Queensland Government

Department of Regional Development, Manufacturing and Water

Water Plan (Gulf) 2007

Minister's Performance Assessment Report

November 2023

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Acknowledgement of Traditional Owners

The Department of Regional Development, Manufacturing and Water respectfully acknowledges the Traditional Custodians of Country. We recognise the ongoing spiritual and cultural connection Aboriginal Peoples and Torres Strait Islander Peoples have with land, water, sea and sky. We pay our deep respects to their Elders past and present, support future leaders, and acknowledge First Nations People's right to self-determination.

This publication has been compiled by North Region Water Planning and Science, Department of Regional Development Manufacturing and Water.

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Minister’s foreword

I am pleased to publish the performance report for the Gulf water plan. Performance reports are an important part of the water planning process in Queensland for each of the state’s 23 water plans. The current Gulf water plan is scheduled to expire on 1 November 2027.

This report showed that the plan and its implementation were largely effective in advancing sustainable water resource management and minimising the adverse impacts on the existing water entitlement holders and natural ecosystems in the plan area. However, the report also identified some emerging issues and matters that necessitate me to bring forward the plan review.

The report concluded that the water plan does not effectively support growth in irrigated agriculture and growth in the emerging critical minerals industry (particularly in the Flinders Catchment).

The Gulf water plan area is a major part of the North-West Minerals Province known for its production of copper, cobalt and vanadium. Global demand for these minerals is expected to rise exponentially over the next decade and there is opportunity for further expansion in cobalt, copper, graphite, vanadium and rare earths across the Gulf water plan area. Queensland’s Critical Minerals Strategy sets a framework to accelerate the growth in the critical minerals industry and support Queensland to meet global opportunities to be a forefront leader in transitioning the world to renewable energies.

It is of vital importance this water plan is positioned to support growth in both agriculture and the emerging critical mineral industries. Hence a water plan review and replacement is necessary and will revisit how the share of water is balanced between all water interests, including the interests and values of water for First Nations peoples, towns and communities, agriculture, industries, the emerging critical minerals requirements and the environment. A review also provides the opportunity to better define water products, water reserves and trading markets that will support economic development.

The water plan review will consider climate change impacts on water availability. The review will also consider water requirements to support the social, cultural and economic aspirations of First Nations peoples, while continuing to protect existing water users and the environment. This planning process will include consideration of unallocated water reserves to determine if they are sufficient to meet current and future demand as well as collecting additional targeted science and further consultation with stakeholders to ensure a fair and sustainable outcome for all.

In the coming months I will release a preliminary public consultation notice and a Statement of Proposals to commence the water plan review and guide the community through the water planning process. People will have the opportunity to contribute to the development of a new water plan once these documents are published.

In the meantime, my department will continue to implement the water plan. Ongoing monitoring will continue to enable new, emerging or existing risks that are increasing in threat level, to be identified to ensure the plan continues to effectively allocate the water resources in the plan area.

I encourage anyone with an interest in the management of water resources in the plan area to read this report.

Hon. Mr Glenn Butcher MP
Minister for Regional Development and Manufacturing
Minister for Water

Executive summary

Under section 49 of the *Water Act 2000* (the Water Act), a Minister must prepare a report on each water plan at least every five years to assess its effectiveness on achieving each of the plan's outcomes and its implementation, in accordance with the requirements stated under section 22(4) of the Water Regulation 2016 (the Regulation).

This report provides an assessment of the performance of the Water Plan (Gulf) 2007 (water plan), which is scheduled to expire on 1 November 2027. A summary of the assessment is provided in Table 1.

The assessment showed that the water plan continued to advance the sustainable management of water resources and that the implementation of the plan had been effective in achieving most of the plan's outcomes. However, there was insufficient information to fully assess the achievement of outcomes that support the water-related cultural values of First Nations peoples.

A risk assessment was undertaken to identify the issues that threaten the ability of the water plan to achieve its intended outcomes. For the plan's 29 outcomes, one was found to be high risk of not being achieved, two were found to be at medium risk of not being achieved, three could not be fully assessed due to knowledge gaps, and the rest were ranked as low risk (Appendix A).

The one outcome identified at high risk was related to the ability of the water plan to support growth in industries dependent on water resources where current water availability is unlikely to meet future demand for mining industries.

For the two outcomes identified as at medium risk, one outcome related to the ability of the plan to support growth in irrigated agriculture in the Flinders River catchment area where several factors were identified as limiting growth. The second outcome related to the desire to minimise changes to natural variability in water levels, including maintaining water levels in waterholes and lakes. While it is recognised that water use across the plan area remains very low, some threats to achieving this outcome were identified. More targeted science is required across all catchments to understand the appropriate drawdown thresholds for waterholes.

The assessment identified a range of matters that necessitate early initiation of the water plan review and replacement. These include the need to:

- revisit how the share of water is balanced between all water interests, including the environment, cultural and end of system fisheries in the Gulf
  - consider how opportunities to meet the growing demand for new irrigated agriculture and emerging critical minerals industry (outlined in Queensland's Critical Minerals Strategy) are balanced against the associated impact of these developments on the other water interests and values across the plan area
- update the plan outcomes in accordance with the latest Water Act requirements, contemporary water planning policies and emerging matters
- consider climate change projections on water availability[1]
- incorporate best-available science and information, including the latest hydrological modelling and improving the understanding of water requirements for key environmental assets
- assess the impacts of the existing water management arrangements and future policy decisions using a new hydrologic model, developed by Queensland Hydrology, that incorporates the latest science and new hydrologic data

[1] Climate modelling projections conducted by the Queensland Government forecast an increase in temperature and evapotranspiration and uncertainty regarding rainfall patterns over the next decades. These changes may result in similar overall annual rainfall totals, trending towards small increases in rainfall in summer months and small decreases or no change in the dry season. Changes in climate may lead to increases in consumption and evaporation losses from storages and watercourses and reduced persistence of waterholes through time.

- undertake targeted engagement with First Nations peoples to improve our understanding of their cultural water values, aspirations and uses of water and the associated water requirements across the plan area
- review water availability and unallocated water volumes across the plan area to address current and emerging demands for new or additional access to water, to support economic growth, town water supplies and values and aspirations of First Nations peoples
- consider cumulative impacts and risks from different levels of water allocation and catchment development on the Gulf of Carpentaria and the associated fishing industry
- improve understanding of groundwater resources, particularly connectivity to surface water, as well as groundwater dependant ecosystems.

The review and replacement of the water plan is necessary to respond to increasing water demand, as well as the intricate nature of the emerging challenges identified in this assessment. The review process will involve technical assessments and targeted stakeholder consultation to inform the replacement plan. The learnings gained from implementing the existing plan will also be used to improve water management arrangements in the plan area under the replacement plan.

Table 1: Summary of the performance assessment of the Water Plan (Gulf) 2007

	Completed		On track		Some issues
	Some major issues		Not achieved		Insufficient information available

Matters to be addressed	Comment	Report section	Status
Effectiveness of the plan in advancing the sustainable management of Queensland's water resources	Overall, this assessment indicates that the plan is achieving the purposes of the Water Act.	Section 3	On track
Effectiveness of the implementation of the plan in achieving the plan outcomes	A risk assessment found that most plan outcomes have been achieved. Of the 29 outcomes, one was found to be of high risk of not being achieved, two were found to be medium risk of not being achieved, three (relating to supporting cultural water values) could not be fully assessed due to knowledge gaps and the rest were ranked as low risk.	Section 4	On track
Summary of water usage and entitlements including those taken or interfered with under statutory authorisations	Information on water use under metered entitlements is collected and reported. No issues were identified as water use is low in the plan area, compared with the water availability.	Section 5	On track
Summary of research and monitoring findings	There was limited specific ecological monitoring conducted by the department across the catchment over the past five years, however there was considerable research undertaken under the National Environmental Science Program. Knowledge gaps associated with waterholes, groundwater and surface water interaction and riparian vegetation water use have been identified through the risk assessment process. Filling these knowledge gaps would provide greater confidence in the future assessment of risks to plan ecological outcomes.	Section 6	On track
Summary of amendments to the plan since its commencement	Two major amendments to the plan were made to provide additional volumes of unallocated water and three minor administrative amendments were made to reflect amendments to other legislation. In 2018, the plan's expiry was postponed to 1 November 2027.	Section 10	On track
Summary of identified risks to plan outcomes	Of the 29 outcomes assessed, one risk was found to be of high risk of not being achieved, two were found to be medium risk of not being achieved, three (relating to supporting cultural water values) could not be fully assessed due to knowledge gaps and the rest were ranked as low risk. Engagement with First Nations peoples will be undertaken as part of a plan review process to fill the identified knowledge gaps.	Section 11	Some major issues
Summary of non-compliances under a water entitlement or other authorisation in the plan area	Over the past five years, there have been 20 instances of non-compliance. Most of the incidents related to failure to supply a meter reading. All these issues have been resolved.	Section 13	On track
Overall status and recommendation for the plan	Overall, the plan is fit for purpose and risks to water users and environment are considered to remain low within the lifetime of the plan (until 2027). However, assessments did identify some opportunities and complex emerging matters that should be considered in developing the replacement plan, in consultation with key stakeholders.	Section 14	On track

Contents

Appendices

1. Purpose of the report

The Water Act (s49) requires the Minister to prepare reports for each water plan, to ensure the implementation and effectiveness of each plan is regularly assessed as part of an adaptive management water planning cycle. This cycles involves plan development, implementation, monitoring, and reporting. The Regulation (s22(4)) requires these reports be prepared at least at five-yearly intervals and to address the following matters:

- Whether or not the plan is advancing the sustainable management of Queensland's water resources
- an assessment of the effectiveness of the implementation of the plan in achieving the plan's outcomes
- information on water usage and authorisations in the plan area, including water entitlements and water taken or interfered with under statutory authorisations
- a summary of the findings of research and monitoring for the plan
- any identified risks to the plan's outcomes
- what amendments, if any, have been made to the plan since its commencement
- any non-compliance under a water entitlement or other authorisation in the plan area.

This report is prepared to assess the performance of the water plan and its implementation to meet the above statutory requirements, with an emphasis on progress since the previous Minister's report in 2018. It also analyses issues that should be considered, as well as emerging matters and pressures that may be considered, as part of the next plan review process.

Considerations were also given to whether or not the water plan's outcomes and strategies continue to be appropriate for the plan area.

A risk assessment was conducted in October 2022 to underpin this report. The risk assessment was consistent with the ISO 31000:2018 Risk Management Guideline. This approach ensures a consistent, repeatable and defensible consideration of risks and that outcomes of the assessment are documented for future reference. The details and outcomes of the risk assessment are provided in section 11 and Appendix A of this report.

2. Water plan area

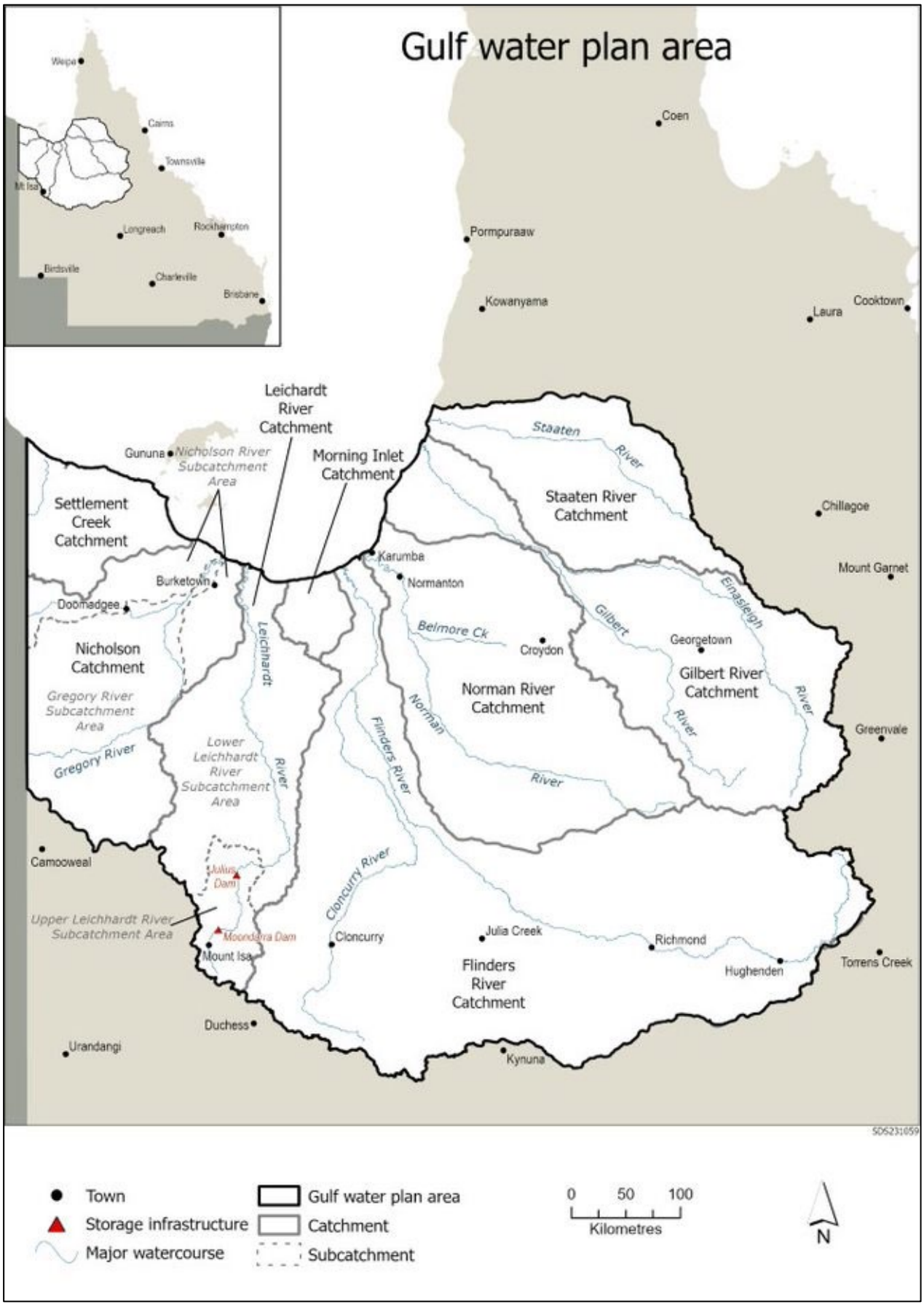
The water plan area is in far North-West Queensland and covers approximately 315,000km^2. It includes eight river catchments (Figure 1) that account for an average annual discharge of about 24,700GL (that is about 15% of the total state water run-off) to the Gulf of Carpentaria.

Key urban or regional centres include Mount Isa, Georgetown, Richmond, Croydon and Hughenden, and other smaller centres include Burketown, Normanton, Karumba, Julia Creek and Cloncurry. First Nations peoples represent a substantial and growing proportion of the population in the plan area.

There are two major dams in the water plan area, both on the Leichhardt River:

- Moondarra Dam (a storage capacity of 106,833ML; a catchment area of 1,070km^2) is managed by the Mount Isa Water Board. It was constructed in 1958 to provide water for Mount Isa urban water supply and surrounding mines and remains the principal water supply storage for Mount Isa today.
- Julius Dam (a storage capacity of 107,500ML; a catchment area of 3,730km^2) is owned and operated by Sunwater. It was constructed in 1976 to augment urban water supply from the Moondarra Dam and to supply water for the Cloncurry Shire Council (urban water supply) and mines in the North West Mineral Province including Ernest Henry copper mine and MMG (Dugald River).

Figure 1: Map of the Gulf water plan area



The main consumptive water uses in the plan area are the small-scale irrigation industry (using unsupplemented surface and underground water), mining activity in the Mount Isa area (supported by supplemented water) and urban use (dependent on several sources).

The Flinders and Gilbert catchments are the key areas where consumptive uses have the most potential for growth, particularly for irrigation. Mean annual discharge from the Gilbert River and Flinders River have been estimated to be 6,373,000ML and 3,640,000ML, respectively.

Non-consumptive water uses with a social, economic, or cultural value include recreational and commercial fisheries in the Gulf of Carpentaria and a growing tourism industry.

Natural environmental values in the plan area are highest in Staaten River, Settlement Creek and Morning Inlet catchments and the Gregory River subcatchment.

The plan area has very high ecological, environmental and heritage values (Sattler and Williams, 1999; SKM, 2009; Hogan and Vallance, 2005; DES, 2020). It includes five of the 13 bioregions of Queensland (Gulf Plains, Northwest Highlands, Mitchell Grass Downs, Einasleigh Uplands and Desert Uplands). The Gulf Plains bioregion includes numerous wetlands of national significance and migratory shorebird habitat that is internationally recognised.

The coastal wetlands and intertidal habitat adjacent to the rivers in the Gulf water plan region supports some of the most important habitat in Australia for migratory shorebirds, marine mammals and reptiles, and commercially important species (Hydrobiology, 2006). The Gulf water plan region has three designated flyway sites for the East Asian–Australasian Flyway Partnership, representing internationally recognised migratory shorebird habitat. There is a near continuous stretch of coastal wetland areas in the southeast Gulf of Carpentaria designated as wetlands of High Environmental Significance and are mapped as Matters of State Environmental Significance under the State Planning Policy. Wetlands of national significance include the inter-tidal and estuarine wetland systems of the Southeast Karumba Plain Aggregation and Smithburne-Gilbert Fan Aggregation, both listed in the Directory of Important Wetlands of Australia. The diversity and extent of the freshwater wetlands within the Gulf Plains bioregion is only exceeded by those in the Cape York bioregion (Sattler and Williams, 1999). The Gregory River and Lawn Hill Creek are unique as the only extensive perennial watercourses known in the plan area. The riparian zone of these waterways is adapted to the perennial flow regime (Hydrobiology, 2006).

Information of culturally significant areas within the plan area is limited. These may include, but are not limited to, areas where native title rights have been granted and pastoral land owned by the First Nations peoples through land trusts. Culturally significant areas may be included on the Cultural Heritage Database and Register, such as declared Aboriginal Sites near Cloncurry, Indigenous Protected Areas north and north-west of Doomadgee and Burketown and several Cultural Heritage Management Plans in place across the plan area. Migratory shorebird flyway sites for the East Asian–Australasian Flyway Partnership were nominated by the Carpentaria Land Council Aboriginal Corporation together with Traditional Owners and supported by Queensland Government. Other culturally significant areas may be located within areas where Native Title has been determined.

Rainfall in the region is predominantly seasonal, with approximately 80 per cent of falls occurring from December to March. Tropical cyclones or depressions are common and can result in significant rainfall leading to flooding. Average annual rainfall varies across catchments – from 480mm in the comparatively arid inland areas to 1,250mm in coastal areas. However, this seasonal abundance is countered by high evaporation rates of up to 3,800mm per annum (mm/a), which presents efficiency challenges for irrigation and water storage management.

3. How the water plan advances the sustainable management of Queensland's water resources

The water plan manages surface water (both supplemented and unsupplemented), overland flow water and underground water and is implemented through the Gulf Resource Operations Plan (ROP). It advances the sustainable management of Queensland's water resources by establishing a framework for the allocation and management of water resources in the plan area for the economic, physical and social wellbeing of the people of Queensland. The outcomes and strategies in the plan were designed to promote sustainable management of ecosystems, water quality, water-dependent ecological processes and biological diversity associated with watercourses, lakes, springs, aquifers, and other natural water systems. Table 2 provides a summary of the plan's framework and how it advances sustainable management of water. For a more detailed summary of the linkages between plan outcomes, strategies and rules see Appendix A.

Table 2: The water plan's framework for advancing sustainable management of water.

Water plan framework	How is this achieved?	Comment
Ecologically sustainable development	The plan includes ecological outcomes to ensure ecologically sustainable development in the plan area. These outcomes identify key ecological assets and functions and seek to minimise changes to flow regimes within the plan area, particularly in areas of high ecological value. They also seek to minimise changes, as far as practicable, to the volume and seasonality of freshwater flows in the plan area. The plan also includes environmental flow objectives (EFO) for surface water to ensure ecologically sustainable development in the plan area. The rules in the ROP implement the strategies in the water plan to protect environmental flows and to maintain the ecological integrity of the river systems to achieve plan outcomes.	The plan was developed based on a long-term hydrologic model to enable a better understanding of the patterns of water use and availability for both consumptive and non-consumptive uses. Ecological sustainable development is achieved through the social, economic, and environmental outcomes prescribed by the water plan that all development is required to accommodate.
Allocation and use of water resources for economic, physical, and social wellbeing of the people of Queensland	The water plan provides a framework for taking water under the water entitlements, which balances the interest of all water users in the plan area. It also provides a framework for the release of unallocated water (UAW) from the Indigenous strategic and general reserves, as well as a water trading framework, which enables both permanent and temporary trades. The trading rules and the process for the release of UAW is stated in the ROP. Water in the plan area can also be accessed without a water entitlement for cultural, stock and domestic purposes and prescribed activities, subject to limitations outlined in the water plan, the Water Act or the Regulation.	UAW volumes have been reserved for future development to promote economic development, while also supporting population and industry growth, as well as aesthetic, recreational and cultural values. Since the plan commencement, there have been several releases of UAW from both the general and strategic reserve, totalling 211,826ML across the plan area. There are also several UAW release processes that have been initiated but not yet completed, totalling 220,200ML from the general and strategic reserves. For detailed information on UAW releases, refer to section 5 of the report. The risk assessment identified a high risk to the capacity of the plan to support growth in industries and medium risk to the capacity of the plan to meet growing agricultural demands for additional water

Water plan framework	How is this achieved?	Comment
		from the existing UAW reserves, over the life of the current plan (Appendix A).
Sustain the health of ecosystems	The plan contains ecological outcomes which aim to support the ongoing protection of ecological assets and their habitats. It also includes EFOs to sustain the health of ecosystems in the plan area and other strategies for achieving ecological outcomes.	Targeted research and monitoring data helped to inform the current assessment (see section 6 for details). Furthermore, the risk assessment identified that the ecological outcomes were achieved in the reporting period. It ranked the risks to sustaining the health of ecosystems in the plan area as low, except the risk to the outcome under section 15(c) which will require more targeted science to address knowledge gaps (for details see Appendix A). Additional EFO nodes would assist measuring water plan outcomes at the river reach scales rather than just catchment scale. This would also assist with implementing UAW and water trading provisions.
Recognise the interests of Aboriginal and Torres Strait Islander peoples	The water plan contains outcomes to support water-related cultural values of First Nations peoples in the plan area and to help them achieve their social and economic aspirations. The plan also includes strategies for minimising negative impacts of taking, or interfering with, water under the water entitlements on cultural values. The plan also provides Indigenous reserves of UAW to help First Nations communities to achieve their economic and social aspirations. The Water Act allows First Nations peoples to take or interfere with water for traditional activities or cultural purposes without an entitlement.	There was insufficient data available to assess the effectiveness of the plan in supporting interests of First Nations Peoples in the plan area (Appendix A). Further consultation with First Nations peoples will be undertaken as part of the plan review process to fill the identified knowledge gaps and to better understand the interests of cultural, spiritual, and economic value in water to meet the aspirations of First Nations communities across the plan area. The department will also engage with First Nations peoples regarding who may be eligible to, and how to access UAW from an Indigenous reserve.
Enable water resources to be obtained through fair, transparent, and orderly processes	Water in the plan area can be obtained through the water market or through access to the UAW reserved for specific purposes. The plan identifies volumes of UAW available across the plan area and states a framework for establishing[2] and dealing with UAW and limitations on granting UAW[3] from a particular reserve (Indigenous, strategic or general). Fair and transparent processes for the release of UAW have been established under the ROP and the Regulation. The plan also provides a water trading framework and the ROP outlines water trading rules.	The water trading and UAW frameworks were developed in consultation with all interested parties and aim to balance their water needs and interests.
Build confidence regarding availability, security and value of water	The plan states outcomes which aim to provide, protect, and improve access to available water resources. The plan provides for the continued use of existing water entitlements and other	There are many rural and rural residential properties that do not have access to a reticulated supply, and they access water from an on-site tank or dam, underground water, run-of-river or other storages. Due to the nature of the raw water sources,

[2] Provides for a breakdown of the three types of UAW (Indigenous, strategic, or general reserve) and the locations within the plan area where those reserves may be made available.
[3] The process for granting UAW in the plan area is a process stated in the Water Regulation 2016.

