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High and low flow regime changes at environmental assets across northern Australia under future climate and development scenarios

A report to the Australian Government from the CSIRO Northern Australia Sustainable Yields Project

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Preface

This is a report to the Australian Government from CSIRO. It is an output of the CSIRO Northern Australian Sustainable Yields Project which, together with allied projects for Tasmania and sout-west Western Australia, will provide a nation-wide expansion of the assessments that began with the CSIRO Murray-Darling Basin Sustainable Yields Project.

The projects are the first rigorous attempt to estimate the impacts of catchment development, changing groundwater extraction, climate variability and anticipated climate change on water resources at a whole-of-region scale, explicitly considering the connectivity of surface and groundwater systems. The CSIRO Northern Australian Sustainable Yields Project has undertaken the most comprehensive hydrological modelling ever attempted for the region, using rainfall-runoff models, groundwater recharge models, river system models and groundwater models, and considering all upstream-downstream and surface-subsurface connections.

Summary

The National Water Commission – on behalf of the Council of Australian Governments and in consultation with the Australian Government Department of the Environment, Water, Heritage and the Arts – commissioned CSIRO to assess the water resources of northern Australia, covering the Timor Sea and Gulf of Carpentaria drainage divisions and that part of the North-East Coast Drainage Division that lies north of Cairns (Figure A). This area comprises 64 Australian Water Resources Council (AWRC) river basins, including the Torres Strait Islands, Gulf of Carpentaria islands and Tiwi Islands. Building on the success of the Murray-Darling Basin Sustainable Yields Project (completed in 2008), the Northern Australia Sustainable Yields (NASY) Project has developed a methodology for a contiguous and repeatable assessment of water resources and has applied those methods to assess the likely implications of climate change and future development on these water resources. An additional part of this project involved an assessment of the impact of current and future predicted water resource development on key environmental assets. This report summarises the Environmental Assessment component of this project and provides technical details regarding the approaches used and data produced. Most importantly, this report summarises data and knowledge gaps which must be addressed if robust sustainable yields assessments are to be made in the future.

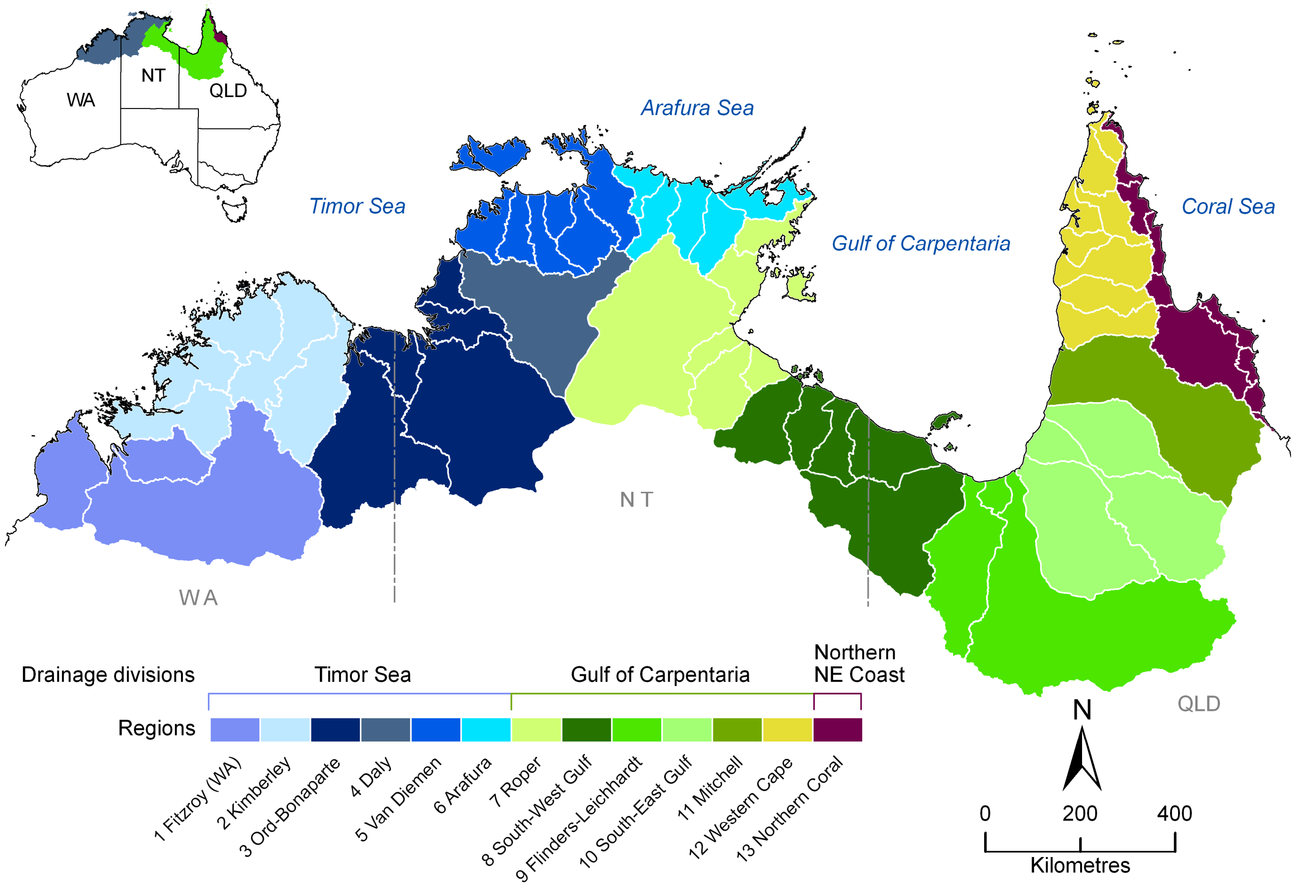

Figure A. Extents of surface water catchments, reporting regions and drainage divisions (inset) for the Northern Australia Sustainable Yields Project

Environmental asset assessment

This assessment considers the environmental assets already identified by state governments or the Australian Government that are listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001) or the updated online database of the directory. From this directory, environmental assets were selected for assessment of changes to the hydrological regime under the various climate and development scenarios. The selection of the assets for assessment and hydrological indicators was undertaken in consultation with state governments and the Australian Government through direct discussions and through internal reviews. It is recognised that this list is far from comprehensive and there are many more highly significant water-dependent assets, both environmental and cultural, which are not included in this report.

Within the NASY reporting area there are 87 wetlands registered in the Directory of Important Wetlands in Australia; with the aim of representing the range of wetland types found in the reporting area 43 of these were selected for assessment of changes to the hydrological regime under the various scenarios. Twenty two environmental assets were selected in the Timor Sea Drainage Division, 16 in the Gulf of Carpentaria Drainage Division and 5 in the Northern North-East Coast Drainage Division. Within the Timor Sea Drainage Division there are eight wetlands classified as Ramsar sites and all were assessed by this project. The surface water flow regime at the 43 selected assets was represented by 96 streamflow reporting nodes which were located on the major streams flowing through the selected assets.

Changes to the hydrological regime at environmental assets across northern Australia took one of two main forms which were defined by the availability of hydrologically based ecological and environmental metrics. Under ideal circumstances, where flow related metrics for the sustainability of specific ecological systems or species were already known and published, these 'site specific' metrics were used. Site specific metrics for the sustainability of specific ecological systems or species were available for only 3 of the 45 environmental assets selected for assessment within the NASY project. All of these metrics were for locations within the Timor Sea Drainage Division. However, for most assets across northern Australia the flow requirements for environmental assets and the ecosystems that they support are largely unknown, therefore to include these assets in the analysis and provide a consistent means for cross-regional comparison, we derived a set of 'standard metrics' of the hydrological regime were derived against which changes under the various scenarios were reported.

In reporting changes to the hydrological regime at an environmental asset the confidence levels in modelled stream flow were also assessed. Confidence in results for low and high flows were reported separately on a scale of 1 to 5, with 1 indicating results with the highest confidence.

For both site specific and standard metrics, results were presented which showed changes to hydrological regime for the four water resource scenarios used in the NASY project:

- Scenario A - historical climate and current development;
- Scenario B - climate for the last 11 years and current development;
- Scenario C - 2030 climate change and current development;
- Scenario D - 2030 climate change and 2030 development of farm dams, plantations, groundwater systems and proposed irrigation development.

The climate change scenarios are based on results from 15 global climate models (GCMs) which provide a large variation in the expected future climate. Rather than present results for all GCMs only results from an extreme 'wet', 'mid' and extreme 'dry' variant are shown (referred to as scenarios Cwet, Cmid and Cdry). Under Scenario Cwet, results from the second highest increase in mean annual runoff from the high global warming scenario are used. Under Scenario Cdry, results from the second highest reduction in mean annual runoff from the high global warming scenario are used. Under Scenario Cmid, the median mean annual runoff results from the medium global warming scenario are used. Scenario D results all include the extreme 'wet', 'mid' and extreme 'dry' variant of the climate change scenarios with the addition of proposed future development (i.e. Dwet, Dmid, Ddry). In considering changes to the hydrological regime at selected environmental assets under different scenarios all results were assessed relative to current conditions (i.e. Scenario A, which is based on historical climate and current development).

Results

Streamflow confidence at environmental assets

Confidence in the modelled dry season and wet season streamflow for each drainage division and all 96 streamflow reporting nodes is summarised in Figure B. Confidence levels of 1, 2 or 3 were considered reliable, while confidence levels of 4 or 5 were considered unreliable. Across all drainage divisions the confidence in high flows was much greater than in low flows. In the Timor Sea Drainage Division high flows were considered to be reliable for 80 percent of streamflow reporting nodes compared to 56 percent for low flows. In the Gulf of Carpentaria Drainage Division high flows were considered to be reliable for 59 percent of streamflow reporting nodes compared to 27 percent for low flows. In the Northern North-East Coast Drainage Division high flows were considered to be reliable for 75 percent of streamflow reporting nodes compared to 25 percent for low flows. Across the entire NASY reporting area high flows were considered to be reliable for 70 percent of streamflow reporting nodes compared to only 40 percent for low flows. Low flows were particularly poorly represented in the Gulf of Carpentaria and Northern North-East Coast Drainage Divisions. The maximum high flow confidence level of 1 was reported for just 4 of the 96 streamflow reporting nodes within environmental assets.

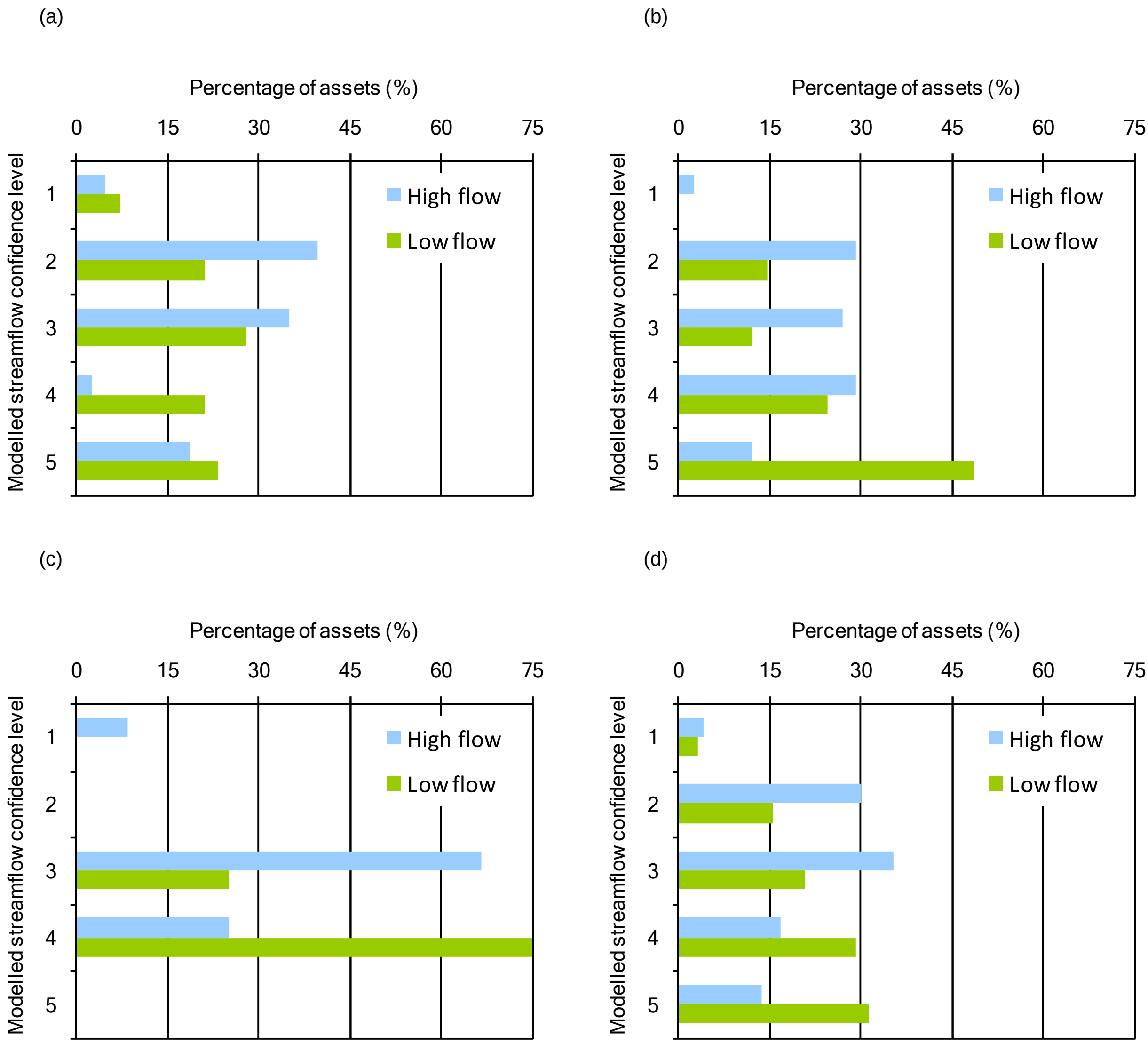

Figure B. Summary of high and low flow regime confidence levels for surface water reporting nodes in the Timor Sea Division (a), Gulf of Carpentaria Division (b), Northern North-East Coast Division (c), and across all environmental assets in NASY reporting area (d). Level 1 is the highest confidence and level 5 is the lowest confidence

Specific metrics related to sustainability of ecological systems

Camballin Floodplain (Le Livre Swamp System)

At Camballin Barrage, which is located near the Camballin Floodplain environmental asset in the Fitzroy (WA) region, environmental flow metrics have been defined which relate to fish passage across the Barrage. The first of these is the river depth when fish passage across the Barrage can commence. The second metric is the river depth when the Barrage was completely inundated and fish passage is considered to be completely unimpeded.

An analysis of site-specific high flow metrics for the Camballin Barrage has shown that opportunities for fish passage were more frequent in the recent past (Scenario B) but changed little under future climate (Cmid) and wet extreme future climate (Cwet). The biggest impact on fish passage was under the dry extreme future climate (Cdry) where the number of days of unimpeded fish passage was reduced by 30 percent.

Lower Ord downstream of Lake Kununurra

The environmental flow requirements of the lower Ord River downstream of the Kununurra Diversion Dam have been defined based on a series of hydro-ecological studies of this stretch of river. The Department of Water, Western Australia have recognised the intrinsic ecological values of the region below the Ord River Dam and as such have developed water release rules which attempt to meet the defined environmental water requirement regime. Low flow metrics have been defined for sustaining fish and macrophyte habitats and high flow metrics have been defined for riparian inundation and fish passage across the floodplain. The results presented here represent the flow conditions under existing operating rules for the Kununurra diversion Dam, however, being a managed system the opportunity exists in the future to modify release rules for this storage in order to deal with changing water resource conditions.

Under modelled future climate and development scenarios, periods of low environmental flow would be extended. The largest impacts are under the dry extreme future climate (Cdry) where the period below the defined threshold would increase by a factor of six and under the dry extreme future climate with development (Ddry) where the period below the defined threshold would increase by a factor of nine. This could be compensated through revision of storage release rules. Modelling results suggest that that the high flow environmental requirements for the Lower Ord river will be met under all climate and development scenarios.

Daly River Middle Reaches (Oolloo Crossing)

At Oolloo Crossing, which falls within the bounds of the Daly River Middle Reaches, environmental flow metrics are available which relate to habitat suitability for key plant and animal species. The first of these is a flow threshold which is a minimum level recommended for Pig-Nosed Turtles (*Carettochelys insculpta*) and the aquatic macrophyte, *Vallisneria nana*. The second metric is related to the minimum flow requirements to meet the transpiration requirements of riparian vegetation.

Analysis of these site-specific metrics at the Daly River Middle Reaches environmental asset showed no threat to the specified minimum environmental flow requirement for transpiration of riparian vegetation under any scenario. Under the dry extreme future climate, with both current (Cdry) and proposed future development (Ddry), there is an increase in the mean annual number of days in which flows are below the optimal threshold for nesting success for Pig-Nosed Turtles (*Carettochelys insculpta*) and for *Vallisneria nana* beds. Results show a 30 percent increase in days below the threshold for Cdry and 37 percent increase under Ddry. These results suggest that under such scenarios the populations of these species may be threatened.

Standard hydrological metrics

Flow requirements for environmental assets and the ecosystems that they support are largely unknown across northern Australia. To include these assets in the analysis and provide a consistent means for cross-region comparison a set of metrics of hydrological regime change were derived to report against. These metrics relate to low and high flow conditions and are summarised as:

- annual flow (mean)
- wet season flow (mean)
- dry season flow (mean)
- low flow threshold (discharge exceeded 90 percent of the time under Scenario A)
- number of days below low flow threshold (mean)
- number of days of zero flow (mean)
- high flow threshold (discharge exceeded 5 percent of the time under Scenario A)

These standard metric results give good information about the direction of likely change under the given scenarios but have limited direct relevance to ecological impacts.

The following section represents generalised observations of the direction of change with respect to the different scenarios defined for the NASY project. Under some circumstances (e.g. managed water storages) and in some areas the observations may not apply.

Scenario A

At environmental assets, flows are highly dominated by wet season flows, with dry season flows only a small fraction of total annual flow. However, environmental assets are adapted to this strong seasonality and any significant changes in the frequency and duration of wet season high flows and dry season low flows are likely to have an environmental impact.

Scenario B

Under Scenario B conditions have been wetter than under Scenario A. While this has resulted in higher wet season flows results suggest that flow at environmental assets is, on average, less during the dry season than under Scenario A. This suggests that there are unlikely to be too many negative impacts on environmental assets during the wet season. However species restricted by low flow conditions may have been under increased stress.

Scenario C

The projected future climate under Scenario C includes a range of conditions which vary from being wetter than Scenario A to drier with the absolute change in the extremes being roughly the same order of magnitude. In a hydrological sense the ecological impacts at environmental assets is likely to be much less for wetter conditions when compared to the drier conditions due to the ephemeral nature of many of the streams in the NASY project area. With that in mind, it should be noted that wetter conditions and, hence, higher flows may not always be beneficial to environmental assets. For example, more extreme floods may be detrimental to extant ecosystems. Drier conditions could extend periods of zero flow and reduce the viability of refugia pools found in river systems.

Scenario D

The projected future climate under Scenario C and proposed future development provides the conditions used to form Scenario D. Under this scenario the general trend is for stream flows to be further reduced compared to Scenario C. This is of particular concern where the projections under Scenario C are much drier than those encountered historically. Clearly, planning for such a scenario must balance the water requirements for development against the minimum requirements for the environment and cultural and social uses.

Key messages and recommendations

1. There are very few quantified environmental flow thresholds in the NASY reporting area.

Stream flow metrics related to ecosystem function are available for only three of the 45 selected environmental assets in the NASY reporting area. The Ord-Bonaparte, Daly and Fitzroy (WA) regions have had sufficient research for the development of site-specific ecological flow metrics against which changes to flow regime can be assessed, however, this is a rarity for northern Australia. There is a general lack of quantitative relationships between flow and specific ecological entities (e.g. macrophyte populations, fish passage, faunal and floral habitats), meaning that the consequence of flow changes on ecological systems is largely unknown. The existing site-specific metrics provide a good base to work from and resources for development of such metrics are best targeted at areas flagged for development or high priority assets. The opportunity exists to include such metrics in defining ‘sustainable yields’ for the future. Approaches to address this lack of information are being investigated as part of the Northern Australia Water Futures Assessment Ecological Program.

2. Confidence in streamflow modelling results is variable across the NASY project area.

There is a paucity of data for streamflow modelling in northern Australia which often results in model results with low levels of confidence. There are significant gaps in rainfall data and stream gauging stations are sparsely located. Modelled climate change response at environmentally important sites has greatest effect on low flow conditions, but the poor quality of the calibration data at most sites provides low confidence in quantitative assessments of flow regime change. For many environmental assets it is not possible to calculate the potential impacts of the various scenarios because the high and low ends of the flow regime are not well defined. Data are especially sparse in floodplain regions where maintenance of recording equipment is difficult and, for streamflow data, establishing and updating rating curve relationships can be problematic.

3. Streamflow at environmental assets is extremely seasonal and ecosystems are adapted to the prevailing conditions.

In unregulated streams the vast majority (> 90 percent) of total annual flow occurs during the wet season months (November to April). Many rivers that persist through the dry season are sustained through localised groundwater discharge which occurs where streams intersect shallow aquifers, or where deeper artesian waters puncture the landscape generating springs. These discrete points of discharge are rare and risk to disturbance is high. Ecosystems have adapted to environments with persistent dry season flow and have become dependant on this flow. This leads to a high level of endemism across the drainage division.

4. Dry season flows and the impacts on ecological systems are poorly understood for much of the NASY reporting area.

Poor quality low flow data greatly inhibit the potential to assess the linkages between ecological systems and hydrological regime. Dry season flows are poorly understood in this region therefore the ability to predict the potential impacts of climate and development on low or zero flows at environmental assets is very limited. This issue is particularly important considering that future scenarios show the biggest impacts to stream ecology under the dry extreme climate. The collection of more reliable low-flow data and corresponding ecological data is required to remedy this situation. In some streams dry season low flows are largely sustained by groundwater flows. To predict the potential impacts of the various scenarios, these streams require hydrological models that combine surface and groundwater regimes, which are rarely available in the northern Australian rivers.

5. Floods are vital ecosystem events yet they are poorly understood in many areas.

Flooding is an important factor that sustains many environmental assets and this occurs when the stream breaks out of its banks (a level known as bankfull stage or discharge). However, bankfull discharge is not known for many streams, nor is the dependence of area flooded on increasing stream depth, so it is difficult to predict when assets are inundated. Information on discharge and area of flooding in relation to the distribution of and connectivity of habitats and biotic communities is also required. Overbank inundation provides the conditions needed for many fish to migrate and also fills hollows and pools that persist through the dry season, sustaining vital ecosystems until the next wet season. Further information about bankfull stage and discharge are needed for most environmental assets. Again, information on flooding is especially sparse in remote floodplain regions where discharge measurements are difficult to make.

6. Further environmental and ecological information is required to predict the impact of water resource change on the environment.

Prediction of the impact of flow changes on environmental assets and the ecology of northern Australia will require further research investment in several key areas. The current distribution and condition of habitats, biotic communities, and key species is poorly understood. Description and classification of these habitats, biotic communities and key species in different catchments is required. Hydrological connectivity (longitudinal, lateral and vertical) in relation to habitats, biotic communities, and key species needs to be better understood, and water regime characteristics that sustain habitats and communities, such as timing, frequency and duration of events and depth and velocity of flows, need to be further investigated. Response curves and thresholds relating habitats and biotic communities to altered water regimes need to be developed. Further research is also required in the areas of ecosystem resilience, population maintenance, community composition, energy and material flows and food web connections. Such research will require a combination of innovative monitoring methods and the development of system scale models.

7. Standard metric results have limited direct relevance to ecological impacts.

A set of standard metrics related to high and low streamflow conditions have been utilised to provide useful information regarding changes to the hydrological regime at all environmental assets. However, conversion of these metrics into environmental impacts still requires development of quantitative relationships between flow and specific ecological entities (for example, macrophyte populations, fish passage, faunal and floral habitats, etc.). Many environmental assets depend not simply on duration above or below certain flow levels, but on triggers (e.g. for reproduction or migration) set by the rate of change of flow. Further analysis is therefore required to look at how the timing and rate of rise and fall in flow rates at critical times of the season will vary under the various scenarios.

8. There are no known metrics related to groundwater.

Despite the fact that there are large areas of groundwater dependant ecosystems in northern Australia there are no known locations with groundwater related ecological metrics. Further monitoring of the interactions between groundwater level and the functioning of ecosystems is also required so that the potential impacts of climate change and development can be better understood.

9. Water quality is likely to change under the scenarios considered

While water quality issues are beyond the scope of the NASY study, it is worth noting that any change in flow is likely to result in changes to water quality and sediment and nutrient loads. These changes in turn will also affect productivity and habitat quality and as such should be carefully considered in future investigations of the impacts of climate and development scenarios on the environmental assets of northern Australia.

Table of Contents

1 Introduction

1.1 Northern Australia Sustainable yields

The Northern Australian Sustainable Yields (NASY) Project is the most comprehensive assessment of water availability ever undertaken in northern Australia. The project area includes all catchments discharging into the Timor Sea, Arafura Sea, the Gulf of Carpentaria and the Coral Sea north of Cairns. Assessments were made of the surface water and groundwater resources of this region with an emphasis on current and potential development and sophisticated computer models were used with information supplied by state jurisdictions to assess water resources on an individual catchment and aquifer basis.

The project investigated water resources under four different scenarios:

- Scenario A - Historical climate and current development
- Scenario B - Recent climate (the last 11 years) and current development
- Scenario C - Future climate (2030) and current development
- Scenario D - Future climate (2030) and future development

The project accounts for the unique seasonal characteristics and interconnectivity of surface and groundwater systems in northern Australia and advises on how these might impact on water availability. The defined project area includes some of the most pristine environments in Australia and a further component of the NASY project assessed the potential impacts of climate change and development scenarios on key environmental assets in the region. This report provides a detailed description of the environmental assessment and presents results for key assets in the reporting area.

The NASY project forms part of the larger Northern Australia Water Futures Assessment (NAWFA), a Commonwealth Government initiative with the objective of developing an enduring knowledge base of northern Australia's water resources, so that development proceeds in an ecologically, culturally and economically sustainable manner. The assessments from this project provide key information for further investigations into environmental impacts and socio-economic impacts as well as information to facilitate stakeholder and community consultation. Ultimately, this will then inform water resource planning, management and investment (Figure 1).

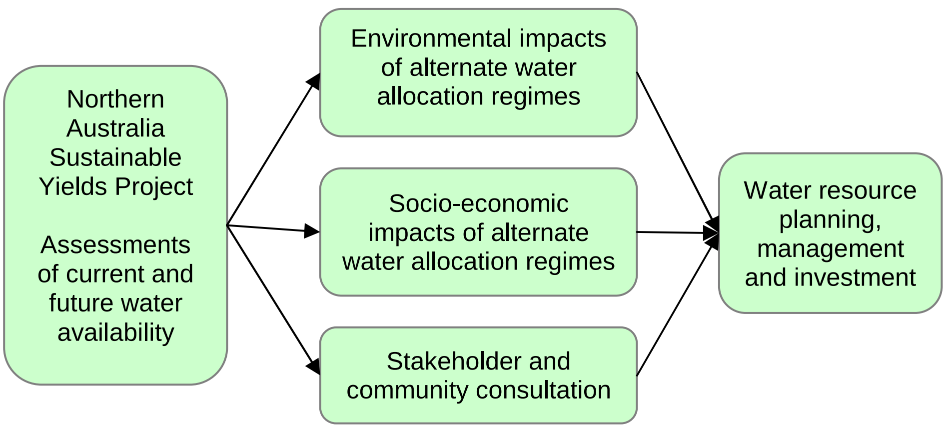

Figure 1. Project context

1.2 Definition of reporting regions

The extent of the project area is guided by the extent of the surface water drainage divisions (based on those defined by the Australian Water Resources Council - AWRC), and encompasses those catchments that drain to the Timor Sea (Drainage Division VIII), the Gulf of Carpentaria (Drainage Division IX) and the Coral Sea, north of Cairns (the northern North-East Coast Drainage Division I). These three drainage divisions are shown in Figure 2.

The project area consists of 62 major rivers (and numerous more minor ones) that drain into the northern seas, together with three major island groups. Aggregating rivers into manageable groups is problematic. Whilst analyses are carried out at the AWRC level, reporting is at a regional scale, with 13 regions defined on the basis of landscape differences and jurisdictional imperatives (such as the Wild Rivers legislation of Queensland). These regions and the drainage divisions are shown in Figure 2.

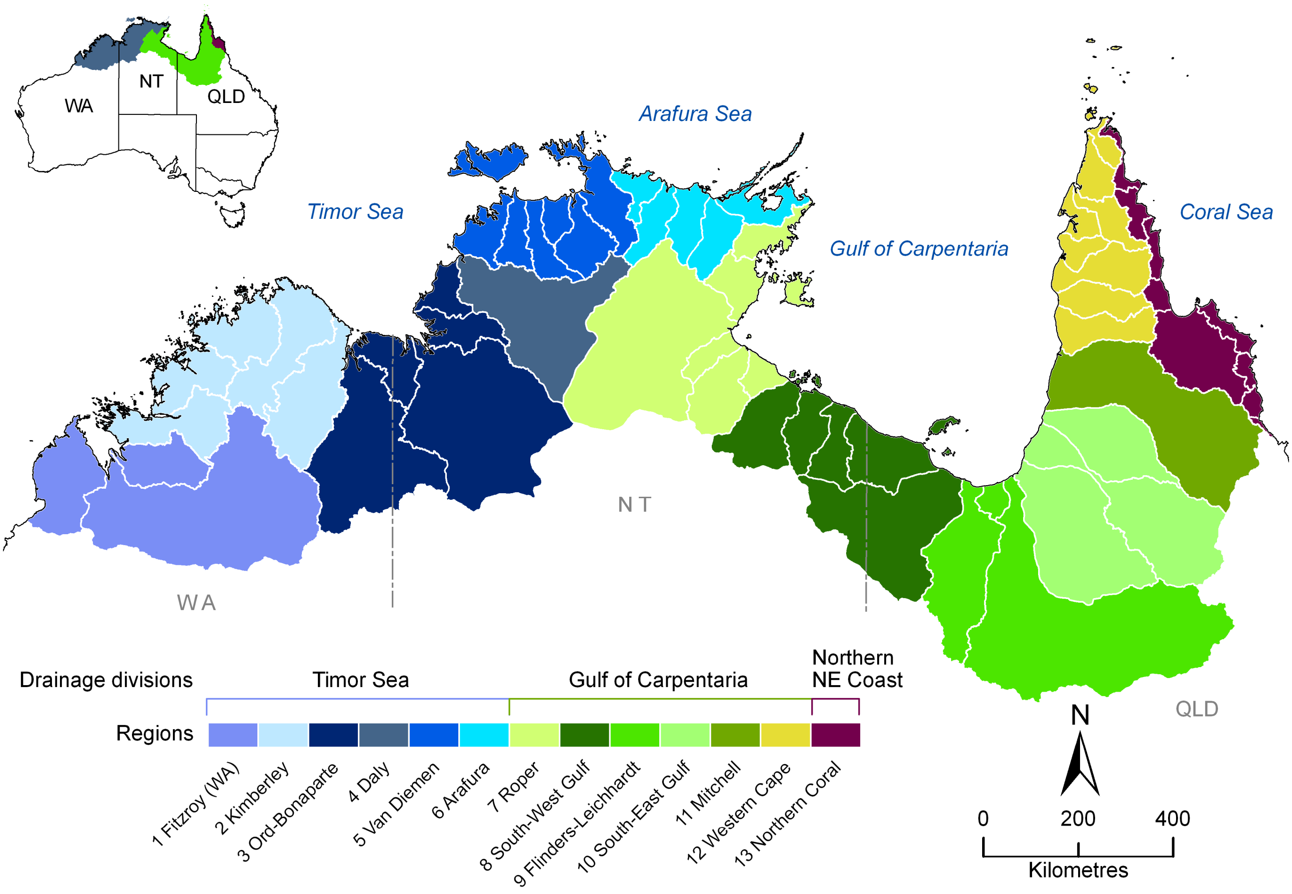

Figure 2. Extents of surface water river basins, regions and drainage divisions (inset) for the Northern Australia Sustainable Yields Project

Beneath the drainage divisions lie a number of groundwater basins, which variously connect to the surface water drainage and may supply water to it. The NASY project also assesses those basins and their aquifers, together with those aquifers which may deliver water to the project area (Figure 3).

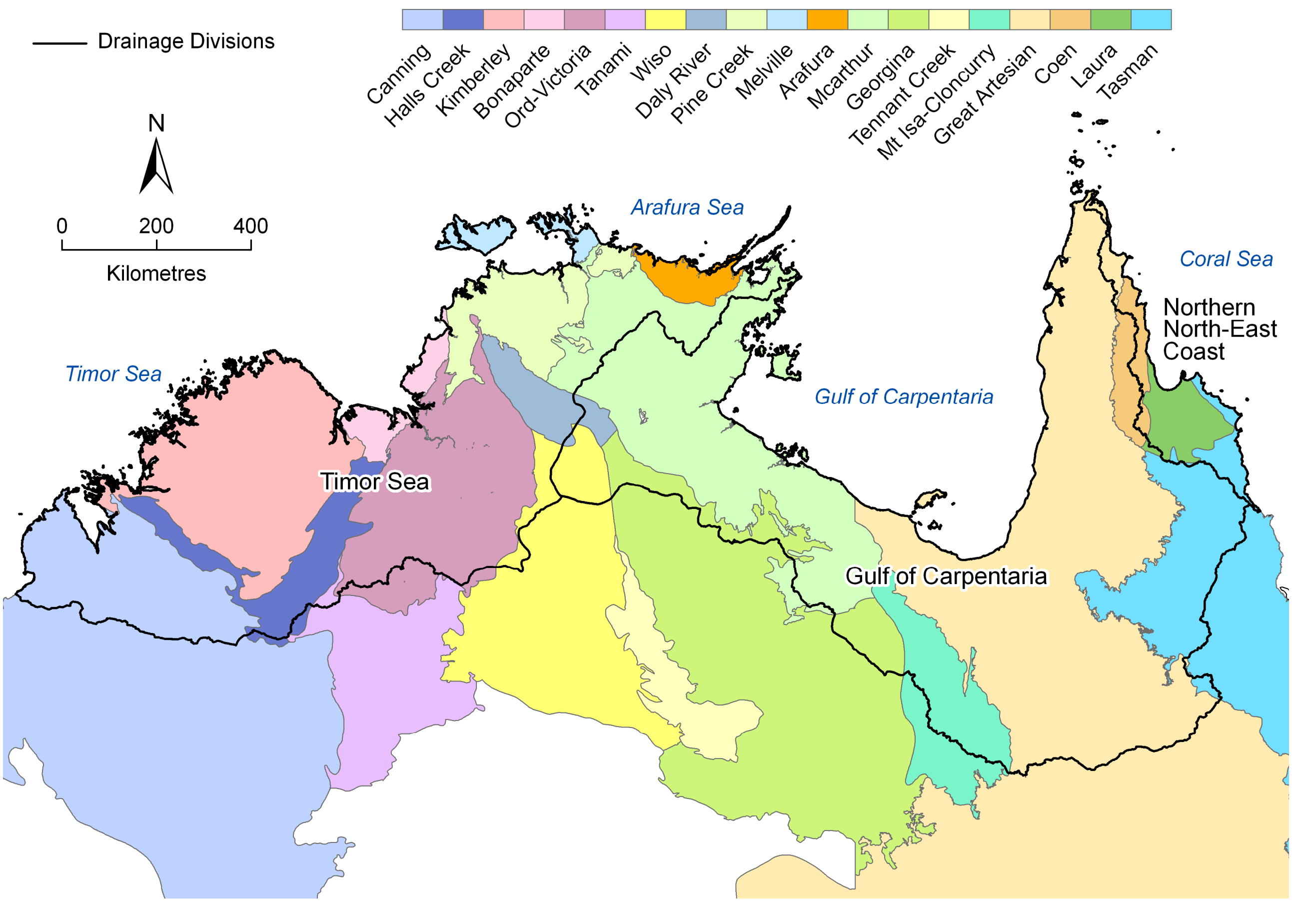

Figure 3. Extents of groundwater basins that (at least in part) underlie the drainage divisions of northern Australia. Note: Only the north-flowing region of the Great Artesian Basin is considered in this project

1.3 Project methods overview

While this report is mainly concerned with the impacts of climate change and development on key environmental assets, it is first useful to consider the modelling exercises which have been undertaken in order to obtain the data for these assessments. The following section provides a brief description of the models used. Readers interested in more detailed information are directed towards science reports produced for each aspect of the methods used in the NASY project (see references below).

The methodology used in the NASY project is summarised in Figure 4. The steps undertaken included:

- defining different climate scenarios and generating time series of climate data to describe these scenarios;
- spatio-temporal modelling of the implications of these climate scenarios for catchment runoff and aquifer recharge;
- propagating the runoff/recharge implications through existing river system and groundwater models including explicit consideration of the surface–groundwater exchanges; and
- assessment and reporting of the implications for water availability and water use.

The last step included the assessment of the impacts of the different scenarios on the hydrological regime at key environmental assets. This will be covered in detail in Section 2 of this report. The steps necessary to achieve the environmental assessment are outlined below.

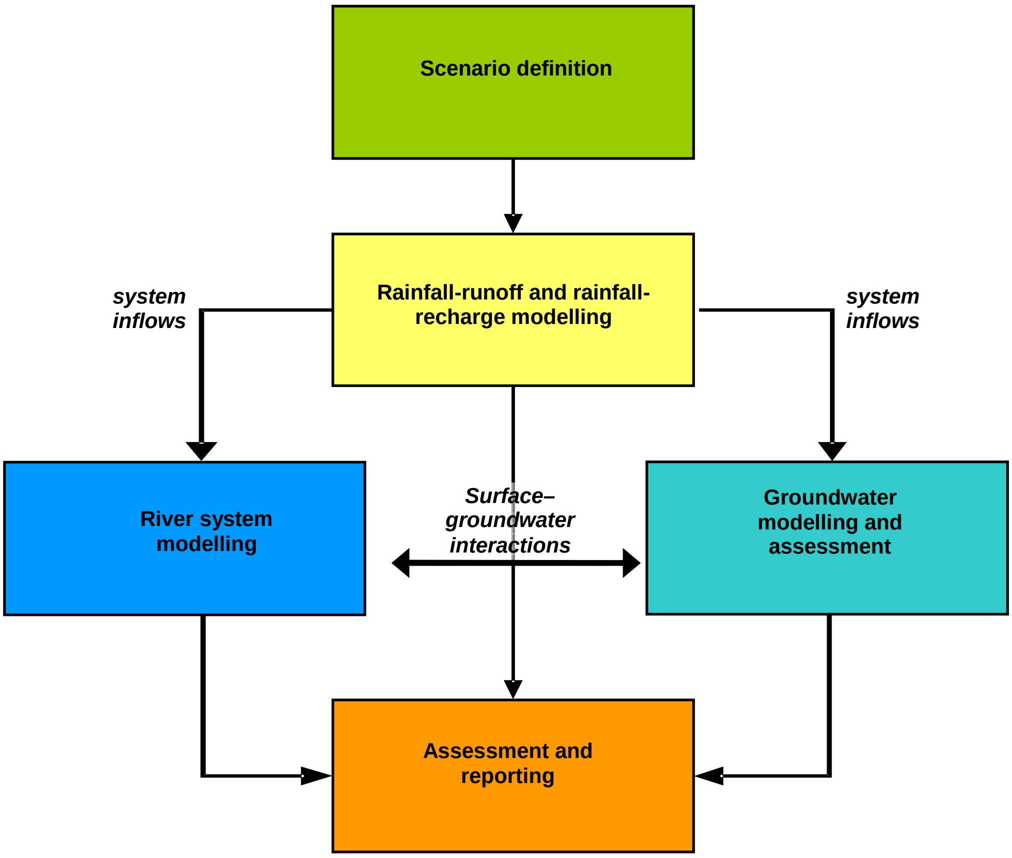

Figure 4. The overall project approach and the flow of information

1.4 Climate scenario estimation

Water resources were assessed under four scenarios:

- historical (1930 to 2007) climate and current development (Scenario A)
- recent (1996 to 2007) climate and current development (Scenario B)
- future (~2030) climate and current development (Scenario C)
- future (~2030) climate and future (~2030) development of farm dams, plantations, groundwater systems and proposed irrigation development (Scenario D).

The following three sections describe the methods used to generate the required climate data for scenarios A, B and C (note that Scenario D uses the same climate data as Scenario C). For a detailed description of development of these climate scenarios see Li et al. (2009).

1.4.1 Historical climate (Scenario A)

Historical daily climate data from 1 September 1930 to 31 August 2007 at 0.05 x 0.05 degree (~ 5 x 5 km) grid cells across the project area are used. The source of the data is the SILO database developed and maintained in real-time by the Queensland Climate Change Centre of Excellence <http://www.longpaddock.qld.gov.au/silo/> and (Jeffrey, 2006; Jeffrey et al., 2001). As rainfall data are highly discontinuous in space and time, due to the processes governing tropical cyclone activity and local thunderstorms, their interpolation was carried out using the approach described by Jeffrey (2006) where a rainfall normalisation parameter was interpolated with ordinary kriging and after removal of stations with large residuals. Spatially distributed values of other climate variables (e.g. temperature, humidity) were interpolated using a tri-variate thin plate spline as a function of longitude, latitude and elevation (Jeffrey et al., 2001).

In addition to daily rainfall data, the rainfall-runoff models also require areal potential evapotranspiration (APET) to limit the actual evapotranspiration. Morton's wet environment APET (Chiew and Leahy, 2003; Morton, 1983) was calculated for a daily time step at 0.05 x 0.05 degree resolution using SILO data (temperature; relative humidity and incoming solar radiation).

1.4.2 Recent climate (Scenario B)

The recent climate scenario (Scenario B) covers the period from 1 September 1996 to 31 August 2007 and is used to assess future water availability should the climate in the future prove to be similar to that of the recent past. As with Scenario A, 0.05 x 0.05 degree resolution data for Scenario B was sourced from the SILO database.

1.4.3 Future climate (Scenario C and D)

The future climate scenario (Scenario C) is used to assess a range of possible climate conditions around the year 2030. This is achieved by scaling the climate data from 1 September 1930 to 31 August 2007 to represent the climate around 2030, based on analyses of 15 global climate models (GCMs) under three global warming scenarios. Thus, 45 future climate variants, each with 77 years of daily climate sequences for 0.05 x 0.05 degree grid cells across the project area, were used for the rainfall-runoff modelling.

The future climate scenario (Scenario C) provides estimates of possible conditions around the year 2030 under three different potential global warming scenarios based on projected high, median and low greenhouse gas emissions. These three scenarios are inferred from the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007) and the latest climate change projections for Australia (CSIRO and Bureau of Meteorology, 2007).

1.5 Surface water modelling

1.5.1 General approach

The surface water assessment involved six separate tasks:

- gauging station selection and data preparation
- rainfall-runoff modelling at the regional scale under scenarios A, B and C
- river system modelling
- assessment of regions without river models
- evaluation of levels of confidence
- an alternative approach using multiple linear regression to compute key hydrological metrics.

A more detailed description of the rainfall-runoff modelling methods and the multiple regression analysis is provided by Petheram et al. (2009) Crosbie et al. (2009) and SKM (2009).

1.5.2 Rainfall runoff modelling

Preliminary testing of five different rainfall-runoff models indicated that the ensemble of Sacramento and IHACRES Classic was the optimal combination of models for this project. This combination balanced model performance with the practicalities of running multiple rainfall-runoff models at a 5 x 5 km grid cell scale across an area of 1.25 million km^2 in a short space of time. The Sacramento and IHACRES Classic models were used to extend streamflow records at existing gauging station locations and to simulate runoff at each 0.05 degree grid cell over the entire project region under each scenario.

1.5.3 Confidence levels for surface water assessment

For rainfall-runoff modelling, the Nash-Sutcliffe (Nash and Sutcliffe, 1970) metrics provide a direct measure of level of confidence. These metrics were computed for every calibration catchment. However, in northern Australia there are vast ungauged areas. To assess the reliability with which model parameters can be transposed from a gauged catchment to an ungauged subcatchment, cross-verification simulations were undertaken. In this analysis every calibration catchment was simulated using the parameters from every other calibration catchment, generating a cross-verification matrix of Nash-Sutcliffe values. Because rainfall-runoff models are biased in their calibration to a particular range of flows, usually the mid-to high flows (i.e. peak flow events), the level of confidence for the high and low flow predictions were estimated separately. Levels of confidence in high and low flow prediction were expressed on a scale of 1 through 5; with 1 representing results with the highest confidence and 5 representing the most unreliable results. Details are provided in Petheram et al. (2009).

1.5.4 River system modelling

Wherever state agencies have developed river system models, these were used within the NASY project. These models encapsulate descriptions of current infrastructure, water demands and water management and sharing rules and can be used to assess the implications of the changes in inflows described in the rainfall-runoff section on the reliability of water supply to users. They may also be used to support water management planning by assessing the trade-offs between supplies to various competing categories of users.

1.5.5 Multiple linear regression approach

A multiple linear regression approach to predicting streamflow metrics was also undertaken in parallel to the rainfall-runoff modelling. This alternative approach was undertaken because of the large area of ungauged land in northern Australia and the uncertainty associated with predicting streamflow in ungauged catchments. Comparing the results from the rainfall-runoff modelling with an alternative and independent method provided an additional assessment of the level of confidence of the predictions. At those streamflow reporting nodes (SRN) where there was good agreement between approaches, there is a higher level of confidence than at those SRN where there was poor agreement. Having two complementary approaches also enabled the better of the two approaches to be selected for a particular task, where one approach was superior to the other. Details are provided in Petheram et al. (2009).

1.6 Groundwater modelling

1.6.1 General approach

The groundwater assessment and modelling component of the project collated existing data to report on the occurrence, status and possible future condition of groundwater resources across the three drainage divisions of the project. Detailed assessments focussed on the important aquifers and how they interact with one another and surface water systems, rather than on the surface water catchments that define each region.

Across all regions there has been an assessment of current and future levels of groundwater allocations and use, the derivation of a conceptual groundwater recharge-flow-discharge model, and a detailed analysis of groundwater recharge rates under historical, recent and future climates. Detailed description of the methodology used is given in Harrington et al. (2009) and Crosbie et al. (2009).

1.6.2 Groundwater assessments

Quantitative groundwater modelling was only possible in the Daly region, the Fitzroy (WA) region and a very small part of the Van Diemen region, due to limited data and lack of groundwater models for the remaining regions and drainage divisions in northern Australia. The only region in the NASY reporting area where a detailed groundwater model was available in proximity to environmental assets was the Daly region.

The Daly region is represented with an existing, calibrated, regional-scale, FEFLOW numerical groundwater flow model coupled to a calibrated MIKE11 surface water model (Knapton, 2006). The input to the MIKE11 model is via the NAM rainfall-runoff module which generates runoff discharges based on climatic data. The recharge input to the FEFLOW was generated using the WAVES model. Surface–groundwater interaction along the rivers occurs where the MIKE11 model is joined to the FEFLOW model. Input climatic data are consistent for both the NAM and WAVES models. The coupled model has enabled quantitative assessment of the impacts of climate change and current and future development through implementation of the four scenarios (scenarios A, B, C and D).

1.6.3 Modelling surface–groundwater interaction

For the Daly region the regional groundwater FEFLOW model of Knapton (2006) is linked directly to a MIKE-11 river routing model, enabling simultaneous simulations of groundwater head, surface water stage and thus surface-groundwater exchange fluxes. In particular, baseflow in the main river channel was assessed under all four scenarios (scenarios A, B, C and D) using groundwater recharge scaling factors from WAVES (Section 2.3.3) and runoff scaling factors from rainfall-runoff modelling. Surface-groundwater interaction were modelled elsewhere in the NASY reporting region, but only the Daly region were they suitable for describing the changes to hydrological regime at environmental assets.

Groundwater pumping initially depletes the aquifer but can eventually deplete flow in nearby rivers. The extent of river depletion depends on the magnitude of pumping and the connectivity between the river and the aquifer, while the time lag varies with aquifer properties (transmissivity and specific yield) and the distance between the river and the pumping activity.

Modelling of the interaction between surface and groundwater is discussed in more detail in Harrington et al. (2009).

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2 Description of environmental assets

2.1 Overview

Environmental assets for hydrological assessment were selected from those already listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001) or the updated online database of the directory. From this directory, environmental assets are selected for assessing changes to the hydrological regime under the proposed scenarios. The selection of the assets for hydrological assessment and hydrological indicators was undertaken in consultation with state governments and the Australian Government through direct discussions and through internal reviews. It is recognised that this list is far from comprehensive and there are many more highly significant water-dependent assets, both environmental and cultural, which are not included in this report. The following sections introduce the Directory of Important Wetlands in Australia and describe the asset selection process used.

2.2 Directory of Important Wetlands in Australia

The Directory of Important Wetlands in Australia lists a total of 851 wetlands, 87 of which are found within the defined NASY project area, including eight listed as internationally important through the Ramsar Convention. Criteria for inclusion of a wetland within the Directory of Important Wetlands are as follows:

- It is a good example of a wetland type occurring within a biogeographic region in Australia.
- It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
- It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.
- The wetland supports 1% or more of the national populations of any native plant or animal taxa.
- The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.
- The wetland is of outstanding historical or cultural significance.

Listings in the Directory of Important Wetlands are classified into 40 different wetland types which are grouped into 3 broad categories which reflect the environment in which the different wetland types are found: A – Marine and Coastal Zone wetlands, B – Inland wetlands, and C – Human-made wetlands (Environment Australia, 2001).

2.3 Asset selection process

The complete list of 87 assets identified from the Directory of Important Wetlands in Australia for the project area was first short-listed by selecting only those assets where stream gauging data was available at, or in close proximity to, the asset. The aim of this process was to ensure that the hydrological model performance could be tested against gauged data, thereby increasing confidence in the results reported for a given asset. This initial list was then reduced to cover the range of wetland types and geographic extent identified within the Directory of Important Wetlands in Australia for the project area. Following consultation with representatives from state and federal Government the list was reviewed, modified, and signed off on by relevant parties. A total of 43 environmental assets were selected for assessing changes to the hydrological regime under the proposed scenarios, including seven of the eight Ramsar-listed sites. A description of assets in each Drainage Division is given below and more detailed individual site descriptions and satellite images are provided in Appendix 1.

2.4 Environmental assets by drainage division

The following sections detail the key environmental assets to be assessed under this project for each of the three drainage divisions in the NASY reporting area. Drainage divisions and regions are described in more detail in Section 1.2 of this report.

2.4.1 Timor Sea

Table 1 shows all 34 sites from the Directory of Important Wetlands in Australia that are within the Timor Sea Drainage Division. The 22 assets selected for assessment are indicated in Table 1 and are shown in Figure 5 to Figure 10 for each of the six regions in the Timor Sea Drainage Division. All seven of the Ramsar-listed wetlands selected for assessment with the NASY project lie within the Timor Sea Drainage Division. Appendix 1 contains descriptions and satellite images of all the assets selected for assessment. Some of the selected environmental assets in this region are very large and have multiple streams feeding into them, in response these larger assets have multiple nodes at which streamflow modelling results are available. Table 2 lists all of the nodes for the selected environmental assets and describes their locations. Node locations are shown on satellite images for each asset in Appendix 1. **The following broad description of the Directory of Important Wetlands in Australia sites in the Timor Sea Drainage Division is based largely on the description of these assets as outlined by Environment Australia (2001).**

Mudflats and coastal floodplains occur in Roebuck Bay, Mary Floodplain, Blyth-Cadell Floodplain and Boucaut Bay System, Murgenella-Cooper Floodplain System, Daly-Reynolds Floodplain-Estuary System, and Adelaide River Floodplain Systems. These provide significant waterbird breeding sites and are major stop-over points for migratory shorebirds. Roebuck Bay is one of the most important migratory stop-overs not only in Australia but globally.

Mangroves and river estuaries in the Ord Estuary, Prince Regent River System, Adelaide River Floodplain Systems, Kakadu National Park and Port Darwin provide major nurseries and habitat for fish, crustaceans and crocodiles and provide habitat for other marine fauna such as dolphins and turtles. Mangroves, river estuaries and their adjacent marine environments are often important commercial or recreational fishing areas. The Daly-Reynolds Floodplain-Estuary System is considered the best barramundi fishing river in Australia.

