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Cross River Rail

Environmental Impact Statement

Technical Report No. 5 – Surface water

July 2011

Cross River Rail

TECHNICAL REPORT NO.5

SURFACE WATER QUALITY

JULY 2011

Contents

Abbreviations

The following abbreviations have been used in this document:

ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BCC	Brisbane City Council
CRC	Cooperative Research Centre
Coastal Act	*Coastal Protection and Management Act 1995*
DERM	Department of Environment and Resource Management
EHMP	Ecosystem Health Monitoring Program
EP Act	*Environmental Protection Act 1994*
EPP (Water)	*Environmental Protection (Water) Policy 2009*
KBCN	Kedron Brook Catchment Network
NWQMS	*National Water Quality Management Strategy 2000*
OCCA	Oxley Creek Catchment Authority
QWQG	*Queensland Water Quality Guidelines 2009*
SEQHWP	South East Queensland Healthy Waterways Partnership
SEQRP	*South East Queensland Regional Plan 2009-2031*
SoE	State of the Environment
ToR	Terms of Reference
WQO	Water Quality Objective

1 Introduction

1.1 Terms of Reference

This report addresses section 3.5.2 of the Terms of Reference (ToR) for the Project, by describing the existing environment for surface water, as well as the potential impacts and mitigation measures for water quality that may be affected by the Project. This is in the context of environmental values as defined in local, state and/or national documents. Details and significance of the watercourses and surface waters that lie within and adjacent to the study area are provided. Strategies for protecting surface waters, achieving nominated quantitative standards and indicators and ways that the potential impacts may be monitored, audited and managed are also presented.

Hydrological impacts of the Project relating to drainage, water table, flooding and climate change are addressed in *Technical Report No 4 – Groundwater Assessment* (ToR section 3.5.1) and *Technical Report No 6 – Flood Study* Report (ToR section 3.5.3).

1.2 Methodology

This report was prepared by conducting a literature review of existing regulations, guidelines, strategies and management plans relevant to water quality in Brisbane's waterways. Site visits to waterways within the study corridor were undertaken to observe their condition (eg degree of channelisation, riparian vegetation, proximity to rail alignment) and to collect water samples for analysis of water quality prior to the commencement of construction.

Information on existing and historical water quality in terms of physical, chemical and biological characteristics (within the watercourses and surface waters potentially affected by the Project) was sourced from water quality monitoring programs such as the South East Queensland (SEQ) Healthy Waterway's Ecosystem Health Monitoring Program (EHMP) and Brisbane City Council's (BCC) Waterway Health Assessments. Environmental values and numerical water quality objectives were sourced from the *Environmental Protection (Water) Policy 2009* and the *Queensland Water Quality Guidelines 2009*. Local waterway catchment groups such as Oxley Creek Catchment Association and Kedron Brook Catchment Network were also utilised for additional information on the history and health of the watercourses.

1.3 Study area

The Project study corridor is the area specifically addressed by the Terms of Reference (ToR) and extends from Wooloowin in the north to Salisbury in the south (refer to **Figure 3-1**). The term 'study area' is also used in this report and refers to the study corridor and where investigations extend to surrounding parcels of land and/or waterways, which sit outside the study corridor.

2 Legislation, policies and support tools

Australia places most of the responsibility for natural resources management within the states and territories, for which regional and local government frameworks have been created (ANZECC & ARMCANZ, 2000). As outlined in the National Water Quality Management Strategy, water resources are best managed by utilising a three-tiered approach (ANZECC & ARMCANZ, 2000). This approach integrates national, state, regional and local powers and responsibilities, in conjunction with complementary planning and policy tools. Local level management strategies should be applied after all available technical information for a particular waterway has been collated. This includes identifying the environmental values that are to be protected, as well as the management goals, water quality guidelines and water quality objectives (ANZECC & ARMCANZ, 2000). Relevant legislation, policies, and support tools used to identify the key environmental values, management goals, guidelines and applicable water quality objectives for waterways in the study corridor and study area are listed below. These are further described in **Section 2.1** to **Section 2.3**.

National level

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC) 2000
- *National Water Quality Management Strategy (NWQMS) 2000*
- *Environmental Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

State level

- *Queensland Environmental Protection Act 1994 (EP Act)*
- *Queensland Environmental Protection (Water) Policy 2009 (EPP (Water))*
- *Queensland Water Act 2000*
- *Queensland Coastal Protection and Management Act 1995 (Coastal Act)*
- *Queensland Fisheries Act 1994*
- *Queensland Sustainable Planning Act 2009*
- *Queensland Water Quality Guidelines 2009 (QWQG)*
- *State Coastal Management Plan 2002* (the *Queensland Coastal Plan* has been finalised and is proposed to come into effect in 2011, replacing the *State Coastal Management Plan 2002*)
- *Draft Urban Stormwater – Queensland Best Practice Environmental Management Guidelines 2009*
- *EPA Best Practice Urban Stormwater Management – Erosion and Sediment Control Guidelines 2007*
- *Draft State Planning Policy for Healthy Waters 2009*
- *Queensland Acid Sulfate Soil Technical Manual – Legislation and Policy Guide 2004*
- *State Planning Policy 2/02 – Planning and Managing Development Involving Acid Sulfate Soils*
- *State Planning Policy 4/10 - Healthy Waters*
- *Queensland Urban Drainage Manual 2007*
- *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland 1998*
- *Water Resource (Moreton) Plan 2007*

Regional and Local

- *SEQ Regional Plan 2009-2031*
- *SEQ Regional Coastal Management Plan 2006*
- *SEQ Healthy Waterways Strategy 2007-2012*
- *Sediment Basin Design, Construction and Maintenance Guidelines 2001*
- *BCC Water Sensitive Urban Design Engineering Guidelines: Stormwater 2005.*

2.1 National level framework

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Water Quality Guidelines) 2000

The Australian and New Zealand Environment Conservation Council (ANZECC) developed the ANZECC Water Quality Guidelines as part of Australia's National Water Quality Management Strategy (NWQMS) in 2000. The ANZECC Water Quality Guidelines provide a set of tools for assessing and managing water quality. They contain an authoritative guide for setting water quality objectives required to sustain environmental values for water resources in Australia and New Zealand. Section 3 of the ANZECC Water Quality Guidelines cover aquatic ecosystems and specify the biological, water and sediment quality guidelines for protecting freshwater and marine aquatic ecosystems.

National Water Quality Management Strategy (NWQMS) 2000

The NWQMS provide a national approach to improving water quality in Australia's waterways and is part of the Government's strategic program *Water for the Future* (SEQPC, 2010). The NWQMS aims to achieve sustainable use of the nation's water resources by protecting and enhancing their quality and reducing pollutants, while maintaining economic and social development.

***Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act)**

The EPBC Act is Australia's key piece of environmental legislation for protecting the environment and heritage and conserving biodiversity. The EPBC Act enhances the protection and management of important natural and cultural places, including Australia's Ramsar wetlands. Chapter 2, Part 3, Subdivision B of the EPBC Act defines Wetlands of international importance, describes requirements for approval of activities and outlines offences relating to declared Ramsar wetlands. The Moreton Bay Ramsar Wetlands are recognised as a matter of national environmental significance under the EPBC Act. Consequently, any action that may have a significant impact on the ecological character of a Ramsar wetland must be referred to the Minister and undergo an environmental assessment and approval process. A referral for the Project was submitted to the Australian Government in April 2010. In July 2010, the Department determined that the Project is not a 'controlled action' pursuant to EPBC Act, stating that measures must be taken to avoid significant impacts on wetlands of international importance.

2.2 State level framework

***Queensland Environmental Protection Act 1994* (EP Act)**

The objective of the EP Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains ecologically sustainable development. The objective of the EP Act is achieved by establishing the state of the environment and its values, implementing strategies to protect the values from environmental harm, developing environmental indicators, monitoring impacts to the environment and evaluating the results of management strategies. Part 3 of the EP Act describes offences relating to environmental harm, including water contamination.

***Queensland Environmental Protection (Water) Policy 2009* (EPP (Water))**

The EPP (Water) is subordinate legislation under the EP Act, which aims to identify environmental values and management goals for all waterways in Queensland. This Policy commenced in 2009 and replaces the original policy released in 1997. It provides water quality guidelines and objectives required for protecting environmental values, provides a framework for making informed decisions and monitors and reports on the condition of Queensland waterways. Part 4 of the EPP (Water) describes management goals and water quality objectives. Schedule 1 defines the waterway basins and the water quality objectives required for protection of aquatic ecosystem environmental values within these basins.

***Queensland Water Act 2000* (Water Act)**

The Water Act provides for the sustainable management of water and other resources. It defines and describes watercourses and aims to advance sustainable management of water, including protection of the biological diversity and health of natural ecosystems. The Water Act aims to maintain or improve the quality of naturally occurring waters and to protect them from degradation. Part 7 of the Water Act covers catchment area land use. Part 8 details riverine protection and criteria and permit processes for excavating, filling or destroying vegetation in surface waters.

***Queensland Coastal Protection and Management Act 1995* (Coastal Act)**

The Coastal Act provides a comprehensive framework for the protection, conservation, rehabilitation and coordinated management of coastal resources and values, as well as tools for its implementation (eg the State Coastal Management Plan and regional management plans). It is designed to be used in conjunction with other legislation to enhance knowledge of coastal resources and the effect of human activities on the coastal zone.

Queensland Fisheries Act 1994

The Fisheries Act provides for the use, conservation and enhancement of the community's fisheries resources and fish habitat, by ensuring the principles of ecologically sustainable development are applied and promoted. Part 6 of the Fisheries Act provides information on the protection and conservation of fish habitats.

Queensland Sustainable Planning Act 2009

The Sustainable Planning Act 2009 replaced the Integrated Planning Act 1997. It is a framework that integrates planning and development assessment to manage development and the effects of development in an ecologically sustainable manner. The Act coordinates and integrates planning at local, regional and State levels and aims to ensure the process of development is accountable, effective and efficient and delivers sustainable outcomes.

Queensland Water Quality Guidelines 2009 (QWQG)

The QWQG provide water quality trigger values tailored to Queensland regions and water types, and also provides a framework that allows application of locally specific guidelines. The QWQG identify levels of ecosystem condition and focus on protecting aquatic ecosystems for the South-east, Central and Wet Tropic geographic regions of Queensland. Section 2 of the QWQG define levels of aquatic ecosystem condition and describe how water quality trigger values should be applied in order to protect these environments. Section 3 defines Queensland guideline values for physico-chemical water quality indicators, and Section 8 details the urban stormwater guidelines.

Queensland State Coastal Management Plan 2002

The State Coastal Management Plan (Queensland's Coastal Policy) is a statutory instrument that has effect under the Coastal Act, which outlines how the coastal zone is to be managed. The Coastal Plan must be appropriately considered in relevant decisions that may affect Queensland's coastal resources, which have ecological, economic and social values. The State Coastal Management Plan seeks to protect and manage Queensland's coastal resources, as identified by the State of the Environment report. Section 2.4 of the State Coastal Management Plan describes management responsibilities and outcomes relating to water quality, such as wastewater discharges and stormwater management.

Draft Urban Stormwater – Queensland Best Practice Environmental Management Guidelines 2009

The Draft Urban Stormwater Guidelines were created to assist urban developers, catchment managers and government decision-makers manage urban stormwater quality and quantity, in order to protect relevant environmental values and water quality objectives in Queensland's waterways. They provide design objectives, planning controls and several measures to help reduce stormwater pollution and manage stormwater quality during the planning, development design phase, construction phase and operational phase of development. The guide supports the EPP (Water), the State Coastal Plan and local government planning schemes.

EPA Best Practice Urban Stormwater Management – Erosion and Sediment Control Guidelines 2007

This guideline supports the State and Regional Coastal Management Plans for planning schemes and development assessments, specifically informing Policy 2.4.1 Water Quality, Policy 2.4.4 Stormwater Management (EPA, 2007). This guideline also informs on the implementation of water sensitive urban design principles to address erosion and sediment control from construction phases and operational phases of urban development.

Queensland Draft State Planning Policy for Healthy Waters 2009

The Draft State Planning Policy was prepared by the Department of Environment and Resource Management (DERM). It aims to ensure that development is planned, designed, constructed and operated to manage stormwater and waste water in ways that protect environmental values specified in the EPP (Water). This Draft Policy supports and complements existing legislation, such as the EP Act, the Water Act and the Coastal Act. It also complements the SEQ Regional Plan and provides for the adoption of water sensitive design for achieving water quality objectives as set out in the EPP (Water).

Queensland Acid Sulfate Soil Technical Manual – Legislation and Policy Guide 2004

This guide is a chapter of the Queensland Acid Sulfate Soil Technical Manual and provides a summary of Queensland and Commonwealth legislation, policies and requirements as they relate to Acid Sulfate Soils (ASS). It should be used in conjunction with other chapters of the Technical Manual, such as the *Soil Management Guidelines*.

State Planning Policy 2/02 – Planning and Managing Development Involving Acid Sulfate Soils

This policy sets out the State's interests concerning development involving ASS in low-lying coastal areas. It provides information and advice on the methods for investigation and management of ASS.

State Planning Policy 4/10 – Healthy Waters

The *State Planning Policy for Healthy Waters* was approved in October 2010 (SPP 4/10) and commenced on 2 May 2011. SPP 4/10 seeks to ensure development for urban purposes, including community infrastructure, is planned, designed, constructed and operated to manage stormwater and wastewater in ways to help protect the environmental values specified in the EPP (Water).

Queensland Urban Drainage Manual 2007

This manual provides information on stormwater quality treatment and the management of environmental impacts. It is designed to be used in conjunction with other recognised manuals that cover topics such as Water Sensitive Urban Design, Erosion and Sediment Control and Natural Channel Design.

Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland 1998

The purpose of these guidelines is to establish best practice for managing contaminated land through planning and development control processes and remains current in 2010 (DERM, 2010a). Roles and responsibilities for contaminated land management are described in section 4 of the Guidelines.

Water Resource (Moreton) Plan 2007

The Project would be located in the area covered by the *Water Resource (Moreton) Plan 2007* (WRP). The purpose of the plan is to provide a framework for sustainably managing water and identifying priorities and mechanisms for dealing with future water requirements. The plan also provides a framework for reversing, where practicable, degradation that has occurred in natural ecosystems. The WRP identifies a range of sustainable water management outcomes, environmental flow objectives and water allocation security objectives that should be achieved within the WRP area.

2.3 Regional and local framework

SEQ Regional Plan 2009-2031

The SEQ Regional Plan is the major statutory planning document for SEQ and supports the State Coastal Plan, by managing regional growth and change in the most sustainable way, to protect and enhance quality of life in South East Queensland. The SEQ Regional Plan was prepared in accordance with Sections 2.5A and 2.5C of the *Integrated Planning Act 1997* and remains in effect under the *Sustainable Planning Act 2009*. Section 11 of the SEQ Plan addresses water management, which includes managing water quality at all phases to preserve water quality for the community and the environment. Section 11.4 deals with protection and enhancement of ecological health, environmental values and water quality of surface and groundwater.

SEQ Regional Coastal Management Plan 2006

This plan follows the framework provided by the State Coastal Plan, supports the vision of the SEQ Regional Plan and provides specific regional direction for implementing coastal management in South East Queensland. It operates in conjunction with a range of statutory and non-statutory plans and policies developed by Commonwealth, State and local governments to help manage growth in SEQ in the most sustainable way. The Plan defines South East Queensland’s coastal resources, their location, values, pressures and water resource issues which were developed under the Water Act 2000.

The SEQ Healthy Waterways Strategy 2007-2012

The SEQ Healthy Waterways Strategy was prepared by the Partners of the SEQ Healthy Waterways Partnership. It forms a framework for maintaining the health of SEQ waterways and serves as the Moreton Bay Water Quality Improvement Plan (EHMP, 2008). This strategy implements water quality objectives for SEQ estuaries and some freshwater systems, provides specific issue-based action plans for reducing pollution from urban and non-urban point and diffuse sources, and aims to implement water sensitive urban design.

Sediment Basin Design, Construction and Maintenance Guidelines 2001

These guidelines provide advice on BCC's preferred method for the design, construction, operation and maintenance of sediment basins in order to minimise or prevent environmental harm to the city's waterways and associated ecosystems.

BCC Water Sensitive Urban Design Engineering Guidelines: Stormwater 2005

These guidelines provide stormwater management solutions for urban development that aim to protect waterway health by improving stormwater quality and reducing run-off, minimise effluent discharge, increase recycling opportunities and reduce water demand by providing alternative sources.