Water plan framework	How is this achieved?	Comment
entitlements and authorisations	authorisations (i.e., overland flow works) to take or interfere with water. The plan's strategies and objectives provide certainty and security for current water users while also ensuring water is available to support towns, communities, and industrial growth. The plan prevents any decision (excluding water permits or the release of the UAW reserve) regarding the allocation or management of water that would increase the volume of water available be taken. This strategy protects existing water entitlements and authorisations.	these water supplies can be more sensitive to changes in weather conditions, resulting in a quick decline of water security. Options for water supply during low water availability are varied.
Promote efficient use of water through water markets, allocation, risk assessments and community education	The plan and the ROP provide for both permanent and temporary (seasonal water assignment) trading of water allocations and water licences to take unsupplemented water within certain zones. This allows users to value water as a secure asset, encourages water use efficiency, enables entitlement holders to sell water without selling land, enables users to increase water supplies and improve reliability and provides for new industries to acquire water without jeopardising the environment or affecting other water users. Water use efficiency of proposals is one of the considerations when granting water entitlements from UAW reserves. When the state releases UAW, a price may be set, encouraging the recognition of water as a valuable resource, and promoting its highest value for efficient use.	Water trading data for the reporting period is provided in section 5.5 and Appendix B of this report. Over the years, general community education about water saving practices has helped to promote more efficient use of water. Self-regulation due to factors outside of the water plan control (i.e., power costs, different crop requirements) also helps to encourage efficient use of water.
Facilitate community involvement in planning for the management and allocation of water	Community involvement is ensured through the consultation and engagement processes in developing and finalising the plan and the ROP in line with the requirements of the Water Act.	The plan and the ROP were developed in consultation with key stakeholders and all other interested parties. Further community consultation will occur to inform the plan review prior to its expiry and to underpin the development of the new plan.

4. Assessment of the effectiveness of the implementation of the water plan in achieving its outcomes

The department monitors the implementation of the water plan to make sure it is achieving its outcomes. The plan commenced in 2007 and was originally scheduled to expire in 2018. In 2018, the plan's expiry was extended to 2027 (to the maximum term of 20 years from plan commencement), following the finding of the Minister's report 2018 on the performance and the effectiveness of the plan, as well as the risk level to achieving the plan's outcomes over the next decade.

Key achievements in implementing the plan since 2018 include:

- release of UAW to support economic development opportunities for irrigated agriculture and other commercial enterprises in the Flinders, Gilbert, Norman and Nicholson catchments and the Lower Leichhardt sub-catchment, and to stimulate the economic recovery of regional Queensland (see section 5.5 for details)
- establishment of metered entitlements in the Flinders catchment
- continued implementation of seasonal and permanent water trading provisions
- continued implementation of water monitoring.

Appendix A summarises findings of an assessment of the effectiveness of the implementation of the water plan in achieving its outcomes since 2018. The assessment shows that implementation of the water plan is achieving most of the its outcomes.

Insufficient information was available to adequately assess the effectiveness of the plan in achieving the outcome to support the water-related cultural values of First Nations peoples in the plan area. The risk assessment indicated that this outcome is partly met through environmental flow provisions, where key ecosystems protected by the plan overlap with cultural values, as well as provisions in the Water Act which allow First Nations peoples to take or interfere with water for traditional activities or cultural purposes without an entitlement. Consultation with First Nations peoples will be undertaken as part of the plan review and replacement, to fill the identified knowledge gaps including, to improve understanding and recognition of the cultural values, aspirations and uses of water and associated water requirements.

The assessment also identified emerging matters (refer to section 12) that may affect effectiveness of the plan in the future and that should be considered in developing the replacement plan.

5. Information on water use and authorisations in the plan area

Water users in the plan area have access to water taken under a water entitlement (water licence or water allocation) or under a statutory authorisation through the Water Act for low-risk activities such as stock and domestic or prescribed activities (e.g., washing down equipment, plant, or vehicles to prevent the spread of weed seeds, or for safety purposes). UAW is reserved and can be made available for future use with consideration to protecting existing entitlements and flows for the environment.

General information about water trading and pricing can be found on the Business Queensland website.

5.1 Water entitlements

Water entitlements in the plan area include:

- water allocations to take supplemented water from Julius Dam and Moondarra Dam water supply schemes (WSS)
- water licences to take unsupplemented surface water
- water licences to take overland flow water
- water licences to take underground water in the Nicholson groundwater management area.

All water allocations within the Julius Dam WSS are high priority entitlements and within the Moondarra Dam WSS are medium priority entitlements.

Appendix B-2 provides data on the number of specific entitlements and the volumes of water allocated under these entitlements. In summary:

- Out of the 373,179ML allocated under all entitlements, approximately 78.0% (291,177ML) has been allocated as unsupplemented surface water, 20.1% (75,150ML) as supplemented surface water, 1.6% (6,000ML) as overland flow water and 0.2% (852ML) as underground water. This includes water existing on land within 1km of a prescribed watercourse, which is declared to be water in the watercourse.
- Approximately 75.6% (220,012ML) of unsupplemented surface water has been allocated within Flinders River WMA.
- Approximately 65% (48,850ML) of supplemented water is supplied from the Julius Dam WSS, with the remaining 35% (26,300ML) supplied from the Moondarra Dam WSS.
- The volumes of supplemented surface water allocated for distribution loss purposes, correspond to 2.6% (1,250ML) and 4.8% (1,250ML) for the Julius Dam and Moondarra Dam schemes, respectively.
- The volumes of unsupplemented water allocated for mining purposes, correspond to 77.5% (660ML) and 0.1% (200ML) of the total underground and surface water volumes, respectively.

5.1.1 Uncommitted water

Uncommitted water are supplemented water allocations held by entities that hold a resource operations licence (the bulk water system operator) that have not yet been committed to customers. These water allocations are usually available for lease, sale, or contract subject to transportation infrastructure constraints, or may be held for future business opportunities.

While there is no uncommitted water in the Moondarra Dam WSS, as of June 2022 there was approximately 20,000ML of uncommitted water in the Julius Dam WSS that could potentially be purchased or leased from the water allocation holders, specifically:

- Sunwater currently holds 10,850ML of water allocation, most of which remains uncommitted.
- North-West Queensland Water Pipeline Pty Ltd holds 15,000ML of water allocation, of which around half remains uncommitted.
- Mount Isa Water Board (MIWB) holds 5,000ML of water allocation of which about 2,350ML remains uncommitted.

Under the current rules, having uncommitted water in Julius Dam improves the water security for existing customers as any water not used by the end of the water year is shared between all water allocation holders in the following water year.

5.2 Announced allocations

Announced allocation provisions are outlined in the ROP and apply to supplemented water allocations in a WSS. These are rules for sharing the available water in storages between allocation holders until

the end of the water year. Water allocation holders within both WSS were issued with an Announced Allocation of 100% of their entitlement in each water year over the reporting period. A summary of announced allocations for the reporting period is provided in Appendix B-3.

5.3 Water use

Metered entitlements in the water plan area include water allocations within the WSS and all active unsupplemented surface water licences, other than licences for stock or domestic purposes only, within the Gilbert River and Flinders River water management areas (WMA)[4]. The Flinders River WMA became a metered entitlement area in the 2018/19 water year. Other entitlements in the plan area are not metered entitlements for taking water for prescribed activities, in accordance with section 25 of the Regulation. Some entitlements within the plan area are required to measure use under conditions specified on the water licence.

The holder of a metered entitlement must not take water under the entitlement other than through works that have an approved meter attached. In line with the Regulation, the holders of metered entitlements or owners of water works must report meter readings to the department. Within the WSS, the resource operations licence holders are responsible for reading all customers' water meters and reporting annually to the department.

A summary of water use is provided in Table 3 and detailed in Appendix B-4.

Table 3: Water use in 2017/18 - 2021/22 water years.

Area	Range of water use (ML)	Range of water use as a percentage of authorised entitlements (%)
Julius Dam WSS	5,549 – 14,028	11.4 – 28.7
Moondarra Dam WSS	13,773 – 17,397	52.4 – 66.1
Gilbert River WMA	120 – 846	0.4 – 2.9
Flinders River WMA	831 – 11,997	0.4 – 5.5%

Over the last five water years, the use of supplemented water ranged from approximately 11% to 29% and 52% to 66% of the entitlement for Julius Dam WSS and the Moondarra Dam WSS, respectively. Since 2014, water use by Mt Isa Mines Glencore has declined due to the introduction of water recycling practices, reducing from an average of 11,365ML/a (from 2008/09 to 2013/14) to an average of about 8,275ML/a (2014/15 to 2015/16) (DNRME, 2019).

The water use in the Gilbert and Flinders WMA in the reporting period was relatively low (Table 3), which reveals that development of irrigation infrastructure remained low in these areas. This also indicates that there is potential for increased water market activity through trading of unused entitlements.

The rest of the catchments are yet to be metered as they are not metered entitlement areas or users have not activated their take.

5.4 Water supply scheme performance

Moondarra Dam has a much larger surface area than Julius Dam and therefore experiences greater losses through evaporation, which adds incentive for MIWB to use the water from Moondarra Dam first.

Water volumes in Moondarra Dam frequently become relatively low. Since the water plan commencement in 2007, Moondarra Dam has experienced three occasions when the storage has fallen below 25% of its capacity (in 2008/2009, 2013/2014 and 2014/15 water years), for periods ranging from a few weeks to nearly a full year. However, during the same period, water levels in Julius

[4] The areas where entitlements must be metered are listed in Schedule 11 of the Water Regulation 2016.

Dam generally remained above 80% of storage capacity, occasionally falling to 60% due to increased use of supplemented supplies from Moondarra Dam (MIWB, 2022a).

Over the reporting period, the storage levels of the Moondarra and Julius Dams have not fallen below 34% and 71% of their capacities respectively (MIWB, 2022a; MIWB, 2022b).

The Mount Isa regional water supply security assessment (DNRME, 2019) investigated the capability of the Julius Dam and Moondarra Dam schemes to meet future regional water demands. The assessment concluded that the combined annual capacity of these two dams can provide several years' supply based on typical rainfall and annual water consumption rates. In an average year, Moondarra Dam has enough capacity to meet the existing water demand of all MIWB's customers.

5.5 Water trading

There are three water markets currently in the water plan area:

1. Water allocation market (permanent trades) - trading of registered water allocation titles associated with Moondarra Dam and Julius Dam water supply schemes.
2. Seasonal water assignment market (temporary trades) - seasonal assignment of water allocations associated with:
    - Moondarra Dam and Julius Dam water supply schemes
    - water licences within Flinders and Gilbert River water management areas (WMA)
    - water licences granted from the Indigenous reserve.
3. Relocatable water licence market (permanent trades) - transferring of water licences from one parcel of land to another within the Flinders and Gilbert River water management areas.

The establishment of these water markets provides certainty for the water users and creates a more secure business environment. Trading water entitlements can stimulate better decision making about usage and requirements. Over time, this promotes efficiency and can make businesses more profitable.

The overall benefits of trading water:

- helps water users see the value of their water as a secure asset, and obtain finance against its value
- encourages water-use efficiency by saving water to enable entitlement holders to sell or seasonally assign spare water
- enables business owners to sell their water without selling their land
- enables users to increase water supplies and improve the reliability of current allocations, and to switch to an alternative use of the water that may generate higher returns
- enables new industries to acquire water without jeopardising the environment or affecting other water users.

There are large volumes of underutilised water (as outlined in section 5.3), and the water market remains immature in the plan area. This is partly due to water licence holders not being willing to trade water at offered prices. Previous reports by the department have also found that lack of high-quality trading data and information is a significant barrier to trade across Queensland's water markets. Over the last five water years, there were four permanent water licence transfers in the Flinders catchment and one seasonal water assignment in the Gilbert catchment. No water trades (permanent nor temporary) of water allocations occurred in the plan area (Appendix B-4).

5.6 Entitlements granted from the unallocated water reserve

The plan reserves volumes of UAW held in the Indigenous, strategic and general reserves to meet the potential future water demands over the lifetime of the plan. Since the plan commencement, there have been several releases of UAW across the plan area. Table 4 shows data for the release

processes that have been completed. The details of the initial and the remaining UAW reserves for each catchment are provided in Appendix B-6.

Table 4: Completed unallocated water release processes for the plan area[5]

Year of Release	Reserve	Area	Volume available for release (ML)	Volume granted (ML)
2012	General	Flinders and Gilbert rivers catchments	95,000	94,200
2013	Strategic	Flinders and Norman rivers catchments, Nicholson River subcatchment	3,266	3,266
2014	Strategic	Lake Corella[6]	2,500	2,500
2015	General	Flinders River catchment, Gregory River and Lower Leichhardt River subcatchments	264,550	100,000
2017	Strategic	Gilbert River catchment	1,860	1,860
2017	General	Gilbert River catchment and Cloncurry River	92,500	7,500
2020	General	Gilbert River catchment, Norman River catchment, Leichhardt subcatchment and Nicholson subcatchment	102,400	10,000

The UAW was released:

- In 2012 - from the general reserve in the Flinders River and Gilbert River catchments; the entire 80,000ML that were made available in the Flinders Rivers catchment and 14,220ML in the Gilbert Rivers catchment were allocated.
- In 2013 - from the strategic reserves in the Flinders and Norman rivers catchments and the Gilbert and Nicholson rivers subcatchments that was granted to the Flinders Shire (1,450ML), Carpentaria Shire (1,000ML), Cloncurry Shire (700ML) and Burke Shire (116ML) councils for town water supply.
- In 2014 - from the strategic reserve in Lake Corella and granted to the Department of Energy and Water Supply.
- In 2015 - from the general reserves in the Flinders River catchment (92,500ML was allocated, leaving 147,150ML in reserve), the Gregory River subcatchment (the entire 2,500ML was allocated), and in the Lower Leichhardt River subcatchment (5,000 ML of the 15,000ML available was also allocated).
- In 2017 - from the strategic reserve in the Gilbert River catchment that was granted to the Etheridge Shire Council for Georgetown (1,360ML) and Forsayth (500ML) town water supply.
- In 2017 – from general reserve in the Cloncurry River catchment that was granted to Etta Plains Holdings Pty Ltd (2 entitlements, total of 7,500ML) for the purpose of irrigated agriculture.
- In 2020 – from the general reserve in the Lower Leichhardt that was granted to JT & AR McClymont (3 entitlements, total of 10,000ML) for the purpose of irrigated agriculture and the Falls Roadhouse development.

[5] 'Volume available for release' refers to the amount of volume released during the process. 'Volume granted' refers to the amount of water granted during the release, which was less than the volume available due to either there was insufficient interest or applicants were unable to meet the criteria for purchase of the water.
[6] In 2007, the original plan included the strategic reserve for Lake Corella that was removed from the plan in 2015 (as part of the plan amendment), as water from this reserve was released and fully allocated/granted in 2012.

Total amounts of UAW currently held in the reserves are shown in Table 5.

Table 5: Total amounts of unallocated water currently held in a reserve.

Type of reserve	Total Volumes (ML)
Indigenous reserve	30,550
Strategic reserve – Lake Mary Kathleen	1,100
Strategic reserve – State	49,272
General reserve	604,050

There are also several release processes that have been initiated but not yet completed, including the release of UAW held:

- as a strategic reserve for the Flinders River catchment area to support the development of the Saint Elmo Vanadium Project (up to 12,000ML, through fixed price sale), which is a project of regional significance
- as a general reserve for the Flinders River catchment (110,000ML) to support irrigated agriculture developments (applications closed 30 June 2022 and the department is now assessing the tenders against the requirements for Stage 2 – Competitive Tender Assessment of the Terms of Sale)
- in a general reserve for the Gilbert (up to 85,000ML), Norman (up to 3,000ML) and Nicholson (up to 4,400ML) rivers catchments to support irrigated agriculture and other commercial enterprises in these areas (through fixed price sale; applications will be accepted until all the water is allocated).

The volumes of water made available through these processes are a balance between known demand, along with the need to reserve water for future uses such as town water supplies and minerals development.

5.7 Water taken under statutory authorisations

The Water Act (sections 93 to 103) allows water to be taken or interfered with, without an entitlement for certain purposes (e.g. stock or domestic take, and other low risk activities). The volume of water taken under a statutory authorisation is not required to be measured. This makes an accurate quantitative assessment difficult. However, by identifying broad trends in consumptive water use behaviour, it is possible to infer whether these trends are at risk of affecting existing water users' access to water or are a risk to the environment.

Appendix A provides an assessment of the risk to water users and the environment from the use of water under statutory authorisations. The assessment shows that take is unlikely to have changed significantly over the life of the plan so there are unlikely to be any new impacts on existing water users or the environment.

A qualitative assessment of broad trends in consumptive water use and water user behaviour was used to identify any risks that these statutory authorisations pose to existing water users' rights or the environment. A summary of this assessment is presented in Appendix C, which is based on the best available information.

The assessment indicates that there is no identifiable change in existing water users' access due to the take of water for activities under statutory authorisations in the Gulf plan area.

6. Research and monitoring findings for the water plan

Recent research in the Gulf catchments has highlighted the ecological significance of flood flows and floodplain connectivity to productivity in these systems. Seasonal flooding stimulates aquatic plant and

algal growth in floodplain wetlands, which then become productivity hotspots during the wet season. Connectivity between these floodplain wetlands, riverine channels and their estuaries provide opportunities for aquatic fauna to access productive habitats and fulfil their migratory life cycle requirements. Flood flows also deliver important nutrients to the mudflats and sand flats of estuaries and near shore environments, which in turn fuels productivity to support migratory wader bird populations and significant offshore fisheries.

Ecological modelling has indicated (see section 6.1 of the report for details) that years of low to medium flow, increased water extraction, and potential impoundment of flows by dam construction or combinations of these would create significant ecological impacts through reduction in connectivity, nutrient export, and productivity of these systems. This would also impact flow-dependent marine fisheries of economic importance. Section 6.1 provides further details on this research.

6.1 Summary of ecological monitoring

The Queensland Government undertakes ecological monitoring through the Environmental Flows Assessment Program (EFAP) to assess the ecological performance of each water plan in meeting its stated ecological outcomes. EFAP projects are targeted to water plan areas with significant knowledge gaps or where previous risk assessments indicate that ecological outcomes are at medium to high risk of not being achieved.

Since the last Minister's report, departmental monitoring as part of the EFAP has investigated the persistence times of refugial waterholes, involving bathymetric surveys and water level monitoring in ten waterholes of the Flinders and Gilbert catchments. This project spanned a two-year period (2016-2018), and data was reported to the Department of Environment and Science for the modelling of waterhole persistence in these catchments. Site selection was based on an earlier EFAP remote sensing project conducted to ensure that subsequent monitoring and modelling effort would be directly targeted to relevant sites. Future modelling output will help to fill important knowledge gaps for these catchments concerning the persistence of waterholes and floodplain lagoons during spells of no flow, and to improve understanding of the effects of water extraction.

There is also considerable recent research directed at Gulf catchments available from the Northern Australia Resilient Landscapes Hub (operating under the National Environmental Science Program (NESP)), CSIRO's Northern Australia Water Resource Assessment (NAWRA), the National Groundwater Dependent Ecosystems (GDE) Atlas (Bureau of Meteorology) and the Queensland Wetlands Program (Queensland Government).

Research in the water plan area continues with CSIRO's Southern Gulf Water Resource Assessment (due for reporting in 2024) focussing on the catchments and tributaries of Settlement Creek, Gregory–Nicholson River, Leichhardt River and Mornington Inlet.

Research under the NESP program has highlighted the ecological significance of flood flows to these systems and the freshwater flow-dependence of marine fisheries of the Gulf of Carpentaria (i.e., banana prawns and barramundi). Growth rates of these species are enhanced by freshwater flows, which lead to greater recruitment success and survival of young consequently leading to greater commercial catches. The abundance of many other species which become prey for fisheries species are also dependent on freshwater flows. Research evaluating the potential risks from proposed future water resource development scenarios for water storage infrastructure in the Gulf catchments also concludes that yield (and hence profitability) of these fisheries would also be adversely affected by reduced flows caused by increased water extraction (Duggan et al 2019; Broadley et al 2020; Smart et. al. 2021). The natural variability of flow is also important for migratory cues, windows of connectivity to new habitats (e.g., barramundi grow faster in freshwater habitats) and the provision of variable salinity estuaries where juvenile prawns can utilise a broader range of habitats, which enhance growth and eventual recruitment biomass to the offshore fishery.