Freshwater swamps and billabongs such as occur in the Daly River Middle Reaches, Finniss Floodplain and Fog Bay System, Murgenella-Cooper Floodplain System, Arafura Swamp, Adelaide River Floodplain System and Mary Floodplain provide breeding grounds for Magpie geese as well as freshwater fauna such as fish, turtles and crocodiles. The swampy wetlands are of significant value to the local aboriginal communities. Floating mat swamps, used as breeding grounds by crocodiles, occur in the Arafura Swamp and the Finniss Floodplain. The Daly River Middle Reaches is a major breeding ground and dry season habitat for five species of freshwater turtle, notably the Pig-Nosed Turtle. The highest known density of breeding by Magpie Geese occurs in the Adelaide River Floodplain System.

Permanent freshwater river channels and deep pools occur in the permanent and seasonal rivers and streams draining into Kakadu, and in the Daly Middle Reaches, Drysdale River, Windjana Gorge, Katherine River Gorge, and Fitzroy River (Camballin Floodplain). These provide refuge for fishes and waterbirds, as well as recreational opportunities such as tourism and fishing during the dry season. Sites of permanent water are also of importance in aboriginal culture and often include locations of sacred or cultural significance. As well as 20 waterbird species, the Drysdale River supports the richest freshwater fish fauna (26 species) known in Western Australia of which three species are possibly endemic. Similarly, twenty frog species, a rich fish fauna, as well as freshwater snakes and turtle species occur in the Katherine River Gorge. Artificial impoundments such as Lake Kununurra and Lake Argyle provide significant wildlife habitat and are popular for recreational activities.

Table 1. List of Wetlands of National Significance located within the Timor Sea Drainage Division

Site code	Name	Area	Region
		ha	
WA020 *	Roebuck Bay	50,000	Fitzroy
WA114	Big Springs	<10	Fitzroy
WA016	Bunda-Bunda Mound Springs	23	Fitzroy
WA017 *	Camballin Floodplain (Le Livre Swamp System)	30,000	Fitzroy
WA019 *	Geikie Gorge	272	Fitzroy
WA111	Gladstone Lake	<10	Fitzroy
WA021	Roebuck Plains System	1,180	Fitzroy
WA012	Tunnel Creek	20	Fitzroy
WA022	Willie Creek Wetlands	2,950	Fitzroy
WA013 *	Windjana Gorge	20	Fitzroy
WA098 *	Lake Kununurra	2,500	Ord-Bonaparte
WA062 *	Drysdale River	5,670	Kimberley
WA063 *	Mitchell River System	1,120	Kimberley
WA064 *	Prince Regent River System	19,100	Kimberley
WA097 *	Lake Argyle	98,000	Ord-Bonaparte
WA100 *	Parry Floodplain	9,000	Ord-Bonaparte
WA099 *	Ord Estuary System	94,700	Ord-Bonaparte
NT033	Bradshaw Field Training Area	<10	Ord-Bonaparte
NT024 *	Daly-Reynolds Floodplain-Estuary System	159,000	Daly
NT030	Legune Wetlands	10,300	Ord-Bonaparte
NT027	Moyle Floodplain and Hyland Bay System	74,700	Ord-Bonaparte
NT001 *	Daly River Middle Reaches	1,470	Daly
NT018 *	Katherine River Gorge	354	Daly
NT023	Cobourg Peninsula System	254,000	Van Diemen
NT028 *	Murgenella-Cooper Floodplain System	81,500	Van Diemen
NT017 *	Kakadu National Park	233,000	Van Diemen
NT020 *	Adelaide River Floodplain System	134,000	Van Diemen
NT025 *	Finniss Floodplain and Fog Bay Systems	81,300	Van Diemen
NT026 *	Mary Floodplain System	128,000	Van Diemen
NT031	Mount Bundey Training Area - Mary River Floodplain	<10	Van Diemen
NT029 *	Port Darwin	48,800	Van Diemen
NT032	Shoal Bay - Micket Creek	<10	Van Diemen
NT021 *	Arafura Swamp	71,400	Arafura
NT022 *	Blyth-Cadell Floodplain & Boucaut Bay System	35,500	Arafura

*assets shortlisted for assessment of changes to hydrological regime.

Table 2. List of nodes used for assessing changes to the hydrological regime under the proposed scenarios for the selected assets in the Timor Sea Drainage Division

Region*	Environmental Asset Name	Node	Description
FI	Camballin Floodplain (Le Livre Swamp System)	1	Surface water modelling node 20074 on Mt Wynne Creek side of Fitzroy River
FI	Camballin Floodplain (Le Livre Swamp System)	2	Camballin Barrage (gauge G802003)
FI	Geikie Gorge	1	Surface water modelling node 20072 on Fitzroy River
FI	Roebuck Bay	1	Surface water modelling node 20081 on unnamed creek
FI	Roebuck Bay	2	Surface water modelling node 20082 on unnamed creek
FI	Roebuck Bay	3	Surface water modelling node 20083 on unnamed creek
FI	Roebuck Bay	4	Surface water modelling node 20084 on unnamed creek
FI	Windjana Gorge	1	Surface water modelling node 20069 on Lennard River
KI	Drysdale River	1	Surface water modelling node 20073 on Drysdale River 3 km downstream of convergence with Crossland Creek
KI	Mitchell River System	1	Surface water modelling node 20070 on Mitchell River
KI	Mitchell River System	2	Surface water modelling node 20071 on Mitchell River
KI	Prince Regent River System	1	Surface water modelling node 20075 on Prince Regent River
OB	Lake Argyle	1	Surface water modelling node 60013 representing all inflows to the dam
OB	Lake Kununurra	1	Mike-11 model results for Lake Argyle
OB	Lake Kununurra	2	Tarrarra Bar (gauge G809339)
OB	Ord Estuary System	1	Surface water modelling node 20078 on unnamed creek
OB	Ord Estuary System	2	Surface water modelling node 20079 on unnamed creek
OB	Ord Estuary System	3	Surface water modelling node 20080 on Station Creek
OB	Parry Floodplain	1	Surface water modelling node 20076 on the Ord River - modified using inputs from Lake Argyle Mike-11 model
DA	Daly River Middle Reaches	1	Combined surface/ground water model results at gauge G8140042
DA	Daly River Middle Reaches	2	Surface/ground water model results from bore site RN020614
DA	Daly River Middle Reaches	3	Surface/ground water model - located at gauge G8140038
DA	Daly-Reynolds Floodplain-Estuary System	1	Surface/ground water model results at stream gauge G8140040
DA	Katherine River Gorge	1	Surface/ground water model results at stream gauge G8140001
VD	Adelaide River Floodplain System	1	Surface water modelling node 20061 1km upstream of G8170021
VD	Finniss Floodplain and Fog Bay Systems	1	Surface water modelling node 20065 on Finniss River downstream 15-20km of G8150180
VD	Kakadu National Park	1	Surface water modelling node 20054 on the Wildman River
VD	Kakadu National Park	2	Surface water modelling node 20055 on the Marangarrayu (West Alligator River) 20km downstream of G8190001
VD	Kakadu National Park	3	Surface water modelling node 20056 just below convergence of South Alligator River and Jim Jim Creek
VD	Kakadu National Park	4	Surface water modelling node 20057 on Nourlangie Creek 10km downstream of G8200112
VD	Kakadu National Park	5	Surface water modelling node 20058 on Magela Creek near G8210018
VD	Kakadu National Park	6	Surface water modelling node 20059 on East Alligator Creek 5km downstream of G8210015
VD	Mary Floodplain System	1	Surface water modelling node 20060 on Mary River
VD	Murgenella-Cooper Floodplain System	1	Surface water modelling node 20052 on Murgenella Creek
VD	Murgenella-Cooper Floodplain System	2	Surface water modelling node 20053 on Cooper Creek 15km downstream of G8210016
VD	Port Darwin	1	Surface water modelling node 20062 just below convergence of Darwin and Blackmore Rivers. Darwin River dam lies 20 km upstream of convergence) and is being modelled in IQQM
VD	Port Darwin	2	Surface water modelling node 20063 on Berry Creek 2km downstream of G8150028
VD	Port Darwin	3	Surface water modelling node 20064 on Elizabeth River 5km downstream of G8150018
AR	Arafura Swamp	1	Surface water modelling node 20048 on Goyder River 30km downstream from G8250002
AR	Arafura Swamp	2	Surface water modelling node 20049 on Gulbuwangay River
AR	Blyth-Cadell Floodplain & Boucaut Bay System	1	Surface water modelling node 20050 on Cadell River 20km downstream of G8240001
AR	Blyth-Cadell Floodplain & Boucaut Bay System	2	Surface water modelling node 20051 on Blyth River 40km downstream of G8240002

*FI – Fitzroy, KI – Kimberley, OB – Ord-Bonaparte, DA – Daly, VD – Van Diemen, AR – Arafura

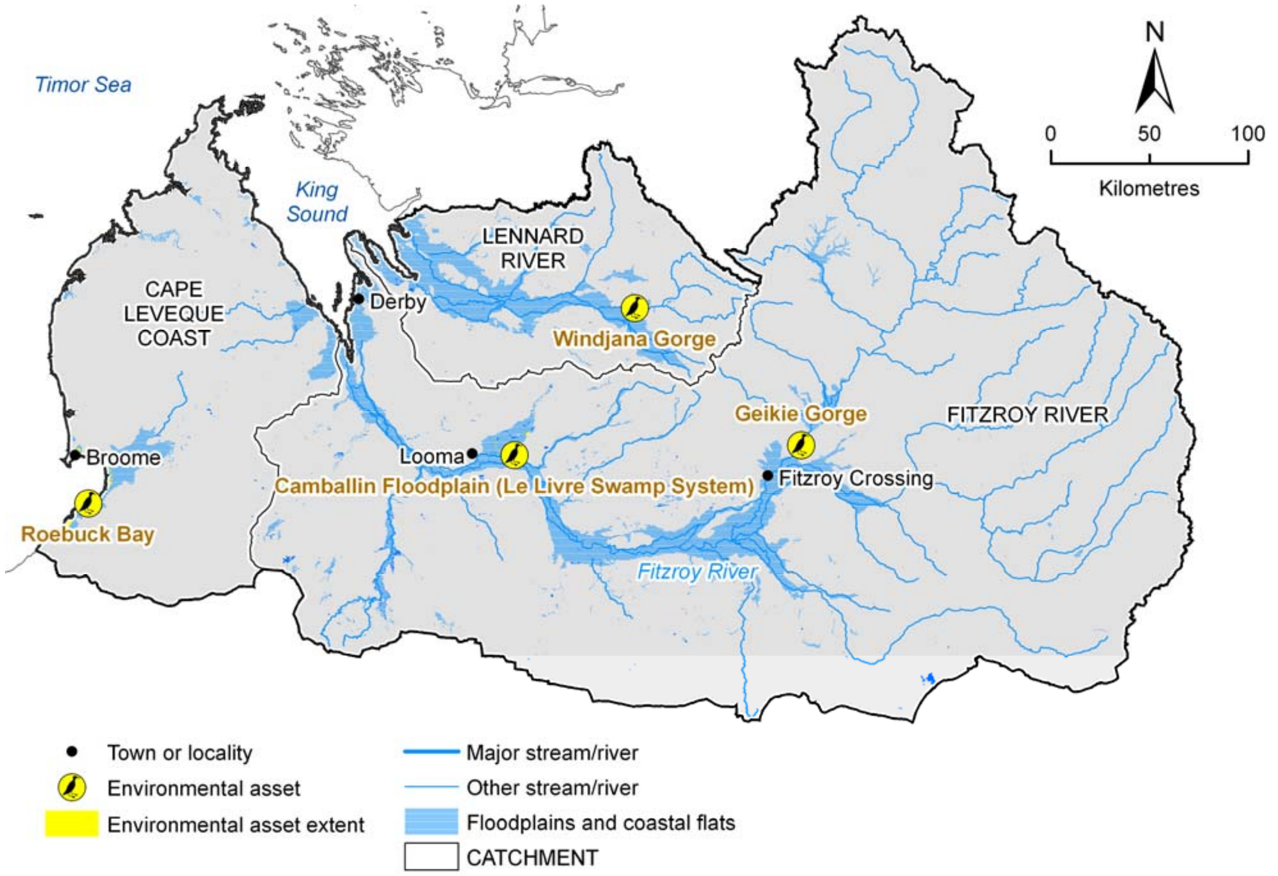

Figure 5. Location of all selected assets in the Fitzroy region of the Timor Sea Drainage Division

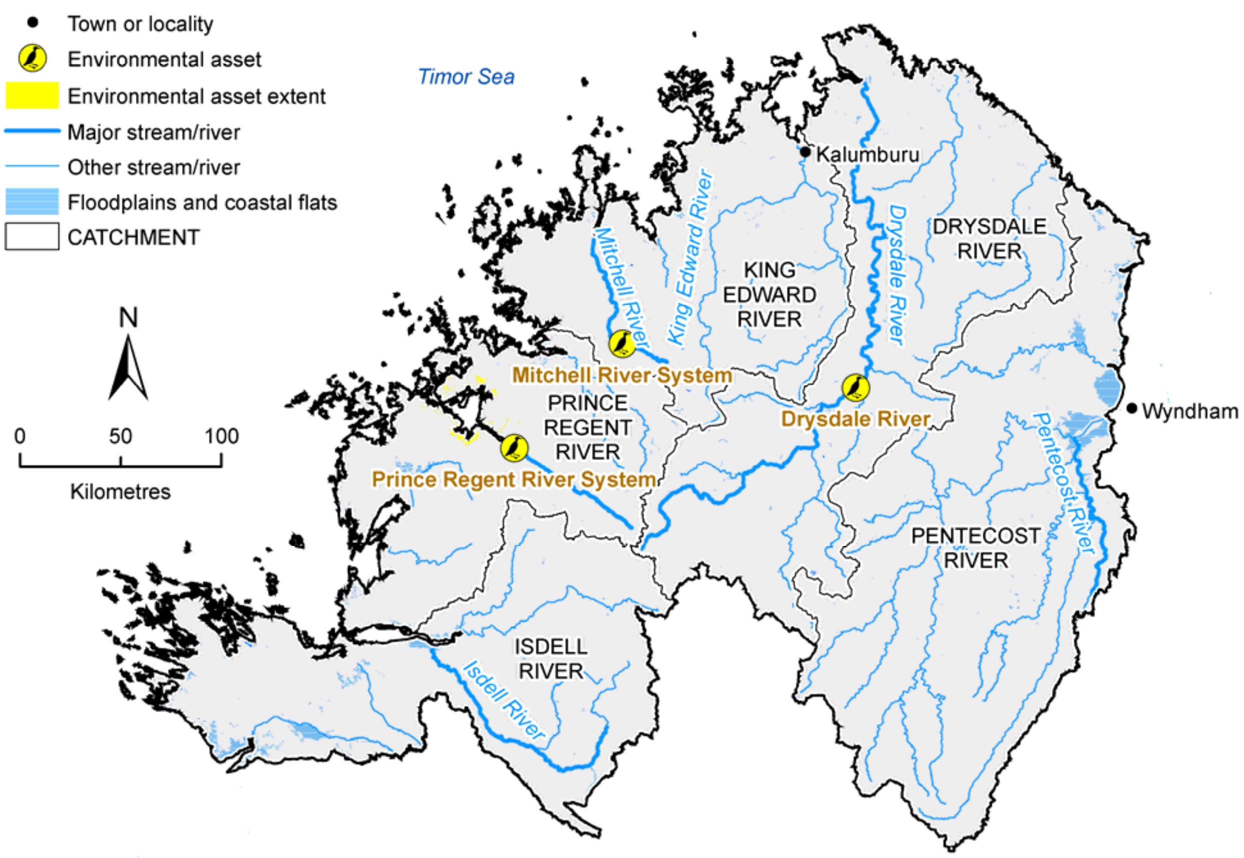

Figure 6. Location of all selected assets in the Kimberley region of the Timor Sea Drainage Division

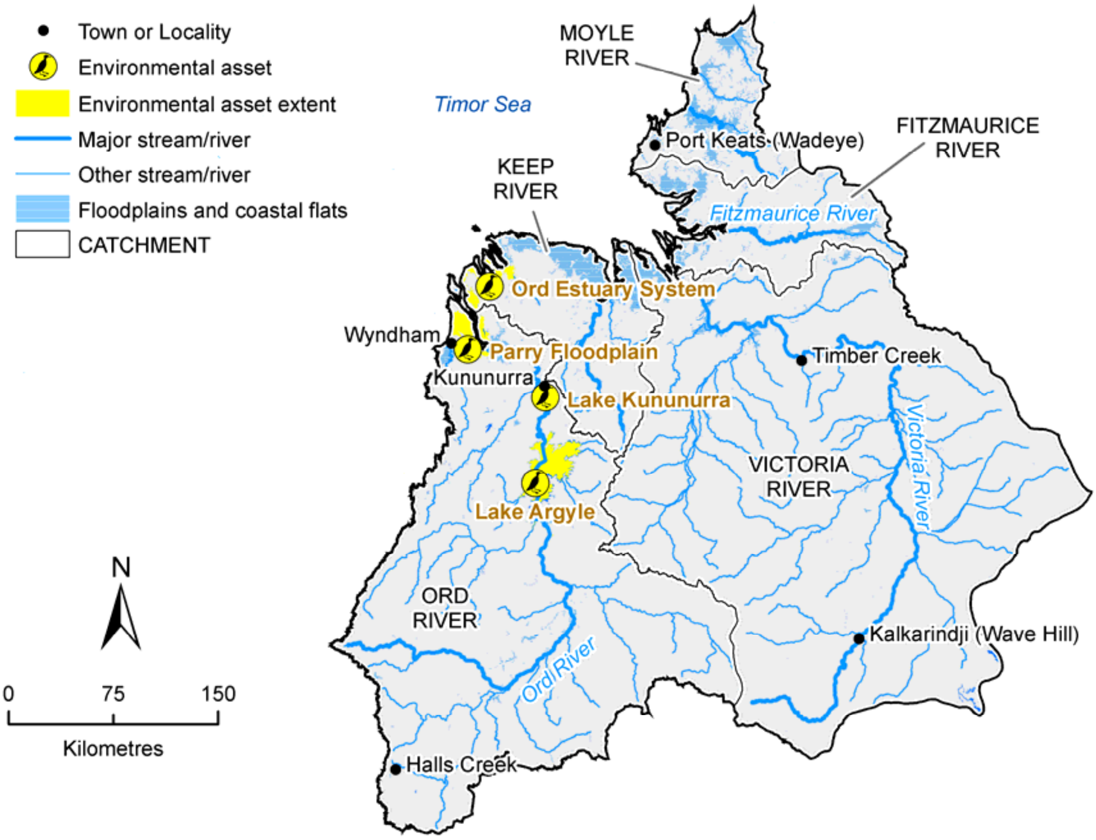

Figure 7. Location of all selected assets in the Ord-Bonaparte region of the Timor Sea Drainage Division

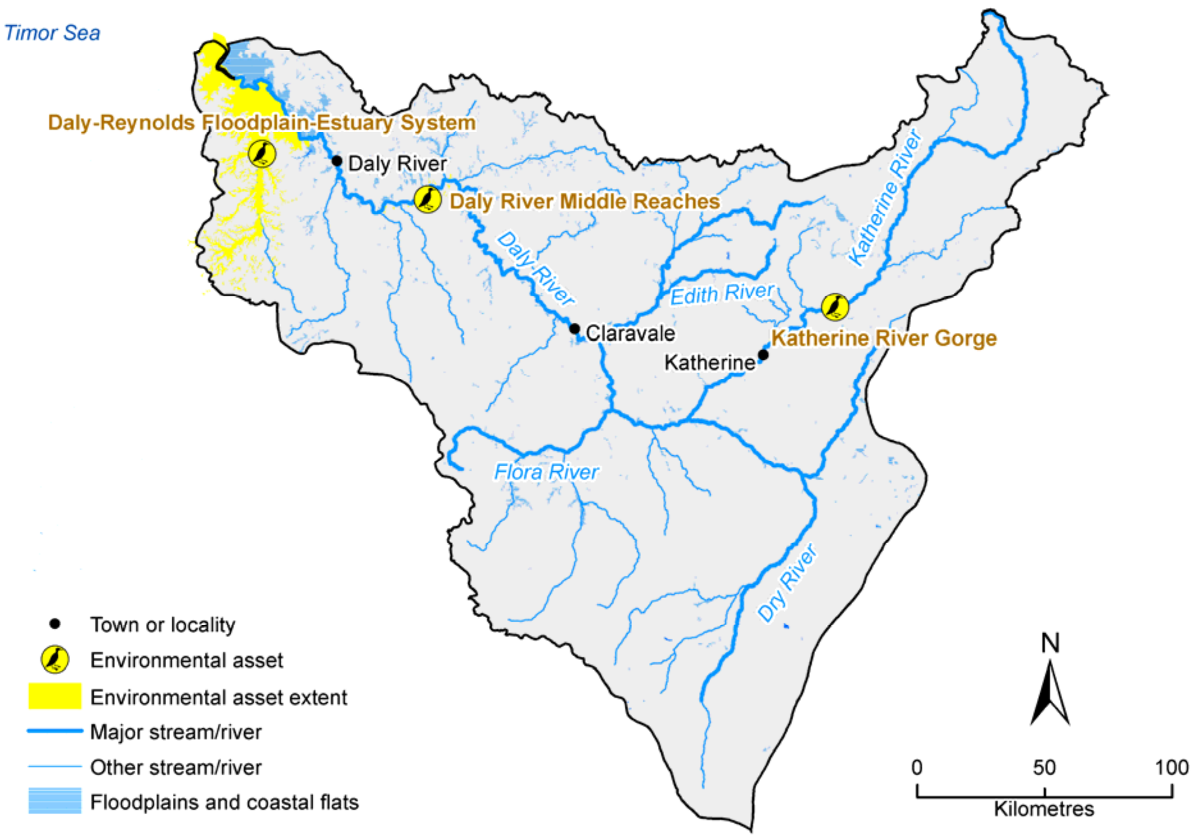

Figure 8. Location of all selected assets in the Daly region of the Timor Sea Drainage Division

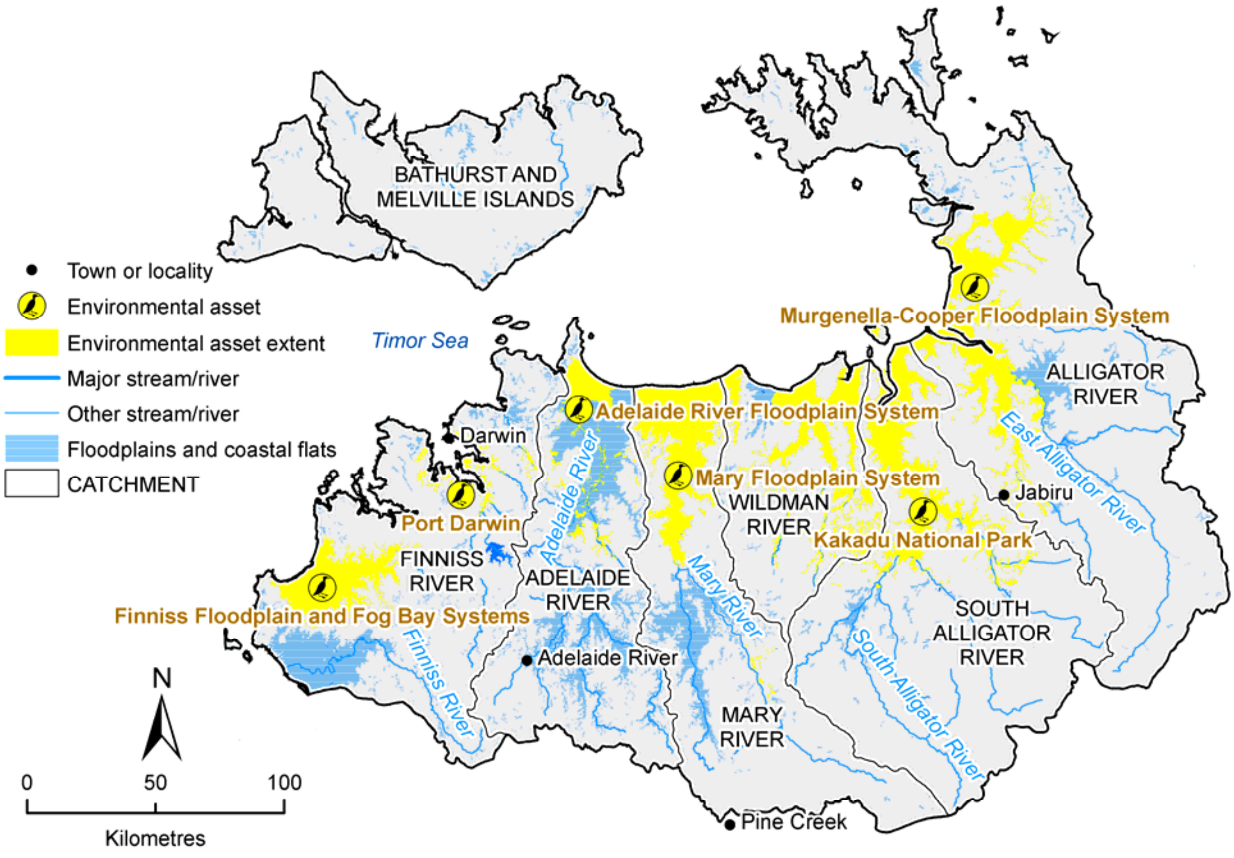

Figure 9. Location of all selected assets in the Van Diemen region of the Timor Sea Drainage Division

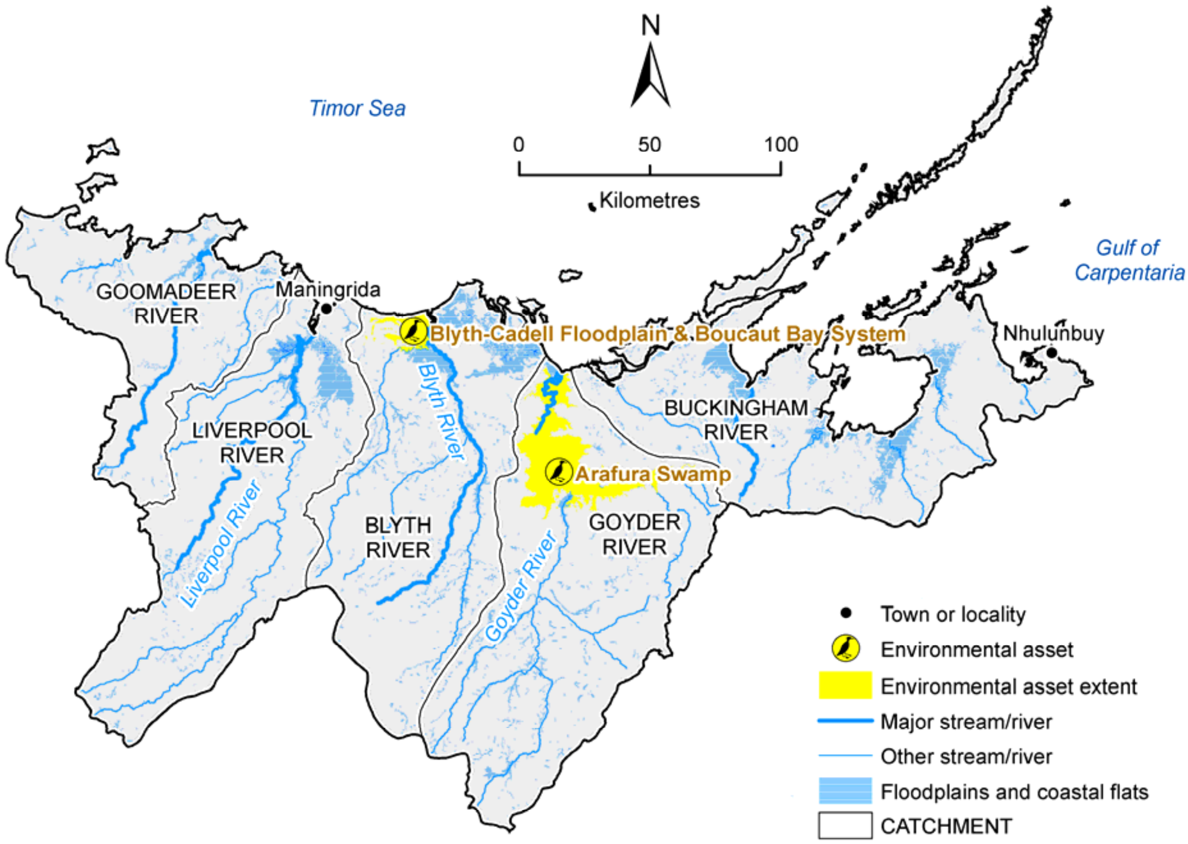

Figure 10. Location of all selected assets in the Arafura region of the Timor Sea Drainage Division

2.4.2 Gulf of Carpentaria

Table 3 shows all 35 sites from the Directory of Important Wetlands in Australia that are within the Gulf of Carpentaria Drainage Division. The 16 assets selected for assessment are indicated in Table 3 and are shown in Figure 11 to Figure 16 for each of the six regions in the Gulf of Carpentaria Drainage Division. There are no Ramsar-listed sites within the Drainage Division. Some of the selected environmental assets in this region are very large and have multiple streams feeding into them, in response these larger assets have multiple nodes at which streamflow modelling results are available. Table 4 lists all of the nodes for the selected environmental assets and describes their locations. Node locations are shown on satellite images for each asset in Appendix 1. **The following broad description of the Directory of important Wetlands in Australia sites in the Gulf of Carpentaria Drainage Division is based largely on the description of these assets as outlined by Environment Australia (2001).**

Mudflats, saline flats and estuaries associated with coastal floodplains occur extensively in the Limmen Bight (Port Roper) Tidal Wetlands System and the Port McArthur Tidal Wetland System. The Port Roper mudflats are among the most important coastal areas for shorebirds in the Northern Territory while the Southern Gulf Aggregation is one of the three most important areas for shorebirds in Australia. The Port McArthur Tidal Wetland System contains the widest and largest area of intertidal mudflats in the south-west of the Gulf. The Limmen Bight (Port Roper) Tidal Wetlands System is the second largest area of saline coastal flats in the Northern Territory. Swamps and lakes, associated with coastal dune systems occur in the Jardine River Wetlands and the Buffalo Lake and Southern Gulf Aggregations. These sites form important habitat for numerous bird species and support populations of bats, frogs, snakes and turtles.

Port McArthur Tidal Wetland System contains the only substantial area of mangrove swamp in the south-west of the Gulf. At least two substantial waterbird breeding rookeries and at least 24 seabird breeding rookeries occur on the site and the mangroves are considered an important link between Top End and Cape York bird populations adapted to this habitat. The mangrove forests of the Wenlock and Ducie rivers in the Port Musgrave Aggregation on Cape York are outstanding representative examples of their type and the large extent of good crocodile nesting habitat is considered to be responsible for numbers nearly double that recorded at any other surveyed site on Cape York Peninsula.

In the South East Gulf and northwards along the Western Cape a number of wetlands represent extensive alluvial plain systems with semi-abandoned river channels, river terraces, flooded back plains and swamps, and depressions and oxbows (some with permanent water). Such systems include Dorunda Lakes Area, Archer River Aggregation, Northern Holroyd Plain Aggregation, Mitchell River Fan aggregation, and Smithburne-Gilbert Fan Aggregation. The Northern Holroyd Plain Aggregation represents some of the most pristine inland wetlands in western Cape York and contains the best examples of a characteristic suite of wetlands (ephemeral lakes and ponds dominated by grasses and sedges) within an area of high wilderness quality. These wetlands provide significant drought and seasonal habitat refuge for waterbirds other species.

Permanent freshwater river and spring systems such as Mataranka Thermal Pools, Gregory River, (and associated wetlands of the Thorntonia Aggregation) as well as artificial lakes such as Lake Julius, provide refuges for a wide range of flora and fauna in an otherwise semi-arid seasonally dry environment. A notable feature of the Thorntonia Aggregation is the rainforest influence and marked differences between the fringing communities of the gorges and channels and the surrounding semi-arid country.

Table 3. List of Wetlands of National Significance located within the Gulf of Carpentaria Drainage Division

Site code	Name	Area	Region
		ha	
NT007 *	Limmen Bight (Port Roper) Tidal Wetlands System	185,000	Roper
NT003 *	Mataranka Thermal Pools	<10	Roper
QLD102	Bluebush Swamp	879	South-West Gulf
NT006	Borroloola Bluebush	70	South-West Gulf
QLD105	Forsyth Island Wetlands	6,390	South-West Gulf
QLD119 *	Gregory River	26,600	South-West Gulf
QLD101	Lawn Hill Gorge	1,130	South-West Gulf
QLD108	Marless Lagoon Aggregation	167,000	South-West Gulf
QLD110	Musselbrook Creek Aggregation	45,100	South-West Gulf
QLD111 *	Nicholson Delta Aggregation	63,600	South-West Gulf
NT008 *	Port McArthur Tidal Wetlands System	119,000	South-West Gulf
QLD114 *	Southern Gulf Aggregation	546,000	South-West Gulf/Flinders-Leichhardt/South-East Gulf
QLD122 *	Thorntonia Aggregation	299,000	South-West Gulf
QLD116	Wentworth Aggregation	82,300	South-West Gulf
QLD103 *	Buffalo Lake Aggregation	1,910	Flinders-Leichhardt
QLD120 *	Lake Julius	1,940	Flinders-Leichhardt
QLD121	Lake Moondarra	1,740	Flinders-Leichhardt
QLD106	Lignum Swamp	283	Flinders-Leichhardt
QLD115	Stranded Fish Lake	68	Flinders-Leichhardt
QLD104 *	Dorunda Lakes Area	6,810	South-East Gulf
QLD107	Macaroni Swamp	258	South-East Gulf
QLD109 *	Mitchell River Fan Aggregation	715,000	South-East Gulf/Mitchell
QLD112 *	Smithburne–Gilbert Fan Aggregation	251,000	South-East Gulf
QLD113	Southeast Karumba Plain Aggregation	336,000	South-East Gulf/Mitchell/Western Cape
QLD094	Undara Lava Tubes	1,250	South-East Gulf
QLD067	Northeast Karumba Plain Aggregation	183,000	Mitchell
QLD093	Spring Tower Complex	75	Mitchell
QLD056	Archer Bay Aggregation	29,900	Western Cape
QLD057 *	Archer River Aggregation	150,000	Western Cape
QLD058	Bull Lake	27	Western Cape
QLD063 *	Jardine River Wetlands Aggregation	81,800	Western Cape
QLD068 *	Northern Holroyd Plain Aggregation	1,110,000	Western Cape
QLD071 *	Port Musgrave Aggregation	52,700	Western Cape
QLD074	Skardon River – Cotterell River Aggregation	63,200	Western Cape
QLD075	Somerset Dunefield Aggregation	7,940	Western Cape

*assets shortlisted for assessment of changes to hydrological regime.

Table 4. List of nodes used for assessing changes to the hydrological regime under the proposed scenarios for the selected assets in the Gulf of Carpentaria Drainage Division

Region*	Environmental Asset Name	Node	Description
RO	Limmen Bight (Port Roper) Tidal Wetlands System	1	Surface water modelling node 20043 on Phelp River
RO	Limmen Bight (Port Roper) Tidal Wetlands System	2	Surface water modelling node 20044 on unnamed river
RO	Limmen Bight (Port Roper) Tidal Wetlands System	3	Surface water modelling node 20045 on Roper River
RO	Limmen Bight (Port Roper) Tidal Wetlands System	4	Surface water modelling node 20046 on Towns River just below convergence of Towns River, Yumanji Creek and Magaranyi River
RO	Limmen Bight (Port Roper) Tidal Wetlands System	5	Surface water modelling node 20047 just below convergence of Limmen Bight River and Nathan River
RO	Mataranka Thermal Springs	n/a	Mataranka will not be analysed as there are no groundwater results.
SW	Gregory River	1	Surface water modelling node 20085 2km upstream from G912105A on Gregory River 2km below convergence with O'Shannassy River
SW	Nicholson Delta Aggregation	1	Surface water modelling node 20033 on Nicholson River below convergence with Gregory River 7km above G912109
SW	Nicholson Delta Aggregation	2	Surface water modelling node 20034 on Albert River below convergence of Barkly River and One Mile Creek
SW	Port McArthur Tidal Wetlands System	1	Surface water modelling node 20038 on Batten Creek
SW	Port McArthur Tidal Wetlands System	2	Surface water modelling node 20039 on McArthur River
SW	Port McArthur Tidal Wetlands System	3	Surface water modelling node 20040 on Wearyan River 7km below convergence of Wearyan and Foelsche Rivers
SW	Port McArthur Tidal Wetlands System	4	Surface water modelling node 20041 on the Fletcher
SW	Port McArthur Tidal Wetlands System	5	Surface water modelling node 20042 on McPherson Creek
SW	Southern Gulf Aggregation	1	Surface water modelling node 20031 just below convergence of Millar Creek and Albert River
SW	Thorntonia Aggregation	1	Surface water modelling node 20035 on Lawn Hill Creek
SW	Thorntonia Aggregation	2	Surface water modelling node 20036 on Gregory River 5km below convergence with Goonooma Creek
SW	Thorntonia Aggregation	3	Surface water modelling node 20037 on O'Shannassy River 10km below convergence with Thornton River
FL	Buffalo Lake Aggregation	1	Surface water modelling node 20032 at Buffalo Lake
FL	Lake Julius	1	Used dam "inflows" data from Leichhardt River IQQM model
FL	Southern Gulf Aggregation	2	Leichhardt River IQQM model end-of-system results
FL	Southern Gulf Aggregation	3	Flinders River IQQM model end-of-system results
SE	Dorunda Lakes Area	1	Surface water modelling node 20026 on unnamed creek
SE	Smithburne - Gilbert Fan Aggregation	1	Gilbert River IQQM model node 138 at gauge G917009A
SE	Southern Gulf Aggregation	4	Surface water modelling node 20028 just below convergence of Walker Creek and Norman River
MI	Mitchell River Fan Aggregation	1	Mitchell River IQQM node 93 at gauge location G919009A
WC	Archer River Aggregation	1	Surface water modelling node 20015 on Picanniny Creek
WC	Archer River Aggregation	2	Surface water modelling node 20016 on Archer River 40km downstream of G922001A
WC	Archer River Aggregation	3	Surface water modelling node 20017 on Coen River
WC	Archer River Aggregation	4	Surface water modelling node 20018 on Running Creek
WC	Jardine River Wetlands Aggregation	1	Surface water modelling node 20008 on Eliot Creek
WC	Jardine River Wetlands Aggregation	2	Surface water modelling node 20009 on Jardine River
WC	Northern Holroyd Plain Aggregation	1	Surface water modelling node 20019 on unnamed creek
WC	Northern Holroyd Plain Aggregation	2	Surface water modelling node 20020 on Coleman River
WC	Northern Holroyd Plain Aggregation	3	Surface water modelling node 20021 on Holroyd River
WC	Northern Holroyd Plain Aggregation	4	Surface water modelling node 20022 on Kendall River
WC	Port Musgrave Aggregation	1	Surface water modelling node 20010 on the Dulhunty River
WC	Port Musgrave Aggregation	2	Surface water modelling node 20011 on unnamed creek
WC	Port Musgrave Aggregation	3	Surface water modelling node 20012 on North Alice Creek
WC	Port Musgrave Aggregation	4	Surface water modelling node 20013 on Ducie River
WC	Port Musgrave Aggregation	5	Surface water modelling node 20014 on unnamed creek
WC	Port Musgrave Aggregation	6	Surface water modelling node 10025 on Wenlock River

*RO - Roper, SW - South-West Gulf, FL - Flinders-Leichhardt, SE - South-East Gulf, MI - Mitchell, WC - Western Cape

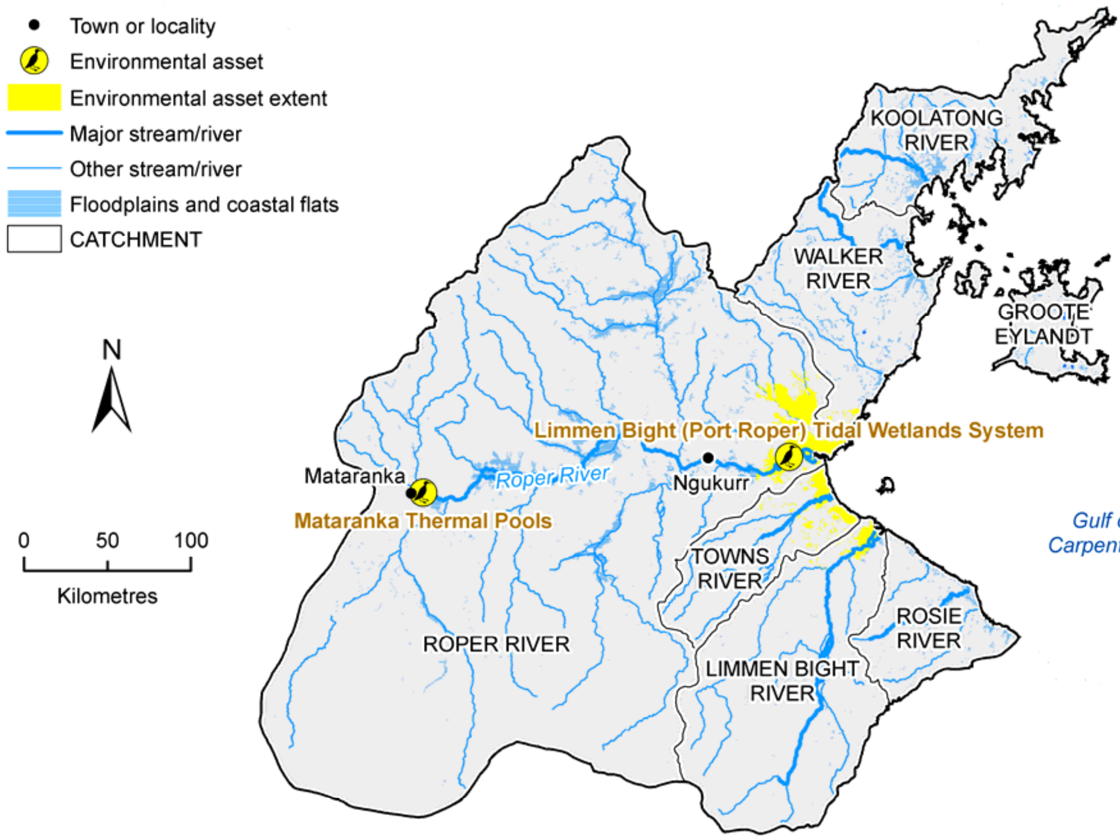

Figure 11. Location of all selected assets in Roper region of the Gulf of Carpentaria Drainage Division

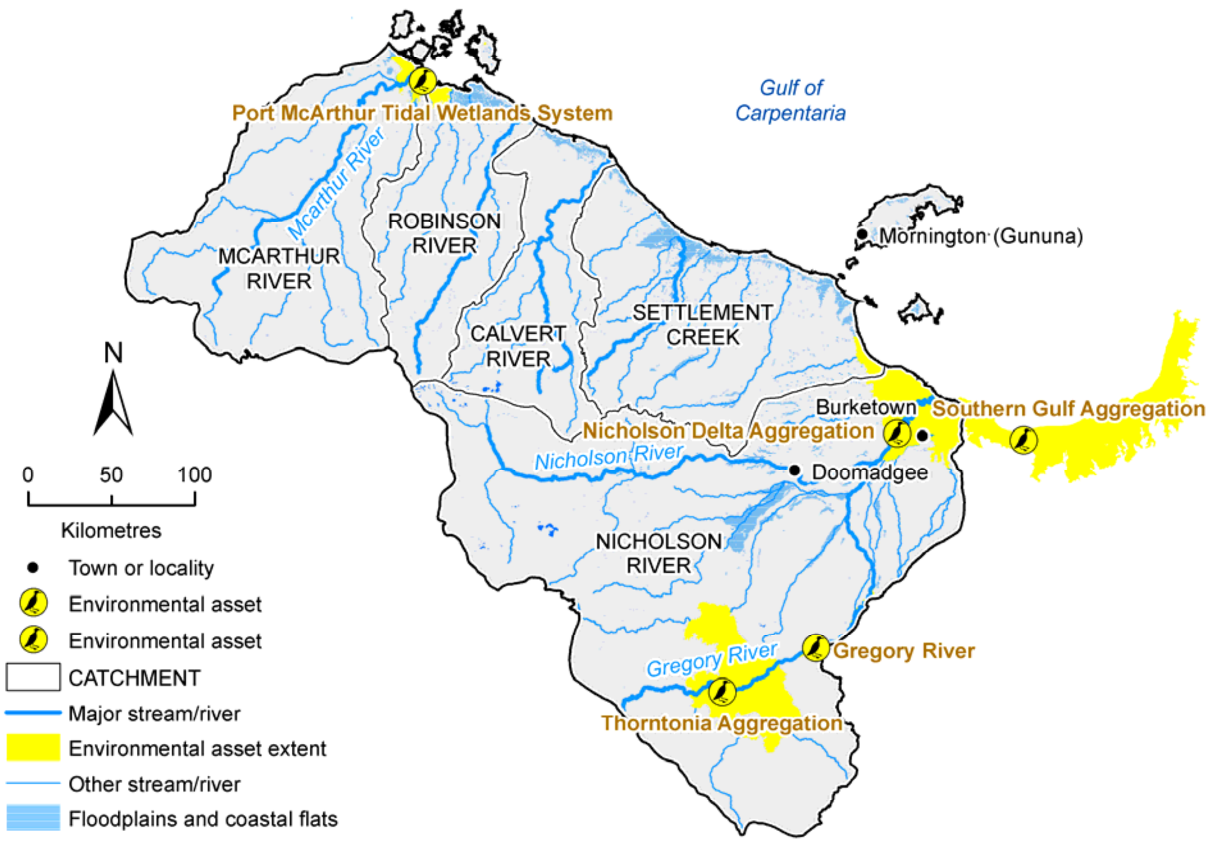

Figure 12. Location of all selected assets in the South-West Gulf region of the Gulf of Carpentaria Drainage Division

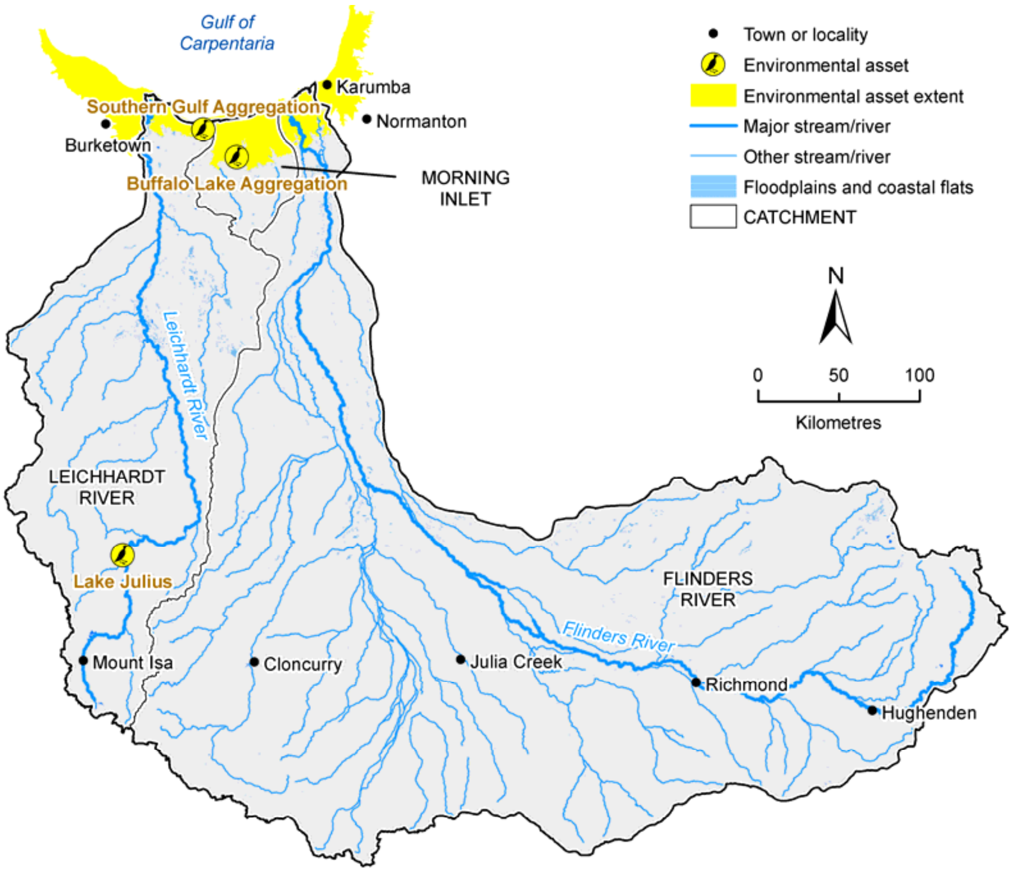

Figure 13. Location of all selected assets in the Flinders-Leichhardt region of the Gulf of Carpentaria Drainage Division

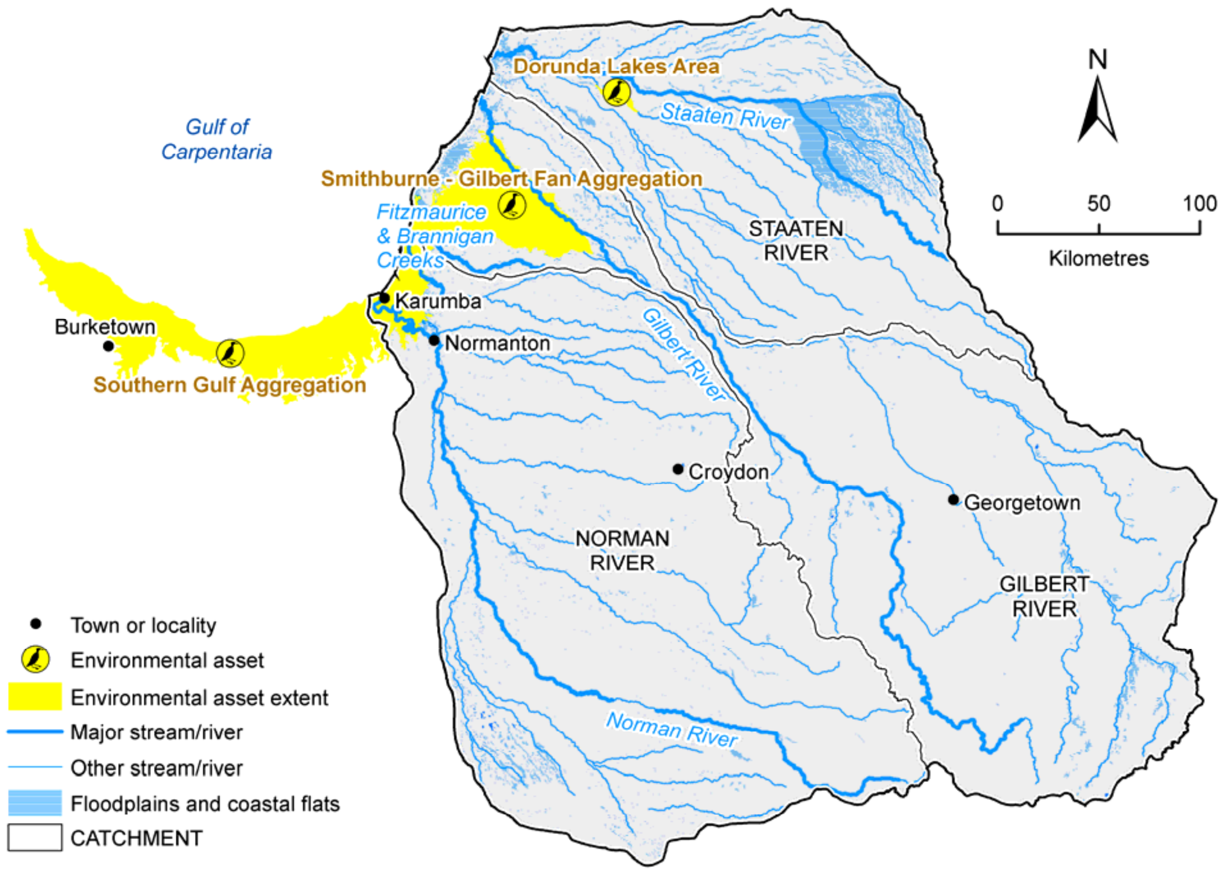

Figure 14. Location of all selected assets in the South-East Gulf region of the Gulf of Carpentaria Drainage Division

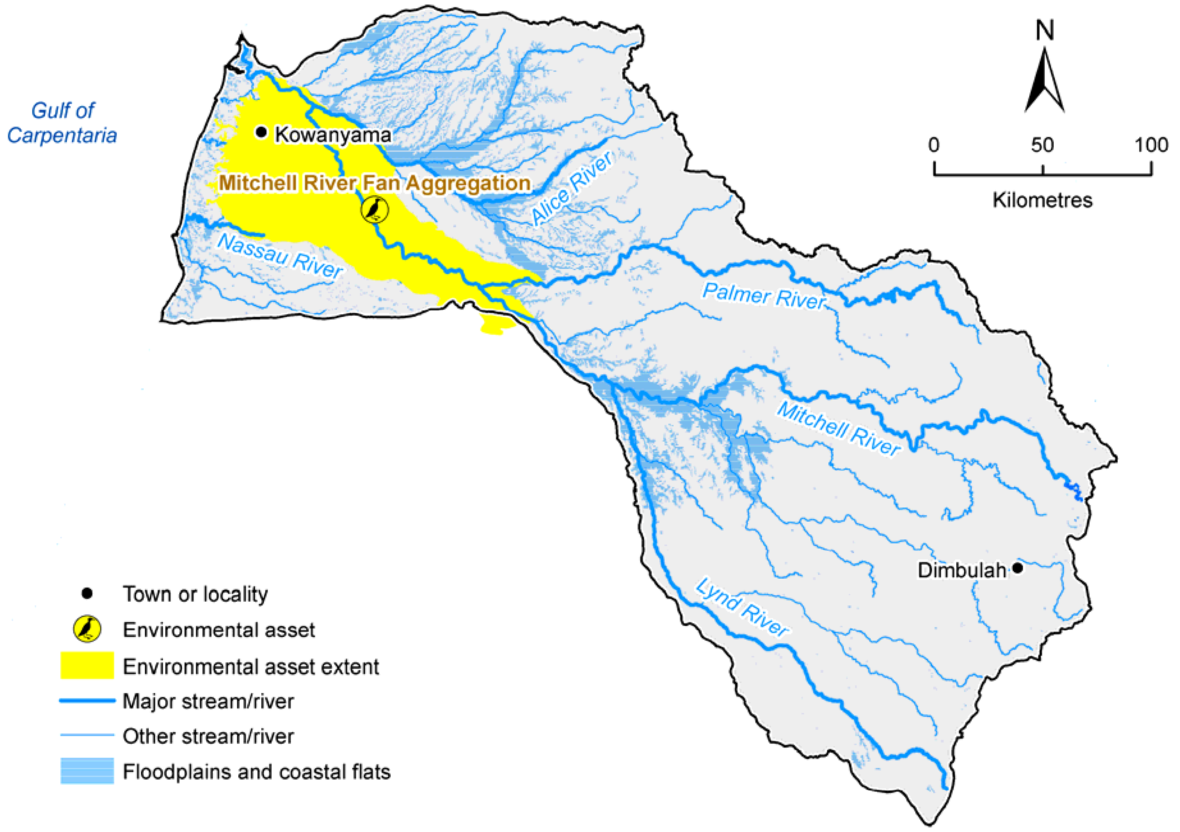

Figure 15. Location of all selected assets in the Mitchell region of the Gulf of Carpentaria Drainage Division

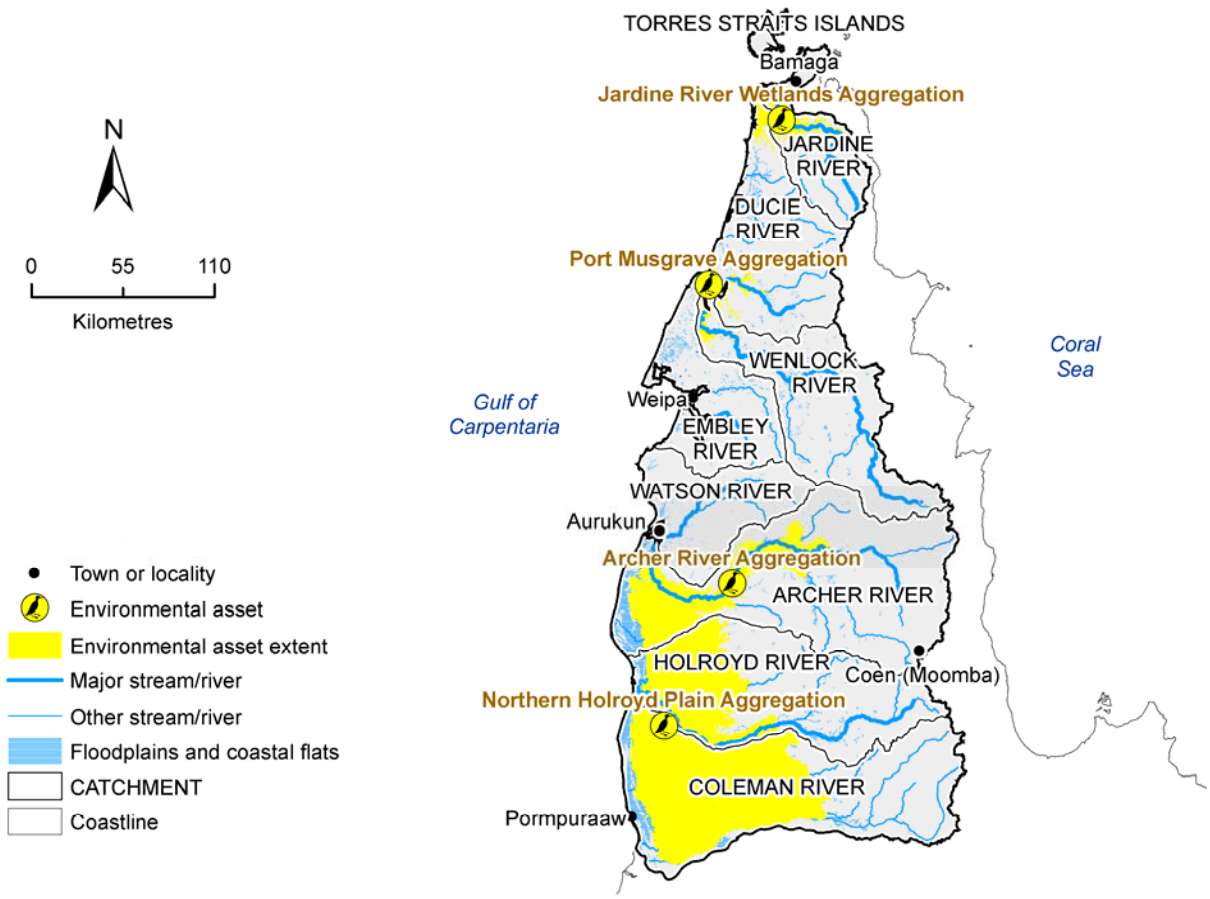

Figure 16. Location of all selected assets in the Western Cape region of the Gulf of Carpentaria Drainage Division

2.4.3 Northern North-East Coast

Table 5 shows all 18 sites from the Directory of Important Wetlands in Australia that are within the Northern North-East Coast Drainage Division. The five assets selected for assessment are indicated in Table 5 and are shown in Figure 17. There are no Ramsar-listed sites within the drainage division. Some of the selected environmental assets in this region are very large and have multiple streams feeding into them, in response these larger assets have multiple nodes at which streamflow modelling results are available. Table 6 lists all of the nodes for the selected environmental assets and describes their locations. Node locations are shown on satellite images for each asset in Appendix 1. **The following broad description of the Directory of Important Wetlands in Australia sites in the Northern North-East Coast Drainage Division is based largely on the description of these assets as outlined by Environment Australia (2001).**

The Lower Daintree River and Olive River contain a diverse range of habitats. The Lower Daintree has significant impacts from development while the Olive River is of high to very high wilderness quality. Despite development, the Lower Daintree has over fourteen vegetation types including mangrove communities, melaleuca communities, rainforest communities, dune woodlands and thickets, and sedge lands. The melaleuca swamps of the northern bank of the Daintree are an outstanding and spectacular example of this type of forest and may also be the most significant breeding area for the estuarine crocodile in the Wet Tropics bioregion.

