kinds of water quality objectives (WQOs) that are applicable to the Project site:

- catchment specific objectives based on the maintenance of environmental values; and
- default trigger values included in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000), which provide a threshold or a range of desired values to achieve WQOs.

Indicators to achieve aquatic ecosystem WQOs for 'waterways affected by urban development' for the Georges River were obtained from NOW and are provided below in Table 16.3. Where relevant, specific NOW WQO indicators applicable to both 'lowland rivers' and 'estuaries' within the 'waterways affected by an urban environment' sub-catchment have been adopted.

Table 16.3 WQO indicators for lowland rivers and estuaries of the Georges River

	Lowland river	Estuaries
Total phosphorus (µg/L)	25	30
Total nitrogen (µg/L)	350	300
Chlorophyll-*a* (µg/L)	5	4
Turbidity (NTU)	6–50	0.5–10
Electrical conductivity (µS/cm)	125–2200	–
Dissolved oxygen (% saturation)	85–110	80–110
pH	6.5–8.5	7.0–8.5
Temperature	Default trigger values are provided in ANZECC 2000 guidelines. An unnatural change in temperature (>80%ile, <20%ile) is the default trigger value.	
Chemical contaminants or toxicants	Default trigger values are provided in Table 3.4.1 in the ANZECC 2000 guidelines.	
Biological assessment indicators	This form of assessment directly evaluates whether management goals for ecosystem protection are being achieved. Many potential indicators exist.	

Source: Appendix A to Technical Paper 6 – *Surface water assessment and NSW Water Quality and River Flow Objectives for the Georges River* (http://www.environment.nsw.gov.au/ieo/GeorgesRiver/report-03.htm#P405_33547)

Existing stormwater and downstream receptor water quality

The quality of the stormwater discharging from the existing Project site to the Georges River is influenced by the developed areas of the site, site activities and water bodies located within the site.

Water quality at onsite water bodies

In January 2011, Parsons Brinckerhoff conducted a Phase 2 environmental site assessment (ESA) to assess the nature and likely extent of contamination at the main IMT site, based on the areas of potential environmental concern (refer to Chapter 15 – *Contamination and soils*). The Phase 2 ESA has since been updated in accordance with the *National Environmental Protection (Assessment of Site Contamination) Amendment Measure 2013* (No. 1) (NEPM). The following field parameters were collected at various surface water sampling locations scattered across the main IMT site using a water quality meter:

- pH ranged between 6.47 to 9.37, indicating a wide range of values from slightly acidic to alkaline conditions;
- electrical conductivity ranged from 65.4 to 528 micro Siemens per centimetre (µs/cm), indicating fresh water; and
- dissolved oxygen ranged between 4.02 to 8.44, indicating that surface waters are well oxygenated.

The majority of samples returned results below the levels required to undertake laboratory assessment. However, concentrations of copper, nickel and zinc were above the default trigger values provided in the ANZECC guidelines for these metals (refer Table 16.3). Based on the findings of the ESA, the soil and groundwater contamination identified at the Project site is considered unlikely to contribute significantly to the water quality within the Georges River through surface and/or groundwater migration.

Water quality in the Georges River and Anzac Creek

A water quality monitoring program for the Georges River and Anzac Creek is being undertaken for the Project, with key results published on the MIC website (http://www.micl.com.au/environment/monitoring-results/water-quality.aspx) every month. This program commenced in July 2013 and would be expected to continue throughout the construction and operation of the Project. The program involves water quality sampling at five locations within the Georges River and one location in Anzac Creek, along with analysis of antecedent rainfall and river flow conditions. Samples are analysed for the full range of water quality indicators, including field parameters, physical parameters, major ions, metals, nutrients, microbial indicators and hydrocarbons.

The findings of the water quality monitoring program to date are as follows:

- Weather conditions have been relatively dry with below average rainfall. The sampling events to date have therefore not captured a high flow event, and results to date reflect water quality for the lower range of flow conditions.
- Exceedances for total nitrogen (TN) and total phosphorus (TP) have been recorded for all monitoring locations.
- The single sampling location in Anzac Creek most commonly exceeds TN and TP trigger values, likely to be due to fertilisers used at the RAE golf course.
- No major exceedances for metals have been recorded.
- Other exceedances have been recorded but none indicating unusual or long-term trends of concern.

At the time of preparation of this EIS the program was approximately 50% complete, and the results generally reflected the prevailing low flow conditions. It is therefore proposed that summary statistics from the program be prepared at a more advanced stage of the program, when a longer term record is available that captures more variability in flow conditions.

Water quality sampling was also undertaken as part of the aquatic survey for the SIMTA environmental assessment (Hyder 2011). The survey found that the majority of water quality parameters were within ANZECC guidelines for lowland aquatic ecosystems of south-eastern Australia. Some noted exceptions include pH and dissolved oxygen (DO%). The pH recording in Anzac Creek of 5.62 was below the lower guideline of 6.5. The DO% of Anzac Creek of 11.6% was considerably lower than the lower guideline of 60%.

Other Georges River water quality data from NOW and NSW Office of Environment and Heritage (OEH) indicates that while some water quality parameters are within the ANZECC guidelines, others – such as TN, TP and turbidity – are consistently exceeding the guidelines. This is consistent with the lower Georges River's status as a deteriorated urban waterway.

Further details of baseline water quality conditions in the Georges River are included in Appendix B to Technical Paper 6 – *Surface water assessment*.

16.2.3 Groundwater environment

Hydrogeological setting

Three main groundwater systems occur within the Project site and surrounds:

- Quaternary and Tertiary alluvium in the area contains a shallow, unconfined aquifer that is likely to be hydraulically connected to the Georges River.
- Ashfield Shale in the area generally behaves as a deeper regional aquitard, storing and transmitting groundwater slowly between aquifers. The thickness of this low-permeability shale varies across the Project site from 3 to 10 metres (m) (HLA Envirosciences 2003).
- The Hawkesbury Sandstone aquifer in the area is unlikely to influence groundwater flow characteristics of the Project site and surrounds, as the Ashfield Shale aquitard acts as a barrier for groundwater flow between the overlying alluvial aquifer and the underlying sandstone aquifer.

Alluvial soils are generally quite vulnerable to transmitting contamination within urban environments. Previous hydraulic testing indicates that hydraulic conductivity ranges between 3.4×10^{-3} and 1.1×10^{-1} metres per day (m/day) for alluvial aquifers and 1.1×10^{-2} m/day and 8.2×10^{-2} m/day for the Ashfield Shale aquitard in the Sydney Basin (HLA Envirosciences 2003).

Groundwater levels within a 1 kilometre radius of the Project site were inferred from registered bores within NOW's groundwater database in 2010, as shown in Table 16.4.

Table 16.4 NOW groundwater level data

Bore No.	Easting	Northing	Drilled depth (m)	Static water level (mBGL)	Screened aquifer
GW016829	308850	6243074	5.4	3.6	Quaternary alluvium
GW017321	309953	6242582	5.4	0.9	Quaternary alluvium
GW017324	309878	6242457	9.1	2.1	Quaternary alluvium
GW028330	309728	6243564	6.4	1.8	Quaternary alluvium
GW101280	306840	6245172	6	1.34	Quaternary alluvium
GW101281	306840	6245171	3.5	1.3	Quaternary alluvium
GW101282	306840	6245171	4	1.1	Quaternary alluvium
GW101283	306840	6245171	4.6	1.4	Quaternary alluvium
GW102015	303949	6243093	9	3	Ashfield Shale
GW102053	310024	6242811	12	2.4	Quaternary alluvium
GW102641	308873	6243885	16.5	5.1	Tertiary alluvium
GW107018	311237	6240818	150	5.5	Hawkesbury Sandstone
GW108346	306023	6238008	210.3	35	Hawkesbury Sandstone

Notes: mBGL = metres below ground level

On a regional scale, groundwater flow in the alluvium is generally towards the north-north-east, following the flow direction of the Georges River. However, local groundwater levels in the alluvium are very shallow, with groundwater flowing west to north-west towards the Georges River (GHD 2004).