Floodplain inundation increases the primary productivity of floodplain wetlands by providing greater space for macrophytes to grow. This provides increased surface area for algae to attach and proliferate, which then form a vital base to riverine food webs (Burford and Faggotter 2021). The enhanced floodplain connectivity provided by flood flows permits mobile species to access and transfer this energy.

Flood flows are also important for the delivery of nutrients to estuarine and near-shore habitats which are otherwise chronically nutrient-limited. Although nutrient concentrations in flood waters are only slightly higher than background concentrations, it is the volume of flows delivered to these habitats, most especially in first flush flows, that supply the necessary nutrient loads to fuel productivity (Burford and Faggotter 2021; Burford et al 2021; Cramer & Burford 2021). This enhances growth of both juvenile prawns and the macroinvertebrates of sand and mudflats which provide food for migratory wader birds in numerous important bird feeding grounds (Burford et. al. 2021; Lowe et al 2022).

Application of this research to ecological outcomes of the plan and more detailed summaries of the reports (including citations to the relevant publications) are presented in Appendices A and H, respectively.

Streamflow statistics are also important to monitoring volume of water flows throughout the plan area. The most recent gauging stations that have been installed in the Gulf post 2012 are seen in Table 6.

Table 6: Most recent gauging stations installed post 2012 in the Gulf water plan area

Catchment	Gauging Station Number	Gauging Station
Flinders Basin	915015A	Flinders River at Glendower Crossing
	915016A	Flinders River at Punchbowl
	915017A	Saxby River at Punchbowl Road
Gilbert Basin	917014A	Gilbert River at Burke Development Road

While the assessment completed for this report indicates that all ecological outcomes of the water plan are being achieved, the recent risk assessment has identified some uncertainty associated with the lack of mapping and monitoring data available. These uncertainties relate to:

- Identification of permanent waterholes across all catchments, as well as:
  - information about drawdown thresholds
  - local validation of risk thresholds determined by completed waterhole modelling
  - information on waterholes located outside of the Gilbert and Flinders catchments.
- Connectivity and interactions between groundwater and surface water flows.
- Groundwater use by riparian vegetation (and any associated thresholds of concern).
- Groundwater Dependent Ecosystem (GDE) mapping: the National Groundwater Dependent Ecosystem Atlas currently plots areas as being of high or moderate ‘potential’ GDEs but further refinement and ground-truthing is required to determine ‘actual’ GDEs. GDE mapping available on Queensland’s WetlandInfo is incomplete for large areas of the state and requires refinement and ground-truthing.
- Poor understanding of ecosystem low flow dependencies (particularly those related to bed sands and the effect of water take on these ecosystems).
- The Leichhardt and other southern catchments have higher uncertainty than other areas (i.e., little information regarding contribution of these catchments to commercial fisheries).
- Uncertainty around actual ground water use.
- Uncertainty around locally relevant ecological thresholds of concern.

There will always be uncertainties relating to the management of water resources at a local scale. Targeted monitoring of ecological assets potentially at risk from water management can help improve uncertainty over time. Where possible, further targeted studies will be completed to support the evaluation and review of the water plan.

7. Social and economic assessment

The water plan supports growth in population and industries and aims to maintain flows that support water-related social and economic values in the plan area.

The plan area is sparsely populated and relatively undeveloped. Mount Isa is the administrative, commercial, and industrial centre of the region. Other key urban or regional centres include Georgetown, Richmond and Hughenden, and smaller centres include Burketown, Normanton, Karumba, Julia Creek and Cloncurry.

Data from the Australian Bureau of Statistics (ABS, 2022) was used to assess if there were any significant changes in population rate or industry as this could signal a possible change in water demand. Data from 2016, and 2020 where available, were sourced from the ABS website. Most data were relevant to the Statistical Area 2 (SA2) spatial extents (of Mount Isa, Carpentaria, Northern Highlands and Croydon-Etheridge), however SA2 boundaries are not consistent with Queensland water plan borders and overlap exists between the two. Therefore, this socio-economic assessment is based on data that is not entirely representative of the plan area but is still expected to reflect the socio-economic status of the Gulf water plan area.

7.1 Population trends

The estimated population for the plan area in 2020 was approximately 32,000 people with around 33.8% of the population being of First Nations descent. Overall, the population shows a negative growth rate, declining slightly since 2015. The population of the plan area is expected to remain steady to 2027 when the plan expires.

7.2 Economic profile

According to the ABS (2022), the top three industries for employment in the plan area are agriculture, forestry, and fishing (23%), public administration and safety (14%) and mining (8%). Mining, livestock, and tourism are the three main economic drivers of the region (Eccles et al., 2022). Irrigated agriculture is also identified as an economically viable sector, based on the findings of the Flinders and Gilbert Agricultural Resource Assessment (FGARA) report by CSIRO, which evaluated the feasibility, economic viability, and sustainability of agricultural development in these two catchments (Petheram, Watson and Stone, 2013a; 2013b). Following this report, the Australian Government identified the Flinders and Gilbert catchments, along with river catchments of the Northern Territory and Western Australia, as regions for further agricultural development, based on access to additional water in these catchments (Australian Government, 2015).

The water plan supports current and future economic development, while also supporting population and industry growth, as well as aesthetic, recreational and cultural values, primarily through making water available from UAW reserves. Whilst 201,826ML of UAW have been released from the general and strategic reserves and several release processes have been initiated but not yet completed, totalling 230,200ML, there are insufficient water volumes in the existing UAW reserves to accommodate current demand. Therefore, as part of the water plan review process UAW volumes, and specification, will be reviewed to address current and emerging demands for access to water, to support economic growth, town water supplies and values and aspirations of First Nations peoples.

Any new irrigated agricultural development in the Flinders and Gilbert catchments that use water from UAW reserved under the plan, will be assessed by the department, and will consider potential impacts on the environment, cultural values and other consumptive water users, particularly on commercial and recreational fisheries. The existing water trading framework provided for under the plan also provides an opportunity for new or expanded agricultural development.

7.3 Land use

The water plan area is in a remote, relatively isolated region of predominantly rural nature with little land development (DES, 2021). There has been recent increases in the proportion of rural land under

intensive cropping use, such as irrigated agriculture, during the reporting period. The impact of these changes on water availability across the plan area are considered negligible for this assessment.

The main land use is pastoralism (95%), and the cattle industry is the main agricultural land user in the plan area. The water needs of the cattle industry are primarily sourced from local farm dams and underground water sources.

8. Cultural values assessment

While the water plan includes an outcome for supporting water related cultural value and to support the economic and social aspirations of First Nations peoples, there was insufficient information available to fully assess the effectiveness of the plan and its implementation in achieving these outcomes under sections 13(f), 14(a) and 14(b). The existing information, gained through the economic and social assessment underpinning the current plan (DNRMW, 2006), the Flinders and Gilbert Agricultural Resource Assessment completed by CSIRO, the National Environmental Science Program (NESP) Tropical Water Quality Hub and the Northern Australia Water Futures Assessment (NAWFA)–Cultural and Social Program commissioned by the Australian Government, was mainly focused on developing background knowledge on relevant matters. A cultural values assessment and consultation with First Nations peoples, will be undertaken by the department to improve our understanding of their cultural values, aspirations and water uses to underpin the plan review and replacement.

9. Climate change assessment

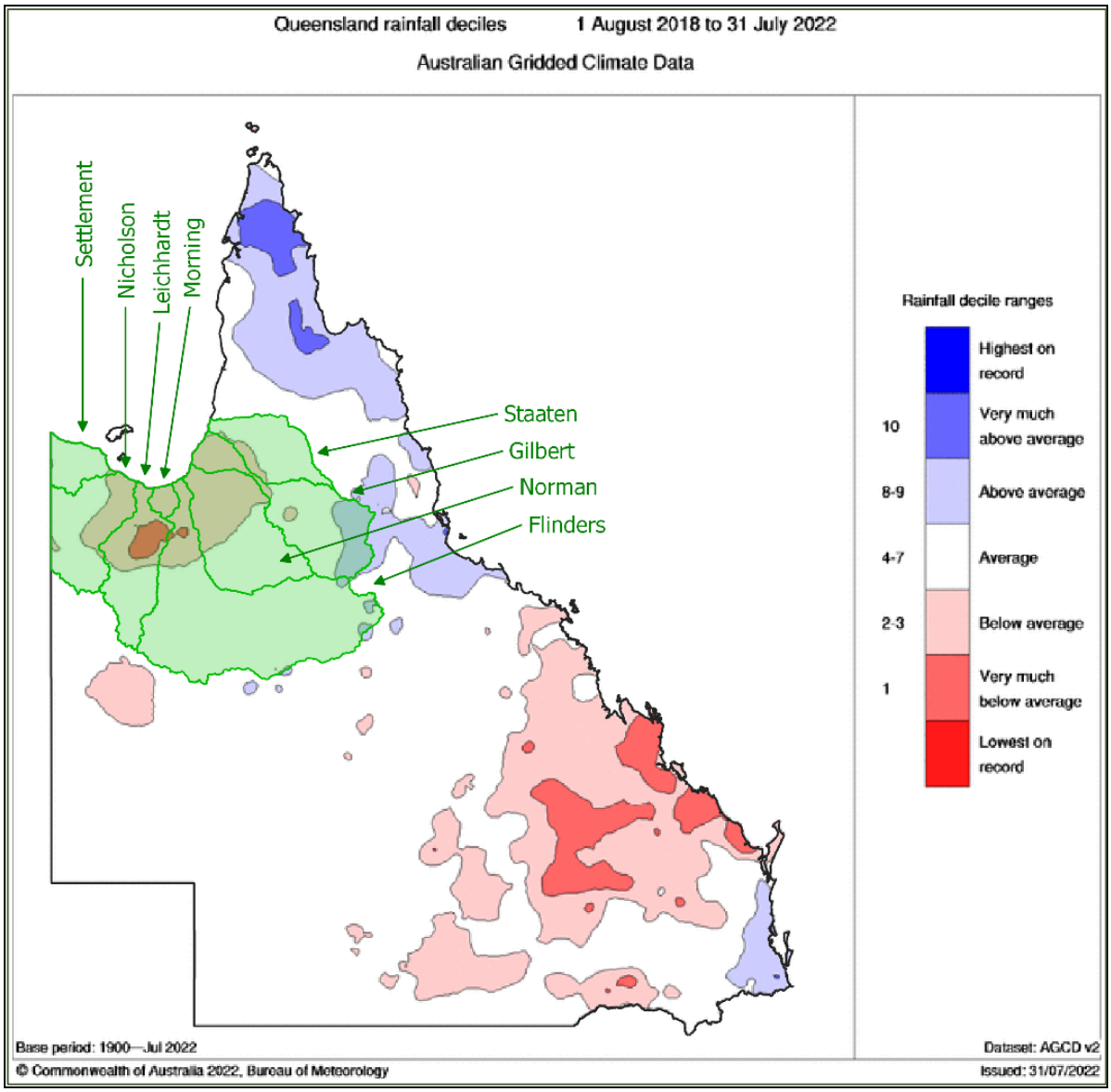
The Queensland Government is committed to incorporating the best available science on climate change into water planning activities. The department aims to build a shared understanding with the community of the risk that projected climate change may pose to future availability of water resources, helping water users and businesses better manage the risk from an increasingly variable and extreme climate. This section outlines climate change trends in the plan area over the reporting period (2017-2022) and provides outlook of the anticipated future climate change patterns (climate change projections).

9.1 Recent climate variation in the water plan area

The climate events of most concern are those that reduce the availability and reliability of water supplies, including the occurrence of prolonged dry periods (droughts). The key climate variables are rainfall, temperature and evaporation, and their variability on daily, monthly, seasonal and annual timescales.

Rainfall data from the Bureau of Meteorology (BoM) and streamflow data from the department's gauging stations were used to characterise recent climate variation in the Gulf water plan area (DES, 2022). For the past four years, annual rainfall was below average in the catchment areas close to the coastline and average in those regions further away from the coast, except for the eastern area of the Gilbert catchment which received above average rainfall (Figure 2).

Figure 2: Catchment rainfall over the past four years (Source: BOM)



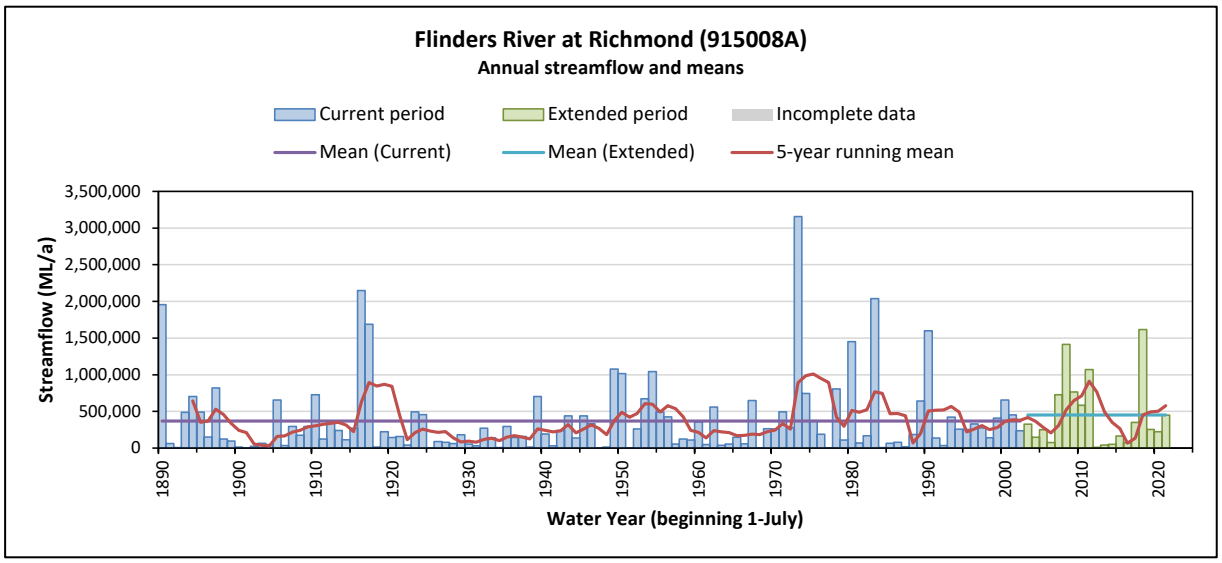
Streamflows were assessed at gauging stations where long-term data (1890-2022) was available[7]. These stations are in the Nicholson, Leichhardt, Flinders, Norman, Gilbert and Staaten River catchments. There are no departmental gauging stations in the Settlement Creek catchment nor in the Morning Inlet catchment.

Figure 3 shows streamflow data for the Flinders River at Richmond gauging station (915008A) to demonstrate annual variability of streamflow in the plan area. The blue bars represent data which are included in the department's water plan simulation model[8] for the Gulf (spanning the period 1890-2003), while the green bars are recent data (2003-2022) not included in the plan assessments.

Graphs showing streamflow for other gauging stations in the plan area with long-term data sets are in Appendix F.

[7] Time periods for specific stations are shown in Figure 3 and Appendix F.
[8] Integrated Water Quantity and Quality Simulation Model (IQQM)

Figure 3: Annual streamflow at Flinders River at Richmond (915008A)



From 2003, annual streamflow in the gauged catchments was average to slightly above average, with some catchments exhibiting extreme variability between years. For the Nicholson and Leichhardt Rivers, the highest and lowest annual flows were recorded during this time. The gauging station on the Cloncurry River also recorded the lowest annual flow since records began. This variability is evident in the 2015-16 drought, which contributed to one of the worst instances of mangrove forest dieback ever recorded globally, that was followed by the floods of 2019 resulting in the death of 600,000 cattle.

Over the past 19 years since the end of the water plan hydrological model simulation period, the flows fit reasonably well within the distribution of existing data. Despite recent extreme events, this suggests that there has been no dramatic change in either annual average rainfall or streamflow variability in the past 19 years compared to historical long-term records.[9]

9.2 Climate change projections for the water plan area

The climate is changing primarily because increasing amounts of greenhouse gases (GHG) in the atmosphere are trapping heat, warming the air and oceans. An assessment of the climate change projections for the Gulf water plan catchments was undertaken by the Department of Science (DES) to inform this report (DES, 2022). To determine the potential climate changes in the plan area, DES used global climate models to simulate the Earth's climate system.

9.2.1 Overview of assessment approach

General Circulation Models (GCM) were used to produce projections of climate variables such as average daily temperatures, annual potential evapotranspiration and annual rainfall. The GCMs were sourced from the Coupled Model Intercomparison Project, phase 5 of the Intergovernmental Panel on Climate Change (IPCC), Assessment Report 5 (WCRP, 2022). The GCMs consider a trajectory of GHG emissions using numerous scenarios. Emission scenarios chosen for this assessment are Representative Concentration Pathway (RCP) 4.5 and RCP 8.5.

RCP 4.5 represents a future scenario of moderate GHG emissions where action is taken to reduce greenhouse gas emissions (for example, by way of technologies and strategies) resulting in a peak of emissions around 2040 and then followed by a decline.

RCP 8.5 represents a future scenario of continued very high GHG emissions where emissions continue to rise throughout the 21st century.

[9] While the recent record high and low flows observed for some catchments may be evidence of emerging climate change in the Gulf, these flows fit within the highly variable flows recorded previously, and a variability analysis would be required to confirm this fit.

It is important to note that climate models are simulations of possible future outcomes depending on a range of assumptions. As such, these models are not perfect replicas of reality, but “what if” representations of possible real-life situations. All models have some degree of scientific uncertainty.

9.2.2 Overview of projected changes

Prior to considering possible future climate change events, it is useful to review historical climatic data to understand what has occurred climatically in the past, especially since the plan was first implemented. A time-of-emergence analysis was used on climate variables (e.g., air temperature, sea level, rainfall) to help identify the time when climate change may have caused local conditions to deviate from past conditions. The time-of-emergence analysis identifies when the signal of the variable emerges from the background “noise”, thereby reflecting the onset of change (Walker *et al*, 2022). The results of the time-of-emergence analyses undertaken for the Gulf water plan area indicates that a temperature increase emerges around the 1990s, as identified by the Signal-to-Noise Ratio (Figure 4). The orange shading represents the time the signal emerged by one standard deviation and the red bar represents emergence by two standard deviations. There was no emergence for annual evapotranspiration (Figure 5) or annual rainfall (Figure 6).

Figure 4: Results of time-of-emergence analyses for average daily temperature

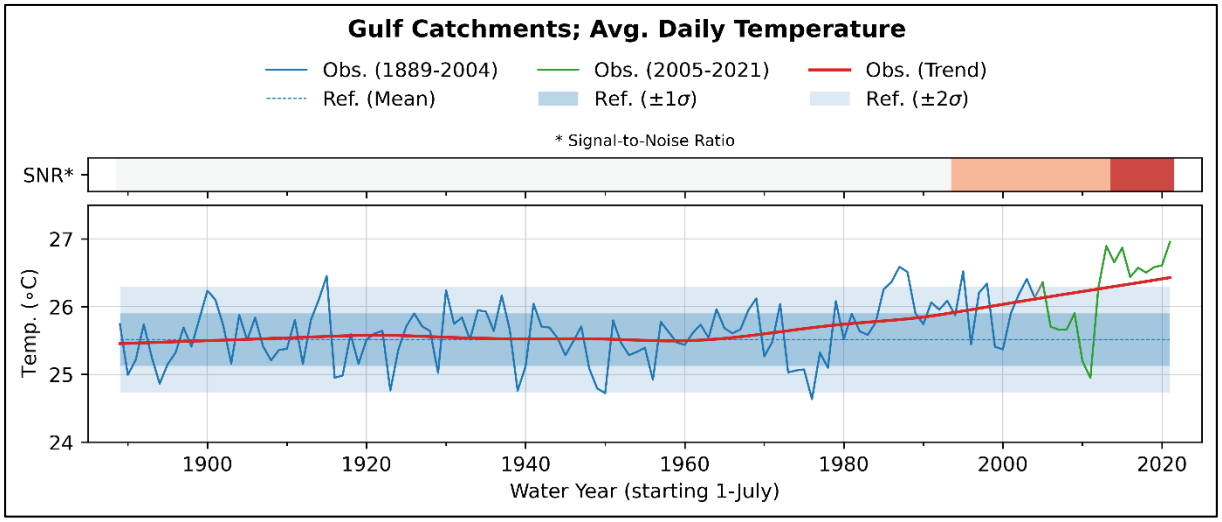


Figure 5: Results of time-of-emergence analyses for potential evapotranspiration

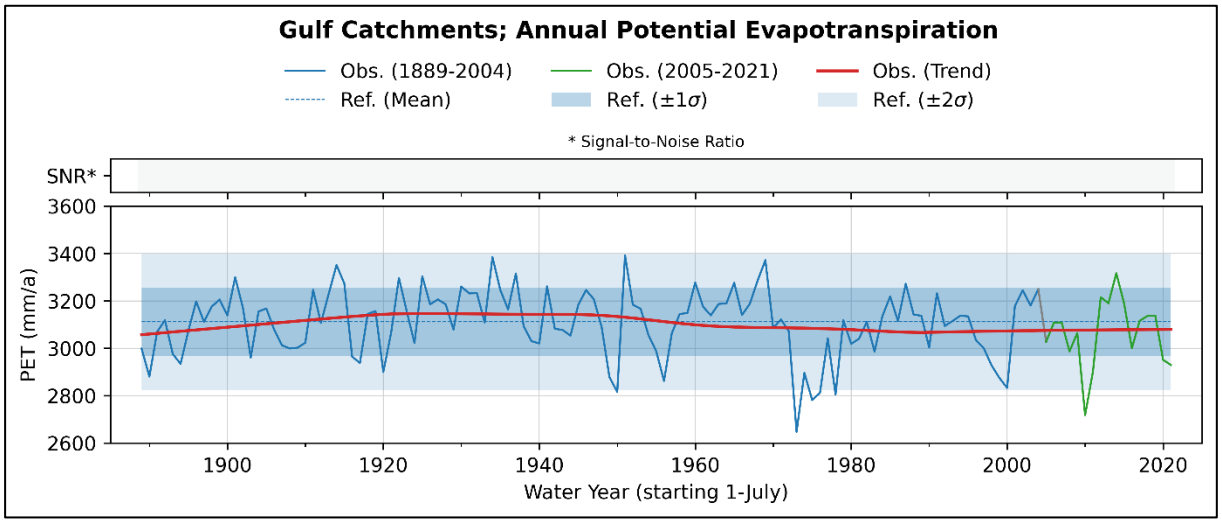
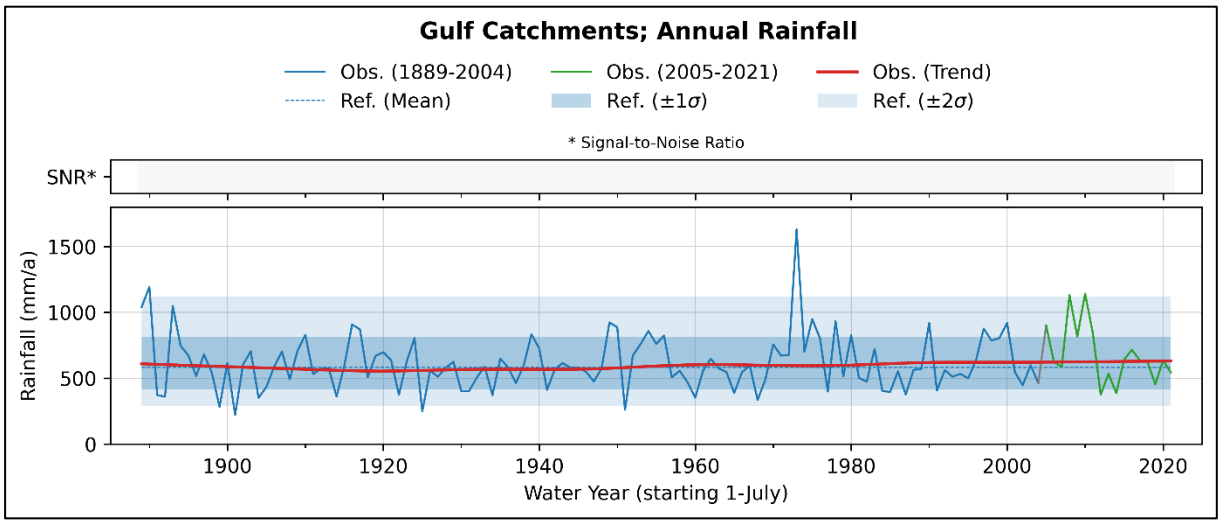


Figure 6: Results of time-of-emergence analyses for rainfall



Climate projections at the catchment scale using the GCMs are presented below. Temperature projections show an increase with the two scenarios diverging around 2040, meaning that some temperature rise is now inevitable (Figure 7). There is also an associated increase in potential evaporation across the catchment (Figure 8). Furthermore, there is a trend towards a slightly increased average annual rainfall. The recently observed climate data falls within the projections (Figure 9). The shaded coloured bands represent the uncertainties in the model structures.