Other sites such as Lloyd Bay, and Newcastle Bay - Escape River Estuarine Complex represent coastal estuaries with associated mangrove forests, salt flats, dunes, swamps, and swamp forests. They both support seagrass beds of importance as dugong habitat. Notophyll vine forests, heath and sedge lands are also present. The Marina Plains - Lakefield Aggregation contains permanent rivers streams and ponds. Most of the area is inundated during the wet season and contains a very large number of ephemeral lakes and lagoons and these are occupied by many species of aquatic plants. It contains some of the best examples of many vegetation communities on the eastern side of Cape York.

Table 5. List of Wetlands of National Significance located within the Technical Report Drainage Division

Site code	Name	Area	Region
		ha	
QLD137	Alexandra Bay	862	Northern Coral
QLD059	Cape Flattery Dune Lakes	44,000	Northern Coral
QLD060	Cape Grenville Area	7,310	Northern Coral
QLD061	Cape Melville - Bathurst Bay	5,460	Northern Coral
QLD062	Harmer Creek - Shelburne Bay Aggregation	31,300	Northern Coral
QLD147	Hilda Creek Headwater	<10	Northern Coral
QLD090	Laura Sandstone	1,090	Northern Coral
QLD064 *	Lloyd Bay	15,700	Northern Coral
QLD154 *	Lower Daintree River	5,270	Northern Coral
QLD065 *	Marina Plains - Lakefield Aggregation	392,000	Northern Coral
QLD066 *	Newcastle Bay - Escape River Estuarine Complex	42,300	Northern Coral
QLD069 *	Olive River	17,600	Northern Coral
QLD070	Orford Bay - Sharp Point Dunefield Aggregation	17,100	Northern Coral
QLD072	Princess Charlotte Bay Marine Area	87,700	Northern Coral
QLD073	Silver Plains - Nesbitt River Aggregation	44,800	Northern Coral
QLD076	Temple Bay	4,400	Northern Coral
QLD077	The Jack Lakes Aggregation	35,000	Northern Coral
QLD078	Violet Vale	1,890	Northern Coral

*assets shortlisted for assessment of changes to hydrological regime.

Table 6. List of nodes used for assessing changes to the hydrological regime under the proposed scenarios for the selected assets in the Northern North-East Coast Drainage Division

Region*	Environmental Asset Name	Node	Description
NC	Lloyd Bay	1	Surface water modelling node 20002 on Lockhart River
NC	Lloyd Bay	2	Surface water modelling node 20003 on Claudie River
NC	Lower Daintree River	1	Surface water modelling node 20001 8km downstream of 108900 and 20 km downstream of 108002A
NC	Marina Plains - Lakefield Aggregation	1	Surface water modelling node 20086 on the Haan River 1km downstream of 105001B and 1.5 km upstream of 105001A
NC	Marina Plains - Lakefield Aggregation	2	Surface water modelling node 20087 on North Kennedy River (Koolburra Creek) 1 km downstream from convergence with Eighteen Mile Ridge Creek
NC	Marina Plains - Lakefield Aggregation	3	Surface water modelling node 20088 on the Kennedy River
NC	Marina Plains - Lakefield Aggregation	4	Surface water modelling node 20089 on Normanby River just downstream of convergence with Laura River
NC	Marina Plains - Lakefield Aggregation	5	Surface water modelling node 20090 on Morehead River 25km downstream of convergence with Healy Creek
NC	Newcastle Bay - Escape River Estuarine Complex	1	Surface water modelling node 20005 on Jacky Jacky Creek
NC	Newcastle Bay - Escape River Estuarine Complex	2	Surface water modelling node 20006 on unnamed creek
NC	Newcastle Bay - Escape River Estuarine Complex	3	Surface water modelling node 20007 on Escape River
NC	Olive River	1	Surface water modelling node 20004 6 km downstream of convergence with Glennie Creek

*NC – Northern Coral

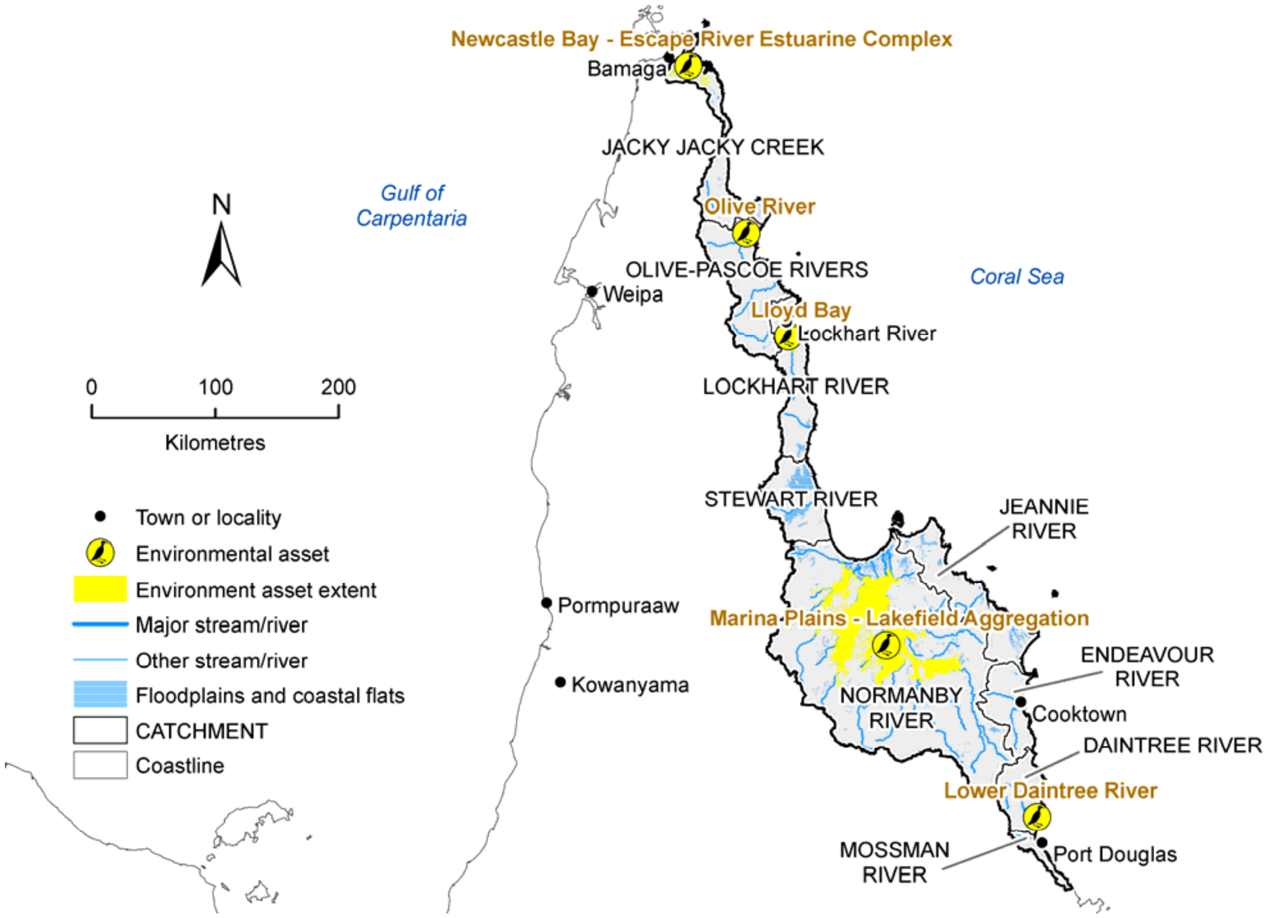

Figure 17. Location of all selected assets in the Northern Coral region of the Northern North-East Cost Drainage Division

Environment Australia (2001) A directory of important wetlands in Australia. Environment Australia, Canberra, Third Edition. Available at < http://www.environment.gov.au/water/publications/environmental/wetlands/pubs/directory.pdf >

3 Environmental metrics

Flow requirements for the ecosystems and biota of environmental assets across northern Australia are largely unknown. However, in a few locations in the Timor Sea Division, such as the Daly River (see Erskine et al., 2003) the Fitzroy River (see Morgan et al., 2005) and the Ord River (Braimbridge and Malseed, 2007; Trayler et al., 2006) environmental flow information has been reported. The site specific metrics used for these assets are described in Section 3.1. For assets where there is little or no quantitative information, a set of standard metrics was derived for high and low flow regime change which were used to assess the potential impacts of future climate and development scenarios. These standard metrics are described below in Section 3.2. The use of standard metrics for all environmental assets provides a consistent means for cross regional comparison.

The main uncertainties involving analysis and reporting of changes to the hydrological regime at selected assets are related to the following issues:

- Aquatic and wetland ecosystems are highly complex and many factors in addition to water regime can affect ecological features and processes. Water quality and land use practices are key factors.
- The indicators are based on limited hydrological parameters with, in general, no direct quantitative relationships for environmental responses. This project therefore only makes general observations on the potential implications of changed water regimes and some related ecological responses.
- Considering only a few of the important environmental assets and using a limited number of indicators to represent overall aquatic ecosystem outcomes is a major simplification. Actual effects on these and other assets or localities are likely to vary.
- Uncertainties affecting the hydrological information used for the environmental assessments.

3.1 Site specific regime metrics

In the Timor Sea Drainage Division site-specific environmental flow metrics exist for assets in the Daly, Fitzroy (WA) and Ord-Bonaparte regions as detailed below.

Daly River – Daly River Middle Reaches

The report by Erskine et al. (2003) and its update Erskine et al. (2004) summarise the results from five projects within the National River Health Environmental Flow Initiative. The aim of these projects was to provide recommendations on environmental flows consistent with maintaining the biota and wider ecosystem values of the Daly River. These projects have made a range of environmental streamflow recommendations and some of these are suitable for assessment under this project’s scenario analysis.

The work by Georges et al. (2002) reported in Erskine et al. (2003; 2004) gives data for the success of Pig-Nosed Turtle (*Carettochelys insculpta*) nesting and their main food source, the aquatic macrophyte *Vallisneria nana*. In these reports turtle nesting success and *V. nana* bed occurrence are related to the Daly river flow at the Oolloo gauge (gauge G8140038). The Erskine et al. (2004) report recommends that at least 80 percent of flow should exceed 1.04 GL/day to provide habitat for Pig-Nosed Turtles and *V. nana*.

Erskine et al. (2003) also reviewed the existing data on riparian vegetation water use along the Daly River and concluded that all of the riparian vegetation water use can be met by maintaining a streamflow of greater than 0.17 GL/day during the dry season, assuming that there is no loss of streamflow to regional aquifers.

The specific metrics to be assessed under each scenario are:

- For Pig-Nosed Turtle nesting success and *V. nana* bed occurrence - the mean number of days per year at Oolloo Gauge with flows below identified the threshold of 1.04 GL/day
- For riparian vegetation water requirements - the mean number of days per year at Oolloo Gauge with flows below the identified threshold of 0.17 GL/day.

Fitzroy River – Camballin Floodplain

Morgan et al. (2005) reported that the water level in the Fitzroy River at the Camballin Barrage (gauge G802003) required for fish passage is ~11 m, or 1 m above the Barrage itself. Using this metric they calculated the number of consecutive days per year that the river stage was above this height. This ranged from ~20 to 250 days per year, with most years (80 percent) having a fish passage duration of less than 3 months. Morgan et al. (2005) also calculated the number of days when the Barrage was completely inundated, and this was associated with a stage height greater than 12.3 m. They found that this occurred in all years between 1986 and 2004 except one (1994). These same metrics will be used for all scenarios being assessed for the Camballin Floodplain Asset. The height metrics were converted to flow thresholds using the rating curve for the gauge. The metrics to be assessed under each scenario are:

- Flows at which fish could negotiate the Camballin Barrage - the mean number of days per year where stage height exceeded 11.0 m which is equivalent to 8.1 GL/day
- Complete barrage inundation of Camballin Barrage and unobstructed fish passage - the mean number of days per year where stage height exceeded 12.3 m which is equivalent to discharge of 28.8 GL/day.

Ord River – Lake Kununurra

Extensive analyses of the environmental flow requirements of the lower Ord River downstream of the Lake Kununurra Diversion Dam have been carried out by Trayler et al. (2006). They derived a range of relationships between key hydraulic parameters and ecological health indices associated with macroinvertebrates, fish, riparian vegetation and ecosystem processes and connectivity. Further analyses of these relationships was carried out by Braimbridge and Malseed (2007) which allowed for the definition of a number of low and high flow conditions that provide thresholds above and below which undesirable ecological impacts may occur. The environmental water release rules for the lower Ord River are based on the recommendations of the Braimbridge and Malseed (2007) report. One of the recommendations for the 58 km section of the Ord River downstream of the Kununurra Dam was that a low flow threshold of 3.63 GL/day should be sustained throughout the dry season in order to meet the environmental flow requirements for fish and macrophyte habitats and pools for algal production. In the same river reach, high flow thresholds are also recommended, for example, the maintenance of wet season flows in excess of 10.8 GL/day for at least 10 days per year in order to sustain regular inundation of riparian zones and deep backwater pools. An even higher wet season flow threshold is recommended to maintain fish passage, i.e. 36.7 GL/day for at least 2 days per year.

The specific metrics to be assessed under each scenario for the lower Ord River downstream of the Lake Kununurra are:

- For fish and macrophyte habitats and pools for algal production - the mean number of days per year with flows below the identified threshold of 3.63 GL/day.
- To sustain regular inundation of riparian zones and deep backwater pools - the mean number of days per year with flows above the identified threshold of 10.8 GL/day.
- To maintain fish passage - the mean number of days per year with flows above identified threshold of 36.7 GL/day.

It is worth noting that a more recent report by Robson et al. (2008) showed that algal production is actually higher at lower flows in the lower Ord River, therefore flows below the identified threshold of 3.63 GL/day should not be considered to be detrimental to algal production.

3.2 Standard regime metrics

One of the key characteristics of the rivers of northern Australia is their highly seasonal flow regimes which can be partitioned into either flood events and low flow, or no flow, periods (Hamilton and Gehrke, 2005). Each of these regimes, which are at opposite ends of the flow spectrum, will have different implications for aquatic biota and ecosystem processes. For example, flood events can be important for such things as wetland connectivity and floodplain rejuvenation (Douglas et al., 2005) while low flows can be crucial for survival of riparian vegetation (Lamontagne et al., 2005), maintenance of ecosystem production and food webs (Townsend and Padovan, 2005; Webster et al., 2005), and provision of refuge for sustaining populations of aquatic species (Hamilton et al., 2005).

Many metrics have been used in the literature to report changes to the low flow regime of a river (Olden and Poff, 2003; Nathan and McMahon, 1992; Kennard et al., In Press). One of the most commonly used metrics is the flow that is exceeded for 90 percent of the time (Gordon et al., 1992). To determine changes to the low flow regime of northern Australian rivers, this metric is calculated under Scenario A for all 77 years, then the number of days that flow is below this threshold in any hydrological year (September to August) is calculated for all other scenarios. The mean number of days below this threshold across all years is then calculated and reported for all scenarios. It has been noted by Petheram et al. (2008) that for many of the streams of northern Australia the value of this flow metric is zero, therefore it is best suited to rivers where flow is perennial. In streams that cease to flow a more suitable metric is the mean number of days per year with zero flow. Finally, changes to the low flow regime are also assessed through changes to the mean dry season (May to October) flow.

Many of the wetlands of northern Australia require flood or high level flows to facilitate connectivity with other water bodies, therefore it is essential that some metrics for assessing the change to the high flow regime at selected assets are also defined. The flow above which floodplains commence inundation is not known for most of the asset locations. We must therefore rely on some other metric of high flow as a surrogate. Other studies have used high flow metrics based on flows exceeded between 10 and 1 percent of the time (Olden and Poff, 2003; Kennard et al., In Press). In this project the flow exceeded 5 percent of the time for all 77 years is calculated under Scenario A. The number of days above this threshold is then calculated for each hydrologic year and for all scenarios. This project reports, under all scenarios, the mean number of days per year that flow is above this threshold. Changes to high flows are also assessed through changes to the mean wet season (November to April) flow.

The final and most general metric reported is changes to the mean annual flow. Such a metric when combined with wet season and dry season metrics described above gives a good indication of the direction of changes to the hydrological regime under the given scenarios.

The above low and high flow metrics are summarised as:

- annual flow (mean)
- wet season flow (mean)
- dry season flow (mean)
- low flow threshold (discharge exceeded 90 percent of the time in Scenario A)
- number of days below low flow threshold (mean)
- number of days of zero flow (mean)
- high flow threshold (discharge exceeded 5 percent of the time in Scenario A)
- number of days above high flow threshold (mean).

In reporting changes to the hydrological regime at an environmental asset it is important to consider the confidence levels in modelled streamflow. Confidence in results for low and high flows is reported separately on a scale of 1 to 5, with 1 indicating results with the highest confidence (see Section 2.2.6 in this chapter). Hydrological regime metrics for both high and low flows are only reported where confidence levels are 1, 2 or 3. If either the high or low flow metrics are ranked 4 or 5, results are not reported.

The Daly region of the Timor Sea Drainage Division offers a unique opportunity within this project as it has a groundwater model which enables assessment of the changes to groundwater depths and flows under the different scenarios. Similar metrics to those employed for surface water flows are used to assess changes to groundwater flows. Groundwater flows are important for discharge of streams and sustaining base flows while groundwater depth is important for groundwater dependant ecosystems.

The most general metric reported is changes to the mean annual contribution of groundwater flow to streamflow at a location. Such a metric when combined with similar wet and dry season metrics gives a good indication of the direction of changes to the hydrological regime under the given scenarios. To determine changes to the low flow groundwater regime the flow exceeded 90 percent of the time is calculated for Scenario A; then the number of days flow is below this threshold is reported for all scenarios. Similarly, changes to the high flow groundwater regime will be assed using a similar method but by using the flow exceeded 5 percent of the time. The metric used to assess change to groundwater depth under different scenarios is mean dry season groundwater depth. Only the dry season depth is used as a metric because this reflects the period when groundwater dependent ecosystems are most likely to be exposed to water stress.

Groundwater level is reported as depth below the soil surface. A reduction of groundwater level under a given scenario (i.e. negative value) means the groundwater level is shallower and vice versa.

The groundwater flow metrics are summarised as:

- annual groundwater contribution to streamflow (mean)
- wet season (November-April) groundwater flow (mean)
- dry season (May-October) groundwater flow (mean)
- low flow threshold (discharge exceeded 90 percent of the time under Scenario A)
- number of days below low flow threshold (mean)
- high flow threshold (discharge exceeded 5 percent of the time under Scenario A)
- number of days above high flow threshold (mean)
- dry season depth to groundwater (mean).

3.3 Summary of assessments

All of the environmental assets used in this project and the type of flow regime assessment performed for each one are listed by drainage division in the sections below (Table 7, Table 8 and Table 9). The asset type classification has been taken from the report on ecological assets of Northern Australia by SKM (2009). Assessment types are grouped into those where site-specific surface water metrics were available (see section 3.1), those where site specific groundwater metrics were available, and those where standard metrics are used for either the surface water regime and groundwater regime. Table 7, Table 8 and Table 9 also identify the confidence level in the hydrological regime at each asset. In reporting results, confidence levels of 1, 2 or 3 were considered reliable, while confidence levels of 4 or 5 were considered unreliable. Green dots (●) indicate that the confidence levels for both high and low flows is 3 or better, amber diamonds (✸) indicate that the confidence levels for only one of the high or low flows is 3 or better and red triangles (▲) indicate that the confidence levels for both high and low flows is 4 or 5.

3.3.1 Timor Sea Drainage Division

The Timor Sea Drainage Division has a total of 43 environmental asset nodes for which surface and/or groundwater metrics were calculated for each of the scenarios (Table 7). Groundwater modelling for environmental assets assessments was only available for two locations in the Daly region and there are only three locations where site specific surface metrics are available. The remaining environmental assets have standard surface water metric analysis only Figure 18 shows that the flow regime confidence levels for high flows are 3 or better for around 80 percent of environmental asset nodes. Low flows are less reliable with confidence levels 3 or better for 56 percent of environmental asset nodes.

Table 7. List of environmental assets considered in the Timor Sea Drainage Division including river basins which drain to the asset, types of assessment undertaken and confidence in model results (see text for full explanation)

Asset name	Node	River basin(s)	Asset Type*	Assessment Type			
				Specific surface water metric	Specific ground-water metric	Standard surface water metric	Standard ground-water metric
Fitzroy (WA) region							
Camballin Floodplain (Le Livre Swamp System)	1	Fitzroy River	L, P, & R			●	
Camballin Floodplain (Le Livre Swamp System)	2	Fitzroy River	L, P, & R.	●		●	
Geikie Gorge	1	Fitzroy River	R			●	
Roebuck Bay	1	Cape Leveque Coast	C & M			▲	
Roebuck Bay	2	Cape Leveque Coast	C & M			▲	
Roebuck Bay	3	Cape Leveque Coast	C & M			▲	

Asset name	Node	River basin(s)	Asset Type*	Assessment Type			
Roebuck Bay	4	Cape Leveque Coast	C & M			▲	
Windjana Gorge	1	Lennard River	R			✷	
Kimberley region							
Drysdale River	1	Drysdale River	R			●	
Mitchell River System	1	King Edward River	E & R			✷	
Mitchell River System	2	King Edward River	E & R			●	
Prince Regent River System	1	Prince Regent River	E & R			▲	
Ord-Bonaparte region							
Lake Argyle	1	Ord River	A & L			✷	
Lake Kununurra	1	Ord River	A & L			●	
Lake Kununurra	2	Ord River	A & L			●	
Ord Estuary System	1	Keep River	C & E			▲	
Ord Estuary System	2	Keep River	C & E			▲	
Ord Estuary System	3	Keep River	C & E			▲	
Parry Floodplain	1	Ord River	L & P			●	
Parry Floodplain	2	Ord River	L & P			✷	
Daly region							
Daly River Middle Reaches	1	Daly River	R			●	
Daly River Middle Reaches	2	Daly River	R			●	
Daly River Middle Reaches	3	Daly River	R	●		●	●
Daly-Reynolds Floodplain-Estuary System	1	Daly River	E, L, P, & R			●	●
Katherine River Gorge	1	Daly River	R			●	
Van Diemen region							
Adelaide River Floodplain System	1	Adelaide River	E, L, P, & R			✷	
Finniss Floodplain and Fog Bay Systems	1	Finniss River	E, P, & R			●	
Kakadu National Park	1	Wildman River	C, E, L, P, & R			●	
Kakadu National Park	2	Wildman River	C, E, L, P, & R			●	
Kakadu National Park	3	South Alligator River	C, E, L, P, & R			✷	
Kakadu National Park	4	South Alligator River	C, E, L, P, & R			●	
Kakadu National Park	5	East Alligator River	C, E, L, P, & R			●	
Kakadu National Park	6	East Alligator River	C, E, L, P, & R			●	
Mary Floodplain System	1	Adelaide River	E, P, & R			●	
Port Darwin	1	Finniss River	C & M			●	
Port Darwin	2	Finniss River	C & M			✷	
Port Darwin	3	Finniss River	C & M			●	
Murgenella-Cooper Floodplain System	1	East Alligator River	E & P			▲	
Murgenella-Cooper Floodplain System	2	East Alligator River	E & P			●	
Arafura region							
Arafura Swamp	1	Goyder River	P & R			✷	
Arafura Swamp	2	Goyder River	P & R			✷	
Blyth-Cadell Floodplain & Boucaut Bay System	1	Blyth River	E & P			●	
Blyth-Cadell Floodplain & Boucaut Bay System	2	Blyth River	E & P			●	

* From SKM (2009) L – Lacustrine, P – Palustrine, R – Riverine, E – Estuarine, C – Coastal, M – Marine, A - Artificial

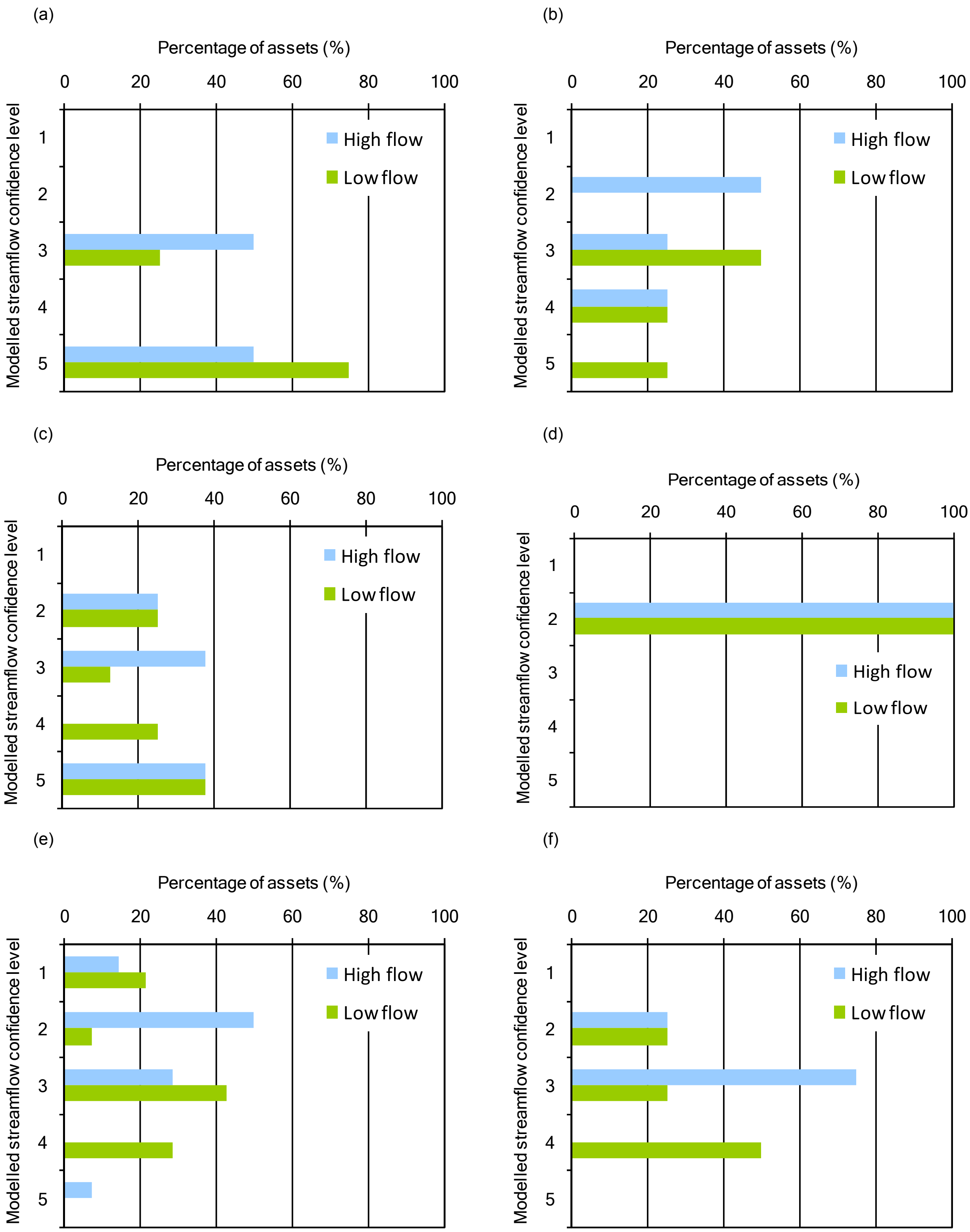

Figure 18. High and low flow regime confidence levels for environmental asset reporting nodes in the Fitzroy (a), Kimberley (b), Ord-Bonaparte (c), Daly (d), Van Diemen (e), and Arafura (f) regions

3.3.2 Gulf of Carpentaria Drainage Division

The Gulf of Carpentaria Drainage Division has a total of 41 environmental asset nodes for which surface water metrics were calculated for each of the scenarios (Table 8). There are no assets where groundwater metrics can be calculated. There are no locations where site specific surface metrics are available, so all the assets have standard surface water metric analysis only. Figure 19 shows that the flow regime confidence levels for high flows are 3 or better for around 60 percent of environmental asset nodes. Low flows are much less reliable with confidence levels 3 or better only occurring at 25 percent of environmental asset nodes.

Table 8. List of environmental assets considered in the Gulf of Carpentaria Drainage Division including river basins which drain to the asset, types of assessment undertaken and confidence in model results (see text for full explanation)

Asset name	Node	River basin(s)	Asset Type*	Assessment Type			
				Specific surface water metric	Specific ground-water metric	Standard surface water metric	Standard ground- water metric
Roper region							
Limmen Bight (Port Roper) Tidal Wetlands System	1	Roper River	E			▲	
Limmen Bight (Port Roper) Tidal Wetlands System	2	Roper River	E			▲	
Limmen Bight (Port Roper) Tidal Wetlands System	3	Roper River	E			▲	
Limmen Bight (Port Roper) Tidal Wetlands System	4	Roper River	E			▲	
Limmen Bight (Port Roper) Tidal Wetlands System	5	Limmen Bight River	E			▲	
Mataranka Thermal Springs	1	Roper River	A & L			▲	
South-West Gulf region							
Gregory River	1	Nicholson River	P & R			✸	
Nicholson Delta Aggregation	1	Nicholson River	L, P, & R			▲	
Nicholson Delta Aggregation	2	Nicholson River	L, P, & R			▲	
Port McArthur Tidal Wetland System	1	McArthur River	C, E, L, & M			▲	
Port McArthur Tidal Wetland System	2	McArthur River	C, E, L, & M			▲	
Port McArthur Tidal Wetland System	3	Robinson River	C, E, L, & M			✸	
Port McArthur Tidal Wetland System	4	McArthur River	C, E, L, & M			▲	
Port McArthur Tidal Wetland System	5	Robinson River	C, E, L, & M			▲	
Thorntonia Aggregation	1	Nicholson River	P & R			✸	
Thorntonia Aggregation	2	Nicholson River	P & R			✸	
Thorntonia Aggregation	3	Nicholson River	P & R			✸	
Southern Gulf Aggregation	1	Nicholson River	C, E, L, M, P, & R			▲	
Flinders-Leichhardt region							
Lake Julius	1	Leichhardt River	A, L, & P			●	
Southern Gulf Aggregation	2	Leichhardt River	C, E, L, M, P, & R			●	
Southern Gulf Aggregation	3	Flinders River	C, E, L, M, P, & R			●	
South-East Gulf region							
Southern Gulf Aggregation	4	Norman River	C, E, L, M, P, & R			▲	
Dorunda Lakes Area	1	Staaten River	L, P, & R			▲	
Smithburne - Gilbert Fan Aggregation	1	Gilbert River	L, P, & R			●	
Mitchell region							
Mitchell River Fan Aggregation	1	Mitchell River	L, P, & R			●	
Western Cape region							
Archer River Aggregation	1	Archer River	E, L, P, & R			✸	
Archer River Aggregation	2	Archer River	E, L, P, & R			●	
Archer River Aggregation	3	Archer River	E, L, P, & R			✸	
Archer River Aggregation	4	Archer River	E, L, P, & R			✸	
Jardine River Wetland Aggregation	1	Jardine River	E, P, & R			✸	
Jardine River Wetland Aggregation	2	Jardine River	E, P, & R			✸	
Northern Holroyd Plain Aggregation	1	Holroyd River	E, L, P, & R			✸	

Asset name	Node	River basin(s)	Asset Type*	Assessment Type			
Northern Holroyd Plain Aggregation	2	Coleman River	E, L, P, & R			✸	
Northern Holroyd Plain Aggregation	3	Holroyd River	E, L, P, & R			●	
Northern Holroyd Plain Aggregation	4	Holroyd River	E, L, P, & R			✸	
Port Musgrave Aggregation	1	Ducie River	E, P, & R			●	
Port Musgrave Aggregation	2	Ducie River	E, P, & R			✸	
Port Musgrave Aggregation	3	Ducie River	E, P, & R			✸	
Port Musgrave Aggregation	4	Ducie River	E, P, & R			✸	
Port Musgrave Aggregation	5	Ducie River	E, P, & R			✸	
Port Musgrave Aggregation	6	Wenlock River	E, P, & R			▲	

* From SKM (2009) L – Lacustrine, P – Palustrine, R – Riverine, E – Estuarine, C – Coastal, M – Marine, A – Artificial

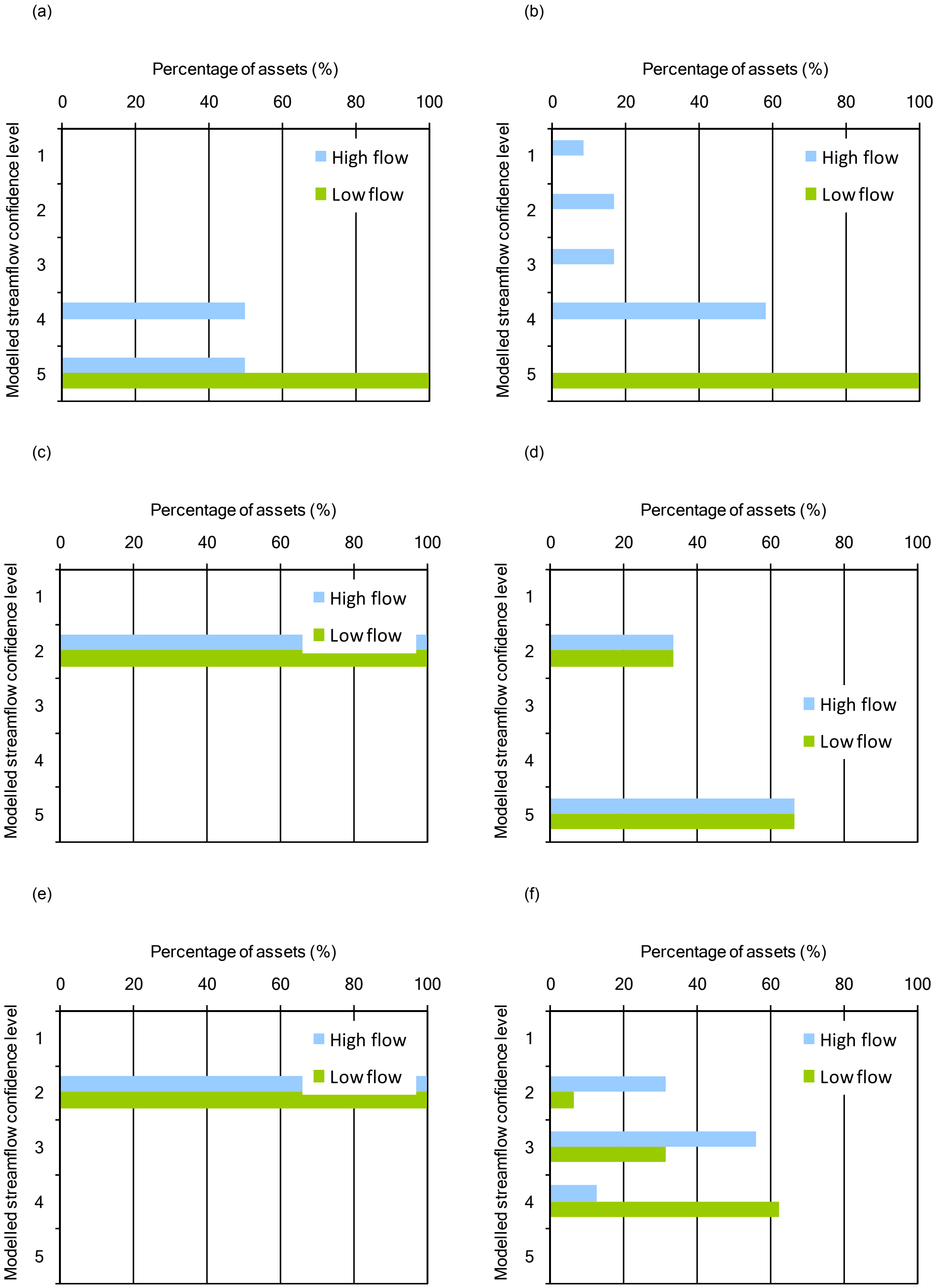

Figure 19. High and low flow regime confidence levels for environmental asset reporting nodes in the Roper (a), South-West Gulf (b), Flinders-Leichhardt (c), South-East Gulf (d), Mitchell (e), and Western Cape (f) regions

3.3.3 Northern North-East Coast Drainage Division

The Northern North-East Coast Drainage Division has a total of 12 environmental asset nodes for which surface water metrics were calculated for each of the scenarios (Table 9). All of these assets are in the Northern Coral region. There are no assets where groundwater metrics can be calculated and no assets where site specific surface metrics are available, so all the assets have standard surface water metric analysis only. Figure 20 shows that the flow regime confidence levels for high flows are 3 or better for around 75 percent of environmental asset nodes. Low flows are much less reliable with confidence levels 3 or better only occurring at 25 percent of environmental asset nodes.

Table 9. List of environmental assets considered in the Northern North-East Drainage Division including river basins which drain to the asset, types of assessment undertaken and confidence in model results (see text for full explanation)

Asset name	Node	River basin(s)	Asset Type*	Assessment Type			
				Specific surface water metric	Specific ground-water metric	Standard surface water metric	Standard ground-water metric
Northern Coral region							
Lloyd Bay	1	Lockhart River	E, L, M, P, & R			✸	
Lloyd Bay	2	Lockhart River	E, L, M, P, & R			✸	
Lower Daintree River	1	Daintree River	E, M, P, & R			●	
Marine Plains – Lakefield Aggregation	1	Normanby River	E, L, & P			●	
Marine Plains – Lakefield Aggregation	2	Normanby River	E, L, & P			✸	
Marine Plains – Lakefield Aggregation	3	Normanby River	E, L, & P			✸	
Marine Plains – Lakefield Aggregation	4	Normanby River	E, L, & P			●	
Marine Plains – Lakefield Aggregation	5	Normanby River	E, L, & P			✸	
Newcastle Bay – Escape River Estuarine Complex	1	Jacky Jacky Creek	R			▲	
Newcastle Bay – Escape River Estuarine Complex	2	Jacky Jacky Creek	R			▲	
Newcastle Bay – Escape River Estuarine Complex	3	Jacky Jacky Creek	R			▲	
Olive River	1	Olive-Pascoe Rivers	R			✸	

* From SKM (2009) L – Lacustrine, P – Palustrine, R – Riverine, E – Estuarine, C – Coastal, M – Marine, A – Artificial

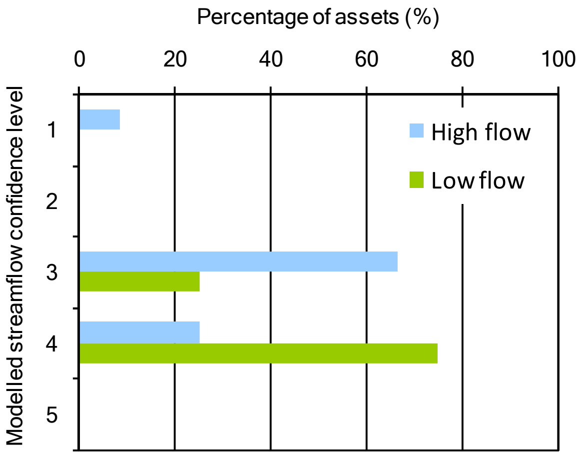

Figure 20. High and low flow regime confidence levels for environmental asset reporting nodes in the Roper (a), South-West Gulf (b), Flinders-Leichhardt (c), South-East Gulf (d), Mitchell (e), and Western Cape (f) regions

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4 Results and discussion

4.1 Site specific metrics

There are only three environmental assets where there is sufficient information about the relationships between flow regime and key species of plants or animals for specific metrics to be derived. They are the Camballin Floodplain, the Lower Ord downstream of Lake Kununurra and Daly River Middle Reaches all of which are in the Timor Sea Drainage Division.

4.1.1 Camballin Floodplain (Le Livre Swamp System)

Note that results discussed in this section should be treated with some caution as the rating curve for this location is currently being refined.

At Camballin Barrage, which is located near the Camballin Floodplain environmental asset (see Appendix 1, Figure 22), environmental flow metrics have been defined by Morgan et al. (2005) which are related to fish passage across the barrage. The number of days when the flow is above the 8.0 GL/day threshold needed for fish passage to commence increased by 27.6 days per year under Scenario B when compared to Scenario A which averaged 69 days per year (Table 10) relative to Scenario A. There is little change to the exceedance of this flow threshold under Scenarios Cmid and Cwet, but there is a decrease of 15.9 days per year under Scenario Cdry when compared to Scenario A. The number of days when the flow is above the higher flow threshold of 28.8 GL/day (unimpeded fish passage) increases considerably under Scenario B (Table 10). There is little change to the exceedance of this flow threshold under Scenarios Cmid and Cwet, but there is a moderate decrease in this threshold exceedance under Scenario Cdry. Fish passage across the barrage would likely be facilitated under Scenario B, but restricted under Scenario Cdry.

Table 10. Site-specific reported metrics for changes to flow regime at Camballin Barrage under Scenario A and under scenarios B, C and D relative to Scenario A

Reported metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Camballin Floodplain - Fish passage across Camballin Barrage									
Number of days with flows above 8.0 GL/d (mean) *	d/y	69	+27.6	+3.9	-1.7	-15.9	nm	nm	nm
Number of days with flows above 28.8 GL/d (mean) **	d/y	42	+24.9	+3.3	-1.1	-12.3	nm	nm	nm

* Fish passage across barrage commences.

** Fish passage across barrage unimpeded.

nm – not modeled.

4.1.2 Lower Ord downstream of Lake Kununurra

The environmental flow requirements of the lower Ord River downstream of the Kununurra Diversion Dam have been defined by Braimbridge and Malseed (2007). The Department of Water, Western Australia have recognised the intrinsic ecological values of the region below the Ord River Dam and as such have developed an environmental water requirement regime based on the flow requirements defined by Braimbridge and Malseed (2007). It should be noted that the low flow threshold of Braimbridge and Malseed (2007) is the same as the minimum environmental flow release from the Kununurra Diversion Dam during the dry season months under conditions of no water restrictions. The environmental flow release is progressively reduced under Level 1 and 2 water restrictions for the irrigation area. For Level 1 and Level 2 water restrictions the minimum environmental flow release is reduced to 37 m^3/second (3.2 GL/day) and 32.3 m^3/second (2.8 GL/day), respectively. Being a managed system the opportunity exists in the future to modify release rules for the storage in order to deal with changing water resource conditions.

Table 11 shows how these site-specific metrics changed under the various scenarios. Under Scenario A flow is below the low flow threshold of 3.63 GL/day on just eight days/year on average. Under Scenario B flow is never under this threshold and Scenario Cmid shows little change when compared to Scenario A. However, there is a large increase in low flow days under Scenario Cdry when compared to Scenario A. Under Scenario D the combination of climate change and development results in even longer periods below the suggested low flow threshold when compared to scenario A. While there were an additional 1.3 days/year below the threshold under Scenario Cmid, this increased to an additional 15 days/year under Scenario Dmid. This implies that much of the change to be expected with regard to this flow metric is attributed to the proposed development. Current operating rules will require adaption if such conditions develop.

Table 11. Site-specific reported metrics for changes to flow regime at Lake Kununurra

Reported metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Lower Ord downstream of Lake Kununurra – Node 2 (confidence level: low flow = <3, high flow = <3)									
Number of days with flows below 3.63 GL/d (mean) (1)	d/y	8.1	-8.1	-4.3	-1.3	+44.6	-1.4	+14.6	+70.4
Number of days with flows above 10.80 GL/d (mean) (2)	d/y	58	+80.7	+16.2	+2.6	-25.7	+10.3	-2.6	-30.8
Number of days with flows above 36.72 GL/d (mean) (3)	d/y	15	+43	+10.5	+1.7	-7.8	+11.5	+2.5	-7.2

(1) Threshold for fish and macrophyte habitat requirements

(2) Threshold for deep backwater habitat and flooded riparian benches

(3) Threshold for fish passage by migratory species

The effect of the various scenarios on the Braimbridge and Malseed (2007) high flow thresholds are also shown in Table 11. Their first high flow threshold 10.8 GL/day is exceeded for much more than the minimum ten day requirement in all scenarios, despite the large changes in high flow threshold exceedance that occurs between scenarios. The same is true for the second high flow threshold 36.7 GL/day, which is exceeded for much more than the minimum two days required to maintain fish passage. This implies that regular inundation of riparian zones and deep backwater pools as well as fish passage for migratory species is maintained in all the climate and development scenarios.

4.1.3 Daly River Middle Reaches (Oolloo Crossing)

At Oolloo Crossing, which falls within the bounds of the Daly River Middle Reaches (see Appendix 1, Node 3 on Figure 32), environmental flow metrics have been defined by Erskine et al. (2003; 2004) which relate to habitat suitability for key plant and animal species. The first of these is a threshold of 1.04 GL/day, which is the minimum recommended flow threshold for Pig-Nosed Turtles (*Carettochelys insculpta*) and *Vallisneria nana* beds. Under Scenario A there is an average of 151 days per year when conditions are below the threshold (Table 12). This number decreases greatly under scenarios B, Cwet and Dwet. There is little change to the number of days below the identified threshold under scenarios Cmid and Dmid. The greatest increase in days below the threshold for the nesting success of the Pig-Nosed Turtle and the number of *V. nana* beds is under scenarios Cdry and Ddry with 30 and 37 percent increases, respectively. These changes are likely to result in a reduction in the number of *V. nana* beds and a decline in the nesting success of the Pig-Nosed Turtle.