Existing groundwater quality

Table 16.5 presents information on current licensed bores registered with NOW in the area surrounding the Project site. These results show that salinity in the alluvium is generally low, but is generally higher in the Ashfield Shale (brackish). Groundwater within the shales typically exceeds 3,000 milligrams per litre (mg/L) total dissolved solids (TDS), while in the Hawkesbury Sandstone, water quality is typically below 500 mg/L TDS (SCA 2007). The measured salinities for the Hawkesbury Sandstone are also high, and are likely to be influenced by the overlying Ashfield Shale.

Table 16.5 Summary of groundwater salinity in NOW bores (2010)

Bore No.	Easting	Northing	Salinity	Screened aquifer
GW017321	309953	6242582	Good (500–1000 µS/cm)	Quaternary alluvium
GW017325	309878	6242457	Good (500–1000 µS/cm)	Quaternary alluvium
GW017343	310382	6245518	3001–7000 µS/cm	Ashfield Shale
GW102015	303949	6243093	Brackish (3001–7000 µS/cm)	Ashfield Shale
GW102641	308873	6243885	420 µS/cm	Tertiary alluvium
GW107018	311237	6240818	3800 µS/cm	Hawkesbury Sandstone
GW108346	306023	6238008	7000 µS/cm	Hawkesbury Sandstone

Note: µS/cm = micro Siemens per cm

Previous groundwater investigations for the study area indicate that groundwater pH in the alluvial deposits ranges between 4.3 and 8.0 (HLA Environsciences 2003), while electrical conductivity (EC) ranges between 31 (µS/cm and 24,500 µS/cm. Groundwater investigations conducted by GHD in 2004 indicate that groundwater pH within the Project site is acidic, ranging between 4.76 and 5.83.

Water quality measurements from monitoring wells installed in the Ashfield Shale and the Hawkesbury Sandstone indicated both fresh and salty water quality (up to18,500 µS/cm). The higher salinity in the sandstone is probably due to leakage of saline groundwater from the overlying shales (HLA Envirosciences 2003).

Previous investigations of the Project site (HLA Envirosciences 2003) identified elevated levels of total petroleum hydrocarbons (TPH), chromium, copper, nickel, zinc and lead concentrations in groundwater sampled across the site.

16.3 Impact assessment

This section summarises the potential surface water hydrology and water quality impacts of the Project associated with the proposed Early Works, and the worst case construction and operational scenarios. Where possible, individual impacts relating to a specific concept layout (northern, central or southern rail access option) have been identified; however, many of the impacts would be applicable for all three indicative layouts. Potential groundwater impacts are also summarised where relevant.

16.3.1 Project works with potential for surface water impacts

The following Project works have the potential to influence local surface water hydrology and/or water quality.

Early Works

As part of the Early Works, a dedicated conservation area would be established between the Georges River and the 1% AEP flood level. The only development proposed in this area is the rail access connection, the Georges River bridge crossing (see below) and stormwater drainage channels (which are part of the Phase A and C developments – see Chapter 8 – *Project development phasing and construction*). The establishment of this conservation area would minimise the potential risk of flooding of the Project, and would also minimise the impact of regional flooding on the Project.

Rail access connection and Georges River bridge crossing

As described in Chapter 7 – *Project built form and operations*, the Project requires development of a northbound and a southbound rail access connection across the Georges River floodplain (to be delivered during Phase A and Phase C respectively), and a crossing over the Georges River to connect the IMT to the Southern Sydney Freight Line (SSFL). The location of these rail access connections and bridges differs depending on the rail access option being considered. The designs of these bridges are described in section 7.5 of Chapter 7.

The bridges would have multiple piers located within the Georges River and the Georges River floodplain. None of the rail bridges would orientate perpendicular to the river, instead crossing the main channel and floodplain at an oblique angle to the main flow direction. The piers would, however, be designed so that they were orientated in the direction of flow as far as possible to minimise afflux (i.e. increase in flood levels) impacts.

Generally the bridge piers would be 1.8 m in diameter. In the floodplain, these piers would extend below ground to their founding depth. Piers located within the river channel would terminate above normal water level, where they would be supported on a pile cap and a raft of piles. The bridge deck soffit would be set 500 millimetres (mm) above the predicted 1% AEP flood level, although headstocks would be partially submerged during this event.

General infrastructure and stormwater drainage

The Project requires construction of warehouses, administration buildings, hardstand areas, roads, parking areas, rail infrastructure, and container transfer and storage areas. With the exception of the conservation area, the majority of the Project site is likely to be utilised for these facilities; therefore, the percentage of impervious surfaces would be greatly increased.

Stormwater quality and quantity would need to be managed to prevent proposed discharges having any impact on the downstream receiving environment, the Georges River and Anzac Creek. For each rail access option layout, a conceptual stormwater flow breakdown was developed to identify the minimum stormwater management infrastructure required. As all flows from the developed IMT site would discharge directly into the Georges River and Anzac Creek, there would be no stormwater pollution impacts on adjacent lands, and the impact assessment focused on the receiving waterways.

Figure 16.3 to Figure 16.5 present drainage strategies for each of the three rail access option site layouts. The key elements of the drainage strategy include:

- piped 10% AEP drainage capacity from all hardstand areas;
- piped 2% AEP drainage capacity from all rail corridors;
- 1% AEP overland flows across the IMT site;

- direct piped drainage from upstream catchments across the developed IMT site to the Georges River;
- direct piped drainage at the southern end of the IMT site to Anzac Creek;
- diversion of M5 Motorway surcharge to the developed IMT site drainage and detention system;
- diversion of runoff from the Moorebank Business Park through open channels or box culverts crossing the developed IMT site;
- provision of overland flow paths across the IMT site to detention basins that will discharge to Georges River;
- constructed biofiltration/wetlands along the east bank of Georges River to treat IMT site runoff prior to discharge to Georges River; and
- stormwater pollution prevention and treatment systems distributed across the IMT site.

The proposed Project site drainage system has been developed to contain stormwater runoff in an underground piped network for all events up to and including the 10% AEP design event. Runoff from larger events would surcharge the network and travel overland via the road network, dedicated open channels or via graded channels across the Project site. The proposed system would be designed to minimise disturbance to Project site operations as a result of a rainfall event or from a flood event within the Georges River. All outlets from the Project's stormwater system would be set above the 1% AEP design flood level in the Georges River.

Detention basins have been sized for each layout to detain stormwater runoff and reduce peak discharge flow rates to pre-development conditions (as required by LCC). Stormwater treatment measures would be included in the layout where possible, and may include the following or other approved equivalent measures:

- grassed swales;
- rain gardens;
- sedimentation basins (at detention basin inlets); and
- biofiltration basins and permanent ponds (at detention basin inlets).

The final stormwater treatment system would be determined during detailed design.

For the construction phase (primarily Phase A) of the Project it is proposed that temporary sedimentation basins be built in the locations of the permanent basins, then converted to permanent structures for the operational phase.