Figure 7: Observed and projected catchment average annual climate for average daily temperature

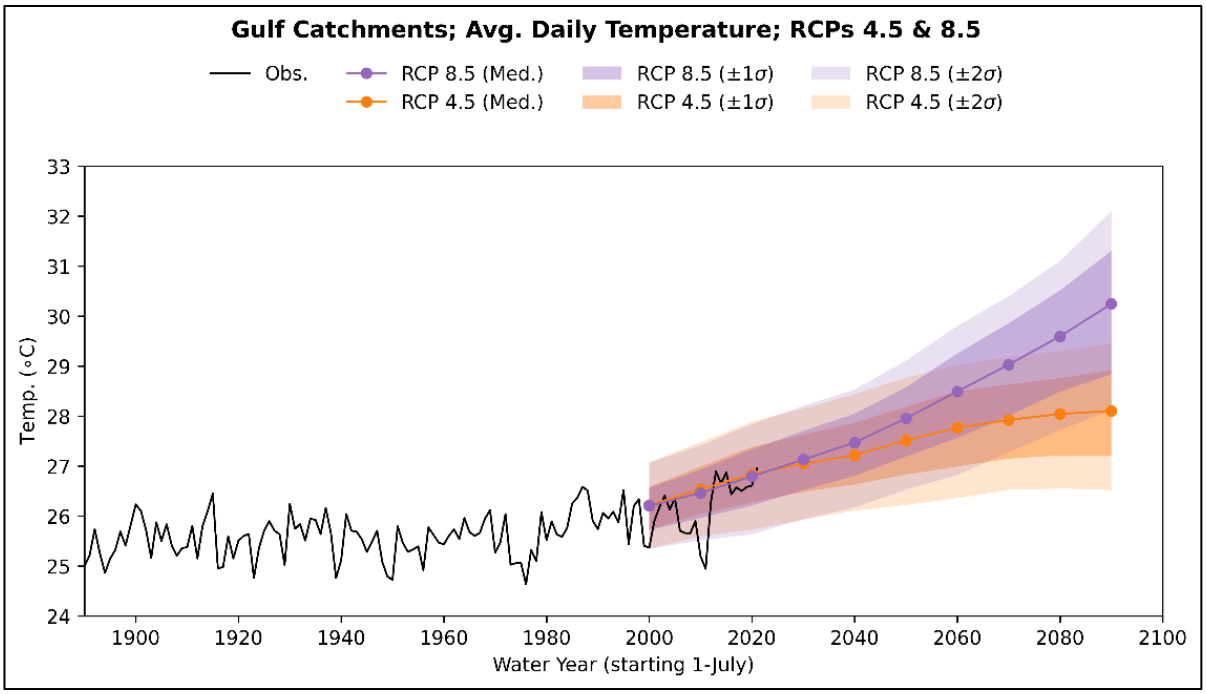


Figure 8: Observed and projected catchment average annual climate for annual potential evapotranspiration

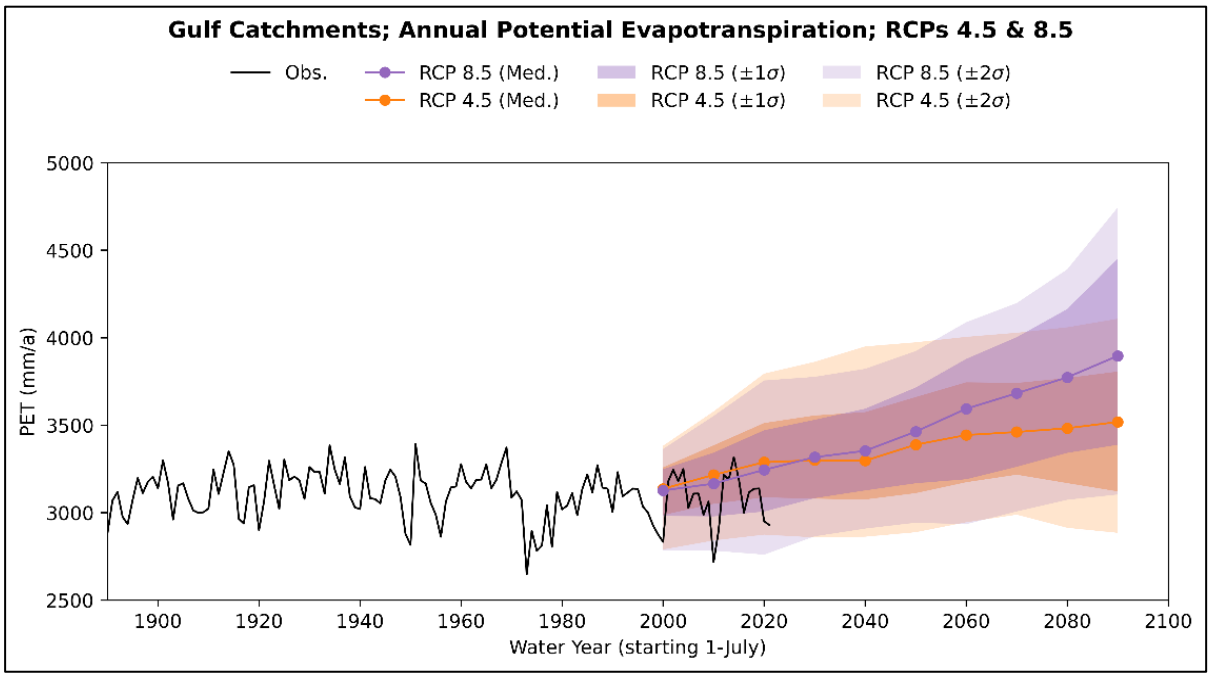
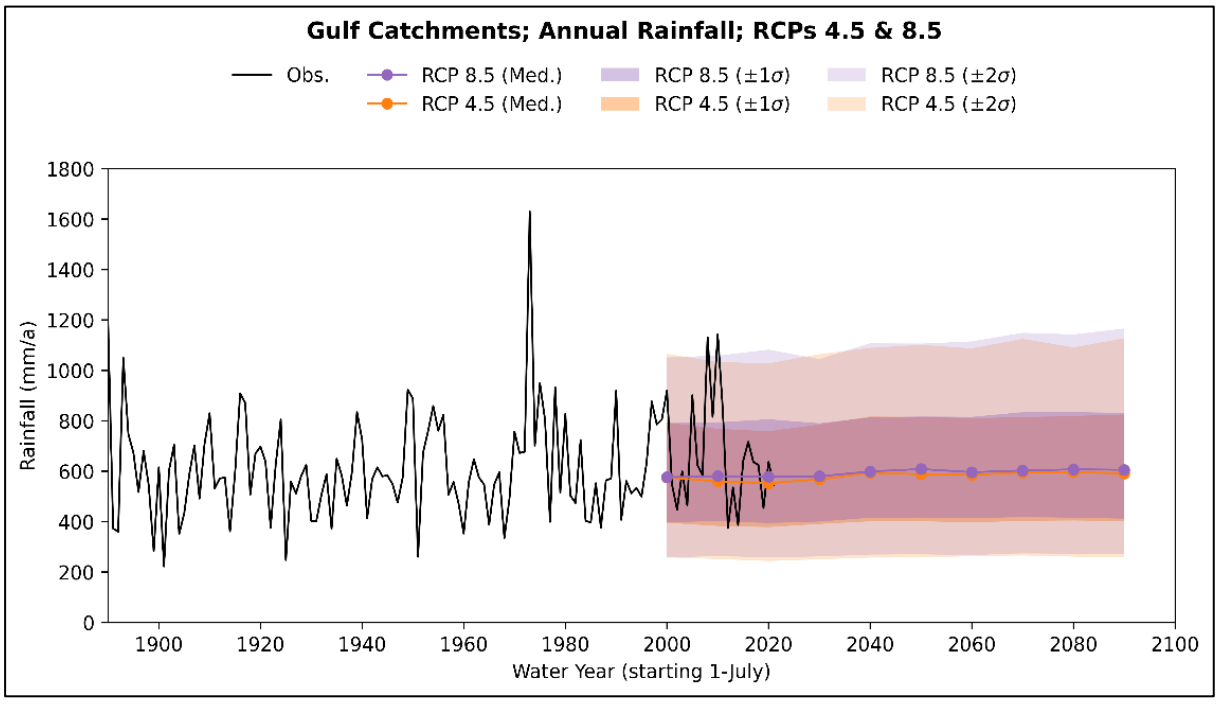


Figure 9: Observed and projected catchment average annual climate for annual rainfall



Projections were also undertaken to investigate seasonal changes in climate variables. The temperature and evapotranspiration projections broadly show increases for all months. The monthly rainfall has more variability but is trending towards a smaller increase in summer months for both scenarios and smaller decreases in the winter months. These monthly changes result in a similar annual rainfall but indicate a potentially drier catchment leading into the wet season. This may have some effect on streamflow generation. These results are consistent with a recent assessment undertaken by Alluvium (Eccles, 2022) who used GCMs to model climate change in the Flinders and Gilbert catchments. Projections indicate an increase in summer rainfall in the Flinders and Gilbert with a decrease or little change in the dry season.

There is evidence that climate change is occurring in the Gulf water plan catchments as indicated by the time-of-emergence analysis for temperature and the GCM climate projections for temperature,

evapotranspiration, and rainfall. The recent record high and low flows observed for some catchments may be evidence of emerging climate change in the Gulf, however these flows fit within the range of flows historically recorded. A more detailed variability analysis would be required to confirm this fit.

An increase in temperature has been observed since around 1990 and it is expected that this will eventually lead to an increase in evapotranspiration. This may already be occurring but the high variability within annual potential evapotranspiration makes it difficult to detect changes. Projected changes in climate may lead to an increase in evaporation from dams, affecting the reliability of water for water supply schemes. Projected changes to temperature and evaporation may also increase demand for agricultural irrigation and residential water demands. Reliability may also be affected by potential changes in streamflow, for example, climate change is likely to alter streamflow generation within catchments and could lead to more extreme wet season events and drier dry seasons.

Climate change analyses is an evolving field with new understandings, models and syntheses published regularly. The information in this assessment represents the best understanding at the time and is subject to change as new science becomes available.

10. Water plan amendments and previous reports

Several amendments have been made to the water plan since it commenced, including consequential minor amendments to align with changes made to the Water Act, the Water Regulation and the Sustainable Planning Regulation 2009 (Appendix D). The key amendments to the water plan were made to provide additional volumes of UAW and to establish a water market framework for water licences in the Flinders and Gilbert River catchments (to enable both temporary and permanent relocation/transfer of water licences).

In 2018, the water plan expiry was postponed until 1 November 2027.

The major milestones since the plan commencement are detailed in Appendix D.

11. Identification of potential risks to the water plan's outcomes

In October 2022, a risk assessment was undertaken to identify potential risks to achieving the water plan's outcomes that could emerge within the lifetime of the plan. An analysis of potential risks and emerging matters for the water plan was undertaken. Further updates were made in August 2023 to consider new information about mining developments and emerging demand. Data and expert opinion were used to rank the likelihood and consequence of risk from a standardised list of threats, and the risk level and rationale for this ranking were documented (see Appendix A).

Of the plan's 29 outcomes, one[10] was found to be of high risk of not being achieved, two[11] were found to be at medium risk of not being not achieved, three[12] could not be fully assessed due to limited information available and the rest were ranked as at low risk (Appendix A).

One outcome identified as at high risk of not being achieved is related to the ability of the water plan to support growth in industries dependent on water. It is expected that significant growth in mineral development will occur over the coming decade. The Queensland Critical Mineral Strategy highlights the importance of critical minerals for Queensland's future sustainable economic prosperity — to mine and process minerals and manufacture the renewable technologies needed for the clean energy industrial revolution. The Gulf water plan area occupies a large proportion of the significant North West

[10] The outcome under s13(c) relating to the availability of water to support growth in industries dependent on water.
[11] The outcomes under s13(e)(ii) relating to availability of water to support growth in irrigated agriculture in the Flinders River catchment and s15(c) relating to minimisation of changes to natural variability in water levels to support ecological processes.
[12] The outcomes under sections 13(f), 14(a)(ii) and 14(b) relating to cultural water values.

Minerals Province known for its production of copper, cobalt and vanadium with potential opportunities for expansion of cobalt, copper, graphite, vanadium and rare earths.

One outcome identified as at medium risk of not being achieved is related to the ability of the water plan to support growth in irrigated agriculture in the Flinders River catchment area. For instance, several parties have approached the department seeking additional water which in total exceeds the volume of water in the existing UAW reserves. In addition, the specification of the reserves do not align well with other proposed projects for example:

- The location of the UAW reserves and the proposed projects are not located in the same parts of the catchment.
- The water plan requires that an entitlement granted from the general UAW reserves specify a passing flow condition before water can be accessed which may not suit the needs of a proposed water supply scheme project which rely on low flows to improve supply reliability.

These matters will need to be considered as part of a water plan review along with ensuring the plan supports ecological water requirements, cultural water values and needs and other water dependent industries such as fisheries.

While demands for additional water access may be partly met through the water trading frameworks established under the current plan (outlined above in section 5.5), in practice there are several barriers potentially limiting the effectiveness of the water market:

- Unwillingness of water licence holders to trade water at offered prices.
- The trading framework may limit the ability to move water entitlements of sufficient volume to meet demand.
- Limited understanding of how the water markets and entitlements operate.

It is anticipated that once water in the plan is fully allocated and water dependant industries are developed that interest in the water market will increase.

The other outcome identified as medium risk of not being achieved related to the need to minimise changes to the natural variability in water levels associated with waterholes and lakes. Waterholes and lakes have an important role as a place of refuge for aquatic fauna during dry periods. While overall water use is low and there are water management strategies to protect low flows in the Leichhardt, Gilbert and Flinders catchments, similar protections are not in place in other catchments. Furthermore, waterhole features in these other catchments have not been studied. More targeted scientific information is required across all catchments on appropriate drawdown thresholds for waterholes is recommended.

The three outcomes for which there was insufficient information to complete the assessment relate to the ability of the plan to support water related cultural values of First Nations communities in the water plan area and the availability of water to help First Nations communities achieve both their social and economic aspirations in particular parts of the plan area.

12. Opportunities and emerging matters

The risk assessment underpinning this report identified knowledge gaps that could be addressed through further research and/or monitoring aimed at collecting the key data to inform future assessments and decision making. It also identified matters potentially emerging over or beyond the lifetime of the current plan that should be considered in developing the replacement plan. These include:

- The need to modernise the plan outcomes in accordance with the latest Water Act requirements, contemporary water planning policies and emerging matters.
- Consideration of climate change impacts on water availability in the plan area. Scientific modelling projections conducted by the Queensland Government forecast an increase in temperature and evapotranspiration and uncertainty regarding rainfall patterns. These changes may result in similar

overall annual rainfall totals, trending towards small increases in rainfall in the summer months and small decreases or no change in the dry season. Changes in climate may lead to increases in consumption and losses from storages and watercourses and reduced persistence of waterholes through time.

- The need to develop a new hydrologic model to assess the impacts of the existing water management arrangements, identified priority issues, emerging matters and inform future policy decisions across the plan area. It is recommended that a new hydrologic model should be developed by Queensland Hydrology, because the existing model was developed by CSIRO under the FGARA project. Developing a new model would also provide the opportunity to incorporate the latest science and new hydrologic data.
- The need to better understand cultural water values of First Nations people, as well as their economic and spiritual aspirations and the associated water needs. There is also the need to engage and consult with First Nations peoples with regard to defining eligibility and the process to access UAW from an Indigenous reserve.
- The need to consider growing interest and water demand for proposed new irrigated agriculture developments and emerging critical minerals developments, and the associated impact on all water uses and values across the plan area, including the environment and end of system fisheries.
- The need to review water availability and UAW volumes across the plan area to address current and emerging demands in new or additional water, and to support economic growth, town water supplies and values and economic aspirations of First Nations peoples.
- The need to consider cumulative impacts and risks from different levels of water allocation and catchment development on Gulf of Carpentaria and the associated fishing industries.
- The need to better understand groundwater resources, particularly connectivity to surface water, as well as groundwater dependant ecosystems.

It is proposed that these matters will be considered as part of the next plan review, which will underpin its replacement. The learnings gained from implementing the existing plan to date will be used to make improvements to the new plan as part of an adaptive management cycle based on revised future water needs, enhanced scientific information, and targeted stakeholder consultation.

13. Any non-compliance under a water entitlement or other authorisation in the water plan area

Over the past five years, there were 20 non-compliance incidents recorded, all of which were associated with unsupplemented water entitlements. Most of the incidents related to the failure to supply a meter reading. Appendix E provides further details on the number and type of alleged non-compliance incidents and the outcome of departmental investigations and compliance response that have occurred over the reporting period (2017/18-2021/22 water years).

There were no changes reported by the Resource Operations Licence or Distribution Operations Licence holders that may impact on the compliance with the rules for managing supplemented water entitlements.

The department uses a range of methods to identify non-compliance including field and desktop audits, metering, and third-party notification. These activities support public confidence in how water is managed and protects the rights of all entitlement holders and the broader community.

To ensure our water resources are managed fairly and responsibly the department has developed a Regulatory Strategy Water Resource Management 2022 – 2024 establishing our regulatory approach for the delivery of our regulatory functions and activities. The strategy explains the principles

underlying our regulatory approach, the tools we utilise and our compliance and enforcement pathway. The objectives and principles set out in the Regulatory Strategy sets the foundation for our annual compliance planning.

The department's Annual Compliance Plan 2022-2023 identifies activities that support the department's compliance approach, including compliance outcomes, performance measures, focus areas, activities, targets, and measures. The plan supports the department to take a risk-based, transparent, and consistent approach to how we regulate Queensland's water resources.

In addition, the work being done under the Rural Water Futures Program will support improved compliance outcomes. Further information on the Rural Water Futures program and its initiatives can be found on the department's website.

14. Way forward

This assessment has highlighted some emerging matters (outlined in section 12) that may impact the water plan's continued effectiveness in the future. These will be considered as part of the plan review and replacement.

Overall, the current implementation of the plan continues to advance the sustainable management of water resources. Most plan outcomes are being achieved and implementation will continue until the plan is reviewed and replaced.

In response to increased water demand, the complexity of the issues that were identified through this assessment, and the time required for technical assessments and targeted stakeholder consultation, the plan review and replacement process will begin earlier than planned to provide enough time to give due consideration to the matters mentioned herein.

The learnings gained from implementing the existing plan to date will be used to make improvements to the new plan as part of an adaptive management cycle based on revised future water needs, increased scientific information, and targeted stakeholder consultation.

