3 Living and built environment of the Darwin catchments

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Chapter 3 discusses a wide range of considerations relating to the living component of the catchment and the environments that support these components, the people who live in the catchment or have strong ties to it, the perspectives of investors, the existing transport, power and water infrastructure and the legal, policy and regulatory environment relating to the development of land and water.

The key components and concepts of Chapter 3 are shown in Figure 3-1.

**Figure 3-1 Schematic diagram of key components of the living and built environment to be considered in the establishment of a greenfield irrigation development**
3.1 Summary

This chapter provides information on the living and built environment including information about the people, the ecology, the infrastructure and the institutional context of the Darwin catchments. It also examines the values, rights, interests, and development objectives of Indigenous people.

3.1.1 KEY FINDINGS

Ecology

The Darwin catchments support a diverse range of flora and fauna that are fundamentally adapted to the seasonal wet-dry climate (Warfe et al., 2011). Seasonal flows of the Darwin catchments underpin river-floodplain productivity and provide critical habitats for species (Warfe et al., 2013). These flows also support a range of fish species, including the freshwater sawfish (*Pristis pristis*) (listed as vulnerable under the *Environment, Protection and Biodiversity Conservation Act 1999* (Cth) EPBC Act) and a commercial and recreational barramundi (*Lates calcarifer*) fishery.

The intact landscapes of the Darwin catchments provide ecosystem services that support the water supply of Darwin, recreational activities, tourism, and some areas of agricultural production. The study area also supports some of northern Australia’s most iconic wildlife species, such as saltwater crocodiles (*Crocodylus porosus*), magpie geese (*Anseranas semipalmata*) and barramundi, as well as many lesser-known plants and animals that are also of great conservation significance. Five of the 33 wetlands in the NT listed on the Directory of Important Wetlands in Australia are found in the Darwin catchments (Environment Australia, 2001).

The richness of biodiversity in the study area is attributed to the integrity, extent and heterogeneity of its wetland habitats (Department of Land Resource Management, 2015; Environment Australia, 2001). This includes a high fish biodiversity, with the Finniss River having had 46 fish species recorded, the Adelaide River 44, the Mary River 34 and the Wildman River 22. There is also high fish endemism, and there are a number of rare species in the study area.

In the dry season, waterholes provide crucial refugia in an otherwise dry landscape and allow plants and animals to colonise areas in the wet season. In the wet season, flows also lead to a boost of productivity with the addition of carbon and nutrients draining from the landscape. Changes in land and water resources can have serious consequences for the ecology of rivers (Bunn and Arthington, 2002). Flow change can also facilitate or exacerbate impacts, including the spread of invasive species and changes to water quality, particularly in the availability and distribution of nutrients (Olden et al., 2008).

Demographics, industries and infrastructure

The population of the Darwin catchments is about 140,000, of whom 98% live within the Greater Darwin area. Unemployment (4.7%) is below the national mean (6.9%) and socio-economic advantage is similar to the rest of the country. The main land uses are for conservation (53%) and grazing (37%, including modified pastures). The gross value of agricultural production (GVAP) in the Darwin area is approximately $136 million (ABS, 2017; NT Farmers Association, 2016). Cropping accounts for about 90% of the GVAP ($123 million), mostly from fruit, vegetables and hay (NT Farmers Association, 2016). Beef cattle contribute around $13 million to GVAP (ABS, 2017).
Outside the Darwin urban footprint, the study area is characterised by a sparse network of major roads, with the Stuart Highway being the main access to Darwin from the south. Except for urban roads in Darwin and other towns, all roads within the Darwin catchments permit Type 2 road trains, which are vehicles up to 53 m in length. Darwin Port is also accessible by these road trains. The Darwin catchments have a good quality standard gauge rail line, providing freight access to the port. From 2000 to 2004 the line was extended from Alice Springs to Darwin Port (East Arm), providing rail access to the southern states. The rail line is primarily used for bulk commodity transport (mostly minerals) to Darwin Port. Electricity in the Darwin catchments is supplied by four main power stations and delivered via the Darwin-Katherine Interconnected System (DKIS). Darwin River Dam currently supplies 85% of the urban water demand and the McMinns and Howard East Borefields in the Darwin Rural Water Control District (DRWCD) area currently supply on average 15% of urban water demand (Power and Water Corporation, 2015a).

Social and investor values
The diverse stakeholders in the Darwin catchments sometimes have conflicting interests and values relating to the use of water resources and irrigated agricultural development. This has implications for the ability of developers to gain and maintain social licence to operate through the development process. Stakeholder values relate to the purpose of development, the environmental conditions and ecosystem services that development may alter, how stakeholders are engaged, and to whom benefits accrue. Systematic social impact analysis that investigates stakeholders and their interests will be needed for development at scale. A survey of potential agricultural investors identified that they perceived institutional certainty, simplicity and bureaucratic speed as the key enablers of investment in irrigated agriculture. There was less consistency between investors regarding other enablers of irrigated development.