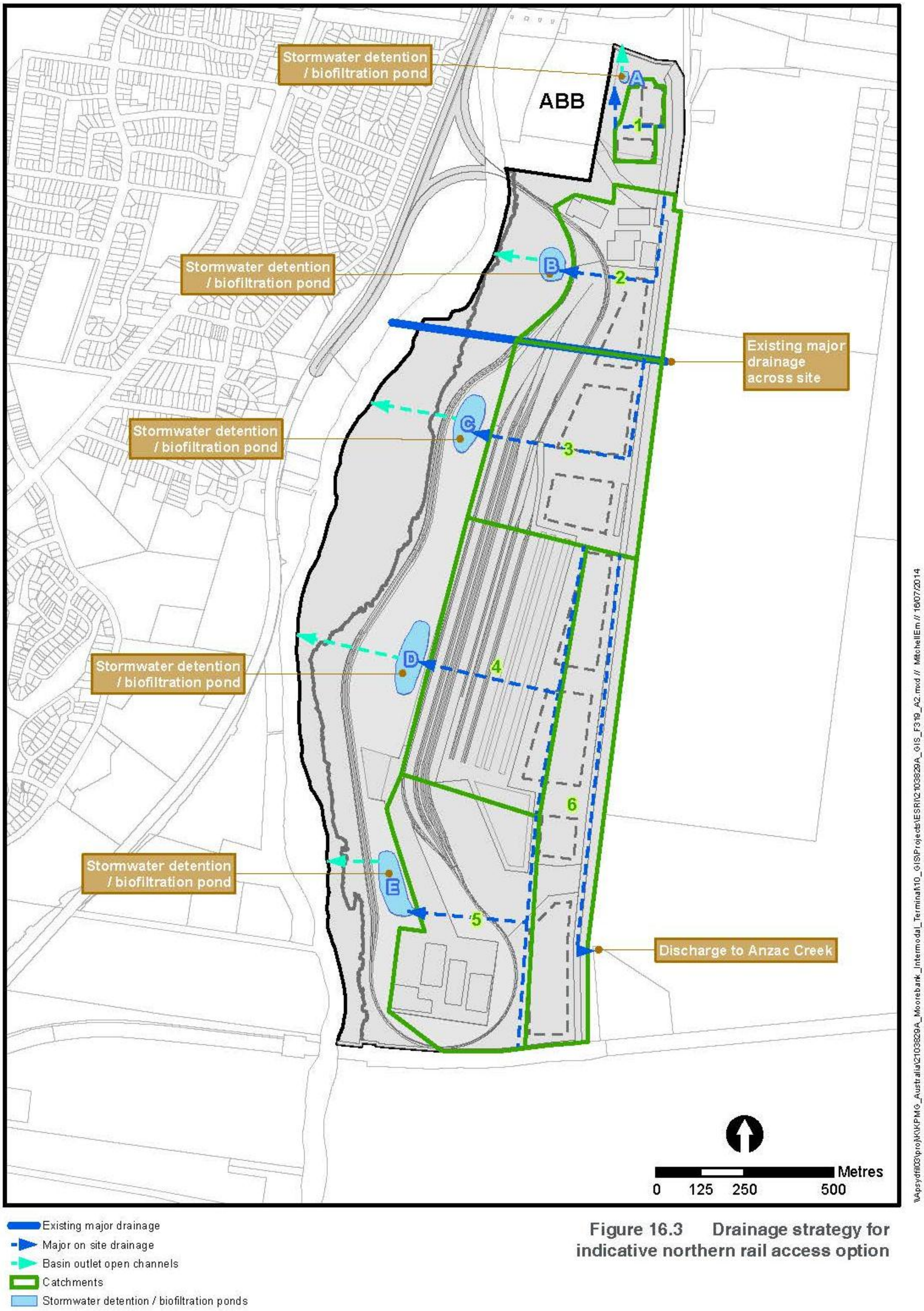

Figure 16.3 Drainage strategy for indicative northern rail access option

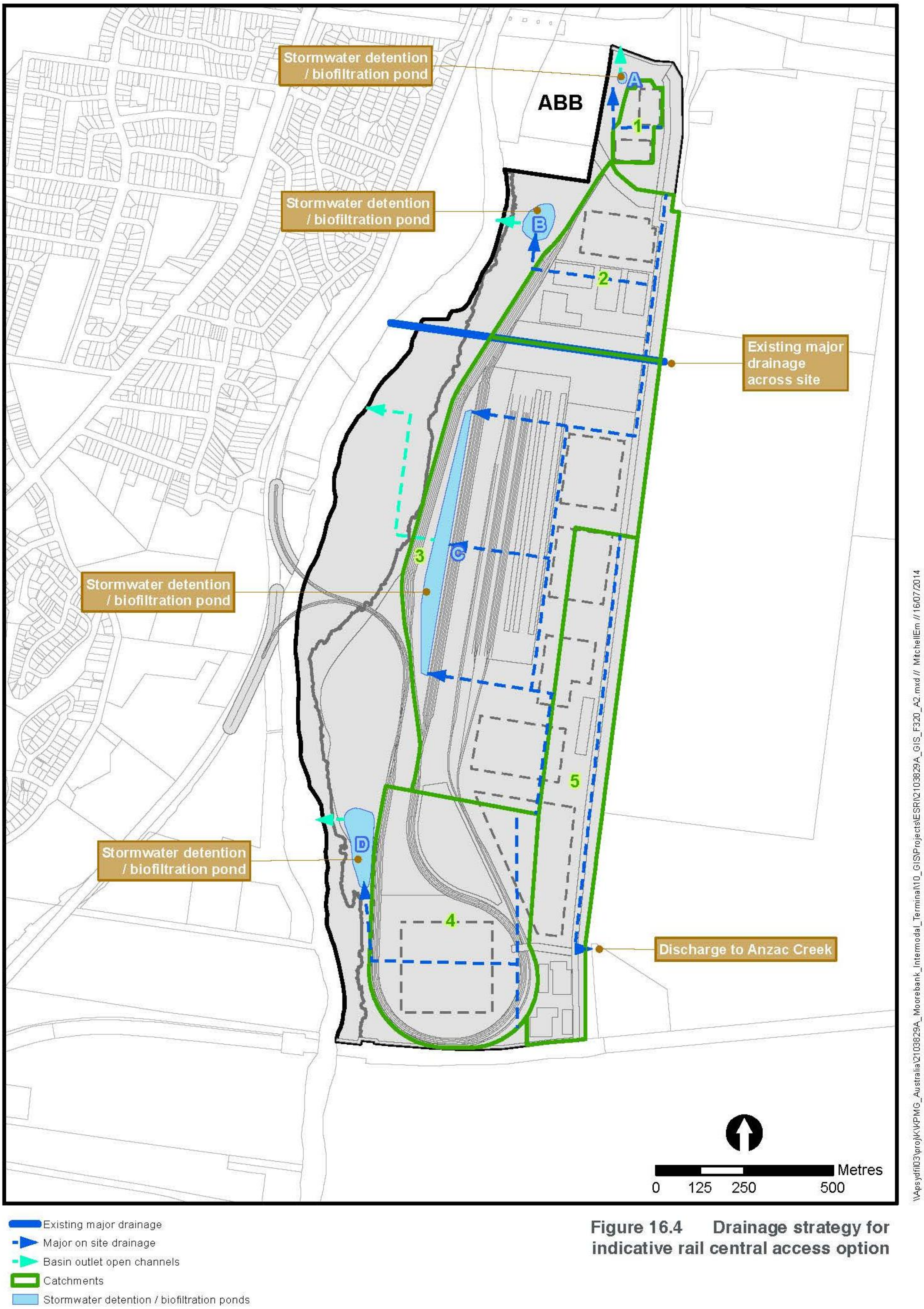

Figure 16.4 Drainage strategy for indicative rail central access option

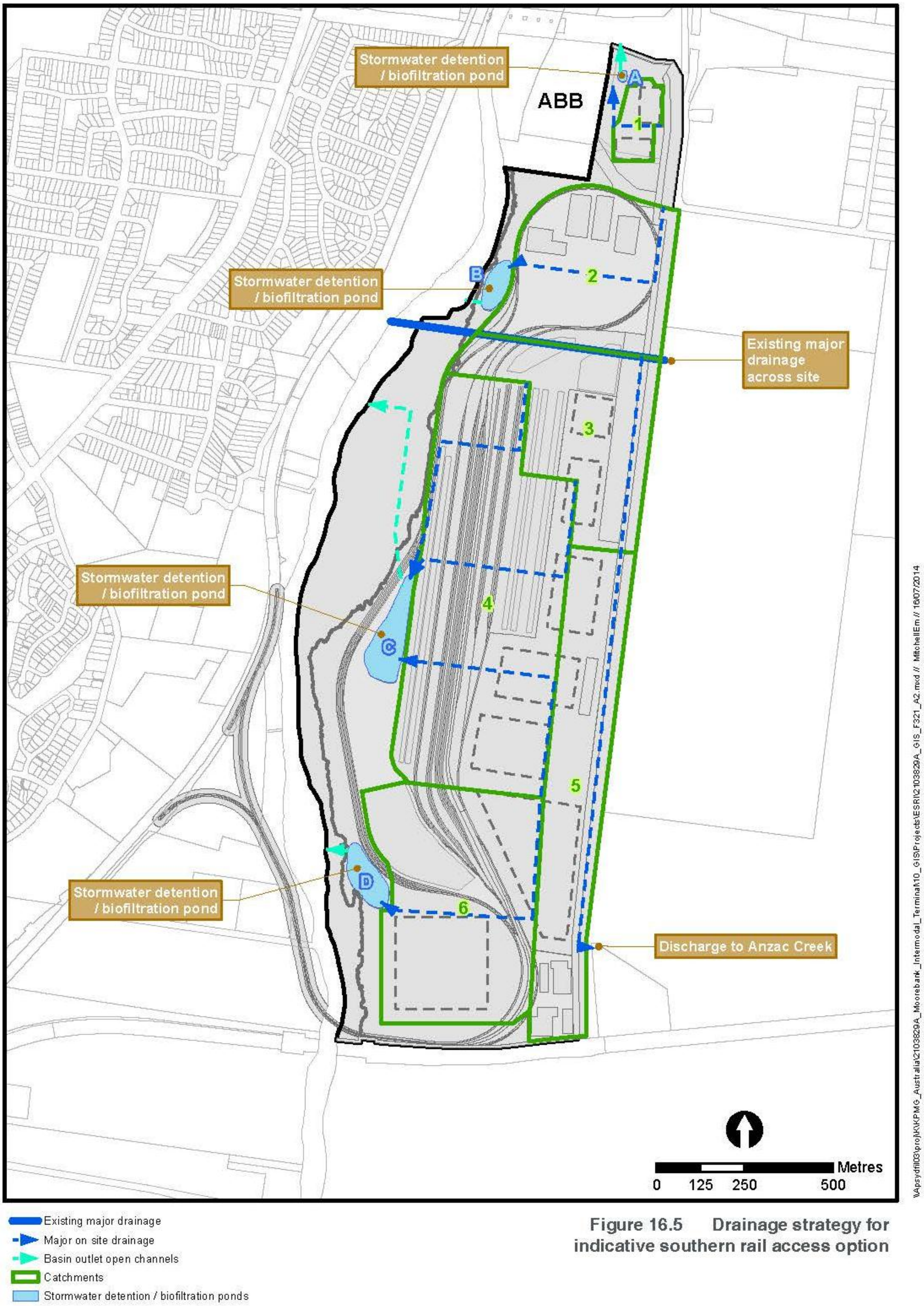

Figure 16.5 Drainage strategy for indicative southern rail access option

Regional flooding impacts

In developing the Project concept layouts, consideration was given to the existing regional flooding constraints and to the NSW Flood Prone Land policy as outlined in the *NSW Floodplain Development Manual* (DIPNR 2005). New infrastructure and changes to ground levels are only proposed in zones of low, or no, flood risk. The exceptions are the rail link to the SSFL and the Georges River bridge(s), which would cross medium and high risk flood zones. A conservation area would be established within these medium and high risk flood zones.

The development of the Georges River bridge crossings could have adverse impacts on flooding in the vicinity of the new structures and the upstream catchment. An hydraulic investigation was undertaken to assess the potential afflux generated by the construction and operation of the proposed rail crossings and associated piers within the Georges River and floodplain (refer to Appendix A in Technical Paper 6 – *Surface water assessment*). The findings are summarised below.

Early Works phase impacts

The potential impact of the Early Works on regional flooding is negligible; the only work to take place within the flood affected area at this stage is the establishment of the conservation area. As long as the materials and equipment for the conservation area are stored outside the flood zone, there would be no impact on regional flooding.

Construction phase impacts

Temporary works for the construction of the bridge piers and their foundations would likely involve temporary localised obstructions to flood flow within the main channel of the Georges River and its floodplain. If a large flood (greater than 5% AEP) occurred during construction, when these temporary works were present in the channel and/or floodplain, there would be a potential for local flood levels to increase upstream of the works. Occurrence of a large flood (greater than 5% AEP) during construction also has the potential to cause damage to the temporary works and result in the release of debris from the works, which could contribute to flood damage to land and property downstream. These impacts could be minimised through appropriate staging of the temporary works and the deployment of a flood emergency plan. This plan would detail the requirements for disassembly of the works, preparation for flood waters prior to large flood event peaks reaching the site, and recovery actions to minimise potential impacts and to enable works to resume as quickly as possible following the event (refer section 16.4 for details on proposed mitigation measures).

At this stage, construction techniques are yet to be defined. Therefore, the effects of various flood events on construction phase works and the appropriate mitigation would require further investigation during detailed design.

