Draft for public consultation

Draft Black Ross (Townsville) Water Quality Improvement Plan

Improving Water Quality from Creek to Coral

June 2009

Queensland Government

Australian Government

City of Townsville

This publication was funded by the Australian Government's Coastal Catchments Initiative through the Department of Environment, Water, Heritage and the Arts.

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creek to coral
our waterways – our responsibility

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Forward

To be added after incorporation of comments from the public consultation phase.

Acknowledgements

The Black Ross Water Quality Improvement Plan (WQIP) was developed by the Townsville City Council, through its Creek to Coral initiative, which is a partnership between Council, Government and the community. The WQIP was developed with funding assistance from the Australian Government's Coastal Catchments Initiative (CCI), through the Department of Environment, Water, Heritage and the Arts.

Development of the WQIP was guided by a Steering Committee of key stakeholders from government, industry, non-government organisations and the scientific community. Members contributed their time and expertise, and provided valuable information and feedback throughout the development process. Members of the Steering Committee were Jon Brodie (ACTFR), Niall Connolly (DERM/EPA), Melinda Louden/Anna Skillington (TPA), Peter Verwey/Ian Sinclair (DERM/NRW), Jane Waterhouse (CSIRO), Alan Walker/Clint Burgess (TCC), Jos Hill/Marie-Lise Schlappy (Reef Check Australia), Allan McManus (Defence), Adam Sadler/Ben Daniel (TCC), Margaret Gooch (JCU), Evan Kruckow/Greg Willcox (CVA), Scott Crawford/Ian Dight/Sarah Connor (NQDT) and Iony Woolaghan (DPI&F)

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Photos are acknowledged as Townsville City Council unless otherwise stated.

Chris Manning

Have Your Say - Comments Please

The Draft Black Ross Water Quality Improvement Plan (WQIP) isn't finished yet because we don't have your comments. Townsville City Council, through the Creek to Coral initiative, has developed the draft WQIP with the to inform the draft Black Ross WQIP, but we don't think that we know it all.

Your comments on the draft WQIP and the background reports will help us finish this part of the process to improve water quality in our streams, estuaries and the Great Barrier Reef lagoon. The background reports and the draft WQIP can be viewed on the Creek to Coral website at:

www.creektocoral.org/draftwqip

Please take the time to look at the draft documents and provide comments so we can improve the final products. As you will see from the adaptive planning and management approach in the draft WQIP this is not the final WQIP rather the start of an ongoing process that can only work effectively with community input and ongoing action. That includes continually updating the WQIP and actions as we learn about what works and what doesn't.

To make commenting a bit easier we have prepared a feedback form for your use which is available to download from the Creek to Coral website. Feel free to add supporting information or additional notes and please provide your contact details so that we can discuss any comments with you if necessary.

Please address all comments to Chris Manning at:

Email: creektocoral@townsville.qld.gov.au (best option)

Post: PO Box 1268, Townsville 4810

Delivered: TCC Administration Building, Walker Street (Integrated Sustainability Services office)

If you have any questions please contact Chris on 47279000

Feel free to add supporting information or additional notes and please provide your contact details so that we can discuss any comments with you if necessary.

Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Annual recurrence interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AWQG	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000*
AWR	Australian Water Resources (Council) – River basins
C2C	Creek to Coral
DERM	Department of Environment and Resource Management (combined DNRW and EPA)
DNRW	Department of Natural Resources and Water (Queensland Government)
DPIF	Department of Primary Industries and Fisheries (Queensland Government)
ESD	Ecologically Sustainable Development
EPA	Environmental Protection Agency (Queensland Government)
EPP Water	*Environmental Protection (Water) Policy 1997*
EP Act	*Environmental Protection Act 1994*
ERA	Environmentally Relevant Activity
EVs	Environmental Values
GBR	Great Barrier Reef
GBRC	Great Barrier Reef Catchment
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
HEV	High Ecological Value
IDAS	Integrated Development Assessment System
IP ACT	*Integrated Planning Act 1997*
LGAQ	Local Government Association of Queensland
NPI	National Pollutant Inventory
NRM	Natural resource management
QA	Quality Assurance
TBL	Triple Bottom Line
TCC	Townsville City Council
WG	Working Group
WQ	Water Quality
WQG	Water Quality Guideline
WQOs	Water Quality Objectives
WSUD	Water sensitive urban design

1. Introduction

1.1 Why We Need to Protect Water Quality

There are many pressures impacting water quality throughout Australia with some of the more intense pressures arising from the relatively concentrated human population and associated industry and infrastructure in our coastal areas. Where does the rainwater go after it leaves your backyard in Townsville? It usually finds it way to the nearest creek and then heads downstream and flows to meet the waters of the Great Barrier Reef.

The Great Barrier Reef – Worth Protecting

The Great Barrier Reef Marine Park (GBRMP) is almost 350,000 square kilometres in area and is located along 2,100 kilometres of the Queensland coastline, spanning 14 degrees of latitude. The Great Barrier Reef (GBR) is a complex maze of about 2900 separate coral reefs accounting for around 6% of the area of the Great Barrier Reef Marine Park.

"*The Great Barrier Reef is renowned internationally for its ecological importance and the beauty of its seascapes and landscapes. These natural values also provide important ecosystem services, which underpin Australian $6.9 billion worth of economic activity and incalculable social values. In combination, the social-ecological system centred on the reef is extraordinary in its importance, and in its complexity*"

"*About 36 percent of the Great Barrier Reef Marine Park is continental slope, where the water is between 150 and 2000 metres deep. The remaining 64 percent is continental shelf, including the coral reefs, which is anywhere from 1 to 150 metres deep. The other main geographical components of the continental shelf are the inter-reef areas (25% of the Marine Park) and the lagoon (33%)*".

"*Within these major geographic divisions of the Great Barrier Reef are many different types of habitat and biological community. The best known of these are the coral reefs, but there are also seagrass beds, algal meadows, sponge and soft coral gardens, sandy and muddy areas, mangrove forests and islands. This array of habitats supports an amazing biodiversity*" (Johnson and Marshall (eds) 2007, pp.2-3).

The quality of water in the GBR lagoon is important to the maintenance of the habitats and amazing biodiversity of the GBRMP, and especially of the near shore areas. The water quality of the GBR is impacted by the quality of water entering the GBRMP from the catchments stretching the 14 degrees of latitude from Cape York to the Burnett-Mary catchment. Collectively known as the GBR catchments, the activities that take place on this land mass ultimately have significant impacts on the quality of water of the GBR. The Black and Ross River Basins are part of the GBR catchment and Townsville is home to the largest urban population in the GBR catchments.

A report released by the Great Barrier Reef Marine Park Authority in 2001 significantly raised the profile of water quality issues associated with the GBR. The report, *Great Barrier Reef catchment water quality action plan: A report to Ministerial Council on targets for pollutant loads* (Brodie et al 2001), generated a great deal of debate opening with the statement "*Decades of scientific research and evaluation has now clearly and unequivocally established that land use activities in the catchments adjacent to the Great Barrier Reef are directly contributing to a decline in water quality*" (Brodie et al 2001, p.i). We are all part of that land use activity.

1.2 Water Quality Protection Initiatives

To manage water quality in our populated coastal regions requires a joint effort at all levels of government in partnership with industry and the community. A variety of water quality improvement initiatives are being implemented throughout Queensland and Australia at different scales and with a range of objectives. The health of the Great Barrier Reef (GBR) has been the focus of water quality improvement for the GBR catchments in recent times with support from the Commonwealth government, State agencies and an array of land managers and community members within the catchments of the Great Barrier Reef.

1.2.1 Reef Plan – It's About the Reef and the Land

The Reef Water Quality Protection Plan (Reef Plan) is an initiative of the Australian and Queensland governments, in partnership with industry and the community. The Plan was released in 2003 in response to concerns over declining Great Barrier Reef (Reef) water quality resulting from land-based activities in the Reef catchment. The goal is to halt and reverse the decline in water quality entering the Reef within ten years.

The objectives of the Reef Plan are:

- A reduction of the load of pollutants from diffuse sources in the water entering the Reef;
- Rehabilitated and conserved areas of the Reef catchment that have a role in removing water borne pollutants.

To achieve these objectives the Reef Plan focuses on the following:

- Provide priorities for actions and investment based on the best available science and a risk management approach to achieve the greatest improvement in Reef water quality;
- Provide a foundation for Regional NRM bodies and other stakeholders to develop and achieve water quality improvement targets for rivers discharging into the Reef;
- Promote and facilitate the adoption of sustainable production systems that improve the quality of water entering the Reef;
- Enhance co-operative partnerships to develop cost effective short and longer-term measures that can improve the quality of water entering the Reef; and
- Establish a science-based performance monitoring and evaluation program to support a responsive and adaptive management regime for the Reef Plan.

The Reef Plan is an umbrella plan designed to integrate and coordinate action on Reef water quality by government agencies and a wide range of industry and community groups. It consists of nine main strategies and sixty-four subservient actions. One such action (Reef Plan Action D4), promotes the development of water quality improvement plans by local governments and regional NRM bodies.

1.2.2 Coastal Catchments Initiative and Water Quality Improvement Plans

The Coastal Catchments Initiative (CCI) is an Australian Government funded program aimed at achieving targeted reductions in pollution discharges to coastal water quality 'hot spots'. Hot spots, in this context are coastal waters with high conservation value and are threatened by pollution from various sources. The receiving waters of the Great Barrier Reef lagoon are considered to be one such hot spot.

The CCI supports the development and implementation of Water Quality Improvement Plans (WQIP) in accordance with the Australian Government's Framework for Marine and Estuarine Water Quality Protection. The Framework is based on the National Water Quality Management Strategy and the National Principles for the Provision of Water for Ecosystems; both approved by Australian Government/State Ministerial Councils.

WQIPs will identify the most cost-effective and timely projects for investment by all parties, including the Australian, State and Local Governments, industry and the community. The Australian Government targets projects that are most likely to deliver cost-effective water quality improvements and through an assurance from the respective jurisdictions, ensure that these improvements are sustained into the future.

The development of WQIPs in the Great Barrier Reef catchment will help local governments and regional Natural Resource Management (NRM) bodies determine environmental values and water quality objectives for waterways in their catchment. Once developed, WQIPs will be integrated with regional NRM plans and other relevant planning processes to ensure ongoing implementation and achievement of objectives, including water quality objectives for the GBR lagoon (Source: www.environment.gov.au/coasts/pollution/cci/index.html).

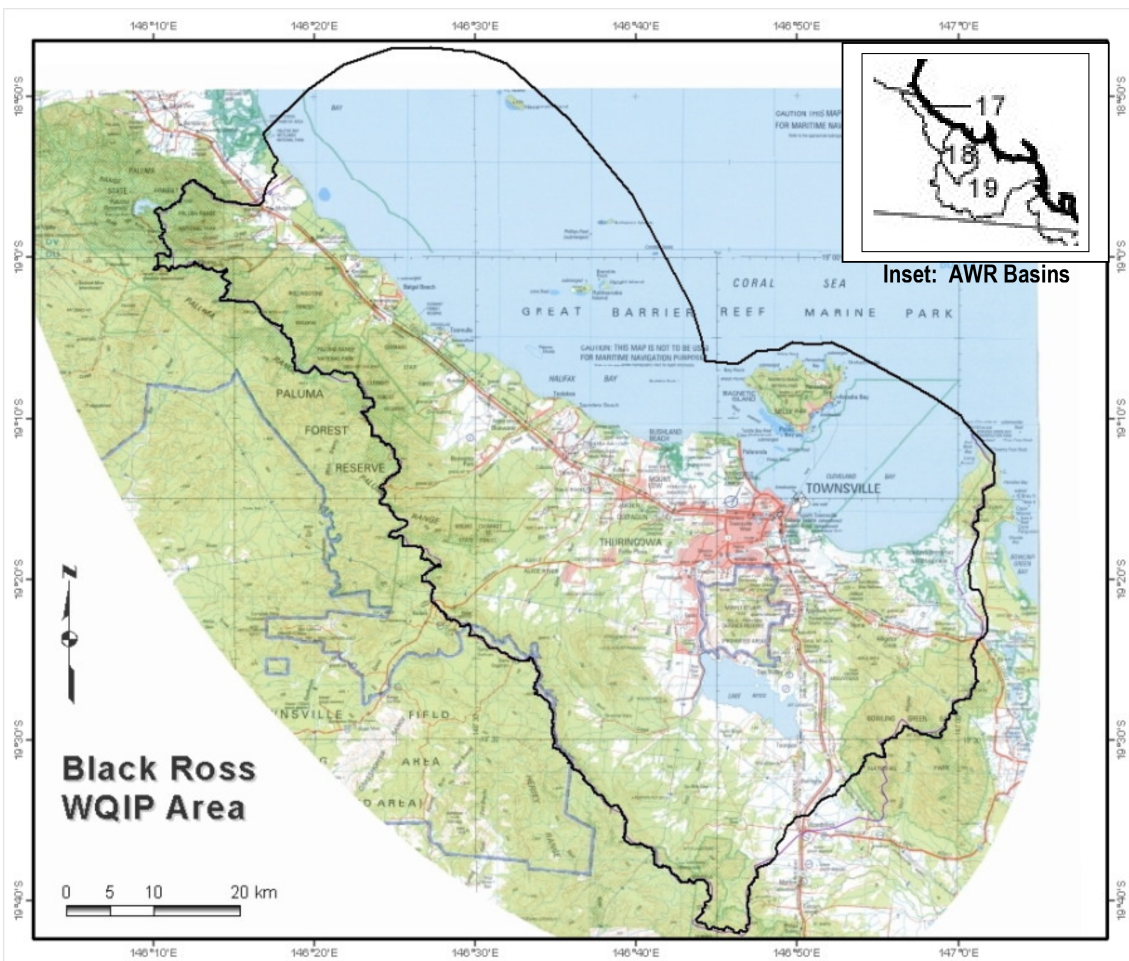
1.2.3 WQIPs in the Great Barrier Reef catchment

WQIPs have been developed for the (former) Douglas Shire, the Mackay Whitsunday NRM region, the Tully and Murray River Basins, and the Burdekin and Haughton Basins (draft). WQIPs are also being prepared for parts of the Burnett/Mary NRM region and the Barron River Basin (Cairns).

1.2.4 Black and Ross Basins WQIP Area

The Black/Ross WQIP area covers most waterways within the Townsville City local government area with the exception of the Reid River and Major Creek catchments, which are part of the Haughton River Basin.

Figure 1-1 Black/Ross WQIP Area



The WQIP area includes the Black River (No. 17) and Ross River (No. 18) Australian Water Resource Council (AWR) Basins and a small part of the Haughton River Basin (No. 19) where the waterways flow to Cleveland Bay. It also includes Magnetic Island, as well as the coastal and marine waters of Cleveland Bay and Halifax Bay (see Figure 1-1 and Figure 2-1).

1.2.5 Creek to Coral

Creek to Coral is managing the CCI project for the Black and Ross River Basins and, with the assistance of its many partners, is responsible for the preparation of a Water Quality Improvement Plan (WQIP).

Townsville and Thuringowa City Councils established the Creek to Coral initiative in 2003 in partnership with the Queensland Environmental Protection Agency (EPA) and supported by the Great Barrier Reef Marine Park Authority (GBRMPA). The Creek to Coral initiative is a locally adapted version of the South East Queensland (SEQ) Healthy Waterways Program and emphasises local concerns and issues in an environmental context that is relevant to the Townsville Dry Tropics adjacent to the Great Barrier Reef.

The Creek to Coral concept is simple and all encompassing whereby creek applies to the top of the catchment and relates to freshwater, all the way through to more estuarine waterways which ultimately lead to the Great Barrier Reef, hence the choice of the word coral (For further information visit www.creektocoral.org.au).

1.3 Water Quality Improvement Plan Development

The development of the Black/Ross WQIP by Creek to Coral was guided by a Steering group comprising representatives from the main stakeholder groups in the Townsville region (see Acknowledgement page). Consultation involved the Steering group, technical panels and working groups, and community involvement (see Figure 4-2). The key components of the WQIP, involving the preparation of background reports and consultation included (see Figure 1-2):

- Gathering background information including identifying issues and threats;
- Defining draft environmental values and water quality guidelines;
- Setting water quality objectives (targets) for protecting environmental values;
- Identifying management options to achieve targets and determining the most cost effective actions;
- Preparing an implementation plan with a reasonable assurance statement; and
- Developing agreed adaptive management strategies and WQIP evaluation frameworks.

1.3.1 Complementary Components of the Black/Ross WQIP

The development of the Black/Ross Water Quality Improvement Plan (WQIP) was underpinned by a number of complementary components of the ongoing Creek to Coral program. The two main components are briefly described below.

I. Water quality monitoring and modelling program

Results from the water quality monitoring and modelling program have been used as input to inform the WQIP.

- An integrated water quality monitoring programme including event monitoring in 2006/2007 and 2007/2008 ‘wet seasons’;
- Sediment monitoring post 2007/2008 wet season;
- Modelling to establish pollutant loading;
- Identification of complementary elements between the WQIP, the Stormwater Management Framework for Townsville and Water Sensitive Urban Design (WSUD);
- Establishment of a report card format outlining catchment condition.

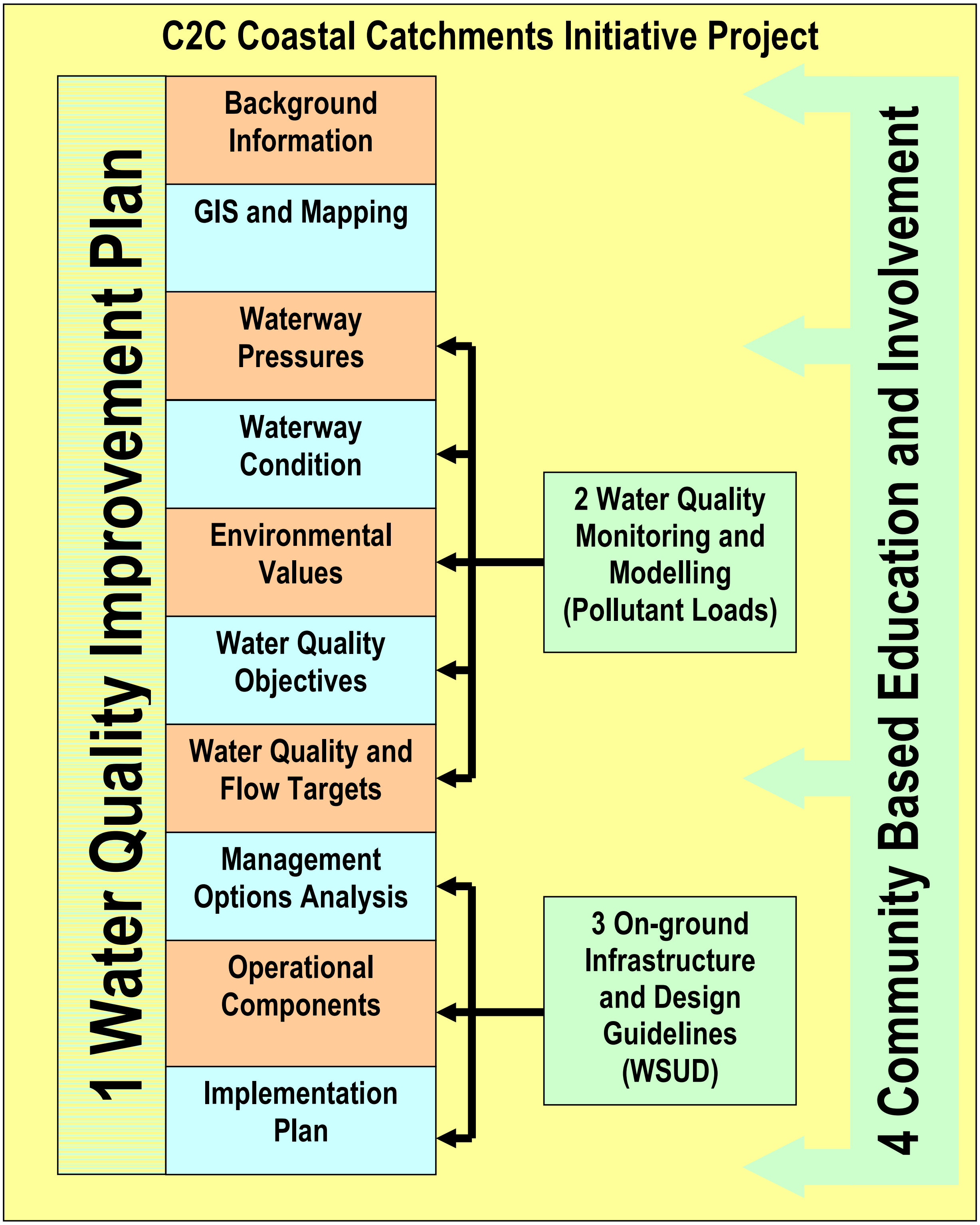
II. Support for the Strategic Partnership Approach and the Community Based Education and Involvement (CBEI) Network

The main elements of this task included:

- Establishment of a central communication and information exchange forum based web portal;
- Support for the Creek to Coral Community Based Education and Involvement (CBEI) program and network including Citischools, Creekwatch, Reefcheck, Seagrass Watch, and Reef Guardian Schools through the Sustainable Education Network (SEN). Community involvement opportunities (e.g. catchment tours), community events and school curriculum input;
- Development of a stakeholder consultation strategy;
- Behaviour change investigations and training.

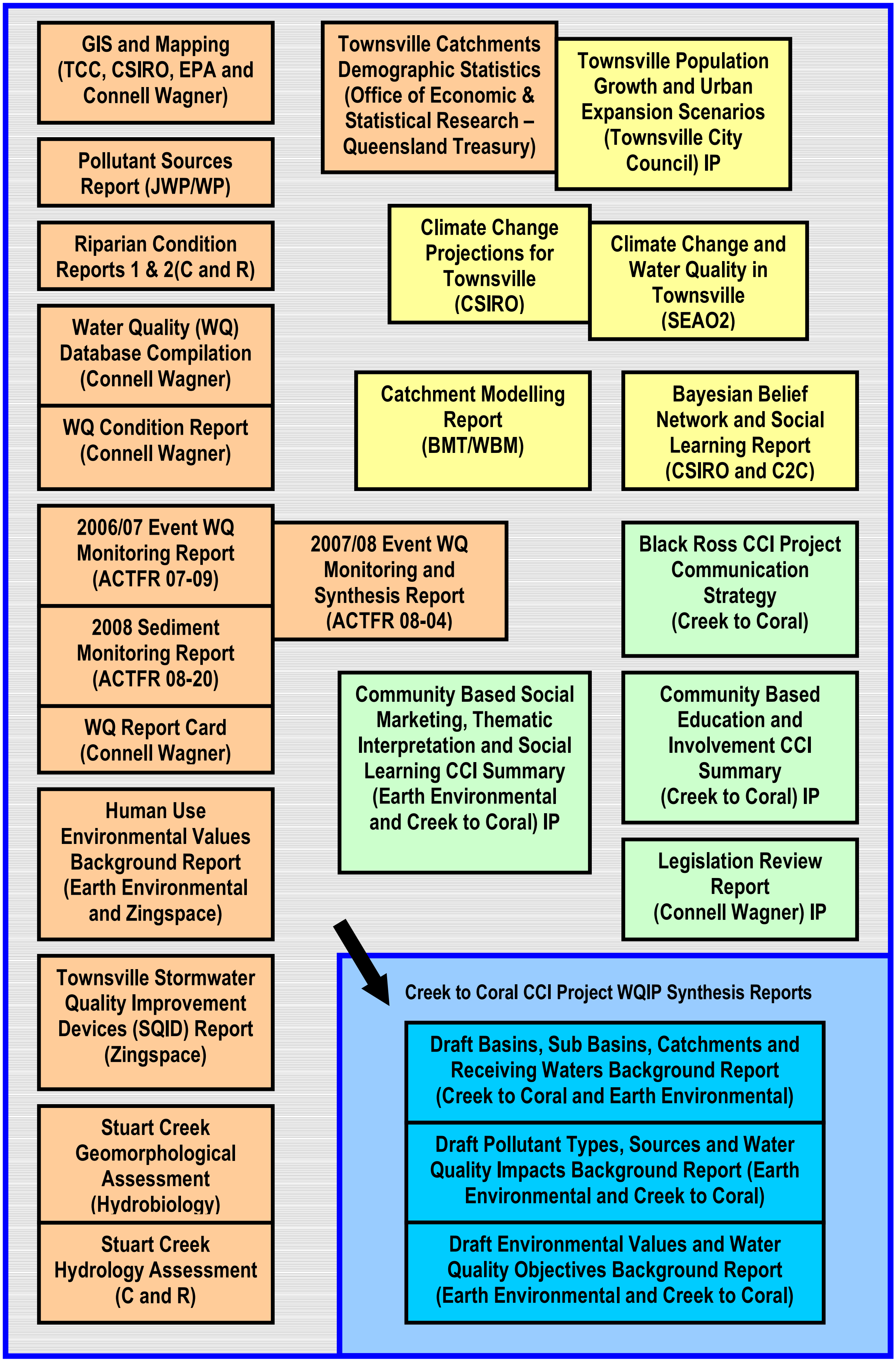
Another key initiative that emerged during the development of the WQIP was the desire by partner organisations and Council departments to develop Water Sensitive Urban Design (WSUD) Guidelines for the Townsville region. A set of WSUD technical design guidelines for Townsville were developed and the testing, refinement, adoption and delivery of the WSUD concept has been incorporated into the WQIP as an integral management action for long term water quality improvement in the ‘mature’ (developed) urban environment.

Figure 1-2 Creek to Coral CCI Components



Source: Black Ross CCI Project Communication Strategy Jan 08

Figure 1-3 Creek to Coral CCI Project Reports and Studies



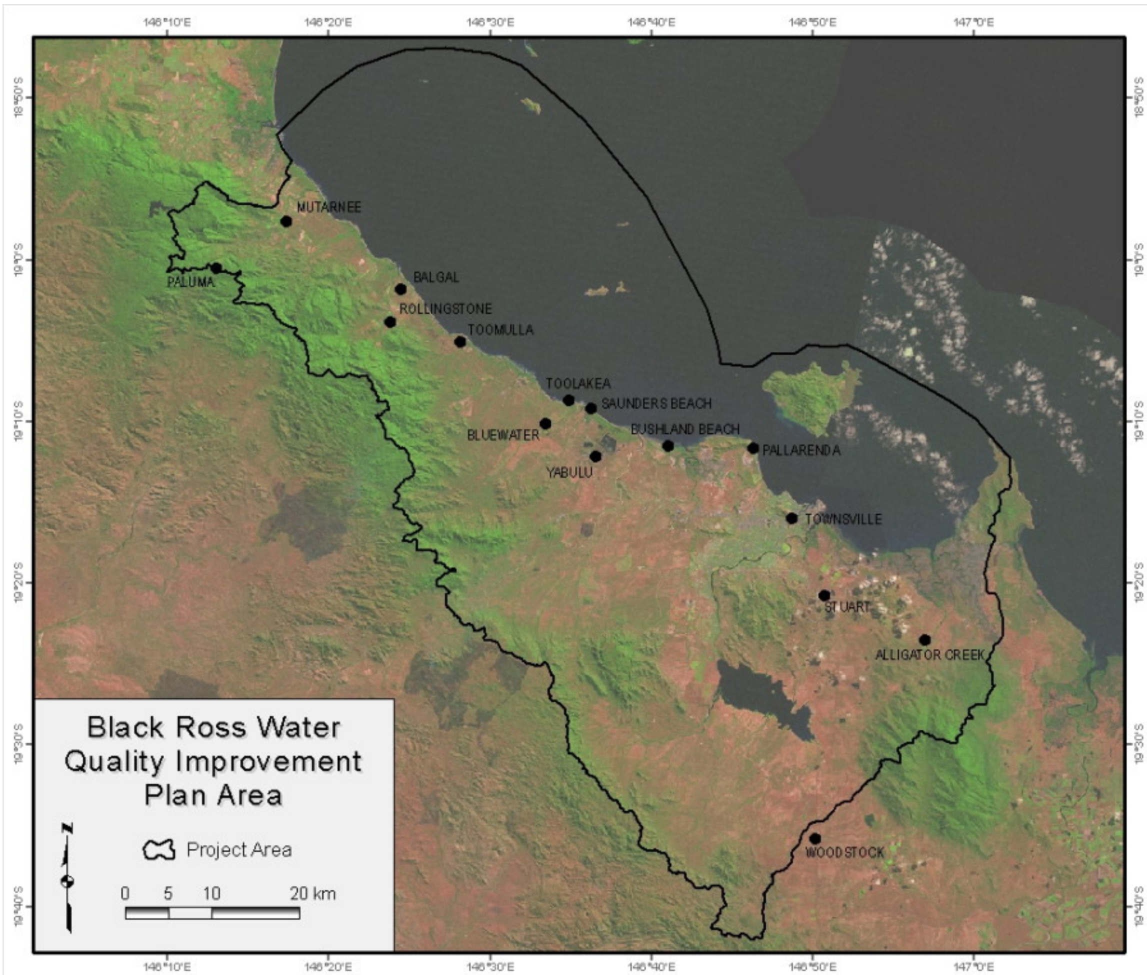
2. Characteristics of the Black/Ross WQIP Area

2.1 Background

This section provides a brief summary of the main characteristics of the Black Ross WQIP area. For more detailed information please refer to the main background report - *Basins, Catchments and Receiving Waters of the Black and Ross River Basins Water Quality Improvement Plan Area* (Gunn, Manning, and Connolly 2009).

The coastline of the Black Ross WQIP area (including Magnetic Island) is approximately 130 kilometres, which is equivalent to approximately 6% of the total GBR catchments coastline.

Figure 2-1 Black Ross WQIP Area Satellite Imagery



Note: The Ross River Dam is a prominent feature of the Ross River Basin and is the main water supply for Townsville.

The total land area of the catchments in the Black and Ross Basins that flow to Cleveland and Halifax Bays is 270,065 hectares (2,700 square kilometers). This represents approximately 0.6% of the total area of the GBR catchments. The individual areas of the river Basins and Magnetic Island are listed in Table 2-1.

Table 2-1 Black/Ross WQIP River Basin and Catchment Areas

Basin/Catchment	Land area (hectares)	Square kilometres	% of WQIP land area
Black River Basin (AWR)	106,284	1062.84	39.4
Ross River Basin (AWR)	132,092	1320.92	48.9
Haughton Basin (AWR) (part)	26,541	265.41	9.8
Magnetic Island	5,148	51.48	1.9
WQIP area total	**270,065**	**2,700.65**	**100**

Note: The Black Ross WQIP uses the AWR Basins. Drainage Basins as defined by the predecessors of the Queensland Department of Natural Resources and Water (DNRW) are not the same as the AWR Basins i.e. DNRW Ross Basin is larger and includes part of the AWR Haughton Basin (DNRW Ross Basin is 1,707 sq km compared to AWR Ross Basin 1,321 sq km. Difference = 386 sq km).

The Black/Ross WQIP area (see section 1.2.4) has been further divided into 10 sub basins (Figure 2-2) and 47 catchments and sub catchments. These divisions have been established to assist with condition assessment, monitoring, modelling and reporting. Profiles of the Black River and Ross River Basins, catchments, sub catchments and associated waterways and wetlands are provided in the main background report (Gunn, Manning, and Connolly 2009).

Figure 2-2 WQIP Area Sub Basins

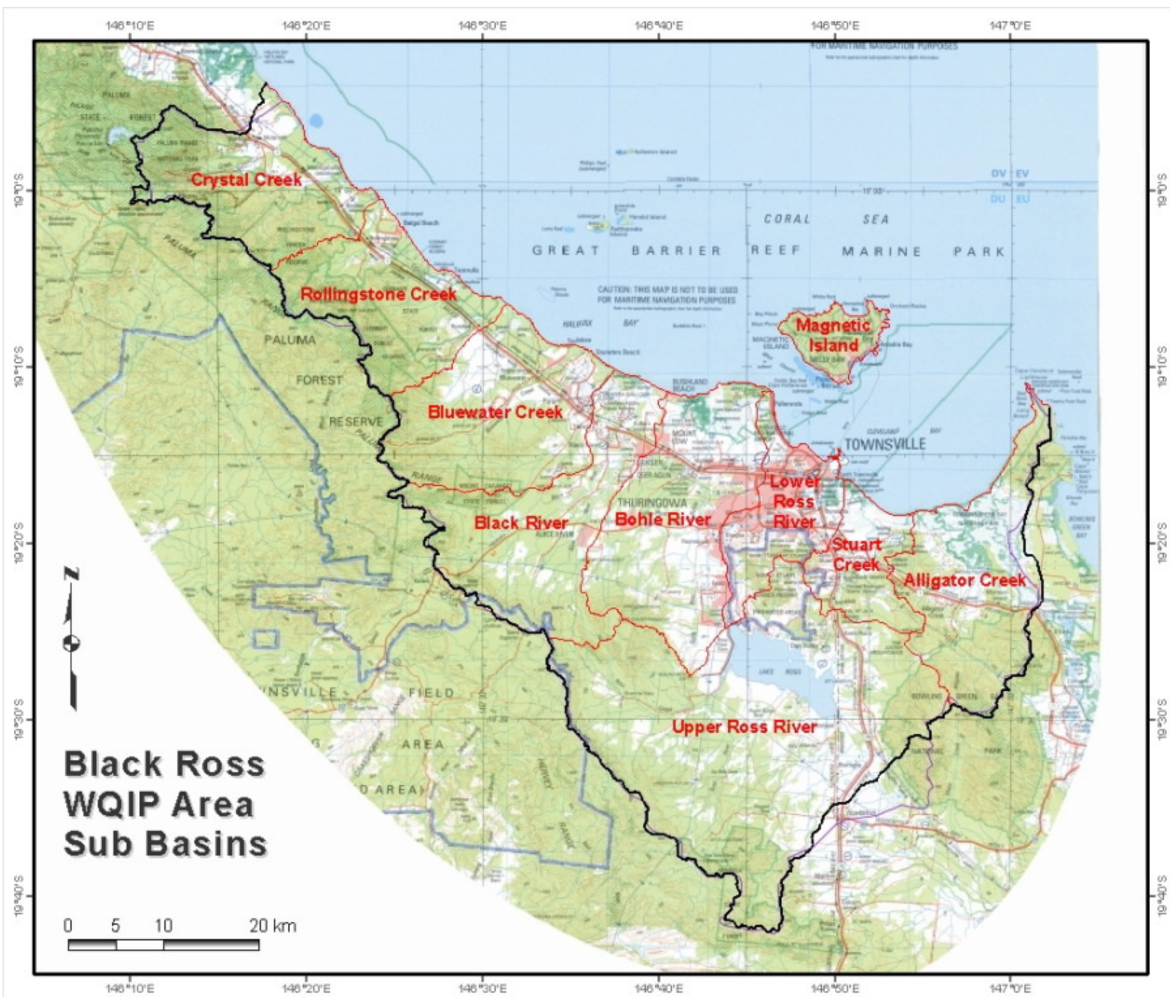


Table 2-2 Sub Basins of the Black/Ross WQIP Area

No.	Sub Basin	Main Waterways
1	**Crystal Creek**	Crystal Creek, Lorna Creek, Ollera Creek, Scrubby Creek, Hencamp Creek
2	**Rollingstone Creek**	Rollingstone Creek, Surveyors Creek, Saltwater Creek, Leichhardt Creek
3	**Bluewater Creek**	Bluewater Creek, Sleeperlog Creek, Althaus/Deep Creek, Healy Creek
4	**Black River**	Black River, Alice River, Alick Creek, Log Creek, Scrubby Creek, Canal Creek
5	**Bohle River**	Bohle River, Saunders Creek, Stoney Creek, Louisa Creek, Town Common
6	**Ross River (lower)**	Ross River, Ross Creek
7	**Ross River (upper)**	Ross River, Six Mile Creek, Sachs Creek, Antill Plains Creek, Toonpan Lagoon
8	**Stuart Creek**	Stuart Creek, Sandfly Creek
9	**Alligator Creek**	Alligator Creek, Crocodile Creek, Cocoa Creek
10	**Magnetic Island**	Gustav Creek, Petersen Creek, Gorge Creek, Endeavour Creek, Retreat Creek

The main elements for determining water quality issues and pressures in the Black Ross WQIP area are land use and management practices. Climatic and geographic factors also play a part however it has been shown that land use and associated management practices are the most influential factors for water quality. Land use is therefore the main focus of this section.