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Appendix A: Assessment of plan outcomes

Table A-1: Risk assessment for economic and social outcomes in the plan

Plan outcome	Plan strategies that provide for outcome	Resource operations plan (ROP) rules that provide for outcome	Qualitative risk ranking and assessment of outcome
13. Each of the following is an economic outcome for water in the plan area			
a. provision for the continued use of all water entitlements and other authorisations to take or interfere with water	The plan does not limit or restrict existing users, or the taking of water under statutory authorisations. The plan outlines: • performance indicators and water allocation security objectives • processes for dealing with UAW • restrictions on taking water from waterhole or lake • limits on take • process for applying conditions to licences (groundwater and surface water) • limits on taking overland flow	The ROP provides for: • metering • permanent transfer rules • granting and amending water licences to take overland flow water • dealing with water licence applications	LOW risk This outcome is being achieved. The plan provides ongoing access to water under existing and new water entitlements. The plan and ROP contain rules and strategies to protect users.
b. protection of the probability of being able to take water under a water allocation, including— i. water for the supply of urban water for Mount Isa City; and ii. water to support growth in the mining industry in north-west Queensland	The plan defines the water allocation security objectives for supplemented take from Lake Moondarra and Julius Dam. The plan provides for UAW reserves.	The ROP provides for: • water allocation change rules • seasonal water assignment rules • dealing with UAW • water sharing rules including critical water supply arrangements • permanent transfer rules	LOW risk This outcome is being achieved. Water for Mount Isa city is accessed from the Moondarra Dam water supply scheme. An alternative supply from the Julius Dam water supply scheme is available if required. The population of Mt Isa is not likely to increase significantly over the next 5 years.

c. availability of water to support growth in industries dependent on water in the plan area	The plan outlines: • processes for dealing with UAW • performance indicators and environmental flow objectives	The ROP provides for: • dealing with UAW • water allocation change rules • seasonal water assignment rules • dealing with UAW • water sharing rules including critical water supply arrangements • permanent transfer rules	HIGH risk This outcome is partially being achieved. The plan provides ongoing access to water under existing and new water entitlements, however UAW reserves remaining are unlikely to meet expected demand into the future. There is uncertainty about when these water demands will eventuate.
d. provision for the taking of water in Lake Mary Kathleen;	The plan outlines: • processes for dealing with UAW • performance indicators and environmental flow objectives The plan also provides for 1,100ML of strategic UAW reserves specifically for Lake Mary Kathleen.	The ROP provides a process for dealing with UAW.	LOW risk This outcome is being achieved. The plan provides ongoing access to UAW reserves via specific processes.
e. availability of water in the following areas to support growth in irrigated agriculture— i. Gilbert River catchment area; ii. Flinders River catchment area; iii. Nicholson River catchment area; iv. Lower Leichhardt River subcatchment area;	The plan outlines: • processes for dealing with UAW • performance indicators and environmental flow objectives The plan also provides UAW reserves specifically for each of these (sub)catchment areas.	The ROP provides a process for dealing with UAW and permanent transfer rules.	LOW risk - Gilbert, Nicholson, Lower Leichhardt MEDIUM risk - Flinders This outcome has been achieved in the reporting period through providing ongoing access to the existing UAW reserves. However, the identified new and emerging demands for UAW exceed volumes currently provided under the plan. The specification of the existing reserves also needs to be revised, to meet future water demand for UAW. The existing plan's UAW framework must therefore be revised, to achieve this outcome in the future.

f. availability of water in the following areas to help Indigenous communities in those areas achieve their economic aspirations— i. Cape York Peninsula Region area; ii. Flinders River catchment area; iii. Gilbert River catchment area; iv. Morning Inlet catchment area; v. Settlement Creek catchment area; vi. Staaten River catchment area; vii. Gregory River subcatchment area;	The plan outlines: processes for dealing with UAW, including for Indigenous reserves performance indicators and environmental flow objectives to protect environmental assets which may be valued by First Nations peoples The plan also provides indigenous UAW reserves specifically for each of these (sub)catchment areas.	The ROP provides a process for dealing with UAW and seasonal water assignment rules.	Not assessed. There is insufficient information available on the economic aspirations of Indigenous communities to assess this outcome
g. encouragement of continual improvement in efficient use of water;	The plan provides a framework for specifying and converting area-based water licences to volumetric water licences, including consideration for efficient irrigation in plan area. In dealing with UAW, the plan requires the chief executive to consider the efficiency of present and proposed uses of water.	The ROP provides for: • scheme licence holder monitoring of water take • metering • water allocation change rules • seasonal water assignment rules • permanent transfer rules	LOW risk This outcome is being achieved.
h. support of tourism in the plan area, including, for example, by protecting flows that support the natural aesthetics of watercourses and their surroundings;	The plan outlines: • processes for dealing with UAW • performance indicators and environmental flow objectives • limitations to interference to flow via structures or excavations • restrictions on taking water from waterhole or lake • limits on take • process for applying conditions to licences (groundwater and surface water) • limits on taking overland flow	The ROP: • outlines the process for the granting of UAW. • establishes annual volumetric limits in water management areas as well as setting flow conditions for the seasonal assignment of water. • outlines the process for granting overland flow water	LOW risk This outcome is being achieved. The plan and ROP contain rules and strategies to protect environmental values which are the principle drivers of tourism in the Gulf plan area.

i. support of commercial fishing in the Gulf of Carpentaria, including, for example, by protecting flood flows that may deliver nutrients and water to estuarine and marine environments to stimulate growth and movement of native aquatic animals, including fish, prawns and crabs.	The plan outlines: • processes for dealing with UAW • performance indicators and environmental flow objectives • limitations to interference to flow via structures or excavations • restrictions on taking water from waterhole or lake • limits on take • process for applying conditions to licences (groundwater and surface water) • limits on taking overland flow	The ROP • outlines the process for the granting of UAW • establishes annual volumetric limits in water management areas as well as setting flow conditions for the seasonal assignment of water • outlines the process for granting overland flow water	LOW risk This outcome is being achieved. The plan and ROP contain rules and strategies to protect flows, including flood flows, to the estuaries and marine environments which support the growth of aquatic animals necessary to maintain commercial fishing in the Gulf of Carpentaria.
14. Each of the following is a social outcome for water in the plan area			
j. availability of water for the following purposes— i. support of population growth in towns and communities dependant on water in the plan area; ii. help of Indigenous communities in the following areas achieve their social aspirations— A. Cape York Peninsula Region area; B. Flinders River catchment area; C. Gilbert River catchment area; D. Morning Inlet catchment area; E. Settlement Creek catchment area; F. Staaten River catchment area; G. Gregory River subcatchment area;	The plan: • allows for strategic reserves of UAW for future growth • provides for continued use of water entitlements in the plan area • establishes Indigenous reserves of UAW	The ROP provides for: • dealing with UAW • water allocation change rules • seasonal water assignment rules • dealing with UAW • water sharing rules including critical water supply arrangements • permanent transfer rules	LOW risk - 14(a)(i) is being achieved. 14(a)(ii) not assessed. There was insufficient information available on the social aspirations of Indigenous communities to assess the risks to 14(a)(ii) Overall, this outcome is being partially achieved. While the plan provides ongoing access to water under existing entitlements and to UAW, there has been limited consultation on water resources of cultural significance to First Nations peoples as well as their social aspirations and relevant water demands.
k. support of water-related cultural values of Aboriginal and Torres Strait Islander communities in the plan area;	The Plan: • provides a process for UAW releases; the assessment criteria for this process supports cultural values and considers cultural heritage	The ROP provides the following: • process for dealing with UAW including consideration of cultural values • operating and environmental management rules e.g., waterhole management at provide for both the	There is insufficient information to assess this outcome. While the plan and ROP provide strategies to support this outcome, there has been limited consultation with First Nations peoples to date and their cultural water values across the plan area are poorly understood.

	• outlines environmental flow objectives which support water features that have cultural value	environmental and cultural values of waterholes	
l. promotion of a cooperative approach between the State and relevant Northern Territory government agencies to water resource development			LOW risk This outcome is being achieved. There has been no known development in Northern Territory to date which threatens the water resources covered by the Gulf plan.
m. maintenance of flows that support water-related aesthetic, cultural and recreational values in the plan area.	The plan outlines: • processes for dealing with UAW • performance indicators and environmental flow objectives • limitations to interference to flow via structures or excavations • restrictions on taking water from waterhole or lake • limits on take • process for applying conditions to licences (groundwater and surface water) • limits on taking overland flow	The ROP provides for: • operating and environmental management rules (e.g., rules for operation of infrastructure, minimum stream flow requirements) • environmental flows • chief executive data collection and assessment	This outcome has been partially achieved. While the plan has provided water to develop social amenities for residents and tourists throughout the plan area, there has been limited consultation with the First Nations peoples and their cultural values are not known.

Table A.2: Risk assessment to ecological outcomes in the plan

Plan outcome	Plan strategies and Resource Operations Plan rules that provide for outcome	Related ecological assets	Summary of monitoring and assessment	Qualitative risk ranking and preliminary assessment of outcomes
15. (1) Each of the following is an ecological outcome for water in the plan area				
a. maintenance of the natural variability of flows that support the habitats of native plants and animals and migratory birds in watercourses, floodplains, wetlands, lakes and springs	The plan identifies performance indicators and provides for the maintenance of flows through EFOs The ROP: • outlines the process for the granting of UAW. • establishes annual volumetric limits, maximum rates of take, as well as setting flow conditions. • outlines the process for managing overland flow	• Floodplain vegetation • Floodplain wetlands • Fluvial geomorphology and river forming processes • Southern Mitchell Aggregation/Southeast Karumba Plain Aggregation • Brackish estuarine habitat • Waterholes • Riffles • Stable flow spawning fish	Rivers within the plan area have highly variable and seasonal flow regimes and the biota found in the Gulf systems would be expected to be resilient to natural levels of flow variability at a variety of times scales (i.e., daily, seasonal, annual). Recent work by the Northern Australia Environmental Resources Hub has demonstrated the importance of natural flow variability in supporting ecosystems in the Gulf. At present there is little large-scale water take in the plan area and there are few significant storages in the plan area. Therefore, changes to flow variability are more likely to be occurring at small spatial scales (e.g., waterholes within reaches). The only large storages in the plan area occur on the Leichhardt River. Ecological implications of changes to flow variability from operation of these storages have not been investigated.	LOW risk. This outcome is being achieved. Current water use is low, and the water plan contains performance indicators and environmental flow objectives to protect flows throughout the plan area.
b. provision for the continued capability of a part of a river system to be connected to another part, including by	The plan: • outlines the volumes of UAW that may be accessed as well	• Floodplain vegetation • Floodplain wetlands	Connectivity is an essential component of the ecology of the Gulf systems and underpins several ecological	LOW risk. This outcome is being achieved.

maintaining flood flows that— i. allows for the movement of native aquatic animals between riverine, floodplain, wetland, estuarine and marine environments; and ii. deliver nutrients and organic matter throughout the plan area to support natural processes such as breeding, growth and migration in riverine, floodplain, wetland, estuarine and marine environments; and **iii.** deliver water and sediment throughout the plan area to support river-forming processes;	as providing for the environment through setting of EFOs. • limits the level of interference to flow through either diversion structures or excavation of the stream bed. • The ROP: • outlines the process for the granting of UAW. • establishes annual volumetric limits, maximum rates of take, as well as setting flow conditions. • outlines the process for managing overland flow	• Fluvial geomorphology and river forming processes • Southern Mitchell Aggregation/Southeast Karumba Plain Aggregation • Brackish estuarine habitat • Riffles • Migratory aquatic biota • Freshwater turtles	processes including nutrient processing and estuarine productivity. Floodplains are the drivers of productivity and an essential part of the ecology. Recent research in the Gulf has provided critical information on the importance of flood flows for habitat connectivity and productivity (e.g., aquatic plants on floodplains, and sand and mudflats used by migratory birds). At present, there is little large-scale water take in the plan area and connectivity is not adversely impacted.	Current water use is low, and the water plan contains performance indicators and environmental flow objectives to protect flows throughout the plan area.
c. minimisation of changes to natural variability in water levels to support natural ecological processes, including the maintenance of refugia associated with waterholes and lakes;	The plan: • establishes groundwater management areas • declares groundwater within 1 km of prescribed watercourses to be water in the watercourse. • establishes EFOs and performance indicators for EFOs • limits instream interference • regulates overland flow take • allows for restrictions to be placed on new licences in unsupplemented reaches regarding the take of water from waterholes or lakes. The ROP outlines rules for trading water licences within volumetric limits and zones, and	• Waterholes as refugia • Floodplain wetlands • Floodplain vegetation • Fluvial geomorphology and river forming processes • Southern Mitchell Aggregation/Southeast Karumba Plain Aggregation • Brackish estuarine habitat • Riffles • Migratory aquatic biota • Freshwater turtles	Permanent waterholes occur throughout the plan area. These are a major feature of the landscape in the wet-dry tropics and are important refugial habitats, providing for repopulation of the system when flows re-commence. Most research to date has been undertaken in the Gilbert and Flinders catchments, and more work is required in other areas. Risk thresholds for waterhole modelling already undertaken need further work, including local validation.	MEDIUM risk. This outcome is being achieved. Current water use is low, and the water plan contains performance indicators and environmental flow objectives to protect flows throughout the plan area. Low flows are protected in the Leichhardt, Gilbert and Flinders via Performance Indicators and EFOs, however, the same protections for low flows are not in place in the other catchments.

	imposing flow conditions on licences either established through trading or granted from UAW.			
d. maintenance of the permanence of water in naturally perennially flowing watercourses and in riverbed sands that provide water to support native plants and animals, particularly during dry seasons;	The plan: • declares groundwater within 1 km of prescribed watercourses to be managed as water in the watercourse. • establishes maximum volumes for UAW reserves. • requires for considering the availability of water in the bed sands when deciding water sharing rules. • Includes monitoring requirements • limits instream interference. The ROP outlines: • maximum annual volumetric limits for water extraction in Water Management Zones that limits the maximum take of water. Water may be transferred in these zones but only up to this maximum limit. The ROP also outlines the need for chief executive data collection and assessment. • maximum annual volumetric limits for water extraction in Water Management Zones that limits the maximum take of water. Water may be transferred in these zones but only up to this maximum limit. All entitlements that actively take water are metered entitlements.	• Riffles • Migratory aquatic biota • Freshwater turtles • Waterholes as refugia • GDEs	Perennial systems have unique ecological values (when compared to intermittent systems), so changes to the flow regimes of the perennial waterways in the plan area would have significant consequences. Knowledge of these systems is poor. While utilisation of surface water and groundwater resources is low, and the plan provides mechanisms to protect these waterways, further research is required to better understand the ecological characteristics and relationships with hydrology, including groundwater-surface water connectivity.	LOW risk. This outcome is being achieved. Current water use is low, and the water plan contains performance indicators and environmental flow objectives to protect flows throughout the plan area. The plan manages specific areas to provide for ecological outcomes for perennial streams.
e. the promotion of improved understanding of the	The plan includes monitoring and reporting requirements. The	All	The Queensland government contributes to	LOW Risk.

	matters affecting flow-related health of ecosystems in the plan area;	minister must regularly report on matters affecting the environment and water users, as well as on the performance of the plan and effectiveness of its implementation.		and invests in programs which improve understanding of flow and the ecosystems of the Gulf water plan area - DRDMW's Environmental Flows Assessment Program (EFAP) and the National Environmental Science Program (NESP).	The outcome is being achieved. The Water Planning Science Plan outlines the Queensland government approach to providing the science to inform the water planning process.
f.	maintenance of water in the bed sands of the Gilbert River between AMTD 317km and AMTD 263km— i. to provide aquatic habitat for native aquatic plants and animals, particularly during dry seasons; and ii. to support riparian vegetation; and iii. to contribute to the flow of water in the Gilbert River;	The plan: • Declares groundwater within 1 km of prescribed watercourses to be managed as water in the watercourses establishes UAW reserves • Establishes EFOs which limit access to surface water flows. • Prohibits granting new entitlements within bed sands zones from general reserve UAW. • Includes monitoring requirements The ROP: • outlines maximum annual volumetric limits for water extraction in Water Management Zones that limits the maximum take of water. Water may be transferred in these zones but only up to this maximum limit. Bed sand zones are capped to prevent an overall increase to bed sands take. • requires data collection and assessment.	• Riffles • Waterholes as refugia • Other GDE's	The Gilbert Riverbed sands is a hyporheic aquifer of varying thickness and width, located in the mid-lower Gilbert River. It is estimated that the volume of the aquifer is approximately 20,000ML, of which 10,000ML has been allocated. Allocations from the bed sands were made considering the expected total volume of water available. However, it is unknown to what extent riparian vegetation uses bed sands water, and how it contributes to dry season flow of the Gilbert River. Groundwater dependent ecosystems such as riparian vegetation and baseflows have multiple dependencies at different spatial and/or temporal scales and could be impacted by take. There are substantial knowledge gaps in this area.	LOW risk. This outcome is being achieved. Current water use is low, and the water plan contains performance indicators and environmental flow objectives to protect flows throughout the plan area. However, there is high uncertainty associated with the assessment of this outcome, with no recent monitoring data available to assess the impact of water take on bed sand ecosystems.

g. maintenance of the permanence of water flows in the Gregory River and Lawn Hill Creek to provide aquatic habitat for native aquatic plants and animals, particularly during dry seasons;	The plan: • states the groundwater management areas where specific management of the resource occurs (Nicholson Groundwater Management Area) (GMA). • declares groundwater under prescribed watercourses (including the Gregory River and Lawn Hill Creek) to be managed as water in the watercourse. • establishes maximum volumes for UAW reserves. The ROP outlines: • that the chief executive may require a water entitlement to take water in this GMA to outline likely impact on groundwater or surface water flows. • data to be collected and assessed by chief executive	• Riffles • Freshwater turtles • Waterholes as refugia • Other GDE's • Stable flow spawning fish	Perennial systems have unique ecological values (when compared to intermittent systems), so changes to the flow regimes of the perennial waterways in the plan area would have significant consequences. Knowledge of these systems is poor. The perennial flow of the Gregory River is essential to maintenance of the Thorntonia Aggregation (habitat frequented by over half of Queensland's migratory bird populations), offshore seagrass beds, and contribution to the shallow aquifers supporting coastal wetland habitats. While utilisation of surface water and groundwater resources is low and the plan provides mechanisms to protect perennial waterways, further research is required to better understand the ecological characteristics and relationships with hydrology, including groundwater-surface water connectivity.	LOW risk. This outcome is being achieved. Current water use is low, and the water plan contains performance indicators and environmental flow objectives to protect flows throughout the plan area. However, there is high uncertainty associated with the assessment of this outcome, with limited understanding of the hydrology in terms of surface water and groundwater connectivity.
h. maintenance of flood flows to the estuarine and marine environments of the Gulf of Carpentaria to stimulate breeding, growth and migration of native aquatic animals;	The plan: • protects the flood flows in the Gulf by identifying floodplain inundation as a performance indicator and setting wet season EFOs at key nodes in the plan. • establishes maximum volumes for UAW reserves.	• Floodplain vegetation • Floodplain wetlands • Fluvial geomorphology and river forming processes • Southern Mitchell Aggregation/Southeast Karumba Plain Aggregation • Brackish estuarine habitat	Flood flows to the estuaries and marine environment are critical for supporting life history requirements of ecologically and commercially important fauna. Flood flows are also vital in providing the nutrients that drive primary and secondary productivity	LOW risk. This outcome is currently being achieved.

		• Manages overland flow and instream interferences The ROP: • outlines the process to grant water licences for overland flow. • provides additional considerations for UAW and for water licence trading within volumetric limits and zones. Flow conditions are also required, and environmental needs must be assessed for water licence trading. • outlines the need for chief executive data collection and assessment	• Migratory aquatic	which support this fauna. Changes to estuarine inflows would have significant impacts to estuarine productivity and salinity gradients. Relatively low utilisation coupled with EFOs that protect wet season and/or medium to high flows, mean that there is minimal impact to flood flows in the plan area at the present time.	
i.	maintenance of the natural variability of flood flows that inundate, and deliver nutrients, organic matter and sediment to, the wetlands of the areas known as the Southern Gulf Aggregation and the Southeast Karumba Plain Aggregation;	The plan: • protects the flood flows in the Gulf by setting EFOs at key nodes in the plan. • establishes maximum volumes for UAW reserves. • Manages overland flow and instream interferences The ROP outlines: • the process to grant water licenses for overland flow. • the need for chief executive data collection and assessment	• Floodplain vegetation • Floodplain wetlands • Fluvial geomorphology and river forming processes • Southern Mitchell Aggregation/Southeast Karumba Plain Aggregation	The Southern Gulf Aggregation and the Southeast Karumba Plain Aggregation are systems of high ecological value and include dependent mud flats and migratory shore birds. Flood flows are vital to the delivery of nutrients to these downstream habitats and changes to inflows would have significant impacts to estuarine productivity and salinity gradients. Relatively low utilisation coupled with EFOs that protect wet season and/or medium to high flows, mean that there is minimal impact to flood flows in these systems at the present time.	LOW risk. This outcome is being achieved.
j.	maintenance of flows in the Gilbert River to provide brackish estuarine habitat	The plan:	• Floodplain vegetation • Floodplain wetlands	It has been well established that the life cycle of banana prawns is dependent upon	LOW risk.

	for juvenile banana prawn development.	• protects the flood flows in the Gulf by setting EFOs at key nodes in the plan. • establishes maximum volumes for UAW reserves and instream interferences are managed in the plan. The ROP outlines: • the process to grant water licences for overland flow. • the need for chief executive data collection and assessment.	• Fluvial geomorphology and river forming processes • Southern Mitchell Aggregation/Southeast Karumba Plain Aggregation • Brackish estuarine habitat	flows that provide critical habitat requirements. Recent research indicates that flow extractions, particularly in low-medium flow years, would reduce profitability of the Northern Prawn Fishery. Relatively low utilisation coupled with EFOs that protect wet season and/or medium to high flows, mean that there is minimal impact to flows in the Gilbert at the present time.	This outcome is being achieved.
15 (2) Each of the following is an additional ecological outcome for groundwater in the plan area					
k.	maintenance of groundwater contributions to the flow of water in watercourses, lakes and springs.	The plan: • declares water within 1 km of prescribed watercourses to be water within the watercourse so long as it is hydraulically connected. • water licences in the Einasleigh groundwater management area are required to have an annual volumetric limit. The ROP outlines that the plan applies to groundwater that is not from GAB artesian or sub-artesian water.	• Riffles • Waterholes as refugia • GDEs	Lawn Hill Creek and Gregory River are the principal groundwater-fed waterways of the plan area, other than GDE-dependent watercourses derived from the GAB. Western (Gregory-Nicholson) and eastern (Einasleigh) catchments are most likely to be affected by loss of groundwater contributions to surface water flow. While utilisation of surface water and groundwater resources is low, further research is required to better understand the ecological characteristics and relationships with hydrology, including groundwater-surface water connectivity. Furthermore, GDE mapping and groundwater monitoring is required to understand the effects of take on GDEs in	LOW risk. This outcome is being achieved.

			the plan area, including baseflows. No unallocated groundwater is available in the plan area.	
l. the support of ecosystems dependent on groundwater, including, for example, riparian vegetation, wetlands, and waterholes;	The plan: • declares that hydrologically connected water within 1 km of prescribed watercourses to be water within the watercourse • requires water licences in the Einasleigh groundwater management area to state an annual volumetric limit. The ROP outlines that the plan applies to groundwater that is not from GAB artesian or subartesian water.	• GDEs • Waterholes as refugia	Ecosystems dependent on groundwater have multiple dependencies at different spatial and/or temporal scales and may be impacted upon in the plan area by the lowering of groundwater tables due to take. There is a high level of uncertainty about the level of contribution from groundwater to the support of GDEs. While utilisation of groundwater resources in the plan area is low, further research is required to better understand the ecological characteristics and relationships with hydrology, including groundwater-surface water connectivity. Further GDE mapping, ground truthing and groundwater monitoring is required to understand the effects of take in the plan area on GDEs, including riparian vegetation, wetlands, and waterholes.	LOW risk. This outcome is being achieved. See outcome 15(2)(a) above.
m. allocation and management of groundwater in a way that is compatible with the outcomes of the Water Plan (Great Artesian Basin and	The plan outlines that only groundwater take in the Nicholson and Einasleigh groundwater management areas	• Waterholes • Riffles • GDE's	The Gulf Water Plan identifies the underground water that applies to the plan and states in section 11(2) that the plan does not	LOW risk. This outcome is being achieved across the plan area.