The minimum flow requirement to maintain the transpiration requirements of riparian vegetation has been reported by Erskine et al. (2003) to be 0.17 GL/day at the Oolloo Crossing gauge. The flow threshold analysis showed that flow levels were maintained above this level under all scenarios (Table 12), so there is likely to be little or no impact of climate or development on transpiration of riparian vegetation at this asset.

Table 12. Site-specific reported metrics for changes to flow regime at Daly River Middle Reaches

Reported metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Daly River Middle Reaches - Pig-Nosed Turtle nesting habitat suitability and *V. nana* bed occurrence									
Number of days with flows below identified threshold (mean)*	d/y	151	-139.6	-49.1	+9.8	+45.3	-47.7	+13.4	+56.3
Daly River Middle Reaches - Riparian vegetation water requirement									
Number of days with flows below identified threshold (mean)**	d/y	0	0	0	0	0	0	0	0

*Pig-Nosed Turtle nesting habitat threshold = 1.037 GL/day (see text for explanation).

**Riparian vegetation threshold = 0.17 GL/day (see text for explanation).

4.2 Standard metrics

4.2.1 Timor Sea Division

The standard metric analysis was undertaken for 43 environmental asset reporting nodes in the Timor Sea Division. Results for all nodes are presented in Appendix 2. This Section provides an overview of results for each asset in each region. For assets with more than one reporting node a single node was selected for the overview below. The selected node was that with the highest streamflow confidence level and the largest proportion of streamflow to the asset. It should be noted that the conversion of these standard metrics into environmental impacts still requires development of quantitative relationships between flow and ecology. In this division, nine environmental asset reporting nodes do not have flow data with sufficient reliability to estimate change under any of the scenarios.

Fitzroy (WA) Region

Four environmental assets have been analysed in the Fitzroy region: Camballin Floodplain, Geikie Gorge, Windjana Gorge and Roebuck bay; the locations of these assets are shown in Figure 5. The surface water flow confidence level for Roebuck bay is 5 for both high and low flows which are too unreliable to allow environmental flow metrics to be calculated for this asset. Changes to the flow regime at the remaining assets are broadly similar and so they are summarised collectively below.

Under Scenario A annual flow into the assets in the Fitzroy region is dominated by wet season flows (over 95 percent) which are significantly higher (30 to 60 percent) under Scenario B (Table 13 and Appendix 2). Conversely dry season flows tend to be lower under Scenario B relative to Scenario A. Annual and seasonal flows do not change much under Scenario Cmid, but there are moderate to large increases under Scenario Cwet (16 to 31 percent) and moderate to large decreases under Scenario Cdry (16 to 45 percent) compared to Scenario A. There are no development scenarios for the areas upstream of the Fitzroy region assets.

The number of days when flow is less than the low flow threshold does not change much under Scenarios Cmid and Cwet, but there is a large increase under Scenario Cdry (Table 13) relative to Scenario A. A similar pattern is seen in the number of days of zero flow, which currently range from 12 to 126 days at the Fitzroy region assets examined. Under Scenario B the high flow threshold exceedance is much more frequent than under Scenario A. There is little change in high flow threshold exceedance under Scenario Cmid compared to Scenario A. Under Scenario Cwet there is a moderate increase in high flow exceedance from Scenario A; conversely there is a large decrease in high flow days under Scenario Cdry.

Table 13. Standard metrics for changes to flow regime at environmental assets in the Fitzroy (WA) region under Scenario A and under scenarios B, C and D relative to Scenario A

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Geikie Gorge - Node 1 (confidence level: low flow = 3, high flow = 3)									
Annual flow (mean)	GL	2290	+50%	+16%	-7%	-31%	nm	nm	nm
Wet season flow (mean)*	GL	2240	+52%	+16%	-7%	-30%	nm	nm	nm
Dry season flow (mean)**	GL	49.5	-18%	+31%	-3%	-45%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0							
Number of days below low flow threshold (mean)	d/y	62.2	-25.5	-1.9	+2.4	+22	nm	nm	nm
Number of days of zero flow (mean)	d/y	62.2	-25.5	-1.9	+2.4	+22	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	34.5							
Number of days above high flow threshold (mean)	d/y	18.3	+13.2	+2.5	-0.9	-6.7	nm	nm	nm
Camballin Floodplain (Le Livre Swamp System) - Node 2 (confidence level: low flow = 5, high flow = 3)									
Annual flow (mean)	GL	7540	+56%	+17%	-6%	-36%	nm	nm	nm
Wet season flow (mean)*	GL	7380	+58%	+16%	-6%	-36%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	111							
Number of days above high flow threshold (mean)	d/y	18.3	+12.4	+2.1	-0.9	-7	nm	nm	nm
Windjana Gorge - Node 1 (confidence level: low flow = 5, high flow = 3)									
Annual flow (mean)	GL	366	+27%	+16%	-7%	-29%	nm	nm	nm
Wet season flow (mean)*	GL	354	+29%	+16%	-7%	-29%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	3.89							
Number of days above high flow threshold (mean)	d/y	18.3	+10	+1.5	-0.5	-6.6	nm	nm	nm

*Wet season covers the six months from November to April.
**Dry season covers the six months from May to October.
NR – metrics not reported because streamflow confidence level is ranked 4 or 5
nm – not modelled

Kimberley Region

Three environmental assets have been analysed in the Kimberly region: Drysdale River, Mitchell River System and Prince Regent River System; the locations of these assets are shown in Figure 6. The surface water flow confidence level for the Prince Regent River System is 4 for high flows and 5 for low flows which are too unreliable to allow environmental flow metrics to be calculated for this asset. Changes to the flow regime at the remaining assets are broadly similar and so they are summarised collectively below.

Table 14. Standard metrics for changes to surface water flow regime at environmental assets in the Kimberley region

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Drysdale River - Node 1 (confidence level: low flow = 3, high flow = 3)									
Annual flow (mean)	GL	667	+77%	+6%	-2%	-27%	nm	nm	nm
Wet season flow (mean)*	GL	637	+77%	+5%	-3%	-27%	nm	nm	nm
Dry season flow (mean)**	GL	29.8	+67%	+10%	+2%	-39%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.00012							
Number of days below low flow threshold (mean)	d/y	36.5	-29.8	-2.3	+3	+34.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	32.7	-27.7	-2.1	+3	+33.8	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	10.7							
Number of days above high flow threshold (mean)	d/y	18.3	+20	+1.5	-0.7	-6.7	nm	nm	nm
Mitchell River System - Node 2 (confidence level: low flow = 3, high flow = 2)									
Annual flow (mean)	GL	382	+69%	+9%	-5%	-23%	nm	nm	nm
Wet season flow (mean)*	GL	370	+70%	+9%	-5%	-22%	nm	nm	nm
Dry season flow (mean)**	GL	11.9	+34%	+10%	-1%	-33%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.00774							
Number of days below low flow threshold (mean)	d/y	36.5	-35.2	-3.2	+11.2	+42	nm	nm	nm
Number of days of zero flow (mean)	d/y	1.17	+0.2	0	0	+0.3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	5.55							
Number of days above high flow threshold (mean)	d/y	18.3	+15.2	+1.6	-1.1	-5.8	nm	nm	nm

* Wet season covers the six months from November to April.

** Dry season covers the six months from May to October.

NR – metrics not reported because streamflow confidence level is ranked 4 or 5.
nm – not modelled.

Under Scenario A annual flow into the assets in the Kimberley region is dominated by wet season flows (96 to 97 percent) which are 70 to 77 percent higher under Scenario B (Table 14 and Appendix 2). Dry season flows are also 34 to 67 percent higher under Scenario B when compared to Scenario A. Annual and seasonal flows do not change much under Scenarios Cmid and Cwet compared to Scenario A, but there are large decreases under Scenario Cdry (22 to 39 percent). There are no development Scenarios for the area upstream of this asset.

The number of days when flow is less than the low flow threshold does not change very much under Scenarios Cwet, but under Scenario Cdry the number of low flow days doubles (Table 14) relative to Scenario A. A similar pattern is seen in the number of days of zero flow in rivers such as the Drysdale, but as these are very rare in the Mitchell River System, there is little change under any of the scenarios for this river. Under Scenario B the high flow threshold exceedance is much more frequent than under Scenario A. There is little change in high flow threshold exceedance under Scenarios Cmid and Cwet relative to Scenario A. Under Scenario Cdry there is a large decrease in high flow threshold exceedance compared to Scenario A.

Ord-Bonaparte Region

Four environmental assets have been analysed in the Ord-Bonaparte region: Lake Argyle, Lake Kununurra, the Ord Estuary System and the Parry Floodplain. The locations of these assets are shown in Figure 7. The surface water flow confidence level for the Ord Estuary System is 5 for both high flows and low flows which are too unreliable to allow environmental flow metrics to be calculated for this asset. While surface water modelling from this study is considered unreliable for the lower Ord River, it should be noted that a detailed hydrodynamic model has been developed for the Ord estuary (Robson et al., 2008) which could be used to assess flow metrics for this area. However, application of this hydrodynamic model is beyond the scope of this study. Changes to the flow regime at the remaining assets are reported separately as they are quite different and based on different surface and groundwater modelling schemes.

Kununurra Diversion Dam (see location on Figure 7) is operated with the aim of maintaining the water level in the lake at as close as possible to 41.9 m AHD. The reservoir is operated to maintain this level to enable water to be gravity fed through most of the irrigation district. As a result of the management procedure the level in Kununurra Diversion Dam is a relatively stable system which will vary little across scenarios. Of more importance are the changes to assets downstream of the storage and these are discussed below for Parry Floodplain (standard metrics) and in Section 4.1.2 for the Lower Ord River below the dam (site-specific metrics).

Under Scenario A annual flow into Lake Argyle is highly dominated by wet season flows (98 percent) which are 68 percent higher under Scenario B (Table 15). Annual and wet seasonal flows do not change much under Scenario Cmid when compared to Scenario A. There are moderate decreases in wet season flow under Scenario Cdry (22 percent) when compared to Scenario A and moderate increases under Scenario Cwet (20 percent). There are no development scenarios for the area upstream of this asset.

Under Scenario B the high flow threshold exceedance has been much more frequent than under Scenario A. There is little change in high flow threshold exceedance under Scenario Cmid. Under Scenario Cwet high flow exceedance increases moderately compared to Scenario A; conversely, there is a moderate decrease in high flow days under Scenario Cdry.

Table 15. Standard metrics for changes to surface water flow regime at environmental assets in the Ord-Bonaparte region

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Lake Argyle - Node 1 (confidence level: low flow = 4, high flow = 3)									
Annual flow (mean)	GL	4260	+69%	+20%	+3%	-22%	nm	nm	nm
Wet season flow (mean)*	GL	4180	+68%	+20%	+4%	-22%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	54							
Number of days above high flow threshold (mean)	d/y	18.3	+12.2	+2.6	+0.4	-4.6	nm	nm	nm
Parry Floodplain - Node 1 (confidence level: low flow = <3, high flow = <3)									
Annual flow (mean)	GL	3590	+95%	+23%	+3%	-27%	+11%	-9%	-37%
Wet season flow (mean)*	GL	2250	+103%	+24%	+4%	-29%	+17%	-3%	-37%
Dry season flow (mean)**	GL	1340	+81%	+21%	+2%	-25%	+1%	-17%	-38%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	3.63							
Number of days below low flow threshold (mean)	d/y	8.1	-8.1	-4.3	-1.3	+44.6	-1.4	-14.6	+70.4
Number of days of zero flow (mean)	d/y	0.013	0	0	0	+0.2	0	0	+0.2
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	32.3							
Number of days above high flow threshold (mean)	d/y	18.3	+45.1	+11.2	+1.8	-9.2	+12.2	+2.5	-9.1

*Wet season covers the six months from November to April.

**Dry season covers the six months from May to October.

NR – metrics not reported because streamflow confidence level is ranked 4 or 5
nm – not modelled..

The Parry Floodplain (Node 1; see Appendix 1 Figure 33) is representative of the conditions experienced in the lower Ord River which, since the construction of the Ord River Dam, only contributes significant flood water to the Parry Floodplain during very large floods. While this river is adjacent to the defined boundaries of this asset it should be noted that much of the wet season runoff and flooding generated at this asset comes from the local creeks that drain this sub-catchment area. This coupled with the regulated nature of flows in the Ord River below the Ord River Dam means that caution must be exercised in the interpretation of results for this asset.

Under Scenario A annual flows into this asset are more evenly distributed between the wet season (63 percent) and the dry season (37 percent), because the dry season flows are sustained by water releases from the Kununurra Dam (Table 15). Under Scenario B flows are about twice those under Scenario A. Annual and wet seasonal flows do not change much under Scenario Cmid when compared to Scenario A, but there are moderate decreases in flow (25 to 29 percent) under Scenario Cdry and moderate increases in flow under Scenario Cwet (21 to 24 percent). There are also moderate decreases in annual and seasonal flows under Scenario Dmid when compared to Scenario A, so these must be due to the upstream water development plans. When these plans are combined with the dry climate option (i.e. Scenario Ddry), there are large changes in annual and seasonal flows (37 to 38 percent).

Under the wetter conditions of Scenario B, flows are maintained above the low flow threshold under Scenario A at all times. The number of days when flow is less than the low flow threshold does not change very much under Scenarios Cmid and Cwet when compared to Scenario A, but there is a large increase in low flow days under Scenario Cdry (Table 15). Zero flow days are very rare at this asset and this does not change much under any of the scenarios. Adding the upstream development plans to the climate scenarios has a very large effect on the number of days below the low flow threshold under Scenario Dmid and Dwet. It should be noted that due to the regulated nature of the flows to this node, there is an opportunity for dam managers to modify future release rules in order to balance the demands of agriculture, environmental flows and other uses.

Under Scenario B the high flow threshold exceedance is much more frequent than under Scenario A. There is little change in high flow threshold exceedance under Scenario Cmid. Conversely, under Scenario Cwet and Cdry there are very large increases and decreases respectively in the high flow threshold exceedance relative to Scenario A.

Daly Region

Unlike other regions, almost the entire Daly region is represented with an existing, calibrated, regional-scale, FEFLOW numerical groundwater flow model coupled to a calibrated MIKE11 surface water model. Comparison of scenarios using this modelling approach is over a 23-year period rather than the 77-year period used in other modelling approaches. This model has been calibrated against existing gauges and developed over a number of years. Confidence in results, therefore, is considered high enough (i.e. <3) to report standard metrics at all three environmental assets, the Daly Middle Reaches, the Daly-Reynolds Floodplain-Estuary System and the Katherine River George (Figure 8).

Daly River Middle Reaches

Under Scenario A annual flow at the selected node for this asset (see location on Figure 36) is dominated by wet season flows (95 percent) which rise by a factor of ~ 3 under Scenario B (Table 16). Dry season flows are also higher (87 percent) under Scenario B. Annual and seasonal flows do not change much under Scenario Cmid when compared to Scenario A, but there are large increases under Scenario Cwet (26 to 34 percent) and moderate decreases under Scenario Cdry (13 to 32 percent). Changes to annual and seasonal flows under scenarios Dwet, Dmid and Ddry when compared to Scenario A are similar to those under Scenario C, indicating very little additional impact on the hydrological regime as a result of proposed development. Slight increases in flow under Scenario D as compared to Scenario C are possibly the result of changes to the location of major groundwater extraction between these scenarios. Under Scenario C many of the pumping bores are in an area where there is very good connection between the river and the aquifer. Under Scenario D the majority of extraction occurs where there is less connectivity between the aquifer and the river (for more details refer to Harrington et al. (2009)).

The number of days when flow is less than the low flow threshold decreases moderately under Scenario Cmid compared to Scenario A, but there is a large increase in low flow days under Scenario Cdry and a large decrease in low flow days under Scenario Cwet (Table 16). The number of days when flow is less than the low flow threshold also decreases moderately under Scenario Dmid when compared to Scenario A. Scenario Dwet is similar to Cwet indicating little impact due to proposed development, but there is a larger increase in low flow days under Scenario Ddry when compared to Scenario Cdry. There were no zero flow days at this asset under any scenario.

Under Scenario B high flows are much more frequent than under Scenario A. Compared to Scenario A there is little change in high flow threshold exceedance under Scenario Cmid. Under Scenario Cwet high flow exceedance increases moderately from Scenario A; conversely, there is a large decrease in high flow days under Scenario Cdry. Changes to high flow threshold exceedance under scenarios Dwet, Dmid and Ddry are similar to those under Scenario C indicating very little additional impact on hydrological regime due to proposed development.

Table 16. Standard metrics for changes to flow regime at environmental assets in the Daly region under scenarios A, B, C and D

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Daly River Middle Reaches - Node 1 (confidence level: low flow = <3, high flow = <3)									
Annual flow (mean)	GL	6520	+186%	+34%	-1%	-31%	+34%	0%	-32%
Wet season flow (mean)*	GL	6210	+191%	+34%	-1%	-32%	+35%	-1%	-32%
Dry season flow (mean)**	GL	311	+87%	+26%	+2%	-13%	+26%	+2%	-16%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	1.04							
Number of days below low flow threshold (mean)	d/y	36.6	-36.2	-31.9	-6.7	+27.4	-31.1	-5.8	+38.3
Number of days of zero flow (mean)	d/y	0	0	0	0	0	0	0	0
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	108							
Number of days above high flow threshold (mean)	d/y	18.3	+31.6	+5.4	-0.4	-7.7	+5.7	-0.3	-7.7
Daly-Reynolds Floodplain-Estuary System - Node 1 (confidence level: low flow = <3, high flow = <3)									
Annual flow (mean)	GL	8180	+168%	+32%	-1%	-32%	+33%	-1%	-32%
Wet season flow (mean)*	GL	7820	+172%	+33%	-1%	-33%	+34%	-1%	-33%
Dry season flow (mean)**	GL	363	+89%	+24%	+2%	-13%	+25%	+1%	-16%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	1.19							
Number of days below low flow threshold (mean)	d/y	36.6	-36.1	-31.7	-7.2	+25.5	-30.6	-6.3	+35.3
Number of days of zero flow (mean)	d/y	0	0	0	0	0	0	0	0
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	135							
Number of days above high flow threshold (mean)	d/y	18.3	+29.7	+5.7	-0.2	-8.2	+5.9	0	-8.2
Katherine River Gorge - Node 1 (confidence level: low flow = <3, high flow = <3)									
Annual flow (mean)	GL	920	+200%	+26%	+1%	-23%	+26%	+0%	-23%
Wet season flow (mean)*	GL	898	+202%	+26%	+1%	-23%	+26%	+1%	-23%
Dry season flow (mean)**	GL	22.1	+115%	+18%	-3%	-21%	+11%	-10%	-28%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.0569							
Number of days below low flow threshold (mean)	d/y	36.6	-36.3	-29.4	+4.8	+47.4	-9.9	+35	+79.3
Number of days of zero flow (mean)	d/y	0	0	0	0	0	0	0	0
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	14.9							
Number of days above high flow threshold (mean)	d/y	18.3	+32.5	+4.4	+0.1	-4.5	+4.4	+0.1	-4.4

*Wet season covers the six months from November to April.

**Dry season covers the six months from May to October.

NR – metrics not reported because streamflow confidence level is ranked 4 or 5.

Daly-Reynolds Floodplain-Estuary System

Under Scenario A annual flow at the selected node for this asset (see location on Figure 37) is dominated by wet season flows (96 percent) which are 172 percent higher under Scenario B (Table 16). Dry season flows are also 89 percent higher under Scenario B when compared to Scenario A. Annual and seasonal flows do not change much under Scenario Cmid when compared to Scenario A, but there are large increases under Scenario Cwet (24 to 33 percent) and moderate decreases under Scenario Cdry (13 to 33 percent). Changes to annual and seasonal flows under scenarios Dwet, Dmid and Ddry compared to Scenario A are similar to those under Scenario C, indicating very little additional impact on hydrological regime due to proposed development. Slight increases in flow under Scenario D as compared to Scenario C are possibly the result of changes to the location of major groundwater extraction between these scenarios. Under

Scenario C many of the pumping bores are in an area where there is very good connection between the river and the aquifer. Under Scenario D the majority of extraction occurs where there is less connectivity between the aquifer and the river (for more details refer to Harrington et al. (2009)).

The number of days when flow is less than the low flow threshold under Scenario A decreases moderately under scenarios Cmid or Dmid, but there is a large increase in low flow days under Scenario Cdry and a doubling under Scenario Ddry. Conversely, there are large decreases in low flow days under scenarios Cwet and Dwet when compared to Scenario A (Table 16). Scenario Dwet shows very little difference from Scenario Cwet indicating little impact from proposed development. There is a larger increase in low flow days under Scenario Ddry when compared to Scenario Cdry indicating that development is likely to have a much greater impact on dry season flows at this location. There were no zero flow days at this asset under any scenario, so this system remains perennial in all cases.

Under Scenario B high flows are more than twice as frequent as under Scenario A. There is little change in high flow threshold exceedance under Scenario Cmid relative to Scenario A. Under Scenario Cwet high flow exceedance shows a moderate increase from Scenario A; conversely, there is a moderate decrease in high flow days under Scenario Cdry. Changes to high flow threshold exceedance under scenarios Dwet, Dmid and Ddry are similar to those under Scenario C, indicating little additional impact on the hydrological regime as a result of proposed development.

Katherine Gorge

The Katherine River Gorge is located outside the bounds of the coupled groundwater and surface model for the Daly region, however, model results are available at the town of Katherine (Gauge no. G814001 indicated by Node 1 on Figure 38) which is about 25km downstream of the gorge itself. While results are reported for this downstream node it should be noted that they do not represent conditions in the gorge itself. The area around Katherine also supports some agriculture which is expected to be developed further in the near future so these impacts will be seen under Scenario D results.

Under Scenario A annual flow at the selected node for this asset (Figure 38) is dominated by wet season flows (98 percent) which are 202 percent higher under Scenario B (Table 16). Dry season flows are also 115 percent higher under Scenario B. Annual and seasonal flows do not change much under Scenario Cmid when compared to Scenario A, but there are moderate increases under Scenario Cwet (18 to 26 percent) and moderate decreases under Scenario Cdry (21 to 23 percent). Changes to annual and seasonal flows under scenarios Dwet and Dmid compared to Scenario A are similar to those under scenarios Cwet and Cmid, indicating little additional impact (~7 percent) on the hydrological regime due to proposed development. However, comparison of scenarios C and D indicates that development results in lower dry season flows.

Compared to Scenario A the number of days when flow is less than the low flow threshold increases moderately under Scenario Cmid, but there is a doubling of this threshold exceedance under Scenario Dmid. There are even larger increases in low flow days under scenarios Cdry and Ddry, the latter being over three times that under Scenario A. There is also a large decrease in low flow days under Scenario Cwet when compared to Scenario A (Table 16). There is a much larger increase in low flow days under Scenario Ddry when compared to Scenario Cdry indicating drier conditions which take the flow below the low flow threshold of Scenario A much more often. There are no zero flow days at this asset under any scenario, so despite these changes this asset should remain perennial.

Under Scenario B high flows are more than twice as frequent as under Scenario A. There is little change in high flow threshold exceedance under Scenario Cmid when compared to Scenario A. Under Scenario Cwet high flow exceedance increases moderately from Scenario A; conversely, there is a moderate decrease in high flow days under Scenario Cdry. Changes to high flow threshold exceedance under scenarios Dwet, Dmid and Ddry are very similar to those under Scenario C, indicating little additional impact on high flows due to proposed development. For this asset development appears to have the most effect on the low flow regime.

Van Diemen Region

Six environmental assets have been analysed in the Van Diemen region: Murgenella-Cooper Floodplain System, Kakadu National Park, Adelaide River Floodplain System, Finniss Floodplain and Fog Bay Systems, Mary Floodplain System, and Port Darwin; the locations of these assets are shown in Figure 9. Changes to the flow regime at the remaining assets are broadly similar and so they are summarised collectively below.

Table 17. Standard metrics for changes to surface water flow regime at environmental assets in the Van Diemen region

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Murgenella-Cooper Floodplain System - Node 2 (confidence level: low flow = 3, high flow = 3)									
Annual flow (mean)	GL	679	+32%	+21%	-1%	-22%	nm	nm	nm
Wet season flow (mean)*	GL	660	+32%	+22%	-1%	-22%	nm	nm	nm
Dry season flow (mean)**	GL	19.1	+34%	+2%	0%	-24%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.00307							
Number of days below low flow threshold (mean)	d/y	36.5	-13.8	-12.5	+2.1	+26.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	1.19	+0.1	0	+0	+0.4	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	9.63							
Number of days above high flow threshold (mean)	d/y	18.3	+8.3	+5.6	-0.8	-5.6	nm	nm	nm
Kakadu National Park - Node 6 (confidence level: low flow = 3, high flow = 3)									
Annual flow (mean)	GL	1700	+53%	+24%	-3%	-23%	nm	nm	nm
Wet season flow (mean)*	GL	1670	+53%	+24%	-3%	-23%	nm	nm	nm
Dry season flow (mean)**	GL	27.8	+49%	-2%	-1%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.000672							
Number of days below low flow threshold (mean)	d/y	36.5	-18.4	-14.1	+2.6	+27.8	nm	nm	nm
Number of days of zero flow (mean)	d/y	2.21	-0.9	-0.9	+0.2	+3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	26.3							
Number of days above high flow threshold (mean)	d/y	18.3	+13.6	+6.2	-1	-5.7	nm	nm	nm
Adelaide River Floodplain System - Node 1 (confidence level: low flow = 4, high flow = 2)									
Annual flow (mean)	GL	1490	+48%	+29%	0%	-26%	nm	nm	nm
Wet season flow (mean)*	GL	1450	+47%	+29%	0%	-26%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	23.8							
Number of days above high flow threshold (mean)	d/y	18.3	+13.2	+6	-0.2	-7.1	nm	nm	nm
Finniss Floodplain and Fog Bay Systems - Node 1 (confidence level: low flow = 1, high flow = 1)									
Annual flow (mean)	GL	504	+65%	+26%	+0%	-24%	nm	nm	nm
Wet season flow (mean)*	GL	489	+65%	+27%	+0%	-24%	nm	nm	nm
Dry season flow (mean)**	GL	15	+56%	+17%	0%	-28%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.0175							
Number of days below low flow threshold (mean)	d/y	36.5	-33.7	-22.2	+2.3	+39.5	nm	nm	nm
Number of days of zero flow (mean)	d/y	0.792	-0.2	0	0	+0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	8.26							
Number of days above high flow threshold (mean)	d/y	18.3	+17.1	+5.3	+0.1	-5.5	nm	nm	nm
Mary Floodplain System - Node 1 (confidence level: low flow = 1, high flow = 2)									
Annual flow (mean)	GL	1550	+50%	+28%	-1%	-29%	nm	nm	nm
Wet season flow (mean)*	GL	1540	+49%	+28%	-1%	-29%	nm	nm	nm
Dry season flow (mean)**	GL	16.9	+125%	+8%	+1%	-37%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.00118							
Number of days below low flow threshold (mean)	d/y	36.5	-15	-15.5	+4.7	+29.9	nm	nm	nm

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Number of days of zero flow (mean)	d/y	1.42	-0.5	-0.5	+0.4	+6.3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	25							
Number of days above high flow threshold (mean)	d/y	18.3	+11.2	+6.2	-0.3	-7	nm	nm	nm
Port Darwin - Node 3 (confidence level: low flow = 2, high flow = 1)									
Annual flow (mean)	GL	87	+50%	+26%	0%	-21%	nm	nm	nm
Wet season flow (mean)*	GL	84.3	+50%	+26%	0%	-20%	nm	nm	nm
Dry season flow (mean)**	GL	2.75	+50%	+9%	+1%	-27%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.00051							
Number of days below low flow threshold (mean)	d/y	36.5	-19.8	-20.1	+3.8	+27.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	10.6	-4.8	-8	+2	+15.2	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	1.32							
Number of days above high flow threshold (mean)	d/y	18.3	+8.4	+4.5	-0.6	-4.8	nm	nm	nm

*Wet season covers the six months from November to April.

**Dry season covers the six months from May to October.

NR – metrics not reported because streamflow confidence level is ranked 4 or 5
nm – not modelled.

Under Scenario A annual flow into the assets in the Van Diemen region is dominated by wet season flows (97-99 percent) which are 32 to 65 percent higher under Scenario B (Table 17). Dry season flows have also been 34 to 125 percent higher under Scenario B when compared to Scenario A. In contrast, at Port Darwin dry season flows have only increased by 9 percent under Scenario B and wet season flows by only 26 percent. Annual and seasonal flows do not change much under Scenario Cmid compared to Scenario A, but there is a moderate increase under Scenario Cwet (2 to 29 percent) and a moderate to large decrease under Scenario Cdry (22 to 37 percent). There are no development scenarios for the area upstream of this asset.

Compared to Scenario A the number of days when flow is less than the low flow threshold does not change very much under Scenario Cmid, but there is a large decrease in low flow days under Scenario Cwet, and a very large increase in low flow days under Scenario Cdry (Table 17). At many of the assets in this region there are very few zero flow days when this is the case this does not change under any of the scenarios. However, there are some nodes that enter the Kakadu National Park where zero flow occurs for between 27 and 36 percent of the year (on average) and there are moderate increases and decreases in the number of zero flow days under scenarios Cdry and Cwet respectively.

Under Scenario B the high flow threshold exceedance has been much more frequent than under Scenario A. There is little change in high flow threshold exceedance under Scenario Cmid. Under Scenario Cwet there are moderate to large increases in high flow exceedance from Scenario A; conversely there are moderate to large decreases in high flow days under Scenario Cdry.

Arafura Region

Two environmental assets have been analysed in the Arafura region: the Arafura Swamp and the Blyth-Cadell Floodplain and Boucaut Bay System; the locations of these assets are shown in Figure 10. Changes to the flow regime at the remaining assets are broadly similar and so they are summarised collectively below.

Table 18. Standard metrics for changes to surface water flow regime at environmental assets in the Arafura region

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Arafura Swamp - Node 1 (confidence level: low flow = 4, high flow = 3)									
Annual flow (mean)	GL	741	+50%	+18%	-3%	-28%	nm	nm	nm
Wet season flow (mean)*	GL	714	+48%	+19%	-3%	-28%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	12.4							
Number of days above high flow threshold (mean)	d/y	18.3	+11.6	+4.7	-1	-6.6	nm	nm	nm
Blyth-Cadell Floodplain & Boucaut Bay System - Node 2 (confidence level: low flow = 3, high flow = 3)									
Annual flow (mean)	GL	663	+55%	+20%	-4%	-27%	nm	nm	nm
Wet season flow (mean)*	GL	610	+55%	+21%	-4%	-27%	nm	nm	nm
Dry season flow (mean)**	GL	53.1	+51%	+6%	0%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.0584							
Number of days below low flow threshold (mean)	d/y	36.5	-32.6	-13.5	+4.3	+34.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	1.27	+0.2	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	9							
Number of days above high flow threshold (mean)	d/y	18.3	+11.6	+5.6	-1.2	-6.1	nm	nm	nm

*Wet season covers the six months from November to April.

**Dry season covers the six months from May to October.

NR – metrics not reported because streamflow confidence level is ranked 4 or 5
nm – not modelled.

Under Scenario A annual flow into the assets in the Arafura region is dominated by wet season flows (92 to 96 percent) which are 48 to 55 percent higher under Scenario B (Table 18). Annual and seasonal flows do not change much under Scenario Cmid when compared to Scenario A, but there are moderate increases under Scenario Cwet (6 to 21 percent) and moderate decreases under Scenario Cdry (25 to 28 percent). There are no development scenarios for the area upstream of this asset.

Compared to Scenario A the number of days when flow is less than the low flow threshold increases by 4 days under Scenario Cmid, but there is a large increase in low flow days under Scenario Cdry and also a large decrease in low flow days under Scenario Cwet (Table 18). There are very few zero flow days at the assets in this region and this does not change under any of the scenarios. Under Scenario B the high flow threshold exceedance has been much more frequent than under Scenario A. There is only a small change in high flow threshold exceedance under Scenario Cmid when compared to Scenario A. Under Scenario Cwet there is a large increase in high flow exceedance from Scenario A; conversely, there is a large decrease in high flow days under Scenario Cdry.

4.2.2 Gulf of Carpentaria Drainage Division

The standard metric analysis was undertaken for 41 environmental asset reporting nodes in the Gulf of Carpentaria Division. Results for all nodes are presented in Appendix 2. This Section provides an overview of results for each asset in each region. For assets with more than one reporting node a single node was selected for the overview below. The selected node was that with the highest streamflow confidence level and the largest proportion of streamflow to the asset. It should be noted that the conversion of these standard metrics into environmental impacts still requires development of quantitative relationships between flow and ecology. In this division, 15 environmental asset reporting nodes do not have flow data with sufficient reliability to estimate change under any of the scenarios.

Roper Region

The surface water flow confidence levels for both high and low flows for the Limmen Bight (Port Roper) Tidal Wetlands System within the Roper region (see location on Figure 11) are ranked unreliable (4 or 5); therefore model data are of insufficient quality to allow environmental flow metrics to be calculated .

The Mataranka Thermal Pools (see location on Figure 11) are fed by perennial groundwater springs in the upper reaches of the Roper River however there is currently not enough confidence in existing groundwater models to report any results for the different scenarios. In addition, the surface water flow confidence levels for both high and low flows for the asset within the Roper region are ranked unreliable (4 or 5); therefore model data are of insufficient quality to allow environmental flow metrics to be calculated.

South-West Gulf Region

Five environmental assets have been analysed in the South-West Gulf region: Gregory River, Nicholson Delta Aggregation, Port McArthur Tidal Wetlands System, Southern Gulf Aggregation and Thorntonia Aggregation; the locations of these assets are shown in Figure 12. The surface water flow confidence level for the Nicholson Delta Aggregation and the Southern Gulf Aggregation is 4 for high flows and 5 for low flows which are too unreliable to allow environmental flow metrics to be calculated for this asset. Changes to the flow regime at the Gregory River and Thorntonia Aggregation are broadly similar and so they are summarised collectively below.

Under Scenario A annual flow into the South-West Gulf Regions assets is dominated by wet season flows (84 to 97 percent) which under Scenario B are 21 to 25 percent higher in the Gregory River and Thorntonia Aggregation assets and 72 percent higher in the Port McArthur Tidal Wetlands System (Table 19). Annual and seasonal flows do not change much for any of the assets under Scenario Cmid when compared to Scenario A, but there are small to moderate increases under Scenario Cwet (3 to 26 percent) and moderate decreases under Scenario Cdry (18 to 20 percent). There are no development scenarios for the area upstream of this asset.

Under Scenario B the high flow threshold exceedance is more frequent than under Scenario A (Table 19). Under Scenario Cmid high flow threshold exceedance does not change much from Scenario A, but there are moderate increases and decreases under Cwet and Cdry respectively. There are no low flow metrics reported for this asset.

Table 19. Standard metrics for changes to surface water flow regime at environmental assets in the South-West Gulf region

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Gregory River - Node 1 (confidence level: low flow = 5, high flow = 1)									
Annual flow (mean)	GL	455	+19%	+24%	-3%	-18%	nm	nm	nm
Wet season flow (mean)*	GL	387	+21%	+24%	-3%	-18%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario A)	GL/d	3.1							
Number of days above high flow threshold (mean)	d/y	18.3	+5.3	+3.8	-0.4	-3.1	nm	nm	nm
Port McArthur Tidal Wetlands System - Node 3 (confidence level: low flow = 5, high flow = 3)									
Annual flow (mean)	GL	401	+71%	+4%	-10%	-19%	nm	nm	nm
Wet season flow (mean)*	GL	390	+72%	+3%	-9%	-19%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario A)	GL/d	5.97							
Number of days above high flow threshold (mean)	d/y	18.3	+10.5	+0.3	-1.8	-3.4	nm	nm	nm
Thorntonia Aggregation - Node 3 (confidence level: low flow = 5, high flow = 2)									
Annual flow (mean)	GL	232	+23%	+26%	-2%	-20%	nm	nm	nm
Wet season flow (mean)*	GL	195	+25%	+26%	-3%	-20%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario A)	GL/d	1.57							
Number of days above high flow threshold (mean)	d/y	18.3	+6.2	+3.9	-0.4	-3.4	nm	nm	nm

* Wet season covers the six months from November to April

** Dry season covers the six months from May to October

NR – metrics not reported because streamflow confidence level is ranked four or five
nm – not modelled

Flinders-Leichhardt Region

Three environmental assets have been analysed in the Flinders-Leichhardt region: Buffalo Lake Aggregation, Lake Julius and Southern Gulf Aggregation. The locations of these assets are shown in Figure 13. The surface water flow confidence level for the Buffalo Lake Aggregation is 5 for both high and low flows which are too unreliable to allow environmental flow metrics to be calculated for this asset. Changes to the flow regime at Lake Julius and Southern Gulf Aggregation are broadly similar and so they are summarised collectively below.

Note that the results for this region come from an IQQM model therefore Scenario AN is used. Due to the way the IQQM models are run, Scenario AN results represent predevelopment conditions with historical climate. Scenario B represents the last 11 years of climate with full allocation of existing water entitlements and Scenario C represents climate change scenarios with full allocation of existing water entitlements (see Petheram et al. (2009) for details).

Table 20. Standard metrics for changes to flow regime at environmental assets in the Flinders-Leichhardt region

Standard metrics	Units	AN	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Lake Julius - Node 1 (confidence level: low flow = <3, high flow = <3)									
Annual flow (mean)	GL	279	+72%	+16%	+0%	-40%	nm	nm	nm
Wet season flow (mean)*	GL	251	+87%	+19%	+3%	-36%	nm	nm	nm
Dry season flow (mean)**	GL	28.0	-58%	-7%	-22%	-68%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario AN)	GL/d	0							
Number of days below low flow threshold (mean)	d/y	188	+57.1	+56	+58.1	+65.4	nm	nm	nm
Number of days of zero flow (mean)	d/y	188	+57.1	+56	+58.1	+65.4	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario AN)	GL/d	2.1							
Number of days above high flow threshold (mean)	d/y	18.3	+5.9	+0.9	-0.8	-5.4	nm	nm	nm
Southern Gulf Aggregation - Node 2 (confidence level: low flow = <3, high flow = <3)									
Annual flow (mean)	GL	1949	+44%	+18%	+10%	-32%	nm	nm	nm
Wet season flow (mean)*	GL	1855	+50%	+17%	+11%	-31%	nm	nm	nm
Dry season flow (mean)**	GL	94.0	-72%	+37%	-7%	-50%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario AN)	GL/d	0							
Number of days below low flow threshold (mean)	d/y	118	-4.9	+6.3	-11.6	-3.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	118	-4.9	+6.3	-11.6	-3.1	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario AN)	GL/d	17.2							
Number of days above high flow threshold (mean)	d/y	18.3	+2.6	+0.3	+0.1	-4.4	nm	nm	nm

* Wet season covers the six months from November to April.

** Dry season covers the six months from May to October.

nm – not modelled

Under Scenario AN annual flow into the assets in the Flinders-Leichhardt region is dominated by wet season flows (90 to 95 percent) which increase greatly (50 to 87 percent) under Scenario B (Table 20). In contrast, compared to Scenario AN, dry season flows are less than half (-58 to -72 percent) under Scenario B. Annual and wet season flows only change a little under Scenario Cmid compared to Scenario AN, but there are moderate to large increases under Scenario Cwet (7 to 37 percent) and moderate to large decreases under Scenario Cdry (31 to 68 percent). There are no development scenarios for the area upstream of the Gregory River and no separate Scenario D modeling was undertaken for Lake Julius.

The low flow threshold for both of the above assets is zero, which occurs 32 to 52 percent of the year on average under Scenario AN (Table 20). The number of days when flow is less than the low flow threshold increases dramatically under all three scenarios Cdry, Cmid and Cwet at Lake Julius, but changes to zero flow days at the Southern Gulf aggregation are smaller and more variable. Under Scenario B high flows are more frequent than under Scenario AN. Under scenarios Cmid or Cwet high flow threshold exceedance do not change much from Scenario AN. However, there is a moderate decrease in high flow days under Scenario Cdry.

South-East Gulf Region

Three environmental assets have been selected in the South-east Gulf region: Dorunda Lakes Area, Smithburne–Gilbert Fan Aggregation, and Southern Gulf Aggregation. The locations of these assets are shown in Figure 14. The surface water flow confidence level for all three of these assets is considered unreliable (4 or 5) for both wet season and dry season flows which is too unreliable to allow environmental flow metrics to be calculated for any of these assets.

Mitchell Region

One environmental asset has been analysed in the Mitchell region; the Mitchell River Fan Aggregation, the location of this asset is shown in Figure 15. Note that the results for this region come from an IQQM model therefore Scenario AN is used. Due to the way the IQQM models are run, Scenario AN results represent predevelopment conditions with historical climate. Scenario B represents the last 11 years of climate with full allocation of existing water entitlements and

Scenario C represents climate change scenarios with full allocation of existing water entitlements (see Petheram et al. (2009) for details).

Under Scenario AN annual flow into this asset is highly dominated by wet season flows (97 percent) which are only been 3 percent higher under Scenario B (Table 21). Dry season flows are also marginally higher (2 percent) under Scenario B when compared to Scenario AN. Annual and seasonal flows do not change much under Scenario Cmid (6 to 12 percent) compared to Scenario AN, but there are large increases under Scenario Cwet (29 to 40 percent). Under Scenario Cdry there are moderate decreases in wet season flow (26 percent) compared to Scenario AN and a larger decrease in dry season flow (37 percent). No separate Scenario D modelling was undertaken.

Under Scenario Cdry, there are more than twice the number of days with flow below the low flow threshold as defined by Scenario AN (Table 21). There is also a large increase in low flow days under Scenario Cmid when compared to Scenario AN and little change under Scenario Cwet. A similar pattern is seen in the number of days of zero flow days, although these only occur about 2 percent of the time. Under Scenario B the exceedance of the high flow threshold is similar to that under Scenario AN. In contrast, compared to Scenario AN, there are large increases and decreases in the high flow threshold exceedance under scenarios Cwet and Cdry respectively, with little change under Scenario Cmid.

Table 21. Standard metrics for changes to flow regime at environmental assets in the Mitchell region under Scenario A and under scenarios B, C and D relative to Scenario A

Standard metrics	Units	AN	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Mitchell River Fan Aggregation - Node 1 (confidence level: low flow = <3, high flow = <3)									
Annual flow (mean)	GL	6790	+3%	+40%	-6%	-26%	nm	nm	nm
Wet season flow (mean)*	GL	6620	+3%	+40%	-6%	-26%	nm	nm	nm
Dry season flow (mean)**	GL	164	+2%	+29%	+12%	-37%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario A)	GL/d	0.0454							
Number of days below low flow threshold (mean)	d/y	36.5	-2.7	-3.7	+13.5	+44.7	nm	nm	nm
Number of days of zero flow (mean)	d/y	6.13	-0.7	-0.2	+6.2	+21.3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario A)	GL/d	105							
Number of days above high flow threshold (mean)	d/y	18.3	+0.6	+7.2	-1.2	-4.9	nm	nm	nm

*Wet season covers the six months from November to April.
** Dry season covers the six months from May to October.
NR – metrics not reported because streamflow confidence level is ranked 4 or 5.
nm – not modelled.

Western Cape Region

Four environmental assets have been analysed in the Western Cape region: Archer River Aggregation, Jardine River Wetlands Aggregation, Northern Holroyd Plain Aggregation, and Port Musgrave Aggregation; the locations of these assets are shown in Figure 16. Changes to the flow regime at these assets are broadly similar and so they are summarised collectively below.

Under Scenario A annual flow into the assets in the Western Cape region is dominated by wet season flows (94 to 97 percent) which are 16 percent higher under Scenario B (Table 22). Dry season flows have also been (36 to 115 percent) higher under Scenario B when compared to Scenario A. Annual and seasonal flows do not change much under Scenario Cmid compared to Scenario A, but there are large increases under Scenario Cwet (17 to 53 percent) and more moderate decreases under Scenario Cdry (16 to 25 percent). There are no development scenarios for the area upstream of this asset.

Compared to Scenario A, the number of days when flow is less than the low flow threshold does not change very much under Scenario Cmid, but there is a large increase in low flow days under Scenario Cdry and moderate to large decreases in low flow days under Scenario Cwet (Table 22). For two of the assets, the Jardine River and Port Musgrave aggregations, zero flow days only occur 3 to 4 percent of the year on average under Scenario A, with no change in any of the scenarios. Where there are a significant number of zero flow days, as in the Northern Holroyd Aggregation, the number of days when flow stops does not change very much under Scenario Cmid compared to Scenario A, but there is a moderate increase in low flow days under Scenario Cdry and a moderate decrease in low flow days under Scenario Cwet.

Under Scenario B high flows are more frequent at all of the assets than under Scenario A. Compared to Scenario A there is little change in high flow threshold exceedance under Scenario Cmid. Under Scenario Cwet high flow exceedance increases considerably from Scenario A; conversely, there is a more moderate decrease in high flow days under Scenario Cdry.

Table 22. Standard metrics for changes to surface water flow regime at environmental assets in the Western Cape region under scenarios A, B, C and D

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Archer River Aggregation - Node 2 (confidence level: low flow = 3, high flow = 2)									
Annual flow (mean)	GL	1550	+18%	+33%	+1%	-21%	nm	nm	nm
Wet season flow (mean)*	GL	1470	+16%	+34%	+1%	-22%	nm	nm	nm
Dry season flow (mean)**	GL	76.2	+43%	+17%	-3%	-19%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario A)	GL/d	0.0006							
Number of days below low flow threshold (mean)	d/y	36.5	-3.3	-4.9	+0.6	+17	nm	nm	nm
Number of days of zero flow (mean)	d/y	11.2	-0.8	-1.9	+0.5	+8.5	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario A)	GL/d	22.5							
Number of days above high flow threshold (mean)	d/y	18.3	+3.6	+6.9	+0.1	-5.6	nm	nm	nm
Jardine River Wetlands Aggregation - Node 2 (confidence level: low flow = 3, high flow = 4)									
Annual flow (mean)	GL	NR	NR	NR	NR	NR	nm	nm	nm
Wet season flow (mean)*	GL	NR	NR	NR	NR	NR	nm	nm	nm
Dry season flow (mean)**	GL	193	+31%	+22%	+0%	-14%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario A)	GL/d	0.291							
Number of days below low flow threshold (mean)	d/y	36.5	-26.3	-14.7	-0.8	+16.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	1.55	-0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario A)	GL/d	NR							
Number of days above high flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Northern Holroyd Plain Aggregation - Node 3 (confidence level: low flow = 2, high flow = 2)									
Annual flow (mean)	GL	1230	+20%	+52%	+2%	-23%	nm	nm	nm
Wet season flow (mean)*	GL	1190	+16%	+53%	+3%	-23%	nm	nm	nm
Dry season flow (mean)**	GL	42.7	+115%	+38%	-6%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario A)	GL/d	0							
Number of days below low flow threshold (mean)	d/y	88.2	-14	-12.5	-2.1	+11.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	88.2	-14	-12.5	-2.1	+11.1	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario A)	GL/d	20.7							
Number of days above high flow threshold (mean)	d/y	18.3	+3.7	+15	+0.5	-6.8	nm	nm	nm
Port Musgrave Aggregation - Node 6 (confidence level: low flow = 3, high flow = 3)									
Annual flow (mean)	GL	3330	+17%	+34%	+1%	-22%	nm	nm	nm
Wet season flow (mean)*	GL	3140	+16%	+35%	+1%	-22%	nm	nm	nm
Dry season flow (mean)**	GL	190	+36%	+21%	-2%	-16%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time under Scenario A)	GL/d	0.0727							
Number of days below low flow threshold (mean)	d/y	36.5	-12.6	-11.9	-0.1	+15.3	nm	nm	nm
Number of days of zero flow (mean)	d/y	1.88	-1.4	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time under Scenario A)	GL/d	52.3							
Number of days above high flow threshold (mean)	d/y	18.3	+3.3	+11.9	+0.6	-6.7	nm	nm	nm

*Wet season covers the six months from November to April.
** Dry season covers the six months from May to October.
NR – metrics not reported because streamflow confidence level is ranked 4 or 5.
nm – not modelled.

4.2.3 Northern North-East Coast Drainage Division

The standard metric analysis was undertaken for 12 environmental asset reporting nodes in the Northern North-east Coast Division. Results for all nodes are presented in Appendix 2. This Section provides an overview of results for each asset in each region. For assets with more than one reporting node a single node was selected for the overview below. The selected node was that with the highest streamflow confidence level and the largest proportion of streamflow to the asset. It should be noted that the conversion of these standard metrics into environmental impacts still requires development of quantitative relationships between flow and ecology. In this division, 3 environmental asset reporting nodes do not have flow data with sufficient reliability to estimate change under any of the scenarios.

Northern Coral Region

Five environmental assets have been analysed in the Northern Coral region: Lloyd Bay, Lower Daintree River, Marina Plains – Lakefield Aggregation, Newcastle Bay – Escape River Estuarine Complex, and Oliver River; the locations of these assets are shown in Figure 17. The surface water flow confidence levels for both high and low flows for all nodes within the Newcastle Bay – Escape River Estuarine Complex are ranked unreliable (4 or 5) therefore they are of insufficient quality to allow environmental flow metrics to be calculated. Changes to the flow regime at the remaining assets are broadly similar and so they are summarised collectively below.

Under Scenario A annual flow into the assets in the Northern Coral region is dominated by wet season flows (79 to 97 percent) which are 9 to 30 percent higher under Scenario B in the Lower Daintree and Lloyd Bay, but only 1 percent lower in the Marina Plains Lakefield Aggregation (Table 23). Dry season flows either increase (Marine Plains) or decrease (Lower Daintree) under Scenario B when compared to Scenario A. Annual and seasonal flows do not change much under Scenario Cmid when compared to Scenario A, but there are moderate to large increases under Scenario Cwet (9 to 46 percent) and similar decreases under Scenario Cdry (18 to 34 percent). There are no development scenarios for the area upstream of this asset.

Compared to Scenario A, the number of days when flow is less than the low flow threshold does not change very much under Scenarios Cmid, but there is a very large increase in low flow days under Scenario Cdry (Table 23). There were no zero flow days at these assets and all rivers remained perennial under all of the scenarios. Under Scenario B the high flow threshold exceedance is more frequent than under Scenario A. There is little change in high flow threshold exceedance under Scenario Cmid. Under Scenario Cwet high flow exceedance increases substantially relative to Scenario A; conversely, there is a large decrease in high flow days under Scenario Cdry.

Table 23. Standard metrics for changes to surface water flow regime at environmental assets in the Northern Coral region

Standard metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Lloyd Bay - Node 1 (confidence level: low flow = 4, high flow = 3)									
Annual flow (mean)	GL	348	+29%	+34%	0%	-18%	nm	nm	nm
Wet season flow (mean)*	GL	319	+30%	+35%	0%	-19%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	4.84							
Number of days above high flow threshold (mean)	d/y	18.3	+8.3	+5.6	+0.1	-4.3	nm	nm	nm
Lower Daintree River - Node 1 (confidence level: low flow = 3, high flow = 3)									
Annual flow (mean)	GL	1120	+6%	+15%	-3%	-25%	nm	nm	nm
Wet season flow (mean)*	GL	885	+9%	+17%	-2%	-26%	nm	nm	nm
Dry season flow (mean)**	GL	236	-6%	+9%	-5%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.276							
Number of days below low flow threshold (mean)	d/y	36.5	+3.3	-2.5	-1.4	+31.4	nm	nm	nm
Number of days of zero flow (mean)	d/y	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	11							
Number of days above high flow threshold (mean)	d/y	18.3	+1.9	+3.3	-0.5	-6	nm	nm	nm
Marina Plains - Lakefield Aggregation - Node 4 (confidence level: low flow = 3, high flow = 3)									
Annual flow (mean)	GL	1410	0%	+45%	-6%	-31%	nm	nm	nm
Wet season flow (mean)*	GL	1370	-1%	+46%	-6%	-31%	nm	nm	nm
Dry season flow (mean)**	GL	38.2	+27%	+27%	-13%	-34%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	0.00587							
Number of days below low flow threshold (mean)	d/y	36.5	+6.9	-14.1	+1.8	+24.9	nm	nm	nm
Number of days of zero flow (mean)	d/y	0	0	0	0	+0.5	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	21.9							
Number of days above high flow threshold (mean)	d/y	18.3	-0.7	+6.8	-0.8	-6.4	nm	nm	nm
Olive River - Node 1 (confidence level: low flow = 4, high flow = 3)									
Annual flow (mean)	GL	840	+14%	+32%	0%	-19%	nm	nm	nm
Wet season flow (mean)*	GL	760	+14%	+33%	0%	-20%	nm	nm	nm
Dry season flow (mean)**	GL	NR	NR	NR	NR	NR	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	NR							
Number of days below low flow threshold (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
Number of days of zero flow (mean)	d/y	NR	NR	NR	NR	NR	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	11.9							
Number of days above high flow threshold (mean)	d/y	18.3	+2.3	+7.8	+0.1	-5.4	nm	nm	nm

*Wet season covers the six months from November to April.
** Dry season covers the six months from May to October.
NR – metrics not reported because streamflow confidence level is ranked 4 or 5.
nm – not modelled.