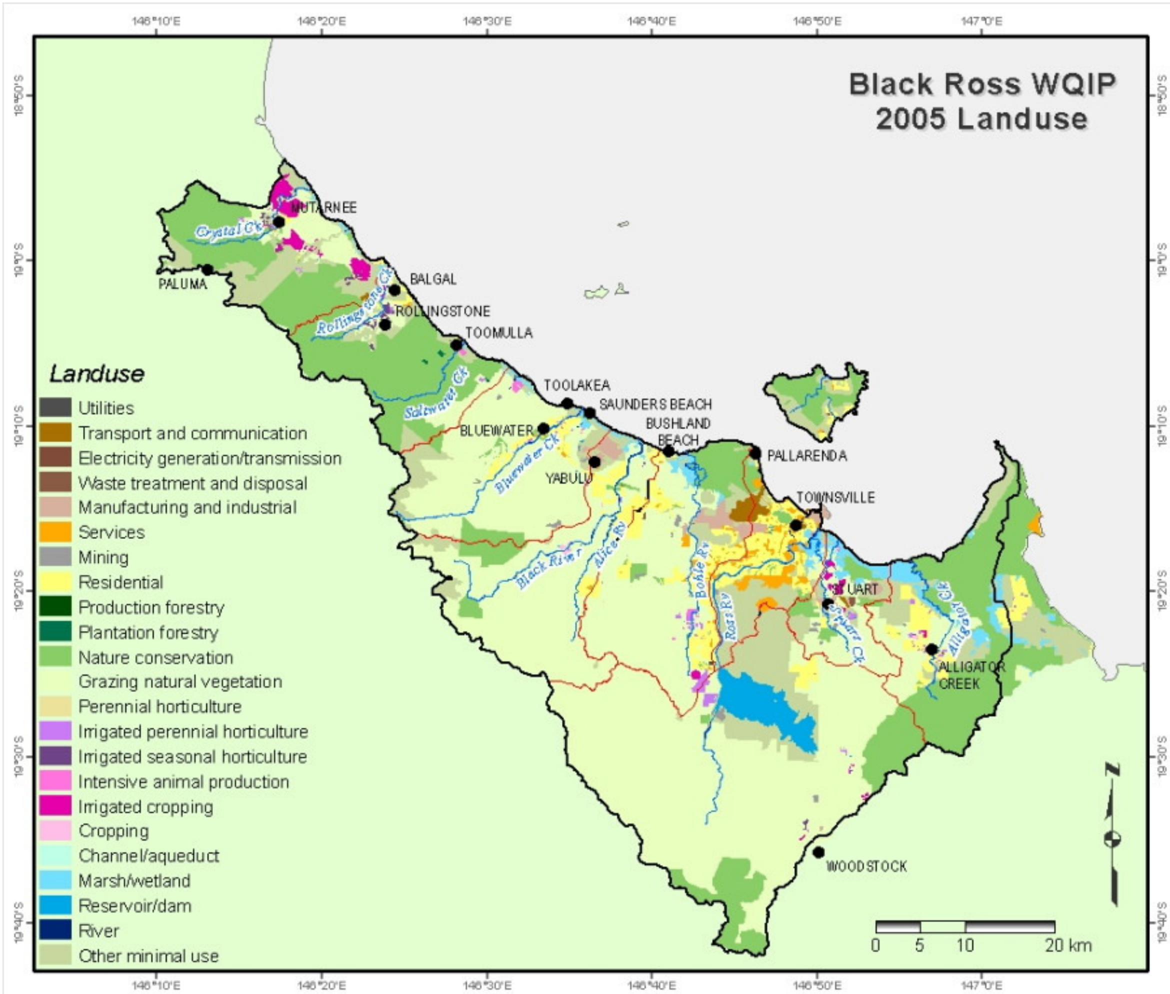
2.2 Land Use

At the start of the Townsville CCI project the most current broad scale land use mapping available was from the Queensland Land Use Mapping Program (QLUMP) (DNRM 1999) and did not reflect the present land use situation, particularly in the expanding urban area. The QLUMP land use mapping was updated by Creek to Coral as part of the CCI project, with emphasis on the urban and peri-urban areas (see Figure 2-3 and Table 2-3). The purpose was to enable more accurate assessment of land use based water quality impacts and potential outcomes of WQIP interventions.

Table 2-3 Principal Land Use Categories (2005)

Land use (non urban)	Hectares	%
Grazing	133,908	49.7
Nature conservation/minimal use	99,786	37.1
Water and wetlands	10,020	3.7
Intensive agriculture	4,112	1.5
Mining/quarrying	462	0.2
Forestry	74	<0.1
Urban		
Residential	15,186	5.6
Services and utilities	4,026	1.5
Manufacturing and industrial	1,599	0.6
Urban sub total	**20,811**	**7.7**
Total (hectares)	**269,173**	

Figure 2-3 Black Ross WQIP Area Updated Land Use Map



Note: The 1999 QLUMP land use data was updated using 2004/2005 aerial photography provided by Townsville City Council, and SPOT satellite imagery provided by NQ Dry Tropics (formerly Burdekin Dry Tropics NRM).

The dominant land use in the Black Ross WQIP area (see Table 2-3) is grazing (approximately half of the area) with another 37% being minimal use and conservation. The urban land use extent, at 7.7%, is well above the average for more rural based WQIPs e.g. Mackay Whitsunday 1% and Burdekin 0.09%. The peri-urban zone 'surrounds' the urban areas and is comprised of parts of the 'non-urban' land uses. The peri-urban zone covers approximately 30% of the total Black Ross WQIP area. A summary of land use by sub basins in the Black Ross WQIP is provided in Table 2-4. Peri-urban areas are 'disguised' as rural type land uses.

Table 2-4 Land Use Summary by Sub Basin

Land Use	Crystal		Rollingstone		Bluewater		Black		Bohle		Lower Ross		Upper Ross		Stuart		Alligator		Magnetic Is	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Channel/Aquaduct					7	0.0														
Cropping	10	0.0	28	0.1			103	0.3	4	0.0							43	0.2		
Grazing Natural Vegetation	2,287	9.5	2,382	10.8	21,912	75.3	23,295	76.2	19,965	61.9	316	2.3	54,437	71.7	5,203	50.2	4,111	15.5		
Intensive Animal Production			40	0.2	105	0.4			90	0.3					23	0.2				
Irrigated Cropping	1,697	7.1	52	0.2			7	0.0	254	0.8			63	0.1	234	2.3	26	0.1		
Irrigated Perennial Horticulture	88	0.4	70	0.3	77	0.3	58	0.2					323	0.4	56	0.5	184	0.7		
Irrigated Seasonal Horticulture	178	0.7	215	1.0									35	0.0			15	0.1		
Manufacturing and industrial							119	0.4	837	2.6	268	2.0	11	0.0	359	3.5			5	0.1
Marsh/Wetland	205	0.9	96	0.4	352	1.2	165	0.5	529	1.6	516	3.8			1,033	10.0	1,755	6.6		
Mining	4	0.0			169	0.6			95	0.3	21	0.2	53	0.1	109	1.1	11	0.0		
Nature Conservation	11,786	49.2	15,865	72.1	1,682	5.8	1,963	6.4	3,185	9.9	944	7.0	8,367	11.0	1,366	13.2	14,229	53.6	2,639	52.9
Other minimal use	7,365	30.7	2,863	13.0	3,185	10.9	2,284	7.5	2,115	6.6	5,016	37.2	7,580	10.0	1,753	16.9	3,676	13.9	1,924	38.6
Perennial Horticulture	4	0.0							27	0.1							3	0.0		
Plantation Forestry			70	0.3																
Production Forestry	1	0.0	2	0.0																
Reservoir/Dam	2	0.0	5	0.0	27	0.1	183	0.6	3	0.0	149	1.1	4,335	5.7	16	0.2				
Residential	171	0.7	253	1.1	1,473	5.1	1,979	6.5	3,944	12.2	3,737	27.7	647	0.9	173	1.7	2,427	9.2	383	7.7
River	61	0.3	10	0.0	58	0.2	343	1.1	16	0.0	92	0.7	27	0.0			43	0.2		
Services	25	0.1	34	0.2	45	0.2	53	0.2	694	2.2	2,017	15.0	75	0.1	33	0.3			27	0.5
Transport and Communication	85	0.4	15	0.1			7	0.0	443	1.4	390	2.9			14	0.1				
Utilities									17	0.1	9	0.1			2	0.0				
Waste treatment and disposal			5	0.0	4	0.0			12	0.0									13	0.3
Total (hectares)	23,969		22,003		29,096		30,559		32,230		13,475		75,953		10,374		26,523		4,990	

Note: The dominant landuse is shaded as: 1st Yellow, 2nd Blue, 3rd Green, 4th Pink. More detailed land use has been described for the Bohle catchment for use in modelled sub catchments (results in Modelling Report (BMT/WBM 2009) and BBN Modelling and Social Learning Report (Lynam et al 2008) – draft only/not for distribution). Dominant land use –.

Land use categories have been grouped and subdivided for different studies as part of the process of developing the Black Ross WQIP. This was seen as necessary as the urban component of the study area is a significant factor in determining water quality condition and pollutant loads. Various land use divisions adopted for elements of the Black Ross WQIP, and their relationship to each other, are shown in Table 2-5.

Table 2-5 Initial Land Use Divisions by Study

Pollutant source identification	E2 Catchment Modelling	Bayesian Belief Network (BBN)
	Rural	
Minimal Use/Natural Areas	Greenspace (includes forestry)	Natural areas/minimal use *
		Forestry
Intensive agriculture	Agriculture (intensive)	Intensive agriculture/Horticulture
Rural (with rural residential)	Grazing	Grazing
Urban		
Urban/residential	Traditional i.e. houses Dense i.e. units etc	Traditional residential * High density residential
Commercial	Commercial	Commercial/Light industrial *
Industry (includes ports and railways)	Industry (includes manufacturing, services, utilities, transport and waste treatment and disposal)	Heavy industry (includes manufacturing, some services, some utilities, ports, railways, airports and waste disposal)
		Low urban
		Formal parkland
	Rural residential	Peri-urban/Rural residential *
	Mining	Mining
		Bare ground (developing urban) *
	Water	(Water to be separated from natural areas/minimal category)

Note: Separate rows are assigned to the landuse category adopted for each of the studies. The BBN project has adopted three primary land use categories i.e. rural, urban and low urban, and placed the sub categories within these. Low urban is conceptualised as the zone between urban and rural areas where the next ‘wave’ of development is likely to take place. *Primary land use categories used by ACTFR in event monitoring 2006-2008 – Established urban, developing urban, light industrial, urban industrial, rural residential, minimal use and conservation.

2.3 People and Place

A more detailed picture of the socio-economic characteristics of the Black Ross WQIP area is provided in the Catchment Profiles report (Gunn, Manning and Connolly 2009). A brief snapshot is provided below.

The amalgamated City of Townsville covers an area of 3,736 square kilometres, encompassing the Black Ross Water Quality Improvement Plan (WQIP) area. In 2005 (the base year for the Black Ross WQIP relative to updated land use mapping) the Estimated Resident Population (ERP) for Townsville stood at 160,220 people representing an annual increase of 3.1% from 2004. Estimated resident population (ERP) trends are shown in Table 2-6 and Figure 2-4.

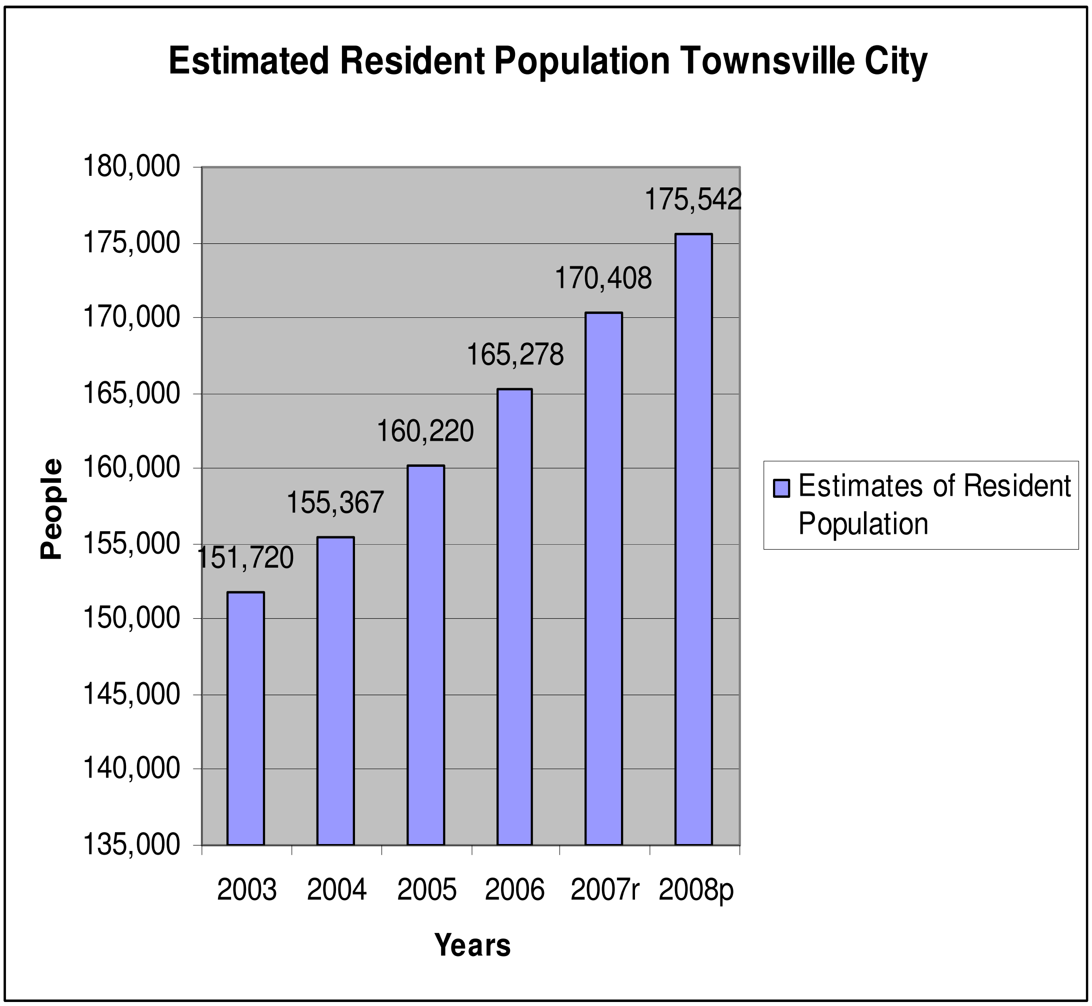
Table 2-6 Estimated Resident Population Growth Trends

Year at 30 June	Number	Year to 30 June	Growth	
			Number	Percentage
2003	151,720			
2004	155,367	2004	3,647	2.40%
2005	160,220	2005	4,853	3.10%
2006	165,278	2006	5,058	3.20%
2007r	170,408	2007r	5,130	3.10%
2008p	175,542	2008p	5,134	3.00%
2003-2008p			23,822	3.00%

Source: Australian Bureau of Statistics Catalogue Number: 3218.0 - Regional Population Growth, Australia, 2007-08; released 23 April 2009.

Note: Population estimates are final for 2003 to 2006 and revised for 2007 (2007r) to align with new June 2007 state totals released in September 2008. Estimates for 2008 are preliminary (denoted 2008p).

Figure 2-4 Townsville Recent Population Growth Trend



Source: Australian Bureau of Statistics Catalogue Number: 3218.0 - Regional Population Growth, Australia, 2007-08; released 23 April 2009.

During the years 2004-2006, Townsville experienced strong population growth. The rate of growth has tapered slightly since that time. As at 30 June 2008, the estimated resident population was 175,542 people, which represents 4.1% of Queensland's population. Townsville's annual increase of 5,134 people over the year to June 2008 represents a 3% growth rate. This compares with an increase of 5,130 people, or 3.1% growth rate, for the year to 30 June 2007.

Between 2007-2008, the growth rate for the state of Queensland was 2.3%. This was the slowest annual growth for Queensland in the five years to June 2008. The average annual rate of change in population in the Townsville local government area, over the five years between 30 June 2003 and 30 June 2008 was 3%, compared with 2.4% for the State.

Residential land activity is a strong potential indicator of both population growth and expansion of the urban footprint. In the year to the June quarter 2005, Townsville produced 1743 residential lots. Lot production has continued to be strong through the years to 2008, however the economic downturn has acted to dampen the volume of recent land sales. Land sales for the year to June 2008 were down significantly from previous years while lot consumption i.e. dwellings being constructed, continued to record strong growth during 2008.

New household formation is an important indicator for population growth. If there is a downturn or upswing in new household formation there is likely to be a corresponding movement in the annual percentage population change.

The 2006 Census showed the average household size for Townsville City to be 2.8 people per dwelling. This is high in comparison with the average household size for Queensland (2.6 people) and for Australia (2.6 people). It is likely that the young population profile for Townsville, which includes significant numbers of families with children, is a factor contributing to the higher than average household occupancy.

Coupled with residential land activity, Building Approval data offers a key indicator for population growth. In the year ended March 2009, there were 1,575 residential dwelling approvals in Townsville City Council. These approvals were valued at $495.8 million and represented 5.0% of the overall total for the State.

The labour force in the Northern labour force region, encompassing the City of Townsville, grew by 3.2% in the 2005 calendar year, while the labour force participation rate was generally higher than overall participation rates for Queensland and Australia. At the time of the 2006 Census of Population and Housing in Townsville City Council, there were 3,523 unemployed persons. With a labour force consisting of 79,849 persons, this corresponded to an unemployment rate of 4.4 per cent. The unemployment rate in Queensland as a whole was 4.7 per cent.

The median weekly income for Townsville at the 2006 Census for individual income was $ 531.00, household income $1,101.00 and family income $ 1,237.00. Median household income levels in Townsville were significantly higher than the medians for Queensland and Australia.

The 1996 Census indicated a median age for Townsville of 31 years. At the 2006 Census, the median age for Townsville increased to 33 years, still significantly younger than the median age for Queensland (36 years) and for Australia (37 years). Projections from the Queensland Department of Infrastructure and Planning indicate the median age of Townsville City Council's population will increase to 39 by 2031 (an increase of 6 years from the 2006 median age.

3. Know the Issues, Pressures and Threats

3.1 Some Background and Assumptions

Pressures and threats to water quality are assumed to be those things resulting from human actions (past, current and future), which have potential to impact water quality, as well as natural phenomena. Issues includes the whole range of pressures and threats, which may be natural phenomena, or natural phenomena exacerbated by human interaction and any other relevant and unresolved matters. It is assumed that the majority of water quality issues are associated with land based human activities, which can be defined in terms of pollutant type and source i.e. associated with a particular land use.

It is recognised that not all pressures are threats, and that pressures and threats may not be translated to actual impacts on water quality. Determining the level of impact is a function of observation over time usually through water quality monitoring and analysis of the collected data. In the absence of adequate resources to collect water quality data, catchment modelling is used to predict the theoretical impact of pressures. This is an iterative learning process of monitoring and modeling in order to better understand the correlation between pressures and water quality impacts is still being determined for many situations in our region.

Where information is available to observe or predict a correlation between pressures and impacts it is then possible to develop appropriate management measures with reasonable assurance that the cause of the water quality issue will be addressed. Where the link between a pressure and a water quality impact is still uncertain additional investigations may be required to ensure that we have enough understanding of the situation to design meaningful and effective interventions.

We need to be mindful of the idea that for most situations we are not directly managing the environment rather we are assisting the people who inhabit the environment to manage their behaviour so that it doesn't adversely impact the environment i.e. their life support system.

Within the Black Ross WQIP area the principal pressure impacting water quality, and other environmental parameters, is land use intensification resulting from population growth. Threats to water quality from land use intensification are generally due to inappropriate planning, design and/or management. It follows that improvements in planning; design and management practices can have a positive impact on water quality compared to the 'business as usual' scenario.

3.1.1 Issues by location

Land use type is the primary geographic division used when identifying and locating pressures and threats, determining natural asset condition, and subsequently when implementing management actions. Along with the general land use divisions e.g. residential and commercial, the urban and per-urban environment can be classified as being either developed (brownfield) or developing (greenfield). As with different types of rural land use this is significant in terms of the type and amount of pollutants generated i.e. pressures and threats. While land use type and development stage are the main points of reference one or more of the following geographic divisions may also be appropriate for condition assessment, monitoring, modelling and reporting purposes:

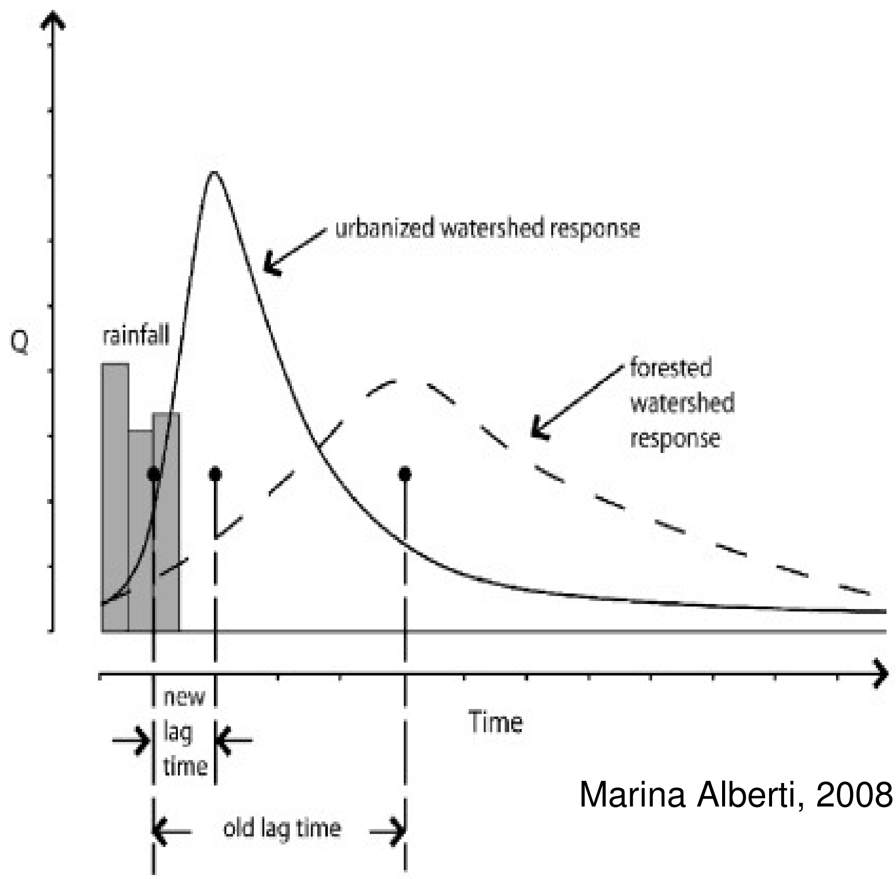
- The whole WQIP study area;
- Terrestrial areas;
- Waterways (freshwater, estuarine or marine);
- Basin, sub basin, catchment and sub catchment units; and
- Specific physical features e.g. escarpments.

3.2 Issues and Development Stage

Water quality issues vary across catchments as a function of land use, management regime and the level or stage of development. Issues associated with developed urban areas are significantly different to those of developing areas and relatively undeveloped and rural areas.

In addition to an increase in pollutants in run off, the conversion of natural areas to urban land uses alters the hydrology of sub catchments due to physical intervention, including the installation of stormwater systems, and through an increase in impervious services i.e. less infiltration and more stormwater run off. This increase in run-off and flow has implications for in-stream health as an increase in bank and bed erosion may result (see Figure 3-1).

Figure 3-1 Hydrology Change Through Urbanisation



The variability of water quality issues also applies to rural areas where development is often associated with land use transitions from a relatively natural state to more intensive production systems. This change can be gradual with relatively low potential water quality impacts e.g. bushland to grazing, or more sudden with potential for greater impacts as with conversion from bushland to intensive agriculture. Management practices associated with each land use type, and development activity, also have a critical role in the magnitude of water quality impacts.

The different pressures and threats in both urban and rural areas require appropriate management measures to address any associated water quality impacts. To assist with the definition of relevant water quality issues and impacts, and the subsequent development of appropriate management measures, land use has been aggregated into urban, peri-urban and rural groupings (see Table 3-1).

It is recognised that there will be areas that fall somewhere between urban and rural land uses i.e. peri-urban. It is generally the peri-urban areas that are under the most pressure from the intensification of land use i.e. urban expansion and development. This has been identified in the functional state column where peri-urban constitutes the main proportion of the 'Developing' functional state.

Table 3-1 Land Use Divisions for Urban WQIP Purposes

Broad land use	Principal land uses	Functional state	New land use distribution
Urban	Residential - traditional housing Residential - high density Commercial Light industrial Heavy industrial Formal parks Minimal Use Natural areas	**Developed/Operational**	**Urban**
Peri-urban	Natural Areas Minimal Use Forestry Rural residential Grazing Intensive agriculture Mining/Quarrying	**Developing**	**Peri-urban**
Rural	Grazing Natural Areas/Minimal Use Forestry Intensive agriculture Mining/Quarrying Dam catchment	**Developed/Operational**	**Rural**

Note: Developing includes change to a more intensive land use e.g. grazing to horticulture. The catchment area of the Ross River Dam is classed as a separate land use as it requires special management attention to ensure that existing land uses within the catchment do not compromise water quality of the urban water supply storage.

Appropriate management actions for water quality improvement will be based on the identified threats to water quality (current and potential future) associated with the general land use divisions described above and their associated water quality pollutants identified from existing literature and the experience of stakeholders involved in the development of the Black/Ross WQIP. Additional investigations are required for peri-urban areas.

3.3 Population Growth

Population growth is the primary driver of development activity and the associated demand for infrastructure and services in the region. This results in land use change intensification pressures. Projections published by the Department of Local Government and Planning in 2006 (see Table 3-2) indicate that the population of the new Townsville City will increase from 144,789 in 2001 to 220,136 by 2026. The annual average growth rate between 2001 and 2026 in the new Townsville City is projected to be 1.7%. This compares with an annual average growth rate of 1.7% for Queensland as a whole.

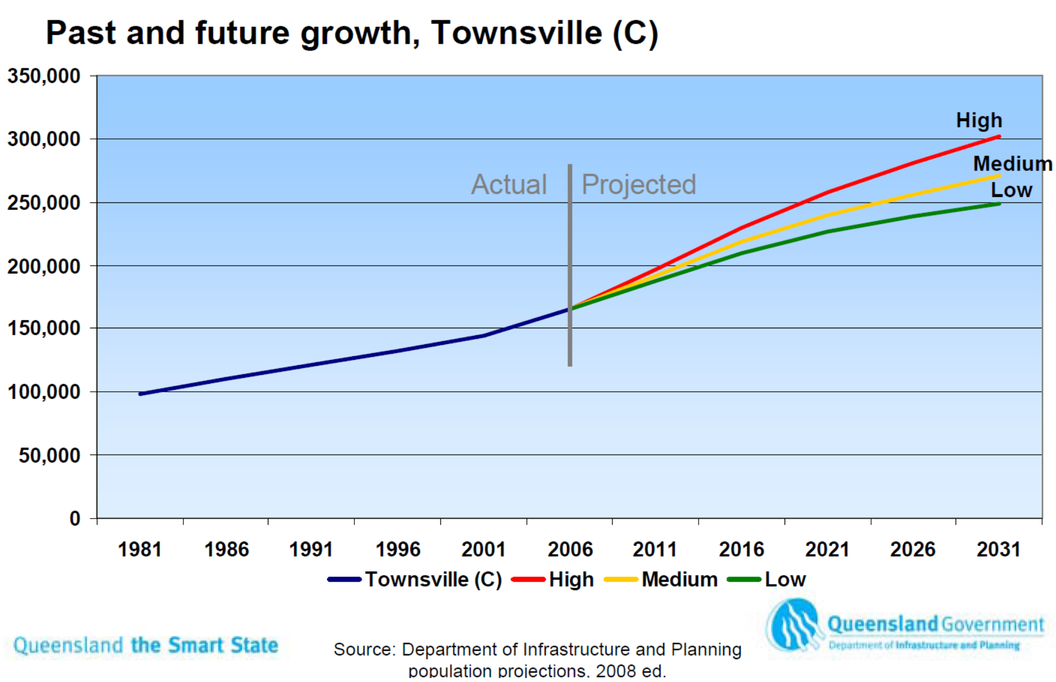
As a result, Townsville's share of Queensland's population is projected to be 3.9 per cent in 2026 compared with 4.0 per cent in 2001. The graph in Figure 3-2 illustrates past and projected future growth of Townsville.

Table 3-2 Population Growth Projections for Townsville

Year	Projections			Population change	
	Low	Medium	High	Five years to 30 June	Annual average change
2011	187441	191329	196145	2011	3.0%
2016	210078	218660	229941	2016	2.7%
2021	226401	239619	257722	2021	1.8%
2026	238451	255986	280736	2026	1.3%
2031	248287	270500	302044	2031	1.1%

Note: Future Trends data is not comparable to Estimated Resident Population (ERP) due to ERP using more up to date/revised data. For regions within the Fitzroy and Mackay statistical divisions, the Department of Local Government and Planning have recommended the use of the high series.

Figure 3-2 Longer Term Population Projection



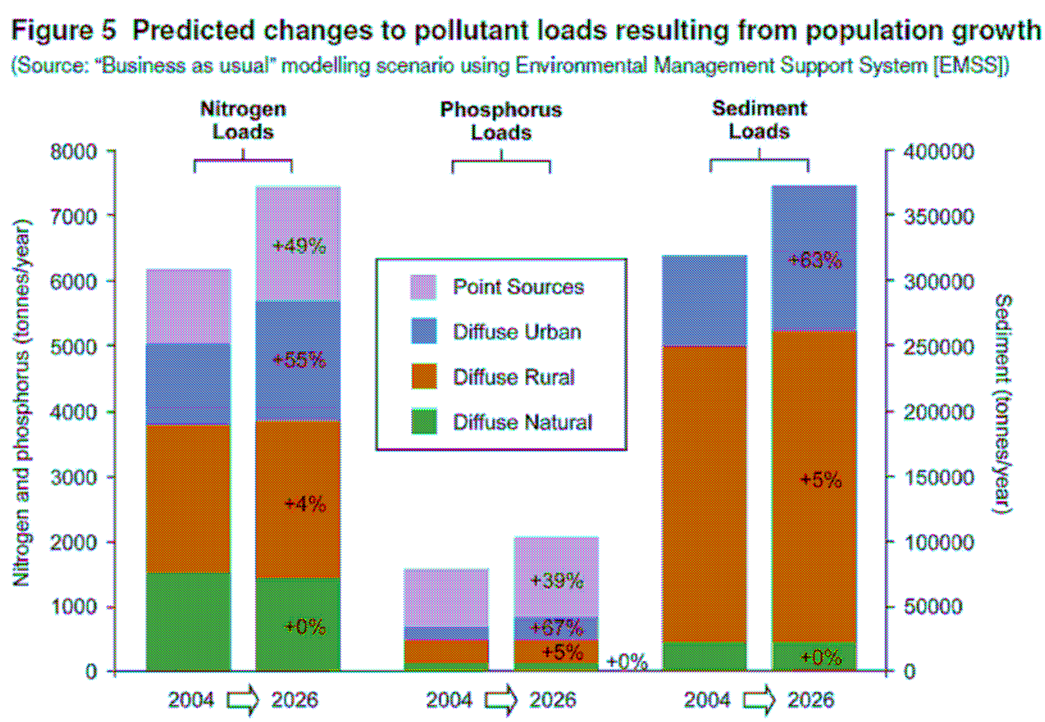
Notes: A 1.1% growth rate for the medium forecast was used to project the growth beyond the life of the current Planning Scheme(s) i.e. beyond PIFU 2031 projections in Table 3-2. The current planning scheme(s) population of 361,338 is achieved in 2057.

Population growth estimates used in the Black Ross WQIP have been generated using a population growth model developed by TCC for the Townsville Strategic Road Network Planning process to guide Councils twenty-year timeframe for capital works. The model uses population growth projection figures from the Population Information and Forecasting Unit (PIFU) to generate population increase estimates across the various planning scheme zones. These estimates were then used to generate predicted land use extent in the modelling sub catchments used by Creek to Coral to determine pollutant loads across a range of scenarios.

Predicted population growth was coupled with known dwelling occupancy rates, known and anticipated urban expansion areas, planning scheme zonings, the Townsville-Thuringowa Strategy Plan and land use mapping to produce population and development growth maps across the following scenario horizons: 2005 (base case), 2012 (Wastewater upgrades), 2021 (achievable management practice adoption timeframe) and 2045 (measurable water quality outcomes timeframe).

Following the collation of this information a number of scenarios were examined using the WaterCAST catchment model, principally for the urban and peri-urban catchments of the Black Ross WQIP area. The scenarios were designed to predict the likely water quality outcomes, with and without the proposed urban water quality improvement measures, and to help verify the need to implement these actions to alleviate the impact of the anticipated population growth in the region.

Figure 3-3 Water Quality and Population Relationship



Note: This is not the final illustration. The concept will be adapted to include local load information

3.4 Water Quality Pollutants and Sources

Determining pollutant types and their source within the Black Ross WQIP area was essential particularly as many of the pollutants emanating from urban and peri-urban areas are not typical of rural areas and therefore the agricultural based GBR catchments and other WQIP regions. This section, amongst other things, summarises the findings of the report prepared for the Creek to Coral CCI project titled *Water Quality Pollutant Types and Sources for the Black and Ross River Basins Water Quality Improvement Plan* (Gunn and Barker 2008).

This information, combined with land use information (see *Basins, Catchments and Receiving Waters of the Black and Ross River Basins Water Quality Improvement Plan Area*, Gunn, Manning, and Connolly 2009), and event water quality monitoring data (*Water Quality Monitoring of the Black Ross Basins: 2007/08 Wet Season, Report No. 08/04*, Lewis, S., Bainbridge, Z., Brodie, J., Butler, B., and Maughan, M. 2008) were used to inform catchment and receiving waters models to identify and quantify the level of pollutants emanating from catchments of the Black Ross WQIP area.

3.5 Land Use Contribution

Contribution of sediment and nutrients from various land uses in the Black/Ross WQIP area has been estimated from literature reviews, water quality monitoring results and catchment modelling. The relative contributions from the various land uses used for the initial run of Bayesian Belief Network model for the Bohle River catchment are listed in Table 3-3. The preliminary areal pollutant export rates and event mean concentrations for the BBN were extracted from the MUSIC model.

Table 3-3 Relative Pollutant Contribution by Land Use

Landuse	Run-off coefficient	Export rate (kg/ha/yr)			Adopted EMC (mg/L)		
		TSS	TP	TN	TSS	TP	TN
Formal parks	0.32	42.4	0.21	1.29	9	0.05	0.33
Rural residential	0.35	55.9	0.18	1.74	11	0.04	0.43
Traditional residential	0.40	823.0	1.31	3.01	152	0.26	0.64
High density residential	0.44	954.0	1.49	3.29	152	0.26	0.64
Commercial/light industrial	0.51	984.0	1.17	3.75	143	0.19	0.62
Heavy industrial	0.66	1330.0	1.57	4.75	143	0.19	0.62
Bare ground	0.33	4340.0	1.29	7.60	1000	0.32	1.95
Natural areas	0.32	43.3	0.21	1.24	9	0.05	0.33
Forestry	0.32	37.8	0.19	1.30	9	0.05	0.33
Grazing	0.32	1180.0	0.62	3.09	260	0.15	0.80
Intensive agriculture	0.32	1390.0	1.30	7.11	300	0.32	1.95
Mining	0.35	692.0	0.83	2.52	143	0.19	0.62

Source: BMT WBM Internal memo 13 November 2008. Note: Bare ground is the default landuse for developing areas.

After a review of preliminary catchment model (E2/WaterCAST) results it was decided that the northern catchments of the Black Basin should be treated differently to the drier southern catchments of the Ross Basin due to the difference in rainfall regime, vegetation and run-off and erosion characteristics. The original EMC input figures for the catchment modelling was derived from the ACTFR event monitoring results. Data from the Black Ross event monitoring was combined with event monitoring data from the Tully catchment to provide a set of ‘dry’ and ‘wet’ catchment EMC values (event mean concentrations) for grazing and green space.