Other Regional Aquifers) 2017 to the greatest practicable extent.	require a water licence, except for stock and domestic purposes. The ROP outlines that the plan does not apply to water managed under the GABORA plan.		include water of the Great Artesian Basin. Both plans seek to achieve a sustainable balance between plan outcomes providing for economic, social, cultural, and environmental values. The outcomes of both plans are consistent in their protection of flow to support groundwater dependent ecosystems, the continued use of authorisations, and the aspirations of First Nations peoples. Outcomes of both plans also encourage the efficient use of water and the facilitation of efficient water markets.

Appendix B: Entitlements and use

Water entitlements

Table B-1: Summary of water licences to take unsupplemented water in the plan area *

Water classification	Area/Subcatchment	Volumetric licences		Area-based licences	Other **
		Number of water licences	Nominal entitlement (ML)	Number of water licences	Number of water licences
Surface water	Water plan area	103	291,177	0	0
	Flinders River WMA***	44	220,012	0	0
	Gilbert River WMA***	31	28,959	0	0
	Gregory River Subcatchment	9	6,126	0	0
	Lower Leichhardt River Subcatchment***	10	28,995	0	0
	Morning Inlet Catchment	1	743	0	0
	Nicholson River Subcatchment	4	1,716	0	0
	Norman River Catchment	1	3,100	0	0
	Upper Leichhardt River Subcatchment	3	1,526	0	0
Groundwater	Nicholson GMA	3	852	0	2
Overland flow water	Gilbert River WMA	1	6,000	0	0
All	**Water plan area**	**107**	**298,029**	**0**	**2**

* For 2021/22 water year
** Water licences with no volume or area specified
*** Subcatchments with water licences for the take of watercourse water plus overland flow into a storage

Table B-2 Summary of supplemented water allocations in the plan area

Water supply scheme	Water allocation holder	Nominal volume (ML)
Julius Dam	North-West Queensland Water Pipeline	15,000
	Mount Isa Water Board (MIWB) (Any)	5,000
	Sun Water	10,850
	Mount Isa City Council (MICC)	7,900
	Mount Isa Mines (MIM)	8,850
	Mount Isa Water Board (MIWB) (Distribution Loss)	1,250
	All	48,850
Moondarra Dam	Mount Isa City Council (MICC)	12,500
	Mount Isa Mines (MIM)	12,500
	Mount Isa Water Board (MIWB) (Distribution Loss)	1,250
	Mount Isa Water Board (MIWB) (Any)	50
	All	26,300
All	All	75,150

Announced allocations

Table B-3 Announced allocations in the plan area

Water supply scheme	Water year	Announced allocation (%)
Julius Dam	2017-2018	100
	2018-2019	100
	2019-2020	100
	2020-2021	100
	2021-2022	100
Moondarra Dam	2017-2018	100
	2018-2019	100
	2019-2020	100
	2020-2021	100
	2021-2022	100

Water use

Table B-4 Metered water use in the plan area

Metered Area	Water Year	Authorised Entitlement (ML)	Metered Entitlements (ML)	Water Use (ML)	Water Use as a percentage of authorised entitlement (%)
Julius Dam WSS *	2017-2018	48,850	48,850	9,817	20.1
	2018-2019	48,850	48,850	8,186	16.8
	2019-2020	48,850	48,850	14,028	28.7

Metered Area	Water Year	Authorised Entitlement (ML)	Metered Entitlements (ML)	Water Use (ML)	Water Use as a percentage of authorised entitlement (%)
	2020-2021	48,850	48,850	8,866	18.2
	2021-2022	48,850	48,850	5,549	11.4
Moondarra Dam WSS	2017-2018	26,300	26,300	13,773	52.4
	2018-2019	26,300	26,300		
	2019-2020	26,300	26,300	17,397	66.1
	2020-2021	26,300	26,300	15,943	60.6
	2021-2022	26,300	26,300	15,944	60.6
Gilbert River WMA	2017-2018	28,959	3,752	120	0.4
	2018-2019	28,959	3,752	846	2.9
	2019-2020	28,959	3,752	480	1.7
	2020-2021	28,959	3,752	562	1.9
	2021-2022	28,959	3,752		
Flinders River WMA	2017-2018	NA	NA	NA	NA
	2018-2019	220,012	3,460	1,309	0.6
	2019-2020	220,012	3,460	831	0.4
	2020-2021	220,012	35,460	4,451	2
	2021-2022	220,012	35,460	11,997	5.5

* Total volume taken includes supplemented water use, streamflow use, loss transactions, water taken under risk entitlements and riparian entitlement use

Water trading

Table B-5 Permanent trades and seasonal water assignments of unsupplemented water in the plan area

Water year	Number of permanent water trades	Volume traded (ML)	Number of seasonal assignments	Volume assigned (ML)
2017-2018	1	5,000	1	50
2018-2019	2	12,000	0	0
2019-2020	0	0	0	0
2020-2021	0	0	0	0
2021-2022	1	50,000	0	0

Unallocated water

Table B-6 Unallocated water reserved in the plan area since plan amendment in 2015

Type of Reserve	Area	Initial reserve (ML)	Volume granted (ML)	Remaining reserve (ML)
Indigenous – for Indigenous purposes	Cape York Peninsula Region area	1,000	0	1,000
	Flinders River catchment area	8,500	0	8,500
	Gilbert River catchment area	17,000	0	17,000

Type of Reserve	Area	Initial reserve (ML)	Volume granted (ML)	Remaining reserve (ML)
	Morning Inlet catchment area	50	0	50
	Settlement Creek catchment area	1,500	0	1,500
	Gregory River subcatchment area	1,000	0	1,000
	Staaten River catchment area*	1,500	0	1,500
	Sub-total	*30,550*	*0*	*30,550*
Strategic – for any purpose	Lake Mary Kathleen	1,100	0	1,100
Strategic- for State** purpose	Flinders River catchment area	17,850	0	17,850
	Gilbert River catchment area	5,000	1,860	3,140
	Gregory River subcatchment area	5,000	0	5,000
	Lower Leichhardt River subcatchment area	15,000	0	15000
	Morning Inlet catchment area	1,000	0	1,000
	Nicholson River subcatchment area	4,282	0	4,282
	Norman River catchment area	1,000	0	1,000
	Settlement Creek catchment area	1,000	0	1,000
	Staaten River catchment area	1,000	0	1,000
	Sub-total	*52,232*	*1,860*	*50,372*
General – for any purpose	Flinders River catchment area	239,650	100,000	139,650
	Gilbert River catchment area	467,000	0	467,000
	Gregory River subcatchment area	2,500	2,500	0
	Lower Leichhardt River subcatchment area	15,000	15,000	0
	Nicholson River subcatchment area	4,400	0	4,400
	Norman River catchment area	3,000	0	3,000
	Sub-total	*731,550*	*117,500*	*614,050*
All	**Total**	**814,332**	**119,360**	**694,972**

- Other than the part of the area that is within the Cape York Peninsula Region area

** As defined under the plan, State purpose means—a project of State significance, a project of regional significance, town water supply or ecotourism— where purpose of water use is for ecotourism, the area is restricted to Morning Inlet, Settlement Creek and Staaten River catchment areas, and the part of plan area within the Cape York Peninsula Region.

Appendix C: Water taken or interfered with under statutory authorisations

Table C-1 Information on water authorisations in the plan area as prescribed in the Water Act

Form of take	Catchment information sources
Authorisations that may *not* be limited by water planning instrument	
S93 General authorisations to take water (e.g., firefighting, watering travelling stock)	**No major change in water taken under this general authorisation.** There have been no major increases in take of water for incidences of firefighting or travelling stock. Stock routes are predominantly serviced by state-controlled bores. The stock network in this area is classified as either 'minor' or 'unused', with little use by travelling stock over the last 5 years.
S94 General authorisations to interfere with overland flow water or interfere by impoundment for structures used for collecting monitoring data	**No identified change in interference under this general authorisation.** Between 2012 and 2014 five new gauging stations have been installed across the plan areas, including on the Flinders, Saxby, and Gilbert Rivers. For further details on gauging stations installed from 2012 refer to section 6.1 of the report. For a full list of gauging stations in the plan area refer to Appendix G. Monitoring data is also collected at natural controls. There is no observed increase in structures that interfere with overland flow, e.g., those use for stock water or ponded pasture.
S95 Aboriginal and Torres Strait Islander parties	**No identified change in water take under this general authorisation.** There has been no notified increase in the take or interference with water for traditional or cultural activities.
S96 Landowners may take water for stock or domestic purposes	**No impacts identified under this general authorisation.** Stock and domestic water can be taken from any location in the plan area. Several landowners have made enquiries with regards to stock water from a watercourse and OLF. There have been no reported incidents of significant increases in take for stock or domestic purposes.
S97 Environmental authorities to take or interfere with overland flow	**No identified change in water taken under this general authorisation.** Notification is required under the Planning Regulation 2017 and Water Regulation 2016 for the construction of overland flow storages to satisfy an environmental authority or a development permit for carrying out an environmentally relevant activity. DRDMW is not aware of a significant increase in the construction of overland flow dams for these purposes through the notification process.
S98 Resource activities that interfere with the flow of water by diversion of a watercourse	**No identified change in water taken under this general authorisation.** The department is not aware of any new environmental authorities conditioned in relation to diversions of a watercourse.

	There has been no increase in the number of interferences by diversion within the plan area for this purpose.
S99 Constructing authorities and water service providers	**No impacts identified in water taken under this general authorisation.** Limited volumes of water as required for road and rail construction and maintenance, and public amenities. Nineteen construction authority entities have been identified in the plan area. Limited volumes of water are required for road and rail construction and maintenance and public amenities. No significant increase in infrastructure and/or amenities has been identified. There are two water service providers within the Gulf Plan area. The department has not identified any change in water used by these service providers for this purpose.
Authorisation that may be limited by water planning instrument or regulation	
s101 Authorisation that may be altered or limited by water planning instrument or regulation.	**No identified change in water taken under this authorisation.** 1a) Along the Flinders and Gilbert Rivers, land use is predominately grazing with a mix of agriculture, with groundwater taken for farming activities for washing and packing produce, mixing herbicides and pesticides and constructing infrastructure. Many farms do not have access to potable supplies and utilise both rainwater and bores for prescribed activities. The balance of the catchment, the land use becomes predominantly grazing. The Water Plan has not set the limit for prescribed activities. 1b) three (3) notifications have been received for existing overland flow dams that are greater than 250ML. Existing overland flow dams are those constructed prior to 2 November 2007. Notification is required for the construction of overland flow storages for works less than 250ML and for new stock or domestic overland flow storages under the Water Regulation. The department has not received any new notifications for overland flow dams less than 250ML or for stock and domestic purposes through the notification process. 1c) Underground water is currently managed under the plan for the Great Artesian, Nicholson and the Einasleigh groundwater management areas. There are 550 was new and replacement subartesian bores drilled 1 November 2018 to 11 January 2023. The take of groundwater has likely increased due ongoing drought conditions, to provide stock water. Underground in certain areas is managed under the Water Regulation 2016. In unregulated areas, there has been no notable increase in the take of underground water. 1d) Unlikely to be significant across the plan area at this stage.
s102 Authorisations under water plans or regulation	**No impacts identified in water taken under this authorisation.** The plan provides for the authorisation of overland flow dams for any purpose up to the capacity of 250ML. The plan also provides for the take of

	groundwater through existing works within the undeclared area of the plan. DRDMW has not identified any new or expanding developments identified that are likely to increase take of overland flow water, other than works associated with the release of UAW. Notification of the existing works are required to take under this authorisation. There have been 3 notifications received for the taking of groundwater and 3 notifications received for the take of overland flow.
s103 Authorisations to take water for stock or domestic purposes may be limited	**No identified change in water taken under these authorities.** The plan does not provide any additional rules on how water for stock and domestic is managed.

Appendix D: Planning milestones and amendments

Table D-1 Water planning milestones for the plan

Effective date	Milestones
1 November 2007	The water plan was released and applied to water in a watercourse, lake or spring, groundwater and overland flow water and provided: • UAW for future water requirements • framework for establishing volumetric water licences • framework for establishing tradeable water allocations for Julius and Moondarra dams • recognition of the cultural value that water holds for First Nations peoples. • factors that must be considered in granting new licences to protect existing water users and environmental and cultural values
June 2010	The ROP was released to implement the water plan • improved specification for existing water entitlements, including converting area-based licences to volumetric licences • implemented strategies to support a range of ecological outcomes and the water and natural ecosystems monitoring requirements • included operating rules and management arrangements for water infrastructure operators • provided rules for seasonal water assignment and permanent transfer of water licences in selected areas of the Gilbert River catchment.
November 2011	The water plan was amended to establish Indigenous reserves of UAW to support aspirations of First Nations peoples in Gulf wild river areas.
November 2011	The ROP was amended to allow water licences granted from the Indigenous reserves to be seasonally assigned.
May 2012	Water licences were granted in the Flinders and Gilbert River catchments via the UAW tender process: • Three licences granted in the Flinders River catchment totalling 80,000ML (all available water allocated) • Three licences granted in the Gilbert River catchment totalling 14,220ML (of an available 15,000ML)
February 2013	2,266ML of UAW were released from the strategic reserves after an expression of interest process, resulting in granting water licences to Burke, Cloncurry and Flinders Shire Councils.
June 2014	The water plan was amended by the *Water Resource Plans Amendment Plan (No. 1) 2014* which: • changed the Minister's reporting period on the plan to five years • removed unnecessary prescription while retaining policy intent • removed redundant provisions; and removed duplication – with the Water Act and the Water Regulation 2002.

Effective date	Milestones
July 2014	The ROP was amended to allow licences in the Flinders and Gilbert catchments to be permanently and seasonally transferred. 2,500ML of UAW was released from the strategic reserve in Lake Corella and granted to the Department of Energy and Water Supply.
August 2014	Water licence was granted to Carpentaria Shire Council from the strategic UAW reserve after the expression of interest process.
August 2015	The water plan amended environmental flow objectives in the Flinders and Gilbert River catchments to protect the health of natural ecosystems both under current levels of water resource development and from future development decisions made under the plan. The water plan and the ROP were amended to provide new general and Indigenous reserves of UAW in the Flinders and Gilbert River catchments.
December 2016	The plan was amended by the *Water Reform and Other Legislation Amendment Act 2014* and the Water Regulation 2016 to update the short title of the plan, clarify the definition for water to which the plan applies, and provide an interim definition for the term subartesian water until such time as the plan is reviewed and replaced, and to update cross references.
November 2016 – March 2017	Water licences were granted from general reserve UAW for Gulf catchments (100,000ML).
December 2017	Water licence was granted to Etheridge Shire Council from the strategic UAW reserve after expression of interest process.
August 2018	A notice was published postponing the expiry date of the water plan to 1 November 2027.

Appendix E: Overview of non-compliance by entitlement holders

Table E-1: Summary of non-compliance incidents in the plan area in 2017/18 - 2021/22 water years

Type of alleged non-compliances	Number of alleged non-compliances	Outcome
Contravene licence conditions	3	Two advisory letters were sent to resolve two incidents and one incident was addressed without taking any administrative actions.
Faulty meter	6	Nine formal warnings were provided to resolve five incidents and one incident was addressed without any administrative action taken.
Non-supply of meter readings	7	One incident required action (sending three formal warnings) to resolve the issue, and compliance of six incidents was achieved without any administrative action taken.
Overuse under entitlement	1	One advisory letter was sent.
Unauthorised take	2	One compliance notice and two verbal educations provided.
Unauthorised interference	1	One advisory letter was sent.

Appendix F: Annual streamflow for DRDMW gauging stations in the plan area

For updated information on gauging stations please refer to: [WMIP: Queensland Government (information.qld.gov.au)]

In the streamflow graphs below, current period (blue bars) refers to the current period that is captured in the hydrologic model. The extended period (green bars) represents data collected since the hydrologic model was completed i.e., not captured in the current hydrologic model.

Figure F-1: Annual streamflow at Gregory River at Gregory Downs (912101A)

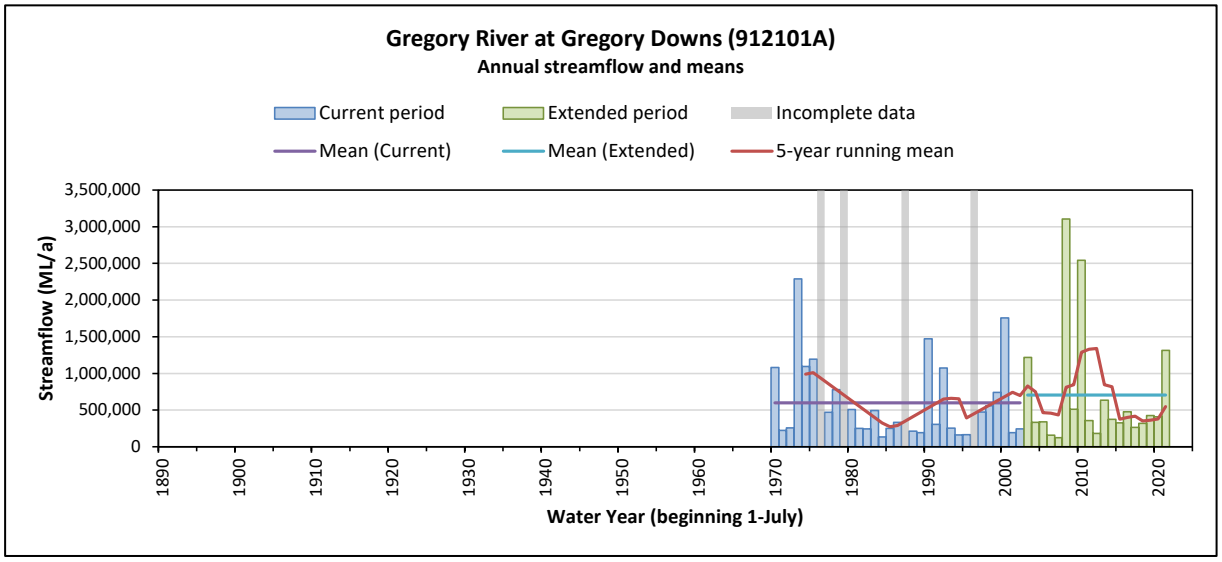


Figure F-2: Annual streamflow at Gunpowder Creek at Gunpowder (913006A)

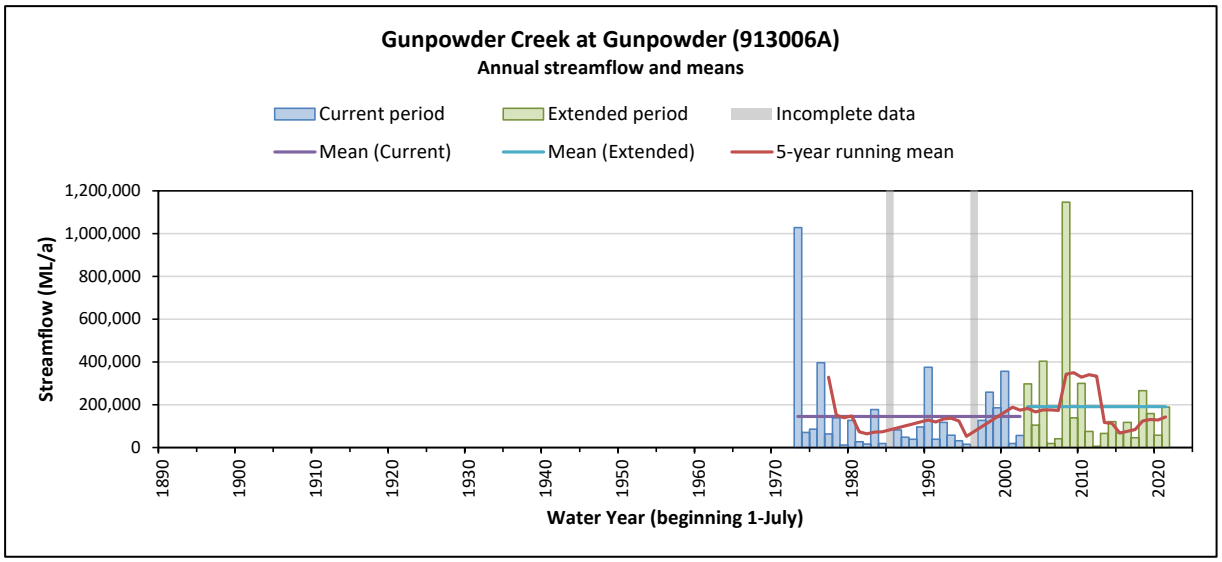


Figure F-3: Annual streamflow at Cloncurry River at Canobie (915212A)