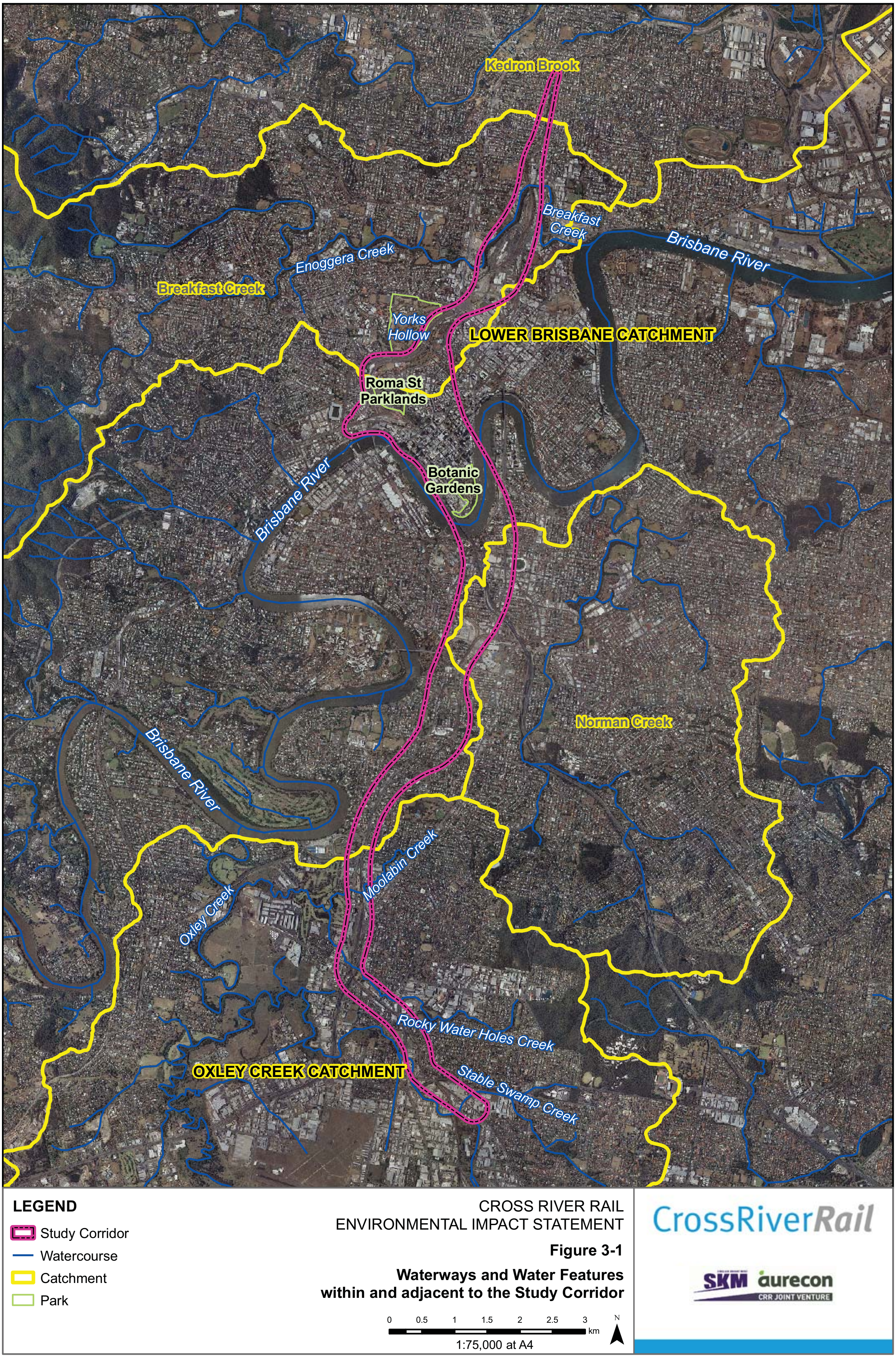
3 Existing environment

Brisbane's waterways feed directly into Moreton Bay, an important coastal resource that supports commercial fisheries, recreational fisheries and important ecological values, such as the Moreton Bay Ramsar wetlands (DEWHA, 2010). The Moreton Bay ecosystem was added to the List of Wetlands of International Importance in 1993, subsequent to the Ramsar convention. It is therefore recognised as representative, rare or unique, or important for conserving biological diversity and is protected under the EPBC Act 1999 (DEWHA, 2010).

The Project study corridor extends from the northern suburb of Wooloowin to the southern suburb of Salisbury in Brisbane (see **Figure 3-1**). Information on existing and historical surface water quality in the study corridor and surrounding areas is presented, in terms of physical, chemical and biological characteristics within the watercourses and surface waters potentially affected by the Project.

Streams on the north side of the Brisbane River drain in a west to east direction, and those on the south side of the river flow south-north (Boughton & Neller, 1981). The two major waterways within the study corridor are the Brisbane River and Enoggera/Breakfast Creek. Smaller estuaries and creeks in the study corridor are the Oxley Creek and its tributaries Moolabin Creek, Rocky Water Holes Creek and Stable Swamp Creek. Kedron Brook and Norman Creek are also included in this report, because their catchment boundaries extend inside the study corridor. Other surface water features in the study corridor include the City Botanic Gardens ornamental ponds, Roma Street Parklands freshwater lake and York's Hollow in Victoria Park, Herston. All waterways discussed in this report that fall within the study corridor are located within the Lower Brisbane Catchment and the Oxley Catchment (see **Figure 3-2** and **Figure 3-3**). Bundamba Creek, which runs through the Bremer Catchment (see **Figure 3-4** and **Figure 3-5**), is outside the study corridor but has also been included in this report based on the assumption that spoil placement will occur at Swanbank, near Ipswich. Reaches of all these waterways currently receive road and stormwater runoff and eventually flow into Moreton Bay.

Section 3.1 to **Section 3.4** provides an overview of the existing environment for each catchment in the study area, as well as the watercourses and surface waters that lie within them. **Section 4** defines and describes water quality objectives, environmental values and water quality monitoring programs for watercourses and surface waters potentially affected by the Project in the study area.



CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 3-1

Waterways and Water Features within and adjacent to the Study Corridor

CrossRiverRail

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3.1 Lower Brisbane Catchment

The Lower Brisbane Catchment (see **Figure 3-2**) covers a total area of 1,195 km² and the stream networks extend for 2,475 km (EHMP, 2010). This catchment is highly modified and heavily urbanised. Riparian vegetation from the majority of waterways in the Lower Brisbane Catchment has been cleared. A number of naturally vegetated areas and grazing lands occur in the upper regions (EHMP, 2010). Large volumes of stormwater enter the waterways during or subsequent to storm events, and freshwater streams within the Lower Brisbane Catchment are rated to be in poor condition by the Ecosystem Health Monitoring Program (EHMP), receiving a Report Card Rating of 'F' in 2009 (EHMP, 2010) (see **Table 4-2** and **Table 4-3**). Water quality and nutrient cycling has declined in comparison to previous years, with the catchment achieving higher ratings in both 2002 and 2005 ('D' and 'D-' rating, respectively) (**Table 4-2** and **Table 4-3**) (EHMP, 2010).

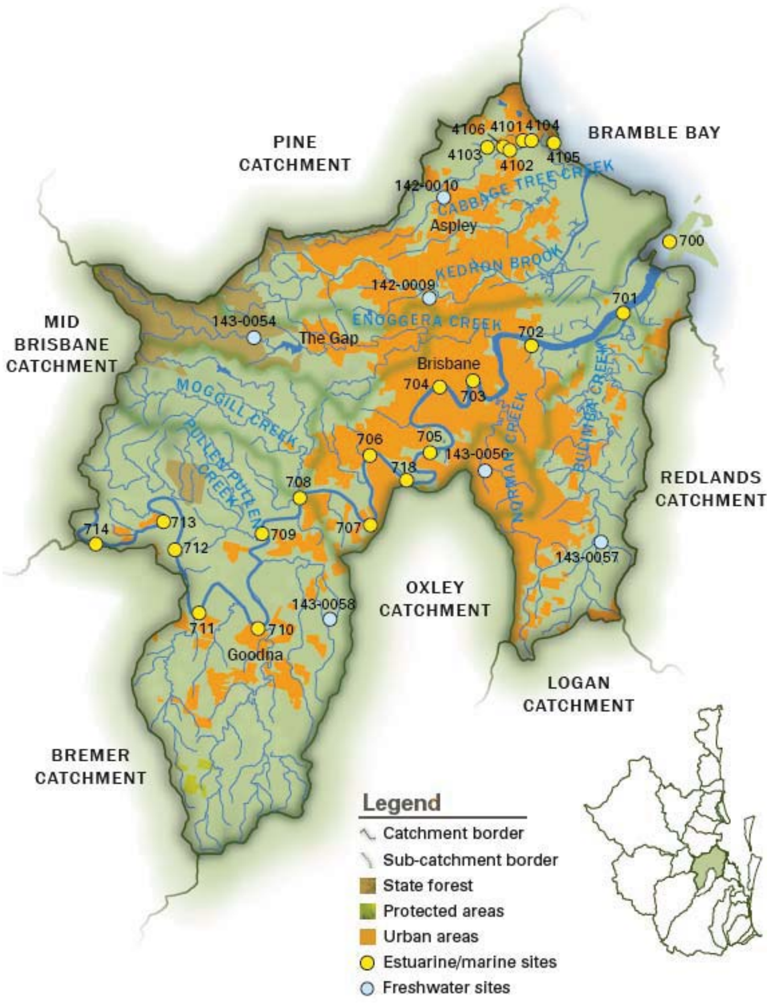


Figure 3-2 Lower Brisbane Catchment

Source: EHMP, 2010

3.1.1 Brisbane River

The Brisbane River is the largest river in the Lower Brisbane catchment (refer to **Figure 3-2**) that intercepts the study corridor and includes over 80 km of tidal reaches. The Brisbane River catchment area covers approximately 13,560 km² and contains 850 km of river and lake banks and 50 major creeks (CRC, 2004; DEH, 1993). Approximately 14% of the catchment remains uncleared, with land uses including grazing, agriculture and forest in the upper catchment (CRC, 2004). Lower parts of the catchment are heavily urbanised and form the Lower Brisbane River Catchment (EHMP, 2010). The Brisbane River hosts a range of commercial and recreational activities. **Table 4-1** outlines qualities determined to be of environmental value for the Brisbane River. Water quality monitoring conducted by the EHMP in 2009 found that the overall biological health of this estuary was lower in 2009 than results from previous years (a rating of ‘D’ compared with ‘D+’ in 2009 and 2007-08, respectively) (refer to **Table 4-2** and **Table 4-3**) (EHMP, 2010).

3.1.2 Breakfast and Enoggera Creek

The Breakfast/Enoggera Creek Catchment covers approximately 90 km² and the main waterway extends for almost 39 km eastwards, from Brisbane Forest Park to the Brisbane River within the Lower Brisbane Catchment (BCC, 2010a; BCC, 2004). Much of the catchment has been cleared for urban development and although extensive revegetation has occurred, bank instability is a problem that occurs across the catchment (BCC, 2004). The waterway’s upper, freshwater reaches are known as Enoggera Creek and its lower, tidal reaches are known as Breakfast Creek. The waterway becomes tidal from the weir at Bancroft Park near the Kelvin Grove Road crossing and flows into the Brisbane River at Newstead (BCC, 2010a; BCC, 2004).

Breakfast Creek intercepts the study corridor in the suburb of Windsor. The main channel of Breakfast Creek has been straightened widened and dredged to increase its drainage capacity, due to the creek’s history of flooding and drainage problems (BCC, 2004). Land use near the mouth of the river is dominated by industrial and commercial uses (BCC, 2004).

Enoggera creek’s upper reaches sit within Brisbane Forest Park and contain riparian vegetation that is much more diverse than in the downstream sections, which flow through urban areas (BCC, 2010a; BCC, 2004; Webb, 2000). Several remnant areas of bushland occur within Enoggera Creek catchment, including Banks Street Reserve, Enoggera Military Camp and privately owned bushland at The Gap (BCC, 2004).

Breakfast/Enoggera Creek is a public waterway and under the provisions of the *Native Title Act 1993*, relevant indigenous groups would be consulted prior to works commencing on or near the waterway (BCC, 2004). The Turrbal and Jinibara peoples have registered Native Title claims over the Breakfast/Enoggera Creek catchment (BCC, 2004). Members of the community organisation Save Our Waterways Now (SOWN) work towards restoring the habitats of north Brisbane’s waterways, including the Enoggera/Breakfast Creek (SOWN, 2008).

Aquatic health assessments across the Breakfast/Enoggera Creek catchment by BCC in 2003 rated the overall waterway health to be of ‘moderate’ quality (BCC, 2010a). The waterways of Enoggera/Breakfast Creek are of importance for several qualities identified and declared to be of environmental value in the EPP (Water), which are detailed in **Table 4-1** and **Table 4-4**. Further details on existing and historical water quality for Breakfast/Enoggera Creek are also provided in **Section 4** (refer to **Table 4-5** and **Table 4-6**).

3.1.3 Kedron Brook

Kedron Brook lies outside the study corridor, intercepting the North Coast Railway at Toombul. Whilst any potential impacts are thought to be negligible, Kedron Brook has been included in this report as the parts of the catchment of Kedron Brook lie inside the study corridor.

Kedron Brook flows in an easterly direction for around 25 km from the Cedar Creek confluence, through the northern suburbs of Brisbane and into Moreton Bay at Nudgee Beach (KBCN, 2010; BCC, 2010b). Upstream sections of the creek are ephemeral and contain healthy natural riparian vegetation. Further downstream in the suburban environments, Kedron Brook becomes channelized and contains sections of largely non-native riparian vegetation (KBCN, 2010). The downstream sections of Kedron Brook have been diverted several times since European settlement, to allow expansion of the Brisbane airport and for flood mitigation purposes (BCC, 2010b).

The quality of water in Kedron Brook is reported to be in fair condition by the Kedron Brook Catchment Network (KBCN, 2010). Water quality monitoring conducted by DERM in 1999-2000 found water quality to be good in the upper freshwater reaches, but poor quality further downstream where the creek becomes estuarine (refer to **Table 4-6**). Kedron Brook is declared to be an important waterway for aquatic ecosystems, recreation and cultural environmental values, as per the EPP (Water) (refer to **Table 4-1**).

3.1.4 Norman Creek

Norman Creek lies adjacent to the study corridor, on the eastern side of Brisbane and whilst any potential impacts are considered negligible, it has been included in this report because the catchment boundaries extend inside the study corridor. Norman Creek originates as Ekibin Creek and flows through the south-eastern suburbs of Mount Gravatt, Tarragindi, Annerley, Coorparoo and Woolloongabba in Brisbane (BCC, 2008). The Norman Creek catchment covers almost 30 km² and is heavily urbanised, with waterways that have been highly modified. Some areas of remnant vegetation exist within the catchment, including Toohey Forest, Wellers Hill, Mount Stevens and Tarragindi Recreation Reserve (BCC, 2008). The lower reaches of Norman Creek become tidal at Stones Corner and the waterway flows into the Brisbane River at East Brisbane (BCC, 2008).

Water quality monitoring in 1999-2000 found Norman Creek to be in poor condition at the lower reaches, where desirable levels of nutrients were exceeded, but almost all indicators complied with objectives in the freshwater sections (see **Table 4-6**) (BCC, 2008; Webb, 2000). Upper reaches of Norman Creek and its tributaries had higher dissolved oxygen and lower nutrient concentrations, compared with the estuarine reaches, which had high nutrients and low dissolved oxygen (BCC, 2008; Webb, 2000). Norman Creek is declared to be an important waterway for aquatic ecosystems, recreation and cultural environmental values, as per the EPP (Water) (see **Table 4-1**).

3.2 Oxley Catchment

Oxley catchment (see **Figure 3-3**) covers an area of 258 km² and lies on the south-western side of Brisbane (EHMP, 2009). The southern section of the catchment is steep and contains elevated regions with native forest and grazing land. Increased development pressure and expansion of rural residential and urban uses, however, has resulted in a loss of forests and farm land (OCCA, 2010; Marston, 2000). A substantial area of undisturbed vegetation remains intact within the Greenbank Military Training Area, in the mid section of the catchment (OCCA, 2010).

Freshwater streams in the Oxley catchment are rated to be in poor condition by the SEQ Healthy Waterways monitoring program and have generally failed to meet ecosystem health guidelines (EHMP, 2010). Water quality monitoring by the Ecosystem Health Monitoring Program (EHMP) in 2006-2009 found that the Oxley Creek catchment conditions did not meet set ecosystem health values, where waterways scored lower Report Card Grades than surveys in the previous year ('F' ratings in 2006-2009, compared with 'D-' in 2005, 'F' in 2003-04 and 'D' in 2002) (see **Table 4-2** and **Table 4-3**). The 2009 survey found that nutrient cycling had significantly declined in comparison to previous years. Physical and chemical indicators, however, had slightly improved, though the catchment was still given a Report Card Grade of 'F' (EHMP, 2010).

Figure 3-3 **Oxley Catchment**

Source: EHMP, 2010

3.2.1 Oxley Creek and Tributaries (Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek)

Oxley Creek is the major waterway in the Oxley Catchment (see **Figure 3-3**), which extends for around 70 km and flows into the Brisbane River at Tennyson (OCCA, 2010). Oxley Creek passes through grazing and forested sections of land in the upper-mid reaches. The lower sections are highly modified and include floodplains, the Oxley Creek Common, industrial estates and urbanised residential development (EHMP, 2010; OCCA, 2010).

The study corridor intercepts the Oxley Creek tributaries of Moolabin Creek, Rocky Water Holes Creek and Stable Swamp Creek in the suburbs of Yeerongpilly, Moorooka, Rocklea and Salisbury (refer to **Appendix A**, **Figure 8-1(a-h)**). These creeks pass through highly urbanised areas and industrial estates, receive urban stormwater runoff and have been significantly modified from their natural state.

In the past, water quality standards in Oxley Creek have been exceeded, with degradation attributed to sewage treatment discharge, sand extraction, land development and stormwater run-off (Boughton & Neller, 1981; OCCA, 1999). Water quality studies in 1999-2000 found that freshwater sites had moderate-good water quality, including the highly modified tributaries of Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek (refer to **Table 4-6**) (Webb, 2000). Assessment of water quality in 2008 and 2009 by the EHMP found that the estuarine reaches of Oxley creek was in poor condition (Report Card grades ‘F’ and ‘D’, respectively), with low dissolved oxygen and increases in turbidity and nutrients (refer to **Table 4-3**) (EHMP, 2010). Water quality results in 2008 were an improvement on previous years, although most parameters did not comply with the QWQG (EHMP, 2008). Improvements in stream health in Oxley Creek have been attributed to tidal flushing in the lower reaches of the estuary, and the elevated turbidity is thought to a result of runoff from extractive industries in the freshwater sections of the creek (EHMP, 2008). Existing and historical water quality data for Oxley Creek is presented in **Section 4**. Oxley Creek is declared to be an important waterway for aquatic ecosystems and recreational and cultural environmental values, as per the EPP (Water) (refer to **Table 4-1**).

3.3 Bremer Catchment

The Bremer Catchment (refer to **Figure 3-4**) lies outside the study corridor to the south west of the Lower Brisbane Catchment and covers a total area of 2,031 km², with stream networks extending for 4,425 km (EHMP, 2010). This catchment is included in this report based on the assumption that spoil placement will occur at Swanbank.

Land use in the Bremer Catchment is diverse and includes agriculture, mining and urban development (ICC, 2010). The Bremer River flows north-north-east for 82 km, originating in the Great Dividing Range before converging with the Brisbane River at Riverview, Ipswich (BCA, 2005; Telfer *et al*, 1998). The six major tributaries of the Bremer River are Reynolds Creek, Warrill Creek, Western Creek, Purga Creek, Deebing Creek and Bundamba Creek, for which each has its own sub-catchment (BCA, 2005). Freshwater streams in the Bremer Catchment are rated to be generally in poor condition by the Ecosystem Health Monitoring Program, receiving a Report Card Rating of ‘D+’ in 2009 (EHMP, 2010) (refer to **Table 4-2** and **Table 4-3**).