The EMCs for the other main land use categories delineated during the event monitoring were also recalculated and nitrogen and phosphorus species were separated. The 'new' EMC values are shown in Table 3-4.

Table 3-4 Recalculated EMC Values

Landuse	TSS	NH4	NOx	PN	DON	TN	FRP	PP	DOP	TP
	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Dry savanna grazing	130	15	105	175	240	535	29	70	11	110
Green space (dry)	25	8	50	125	200	383	25	20	6	51
Wet Tropics grazing	25	18	500	90	160	268	7	14	6	27
Green space (wet)	4	8	50	45	90	193	3	8	4	15
Urban/peri-urban										
Rural residential	35	9.6	149	114	228	501	26	20	10	56
Established urban	20	29	127	221	364	741	152	69	60	281
Light industrial	57	17	102	313	394	826	195	123	129	447
Urban industrial	129	6.9	94	210	313	624	104	111	15	230
Developing urban¹	793	38	122	190	397	747	130	128	19	277
Developing urban²	11,142									

Source: Unpublished data (Stephen Lewis (ACTFR) 2009). Notes: ¹ is coastal plains and ² is hillslopes. Highest values.

Note: See *Water Quality Pollutant Types and Sources for the Black and Ross River Basins Water Quality Improvement Plan* (Gunn and Barker 2008) for more detail on the catchment modelling, land use contributions and loads.

3.6 Urban Specific and Point Source Pollutants

The urban environment is generally dominated by small 'paddock' residential allotments, transport and infrastructure corridors, commercial and industrial centres. The urban environment also has a high proportion of impervious surfaces, a greater number of 'land managers', larger waste management issues, concentrated industrial areas and constructed stormwater systems. Urban areas are often associated with point source pollutants, and rightly so, as it is the concentration of people and industry that results in the waste management issues associated with large population centres. However, with a few exceptions, urban diffuse pollutant sources are the greatest overall contributors to water quality issues. A conceptual diagram of urban and peri-urban pollutant sources and destinations is shown in Figure 3-4.

Figure 3-4 Black Ross WQIP Urban and Peri-urban WQ Pollutants Concept Model

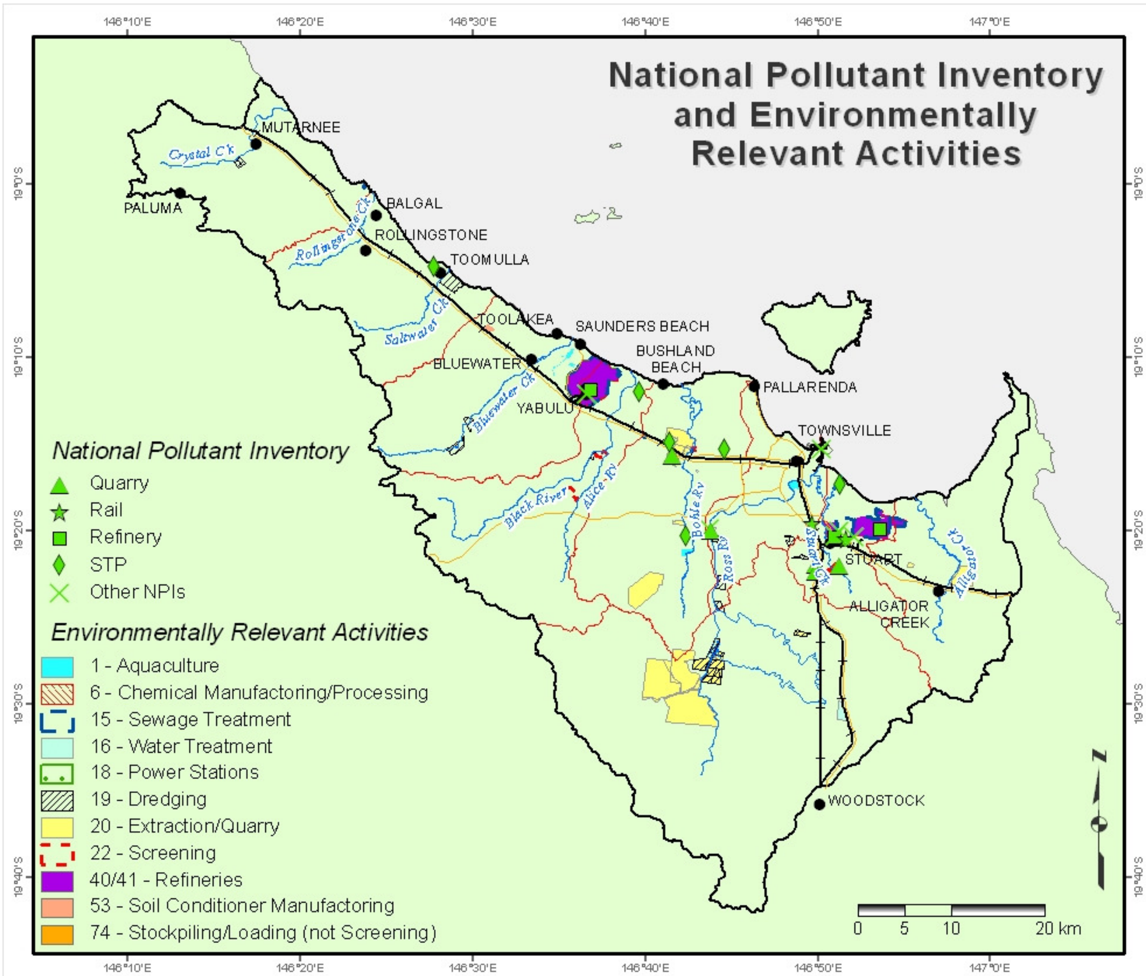
Diagram Key

1. Developing urban areas – Stormwater discharge of high sediment loads (brown arrows) to streams
2. Developed urban areas – Stormwater discharge of high nutrient (red arrow) and sediment (brown arrow) loads to streams
3. Other pollutants such as hydrocarbons, litter, metals and pesticides
4. Sewage treatment plant nutrient discharges – currently being upgraded
5. Sediment, nutrient and freshwater discharge during rainfall events
6. Impacts on marine environment

3.6.1 Point sources and industry

Point source pollution is easily identified as it involves intensive land use in a relatively small area, usually involving an industrial activity. The pollutants, generally waste products, are discharged from the facility at a specific point or points e.g. pipe or chimney, hence the term point source discharge. The main point source pollutant emitters in Townsville have been identified and described detail in the *Water Quality Pollutant Types and Sources* report (Gunn and Barker 2008). The locations of point source pollutant emitters in the Black Ross WQIP area are illustrated Figure 3-5.

Figure 3-5 Air, Land and Water Point Source Emitters



The only significant point source pollutant emitters identified in terms of water quality impacts in the Townsville region were the wastewater treatment plants as most of them discharge direct to receiving waters. Other industrial activities generally emitted pollutants to air or land (contained) and as such did not have a direct and measurable impact on water quality. The emissions to air were taken into account as diffuse sources of pollution and are considered in the section on atmospheric deposition (see section 3.10).

Current average annual point source pollutant contributions, from wastewater/sewage treatment plants (STPs), have been estimated and are shown in Table 3-5. The percentage contribution from point sources will vary from year to year depending on rainfall, run off and subsequent river flow. By contrast discharge volumes from STPs remain relatively constant, with predictable incremental increases associated with population growth.

Table 3-5 Point Source Pollutant Load Contributions

Receiving Waters	Facilities	Total N (t/yr)	%	Total P (t/yr)	%
Bohle River	Condon, Deeragun, Mt St John	131	~60%	21	~50%
Black River	Mt Low	1.9	~3%	1.3	~8%
Cleveland Bay[1]	Cleveland Bay	126	~40%	40	~63%

Note: Percentage is the proportional average annual contribution to the end of catchment load from point sources. [1]Cleveland Bay was calculated by adding the discharge loads for the Ross River, Stuart / Sandfly Creeks (estimate) and Alligator Creek and expressing the point source input as a proportion of the aggregated loads i.e. point source load divided by the combined waterway loads plus the point source load, to give a Cleveland Bay receiving waters load contribution rather than end of catchment. This has since been recalculated using Stuart Creek sub basin discharge figures provided from modelling results (see Table 5-13). Cleveland Bay load contribution based on average 2004 to 2006 discharge figures.

Table 3-6 Comparison of Cleveland Bay STP Contribution Pre and Post Upgrade

Nutrient/Year	Alligator	Stuart	Ross	CBay STP	Total	Percentage
TN 2006/07 (Pre)	9,440	6,560	173,000	126,000	315,000	40
TN 2007/08 (Post)	9,440	4,300	149,700	27,300	190,740	14
TP 2006/07 (Pre)	1,540	960	20,800	40,000	63,300	63
TP 2007/08 (Post)	1,540	940	22,300	5,900	30,680	19

Source: Lewis et al 2008 and BMT WBM initial modelling results

The wastewater treatment plants servicing Townsville are being progressively upgraded over the next three years to provide capacity for the expected population growth up to 2025 (Maunsell Australia 2008). These upgrades will result in significant reductions in the nutrient concentration and loads (at current population levels) being discharged to receiving waters. Upgrade of the Cleveland Bay plant has been completed and this is reflected in the nutrient load reduction as illustrated in Table 3-6.

However, with the expected population increases the amount of wastewater requiring treatment also increases. Regardless of the improved efficiency of treatment plants and nutrient concentration reductions this will inevitably result in increased nutrient loads as additional volumes of wastewater is treated and subsequently released from the STPs. Alternative options to the release of treated wastewater to receiving waters need to be implemented if this significant source of nutrients is to be adequately addressed in the longer term e.g. water reuse over land.

There are no other significant industrial (point source) activities that have been identified as adversely impacting water quality in the Black/Ross WQIP area.

3.7 Urban Diffuse

Principal pollutants of urban areas are; sediments, nutrients (principally nitrogen and phosphorus), oxygen demanding materials (biodegradable organic material), metals, toxic organic wastes (garden and household chemicals), pathogenic micro-organisms (bacteria, viruses etc), hydrocarbons and litter.

Some pollutants can be carried relatively long distances by wind and rain before being deposited (distributed sources) while others have local origins. Some of the more significant local sources of pollutants in developed areas are associated with motor vehicles and roadways. The main urban diffuse pollutants are listed in Table 3-7.

Table 3-7 Urban Diffuse Water Quality Pollutants

Local Sources	Water Quality Issue
Leaf litter, grass clippings and other vegetation	BOD, N, P
Dog and other domesticated animal faeces	P, N, BOD, biological pathogens
Pesticides, herbicides and fertilisers	Pesticide, N, P
Sewer overflows	N, P, biological pathogens
Sewer outlets illegally connected to stormwater systems	N, P, biological pathogens
Septic tank leakage	N, P, biological pathogens
Leakage and spillage of materials from; vehicles, storage tanks and bins	Hydrocarbons, chemicals, litter
Seepage from land fill waste disposal sites	Metals, biological pathogens
Waste water from cleaning operations	Hydrocarbons, chemicals, P
Corrosion of roofing and other metallic materials	Metals
Industrial emissions	PM, NO2, SO2, NH4
Vehicle emissions	PM, NO2,
Vehicle component wear e.g. tyres and brakes	PM, metals
Wear of road surfaces	PM, metals, hydrocarbons
Erosion from construction activity and vegetation removal	SS, P, N
Litter – plastic, glass and metal containers, plastic, foam etc	Gross pollutants
Ash and smoke from fires	PM, nutrients, VOC, metals
Windblown pollen, insects and micro-organisms	PM, N, P, VOC

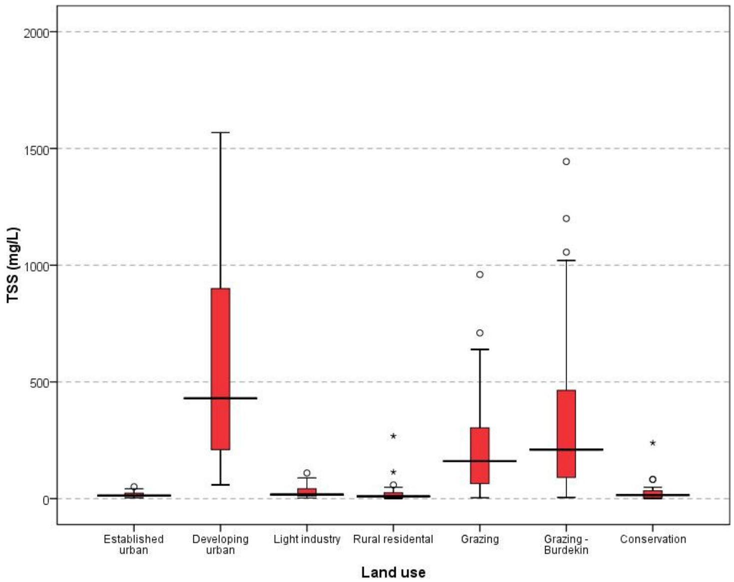
Notes: BOD is biochemical oxygen demand, P is phosphorus, N is nitrogen, PM is particulate matter, SS is suspended solids, NO2 is nitrogen dioxide, VOC is volatile organic compounds, SO2 is sulphur dioxide, NH4 is ammonia.

It should be noted that the majority of the pollutants listed are associated with developed urban areas. The main local source of pollutants from developing areas is listed as “Erosion from construction activity and vegetation removal”. Additional information on the main groupings of urban pollutants is provided in the sections below.

3.7.1 Sediment

Sediment generated from developed urban areas is relatively low and, depending on how figures have been calculated, can be comparable to natural areas. Sediment (total suspended solids) generation from developing areas however, is at the other end of the spectrum. This is graphically illustrated in Figure 3-6. As can be seen the sediment concentration from developing areas is significantly higher per hectare than for any other land use.

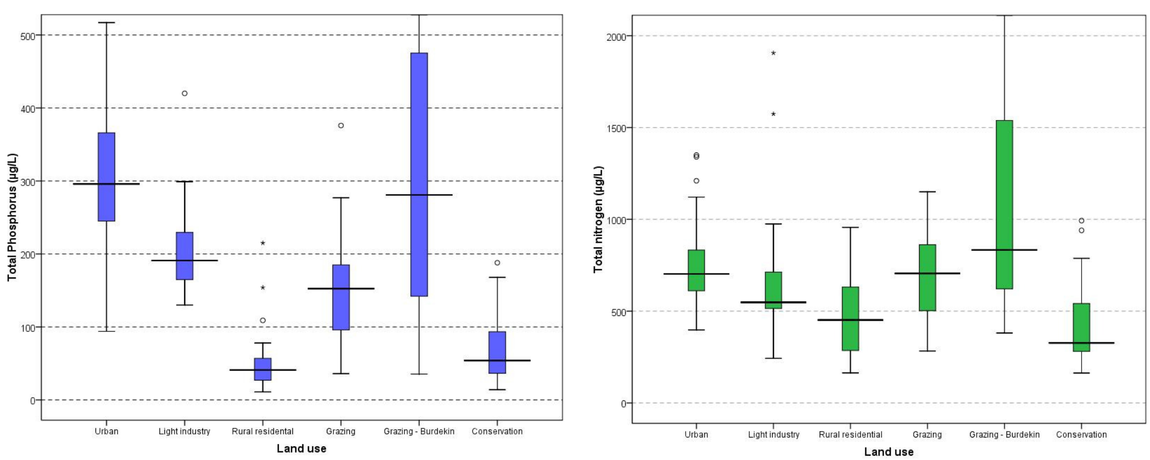
Figure 3-6 Relative Concentrations of Sediment by Land Use



3.7.2 Nutrients

Nutrient concentrations in stormwater from developed urban areas are generally less than concentrations from areas of intensive agriculture and are significantly greater than from forested catchments (phosphorus is two to ten times greater) and undeveloped catchments (nitrogen is two to five times greater). There are a number of sources of nutrients in developed urban areas (see Table 3-7) with initial analysis of water quality monitoring showing urban and light industrial areas being higher contributors of nutrients than non-urban land uses. Relative land use concentrations of total phosphorus and total nitrogen are illustrated in Figure 3-7.

Figure 3-7 Relative Nutrient Concentrations by Land Use (µg/L)



Nutrient concentrations generated from developing areas can be as high as those from intensive agriculture (see Table 3-3) due in part to activities associated with development such as vegetation removal and soil disturbance. This disturbance can lead to higher erosion rates and the mobilisation of near surface nutrient stores in the soils with potential for transport of the nutrients to waterways in both particulate and soluble forms.

3.7.3 Metals

Heavy metals are often found to be more highly concentrated in urban areas than in rural areas, as a result of higher densities of source emissions such as wear of tyres and brakes, vehicle emissions, road and pavement degradation, water pipes, roof corrosion and industrial activity e.g. spillages and dust from the handling of metal ores at Townsville Port. Metals (Cadmium, Chromium, Copper, Nickel, Lead, Zinc) and their compounds are therefore a potential pollutant issue in the Black Ross WQIP area. Excessive levels of metals can be toxic to aquatic organisms and can bioaccumulate and be passed along the food chain. Metals are known to accumulate in sediments and can be remobilised and return to the water column under certain conditions.

3.7.4 Hydrocarbons (Fossil fuels, oil and grease)

Hydrocarbons are generally liquid fuels and oils e.g. diesel and petroleum, however there is a wide range of hydrocarbons in everyday use e.g. cleaning fluids. Many are highly volatile and readily evaporate when exposed to air. Hydrocarbons with higher oil content are more likely to persist in the environment. Hydrocarbon derivatives stem from oil and grease used in lubricants, protective coatings, combustible fuels and detergents.

Spills of such oils can exceed recommended levels and result in short term toxicity. Further, surfactants found in detergents can impact on aquatic flora and fauna by damaging biological membranes. Excessive hydrocarbons can result in smothering of aquatic habitats. They can also increase morbidity and mortality in freshwater species, and impact upon reproductive cycles.

3.7.5 Other chemicals

Detergents, acids and other chemicals used in the urban environment can contribute to water quality issues especially when they are used on impervious surfaces and are washed directly into urban stormwater systems. While most chemicals do not enter waterways in large enough quantities to have an impact chemicals that add to the load of other pollutants are a water quality issue e.g. phosphates in detergents.

3.7.6 Gross pollutants

Gross pollutants are relatively large pieces of debris flushed through urban catchments and stormwater systems. Gross pollutants include plastics and other packaging, garden waste (lawn clippings, leaves and other plant material) and coarse sediment. While the litter component of gross pollutants is an aesthetic water quality detractor there can also be deleterious impacts on aquatic animals from plastic litter in waterways through ingestion and entanglement. Organic material i.e. leaves, twigs and grass clippings, constitute the largest proportion of gross pollutant load (by mass) carried by urban stormwater. Organic gross pollutants can lead to oxygen depletion during decomposition (biochemical oxygen demand - BOD), and also release nutrients, albeit relatively slowly.

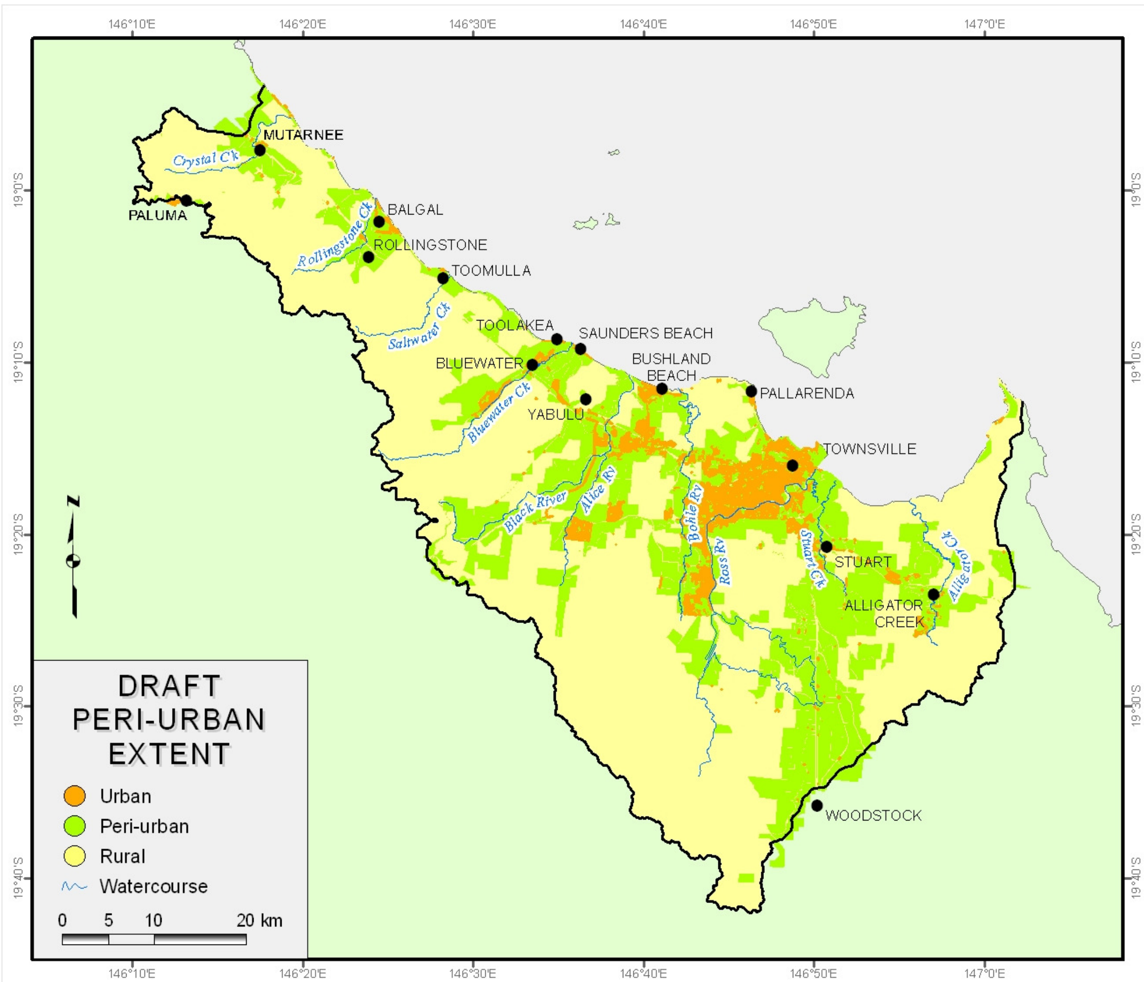
If unmanaged gross pollutants also have the potential to obstruct stormwater systems and contribute to localised flooding.

3.8 Peri-urban Diffuse

While the peri-urban land use area has not been extensively investigated it is recognised as an important landscape component being the transition zone between rural and urban areas. Peri-urban areas are typified by 'small' rural blocks, industry located away from mainstream urban areas e.g. quarries, and outlier or 'village' communities. The peri-urban land use area is where the majority of development takes place and as such is a principal source of 'intensive' short term diffuse pollutants as well as the normal range of rural pollutants.

Given the larger number of properties and land managers per unit area compared to rural areas, it is likely that the pollutant output from peri-urban areas is greater than that for rural areas on a per unit area basis. Further work is required to determine the relationship between peri-urban areas and pollutant outputs. A preliminary map of peri-urban areas is provided in Figure 3-8.

Figure 3-8 Draft Peri-urban Landuse Extent



3.9 Diffuse Source Pollutants - Rural

Diffuse source pollutants are those that cannot be identified as emanating from a particular point e.g. pipe or chimney stack. In terms of water quality, air quality pollutants emanating from a chimney stack, or similar, are considered to be diffuse source pollutants as they are dispersed through the atmosphere and may eventually settle on land and water surfaces.

Typical diffuse source pollutants include sediment, nutrients (nitrogen and phosphorus) and pesticides, which are eroded and/or collected from land surfaces, typically in rainfall run-off, and carried to receiving waters e.g. streams, lakes, reservoirs and wetlands. In terms of catchment scale modelling this diffuse source is classed as hillslope erosion with gully erosion and streambank erosion being the other sources of pollutants contributing to total pollutant loads. Small quantities of diffuse source pollutants are also transported by wind.

Movement of sediment and nutrients in rainfall run-off is a normal component of natural weathering and erosion processes. Additional inputs of bioavailable/soluble nutrients combined with land disturbance and inappropriate management practices often results in accelerated run off and erosion rates and the subsequent transport of sediment and nutrients to receiving waters, well above normal background levels. It is the delivery of sediment and nutrients to receiving waters at elevated levels (and for nutrients in forms that are bioavailable) that creates threats to aquatic habitats and biodiversity and, in some cases, human health.

Pesticides are an input not measured against natural background levels. Inappropriate management practices, increased stormwater run off and accelerated erosion rates also affect the amount of pesticides reaching receiving waters. Pesticides that do not remain in the place they were intended for become a water quality threat with a range of impacts depending on the pesticide type and concentration.

Rural land uses are generally grouped into minimal use/conservation, grazing and intensive agriculture. Intensive agriculture is often subdivided by crop type and irrigated versus dryland. Sediment, nutrients and pesticides are the main diffuse source pollutants emanating from the rural environment. These pollutants and their sources, as identified for the Burdekin WQIP, are listed in Table 3-8.

Table 3-8 Main Pollutants and Sources

Pollutant	Source	Rating	Notes
Nutrients			
Nitrate (NO3)	Fertiliser	5	Low natural levels
Ammonia (NH4)	Fertiliser	2	Low natural levels
DON	Fertiliser	2	Moderate natural levels, slow turnover
PN	Fertiliser and erosion	4	Moderate natural levels, loss to sediments
Phosphate (PO4)	Fertiliser, salt licks	2	Low natural levels
DOP	Fertiliser	1	Moderate natural levels, slow turnover
PP	Fertiliser and erosion	3	Moderate natural levels, loss to sediments
Silicate (Si(OH)4)	Erosion	0	
Sewage	STP discharge, septics	5	Contains all N, P forms at high levels
Suspended sediment			
Coarse (>63 µm)	Erosion	0	No likely impact, forms delta fans
Medium (2-63 µm)	Erosion	2	Carried only short distance
Fine (< 2µm)	Erosion	4	Carried widely over shelf, especially after dry year

Source: Mitchell et al 2007 (p.7) Note: Suspended sediment varies between sub-catchments and is greatly increased by grazing. Urban specific sources, other than STPs, have not been included as there are a variety of chemicals that may contribute to N and P levels but there is little water quality monitoring evidence available for Townsville to be specific. Rating is potential threat posed by the pollutant where 5 is greatest threat and 0 is no threat.

In addition to sediment, nutrients and pesticides a range of pollutant groupings relevant to rural areas were identified by Mitchell et al (2007)(see Table 3-9).

Table 3-9 Other Rural Pollutants

Pollutant Group	Specific Pollutant and Comments
DO reducing materials (organic material)	Sucrose, dunder, mill effluent – are products of sugar cane production and are limited to the Lower Burdekin. Manure principally from cattle grazing. Sewage from urban areas. Plant litter occurs naturally and is increased as by products of intensive agriculture and urban park and garden maintenance
Herbicides	Diuron, Atrazine, Ametryn, Hexazinone and 2,4-D are principally used in the sugar industry. Simazine used in forestry. Tebuthiuron used in grazing industry. Glyphosate and paraquat used broadly in sugar cane, horticulture and urban areas
Insecticides	Organochlorines e.g. endosulfan, and a variety of others are used principally in horticulture and to a lesser extent sugar cane and the urban setting. Chlorpyrifos used in sugar cane for cane grubs
Fungicides	Methoyetholmercuric chloride (MEMC) used in the sugar industry
Non insecticide organochlorines	PCB's from industry (reduced use but residues may persist) and Dioxins from agriculture and industry PAH's (polcyclic aromatic hydrocarbons) from cane firing, forest fires and oil spills
Heavy metals	Cadmium and potassium from fertiliser and mercury from fungicide. Other trace elements
Oil or hydrocarbons	Primarily from liquid fossil fuels and oil spills
Salinity	Both dryland and irrigation salinity resulting from land clearing (dryland) and irrigation activities
Antifoulants	Used primarily in the fishing industry at mooring sites (TBT now banned)
Acid	Principally associated with disturbance of acid sulphate soils

Source: Mitchell et al 2007, pp.7-8

3.10 Atmospheric Deposition

The principal pollutants by volume associated with atmospheric deposition are particulate matter and oxides of nitrogen. Background deposition levels of both these pollutants are not known specifically for the Townsville area and current air quality monitoring is principally associated with airborne concentrations as a function of human health. Contributions from atmospheric deposition of both particulate matter and oxides of nitrogen are a combination of natural background levels and any additional contributions from human sources.

An estimate of average atmospheric deposition of particulate matter (PM10) from all sources for the Townsville urban footprint (250 square kilometres) is 15 kg/ha/year (equivalent to a depth of 0.0015 millimetres). The average annual contribution of particulate matter from atmospheric deposition to the sediment load of waterways in the Black Ross WQIP area is considered to be minimal across the region although it may be locally significant, in relative terms, in the vicinity of industrial sites such as loading facilities at Townsville Port.

The main source of nitrogen dioxide (NO2) is a by-product of the combustion of fossil fuels from industrial facilities and motor vehicles. Background levels of atmospheric nitrogen deposition are in the order of 2-3 kg/ha/year. Potential deposition of NO2 from human sources is estimated to be approximately 5-6 kg/ha/year in the urban footprint, to give a total NO2 deposition of 8 kg/ha/yr. This is considered to be a significant overestimate as the atmospheric deposition rate has been overestimated and there has been no attempt to convert NO2 mass to N mass.

There are two components to atmospheric deposition i.e. direct deposition to water and deposition to land. Deposition to land becomes a potential component of run-off from different land uses while deposition to water is a direct contribution. Deposition to water has been calculated by determining the area of water in each catchment and multiplying this by the deposition rate to give a load that can be used to determine the overall contribution in terms of end of catchment loads. The results by sub basin and/or catchment are displayed in Table 3-10. The elevated deposition rates for the urban footprint have only been applied to the lower Ross, Bohle and Stuart Creek sub basins. ACTFR event water quality monitoring end of catchment load estimates were used to calculate atmospheric deposition load contributions.

Table 3-10 Estimated Atmospheric Deposition Contributions to Main Catchments

Sub basin	River (ha)	Water (ha)	PM10 (kg)	%	TN (kg)	%	TP (kg)	%
Crystal Creek	61	268 [1]	2,144		536		54	
Rollingstone Ck	10	110 [0.5]	880		220		22	
Bluewater Ck	58	426 [1.5]	3,408	0.17	852	5.68	85	7.10
Black River	343	513 [1.7]	4,104	0.01	1,026	1.37	103	0.64
Bohle River	16	532 [1.7]	7,980	0.03	2,128	2.66	213	0.89
Ross River (btd)	91	754 [5.6]	11,310		3,016		302	
Ross River (atd)	27	4,372 [5.8]	34,976		8,744		874	
Ross River	118	5,126 [6]	46,286	0.31	11,760	7.84	1,176	5.6
Stuart Creek	0	1,047 [10]	15,705		4,188		419	
Alligator Creek	43	1,798 [6.8]	14,384	2.40	3,596	39.96	360	23.97
Magnetic Island	0	0						
Totals	649	9,820	94,891		24,306		2,431	

Notes: The Water primary land use category was used to determine the area for calculating atmospheric deposition contributions to water. The Water primary land use category includes the secondary land use categories; Marsh/wetland, River, Channel/aqueduct and Reservoir/dam.

Atmospheric deposition rates used: Urban footprint - PM10 15 kg/ha/year, N 4kg/ha/yr (2kg/ha/yr background and 2kg/ha/yr anthropogenic), and P 0.4 kg/ha/year (equivalent to double the figure from a South Australian study). Non-urban footprint - PM10 8 kg/ha/year, N 2kg/ha/yr and P 0.2 kg/ha/year.

For Ross River bdt is below the dam and atd is above the dam. These were added to provide figures for the whole Ross River catchment. % is percentage contribution. In the Water column the figures in square brackets indicate the percentage of the sub basin comprised of the Water land use category. End of river load figures to calculate % contributions were sourced from ACTFR event monitoring data and initial results of the modelling prepared by BMT WBM.

There is considerable variation in the percentage contribution from atmospheric deposition to water across the sub basins. The Alligator Creek figures are significantly different to the other sub basins even allowing for the high percentage of water land use within the sub basin. Atmospheric deposition contributions were recalculated using preliminary end of catchment load estimates from WaterCAST modelling (see Table 3-11). Most atmospheric deposition percentage contributions were significantly lower using the modelled EOC loads showing the sensitivity of the calculations to EOC load and river flow estimates.

Table 3-11 Atmospheric Deposition Contributions Using Modelled EOC Loads

Sub basin	River (ha)	Water (ha)	PM10 (kg)	%	TN (kg)	%	TP (kg)	%
Crystal Creek	61	268 [1]	2,144	0.02	536	0.37	54	0.26
Rollingstone Ck	10	110 [0.5]	880	0.02	220	0.30	22	0.23
Bluewater Ck	58	426 [1.5]	3,408	0.02	852	0.81	85	0.55
Black River	343	513 [1.7]	4,104	0.03	1,026	1.25	103	0.85
Bohle River	16	532 [1.7]	7,980	0.06	2,128	2.18	213	1.30
Ross River (btd)	91	754 [5.6]	11,310	0.26	3,016	7.27	302	3.75
Ross River (atd)	27	4,372 [5.8]	34,976		8,744		874	
Ross River	118	5,126 [6]	46,286	(0.31)	11,760	(7.84)	1,176	(5.6)
Stuart Creek	0	1,047 [10]	15,705	0.87	4,188	19.70	419	13.44
Alligator Ck	43	1,798 [6.8]	14,384	1.23	3,596	7.93	360	7.07
Magnetic Island	0	0						
Totals	649	9,820	94,891	0.14	24,306	3.90	2,431	2.63

Notes: Atmospheric deposition rates used: Urban footprint - PM10 15 kg/ha/year, N 4kg/ha/yr (2kg/ha/yr background and 2kg/ha/yr anthropogenic), and P 0.4 kg/ha/year (equivalent to double the figure from a South Australian study).

Non-urban footprint - PM10 8 kg/ha/year, N 2kg/ha/yr and P 0.2 kg/ha/year.

End of river load figures to calculate % contributions were sourced from initial results of the modelling prepared by BMT WBM. Percentages in brackets for Ross River are taken from Table 3-10.

From the information assessed in the *Water Quality Pollutant Types and Sources* report (Gunn and Barker 2008) atmospheric deposition of sediment, phosphorus, heavy metals, pesticides and sulphur dioxide is not found to contribute measurably to water quality issues. This is confirmed in Table 3-11 with the exception of Stuart Creek and Alligator Creek for phosphorus.

The atmospheric deposition contribution of nitrogen was also elevated for Ross River, Alligator Creek and Stuart Creek. As phosphorus levels were also elevated for the same waterways these figures may be anomalies associated with load and flow calculations and is not an accurate measure of actual deposition rates. The calculated atmospheric deposition figures need to be tested to determine whether they are plausible.

3.11 Climate Change

Creek to Coral commissioned local sustainability consultant SEA O2 to compile a report on the potential impacts of climate change in Townsville on water quality to inform the WQIP. While collating information for the report it was recognised that climate models had not been run specifically for the Townsville region. Townsville is part of the Dry Tropics and has a significantly different climate regime to neighbouring regions i.e. Wet Tropics (north) and Central Queensland Coast (south), and other parts of Australia. Subsequently, Creek to Coral commissioned CSIRO to run a climate model specific to Townsville (*Climate Change Projections for the Townsville Region*.

The CSIRO climate change projections are presented as 10th, 50th and 90th percentile units, reflecting the uncertainty inherent in global climate modeling. While the 10th and 90th percentiles give an indication of the range of uncertainty contained in the projections, the 50th percentile, or central estimate, can be taken as the most likely scenario based on current knowledge. The climate change projections for Townsville in the years 2030 and 2070 were developed by CSIRO for the following features:

- Mean Temperature;
- Number of days over 35º C;
- Precipitation;
- Potential evapo-transpiration;
- Wind speed;
- Relative humidity;
- Fire risk;
- Solar radiation;
- Sea surface temperature and sea level rise.

The SEA O2 report considers how climate change scenarios are developed then reviews the results of the climate change model run by the CSIRO specifically for the Townsville region. Using these results a qualitative assessment of the potential impacts on local water quality was made.

As with the overall impacts of global warming on climate change the exact impacts of climate change on water quality are uncertain. It has been possible to identify a range of factors associated with climate change, which could impact water quality. Quantifying the water quality impacts with any level of certainty will, however, require further research and/or modelling.