4.3 Groundwater metrics

The Daly region of the Timor Sea Drainage Division offers a unique opportunity within this project as it has a groundwater model which will enable assessment of the changes to groundwater depths and flows under the different scenarios. Similar metrics to those employed for surface water flows will be used to assess changes to groundwater flows. Groundwater assessments are important to assess changes to stream baseflow and depth to groundwater under different scenarios. Groundwater flows are important for discharge of streams while groundwater depth is important for groundwater dependant ecosystems.

4.3.1 Daly Region

Daly River Middle Reaches

Under Scenario A annual groundwater flow to the Daly River Middle Reaches (Node 1 on Figure 36) is dominated by dry season flows (65 percent) which are 35 percent higher under Scenario B (Table 24). Wet season flows are 17 percent lower under Scenario B than those under Scenario A. Annual and seasonal flows do not change much under Scenario Cmid when compared to Scenario A, but there are moderate increases under Scenario Cwet (23 to 33 percent) and small changes under Scenario Cdry. Changes to annual and seasonal flows under Scenario Dwet show less of an increase than Scenario Cwet when compared to Scenario A. Changes to annual and seasonal flows under Scenario Ddry show more of a decrease when compared to Scenario A than Scenario Cdry; these changes are indicative of additional flow decreases under development scenarios.

There is a large increase in the number of days below the low flow threshold under Scenario B when compared to Scenario A and only small changes to the number of days below the low flow threshold for all other scenarios (Table 24). In the case of groundwater flow, the low flow threshold is not necessarily a measure of dry season conditions. In fact, negative groundwater flows occur during the peak of the wet season when surface water flows, and hence the hydraulic head, are high. In this case, an increase in the number of days below the low flow threshold is an indication of wetter conditions (higher surface flows and hence higher hydraulic head) under Scenario B as compared to Scenario A.

Under Scenario B the high flow threshold is exceeded four times as frequently as under Scenario A (Table 24). Compared to Scenario A there is only a small change in high flow threshold exceedance under scenarios Cmid and Dmid. Under Scenario Cwet high flow exceedance increases greatly from Scenario A; conversely, there is a small decrease in high flow days under scenarios Cdry and Ddry. Changes to the exceedance of the high flow threshold under Scenario Dwet when compared to Scenario A show less of an increase than under Scenario Cwet while changes under Scenario Ddry show more of a decrease than under Scenario Cdry; these changes are indicative of additional flow decreases under development scenarios.

Under Scenario B mean dry season groundwater depth (metres below soil surface) decreased by 1.1 m when compared to Scenario A (refer to Node 2 on Figure 36 for location). Thus, the groundwater is closer to the surface and these changes might be likely to better sustain groundwater-dependent ecosystems of this floodplain. Very little change in groundwater depth occurs under scenarios Cmid and Dmid as compared to Scenario A. Under Scenario Cwet groundwater depth is 0.7 m closer to the surface than under Scenario A and under Scenario Cdry groundwater depth increased by 0.3 m. The same changes to groundwater depth occur under scenarios C and D indicating no additional impact on watertable level at this asset with proposed future development.

Table 24. Metrics for changes to groundwater regime at environmental assets in the Daly region

Groundwater metrics	Units	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A						
Daly River Middle Reaches									
Annual groundwater flow (mean)	GL	410	+19%	+26%	+4%	-5%	+21%	-1%	-11%
Wet season groundwater flow (mean)*	GL	126	-17%	+33%	+7%	+1%	+24%	-2%	-9%
Dry season groundwater flow (mean)**	GL	283	+35%	+23%	+3%	-8%	+19%	-1%	-12%
Low flow threshold (groundwater discharge exceeded 90% of the time in Scenario A)	GL/d	0.0488							
Number of days below low flow threshold (mean)	d/y	36.6	+14.5	-3.2	-1.3	-3	-0.9	+0.7	+0.7
High flow threshold (groundwater discharge exceeded 5% of the time in Scenario A)	GL/d	2.19							
Number of days above high flow threshold (mean)	d/y	18.3	+58.6	+42.6	+4.2	-5.6	+34.6	-0.8	-8.8
Dry season depth to groundwater (mean)*** Monitoring Well - RN020614	m	19	-1.1	-0.7	-0.1	+0.3	-0.7	-0.1	+0.3
Daly-Reynolds Floodplain-Estuary System									
Annual groundwater flow (mean)	GL	493	+17%	+25%	+4%	-5%	+21%	0%	-10%
Wet season groundwater flow (mean)*	GL	172	-12%	+33%	+7%	+1%	+26%	+1%	-6%
Dry season groundwater flow (mean)**	GL	320	+33%	+22%	+3%	-8%	+19%	-1%	-12%
Low flow threshold (groundwater discharge exceeded 90% of the time in Scenario A)	GL/d	0.368							
Number of days below low flow threshold (mean)	d/y	36.6	+15.4	-5.3	-1.8	-3.3	-3.9	-0.3	-0.6
High flow threshold (groundwater discharge exceeded 5% of the time in Scenario A)	GL/d	2.47							
Number of days above high flow threshold (mean)	d/y	18.3	+57.6	+43	+5	-5.7	+36.2	-0.5	-8.8
Dry season depth to groundwater (mean)***	m	-	-	-	-	-	-	-	-

*Wet season covers the six months from November to April.

**Dry season covers the six months from May to October.

***A negative change in depth from Scenario A indicates that the watertable is closer to the surface.

Daly-Reynolds Floodplain-Estuary System

Under Scenario A annual groundwater flow to the Daly River Middle Reaches at the selected node (see location on Figure 37) is dominated by dry season flows (65 percent) which are 33 percent higher under Scenario B (Table 24). Wet season flows are 12 percent lower under Scenario B when compared to Scenario A. Annual and seasonal flows do not change much from Scenario A under Scenario Cmid, but there are moderate increases under Scenario Cwet (23 to 33 percent) and small changes under Scenario Cdry. Changes to annual and seasonal flows under Scenario Dwet when compared to Scenario A show less of an increase than under Scenario Cwet while changes under Scenario Ddry show more of a decrease than under Scenario Cdry; these changes are indicative of additional flow decreases under development scenarios.

Compared to Scenario A there is a large increase in the number of days below the low flow threshold under Scenario B and only small changes to the number of days below the low flow threshold for all other scenarios (Table 24). In the case of groundwater flow the low flow threshold is not necessarily a measure of dry season conditions. In fact, negative groundwater flows occur during the peak of the wet season when surface water flows, and hence the hydraulic head, are high. In this case an increase in the number of days below the low flow threshold when compared to Scenario A is an indication of wetter conditions under Scenario B.

Under Scenario B the high flow threshold is exceeded four times as frequently as that for Scenario A (Table 24). Compared to Scenario A there is little change in high flow threshold exceedance under Scenario Cmid and Dmid. Under Scenario Cwet high flow exceedance increases greatly from Scenario A; conversely, there is a small decrease in high flow days under scenarios Cdry and Ddry. Changes to the exceedance of the high flow threshold under Scenario Dwet compared to Scenario A show less of an increase than Scenario Cwet while changes under Scenario Ddry show more of a decrease than under Scenario Cdry; these changes are indicative of additional flow decreases under development scenarios.

There were no modelled groundwater depth results available for this asset.

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Morgan D, Thorburn D, Fenton J, Wallace-Smith H and Goodson S (2005) Influence of the Camballin Barrage on fish communities in the Fitzroy River. Western Australia. Murdoch University/Kimberley Land Council/Department of Environment report to Land and Water Australia. Available at < http://www.cffr.murdoch.edu.au/reports/Camballin_Barrage_Final_Report.pdf >

Petheram C, Rustomji P and Vleeshouwer J (2009) Rainfall-runoff modelling across northern Australia. CSIRO Water for a Healthy Country Flagship, Canberra.

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5 Conclusions

1. There are very few quantified environmental flow thresholds in the NASY reporting area.

Stream flow metrics related to ecosystem function are available for only three of the 45 selected environmental assets in the NASY reporting area. The Ord-Bonaparte, Daly and Fitzroy (WA) regions have had sufficient research for the development of site-specific ecological flow metrics against which changes to flow regime can be assessed, however, this is a rarity for northern Australia. There is a general lack of quantitative relationships between flow and specific ecological entities (e.g. macrophyte populations, fish passage, faunal and floral habitats), meaning that the consequence of flow changes on ecological systems is largely unknown. The existing site-specific metrics provide a good base to work from and resources for development of such metrics are best targeted at areas flagged for development or high priority assets. The opportunity exists to include such metrics in defining ‘sustainable yields’ for the future. Approaches to address this lack of information are being investigated as part of the Northern Australia Water Futures Assessment Ecological Program.

2. Confidence in streamflow modelling results is variable across the NASY project area.

There is a paucity of data for streamflow modelling in northern Australia which often results in model results with low levels of confidence. There are significant gaps in rainfall data and stream gauging stations are sparsely located. Modelled climate change response at environmentally important sites has greatest effect on low flow conditions, but the poor quality of the calibration data at most sites provides low confidence in quantitative assessments of flow regime change. For many environmental assets it is not possible to calculate the potential impacts of the various scenarios because the high and low ends of the flow regime are not well defined. Data are especially sparse in floodplain regions where maintenance of recording equipment is difficult and, for streamflow data, establishing and updating rating curve relationships can be problematic.

3. Streamflow at environmental assets is extremely seasonal and ecosystems are adapted to the prevailing conditions.

In unregulated streams the vast majority (> 90 percent) of total annual flow occurs during the wet season months (November to April). Many rivers that persist through the dry season are sustained through localised groundwater discharge which occurs where streams intersect shallow aquifers, or where deeper artesian waters puncture the landscape generating springs. These discrete points of discharge are rare and risk to disturbance is high. Ecosystems have adapted to environments with persistent dry season flow and have become dependant on this flow. This leads to a high level of endemism across the drainage division.

4. Dry season flows and the impacts on ecological systems are poorly understood for much of the NASY reporting area.

Poor quality low flow data greatly inhibit the potential to assess the linkages between ecological systems and hydrological regime. Dry season flows are poorly understood in this region therefore the ability to predict the potential impacts of climate and development on low or zero flows at environmental assets is very limited. This issue is particularly important considering that future scenarios show the biggest impacts to stream ecology under the dry extreme climate. The collection of more reliable low-flow data and corresponding ecological data is required to remedy this situation. In some streams dry season low flows are largely sustained by groundwater flows. To predict the potential impacts of the various scenarios, these streams require hydrological models that combine surface and groundwater regimes, which are rarely available in the northern Australian rivers.

5. Floods are vital ecosystem events yet they are poorly understood in many areas.

Flooding is an important factor that sustains many environmental assets and this occurs when the stream breaks out of its banks (a level known as bankfull stage or discharge). However, bankfull discharge is not known for many streams, nor is the dependence of area flooded on increasing stream depth, so it is difficult to predict when assets are inundated. Information on discharge and area of flooding in relation to the distribution of and connectivity of habitats and biotic communities is also required. Overbank inundation provides the conditions needed for many fish to migrate and also fills hollows and pools that persist through the dry season, sustaining vital ecosystems until the next wet season. Further information about bankfull stage and discharge are needed for most environmental assets. Again, information on flooding is especially sparse in remote floodplain regions where discharge measurements are difficult to make.

6. Further environmental and ecological information is required to predict the impact of water resource change on the environment.

Prediction of the impact of flow changes on environmental assets and the ecology of northern Australia will require further research investment in several key areas. The current distribution and condition of habitats, biotic communities, and key species is poorly understood. Description and classification of these habitats, biotic communities and key species in different catchments is required. Hydrological connectivity (longitudinal, lateral and vertical) in relation to habitats, biotic communities, and key species needs to be better understood, and water regime characteristics that sustain habitats and communities, such as timing, frequency and duration of events and depth and velocity of flows, need to be further investigated. Response curves and thresholds relating habitats and biotic communities to altered water regimes need to be developed. Further research is also required in the areas of ecosystem resilience, population maintenance, community composition, energy and material flows and food web connections. Such research will require a combination of innovative monitoring methods and the development of system scale models.

7. Standard metric results have limited direct relevance to ecological impacts.

A set of standard metrics related to high and low streamflow conditions have been utilised to provide useful information regarding changes to the hydrological regime at all environmental assets. However, conversion of these metrics into environmental impacts still requires development of quantitative relationships between flow and specific ecological entities (for example, macrophyte populations, fish passage, faunal and floral habitats, etc.). Many environmental assets depend not simply on duration above or below certain flow levels, but on triggers (e.g. for reproduction or migration) set by the rate of change of flow. Further analysis is therefore required to look at how the timing and rate of rise and fall in flow rates at critical times of the season will vary under the various scenarios.

8. There are no known metrics related to groundwater.

Despite the fact that there are large areas of groundwater dependant ecosystems in northern Australia there are no known locations with groundwater related ecological metrics. Further monitoring of the interactions between groundwater level and the functioning of ecosystems is also required so that the potential impacts of climate change and development can be better understood.

9. Water quality is likely to change under the scenarios considered

While water quality issues are beyond the scope of the NASY study, it is worth noting that any change in flow is likely to result in changes to water quality and sediment and nutrient loads. These changes in turn will also affect productivity and habitat quality and as such should be carefully considered in future investigations of the impacts of climate and development scenarios on the environmental assets of northern Australia.

Appendix 1 – Environmental asset descriptions and satellite images

Appendix 1.1 Timor Sea

Appendix 1.1.1 Fitzroy

A list of all sites from the Directory of Important wetlands in Australia located in the Fitzroy region is shown in Table 25. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 25. List of Wetlands of National Significance located within the Fitzroy (WA) region

Site code	Name	Area	Ramsar site
		ha	
WA020 *	Roebuck Bay	50,000	Yes
WA114	Big Springs	<10	No
WA016	Bunda-Bunda Mound Springs	23	No
WA017 *	Camballin Floodplain (Le Livre Swamp System)	30,000	No
WA019 *	Geikie Gorge	272	No
WA111	Gladstone Lake	<10	No
WA021	Roebuck Plains System	1180	No
WA012	Tunnel Creek	20	No
WA022	Willie Creek Wetlands	2950	No
WA013 *	Windjana Gorge	20	No

*assets selected for assessment of changes to hydrological regime

Roebuck Bay

Roebuck Bay is on the Cape Leveque Coast and is an International Ramsar site. It is a tropical marine bay with extensive, highly biologically diverse, intertidal mudflats (covering an area of about 160 km^2) (Figure 21). The site is internationally important for at least 20 species of migratory shorebirds with total numbers of waders using the site each year estimated at over 300,000. The site is one of the most important migration stopover areas for shorebirds in Australia and globally. It is the arrival and departure point for large proportions of the Australian populations of several shorebird species, some of which fly non-stop between continental East Asia and Australia. A total of 64 waterbird species have been recorded, including four darters and cormorants, 11 herons and allies, 34 shorebirds and 11 gulls and terns. In addition to being a rich water bird feeding ground, Roebuck Bay supports an exceptionally high amount of benthic invertebrates, including many species believed new to science.

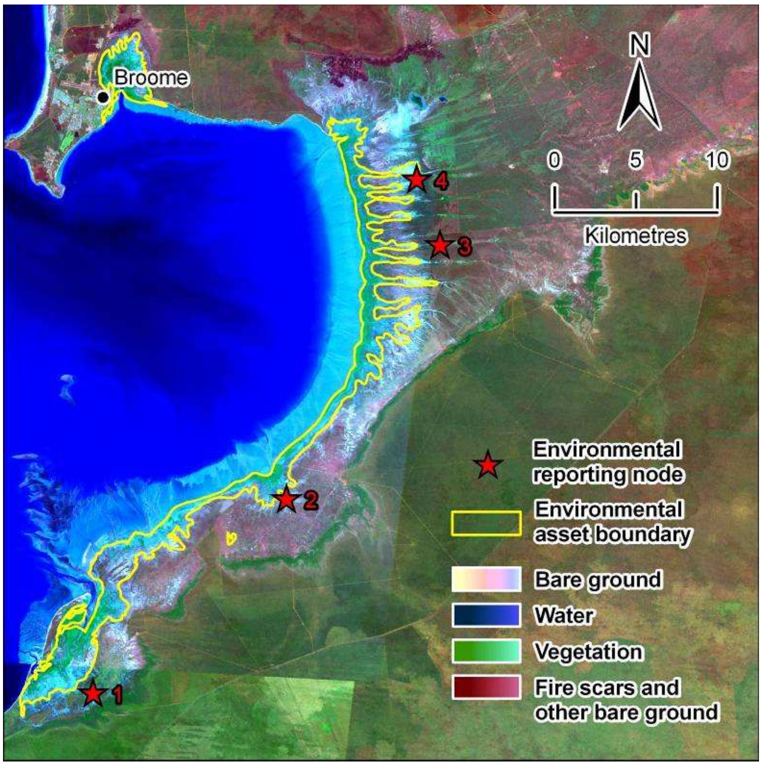

Figure 21. False colour satellite Image (ACRES Landsat7 mosaic, 1999–2000) of Roebuck Bay as defined by the Directory of Important Wetlands (Environment Australia, 2001)

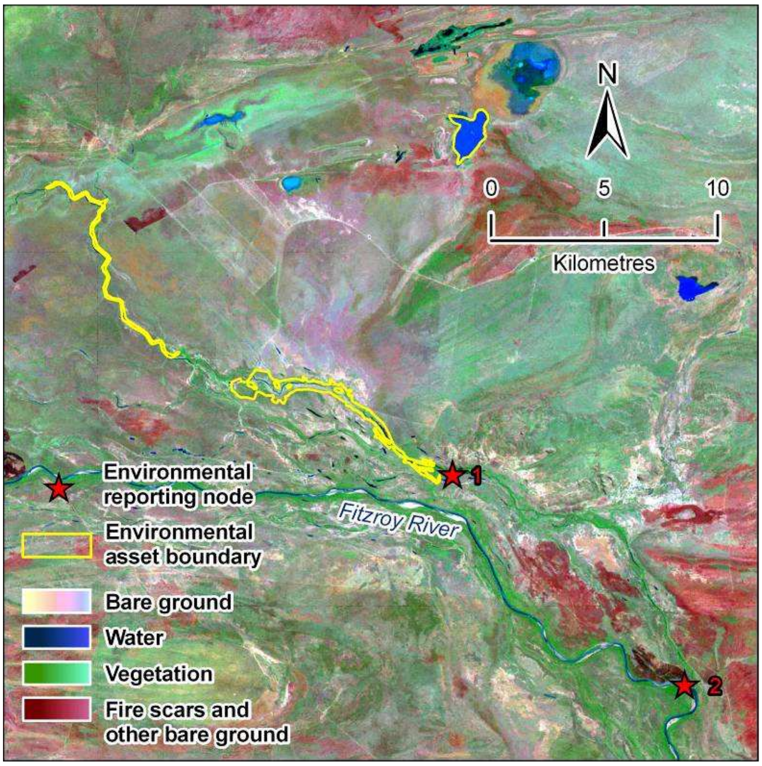

Figure 22. False colour satellite Image (ACRES Landsat7 mosaic, 1999–2000) of Camballin Floodplain (Le Livre Swamp System) as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Camballin Floodplain

The Camballin Floodplain is in the central reaches of the Fitzroy River and includes the Le Livre Swamp System and numerous other seasonal wetlands (Figure 22) (Environment Australia, 2001). Halse and Jaensch (1998) have reported that the Camballin Floodplain is an important bird habitat and that there are at least 67 recorded species and bird numbers often exceed 20,000. The Fitzroy river channel is an important habitat for fish, especially as its large deep pools provide dry season refuges. The river contains a high diversity of fish, including some that are listed as threatened species, for example, the Northern River Shark and the Freshwater Sawfish – see Storey et al. (2001) and Morgan et al. (2002). The middle reaches of the Fitzroy River contain the Camballin Barrage and Morgan et al. (2005) have shown that it presents a considerable barrier to fish migrations. They found that in most years (~80 percent) since 1987 the Barrage was only negotiable by fishes for up to three months a year. There is therefore a considerable bottleneck at the Barrage affecting fish passage which may disrupt the natural ecological balance of the river. A more comprehensive description of the Camballin floodplain wetlands is given by Sutton (1998) and van Dam et al. (2008).

Geikie Gorge

Geikie Gorge is in the upper Fitzroy catchment approximately 30 km upstream of Fitzroy Crossing. It is a permanent pool on the Fitzroy River about 13 km long and 100 m wide (Figure 23). The gorge is an important refuge area for freshwater and marine fish, especially during periods of drought (van Dam et al., 2008). The gorge's permanent water and food resources are valuable to Aboriginal people, who are now involved in promoting the park's cultural values to tourists.

Windjana Gorge

Windjana Gorge is in the Lennard River catchment adjacent to the Fitzroy catchment (Figure 24). It is a 3.5 km long gorge that cuts through a 300 million year old Devonian Reef system. River flows are ephemeral and the gorge contains pools of freshwater outside the wet season that provide a vital habitat for a wide range of animals, birds and fish, including freshwater crocodiles. The site is of considerable cultural significance to Aboriginal people and is the site of a number of cave paintings including the 'wandjina' figure.

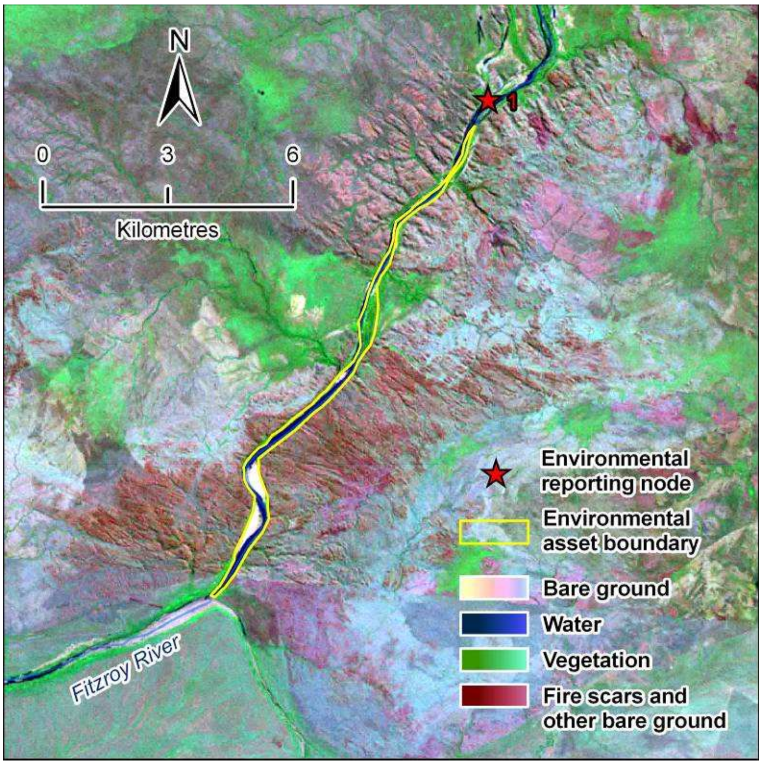

Figure 23. False colour satellite Image (ACRES Landsat7 mosaic, 1999–2000) of Geikie Gorge as defined by the Directory of Important Wetlands (Environment Australia, 2001)

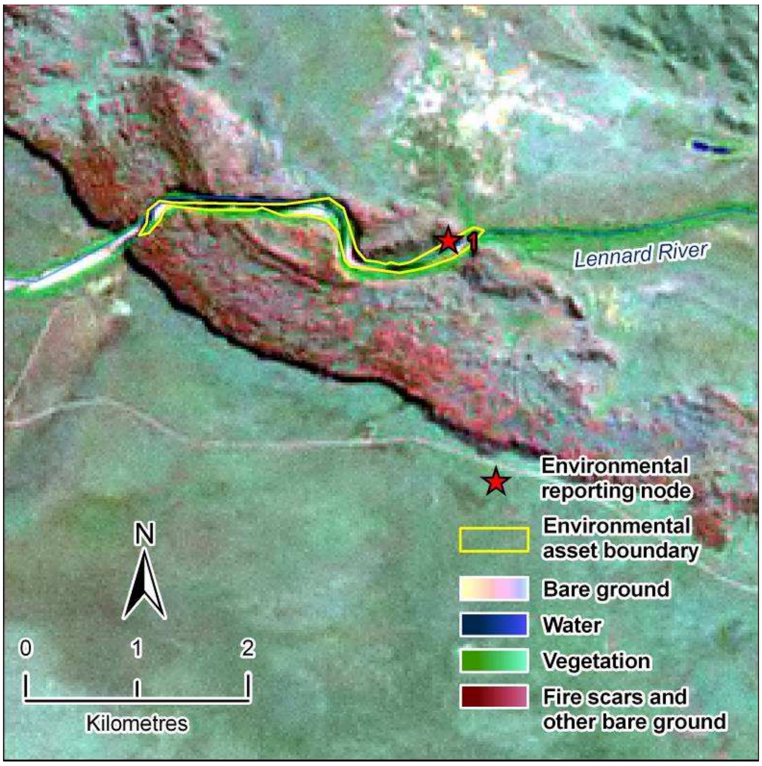

Figure 24. False colour satellite Image (ACRES Landsat7 mosaic, 1999–2000) of Windjana Gorge as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Appendix 1.1.2 Kimberley

A list of all sites from the Directory of Important wetlands in Australia located in the Kimberley region is shown in Table 26. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 26. List of Wetlands of National Significance located within the Kimberley region

Site code	Name	Area	Ramsar site
		ha	
WA062*	Drysdale River	5,670	No
WA063*	Mitchell River System	1,120	No
WA064*	Prince Regent River System	19,100	No

*assets selected for assessment of changes to hydrological regime.

Drysdale River

The Drysdale River site (Figure 25) is a good example of a permanent river of the bioregion and constitutes the largest system of river pools in the high rainfall north-west of the Kimberley. The site runs within or beside Drysdale River National Park. The site has an area of 5670 ha and an elevation ranging between approximately 80 and 310 m (Environment Australia, 2001). The site has 20 waterbird species that have been recorded, including four darters and cormorants and nine herons. The Drysdale system has the richest freshwater fish fauna (26 spp.) known in Western Australia. Three fish species are possibly endemic to the Drysdale River. The escarpment of the Drysdale River contains very important Aboriginal art gallery sites.

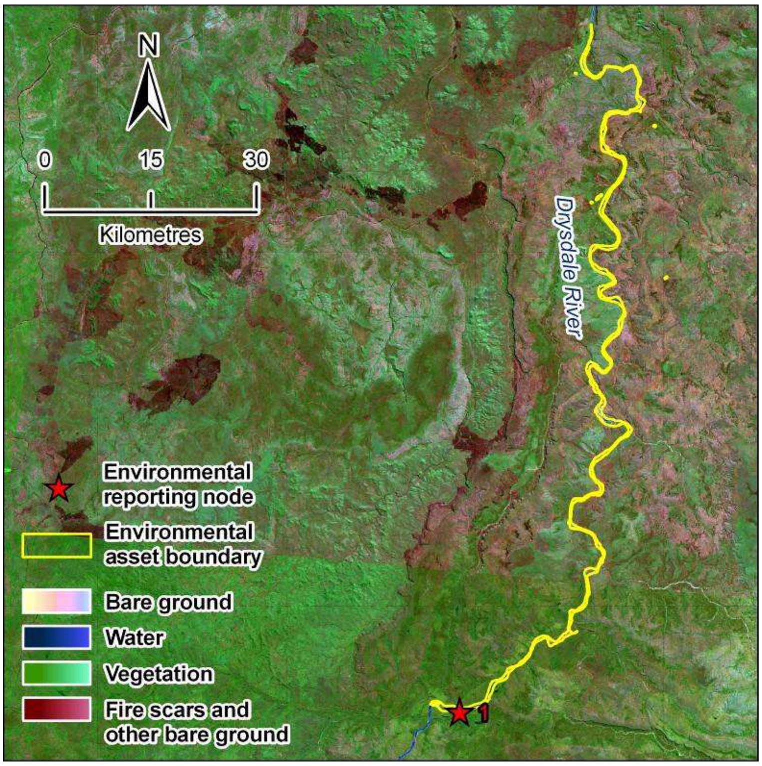

Figure 25. False colour satellite Image (ACRES Landsat7 mosaic, 1999–2000) of Drysdale River as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Mitchell River System

The Mitchell River System (Figure 26) is a good example of a complete, relatively small river system and estuary in the bioregion, with outstanding examples of escarpment waterfalls. The site comprises the entire Mitchell River drainage system and has an area of 1,120 ha with an elevation between zero and 500 m above sea level (Environment Australia, 2001).

The site has notable terrestrial and aquatic flora including cycads and mangroves. Vegetation on Mitchell Plateau is dominated by eucalypts but *Livistona* sp. palms are common in the understorey and patches of rainforest occur near the escarpment (Burbidge et al., 1991; Johnstone, 1990).

The permanent fresh water and food resources of the site were valuable to Aboriginal people in the past and some usage is likely to still occur (Environment Australia, 2001). Mitchell Falls are an increasingly popular tourist destination. The site's spectacular waterfalls are among the greatest aesthetic assets of the Kimberley. Most of the site's other wetlands are undisturbed and rarely visited (Environment Australia, 2001).

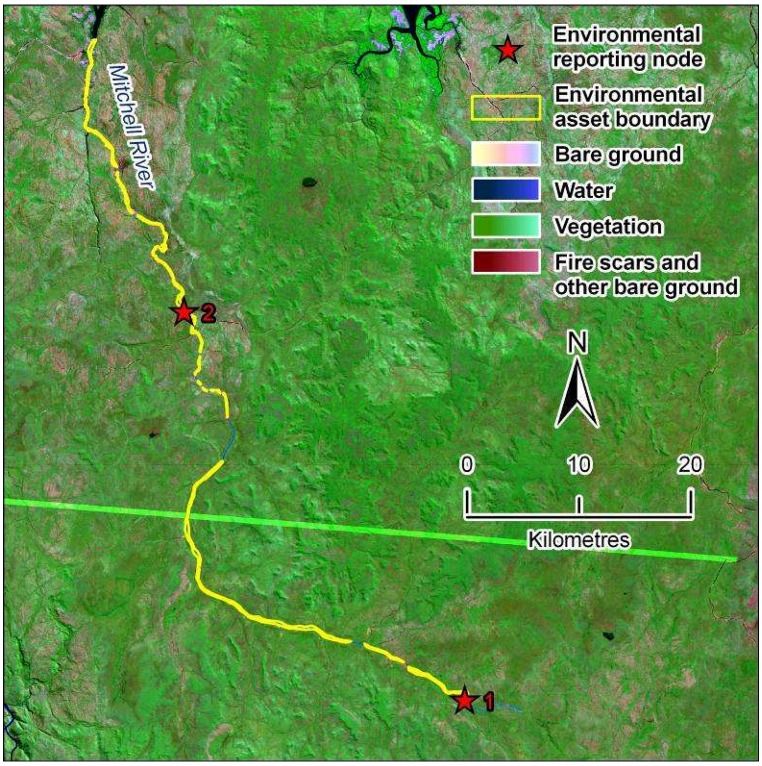

Figure 26. False colour satellite image (ACRES Landsat7, 1999-2000) of the Mitchell River System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

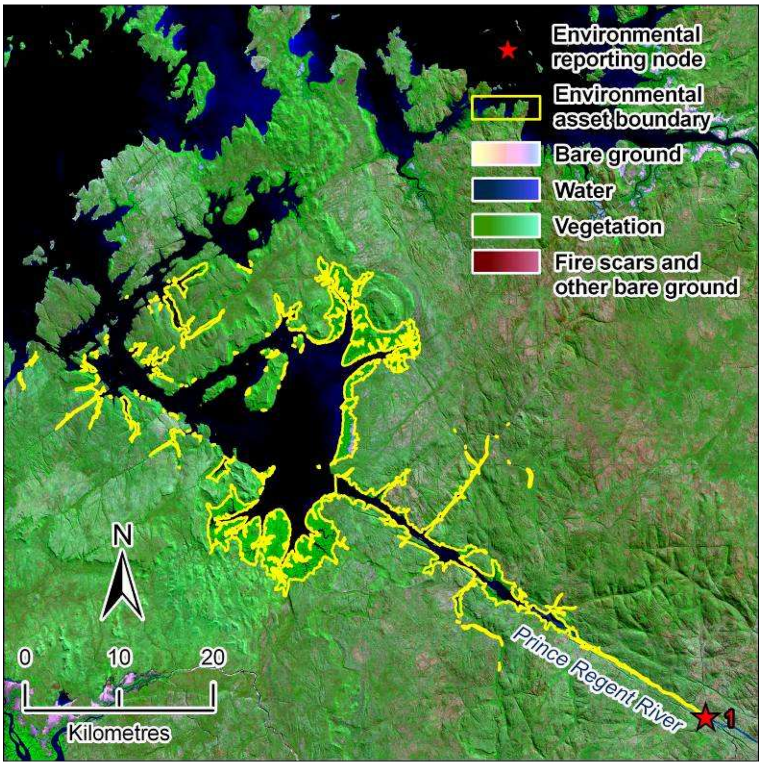

Figure 27. False colour satellite image (ACRES Landsat7, 1999-2000) of the Prince Regent River System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Prince Regent River System

The Prince Regent River System (Figure 27) is an outstanding example of a tropical estuary and river system incised in a plateau, and a good example of the mangrove-fringed embayments typical of the west coast of the bioregion. The site comprises the entire Prince Regent River System and large areas of mangrove on either side of the river mouth. The site has an area of 19,100 ha and has an elevation between zero and 779 m above sea level (Environment Australia, 2001).

At least ten mangrove species occur at the site (Environment Australia, 2001) and 15 waterbird species have been recorded. Both Freshwater and Saltwater Crocodiles occur, with the site including some of the most suitable and extensive breeding habitat for Saltwater Crocodile in Western Australia (Environment Australia, 2001). Aboriginal cave paintings are situated in the reserve (Environment Australia, 2001). The area is becoming very popular for recreation, with access from the ocean by private and charter boats. Some of the most spectacular coastal scenery in Western Australia is found at the site.

Appendix 1.1.3 Ord-Bonaparte

A list of all sites from the Directory of Important wetlands in Australia located in the Ord-Bonaparte region is shown in Table 27. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 27. List of Wetlands of National Significance located within the Ord-Bonaparte region

Site code	Name	Area	Ramsar site
		ha	
WA097 *	Lake Argyle	98,000	Yes
WA098 *	Lake Kununurra	2,500	Yes
WA100 *	Parry Floodplain	9,000	Yes
WA099 *	Ord Estuary System	94,700	Yes
NT033	Bradshaw Field Training Area	<10	No
NT030	Legune Wetlands	10,300	No
NT027	Moyle Floodplain and Hyland Bay System	74,700	No

*assets selected for assessment of changes to hydrological regime

Lake Argyle

Lake Argyle (Figure 28) is a human-made wetland formed by the creation of a water storage. The site extends to the usual high water mark of Lake Argyle. The site has an area of 98, 000 ha and an elevation ranging between 92.2 m (top of the spillway) and 97.3 m (high water mark of the largest recorded flood in 1992) (Environment Australia, 2001). It is a good example of an artificial freshwater lake in the Australian tropics, being the largest such lake in northern Australia. The site is listed jointly with Lake Kununurra as a Wetland of International Importance under the Ramsar Convention (Government of Western Australia, 1990).

The lake supports extensive mats of aquatic plants and large numbers of waterbird species. Both Australian species of crocodile and at least 15 fish species occur in the lake. Lake Argyle is a significant tourist destination and supports commercial boat tours and private recreational boating and fishing.

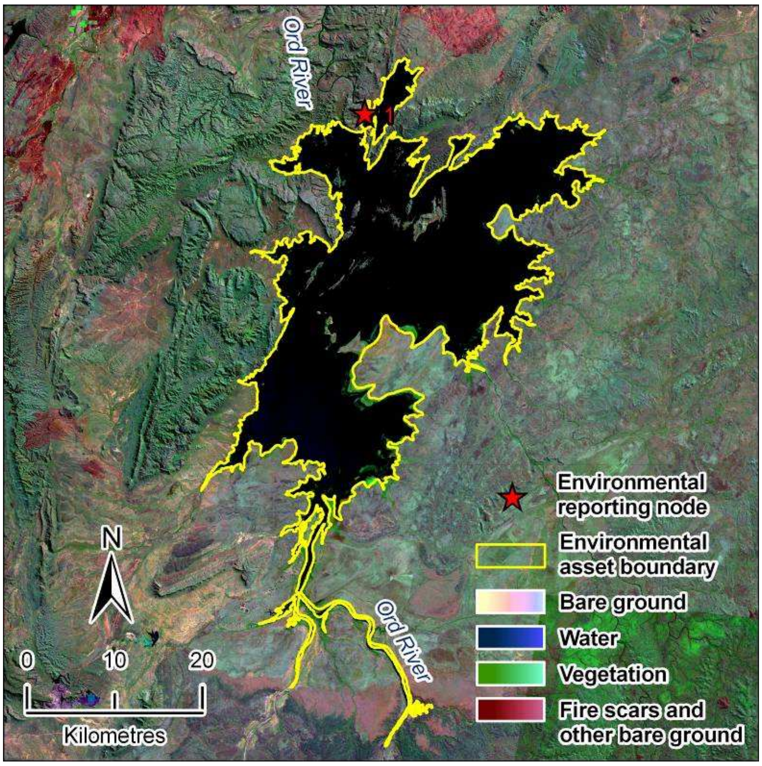

Figure 28. False colour satellite image (ACRES Landsat7, 1999-2000) of Lake Argyle as defined by the Directory of Important Wetlands (Environment Australia, 2001)

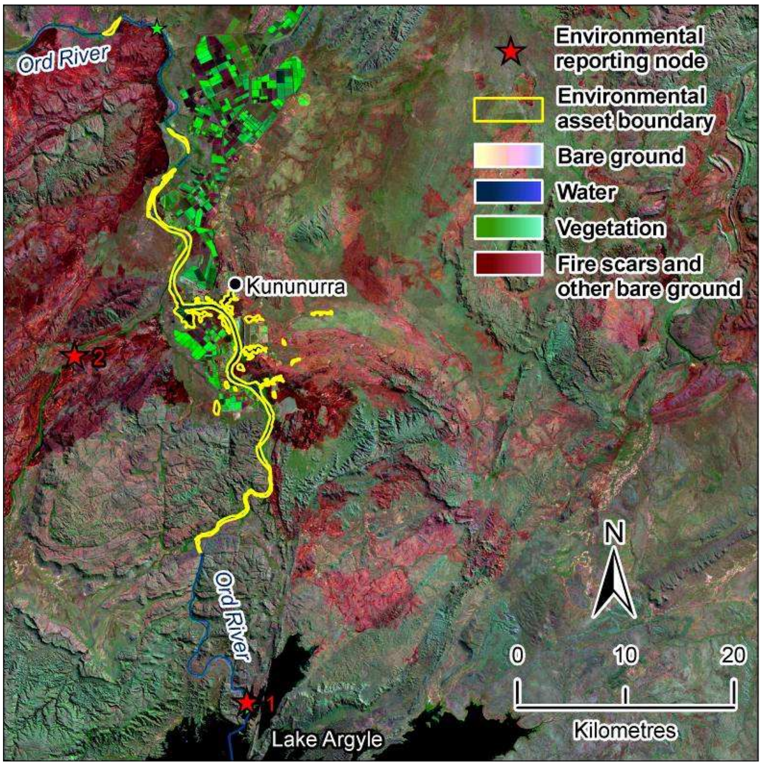

Figure 29. False colour satellite image (ACRES Landsat7, 1999-2000) of Lake Kununurra as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Lake Kununurra

Lake Kununurra (Figure 29) is a good example of an artificial tropical wetland system with extensive, permanently-inundated emergent vegetation. It is one of the few large, permanent freshwater marshes in the Kimberley. The site is listed, jointly with Lake Argyle, as a Wetland of International Importance under the Ramsar Convention (Government of Western Australia, 1990). The site is the lake formed by damming of the Ord River (Ord Diversion Dam) at Kununurra and comprises the drowned river channel and fringing swamps formed by flooding of surrounding dryland. The lake extends upstream to the Lake Argyle Dam. The site has an area of 2, 500 ha and an elevation ranging between approximately 40 m and 60 m above sea level (Environment Australia, 2001).

The site Bulrush beds at this site are the most extensive in WA outside the Swan Coastal Plain bioregion (WADCALM, 1990). The site supports colonies of Flying Foxes and at least 15 species of freshwater fishes. The site is a major breeding area for Freshwater Crocodiles. The lake is popular with local residents and tourists for swimming; recreational fishing and boating; charter boat and float-plane tours; and bird-watching.

Parry Floodplain

Parry Floodplain (Figure 30) is a good example of a tropical floodplain with permanent billabongs, seasonal marshes and wooded swamp. It is one of the few such floodplains of substantial area in WA. It is listed jointly with the Ord Estuary System as a Wetland of International Importance under the Ramsar Convention (Government of Western Australia, 1990 2000).The site has an area of 9,000 ha and an elevation ranging between 5 m and 10 m above sea level (Environment Australia, 2001).

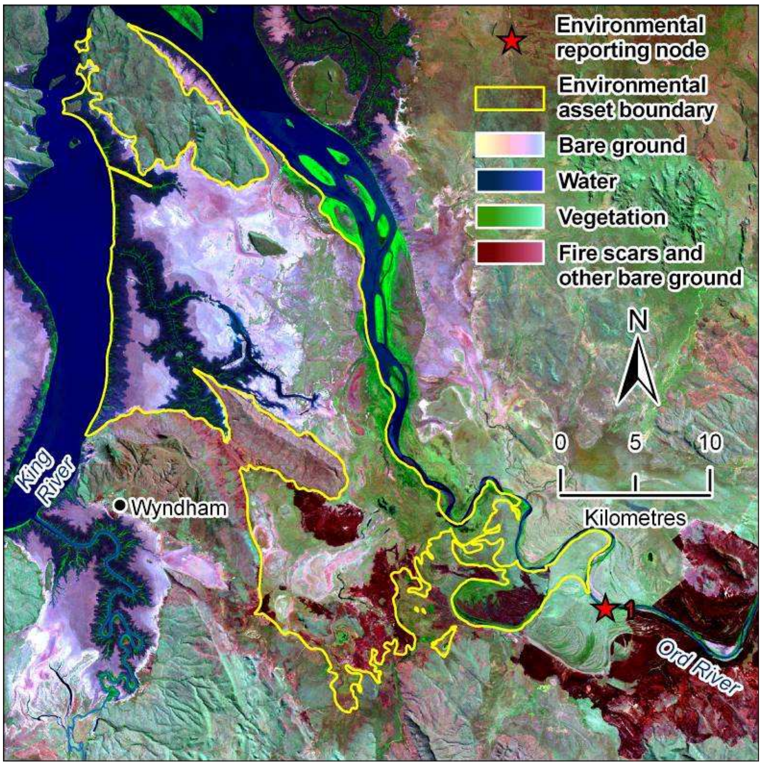

Figure 30. False colour satellite image (ACRES Landsat7, 1999-2000) of the Parry Floodplain as defined by the Directory of Important Wetlands (Environment Australia, 2001)

The floodplain's herbland/grassland communities are the most extensive in WA (Burbidge et al., 1991; WADCALM, 1990). 77 waterbird species have been recorded at the site (one of the highest totals in the Kimberley). The permanent freshwater and food resources of the site were valuable to Aboriginal people. Areas of this site are popular picnic and bird-watching areas and the site in general is popular with tourists.

Ord Estuary System

The Ord Estuary System (Figure 31) is an outstanding example of an estuary system of tropical north-west Australia with the most extensive mudflat and tidal waterway complex in WA. It is listed, jointly with Parry Floodplain, as a Wetland of International Importance under the Ramsar Convention (Government of Western Australia, 1990 2000). The Ord Estuary System has an area of 94,700 ha at an elevation at or near sea level (Environment Australia, 2001).

Many mangrove species have been recorded at the site. Substantial numbers of bird species have been observed. By virtue of the great extent of the mangrove area, the site supports a substantial population of Saltwater Crocodiles.

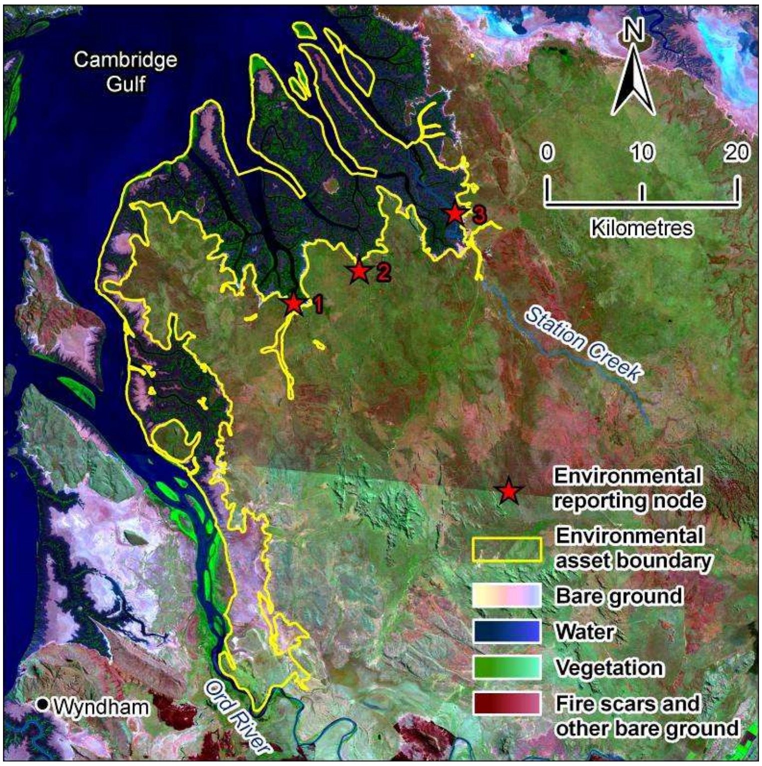

Figure 31. False colour satellite image (ACRES Landsat7, 1999-2000) of the Ord Estuary System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Appendix 1.1.4 Daly

A list of all sites from the Directory of Important wetlands in Australia located in the Daly region is shown in Table 28. The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).

Table 28. List of Wetlands of National Significance located within the Daly region

Site code	Name	Area	Ramsar site
		ha	
NT001 *	Daly River Middle Reaches	1,470	No
NT024 *	Daly-Reynolds Floodplain-Estuary System	159,000	No
NT018 *	Katherine River Gorge	354	No

*assets selected for assessment of changes to hydrological regime

Daly River Middle Reaches

The Daly River system has been identified as being of national significance due to a range of aquatic environmental assets (Begg et al., 2001; Blanch, 2005; Erskine et al., 2003). The river is perennial and has the highest baseflow of all the rivers in the Northern Territory due to discharge from limestone aquifers. These hydrological characteristics have led to some very significant environmental assets, particularly in the middle reaches of the Daly River. The Daly River Middle Reaches includes the reaches of the Daly River from the junction of Stray Creek (upstream of Oolloo Crossing) downstream to Daly River (Policeman's) Crossing. The asset as defined by Environment Australia (2001) includes the main channel and billabongs and swamps within 1 km of the channel (Figure 32).

The river reach is permanent and billabongs are generally seasonal except for deeper channels. During the wet season, floodwaters sometimes extend 1 to 2 km from the main channel. The Daly River Middle Reaches are a major breeding and dry season habitat for Freshwater Turtles (five species, notably the Pig-Nosed Turtle, *Carettochelys insculpta*), fishes, and Freshwater Crocodile. Also found in this area are rare species of shark and sawfish (Blanch, 2005; Erskine et al., 2003). The Daly River Middle Reaches include many popular destinations for recreational fishing, swimming, boating and camping.

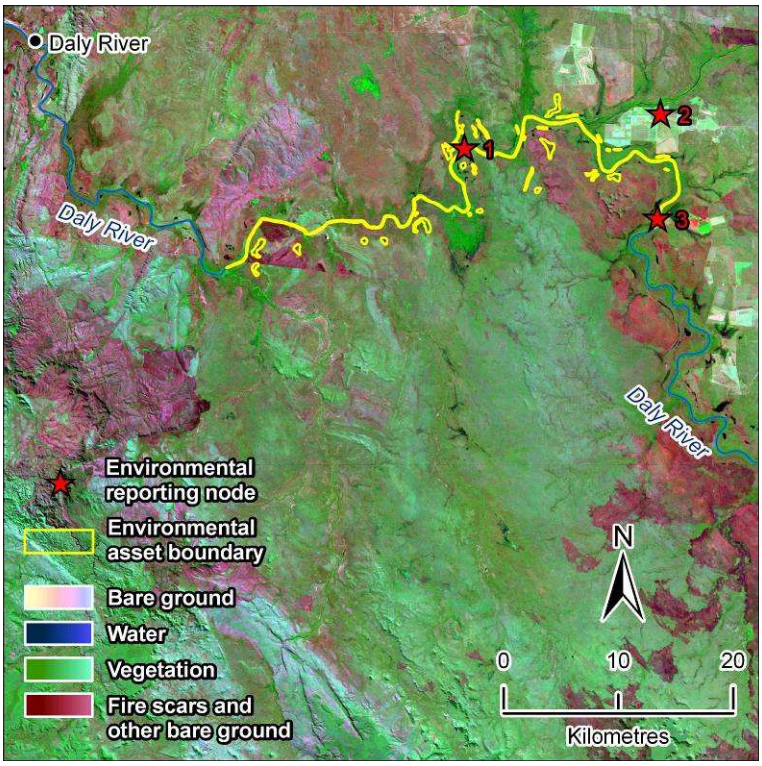

Figure 32. False colour satellite Image (ACRES Landsat7 Mosaic, 1999-2000) of Daly River Middle Reaches as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Daly-Reynolds Floodplain-Estuary System

The Daly-Reynolds Floodplain-Estuary system covers an area of 1590 km^2 and includes the entire floodplain and estuary of the Daly River (Figure 33). The system represents one of the largest floodplains in the Northern Territory and it contains a diverse mixture of wetland types (van Dam et al., 2008). These include estuarine mudflats, marshes and mangroves as well as freshwater wetlands and seasonally flooded swamps and forests. A more comprehensive description of the major wetland types in the Daly Basin is given by Begg et al. (2001). The Daly's estuary and lower floodplain wetlands support a number of significant waterbird breeding sites. For example Blanch (2005), reported that the area is the most significant place for waterbirds between Darwin and the Moyle River, containing 14 feeding and 6 breeding sites that can host over 30,000 waterbirds in a single season. There are also numerous species of freshwater and estuarine fish (48 species compared to 33 for the whole Murray-Darling Basin, which has an area 19 times larger than the Daly Basin) and it is considered the best barramundi fishing river in Australia (Blanch, 2005). The river also has important marine influence, since its discharge to the Timor Sea is the second highest of any Australian river.