Figure 3-4 Bremer Catchment

Source: EHMP, 2010

3.3.1 Bundamba Creek Sub-catchment

The Bundamba Creek sub-catchment (refer to **Figure 3-4** and **Figure 3-5**) lies in the top north-east corner of the Bremer Catchment in the Ipswich Shire, covering an area of 117 km² (Telfer *et al*, 1998). This sub-catchment is included in this report based on the assumption that spoil placement will occur at Swanbank, within the Bundamba Creek sub-catchment.

Bundamba Creek is the major tributary in this sub-catchment, with a total major stream length of approximately 52.3 km (Telfer *et al*, 1998). The major land uses in this sub-catchment are grazing, urban residential, manufacturing, urban parks and rural residential (Telfer *et al*, 1998). The condition of Bundamba Creek sub-catchment is reported to be predominantly poor to very poor. This is due to extensive clearing of natural vegetation along the streams for cropping and grazing purposes. Erosion is also a widespread problem within the sub-catchment (Telfer *et al*, 1998). Bridge or culvert structures, as well as channelisation, have also been identified as contributing factors to poor stream health (Telfer *et al*, 1998).

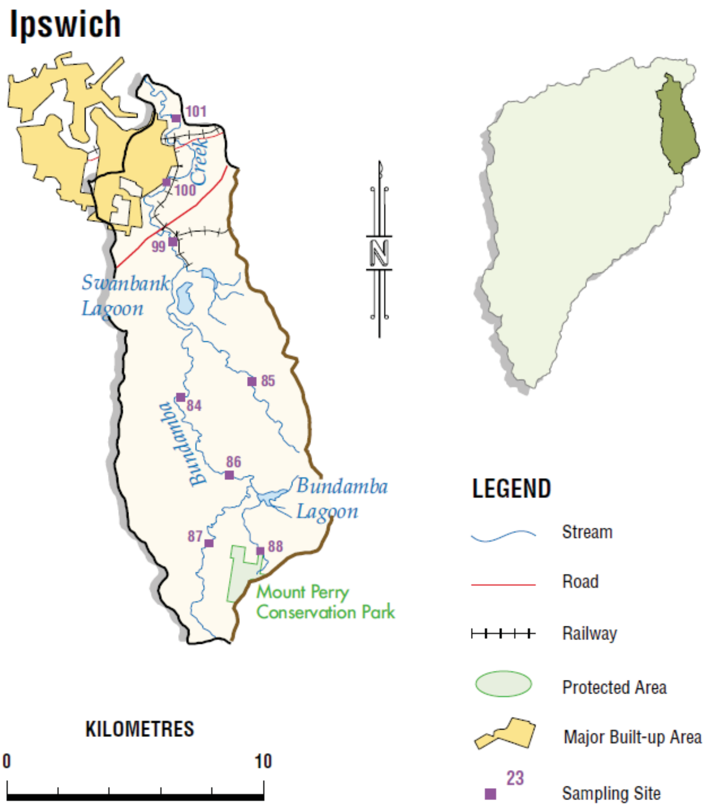


Figure 3-5 Bundamba Creek Subcatchment

Source: Telfer et al, 1998

3.3.2 Bundamba Creek

Bundamba Creek is located in the Bundamba Creek sub-catchment (Bremer River Catchment) (see **Figure 3-4** and **Figure 3-5**) and whilst it is outside the study corridor, the creek lies near the area of Swanbank, which is the proposed site for spoil placement. The total stream length is approximately 52.3 km (Telfer *et al*, 1998). The upper section of Bundamba Creek contains extractive industries and suffers from salinity problems, flooding, industrial discharges, vegetation clearance and degraded water quality (BCA, 2005; ICC, 2010). Significant wetlands are located on the upper reach of Bundamba Creek (known as Bundamba or Daly's Lagoon). The lower section of Bundamba Creek is largely urbanised and is also prone to salinity problems, flooding, poor water quality and lack of vegetation, as well as erosion and sediment problems (ICC, 2010). Bundamba Creek is declared to be an important waterway for aquatic ecosystems, irrigation, stock water, recreation, cultural environmental values and industrial use, as per the EPP (Water) (refer to **Table 4-1**).

3.4 Other water features

3.4.1 City Botanic Gardens

Brisbane's City Botanic Gardens is located adjacent to the Brisbane River and fall within the study corridor. These Gardens contain freshwater ornamental ponds which were created between 1958 and 1960 and the lower pond was originally part of the area's natural creek system (BCC, 2010c).

3.4.2 Roma Street Parklands

Roma Street Parklands is located on 16 hectares just 500 metres from Brisbane City, within the study corridor between Wickham Terrace and Parkland Boulevard, adjacent to the existing rail alignment near Roma Street train station (DPW, 2009). The Parkland contains a freshwater lake which has a surface area of over 6000 m^2, holds 11 million litres of water and contains small streams that are pumped to generate flow and maintain water quality (DPW, 2009). The lake precinct contains wetlands and its waters have been stocked with native freshwater fish including silver perch, mullet, Queensland lungfish, Pacific blue-eye, rainbowfish and gudgeon (DPW, 2009).

3.4.3 York's Hollow

York's Hollow is an artificial gully and pond system that runs through Victoria Park and the Exhibition Grounds in the northern suburb of Herston, adjacent to the Inner City Bypass and within the study corridor. Victoria Park contains 27 hectares of landscaped parkland, which is bordered by Bowen Bridge Road, Gregory Terrace and Breakfast Creek (DERM, 2009a). York's Hollow lies at the bottom of the ridge and contains an artificial lake development (refer to **Appendix A**, **Figure 8-1(i)** and **Figure 8-1(j)**), which was created as an ornamental feature of the park in the 1930s and subsequently in the early 2000's, to improve and draining and control flooding (DERM, 2009a). Stormwater overflow from these ponds drains underground and eventually flows into Breakfast Creek.

4 Water quality objectives, environmental values and water quality monitoring

This section describes the water quality objectives, environmental values and water quality monitoring programs for waterways in the study area that are described in **Section 3** of this report, under 'Existing Environment'.

4.1 Water quality objectives

Water Quality Objectives (WQOs) are long term goals for water quality management, in the form of numerical concentrations or descriptive statements of indicators established to support and protect the designated environmental values for a particular waterway (ANZECC & ARMCANZ, 2000). Protecting aquatic ecosystems from degradation is important for maintaining the benefits they provide.

Aquatic ecosystems comprise the organisms (eg animals, plants, algae); physical conditions (eg light, temperature, flow, habitat); and chemical components (eg carbon, oxygen, nutrients) that the fauna and flora interact with (ANZECC & ARMCANZ, 2000). The physical and chemical components of aquatic ecosystems have a large impact on their inhabitants, therefore these aspects are important for assessing and/or protecting aquatic ecosystems (ANZECC & ARMCANZ, 2000). The WQOs provide *guideline trigger values* for chemical and physical water quality indicators, as well as biological indicators (ANZECC & ARMCANZ, 2000). If exceeded, these values *trigger* the incorporation of further investigations to analyse the risks to the ecosystem and, if possible, undertake assessments on local or site-specific scales (ANZECC & ARMCANZ, 2000).

The ecosystem conditions for many of the waterways that fall within the study corridor are urban streams that receive road and stormwater runoff (DERM, 2010b, 2010c, 2010d, 2010e). If the definitions of aquatic ecosystem condition from the ANZECC Water Quality Guidelines are consulted, these waterways could be categorised as Level 3 ecosystems (highly disturbed). However, the QWQG acknowledges that assessing water quality for highly disturbed ecosystems in Australia is difficult due to lack of suitable data and recommends that guideline trigger values for slightly-to-moderately disturbed ecosystems be applied wherever possible (DERM, 2009b).

WQOs for waterways in the study corridor and surrounding study area are presented in **Table 4-1**, **Table 4-2**, **Table 4-3** and **Table 4-4**. The guideline trigger values presented are for Level 2 ecosystems (slightly-to-moderately disturbed) in Queensland and were sourced from local guidelines (DERM, 2009b) where possible. The QWQG recommends that these guideline values should be compared and assessed against any test sites. To comply with these WQOs, the median value of water quality data sets should lie within the concentration range, or below the maximum concentration. These WQOs should be referred to for planning/decision making under the EPP (Water) (DERM, 2009b). For WQOs in the study area, see:

- Table 4-1: Brisbane River and tributaries (other than Oxley Creek and Kedron Brook)
- Table 4-2: Oxley Creek and tributaries
- Table 4-3: Kedron Brook
- Table 4-4: Bundamba Creek

Table 4-1 Physico-chemical and toxicant water quality objectives to support aquatic ecosystems for waters in the Brisbane River and all creeks of the Brisbane River Estuary, other than Oxley Creek and Kedron Brook

Brisbane River and all creeks of the Brisbane River Estuary (other than Oxley Creek and Kedron Brook) – Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)					
Indicator	**Mid Estuary**	**Tidal canals, constructed estuaries**	**Upper estuary**	**Lowland Freshwaters**	**Upland Freshwaters**
pH	7.0-8.4	7.0-8.4	7.4-8.4	6.5-8.0	6.5-8.2
Dissolved oxygen	80-105 % saturation	80-105 % saturation	80-105 % saturation	85-110 % saturation	90-110 % saturation
Oxidised N	<10 µg/L	<10 µg/L	<15 µg/L	<60 µg/L	<40 µg/L
Organic N	<280 µg/L	<280 µg/L	<400 µg/L	<420 µg/L	<200 µg/L
Ammonia N	<10 µg/L	<10 µg/L	<30 µg/L	<20 µg/L	<10 µg/L
Total nitrogen	<300 µg/L	<300 µg/L	<450 µg/L	<500 µg/L	<250 µg/L
Total phosphorus	<25 µg/L	<25 µg/L	<30 µg/L	<50 µg/L	<30 µg/L
Filterable Reactive Phosphorus	<6 µg/L	<6 µg/L	<10 µg/L	<20 µg/L	<15 µg/L
Chlorophyll a	<4 µg/L	<4 µg/L	<8 µg/L	<5 µg/L	<2 µg/L
Turbidity	<8 NTU	<8 NTU	<25 NTU	<50 NTU	<25 NTU
Secchi depth	>1 m	>1 m	>0.5 m	n/a	n/a
Conductivity	n/a	n/a	n/a	600 µS/cm	600 µS/cm
Suspended solids	<20 mg/L	<20 mg/L	<25 mg/L	<6 mg/L	<6 mg/L
Aluminium pH >6.5 (if pH <6.5)**	0.8 µg/L[(1)]	0.8 µg/L[(1)]	0.8 µg/L[(1)]	55 µg/L	55 µg/L
Iron**	ID	ID	ID	ID	ID
Arsenic (AsIII)**	2.3 µg/L[(2)]	2.3 µg/L[(2)]	2.3 µg/L[(2)]	24 µg/L	24 µg/L
Arsenic (AsV)**	4.5 µg/L[(2)]	4.5 µg/L[(2)]	4.5 µg/L[(2)]	13 µg/L	13 µg/L
Cadmium**	0.7 µg/L[(B)]	0.7 µg/L[(B)]	0.7 µg/L[(B)]	0.2 µg/L	0.2 µg/L
Chromium (CrIII) **	27.4 µg/L	27.4 µg/L	27.4 µg/L	3.3 µg/L[(1)]	3.3 µg/L[(1)]
Chromium (CrVI) **	4.4 µg/L	4.4 µg/L	4.4 µg/L	1 µg/L[(C)]	1 µg/L[(C)]

Brisbane River and all creeks of the Brisbane River Estuary (other than Oxley Creek and Kedron Brook) – Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)					
Indicator	**Mid Estuary**	**Tidal canals, constructed estuaries**	**Upper estuary**	**Lowland Freshwaters**	**Upland Freshwaters**
Copper**	1.3 µg/L	1.3 µg/L	1.3 µg/L	1.4 µg/L	1.4 µg/L
Lead**	4.4 µg/L	4.4 µg/L	4.4 µg/L	3.4 µg/L	3.4 µg/L
Nickel**	7 µg/L	7 µg/L	7 µg/L	11 µg/L	11 µg/L
Zinc**	15 µg/L(C)	15 µg/L(C)	15 µg/L(C)	8 µg/L(C)	8 µg/L(C)
Mercury (inorganic) **	0.1 µg/L	0.1 µg/L	0.1 µg/L	0.06 µg/L	0.06 µg/L
Chlorine**	3 µg/L(1)	3 µg/L(1)	3 µg/L(1)	3 µg/L	3 µg/L
Polycyclic Aromatic Hydrocarbons**					
Naphthalene	50 µg/L(C)	50 µg/L(C)	50 µg/L(C)	16 µg/L	16 µg/L
Anthracene	0.4 µg/L(1)	0.4 µg/L(1)	0.4 µg/L(1)	0.4 µg/L(1)	0.4 µg/L(1)
Phenanthrene	2 µg/L(1)	2 µg/L(1)	2 µg/L(1)	2 µg/L(1)	2 µg/L(1)
Fluoranthene	1.4 µg/L(1)	1.4 µg/L(1)	1.4 µg/L(1)	1.4 µg/L(1)	1.4 µg/L(1)
Benzo(a)pyrene	0.2 µg/L(1)	0.2 µg/L(1)	0.2 µg/L(1)	0.2 µg/L(1)	0.2 µg/L(1)
BTEX**					
Benzene	500 µg/L(C)	500 µg/L(C)	500 µg/L(C)	950 µg/L	950 µg/L
Toluene	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)
Ethylbenzene	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)
Ortho-xylene	ID	ID	ID	350 µg/L	350 µg/L
Meta-xylene	75 µg/L(1)	75 µg/L(1)	75 µg/L(1)	75 µg/L(1)	75 µg/L(1)
Para-xylene	ID	ID	ID	200 µg/L	200 µg/L

Notes: Indicator values in the above table were sourced from the EPP (Water) 2009 Environmental Values and WQOs for the Brisbane River (Basin No. 143) (DERM, 2010b). Indicators marked with (**) were sourced from Section 3.4, Table 4.3.1 of the ANZECC Water Quality Guidelines 2000. If a particular parameter is not given in the above table, reference should be made to the EPP (Water) 2009 and the ANZECC Water Quality Guidelines 2000.
n/a = not applicable for this indicator and water type.
ID = insufficient data available to derive a reliable goal value.
(B) = chemicals for which bioaccumulation and secondary poisoning effects should be considered.
(C) = Figure may not protect key test species from chronic toxicity (ANZECC & ARMCANZ, 2000,Section 3.4, Table 4.3.1).

To comply with these WQOs, the median value of the water quality data set should lie within the concentration range, or below the maximum concentration (DERM, 2009b).
(1) Low reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000 (should only be used as an indicative interim working level value).
(2) High reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000.
** Sourced from QWQG, Appendix G, Table G.1.*
To comply with these WQOs, the median value of the water quality data set should lie within the concentration range, or below the maximum concentration (DERM, 2009b).

Table 4-2 Physico-chemical and toxicant water quality objectives to support aquatic ecosystems for waters in Oxley creek and all tributaries of Oxley Creek

Oxley Creek and all tributaries of Oxley Creek (waters within the BCC Local Authority area) – Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)					
Indicator	**Mid Estuary**	**Tidal canals, constructed estuaries**	**Upper estuary**	**Lowland Freshwaters**	**Upland Freshwaters**
pH	7.0-8.4	7.0-8.4	7.4-8.4	6.5-8.0	6.5-8.2
Dissolved oxygen	85-105 % saturation	85-105 % saturation	85-105 % saturation	85-110 % saturation	90-110 % saturation
Oxidised N	<10 µg/L	<10 µg/L	<15 µg/L	<60 µg/L	<40 µg/L
Organic N	<280 µg/L	<280 µg/L	<400 µg/L	<420 µg/L	<200 µg/L
Ammonia N	<10 µg/L	<10 µg/L	<30 µg/L	<20 µg/L	<10 µg/L
Total nitrogen	<300 µg/L	<300 µg/L	<450 µg/L	<500 µg/L	<250 µg/L
Total phosphorus	<25 µg/L	<25 µg/L	<30 µg/L	<50 µg/L	<30 µg/L
Filterable Reactive Phosphorus	<6 µg/L	<6 µg/L	<10 µg/L	<20 µg/L	<15 µg/L
Chlorophyll a	<4 µg/L	<4 µg/L	<8 µg/L	<5 µg/L	<2 µg/L
Turbidity	<8 NTU	<8 NTU	<25 NTU	<50 NTU	<25 NTU
Secchi depth	>1 m	>1 m	>0.5 m	n/a	n/a
Conductivity	n/a	n/a	n/a	1120 µS/cm*	1120 µS/cm*
Suspended solids	<20 mg/L	<20 mg/L	<25 mg/L	<6 mg/L	<6 mg/L
Aluminium pH >6.5 (if pH <6.5)**	0.8 µg/L(1)	0.8 µg/L(1)	0.8 µg/L(1)	55 µg/L	55 µg/L
Iron**	ID	ID	ID	ID	ID
Arsenic (AsIII)**	2.3 µg/L(2)	2.3 µg/L(2)	2.3 µg/L(2)	24 µg/L	24 µg/L
Arsenic (AsV)**	4.5 µg/L(2)	4.5 µg/L(2)	4.5 µg/L(2)	13 µg/L	13 µg/L