Key drivers for changes to water quality as a result of climate change are primarily indirect and are associated with changes to the physical condition and structure of vegetation and vegetation communities with potential corresponding changes in soil erosion rates. Direct impacts could include an increase in the temperature of water bodies due to increases in average temperatures and extreme daily temperatures i.e. number of days with temperatures over 35 degrees Celsius, and sea level rise altering fresh water coastal wetlands to brackish or salt water.

What we can conclude from the short-term projections about climate change in Townsville is that there is unlikely to be any significant direct or indirect impacts on water quality during the term of the Water Quality Improvement Plan (WQIP). This conclusion is based on the fact that there will only be minor climatic variations, which will not have significant broadscale impacts on the distribution or structure of vegetation through direct association i.e. reduced rainfall and increased temperatures, or through indirect means e.g. increased fire weather. Therefore the main factor impacting water quality, erosion and sedimentation, is unlikely to increase.

4. Catchment Condition and Environmental Values

4.1 State of the Black/Ross Basins

Two primary studies have been undertaken to determine the current condition of the Black and Ross River Basins and these have been included in a synthesis document i.e. *Basins, Sub Basins, Catchments and Receiving Waters Background Report* (Gunn, Manning and Connolly 2009).

4.1.1 Condition of Receiving Waters

A study was undertaken by Connell Wagner to collate available water quality data for the study area and provide a report on the condition of the waterways with reference to the data collected. The report has been used to provide an indicative current condition figure (or assumed current condition for dated water quality data) as part of the development of water quality objectives and targets for the freshwaters of the Black/Ross WQIP area. A discussion on the condition of marine waters is provided in the catchments background report mentioned above (Gunn, Manning and Connolly 2009).

4.1.2 Catchment Condition

Catchment condition is more difficult to measure due to the number of variables. The two main variables chosen, which are relatively easy to measure, are land use and riparian condition. C and R Consulting prepared a riparian condition report (2 stages) to provide an overview of the current state of the vegetation in the riparian zones of the main waterways in the Black and Ross River Basins.

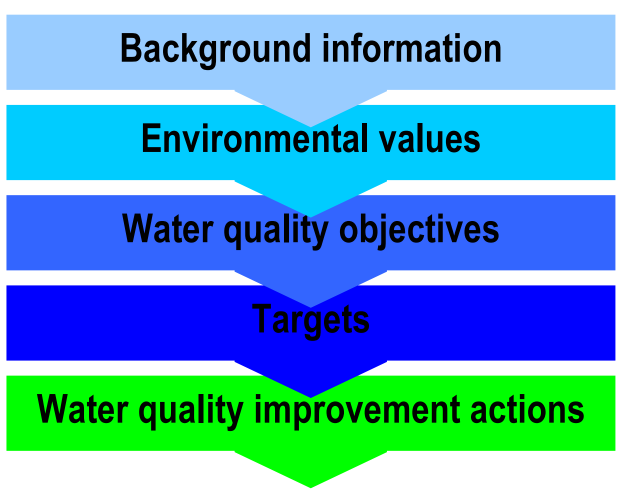
Land use information for the Black/Ross WQIP was updated by Creek to Coral using aerial photography, SPOT imagery and local knowledge of the area. The combined land use and riparian condition assessment was used to determine the current catchment condition and this was then cross referenced with the water quality condition report and environmental values results to determine priority catchments for water quality improvement activities.

4.2 Determining Environmental Values

The National Water Quality Management Strategy (NWQMS) provides a framework for protecting and enhancing the quality of the nation's waters. The framework includes the determination of environmental values of waterways and waterbodies as a starting point to establish the level of protection required.

A simplified diagram of the NWQMS framework used in this WQIP is shown in Figure 4-1.

Figure 4-1 Environmental Values in the NWQMS Framework



Environmental values (EVs) are those qualities of the waterway that make it suitable to support particular aquatic ecosystems and human uses, also know as beneficial uses. Human use EVs are divided into a variety of categories reflecting the types of human use while aquatic ecosystem EVs are divided into condition classes reflecting the degree of modification from natural conditions. Definitions of the various environmental values as per the NWQMS are provided in Table 4-1.

Table 4-1 Environmental Values Definitions

EV symbol	Symbol	Interpretation
	**Aquatic Ecosystems**	There are three EV levels (for levels of protection): High conservation/ecological value systems (HCV or HEV). They are often found within national parks, conservation reserves or inaccessible locations. Targets for these systems aim to maintain no discernable change from this natural condition. Slightly to moderately disturbed systems (SMD). These systems have undergone some changes but are not considered so degraded as to be highly disturbed. Highly disturbed systems (HD). These are degraded systems likely to have lower levels of naturalness. These systems may still retain some ecological or conservation values that require protecting. Targets for these systems are likely to be less stringent and may be aimed at remediation and recovery or retaining a functional but highly modified ecosystem that supports other environmental values also assigned to it.
Human Use (Beneficial use)		
	Irrigation	Irrigating crops such as sugar cane, lucerne, etc
	Stock watering	Water for stock e.g. cattle, horses, sheep
	Farm use	Water for farm use such as in fruit packing or milking sheds, etc
	Aquaculture	Water for aquaculture such as barramundi or red claw farming
	Human consumption	Human consumption of wild or stocked fish or crustaceans
	Primary recreation	Primary recreation with direct contact with water such as swimming or snorkelling
	Secondary recreation	Secondary recreation with indirect contact with water such as boating, canoeing or sailing
	Visual appreciation	Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing
	Drinking	Raw drinking water supplies for human consumption
	Industrial	Water for industrial use such as power generation, manufacturing plants
	Cultural & Spiritual	Cultural and spiritual values including the cultural values of traditional owners

4.3 Science and Community Consultation

Compilation of background information for determination of environmental values for the Black/Ross WQIP was done separately for aquatic ecosystems and human use before taking the information to community workshops.

Creek to Coral partners, Queensland Environmental Protection Agency (EPA) and the Great Barrier Reef Marine Park Authority (GBRMPA), took the lead role in collating the background information to determine a preliminary set of aquatic ecosystem high ecological value (HEV) areas for discussion, and produced the associated mapping.

After the initial compilation of information an expert panel workshop was held (12 October 2007) for the freshwater areas of the Black Ross WQIP area to review the concepts and draft information. A similar workshop was held for the estuarine and marine areas, in conjunction with the Burdekin WQIP team, for the Black Ross WQIP and Burdekin WQIP in March 2008.

The results of both workshops, including possible changes to HEV waters and identification of natural assets in modified systems, were compiled by the EPA and formed the basis for the suggested high ecological value (HEV) areas to be taken to the community workshops.

An information report and draft set of human use environmental values was prepared by Creek to Coral as background for the community consultation workshops through:

- An initial questionnaire sent out to selected stakeholders. The results were collated and used as the starting point for the information report on human uses;
- A desktop study using a variety of public domain information sources. In some cases individuals were also consulted to clarify or source information; and
- Water extraction licence information provided by the Department of Natural Resources and Water. This information was used to collate human uses for the waterways in the vicinity of the licenced property based on the purpose noted for the extraction licence.

Community workshops were held in July 2008 using the combined background information prepared by Creek to Coral, EPA and GBRMPA. For consultation purposes the Black Ross WQIP sub basins were grouped into 3 geographic regions:

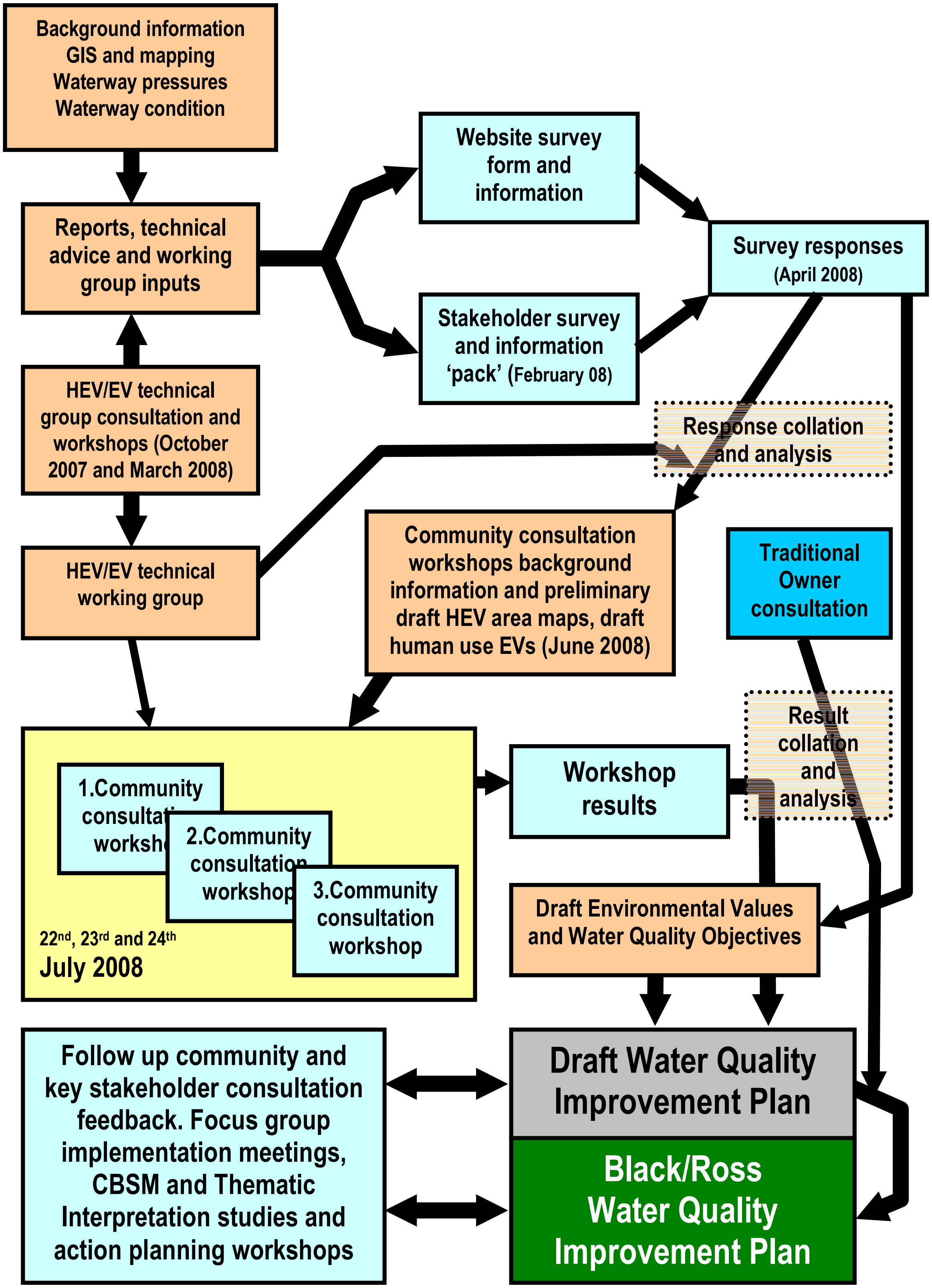
1. Rural (Crystal Creek to Black River and upper Ross River –above the Ross River Dam);
2. Urban and rural residential (lower Ross River, Bohle River, Stuart Creek and Alligator Creek sub basins including waterways to Cape Cleveland); and
3. Magnetic Island.

The community workshops were held at:

- Magnetic Island (Arcadia) on 22 July 2008,
- Bluewater on 23 July 2008 (Rural), and
- Annandale on 24 July 2008 (Urban and rural residential).

Results from the workshops were compiled by Creek to Coral for human use and by EPA for aquatic ecosystems. Human use results were posted on the Creek to Coral website in September 2008 and emailed to workshop participants for review and comment. Comments were incorporated and both the human use and aquatic ecosystem draft results were posted on the Creek to website in January 2009 (see Figure 4-2). Additional consultation will be undertaken with Traditional Owner groups and individuals as part of the implementation phase to better establish the cultural and spiritual human use values associated with waterways and waterbodies of the Black/Ross WQIP area.

Figure 4-2 Stakeholder Consultation Process



*Source: Communication Strategy Jan 08 (p.21) with modifications Nov 2008 and May 2009

4.4 Environmental Values for the Black/Ross WQIP Area

The combined results of the environmental values determination process are provided in Table 4-2 to Table 4-7. The areas identified as aquatic ecosystem HEVs are displayed in Figure 4-3 and Figure 4-4.

Figure 4-3 Draft Aquatic Ecosystem HEV Areas

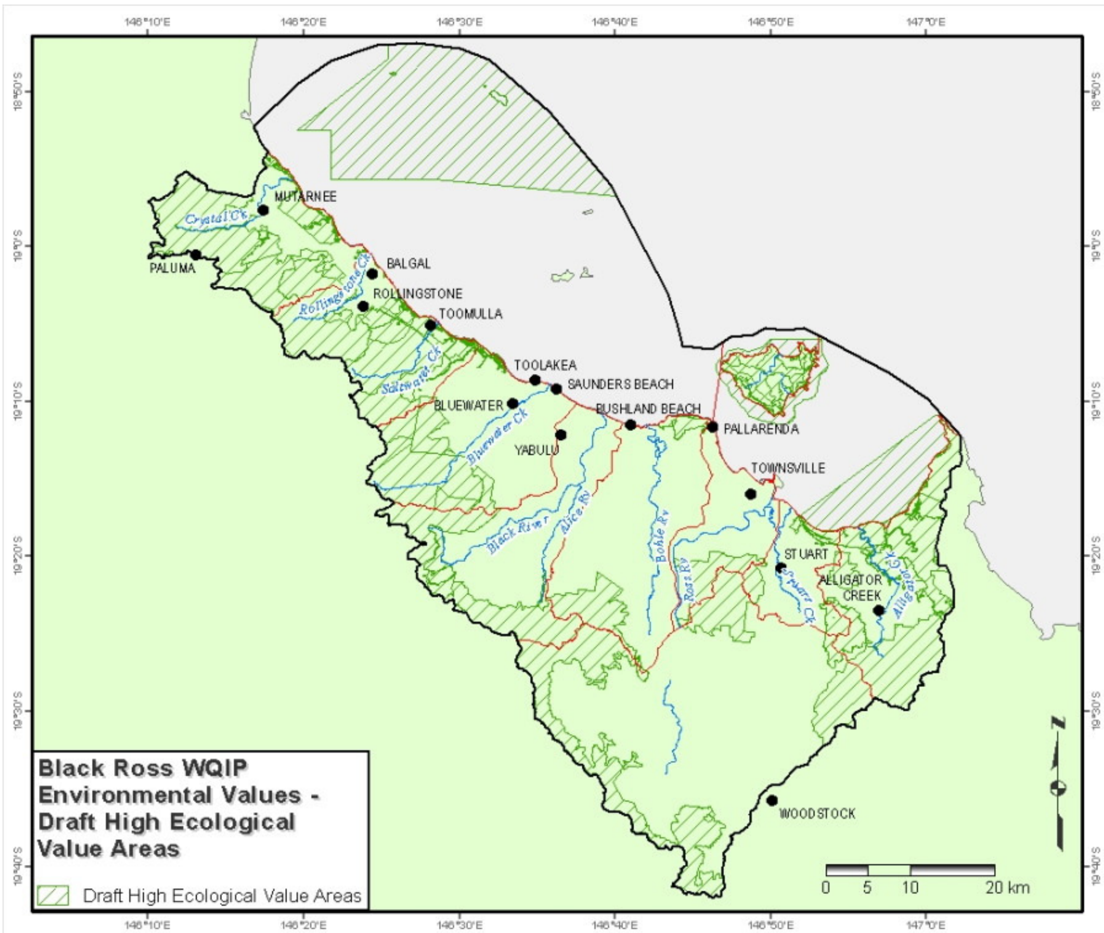


Figure 4-4 Magnetic Island Draft Aquatic Ecosystem HEV Areas

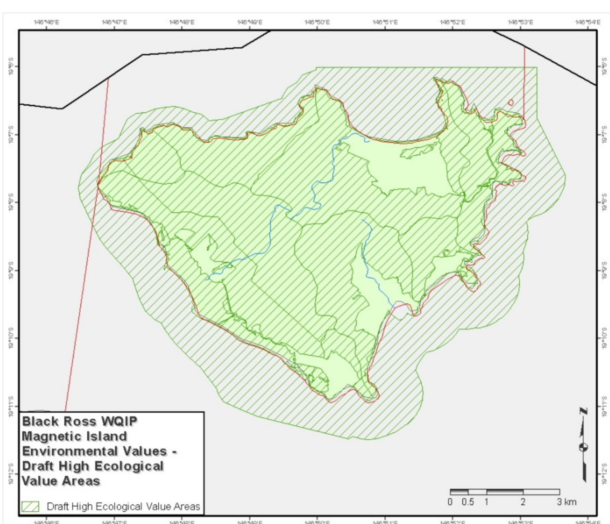


Table 4-2 Draft Environmental Values Black Basin

Waterway	Irrigation	Farm supply	Stock watering	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual appreciation	Drinking water	Industrial use	Cultural and spiritual values	Aquatic ecosystems
Freshwaters (Note: Instream storages (dams, weirs and barrages) have been underlined)												
Black River Basin												
Crystal Creek (Upland)						L	L	M - H	H		H	HEV
Crystal Creek (Lowland)	M	M	H		M	H	L - M	H	H		H	SMD
Lorna Creek (Upland)						L	L	L			H	SMD
Lorna Creek (Lowland)	M	M	H		M	H	L - M	H			H	SMD
Ollera Ck (Upland)						L	L	L			H	HEV
Ollera Creek (Lowland)	M	M	H		M	H	L - M	H			H	SMD
Scrubby Ck (Upland)						L	L	L			H	HEV
Scrubby Creek (Lowland)	M	M	H		M	H	L - M	H			H	SMD
Hencamp Ck (Upland)						L	L	L			H	HEV
Hencamp Ck (Lowland)	M	M	H		M	H	L - M	H			H	SMD
Rollingstone Ck (Upland)						L	L	L			H	HEV
Rollingstone Ck (Lowland)	M	L	H		M	H	L - M	H	L		H	SMD
Surveyors Ck	L					L	L	L			H	HEV
Wild Boar Creek						L	L	L			H	HEV
Station Creek					L	L	L	L			H	HEV
Saltwater Ck (Upland)						L	L	L			H	HEV
Saltwater Creek (Lowland)	M	L	H		M	H	M	M			H	HEV
Cassowary Ck (Upland)						L	L	L			H	HEV
Cassowary Ck (Lowland)	M	L	H		M	H	L - M	H			H	HEV
Leichhardt Ck (Upland)											H	HEV
Leichhardt Ck (Developed)	M	L	H		M	H	M	M	L		H	SMD
Christmas Ck (Upland)											H	HEV
Christmas Ck (Developed)	L	L	H		M	H	L - M	H			H	SMD
Sleeper Log Ck (Upland)											H	HEV

Waterway	Irrigation	Farm supply	Stock watering	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual appreciation	Drinking water	Industrial use	Cultural and spiritual values	Aquatic ecosystems
Sleeper Log Ck (Developed)	L	L	H		M	H	L - M	H			H	SMD
Two Mile Creek					L		L				H	SMD
Bluewater Ck (Upland)						L	L	M - H			H	HEV
Bluewater Ck (Lowland)	M - H	M	H		M	H	H	H			H	SMD
Althaus Creek (Upland)						L	L	M - H			H	HEV
Althaus Creek (Lowland)			H		L	H	H	H			H	SMD
Deep Creek (Upland)						L	L	M - H			H	SMD
Deep Creek (Lowland)	M - H	M	H		L	H	H	H			H	SMD
Healy Creek				?	L		L	L			H	SMD
Black River (Upland)						L	L	L			H	HEV
Black River (Lowland)	L		H		L	L			L	M	H	SMD
Alick Creek (Black R trib.)	L		L								H	SMD
Log Creek (Black R trib.)	L		L								H	SMD
Scrubby Ck (Upland)					L	L	L	L			H	SMD
Alice River (Developed)	L		H		L	L					H	SMD
Canal Creek (Alice R trib.)	L								L		H	SMD

Notes: These notes apply to all draft Environmental Values tables. Most of the human use values have been identified from stakeholder workshops where L = Low, M = Medium and H = High use/value. The level of human use (recreation and human consumption) was assigned on the basis of input from the community workshops where high use/value was assigned when it was recognised that people travelled from other parts of the region to use the resource, medium use was associated with areas being important locally with less external utilisation i.e. by visitors, and low use was infrequent or seasonal use predominantly by landowners and locals. Low use was also attributed to inaccessibility. Agricultural use was assigned on the local/catchment importance associated with land use and stream size, and in the context of the region. Some use levels were assigned on the basis of water extraction data. Industrial and drinking water use was assigned on the basis of regional importance followed by local importance.

Additional uses identified through a prior study and not identified at the workshop have also been included; from the preliminary stakeholder survey, the human use study and from DNRW water licencing extraction data (see Human Use EVs Report for more detail). Unless otherwise indicated by the background information a low level of use was assigned to the human uses not identified at the workshops. For Cultural and Spiritual human use a default high value was assigned at workshops. Traditional Owner consultation will be used to define the values.

In some cases future uses, which are different to current uses, have also been identified. These are marked on the appropriate table/s.

Aquatic ecosystem environmental values were initially identified through a desktop review and technical panel workshops. The draft aquatic ecosystem environmental values were then reviewed at stakeholder workshops. The WQIP study team is continuing to review/update this information and we welcome further comment on the draft ecological values identified in the tables.

HEV = High ecological/environmental value, SMD = Slightly to moderately disturbed, HD = Highly disturbed

Table 4-3 Draft Environmental Values Upper Ross River Catchment (Ross Basin)

Waterway	Irrigation	Farm supply	Stock watering	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual appreciation	Drinking water	Industrial use	Cultural and spiritual values	Aquatic ecosystems
Freshwaters												
Ross River Basin (Ross River Dam and upstream)												
Lake Ross (Ross Dam)	L				L	L	L	M	H	M	H	SMD
Ross River (FrW)	L		M - H			L	L	L			H	SMD
Round Mountain Ck (Upland)											H	HEV
Round Mountain Creek	L		M - H			L	L	L			H	SMD
Lagoon Creek	L		M - H			L	L	L			H	SMD
Plum Tee Creek	L		M - H			L	L	L			H	SMD
Central Ck (aka Ross Ck)	L		M - H			L	L	L			H	SMD
Sandy Creek	L		M - H			L	L	L			H	SMD
Spring Creek	L		M - H			L	L	L			H	SMD
Deep Creek	L		M - H			L	L	L			H	SMD
Leichhardt Creek	L		M - H			L	L	L			H	SMD
Cattle Creek	L		M - H		L	L	L	L			H	SMD
Six Mile Creek	L	L	M					L			H	SMD
Toonpan Lagoon	M	L	M					L			H	SMD
Jimmys Lagoon	L	L	M					L			H	SMD
Four Mile Ck /Flagstone Ck	L	L	M					L			H	SMD
One Mile Creek/Spring Creek	H	L	M					L			H	SMD
Lansdowne Creek	H	L	M					L			H	SMD
Antill Plains Creek	L	L	M					L			H	SMD
Sachs Creek (Upland)											H	HEV
Sachs Creek	M					L	L	M	L		H	SMD
Blacksoil Gully/Mt Stuart (Upland)											H	HEV
Blacksoil Gully/Mt Stuart						L	L	L			H	SMD

Table 4-4 Draft Environmental Values Ross River Basin (exc. Upper Ross River Catchment)

Waterway	Irrigation	Farm supply	Stock watering	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual appreciation	Drinking water	Industrial use	Cultural and spiritual values	Aquatic ecosystems
Freshwaters												
Ross River Basin (east)												
Alligator Ck (Upland)	L?					H	H	H	L		H	HEV
Alligator Creek (Lowland)	L - M	M	L		L - M	L	L - M	L - M	L		H	SMD/HD
Whites Creek (Upland)											H	HEV
Whites Creek	L		L		L	L	L - M	L - M			H	SMD
Slippery Rocks Ck (Upland)											H	HEV
Slippery Rocks Creek	L		L		L	L	L - M	L - M			H	SMD
Crocodile Creek	L		L		L	L	L - M	L - M	L		H	SMD
Killymoon Creek (Upland)											H	HEV
Killymoon Creek	M		L		L	L	L - M	L - M	L		H	SMD
Cape Cleveland						L	L	L			H	HEV
Stuart Creek (ephemeral)	L	L	L			L		L			H	SMD
Stuart Creek (includes pools)	L	L	L		M	L	M	L - M			H	SMD/HD
Sandfly Creek			L			L	L	M			H	SMD
Ross River Basin (west)												
	Now / future	Now / future	Now / future	Now / future	Now / future	Now / future	Now / future	Now / future	Now / future	Now /future	Now / future	
Stoney Creek	L		L		L	L	L	M			H	SMD
Saunders Creek	L		L		L	L	L	M			H	SMD
Bohle R (above Condon STP)	L	L	L		L	L	L	L			H	SMD
Bohle R (below Condon STP)	L	L	L		M	M/H	M/H	M/H			H	SMD
Little Bohle River	L		L		L	L	L	M			H	SMD
Middle Bohle Creek	L		L		L	L	L	M			H	SMD
Louisa Creek					L		L	L			H	HD
Town Common							L - M	H			H	SMD

Waterway	Irrigation	Farm supply	Stock watering	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual appreciation	Drinking water	Industrial use	Cultural and spiritual values	Aquatic ecosystems
Ross River Basin (below the Ross River Dam)												
Ross River (below Dam)	M	L			H	H	H	H			H	SMD
Ross River Weir Pools (All)	M				H	H	H	H			H	HD
Ross River (Black Weir)	H				H	H	H	H	H		H	HD
Ross R (Gleesons Weir)	L				H	H	H	H			H	HD
Ross River (Aplins Weir)	L				H	H	H	H			H	HD
Tributaries (Defence land)					L	L	L	L			H	HEV to HD
University (Campus) Creek					L	L	L	M			H	HEV to HD
Lavarack Creek with weirs					L	L	L	M			H	HD
Ross Creek and tributaries					H	L	L	H			H	HD
Pallarenda					H		H	H			H	HD

Table 4-5 Draft Environmental Values for Magnetic Island

Waterway	Irrigation	Human consumer	Primary recreation	Secondary recreation	Visual appreciation	Drinking water	Cultural and spiritual values	Aquatic ecosystems
Freshwaters								
Magnetic Island								
Retreat Creek	H	L	M	H	H	L	H	HEV/SMD
Duck Creek	L		M	H	L	L	H	HEV/SMD
Chinamans Gully		L	L	L	L		H	HEV/SMD
Ned Lee Creek			H	H	H	L	H	HEV/SMD
Butler Ck (Picnic Bay)		L	L	L	M		H	SMD/HD
Picnic Bay west creek		L	L	L	M		H	SMD/HD
Gustav Creek (Upland)		L	M	M - H	M - H		H	HEV
Gustav Creek (Lowland)		L	L	H	H		H	SMD/HD
Hoyer Creek (Nelly Bay)			L	L	H		H	SMD/HD
North Nelly Bay creek				L	H		H	HEV/SMD
Petersen Creek (Upland)		L	M - H	H	H		H	HEV
Petersen Creek (Lowland)			M - H	H	H		H	SMD/HD
Gorge Creek (Upland)		L	M - H	H	H		H	HEV
Gorge Creek (Lowland)		L	L	L	H		H	SMD/HD
Endeavour Creek (Upland)		L	M - H	H	H		H	HEV
Endeavour Creek (Lowland)			M - H	H	H		H	SMD
East Horseshoe Bay creek		L	L	L - M	H		H	SMD
Five Beach Bay			M - H	H	H		H	HEV

Table 4-6 Draft Environmental Values Mainland Estuaries (Black and Ross Basins)

Waterway	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual appreciation	Industrial use	Cultural and spiritual values	Aquatic ecosystems
Estuarine Waters								
Crystal Creek		H	M	M - H	H		H	SMD
Lorna Creek		H	M	M - H	H		H	SMD
Ollera Creek		H	M	M - H	H		H	HEV
Scrubby Creek		H	M	M - H	H		H	HEV
Hencamp Creek		H	M	M - H	H		H	SMD
Rollingstone Creek		H	L	H	H		H	SMD
Surveyors Creek		H	M	M - H	H		H	HEV
Wild Boar Creek		H	M	M - H	H		H	HEV
Station Creek		H	M	M - H	H		H	HEV
Saltwater Creek	H	H	L	H	H		H	HEV
Cassowary Creek		L	L	L	L		H	HEV
Leichhardt Creek		H	L	H	H		H	SMD
Christmas Creek		H	L	H	H		H	SMD
Two Mile Creek		H	L	H	H		H	SMD
Bluewater Creek		H	L	L	H		H	SMD
Deep Creek		H	L	H	H		H	SMD
Healy Creek		H	L	H	H		H	SMD
Black River		H	L	M	L		H	SMD
Bohle sub basin (upper)		M		M	L - M		H	SMD
Bohle sub basin (lower)		H		H	H		H	SMD
Town Common		L					H	SMD
Louisa Creek		M		M	M		H	SMD
Ross River sub basin		H		H	H	M	H	SMD
Stuart Creek sub basin	L	H	L	H	H		H	SMD
Alligator Creek sub basin	L	H	L	H	H		H	HEV

Table 4-7 Draft Environmental Values Magnetic Island Estuaries and Coastal and Marine

Waterway	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual appreciation	Cultural and spiritual values	Aquatic ecosystems
Estuaries							
All Magnetic Island		H	L	L	H	H	HEV
Butler Creek (Estuary)		L	M	M	H	H	SMD
Gustav Creek		L - M	H	H	H	H	HD
East Horseshoe Bay creek		L	L	L	H	H	SMD
Near Coastal and Marine Waters							
All near coastal waters MIs		H	M - H	H	H	H	HEV
Horseshoe Bay	M	H	H	H	H	H	HEV
West Channel		H	H	H	H	H	SMD
Cleveland Bay		H	H	H	H	H	HEV/SMD
Halifax Bay		H	H	H	H	H	SMD
Outer Marine		H	H	H	H	H	HEV/SMD

5. Water Quality Objectives and Targets

5.1 Introduction

Updated Australian water quality guidelines (AWQG) were published in 2000 as part of the ongoing National Water Quality Management Strategy (NWQMS) program. The guidelines set benchmark values against which the quality of waters can be assessed and provided the technical base for establishing draft water quality objectives.

The *Queensland Water Quality Guidelines 2006* (QWQG) were developed by the Queensland Environmental Protection Agency (EPA) as an extension of the NWQMS and AWQG, by delivering guidelines that include locally and regionally relevant water quality data for fresh, estuarine and marine waters. The QWQG focus largely on aquatic ecosystem protection, initially across three geographic regions where regional data was available i.e. Southeast, Central Coast, and the Wet Tropics.

5.2 Water Quality Guidelines Relevant to the Dry Tropics

Local water quality guidelines for non-marine areas have not yet been established for the Black/Ross WQIP area so in lieu of local guidelines the Queensland guidelines for the Central Coast (Wet Tropics guidelines are used for the for the northern catchments) have been adopted for freshwaters and estuaries. Water quality trigger value guidelines prepared by GBRMPA have been adopted for marine areas (see Gunn et al 2009).

5.3 Water Quality Condition Indicators

A range of indicators can be used to assess water quality and aquatic ecosystem condition. These are usually divided into physico-chemical indicators and biological indicators. Physico-chemical indicators are most often used as they are more easily measured using standard sampling and analysis procedures. Biological indicators are discussed briefly in section 5.6. The physico-chemical water quality indicators considered for use when establishing water quality objectives are listed in Table 5-1. Some of the indicators are specific to urban areas and not all indicators are used in all situations e.g. freshwater versus marine or ambient concentrations versus event-based loads.

Table 5-1 Condition Indicators

WQ Indicator	Description	Reason for Use
TSS	Total suspended sediment/solids	Indicator of erosion and transport of sediment to waterbodies. Can be related to vegetation cover/bare ground and management practices. Can result in smothering of benthic organisms and inhibition of primary production
Turbidity	Visual measure of water clarity	Light penetration and subsequent biological activity is impacted by water clarity
OrgN/PN	Organic nitrogen / particulate nitrogen	Provides an indication of the amount of plant material entering the system and will become bioavailable in the longer term through decomposition
DIN	Dissolved inorganic nitrogen	Readily bioavailable and supports a range of biological interactions including algal growth
Total N	The sum of all forms of nitrogen	Available data sets may not provide analysis of the different species of nitrogen
PP	Particulate phosphorus	Can become bioavailability in the longer term and is often related to TSS levels
FRP	Filterable reactive phosphorus	Readily bioavailable and supports a range of biological interactions including algal growth

Total P	The sum of all forms of phosphorus	Available data sets may not provide analysis of the different species of phosphorus
Chlorophyll a	A measure of algal growth	Is an indicator of algal growth and has a close relationship to nutrient concentrations, modified to some extent by water clarity
DO	Dissolved oxygen (percentage saturation)	Oxygen levels are important for fish and other aquatic organisms to survive. Low oxygen levels are one of the main water quality issues in tropical Queensland, often resulting from natural causes
pH	Indicator of acidity and alkalinity	pH is important for chemical and biological processes with highly acid and highly alkaline waters resulting in stressful or toxic conditions for many organisms leading to a change in biodiversity
EC	Electrical conductivity is a simple way to measure salt levels	In freshwaters, high levels of salt can impact plant growth and create conditions that are toxic to many organisms leading to a change in biodiversity
Pesticides	Various types	Inhibits plant growth and may bioaccumulate
Urban Specific		
Hydrocarbons	Oil and petroleum based products	Excessive hydrocarbons can result in smothering of aquatic habitats. They can also increase morbidity and mortality in aquatic species, and impact reproductive cycles
Gross Pollutants	Debris items often >5mm. Litter including plastics, garden waste and coarse sediment	Organic material can lead to oxygen depletion during decomposition. Litter, especially plastic bags, can be harmful to marine organisms, as well as being aesthetically unpleasant.
Metals/Heavy metals	Cadmium, Chromium, Copper, Nickel, Lead, Zinc	Excessive levels can be toxic to aquatic organisms and can bioaccumulate and be passed along the food chain (Cobalt, Sellenium, Thallium, Silver, Arsenic, Antimony)

5.4 Water Quality Objectives

Water quality objectives (WQOs) are based on the adoption of the most stringent water quality guidelines (WQGs), for the relevant water quality parameters, which will maintain the identified environmental values (EVs) of the waterways and waterbodies in the study area.

Stream flow in the Dry Tropics is highly seasonal with potentially high and flood flows during the wet season (December to April) and limited baseflow, or no flow, in many of the streams during the drier months (May to November). The amount of pollutants in waterways will vary depending on rainfall and stream flow so water quality objectives also need to be tailored to appropriately reflect climatically influenced situations.

5.4.1 Ambient Concentrations

A set of draft physico-chemical water quality objectives for ambient conditions have been adopted for the Black Ross WQIP area based on the EVs established and on the Queensland Water Quality Guidelines (see Table 5-2) and GBRMPA marine water quality guideline trigger values (see Table 5-3).

For freshwater and estuaries the draft water quality objectives are based principally on the guidelines for slightly to moderately disturbed aquatic ecosystems, which provide a higher level of water quality protection than is required for most human use environmental values i.e. more stringent guideline values. In this way all human use environmental values are protected by default if the aquatic ecosystem water quality guideline values are maintained.

Where there is an exception to this generalisation the higher level of protection for human use is adopted where a waterway or water body has been identified as having one or more of those human use environmental values. Exceptions are listed in the table endnotes. Wet Tropics water quality objectives (to be inserted) have been adopted for Crystal Creek and Rollingstone sub basins.

Table 5-2 Draft Ambient Physico-chemical Water Quality Objectives Freshwater and Estuaries

Indicator	Freshwater			Estuarine	
	Upland	Lowland	Lakes	Mid Estuary	Upper Estuary
TSS (mg/L)	-	10	10	20	25
OrgNQ/PNG – N (µg/L)	225	420	330	260	400
DIN – N (µg/L)	25	80	20	20	45
Total N (µg/L)	250	500	350	300	450
PP – P (µg/L)	15	30		17	30
FRP – P (µg/L)	15	20	5	8	10
Total P (µg/L)	30	50	10	25	40
Turbidity (NTU)	25	50	1-20	8	25
Chlorophyll a (µg/L)	na	5	5	4	10
Dissolved Oxygen (%)	90-110	85-110	90-110	85-100	70-100
pH	6.5-7.5	6.5-8.0	6.5-8.0	7.0-8.4	7.0-8.4
EC* (µS/cm)	375/271	375/271	375/271		

Notes: Values are for Slightly to Moderately Disturbed waterways. PP = Total P – FRP. Dissolved oxygen is % saturation.