Construction within the main IMT site would have minimal or no impact on regional flooding, as these works are located outside the flood affected land.

Operation phase impacts

During the operation of the Project, the main potential impacts on regional flooding would be associated with the new rail access connection and Georges River crossing. The hydraulic modelling results are presented in Table 16.6 below for the northern, central and southern rail access options.

Table 16.6 1% AEP flood levels and afflux results for northern, central and southern rail access options

Model cross-section	MIKE11 chainage	Location	Existing flood levels (m AHD)	Developed case flood levels (m AHD)			Afflux (m)		
				N[1]	C[2]	S[3]	N[1]	C[2]	S[3]
38	100630	Upstream of Cambridge Avenue	12.74	12.79	12.85	12.75	0.05	0.11	0.01
32	101270	Upstream of East Hills Line rail bridge	11.98	12.06	12.13	12.01	0.08	0.15	0.03
24	102390	Just upstream of Glenfield Creek confluence	10.97	11.09	11.19	10.97	0.12	0.22	0
19	103555	Downstream of Glenfield Creek confluence	10.92	11.05	10.92	10.92	0.13	0	0
15	104095	Upstream of M5 road bridge	10.69	10.84	10.69	10.69	0.15	0	0
14	104185	Upstream of M5 road bridge	10.69	10.84	10.69	10.69	0.15	0	0
13	104355	Upstream of M5 road bridge	10.52	10.60	10.52	10.52	0.08	0	0
12	104535	Just upstream of M5 road bridge	10.42	10.42	10.42	10.42	0	0	0
7	105560	Downstream of M5 road bridge	9.75	9.75	9.75	9.75	0	0	0

Source: Tables 3.1 to 3.3, Technical Paper 6 – *Surface Water Assessment* (Volume 6)
Note 1: N = Northern rail access bridge option
Note 2: C = Central rail access bridges option
Note 3: S = Southern rail access bridge option

The modelling indicates that the maximum afflux for a 1% AEP event would occur immediately upstream of the proposed rail bridge for each option and would be limited to:

- 150 mm for the northern rail access option;
- 220 mm for the central rail access option; and
- 30 mm for the southern rail access option.

At the upstream extent of the Project site, the southern rail access option has the lowest predicted afflux, with an afflux of 20 mm noted at the upstream cross-section of the model. This compares to an afflux of 60 mm for the northern option and 90 mm for the central option. The model was built using cross-sections at varied spacing of no less than 100 m which limits the definition of the flowpaths and may not account for all storage available. Due to these limitations in the model, these estimated affluxes are likely to be larger (i.e. more conservative) than would actually occur and would need to be verified with more detailed modelling during detailed design.

The central and northern rail access bridge options would present new hydraulic restrictions across the Georges River floodplain. The central option would have the largest predicted impact at the upstream model extent. This predicted impact is of concern as it could result in a change to the flood level at the upstream extent of the model, which could in turn affect flood planning considerations.