Oxley Creek and all tributaries of Oxley Creek (waters within the BCC Local Authority area) – Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)					
Indicator	**Mid Estuary**	**Tidal canals, constructed estuaries**	**Upper estuary**	**Lowland Freshwaters**	**Upland Freshwaters**
Cadmium**	0.7 µg/L[(B)]	0.7 µg/L[(B)]	0.7 µg/L[(B)]	0.2 µg/L	0.2 µg/L
Chromium (CrIII) **	27.4 µg/L	27.4 µg/L	27.4 µg/L	3.3 µg/L[(1)]	3.3 µg/L[(1)]
Chromium (CrVI) **	4.4 µg/L	4.4 µg/L	4.4 µg/L	1 µg/L[(C)]	1 µg/L[(C)]
Copper**	1.3 µg/L	1.3 µg/L	1.3 µg/L	1.4 µg/L	1.4 µg/L
Lead**	4.4 µg/L	4.4 µg/L	4.4 µg/L	3.4 µg/L	3.4 µg/L
Nickel**	7 µg/L	7 µg/L	7 µg/L	11 µg/L	11 µg/L
Zinc**	15 µg/L[(C)]	15 µg/L[(C)]	15 µg/L[(C)]	8 µg/L[(C)]	8 µg/L[(C)]
Mercury (inorganic) **	0.1 µg/L	0.1 µg/L	0.1 µg/L	0.06 µg/L	0.06 µg/L
Chlorine**	3 µg/L[(1)]	3 µg/L[(1)]	3 µg/L[(1)]	3 µg/L	3 µg/L
Polycyclic Aromatic Hydrocarbons**					
Naphthalene	50 µg/L[(C)]	50 µg/L[(C)]	50 µg/L[(C)]	16 µg/L	16 µg/L
Anthracene	0.4 µg/L[(1)]	0.4 µg/L[(1)]	0.4 µg/L[(1)]	0.4 µg/L[(1)]	0.4 µg/L[(1)]
Phenanthrene	2 µg/L[(1)]	2 µg/L[(1)]	2 µg/L[(1)]	2 µg/L[(1)]	2 µg/L[(1)]
Fluoranthene	1.4 µg/L[(1)]	1.4 µg/L[(1)]	1.4 µg/L[(1)]	1.4 µg/L[(1)]	1.4 µg/L[(1)]
Benzo(a)pyrene	0.2 µg/L[(1)]	0.2 µg/L[(1)]	0.2 µg/L[(1)]	0.2 µg/L[(1)]	0.2 µg/L[(1)]
BTEX**					
Benzene	500 µg/L[(C)]	500 µg/L[(C)]	500 µg/L[(C)]	950 µg/L	950 µg/L
Toluene	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]
Ethylbenzene	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]
Ortho-xylene	ID	ID	ID	350 µg/L	350 µg/L
Meta-xylene	75 µg/L[(1)]	75 µg/L[(1)]	75 µg/L[(1)]	75 µg/L[(1)]	75 µg/L[(1)]
Para-xylene	ID	ID	ID	200 µg/L	200 µg/L

Notes: Indicator values in the above table were sourced from the EPP (Water) 2009 Environmental Values and WQOs for Oxley Creek (Basin No. 143) (DERM, 2010b). Indicators marked with (**) were sourced from Section 3.4, Table 4.3.1 of the ANZECC Water Quality Guidelines 2000. If a particular parameter is not given in the above table, reference should be made to the EPP (Water) 2009 and the ANZECC Water Quality Guidelines 2000.
n/a = not applicable for this indicator and water type.
ID = insufficient data available to derive a reliable goal value.
(B) = chemicals for which bioaccumulation and secondary poisoning effects should be considered.
(C) = Figure may not protect key test species from chronic toxicity (ANZECC & ARMCANZ, 2000,Section 3.4, Table 4.3.1).
To comply with these WQOs, the median value of the water quality data set should lie within the concentration range, or below the maximum concentration (DERM, 2009b).
(1) Low reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000 (should only be used as an indicative interim working level value).
(2) High reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000.
** Sourced from QWQG, Appendix G, Table G.1.*
To comply with these WQOs, the median value of the water quality data set should lie within the concentration range, or below the maximum concentration (DERM, 2009b).

Table 4-3 Physico-chemical and toxicant water quality objectives to support aquatic ecosystems for waters in Kedron Brook

Kedron Brook (waters within the BCC Local Authority area) – Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)					
Indicator	**Mid Estuary**	**Tidal canals, constructed estuaries**	**Upper estuary**	**Lowland Freshwaters**	**Upland Freshwaters**
pH	7.0-8.4	7.0-8.4	7.0-8.4	6.5-8.0	6.5-8.2
Dissolved oxygen	85-105 % saturation	85-105 % saturation	85-105 % saturation	85-110 % saturation	90-110 % saturation
Oxidised N	<10 µg/L	<10 µg/L	<15 µg/L	<60 µg/L	<40 µg/L
Organic N	<280 µg/L	<280 µg/L	<400 µg/L	<420 µg/L	<200 µg/L
Ammonia N	<10 µg/L	<10 µg/L	<30 µg/L	<20 µg/L	<10 µg/L
Total nitrogen	<300 µg/L	<300 µg/L	<450 µg/L	<500 µg/L	<250 µg/L
Total phosphorus	<25 µg/L	<25 µg/L	<30 µg/L	<50 µg/L	<30 µg/L
Filterable Reactive Phosphorus	<6 µg/L	<6 µg/L	<10 µg/L	<20 µg/L	<15 µg/L
Chlorophyll a	<4 µg/L	<4 µg/L	<8 µg/L	<5 µg/L	<2 µg/L
Turbidity	<8 NTU	<8 NTU	<25 NTU	<50 NTU	<25 NTU
Secchi depth	>1 m	>1 m	>0.5 m	n/a	n/a
Conductivity	n/a	n/a	n/a	1120 µS/cm*	1120 µS/cm*
Suspended solids	<20 mg/L	<20 mg/L	<25 mg/L	<6 mg/L	<6 mg/L
Aluminium pH >6.5 (if pH <6.5)**	0.8 µg/L(1)	0.8 µg/L(1)	0.8 µg/L(1)	55 µg/L	55 µg/L

Kedron Brook (waters within the BCC Local Authority area) – Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)					
Indicator	**Mid Estuary**	**Tidal canals, constructed estuaries**	**Upper estuary**	**Lowland Freshwaters**	**Upland Freshwaters**
Iron**	ID	ID	ID	ID	ID
Arsenic (AsIII)**	2.3 µg/L[(2)]	2.3 µg/L[(2)]	2.3 µg/L[(2)]	24 µg/L	24 µg/L
Arsenic (AsV)**	4.5 µg/L[(2)]	4.5 µg/L[(2)]	4.5 µg/L[(2)]	13 µg/L	13 µg/L
Cadmium**	0.7 µg/L[(B)]	0.7 µg/L[(B)]	0.7 µg/L[(B)]	0.2 µg/L	0.2 µg/L
Chromium (CrIII) **	27.4 µg/L	27.4 µg/L	27.4 µg/L	3.3 µg/L[(1)]	3.3 µg/L[(1)]
Chromium (CrVI) **	4.4 µg/L	4.4 µg/L	4.4 µg/L	1 µg/L[(C)]	1 µg/L[(C)]
Copper**	1.3 µg/L	1.3 µg/L	1.3 µg/L	1.4 µg/L	1.4 µg/L
Lead**	4.4 µg/L	4.4 µg/L	4.4 µg/L	3.4 µg/L	3.4 µg/L
Nickel**	7 µg/L	7 µg/L	7 µg/L	11 µg/L	11 µg/L
Zinc**	15 µg/L[(C)]	15 µg/L[(C)]	15 µg/L[(C)]	8 µg/L[(C)]	8 µg/L[(C)]
Mercury (inorganic) **	0.1 µg/L	0.1 µg/L	0.1 µg/L	0.06 µg/L	0.06 µg/L
Chlorine**	3 µg/L[(1)]	3 µg/L[(1)]	3 µg/L[(1)]	3 µg/L	3 µg/L
Polycyclic Aromatic Hydrocarbons**					
Naphthalene	50 µg/L[(C)]	50 µg/L[(C)]	50 µg/L[(C)]	16 µg/L	16 µg/L
Anthracene	0.4 µg/L[(1)]	0.4 µg/L[(1)]	0.4 µg/L[(1)]	0.4 µg/L[(1)]	0.4 µg/L[(1)]
Phenanthrene	2 µg/L[(1)]	2 µg/L[(1)]	2 µg/L[(1)]	2 µg/L[(1)]	2 µg/L[(1)]
Fluoranthene	1.4 µg/L[(1)]	1.4 µg/L[(1)]	1.4 µg/L[(1)]	1.4 µg/L[(1)]	1.4 µg/L[(1)]
Benzo(a)pyrene	0.2 µg/L[(1)]	0.2 µg/L[(1)]	0.2 µg/L[(1)]	0.2 µg/L[(1)]	0.2 µg/L[(1)]
BTEX**					
Benzene	500 µg/L[(C)]	500 µg/L[(C)]	500 µg/L[(C)]	950 µg/L	950 µg/L
Toluene	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]
Ethylbenzene	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]	80 µg/L[(1)]
Ortho-xylene	ID	ID	ID	350 µg/L	350 µg/L

Kedron Brook (waters within the BCC Local Authority area) – Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)					
Indicator	**Mid Estuary**	**Tidal canals, constructed estuaries**	**Upper estuary**	**Lowland Freshwaters**	**Upland Freshwaters**
Meta-xylene	75 µg/L(1)	75 µg/L(1)	75 µg/L(1)	75 µg/L(1)	75 µg/L(1)
Para-xylene	ID	ID	ID	200 µg/L	200 µg/L

Notes: Indicator values in the above table were sourced from the EPP (Water) 2009 Environmental Values and WQOs for Kedron Brook (Basin No. 142) (DERM, 2010b). Indicators marked with (**) were sourced from Section 3.4, Table 4.3.1 of the ANZECC Water Quality Guidelines 2000. If a particular parameter is not given in the above table, reference should be made to the EPP (Water) 2009 and the ANZECC Water Quality Guidelines 2000.
n/a = not applicable for this indicator and water type.
ID = insufficient data available to derive a reliable goal value.
(B) = chemicals for which bioaccumulation and secondary poisoning effects should be considered.
(C) = Figure may not protect key test species from chronic toxicity (ANZECC & ARMCANZ, 2000,Section 3.4, Table 4.3.1).
To comply with these WQOs, the median value of the water quality data set should lie within the concentration range, or below the maximum concentration (DERM, 2009b).
(1) Low reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000 (should only be used as an indicative interim working level value).
(2) High reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000.
** Sourced from QWQG, Appendix G, Table G.1.*
To comply with these WQOs, the median value of the water quality data set should lie within the concentration range, or below the maximum concentration (DERM, 2009b).

Table 4-4 Physico-chemical and toxicant water quality objectives (WQOs) to support aquatic ecosystems for waters in Bundamba Creek

Bundamba Creek (waters draining the Bremer River catchment within the broader Brisbane (Basin 143)) - Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)				
Indicator	**Mid estuary**	**Upper estuary**	**Lowland Freshwater**	**Upland Freshwaters**
pH	7.0-8.4	7.0-8.4	6.5-8.0	6.5-8.2
Dissolved oxygen	85-105 % saturation (20th - >80th percentile)	80-105 % saturation (20th - >80th percentile)	85-110 % saturation	90-110 % saturation
Oxidised N	<10 µg/L	<15 µg/L	<60 µg/L	<40 µg/L
Organic N	<280 µg/L	<400 µg/L	<420 µg/L	<200 µg/L
Ammonia N	<10 µg/L	<30 µg/L	<20 µg/L	<10 µg/L
Total nitrogen	<300 µg/L	<450 µg/L	<500 µg/L	<250 µg/L
Total phosphorus	<25 µg/L	<30 µg/L	<50 µg/L	<30 µg/L
Filterable Reactive Phosphorus	<6 µg/L	<10 µg/L	<20 µg/L	<15 µg/L
Chlorophyll a	<4 µg/L	<8 µg/L	<5 µg/L	<2 µg/L
Turbidity	<8 NTU	<25 NTU	<17 NTU	<17 NTU

Bundamba Creek (waters draining the Bremer River catchment within the broader Brisbane (Basin 143)) - Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)				
Indicator	**Mid estuary**	**Upper estuary**	**Lowland Freshwater**	**Upland Freshwaters**
Secchi depth	>1 m (20^{th} percentile)	>0.5 m (20^{th} percentile)	n/a	n/a
Conductivity	n/a	n/a	<770 µS/cm	<770 µS/cm
Suspended solids	<20 mg/L	<25 mg/L	<6 µg/L	<6 µg/L
Aluminium pH >6.5 (if pH <6.5)**	0.8 µg/L[(1)]	0.8 µg/L[(1)]	55 µg/L	55 µg/L
Iron**	ID	ID	ID	ID
Arsenic (AsIII)**	2.3 µg/L[(2)]	2.3 µg/L[(2)]	24 µg/L	24 µg/L
Arsenic (AsV)**	4.5 µg/L[(2)]	4.5 µg/L[(2)]	13 µg/L	13 µg/L
Cadmium**	0.7 µg/L[(B)]	0.7 µg/L[(B)]	0.2 µg/L	0.2 µg/L
Chromium (CrIII) **	27.4 µg/L	27.4 µg/L	3.3 µg/L[(1)]	3.3 µg/L[(1)]
Chromium (CrVI) **	4.4 µg/L	4.4 µg/L	1 µg/L[(C)]	1 µg/L[(C)]
Copper**	1.3 µg/L	1.3 µg/L	1.4 µg/L	1.4 µg/L
Lead**	4.4 µg/L	4.4 µg/L	3.4 µg/L	3.4 µg/L
Nickel**	7 µg/L	7 µg/L	11 µg/L	11 µg/L
Zinc**	15 µg/L[(C)]	15 µg/L[(C)]	8 µg/L[(C)]	8 µg/L[(C)]
Mercury (inorganic) **	0.1 µg/L	0.1 µg/L	0.06 µg/L	0.06 µg/L
Chlorine**	3 µg/L[(1)]	3 µg/L[(1)]	3 µg/L	3 µg/L
Polycyclic Aromatic Hydrocarbons**				
Naphthalene	50 µg/L[(C)]	50 µg/L[(C)]	16 µg/L	16 µg/L
Anthracene	0.4 µg/L[(1)]	0.4 µg/L[(1)]	0.4 µg/L[(1)]	0.4 µg/L[(1)]
Phenanthrene	2 µg/L[(1)]	2 µg/L[(1)]	2 µg/L[(1)]	2 µg/L[(1)]
Fluoranthene	1.4 µg/L[(1)]	1.4 µg/L[(1)]	1.4 µg/L[(1)]	1.4 µg/L[(1)]
Benzo(a)pyrene	0.2 µg/L[(1)]	0.2 µg/L[(1)]	0.2 µg/L[(1)]	0.2 µg/L[(1)]
BTEX**				

Bundamba Creek (waters draining the Bremer River catchment within the broader Brisbane (Basin 143)) - Aquatic Ecosystem Level 2 (Slightly-to-moderately disturbed)				
Indicator	**Mid estuary**	**Upper estuary**	**Lowland Freshwater**	**Upland Freshwaters**
Benzene	500 µg/L(C)	500 µg/L(C)	950 µg/L	950 µg/L
Toluene	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)
Ethylbenzene	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)	80 µg/L(1)
Ortho-xylene	ID	ID	350 µg/L	350 µg/L
Meta-xylene	75 µg/L(1)	75 µg/L(1)	75 µg/L(1)	75 µg/L(1)
Para-xylene	ID	ID	200 µg/L	200 µg/L

Notes: Indicator values in the above table were sourced from the EPP (Water) 2009 Environmental Values and WQOs for Bremer River, including all tributaries of the Bremer River (Basin No. 143) (DERM, 2010b). Indicators marked with (**) were sourced from Section 3.4, Table 4.3.1 of the ANZECC Water Quality Guidelines 2000. If a particular parameter is not given in the above table, reference should be made to the EPP (Water) 2009 and the ANZECC Water Quality Guidelines 2000.
n/a = not applicable for this indicator and water type.
ID = insufficient data available to derive a reliable goal value.
(B) = chemicals for which bioaccumulation and secondary poisoning effects should be considered.
(C) = Figure may not protect key test species from chronic toxicity (ANZECC & ARMCANZ, 2000,Section 3.4, Table 4.3.1).
To comply with these WQOs, the median value of the water quality data set should lie within the concentration range, or below the maximum concentration (DERM, 2009b).
(1) Low reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000 (should only be used as an indicative interim working level value).
(2) High reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000.
** Sourced from QWQG, Appendix G, Table G.1.*
To comply with these WQOs, the median value of the water quality data set should lie within the concentration range, or below the maximum concentration (DERM, 2009b).

4.2 Environmental values

Environmental values for waterways describe the key qualities that are important for the health of an ecosystem and for safe human waterway use. These environmental values need to be protected from the effects of pollution, waste discharges and deposits (eg litter, sediment and stormwater runoff) to ensure the waterways are healthy and safe for community use (DERM, 2010b, 2010c, 2010d, 2010e). Waters of the Brisbane River, Enoggera/Breakfast Creek, Norman Creek, Oxley Creek and Bundamba Creek fall within Basin No. 143 of the broader Brisbane basin (DERM, 2010b, 2010c, 2010e), while Kedron Brook waters fall within Basin 142 of the broader Brisbane basin (DERM, 2010d). Particular waters may have different environmental values. **Table 4-5** summarises the environmental values which apply to waterways in the study area, as defined in the EPP (Water). Environmental values for Breakfast/Enoggera Creek are also defined in the BCC's *Breakfast/Enoggera Creek Waterway Management Plan,* which were designed through stakeholder consultation in accordance with, but in addition to, those listed in the EPP (Water)) (refer to **Table 4-6**).

Table 4-5 Environmental values for waterways in the study area

	Aquatic Ecosystems	Irrigation	Human Consumer	Stock water	Primary Recreation	Secondary Recreation	Visual Recreation	Cultural and spiritual values	Industrial Use
Brisbane River - freshwater creeks and drains	✓					✓	✓	✓	
Brisbane River - tidal creeks/drains, estuarine	✓					✓	✓	✓	
Brisbane River – estuarine and enclosed coastal	✓		✓		✓	✓	✓	✓	✓
Enoggera Creek - freshwater	✓		✓		✓	✓	✓	✓	
Breakfast Creek - estuarine	✓		✓		✓	✓	✓	✓	
Kedron Brook – freshwater (urban reach)	✓					✓	✓	✓	
Kedron Brook – freshwater (urban reach)	✓					✓	✓	✓	
Norman Creek - freshwater	✓					✓	✓	✓	
Norman Creek – estuarine	✓					✓	✓	✓	
Upper Oxley Creek - freshwater	✓					✓	✓	✓	
Lower Oxley Creek - estuarine	✓		✓		✓	✓	✓	✓	
Bundamba Creek - freshwater	✓	✓		✓		✓	✓	✓	✓
Bundamba Creek - estuarine	✓					✓	✓	✓	

Source: DERM, 2010b, 2010c, 2010d, 2010e.