* Conductivity values (EC) for freshwaters (from the QWQG Appendix G, p.103) for Central Coast North, based on the 75th percentile value, is 375 µS/cm for the Black Basin. The Ross Basin is in the Burdekin-Bowen region and the corresponding value is 271 µS/cm.

Water Quality Guideline values - Exceptions to the aquatic ecosystem guidelines:

Ammonia - Recreation (Primary and Secondary) guidelines for Ammonia are more stringent in upper estuaries and lowland streams i.e. 10 µg/L.

Turbidity - Drinking water (aesthetics) guidelines for turbidity are more stringent for freshwater i.e. 5 NTU. (Nephelometric turbidity unit)

Secchi depth - Primary recreation guidelines for Secchi depth are more stringent for estuaries i.e. >1.6m.

Table 5-3 Draft Marine Physico-chemical Water Quality Objectives

	Enclosed Coastal	Coastal/ Inshore	Offshore
TSS (mg/L)	15 [1]	2.0 [1]	0.7 [1]
OrgNQ/PNG – N (µg/L)	180 [2]	20 [1]	17 [1]
DIN – N (µg/L) *	11 [2]	9 [2]	
Total N	200 [2]	29*	
PP – P (µg/L)	14 [2]	2.8 [1]	1.9 [1]
FRP – P (µg/L)	6 [2]	6 [2]	
Total P	20 [2]	8.8*	
Turbidity (NTU)	6 [2]	1 [2]	
Chlorphyll a (µg/L)	2 [1]	0.45 [1]	0.4 [1]
Dissolved Oxygen (%)	90-100 [2]	95-105 [2]	
pH	8.0-8.4 [2]	8.0-8.4 [2]	
Secchi depth	1.5 [1]	10 [1]	17 [1]

Notes: [1] indicates values from the WQ Guideline for the GBRMP (GBRMPA 2008) and [2] indicates values from the Queensland WQ Guidelines (EPA 2006). * Based on the locally derived particulate nitrogen and phosphorous trigger levels an adjustment to the QWQG concentration for the total nitrogen and phosphorus values has been calculated

Table 5-4 Draft Pesticide Water Quality Objectives

Pesticides (µg/L)	Freshwater				Marine	
	Upland	Lowland	HEV	SMD	HEV	SMD
Diuron	<LOD	0.5		2.0	0.9*	1.6*
Atrazine	<LOD	0.3	0.7	13	0.4*	2.4*
Simazine	<LOD	0.01	0.2	3.2	0.2*	3.2*
Bromacil						
Hexazinone	<LOD	0.4			75*	75*
Endosulfan[1]			0.03	0.03	0.005	0.005
Malathion			0.002	0.05		
Chlorpyrifos					0.005*	
Ametryn					0.5*	
2,4-D					0.8*	
Tebuthiuron					0.02*	
MEMC					0.002*	
Diazinon					0.00003*	
Tributytlin[2]					0.0002*	

Pesticides (from Leissmann et al 2007, ACTFR 07/09). Pesticide concentrations for upland and lowland freshwater from MWWQIP p.28 LOD is limit of detection (generally 0.01µg/L)
HEV and SMD values for freshwater from AWQG ANZECC 2000 Table 3.4.1 Trigger values for toxicants at alternative levels of protection (aquatic ecosystems) Part 8, 9 and 10 (all other values ID).
* Marine values from GBR

[1] This trigger value may not protect keystone species given effect concentrations for adult coral colonies are observed at significantly lower concentrations. [2] Tributytlin is a biocide.

Additional water quality objectives have also been adopted for the high urban catchments i.e. catchments where urban land uses are >65%. Draft objectives for heavy metals and hydrocarbons, and heavy metals in sediment are listed in Table 5-5 and Table 5-6.

Table 5-5 Draft Heavy Metal Water Quality Objectives

Indicator	Freshwater		Marine	
Heavy metal (µg/L)	HEV	SM Dist.	HEV	SM Dist.
Cadmium	0.06	0.2	0.7	5.5
Chromium	0.01	1.0	0.14	4.4
Copper	1.0	1.4	0.3	1.3
Lead	1.0	3.4	2.2	4.4
Nickel	8	11	7	70
Zinc	2.4	8.0	7	15
Hydrocarbons *	300	300		

Source: AWQG Table 3.4.1 Trigger values for toxicants at alternative levels of protection
Note: Trigger values for toxicants (µg/L) at alternative levels of protection (AWQG, pp.3.4-5 to 3.4-10) i.e. 99%, 95%, 90% and 80% for freshwaters and marine waters.
* Hydrocarbon reference (Oils and greases (including petrochemicals) <300 µg/L) appears in Aquaculture Table 4.4.3 Toxicant guidelines for the protection of aquaculture species Part 2.
A range of hydrocarbons are included in AWQG Table 3.4.1

Table 5-6 Draft Heavy Metals in Sediment Objectives

Metals in sediment	ISQG low	ISQG high
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Nickel	21	52
Zinc	200	410

Heavy metals from Interim Sediment Quality Guidelines (ANZECC 2000) Measured as mg/kg (dry weight) = ppm Table 3.5.1

A water quality objective has been set for gross pollutants as part of the process for developing the Water Sensitive Urban Design guidelines. This is expressed as a 90% reduction in gross pollutants from current levels.

5.4.2 Event Concentrations

It is important in urban areas to reduce the amount of sediment moving off construction sites to waterways and it is also important to provide an indication to the development and construction industry of acceptable water quality levels of run-off from construction sites. As the majority of pollutants load (80-90%) is discharged from catchments during event flows the concentrations during events is greater than that of background readings.

Indicating appropriate water quality objectives is best done using event concentrations rather than unrealistic background or low flow concentrations. Local event water quality monitoring data has been used to calculate a draft set of event based water quality objectives. Data was collected during event monitoring over the 2006/2007 and 2007/2008 'wet seasons'. The draft objectives are listed in Table 5-7.

Table 5-7 Event Based Water Quality Objectives

Indicator	Event based WQOs	
	Developing Urban	All Other Landuse
TSS (mg/L)	285 (476)	75
OrgNQ/PN – N (μg/L)	119 (198)	149
DIN – N (μg/L)	-	75
Total N (μg/L)	-	426
PP – P (μg/L)	75 (125)	33
FRP – P (μg/L)	-	20
Total P (μg/L)	-	59

Source: Townsville WQO EMC for TSS, PN and PP for developing areas was derived by summing three of four event monitoring samples taken from developing coastal plains in Townsville (discard the outlier) and then reducing the mean by 40% (numbers in brackets are the mean prior to reduction) to the initial target figures.

Table 5-8 Freshwater Ambient WQOs and Targets (µg/L)

Sub Basin	Catchment/Management Unit		DIN			PN			Total N			FRP			PP			Total P			TSS		
			WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T
Crystal Creek Sub Basin	Crystal Creek (Upland) 1-1	HEV	PCC	14	14	PCC	95	95	PCC	108	108	PCC	2	2	PCC	2	2	PCC	4	4	PCC	2	2
	Crystal Creek (Lowland FW) 1-1	SMD	10	14	10	200	95	200	240	108	240	4	2	4	6	2	6	10	4	10	ND	4	ND
	Lorna Creek (Upland) 1-2	SMD	36	14	36	125	95	125	150	108	150	5	2	5	5	2	5	10	4	10	ND	4	ND
	Lorna Creek (Lowland FW) 1-2	SMD	10	14	10	200	95	200	240	108	240	4	2	4	6	2	6	10	4	10	ND	4	ND
	Ollera Ck (Upland) 1-3	HEV	PCC	14	14	PCC	95	95	PCC	108	108	PCC	2	2	PCC	2	2	PCC	4	4	PCC	4	4
	Ollera Creek (Lowland FW) 1-3	SMD	10	14	10	200	95	200	240	108	240	4	2	4	6	2	6	10	4	10	ND	4	ND
	Scrubby Ck (Upland) 1-4	HEV	PCC	14	14	PCC	95	95	PCC	108	108	PCC	2	2	PCC	2	2	PCC	4	4	PCC	4	4
	Scrubby Creek (Lowland FW) 1-4	SMD	10	14	10	200	95	200	240	108	240	4	2	4	6	2	6	10	4	10	ND	4	ND
	Hencamp Ck (Upland) 1-5	HEV	PCC	35	35	PCC	300	300	PCC	340	340	PCC	5	5	PCC	5	5	PCC	20	20	PCC	20	20
	Hencamp Ck (Lowland FW) 1-5	SMD	10	35	10	200	300	200	240	340	240	4	5	4	6	5	6	10	20	10	ND	20	ND
Rollingstone Creek Sub Basin	Rollingstone Ck (Upland) 2-1	HEV	PCC	40	40	PCC	300	300	PCC	360	360	PCC	ND	5	PCC	ND	5	PCC	20	20	PCC	20	20
	Rollingstone Ck (Lowland FW) 2-1	SMD	10	40	10	200	300	200	240	360	240	4	ND	4	6	ND	6	10	20	10	ND	20	ND
	Unnamed Creek 2-2	SMD	10	15	10	200	200	200	240	223	240	4	5	4	6	5	6	10	20	10	ND	20	ND
	Surveyors Ck 2-3	HEV	PCC	15	15	PCC	200	200	PCC	223	223	PCC	5	5	PCC	5	5	PCC	20	20	PCC	20	20
	Wild Boar Creek 2-4	HEV	PCC	15	15	PCC	200	200	PCC	223	223	PCC	5	5	PCC	5	5	PCC	20	20	PCC	20	20
	Station Creek 2-5	HEV	PCC	15	15	PCC	200	200	PCC	223	223	PCC	5	5	PCC	5	5	PCC	20	20	PCC	20	20
	Saltwater Ck (Upland) 2-6	HEV	PCC	15	15	PCC	200	200	PCC	223	223	PCC	5	5	PCC	5	5	PCC	20	20	PCC	20	20
	Saltwater Creek (Lowland FW) 2-6	HEV	PCC	15	15	PCC	200	200	PCC	223	223	PCC	5	5	PCC	5	5	PCC	20	20	PCC	20	20
	Cassowary Ck (Upland) 2-7	HEV	PCC	15	15	PCC	200	200	PCC	223	223	PCC	5	5	PCC	5	5	PCC	20	20	PCC	20	20
	Cassowary Ck (Lowland FW) 2-7	HEV	PCC	15	15	PCC	200	200	PCC	223	223	PCC	5	5	PCC	5	5	PCC	20	20	PCC	20	20
	Leichhardt Ck (Upland) 2-8	HEV	PCC	30	30	PCC	300	300	PCC	330	330	PCC	ND	5	PCC	ND	5	PCC	20	20	PCC	20	20
	Leichhardt Ck (Developed) 2-8	SMD	10	30	10	200	300	200	240	330	240	4	ND	4	6	ND	6	10	20	10	ND	20	ND
Bluewater Creek Sub Basin	Christmas Ck (Upland) 3-1	HEV	PCC	17	17	PCC	200	200	PCC	240	240	PCC	5	5	PCC	5	5	PCC	30	30	PCC	30	30
	Christmas Ck (Developed) 3-1	SMD	80	17	80	420	200	420	500	240	500	20	5	20	30	5	30	50	30	50	10	30	10
	Sleeper Log Ck (Upland) 3-1	HEV	PCC	17	17	PCC	200	200	PCC	240	240	PCC	5	5	PCC	5	5	PCC	30	30	PCC	30	30
	Sleeper Log Ck (Developed) 3-1	SMD	80	17	80	420	200	420	500	240	500	20	5	20	30	5	30	50	30	50	10	30	10
	Two Mile Creek 3-2	SMD	80	19	80	420	200	420	500	228	500	20	9	20	30	9	30	50	40	50	10	40	10
	Bluewater Ck (Upland) 3-3	HEV	PCC	61	61	PCC	196	196	PCC	282	282	PCC	6	6	PCC	6	6	PCC	20	20	PCC	20	20
	Bluewater Ck (Lowland FW) 3-3	SMD	80	61	80	420	196	420	500	282	500	20	6	20	30	6	30	50	20	50	10	20	10
	Althaus Creek (Upland) 3-4	HEV	PCC	40	40	PCC	300	300	PCC	370	370	PCC	ND	15	PCC	ND	15	PCC	20	20	PCC	20	20
	Althaus Creek (Lowland FW) 3-4	SMD	80	40	80	420	300	420	500	370	500	20	ND	20	30	ND	30	50	20	50	10	20	10
	Deep Creek (Upland) 3-4	SMD	25	40	25	225	300	225	250	370	250	15	ND	15	15	ND	15	30	20	30	-	20	-
	Deep Creek (Lowland FW) 3-4	SMD	80	40	80	420	300	420	500	370	500	20	ND	20	30	ND	30	50	20	50	10	20	10
	Healy Creek 3-4	SMD	80	40	80	420	300	420	500	370	500	20	ND	20	30	ND	30	50	20	50	10	20	10
River	Black River (Upland) 4-1	HEV	PCC	40	40	PCC	300	300	PCC	335	335	PCC	35	35	PCC	35	35	PCC	32	32	PCC	32	32
	Black River (Lowland FW) 4-1	SMD	80	40	80	420	300	420	500	335	500	20	35	20	30	35	30	50	32	50	10	32	10

	Catchment/Management Unit		DIN			PN			Total N			FRP			PP			Total P			TSS		
			WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T
	Alick Creek (Black R trib.) 4-1	SMD	80	40	80	420	300	420	500	335	500	20	35	20	30	35	30	50	32	50	10	32	10
	Log Creek (Black R trib.) 4-1	SMD	80	40	80	420	300	420	500	335	500	20	35	20	30	35	30	50	32	50	10	32	10
	Scrubby Ck (Alice R trib.) (Up) 4-2	SMD	80	40	80	420	300	420	500	335	500	20	35	20	30	35	30	50	32	50	10	32	10
	Alice River (Developed) 4-2	SMD	80	40	80	420	300	420	500	335	500	20	35	20	30	35	30	50	32	50	10	32	10
	Canal Creek (Alice R trib.) 4-2	SMD	80	40	80	420	300	420	500	335	500	20	35	20	30	35	30	50	32	50	10	32	10
Bohle River Sub Basin	Stoney Creek 5-1	SMD	80	69	80	420	500	420	500	620	500	20	130	20	30	130	30	50	130	50	10	130	10
	Saunders Creek 5-1	SMD	80	69	80	420	500	420	500	620	500	20	130	20	30	130	30	50	130	50	10	130	10
	Bohle R (below Bruce Hway) 5-1	SMD	80	69	80	420	500	420	500	620	500	20	130	20	30	130	30	50	130	50	10	130	10
	Louisa Creek 5-1	HD	80	69	80	420	500	420	500	620	500	20	130	20	30	130	30	50	130	50	10	130	10
	Town Common 5-1	SMD	80	69	80	420	500	420	500	620	500	20	130	20	30	130	30	50	130	50	10	130	10
	Bohle R (above Condon STP) 5-2	SMD	80	931	80	420	1000	420	500	1822	500	20	4000	20	30	4000	30	50	2500	50	10	2500	10
	Bohle R (below Condon STP) 5-2	SMD	80	931	80	420	1000	420	500	1822	500	20	4000	20	30	4000	30	50	2500	50	10	2500	10
	Little Bohle River 5-2	SMD	80	931	80	420	1000	420	500	1822	500	20	4000	20	30	4000	30	50	2500	50	10	2500	10
	Middle Bohle Creek 5-2	SMD	80	931	80	420	1000	420	500	1822	500	20	4000	20	30	4000	30	50	2500	50	10	2500	10
Lower Ross River Sub Basin	Pallarenda 6-1	HD	80	57	80	420	245	420	500	356	500	20	20	20	30	20	30	50	40	50	10	40	10
	Mundy Creek 6-2	SMD	80	72	80	420	359	420	500	642	500	20	138	20	30	138	30	50	245	50	10	245	10
	Esplanade 6-3	SMD	80	30	80	420	300	420	500	345	500	20	ND	20	30	ND	30	50	40	50	10	40	10
	Ross Creek and tributaries 6-4	HD	80	57	80	420	245	420	500	356	500	20	20	20	30	20	30	50	40	50	10	40	10
	Ross River (below Dam) 6-5	SMD	80	40	80	420	336	420	500	430	500	20	12	20	30	12	30	50	44	50	10	44	10
	Ross River (Black Weir) 6-5	HD	80	40	80	420	336	420	500	430	500	20	12	20	30	12	30	50	44	50	10	44	10
	Ross R (Gleesons Weir) 6-5	HD	80	40	80	420	336	420	500	430	500	20	12	20	30	12	30	50	44	50	10	44	10
	Ross River (Aplins Weir) 6-5	HD	80	40	80	420	336	420	500	430	500	20	12	20	30	12	30	50	44	50	10	44	10
	Tributaries (Defence land) 6-5	SMD	80	40	80	420	336	420	500	430	500	20	12	20	30	12	30	50	44	50	10	44	10
	University (Campus) Creek 6-5	SMD	80	40	80	420	336	420	500	430	500	20	12	20	30	12	30	50	44	50	10	44	10
	Lavarack Ck with weirs (?)6-5	HD	80	40	80	420	336	420	500	430	500	20	12	20	30	12	30	50	44	50	10	44	10
Upper Ross River Sub Basin	Lake Ross (Ross Dam) 7-1	SMD	20	40	20	330	500	330	350	560	350	5	15	5	0	15	0	10	30	10	10	30	10
	Ross River (FrW) 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Round Mountain Ck (Upland) 7-1	HEV	PCC	40	40	PCC	500	500	PCC	560	560	PCC	15	15	PCC	15	15	PCC	30	30	PCC	30	30
	Round Mountain Creek 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Lagoon Creek 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Plum Tee Creek 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Central Ck (aka Ross Ck) 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Sandy Creek 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Deep Creek 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Leichhardt Creek 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Cattle Creek 7-1	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Six Mile Creek 7-2	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10

Catchment/Management Unit			DIN			PN			Total N			FRP			PP			Total P			TSS		
			WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T
	Toonpan Lagoon 7-3	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Jimmys Lagoon 7-3	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Four Mile Ck /Flagstone Ck 7-3	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Spring Creek 7-3	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	One Mile Creek/Spring Creek 7-3	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Lansdowne Creek 7-3	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Antill Plains Creek 7-4	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
	Sachs Creek (Upland) 7-5	HEV	PCC	181	181	PCC	248	248	PCC	564	564	PCC	29	29	PCC	29	29	PCC	50	50	PCC	50	50
	Sachs Creek 7-5	SMD	80	181	80	420	248	420	500	564	500	20	29	20	30	29	30	50	50	50	10	50	10
	Blacksoil Gully/Mt Stuart (Up) 7-6	HEV	PCC	40	40	PCC	500	500	PCC	560	560	PCC	15	15	PCC	15	15	PCC	30	30	PCC	30	30
	Blacksoil Gully/Mt Stuart 7-6	SMD	80	40	80	420	500	420	500	560	500	20	15	20	30	15	30	50	30	50	10	30	10
Stuart Ck	Stuart Creek (ephemeral) 8-1	SMD	80	40	80	420	500	420	500	708	500	20	79	20	30	79	30	50	130	50	10	130	10
	Stuart Creek (includes pools) 8-1	HD	80	40	80	420	500	420	500	708	500	20	79	20	30	79	30	50	130	50	10	130	10
	Sandfly Creek 8-2	SMD	80	780	80	420	1400	420	500	2040	500	20	ND	20	30	ND	30	50	460	50	10	460	10
Alligator Creek Sub Basin	Alligator Ck (Upland) 9-1	HEV	PCC	30	30	PCC	300	300	PCC	330	330	PCC	15	15	PCC	15	15	PCC	30	30	PCC	30	30
	Alligator Creek (Lowland FW) 9-1	HD	80	30	80	420	300	420	500	330	500	20	15	20	30	15	30	50	30	50	10	30	10
	Whites Creek (Upland) 9-1	HEV	PCC	30	30	PCC	300	300	PCC	330	330	PCC	15	15	PCC	15	15	PCC	30	30	PCC	30	30
	Whites Creek 9-1	SMD	80	30	80	420	300	420	500	330	500	20	15	20	30	15	30	50	30	50	10	30	10
	Slippery Rocks Ck (Upland) 9-1	HEV	PCC	30	30	PCC	300	300	PCC	330	330	PCC	15	15	PCC	15	15	PCC	30	30	PCC	30	30
	Slippery Rocks Creek 9-1	SMD	80	30	80	420	300	420	500	330	500	20	15	20	30	15	30	50	30	50	10	30	10
	Crocodile Creek 9-2	SMD	80	30	80	420	300	420	500	330	500	20	15	20	30	15	30	50	30	50	10	30	10
	Killymoon Creek (Upland)	HEV	PCC	30	30	PCC	300	300	PCC	330	330	PCC	15	15	PCC	15	15	PCC	30	30	PCC	30	30
	Killymoon Creek	SMD	80	30	80	420	300	420	500	330	500	20	15	20	30	15	30	50	30	50	10	30	10
	Cocoa Creek 9-3	SMD	80	30	80	420	300	420	500	330	500	20	15	20	30	15	30	50	30	50	10	30	10
	Cape Cleveland 9-4	HEV	PCC	30	30	PCC	300	300	PCC	330	330	PCC	15	15	PCC	15	15	PCC	30	30	PCC	30	30
Magnetic Island	Retreat Creek (upland) 10-1	HEV	PCC	20	20	PCC	ND	420	PCC	630	630	PCC	10	10	PCC	10	10	PCC	105	105	PCC	105	105
	Retreat Creek (lowland) 10-1	SMD	80	20	80	420	ND	420	500	630	500	20	10	20	30	10	30	50	105	50	10	105	10
	Duck Creek (upland) 10-1	HEV	PCC	20	20	PCC	ND	420	PCC	630	630	PCC	10	10	PCC	10	10	PCC	105	105	PCC	105	105
	Duck Creek (lowland) 10-1	SMD	80	20	80	420	ND	420	500	630	500	20	10	20	30	10	30	50	105	50	10	105	10
	Chinamans Gully (upland) 10-1	HEV	PCC	20	20	PCC	ND	420	PCC	630	630	PCC	10	10	PCC	10	10	PCC	105	105	PCC	105	105
	Chinamans Gully (lowland) 10-1	SMD	80	20	80	420	ND	420	500	630	500	20	10	20	30	10	30	50	105	50	10	105	10
	Ned Lee Creek (upland) 10-1	HEV	PCC	20	20	PCC	ND	420	PCC	630	630	PCC	10	10	PCC	10	10	PCC	105	105	PCC	105	105
	Ned Lee Creek (lowland)10-1	SMD	80	20	80	420	ND	420	500	630	500	20	10	20	30	10	30	50	105	50	10	105	10
	Butler Ck (Picnic Bay) (upland)10-2	SMD	80	20	80	420	ND	420	500	570	500	20	10	20	30	10	30	50	120	50	10	120	10
	Butler Ck (Picnic Bay) (lowland) 10-2	HD	80	20	80	420	ND	420	500	570	500	20	10	20	30	10	30	50	120	50	10	120	10
	Picnic Bay west creek (upland)10-2	SMD	80	20	80	420	ND	420	500	570	500	20	10	20	30	10	30	50	120	50	10	120	10
	Picnic Bay west creek (lowland) 10-2	HD	80	20	80	420	ND	420	500	570	500	20	10	20	30	10	30	50	120	50	10	120	10
	Gustav Creek (Upland) 10-3	HEV	PCC	20	20	PCC	ND	420	PCC	225	225	PCC	10	10	PCC	10	10	PCC	20	20	PCC	20	20

Catchment/Management Unit			DIN			PN			Total N			FRP			PP			Total P			TSS		
			WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T
	Gustav Creek (Lowland FW) 10-3	SMD	80	20	80	420	ND	420	500	225	500	20	10	20	30	10	30	50	20	50	10	20	10
	Hoyer Creek (Nelly Bay) (upland) 10-3	SMD	80	20	80	420	ND	420	500	225	500	20	10	20	30	10	30	50	20	50	10	20	10
	Hoyer Creek (Nelly Bay) (lowland) 10-3	HD	80	20	80	420	ND	420	500	225	500	20	10	20	30	10	30	50	20	50	10	20	10
	North Nelly Bay creek (upland) 10-3	HEV	PCC	20	20	PCC	ND	420	PCC	225	225	PCC	10	10	PCC	10	10	PCC	20	20	PCC	20	20
	North Nelly Bay creek (lowland) 10-3	SMD	80	20	80	420	ND	420	500	225	500	20	10	20	30	10	30	50	20	50	10	20	10
	Petersen Creek (Upland) 10-4	HEV	PCC	140	140	PCC	ND	420	PCC	770	770	PCC	10	10	PCC	10	10	PCC	70	70	PCC	70	70
	Petersen Creek (Lowland FW) 10-4	SMD	80	140	80	420	ND	420	500	770	500	20	10	20	30	10	30	50	70	50	10	70	10
	Gorge Creek (Upland) 10-6	HEV	PCC	140	140	PCC	ND	420	PCC	770	770	PCC	10	10	PCC	10	10	PCC	70	70	PCC	70	70
	Gorge Creek (Lowland FW) 10-6	SMD	80	140	80	420	ND	420	500	770	500	20	10	20	30	10	30	50	70	50	10	70	10
	Endeavour Creek (Upland) 10-6	HEV	PCC	140	140	PCC	ND	420	PCC	770	770	PCC	10	10	PCC	10	10	PCC	70	70	PCC	70	70
	Endeavour Creek (Lowland FW) 10-6	SMD	80	140	80	420	ND	420	500	770	500	20	10	20	30	10	30	50	70	50	10	70	10
	East Horseshoe Bay creek 10-6	SMD	80	140	80	420	ND	420	500	770	500	20	10	20	30	10	30	50	70	50	10	70	10
	Five Beach Bay 10-7	HEV	PCC	140	140	PCC	ND	420	PCC	770	770	PCC	10	10	PCC	10	10	PCC	70	70	PCC	70	70

Notes: DIN – Dissolved Inorganic Nitrogen, PN – Particulate Nitrogen, Total N – Total Nitrogen, FRP – Filterable Reactive Phosphorus, PP – particulate Phosphorus, Total P – Total Phosphorus, TSS – Total Suspended Sediments

WQO – Water Quality Objective; CC – Current Condition; T – Target, PCC – Protect/Maintain Current Condition; ND – No Data

Table 5-9 Estuarine Ambient WQOs and Targets (µg/L)

Catchment/Management Unit			DIN			PN			Total N			FRP			PP			Total P			TSS		
			WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T
Crystal Creek	Crystal Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Lorna Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Ollera Creek		PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Scrubby Creek		PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Hencamp Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
Rollingstone Creek	Rollingstone Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Surveyors Creek		PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Wild Boar Creek		PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Station Creek		PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Saltwater Creek		PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Cassowary Creek		PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Leichhardt Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
Bluewater Ck	Christmas Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Two Mile Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Bluewater Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Deep Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Healy Creek		20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20

Catchment/Management Unit		DIN			PN			Total N			FRP			PP			Total P			TSS		
		WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T
Black River	Black River	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
Bohle River	Bohle River (upper)	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Bohle River (lower)	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Town Common	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Louisa Creek	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
Ross River	Ross River	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Ross Creek	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Pallarenda	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Mundy Creek	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
Stuart Ck	Stuart Creek	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
Alligator Ck	Alligator Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Crocodile Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Cocoa Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
Magnetic Island	Retreat Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Duck Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Ned Lee Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Butler Creek	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Gustav Creek	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20
	Petersen Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Gorge Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	Endeavour Creek	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
	East Horseshoe Bay Creek	20	ND	20	260	ND	260	300	ND	300	8	ND	8	17	ND	17	25	ND	25	20	ND	20

Notes: DIN – Dissolved Inorganic Nitrogen, PN – Particulate Nitrogen, Total N – Total Nitrogen, FRP – Filterable Reactive Phosphorus, PP – particulate Phosphorus, Total P – Total Phosphorus, TSS – Total Suspended Sediments
WQO – Water Quality Objective; CC – Current Condition; T – Target, PCC – Protect/Maintain Current Condition; ND – No Data

Table 5-10 Marine Ambient WQOs and 2021 Targets (µg/L)

Catchment/Management Unit		DIN			PN			Total N			FRP			PP			Total P			TSS			Chlorophyll a			Secchi Depth		
		WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T	WQO	CC	T
Near Coastal	West Coast	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
Near Coastal	Picnic Bay	PCC	2.1	3	PCC	22.8	23	PCC	91	92	PCC	ND	PCC	PCC	3.81	3	PCC	19.205	15	PCC	2.48	2	PCC	0.96	0.8	PCC	4.25	5
Near Coastal	Nelly Bay	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
Near Coastal	Arcadia	PCC	3.1	4	PCC	20.7	20	PCC	89.8	70	PCC	ND	PCC	PCC	4.55	3	PCC	13.01	10	PCC	4.52	4	PCC	0.88	0.7	PCC	4	5
Near Coastal	Radical Bay	PCC	ND	PCC	PCC	13.6	14	PCC	71.4	72	PCC	ND	PCC	PCC	1.7	2	PCC	18.45	15	PCC	2.07	2	PCC	0.26	0.3	PCC	9.5	10
Near Coastal	Horseshoe Bay	PCC	ND	PCC	PCC	17.9	18	PCC	89	90	PCC	ND	PCC	PCC	3.4	3.5	PCC	22.72	18	PCC	4.14	3	PCC	0.45	0.45	PCC	ND	PCC
Near Coastal	Five Beach Bay	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
Near Coastal	Rollingstone Bay	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC	PCC	ND	PCC
Near Coastal	West Channel	9	ND	9	20	40.44	30	29	138	29	6	ND	6	2.8	6.07	5	8.8	17.93	14	2	6	4	0.45	0.94	0.45	ND	2.13	ND
Near Coastal	Cleveland Bay	9	ND	9	20	ND	20	29	ND	29	6	ND	6	2.8	ND	2.8	8.8	ND	8.8	2	ND	2	0.45	ND	0.45	ND	ND	ND
Near Coastal	Halifax Bay	9	ND	9	20	ND	200	29	ND	29	6	ND	6	2.8	ND	2.8	8.8	ND	8.8	2	ND	2	0.45	ND	0.45	ND	ND	ND
Marine	Outer Marine	ND	ND	ND	17	ND	17	ND	ND	ND	ND	ND	ND	1.9	ND	1.9	ND	ND	ND	0.7	ND	0.7	0.4	ND	0.4	17	ND	17

Notes: DIN – Dissolved Inorganic Nitrogen, PN – Particulate Nitrogen, Total N – Total Nitrogen, FRP – Filterable Reactive Phosphorus, PP – particulate Phosphorus, Total P – Total Phosphorus, TSS – Total Suspended Sediments
WQO – Water Quality Objective; CC – Current Condition; T – Target, PCC – Protect/Maintain Current Condition; ND – No Data. Secchi depth is metres. Revised 9/6/09

5.4.3 End of Catchment Loads

In order to determine sources of pollutants and end of catchment loads for TSS and nutrients a modelling study was undertaken using input from the ACTFR water quality event monitoring (2006/07 and 2007/08 wet seasons) and other local water quality and climatic data. The sub catchment boundaries used for modelling purposes are shown in Figure 5-1. Modelled baseline loads for the Black Ross WQIP sub basins are shown in Table 5-11 without STPs and in Table 5-12 with STPs.

Table 5-11 Modelled Loads by WQIP Sub Basin (No STPs)

Sub Basin		Area	Flow	TSS	TN	TP
	No.	Hectares	ML/Year	kg/Year	kg/Year	kg/Year
Crystal Creek	1	24,074	239,443	5,509,675	90,060	9,376
Rollingstone Creek	2	21,986	144,387	1,601,949	40,420	4,018
Bluewater Creek	3	28,973	145,698	2,805,025	92,637	4,637
Black River	4	30,258	114,396	7,190,500	69,131	10,016
Black Basin total		105,291	643,925	17,107,149	292,248	28,047
Bohle River	5	33,155	131,708	9,289,250	78,275	14,136
Lower Ross River	6	13,478	53,714	4,202,975	33,097	6,976
Upper Ross River	7	(75,950)	196,870	8,103,000	100,375	12,775
Stuart Creek	8	11,158	47,483	1,649,800	18,944	2,957
Alligator Creek	9	27,365	104,834	2,103,495	42,687	4,807
Ross Basin total		85,155	534,608	25,348,520	273,378	41,651
Magnetic Island	10	4,923	27,390	341,983	6,282	943
Black Ross Total		195,369	1,205,923	42,797,652	571,908	70,641

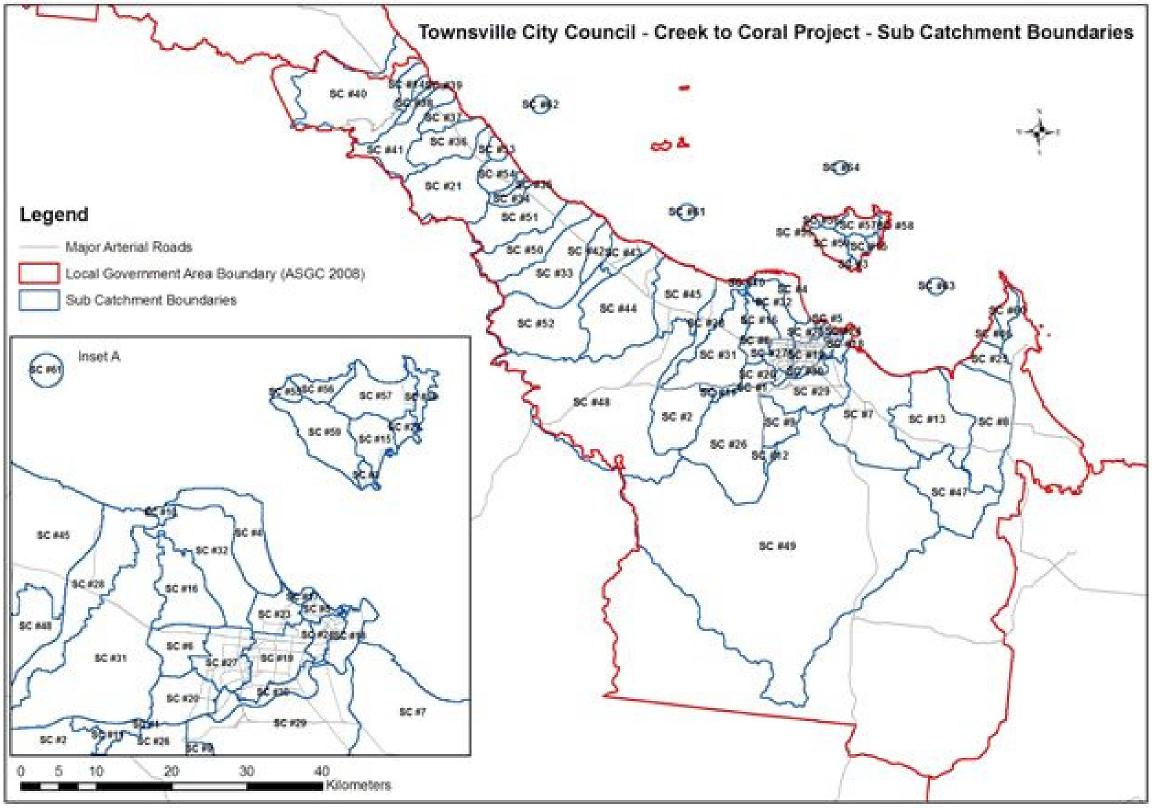
Note: Alligator Creek sub basin has been grouped with the Ross River AWR Basin. It is part of the Haughton River AWR Basin. Loads do not include point source discharges. Areas are from modelled results except for Upper Ross River (in brackets). Flow figures updated using 9/6/09 data

Table 5-12 Modelled Loads by WQIP Sub Basin With STPs (2007)

Sub Basin		Area	Flow	TSS	TN	TP
	No.	Hectares	ML/Year	kg/Year	kg/Year	kg/Year
Crystal Creek	1	24,074	239,443	5,509,675	90,060	9,376
Rollingstone Creek	2	21,986	144,387	1,601,949	40,420	4,018
Bluewater Creek	3	28,973	145,698	2,805,025	92,637	4,637
Black River	4	30,258	114,396	7,190,500	70,591	11,063
Black Basin		105,291	643,925	17,107,149	293,708	29,095
Bohle River	5	33,155	131,708	9,289,250	191,753	29,795
Lower Ross River	6	13,478	53,714	4,202,975	33,097	6,976
Upper Ross River	7	(75,950)	196,870	8,103,000	100,375	12,775
Stuart Creek (pre)	8	11,158	47,483	1,649,800	200,020	58,400
Stuart Creek (post)	8	11,158	47,483	1,649,800	61,320	20,039
Alligator Creek	9	27,365	104,834	2,103,495	42,687	4,807
Ross Basin		85,155	534,608	25,348,520	429,232	74,391
Magnetic Island	10	4,923	27,390	341,983	6,282	943
Black Ross Total		195,369	1,205,923	42,797,652	729,223	104,429

Note: Yellow shaded rows are different to load values in Table 5-11 due to input to sub basins from STPs. Tan shaded row is load value prior to the Cleveland Bay STP upgrade. Flow figures updated using 9/6/09 data

Figure 5-1 Modelled Sub Catchments



Based on the modelled loads, with and without STP contributions, the relative contributions from STPs by sub basin, basin and WQIP area have been calculated (see Table 5-13).