In comparison, the bridge for the southern rail access option would be located adjacent to, and designed in a hydraulically similar manner to, the existing East Hills rail bridge. For this reason, it is predicted to have less impact on flood levels than the northern and central rail access bridge options. The southern rail access option would, however, traverse the western floodplain through the Glenfield Landfill via an embankment and/or a bridge/embankment formation. This would be expected to have an impact on flood levels in the landfill. The flood risk mapping (refer Figure 16.2) indicates that the landfill site is a high flood hazard area; however, the extent of the low hazard area is similar to that of the high hazard area, which indicates that any change to flood levels in the landfill would not change the flood extent, only the depth of flooding. There may also be some impacts on flood levels in the main river channel, as identified above; however, as the embankment would be aligned parallel to the Georges River, these impacts would be minor and would not be likely to extend beyond the Project boundary.

It would be critical to ensure that flood impacts do not negatively affect the residential properties located upstream of the Project site. The modelling indicates that none of the three bridge options considered would increase the flood risk to these properties during a 1% AEP event, as the properties are beyond the 1% AEP flood extent. The flood modelling results also show that the predicted increases in flood level would not translate to a significant increase in flood extent, as the flow would be confined within a relatively steep-sided valley. Furthermore, flow velocities in the river would generally be unaffected, with negligible increases predicted in the immediate vicinity of the proposed bridges. This means that for land upstream of Cambridge Avenue, there are no predicted changes to the floodplain risk management planning considerations outlined in the *Georges River Floodplain Management Study* (Bewsher 2004).

Cambridge Avenue crosses the Georges River to the south of the Project site on a low-lying bridge structure. As shown in Table 16.6, the predicated afflux upstream of Cambridge Avenue is 0.05 m under the northern rail access option, 0.11 m under the central rail access option and 0.01 m under the southern rail access option. While the bridge is low-lying and currently flood prone, the predicted change in afflux would not change the flood hazard and subsequent management of a flood event at Cambridge Avenue.

Given that flood velocities and extents (and therefore the extent of the flood risk zones of the river and floodplain) are not predicted to be significantly affected by the proposed southern and northern rail access option bridges, the impacts on regional flooding within the Georges River are considered acceptable for these options. However, further assessment, design considerations and mitigation would be required for the central option, as discussed further in section 16.4.

The significant increase in hardstand areas on the main IMT site is not expected to affect regional flooding, as the proposed stormwater management system (described in section 16.4) would capture the flows from the hardstand areas and detain them, so that the outflows from the site are reduced to existing flows. When the Georges River is in flood, the increase in flows from the main IMT site would be insignificant by comparison with flows in the Georges River.

Local stormwater catchment impacts are described separately below in section 16.3.3.

Potential impacts of climate change on regional flooding

NSW Government and LCC policies require that new developments are planned to cope with potential future climatic conditions. As a result of climate change, the frequency and intensity of extreme rainfall events in the Sydney area are predicted to increase (Rafter and Abbs 2009), resulting in an increase in the frequency and magnitude of flood events in the Georges River catchment.

The NSW Government's *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC 2007a) recommends assessment of 10%, 20% and 30% increases in rainfall depths when making allowance for climate change. For this assessment, however, the rainfall depth inputs to the hydrological model developed for LCC were not available so the middle level of an increase to flows by 20% was adopted.

A qualitative assessment was undertaken of:

- the predicted change in regional flooding impacts associated with development of the proposed rail bridges; and
- predicted change in flood risk associated with the developed Project site under a climate change scenario, based on the proposed northern, central and southern rail access options.

This assessment made the following conclusions:

- Increases in rainfall intensity would cause increases in the magnitude of flood events for a given design flood in the Georges River, but would not necessarily cause a direct equivalent increase in peak flow for a given event, as the flow response would depend on the catchment characteristics.
- Correspondingly, significant increases in flow would not necessarily cause significant increases in flood level or extent, as the flood level in a large connected river channel and floodplain system may be relatively insensitive to changes in flow.
- For the Georges River adjacent to the Project site, climate change would be expected to raise flood levels and extents to some degree, but the changes in flood levels are likely to be in the order of centimetres rather than metres for high order events such as the 1% AEP event.
- Under climate change scenarios, the afflux caused by the new rail bridge for the 1% AEP event is expected to be similar to that assessed without climate change. This is because the 500 mm clearance of the bridge soffit above the 1% AEP flood level, without the climate change allowance, should also accommodate the likely increase in the flood level under the climate change scenario.
- Due to the steep valley topography on the eastern floodplain, increases in flow due to climate change would not significantly affect the extent of the flood risk zones for most of the Project site. For the northern portion of the Project site, the low flood risk zone extends across the Project site, indicating that the valley topography is flatter at this location. In this area, the increased flow due to climate change is likely to result in an increase in the extent of the high and medium flood risk zones. However, as noted in section 16.3.1, this area would be a key part of the conservation area set aside for rehabilitated vegetated areas and would not contain critical Project infrastructure.

A quantitative impact assessment was completed for the northern rail access option, using the MIKE11 flood model, and assuming a 20% increase in flow from climate change. The northern option was selected for modelling because the afflux for this option was predicted to lie between the predicted affluxes for the southern and central options (refer Table 16.6). The results showed a maximum 0.19 m afflux in the vicinity of the bridges associated with the northern rail access option; this is 0.04 m greater than the predicted afflux under the 'no climate change' scenario. Further details are provided in Table 3.4 in Technical Paper 6 – *Surface water assessment*. This indicates that the impacts of the Project on regional flooding would not be significantly different under a conservative climate change scenario.

16.3.2 Local stormwater catchment flooding impacts

The Project would involve a considerable increase in impervious surfaces on the Project site. This section focuses on potential impacts on the local Project site catchments and on the Anzac Creek catchment with respect to stormwater quantity and flooding.

Early Works phase impacts

The Early Works would not be expected to have an impact on the local stormwater catchments as existing drainage would continue to be used during this phase. If required, temporary basins for onsite detention would be constructed to manage runoff in line with erosion and sediment control plans. This would ensure that any discharge to receiving watercourses (Georges River) would be maintained at pre-development levels.

Construction phase impacts

Stormwater runoff from the Project site during construction would increase with each construction phase, as the vegetation and topsoil are progressively cleared to construct the internal IMT and warehousing precincts, road network and other impervious areas. However, stormwater runoff from the construction phase would be less significant than that generated from the operational Project site, and construction management techniques would be applied to reduce peak stormwater flows and velocities. These mitigation measures are described in detail in section 16.4 and would employ temporary flowpaths and combined onsite detention and sedimentation ponds to manage local flows and flooding events. The nominated contractor would also be required to develop a flood emergency plan, involving the cessation of works (if required) and the prevention of site works and debris from entering flood waters. The contractor's flood emergency plan would also designate the types of flood event and warnings that would invoke the emergency flood plan. The determination of a 'significant flood' event would vary across the site depending on the location and stage of works being undertaken.

Operation phase impacts

The Stormwater Management Plan (included as Appendix B to Technical Paper 6 – *Surface water assessment*) includes an assessment of the increases in runoff rates from the developed Project site. Table 16.7 presents the peak flow estimates for the 1% AEP design storm event for the existing and fully operational concept layout options (the northern, central and southern rail access options). Details for the 2% and 10% AEP design storm events are included in Technical Paper 6 – *Surface water assessment*. The sub-catchment areas are shown in Figures 16.3 to 16.5.

Table 16.7 Existing and developed Project site rates of runoff for 1% AEP

Catchment	Runoff rate (m^3/s)			
	Existing	Developed northern rail access option	Developed central rail access option	Developed southern rail access option
1	0.36	1.43	1.43	1.43
2	1.55	6.20	6.20	6.20
3	2.29	9.15	9.15	9.15
4	2.70	10.81	10.81	10.81
5	2.51	10.03	10.03	10.03
6	1.99	7.96	N/A	7.96

m^3/s – cubic metres per second

Source: Section 3.3.2, Technical Paper 6 – *Surface water assessment* (Volume 6)

The results show that the rates of runoff from the developed Project site are significantly greater than those for the existing Project site, due to the large increase in impervious area. This increase results in a predicted >300 % increase in peak flows for each of the sub-catchments. Without mitigation or the implementation of an appropriate drainage strategy, this increase in runoff rate from the Project site would have the potential to increase flooding on the Project site itself and in the downstream receiving system of the Georges River.