Table 4-6 BCC Waterway Management Plan Environmental Values: Breakfast/Enoggera Creek

Environmental Value	Breakfast Creek and lower Enoggera Creek	Enoggera Creek
Aquatic Ecosystems	✓	✓
Wildlife Habitat	✓	✓
Human consumer of Aquatic Foods	✓	✓
Primary Recreation	✓	✓
Secondary Recreation	✓	✓
Visual Recreation	✓	✓
Cultural Heritage	✓	✓
Industrial Use		✓
Irrigation		✓

Source: BCC, 2004.

4.3 Water quality monitoring and assessment

4.3.1 Ecosystem Health Monitoring Program (EHMP)

Comprehensive water quality monitoring and scientific assessments of ecosystem health in the Lower Brisbane River Catchment, Oxley Creek Catchment and Bremer River Catchment has been conducted since 2000, as part of the EHMP (EHMP, 2008). DERM conducts freshwater aquatic monitoring on a monthly basis and estuarine monitoring twice a year, using a broad range of biological, physical and chemical indicators (EHMP, 2008). Results are published in the form of Ecosystem Health Report Cards, which grade the health of the aquatic ecosystems by analysing compliance with water quality objectives identified in the QWQG. A single Report Card Grade is assigned for each freshwater and estuarine/marine habitat, ranging from ‘A’ (excellent) to ‘F’ (Fail) (EHMP, 2008). Each waterway is measured according to an Ecosystem Health Index (EHI) and a Biological Health Rating (BHR), which is a measure of the proportion of a reporting zone that complied with pre-defined objectives for key indicators monitored as part of the program (EHMP, 2010). The EHMP Report Card Grades and their meanings are detailed in **Table 4-7** and water quality Report Card results for all waterways in the study area are presented in **Table 4-8**.

Table 4-7 EHMP Report Card Grades and their meanings

EHMP Report Card Grade	Grade explanations
A	Excellent – conditions meet all set ecosystem health values; all key processes are functional and all critical habitats are in near pristine condition.
B	Good – conditions meet all set ecosystem health values in most of the reporting region; most key processes are functional and most critical habitats are intact.
C	Fair – conditions meet some of the set ecosystem health values in most of the reporting region; some key processes are functional but some critical habitats are impacted.
D	Poor – Conditions are unlikely to meet set ecosystem health values in most of the reporting region; many key processes are not functional and many critical habitats are impacted.
F	Fail – Conditions do not meet set ecosystem health values; most key processes are not functional and most critical habitats are severely impacted.

Source: EHMP, 2010.

Table 4-8 EHMP Catchment and Waterway Report Card Grades, 2009 to 2000

Waterway	Report card grade									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Lower Brisbane catchment	nd	D-	D	F	F	D-	F	F	F	F
Brisbane River estuary	D	D-	D-	D-	D-	D-	D-	D+	D+	D
Oxley catchment	nd	D-	D	F	F	D-	F	F	F	F
Oxley Creek (estuarine)	nd	nd	nd	nd	F	F	F	F	D	F
Bremer catchment	nd	F	F	D-	D-	D-	D-	D	D-	D+

Source: EHMP, 2010.
Note: nd – no data available

Monitoring of the Lower Brisbane Catchment in 2009 found that streams generally failed to meet ecosystem health guidelines, particularly in terms of nutrient cycling, aquatic macro-invertebrates and physical/chemical indicators (EHMP, 2010). Streams in this catchment during 2009 were in poor condition, although an improvement in the fish indicator and slight improvement in ecosystem processes was reported (EHMP, 2010).

The Brisbane River estuary monitoring results in 2009 found decreases in dissolved oxygen as well as increases in turbidity and the sewage nitrogen signal, in comparison with previous years (EHMP, 2010). Salinity throughout the estuary was the lowest since 2001, indicative of high freshwater inputs and decreased phytoplankton abundance (EHMP, 2010).

Oxley Catchment monitoring results in 2009 found that streams generally failed to meet ecosystem health guidelines, where the waterways were in poor condition and showed a significant decline in nutrient cycling throughout the year (EHMP, 2010). Physical and chemical indicators had slightly improved in 2009, but overall scores were lower than 2008, for four of the five ecological indicators (EHMP, 2010).

For Oxley Creek, monitoring results in 2009 found that dissolved oxygen concentrations continued to be low and nutrients, turbidity and phytoplankton abundance had increased, particularly 7 km from the mouth of the creek (EHMP, 2010). These latest findings are consistent with results for 2004 to 2007 (EHMP, 2010). Information on water quality for Oxley Creek tributaries Rocky Waterholes Creek and Stable Swamp are provided in **Table 4-12** and **Table 4-13**. These tables show whether water quality results conformed with WQOs set by the QWQG and the ANZECC 2000.

The Bremer Catchment streams are generally in poor condition (EHMP, 2010). However, 2009 EHMP monitoring results reported substantial increases in ecosystem processes and slight increases in aquatic macro-invertebrates and fish indicators, resulting in a better Report Card Grade than previous years.

4.3.2 BCC waterway management and health assessments

Breakfast/Enoggera Creek Waterway Management Plan 2004

The Breakfast/Enoggera Creek Waterway Management Plan was developed by BCC in 2004 to assess and manage the scenic, recreational, cultural, environmental and commercial values of Breakfast/Enoggera Creek. It covers ecological health, flooding, drainage and waterway usage issues (BCC, 2004). The Plan was created by culminating three major technical studies and through stakeholder consultation. It aims to promote healthy waterways, improve public access to waterways, retain the bushland character of Breakfast/Enoggera Creek catchment, and promote the waterway as a recreational resource. The Plan characterizes the Breakfast/Enoggera Creek waters, to help guide development and assist in the management of the waterway (BCC, 2004). Environmental values in addition to those listed in the EPP (Water) were defined through stakeholder consultation (refer to **Table 4-6**).

Breakfast/Enoggera Creek Waterway Health Assessment 2001-2002

A waterway health assessment for Breakfast/Enoggera Creek was conducted by BCC in 2001-2002, to provide technical input and help develop management strategies for the Waterway Management Plan (BCC, 2003). This assessment identified pressures on the Breakfast/Enoggera Creek and analysed water quality by using environmental indicators (riparian vegetation, in-stream habitat, macro-invertebrates, water quality, sediment quality and litter) (BCC, 2003). Ratings assigned to each indicator were ‘A’ (*very good*), ‘B’ (*good*), ‘C’ (*moderate*), ‘D’ (*poor*) and ‘E’ (*very poor*) (BCC, 2003).

Analysis of the riparian vegetation identified four species of significance in the catchment, as defined by the *Nature Conservation Act (1992)* (BCC, 2003). The average width of vegetation along the waterway was narrow and weeds were identified as the greatest threat to vegetation cover. Stormwater discharge from residential areas was the secondary threat to vegetation (BCC, 2003). Overall in-stream habitat was rated as *good*, although comparisons with the State of the Rivers pilot study on Breakfast/Enoggera Creek in 1999 (Anderson, 1999) revealed slight declines since 1999 (BCC, 2003).

The condition of macro-invertebrates within Breakfast/Enoggera Creek was *poor to moderate* in the freshwater reaches and *moderate* in the estuarine reaches (BCC, 2003). The estuarine macro-invertebrate community was found to be quite stable, and it was suggested that this fauna possesses a high degree of resistance and resilience to a variety of disturbances (BCC, 2003). Potentially detrimental water column and sediment metal concentrations were observed and the report advised that metal concentrations in Breakfast Creek should be reduced (BCC, 2003).

Water quality was measured and compared against the BCC Water Quality Objectives. Water quality across the catchment was characterised by high concentrations of nutrients, predominantly high total phosphorus and high concentrations of chlorophyll-a and dissolved oxygen (BCC, 2003). Water quality in the upper catchment was *very good*, compared to the lower catchment which was *very poor*, due to urban influences including commercial and industrial activities. Breakfast Creek waters had elevated nitrate/nitrite and total phosphorus, meaning that nutrient-induced impacts such as algal blooms would be more likely to occur (BCC, 2003).

Sediment quality was found to be *very good* at six of the eight sites and moderate at the two remaining sites, which were located towards the mouth of Breakfast Creek (BCC, 2003). Sediment at the sites rated as *moderate* contained levels of zinc and lead that exceeded the ANZECC sediment quality guidelines and this was thought to be due to current and/or past industrial activities (BCC, 2003).

The overall results of the study found Breakfast/Enoggera Creek to have a waterway health rating of C (*moderate*), with the exception of riparian vegetation (BCC, 2003). It was suggested that waterway health could be improved through weed management, protection and enhancement of riparian vegetation with continued support for water quality improvement, particularly within industrial areas of Breakfast Creek (BCC, 2003). It was also suggested that better erosion and sediment controls be utilised at construction sites in the future, to help reduce turbidity problems (BCC, 2003). A summary of the results for this health assessment are provided below in **Table 4-9**.

Table 4-9 BCC Waterway Health Assessment summary: Breakfast/Enoggera Creek Catchment

Sub-catchment	Site	Key Indicator						Site Report Card	Sub-Catchment Report Card
		Water Quality	Riparian vegetation	In-stream habitat	Macro-invertebrates	Sediment	Litter		
Breakfast Creek	1	D	C	C	C	C	B	C	C
	2	-	D	B	C	C	C	C	
	3	-	D	B	-	-	B	C	
	4	D	D	B	C	A	B	C	
	5	D	D	B	C	A	B	C	
Enoggera Creek	6	-	D	C	-	-	C	C	C
	7	-	D	C	-	-	B	C	
	8	-	D	D	-	-	C	D	
	9	-	D	B	-	-	A	B	
	10	B	D	C	D	A	B	C	
	11	-	D	C	-	-	D	D	
	12	-	D	B	-	-	B	B	
	13	B	D	B	D	A	B	B	
	14	-	D	A	-	-	B	B	
	15	E	C	A	-	-	B	B	
	16	-	D	B	-	-	B	B	
	17	-	C	B	-	-	C	C	
	18	E	D	B	E	-	B	B	
	19	-	D	D	-	-	A	A	
	20	-	C	A	-	-	A	A	
	21	B	C	B	B	-	C	C	

Notes:
The numbering of sites begins within the estuarine section of Breakfast Creek (site 1 to site 5) and follows the waterway upstream to the freshwater reservoir (site 21). The term Breakfast/Enoggera Creek denotes the whole creek system. Reference to Breakfast Creek refers to the estuarine section of the waterway, below Bancroft Park. Reference to Enoggera Creek refers to the upper, freshwater reaches of the waterway west of Bancroft Park. Rating 'A' is very good, rating 'B' is good, rating 'C' is moderate, rating 'D' is poor and rating 'E' is very poor. Source: BCC, 2003.

4.3.3 City-wide water quality assessment 2000

A city-wide assessment of water quality in Brisbane's creeks was conducted by the then Queensland EPA (now DERM) and BCC between October 1999 and March 2000 (Webb, 2000). Water quality was monitored during four separate dry-weather surveys and water quality indicators monitored during this study included nutrients, Chlorophyll-a, water clarity, oxygen, pH and faecal contamination (Webb, 2000). Results from this study for waterways in the study area are presented in **Table 4-10**. Waterway health was ranked across five scales (*very good*; *good*; *average*; *poor* and *very poor*).

Table 4-10 City-wide Water Quality Assessment results for creeks in the study area, 1999-2000

Site	Key Findings
Enoggera/Breakfast Creek	**Freshwater**: Good water quality at the three freshwater sites.
	Estuarine: Poor water quality at all three estuarine sites, concentrations of most nutrients exceeded objectives, dissolved oxygen concentrations were below objectives.
Kedron Brook	**Freshwater**: Very good water quality at most of the freshwater sites, almost all indicators complied with objectives.
	Estuarine: Moderate impacts on water quality at the estuarine site, where concentrations of organic nitrogen and filterable reactive and total phosphorus were above objectives. Chlorophyll-a concentrations exceeded objectives and dissolved oxygen concentrations were below objectives. It was suggested that Brisbane River sewage plume may affect water quality.
Norman Creek	**Freshwater**: Generally good water quality at the freshwater sites, where most indicators were within objectives however these sites are highly modified ecosystems with a high degree of channelisation.
	Estuarine: Poor water quality at the estuarine site, where concentrations of most nutrients exceeded objectives.
Oxley Creek (Including Oxley Creek tributaries Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek)	**Freshwater**: Moderate-good water quality at the freshwater sites, although concentrations of organic nitrogen were above objectives and high sediment loads were evident. Tributaries of Oxley Creek Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek had moderately impacted to very good water quality. Concentrations of ammonia and oxidised nitrogen exceeded objectives in Moolabin and Rocky Waterholes Creeks, dissolved oxygen concentrations were below objectives in all three creeks and potentially toxic pH values were measured at Rocky Waterholes Creek.
	Estuarine: Very poor water quality at the estuarine sites, where concentrations of all nutrients exceeded objectives. Water clarity was very poor and dissolved oxygen concentrations were below objectives. Sites impacted by nutrient inputs from Wastewater Treatment Plant upstream, Brisbane River sediments resuspended from tidal exchange and upstream extractive industries.

Source: Webb, 2000.

4.3.4 Brisbane City-wide Local Waterway Health Assessment (LWHA)

In 2006 a long-term City-wide Waterway Health Assessment program commenced, which monitors 48 sites using a range of indicators including water quality, algae, pathogens, fish and vegetation (BCC, 2010d). This program aims to provide a continuous profile of local creek health, identifies the impacts of land use activities on waterway health and evaluates the benefits of various waterway and catchment enhancement activities (BCC, 2010d). This program complements the EHMP, but covers additional sites and provides more regular measures of creek condition. Report cards will be published for this monitoring program in the future, providing information on the condition of Brisbane's creeks, including overall health and trends in particular catchments (BCC, 2010d).

4.3.5 Preliminary water sampling in the Project corridor – southern section

Preliminary water sampling was conducted at the Oxley Creek tributaries Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek, to acquire baseline water quality data prior to construction of the Project (see **Figure 4-1** and **Figure 4-2** for sampling locations). These surface waters are at highest risk of impacts from the Project, due to their proximity to construction areas. Some results may have been influenced by rainfall events that occurred prior to sampling. However, impacts to quality during construction of the Project are most likely to occur after rainfall events and it would be advisable that future sampling was conducted at these times.

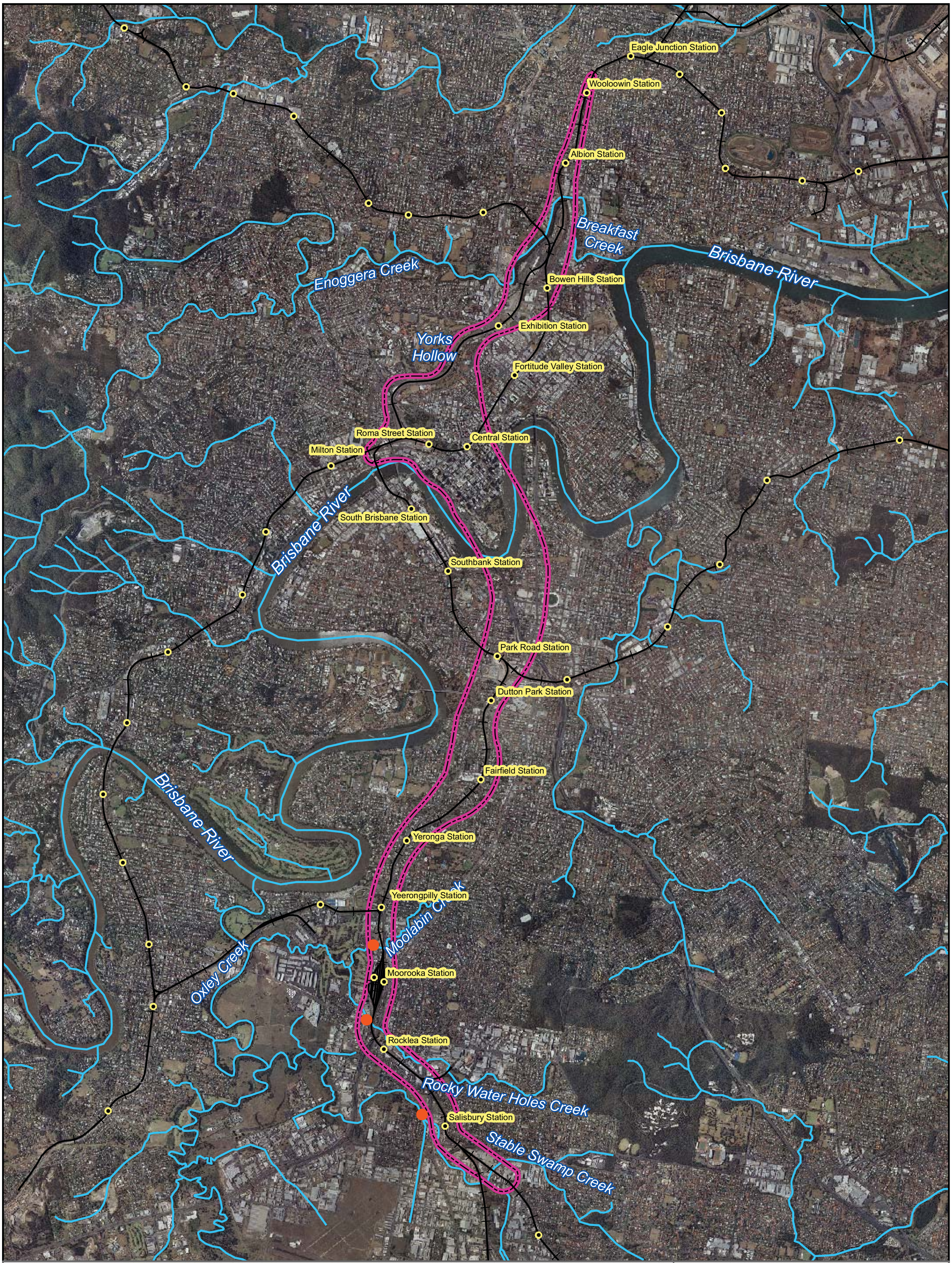
Results of the water sample analyses are provided in **Table 4-11**. Triplicate samples were taken from each site, analysed by a NATA accredited laboratory and the mean values were assessed against the QWQG 2009 and ANZECC 2000 water quality guideline trigger values for waters in Oxley Creek tributaries (see Table 4-2). Several water quality parameters for all three creeks did not comply with the guidelines, particularly turbidity and nutrients. This is consistent with the 2009 EHMP results for Oxley Creek, in which water quality was poor with high turbidity and high levels of nutrient concentrations (EHMP, 2010). pH and chlorophyll-a concentrations at all three creeks did, however, meet with the guidelines likely as a result of the high turbidity levels.