Table 5-13 STP Load Contributions

Sub Basin	Total N (kg/yr)		Difference		Total P (kg/yr)		Difference	
	With	Without	kg/yr	%	With	Without	kg/yr	%
Black River	70,591	69,131	1,460	2.1	11,063	10,016	1,047	9.5
Black Basin	293,708	292,248	1,460	0.5	29,095	28,047	1,047	3.6
Bohle River	191,753	78,275	113,478	59.2	29,795	14,136	15,659	52.6
Stuart Creek	61,320	18,944	42,376	69	20,039	2,957	17,082	85
Ross Basin	429,232	273,378	155,854	36.3	74,391	41,651	32,740	44
Black Ross Total	729,223	571,908	157,315	21.6	104,429	70,641	33,788	32.5

Note: Load contribution totals for basins and the Black Ross WQIP area are from all sources (point source and diffuse) and all sub basins. Only the sub basins with contributions from STPs have been included in the table. For a list of all load contributions see Table 5-11 and Table 5-12.

Point source loads will be reduced over the next three years as a result of upgrades to existing STPs. Expected load reductions from STPs along with post upgrade increases associated with population growth are listed in **Error! Not a valid bookmark self-reference.**.

Table 5-14 Point Source Load Reduction Figures

Upgrade status	Years	Total Flows (ML/day)	Total TSS loads (t/yr)	Total TN loads (t/yr)	Total TP loads (t/yr)
STP upgrade scenario data	Pre 2006	41.54	91.03	296.32	72.08
	2008	41.54	91.03	157.41	33.83
	2010	43.24	94.77	163.29	36.68
	2012	48.43	106.14	70.02	23.92
	2021	55.65	121.97	92.10	28.67
	2045	74.43	163.12	124.64	37.06

Note: Loads are in tonnes per year.

Projected increases in diffuse source pollutant loads have been calculated from modelling results and are presented in Table 5-15. Anticipated load reduction as a result of improved management practices have also been modelled and these will be used to establish draft load reduction targets following analysis of implementation costs. Potential diffuse source TSS load reductions from the modelling are listed in Table 5-16.

Table 5-15 Modelled End of Catchment Loads

Sub Basin	Area	Flow	2005 TSS	2005 TN	2005 TP	2021 TSS	2021 TN	2021 TP	2045 Flow	2045 TSS	2045 TN	2045 TP
	Hectare	ML/Year	kg/Year	kg/Year	kg/Year	kg/Year	kg/Year	kg/Year	ML/Year	kg/Year	kg/Year	kg/Year
Crystal Creek	24,074	239,443	5,509,675	90,060	9,376	6,419,255	97,680	10,272	239,042	8,013,575	109,657	11,798
Rollingstone Creek	21,986	144,387	1,601,949	40,420	4,018	2,071,368	45,353	4,481	14,5008	3,015,229	53,400	5,397
Bluewater Creek	28,973	145,698	2,805,025	92,637	4,637	2,802,835	95,134	4,510	144,566	2,805,390	98,915	4,325
Black River	30,258	114,396	7,190,500	69,131	10,016	7,403,660	70,620	10,239	114,433	7,723,400	72,854	10,574
Black Basin	105,291	643,925	17,107,149	292,248	28,047	18,697,118	308,787	29,503	643,048	21,557,594	334,825	32,093
Bohle River	33,155	131,708	9,289,250	78,275	14,136	8,884,961	75,103	13,527	133,397	9,786,928	78,268	14,333
Lower Ross River	13,478	53,714	4,202,975	33,097	6,976	4,989,039	36,446	7,676	54,795	6,390,420	4,2085	8,933
Upper Ross River		196,870	8,103,000	100,375	12,775	10,147,000	110,157	14,731	196,139	13,213,000	124,830	17,666
Stuart Creek	11,158	47,483	1,649,800	18,944	2,957	2,427,980	23,543	3,774	47,483	3,595,250	30,441	5,001
Alligator Creek	27,365	104,834	2,103,495	42,687	4,807	3,789,503	53,212	6,581	103,775	6,318,515	69,000	9,242
Ross Basin	85,155	534,608	25,348,520	273,378	41,651	30,238,483	298,460	46,290	535,589	39,304,113	344,624	55,174
Magnetic Island	4,923	27,390	341,983	6,282	943	344,275	6,214	947	27,489	484,990	6,523	1,084
Black Ross Total	195,369	1,205,923	42,797,652	571,908	70,641	49,279,876	613,461	76,739	1,206,126	61,346,696	685,973	88,351
Change from base	0	0	0	0	0	6,482,225	41,553	6,097	21,688	16,205,562	103,884	15,243
% change from base						15.1	7.3	8.6	1.8	43.3	20.0	25.1

Note: 2005 figures updated using 9/6/09 data. Interpolated figures not updated.

Note: If the increase in pollutants is a result of conversion of 'rural' land to urban land use then the target load reductions could equate to the WSUD objectives multiplied by the projected increases i.e. TSS 80% TN 65% TP 40%, for those areas. Grazing can be calculated from NQDT projections and natural areas remain the same.

Table 5-16 Potential TSS Load Reductions

Sub Basin	2045 Loads t/year	2045 GF WSUD t/Year	2045 Change t/Year	2045 %	2045 All WSUD t/Year	2045 Change t/Year	2045 %	2045 Rural BMP t/Year	2045 Change t/Year	2045 % kg/Year
Crystal Creek	8,019	7,847	172	2	7,847	172	2	3,349	4,670	60
Rollingstone Creek	3,017	2,841	177	6	2,736	281	9	1,656	1,362	48
Bluewater Creek	2,807	2,803	4	0	2,778	29	1	1,735	1,072	38
Black River	7,729	7,729	0	0	7,433	296	4	4,489	3,240	42
Black Basin	21,572	21,220	353	2	20,795	777	4	11,229	10,343	49
Bohle River	9,794	8,972	822	8	7,268	2,526	26	6,931	2,863	32
Lower Ross River	6,395	6,221	174	3	3,760	2,634	41	4,716	1,678	27
Upper Ross River	13,222	13,222	0	0	13,222	0	0	6,940	6,282	48
Stuart Creek	3,598	3,598	0	0	3,568	29	1	1,855	1,742	48
Alligator Creek	6,323	6,323	0	0	6,323	0	0	3,009	3,314	52
Ross Basin	39,331	38,335	996	3	34,141	5,190	13	23,452	15,879	41
Magnetic Island	485	384	101	21	214	271	56	485	0	0
Black Ross Total	61,389	59,939	1,450	2	55,150	6,238	10	35,166	26,223	44

Notes: GF WSUD denotes potential load reduction from Greenfield (new) development with 100% adoption of water sensitive urban design (WSUD). All WSUD denotes adoption of WSUD measures across all urban areas and Rural BMP denotes 100% uptake of farming best management practice in rural areas.

Potential load reductions are being reviewed in relation to implementation costs for urban and rural management actions in order to set realistic load reduction targets. These will be added to the draft WQIP website as soon as they are available

5.5 Environmental Flow

Environmental flow is a term used to express the amount/proportion of the natural flow of a watercourse required to maintain aquatic habitat health and ecological function in waterways and waterbodies. Environmental flow is usually related to regulated waterways where there are impoundments. Environmental flow also applies to unregulated waterways where water entitlements permit landowners to extract water for irrigation and other purposes.

There are two regulated systems in the Black/Ross WQIP area i.e. the Ross River and Crystal Creek. Both of these systems are the subject of an Interim Resource Operations Licence (IROL) under the *Water Act 2000* (Qld).

The remainder of the WQIP area is subject to the general provisions of the Water Act with regard to taking water from a watercourse or other waterbody. If a landowner wants to take water from a stream, lake or other waterbody they are required to apply to the Department of Natural Resources and Water (DNRW) for a water licence.

If a Water Resource Plan (WRP) of Resource Operations Plan (ROP) is in place for an area then the ROP can define the process for granting a water licence in that area. This is not the case for the majority of the Black Basin and the sub basins of the Ross Basin at present. Unregulated systems and the two regulated systems are discussed below in relation to current extraction and flow regimes.

5.5.1 Unregulated systems

The allocation of water licences, previously permits, has largely been based on an incremental system which started in the late 1960's and accelerated during the 70's (an unusually wet period), resulting in over allocation in some instances. This means the entitlements are not achievable in many years and there is no actual use/extraction i.e. water allocation is higher than actual extraction. New entitlements in these watercourses are generally restricted to flood harvesting to off stream storages, based on minimum start up flows. As yet here has been no systematic approach in the Black and Ross Basins to determine sustainable yields and environmental flows. In the past there has been some attempt to restrict entitlements based on maintenance of minimum flows and protection of waterholes (pers. comm. Ian Boyce DERM - NRW).

As the majority of the streams in the Black and Ross Basins are ephemeral it is not an easy matter to determine sustainable yield based on an 'average' annual flow. Allowing an allocated amount of water harvesting when a stream has reached a minimum flow level is at present the best approach to maintaining adequate flow for environmental purposes in the ephemeral streams of the Townsville coastal Dry Tropics. A WRP will be prepared for Black and Ross Basins by DERM sometime in the future.

Table 5-17 Extraction Rates and Flow for Black and Ross Basins

Name	ML (by ha)	Alloc. (ML)	No. of Alloc.	Flow est.	% of flow
Crystal Creek	1088		8		
Bullocky Toms Creek	437.6		3		
UT Bullocky Toms Creek	48		1		
Little Crystal Creek	280		3		
Crystal Creek and tributaries	**1854**		**15**		
UT Halifax Bay (Spring Gully)	264	28	3		
Ollera Creek	320		2		
Hencamp Creek	448		3		
Crystal Creek Sub basin		**2913.6**	**23**	**288,712**	**1%[1]**

Crystal Creek Sub basin		**21,500**	**1**	**288,712**	**7.4%²**
Rollingstone Creek	792		11		
Rollingstone Creek West	200		1		
Leichhardt Creek	208		1		
Rollingstone Creek Sub Basin		**1200**	**14**	**169,790**	**<1%**
Sleeper Log Creek	4		1		
Bluewater Creek	143.2	27.4	37		
Healy Creek	8		1		
Bluewater Creek Sub Basin		**182.6**	**39**	**155,189**	**<1%**
Black River	544	56.5	10	82,283ML*	
Alick Creek	32		1		
UT Canal Creek	160		1		
Black River Sub Basin		**792.5**	**12**	**116,431**	**<1%**
Black Basin Total	4976.8	111.8	87		
Black Basin Total Megalitres		**5,088.6**	**87**	**730,121**	**<1%**
Black Basin Total Megalitres ²		**26,589**	**88**	**730,121**	**3.6%**
Ross River	30.4	75,000	3	125,784ML**	
Lansdowne Creek	1,360		9		
UT Ross River	240		1		
Lower Ross River Sub Basin				60,464	
Ross River Sub Basin		**76,630.4**		**186,000**	**41%**
Bohle River		50	1	133,854	**<1%**
Stuart Creek	92.8		2	41,943	**<1%**
Alligator Creek	616.8		21	116,589	**<1%**
Gustav Creek (Magnetic Island)		1.8	1		
Ross Basin Totals	2,340	75,051.8	38		
Ross Basin Total Megalitres		**77,392**	38	**478,386**	**7%**
Black/Ross WQIP total ML		**82,480**	**125**	**1,208,500**	**6.8%**
Black/Ross WQIP total ML²		**103,980**	**126**	**1,208,500**	**8.6%**

Source: DNRW "WERD periodic reports at 09 02 2009"

Notes: These are allocations and not an indication of actual use. In the ML (by ha) column nominal mega litre (ML) allocations have been calculated where allocations were provided in hectares (a use rate of 8ML per hectare per annum is assumed). This was the old style of allocation i.e. by land area to be irrigated. Flow estimate is annual average flow in mega litres. * 117002A Black River at Bruce Highway. ** 118104A Ross River at Ross Dam Headwater. Other flows are from WaterCAST modelled outputs (pre 9/6/09 figures used).

If the Ross Dam allocation is excluded the extraction rate for all waterways in the Black and Ross Basins is approximately 7,480 Ml per annum.

¹ This figure does not take into account extraction associated with the water drawn from Crystal Creek as part of the IROL. ² Figures include the total take allowable from the Paluma-Crystal water supply scheme.

Surface water extraction figures for the streams of the Black and Ross Basins, as provided by DERM (formerly DNRW), are included in Table 5-17 along with stream flow estimates. It should be noted that the figures provided in Table 5-17 are indicative only and have not been validated (see associated Notes also). When a Water Resource Plan and Resource Operation Plan is in place for the Black and Ross River Basins a set of validated entitlements will be published by DERM.

5.5.2 Regulated systems

The two regulated systems in the Black/Ross WQIP are at the opposite ends of the WQIP area with the Crystal Creek system having Wet Tropics features i.e. perennial flow, while the Ross River system is a more typical Dry Tropics ephemeral system. Due to its ephemeral nature and the location of three weirs downstream of the dam the Ross River Water Supply Scheme does not provide for environmental flows. The main features of both regulated systems are discussed in brief below.

5.5.3 Paluma-Crystal Water Supply Scheme

An interim water allocation was granted to Townsville City Council (TCC) on 30 April 2008 to service the Paluma-Crystal Water Supply Scheme. The allocation involves the taking of water from the Paluma Dam storage, located on Swamp Creek, and Crystal Creek (Crystal Creek Weir). This is a high priority entitlement of 21,571 megalitres per (water) year. There are other entitlements downstream of Crystal Creek Weir (presumably lower priority).

The Paluma-Crystal Water Supply Scheme involves extraction of water from Crystal Creek and Swamp Creek, as well as inter-catchment transfers. Paluma Dam (11,400ML commandable storage) is located in the Swamp Creek catchment (Burdekin Basin) and water is transferred from the dam to Crystal Creek (Crystal Creek catchment/Black Basin) when required.

Water is drawn from Crystal Creek Weir and piped via the Mt Spec pipeline to supply points. While Crystal Creek is a perennial stream it has characteristic wet and dry season flow patterns. Crystal Creek Weir overflows at median flows of 24ML/day and average flows 62ML/day. Low flows can be as little as 10ML/day in drier periods. It appears from the little data available, the flow regime of Crystal Creek has periodic pulses overtopping a low base flow during the 'dry' season.

The maximum allowable take of water from Crystal Creek weir is 59.1 ML/day, however, as noted, this is probably not achievable and a more realistic maximum extraction rate is in the vicinity of 40 ML/day. The average flows of 62 ML/day may also be misleading, as it is believed that TCC often supplement the volume with water from Paluma Dam to enable extraction of between 30 and 40 ML/day.

Crystal Creek Weir has a capacity of 1ML; therefore pass flows are dependant on three factors:

- Natural Crystal Creek flows, plus
- Water releases from Paluma Dam to Crystal Creek, minus
- Water extraction.

It is recognised in the IROL that due to the seasonal variation in flows the water supply extraction from Crystal Creek Weir can impact downstream entitlements and other interests e.g. environment and public. To accommodate downstream requirements, including environmental flow, the IROL provides for a diversion of water from Paluma Dam to Crystal Creek when the natural flow upstream of Crystal Creek Weir has been less than 65ML/day for a period of 30 days or more. In this event a minimum of 35ML/day is required to be diverted from Paluma Dam to Crystal Creek for a period of two days. In the event that no water has spilled over the weir for a period of nine months, and there has been flow in Crystal Creek, then TCC is required to allow 1ML/day of water to spill over the weir for a period of ten days. While currently correct these figures may change when a WRP is prepared for the Black and Ross Basins.

5.5.4 Ross River Water Supply Scheme

An interim water allocation was granted to Townsville City Council on 30 April 2008 to service the Ross River Supply Scheme. The allocation involves the taking of water from the Ross River (Ross River Dam and Black Weir) with an entitlement of 75,000 megalitres per (water) year. The Ross River Water Supply Scheme also has the option of transferring water from the Burdekin-Haughton Water Supply Scheme, via the Haughton pipeline, into Toonpan Creek, which then flows into the Ross River Dam.

The associated IROL permits Townsville City Council (formerly NQ Water) to "*take a volume equivalent to the amount required to meet town water supply demands*" (nominally 75,000 ML) (DNRW Information Notice 28 April 2008). Water managed under the IROL includes that impounded by the Ross River Dam and Black Weir. Black Weir is the emergency supply (approximately two weeks supply) in the event that water can't be drawn from Ross River Dam. The IROL is an interim arrangement until a WRP and ROP are prepared for the area.

Following the upgrade of the Ross River Dam the commandable (extractable) storage capacity is 233,000ML. Black Weir has a total storage capacity of 3,780ML with a commandable storage of 2,800ML. The only provision for release of water is to maintain Black Weir at a level not lower than 2.5 metres below its full supply (EL 11.31m AHD).

The licensee releases to the Ross River (Black Weir) below the Ross River storage area, all water that has been collected by the Ross River Dam collection system. This collection system aims to maintain groundwater levels below the dam wall at a desired level. The licensee also tests the water quality to assess dam wall integrity.

5.5.5 North Queensland Regional Water Supply Strategy

The Strategy area takes in stream catchments in the coastal strip from Bowen to the northern boundary of Townsville i.e. Crystal Creek, and closely mirrors the Burdekin Dry Tropics NRM area (equivalent to the combined Black/Ross and Burdekin WQIP areas). The various stages in the development process of the North Queensland Regional Water Supply Strategy (NQRWSS) are listed in the text box below.

It should be noted that the NQRWSS is not a statutory document and will not impact surface water allocations in the Black/Ross WQIP area.

Regional Water Supply Strategy Process

1. Research Phase – Define supply objectives
    - Current supply/demand situation;
    - Future demand scenarios;
    - Establish water supply objectives.
2. Investigation Phase – Evaluate supply options in meeting supply objectives
    - Infrastructure options;
        - Stage 1 – selection of viable projects based on course economic/engineering filter,
        - Stage 2 – refinement of viable projects based on triple bottom line and other criteria.
    - Non-infrastructure options;
    - Evaluate options against supply objectives to develop draft Strategy.
3. Development Phase – Develop and consult on a draft Strategy taking in best options
    - Consult with internal stakeholders;
    - Incorporate stakeholder comments and revise draft Strategy.
4. Pre-approval Phase – Seek state-agency support, then Cabinet approval for draft Strategy
    - Consult with State Government agencies;
    - Lodge Cabinet Submission for approval of proposed final Strategy.
5. Approval and Implementation Phase
    - Implementation of approved Strategy and programme of works.

Some of the research and investigations, which are well advanced, may be useful to inform the Black Ross WQIP in terms of background information relevant to environmental flows and aquatic ecosystem health e.g. current extraction rates as a percentage of flow and potential future demand. It is assumed that the information collated for the NQRWSS will be available for inclusion in any future WRP and ROPs prepared for the Black and Ross Basins.

5.6 Aquatic Ecosystem Health

While physico-chemical properties are important for waterway health there are a number of other physical and biological factors that impact aquatic ecosystem health that can be readily measured and contribute to our understanding of water quality issues and areas for improvement.

A draft water quality report card has been developed as part of the Black/Ross WQIP and includes a number of indicators that are relevant to aquatic ecosystem health. The key indicators for the report card are grouped into the following categories:

1) Water quality (physico-chemical);
2) Freshwater fish (aquatic ecosystem);
3) Aquatic invertebrates (aquatic ecosystem);
4) Aquatic vegetation (aquatic ecosystem);
5) Riparian vegetation (catchment condition);
6) Channel and floodplain features (catchment condition).

While all groupings can be related to aquatic ecosystem health, the three principal indicator groups are freshwater fish, aquatic invertebrates and aquatic vegetation. Flow regime modification is also a critical factor for aquatic ecosystem health particularly in perennial streams. Aquatic ecosystems of ephemeral streams are probably less susceptible to impacts of flow modification as they are adapted to the seasonal variations of high and no flow. This is of course a generalisation and flow modification can also be detrimental to ephemeral systems.

While some studies have been done that are relevant to aquatic ecosystem health the range of available information has not been collated for the Black/Ross WQIP area as yet. In the absence of current condition information and local aquatic ecosystem health guidelines the generic aquatic ecosystem health target is to improve the current condition of waterways by at least one report card (see Connell Wagner 2009) grade for a minimum of one out of the six indicator groups by 2014.

6. Water Quality Improvement Management Actions

6.1 Introduction

Management options were identified that have the potential to improve water quality in line with the environmental values identified by the community, and to achieve the water quality objectives and load reduction targets identified in the previous section. The options were considered on the basis of likely water quality improvement results (based on previous experiences and catchment modelling results), value for money, social acceptability and practicality of implementation i.e. available resources and timeframes.

Information about the management options considered including associated costs and benefits can be found in the background report - *Black Ross Water Quality Improvement Plan Options, Costs and Benefits* (Gunn, Manning and McHarg 2009).

To better facilitate land based management practice improvements the Black Ross WQIP area was initially separated into two predominant land use categories i.e. rural and urban. It was envisaged that peri-urban areas would be included in the urban category as they are potential future urban areas and need to be considered in growth scenarios and urban planning.

It became apparent during the development of the WQIP that the peri-urban 'zone', including rural residential areas in close proximity to the urban areas, needed to be classified as a separate major land use category so that peri-urban specific issues could be addressed using appropriate measures. Elements of management measures from both the rural and urban areas will also be adopted as appropriate to the situation.

While many of the management actions are directed at specific land uses and stages of development (see section 3) some of the management actions will be common to the whole of the Black Ross WQIP area, and especially the enabling actions and programs.

This section provides a description of the management actions selected for urban, peri-urban and rural areas as well as cross-catchment and cross-land use actions.

6.2 Priority Management Actions

Priority actions have been selected to address the issues that have the most impact on water quality in the urban, peri-urban and rural environments. The priority actions have been proven to be effective locally or in other parts of Australia, are based on available sound science and are considered to be the best value in terms of benefits for water quality improvement (see Gunn, Manning and McHarg 2009).

Where there was a moderate to high uncertainty about the potential benefit or practicality of management options investigated the subsequent implementation actions are based on:

- Gathering additional data to determine the magnitude of the issue and the potential benefits of interventions in relation to the issue,
- Feeding 'new' information into models such as the Bayesian Belief Network to identify the best management interventions on a catchment basis,
- Undertaking socio-economic studies to determine the most effective course of action to achieve a particular behaviour change e.g. for uptake of water quality improvement management practice, and
- Determining the effectiveness of interventions through pilot programs and case studies.

Priority management actions have initially been divided into major land use groupings i.e. urban, peri-urban and rural, with further internal divisions based on more specific land uses (see Table 3-1) and/or development stage. The main enabling actions, designed to increase capacity to undertake on ground actions and influence behaviour change, have been listed separately as the actions are generally not specific to a particular land use.

The priority management action topics are referenced to the main land use categories with a corresponding priority and relevance rating as shown in Table 6-1.

The priority management actions selected to implement the Black Ross WQIP are discussed below.

6.2.1 Project management

Project management and coordination, communications and information management are overarching enabling 'administrative' actions required for implementation of the WQIP. It is proposed that Creek to Coral (Townsville City Council) manages the delivery of the implementation of the Black Ross WQIP in a similar manner used to prepare the WQIP.

To make project management of the WQIP more effective a management system will be developed based on ISO 9001, and an adaptive management and planning approach used to implement this WQIP. The management system will be integrally linked to the communication strategy and assist with data and information management as part of the overall adaptive management framework.

Table 6-1 Priority Management Action Areas

No.	Action area	Rural and Peri-urban					Urban	
		Grazing	Intensive agriculture	Natural areas	Ross Dam catchment	Peri-urban	Urban (diffuse)	Urban (point)
1	Erosion and Sediment Control for development	O	L	O	H	H	H	O
2	Site based Stormwater Management Plans for development	O	O	O	H	H	H	O
3	Water Sensitive Urban Design (WSUD) guideline finalisation and adoption	O	O	O	M	H	H	L
4	Develop the Coastal Dry Tropics Guide for Urban Water Management	O	O	O	H	H	H	M
5	Urban Stormwater Quality Management Plan integration	O	O	O	L	M	H	O
6	Urban stormwater treatment trains	O	O	O	O	L	H	O
7	WSUD retrofit	O	O	O	O	H	H	O
8	Develop peri-urban catchment management guidelines and implementation activities	M	M	L	H	H	L	O
9	Water Resource Catchment Management (Ross River Dam)	H	M	L	H	H	M	O
10	Promote "*Managing for WQ within grazing lands of the Burdekin Catchment*" (BDT NRM)	H	O	L	H	M	O	O
11	Promote management practice ABCD framework for sugar cane and horticulture (Mackay Whitsunday NRM)	O	H	O	M	M	L	O
12	Legislation and Governance	L	L	L	H	H	H	M
13	Policy investigations and development	L	M	L	H	H	H	M
14	Planning Scheme studies and instruments review	M	M	M	H	H	H	L
15	Strategic landscape mapping and habitat prioritisation	H	H	H	H	H	H	L
16	Population Growth and Climate Change considerations	M	M	M	H	H	H	H
17	Condition assessment and prioritisation	H	H	M	H	H	H	L
18	Community Based Education and Involvement (CBEI) (awareness and capacity building)	M	M	L	H	H	H	L
19	Reef Guardian Councils implementation	O	O	O	L	H	H	H
20	Social learning and behaviour change studies (for determining effective management interventions)	M	M	L	H	H	H	L
21	Market Based Instruments investigation	L	L	L	H	H	H	L
22	Riparian zone rehabilitation	H	M	M	M	H	H	O
23	Wetland restoration and construction	M	M	M	M	H	H	O
24	Aquatic ecosystem health improvement	H	H	M	H	H	H	L
25	Water quality monitoring and modelling (WQM and M)	H	H	H	H	H	H	H
26	Integration, Communication, Monitoring, Evaluation and Adaptive Management	M	M	M	H	H	H	M

Notes: H is high priority activity. Colour coding denotes the principal land use 'style' associated with high priority activity. There will be overlap into peri-urban areas from rural and urban land uses (Purple = rural, green = peri-urban, yellow = urban), M is medium priority activity (grey) L is low priority activity O is not relevant or very low priority.

6.3 Urban Management Actions

The priority management actions for reducing urban diffuse water quality pollutant loads are primarily based around the stage of development and target short-term sediment 'spikes' as well as the long-term leakage of sediment and nutrients from developed areas. Point source pollutants are discussed first in terms of management actions in progress, expected load reductions and potential future actions.

6.3.1 Point source

Wastewater treatment plants are the main point source contributor of water quality pollutants in the Black Ross WQIP area with direct discharge of treated effluent to the Black River, Bohle River and Stuart Creek sub basins. Targets and management actions to reduce point source pollutant loads are listed in Table 6-2.

Table 6-2 Point Source Targets and Management Actions

Management Outcome PS: Management of point source pollution *To ensure that pollutants from point sources in Townsville are managed appropriately to reduce their impact on receiving waters to acceptable levels*		
Target	**Target description**	**Cost**
PSRC 1.1	By 2012 total wastewater treatment plant pollutant loads are reduced from 2006 loads by: • 75% for total nitrogen (225 tonnes/yr) • 65% for total phosphorus (48 tonnes/yr)	
PSMA 1.1	By 2012 all wastewater treatment plants in Townsville are upgraded and meet DERM (EPA) revised permit requirements	$189.4M
PSRC 1.2	By 2021 total wastewater treatment plant pollutant loads are further reduced from 2012 levels by: • 17% for total nitrogen (12 tonnes/yr) • 24% for total phosphorus (5.8 tonnes/yr) • 30% for total flows (14.4 ML/day)	
PSMA 1.2	A effluent reuse scheme for treated effluent from the Cleveland Bay Wastewater Treatment Plant is established and operational by 2021	$32.9M
	Management action	
PS1	Other options for 'fit for purpose' uses of treated wastewater are investigated through Townsville's Integrated Regional Water Strategy (IRWS) and implemented as appropriate.	
PS2	All water quality improvement devices are managed and maintained appropriately over the life cycle of the asset to ensure that treatment efficiencies are maintained	
PS3	Sewer networks are managed appropriately and infrastructure is upgraded in order to minimise wet weather overflows and to achieve zero dry weather overflows.	$20.3M
PS4	Options to reduce the potential impact of wastewater concentrates, toxicants, disinfection residuals, biosolids and salt loads are investigated and implemented where appropriate	
PS5	Ensure new and emerging point sources issues are identified and addressed in a timely manner	

6.3.2 Developing urban areas

The main water quality pollutant issue associated with developing areas is soil erosion and the subsequent movement of sediment to waterways in rainfall run-off. This is particularly relevant to development on sloping sites; however, it is also an issue on flat sites and floodplains, albeit not as severe. The management action targets (MATs) and priority actions for developing areas are listed in Table 6-3. The actions are also relevant to 'urban' style development in rural and peri-urban areas, as the general principles are the same.

Implementation costs for most of the management actions are being reviewed at present and will be added to the draft WQIP website as soon as they are available

Table 6-3 Urban Diffuse Developing Areas

Management Outcome 1: Management of development in urban and peri-urban areas *To ensure that all new development in Townsville is managed appropriately to achieve agreed water quality improvement outcomes including sediment load reductions*	
MAT 1.1	Erosion and sediment control principles and measures implemented across all new development by 2011 (1)
MAT 1.2	Locally specific guidelines and associated tools developed to support the implementation of best practice stormwater management in Townsville by 2013 (2 and 4)
MAT 1.3	Water Sensitive Urban Design (stormwater) principles and actions are progressively incorporated in the design of all new development reaching a 100% adoption rate by 2021 (3-5, 7 and 12-16)
No.	**Action area and tasks**
	Urban (some peri-urban overlap)

1	***Erosion and Sediment Control for development and construction***
	
	• Review the effectiveness of current measures through the development assessment process;
	  ○ TCC Erosion and Sediment Control Course,
	  ○ Planning Scheme provisions and use of Best Practice Erosion and Sediment Control (IECA Australasia 2008)
	  ○ Monitoring and enforcement,
	  ○ State legislation especially EPAct and EP (Water) Policy.
	• Link with the WSUD implementation process and the development of a new Planning Scheme for Townsville;
	• Incorporate risk management for climate change in all new policy settings and measures;
	• Develop generic guidelines for developers/construction industry;
	  ○ General principles about erosion and sediment movement,
	  ○ Linkage with Stormwater Management Planning,
	  ○ Staged clearing commensurate with the progress of development.
	• Monitoring and enforcement.

2	***Site based Stormwater Management Plans for development***
	
	• Review the effectiveness of current measures through the development assessment process including;
	  ○ Linkages with the TCC Erosion and Sediment Control Course,
	  ○ Planning Scheme provisions,
	  ○ Monitoring and enforcement,
	  ○ State legislation especially EP Act and EP (Water) Policy.

	• Link with the WSUD implementation process and the development of a new Planning Scheme for Townsville;
	• Incorporate risk management for climate change in all new policy settings and measures;
	• Develop generic guidelines for developers/construction industry;
	  o General principles about stormwater management,
	  o Linkage to erosion and sediment control.
	• Monitoring and enforcement.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.3.3 Developed urban areas

Developed urban areas have the same water quality pollutants as developing areas i.e. sediment and nutrients, as well as some additional issues and pollutants specific to the population intensive urban environment that are associated primarily with industry and commerce, transport, waste and human behaviour.

The two key strategic management approaches to water quality improvement applied to developed urban areas are: pre-development design and installation of measures i.e. water sensitive urban design (WSUD), for post-development outcomes; and urban stormwater quality management (USQMP) including treatment measure retrofitting (see Table 6-5).

As an adjunct to the preparation of the Black Ross WQIP a set of draft WSUD products were developed for testing in the Townsville region. These products include:

- WSUD Strategy Roadmap - a web based navigation tool to assist access to information and resources relevant to the application of WSUD in the Coastal Dry Tropics;
- WSUD Draft Design Objectives for the Dry Tropics;
- WSUD Technical Design Guidelines for the Coastal Dry Tropics; and
- Factsheets;
    - Factsheet 1 - Concepts and Terms,
    - Factsheet 2 - WSUD in the Dry Tropics,
    - Factsheet 3 - Site Planning and Urban Design,
    - Factsheet 4 - Industrial and Commercial Sites,
    - Factsheet 5 – Carparks,
    - Factsheet 6 - Porous Pavement, and
    - Factsheet 7 - Best Management Practices.

The management action targets and main actions associated with the testing and implementation of WSUD are listed in Table 6-4.

Table 6-4 WSUD Actions

Management Outcome 2: Management of existing urban areas *To ensure that the existing urban areas of Townsville are managed appropriately in order to achieve agreed water quality improvement outcomes including sediment, nutrient and other pollutant load reductions over time*	
MAT 2.1	By 2013 locally specific Water Sensitive Urban Design guidelines and associated tools developed and tested to support the implementation of best practice stormwater management in Townsville (3)
MAT 2.2	Coastal Dry Tropics Guide for Urban Water Management developed by 2011 (4)
MAT 2.3	Water Sensitive Urban Design (stormwater) principles and measures progressively included in all new development reaching 100% adoption rate by 2021 (3-5, 7 and 12-16)
No.	**Action area and tasks (Urban with some peri-urban overlap)**
3	***Water Sensitive Urban Design (WSUD) guideline finalisation and adoption***

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Strategic direction/framework (commenced) for introducing WSUD into:

The development assessment process in existing planning schemes,
The ‘new’ planning scheme for Townsville City,
Development and construction industry.

Develop or adapt additional material as required including:

Concept Design Guidelines,
Construction and Establishment Guideline,
Asset Management Guideline,
Deemed to Comply and Standard Drawings,
MUSIC Auditing Tool (to assist with the development assessment process).

Develop the socio-economic case for WSUD;
Investigate Market Based Incentives to assist WSUD adoption;
Prepare an education and training strategy (Council, developers/construction industry, consultants, community);
Prepare a Communication Strategy including;

Website platform incorporating the ‘Roadmap’ (TCC and Creek to Coral websites),
Internal reporting,
Consultation with key stakeholders,
Community consultation.

Adaptive management;

Incorporation of amendments and updates to initial guidelines and documents, and development of an ongoing improvement/learning process.

Model subdivisions project - monitoring ‘new’ subdivisions from Greenfields stage to test WSUD effectiveness (uptake, and WQ monitoring and modelling);
Full WSUD Integration (i.e. stormwater, potable water and wastewater) Scoping Study in conjunction with Landscape Planning initiatives and Planning Scheme background studies;
Develop a monitoring and enforcement system to complement the development assessment process.

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Develop the Coastal Dry Tropics Guide for Urban Water Management
The complete current story incorporating:

The WSUD Guidelines and products;
Erosion and sediment control components;
Stormwater management principles and USQMP;
Hydrology and hydraulic considerations;
Geology, soils and geomorphic features and influences;
Soil health and soil carbon;
Vegetation and fire;
Aquatic ecosystem health assessment;
Linkages to other programs such as Creekwatch and Dry Tropics Watersmart;
Other relevant findings and components associated with preparation of the Black Ross WQIP e.g. Stormwater Quality Improvement Devices (SQID) case studies report;
Potable water;
Wastewater;
Asset Maintenance/Management Plans.

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Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

Mature urban areas often don't have WSUD features as the earlier intent of stormwater management systems was to remove the quantity of rainfall run-off from urban areas as efficiently as possible. The space available to retrofit established stormwater management systems with water quality treatment measures is often limited in mature urban areas and the cost of land acquisition can be prohibitive. It may be more cost effective to investigate and develop actions that target the source of pollutant loads rather than invest in expensive retrofits that have limited ability to address the issues.