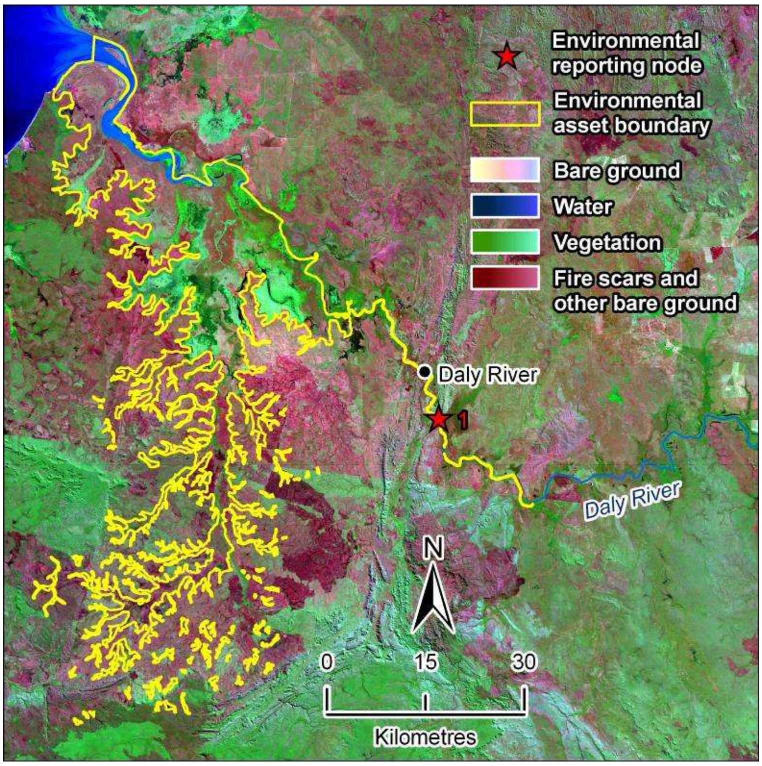

Figure 33. False colour satellite Image (ACRES Landsat7 Mosaic, 1999-2000) of the Daly-Reynolds Floodplain-Estuary System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Katherine River Gorge

The Katherine River flows into the Daly River near Claravale and contributes ~40 percent to the mean annual flow of the Daly River (Begg et al., 2001). The Katherine River basin has the second highest number of wetlands in the Daly Basin and also contains the Katherine River Gorge (Figure 34) which is listed as one of the Nationally Important Wetlands in Australia. Katherine Gorge has near-vertical rock walls and is a major dry season refuge for aquatic fauna, particularly fish, freshwater crocodiles and turtles. Katherine Gorge is located within the Nitmiluk National Park and is the site of significant Indigenous rock art; two major sites (Barraway and Gunbokmo) occur in the gorge. The permanent waters were and are often frequented by Indigenous people. The national park is an immensely popular national and international tourist destination and visitor use of the gorge generates substantial income in the Katherine area. Canoeing, swimming, camping and fishing are permitted in parts of the gorge system. The gorge has spectacular sheer rock faces more than 50 m high along much of its length; these contrast markedly with the still deep waters, plunging waterfalls (in wet season), riverside greenery and abundant (mostly arboreal) bird-life.

Aquatic reptiles occurring at the site include Freshwater Crocodile, Freshwater Snake and turtles. Twenty frog species have been recorded in the national park. A rich fish fauna exists; fishes which may be found in Katherine River based on literature and Northern Territory Museum collection records number 46 species.

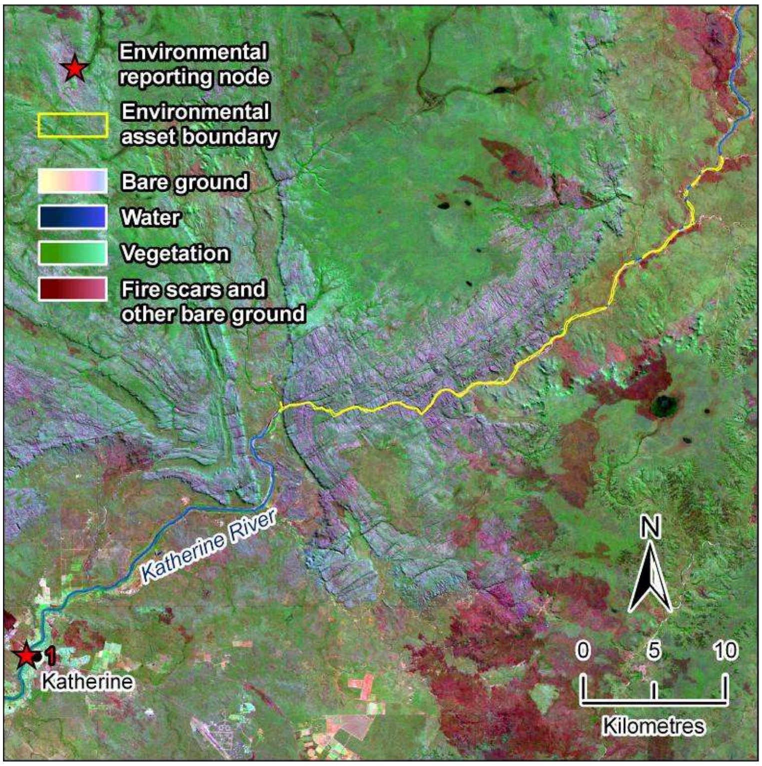

Figure 34. False colour satellite Image (ACRES Landsat7 Mosaic, 1999-2000) of the Katherine River Gorge as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Appendix 1.1.5 Van Diemen

A list of all sites from the Directory of Important wetlands in Australia located in the Van Diemen region is shown in Table 29. The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).

Table 29. List of Wetlands of National Significance located within the Van Diemen region

Site code	Name	Area (ha)	Ramsar site
NT023	Cobourg Peninsula System	254,000	Yes
NT028 *	Murgenella-Cooper Floodplain System	81,500	Yes
NT017 *	Kakadu National Park	233,000	Yes
NT020 *	Adelaide River Floodplain System	134,000	No
NT025 *	Finniss Floodplain and Fog Bay Systems	81,300	No
NT026 *	Mary Floodplain System	128,000	No
NT031	Mount Bundey Training Area - Mary River Floodplain	<10	No
NT029 *	Port Darwin	48,800	No
NT032	Shoal Bay - Micket Creek	<10	No

*assets selected for assessment of changes to hydrological regime

Murgenella-Cooper Floodplain System

The Murgenella-Cooper Floodplain System (Figure 35) is characterised by marine and coastal zone wetlands and inland wetlands. The site has an elevation ranging between 1 and 7 m above sea level and is a good example of a floodplain-tidal wetland system of the Top End Region which has a relatively low volume of freshwater inflow (Environment Australia, 2001).

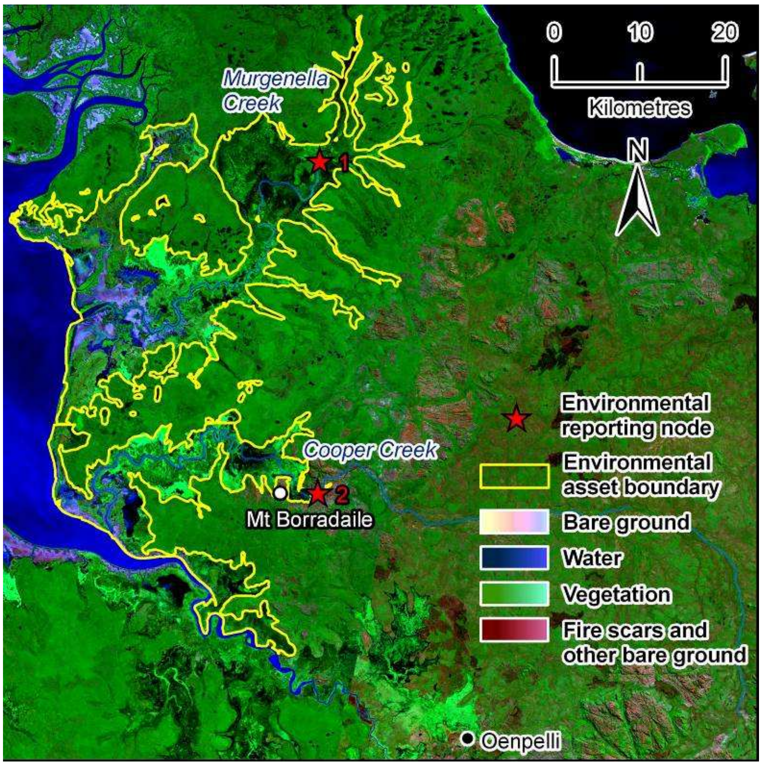

Figure 35. False colour satellite image (ACRES Landsat7, 1999-2000) of the Murgenella-Cooper Floodplain System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Magpie Goose breeds extensively on both Murgenella and Cooper Floodplains. Mudflats and saline coastal flats of the site are used at times by more than 10,000 shorebirds as a migration stop-over. Major dry season concentrations of waterbirds occur on the Cooper Floodplain (up to approximately 100,000) and counts of up to 17,000 "waders" have been recorded.

An Aboriginal community (Oenpelli) is located 33 km from the site and some traditional use of the wetlands is still practised. Significant Aboriginal rock art occurs at Mt Borradaile (Environment Australia, 2001). Commercial fishing occurs at the coast.

Kakadu National Park

Kakadu National Park (Figure 36) is a national icon and is characterised by marine and coastal wetlands, and inland wetlands. Amongst a large list of aquatic environments are marine waters, subtidal aquatic beds, mud and sand flats; tidal marshes and permanent and seasonal rivers and streams (Environment Australia, 2001). Kakadu National Park contains part or all of the catchments of two large and two smaller river systems, including a mosaic of contiguous wetlands associated with them. The wetlands and their catchments encompass sandstone plateau communities, escarpments, lowland open forest and woodland savanna, seasonal floodplains, tidal flats, estuaries, and offshore islands.

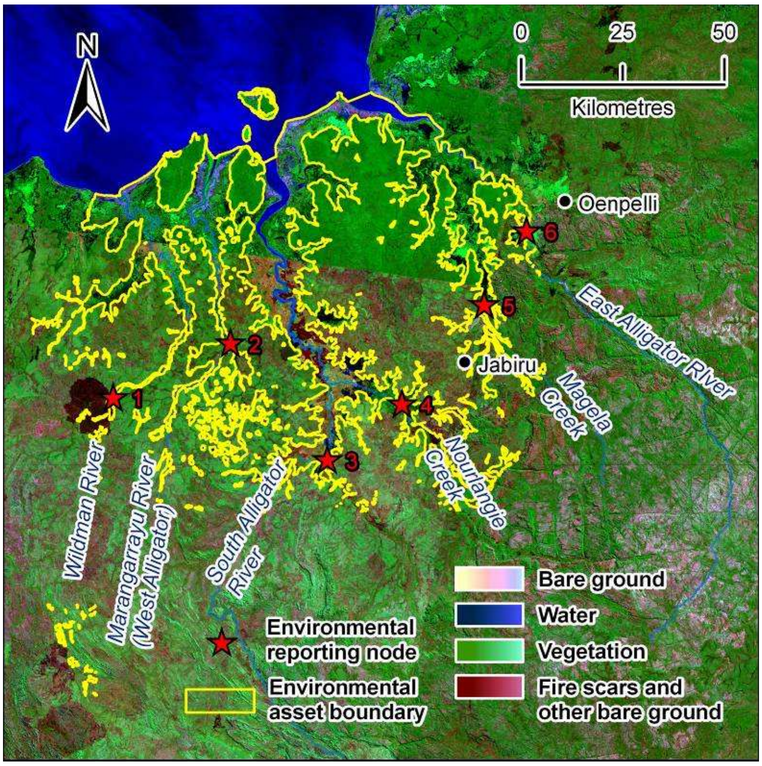

Figure 36. False colour satellite image (ACRES Landsat7, 1999-2000) of Kakadu National Park as defined by the Directory of Important Wetlands (Environment Australia, 2001)

The floodplains and other wetlands support about three million waterbirds. Large populations of many other vertebrate and invertebrate species are also found. The site has an area of 233,000 ha and an elevation ranging between zero and 400 m above sea level (Environment Australia, 2001). The Kakadu wetlands are significant for a number of reasons, including their diversity, the flora and fauna they support, and their ongoing importance to the traditional owners of the area. The international significance of the region, including the wetland ecosystems, is recognised by the fact that it is a proclaimed World Heritage Area. The floodplains are outstanding examples of their flora types in the monsoon tropics (Environment Australia, 2001).

High economic and religious values are placed on the wetlands and surrounding catchment by the Aboriginal people of the region (Environment Australia, 2001). High values are perceived nationally and internationally for conservation, mining, tourism, education and research. Aboriginal sacred sites and art sites are found throughout the park and are important to continuing Aboriginal culture (Environment Australia, 2001). In recognition of the conservation significance of the area, 683,000 hectares of Kakadu National Park are listed under the Ramsar Convention.

Adelaide River Floodplain System

The Adelaide River Floodplain System (Figure 37) is a good example of a major floodplain-tidal wetland system typical of the Top End Region. The site has an area of 134,000 ha and an elevation ranging between zero and 6 m above sea level (Environment Australia, 2001). Notable features include one of the largest blocks of mangrove associated with a Top End floodplain, a tightly meandering major tidal river, the largest floodplain lake in the Top End (Environment Australia, 2001).

The highest known density of breeding by the Magpie Goose occurs at this site. The site supports at least two major waterbird breeding rookeries. Coastal mudflats and nearby areas are important migration stop-over areas, supporting in the order of 10,000 shorebirds on the floodplain at times before the Wet sets in (Environment Australia, 2001). Saltwater Crocodile and Freshwater Crocodile occur at the site.

The site includes registered Indigenous sacred sites and supports several pastoral enterprises and commercial boat tours. Saltwater Crocodile eggs are harvested commercially in areas of this site to support of a significant part of the crocodile farming industry. The lower estuaries support major barramundi and mud crab fisheries. Adelaide River is popular for barramundi fishing, boating, nature study (especially bird- watching at Fogg Dam) and boat tours (especially for crocodile viewing).

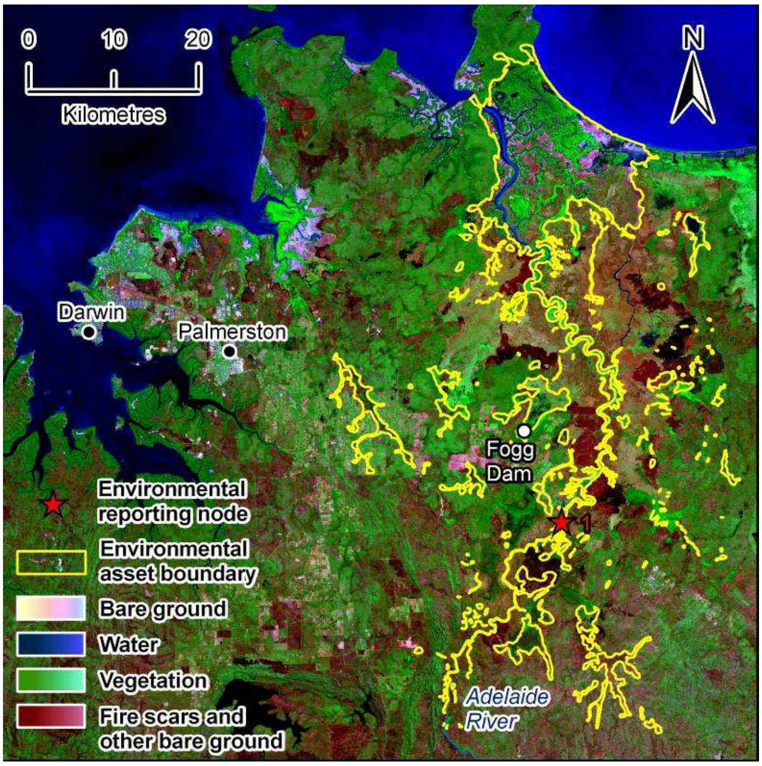

Figure 37. False colour satellite image (ACRES Landsat7, 1999-2000) of the Adelaide River Floodplain System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Finniss Floodplain and Fog Bay System

The Finniss Floodplain and Fog Bay system (Figure 38) is a beach-fringed, curved bay with continuous intertidal mudflats, and a modified but relatively intact floodplain with extensive paperbark swamps. The site has an area of 81,300 ha and an elevation a few metres above sea level (Environment Australia, 2001).

The site supports some of the best floating mat vegetation communities in the NT. In excess of 25,000 migrant shorebirds have been recorded using the area as a migration stop-over. Dugong and Indo-pacific Humpback Dolphin regularly occur in the south-west of Fog Bay (Environment Australia, 2001). The permanent floodplain billabongs in the north-east of the site are a major breeding area for Saltwater and Freshwater Crocodiles (Hill and Webb, 1982; Webb et al., 1983; Wood and Bonnin, 1987).

An Aboriginal community (Wagait) is located at the edge of the site and semi traditional use of the wetlands is still practised (Environment Australia, 2001). Commercial activities in the area include a pastoral grazing enterprise on the floodplain, commercial fishing near the river mouth, and harvesting of Saltwater Crocodile eggs from floating mat swamps. A major harvest of banana prawn occurs in Fog Bay.

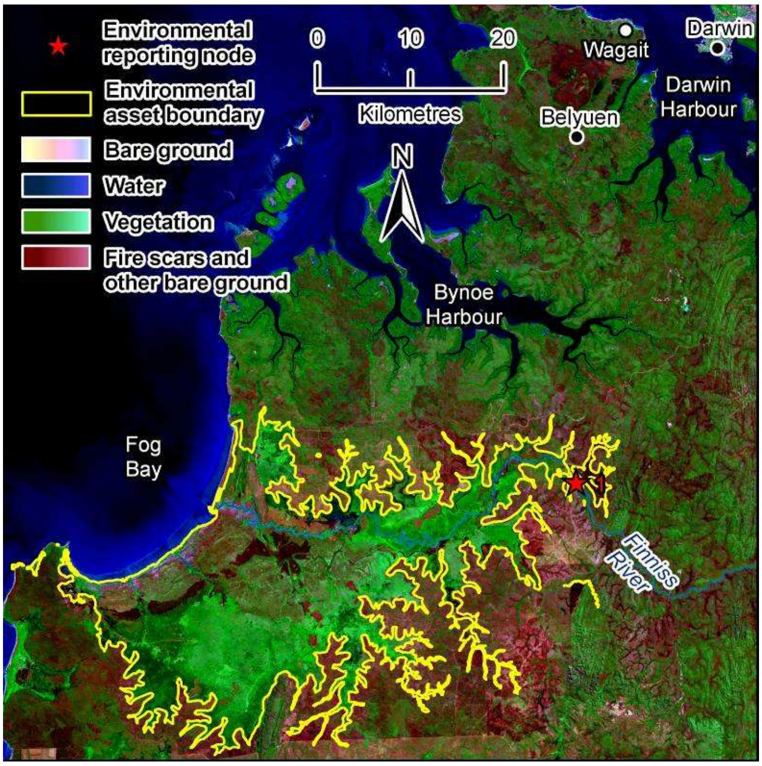

Figure 38. False colour satellite image (ACRES Landsat7, 1999-2000) of the Finniss Floodplain and Fog Bay System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Mary Floodplain System

The Mary Floodplain System (Figure 39) is a good example of a major floodplain-tidal wetland system typical of the Top End Region, but unusual in lacking a coherent river channel or major river estuary. The site has an area of 126,000 ha and an elevation ranging between zero and 10 m above sea level (Environment Australia, 2001). The site includes some of the largest areas of wooded swamp (apart from Arafura Swamp) in the NT, and features a complex network of channels and billabongs. The unusual morphology of the plain contributes to rapid overtopping of levees and inundation of huge seasonal wetlands, even in years of relatively low rainfalls. Drainage rates are also lower than many other systems, such as the Adelaide River, so that the site provides greater areas of wetland habitats over a relatively extended period.

The site includes highest known breeding concentration of sea-eagle in NT (Environment Australia, 2001). The mudflats and coastal flats support at least several thousand migrant shorebirds at times (Environment Australia, 2001). During synchronous flowering of melaleuca swamp forests at this site, fruit bats in numbers in the order of 250,000 have been observed.

A number of registered Aboriginal sites exist on the floodplain (Environment Australia, 2001). The site supports several pastoral (buffalo, cattle) grazing enterprises and commercial wildlife tours. The site (river and estuaries) is the most popular area for amateur fishing of barramundi in the NT. Recreation sites exist at seven points and development of additional facilities and opportunities for wildlife observation, boating, fishing, camping and picnicking have been proposed (Environment Australia, 2001).

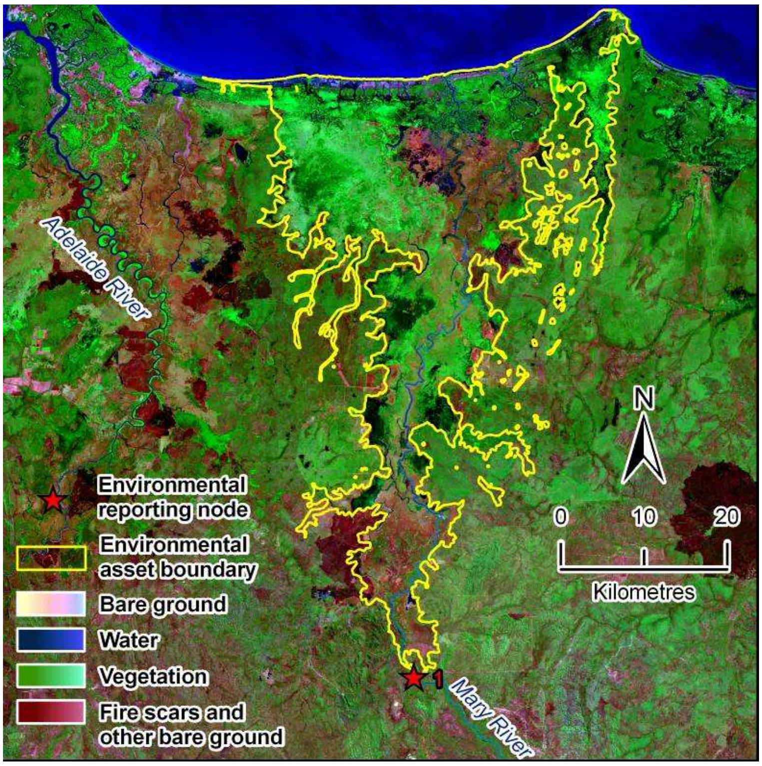

Figure 39. False colour satellite image (ACRES Landsat7, 1999-2000) of the Mary Floodplain System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Port Darwin

Port Darwin (Figure 40) is a good example of a shallow branching embayment of the Top End Region and supports one of the largest discrete areas of mangrove swamp in the NT. The mangrove communities of this site are the most extensive and species-rich of any NT embayment (Wightman, 1989). This site is characterised by marine and costal zone wetlands. The site has an area of 21,900 ha and an elevation at sea level (Environment Australia, 2001).

At least 15 migrant shorebird species use the site as a migration stop-over, most of them probably on a regular basis. Dolphins and turtles are commonly seen. The mangroves and shallows are an important nursery area for fish, crabs, prawns and other marine fauna (Environment Australia, 2001).

The annual cycle of hunting and gathering of the Larrakia Aboriginal people includes the site, where a wide variety of meat and vegetable foods are procured (Environment Australia, 2001). The site is used for commercial fishing pearl culturing, aquaculture, port facilities and industry, and tourism.

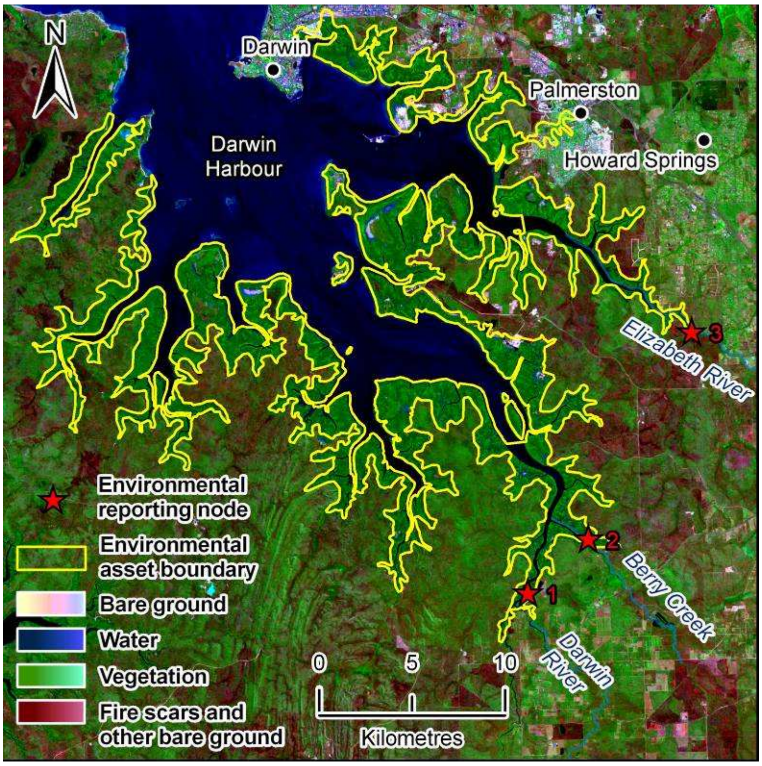

Figure 40. False colour satellite image (ACRES Landsat7, 1999-2000) of Port Darwin as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Appendix 1.1.6 Arafura

A list of all sites from the Directory of Important wetlands in Australia located in the Arafura region is shown in Table 30. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 30. List of Wetlands of National Significance located within the Arafura region

Site code	Name	Area	Ramsar site
		ha	
NT021 *	Arafura Swamp	71,400	No
NT022 *	Blyth-Cadell Floodplain & Boucaut Bay System	35,500	No

*assets selected for assessment of changes to hydrological regime

Arafura Swamp

The Arafura Swamp (Figure 41) is a good example of a wooded swamp, the largest in NT and possibly one of the largest in Australia. The site has an area of 71,400 ha and an elevation ranging between zero and 20 m above sea level (Environment Australia, 2001).

Billabongs and river channels support floating mat communities and monsoon vine-forest occurs in patches along the river. The site is known to be a significant breeding area for Magpie Goose. The site is a major breeding area for both crocodile species. Saltwater crocodiles occur in high densities, especially in billabongs near the northern end. Large numbers of fruit bats roost and feed in the site's large melaleuca forests.

The site has great cultural significance to Aboriginal people, both in the past (mainly Djinba tribe) and present (Ramingining community and others) (Environment Australia, 2001). Campsites and large middens occur around the swamp. Hunting, gathering and fishing using traditional methods continue today. The margins of the swamp are used for pastoral grazing and were formerly a major area for saltwater crocodile hunting. Minor commercial harvesting of crocodile eggs from floating mats occurs within the site.

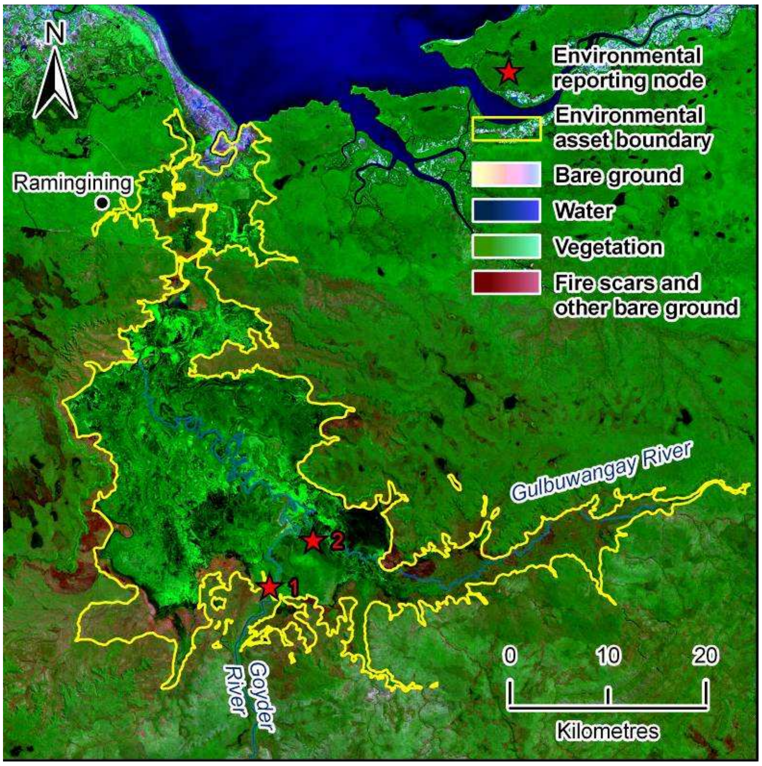

Figure 41. False colour satellite image (ACRES Landsat7, 1999-2000) of the Arafura Swamp as defined by the Directory of Important Wetlands (Environment Australia, 2001)

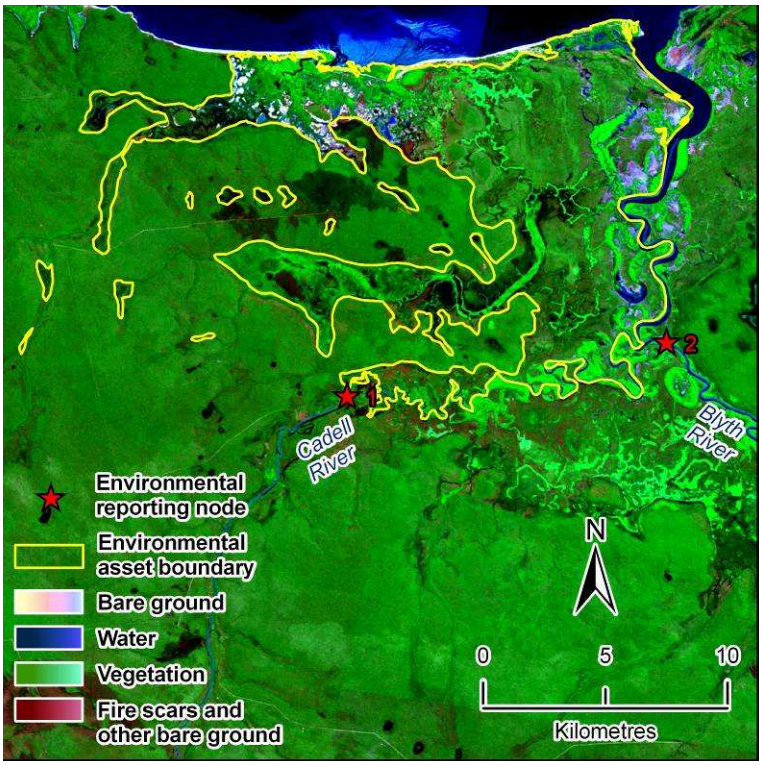

Figure 42. False colour satellite image (ACRES Landsat7, 1999-2000) of the Blyth-Cadell Floodplain and Boucaut Bay System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

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Blyth-Cadell Floodplain and Boucaut Bay System

The Blyth-Cadell Floodplain and Boucaut Bay System (Figure 42) is a good example of a floodplain-tidal wetland system typical of the Top End Region and is the largest, contiguous, non-forested freshwater floodplain in Arnhem Land (excluding sites on Van Diemen Gulf). The site has an area of 35,500 ha and an elevation ranging between zero and 7 m above sea level (Environment Australia, 2001).

The site is an important migration stop-over site for shorebirds in Arnhem Land with more than 15,000 waders regularly recorded in the area 10 km either side of the mouth of the Blyth River (Environment Australia, 2001). The floodplain swamps and grasslands remain a significant breeding area for Saltwater Crocodiles. Two Aboriginal communities are located within 25 km of the site and traditional use of the wetlands is still practised. (Environment Australia, 2001)

Appendix 1.2 Gulf of Carpentaria

Appendix 1.2.1 Roper

A list of all sites from the Directory of Important wetlands in Australia located in the Roper region is shown in Table 31. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 31. List of Wetlands of National Significance located within the Roper region

Site code	Name	Area	Ramsar site
		ha	
NT007*	Limmen Bight (Port Roper) Tidal Wetlands System	185,000	No
NT003*	Mataranka Thermal Pools	<10	No

*assets selected for assessment of changes to flow regime.

Limmen Bight (Port Roper) Tidal Wetlands System

The Limmen Bight (Port Roper) Tidal Wetland System (Figure 43) is a good example of a system of tidal wetlands (intertidal mud flats, saline coastal flats and estuaries) with a high volume of freshwater inflow, typical of the Gulf of Carpentaria coast. It is the second largest area of saline coastal flats in the Northern Territory. The site has an area of 185,000 ha and an elevation ranging between zero and 10 m above sea level (Environment Australia, 2001).

The site, especially the Port Roper mudflats, is among the most important coastal areas for shorebirds in the Northern Territory. The maintenance of populations of commercially harvested Tiger Prawn in the Gulf is linked to their utilisation of inshore seagrass areas in this area (Environment Australia, 2001). Dugong occur offshore of the whole site in the wet season. Medium densities of Saltwater Crocodile occur in the Roper River estuary. Marine turtles use nest sites on offshore islands associated with the site.

Much of the site is Indigenous land and Indigenous communities are located outside the site. Traditional use of the wetlands is still practised. A sacred site occurs near Warrakunta Point. The near-coastal waters and estuaries support a major commercial barramundi and salmon fishery; major harvest of crabs occurs at Port Roper; and aquaculture is maintained near the Roper River (Environment Australia, 2001).

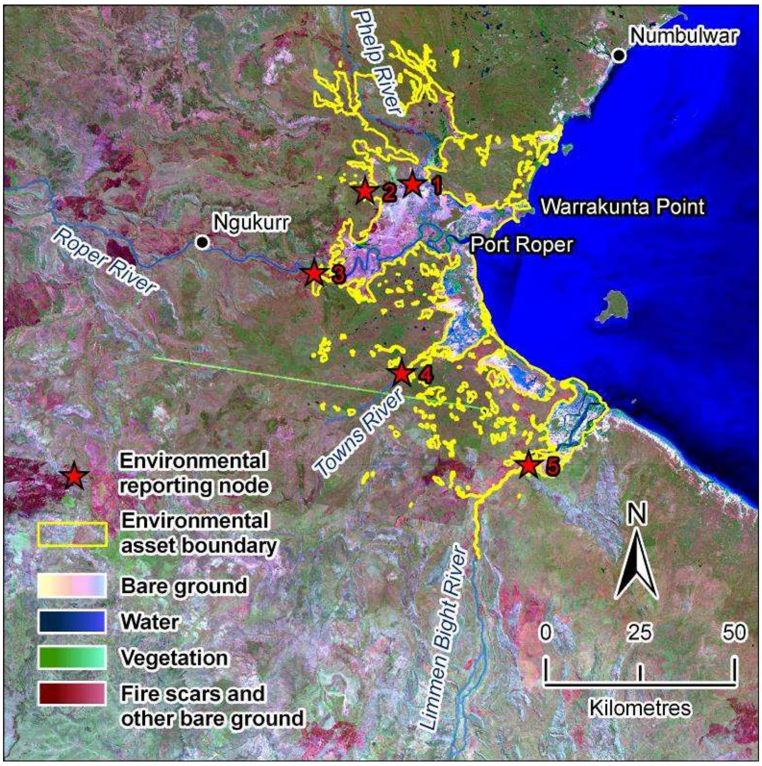

Figure 43. False colour satellite image (ACRES Landsat7, 1999 to 2000) of the Limmen Bight (Port Roper) Tidal Wetlands System as defined by the Directory of Important Wetlands (Environment Australia, 2001).

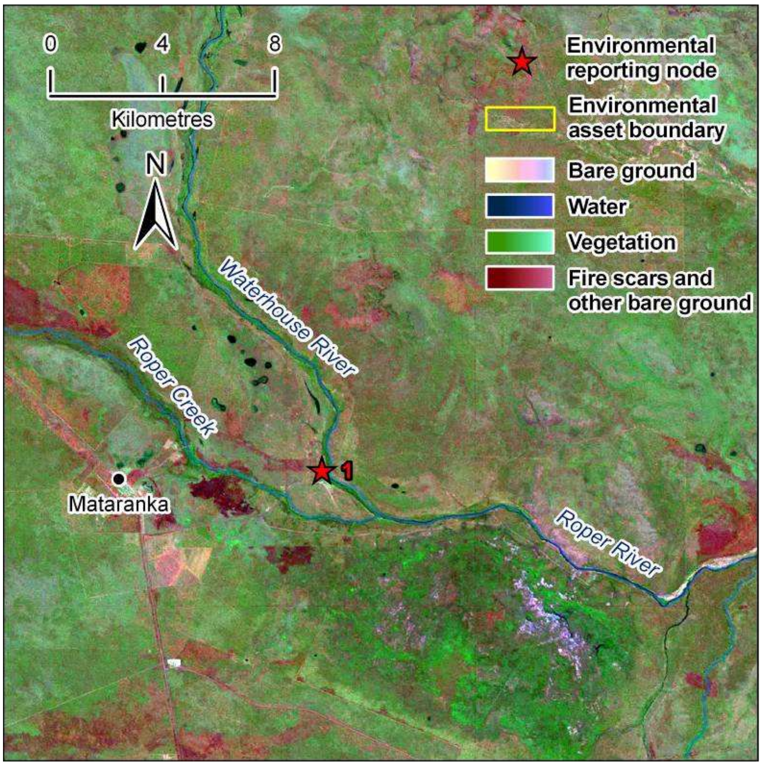

Figure 44. False colour satellite image (ACRES Landsat7, 1999 to 2000) of the Mataranka Thermal Pools as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Mataranka Thermal Pools

The Mataranka Thermal Springs (Figure 44) are one of the best known examples of tropical springs and associated permanent pools in the NT. The site is a popular tourist destination attracting more the 150,000 visitors annually, which results in significant support for local businesses (Environment Australia, 2001). The site has an area of less than 10 ha and an elevation of approximately 115 m above sea level (Environment Australia, 2001). The thermal pools provide a permanent source of water in a seasonally dry environment.

The surrounding woodland includes a *Livistona rigida* palm community which has a restricted distribution in the Top End Region (Wilson et al., 1990). The Little Red Flying-fox, roost in the area in large numbers, sometimes exceeding 200 000, and often use the site as a maternity colony.

Appendix 1.2.2 South-West Gulf

A list of all sites from the Directory of Important wetlands in Australia located in the South-West Gulf region is shown in Table 32. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 32. List of Wetlands of National Significance located within the South-West Gulf region

Site code	Name	Area ha	Ramsar site
QLD102	Bluebush Swamp	879	No
NT006	Borroloola Bluebush	70	No
QLD105	Forsyth Island Wetlands	6,390	No
QLD119 *	Gregory River	26,600	No
QLD101	Lawn Hill Gorge	1,130	No
QLD108	Marless Lagoon Aggregation	167,000	No
QLD110	Musselbrook Creek Aggregation	45,100	No
QLD111 *	Nicholson Delta Aggregation	63,600	No
NT008 *	Port McArthur Tidal Wetlands System	119,000	No
QLD114 *	Southern Gulf Aggregation	546,000	No
QLD122 *	Thorntonia Aggregation	299,000	No
QLD116	Wentworth Aggregation	82,300	No

*assets selected for assessment of changes to flow regime.

Gregory River

Gregory River (Figure 45) is the largest perennial river in arid and semi-arid Queensland. The area encompasses the nationally significant Riversleigh fossil beds associated with the Coal Creek Limestone Formation. The site comprises an extensive perennial riverine complex in a semi-arid environment. All of the major streams of this catchment are spring fed. The site has an area of 26,600 ha and an elevation ranging between 65 m and 150 m above sea level (Environment Australia, 2001). Aquatic beds and occasional sedge emergents occur in still water areas in the lower reaches and forested wetland communities occur on the narrow levees. Estuarine crocodiles occur occasionally in the lower reaches. Levees of the Gregory River are of considerable significance to the local Indigenous community (Environment Australia, 2001).

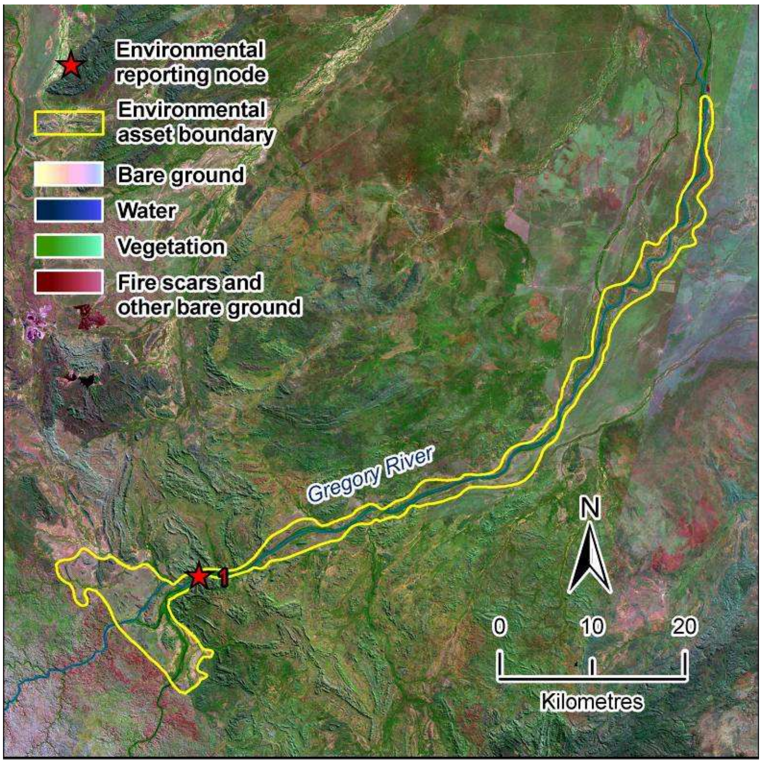

Figure 45. False colour satellite image (ACRES Landsat7, 1999 to 2000) of Gregory River as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Nicholson Delta Aggregation

The Nicholson Delta Aggregation (Figure 46) is the best example of a deltaic, alluvial system in the south-western portion of the southern Gulf of Carpentaria. The aggregation comprises a complex disjunct wetland aggregation (Blackman et al., 1992) of closed depressions in impeded drainage lines, flood-outs, back-plains and riverine channels merging with an extensive estuarine system of saline clay pans and tidal channels. The site has an area of 63,600 ha and an elevation ranging between 5 m and 10 m above sea level (Environment Australia, 2001).

The rich array of permanent, semi-permanent and seasonal wetlands provides drought refuge for waterbirds as well as breeding, roosting, feeding and moulting habitat. Australian freshwater and estuarine crocodiles are common in the area as are large numbers of waterbirds. Parts of this site are frequented by tourists (Environment Australia, 2001).

Port McArthur Tidal Wetland System

The Port McArthur Tidal Wetland System (Figure 47) is a good example of a typical tidal wetland system of the Gulf of Carpentaria, including the only substantial area of mangrove swamp, and the widest and largest area of intertidal mudflats, in the south-west of the Gulf. Lake Eames is the only sizeable, permanent freshwater lake in the south-west of the Gulf. The site has an area of 119,000 ha and an elevation at or near sea level (Environment Australia, 2001).

As many as 26 mangrove species are known to occur in the area, including 15 tree species (Environment Australia, 2001). The number of water birds recorded at this location totals 55, 26 of which are listed under treaties (JAMBA, CAMBA, BONN) (Environment Australia, 2001). The 55 include ten herons and allies, 27 shorebirds and eight terns. At least two substantial waterbird breeding rookeries are located at the site, supporting a total of more than 3000 adult birds (egrets, cormorants and Pied Herons)(Environment Australia, 2001). At least 24 seabird breeding rookeries support more than 300,000 adult birds.

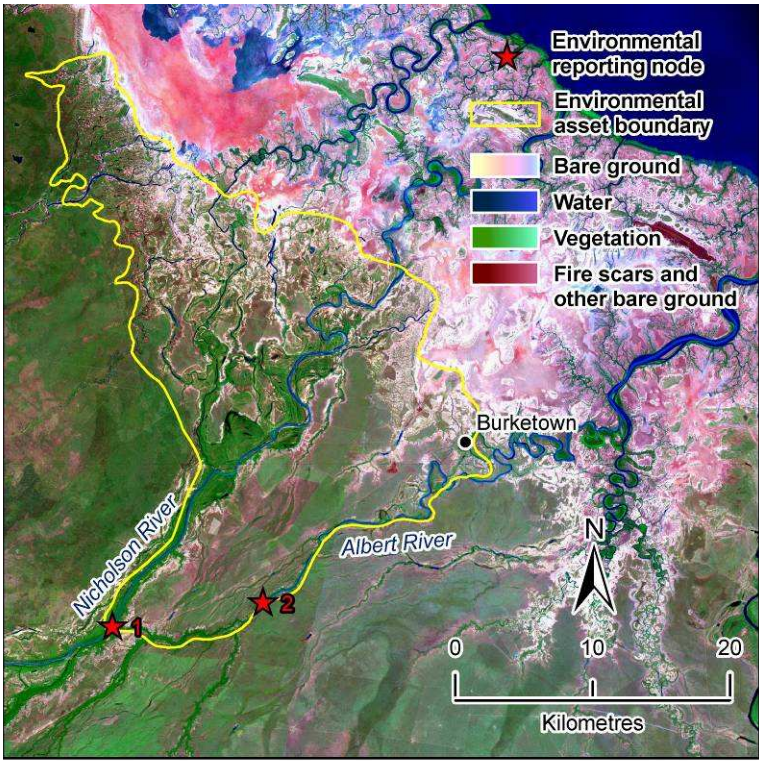

Figure 46. False colour satellite image (ACRES Landsat7, 1999 to 2000) of the Nicholson Delta Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

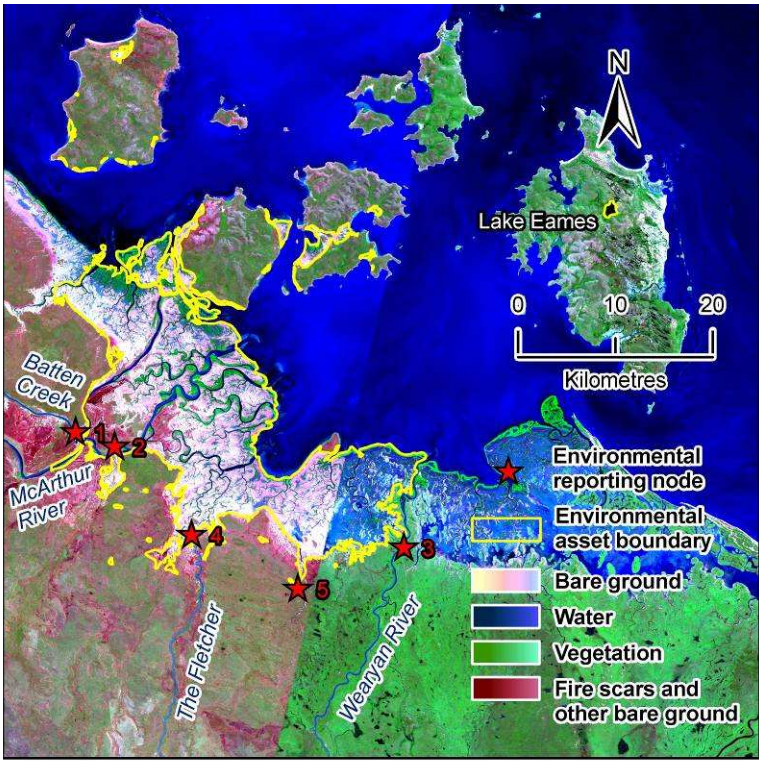

Figure 47. False colour satellite image (ACRES Landsat7, 1999 to 2000) of the Port McArthur Tidal Wetland System as defined by the Directory of Important Wetlands (Environment Australia, 2001)

The site's marine and estuarine habitats are known to support at least 132 fish species (Environment Australia, 2001). The mangroves contain most of the bird species that have adapted to this habitat and probably are an important link between Top End and Cape York bird populations. Turtles occur on most of the islands offshore with all species known to breed regularly in the Northern Territory nesting here.

The islands are occupied by Indigenous people and many sacred sites exist on the islands and some occur on the mainland. Commercial fishing occurs around most of the estuaries and the site supports a major mud crab fishery (Environment Australia, 2001).

Southern Gulf Aggregation

This huge coastal aggregation covers an area of 546,000 ha and ranges in elevation from zero to 10 m above sea level (Figure 48). This wetland area extends across three of the regions defined for this project: Flinders-Leichhardt, South-West Gulf and South-East Gulf regions. In the South-West Gulf region we consider reporting node 1. The Southern Gulf Aggregation is a complex continuous wetland aggregation (Blackman et al., 1992) that also encompasses several complex disjunct aggregations of closed depressions. Seaward to landward it comprises a continuum of extensive marine intertidal flats, beaches and foredunes, secondary dunes and swales, saline clay plains, seaward margins of saline clay plains, margins and levees of tidal channels, low elevated plains, and depressions within low elevated plains. The area is under the dominating influence of estuarine tides and massive freshwater flooding during wet season events.

Marine and estuarine tidal waters permanently inundate or regularly flood much of the area, with wet season flooding by freshwater from the streams and rivers of the inland catchment combined with local runoff from the plains of the Gulf Fall. The wetlands occurring along the inland margins of the area are brackish and all are seasonal. The aggregation has a major influence on nutrient flow into the Gulf of Carpentaria (Wolanski, 1993).The Southern Gulf Aggregation is the largest continuous estuarine wetland aggregation of its type in northern Australia. It is one of the three most important areas for shorebirds in Australia (Watkins, 1993).

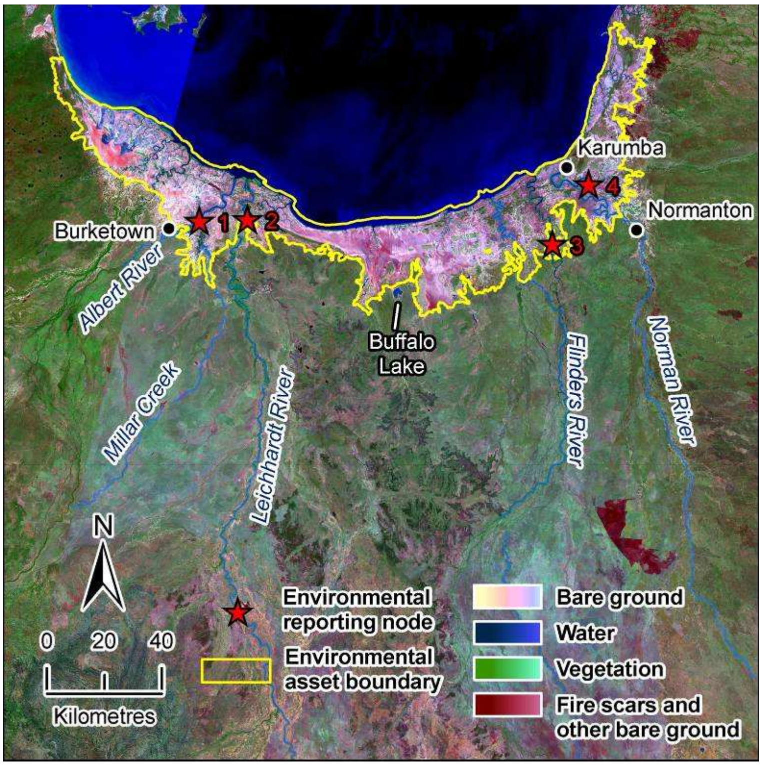

Figure 48. False colour satellite image (ACRES Landsat7, 1999 to 2000) of the Southern Gulf Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Thorntonia Aggregation

The Thorntonia Aggregation (Figure 49) is a good example of a pristine wetland system with permanent deep water in a semi-arid environment. Probably the only perennial streams in arid Queensland also occur at the site. The area includes a large part of the Carl Creek Limestone Formation containing the internationally significant Riversleigh fossil field. The site has an area of 299,000 ha and an elevation ranging between 150 m and 250 m above sea level (Environment Australia, 2001).

Forested and shrub-scrub palustrine wetlands occur on well-developed levees and in the shallower seasonal channels. Aquatic vegetation beds occur in the riverine wetlands. A notable aspect of the flora is the rainforest influence and marked differences between the fringing communities of the gorges and channels and the surrounding semi-arid country. The perennial streams are considered to provide a refuge environment during the dry season (Environment Australia, 2001).