Several total metal concentrations at all three creeks exceeded the trigger levels for toxicants (ANZECC, 2000), including total copper, total lead and total zinc. Trigger level exceedances was also observed for total cadmium and total chromium in waters at Rocky Waterholes Creek and Stable Swamp Creek. Concentrations of arsenic and mercury were below guideline values for all three creeks. As these samples constitute total metal concentrations, it is not possible to determine what proportion of metals are in particulate form (not readily bioavailable) or dissolved form (bioavailable), but do set a baseline for future dissolved metal concentrations to be compared to.

Concentrations of aromatic hydrocarbons benzene, toluene, ethylbenzene and xylenes (known as BTEX) were within guideline values for all three creeks.

Results for polycyclic aromatic hydrocarbons (PAHs) were similar to BTEX, for which concentrations were low and met with the guidelines where water quality guideline trigger values have been set. Results for total petroleum hydrocarbons such as C6 – C36 are also presented in **Table 4-11** however there are currently no water quality guideline trigger values set for these parameters. This data will be useful for comparison to future water quality surveys during construction and operation of the Project.

Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek flow through a highly urbanised environment that are adjacent to industrial areas in some locations, receive road runoff and will be in very close proximity to surface works during construction of the Project. The overall biological health of these waterways is poor and water quality conditions do not meet set water quality guideline trigger values for many water quality parameters. It is therefore important to maintain or improve upon the current level of aquatic health in these creeks.



LEGEND

- Study Corridor
- Station
- Track
- Watercourse
- Water Sampling Sites

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-1

Water Sampling Sites - Study Corridor

0 0.5 1 1.5 2 2.5 3 km

N

1:75,000 at A4

CrossRiverRail

SKM aurecon
CRR JOINT VENTURE

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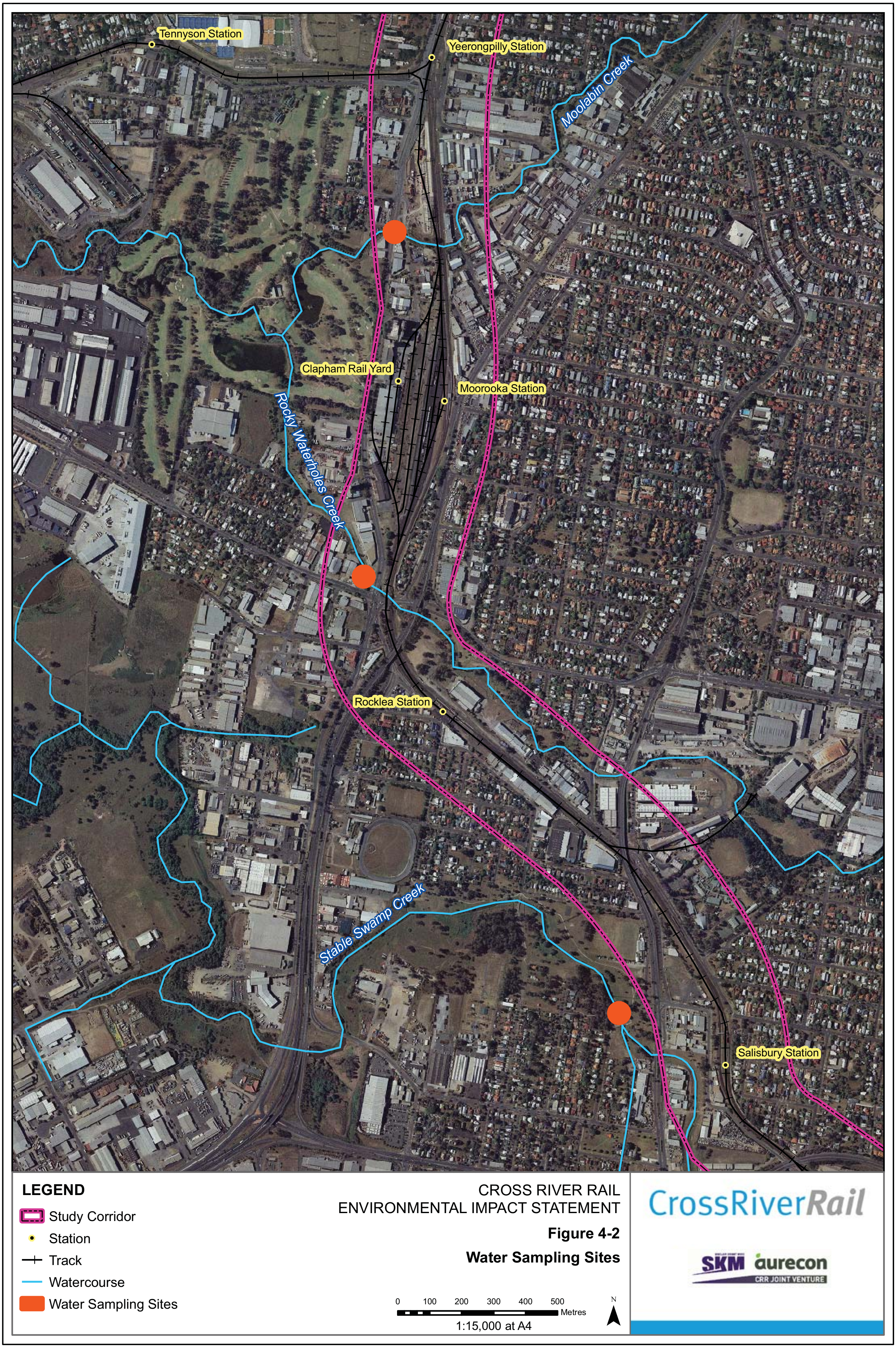

CROSS RIVER RAIL
ENVIRONMENTAL IMPACT STATEMENT

Figure 4-2

Water Sampling Sites

Table 4-11 Preliminary surface water quality for Oxley Creek tributaries Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek. Shaded cells represent non-conformance with QWQG and ANZECC 2000 water quality guideline trigger values.

Water Quality Parameter	Moolabin Creek mean (± SE)	Rocky Waterholes Creek mean (± SE)	Stable Swamp Creek mean (± SE)	WQO
Physico-chemical				
pH	7.5	7.7	7.5	6.5-8.0
Dissolved Oxygen (% saturation)	75	80	80	80-105
Conductivity (µS/cm)	389	230	270	<1075
Turbidity (NTU)	45	110	67	<50
Total N (µg/L)	4267 (± 484)	4733 (± 176)	2833 (± 203)	<500
Ammonia NH_3 (µg/L)	187 (± 3)	50 (± 10)	63 (± 3)	<20
Total Kjeldahl N (µg/L)*	933 (± 67)	833 (± 33)	733 (± 33)	No WQO
Oxidised N (NOx) (µg/L)	3320 (± 420)	3883 (± 182)	2123 (± 213)	<60
Total Phosphorus (µg/L)	320 (± 240)	37 (± 6)	47 (± 12)	<50
Reactive Phosphorus (µg/L)	43 (± 13)	23 (± 9)	30 (± 6)	<20
Chlorophyll-a (µg/L)	2.0	2.0	1.7 (± 0.3)	<5
Trace Metals				
Arsenic (µg/L)	2.0	3.0 (± 0.6)	2.0	13
Cadmium (µg/L)	0.2 (± 0.06)	0.5	0.4 (± 0.2)	0.2
Chromium (µg/L)	1	2 (± 0.6)	1 (± 0.4)	1.0 (2)
Copper (µg/L)	9 (± 0.7)	13 (± 0.7)	9	1.4
Lead (µg/L)	7 (± 0.7)	9 (± 0.7)	5	3.4
Nickel (µg/L)	2 (± 0.3)	4 (± 0.3)	3 (± 0.3)	11
Zinc (µg/L)	160 (± 14.3)	331 (± 3)	115 (± 0.6)	8
Mercury (µg/L)	<0.1	<0.1	<0.1	0.06
Polycyclic Aromatic Hydrocarbons				
Naphthalene (µg/L)	<0.1	<0.1	<0.1	16
Acenaphthylene (µg/L)	<0.1	<0.1	<0.1	ID
Acenaphthene (µg/L)	<0.1	<0.1	<0.1	ID
Fluorene (µg/L)*	<0.1	<0.1	<0.1	No WQO
Fluoranthene (µg/L)	<0.1	<0.1	<0.1	1.4 (3)
Phenanthrene (µg/L)	<0.1	<0.1	<0.1	2 (4)
Anthracene (µg/L)	<0.1	<0.1	<0.1	0.4 (5)
Pyrene (µg/L)*	<0.1	<0.1	<0.1	No WQO
Benz(a)anthracene (µg/L)*	<0.1	<0.1	<0.1	No WQO
Chrysene (µg/L)*	<0.1	<0.1	<0.1	No WQO
Benzo(b)fluoranthene (µg/L)*	<0.1	<0.1	<0.1	No WQO
Benzo(k)fluoranthene (µg/L)*	<0.1	<0.1	<0.1	No WQO

Water Quality Parameter	Moolabin Creek mean (± SE)	Rocky Waterholes Creek mean (± SE)	Stable Swamp Creek mean (± SE)	WQO
Benzo(a)pyrene (µg/L)	<0.5	<0.5	<0.5	0.2 (6)
Indeno(1.2.3.cd)pyrene (µg/L)*	<0.1	<0.1	<0.1	No WQO
Dibenz(a.h)anthracene (µg/L)*	<0.1	<0.1	<0.1	No WQO
Benzo(g.h.i)perylene (µg/L)*	<0.1	<0.1	<0.1	No WQO
BTEX				
Benzene (µg/L)	<1	<1	<1	950
Toluene (µg/L)	<2	<2	<2	180 (7)
Ethylbenzene (µg/L)	<2	<2	<2	80 (8)
Ortho-xylene (µg/L)	<2	<2	<2	350
Meta-xylene (µg/L)	<2	<2	<2	75 (9)
Para-xylene (µg/L)	<2	<2	<2	200
Total Petroleum Hydrocarbons				
C6 – C9 fraction (µg/L)*	<20	<20	<20	No WQO
C10 – C14 fraction (µg/L)*	<50	<50	<50	No WQO
C15 – C28 fraction (µg/L)*	<100	<100	117 (± 44.1)	No WQO
C29 – C36 fraction (µg/L)*	<50	<50	60 (± 10)	No WQO
C10 – C36 fraction (µg/L)*	<50	<50	177	No WQO

*Notes: Shaded cells represent values that did not meet the recommended WQO trigger values. Note that results may have been influenced by rainfall events that occurred prior to sampling. Values given in the above table for each waterway represent the mean value derived from triplicate samples with standard error. WQOs as per QWQG or ANZECC 2000 (see Table 4-2). ID = Insufficient data available to derive a reliable trigger value (DERM, 2010c). * No WQO.*

(1) Moderate reliability freshwater trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000. (2) High reliability trigger value sourced from Section 8.3.7 of the ANZECC 2000. (3) Low reliability trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000. Alternative protection levels are 1 µg/L 99%, 1.7 µg/L 90% and 2 µg/L 80%. (4) Low reliability trigger value for 95% protection, sourced from Section 8.3.7 of the ANZECC 2000. Alternative protection levels are 0.6 µg/L 99%, 4 µg/L 90% and 8 µg/L 80%. (5) Low reliability trigger value for 95% protection sourced from Section 8.3.7 of the ANZECC 2000. Alternative protection levels are 0.01 µg/L 99%, 1.5 µg/L 90% and 7 µg/L 80%. (6) Low reliability trigger value for 95% protection sourced from Section 8.3.7 of the ANZECC 2000. Alternative protection levels are 0.01 µg/L 99%, and 0.7 µg/L 80%). (7) Low reliability trigger value for 95% protection sourced from Section 8.3.7 of the ANZECC 2000. Alternative protection levels are 110 µg/L 99%, 230 µg/L 90% and 330 µg/L 80%). (8) Low reliability trigger value for 95% protection sourced from Section 8.3.7 of the ANZECC 2000. Alternative protection levels are 50 µg/L 99%, 110 µg/L 90% and 160 µg/L 80%). (9) Low reliability trigger value for 95% protection sourced from Section 8.3.7 of the ANZECC 2000. Alternative protection levels are 50 µg/L 99%, 100 µg/L 90% and 150 µg/L 80%).

4.3.6 EHMP water sampling in the Project Corridor – southern section

Water sampling has been conducted twice a year at the Oxley Creek tributaries Rocky Waterholes Creek and Stable Swamp Creek since 2007, as part of the EHMP. Data from these water quality monitoring surveys was sourced from the SEQ Healthy Waterways and DERM and assessed against the QWQG and ANZECC 2000 water quality guideline trigger values for waters in Oxley Creek tributaries (refer to **Table 4-2**).

As demonstrated in **Table 4-12** and **Table 4-13**, many water quality parameters in these surface waters do not meet the recommended water quality guideline trigger values, indicating that the overall biological health of these waterways is generally poor and water quality conditions do not meet set ecosystem health values. These results are also consistent with results from baseline water quality sampling that was conducted for this Project (**Table 4-11**). These results highlight that the aquatic health of these waterways should be maintained or improved upon, and any impacts from construction and operation of the Project should be mitigated to avoid further degradation.

Table 4-12 Historical surface water quality data for Rocky Waterholes Creek, showing whether results met with recommended water quality guideline trigger values.

Water Quality Parameter	Spring 2007	Autumn 2008	Spring 2008	Autumn 2009	WQO
pH	Met	Met	Met	Met	6.5-8.0
Dissolved Oxygen (% saturation)	Not met	Met	Not met	Not met	80-105 %
Total Phosphorus (µg/L)	Not met	Not met	Not met	Not met	<50 µg/L
Reactive Phosphorus (µg/L)	Met	Met	Met	Met	<20 µg/L
Total Nitrogen (µg/L)	Met	Not met	Not met	Not met	<500 µg/L
Oxidised N (NOx) (µg/L)	Not met	Not met	Met	Not met	<60 µg/L
Ammonia NH_3 (µg/L)	Not met	Not met	Not met	Met	<20 µg/L

*Data source: Freshwater EHMP (SEQ Healthy Waterways Partnership and DERM). Shaded cells represent values that did not meet the recommended WQO trigger values. WQOs as per QWQG or ANZECC 2000 (see **Table 4-2**).*

Table 4-13 Historical surface water quality data for Stable Swamp Creek, showing whether results met with recommended water quality guideline trigger values.

Water Quality Parameter	Spring 2007	Autumn 2008	Spring 2008	Autumn 2009	WQO
pH	Met	Met	Met	Met	6.5-8.0
Dissolved Oxygen (% saturation)	Not met	Not met	Not met	Not met	80-105 %
Total Phosphorus (µg/L)	Met	Not met	Met	Met	<50 µg/L
Reactive Phosphorus (µg/L)	Met	Met	Met	Met	<20 µg/L
Total Nitrogen (µg/L)	Met	Not met	Not met	Met	<500 µg/L
Oxidised N (NOx) (µg/L)	Not met	Not met	Met	Not met	<60 µg/L
Ammonia NH_3 (µg/L)	Met	Met	Met	Met	<20 µg/L

*Data source: Freshwater EHMP (SEQ Healthy Waterways Partnership and DERM). Shaded cells represent values that did not meet the recommended WQO trigger values. WQOs as per QWQG or ANZECC 2000 (see **Table 4-2**).*

5 Potential impacts and mitigation measures

This section addresses the potential impacts of the Project on downstream receiving surface waters in the study area and outlines strategies for protecting surface water quality. Methods for achieving nominated quantitative water quality standards and indicators are described, as well as how the potential impacts may be monitored, audited and managed. It is important to maintain or improve upon the current level of aquatic health in these ecosystems to help achieve ecological sustainability, as defined in the Sustainable Planning Act. This will also contribute to protecting Queensland's waters in the face of economic and population growth, which is listed as a major priority for the Queensland Government in the QWQG. Hydrological impacts of the Project relating to drainage, the water table, flooding, climate change and sediment movements are addressed in the *Technical Report No 4 - Groundwater Assessment* (ToR section 3.5.1) and *Technical Report No 6 – Flood Study* Report (ToR section 3.5.3).

5.1 Potential impacts to surface water quality

Surface waters of concern are those in close proximity to track work, road work, construction sites, excavation sites, spoil placement, tunnel portals, vegetation removal and other alterations to existing topography, notably where significant earthworks will occur at the initial stages of site establishment.

All creeks in the study corridor eventually flow into the Brisbane River, including some which are in close proximity to construction areas. These waters subsequently enter Moreton Bay, which contains marine protected zones and the internationally-recognised Ramsar Wetlands. Risks to the Brisbane River from the Project are anticipated to be primarily from indirect sources. For example, surface runoff and sediment input may be discharged from tributaries flowing into the Brisbane River. Risks to Oxley Creek tributaries Moolabin Creek and Rocky Waterholes Creek exist due to the location of a construction site adjacent to Moolabin Creek, the construction of new rail bridges across both creeks and significant surface works near Yeerongpilly and Clapham Rail Yard in Moorooka. Stable Swamp Creek is also at risk of receiving sediment runoff and other pollutants from nearby construction activities, which include new track work and road realignments near Salisbury rail station.

On the north side of Brisbane in Bowen Hills, significant rail infrastructure alterations and road realignments involving earthworks and drainage at RNA Showgrounds and Mayne Rail Yard have the potential to impact upon Breakfast Creek. This will need to be managed to ensure excess sediments and other contaminants do not pollute the Breakfast Creek via surface and stormwater runoff.

The surface waters potentially at risk and the proposed work to be conducted near them is outlined in **Table 5-1**. The main potential impact to surface water quality during Project construction is likely to be from sediment disturbance during earthwork activities. Potential impacts are detailed in **Section 5.1.1** to **Section 5.1.6** and may include:

- sedimentation
- disturbance of ASS (resulting in changes to pH and leaching of soluble metals)
- disturbance of contaminated soils
- introduction of litter and toxicants (eg hydrocarbons, heavy metals)
- impacts to environmental values and water flow.