Potential impacts of climate change on local stormwater catchment flooding

As explained in section 16.4, the relevant climate change scenarios to consider for impacts on site runoff involve increases in flow up to 30%. Such increases in rainfall intensity would produce similar increases in rates of runoff from the developed impervious areas of the Project site. Without mitigation, these increases in runoff from the Project site drainage catchments would increase the frequency of surcharging of the site drainage system and nuisance flooding of the Project site. This would result in localised ponding of stormwater in depressions and sag points of roads, surcharging of stormwater pits and overtopping of drainage channels and ponds/basins. Management measures to avoid this impact are described in section 16.4.

16.3.3 Surface water quality impacts

Early Works phase impacts

The Early Works would be expected to have a minor impact on surface water quality in the local stormwater catchments, as long as a comprehensive erosion and sediment control plan is developed for the Project site. The development of the conservation area within the flood risk zone could have an impact on downstream water quality if a flood were to occur during the establishment of vegetation – such an event could result in loss of topsoil and vegetation, which would pollute the downstream waterway (Georges River). However, this would be no worse an impact than under existing site conditions (as much of the area currently consists of a large exposed surface in the area of the 'dust bowl'). Measures to minimise and manage this impact are detailed in section 16.4.

Construction phase impacts

During construction, the key activities that have the potential to affect stormwater quality include the potential mobilisation and erosion of soils on the Project site due to land disturbance. Mobilised soils have the potential to increase sediment loads and sedimentation of receiving water bodies. Piling activities in the Georges River for the construction of the rail access bridges also have the potential to mobilise sediment on the river bed and expose potential acid sulfate soils. Accidental spills of chemicals and other hazardous construction materials, and uncontrolled discharge of contaminants to receiving waterways, could also have an adverse impact on water quality.

Vegetation removal, earthworks (cut and fill), dewatering excavations, piling, stockpiling of spoil and construction materials, construction of fill and embankments, and fuel and oil spills could all affect stormwater quality during construction. If uncontrolled or improperly managed, these activities have the potential to result in the following impacts:

- increased turbidity of waterways and drainage lines;
- increased nutrient loads to receiving waterways;
- changes to groundwater levels and systems;
- changed concentration of stormwater pollutants;
- changes to volume and velocities of surface water drainage; and
- sedimentation of creeks and drainage lines.

An increase in suspended sediment loads in surface water runoff would increase the turbidity of nearby waterways, potentially resulting in sedimentation smothering aquatic vegetation and habitat. Nutrients, heavy metals and pesticides typically occur in the particulate phase, which in turn can have an impact on the chemical processes that influence water quality.

In order to manage and mitigate potential impacts on water quality, appropriate erosion and sediment control measures would be implemented during the construction phase of the Project (see section 16.4 for further details).

Operational phase impacts

During the operational phase of the Project, land use changes, IMT site activities and operation of the rail access connection have the potential to affect water quality in the Georges River and Anzac Creek through surface water discharge. Key surface water impacts during the operational phase include a potential increase in stormwater pollutants and changes to discharge volume and velocities. Uncontrolled spills and leaks of fuels or oils associated with vehicle and rail transport, and the use and storage of chemicals and hazardous substances, have the potential to contaminate stormwater runoff. Accidental spills have the potential for substantial impact, depending on the volume of the spill and the nature of the substance.

MUSIC modelling was undertaken for the northern rail access option conceptual layout to determine the likely annual pollutant loading contribution of the Project through stormwater discharges. Since the layouts are conceptual, this is considered to be indicative of all three rail access option layouts. Estimated annual loads were compared between the pre-developed Project site and the developed Project site, with and without typical types of stormwater treatment. The results of this modelling are shown in Table 16.8 below.

Table 16.8 MUSIC modelling of stormwater pollutants

Stormwater variable	Pre-developed site	Developed site (pre-treatment	Developed site (post-treatment)	% Reduction from pre-developed site runoff
Total suspended solids (kg/yr)	161,000	370,000	90,500	44%
Hydrocarbons (kg/yr)	315	484	270	14%
Total phosphorus (kg/yr)	256	741	234	9%
Total nitrogen (kg/yr)	2,000	3,770	2,330	-17%

Source: Table 3.5 in Technical Paper 6 – *Surface Water Assessment* (Volume 6)

Notes: kg/yr = kilograms per year

Table 16.8 shows that the total suspended solids, hydrocarbons and total phosphorus annual loads are all estimated to decrease once the Project site is developed and operating, in comparison to the pre-developed Project site. This is due to the proposed introduction of stormwater treatment measures, which are currently non-existent. The one exception is a predicted increase in the TN annual load. However, as the annual volume of stormwater would also increase with the Project site development, the pollutant concentrations would be significantly less than predevelopment concentrations due to dilution; therefore no increases in existing stormwater pollutant concentrations in downstream waterways would be expected from the developed site for these common stormwater pollutants. In regard to TN:

- the *Healthy Rivers Commission inquiry report* (HRC 2001) noted that numeric WQOs for nutrients (including TN) should not, as a general rule, be used for regulatory purposes; and
- the naturally turbid Georges River would be able to sustain higher nutrient loads without the development of algal blooms (HRC 2001).

The proposed stormwater treatment measures are expected to effectively reduce the key water pollutants identified for the Project site. The ANZECC Guidelines, the Georges River Health Monitoring Program (GRCC 2011) and Parsons Brinckerhoff's ongoing water quality monitoring program would all be considered before finalisation of the proposed measures.

Preliminary calculations were undertaken to estimate the area of water quality treatment required to meet best management objectives. In NSW these objectives are generally accepted as a 90% removal of gross pollutants, an 80% removal of total suspended solids (TSS), a 55% removal of TN and a 40% removal of TP. Table 16.9 summarises the estimated treatment area requirement for each rail access connection option.

Table 16.9 Estimated treatment area requirements for layout options

Layout option	Catchment area (total)	Approx. treatment area requirement (sq. m)
Northern rail access option	1,120,000	2,800
Central rail access option	1,283,000	3,208
Southern rail access option	1,355,000	3,388

Source: Tables 3.6 to 3.8 in Technical Paper 6 – *Surface water assessment*

Stormwater treatment systems, designed in accordance with NSW best practice guidelines, would retain and reduce stormwater pollutants and improve the stormwater quality discharging from the Project site. Substantial reductions in pollutant concentrations can be obtained through the use of stormwater improvement devices. Proposed measures are described further in section 16.4.

Without stormwater treatment, the quality of the stormwater runoff discharged from the developed Project site into the Georges River would be considerably worse than under existing conditions and could lead to further degradation of the downstream water quality in the Georges River system. The implementation of stormwater treatment at the developed Project would reduce the annual stormwater pollutant loads that are currently discharging from site, and would improve the quality of the stormwater that is discharged from the site.

The expected improvement in the quality of stormwater discharging from the Project site means that the Project would comply with the objectives of the environmental values for waterways affected by urban development in the Georges River catchment, in that the water quality is expected to be 'maintained or improved' throughout the catchment.

16.3.4 Groundwater impacts

The design and development of the Project would be undertaken in a way that minimises impacts on local and regional groundwater. As with any significant infrastructure development, earthworks and geotechnical construction activities have the potential to interact with the groundwater system. Without careful management, the Project has the potential to cause the following groundwater impacts:

- mobilisation of contaminated groundwater, with potential impacts on the Georges River or other groundwater resources;
- contamination of groundwater bodies through interaction and infiltration of contaminated surface runoff caused by accidental spills and sedimentation;
- water table drawdown as a result of dewatering around subsurface infrastructure, potentially altering ground stability and affecting existing groundwater extraction bores;
- mobilisation of acidic groundwater associated with acidic soils (refer to Chapter 15 – *Contamination and soils*); and
- an increase in saline groundwater and ground surface salinity as a result of altered groundwater conditions.