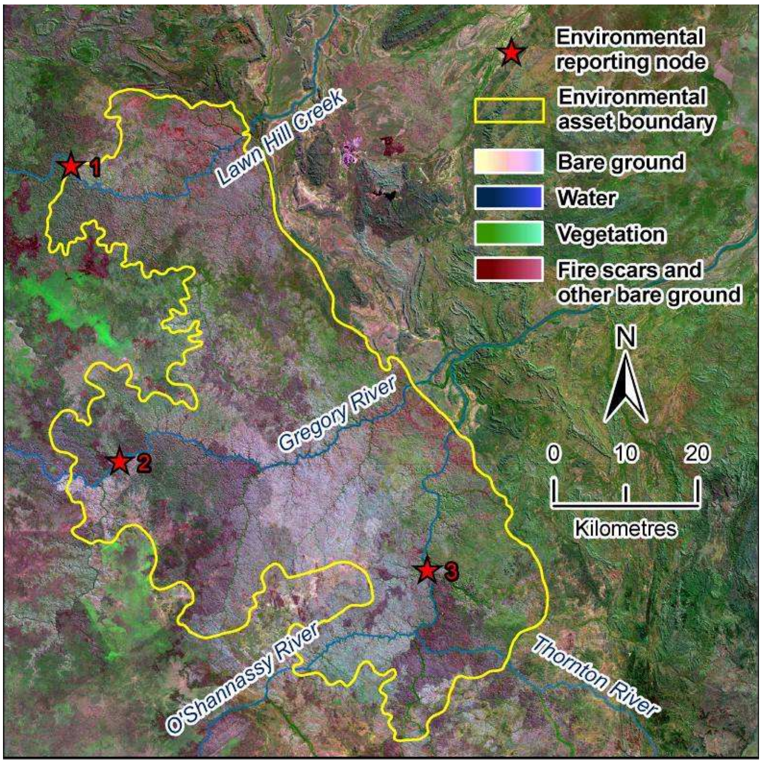

Figure 49. False colour satellite image (ACRES Landsat7, 1999 to 2000) of the Thorntonia Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Appendix 1.2.3 Flinders-Leichhardt

A list of all sites from the Directory of Important wetlands in Australia located in the Flinders-Leichhardt region is shown in Table 33. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 33. List of Wetlands of National Significance located with the Flinders-Leichhardt region

Site code	Name	Area	Ramsar site
		ha	
QLD103 *	Buffalo Lake Aggregation	1,910	No
QLD120 *	Lake Julius	1,940	No
QLD121	Lake Moondarra	1,740	No
QLD106	Lignum Swamp	283	No
QLD114 *	Southern Gulf Aggregation	546,000	No
QLD115	Stranded Fish Lake	68	No

*assets selected for assessment of changes to hydrological regime

Buffalo Lake Aggregation

Buffalo Lake Aggregation has an area of 1910 ha and an elevation range of five to 15 m above sea level (Figure 50). The lake is also flooded in extreme wet season events and tidal surges which periodically inundate much of the coast from Burketown to Normanton. The lake is seasonal, drying out completely in most years. Depth is variable but mostly less than 1 m. Buffalo Lake is a good example of a large shallow lake typical of a suite of lacustrine systems in the Karumba Plains province. The aggregation consists of shallow lacustrine wetlands with extensive areas of both open water with unconsolidated bottom, and emergent wetland interspersed with aquatic beds. It is particularly important as a breeding and feeding habitat for waterfowl, and provides important roosting and feeding habitat for waterbirds and migratory waders. Buffalo Lake is the largest of several similar lakes in the general vicinity (Claridge et al., 1988). The site described in Figure 50 extends to the maximum high water mark of the drainage depression. It is formed in a shallow depression on a slightly elevated plain behind a low dune-swale formation which seasonally dams water from the local catchment of the elevated plain.

Lake Julius

Lake Julius is a water storage formed by damming a valley of the Leichhardt River below the junction with Paroo Creek in 1976 (Figure 51). The lake provides mining and industrial water and town water supply. At maximum storage Lake Julius has an area of 1940 ha and is situated at an elevation of 224 m. The lake is permanent (Finlayson et al., 1984) and provides deep water habitat and lacustrine wetlands dominate, with minor areas of palustrine forested wetland fringing the shoreline (Blackman et al., 1992). Lake Julius is an important dry season refuge for waterbirds and is a significant large permanent waterbody in a semi-arid area. Although artificial, it provides the equivalent of natural lake and lagoonal habitat. Lake Julius includes a minor Aboriginal art site and is an important local recreational area. There is extensive cattle grazing in the land surrounding the lake.

This site is part of or adjacent to a modified water body currently managed for the primary purpose of water supply infrastructure and that also serves as a wetland. Notwithstanding that this is a modified or constructed wetland, the site does have biodiversity values that are consistent with the criteria for listing an important wetland on the Directory of Important Wetlands.

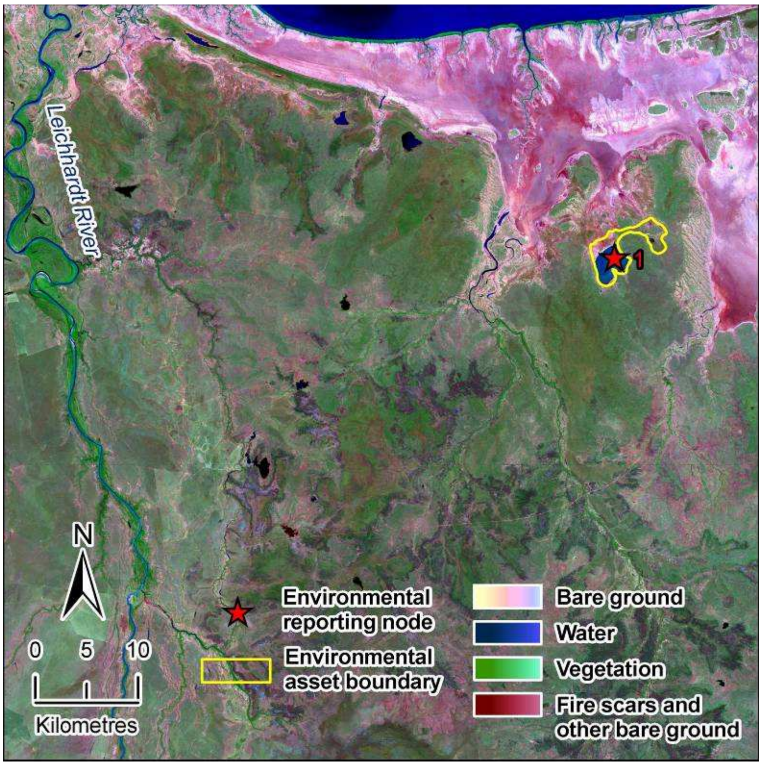

Figure 50. False colour satellite image (ACRES Landsat7, 1999-2000) of the Buffalo Lake Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

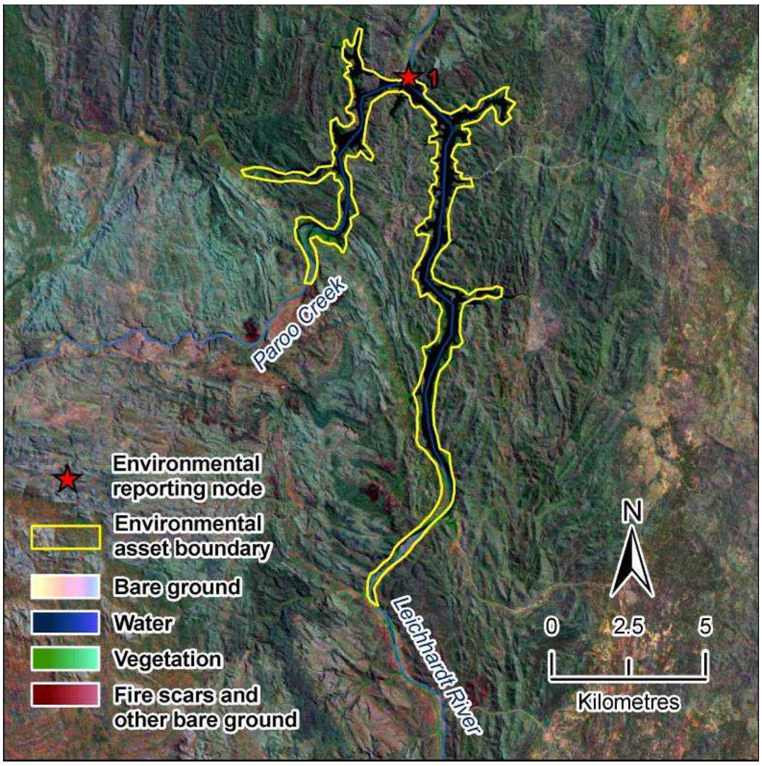

Figure 51. False colour satellite image (ACRES Landsat7, 1999-2000) of Lake Julius as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Appendix 1.2.4 South-East Gulf

A list of all sites from the Directory of Important wetlands in Australia located in the Flinders-Leichhardt region is shown in Table 34. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 34. List of Wetlands of National Significance located within the South-East Gulf region

Site code	Name	Area	Ramsar site
		ha	
QLD104 *	Dorunda Lakes Area	6,810	No
QLD107	Macaroni Swamp	258	No
QLD112 *	Smithburne - Gilbert Fan Aggregation	251,000	No
QLD113	Southeast Karumba Plain Aggregation	336,000	No
QLD114 *	Southern Gulf Aggregation	546,000	No
QLD094	Undara Lava Tubes	1,250	No

*assets selected for assessment of changes to hydrological regime

Dorunda Lakes Area

The Dorunda Lakes Area (Figure 52) is a particularly good example of a complex of permanent, semi permanent and seasonal wetland types with a localised occurrence within the Gulf Plains province of the Gulf Plains bioregion. It is an important refuge for wetland bird species. The Dorunda Lake site is a large semi abandoned riverine channel complex with associated oxbows and swamps. The catchment is a series of unnamed mostly unidirectional streams which drain part of an immense undulating alluvial plain with shallow, widely spaced valleys and a uniform pattern associated with the Mitchell, Staaten and Gilbert rivers. The site has an area of 6, 810 ha and an elevation ranging between 10 and 20 m above sea level (Environment Australia, 2001).

The site's emergent vegetation communities line the large deep riverine pools and aquatic beds occur in the limnetic and littoral areas of the ox-bows and swamps. Upland areas are mostly woodland. The estuarine and freshwater crocodile are found in the area. This is one of the most pristine inland wetland sites in the Gulf Plains (Environment Australia, 2001).

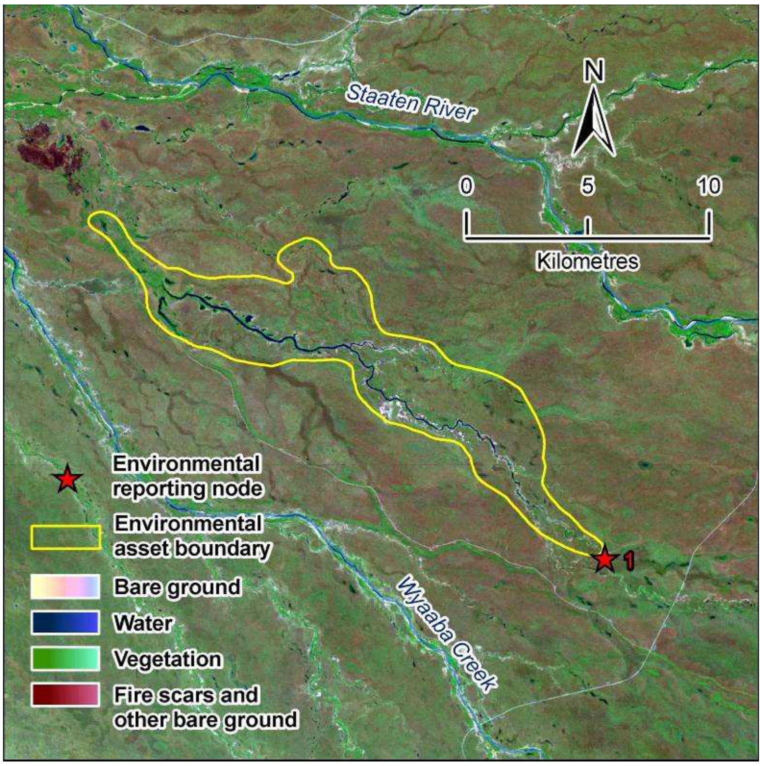

Figure 52. False colour satellite image (ACRES Landsat7, 1999-2000) of the Dorunda Lakes Area as defined by the Directory of Important Wetlands (Environment Australia, 2001)

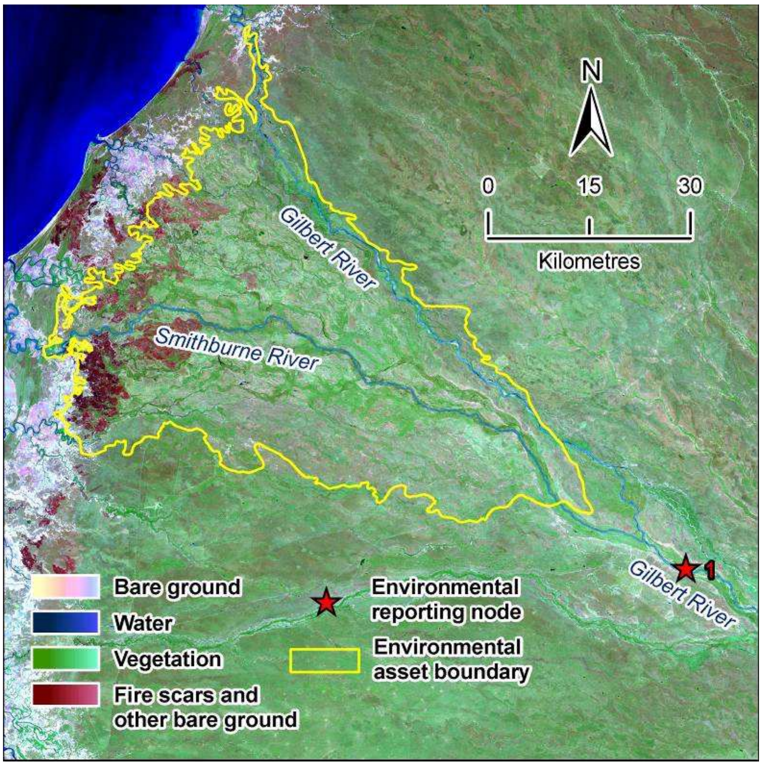

Figure 53. False colour satellite image (ACRES Landsat7, 1999-2000) of the Smithburne – Gilbert Fan Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Smithburne – Gilbert Fan Aggregation

The Smithburne–Gilbert Fan Aggregation (Figure 53) contains the best examples of alluvial plain wetlands characteristic of the southern portions of the Smithburne-Gilbert Fans Province of the Gulf Plains bioregion. The site encompasses portions of a stable alluvial plain incised by a complex system of active, mostly seasonal stream channels, frequently flooded depressions and older shallower channels, and partially flooded plains and level terraces. The broad alluvial plain also provides additional local catchment for the many wetlands of the aggregation. The site has an area of 251,000 ha and an elevation ranging between 10 m and 45 m above sea level (Environment Australia, 2001).

The Smithburne-Gilbert Fan Aggregation contains the greatest concentration of coastal floodplain lagoonal wetlands in the western Cape York Peninsula (Environment Australia, 2001). These provide important dry season habitat for many birds. A breeding rookery on the Smithburne River is one of the largest in the western Cape York Peninsula.

Appendix 1.2.5 Mitchell

A list of all sites from the Directory of Important wetlands in Australia located in the Mitchell region is shown in Table 35. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 35. List of Wetlands of National Significance located within the Mitchell region

Site code	Name	Area	Ramsar site
		ha	
QLD109*	Mitchell River Fan Aggregation	715,000	No
QLD067	Northeast Karumba Plain Aggregation	183,000	No
QLD113	Southeast Karumba Plain Aggregation	336,000	No
QLD093	Spring Tower Complex	75	No

*assets selected for assessment of changes to hydrological regime.

Mitchell River Fan Aggregation

The site is part of a huge alluvial fan bounded by the Mitchell and Alice Rivers and Yanko Creek to the north, and the Nassau River and Sergents Creek in the south. This site has an area of 715,000 ha and an elevation ranging between zero and 70 m above sea level (Figure 54). It is a complex disjunct aggregation of freshwater streams and closed depressions (Blackman et al., 1992). It comprises a complex system of deeply incised stream lines with many permanent waterholes, levees and seasonally flooded back plains, shallow incised valleys with waterholes, and numerous circular depressions, some with permanent water. The major catchments are those of the Lynd and Mitchell rivers rising far to the south-east, and the Palmer River to the east. Both the Palmer and Lynd rivers flow into the Mitchell River. The alluvial plain also acts as a local catchment for the many wetlands of the aggregation.

The Mitchell River Fan Aggregation is an outstanding example of a diverse and rich array of alluvial plain wetlands and deep water habitats which characterise the northern portions of the Mitchell-Gilbert Fan province of the Gulf Plains bioregion. It provides extensive areas of seasonal, semi-permanent and permanent habitat which is used particularly as breeding, roosting, feeding and moulting habitat for a wide range of waterbirds. Much of the area is of very high significance to Aboriginal clans, notably those associated with the Kowanyama Community.

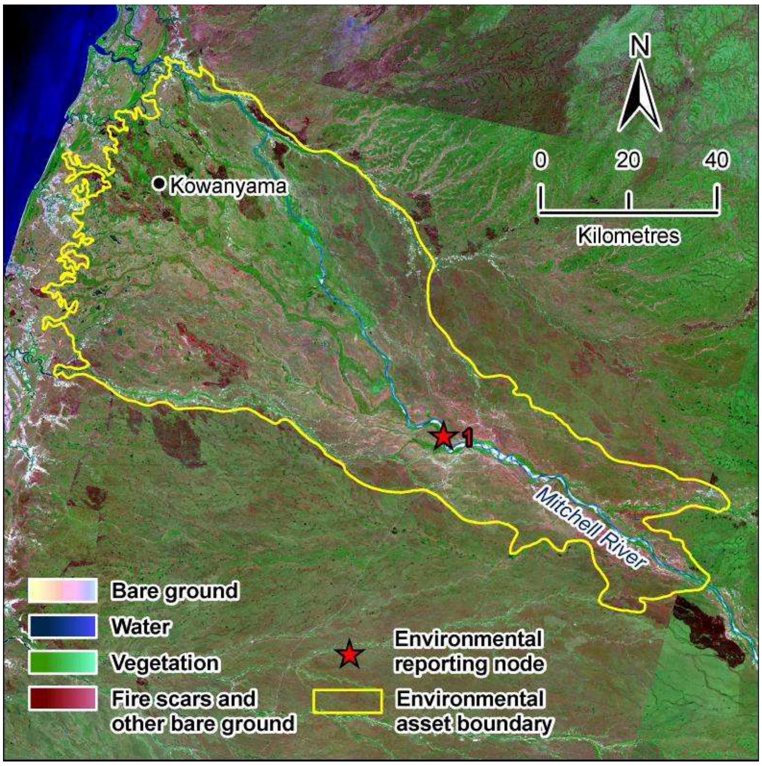

Figure 54. False colour satellite image (ACRES Landsat7, 1999-2000) of the Mitchell River Fan Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Appendix 1.2.6 Western Cape

A list of all sites from the Directory of Important wetlands in Australia located in the Western Cape region is shown in Table 36. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 36. List of Wetlands of National Significance located within the Western Cape region

Site code	Name	Area	Ramsar site
		ha	
QLD056	Archer Bay Aggregation	29,900	No
QLD057 *	Archer River Aggregation	150,000	No
QLD058	Bull Lake	27	No
QLD100	Great Barrier Reef Marine Park	34,100,000	No
QLD063 *	Jardine River Wetlands Aggregation	81,800	No
QLD067	Northeast Karumba Plain Aggregation	183,000	No
QLD068 *	Northern Holroyd Plain Aggregation	1,110,000	No
QLD071 *	Port Musgrave Aggregation	52,700	No
QLD074	Skardon River - Cotterell River Aggregation	63,200	No
QLD075	Somerset Dunefield Aggregation	7,940	No
QLD113	Southeast Karumba Plain Aggregation	336,000	No

* assets selected for assessment of changes to hydrological regime

Archer River Aggregation

The Archer River Aggregation (Figure 55) is probably the best example of a large, relatively pristine system of riverine and associated wetland types characteristic of the western Cape York Peninsula. The site has an area of 150,000 ha and an elevation between 2 m and 139 m above sea level (Environment Australia, 2001).

This site has very high wilderness value and contains many vegetation communities that are either rare or are amongst the best examples of their class on Cape York Peninsula. The riparian forest is an important corridor for the dispersal of many species between the extensive rainforests on the east coast and the smaller sand-ridge rainforests on the west coast. It is also an important dry season corridor for woodland species. The coastal extents are important habitat for seasonal waterfowl and the Archer system has a significant hydrological role in maintaining the extensive permanent and semi permanent Aurukun coastal wetlands (Environment Australia, 2001).

Jardine River Wetlands

The Jardine River Wetlands (Figure 56) contain the largest area and amongst the best examples of sedgeland on Cape York Peninsula (Abrahams et al., 1995). The wetland vegetation of the area is very diverse, reflecting differences in development and hydrology. The site is centred on the large floodplain of the Jardine River and the alluvial plains of its major tributaries. This area contains the largest and most widely spaced series of beach ridges on Cape York Peninsula. The site has an area of 81, 800 ha and an elevation between zero and 40 m above sea level (Environment Australia, 2001). The area contains well developed and representative examples of the landforms associated with a prograding coastline.

Most of the site is of high to very high wilderness value. The site supports mangrove communities, swampy woodland, pure stands of northern paperbark forest and palm forests. The shoreline of the site is important habitat for numerous bird species while terrestrial areas support populations of bats, frogs, snakes and turtles.

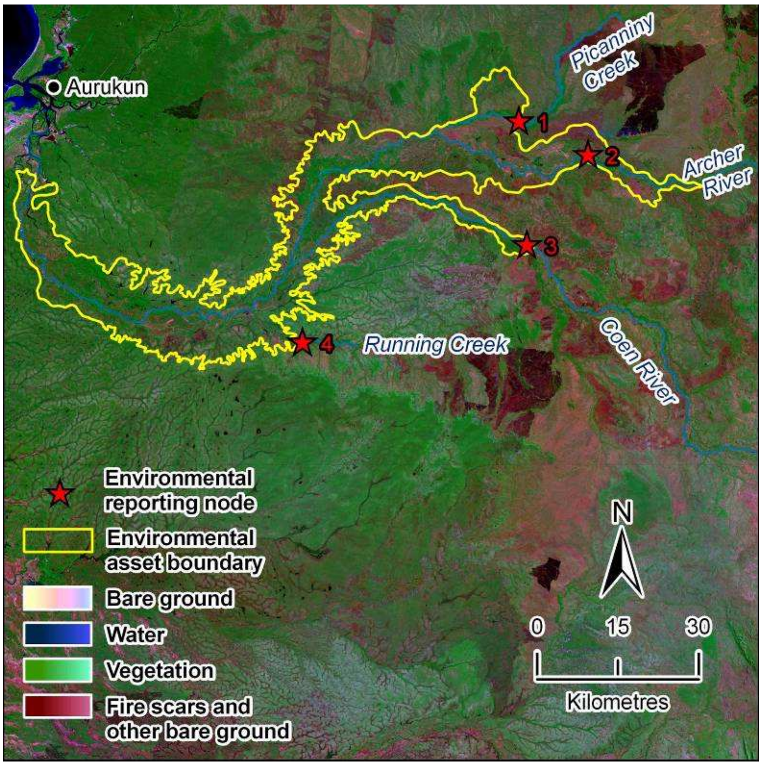

Figure 55. False colour satellite image (ACRES Landsat7, 1999-2000) of the Archer River Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

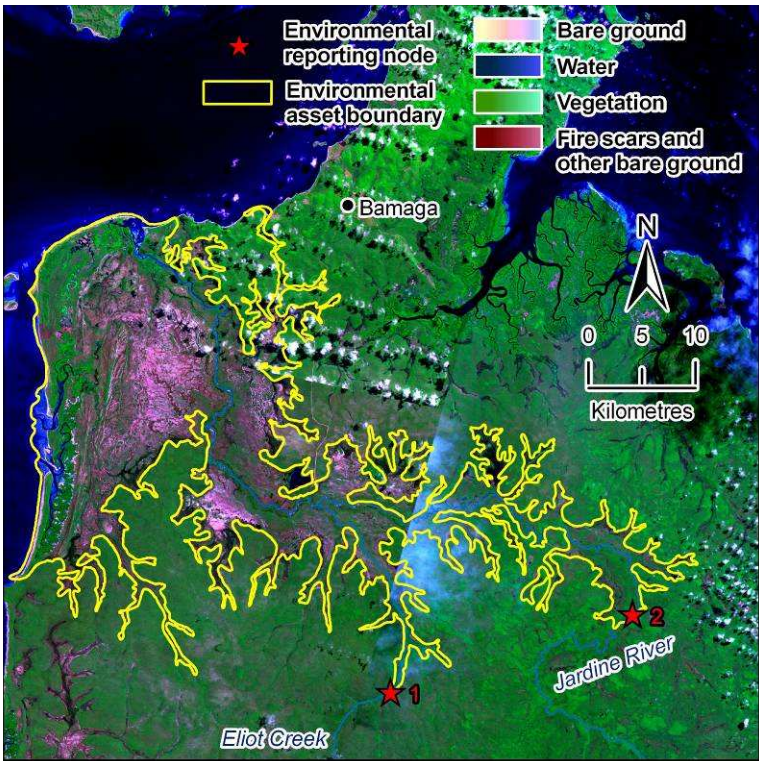

Figure 56. False colour satellite image (ACRES Landsat7, 1999-2000) of the Jardine River Wetlands as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Northern Holroyd Plain Aggregation

The Northern Holroyd Plain Aggregation (Figure 57) contains the best examples of a characteristic suite of wetlands occurring on one of the most striking and peculiar land surfaces of the Cape York Peninsula. Certain areas have never been grazed and contain some of the most pristine inland wetlands in western Cape York (Environment Australia, 2001). The aggregation comprises a huge area of wetland totally within an area of uniformly very high wilderness quality (Abrahams et al., 1995). It contains significant drought and seasonal habitat refuge for waterbird species which disperse in relatively small flocks over the hundreds of individual wetlands which make up the aggregation. The area contains large tracts of the highest quality wilderness recognised for the Cape York Peninsula. The site has an area of 1,110,000 ha and an elevation between 10 m and 90 m above sea level (Environment Australia, 2001).

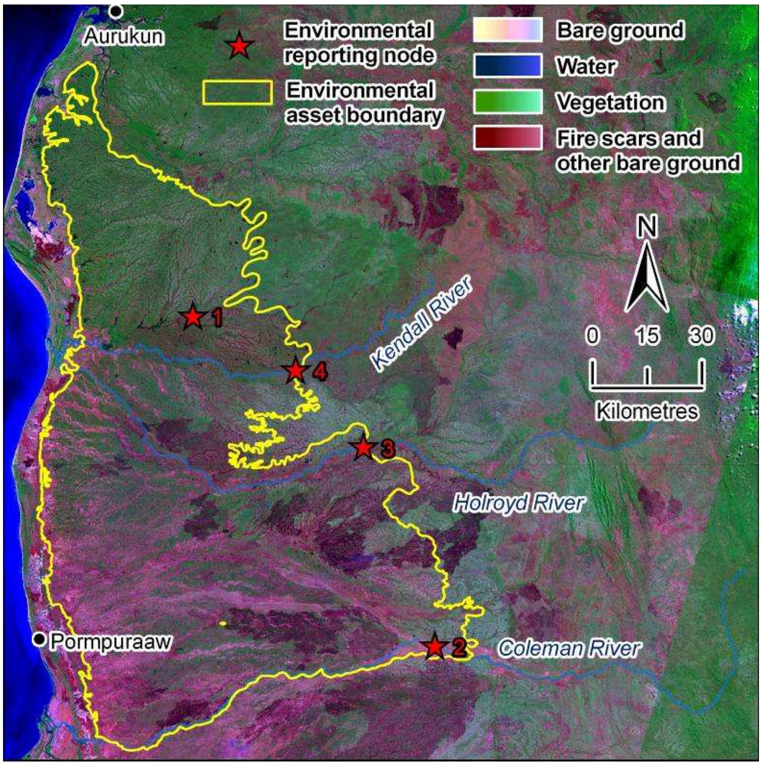

Figure 57. False colour satellite image (ACRES Landsat7, 1999-2000) of the Northern Holroyd Plain Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

The vegetation of ephemeral lakes and ponds is dominated by grasses and sedges. There is a seasonal variation reflecting the waxing and waning of the water bodies; grasses tend to dominate during the dry season and sedges during the wet (Environment Australia, 2001). The site contains areas of high cultural significance to Aboriginal people associated with the Kowanyama, Pormpuraaw and Aurukun communities.

Port Musgrave Aggregation

The Port Musgrave Aggregation (Figure 58) has been identified as one of the most important areas of crocodile habitat on the Cape York Peninsula (Taplin, 1987; Magnusson et al., 1980). The number of crocodiles recorded in the area was nearly double that recorded at any of the other surveyed sites on Cape York Peninsula. The large numbers recorded are considered to be related to the large extent of good nesting habitat present. The mangrove forests of the Wenlock and Ducie rivers are outstanding representative examples of their type. The site has an area of 52, 700 ha and an elevation between zero and 5 m above sea level (Environment Australia, 2001).

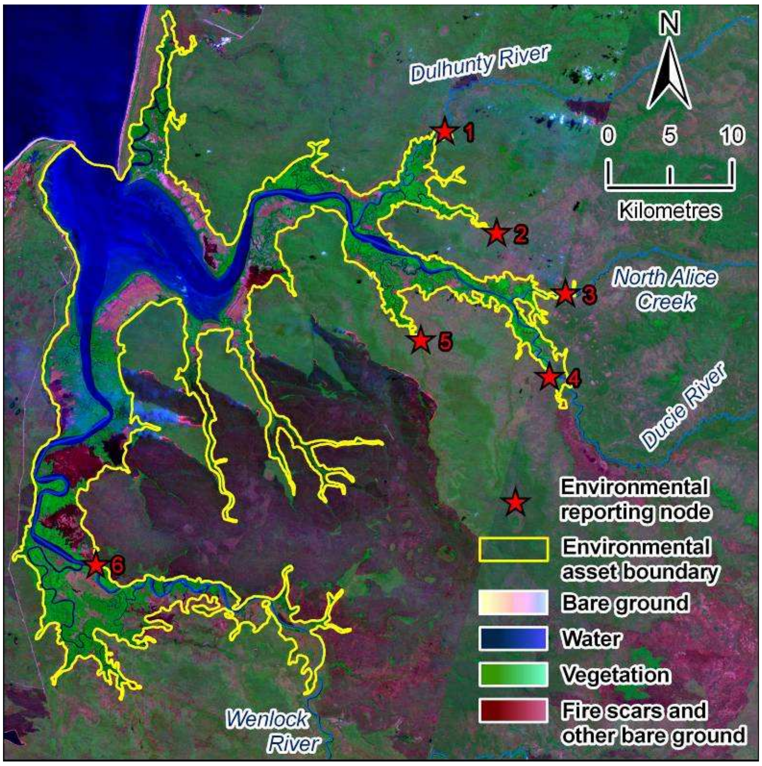

Figure 58. False colour satellite image (ACRES Landsat7, 1999-2000) of the Port Musgrave Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

There are approximately 4800 ha of seagrass beds in shallow water at the mouth of Port Musgrave. A little over half of the area of these beds is located within the site (Environment Australia, 2001). There are numerous mangrove communities and small but significant areas of evergreen notophyll riparian vine forest.

Appendix 1.3 Northern North-East

Appendix 1.3.1 Northern Coral

A list of all sites from the Directory of Important wetlands in Australia located in the Northern Coral region is shown in Table 37. **The following section briefly characterises wetlands in this region and is based largely on the description of this asset as outlined by Environment Australia (2001).**

Table 37. List of Wetlands of National Significance located within the Northern Coral region

Site code	Name	Area	Ramsar site
		ha	
QLD137	Alexandra Bay	862	No
QLD059	Cape Flattery Dune Lakes	44,000	No
QLD060	Cape Grenville Area	7,310	No
QLD061	Cape Melville - Bathurst Bay	5,460	No
QLD100	Great Barrier Reef Marine Park	34,100,000	No
QLD062	Harmer Creek - Shelburne Bay Aggregation	31,300	No
QLD147	Hilda Creek Headwater	<10	No
QLD090	Laura Sandstone	1,090	No
QLD064 *	Lloyd Bay	15,700	No
QLD154 *	Lower Daintree River	5,270	No
QLD065 *	Marina Plains - Lakefield Aggregation	392,000	No
QLD066 *	Newcastle Bay - Escape River Estuarine Complex	42,300	No

Site code	Name	Area	Ramsar site
QLD069 *	Olive River	17,600	No
QLD070	Orford Bay - Sharp Point Dunefield Aggregation	17,100	No
QLD072	Princess Charlotte Bay Marine Area	87,700	No
QLD073	Silver Plains - Nesbitt River Aggregation	44,800	No
QLD075	Somerset Dunefield Aggregation	7,940	No
QLD076	Temple Bay	4,400	No
QLD077	The Jack Lakes Aggregation	35,000	No
QLD078	Violet Vale	1,890	No

*assets selected for assessment of changes to hydrological regime

Lloyd Bay

The heath and closed forest communities that dominate the Lloyd Bay area (Figure 59) are regionally rare and are amongst the best examples of these communities on Cape York Peninsula. The area also supports seagrass beds that are outstanding for their size and diversity (Abrahams et al., 1995). These seagrass beds are important Dugong habitat. The site has an area of 15,700 ha and an elevation between zero and 5 m above sea level (Environment Australia, 2001).

The major vegetation type on the site is heath. A significant area of evergreen notophyll vine forest is also present. Salt flats are relatively extensive, occurring on the landward side of the mangroves. These are almost devoid of vegetation (Environment Australia, 2001). Numerous swamps and dune lakes occur in the area. The site has some Aboriginal and European cultural significance.

Lower Daintree River

The Lower Daintree River (Figure 60) site contains a well defined array of geomorphological features that are representative of coastal expansion within a confined space. The tall closed red mangrove forest that lines the mid tidal reaches of the site is an outstanding example of the type. The paperbark swamps of the northern bank are an outstanding and spectacular example of this type of forest. These swamps may also be the most significant breeding area for the estuarine crocodile in the Wet Tropics bioregion. The site has an area of 5,270 ha and an elevation less than 10 m above sea level (Environment Australia, 2001).

Fourteen vegetation types have been distinguished in the area, including mangrove communities, melaleuca communities, rainforest communities, dune woodlands and thickets, and sedge lands (Environment Australia, 2001). Much of the Daintree floodplain has been cleared for cane production or grazing. Some areas have been cleared to the water's edge, and bank erosion in some areas is severe (Environment Australia, 2001).

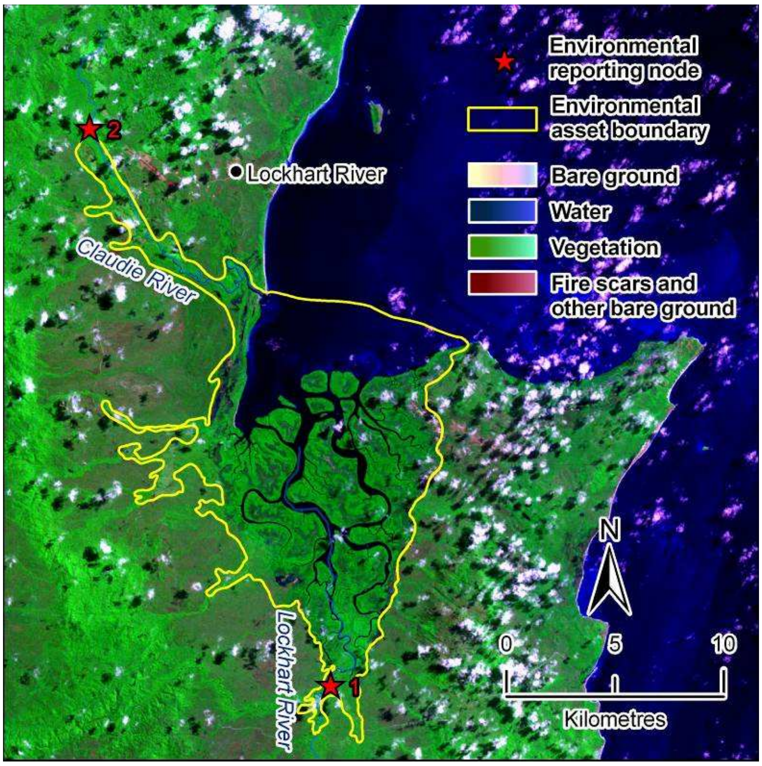

Figure 59. False colour satellite image (ACRES Landsat7, 1999-2000) of the Lloyd Bay as defined by the Directory of Important Wetlands (Environment Australia, 2001)

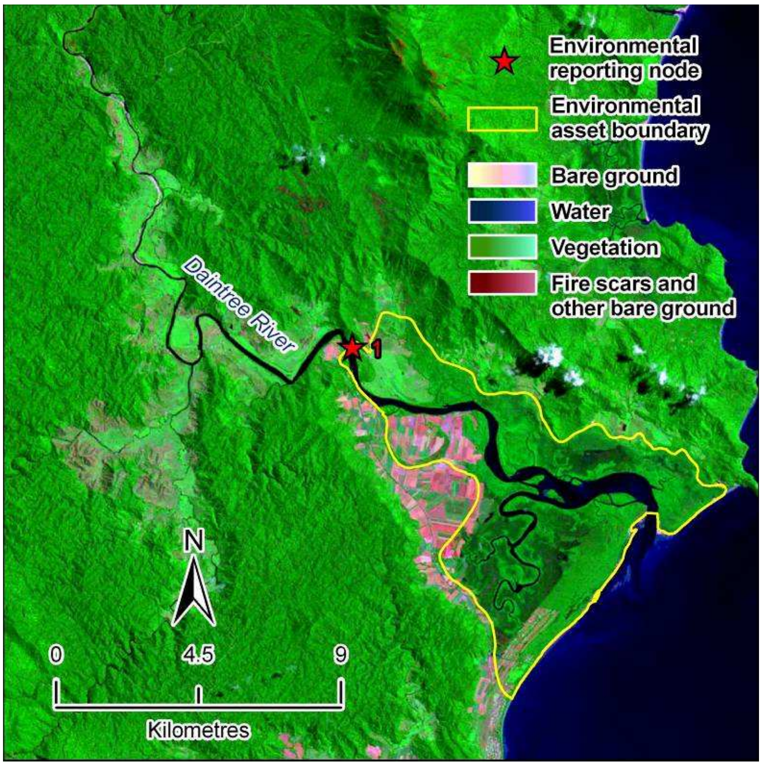

Figure 60. False colour satellite image (ACRES Landsat7, 1999-2000) of the Lower Daintree River as defined by the Directory of Important Wetlands (Environment Australia, 2001)

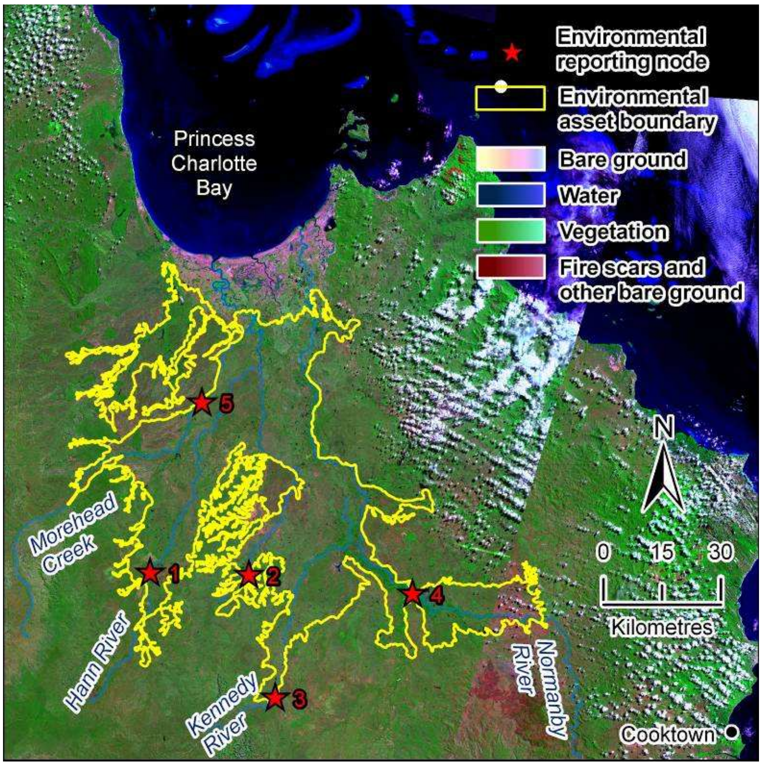

Figure 61. False colour satellite image (ACRES Landsat7, 1999-2000) of the Marina Plains - Lakefield Aggregation as defined by the Directory of Important Wetlands (Environment Australia, 2001)

Marina Plains - Lakefield Aggregation

The Marina Plains - Lakefield Aggregation site (Figure 61) is located to the south of Princess Charlotte Bay. It is characterised by inland wetlands including permanent rivers, streams and ponds, seasonally inundated areas and floodplains. Most of the site is inundated during the wet season. The site has an area of 392,000 ha and an elevation between zero and 100 m above sea level (Environment Australia, 2001).

There are a very large number of ephemeral lakes and lagoons and these are occupied by many species of aquatic plants. This site contains some of the best examples of many vegetation communities on the eastern side of Cape York Peninsula and is a significant habitat for estuarine crocodile (Environment Australia, 2001).

Newcastle Bay - Escape River Estuarine Complex

The Newcastle Bay - Escape River Estuarine Complex site (Figure 62) is characterised by both marine and coastal zone wetlands and inland wetlands including estuarine areas, permanent and seasonal brackish swamps, mud flats, tidal marshes and swamp forests. This site has an area of 42,300 ha and an elevation ranging between zero and 30 m above sea level, although the majority is less than 5 m (Environment Australia, 2001).

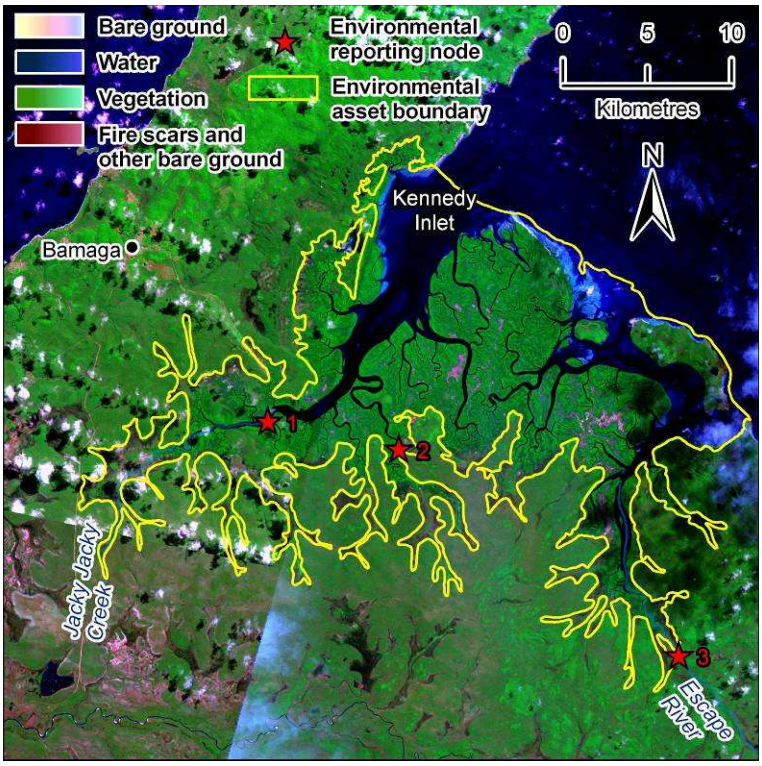

Figure 62. False colour satellite image (ACRES Landsat7, 1999-2000) of the Newcastle Bay - Escape River Estuarine Complex as defined by the Directory of Important Wetlands (Environment Australia, 2001)

This is a large, shallow, sheltered estuarine complex with low gradient foreshores composed of recent sediments that have been colonised by mangroves (Environment Australia, 2001). A distinctive feature is the relative rarity of salt flats in the marine-terrestrial transition area. There are about 2000 ha of salt flats on the site but most of them are located in the middle of mangrove islands. Most of the brackish and freshwater wetlands on the site margins are occupied by sedgeland (Neldner and Clarkson, 1995). Shallow banks of seagrass occur in the Escape River and the site includes some of the best examples of closed red mangrove forest on Cape York Peninsula (Environment Australia, 2001).

The area is traditional Aboriginal land. The area also has European historical significance as it is where the tragic Kennedy expedition ended in 1848. Both Kennedy Inlet and the Escape River are listed as estuaries of high fisheries importance (Bucher and Saenger, 1989).

Olive River

Nearly all of the catchment area of the Olive River site (Figure 63) is of high or very high wilderness quality. The vegetation of the area is very diverse. Soil quality and drainage characteristics vary significantly over short distances and combine to form a very complex and significant vegetation mosaic. Fish diversity is exceptionally high for an Australian river of this size and is of biogeographic significance (Herbert et al., 1994). The site has an area of 17,600 ha and an elevation between zero and 40 m above sea level (Environment Australia, 2001).

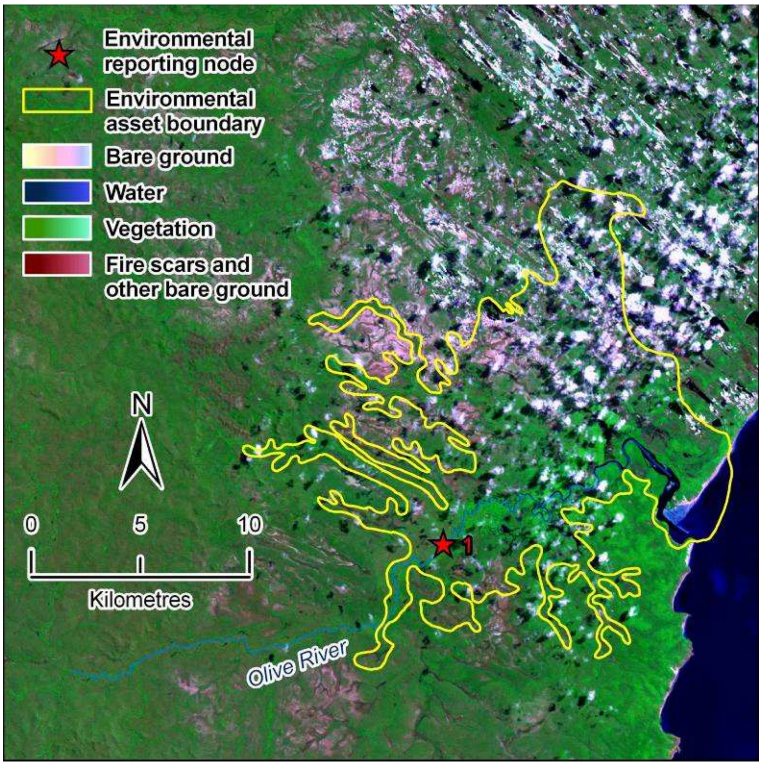

Figure 63. False colour satellite image (ACRES Landsat7, 1999-2000) of Olive River as defined by the Directory of Important Wetlands (Environment Australia, 2001)

The site supports seagrass meadows, communities of mangroves, sedgelands, paperbark forests and aquatic plants. Evergreen mesophyll/notophyll vine forest grows in frequently inundated dune swales near the mouth of the river. The banks of the Olive River support some of the best examples of evergreen mesophyll riparian vine forest on Cape York Peninsula (Environment Australia, 2001). The site is one of three outstanding estuarine crocodile (*Crocodylus porosus*) habitat areas on the Cape York Peninsula (Taplin, 1987). Significant winter concentrations of migrating waders occur in swamps associated with the river (Le Cussan, 1993).

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Appendix 2 – Results for standard metrics

Standard metrics

This Appendix presents results for standard metrics for all 96 streamflow reporting nodes in the NASY reporting region. For these tables the wet season covers the six months from November to April and the dry season covers the six months from May to October. Not all scenarios were modelled for all assets, this is indicated in the tables below by ‘nm’ – not modelled. It is important to note the level of confidence in under lying streamflow modelling when interpreting results. Confidence in the modelled dry season and wet season streamflow was expressed on a scale from 1 to 5 with confidence level 1 representing the highest confidence in results and level 5 representing the poorest confidence in results (see Petheram et al.(2009) for details). In reporting results, confidence levels of 1, 2 or 3 were considered reliable, while confidence levels of 4 or 5 were considered unreliable. Surface water confidence levels were assessed for both high and low flow conditions. In this Appendix, results for standard metrics at all assets are presented and a colour coding scheme, which is shown in Table 38, is used indicate confidence level in high and low flows. The confidence level is shown in the column labelled CL.