Table 5-1 Surface waters in close proximity to proposed track work, road works, excavation and construction sites (north-south approach)

Surface water	Location	Work proposed	Risks
Breakfast Creek	Bowen Hills, Exhibition rail station and Mayne Rail Yard	New track work, significant rail infrastructure alterations and road realignment involving earthworks and drainage adjacent to Breakfast Creek	Indirect risks of surface runoff, sediment discharge and acidification from earthworks, construction and soil exposure/ removal/ storage/haulage. ASS and contaminated land may exist here.
York's Hollow	Victoria Park (eastern side of Inner City Bypass), Spring Hill	Northern portal and construction site, building demolition, excavation. Earthworks involve significant volumes of spoil	Indirect, low-level risks from surface runoff and sediment discharge from construction site, excavation, earthworks and spoil removal/storage/ haulage. Some areas contain potentially contaminated land.
Roma Street Parklands freshwater Lake	Roma Street	Rail station construction	Indirect, low-level risks of sediment discharge via surface runoff during construction.
Botanic Gardens ornamental ponds	Albert Street	Rail station construction and demolition of building and car park	Indirect, low-level risks of surface runoff, sediment discharge, acidification and other toxicants from construction, soil exposure and spoil removal/ storage /haulage. ASS are present in the area and potentially contaminated land exists at Lower Albert Street rail station.
Brisbane River	Roma Street rail station	Rail station construction	Indirect risks of surface runoff, sediment discharge and other toxicants from construction and spoil removal/ storage/ haulage. Potentially contaminated land exists at this site.
	Woolloongabba	Rail station construction	Indirect, risks of surface runoff, sediment discharge and other toxicants from construction and spoil removal/storage/haulage. Potentially contaminated land exists at this site.
	Fairfield	Road and footpath realignments, construction site and ventilation shaft construction approximately 600 m from river.	Indirect, low-level risks of surface runoff, sediment discharge and other toxicants from construction and spoil removal/ storage/haulage. Potentially contaminated land exists at this site.
Moolabin Creek	Yeerongpilly	South portal construction site adjacent to creek. New track work, road and footpath realignments, road construction, building demolition and/or relocation in close proximity to creek and a new rail bridge across the creek.	Direct risks of surface runoff, sediment discharge and other toxicants from demolitions, construction site, wheel wash areas, road works, earthworks, viaduct construction, utilities relocation and spoil removal/storage/haulage. Potentially contaminated land exists at this site.

Surface water	Location	Work proposed	Risks
Rocky Waterholes Creek	Clapham Rail Yard, Moorooka rail station	Track work, significant earthworks and road reconfigurations	Indirect risks of surface runoff and sediment discharge from track construction, road works and spoil removal/storage/haulage. Potentially contaminated land exists at this site.
	North of Rocklea rail station	Road realignments, intersection reconfigurations near Rocklea station and a new two-track rail bridge over the creek at Muriel Avenue	Direct risks of surface runoff, sediment discharge and other toxicants from road works, bridge construction and spoil removal/storage/haulage. Potentially contaminated land exists at this site.
Stable Swamp Creek	Salisbury rail station	New track work, road realignments and intersection reconfigurations	Indirect risks of surface runoff, sediment discharge and other toxicants from road works and spoil removal/storage/haulage. Potentially contaminated land exists at this site.
	North of Salisbury rail station	New track work and road realignments	Indirect risks of surface runoff, sediment discharge and other toxicants from road works and spoil removal/storage/haulage. Potentially contaminated land exists at this site.

5.1.1 Sedimentation and run-off

Suspended sediments are likely to have the greatest effect on water quality and have the potential to impact on other downstream receiving environments if they enter surface waters. There is potential for erosion of soil and for loose or excavated materials to drain from construction sites, excavation areas and spoil placement sites, into local stormwater systems and waterways. Potential adverse impacts associated with excessive sediment input to receiving waters include:

- turbidity (reduced water clarity and light penetration)
- changes to substrate types and blanketing of bottom substrates (impacting upon benthic organisms)
- increased nutrient concentrations eg nitrogen, phosphorus) and subsequent algal growth
- reduced dissolved oxygen
- decreased in-stream plant growth and/or increase in nuisance plant species
- reduced aesthetic qualities and recreational amenity (loss of environmental values).

Increased turbidity from sediment transport may occur in watercourses located in close proximity to construction areas, following periods of rainfall. Turbidity can settle on the creek bed, change the substrate and smother benthic organisms (Harrison, 1996). Suspended sediments can also transport contaminants and reduce light penetration, thereby influencing the ability of aquatic plants to photosynthesize and fix energy (Harrison, 1996). In Moreton Bay, excessive runoff and deposition of fine-grained sediments have previously been linked to a loss of seagrass habitat, subsequent to re-suspension of sediments (Abal *et al,* 2000).

Changes in light and nutrients are the main drivers of algal growth (EHMP, 2008). Disruption of sediments during construction may remobilise and release nutrients into nearby waterways, which can influence oxygen transfer rates, temperature and mixing regime of water bodies (ANZECC & ARMCANZ, 2000). High concentrations of nutrients such as nitrogen and phosphorus can result in the excessive growth of aquatic plants and algae, particularly nuisance species, which can have toxic effects in fresh and brackish waters, resulting in decreasing dissolved oxygen concentrations (ANZECC & ARMCANZ, 2000). Dissolved oxygen (DO) is a measure of oxygen in the water available to aquatic organisms, which require DO in particular concentration ranges for respiration and metabolism (ANZECC & ARMCANZ, 2000). DO concentration changes outside this range can adversely affect many aquatic organisms and can deteriorate the condition of sediments, potentially resulting in the release of toxicants to the water column, resulting in changes to biodiversity and reduced aesthetic qualities and recreational amenity (ANZECC & ARMCANZ, 2000).

Project activities likely to cause impacts on sediment input to local surface waters include:

- clearing of vegetation, resulting in risks of erosion and sediment loss
- excavation and earthworks associated with track works, road/footpath realignments, embankments and bridges, piling operations, tunnel activities and haulage roads
- spoil removal, stockpiling and haulage from tunnel construction.

5.1.2 Disturbance of Acid Sulfate Soils (ASS)

ASS are commonly found in low-lying coastal areas, including the Moreton region (DERM, 2008). In Brisbane, ASS is generally found below 5 m AHD (more commonly below 2 m AHD) and in Holocene sediments (organic-rich mud and silt) (BCC, 2010e). ASS is soil, sediment or rock deposits which contain elevated levels of metal sulfides which, if disturbed, react with oxygen to produce a variety of compounds and sulfuric acid, potentially releasing toxic quantities of iron, aluminium and heavy metals into the environment (DERM, 2008; Fitzpatrick *et al.*, 1996). If exposed, these products can be detrimental to the environment and cause soils to become strongly acidic, bringing their pH below 4 (DERM, 2008). Acidification of surface waters can occur naturally through leaching of organic acids, however human-induced acidification can have greater impacts on freshwater communities, due to factors other than reduced pH (such as elevated concentrations of toxic trace metals) (Greig e*t al,* 2010).

The release of toxic products associated with ASS can corrode steel and concrete, are lethal for vegetation and aquatic fauna and rapid changes in pH can result in adverse effects on the ionic balance and respiratory function of fish and aquatic invertebrates (EHMP, 2008; Harrison, 1996). For example, a study by Felten and Guerold (2006) demonstrated that short-term exposure of three freshwater macro-invertebrate species (amphipod and insect larvae) to strongly acidic water caused significant losses of haemolymph (fluids in the circulatory systems), resulting in significant mortality. Similar results have also been reported in crayfish (Jensen & Malte, 1990) and molluscs (Pynnonen, 1990). In the marine environment, toxic effects of water leached from ASS have significantly decreased the early embryonic development of oysters (Wilson & Hyne, 1997).

Project activities which may expose potential ASS to oxygen include excavation and earthworks associated with track works, road works, embankments and bridges, and spoil stockpiling. Large parcels of land in the northern section of the study corridor throughout Bowen Hills contain sediments likely to contain ASS, which is mapped in the Report on Topography, Geomorphology, Geology and Soils (ToR section 3.3.1). Construction activities at Exhibition Station and Mayne Rail Yard in Bowen Hills could potentially place Breakfast Creek at risk of pollution from surface and stormwater runoff.

5.1.3 Disturbance of contaminated soils

Contaminants are substances which are present in a part of the environment where they would not be expected and become pollutants when they start to cause negative impacts to the environment (Kebbekus & Mitra, 1998). Contaminated soils contain hazardous substances, which may pose a risk to human health and/or the environment and are managed under the EP Act 1994 (DERM, 2010a). Exposure of contaminated soils from excavation, earthworks and construction has the potential to cause adverse impacts to aquatic ecosystems if they pollute surface waters. Hazardous substances (such as oil, arsenic or DDT) can occur in soils as a result of poor environmental management and waste disposal practices, or accidental spills (DERM, 2010a).

Pollutants can harm or have toxic effects on aquatic organisms and most heavy metals are toxic to fish at low concentrations (Benejam *et al,* 2010). Waters contaminated with high concentrations of trace metals and organochlorides, eg pesticides such as DDT and PCBs, have been shown to cause deformities, eroded fins, lesions, tumours, increased occurrences of parasites and reduced reproductive traits in fish (Benejam *et al,* 2010). Adverse impacts to aquatic fauna may also include changes to metabolism, growth, and ultimately, survival (Barton *et al,* 2002; Benejam, 2010).

Petroleum is commonly found to pollute soils and aquatic ecosystems and several studies have demonstrated the toxic effects of oils on aquatic organisms (Wang *et al*, 2008; Weng *et al,* 2000). Fish may be affected by oil pollution by extracting and accumulating oil via respiration, metabolism or even feeding (Wang *et al*, 2008; Weng *et al,* 2000; Zhou *et al*, 2004). Oil contaminated soil can also reduce the reproductive abilities of aquatic organisms (eg spawn survival) and cause abnormalities and mortality in larval fish (Gonzalez-Doncel *et al,* 2008). Responses to pollutants by aquatic organisms can also vary between species, with some found to be more tolerant than others (Benejam *et al,* 2010).

Potentially contaminated soils exist throughout the study corridor, which are identified in *Technical Report No. 2 – Contaminated Land* (ToR section 3.3.2). Contaminated land in close proximity to surface waters pose a higher risk of impacting on water quality, such as land adjacent to Breakfast Creek in the northern section of the study corridor which is documented to contain potentially contaminated land (refer to *Technical Report No. 2 – Contaminated Land*). Earthworks, drainage, infrastructure alterations and spoil storage at Mayne Rail Yard have the potential to indirectly pollute Breakfast Creek if contaminated, untreated sediments enter the waterway via stormwater or surface runoff. Similarly, land containing potentially contaminated soils near the Southern Portal at Yeerongpilly, at Clapham Rail Yard and at construction sites north of Rocklea Station have the potential to directly impact the Oxley Creek tributaries Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek , due to the proximity of construction sites, new bridges, building demolition and road works to the waterways.

5.1.4 Introduction of litter and toxicants

Pollutants such as solid waste (eg packaging litter), toxic trace metals (eg mercury, cadmium, lead), hydrocarbons (eg fuels, oils, hydraulic fluids, lubricants) and associated volatile organic compounds (eg benzene, toluene, ethylbenzene, xylenes), site sewage facilities and other industrial chemicals have the potential to be spilt, leaked, carried, washed or blown from construction site equipment and vehicles into nearby surface waters. Some of these pollutants may also become bound to or absorbed by sediment.

The potential physical, chemical and biological impacts to aquatic ecosystems will depend heavily upon the type of pollutant and their concentration range. For example, trace metals occur naturally in the substrate and some are essential for healthy growth and reproduction by plants and animals, but are toxic to living organisms at certain concentrations (Harrison, 1996). The release of oil, grease and particles from construction surfaces has the potential to introduce trace metals and micro-pollutants such as polycyclic aromatic hydrocarbons (PAHs) into receiving surface waters (Meland *et al*, 2010). Several vehicle-derived chemicals, eg copper, zinc, have been shown to cause adverse impacts to fish in laboratory experiments and field studies, such as osmoregulatory problems or respiratory dysfunction, and PAHs can be carcinogenic and immunotoxic (Heier *et al,* 2009; Jonsson *et al,* 2006; Logan 2007; Meland *et al*, 2010). The introduction of litter and toxicants to surface waters will also reduce aesthetic values and recreational amenity (eg formation of oily surface films, exposed rubbish), therefore impacting upon the designated Environmental Values of the area.

All construction sites, wheel wash areas, chemical storage and site sewage facilities, haulage routes and road works have the potential to impact upon nearby surface waters during the construction phase due to the introduction of litter and toxicants. Surface waters at highest risk of being directly impacted are those located in close proximity to construction areas, such as Moolabin Creek and Rocky Waterholes Creek in the southern section of the study corridor. Other waterways may be affected indirectly by surface runoff and stormwater. During operation, the main risk to surface waters will be spillage or release of litter and toxicants such as heavy metals, petroleum hydrocarbons and PAHs from vehicles, road runoff and rail-associated machinery.

5.1.5 Impacts to environmental values

Environmental values are the key qualities important for ecosystem health and safe human waterway use. Environmental values for surface waters in the study area were identified in **Section 4.1** and potential impacts include:

- reduced aquatic ecosystem health
- protection of human health compromised
- decreased visual amenity and recreational suitability
- changes to cultural and spiritual values
- reduced suitability of surface waters for irrigation and stock watering.

5.1.6 Water flow, reuse and discharge

Water flow is specifically addressed in *Technical Report No 6 - Flood Study* Report (ToR section 3.5.3), drainage or dewatering of groundwater is addressed in *Technical Report No 4 - Groundwater Assessment* (ToR section 3.5.1) and wastewater is discussed in **Chapter 17 Waste Management** (ToR section 3.9). The construction of levee banks or stream diversions has not been proposed as part of this Project. Any works for the installation of bridges has the potential to impact on surface water flow and water quality. Waterways identified at risk of impacts from bridge construction are Moolabin Creek and Rocky Waterholes Creek in Yeerongpilly and Moorooka.

Interference or blockage of water flow in watercourses during periods of normal flow may cause changes to in-stream habitat and ecology (upstream and/or downstream). For example, if water becomes stagnant for prolonged periods, temperatures may increase, dissolved oxygen concentrations can decrease and water quality will decline, providing less desirable conditions for aquatic ecosystem health. Accelerated flow velocity or frequency can lead to creek erosion, deterioration of water quality and place stress on aquatic habitats (DERM, 2007).

The construction phase of the Project would require water to be used for a range of construction activities. Re-cycled water could be used for dust suppression, earth compaction, wash down of vehicles and equipment and production of grout and shotcrete. Any water to be reused on site, including effluent from onsite sewage treatment plants and rain water captured within tanks, has the potential to be hazardous to people and/or the environment. For example, pathogenic bacteria (eg *Salmonella*), viruses (eg *Rotavirus*) and protozoa (eg *Giardia*) may be present in sewage water and can cause human health problems such as gastroenteritis (EPHC e*t al*, 2008). Sewage effluent may also be high in salinity, which may affect surface waters and cause additional stress on aquatic organisms. Wastewater may also contain harmful chemicals such as pesticides (EPHC *at al*, 2008).

Any water to be discharged from sites during construction and operation of the Project has the potential to impact upon the aquatic environment, if water quality is not tested and assessed prior to release into receiving surface waters. Adverse impacts may occur from sudden and significant changes in water quality parameters such as salinity, pH and turbidity, or from the addition of foreign substances (eg hydrocarbons and sewage), as discussed in **Section 5.1.1** to **Section 5.1.5** of this report.

5.2 Mitigating, monitoring, auditing and managing impacts

Any impact to the existing quality of surface waters may threaten the Environmental Values and WQOs outlined in this report. Construction and operation of the Project needs to be managed to ensure that the current condition of surface waters within the study area is maintained and not significantly impacted upon. Impacts of vegetation clearing or any changes to topography and landform on the hydrology of surface waters would be avoided or mitigated where possible, and remediation measures implemented following construction.

Methods for achieving nominated quantitative water quality standards and indicators are described below, as well as how the potential impacts may be monitored, audited and managed.

5.2.1 Sedimentation and run-off

It is likely that impacts of sedimentation from this Project would be temporary and it is not expected that surface water quality would be significantly impacted upon in the long-term. However, with a total estimated *in situ* volume of 1.4 million m^3 of spoil from the Project works, approximately 2.1 million m^3 of excavated spoil will be disposed off-site, measures to avoid or minimise the release of sediments and nutrients during construction and operation of the Project would include:

- erosion, sediment, dust and stormwater controls at construction sites, wash-down areas and spoil placement sites eg containment bunds, silt traps, sediment basins and fences, sediment barriers and diversions, dust suppression, earth compaction
- Water Sensitive Urban Design (WSUD) eg swales, bioretention systems, vegetation buffers
- collection, treatment, diversion and assessment of wastewater via an approved system (on-site or off-site) to ensure pollutants do not enter local surface waters
- water quality monitoring prior to, during and subsequent to construction
- cartage, placement and storage of spoil material to be considered with regard to drainage and proximity of sediments to surface waters
- vehicle washdown prior to exiting construction sites
- placement of spoil outside known flood affected areas and not on or adjacent to creek banks
- monitoring sediment measures to ensure they are working effectively
- identifying and controlling erosion as soon as possible

- restoration and rehabilitation, particularly where new waterway crossings are constructed and where any creek banks are impacted eg Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek.

In addition to sediments being controlled directly from their source, the use of barriers such as vegetated buffer strips can help with channel stability and act as a filter for sediments and nutrients (Barling & Moore, 1994). The use of bioretention systems (eg swales) will promote a higher degree of stormwater treatment by facilitating infiltration of stormwater through particular types of soil media (Wong, 2006). Use of vegetation in bioretention systems is important, because plant roots support a wide range of bacteria (useful in water health) and they can increase the physical trapping and biological uptake of nutrients and water (Wong, 2006). Replacement of traditional piped drainage with swales, vegetated drainage channels and preservation of natural waterways can reduce changes in the rates of runoff and pollutants, improve low-flow water quality, preserve instream ecological values and reduce the possibility of erosion (DERM, 2007). The inclusion of such measures into the urban landscape will also enhance visual and recreational amenity values (Wong, 2006).