The potential groundwater impacts listed above would be considered during the development of the detailed design and, in most cases, mitigated at the detailed design phase. Where potential impacts cannot be dealt with through design, suitable mitigation and management measures would be established to ensure that no significant groundwater impacts result directly from the construction and/or operation of the Project. Section 16.4.3 recommends a number of general mitigation measures and principles that would be implemented to manage potential groundwater impacts.

Licensing

Groundwater management and licensing on the Project site is currently managed under the NSW *Water Act 1912*; however, licences would need to transition across to the NSW *Water Management Act 2000* once the new water sharing plan is introduced.

NOW has advised that if significant dewatering is required to allow construction to proceed, a groundwater licence should be obtained. Groundwater dewatering is unlikely to be required for the Project.

16.4 Management and mitigation

This section outlines mitigation measures that are recommended to minimise and prevent adverse impacts on surface water hydrology, water quality and groundwater, both within the Project site and externally. A number of potential impacts have already been mitigated through the development of the Project concept layouts. Further details of the stormwater management measures are detailed in Appendix B – *Stormwater management plan*, attached to Technical Paper 6 – *Surface Water Assessment*, in Volume 6 of this EIS.

The mitigation measures detailed below would apply to all three of the rail access options assessed in this EIS, with the exception of the last operational measure listed in section 16.4.2 (which only applies to the central rail access option).

16.4.1 Early Works phase mitigation

The Early Works would mainly take place outside the flood affected areas, except for the development of the conservation area. The following measures would be implemented during the Early Works phase to minimise impacts on the Georges River, Anzac Creek, and local and regional water quality, and to minimise the impact of a flood event on the Early Works program:

- A soil and water management plan would be developed before work begins in the conservation area. This plan would include erosion and sediment control plans (ESCPs) and procedures to manage and minimise potential environmental impacts associated with developing this area.

- Site compounds, stockpiling areas and storage areas for sensitive plant, equipment and hazardous materials would be located above an appropriate design flood level, to be determined based on the duration of the construction works.

- A flood emergency response and evacuation plan would be implemented for the conservation area works, to allow work sites to be safely evacuated and secured in advance of any flooding on the site. This plan would also include recovery actions to be implemented following a flood to allow the site works to resume as quickly as possible.

16.4.2 Regional flooding mitigation measures

As discussed above, the only element of the Project that has the potential to affect regional flooding is the construction and operation of the rail access connection and bridge crossing of the Georges River. The proposed regional flooding mitigation measures are therefore focused on this aspect of the Project.

Construction phase mitigation

The following measures would be implemented to minimise adverse flooding impacts on the Georges River system during construction of the rail access connection and Georges River rail bridge crossing:

- Locate site compounds, stockpiling areas and storage areas for sensitive plant, equipment and hazardous materials above an appropriate design flood level, to be determined based on the duration of the construction works.
- Implement a flood emergency response and evacuation plan that allows work sites to be safely evacuated and secured in advance of flooding occurring at the Project site.
- Implement a staged construction process for the building of the Georges River bridges that minimises temporary obstruction of flow in the main channel and floodplain.
- For the building of the Georges River bridges, design temporary works to resist forces and pressures that could occur during the design flood event adopted for the Project construction.
- For all site works, provide temporary diversion channels around temporary work obstructions to allow low and normal flows to safely bypass the work areas.

The potential effects of various flood events on construction phase works would be further investigated during detailed design and preparation of the Stage 2 development approvals.

Operation phase mitigation

During detailed design, the following measures, design considerations and investigations would be undertaken to minimise the impact of the bridge crossings on the existing flood risk in the Georges River channel and floodplain:

- The design of the bridges would ensure structural stability under an appropriate upper limiting flood event, typically the 2000 year ARI event or other event of similar magnitude.
- A detailed scour assessment of the structures would be undertaken and a scour protection scheme for the bridge abutments and piers designed to ensure structural stability and avoid erosion of the channel and floodplain bed local to the structures.
- Further design optimisation of the bridges would consider reducing the afflux impacts as far as possible. The bridge piers should be designed to minimise obstruction to flow and associated afflux under potential blockage and/or debris build-up scenarios.
- Further hydraulic modelling would be undertaken to quantify the impact of climate change on afflux caused by the bridges and on hydraulic loading on the bridge structures.
- For the central rail access option bridges, further design of the structures and their alignment and/or consideration of compensatory measures would be undertaken during detailed design to reduce the impact of this option.

16.4.3 Onsite stormwater management and surface water quality measures

Construction phase mitigation

A soil and water management plan would be developed before land disturbance occurred. The plan would include ESCP(s) and procedures to manage and minimise potential environmental impacts associated with construction of the Project.

A key feature of the onsite stormwater management measures during construction would be the installation of site-wide temporary erosion and sediment controls. The design and performance criteria for these measures would be detailed within the ESCP(s) for the site. The ESCP(s) would be designed in accordance with best management practices and the relevant stormwater management publications including:

- *Managing Urban Stormwater: Soils and Construction* ('the Blue Book'), Volume 1 (Landcom 2004);
- *Managing Urban Stormwater: Soils and Construction – Installation of Services*, Volume 2A (OEH 2008); and
- *Managing Urban Stormwater: Soils and Construction – Main Road Construction*, Volume 2D (OEH 2008).

Biofiltration and detention basins that form part of the proposed stormwater management strategy would be excavated at the outset of Phase A, with the intention that the excavated basins would be used as temporary construction phase sedimentation basins. Once construction phases become operational, these temporary construction phase sedimentation basins would be progressively converted to the permanent biofiltration and detention basins.

During Phase A, all major stormwater pipes and culverts (600 mm diameter and larger) and main channels and outlets would be installed. Minor drainage and upstream systems would then be progressively connected to the major drainage elements during each phase of construction as required.

The following management and mitigation measures would be implemented during construction to minimise soil and water impacts:

- The ESCP(s) would be prepared in accordance with Volume 1 of *Managing Urban Stormwater: Soils and Construction* (Landcom 2004). The ESCP(s) would be established before the start of each construction stage and would be updated as relevant to the changing construction activities.
- Clean runoff from upstream undisturbed areas would be diverted around the Project site to minimise overland flow through the disturbed areas.
- Stabilised surfaces would be reinstated as quickly as practicable after construction.
- All stockpiled materials would be stored in bunded areas and away from waterways to avoid sediment-laden runoff entering the waterways.
- Sediment would be prevented from moving off-site and sediment-laden water prevented from entering any watercourse, drainage line or drainage inlet.
- Erosion and sediment control measures would be regularly inspected (particularly following rainfall events) to monitor their effectiveness and stability.
- Erosion and sediment control measures would be left in place until the works are complete or areas are stabilised.

- Temporary erosion control and energy dissipation measures would be installed to protect receiving environments from erosion.
- Vehicle movements would be managed during rainfall (or while the ground remains sodden) to minimise disturbance to the topsoil.

The following measures would be implemented to control the risk and impact of potential spills and leakages of fuels and hazardous materials:

- Procedures to maintain acceptable water quality and to manage chemicals and hazardous materials (including spill management procedures, use of spill kits and procedures for refuelling and maintaining construction vehicles/equipment) would be implemented during construction.
- Vehicles and machinery would be properly maintained to minimise the risk of fuel/oil leaks.
- Routine inspections of all construction vehicles and equipment would be undertaken for evidence of fuel/oil leaks.
- All fuels, chemicals and hazardous liquids would be stored within an impervious bunded area in accordance with Australian Standards and Environmental Protection Authority guidelines.
- Emergency spill kits would be kept on site at all times. All staff would be made aware of the location of the spill kits and trained in their use.
- Construction plant, vehicles and equipment would be refuelled offsite, or in designated re-fuelling areas located at least 50 m from drainage lines or waterways.
- If landfill cells at the Glenfield Landfill are to be affected, then site-specific erosion and sediment control measures would be developed and implemented to ensure pollutants do not enter the Georges River.