Table 38: Confidence level colour codes

Colour Code	Confidence Level
	1
	2
	3
	4 or 5

Appendix 2.1 Timor Sea Division

Appendix 2.1.1 Fitzroy (WA) Region

Table 39. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Fitzroy (WA) region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Roebuck Bay - Node 1 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	667	+77%	+6%	-2%	-27%	nm	nm	nm
Wet season flow (mean)	GL	●	637	+77%	+5%	-3%	-27%	nm	nm	nm
Dry season flow (mean)	GL	●	29.8	+67%	+10%	+2%	-39%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00012							
Number of days below low flow threshold (mean)	d/y	●	36.5	-29.8	-2.3	+3	+34.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	32.7	-27.7	-2.1	+3	+33.8	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	10.7							
Number of days above high flow threshold (mean)	d/y	●	18.3	+20	+1.5	-0.7	-6.7	nm	nm	nm
Roebuck Bay - Node 2 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Roebuck Bay - Node 3 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Roebuck Bay - Node 4 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Camballin Floodplain (Le Livre Swamp System) - Node 1 (confidence level: low flow = 5, high flow = 3)										
Annual flow (mean)	GL	●	7540	+56%	+17%	-6%	-36%	nm	nm	nm
Wet season flow (mean)	GL	●	7380	+58%	+16%	-6%	-36%	nm	nm	nm
Dry season flow (mean)	GL	●	161	-39%	+26%	+2%	-33%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in	GL/d	●	0							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Scenario A)										
Number of days below low flow threshold (mean)	d/y		126	-21.3	+1.6	-0.2	+4.4	nm	nm	nm
Number of days of zero flow (mean)	d/y		126	-21.3	+1.6	-0.2	+4.4	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		111							
Number of days above high flow threshold (mean)	d/y		18.3	+12.4	+2.1	-0.9	-7	nm	nm	nm
Geikie Gorge - Node 1 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL		2290	+50%	+16%	-7%	-31%	nm	nm	nm
Wet season flow (mean)	GL		2240	+52%	+16%	-7%	-30%	nm	nm	nm
Dry season flow (mean)	GL		49.5	-18%	+31%	-3%	-45%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		62.2	-25.5	-1.9	+2.4	+22	nm	nm	nm
Number of days of zero flow (mean)	d/y		62.2	-25.5	-1.9	+2.4	+22	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		34.5							
Number of days above high flow threshold (mean)	d/y		18.3	+13.2	+2.5	-0.9	-6.7	nm	nm	nm
Windjana Gorge - Node 1 (confidence level: low flow = 5, high flow = 3)										
Annual flow (mean)	GL		366	+27%	+16%	-7%	-29%	nm	nm	nm
Wet season flow (mean)	GL		354	+29%	+16%	-7%	-29%	nm	nm	nm
Dry season flow (mean)	GL		11.4	-40%	+24%	-2%	-39%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		69.4	-25.5	-3.9	+2.8	+29.2	nm	nm	nm
Number of days of zero flow (mean)	d/y		69.4	-25.5	-3.9	+2.8	+29.2	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		3.89							
Number of days above high flow threshold (mean)	d/y		18.3	+10	+1.5	-0.5	-6.6	nm	nm	nm

Appendix 2.1.2 Kimberley Region

Table 40. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Kimberley region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
			change from Scenario A							
Drysdale River - Node 1 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL		667	+77%	+6%	-2%	-27%	nm	nm	nm
Wet season flow (mean)	GL		637	+77%	+5%	-3%	-27%	nm	nm	nm
Dry season flow (mean)	GL		29.8	+67%	+10%	+2%	-39%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.00012							
Number of days below low flow threshold (mean)	d/y		36.5	-29.8	-2.3	+3	+34.6	nm	nm	nm
Number of days of zero flow (mean)	d/y		32.7	-27.7	-2.1	+3	+33.8	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		10.7							
Number of days above high flow threshold (mean)	d/y		18.3	+20	+1.5	-0.7	-6.7	nm	nm	nm
Mitchell River System - Node 1 (confidence level: low flow = 4, high flow = 2)										
Annual flow (mean)	GL		48.1	+76%	+1%	-6%	-24%	nm	nm	nm
Wet season flow (mean)	GL		46.4	+78%	+1%	-6%	-23%	nm	nm	nm
Dry season flow (mean)	GL		1.7	+38%	+6%	-1%	-34%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.00112							
Number of days below low flow threshold (mean)	d/y		36.5	-35.2	+2.1	+11.5	+44.2	nm	nm	nm
Number of days of zero flow (mean)	d/y		1.17	+0.2	0	+0.1	+0.3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		0.691							
Number of days above high flow threshold (mean)	d/y		18.3	+15.8	+0.4	-1.4	-6.2	nm	nm	nm
Mitchell River System - Node 2 (confidence level: low flow = 3, high flow = 2)										
Annual flow (mean)	GL		382	+69%	+9%	-5%	-23%	nm	nm	nm

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Wet season flow (mean)	GL		370	+70%	+9%	-5%	-22%	nm	nm	nm
Dry season flow (mean)	GL		11.9	+34%	+10%	-1%	-33%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.00774							
Number of days below low flow threshold (mean)	d/y		36.5	-35.2	-3.2	+11.2	+42	nm	nm	nm
Number of days of zero flow (mean)	d/y		1.17	+0.2	0	0	+0.3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		5.55							
Number of days above high flow threshold (mean)	d/y		18.3	+15.2	+1.6	-1.1	-5.8	nm	nm	nm
Prince Regent River - Node 1 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL		401	+62%	+5%	-2%	-20%	nm	nm	nm
Wet season flow (mean)	GL		384	+63%	+5%	-2%	-20%	nm	nm	nm
Dry season flow (mean)	GL		17.5	+35%	+9%	+2%	-27%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.0179							
Number of days below low flow threshold (mean)	d/y		36.5	-25	-3.4	+2.3	+34.3	nm	nm	nm
Number of days of zero flow (mean)	d/y		1.17	+0.2	0	0	+0.1	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		6.03							
Number of days above high flow threshold (mean)	d/y		18.3	+14.8	+1.5	-0.8	-5.9	nm	nm	nm

Appendix 2.1.3 Ord-Bonaparte Region

Table 41. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Ord-Bonaparte region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Lake Argyle - Node 1 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL		667	+77%	+6%	-2%	-27%	nm	nm	nm
Wet season flow (mean)	GL		637	+77%	+5%	-3%	-27%	nm	nm	nm
Dry season flow (mean)	GL		29.8	+67%	+10%	+2%	-39%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.00012							
Number of days below low flow threshold (mean)	d/y		36.5	-29.8	-2.3	+3	+34.6	nm	nm	nm
Number of days of zero flow (mean)	d/y		32.7	-27.7	-2.1	+3	+33.8	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		10.7							
Number of days above high flow threshold (mean)	d/y		18.3	+20	+1.5	-0.7	-6.7	nm	nm	nm
Lake Kununurra - Node 2 (confidence level: low flow = <3, high flow = <3)										
Annual flow (mean)	GL		3590	+95%	+23%	+3%	-27%	+11%	-9%	-37%
Wet season flow (mean)	GL		2250	+103%	+24%	+4%	-29%	+17%	-3%	-37%
Dry season flow (mean)	GL		1340	+81%	+21%	+2%	-25%	+1%	-17%	-38%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		3.63							
Number of days below low flow threshold (mean)	d/y		64	-64	-23.9	-3.6	+60.5	+54.2	+77.2	+133.5
Number of days of zero flow (mean)	d/y		0.013	0	0	0	+0.2	0	0	+0.2
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		32.3							
Number of days above high flow threshold (mean)	d/y		18.3	+45.1	+11.2	+1.8	-9.2	+12.2	+2.5	-9.1
Parry Floodplain - Node 1 (confidence level: low flow = <3, high flow = <3)										
Annual flow (mean)	GL		3590	+95%	+23%	+3%	-27%	+11%	-9%	-37%
Wet season flow (mean)	GL		2250	+103%	+24%	+4%	-29%	+17%	-3%	-37%
Dry season flow (mean)	GL		1340	+81%	+21%	+2%	-25%	+1%	-17%	-38%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		3.63							
Number of days below low flow threshold (mean)	d/y		64	-64	-23.9	-3.6	+60.5	+54.2	+77.2	+133.5
Number of days of zero flow (mean)	d/y		0.013	0	0	0	+0.2	0	0	+0.2
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		32.3							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Number of days above high flow threshold (mean)	d/y	●	18.3	+45.1	+11.2	+1.8	-9.2	+12.2	+2.5	-9.1
Parry Floodplain - Node 2 (confidence level: low flow = <3, high flow = <3)										
Annual flow (mean)	GL	●	3594	+95%	+23%	+3%	-27%	+11%	-9%	-37%
Wet season flow (mean)	GL	●	2242	+102%	+24%	+4%	-29%	+17%	-4%	-37%
Dry season flow (mean)	GL	●	1351	+82%	+22%	+2%	-25%	+2%	-17%	-38%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	3.63							
Number of days below low flow threshold (mean)	d/y	●	64.0	-64	-23.9	-3.6	+60.5	+54.2	+77.2	+133.5
Number of days of zero flow (mean)	d/y	●	0	0	0	0	+0.2	0	0	+0.2
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	32.3							
Number of days above high flow threshold (mean)	d/y	●	18.3	+45.1	+11.2	+1.8	-9.2	+12.2	+2.5	-9.1
Ord Estuary System - Node 1 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Ord Estuary System - Node 2 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Ord Estuary System - Node 3 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm

Appendix 2.1.4 Daly Region

Table 42. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Daly region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Daly River Middle Reaches - Node 1 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	●	6520	+186%	+34%	-1%	-31%	+34%	0%	-32%
Wet season flow (mean)	GL	●	6210	+191%	+34%	-1%	-32%	+35%	-1%	-32%
Dry season flow (mean)	GL	●	311	+87%	+26%	+2%	-13%	+26%	+2%	-16%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	1.04							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Number of days below low flow threshold (mean)	d/y	●	36.6	-36.2	-31.9	-6.7	+27.4	-31.1	-5.8	+38.3
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	0	0	0
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	108							
Number of days above high flow threshold (mean)	d/y	●	18.3	+31.6	+5.4	-0.4	-7.7	+5.7	-0.3	-7.7
Daly-Reynolds Floodplain-Estuary System - Node 1 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	●	8180	+168%	+32%	-1%	-32%	+33%	-1%	-32%
Wet season flow (mean)	GL	●	7820	+172%	+33%	-1%	-33%	+34%	-1%	-33%
Dry season flow (mean)	GL	●	363	+89%	+24%	+2%	-13%	+25%	+1%	-16%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	1.19							
Number of days below low flow threshold (mean)	d/y	●	36.6	-36.1	-31.7	-7.2	+25.5	-30.6	-6.3	+35.3
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	0	0	0
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	135							
Number of days above high flow threshold (mean)	d/y	●	18.3	+29.7	+5.7	-0.2	-8.2	+5.9	0	-8.2
Katherine River Gorge - Node 1 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	●	920	+200%	+26%	+1%	-23%	+26%	+0%	-23%
Wet season flow (mean)	GL	●	898	+202%	+26%	+1%	-23%	+26%	+1%	-23%
Dry season flow (mean)	GL	●	22.1	+115%	+18%	-3%	-21%	+11%	-10%	-28%
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0569							
Number of days below low flow threshold (mean)	d/y	●	36.6	-36.3	-29.4	+4.8	+47.4	-9.9	+35	+79.3
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	0	0	0
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	14.9							
Number of days above high flow threshold (mean)	d/y	●	18.3	+32.5	+4.4	+0.1	-4.5	+4.4	+0.1	-4.4

Appendix 2.1.5 Van Diemen Region

Table 43. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Van Diemen region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Murgenella-Cooper Floodplain System - Node 1 (confidence level: low flow = 4, high flow = 5)										
Annual flow (mean)	GL	●	378	+17%	+20%	+0%	-22%	nm	nm	nm
Wet season flow (mean)	GL	●	365	+16%	+20%	+0%	-22%	nm	nm	nm
Dry season flow (mean)	GL	●	12.7	+20%	+1%	+1%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00152							
Number of days below low flow threshold (mean)	d/y	●	36.5	-5.2	-11.4	+2.1	+21.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.17	+0.2	0	0	+0.6	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	5.17							
Number of days above high flow threshold (mean)	d/y	●	18.3	+3.4	+5	-1	-5.3	nm	nm	nm
Murgenella-Cooper Floodplain System - Node 2 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	●	679	+32%	+21%	-1%	-22%	nm	nm	nm
Wet season flow (mean)	GL	●	660	+32%	+22%	-1%	-22%	nm	nm	nm
Dry season flow (mean)	GL	●	19.1	+34%	+2%	0%	-24%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00307							
Number of days below low flow threshold (mean)	d/y	●	36.5	-13.8	-12.5	+2.1	+26.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.19	+0.1	0	+0	+0.4	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	9.63							
Number of days above high flow threshold (mean)	d/y	●	18.3	+8.3	+5.6	-0.8	-5.6	nm	nm	nm
Kakadu National Park - Node 1 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	●	296	+53%	+30%	+1%	-25%	nm	nm	nm

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Wet season flow (mean)	GL		292	+52%	+31%	+1%	-25%	nm	nm	nm
Dry season flow (mean)	GL		3.36	+87%	-7%	+0%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		116	-18.4	-17.4	+1.4	+19.7	nm	nm	nm
Number of days of zero flow (mean)	d/y		116	-18.4	-17.4	+1.4	+19.7	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		4.77							
Number of days above high flow threshold (mean)	d/y		18.3	+10.6	+6.6	-0.1	-6	nm	nm	nm
Kakadu National Park - Node 2 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL		243	+51%	+30%	+1%	-28%	nm	nm	nm
Wet season flow (mean)	GL		240	+50%	+30%	+1%	-28%	nm	nm	nm
Dry season flow (mean)	GL		2.64	+88%	-6%	0%	-21%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		132	-18.2	-15.8	+0.8	+20	nm	nm	nm
Number of days of zero flow (mean)	d/y		132	-18.2	-15.8	+0.8	+20	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		4							
Number of days above high flow threshold (mean)	d/y		18.3	+10.5	+6.1	-0.3	-6.6	nm	nm	nm
Kakadu National Park - Node 3 (confidence level: low flow = 4, high flow = 2)										
Annual flow (mean)	GL		2330	+42%	+25%	+1%	-23%	nm	nm	nm
Wet season flow (mean)	GL		2290	+42%	+25%	+1%	-23%	nm	nm	nm
Dry season flow (mean)	GL		38.5	+39%	+9%	+2%	-24%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.00387							
Number of days below low flow threshold (mean)	d/y		36.5	-22.8	-14.9	+2.4	+32.5	nm	nm	nm
Number of days of zero flow (mean)	d/y		1.01	-0.1	-0.2	+0.1	+0.2	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		34.7							
Number of days above high flow threshold (mean)	d/y		18.3	+12.1	+6.8	+0.1	-5.9	nm	nm	nm
Kakadu National Park - Node 4 (confidence level: low flow = 3, high flow = 2)										
Annual flow (mean)	GL		1050	+52%	+25%	+0%	-23%	nm	nm	nm
Wet season flow (mean)	GL		1040	+52%	+25%	+0%	-23%	nm	nm	nm
Dry season flow (mean)	GL		17.5	+56%	+4%	+1%	-22%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		100	-20.3	-12.3	+4.2	+31.6	nm	nm	nm
Number of days of zero flow (mean)	d/y		100	-20.3	-12.3	+4.2	+31.6	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		15.6							
Number of days above high flow threshold (mean)	d/y		18.3	+15.6	+6.8	0	-5.5	nm	nm	nm
Kakadu National Park - Node 5 (confidence level: low flow = 1, high flow = 2)										
Annual flow (mean)	GL		355	+69%	+29%	+0%	-27%	nm	nm	nm
Wet season flow (mean)	GL		349	+68%	+30%	+0%	-27%	nm	nm	nm
Dry season flow (mean)	GL		6.16	+98%	+6%	+1%	-29%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		99.8	-38.6	-22.3	+1.7	+33	nm	nm	nm
Number of days of zero flow (mean)	d/y		99.8	-38.6	-22.3	+1.7	+33	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		5.58							
Number of days above high flow threshold (mean)	d/y		18.3	+17.5	+6.7	-0.3	-6.4	nm	nm	nm
Kakadu National Park - Node 6 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL		1700	+53%	+24%	-3%	-23%	nm	nm	nm
Wet season flow (mean)	GL		1670	+53%	+24%	-3%	-23%	nm	nm	nm
Dry season flow (mean)	GL		27.8	+49%	-2%	-1%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.00067							
Number of days below low flow threshold (mean)	d/y		36.5	-18.4	-14.1	+2.6	+27.8	nm	nm	nm

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Number of days of zero flow (mean)	d/y	●	2.21	-0.9	-0.9	+0.2	+3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	26.3							
Number of days above high flow threshold (mean)	d/y	●	18.3	+13.6	+6.2	-1	-5.7	nm	nm	nm
Adelaide River Floodplain System - Node 1 (confidence level: low flow = 4, high flow = 2)										
Annual flow (mean)	GL	●	1490	+48%	+29%	0%	-26%	nm	nm	nm
Wet season flow (mean)	GL	●	1450	+47%	+29%	0%	-26%	nm	nm	nm
Dry season flow (mean)	GL	●	34.9	+77%	+20%	+0%	-34%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0186							
Number of days below low flow threshold (mean)	d/y	●	36.5	-24	-18.8	+5.1	+37.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.792	-0.2	0	0	+0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	23.8							
Number of days above high flow threshold (mean)	d/y	●	18.3	+13.2	+6	-0.2	-7.1	nm	nm	nm
Finniss Floodplain and Fog Bay Systems - Node 1 (confidence level: low flow = 1, high flow = 1)										
Annual flow (mean)	GL	●	504	+65%	+26%	+0%	-24%	nm	nm	nm
Wet season flow (mean)	GL	●	489	+65%	+27%	+0%	-24%	nm	nm	nm
Dry season flow (mean)	GL	●	15	+56%	+17%	0%	-28%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0175							
Number of days below low flow threshold (mean)	d/y	●	36.5	-33.7	-22.2	+2.3	+39.5	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.792	-0.2	0	0	+0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	8.26							
Number of days above high flow threshold (mean)	d/y	●	18.3	+17.1	+5.3	+0.1	-5.5	nm	nm	nm
Mary Floodplain System - Node 1 (confidence level: low flow = 1, high flow = 2)										
Annual flow (mean)	GL	●	1550	+50%	+28%	-1%	-29%	nm	nm	nm
Wet season flow (mean)	GL	●	1540	+49%	+28%	-1%	-29%	nm	nm	nm
Dry season flow (mean)	GL	●	16.9	+125%	+8%	+1%	-37%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00118							
Number of days below low flow threshold (mean)	d/y	●	36.5	-15	-15.5	+4.7	+29.9	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.42	-0.5	-0.5	+0.4	+6.3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	25							
Number of days above high flow threshold (mean)	d/y	●	18.3	+11.2	+6.2	-0.3	-7	nm	nm	nm
Port Darwin - Node 1 (confidence level: low flow = 3, high flow = 2)										
Annual flow (mean)	GL	●	227	+45%	+27%	+1%	-20%	nm	nm	nm
Wet season flow (mean)	GL	●	220	+45%	+27%	+1%	-20%	nm	nm	nm
Dry season flow (mean)	GL	●	7.26	+35%	+21%	+1%	-21%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0105							
Number of days below low flow threshold (mean)	d/y	●	36.5	-35.8	-29.1	-1.2	+36.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.792	-0.2	0	+0	+0.5	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	3.37							
Number of days above high flow threshold (mean)	d/y	●	18.3	+10.3	+4.9	+0.4	-4.3	nm	nm	nm
Port Darwin - Node 2 (confidence level: low flow = 4, high flow = 2)										
Annual flow (mean)	GL	●	84.5	+48%	+26%	+1%	-22%	nm	nm	nm
Wet season flow (mean)	GL	●	81.8	+48%	+27%	+1%	-21%	nm	nm	nm
Dry season flow (mean)	GL	●	2.72	+64%	+10%	+2%	-27%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00044							
Number of days below low flow threshold (mean)	d/y	●	36.5	-21.1	-17.8	+2.9	+25.7	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	8.35	-6	-5.8	+1.3	+12.7	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	1.3							
Number of days above high flow threshold (mean)	d/y	●	18.3	+8.3	+5	+0	-5.2	nm	nm	nm
Port Darwin - Node 3 (confidence level: low flow = 2, high flow = 1)										

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Annual flow (mean)	GL	●	87	+50%	+26%	0%	-21%	nm	nm	nm
Wet season flow (mean)	GL	●	84.3	+50%	+26%	0%	-20%	nm	nm	nm
Dry season flow (mean)	GL	●	2.75	+50%	+9%	+1%	-27%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00051							
Number of days below low flow threshold (mean)	d/y	●	36.5	-19.8	-20.1	+3.8	+27.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	10.6	-4.8	-8	+2	+15.2	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	1.32							
Number of days above high flow threshold (mean)	d/y	●	18.3	+8.4	+4.5	-0.6	-4.8	nm	nm	nm

Appendix 2.1.6 Arafura Region

Table 44. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Arafura region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Arafura Swamp - Node 1 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	●	741	+50%	+18%	-3%	-28%	nm	nm	nm
Wet season flow (mean)	GL	●	714	+48%	+19%	-3%	-28%	nm	nm	nm
Dry season flow (mean)	GL	●	27	+88%	-5%	+4%	-32%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0							
Number of days below low flow threshold (mean)	d/y	●	193	-23.3	-4.7	+2.4	+21.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	193	-23.3	-4.7	+2.4	+21.6	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	12.4							
Number of days above high flow threshold (mean)	d/y	●	18.3	+11.6	+4.7	-1	-6.6	nm	nm	nm
Arafura Swamp - Node 2 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	●	403	+54%	+18%	-3%	-25%	nm	nm	nm
Wet season flow (mean)	GL	●	386	+52%	+19%	-3%	-25%	nm	nm	nm
Dry season flow (mean)	GL	●	16.7	+86%	-5%	+4%	-26%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0							
Number of days below low flow threshold (mean)	d/y	●	186	-22.7	-3.6	+2	+19.3	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	186	-22.7	-3.6	+2	+19.3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	6.27							
Number of days above high flow threshold (mean)	d/y	●	18.3	+15	+4.5	-0.9	-5.7	nm	nm	nm
Blyth-Cadell Floodplain & Boucaut Bay System - Node 1 (confidence level: low flow = 2, high flow = 2)										
Annual flow (mean)	GL	●	238	+46%	+19%	-3%	-25%	nm	nm	nm
Wet season flow (mean)	GL	●	231	+46%	+19%	-3%	-25%	nm	nm	nm
Dry season flow (mean)	GL	●	7.18	+54%	-2%	+4%	-26%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00028							
Number of days below low flow threshold (mean)	d/y	●	36.5	-13.2	-11	+0.4	+20.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	10.3	-6.3	-3.9	+0.4	+9.9	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	3.58							
Number of days above high flow threshold (mean)	d/y	●	18.3	+9.7	+5.3	-1	-6	nm	nm	nm
Blyth-Cadell Floodplain & Boucaut Bay System - Node 2 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	●	663	+55%	+20%	-4%	-27%	nm	nm	nm
Wet season flow (mean)	GL	●	610	+55%	+21%	-4%	-27%	nm	nm	nm
Dry season flow (mean)	GL	●	53.1	+51%	+6%	0%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0584							
Number of days below low flow threshold (mean)	d/y	●	36.5	-32.6	-13.5	+4.3	+34.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.27	+0.2	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in	GL/d	●	9							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Scenario A)										
Number of days above high flow threshold (mean)	d/y		18.3	+11.6	+5.6	-1.2	-6.1	nm	nm	nm

Appendix 2.2 Gulf of Carpentaria Division

Appendix 2.2.1 Roper Region

Table 45. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Roper region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Limmen Bight (Port Roper) Tidal Wetlands System - Node 1 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL		667	+77%	+6%	-2%	-27%	nm	nm	nm
Wet season flow (mean)	GL		637	+77%	+5%	-3%	-27%	nm	nm	nm
Dry season flow (mean)	GL		29.8	+67%	+10%	+2%	-39%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.00012							
Number of days below low flow threshold (mean)	d/y		36.5	-29.8	-2.3	+3	+34.6	nm	nm	nm
Number of days of zero flow (mean)	d/y		32.7	-27.7	-2.1	+3	+33.8	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		10.7							
Number of days above high flow threshold (mean)	d/y		18.3	+20	+1.5	-0.7	-6.7	nm	nm	nm
Limmen Bight (Port Roper) Tidal Wetlands System - Node 2 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		nm							
Number of days below low flow threshold (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		nm							
Number of days above high flow threshold (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
Limmen Bight (Port Roper) Tidal Wetlands System - Node 3 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		nm							
Number of days below low flow threshold (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		nm							
Number of days above high flow threshold (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
Limmen Bight (Port Roper) Tidal Wetlands System - Node 4 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		nm							
Number of days below low flow threshold (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		nm							
Number of days above high flow threshold (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Limmen Bight (Port Roper) Tidal Wetlands System - Node 5 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Mataranka Thermal Pools - Node 1 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm

Appendix 2.2.2 South-West Gulf Region

Table 46. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the South-West Gulf region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Gregory River - Node 1 (confidence level: low flow = 5, high flow = 1)										
Annual flow (mean)	GL	●	455	+19%	+24%	-3%	-18%	nm	nm	nm
Wet season flow (mean)	GL	●	387	+21%	+24%	-3%	-18%	nm	nm	nm
Dry season flow (mean)	GL	●	67.9	+11%	+21%	+0%	-20%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.121							
Number of days below low flow threshold (mean)	d/y	●	36.5	-35.4	-17.9	+3.3	+29.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.403	+0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	3.1							
Number of days above high flow threshold (mean)	d/y	●	18.3	+5.3	+3.8	-0.4	-3.1	nm	nm	nm
Nicholson Delta Aggregation - Node 1 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL	●	2020	+69%	+24%	-3%	-19%	nm	nm	nm
Wet season flow (mean)	GL	●	1910	+71%	+24%	-3%	-19%	nm	nm	nm
Dry season flow (mean)	GL	●	105	+30%	+29%	+3%	-27%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.149							
Number of days below low flow threshold (mean)	d/y	●	36.5	-35.4	-18.5	+2.9	+27.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.403	+0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	22.5							
Number of days above high flow threshold (mean)	d/y	●	18.3	+11.1	+3.2	-0.3	-2.9	nm	nm	nm
Nicholson Delta Aggregation - Node 2 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL	●	128	+53%	+11%	-2%	-14%	nm	nm	nm
Wet season flow (mean)	GL	●	126	+54%	+10%	-2%	-14%	nm	nm	nm
Dry season flow (mean)	GL	●	2.55	-2%	+39%	+7%	-37%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00045							
Number of days below low flow threshold (mean)	d/y	●	36.5	-31.6	-8.9	+0.7	+18	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.4	+3.4	-0.2	+1	+7.2	nm	nm	nm

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	1.66							
Number of days above high flow threshold (mean)	d/y	●	18.3	+5.1	+1.5	-0.2	-2.4	nm	nm	nm
Port McArthur Tidal Wetlands System - Node 1 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL	●	323	+75%	+15%	-8%	-13%	nm	nm	nm
Wet season flow (mean)	GL	●	313	+76%	+14%	-8%	-12%	nm	nm	nm
Dry season flow (mean)	GL	●	9.85	+52%	+38%	-14%	-28%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.002							
Number of days below low flow threshold (mean)	d/y	●	36.5	-29.3	-13.7	+14.8	+29.7	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.78	-0.5	0	0	+0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	4.7							
Number of days above high flow threshold (mean)	d/y	●	18.3	+9.9	+2.2	-1.5	-2.6	nm	nm	nm
Port McArthur Tidal Wetlands System - Node 2 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL	●	1210	+89%	+26%	-7%	-15%	nm	nm	nm
Wet season flow (mean)	GL	●	1180	+90%	+26%	-7%	-15%	nm	nm	nm
Dry season flow (mean)	GL	●	22.8	+74%	+42%	-14%	-38%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00458							
Number of days below low flow threshold (mean)	d/y	●	36.5	-30.4	-21.2	+6.4	+26.7	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.03	-0.4	+0.1	+0.1	+0.2	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	14.4							
Number of days above high flow threshold (mean)	d/y	●	18.3	+11.8	+4.2	-0.8	-2.7	nm	nm	nm
Port McArthur Tidal Wetlands System - Node 3 (confidence level: low flow = 5, high flow = 3)										
Annual flow (mean)	GL	●	401	+71%	+4%	-10%	-19%	nm	nm	nm
Wet season flow (mean)	GL	●	390	+72%	+3%	-9%	-19%	nm	nm	nm
Dry season flow (mean)	GL	●	11.3	+57%	+28%	-14%	-42%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00242							
Number of days below low flow threshold (mean)	d/y	●	36.5	-29.5	-5.1	+17.6	+46.8	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.78	-0.3	+0	0	+0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	5.97							
Number of days above high flow threshold (mean)	d/y	●	18.3	+10.5	+0.3	-1.8	-3.4	nm	nm	nm
Port McArthur Tidal Wetlands System - Node 4 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL	●	92.6	+68%	0%	-8%	-19%	nm	nm	nm
Wet season flow (mean)	GL	●	89.9	+68%	-1%	-8%	-18%	nm	nm	nm
Dry season flow (mean)	GL	●	2.76	+67%	+25%	-14%	-39%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00058							
Number of days below low flow threshold (mean)	d/y	●	36.5	-28.1	+2.4	+14.1	+39.7	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.78	-0.3	+0	0	+0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	1.35							
Number of days above high flow threshold (mean)	d/y	●	18.3	+9.6	-0.4	-1.5	-2.9	nm	nm	nm
Port McArthur Tidal Wetlands System - Node 5 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL	●	27.4	+62%	+1%	-8%	-19%	nm	nm	nm
Wet season flow (mean)	GL	●	26.6	+61%	+1%	-8%	-19%	nm	nm	nm
Dry season flow (mean)	GL	●	0.795	+74%	+25%	-13%	-38%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00018							
Number of days below low flow threshold (mean)	d/y	●	36.5	-28.6	+3.1	+16.8	+43.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	5.69	+1.4	-0.7	+5.3	+13.6	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	0.402							
Number of days above high flow threshold (mean)	d/y	●	18.3	+8.6	-0.2	-1.5	-2.9	nm	nm	nm
Southern Gulf Aggregation - Node 1 (confidence level: low flow = 5, high flow = 4)										
Annual flow (mean)	GL	●	373	+57%	+10%	-2%	-13%	nm	nm	nm

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Wet season flow (mean)	GL	●	367	+58%	+10%	-2%	-13%	nm	nm	nm
Dry season flow (mean)	GL	●	6.29	+3%	+37%	+5%	-36%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00139							
Number of days below low flow threshold (mean)	d/y	●	36.5	-31.7	-8.1	+0.3	+16.4	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.623	+0.8	+0.1	+0.3	+0.2	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	4.87							
Number of days above high flow threshold (mean)	d/y	●	18.3	+4.2	+1.4	-0.2	-2.3	nm	nm	nm
Thorntonia Aggregation - Node 1 (confidence level: low flow = 5, high flow = 3)										
Annual flow (mean)	GL	●	39.8	+39%	+18%	-5%	-19%	nm	nm	nm
Wet season flow (mean)	GL	●	36.8	+39%	+18%	-5%	-18%	nm	nm	nm
Dry season flow (mean)	GL	●	2.94	+45%	+18%	-4%	-32%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00337							
Number of days below low flow threshold (mean)	d/y	●	36.5	-32.7	-13.8	+7.4	+35.3	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.403	+0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	0.203							
Number of days above high flow threshold (mean)	d/y	●	18.3	+6.8	+2.1	-0.8	-2.9	nm	nm	nm
Thorntonia Aggregation - Node 2 (confidence level: low flow = 5, high flow = 2)										
Annual flow (mean)	GL	●	92.9	+15%	+21%	-4%	-17%	nm	nm	nm
Wet season flow (mean)	GL	●	80.6	+15%	+22%	-4%	-16%	nm	nm	nm
Dry season flow (mean)	GL	●	12.3	+13%	+19%	-1%	-19%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0212							
Number of days below low flow threshold (mean)	d/y	●	36.5	-35.2	-13.2	+6.2	+23.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.403	+0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	0.563							
Number of days above high flow threshold (mean)	d/y	●	18.3	+5.8	+2.8	-0.7	-3	nm	nm	nm
Thorntonia Aggregation - Node 3 (confidence level: low flow = 5, high flow = 2)										
Annual flow (mean)	GL	●	232	+23%	+26%	-2%	-20%	nm	nm	nm
Wet season flow (mean)	GL	●	195	+25%	+26%	-3%	-20%	nm	nm	nm
Dry season flow (mean)	GL	●	36.9	+13%	+23%	+1%	-21%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0649							
Number of days below low flow threshold (mean)	d/y	●	36.5	-35.4	-18.4	+1	+31.9	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0.403	+0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	1.57							
Number of days above high flow threshold (mean)	d/y	●	18.3	+6.2	+3.9	-0.4	-3.4	nm	nm	nm

Appendix 2.2.3 Flinders-Leichhardt Region

Table 47. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Flinders-Leichhardt region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Buffalo Lake Aggregation - Node 1 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL	●	nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	nm							
Number of days below low flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	nm							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Number of days above high flow threshold (mean)	d/y	●	nm	nm	nm	nm	nm	nm	nm	nm
Lake Julius - Node 1 (confidence level: low flow = <3, high flow = <3)										
Annual flow (mean)	GL	●	279	+72%	+16%	+0%	-40%	nm	nm	nm
Wet season flow (mean)	GL	●	251	+87%	+19%	+3%	-36%	nm	nm	nm
Dry season flow (mean)	GL	●	28	-58%	-7%	-22%	-68%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0							
Number of days below low flow threshold (mean)	d/y	●	188	+57.1	+56	+58.1	+65.4	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	188	+57.1	+56	+58.1	+65.4	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	2.11							
Number of days above high flow threshold (mean)	d/y	●	18.3	+5.9	+0.9	-0.8	-5.4	nm	nm	nm
Southern Gulf Aggregation - Node 2 (confidence level: low flow = <3, high flow = <3)										
Annual flow (mean)	GL	●	1950	+44%	+18%	+10%	-32%	nm	nm	nm
Wet season flow (mean)	GL	●	1850	+50%	+17%	+11%	-31%	nm	nm	nm
Dry season flow (mean)	GL	●	94	-72%	+37%	-7%	-50%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0							
Number of days below low flow threshold (mean)	d/y	●	118	-4.9	+6.3	-11.6	-3.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	118	-4.9	+6.3	-11.6	-3.1	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	17.2							
Number of days above high flow threshold (mean)	d/y	●	18.3	+2.6	+0.3	+0.1	-4.4	nm	nm	nm
Southern Gulf Aggregation - Node 3 (confidence level: low flow = <3, high flow = <3)										
Annual flow (mean)	GL	●	2070	-10%	+27%	-2%	-29%	nm	nm	nm
Wet season flow (mean)	GL	●	1990	-9%	+26%	-1%	-29%	nm	nm	nm
Dry season flow (mean)	GL	●	76.9	-50%	+70%	-12%	-23%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0							
Number of days below low flow threshold (mean)	d/y	●	244	+7	+5.6	+13.1	+19.7	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	244	+7	+5.6	+13.1	+19.7	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	26.9							
Number of days above high flow threshold (mean)	d/y	●	18.3	-2	+2.6	-0.3	-4.3	nm	nm	nm

Appendix 2.2.4 South-East Gulf

Table 48. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the South-East Gulf region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Dorunda Lakes Area - Node 1 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	●	236	+19%	+61%	+5%	-27%	nm	nm	nm
Wet season flow (mean)	GL	●	235	+18%	+61%	+5%	-27%	nm	nm	nm
Dry season flow (mean)	GL	●	0.59	+274%	+71%	-30%	-67%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0							
Number of days below low flow threshold (mean)	d/y	●	247	-19.8	-11.2	+6.1	+12.9	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	247	-19.8	-11.2	+6.1	+12.9	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	3.51							
Number of days above high flow threshold (mean)	d/y	●	18.3	+0.2	+9	-0.3	-4.5	nm	nm	nm
Smithburne - Gilbert Fan Aggregation - Node 1 (confidence level: low flow = ?, high flow = ?)										
Annual flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Wet season flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Dry season flow (mean)	GL		nm	nm	nm	nm	nm	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		nm							
Number of days below low flow threshold (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Number of days of zero flow (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		nm							
Number of days above high flow threshold (mean)	d/y		nm	nm	nm	nm	nm	nm	nm	nm
Southern Gulf Aggregation - Node 4 (confidence level: low flow = 5, high flow = 5)										
Annual flow (mean)	GL	🔴	3100	-33%	+36%	+14%	-21%	nm	nm	nm
Wet season flow (mean)	GL	🔴	3100	-33%	+36%	+14%	-20%	nm	nm	nm
Dry season flow (mean)	GL	🔴	6.94	+1%	+37%	-11%	-78%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🔴	0							
Number of days below low flow threshold (mean)	d/y	🔴	212	-6.2	-9.4	+0.8	+16.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	212	-6.2	-9.4	+0.8	+16.6	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🔴	28.2							
Number of days above high flow threshold (mean)	d/y	🔴	18.3	-1.8	+6.9	+0.6	-4.2	nm	nm	nm

Appendix 2.2.5 Mitchell Region

Table 49. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Mitchell region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Mitchell River Fan Aggregation - Node 1 (confidence level: low flow = <3, high flow = <3)										
Annual flow (mean)	GL	🟠	6790	+3%	+40%	-6%	-26%	nm	nm	nm
Wet season flow (mean)	GL	🟠	6620	+3%	+40%	-6%	-26%	nm	nm	nm
Dry season flow (mean)	GL	🟠	164	+2%	+29%	+12%	-37%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🟠	0.0454							
Number of days below low flow threshold (mean)	d/y	🟠	36.5	-2.7	-3.7	+13.5	+44.7	nm	nm	nm
Number of days of zero flow (mean)	d/y	🟠	6.13	-0.7	-0.2	+6.2	+21.3	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟠	105							
Number of days above high flow threshold (mean)	d/y	🟠	18.3	+0.6	+7.2	-1.2	-4.9	nm	nm	nm

Appendix 2.2.6 Western Cape Region

Table 50. Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Western Cape region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Archer River Aggregation - Node 1 (confidence level: low flow = 4, high flow = 2)										
Annual flow (mean)	GL	🟢	345	+15%	+39%	+1%	-24%	nm	nm	nm
Wet season flow (mean)	GL	🟢	339	+14%	+39%	+1%	-24%	nm	nm	nm
Dry season flow (mean)	GL	🔴	5.55	+97%	+25%	-5%	-19%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🔴	0							
Number of days below low flow threshold (mean)	d/y	🔴	122	-12.7	-10.2	+0	+14.5	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	122	-12.7	-10.2	+0	+14.5	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟢	6.03							
Number of days above high flow threshold (mean)	d/y	🟢	18.3	+4.2	+8.4	+0.4	-5.9	nm	nm	nm
Archer River Aggregation - Node 2 (confidence level: low flow = 3, high flow = 2)										
Annual flow (mean)	GL	🟢	1550	+18%	+33%	+1%	-21%	nm	nm	nm
Wet season flow (mean)	GL	🟢	1470	+16%	+34%	+1%	-22%	nm	nm	nm
Dry season flow (mean)	GL	🟠	76.2	+43%	+17%	-3%	-19%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🟠	0.0006							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Number of days below low flow threshold (mean)	d/y	🟠	36.5	-3.3	-4.9	+0.6	+17	nm	nm	nm
Number of days of zero flow (mean)	d/y	🟠	11.2	-0.8	-1.9	+0.5	+8.5	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟢	22.5							
Number of days above high flow threshold (mean)	d/y	🟢	18.3	+3.6	+6.9	+0.1	-5.6	nm	nm	nm
Archer River Aggregation - Node 3 (confidence level: low flow = 4, high flow = 2)										
Annual flow (mean)	GL	🟢	935	+11%	+36%	+1%	-23%	nm	nm	nm
Wet season flow (mean)	GL	🟢	901	+9%	+37%	+1%	-23%	nm	nm	nm
Dry season flow (mean)	GL	🔴	34.4	+71%	+21%	-2%	-19%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🔴	0.00022							
Number of days below low flow threshold (mean)	d/y	🔴	36.5	-6.5	-6	+0.1	+13.3	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	21.1	-3.1	-4.4	-0.1	+10.6	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟢	13.9							
Number of days above high flow threshold (mean)	d/y	🟢	18.3	+2.4	+6.8	+0.3	-5.2	nm	nm	nm
Archer River Aggregation - Node 4 (confidence level: low flow = 4, high flow = 2)										
Annual flow (mean)	GL	🟢	262	+25%	+39%	+1%	-25%	nm	nm	nm
Wet season flow (mean)	GL	🟢	259	+24%	+39%	+1%	-25%	nm	nm	nm
Dry season flow (mean)	GL	🔴	2.74	+158%	+29%	-5%	-20%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🔴	0							
Number of days below low flow threshold (mean)	d/y	🔴	138	-16.3	-12.3	-0.6	+11.9	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	138	-16.3	-12.3	-0.6	+11.9	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟢	4.54							
Number of days above high flow threshold (mean)	d/y	🟢	18.3	+4.8	+7.1	+0.2	-5.7	nm	nm	nm
Jardine River Wetlands Aggregation - Node 1 (confidence level: low flow = 3, high flow = 4)										
Annual flow (mean)	GL	🔴	249	+34%	+23%	+1%	-13%	nm	nm	nm
Wet season flow (mean)	GL	🔴	199	+34%	+24%	+1%	-13%	nm	nm	nm
Dry season flow (mean)	GL	🟠	49.2	+36%	+22%	+1%	-14%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🟠	0.075							
Number of days below low flow threshold (mean)	d/y	🟠	36.5	-29.3	-13.7	-0.8	+15.9	nm	nm	nm
Number of days of zero flow (mean)	d/y	🟠	1.55	-0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🔴	2.97							
Number of days above high flow threshold (mean)	d/y	🔴	18.3	+8.5	+4.5	-0.2	-2.9	nm	nm	nm
Jardine River Wetlands Aggregation - Node 2 (confidence level: low flow = 3, high flow = 4)										
Annual flow (mean)	GL	🔴	938	+29%	+23%	+1%	-14%	nm	nm	nm
Wet season flow (mean)	GL	🔴	745	+29%	+24%	+1%	-13%	nm	nm	nm
Dry season flow (mean)	GL	🟠	193	+31%	+22%	+0%	-14%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🟠	0.291							
Number of days below low flow threshold (mean)	d/y	🟠	36.5	-26.3	-14.7	-0.8	+16.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	🟠	1.55	-0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🔴	11.1							
Number of days above high flow threshold (mean)	d/y	🔴	18.3	+7.2	+4.5	-0.2	-2.8	nm	nm	nm
Northern Holroyd Plain Aggregation - Node 1 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	🔴	494	+40%	+41%	+2%	-24%	nm	nm	nm
Wet season flow (mean)	GL	🔴	490	+39%	+41%	+2%	-24%	nm	nm	nm
Dry season flow (mean)	GL	🟠	4.53	+163%	+33%	-7%	-26%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🟠	0							
Number of days below low flow threshold (mean)	d/y	🟠	121	-19.5	-12.6	-0.7	+13	nm	nm	nm
Number of days of zero flow (mean)	d/y	🟠	121	-19.5	-12.6	-0.7	+13	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🔴	8.88							
Number of days above high flow threshold (mean)	d/y	🔴	18.3	+7.6	+7.6	+0.4	-5.7	nm	nm	nm

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Northern Holroyd Plain Aggregation - Node 2 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL		373	+23%	+58%	+2%	-26%	nm	nm	nm
Wet season flow (mean)	GL		358	+19%	+58%	+3%	-25%	nm	nm	nm
Dry season flow (mean)	GL		15	+120%	+70%	-7%	-40%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		137	-15.9	-12.1	-1.8	+13.9	nm	nm	nm
Number of days of zero flow (mean)	d/y		137	-15.9	-12.1	-1.8	+13.9	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		5.75							
Number of days above high flow threshold (mean)	d/y		18.3	+3.8	+16.8	+0.5	-7.5	nm	nm	nm
Northern Holroyd Plain Aggregation - Node 3 (confidence level: low flow = 2, high flow = 2)										
Annual flow (mean)	GL		1230	+20%	+52%	+2%	-23%	nm	nm	nm
Wet season flow (mean)	GL		1190	+16%	+53%	+3%	-23%	nm	nm	nm
Dry season flow (mean)	GL		42.7	+115%	+38%	-6%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		88.2	-14	-12.5	-2.1	+11.1	nm	nm	nm
Number of days of zero flow (mean)	d/y		88.2	-14	-12.5	-2.1	+11.1	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		20.7							
Number of days above high flow threshold (mean)	d/y		18.3	+3.7	+15	+0.5	-6.8	nm	nm	nm
Northern Holroyd Plain Aggregation - Node 4 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL		438	+31%	+56%	+2%	-27%	nm	nm	nm
Wet season flow (mean)	GL		433	+29%	+56%	+2%	-27%	nm	nm	nm
Dry season flow (mean)	GL		4.58	+193%	+41%	-8%	-30%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0							
Number of days below low flow threshold (mean)	d/y		127	-15.9	-16.3	-0.2	+16.7	nm	nm	nm
Number of days of zero flow (mean)	d/y		127	-15.9	-16.3	-0.2	+16.7	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		7.7							
Number of days above high flow threshold (mean)	d/y		18.3	+6.1	+10.8	+0.6	-5.6	nm	nm	nm
Port Musgrave Aggregation - Node 1 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL		389	+27%	+28%	+1%	-18%	nm	nm	nm
Wet season flow (mean)	GL		304	+28%	+31%	+1%	-19%	nm	nm	nm
Dry season flow (mean)	GL		84.6	+26%	+16%	0%	-12%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.0999							
Number of days below low flow threshold (mean)	d/y		36.5	-12.5	-9.9	+0.7	+15.1	nm	nm	nm
Number of days of zero flow (mean)	d/y		1.53	-0.1	0	0	+0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		4.06							
Number of days above high flow threshold (mean)	d/y		18.3	+10.7	+9.9	+0.3	-6.7	nm	nm	nm
Port Musgrave Aggregation - Node 2 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL		85.7	+25%	+28%	+1%	-18%	nm	nm	nm
Wet season flow (mean)	GL		67.2	+25%	+31%	+1%	-19%	nm	nm	nm
Dry season flow (mean)	GL		18.5	+24%	+16%	0%	-12%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d		0.022							
Number of days below low flow threshold (mean)	d/y		36.5	-9.5	-10.2	+0.7	+15.2	nm	nm	nm
Number of days of zero flow (mean)	d/y		1.55	-0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d		0.901							
Number of days above high flow threshold (mean)	d/y		18.3	+9.4	+10.2	+0.4	-6.9	nm	nm	nm
Port Musgrave Aggregation - Node 3 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL		223	+22%	+28%	+1%	-18%	nm	nm	nm
Wet season flow (mean)	GL		175	+22%	+31%	+1%	-19%	nm	nm	nm
Dry season flow (mean)	GL		48	+22%	+16%	0%	-12%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in	GL/d		0.0575							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Scenario A)										
Number of days below low flow threshold (mean)	d/y	●	36.5	-7.1	-10.3	+0.8	+15.3	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.55	-0.1	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	2.34							
Number of days above high flow threshold (mean)	d/y	●	18.3	+8.5	+10.5	+0.2	-7.1	nm	nm	nm
Port Musgrave Aggregation - Node 4 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	●	564	+20%	+33%	+1%	-19%	nm	nm	nm
Wet season flow (mean)	GL	●	542	+19%	+34%	+1%	-19%	nm	nm	nm
Dry season flow (mean)	GL	●	22.4	+50%	+16%	-2%	-17%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0							
Number of days below low flow threshold (mean)	d/y	●	136	-5.8	-4.7	+0.4	+9	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	136	-5.8	-4.7	+0.4	+9	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	8.49							
Number of days above high flow threshold (mean)	d/y	●	18.3	+4.1	+9.6	+0.3	-5.7	nm	nm	nm
Port Musgrave Aggregation - Node 5 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	●	77.6	+26%	+32%	+1%	-19%	nm	nm	nm
Wet season flow (mean)	GL	●	75.2	+25%	+32%	+1%	-19%	nm	nm	nm
Dry season flow (mean)	GL	●	2.43	+58%	+16%	-2%	-15%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0							
Number of days below low flow threshold (mean)	d/y	●	143	-8.1	-4.1	+0.5	+8.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	143	-8.1	-4.1	+0.5	+8.2	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	1.16							
Number of days above high flow threshold (mean)	d/y	●	18.3	+5.3	+8.9	+0.4	-5.8	nm	nm	nm
Port Musgrave Aggregation - Node 6 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	●	3330	+17%	+34%	+1%	-22%	nm	nm	nm
Wet season flow (mean)	GL	●	3140	+16%	+35%	+1%	-22%	nm	nm	nm
Dry season flow (mean)	GL	●	190	+36%	+21%	-2%	-16%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0727							
Number of days below low flow threshold (mean)	d/y	●	36.5	-12.6	-11.9	-0.1	+15.3	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	1.88	-1.4	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	52.3							
Number of days above high flow threshold (mean)	d/y	●	18.3	+3.3	+11.9	+0.6	-6.7	nm	nm	nm

Appendix 2.3 Northern North-East Coast

Appendix 2.3.1 Northern Coral

Table 51: Standard metrics for changes to surface water flow regime at all surface water reporting nodes for environmental assets in the Northern Coral region

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
				change from Scenario A						
Lloyd Bay - Node 1 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	●	348	+29%	+34%	0%	-18%	nm	nm	nm
Wet season flow (mean)	GL	●	319	+30%	+35%	0%	-19%	nm	nm	nm
Dry season flow (mean)	GL	●	28.7	+20%	+18%	-5%	-14%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0111							
Number of days below low flow threshold (mean)	d/y	●	36.5	-19.7	-11.7	+0.8	+12.3	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	4.84							
Number of days above high flow threshold (mean)	d/y	●	18.3	+8.3	+5.6	+0.1	-4.3	nm	nm	nm
Lloyd Bay - Node 2 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	●	165	+29%	+32%	-1%	-17%	nm	nm	nm
Wet season flow (mean)	GL	●	149	+31%	+33%	0%	-18%	nm	nm	nm
Dry season flow (mean)	GL	●	16.1	+9%	+19%	-5%	-16%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.00592							
Number of days below low flow threshold (mean)	d/y	●	36.5	-21.3	-10.5	+0.6	+13.4	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	2.12							
Number of days above high flow threshold (mean)	d/y	●	18.3	+8.9	+5.6	+0.1	-3.9	nm	nm	nm
Lower Daintree River - Node 1 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	●	1120	+6%	+15%	-3%	-25%	nm	nm	nm
Wet season flow (mean)	GL	●	885	+9%	+17%	-2%	-26%	nm	nm	nm
Dry season flow (mean)	GL	●	236	-6%	+9%	-5%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.276							
Number of days below low flow threshold (mean)	d/y	●	36.5	+3.3	-2.5	-1.4	+31.4	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	11							
Number of days above high flow threshold (mean)	d/y	●	18.3	+1.9	+3.3	-0.5	-6	nm	nm	nm
Marina Plains - Lakefield Aggregation - Node 1 (confidence level: low flow = 3, high flow = 1)										
Annual flow (mean)	GL	●	116	+25%	+62%	-4%	-28%	nm	nm	nm
Wet season flow (mean)	GL	●	105	+25%	+65%	-4%	-28%	nm	nm	nm
Dry season flow (mean)	GL	●	10.8	+29%	+39%	-5%	-24%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0169							
Number of days below low flow threshold (mean)	d/y	●	36.5	-20.9	-24.1	+2.6	+35.8	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	1.4							
Number of days above high flow threshold (mean)	d/y	●	18.3	+6.3	+11.4	-0.5	-5.3	nm	nm	nm
Marina Plains - Lakefield Aggregation - Node 2 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	●	71.2	+27%	+62%	-4%	-28%	nm	nm	nm
Wet season flow (mean)	GL	●	64.5	+27%	+65%	-4%	-28%	nm	nm	nm
Dry season flow (mean)	GL	●	6.72	+31%	+38%	-5%	-24%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in	GL/d	●	0.0101							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Scenario A)										
Number of days below low flow threshold (mean)	d/y	🔴	36.5	-18.9	-25	+2.6	+34.3	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟠	0.857							
Number of days above high flow threshold (mean)	d/y	🟠	18.3	+6.7	+11.6	-0.6	-5.6	nm	nm	nm
Marina Plains - Lakefield Aggregation - Node 3 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	🟠	137	+21%	+63%	-3%	-28%	nm	nm	nm
Wet season flow (mean)	GL	🟠	124	+20%	+66%	-3%	-28%	nm	nm	nm
Dry season flow (mean)	GL	🔴	13.5	+28%	+40%	-5%	-25%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🔴	0.02							
Number of days below low flow threshold (mean)	d/y	🔴	36.5	-19.1	-26.7	+2.2	+34.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟠	1.66							
Number of days above high flow threshold (mean)	d/y	🟠	18.3	+5	+11.5	-0.2	-5.8	nm	nm	nm
Marina Plains - Lakefield Aggregation - Node 4 (confidence level: low flow = 3, high flow = 3)										
Annual flow (mean)	GL	🟠	1410	0%	+45%	-6%	-31%	nm	nm	nm
Wet season flow (mean)	GL	🟠	1370	-1%	+46%	-6%	-31%	nm	nm	nm
Dry season flow (mean)	GL	🟠	38.2	+27%	+27%	-13%	-34%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🟠	0.00587							
Number of days below low flow threshold (mean)	d/y	🟠	36.5	+6.9	-14.1	+1.8	+24.9	nm	nm	nm
Number of days of zero flow (mean)	d/y	🟠	0	0	0	0	+0.5	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟠	21.9							
Number of days above high flow threshold (mean)	d/y	🟠	18.3	-0.7	+6.8	-0.8	-6.4	nm	nm	nm
Marina Plains - Lakefield Aggregation - Node 5 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	🟠	327	+22%	+62%	-4%	-29%	nm	nm	nm
Wet season flow (mean)	GL	🟠	296	+21%	+65%	-4%	-29%	nm	nm	nm
Dry season flow (mean)	GL	🔴	30.8	+33%	+38%	-6%	-24%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🔴	0.05							
Number of days below low flow threshold (mean)	d/y	🔴	36.5	-22.5	-23.8	+2.3	+34.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🟠	4.2							
Number of days above high flow threshold (mean)	d/y	🟠	18.3	+5.2	+11.9	-0.8	-6	nm	nm	nm
Newcastle Bay - Escape River Estuarine Complex - Node 1 (confidence level: low flow = 4, high flow = 4)										
Annual flow (mean)	GL	🔴	111	+48%	+69%	0%	-5%	nm	nm	nm
Wet season flow (mean)	GL	🔴	86	+50%	+76%	+0%	-5%	nm	nm	nm
Dry season flow (mean)	GL	🔴	25.2	+38%	+45%	-2%	-5%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🔴	0.0271							
Number of days below low flow threshold (mean)	d/y	🔴	36.5	-20.6	-21.9	+1.2	+5.1	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🔴	1.09							
Number of days above high flow threshold (mean)	d/y	🔴	18.3	+16.4	+24.3	+0.3	-1.7	nm	nm	nm
Newcastle Bay - Escape River Estuarine Complex - Node 2 (confidence level: low flow = 4, high flow = 4)										
Annual flow (mean)	GL	🔴	23.7	+42%	+69%	0%	-5%	nm	nm	nm
Wet season flow (mean)	GL	🔴	18.2	+45%	+77%	+0%	-5%	nm	nm	nm
Dry season flow (mean)	GL	🔴	5.54	+32%	+45%	-2%	-5%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	🔴	0.00603							
Number of days below low flow threshold (mean)	d/y	🔴	36.5	-17	-22	+1.4	+5.7	nm	nm	nm
Number of days of zero flow (mean)	d/y	🔴	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	🔴	0.233							

Standard metrics	Units	CL	A	B	Cwet	Cmid	Cdry	Dwet	Dmid	Ddry
Number of days above high flow threshold (mean)	d/y	●	18.3	+15.2	+25.2	+0	-1.6	nm	nm	nm
Newcastle Bay - Escape River Estuarine Complex - Node 3 (confidence level: low flow = 4, high flow = 4)										
Annual flow (mean)	GL	●	43.8	+34%	+70%	0%	-5%	nm	nm	nm
Wet season flow (mean)	GL	●	33.2	+37%	+78%	+0%	-5%	nm	nm	nm
Dry season flow (mean)	GL	●	10.6	+26%	+44%	-2%	-5%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.0115							
Number of days below low flow threshold (mean)	d/y	●	36.5	-14.2	-22.3	+1.3	+5.2	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	0.435							
Number of days above high flow threshold (mean)	d/y	●	18.3	+13.9	+26.3	+0	-1.5	nm	nm	nm
Olive River - Node 1 (confidence level: low flow = 4, high flow = 3)										
Annual flow (mean)	GL	●	840	+14%	+32%	0%	-19%	nm	nm	nm
Wet season flow (mean)	GL	●	760	+14%	+33%	0%	-20%	nm	nm	nm
Dry season flow (mean)	GL	●	79.9	+20%	+17%	-4%	-15%	nm	nm	nm
Low flow threshold (discharge exceeded 90% of the time in Scenario A)	GL/d	●	0.11							
Number of days below low flow threshold (mean)	d/y	●	36.5	-13.7	-17.4	+1.4	+20.6	nm	nm	nm
Number of days of zero flow (mean)	d/y	●	0	0	0	0	0	nm	nm	nm
High flow threshold (discharge exceeded 5% of the time in Scenario A)	GL/d	●	11.9							
Number of days above high flow threshold (mean)	d/y	●	18.3	+2.3	+7.8	+0.1	-5.4	nm	nm	nm

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