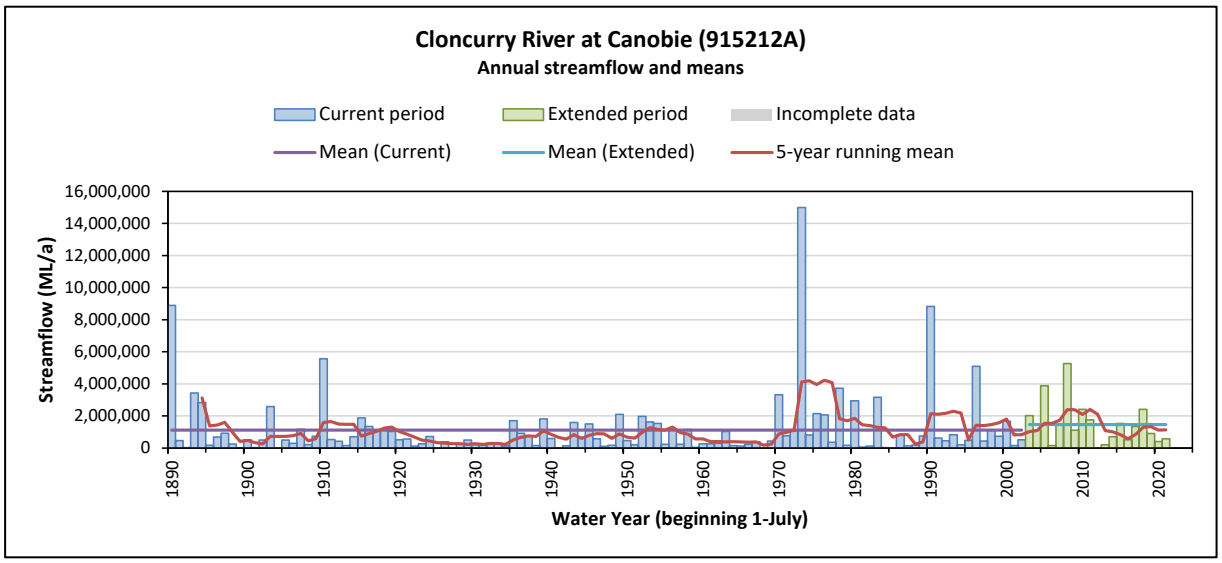


Figure F-4: Annual streamflow at Norman River at Glenore Weir (916001B)

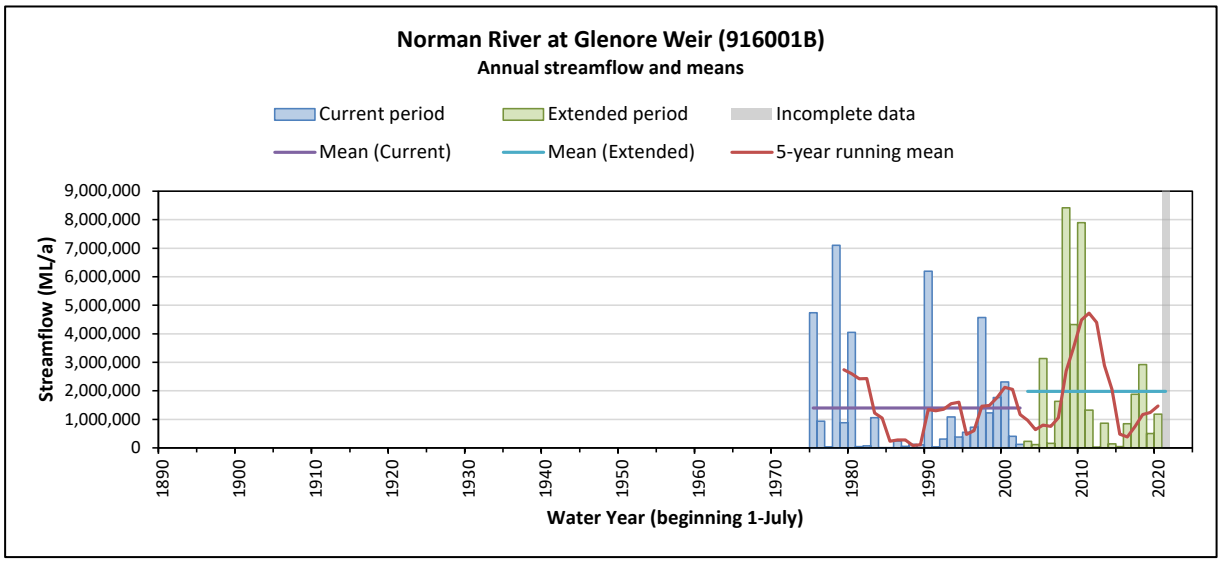


Figure F-5: Annual streamflow at Gilbert River at Rockfords (917001D)

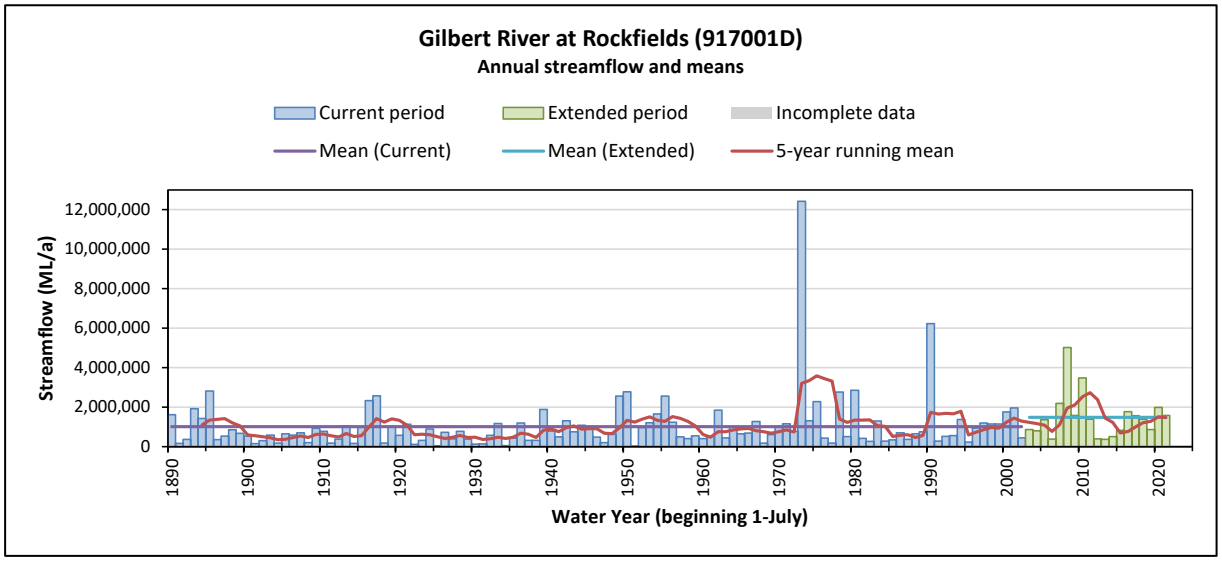


Figure F-6: Annual streamflow at Einasleigh River at Einasleigh (917106A)

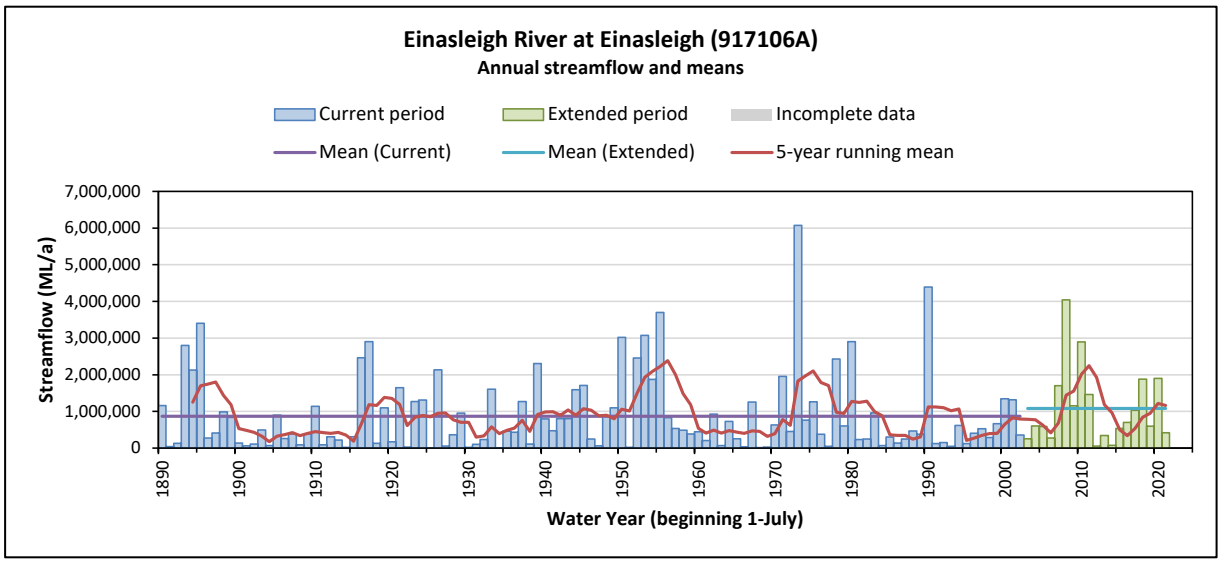
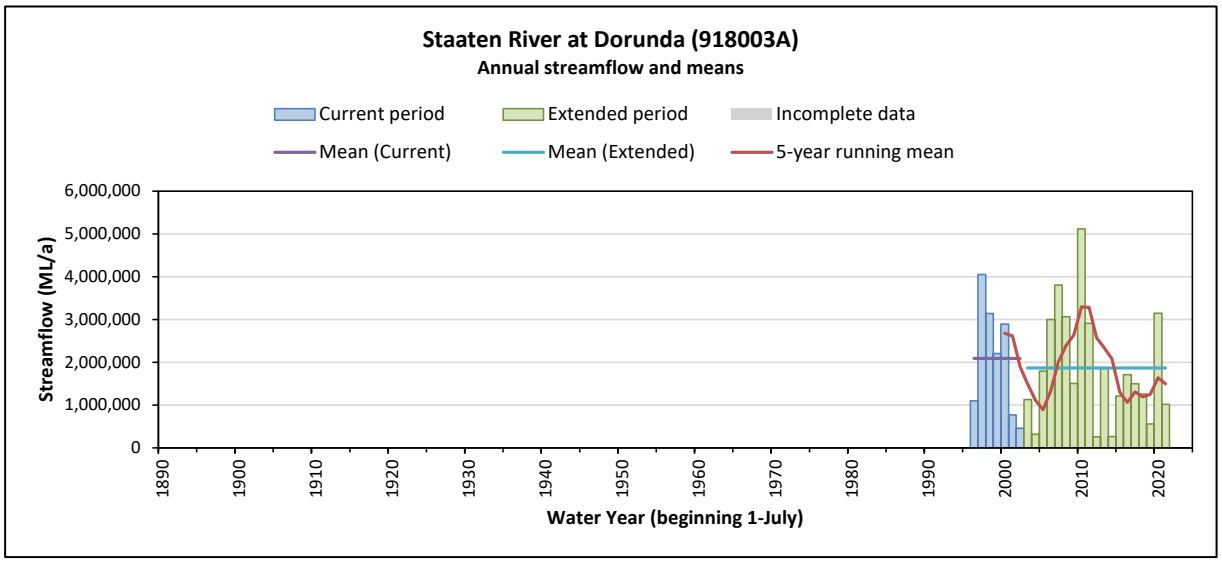


Figure F-7: Annual streamflow at Staaten River at Dorunda (918003A)



Appendix G: List of current departmental gauging stations in the Gulf water plan area

Table G-1: Gauging stations

Catchment	Gauging Station Number	Gauging Station
Nicholson	912101A	Gregory River at Gregory Downs
Nicholson	912105A	Gregory River at Riversleigh No.2
Leichhardt	913006A	Gunpowder Creek at Gunpowder
Leichhardt	913004A	Leichhardt River at Miranda Creek
Leichhardt	913014A	Leichhardt River at Doughboy Creek
Flinders	915008A	Flinders River at Richmond
Flinders	915012A	Flinders River at Etta Plains
Flinders	915016A	Flinders River at Punchbowl
Flinders	915003A	Flinders River at Walkers Bend
Flinders	915015A	Flinders River at Glendower Crossing
Flinders	915212A	Cloncurry River at Glenore Weir
Flinders	915212A	Cloncurry River at Canobie
Flinders	915203C	Cloncurry River at Hensley Drive
Flinders	915206A	Dugald River at Railway Crossing
Flinders	915213A	Gilliat River at Wills Development Road
Flinders	915211A	Williams River at Landsborough Highway
Flinders	915208A	Julia Creek at Julia Creek
Flinders	915017A	Saxby River Punchbowl Road
Norman	916001B	Norman River at Glenore Weir
Gilbert	917001D	Gilbert River at Rockfields
Gilbert	917106A	Einasleigh River at Einasleigh
Gilbert	917014A	Gilbert River at Burke Development Road
Gilbert	917104A	Etheridge River at Roseglen
Gilbert	917107A	Elizabeth Creek at Mount Surprise
Gilbert	917111A	Einasleigh River at Minnies Dip
Gilbert	917115A	Copperfield River at Spanner Waterhole
Staaten	918003A	Staaten River at Dorunda

Appendix H: Summary of research and monitoring findings and assessment of environmental management strategies for the Water Plan (Gulf) 2007

Table H-1: Summary of monitoring completed across the water plan area from 2018 to 2022 and implications for water management.

15 (1) Each of the following is an ecological outcome for water in the plan area—	
Ecological Outcomes	**Summary of Monitoring and Research**
(a) maintenance of the natural variability of flows that support the habitats of native plants and animals and migratory birds in watercourses, floodplains, wetlands, lakes and springs	Rivers within the plan area have highly variable and seasonal flow regimes and the biota found in Gulf systems would be expected to be resilient to natural levels of flow variability at a variety of times scales (i.e., daily, seasonal, annual). Recent work by the NESP hub has demonstrated the importance of natural flow variability in supporting ecosystems in the Gulf (Burford et al 2020; Burford and Faggotter 2021; Cramer and Burford 2021). Flow extremes (dry season cease to flow periods versus wet season floods) account for the high flow variability in intermittent waterways of the plan area. The Flinders River has a more variable interannual flow and longer cease-to-flow spells than the Gilbert River, meaning that it is likely more susceptible to changes in water extraction during low to medium flow years. Effects may not be immediately visible as the river system is highly adapted to variable flow, but multiple years of sustained water extraction will likely impact productivity in the longer term (Burford et al 2020; Burford and Faggotter 2021). Seasonal flooding stimulates aquatic plant growth in floodplain wetlands, which then become productivity hotspots during the wet season (Ndehedehe 2020). Changes to floodplain inundation patterns through water extraction may reduce productivity. Recession of floodwater from floodplains can be rapid. For example, following the 2009 Flinders flood, Ndehedehe et al (2020a) found that post-flood surface extents had receded by 89% within 15 days. Seasonal flood pulses are critical for delivering nutrients to estuarine areas. The nutrients stimulate primary and secondary productivity on intertidal sandflats and mudflats in the estuary and near-shore zone, thus providing resources that support the feeding of migratory wader birds (Burford and Faggotter 2021). Burford et al (2021a) and Lowe et al (2022) investigated the responses of an estuarine macrobenthos (organisms large enough to see with the naked eye living on the bottom of waterbodies) to freshwater flows in the Flinders River estuary. Macrobenthos abundance and species dominance in the Flinders estuary was found to be driven by seasonal changes in flow. Abundance is highest under hypersaline conditions in the late dry season and lowest under low salinity conditions of the late-flood period.

	Polychaetes (marine worms) were the dominant macrobenthic group in the muddy estuarine inter-tidal flats. Bivalves dominated the sandy nearshore intertidal flats in the late-dry and early-dry but were almost completely lost under low salinities during the late-flood. Polychaetes were less impacted by freshwater inputs, possibly due to their burrowing abilities. Macrobenthos recruitment back to the inter-tidal flats commenced once tidal influence re-established in the early-dry season. Correlation between macrobenthic abundance and chlorophyll concentration suggests that flow variability impacts on both primary and secondary production (Burford et al 2021a; Lowe et al 2022). AECOM (2019) stated that 3,000ML is released from Kidston Dam (Copperfield River) in October each year to supply downstream users. This would represent a significant change to the hydrology of this river, particularly during the dry season. However, AECOM (2019) did not state how the water is released. **Implications for flow management** Flow variability is a feature of major waterways within the plan area. There are few significant storages in the plan area so widespread changes to interannual flow variability are unlikely at present. Changes to flow variability are more likely to be occurring at small spatial scales (e.g., waterholes within reaches). At present the only large storages in the plan area occur on the Leichhardt River and Copperfield River. Ecological implications of changes to flow variability from operation of these storages have not been investigated. Burford and Faggotter (2021) cautioned that the Flinders River would be more susceptible than the Gilbert River to changes in water extraction during low-medium flow years. Flow reductions reduce nutrient inputs to estuaries and ultimately reduce primary productivity. Links between flows, food supply and migratory shorebirds have been established, but quantifying the tipping points for productivity in terms of long-term changes in flow frequency, timing and magnitude will require further work (Burford et al 2021a). The work of Ndehedehe (2020) shows that due to the rapid flood recession characteristics of flooding in the lower Flinders, UAW releases have the potential to substantially reduce the duration of floodplain inundation, unless carefully managed. UAW reserves are available in the plan area and the volumes of water available vary between catchments. Work by the NESP hub has shown that flood flows are critical for estuarine and floodplain productivity, hence reductions in flood flows reaching estuaries will have flow on effects for estuarine productivity. However, UAW reserves are capped and meet EFOs set for the plan. Water utilisation in the plan area is low, and under these conditions biota within the plan area would be expected to be resilient to natural levels of flow variability at a variety of time scales.
(b) provision for the continued capability of a part of a river system to be connected to another part, including by maintaining flood flows that— (i) allow for the movement of native aquatic animals between riverine, floodplain, wetland, estuarine and marine environments; and	See comments for outcome 15(a) above. The ecological value of a particular river reach is directly linked, in quantity and quality, to the longitudinal movement of resources such as water, sediment and debris and the migration, recruitment and distribution of species. This also applies to lateral

(ii) deliver nutrients and organic matter throughout the plan area to support natural processes such as breeding, growth and migration in riverine, floodplain, wetland, estuarine and marine environments; and (iii) deliver water and sediment throughout the plan area to support river-forming processes;	movement between the river and off-channel wetland habitats on the floodplain (DES 2020). Connectivity is thus an essential component of the ecology of Gulf systems and underpins several ecological processes. Recent research has provided critical information on the importance of flood flows for habitat connectivity, productivity and the movement of aquatic fauna. Several natural barriers to fish movement, such as Leichhardt and Nicholson Falls occur in the plan area (Hogan and Vallance 2005; DES 2020). Pusey et al (2020) showed that sea catfishes (family Ariidae) use floodplain habitats in the Flinders River during the wet season. This group of fishes includes estuarine and freshwater species. While estuarine species did not use inundated floodplain habitats, freshwater species did. They used the floodplain for feeding but available evidence indicated that they did not use the floodplain for spawning. Ndehedehe et al (2020a,b) identified “hot-spots” for wet season floodplain productivity (aquatic plant biomass) in the Flinders and Gilbert Rivers by integrating remotely sensed biophysical indicators (vegetation and inundation) with hydrological data (rainfall and river discharge). River flows and local rainfall were both key predictors of floodplain inundation and sites of high aquatic plant biomass, but river flows were a better predictor of aquatic plant biomass than rainfall. Flows from the upstream regions in both catchments contributed significantly to total floodplain inundation of the downstream catchment. This replenished freshwater habitats and stimulated aquatic primary production, thus emphasising the role of upstream catchments in the productivity of downstream areas. Local rainfall makes a greater relative contribution to floodplain inundation and the distribution of aquatic plant biomass in the Gilbert catchment than it does in the drier Flinders catchment. Due to higher annual rainfall, Gilbert floodplains are comparatively more productive than those of the Flinders catchment. Ndehedehe (2020) warned that the Flinders catchment could be vulnerable to amplified flow variability if water resource development were to occur in upstream areas. This would lead to negative impacts on freshwater habitats and on hotspots of aquatic plant biomass. Such developments would be less likely to cause disruption to productivity in the Gilbert catchment because of its hydro-climatology (Ndehedehe 2020). Flow regulation or water harvesting may reduce nutrient (and sediment) loads reaching estuaries in the wet season. Nutrients are critical to primary productivity. Years experiencing only low—medium flows are those in which water extraction as a proportion of total flow will be highest and this may result in substantially reduced nutrient and sediment loads transported to the estuary. Experimental addition of nutrients to the Flinders, Gilbert and Mitchell estuaries resulted in increased primary productivity (estuarine mudflat algae) indicating that these estuaries are nutrient-limited (Burford and Faggotter 2021; Burford et al 2021a). Whilst nutrient exports were highly variable from year-to-year, first flush wet season flows are most critical to productivity as these flows will likely deliver the highest nutrient concentrations to estuaries prior to salinity decreasing to the point where primary productivity is adversely affected. Consecutive years of low—medium flows will result in nutrient depletion due to advection, burial and denitrification. Estuarine and nearshore

productivity is therefore best achieved by ensuring that first flush flows are protected, and that water extraction is tightly controlled in low—medium flow years (Burford and Faggotter 2021).

The Flinders River has longer ceased to flow periods than the Gilbert or Mitchell Rivers. During these times, nutrients and sediments are not being delivered to estuaries. This gives further indication that the Flinders is more susceptible to water extraction than the Gilbert and Mitchell in low to medium flow years (Burford and Faggotter 2021). However, despite greater variability in streamflow, the Flinders estuary was found to have higher rates of productivity than the Gilbert and Mitchell estuaries. This was attributed to closer coupling between the estuary and its shallow nearshore habitats leading to greater localised nutrient availability (Burford and Faggotter 2021; Burford et al 2021a).