Operation phase mitigation

Stormwater management plan

The Stormwater Management Plan and drainage strategy included in Appendix B to Technical Paper 6 – *Surface Water Assessment* (Volume 6) has been developed to meet all relevant LCC, Sydney Trains and Australian Rail Track Corporation Limited (ARTC) design specifications. This includes the requirement to control the rate of stormwater runoff from the developed Project site so that it does not exceed the pre-developed rate of runoff.

Based on these design specifications, no adverse impacts on peak flow rates and flow volumes for runoff from the developed Project site are anticipated. Key features of the Project's surface water management design that would be further developed in the detailed design include the following:

- The stormwater system would be designed such that flow from low order events (up to and including the 10% AEP event from the main part of the site, and up to and including the 2% AEP event for the rail access connection corridor) would be conveyed within the formal drainage systems. Flows from rarer events (up to the 1% AEP event) would be conveyed in controlled overland flow paths.
- The proposed onsite detention system would detain flow and control discharge rates to the Georges River at pre-development discharge rates.

- A stormwater treatment system would be implemented, incorporating sedimentation and bio-filtration basins upstream of the stormwater detention basins.

- Use of onsite infiltration would be incorporated into the design through the distribution of swale drains and rain gardens across the Project site.

Additional mitigation

Opportunities for further stormwater management would be considered during development of the detailed design, in accordance with LCC's *Development Control Plan Part 2.4 Development in Moorebank Defence Lands* (LCC 2008b), including:

- polishing water from onsite runoff by directing runoff into onsite dry creek gravel beds with macrophyte plants;

- using drainage swales adjacent to entry roads, instead of kerbs, to slow down stormwater runoff and increase onsite infiltration;

- collecting roof rainwater for reuse onsite;

- installing gross pollutant traps (GPTs) at the outlets of the pipe system before discharge into the sedimentation basins; and

- incorporating impervious surfaces and vegetated areas into the design to increase sub-surface water flow during rain events and reduce the discharge of stormwater pollutants.

As the Project site would contain a number of land uses, specific stormwater treatment systems may be required as pre-treatment to protect the integrity of the downstream sedimentation and biofiltration basins. Best practice pre-treatment systems would need to address potential contaminants associated with each land use during detailed design. In addition to this, rain gardens and swales would be incorporated where area permits. In particular, specific treatment measures may be required on the Glenfield Landfill site if landfill cells are to be affected.

Measures to cater for additional runoff from the potential development of the SIMTA site are described in Chapter 27 – *Cumulative impacts*.

16.4.4 Groundwater mitigation and further investigation

As the Project is currently at the concept layout stage, a number of general groundwater mitigation measures and principles have been proposed. These measures and principles would be developed further and confirmed through the development of the detailed design and subsequent site specific impact assessment.

Mitigation principles

The following mitigation principles would be incorporated through the establishment of the Project Construction Environmental Management Plan (CEMP), Operational Environmental Management Plan (OEMP) and relevant sub-plans as required:

- Concrete structures and other subsurface infrastructure would be constructed from sulfate resistant cement and materials in areas that may potentially interact with local groundwater.

- Where required, water access entitlements such as groundwater licences would be obtained for dewatering activities, in accordance with the requirements of NOW's proposed Aquifer Interference Policy.
- Groundwater quality would be tested to determine salinity levels and inform potential design measures, to ensure the design life of any infrastructure is achieved.
- Suitable groundwater monitoring would be established and undertaken prior to construction, during construction and over the operational life of the Project.
- To prevent the contamination of groundwater during Project construction and operation, suitable water treatment, water retention, water proofing and ground treatments would be investigated and implemented where required.
- Potential impacts on two existing groundwater bores in the vicinity of the proposal would be further investigated during detailed design. Mitigation measures to minimise these impacts would also be developed as required.

Further groundwater investigations

As part of the development of the detailed design and future development approval stages, additional impact assessment investigations would be undertaken to achieve a detailed understanding of the groundwater environment at the Project site. The following groundwater assessments would be carried out:

- an overall assessment of pre-construction groundwater quality and levels;
- characterisation of local and regional groundwater flow systems, including the groundwater contours and flow conditions;
- consideration of potential groundwater supply options, if required;
- assessment of impacts on groundwater levels and quality during construction and ongoing operation;
- confirmation of management and mitigation solutions for potential groundwater impacts; and
- assessment of the potential salinity impacts that may result from the Project.

In addition, a groundwater flow model would be developed to estimate contaminated groundwater runoff volumes, impacts from different mitigation options and construction dewatering impacts.

16.5 Summary of key findings

In summary, the key findings of the hydrology, groundwater and water quality assessment are as follows:

- The Project would cause a substantial increase in the area of impervious surfaces, with subsequent risks for hydrology (flooding) and water quality. A drainage strategy has been developed to manage this issue, including provision of overland flow paths across the Project site to detention basins and biofiltration systems/wetlands, from which treated water would be discharged to the Georges River through upgraded stormwater channels.

- There is potential for an increase in local flood levels upstream and/or release of debris, if a large flood occurred during construction of the Georges River bridge and rail access connection.
- The central and northern rail access bridge options would present new hydraulic restrictions across the Georges River floodplain. The central option has the greatest potential for an increase in flood levels upstream. However, preliminary flood modelling indicates that none of the three bridge options would increase the flood risk to upstream properties during a 1% AEP event, and no significant increase in flood extent is predicted. Flow velocities in the river are also unlikely to be affected.
- Climate change is an additional consideration that may exacerbate flooding risks.
- During construction, the key activities that have the potential to affect stormwater quality and downstream waterbodies include the potential mobilisation and erosion of soils on the Project site due to land disturbance. Piling activities in the Georges River for the construction of the rail access bridges also have the potential to mobilise sediment on the river bed and expose potential acid sulfate soils. Accidental spills of chemicals and other hazardous construction materials, and uncontrolled discharge of contaminants to receiving waterways, could also have an adverse impact on water quality unless carefully managed.
- Overall, the Project is expected to have water quality benefits for the Georges River, due to the proposed treatment of stormwater prior to discharge, which would lead to a reduction in the annual load of total suspended solids, hydrocarbons and total phosphorus discharged from the Project site. This is predicted to be consistent with the objectives of the ANZECC environmental values.
- The Project works have the potential to interact with groundwater and lead to impacts such as lowering of the water table and contamination of groundwater. Potential impacts would be further considered during the development of the detailed design.

Table 16.10 summarises the impacts of the Project at Full Build, without mitigation, for each rail access option.

Table 16.10 Summary of hydrology and water quality impacts at Full Build, without mitigation, for each rail access option

Impact	IMT layout and associated rail access connection option		
	Northern	Central	Southern
Operation of the IMT			
Potential for adverse impacts on downstream water quality (including accidental spills and an increase in stormwater pollutants)	•	•	•
Increase in impervious surfaces leading to potential for adverse impacts on regional flooding	•	•	•
Potential increase in local stormwater catchment flooding	•	•	•
Potential impacts on groundwater including lowering of the water table and contamination of groundwater	•	•	•
Operation of the rail access connection			
New hydraulic restrictions across the Georges River floodplain	•	•	-
Increase in flood risk to upstream properties during a 1% AEP	-	-	-

Key: • = impact, - = no impact

Key measures proposed to avoid, manage and/or mitigate hydrology, groundwater and water quality impacts of the Project include:

- implementation of a stormwater treatment system and drainage strategy, incorporating sedimentation and bio-filtration basins upstream of stormwater detention basins;
- use of onsite infiltration through the distribution of swale drains and rain gardens across the Project site;
- specific treatment measures on the Glenfield Landfill site if landfill cells are to be affected;
- development of an erosion and sediment control plan;
- appropriate storage, use and disposal processes (e.g. use of impervious, bunded storage facilities for fuels and hazardous materials);
- establishment of a conservation zone in the Georges River riparian corridor (eastern side of the river) to avoid substantial development in the floodplain; and
- design of Georges River bridge piers and bridge deck level to minimise flooding impacts.