Management action targets and strategic management actions associated with mature urban areas are listed in Table 6-5. Much of the subsequent management action detail associated with these areas will result from the necessary investigations and preparation of a new city-wide Urban Stormwater Management Plan.

Table 6-5 USQMP and Retrofits

Management Outcome 2: Management of existing urban areas *To ensure that the existing urban areas of Townsville are managed appropriately in order to achieve agreed water quality improvement outcomes including sediment, nutrient and other pollutant load reductions over time*	
MAT 2.4	Waterway management and rehabilitation plans for priority urban waterways developed by 2010 with implementation actions underway by 2012 (17, 14, 15 and 22-24)
MAT 2.5	Best practice erosion and sediment control principles and actions being implemented across all infill and retrofit development by 2010 (5 and 1)
MAT 2.6	An integrated draft Urban Stormwater Quality Management Plan for the Townsville City Council Local Government Area prepared by 2013 (5)
MAT 2.7	All water quality improvement devices managed and maintained appropriately over the life cycle of the asset to ensure that treatment efficiencies are maintained (5-7, 3 and 4)
MAT 2.8	Options investigated, areas prioritised and implementation plan developed for retrofit of appropriate water quality improvement devices into community infrastructure by 2011 (6 and 7)

No.	**Action area and tasks (Urban with some peri-urban overlap)**
5	***Urban Stormwater Quality Management Planning (USQMP)*** • Incorporate existing and recent USQMP related matters/actions into the Stormwater Quality Management Framework for Townsville (2006) including WQIP Environmental Values and Water Quality Objectives, and Bohle River Environmental Values Study (TCC); • Undertake a Scoping Study to determine the requirements for preparing an integrated USQMP for Townsville City Council incorporating previous Thuringowa and Townsville City USQMP components; • Make the appropriate linkages with the WSUD implementation process and the development of a new Planning Scheme for Townsville City; • Prepare the integrated USQMP, incorporating behaviour change strategies and programs; • Prioritise and program the preparation of urban catchment management plans as sub components of the broader landscape and catchment planning initiatives (linked to Planning Studies section); • Develop Catchment Drainage Management Plans for priority areas along the same lines as the Horseshoe Bay Drainage Management Plan and Rocky Springs Drainage Management Plan. Priority areas include Stocklands development (Bohle Plains in general), and Bushland Beach (links to regional landscape planning and catchment planning); • Incorporate Wastewater Management Plans in new development areas (including trade waste and sewage management plans). These plans will outline not only discharge reduction measures and objectives but could also outline waste minimising measures at

	source.
6	***Urban stormwater treatment trains*** • Utilise the USQMP process to prioritise areas for infrastructure upgrades; • Upgrade existing systems where additional water quality benefits can be gained at 'reasonable' cost; • Pilot innovative soil amelioration techniques to increase carbon content, nutrient retention and water infiltration in TCC managed sites; • Investigate (using MUSIC modelling and other techniques) 'household' WSUD options that have the potential to reduce pollutant loads without compromising flood management issues.
7	***WSUD retrofit*** • Expand the SQID Report (Zingspace 2009) to include all levels of WSUD measures in place in the Townsville urban footprint, and categorise previous developments/neighbourhoods using the ABCD framework; • Prioritise areas where WSUD retrofits can be undertaken in a cost effective way for water quality improvement to meet WSUD objectives for sediment, nutrients and gross pollutants. These can be included in USQMP for 'local' areas.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.4 Peri-urban Management Actions

While being strategically important from both the short-term and long-term water quality perspective there is not a large store of information associated with peri-urban areas, which comprise around 30% of the Black Ross WQIP area. Along with application of the 'safe' management actions for developing urban areas, the main management actions associated with the peri-urban landscape involve the quantification and prioritisation of water quality issues, behaviour change investigations and the development of guidelines and programs based on knowledge acquired from investigations. The principle peri-urban specific management actions and associated management actions targets are listed in Table 6-6.

Table 6-6 Peri-urban Management Actions for Water Quality Improvement

Management Outcome 3: Management of peri-urban areas *To ensure that all peri-urban areas in Townsville are managed appropriately to achieve agreed water quality improvement outcomes including sediment, nutrients and pesticide load reductions*	
MAT 3.1	A locally relevant catchment management plan and/or guidelines for managing peri-urban landuse for water quality improvement prepared by 2010 (8)
MAT 3.2	Peri-urban diffuse source pollutant loads reduced through cost-effective approaches to the management of priority pollutant source areas (8, 17, 22-26)
MAT 3.3	All on-site wastewater treatment facilities (including septic tanks) managed according to approved best management practice over the life cycle of the asset (8)
MAT 2.7	All water quality improvement devices managed and maintained appropriately over the life cycle of the asset to ensure that treatment efficiencies are maintained (8 and 3)
No.	**Action area and tasks**
8	***Peri-urban Catchment Management*** • Delineate key peri-urban areas through internal/external stakeholder focus group meeting/s and aerial photograph and cadastral interpretation to develop a GIS layer; • Identify and prioritise catchment management, water quality and socio-economic issues associated with peri-urban areas;

	• Develop biophysical BMP guidelines for peri-urban areas (soil, land, water and biodiversity management) incorporating fire management for catchment health and water quality; • Refine the ABCD framework for peri-urban areas in line with BMP guidelines; • Undertake behaviour change studies (Thematic Interpretation and/or Community Based Social Marketing) in selected catchments e.g. Alligator Creek, Stuart Creek, Ross River, Bohle River, Black River and Bluewater Creek, to determine the most effective programs for water quality and catchment management initiatives (does not include Ross Dam catchment study); • Develop and cost programs based on results of studies; • Incorporate social findings in biophysical BMP guidelines and ABCD framework; • Implement peri-urban land and water management program.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

While not entirely comprised of peri-urban land uses the Ross River Dam catchment is heavily influenced by peri-urban activities especially in the vicinity of the water storage area. The main actions associated with protecting the water quality of the Ross Dam are listed in Table 6-7. Where appropriate rural management practice actions will be adopted as for other rural land uses in the Black Ross WQIP area.

Table 6-7 Water Resource Catchment Management Actions for Water Quality Improvement

Management Outcome 3: Management of peri-urban areas *To ensure that all peri-urban areas in Townsville are managed appropriately to achieve agreed water quality improvement outcomes including sediment, nutrients and pesticide load reductions*	
MAT 3.4	Best practice management actions being implemented within the catchment of the Ross Dam to ensure the improvement in the quality of water draining into the Ross Dam (9, 8, 10-26)
No.	**Action area and tasks (Peri-urban and Rural)**
9	***Ross River Dam Water Resource Catchment Management*** • Integrate the dam catchment water quality monitoring program with the Black/Ross WQIP WQ Monitoring and Modelling Strategy; • Review Planning Scheme provisions in terms of what has worked and what needs to be amended for the information of the new Planning Scheme for Townsville City; • Catchment planning for water quality improvement in higher risk land use areas/sub catchments; • Include Oak Valley in peri-urban management actions and subject to a combination of appropriate rural and urban management interventions; • Include Ross River, Alligator Creek and Stuart Creek catchments, and other areas delineated as peri-urban in the development of the peri-urban BMP guidelines; • Partner with BDT NRM to extend grazing Reef Rescue BMP incentives to the larger grazing properties of the Upper Ross River sub basin; • Review previous catchment plans and studies and provide further recommendations for catchment management and WQIP actions; • Conduct CBSM/Thematic Communication and Social Learning studies for implementation of peri-urban BMP in dam catchment communities e.g. Oak Valley (see sections Options, Costs and Benefits report); • Develop an extension program based on behaviour change findings and the peri-urban BMP guidelines and implement the program.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.5 Rural Management Actions

Rural management actions are based on the predominant land use activity i.e. grazing, sugar cane and horticulture. The main management actions involve adaptation and/or promotion of the management practices that have been identified in the preparation of rural-based WQIPs in the Burdekin, Mackay-Whitsunday and Tully regions. Rural management actions are listed in Table 6-8.

Table 6-8 Rural Management Actions for Water Quality Improvement

<table>
<tr><td colspan="2">Management Outcome 4: Management of rural areas
To ensure that all rural areas in Townsville are managed appropriately to achieve agreed water quality improvement outcomes including sediment load reductions from grazing lands and nutrient and pesticide load reductions from intensive agricultural land uses</td></tr>
<tr><td>MAT 4.1</td><td>Grazing best practice programs being implemented in the rural areas of Townsville (10, 18, 20-26)</td></tr>
<tr><td>MAT 4.2</td><td>Intensive agriculture (horticulture and sugar can cropping) best practice management actions being implemented within rural and peri-urban catchments across Townsville (11, 18, 20-26)</td></tr>
<tr><td>MAT 4.3</td><td>Non-urban diffuse source pollutant loads reduced through cost-effective approaches to erosion prevention and property management in priority sediment source catchments (10, 8-11, 17, 18, 20-26)</td></tr>
<tr><td>No.</td><td>Action area and tasks (Rural with some peri-urban overlap</td></tr>
<tr><td>10</td><td>Promote “Managing for WQ within grazing lands of the Burdekin Catchment” (BDT NRM)

• Investigate the need for ‘wet catchment’ additions to Burdekin rangeland management practices;
• Modify Burdekin rangeland grazing management practices as appropriate to suit local conditions;
• Work with NQ Dry Tropics to develop and roll out BMP adoption programs for rural areas;
• Incorporate grazing BMP components in the Peri-urban Catchment Management guidelines.</td></tr>
<tr><td>11</td><td>Promote management practice improvement as per the ABCD framework for sugar cane and horticulture (developed by Mackay Whitsunday NRM)

• Discuss with NQ Dry Tropics, Reef Catchments (Mackay Whitsunday), and Terrain (Tully) WQIP managers the possibility of including Black/Ross WQIP area in one of their Reef Rescue programs;
• Liaise with DPIF to determine potential actions associated with Nutrient Management Zones and linkages with WQIPs and Reef Rescue programs;
• Work with the appropriate organisation/s to develop and roll out BMP adoption programs for the northern sections of the Black Basin;
• Incorporate intensive agriculture BMP components in the Peri-urban Catchment Management guidelines for the sub basins and catchments from Bluewater Creek to Alligator Creek.</td></tr>
</table>

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.6 Enabling Management Actions

Enabling management actions consist of a number of interrelated tasks, which can be implemented sequentially if necessary, and would be most effective if implemented in parallel.

6.6.1 Policy and strategic planning

The first set of enabling management actions involve some form of policy or governance arrangements, which in terms of local government often overlap with regulatory roles and functions through planning schemes and the development assessment process.

Policy, governance arrangements and regulatory functions all need to have access to the most relevant information from the biophysical and socio-economic realms. The policy and governance management actions listed in Table 6-9 include strategic planning studies and integration of natural asset assessment and are therefore closely linked to condition assessment and behaviour change investigations in subsequent sections.

Table 6-9 Policy and Governance Management Actions

Management Outcome 5: Strategic planning *To ensure that relevant water quality improvement initiatives, information and activities are investigated and integrated where appropriate into Council strategic policy and planning instruments*	
MAT 5.1	Appropriate water quality improvement actions integrated with the Townsville City Council Planning Scheme by 2013 (12-17, 19, 1-4, 8 and 9)
MAT 5.2	Regulatory, policy and land use planning frameworks across all levels of government support the enhanced adoption of water quality improvement actions in Townsville (12-16)
MAT 5.3	An Urban Water Management Strategy developed for Townsville linking stormwater, wastewater, potable water and waterway management (13, 15, 1-5 and 19-26)
No.	**Action area and tasks (Enabling and cross catchment)**
12	***Legislation and Governance*** • Facilitate the incorporation of WSUD guidelines and measures in the current planning schemes, where possible, and as an integral part of the new Townsville City Planning Scheme; • Make recommendations for amendments to planning control measures based on the Erosion and Sediment Control and Site Based Stormwater Management Plans review findings; • Provide advice on potential development control measures and landscape protection mechanisms through the new Townsville City Planning Scheme based on findings from condition assessment studies and strategic landscape mapping; • Assist with the development of Codes associated with 'environmental' Overlays as part of the review process and development of the new Townsville City Planning Scheme; • Further investigate the identified potential mechanisms available to Council for water quality improvement associated with State and Commonwealth legislation and governance arrangements (see Options, Costs and Benefits report).
13	***Policy investigations and development*** • Investigate the potential for development of an Integrated Water Management Policy for total water cycle management in the urban environment; • Investigate the potential and benefits of establishing an Environment Levy to be used exclusively for protecting and managing natural resources such as waterways and wetlands; • Investigate options for the establishment of a Beneficial Rating system based on the level

	of environmental services installed and maintained in sub catchments within the Townsville region (also in Market Based Instruments).

14	***Planning Scheme studies and instruments review***
	
	• Provide input to Planning Scheme scoping investigations to determine linkages between WQIP components and proposed studies to inform the development of the new planning scheme with emphasis on the following study areas, Overlays and associated Codes;
	  ○ Housing Density
	  ○ Growth Spatial Studies
	  ○ Waterways & Wetlands Overlay and Code
	  ○ Biodiversity Overlay and Code
	  ○ Bushfire Overlay and Code
	  ○ Acid Sulphate Overlay and Code
	  ○ Agricultural Overlay and Code
	  ○ Steep Lands Overlay and Code
	  ○ Cultural Heritage Overlay
	• Where possible integrate WQIP condition assessment studies with Planning Scheme studies and/or assist with design and coordination of Planning Scheme studies to achieve mutual outcomes.

15	***Strategic landscape mapping and habitat prioritisation*** • Coordinate ecological and environmental studies and mapping across Council departments and with external partners to produce a comprehensive data set across the Townsville region landscape; • Develop criteria to enable prioritisation of landscape elements critical to water quality, habitat and biodiversity values protection and map GIS; • Integrate relevant protection layers with regional planning processes and the development of the new Townsville City Planning Scheme.
16	***Population Growth and Climate Change considerations*** • Update and refine population growth and urban expansion projections and mapping for inclusion in catchment and receiving waters modelling and the Bayesian Belief Network management practice decision support system; • Adapt management actions as appropriate to compensate for any issues identified by the refined modelling associated with population growth not previously identified. • Literature review of linkages between climate change and water quality; • Based on literature review findings develop a model, or utilise an existing model, to determine likely scenarios and timeframes for potential deterioration or improvement in water quality associated with climate change in the Black Ross WQIP area; • Develop long term, intermediate and short term objectives and actions to address any projected adverse impacts of climate change on water quality in the Black Ross WQIP area.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.6.2 Condition assessment and mapping

Natural asset condition assessment and mapping, combined with socio-economic data, underpins appropriate decision-making and policy development. During the preparation of the Black Ross WQIP a number of information gaps were identified along with areas where greater coordination and integration of information resources could result in more cost effective outcomes. Condition assessment management actions are listed in Table 6-10.

Table 6-10 Condition Assessment and Mapping

Management Outcome 6: Ecosystem health improvement *On-ground actions are prioritised and effective in improving water quality and ecosystem health*	
MAT 6.1	Condition assessment studies progressed by 2010 to enable prioritisation of on-ground works (17)
MAT 6.2	Traditional Owner waterway and water quality values are incorporated into planning and implementation of management actions (17, 22-25 and 12-19)
No.	**Action area and tasks (Enabling and cross catchment)**

17	***Condition assessment and prioritisation***
	
	• Scope requirements for collating and gathering condition assessment data and information associated with;
	  o Catchment condition assessment,
	  o Aquatic ecosystem health assessment,
	  o Riparian condition assessment,
	  o Wetland condition,
	  o Report card format verification,
	  o Acid sulphate soils.
	• Liaise with TCC Planning and Development, and other TCC departments, to identify natural resource condition studies being undertaken by Council departments and possibilities for integration and value adding;
	• Carry out condition assessments and develop a prioritisation process to rank areas for rehabilitation on the basis of water quality improvement potential;
	• Scope the requirements to prepare a greenspace management system for all properties owned or maintained by TCC containing greenspace i.e. parkland and natural areas;
	• Through a staged process of consultation with Traditional Owners determine Indigenous cultural and spiritual environmental values of waterways and waterbodies in the Black Ross WQIP area, including protocols for use of the information and management options to protect the identified environmental values.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.6.3 Socio-economic and behavioural actions

In the realm of energy use and waste management it is less expensive to reduce demand or the need for disposal facilities than it is to construct new infrastructure. The same concept applies to water pollutant load reduction i.e. reduction at the source through behaviour change is less costly than installing physical infrastructure.

Townsville City Council has a range of community based education and involvement (CBEI) initiatives in place, which promote catchment management objectives and people based solutions to environmental issues. More recently a number of behaviour change approaches have been added to the CBEI toolkit to accelerate the uptake of sustainability practices.

Behaviour change strategies can be utilised in most situations where people are involved including the mature urban environment to reduce the need for expensive infrastructure as well as in developing environments to encourage the uptake of erosion and sediment control and WSUD measures (see Gunn 2009). The main CBSM and behaviour change targets and actions are listed in

Table 6-11.

Table 6-11 Socio-economic and Behavioural Actions

<table>
<tr><td colspan="2">Management Outcome 7: Community involvement and capacity
All sectors of the Townsville community have access to the information and training required to contribute to implementation of relevant water quality improvement actions in the Black Ross WQIP area</td></tr>
<tr><td>MAT 7.1</td><td>Community involvement in water quality improvement is supported through continuation of Townsville's community based education and involvement program (18)</td></tr>
<tr><td>MAT 7.2</td><td>Locally relevant training and information provision programs developed and delivered to relevant sector groups based on the identified and agreed priority actions (18-20, 1-4, 8-11 and 22-25)</td></tr>
<tr><td>MAT 7.3</td><td>Best practice management and measures being implemented in the home and workplaces as a result of programs developed using behaviour change study results (19 and 21)</td></tr>
<tr><td>MAT 7.4</td><td>Best practice market based incentive options identified for water quality improvement in Townsville by 2011 (21 and 18-20)</td></tr>
<tr><td>No.</td><td>Action area and tasks (Enabling and cross catchment)</td></tr>
<tr><td>18</td><td>Community Based Education and Involvement (CBEI)
Supporting community and raising capacity through existing programs:
Creek watch,
Catchment tours (eco-certified),
Dry Tropics Watersmart,
Rowes Bay Sustainability Education Centre, Learnscapes and Transect,
Citisolar,
Catchment management/natural resource management via Landcare and Coastcare.
Incorporate behaviour change strategies in CBEI activities.</td></tr>
<tr><td>19</td><td>Reef Guardian Councils implementation of BMP
TCC and GBRMPA are working together to identify and/or develop actions to protect the water quality of the Great Barrier Reef Marine Park including:
Produce media with key Great Barrier Reef messages for events such as Ecofiesta and River Festival;
Developing best management practice approaches and guidelines for Council staff;
Develop behaviour change strategies for uptake of BMP;
Wastewater reuse investigations (as part of Dry Tropics Watersmart).</td></tr>
<tr><td>20</td><td>Social learning and behaviour change studies
Undertake behaviour change studies as required for urban and peri-urban landscapes using methods developed by the leading proponents of Community Based Social Marketing (CBSM) (Dr Doug Mackenzie-Mohr), Thematic Interpretation (Prof. Sam Ham) and Collective Social Learning (Prof. Valerie Brown);
Promote community and community group leaders involvement in behaviour change training programs and studies.</td></tr>
<tr><td>21</td><td>Market Based Instruments investigation
Market Based Instruments (MBIs) are tools that use market-like approaches to positively influence the behaviour of people through the use of market signals rather than through explicit directives or regulations. Market based incentives may be used in their own right and behaviour change studies can be used to help identify the most appropriate MBIs for a particular situation.</td></tr>
</table>

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.6.4 On-ground actions

While the largest gains in water pollutant load reductions are likely to be realised from improved management practices there are also potential gains from on-ground actions, which stabilise waterways, increase groundcover and assist with erosion prevention. There may also be some water quality benefits derived from rehabilitated riparian zones through the filtering of sediment and nutrients. Prior to any on-ground works a rigorous prioritisation process needs to be undertaken to ensure the benefits derived are worthwhile. On ground actions and preliminary investigations are listed in Table 6-12.

Table 6-12 On-ground Actions

Management Outcome 6: Ecosystem health improvement *On-ground actions are prioritised and effective in improving water quality and ecosystem health*	
MAT 6.3	Priority on-ground works for water quality and ecosystem health improvement underway by 2010 (22-24 and 17)
No.	**Action area and tasks (Enabling and cross catchment)**
22	***Riparian rehabilitation*** • Identification and prioritisation of areas for maximum water quality benefit from protection mechanisms and on ground action; • Develop action plans; • Implement actions and protection measures.
23	***Wetland restoration and construction*** • Identification and prioritisation of areas for maximum water quality benefit from protection mechanisms and on ground action; • Develop action plans; • Implement actions and protection measures.
24	***Aquatic ecosystem health improvement*** • Define priority areas for action based on Condition assessment and prioritisation task (16); • Develop Waterway Improvement Plans for high priority urban streams; • Implement priority management actions potentially including; o Freshwater fish - removal or modification of in stream movement barriers, o Aquatic vegetation - control of exotic species, o Channel and floodplain features - maintain ‘natural’ flow regimes and processes, o Riparian vegetation - grazing management e.g. fencing and off stream watering points.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.6.5 Water quality monitoring and modelling

Water quality monitoring and modelling is used not only for measuring success but also to guide management actions as a key component of the adaptive management strategy. Additional information is provided in section 7.3 with priority actions listed in Table 6-13.

Table 6-13 Water Quality Monitoring and Modelling Actions

Management Outcome 8: Monitoring, evaluation and reporting *To ensure that water quality improvement actions are effective in improving water quality and results are communicated appropriately to the Townsville community*	
MAT 8.1	A comprehensive monitoring, modelling and evaluation program developed and being implemented as part of the ongoing adaptive planning and management framework of the Black Ross WQIP

No.	Action area and tasks (Enabling and cross catchment)

25	***Water quality monitoring and modelling (WQM and M)***
	
	• Implement the Integrated Water Quality Monitoring and Modelling Strategy including detailed program design for:
	  o Critical sub catchment and river sites (to inform and validate modelling),
	  o Ecosystem health and ambient water quality monitoring (see Figure 7-1),
	  o Community based education and involvement monitoring (see Figure 7-1),
	  o Developing a set of local water quality guidelines for the wet and dry catchments of the Black Ross WQIP area in conjunction with DERM/EPA (see Figure 7-1),
	  o Socio-economic monitoring and management practice uptake,
	  o Modelling.
	• Update the Creek to Coral water quality monitoring activity report prepared in 2004;
	• Develop protocols and management systems for coordinating water quality monitoring initiatives and analysing and sharing data and results;
	• Extract monitoring data from the database relevant to stormwater treatment measures and land uses for further analysis and to assist with development of mitigation measures;
	• Build on the water quality monitoring database developed by Creek to Coral for the Black Ross WQIP to encompass additional data including from commercial/private sources;
	• Incorporate monitoring data from large scale developments and developing areas e.g. Rocky Springs;
	• Develop strategies for enabling inclusion of water quality monitoring data generated from commercial enterprises e.g. development projects and Environmental Impact Assessments;
	• Refining catchment scale models (WaterCAST and updates) incorporating on-going monitoring results (see Figure 7-2);
	• Improve knowledge on the connection between terrestrial run-off and receiving water health through improved linkage of catchment models and receiving waters models (see Figure 7-2);
	• Investigate linkages between previous socio-economic modelling (Greiner et al 2005) and the Bayesian Belief Network (BBN) model being developed for the Black Ross WQIP area (Lynam et al 2008);
	• Further develop the BBN decision support model;
	• Finalisation of Marine and Tropical Sciences Research Facility (MTSRF) Project 4.9.7. Understanding and enhancing social resilience: science and management integration (Gooch et al 2008) Townsville component through monitoring community response to a water quality management intervention designed after conducting a community based social marketing study.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.6.6 Communication plus

Good communications and management systems along with coordinated and integrated actions are critical to the success of the Black Ross WQIP. The main strategic actions are listed in Table 6-14. Additional information is provided in the following sections.

Table 6-14 Communications Plus

Management Outcome 8: Monitoring, evaluation and reporting *To ensure that water quality improvement actions are effective in improving water quality and results are communicated appropriately to the Townsville community*	
MAT 8.2	Knowledge and information requirements are identified and prioritised for major sector groups by 2010
MAT 8.3	Opportunities identified to invest in research to develop and assess the performance of water quality improvement actions in the Townsville region

MAT 8.4	An integrated report card developed to communicate the progressive outcomes from the implementation of the Black Ross WQIP
No.	**Action area and tasks (Enabling and cross catchment)**
26	***Integration, Communication, Monitoring, Evaluation and Adaptive Management*** • Facilitate WQIP integration with other Council and external processes; • Develop and implement the Black Ross WQIP Communication Strategy; • Foster partnerships and relationships for water quality improvement; • Refine and implement the WQIP Monitoring and Evaluation framework; • Refine and extend the ABCD Management Practice Framework for urban and peri-urban areas; • Progress and test the Bayesian Belief Networks decision support system.

Note: Numbers in (brackets) in the MAT rows refer to the Action area and tasks numbers

6.7 Management Action Targets

A summary of the management action targets from the sections above is provided in Table 6-15.

Table 6-15 Management Action Targets

Target	Target description	Cost
Management Outcome PS: Management of point source pollution *To ensure that pollutants from point sources in Townsville are managed appropriately to reduce their impact on receiving waters to acceptable levels*		
Target	**Target description**	**Cost**
PSRC 1.1	By 2012 total wastewater treatment plant pollutant loads are reduced from 2006 loads by: • 75% for total nitrogen (225 tonnes/yr) • 65% for total phosphorus (48 tonnes/yr)	
PSMA 1.1	By 2012 all wastewater treatment plants in Townsville are upgraded and meet DERM (EPA) revised permit requirements	$189.4M
PSRC 1.2	By 2021 total wastewater treatment plant pollutant loads are further reduced from 2012 levels by: • 17% for total nitrogen (12 tonnes/yr) • 24% for total phosphorus (5.8 tonnes/yr) • 30% for total flows (14.4 ML/day)	
PSMA 1.2	A effluent reuse scheme for treated effluent from the Cleveland Bay Wastewater Treatment Plant is established and operational by 2021	$32.9M
Management Outcome 1: Management of development in urban and peri-urban areas *To ensure that all new development in Townsville is managed appropriately to achieve agreed water quality improvement outcomes including sediment load reductions*		
MAT 1.1	Erosion and sediment control principles and measures implemented across all new development by 2011 (1)	
MAT 1.2	Locally specific guidelines and associated tools developed to support the implementation of best practice stormwater management in Townsville by 2013 (2 and 4)	
MAT 1.3	Water Sensitive Urban Design (stormwater) principles and actions are progressively incorporated in the design of all new development reaching a 100% adoption rate by 2021 (3-5, 7 and 12-16)	
Management Outcome 2: Management of existing urban areas *To ensure that the existing urban areas of Townsville are managed appropriately in order to achieve agreed water quality improvement outcomes including sediment, nutrient and other pollutant load reductions over time*		
MAT 2.1	By 2013 locally specific Water Sensitive Urban Design guidelines and associated tools developed and tested to support the implementation of best practice stormwater management in Townsville (3)	
MAT 2.2	Coastal Dry Tropics Guide for Urban Water Management developed by 2011 (4)	
MAT 2.3	Water Sensitive Urban Design (stormwater) principles and measures progressively included in all new development reaching 100% adoption rate by 2021 (3-5, 7 and 12-16)	
MAT 2.4	Waterway management and rehabilitation plans for priority urban waterways developed by 2010 with implementation actions underway by 2012 (17, 14, 15 and 22-24)	
MAT 2.5	Best practice erosion and sediment control principles and actions being implemented across all infill and retrofit development by 2010 (5 and 1)	
MAT 2.6	An integrated draft Urban Stormwater Quality Management Plan for the Townsville City Council Local Government Area prepared by 2013 (5)	
MAT 2.7	All water quality improvement devices managed and maintained appropriately over the	

	life cycle of the asset to ensure that treatment efficiencies are maintained (5-7, 3 and 4)
MAT 2.8	Options investigated, areas prioritised and implementation plan developed for retrofit of appropriate water quality improvement devices into community infrastructure by 2011 (6 and 7)
Management Outcome 3: Management of peri-urban areas *To ensure that all peri-urban areas in Townsville are managed appropriately to achieve agreed water quality improvement outcomes including sediment, nutrients and pesticide load reductions*	
MAT 3.1	A locally relevant catchment management plan and/or guidelines for managing peri-urban landuse for water quality improvement prepared by 2010 (8)
MAT 3.2	Peri-urban diffuse source pollutant loads reduced through cost-effective approaches to the management of priority pollutant source areas (8, 17, 22-26)
MAT 3.3	All on-site wastewater treatment facilities (including septic tanks) managed according to approved best management practice over the life cycle of the asset (8)
MAT 2.7	All water quality improvement devices managed and maintained appropriately over the life cycle of the asset to ensure that treatment efficiencies are maintained (8 and 3)
MAT 3.4	Best practice management actions being implemented within the catchment of the Ross Dam to ensure the improvement in the quality of water draining into the Ross Dam (9, 8, 10-26)
Management Outcome 4: Management of rural areas *To ensure that all rural areas in Townsville are managed appropriately to achieve agreed water quality improvement outcomes including sediment load reductions from grazing lands and nutrient and pesticide load reductions from intensive agricultural land uses*	
MAT 4.1	Grazing best practice programs being implemented in the rural areas of Townsville (10, 18, 20-26)
MAT 4.2	Intensive agriculture (horticulture and sugar can cropping) best practice management actions being implemented within rural and peri-urban catchments across Townsville (11, 18, 20-26)
MAT 4.3	Non-urban diffuse source pollutant loads reduced through cost-effective approaches to erosion prevention and property management in priority sediment source catchments (10, 8-11, 17, 18, 20-26)
Management Outcome 5: Strategic planning *To ensure that relevant water quality improvement initiatives, information and activities are investigated and integrated where appropriate into Council strategic policy and planning instruments*	
MAT 5.1	Appropriate water quality improvement actions integrated with the Townsville City Council Planning Scheme by 2013 (12-17, 19, 1-4, 8 and 9)
MAT 5.2	Regulatory, policy and land use planning frameworks across all levels of government support the enhanced adoption of water quality improvement actions in Townsville (12-16)
MAT 5.3	An Urban Water Management Strategy developed for Townsville linking stormwater, wastewater, potable water and waterway management (13, 15, 1-5 and 19-26)
Management Outcome 6: Ecosystem health improvement *On-ground actions are prioritised and effective in improving water quality and ecosystem health*	
MAT 6.1	Condition assessment studies progressed by 2010 to enable prioritisation of on-ground works (17)
MAT 6.2	Traditional Owner waterway and water quality values are incorporated into planning and implementation of management actions (17, 22-25 and 12-19)
MAT 6.3	Priority on-ground works for water quality and ecosystem health improvement underway by 2010 (22-24 and 17)
Management Outcome 7: Community involvement and capacity *All sectors of the Townsville community have access to the information and training required to contribute to implementation of relevant water quality improvement actions in the Black Ross WQIP area*	

MAT 7.1	Community involvement in water quality improvement is supported through continuation of Townsville's community based education and involvement program (18)
MAT 7.2	Locally relevant training and information provision programs developed and delivered to relevant sector groups based on the identified and agreed priority actions (18-20, 1-4, 8-11 and 22-25)
MAT 7.3	Best practice management and measures being implemented in the home and workplaces as a result of programs developed using behaviour change study results (19 and 21)
MAT 7.4	Best practice market based incentive options identified for water quality improvement in Townsville by 2011 (21 and 18-20)
Management Outcome 8: Monitoring, evaluation and reporting *To ensure that water quality improvement actions are effective in improving water quality and results are communicated appropriately to the Townsville community*	
MAT 8.1	A comprehensive monitoring, modelling and evaluation program developed and being implemented as part of the ongoing adaptive planning and management framework of the Black Ross WQIP by 2010
MAT 8.2	Knowledge and information requirements are identified and prioritised for major sector groups by 2010
MAT 8.3	Opportunities identified to invest in research to develop and assess the performance of water quality improvement actions in the Townsville region
MAT 8.4	An integrated report card developed to communicate the progressive outcomes from the implementation of the Black Ross WQIP

Note: Numbers in (brackets) refer to the Action area and tasks numbers in previous tables

6.8 Cost of Improved Water Quality and Ecosystem Health

An initial costing of management actions was prepared as part of the proposal submitted to the Australian Government to deliver relevant components of the Caring for Our Country Business Plan 2009/10. These costings are shown in Table 6-16. Detailed budgets are being developed internally and with partner organisations.

Table 6-16 Preliminary Costs

No.	Action Areas	Cost $,000s	Lead Role and Partners
1	Erosion and Sediment Control for development [2009/11]	(36)	TCC, UDIA
2	Site based Stormwater Management Plans for development [2009/11]	(18)	TCC, UDIA
3	Water Sensitive Urban Design (WSUD) guideline adoption and additional products [2009/13]	24 [134] (88)	TCC, UDIA
4	Develop the Coastal Dry Tropics Guide for Urban Water Management [2009/10]	24 [4]	TCC
5	Urban Stormwater Quality Management Plan integration [2009/10]	244 [6]	TCC
6	Urban stormwater treatment trains [2009/11]	580 [80]	TCC
7	WSUD retrofit [2009/11]	(60)	TCC
8	Develop peri-urban catchment management guidelines and implementation activities [2009/12]	262 [5]	TCC, NQ Dry Tropics
9	Water Resource Catchment Management (Ross River Dam) [2009/11]	(40)	TCC
10	Promote "*Managing for WQ within grazing lands of the Burdekin Catchment*" (BDT NRM) [2009/11]	(30)	TCC, NQ Dry Tropics
11	Promote management practice ABCD framework for sugar cane and horticulture (Mackay Whitsunday NRM) [2009/11]	(12)	TCC, Reef Catchments
12	Legislation and Governance [2009/13]	(48)	TCC
13	Policy investigations and development [2009/11]	(14)	TCC
14	Planning Scheme studies and instruments review [2009/13]	(120)	TCC
15	Strategic landscape mapping and habitat prioritisation [2009/13]	158 [260]	TCC, DERM
16	Population Growth and Climate Change considerations [2009/11]	(36)	TCC
17	Condition assessment and prioritisation [2009/13]	(100)	TCC, NQ Dry Tropics, DERM
18	Community Based Education and Involvement (CBEI) (awareness and capacity building) [2009/13]	320 [1,442]	TCC, CVA
19	Reef Guardian Councils implementation [2009/13]	(80)	TCC, GBRMPA
20	Social learning and behaviour change studies (for determining effective management interventions) – urban and peri-urban [2009/11]	75 [141]	TCC, NQ Dry Tropics
21	Market Based Instruments investigation [2009/10]	(13)	TCC
22	Riparian zone rehabilitation [2009/11]	(200)	TCC, CVA
23	Wetland restoration and construction [2009/11]	(40)	TCC, CVA
24	Aquatic ecosystem health improvement [2009/13]	[1,000] (300)	TCC, CVA
25	Water quality monitoring and modelling – event [2009/13]	580 [52] (100)	TCC, ACTFR
26	Integration, Communication, Monitoring, Evaluation and Adaptive Management [2009/13]	645 [1,484] (40)	TCC, EPA

Notes: Funding requested through CFOC/Reef Rescue is followed by approved and yet to be approved budgeted funding in [square brackets]. All figures are exclusive of GST. Figures in (brackets) are preliminary estimates, which need to be confirmed following investigations into requirements of tasks within the activity area.

6.9 Roles and Responsibilities

Roles and responsibility are being negotiated with relevant stakeholders including internally throughout Townsville City Council. An indication of stakeholder involvement in the delivery of the priority actions is provided in Table 6-16.

6.10 Integration With Other Processes

There are a number of NRM initiatives that have direct relevance to the Black/Ross WQIP with a variety of other activities that are indirectly related and/or synergistic. A selection of the key programs, projects and initiatives considered in when developing implementing the Black/Ross WQIP are described briefly in the Options, Costs and Benefits background report.

The process of developing and implementing a WQIP is both incremental and iterative as new information is accumulated and incorporated. Other planning processes need to be taken into account and integrated, as appropriate, into the WQIP development process. In the context of an 'urban' catchment incorporation of elements of the WQIP in Council planning schemes under the *Integrated Planning Act* (IPA), development assessment processes and construction guidelines and codes is particularly important.