Models describing the relationships between nutrient concentrations and freshwater flows are generally lacking and this is a major impediment to understanding estuarine nutrient dynamics. Further challenges arise as the measurement of nutrient concentrations can give a distorted view of the relative productivity of estuaries, particularly in systems where nutrient concentrations are relatively low. Factors that integrate the effect of nutrient inputs (i.e., algal or faunal production) may therefore be better indicators of productivity (Burford and Faggotter 2021).

Venarsky et al (2022) described macrobenthic community dynamics in sandflats and mudflats of the Flinders, Gilbert and Mitchell estuaries. The number of zero flow days in the preceding dry season was the best predicter of community composition. Estuarine salinity regime, interacting with river flows were the likely driver of observed inter-annual patterns in community composition, but neither salinity nor community composition influenced total abundance of biomass of the benthic community. The frequency (daily to yearly), duration (hours to months) and extent (freshwater to hypersaline) of an estuary's salinity regime thus strongly influence the distribution of taxa. Venarsky et al (2022) suggested that significant alterations in benthic community composition can be driven by relatively subtle fluctuations in dry season flow.

River flows can increase the growth rates of juvenile barramundi with growth enhanced by 25% for those accessing freshwater habitats compared with those in estuarine habitats (Roberts et al 2019).

Implications for flow management

At present connectivity is not adversely impacted within the plan area. Work by the NESP Hub has shown how longitudinal (upstream-downstream) and lateral (between river channels and wetlands) connectivity supports a variety of critical ecological and life history processes and how these processes may be influenced by reductions in flow. For example, reductions in end of system flows could reduce nutrient delivery to estuaries, reducing estuarine productivity and reducing food availability for migratory waders.

UAW reserves are available in the plan area and the volumes of water available vary between catchments. UAW releases are accounted for in modelling and current plan settings through EFOs. However, given the extent of the plan area there is a risk that

	insufficient ecological information will be available to properly assess impacts to ecological outcomes of specific UAW releases.
(c) minimisation of changes to natural variability in water levels to support natural ecological processes, including the maintenance of refugia associated with waterholes and lakes;	Permanent waterholes occur throughout the plan area. These are a major feature of the landscape in the wet-dry tropics and are important refugial habitats, providing for repopulation of the system when flows re-commence. There have been several research projects looking at waterholes of the Gulf plan area and these were summarised in the Summary of Monitoring for the previous Minister's report (DNRME 2018). EFAP conducted a Waterholes as Refugia project in ten waterholes of the Flinders and Gilbert catchments. Water levels were monitored over a two-year period (2016-2018) and digital elevation models were created from the bathymetry collected. Data were supplied to DES to inform future waterhole persistence modelling for these catchments. **Implications for flow management** The water plan provides some protection to waterholes. For example, the plan allows for restrictions to be placed on licences in unsupplemented reaches regarding take of water from waterholes or lakes. However, there are several knowledge gaps that should be addressed to enhance management of these features to ensure their persistence. Most of the recent work on waterholes in the plan area has been completed in the Flinders and Gilbert Rivers and previous waterhole investigations undertaken in other parts of the plan area need to be updated. Identification of permanent waterholes is often achieved with satellite imagery, which has limits on the minimum size of waterhole that can be detected. There may be critical permanent waterholes in the plan area in locations where satellite imagery cannot be used to determine permanency, such as in narrow braided channels.
(d) maintenance of the permanence of water in naturally perennially flowing watercourses and in river bed sands that provide water to support native plants and animals, particularly during dry seasons;	Also see comments for outcome 15(g) below. There are few perennial waterways within the plan area, but these include Gregory River, Lawn Hill Creek, Thornton River and the O'Shannassy River. These streams are recognised as the only perennial waterways in arid Queensland (DES 2020). Persistence of these habitats through geological time has provided aquatic refugia for species with disjunct populations across northern Australia. This includes the 'living fossil' Gulf snapping turtle (*Elseya lavarackorum*) and a host of fish species including northern saratoga (*Scleropages jardini*), coal grunter (*Hephaestus carbo*) and blackmast (*Craterocephalus stramineus*) (DES 2020). There is poor understanding of the hydrology of these perennial streams. Although groundwater dewatering associated with mining development has been implicated in alteration to stream baseflows, most of these catchments lack intensive development and critical hydrological connectivity between groundwater, stream flow and floodplains has been retained. However, DES (2020) reports that anecdotal observations suggest the permanence of some aquatic habitats and the permanence of flows in some reaches of the southern Gulf area have declined. The emerging impact of climate change on rainfall and groundwater recharge – discharge processes is likely to drive community shifts in some areas toward more xeric habitats and a

	possible reduction in the extent of perennial refugia. Sites that maintain of perennial status perennially represent potential climate change refugia, particularly in the scenario where wet season rain events become less reliable (DES 2020). **Implications for flow management** Perennial systems have unique ecological values (when compared to intermittent systems), so changes to the flow regimes of the perennial waterways in the plan area would have significant consequences, such as the loss of species adapted to perennial flow and the loss of potential climate change refugia. Locations of the mineralisation process of calcium carbonate precipitates (tufa) could also change with modification to the flow regime and this may alter flow pathways. At present, there are limited threats to these perennial waterways aside from potential mine site development and climate change. Utilisation of surface water is low, and the plan (section 8) has declared that hydrologically connected water within 1 km of a prescribed watercourse is to be treated as water in the watercourse. This means take from groundwater in these instances is treated as surface water, which requires a licence and take must be metered. This mechanism both discourages groundwater take and protects surface water flows. However, prescribed watercourses apply to specific sections of those rivers/streams listed rather than the watercourse in its entirety and unless specifically listed, does not include its tributaries. For example, perennial river sections listed include Lawn Hill Creek to the extent it is downstream of node 3; and the Gregory River to the extent is downstream of node 4. High uncertainty remains, concerning sub-surface flows in bed sands, hyporheic exchange processes between groundwater and surface water and the dry season contribution of bed sand water to support dependent flora and fauna in the Gulf catchments. While utilisation of surface water and groundwater resources is low (and the plan provides mechanisms to protect these waterways) further research is required to better understand the ecological characteristics and relationships with hydrology, including groundwater-surface water connectivity.
(e) the promotion of improved understanding of the matters affecting flow-related health of ecosystems in the plan area	See comments for other ecological outcomes in this table. The details of departmental monitoring and other monitoring conducted within the plan area have been summarised in this report and are used as a tool to assess the achievement of the ecological outcomes. There have been several studies conducted to determine the potential impact of further allocation of water resources in the area – the information from these and other studies have also been summarised. The department will continue to collaborate with other government agencies and research organisations to enhance management of waterways and associated biota within the plan.
(f) maintenance of water in the bed sands of the Gilbert River between AMTD 317km and AMTD 263km— (i) to provide aquatic habitat for native aquatic plants and animals, particularly during dry seasons; and	The Gilbert River bed sands is a hyporheic aquifer of varying thickness and width, located in the mid-lower Gilbert River. Sandstone intrusions act as “upside down dams” to pond water. The aquifer is not thought to extend under the high banks. It is estimated that the volume of the aquifer is approximately 20,000ML, of which 10,000ML could be allocated for use (PPK 2000). The remaining water is considered

(ii) to support riparian vegetation; and (iii) to contribute to the flow of water in the Gilbert River;	necessary to ensure continued down-valley flow. At present, utilisation of the resource is far below what is available. Water is used for mangoes, peanuts, grass seed and hay. PPK (2000) indicated the bed sands aquifer to be generally capable of meeting existing water entitlements but cautioned that there was (at that time) insufficient water available in the western section to grant further water entitlements. **Implications for flow management** Allocations from the bed sands were made considering the expected total volume of water available (PPK 2000). However, it is unknown to what extent riparian vegetation uses bed sands water, and how it contributes to dry season flow of the Gilbert River or provides aquatic habitat. This remains a substantial knowledge gap.
(g) maintenance of the permanence of water flows in the Gregory River and Lawn Hill Creek to provide aquatic habitat for native aquatic plants and animals, particularly during dry seasons	See comments for outcome 15(d) above. The Thorntonia sub-region of the southern Gulf largely comprises karst hills of limestone. The Gregory River and its tributaries (Lawn Hill Creek in the east and the O'Shannassy and Thornton Rivers to the south) drain the area. Perennial flow in the Gregory River and in the lower reaches of these tributaries originates from springs draining the limestone and supports a diverse suite of aquatic habitats, particularly in the larger streams. These systems are unique as the only perennial streams in arid Queensland. These perennial streams host different species assemblages to those found in nearby seasonal creeks of the lower Nicholson River (DES 2020). Aesthetically clear to blue-hued 'limestone' water is characteristic of these perennial habitats, which often contain deep waterholes that are connected by flowing channels containing riffle and race reaches. Dense and diverse fringing riparian communities with rainforest structural and floristic affinities are also supported by the perennial moisture. These riparian habitats have high biodiversity values and are in effect groundwater dependent ecosystems. Where calcium carbonate saturated water draining the limestone flows to surface water it forms unique precipitates called tufa. These perennial limestone spring-supplied aquatic habitats are also very representative of the Nicholson River basin, and to which similar prescribed values can be attributed (DES 2020). The department operates two gauging stations on the Gregory River (912101A Gregory Downs and 912105A Riversleigh No 2). These stations have strongly perennial flow regimes, as shown by flow duration curves (WMIP: Queensland Government (information.qld.gov.au)). The gauging station operated by the department on Lawn Hill Creek was de-commissioned in 1988. The flow duration curve for this gauge shows that the flow regime was near perennial at the time the gauge was operating. There has been little targeted research to date on the hydrology of the Gregory River and Lawn Hill Creek. **Implications for flow management** It is critical that these systems maintain perennial flows, as a change from perennial to intermittent flow regime would be expected to have significant ecological implications. These may include loss of species adapted to perennial flow and the loss of potential

	climate change refugia. Locations of the mineralisation process of calcium carbonate precipitates (tufa) could also change with modification to the flow regime and this may alter flow pathways. At present, there are limited threats to these perennial waterways aside from potential mine site development and climate change. Utilisation of surface water is low, and the plan (section 8) has declared that hydrologically connected water within 1 km of a prescribed watercourse is to be treated as water in the watercourse. This means take from groundwater in these instances is treated as surface water, which therefore requires a licence and take must be metered. This mechanism both discourages groundwater take and protects surface water flows. However, prescribed watercourses apply to specific sections of those rivers / streams listed rather than the watercourse in its entirety and unless specifically listed, does not include its tributaries. For example, perennial river sections listed include Lawn Hill Creek to the extent it is downstream of node 3; the Gregory River to the extent is downstream of node 4.
(h) maintenance of flood flows to the estuarine and marine environments of the Gulf of Carpentaria to stimulate breeding, growth and migration of native aquatic animals	Also see comments for outcome 15(a) above. Flood flows to estuaries and marine environments are critical for primary and secondary productivity processes which support estuarine and marine biota. Flood flows also support the life history requirements of ecologically and commercially important fauna such as barramundi and banana prawns. Leahy and Robins (2021) investigated the relationship between growth rates of juvenile barramundi and river discharge in the Flinders, Gilbert and Mitchell Rivers. Growth was assessed using otolith increment widths. Total river discharges from January to March each year had a strong positive effect on otolith increment widths (growth rate) of barramundi up to three years of age, across all three regions. A particularly strong relationship was found for the Gilbert and Flinders regions which experience intermittent, highly seasonal flows. Strontium isotope ratios in the barramundi otoliths were also examined to investigate movement patterns (see Robins et al 2021). Results indicated that the geomorphology and inter-annual river flow patterns of the Flinders, Gilbert and Mitchell Rivers provided variable opportunities for the spatial and temporal connectivity of aquatic habitats used by barramundi, including access to seasonal floodplains. Barramundi population dynamics, as determined by catch and age data, reveal highly variable recruitment patterns across rivers of the Gulf, with significant relationships to river discharge applicable over multiple years and not just in their first year of life. Barramundi is thus a long-term measure of ecosystem health by which inter-annual patterns in estuarine production (in the broadest sense) and river flows in the Gulf catchments may be assessed (Burford et al 2021b). To maintain a sustainable barramundi fishery, Robins et al (2021) warned that water resource development which reduces or impedes a) spawner biomass or b) juvenile survivorship — will alter the natural fluctuation of barramundi biomass. This will have consequential impacts on the surplus yield that can be sustainably harvested.

Although there are many similarities in physical characteristics of the Flinders, Gilbert and Mitchell estuaries, the Flinders estuary is generally the most productive in terms of primary productivity (algal growth rates), despite displaying the most extreme conditions, with lowest rainfall, highest evaporation and highest interannual variation in discharge (Burford et al 2021a; Burford et al 2021b).

Whilst nutrient exports from Gulf rivers were highly variable from year-to-year, first flush wet season flows are a key attribute most critical to productivity as these flows will likely deliver the highest nutrient concentrations to estuaries prior to salinity decreasing to the point where primary productivity is adversely affected. Estuarine and nearshore productivity is therefore best achieved by ensuring that first flush flows are protected, and that water extraction is tightly controlled in low—medium flow years (Burford & Faggotter 2021).

Intertidal sandflats and mudflats of the Gulf provide integral feeding resources for migratory waders, several of which are critically endangered. Nutrients delivered by river flows to the estuaries promote the growth of algae, which the macrobenthos (worms, snails and crabs) feed on, and which in turn, are food for the migratory waders. Although nutrient concentrations in floodwaters are like those of normal river flows, the sheer volume of floodwaters translates to high amounts of nutrients carried downstream. Productivity of these habitats is thus directly related to the volume of water discharged (Cramer & Burford 2021).

Burford et al (2021a) reported that chlorophyll concentrations in the Flinders, Gilbert and Mitchell estuaries decreased as wet season flows decreased the salinity. This is due to negative effects of low salinity water on the physiology of marine algal species.

Burford et al (2021a) found that inter- and intra-annual patterns of estuarine benthic community composition were best explained by the number of days of cease-to-flow during the preceding dry season, as dry season river flows dictate the salinity regime of estuaries, which in turn influence benthic community composition. Numbers of migratory shorebirds within a species (i.e., Great Knot) present at any given time would thus be expected to decline with reduction in their major food source (i.e., bivalves).

Implications for flow management

To maintain wet season flows to the Gulf estuaries, the plan identifies median wet season flow as the performance indicator at each assessment node. The plan also protects flood flows in the Gilbert and Flinders Rivers with wet season flow objectives. The regulation of overland flow and limitations on instream interferences further assist in minimising threats to this outcome. However, recent research indicates that increased water extraction or the construction of additional water storages would significantly reduce flows to estuaries and the near-shore zone. This would have negative repercussions on natural ecosystems and to the annual catches and profitability of Gulf fisheries.

There are currently 27 active gauging stations in the plan area (refer to section 6.1 for further detail).

(i) maintenance of the natural variability of flood flows that inundate, and deliver nutrients, organic matter and sediment to, the wetlands of the areas known as the Southern Gulf Aggregation and the Southeast Karumba Plain Aggregation;	See comments for outcome 15(h) above. The Southern Gulf Aggregation is listed in the Directory of Important Wetlands of Australia (DIWA). This complex wetland aggregation comprises extensive marine intertidal flats, beaches, dunes, swales, saline clay plains and tidal channels. Dominating estuarine tides are modified during the wet season by massive freshwater flooding events received from several catchments including the Nicholson-Alexandria, Albert, Leichhardt, Flinders, Bynoe and Norman rivers. This aggregation is the largest, continuous, estuarine wetland aggregation of its type in northern Australia and one of the three most important areas for shorebirds in northern Australia (DIWA). The Southeast Karumba Plain Aggregation is also listed in the DIWA. This aggregation includes tidal flats, stream channels, ephemeral and permanent wetlands. Estuarine tidal regimes are a dominant influence over the area, but these are modified by massive freshwater flooding events in the wet season, received via several watercourses including the Smithburne, Gilbert and Staaten rivers. The area provides significant waterbird breeding habitat and supports the second largest summer population of wader birds in Australia. It is one of four important bird habitats in the region. This aggregation also has cultural significance (Petheram et al 2018; DIWA). Seasonal flood pulses are critical for delivering nutrients to estuarine areas which stimulate the primary and secondary production of feeding resources utilised by migratory wader birds. However, concentrations of total nitrogen and phosphorus only increased in short-term spikes and for most of the time concentrations were not greater than dry season values. It is the sheer volumes of flood waters discharged in medium to high flow years that deliver substantial loads of nutrients to the nearshore zone and drive coastal productivity, both directly and indirectly. Productivity of these habitats is thus directly related to the volume of water discharged (Burford et al 2020; Burford and Faggotter 2021; Cramer and Burford 2021). **Implications for flow management** The Southern Gulf Aggregation and the Southeast Karumba Plain Aggregation include freshwater and estuarine wetlands and require freshwater inflows to support ecological processes and biodiversity. At present freshwater inflows into these significant wetlands are not threatened but future UAW allocations will require that freshwater inflows are maintained, particularly during periods of low annual flow. As shown above, flood flows deliver nutrients to estuaries that support primary and secondary productivity and significant wader bird populations. Flood flows will also facilitate growth and dispersal of barramundi into off stream habitats. Seasonal flooding provides hydrologic connectivity, which is a critical influence on biological and physicochemical features of floodplain waterholes (e.g., Pettit et al 2012).
(j) Maintenance of flows in the Gilbert River to provide brackish estuarine habitat suitable for juvenile banana prawn development.	See comments for outcome 14(h) above. It has been well established that the life cycle of banana prawns is dependent upon flows (and the timing of these flows) that provide critical habitat requirements. Accordingly, it is anticipated that flow extractions (water harvesting etc.) may reduce the banana prawn catch, with economic implication for the fishery. For example,

Broadley et al (2020) assessed the impact of several water extraction scenarios on banana prawn catch in the Flinders and Gilbert Rivers. Under all modelled flow extraction scenarios, a greater decline in banana prawn catch would be expected in years with low to medium river flows. Results showed that managing equitable water extraction during extended low flow or drought periods would be especially challenging for sustaining fishery yields (Broadley et al 2020).

Burford et al (2021b) reported substantial annual variation in the density of juvenile banana prawns across the Gulf estuaries and confirmed that during the wet season most juveniles leave the estuaries in favour of offshore areas in response to low salinities and food availability. Adult prawns continued to be caught in the nearshore area, however, albeit at lower densities, indicating that not all juvenile prawns migrated to the offshore fishery. This led Burford et al (2021b) to suggest that adult prawns remaining nearshore may be an important source of post-larval recruits to the estuaries.

Duggan et al (2019) explored the potential effects of flow modification on banana prawn catch originating from the largely unmodified Norman River estuary, by way of a Bayesian belief network (BBN). They examined potential prawn catch resulting from different magnitudes of natural flow, and under three water extraction scenarios:

- reduced wet season flow
- enhanced dry season flow
- a combination of scenarios one and two

These assessments enabled two important flow metrics for a wet-dry tropical estuary to be identified for the first time:

- a threshold of freshwater flow that affects the likelihood of high prawn catches (> 2,500,000ML peak monthly wet season flow volume predicts an 89% probability of high catches in the offshore fishery — driven by low estuarine salinity, low food availability and high rates of emigration from the estuary)
- quantification of the cumulative effects of river flow and potential flow regulation on prawn catch.

All flow modification scenarios reduced the probability of high prawn catches due to changes in salinity, food availability and emigration rates which altered the expected abundance of prawns in the estuary. Recruitment survey data supported these predictions. This study indicated little capacity to regulate or modify freshwater flows of the Norman River estuary without reducing the probability of high prawn catches (Duggan et al 2019).

Implications for flow management

If the full uptake of current entitlements and planned water allocations in Gulf catchments were to occur, vessel-level business profit in the Norther Prawn Fishery (NPF) could reduce by 7—12% for at least half of the time. These reductions due to irrigation development could represent significant financial impacts on the NPF (Smart et al 2021).

	The regulation of overland flow and limitations on instream interferences stated in the plan will assist in minimising threats to this outcome.

Table H-2: Summary of monitoring pertaining to groundwater completed across the plan area from 2018 to 2022 and implications for water management.

15(2) Each of the following is an additional ecological outcome for groundwater in the plan area—	
Ecological Outcomes	**Summary of Monitoring and Research**
(a) maintenance of groundwater contributions to the flow of water in watercourses, lakes and springs;	See comments for outcomes 14(d), 14(f) and 14(g) above. Vertical linkages between surface waters and groundwater ecosystems that occur within the hyporheic zone sustain many endemic or relictual invertebrate fauna (DES 2020). Groundwater contributes to flows in several watercourses of the plan area, particularly the Gregory River, Lawn Hill Creek, and Elizabeth Creek (Einasleigh catchment). The Kidston Pumped Hydro Scheme may have localised impacts on groundwater and an adjacent spring, but these are not thought to be considered significant (AECOM 2019). No UAW is available from groundwater in the water management areas. **Implications for management** There is limited utilisation of groundwater within the plan area. Management strategies have been put in place to manage both surface water and groundwater as one resource. Production bores not managed under the GABORA Water Plan are registered and the majority are for stock watering only.
(b) the support of ecosystems dependent on groundwater, including, for example, riparian vegetation, wetlands and waterholes;	See comments for outcomes 14(d), 14(f) and 14(g) above. Although the contributions of groundwater to riparian vegetation, wetlands and waterholes in the plan area is largely unknown, DES (2020) noted the importance of groundwater connectivity with freshwater wetlands in the southern Gulf catchments, where much of the region is under the influence of groundwater. Further, DES (2020) indicated that floristically rich and structurally diverse riparian vegetation located in some perennial catchments of the Gregory River are groundwater dependent ecosystems. **Implications for management** Detailed GDE mapping and on-ground map truthing is required. Ecological monitoring and targeted research into groundwater – surface water interactions, groundwater levels and usage data are needed to improve certainty of assessment for this outcome.
(c) Allocation and management of groundwater in a way that is compatible with the outcomes of the Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017 to the greatest practicable extent.	The plan outlines that groundwater take only from the Nicholson and Einasleigh groundwater management areas requires a water licence unless it is for stock and domestic purposes. The Gulf ROP outlines that the plan does not apply to water managed under the GABORA plan. All new stock and domestic bores in the groundwater management areas are registered with the department.

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