A soil, erosion and sediment control management plan would be implemented to address items such as dust suppression, overland flow drainage paths, location of vegetated buffer strips, temporary drainage controls, excavation and location of soil stockpiles and to identify who is responsible for establishing and maintaining all erosion and sediment measures (SEQHWP, 2010).

Where bridges or embankments are constructed, they would be designed to minimise impacts on water quality (eg placement of viaduct pilings across Moolabin Creek and bridge construction above Rocky Waterholes Creek). Appropriate management and maintenance of exposed ground surfaces during construction and in the period immediately following construction would need to be undertaken, to minimise sediment runoff following rainfall events and allow new vegetation to establish. Mitigation measures would help to trap and filter sediments, reduce the velocity of runoff and reduce potential sedimentation impacts.

A water quality monitoring program at sites in close proximity to construction would be implemented, in order to monitor and audit the impacts of construction-related sediment runoff and other pollutants. This program would be undertaken prior to, during and after construction and results analysed against the WQOs established by ANZECC & ARMCANZ (2000) and the QWQG (DERM, 2009b) or other developed site-specific guidelines. Results from water quality monitoring programs already in place such as the EHMP or the Brisbane Local Waterway Health Assessment surveys may also be useful for auditing and managing the potential impacts on surface water quality.

5.2.2 Disturbance of Acid Sulfate Soils

Land in the study corridor with low potential for ASS to be present is mapped in **Figure 7-15** of **Chapter 7 Topography, Geology, Geomorphology and Soils** (ToR section 3.3). This includes land surrounding Breakfast Creek in Bowen Hills, where significant earthworks will occur for construction of new tracks, rail infrastructure and road realignments at Exhibition station and Mayne Rail Yard. **Chapter 7 Topography, Geology, Geomorphology and Soils** also provides information on hazards and mitigation measures relating to ASS.

Analysis of the potential extent and severity of ASS in construction areas that are in close proximity to surface waters and Project infrastructure would be undertaken, so relevant mitigation measures can be implemented prior to construction. Investigations would be undertaken in accordance with relevant guidelines, such as the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al.* 2004), the *State Planning Policy 2/02: Planning and Management Development Involving Acid Sulfate Soils* (DIP & DERM, 2002) and the BCC's *Acid Sulfate Soil Planning Scheme Policy* (BCC, 2010e). Mitigation measures may include avoiding exposure of known ASS, which can cause the soils to oxidise and produce sulfuric acid (BCC, 2010e). Additional mitigation measures for ASS relate to protecting nearby surface waters from polluted runoff, as addressed in **Section 5.2.1**.

5.2.3 Disturbance of contaminated soils

Known and potentially contaminated land parcels and mitigation measures at sites where contamination has been identified are provided in *Technical Report No. 2 – Contaminated Land* (ToR section 3.3) and **Chapter 24 Draft Outline EMP**. Part 8 of the EP Act provides information on managing contaminated land, including site management plans for dealing with environmental harm hazardous contaminants may cause.

Further information on the management, environmental impacts, assessment and disposal of contaminated land can be found in the *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland* (DERM, 2010a). Other information (eg historic and current land use, land contaminated by a hazardous substance which may cause serious environmental harm) can be found in the Environmental Management Register (EMR) and the Contaminated Land Register (CLR) (DERM, 2010a). Particular attention would paid to topography, drainage, seepage and the proximity of contaminated soils to surface waters, as well as cartage, placement and storage of contaminated soils (refer to *Technical Report No. 2 – Contaminated Land).*

5.2.4 Introduction of litter and toxicants

WSUD measures to divert or treat contaminated waters prior to runoff into receiving surface waters would be included in the design phase before construction begins, consistent with BCC's *Water Sensitive Urban Design Guidelines: stormwater* (BCC, 2010f), BCC's *Sediment Basin Design, Construction and Maintenance Guidelines* (BCC, 2001) and the *Queensland Urban Drainage Manual* (DERM, 2007). Construction sites will need to be appropriately handled, stored and managed to prevent pollutants such as trace metals, hydrocarbons and other on-site chemicals from entering surface waters. Wastewater produced from toilets and washroom facilities at construction sites must be treated or prevented from being exported to drainage channels and surface waters. Other mitigation measures would include:

- implementation of sound chemical/fuel storage, handling practices and spill prevention measures
- ensuring that equipment and vehicles are inspected, well maintained and that any leaks are repaired immediately
- provision of emergency procedures, equipment and contingency plans for the containment and cleanup of accidental spills to ensure rapid and effective response in the event of a spillage or other emergency
- integrity of site drainage systems ensured, to reduce accidental spillages, including attention to areas used for vehicle or equipment washing or fuelling
- storage of any toxic substances is conducted in a safe and secure manner, where leaks or spills cannot occur
- waste storage and removal is carried out in accordance with all legal requirements
- wastewater is collected and treated via an approved on-site system or removed for off-site disposal
- culverts and drainage structures are maintained to prevent the build-up of excess solids
- Stormwater Quality Improvement Devices (SQIDs) (eg gross pollutant traps, gully pit baskets and nets) to prevent pollution of surface waters and filter stormwater during the operational phase and, if deemed necessary, during construction.

5.2.5 Environmental values

Measures to maintain sufficient quality of surface waters to protect existing beneficial downstream uses of those waters must be applied to all phases of the Project. As described in the EPP (Water), surface waters should not be polluted with materials that may settle to obstruct waterways, form floating debris and visible oil/scum slicks, produce an unpleasant colour/odour or cause adverse impacts to aquatic life. Indigenous and non-indigenous cultural heritage should be protected or restored. Rehabilitation plans would be designed to ensure relevant environmental values are addressed. Surface water monitoring programs would be conducted to help audit, monitor and manage potential impacts to environmental values.

5.2.6 Water flow, reuse and discharge

Water flow is specifically addressed in the *Technical Report No 6 – Flood Study* (ToR section 3.5.3) and drainage or dewatering of groundwater is addressed in *Technical Report No 4 – Groundwater Assessment* (ToR section 3.5.1). Where in-stream works are conducted for the installation of bridges, impacts would be managed to minimise disturbances to natural flow and subsequently water quality.

Temporary water treatment facilities would be provided at the Yeerongpilly, Boggo Road and Woolloongabba worksites. A risk management approach would be adopted for the re-use of any water captured on site, including effluent from onsite sewage treatment plants and rain water captured within tanks, as per *The Australian Guidelines for Water Recycling* (EPHC *et al*, 2008). These guidelines provide a mechanism for the assessment and use of recycled water to occur consistently across Australia. They involve assessing the hazards, estimating the likelihood and significance of impacts and implementing preventative measures to avoid the risks (EPHC *et al*, 2008).

Water Sensitive Urban Design (WSUD) aims to use water in a resource-sensitive and ecologically sustainable manner, by integrating urban stormwater, water supply and wastewater issues into the planning and design phase of development (DERM, 2007). This can be achieved by minimising wastewater generation, treating wastewater to a standard suitable for re-use opportunities and/or release to receiving waters, harvesting stormwater runoff and implementing bioretention systems for stormwater filtration (Wong, 2006). Implementation of WSUD options may help to reduce changes to the volume, rate, frequency and duration of runoff, as well as reduce changes to the export of pollutants, improve low-flow water quality and reduce the likelihood of waterway erosion/expansion (DERM, 2007). WSUD approaches are applicable to the construction and operational phases of the Project. WSUD measures applied to the construction phase will be primarily for mitigating erosion and controlling sediment and drainage (EPA, 2007). Measures applied to the operational phase seek to mitigate cumulative impacts, by reducing runoff volumes and stormwater pollution via natural systems for infiltration, evapotranspiration and the reuse of urban stormwater (EPA, 2007). These measures may include natural drainage structures, engineered swales and vegetated contours for runoff (EPA, 2007). The design and construction of new roads would also aim to utilise Water Sensitive Road Design (WSRD) principles, by incorporating stormwater detention/retention, treatment and pollution containment systems, appropriate street design and by minimising the extent of impervious surfaces (DERM, 2007).

Groundwater in the vicinity of Roma Street and Woolloongabba stations may have some contamination that would require the ingress water collected from the tunnels and stations in these locations to require some level of water treatment. The precise contaminants and their concentration in the ground water are not known at this stage and consequently the water treatment plant cannot be accurately specified. However, an allowance has been made for two water treatment plants, one at each of the two station locations. The outfalls from the water treatment plants would be discharged to the stormwater drainage system. All discharge pipes would be appropriately sized at detailed design stage to accommodate the volume of discharged water.

Drainage structures, settlement ponds and water treatment facilities would be implemented as necessary and controlled discharges would be treated before release to receiving surface waters, in accordance with the ANZECC & ARMCANZ Water Quality Objectives for surface waters (as outlined in **Section 4.1**), and the Australian Guidelines for Water Recycling. Any uncontrolled discharges of water would be avoided and, if they occur, stopped as soon as possible. For waste water discharge to aquatic ecosystems that are recognised as '*slightly to moderately disturbed*', as per the EPP (Water) *Operational Policy for Waste Water discharge to Queensland waters* and in accordance with the EP Act, management actions should:

- maintain the current water quality where existing water quality is better than the scheduled WQOs
- maintain water quality where existing water quality corresponds to the scheduled WQOs
- improve the water quality and prevent further degradation where existing water quality is of a lower quality than the scheduled WQOs. Attainment of the scheduled WQOs would be sought through continual improvement over time and may be a long-term goal.

Stormwater treatment techniques would follow the NWQMS management hierarchy (ANZECC & ARMCANZ, 2000) for protecting water quality, which is:

a) retain, restore or rehabilitate valuable ecosystems

b) source control through non-structural measures (eg pollution prevention)

c) source control through structural measures (eg screening solids/litter/debris; isolating hydrocarbons, chemicals and other toxicants through physical entrapment; separating layers of substances such as sediments and oil; filtration; adsorption; flocculation; infiltration; oxidation)

d) use regional in-stream treatment measures.

Ideally, a combination of different treatment measures is recommended (DERM, 2007). It is also proposed that monitoring of stormwater management measures be conducted at work sites (especially during/after heavy rainfall events).

5.2.7 Water quality monitoring

A water quality monitoring program would be established during construction to ensure compliance with WQOs (in accordance with the QWQG, NWQMS and ANZECC 2000) and to enable potential impacts to surface water to be assessed, mitigated and managed (refer to **Chapter 24 Draft Outline EMP)**. This would involve the collection and analysis of surface water samples at selected locations in the Project corridor, where construction sites are in close proximity to waterways. This would include (but not be limited to), Stable Swamp Creek and Rocky Waterholes Creek near Clapham Rail Yard, Moolabin Creek adjacent to Yeerongpilly construction site and Breakfast Creek near Mayne Rail Yard. The monitoring program would also identify potential sources of pollution during construction.

Water quality parameters that would be measured include pH, conductivity, DO, turbidity, trace metals, hydrocarbons and nutrients. Targeted baseline monitoring of receiving waters for these attributes would be conducted prior to construction, to identify baseline water quality conditions. Monitoring data can be used to assess the potential impact of construction and operational phases of the Project. A reactive management plan would be developed, so that procedures for reporting non-conformances can be conducted via the relevant authority or on-site environmental officer, to ensure that corrective action occurs immediately. Monitoring would also include regular visual inspections of drainage channels and surface waters within and near construction areas, particularly after periods of rainfall to monitor sediment runoff, erosion, waste (eg litter, oil), debris and ponding (potential mosquito breeding habitat).

During the operational phase of the Project, a long-term water quality monitoring program would be implemented, to assess and manage the potential cumulative impacts to surface waters (refer to **Chapter 24 Draft Outline EMP)**.

6 Summary

The existing environment for surface water quality that may be affected by the Project has been described, in the context of environmental values as defined in local, state and/or national legislation, policies and planning documents.

The major waterways in the study corridor are the Brisbane River and Enoggera/Breakfast Creek. Smaller waterways include Oxley Creek and its tributaries Moolabin Creek, Rocky Water Holes Creek and Stable Swamp Creek. Kedron Brook and Norman Creek were included in this report because their catchment boundaries extend inside the study corridor. Other surface water features in the study corridor include the City Botanic Gardens ornamental ponds, Roma Street Parklands freshwater lake and York's Hollow. Bundamba Creek was included based on the assumption that spoil placement will occur at Swanbank.

Table 6-1 provides an overview of these waterways (north-south approach), their location relative to the study corridor, and how these waterways may be implicated with the Project. **Figure 8-1** (**Appendix A**) contains site photographs of selected surface waters which intercept the study corridor.

Table 6-1 Surface waters in the study area – location in the study corridor and implications for the Project (north-south approach)

Surface waters	Locality in relation to study corridor	Project Implications	Potential Impacts
Kedron Brook	Outside	Negligible. Low risk of surface runoff if construction occurs near Wooloowin.	Indirect
Breakfast/ Enoggera Creek	Intercepts	Risk of surface runoff and sediment discharge from construction sites. Creek is in close proximity to earthworks involving new tracks and road realignments in Bowen Hills at Exhibition Park station and Mayne Rail Yard.	Indirect
York's Hollow	Intercepts	Minor risk of surface runoff and sediment discharge from construction. Construction at the north portal in Spring Hill could potentially enter York's Hollow, from which overflow eventually drains into Breakfast Creek.	Indirect
Roma Street Parklands freshwater lake	Intercepts	Minor risk of surface runoff and sediment discharge from construction sites at Roma Street Station, which is near The Parklands.	Indirect
City Botanic Gardens ornamental ponds	Intercepts	Minor risk of surface runoff and sediment discharge from construction at Albert Street rail station, which is in close proximity to the City Botanic Gardens.	Indirect
Brisbane River	Intercepts	Risk of surface runoff and sediment discharge from construction. Tunnelling will occur underneath this waterway, however all waterways in the study area flow into the Brisbane River. Road realignments, a construction site and ventilation shaft construction will occur approximately 600 m from the River in Fairfield and construction of the Roma Street rail station will occur approximately 300 m from the River.	Indirect
Norman Creek	Outside	Negligible. Low risk of surface runoff and sediment discharge from construction.	Indirect

Surface waters	Locality in relation to study corridor	Project Implications	Potential Impacts
Moolabin Creek	Intercepts	High risk of surface runoff and sediment discharge from construction. Moolabin Creek is adjacent to the construction site and in very close proximity to significant earthworks, new track work, road realignments and road construction at Yeerongpilly. A new bridge will be built across this waterway.	Direct
Rocky Waterholes Creek	Intercepts	High risk of surface runoff and sediment discharge from construction. Rocky Waterholes Creek is in very close proximity to significant earthworks, track work, road realignments and intersection reconfigurations near Rocklea rail station and Clapham Rail Yard at Moorooka. A new two-track rail bridge will be built over Muriel Avenue.	Direct
Stable Swamp Creek	Intercepts	High risk of surface runoff and sediment discharge from construction. Stable Swamp Creek is in very close proximity to new track work, road realignments and intersection reconfigurations near Salisbury rail station.	Indirect
Oxley Creek	Outside	Risks of secondary runoff and sediment discharge from construction as a result of tributaries Moolabin Creek, Rocky Waterholes Creek and Stable Swamp Creek, which are in very close proximity to construction works in the southern section of the study corridor and flow to Oxley Creek.	Indirect
Bundamba Creek	Outside	Negligible, spoil placement within the Bundamba Creek catchment.	Indirect

Risks to surface waters from the Project include:

- stormwater runoff and loss of sediments, leading to increased turbidity and release of nutrients
- disturbance of ASS (resulting in changes to pH and leaching of soluble metals)
- disturbance of contaminated land, resulting in the introduction of pollutants
- introduction of litter, trace metals, hydrocarbons, site sewage and other chemicals
- loss of environmental values.

Key mitigation measures to protect surface water quality include:

- runoff, erosion and waste controls at construction and spoil placement sites
- maintenance of culverts and drainage structures
- Water Sensitive Urban Design
- Stormwater Quality Improvement Devices
- safe and secure handling, storage and disposal of substances to avoid leaks or spills
- emergency/spill contingency plans, reporting procedures and equipment
- treatment, assessment and re-use of wastewater and discharges in accordance with relevant WQOs, standards and policies
- uncontrolled discharges of wastewater avoided, reported and remediated
- water quality monitoring and reporting programs established
- post construction restoration and remediation implemented.

Further details of these management measures are provided in **Chapter 24 Draft Outline EMP**.

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Appendix A Site photographs

(a) **Moolabin Creek**, Chale Street crossing Yerongapilly.

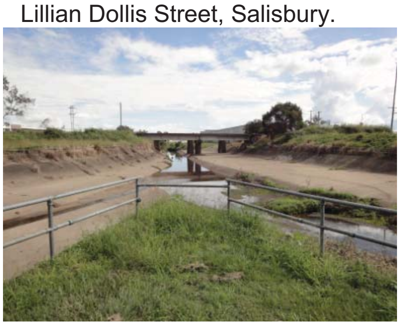
(b) **Rocky Waterholes Creek rail crossing**, Sherwood/Fairfield Roads, Rocklea.

(c) **Rocky Waterholes Creek**, upstream at Muriel Avenue, Salisbury.

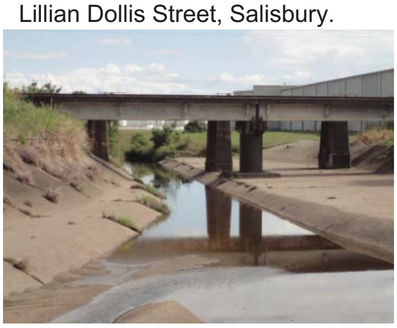
(d) **Stable Swamp Creek**, Lillian Dollis Street, Salisbury.

(e) **Stable Swamp Creek**, Lillian Dollis Street, Salisbury.

(f) **Stable Swamp Creek**, Musgrave Road, Salisbury.



(g) **Stable Swamp Creek rail crossing**, Musgrave Road, Salisbury.



(h) **Stable Swamp Creek rail crossing**, Musgrave Road, Salisbury.

(i) **York's Hollow**, Victoria Park, Herston.

(j) **Stormwater overflow drain** near York's Hollow, Herston.

SINCLAIR KNIGHT MERZ
SKM aurecon
CRR JOINT VENTURE