Coordination between 'external' and evolving planning processes is also appropriate with opportunities sometimes presenting to address a number of issues simultaneously. Opportunities associated with the March 2008 amalgamation of local government areas e.g. Townsville and Thuringowa, and the reorganisation of Australian Government natural resource management (NRM) programs are two relevant examples.

The adaptive management strategy, which is an integral part of this WQIP, makes allowance for the transitional nature of both local government in Queensland, NRM funding programs, partners and partnerships, evolving science and socio-economic influences. This enables the uncertainty inherent in the system to be accounted for and incorporated in the implementation phase of the Black/Ross WQIP.

6.10.1 Communication Strategy

Reporting to the community and stakeholders is to be integrated into relevant and existing reporting mechanisms including NQ Dry Tropics, Reef Plan, Townsville SOE and Creek to Coral websites. The Communication Strategy will be developed after the availability of funding to implement this WQIP is known.

6.10.2 Partnerships

Organisation such as NQ Dry Tropics (formerly Burdekin Dry Tropics NRM) and Terrain are regional NRM bodies funded through the Australian Government to implement NRM activities within their region and, with other NRM bodies, across regions. Creek to Coral is partnering with NQ Dry Tropics to deliver the rural components of the Black Ross WQIP and in return will provide assistance to NQ Dry Tropics with the urban and peri-urban components of their WQIP area. There is scope for future collaborative projects to jointly deliver WQIP components as well as broader biodiversity and catchment management outcomes.

6.11 Are We Confident?

The level of confidence varies between management actions. The actions that been shown to work in other areas elicit a high level of confidence and these are the actions that we plan to implement as priorities. The actions that we are less sure of will be investigated further and tested to determine their worth. When we have a greater level of confidence in their ability to deliver cost effective outcomes then we will look at implementing additional actions.

6.11.1 Reasonable Assurance Statement

A reasonable assurance statement is part of the contractual arrangements associated with funding arrangements under the previous Australian Government's Coastal Catchments Initiative program. This will be provided as an annexure to the final WQIP as required by the original funding agreement between Townsville City Council and the Commonwealth of Australia.

7. Progress Reporting and Adaptation

7.1 WQIP Monitoring and Evaluation

There are two key monitoring and evaluation components associated with the Black/Ross WQIP:

1. WQIP implementation effectiveness;
2. Water quality monitoring.

7.2 WQIP Effectiveness

The main method for determining the effectiveness of the WQIP will be through the measurement of recommended management practice adoption rates. To assist with the task of determining current management practice status and then measuring adoption rates; an ABCD framework for urban and peri-urban areas is being developed. Initially a coarse survey of a range of land managers for different land uses may be required as a starting point to feed into the ABCD framework.

7.2.1 Management practice uptake

Determining management practice uptake needs to commence by assessing the current status of management practice in the various areas of interest for the different land uses across the WQIP area, especially in the near urban developing areas and peri-urban fringe. As yet a data collection system has not been devised as the proposed management practices are inextricably related to a number of other processes within Townsville City Council, including regulatory processes associated with State legislation and policy. Any data collection system proposed will necessarily have implications for the monitoring and enforcement role of Council and needs to be designed in consultation with all relevant Council departments and staff, and linked with each of the associated processes and existing systems.

Each individual action component of the Black Ross WQIP will involve a design that incorporates monitoring of behaviour change, social learning and management practice uptake. In addition specific social studies will be undertaken to determine the most appropriate methods to communicate water quality improvement messages and motivate land managers to adopt management practices aimed at improving water quality and ecosystem health.

7.2.2 ABCD Management Practice Framework

A tool to assist with the promotion and measurement of management practice uptake is the ABCD management practice framework for urban areas. This was initially developed in conjunction with the management team of the Mackay Whitsunday WQIP and Mackay City Council. The framework has a number of functional uses including:

- To set targets for water quality management practice improvement;
- To provide land managers with a list of water quality improvement options;
- To relate the management action improvements to pollutant load reductions;
- To measure improvement in management practice on an ascending grouped scale;
- To provide discreet management classes for inclusion in Bayesian Belief Network modelling;
- To investigate the most effective, and most cost effective, management interventions for water quality improvement using BBN modelling;
- To provide a level of certainty (through probability distribution) of the potential effectiveness of management interventions (using BBN modelling) i.e. reasonable assurance;
- To inform the adaptive management strategy.

The main elements associated with the urban ABCD framework as presented in the Mackay Whitsunday WQIP are listed in Table 7-1.

Table 7-1 Urban ABCD Framework Main Elements

New development	Existing/developed areas

• WSUD
• ESCP – development, implementation and maintenance
• SBSMP – developed, implemented and maintained
• Planning and reporting
  o Relevant to USQMP,
  o Relevant to ESCP,
  o Relevant to SBSMP,
  o Adaptive management,
  o Non-compliance reporting,
  o Staged clearing and development.
• Infrastructure (not determined - a component of WSUD and USQMPs)
	• Infill development as for new development i.e. WSUD, ESCP and SBSMP
	• Planning and reporting based around maturity and implementation of USQMP

Education in conjunction with the development and construction industry	Community based activity associated with total water cycle management

Source: Water Quality Improvement Plan Final report for Mackay Whitsunday region (2008, pp.66-70)

Creek to Coral has continued to work on the framework with the latest urban drafts (developing areas, developed areas and point sources) included in the Options, Costs and Benefits background report.

In addition to the urban areas, a draft framework for peri-urban areas has also been developed and this will be 'road-tested' as part of the WQIP implementation process. The peri-urban areas do not neatly fit into the urban or rural land use categories and require separate consideration, while being mindful that it is the peri-urban areas that are under the most pressure from a development perspective and also have a relatively large number of 'rural' land managers in a relatively small 'rural' area.

7.3 Water Quality Monitoring and Modelling

The WQIP development and implementation process is being used to integrate water quality monitoring in the study area to achieve more effective outcomes including calibrating and verifying water quality models and to inform the adaptive management strategy for the Black Ross WQIP, Townsville (Dry Tropics) WSUD guidelines and Urban Stormwater Quality Management Plan/s.

An integrated water quality monitoring and modelling strategy has been prepared by the Australian Centre for Tropical Freshwater Research (ACTFR)/James Cook University (Bainbridge et al 2008) for the Black Ross WQIP. Since the main aim of the Black Ross WQIP is to reduce sediment, nutrient and pesticide export to the Great Barrier Reef, a coupled monitoring and modelling approach has been designed to measure, assess and report on the effectiveness of the Black Ross WQIP and in particular the impact of improved land management practices on receiving waters associated with WQIP implementation actions.

The ACTFR report provides a monitoring and modelling strategy for the Townsville region, as well as an outline for future plan development. The strategy is presented in three sections:

(i) Catchment Ecosystem Health Framework, *relating to instream waterways and wetlands;*

(ii) Marine Ecosystem Health Framework, *linking catchment management actions to marine ecosystem health*; and

(iii) Social and Economic Framework, *linking socio-economic indicators and management action uptake to water quality outcomes*.

7.3.1 A water quality work in progress

Creek to Coral, through its Coastal Catchments Initiative (CCI)/WQIP project, commissioned:

- The collation of available water quality monitoring data and preparation of a Water Quality Condition Report;
- The development of a draft Report Card format for water quality, ecosystem and catchment health;
- Event water quality monitoring for the 2006/07 and 2007/08 wet seasons; and
- Catchment and receiving waters modelling for the Black Ross WQIP area.

Prior to these studies there have been limited modelling efforts specific to the region and appropriate to the conditions i.e. smaller coastal catchments and altered catchment processes of urbanised landscapes, and virtually no event monitoring (most existing data is ambient monitoring).

The broader integration of all ambient (catchment ecosystem health) and event (marine ecosystem health) water quality monitoring within the Black and Ross Basins (extended to the Townsville City Council local government area) will be developed as part of the implementation of the Black Ross WQIP. Similarly the coupled monitoring and modelling approach described in the strategy (Bainbridge et al 2008) will be an implementation action of the Black Ross WQIP and in particular the continuation of the process for assessing management effectiveness and response for marine ecosystem health (see Figure 7-2) started with the event monitoring and modelling undertaken during the preparation of the WQIP.

In the interim an on-going event monitoring plan has been developed based on results and gaps from the 2006/07 and 2007/08 event monitoring programs, and to fill immediate catchment modelling verification requirements with regard to end-of-catchment sediment and nutrient loads.

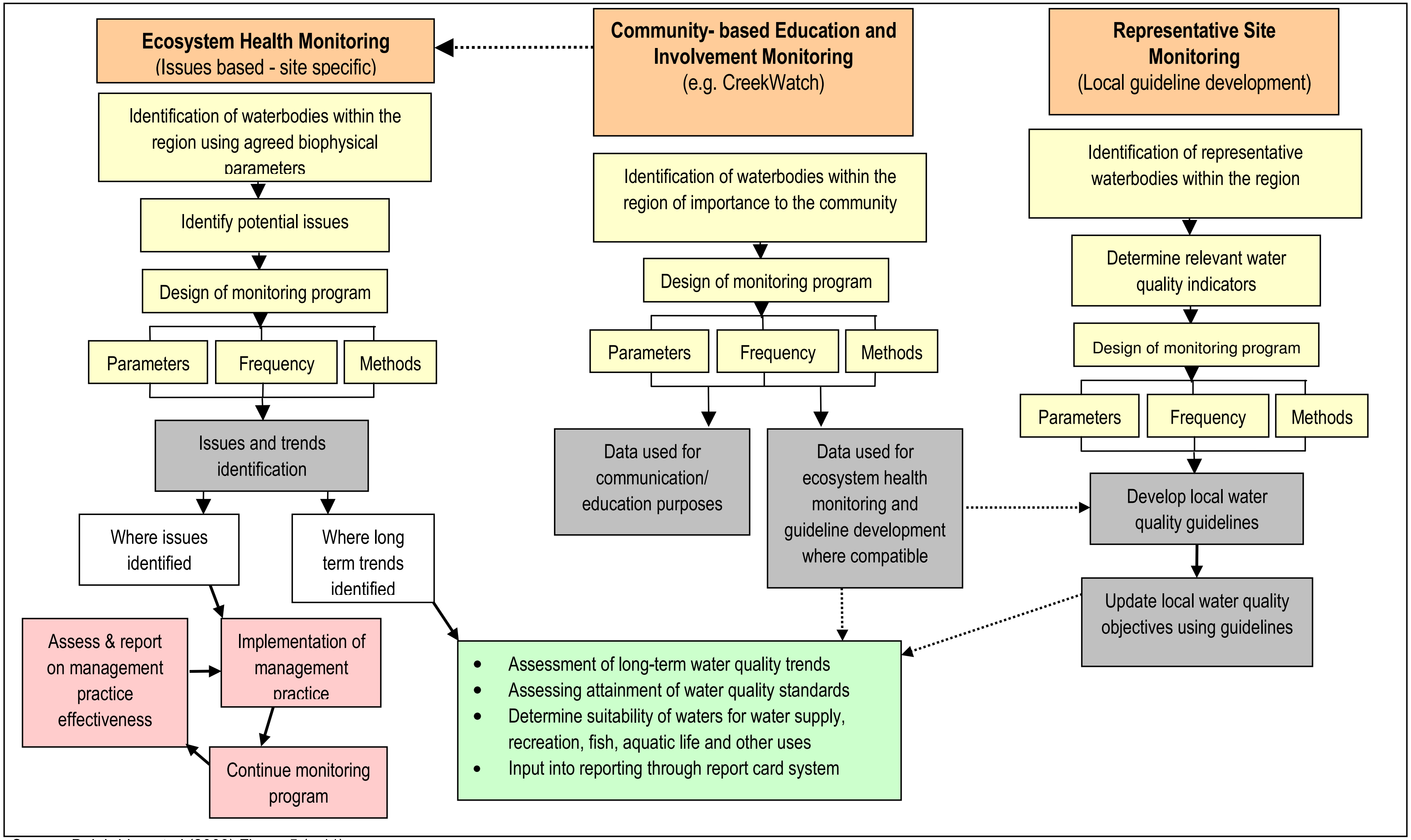
While the coupled modelling and monitoring approach will provide managers with a better understanding of the water quality signals and trends that result from improved land uses over time e.g. WSUD measures, improvement in management practices also need to be audited. Such auditing will be an integral part of the Black Ross WQIP particularly during the first phase of implementation where monitoring data particularly will be limited, and management practice auditing will be the primary means of feedback.

7.3.2 Water quality monitoring scales

Changes in water quality as a result of catchment management actions are only likely to be measured at the smaller sub-catchment/land use scale in the shorter term. Catchment ‘noise’ and lag times associated with particular management actions limit the detection of water quality changes or trends at the catchment (end-of-catchment) scale (Stow et al. 2001; Osidele et al., 2003 in Bainbridge et al 2008).

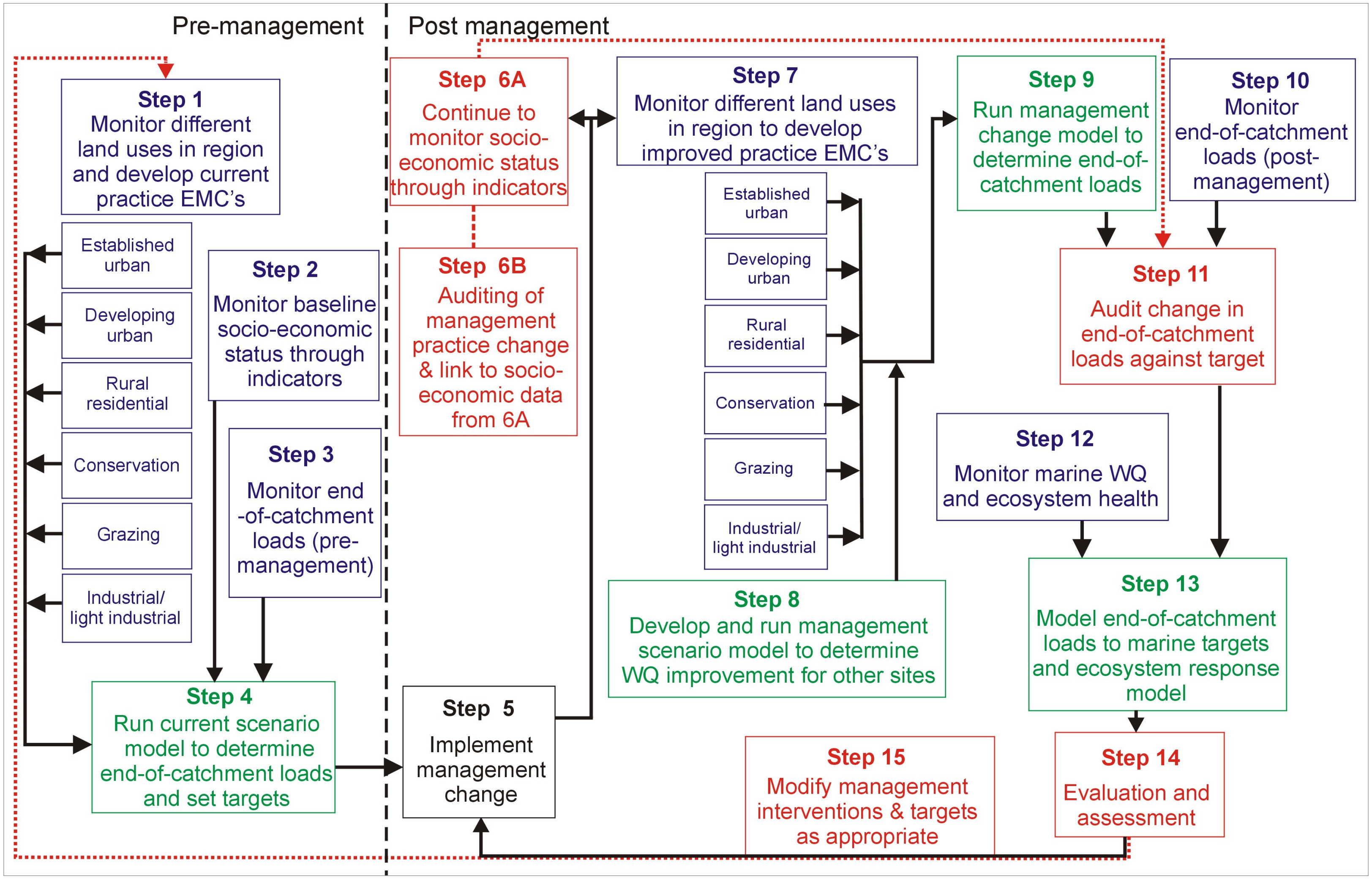
For this reason the most effective form of monitoring to determine improvements in water quality at the end of catchment will be long term and strategically focused. Short-term improvements may be detected through a well-planned program based around ‘isolated’ reaches and water bodies associated with small sub catchments and relatively uniform land uses. Without this level of specificity there are too many variables and too much background ‘interference’ to derive any meaningful cause and effect information from water quality monitoring.

Figure 7-1 Catchment Ecosystem Health Framework



Source: Bainbridge et al (2008) Figure 5 (p.11)

Figure 7-2 Coupled Monitoring and Modelling Marine Ecosystem Health Framework



Source: Bainbridge et al (2008) Figure 6 (p.13). Notes: Monitoring processes shown in blue, modelling in green and (management practice/social) auditing in red.

7.3.3 Connecting management practice to water quality

Verification of the effectiveness of management practices will be through 'micro' scale water quality monitoring at the urban 'paddock' scale. The information gained at this scale can then be used as input to catchment models to determine 'downstream' improvements and to justify broader introduction of effective management practices. 'Macro' scale monitoring will also be used to verify modelled outputs and assist with recalibration of models (Bainbridge et al 2008).

7.3.4 Connecting management practice to ecosystem health

Making the connection between ecosystem health and management practices requires the collection of baseline data, prior to the commencement of 'new' practices; with follow up monitoring after management interventions have been put in place. Available water quality monitoring data has been collated and this needs to be further analysed and combined with as yet to be collated and collected condition assessment data. Ecosystem health relates to all receiving waters and requires different assessment methods and models for freshwaters, estuaries and marine systems (Bainbridge et al 2008).

Making direct connections between marine ecosystem health and catchment land use and management practices is a difficult task and requires a well planned and appropriately resourced monitoring program combining and coordinating local and regional monitoring efforts. The Black Ross WQIP focuses on the local level monitoring i.e. Black and Ross Basins, and relies on linking to regional monitoring undertaken by GBRMPA, and being involved in integrated whole of GBR catchment monitoring programs and activities e.g. exposure modelling undertaken by the Reef Water Quality Partnership.

7.4 Bayesian Belief Networks

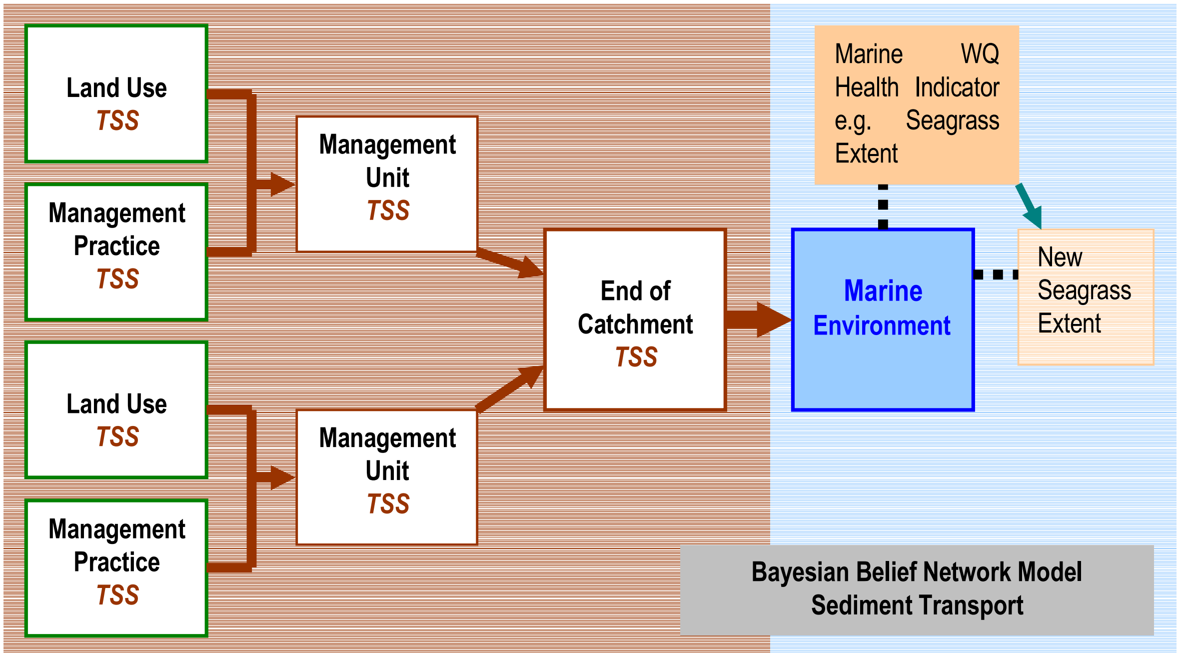
Bayesian Belief Networks (BBN) and their application to the Black Ross WQIP are explained in more detail in a draft report prepared by the BBN project team leader, Tim Lynam (Lynam et al 2008). Creek to Coral has been working in conjunction with CSIRO to develop a water quality based BBN to explore the relationships between management practice, land use and water quality (pollutant loads) as a probability based decision support system. The BBN has been designed to assist with setting, or verifying, direction for potential management interventions and subsequently redirecting management interventions as part of the adaptive management approach to catchment management and water quality improvement in the Black and Ross Basins.

Information derived from the monitoring (ACTFR event monitoring) and modelling processes (e.g. E2 load modelling) feeds into the BBN to provide pollutant coefficients for the various land uses within a sub catchment (management unit). The ABCD management practice framework (see section 7.2.2) is being developed, in part; to provide some form of delineation of the pollutant generation variables associated with different management practices for various land uses.

The end game is to use the BBN to determine the most effective management interventions for each land use based on potential water quality improvement associated with various management practices. A significant amount of testing and calibration of the BBN is required to attain greater levels of certainty associated with results i.e. the better the input the better the output. A simplified diagram showing the initial conceptual BBN for total suspended solids for the Bohle River catchment is provided in Figure 7-3.

The BBN has also been used in conjunction with catchment modelling to provide a level of confidence in the proposed management actions. Additional information on the BBN is provided in the Options, Costs and Benefits background report.

Figure 7-3 Initial BBN Concept for the Bohle River Catchment



A parallel and integrated component of the BBN project involves the observation of the BBN development process as part of a social learning study. Alternatively referred to as collective or collaborative learning, social learning in natural resource management contexts is a process for improving the effectiveness of adaptive management strategies. Creek to Coral in partnership with CSIRO is investigating a range of adaptive management approaches and tools, as recommended by the Reef Water Quality Partnership (Eberhard et al. 2008).

The social learning study seeks to understand the role of social learning in complementing and enhancing approaches and tools currently being trialled in the WQIP process. The social learning component of the BBN project will provide a social learning conceptual framework as well as set of processes and tools to maximise the capacity of Townsville City Council staff (and associated partners) to 'learn by reflection and doing'. BBN and social learning are included in the Decision Support components of the adaptive management framework (see Figure 7-5).

7.5 Adaptive Management Strategy - Learning and Doing

In a report (draft) prepared for the Reef Water Quality Partnership, Eberhard et al (2008) state "*Adaptive management is particularly appropriate in dynamic and complex systems that result in high levels of uncertainty in delivery of actions and achievement of outcomes. These characteristics typify environmental management systems, in both biophysical and socio-economic aspects, and are strong features of the GBR system. Uncertainty in natural resource management systems is systemic in our understanding of the current state of the system (measurement and interpretation), our understanding of how the system will respond to changes over time (prediction) and the influence of other factors outside our control or knowledge*" (Eberhard et al 2008, p.4).

Furthermore, environmental and catchment management takes place in the context of human activity systems (social, economic and political). In essence we are not managing the environment so much as guiding and influencing the people that impact the environment through their everyday behaviour. Adaptive management needs to be mindful of the human activity systems operating in the area of influence and be designed to enable behaviour change in the relevant context.

7.5.1 Adaptive management

Adaptive Management is an approach that involves learning from management actions, and using that learning to improve the next stage of management (Holling, 1978). It is "*learning to manage by managing to learn*" (Bormann et al, 1993). (Source: http://www.connectedwater.gov.au/framework/adaptive_management.html)

In simple terms adaptive management is the application of experiential learning to the management process. We start by managing the preparation of our strategic plan (a water quality improvement plan) and associated action plans, and then manage the plan implementation process i.e. project management. We implement actions devised as part of the WQIP and we review the outputs and outcomes of the actions. We learn from observation and evaluation of the results and we then incorporate the lessons into the action plans and continue to implement the actions.

In some cases the learning may lead to the discontinuation of an action, project or program due to low levels of success i.e. inability to reach targets or achieve outcomes. In reality this is not a failure of the plan, as plans are built using; the best available information at the time, opinions, untested assumptions and, often, limited science. Rather this is an example of the successful implementation of adaptive management. The result is that an ineffective action is prevented from continuing along an unproductive path. In terms of the overall plan this may lead to a revision of 'unrealistic' targets, investigation of innovative options or the creation of a totally new area of focus.

7.5.2 Adaptive management and planning

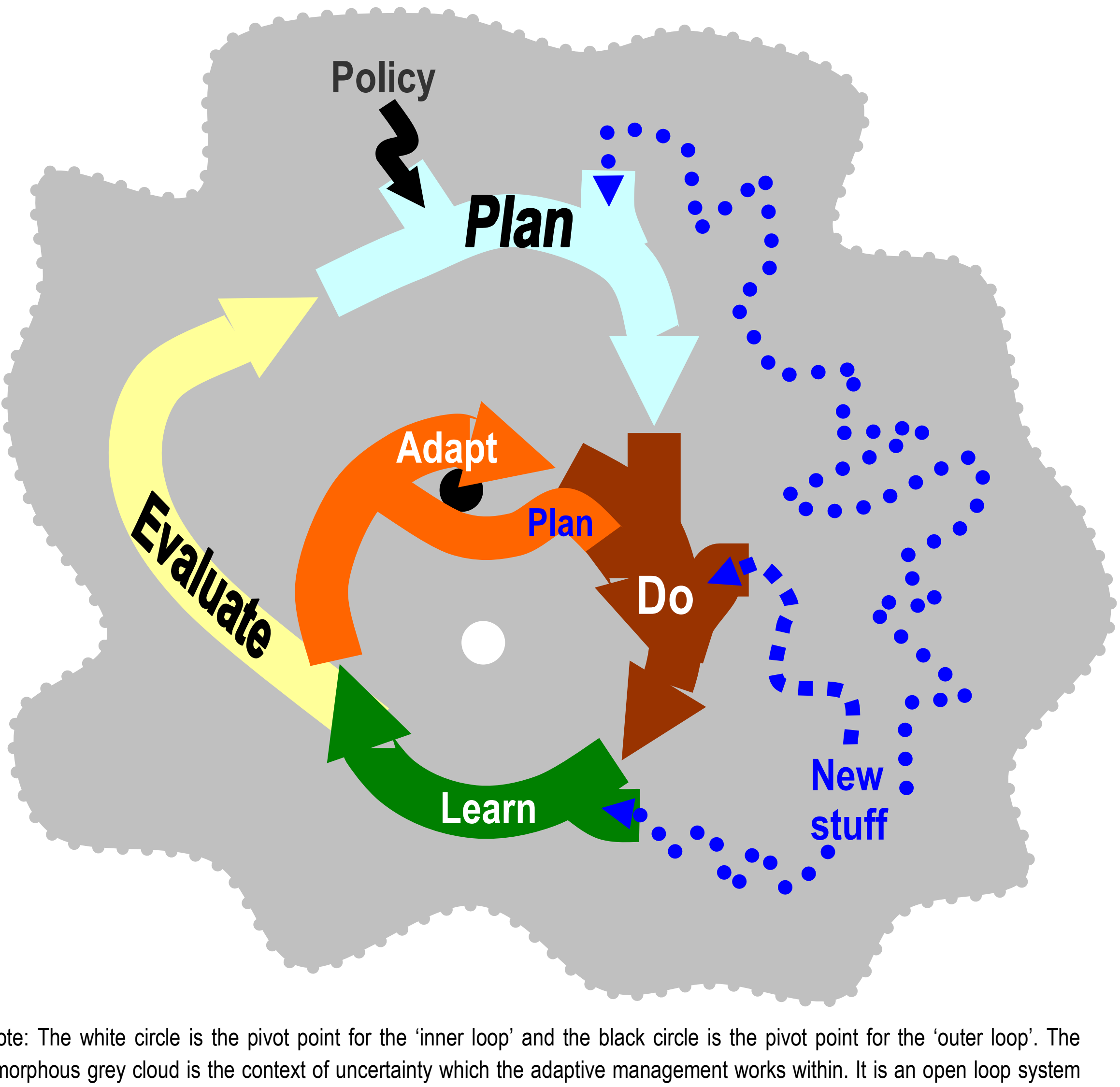
Eberhard et al (2008) describe a double loop model of adaptive management where the inner loop of the cycle represents feedback and adaptive implementation of the current action management of the WQIP. The outer loop represents the review and revision of the overall WQIP itself.

The adaptive management strategy for the Black Ross WQIP follows the general principles proposed in the double loop model with some modification, which allows for greater flexibility in the WQIP implementation process by recognising that the implementation process includes on-going planning processes. The WQIP is in effect an implementation and planning framework. We therefore have an adaptive management and planning process, which recognises the review of the overall WQIP as the outer loop with an additional inner loop component that includes adaptive planning as part of WQIP implementation.

In particular the peri-urban component of the Black Ross WQIP area is part of a dynamic and complex system "*with high levels of uncertainty in delivery of actions and achievement of outcomes*". The adaptive management and planning approach is particularly pertinent for this broad land use zone as little attention has been paid to it in terms of catchment management and water quality as it is not part of the 'mainstream' agricultural scene.

The other factor is the relatively large number of land managers in a relatively small area, more closely resembling geographic and social patterns of intensive agricultural areas than grazing areas. In reality there is a mixture of both types of agriculture along with lifestyle farmers, urban escapists and absentee owners. It has probably been too diverse a mix (too hard) for 'conventional' rural/agricultural management practices to address without the benefit of a robust adaptive management and planning approach incorporating social learning and behaviour change tools. The Black Ross WQIP includes these approaches and tools.

Figure 7-4 Double Open Loop Adaptive Management and Planning Model



Note: The white circle is the pivot point for the 'inner loop' and the black circle is the pivot point for the 'outer loop'. The amorphous grey cloud is the context of uncertainty which the adaptive management works within. It is an open loop system so new stuff can be introduced into the loops as a natural part of the change and innovation process.

The modified double loop model (see Figure 7-4) incorporates the additional element in the inner loop i.e. the linkage between planning, doing and adapting, as well as being an open loop system to enable ‘new stuff’ to be infused into the adaptive management cycle at various points in the loops. In terms of the Black Ross WQIP ‘new stuff’ includes social learning, behaviour change studies, maturing partnerships and project concepts, coupled monitoring and modelling results, Bayesian Belief Network results, new science, legislative change, management practice updates and modified trend reporting e.g. climate change.

7.5.3 Black Ross adaptive management components

The main components and pathways for delivery of the adaptive management strategy for the Black Ross WQIP are illustrated in Figure 7-5.

A review of the WQIP will take place on a two-year cycle and will focus on ‘higher’ level strategic program adaptation based on the information gathered and analysed through the decision support processes. Examples could include the introduction of ‘new’ legislation or a rerun of catchment models revealing different priority areas.

Adaptation will be part of an ongoing process for action planning and implementation with details of monitoring and assessment of each project or task to be built into each action plan as part of the monitoring component. This will include a set of decision rules to revise targets and actions (tasks), including timeframes.

7.6 Conclusion

The draft Black Ross Water Quality Improvement Plan is now available for review and comment. Please take some time and let us know what you think about the results so far, including ideas for a snappy conclusion.

All the background documents and a feedback form can be found on the website at

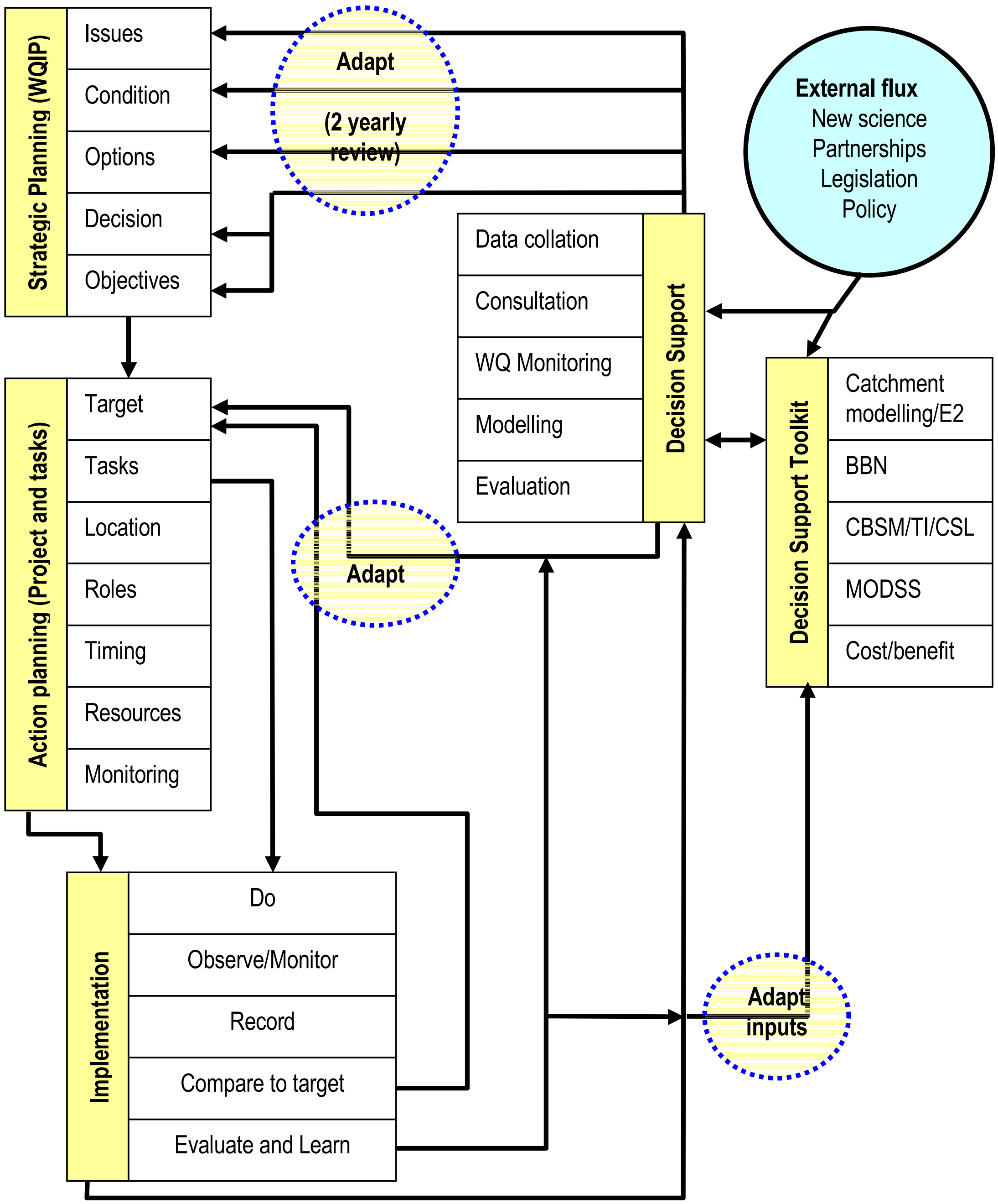
creektocoral.org/draftwqip

Many of the documents are large and will take time to download so if that is an issue please let us know and we can copy the documents to a CD and send them to you.

Please address all comments to Chris Manning at:

Email: creektocoral@townsville.qld.gov.au

Figure 7-5 Adaptive Management Strategy Main Pathways



Note: WQ monitoring and modelling fits into the Decision Support and Implementation and 'boxes' simultaneously (i.e. doing decision support) with Steps 14 and 15 (see Figure 7-2) comprising the adaptive management component.

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