Indigenous values and development objectives
Indigenous people have recognised native title and cultural heritage rights, and control significant natural and cultural resource assets, including land, water, and coastline. Understanding key aspects of pre-colonial and post-colonial patterns of land and natural resource use in the Darwin catchments is important to understanding both present circumstances and Indigenous responses to future possibilities. Indigenous people have strong expectations for involvement in water, catchment, and development planning. Indigenous people have a range of existing business development plans and objectives that may be impacted by development proposals. They wish to be crucial owners, partners, investors, and stakeholders in future development.

Legal, policy and regulatory environment
Government powers and responsibilities concerning the management of land and water resources in the Darwin catchments are shared. The Australian Government oversees native title and the implementation of international law obligations. The Northern Territory Government manages land and water assets. Land in the Darwin catchments is primarily held as Crown leasehold land or reserves, national parks, and freehold land, with much of the catchment also subject to native title, a unique form of property interest that consists of a bundle of rights defined by the laws and customs of the relevant Indigenous community. The rights to the use, flow and control of all water in the NT are vested in the Northern Territory Government, who controls the processes for water planning, the regulation of taking and interference with water, and the construction and operation
of water infrastructure (e.g. dams, bores, levies and pipes). Land owners' rights to use and develop land are limited by government regulations. The most relevant government regulations are those imposed under federal and state planning, environment and heritage statutes. Analysis of 36 recent development proposals (only three that were for agriculture or aquaculture), showed that the median length of the total assessment time under the Environmental Assessment Act (NT) was 517 days, with an average of 784 days. A similar analysis of eight proposals in the Northern Territory under the EPBC Act found that the median time of the assessment and approval process was 511 days.

3.1.2 INTRODUCTION

This chapter seeks to address the question ‘What are the existing: ecological systems; the demographic and economic profile; the land use, industries and infrastructure, stakeholder values and investor perspectives; the values, rights, interests and development objectives of Indigenous people; and the legal, policy and regulatory environment in which development would occur in the Darwin catchments?’

The chapter is structured as follows:

- Section 3.2 examines the ecological systems and assets of the Darwin catchments including the key habitats and key biota, and their important interactions and connections.
- Section 3.3 examines the socio-economic profile of the Darwin catchments including the current demographics and existing industries, and infrastructure of relevance to water resource development.
- Section 3.4 examines the stakeholders, their values and potential engagement strategies and the perspectives of potential investors in the Darwin catchments.
- Section 3.5 examines the Indigenous values, rights, interests, and development objectives of Traditional Owners from the Darwin catchments, generated through direct participation in the Assessment.
- Section 3.6 examines the legal, regulatory and policy environment relevant to water-related development.

3.2 Ecology of the Darwin catchments

3.2.1 INTRODUCTION

The catchments of the north-western portion of the NT encompass a variety of landscapes and ecosystems including the Arnhem Land plateau, undulating hills, coastal plains and coastal saline environments such as mangroves. These are some of northern Australia’s most iconic landscapes and their ecosystems support a great diversity of species and communities. A large part of the Darwin catchments consists of intact, more or less functioning natural landscapes and ecosystems. These intact landscapes are important for the ecosystem services they provide, including the water supply of Darwin, recreational activities, tourism, and some areas of agricultural production, notably cattle grazing on native pastures. In addition, they hold important ecological and environmental values (Figure 3-2). The study area supports large populations of some of northern
Australia’s most iconic wildlife species, such as saltwater crocodiles, magpie geese and barramundi, as well as many lesser-known plants and animals that are also of great conservation significance. Five of the 33 wetlands of national significance in the NT are found in the Darwin catchments (Environment Australia, 2001). The richness of biodiversity in the study area is attributed to the integrity, extent and heterogeneity of its wetland habitats (Department of Land Resource Management, 2015; Environment Australia, 2001).

The Finniss catchment features a number of areas and wetlands of conservation significance, including:

- Finniss River Coastal floodplain, which supports breeding for waterbirds, magpie geese and saltwater crocodiles and is a habitat for threatened species such as the great knot (*Calidris tenuirostris*), eastern curlew (*Numenius madagascariensis*) and marine turtles (members of the super family Chelonioidea) (Northern Territory Government, 2009).
- Fog Bay, which supports migratory shorebirds and marine turtles, many of which are threatened (Northern Territory Government, 2009).
- Darwin Harbour, which has extensive and diverse mangrove areas, supporting specialised bird species. There are also extensive mudflat areas and the harbour supports a diverse range of marine species including dugongs (*Dugong dugon*), dolphins (members of the family Delphinidae), marine turtles (members of the super family Chelonioidea) and a large variety of fish. The harbour is habitat for threatened species such as the curlew sandpiper (*Calidris ferruginea*), red goshawk (*Erythrotriorchis radiates*), flatback turtle (*Natator depressus*) and floodplain monitor (*Varanus panoptes*) (Northern Territory Government, 2009).
- The upper Finniss catchment also has a legacy mining site, the Rum Jungle mine.

The Adelaide catchment features the coastal floodplain of the Adelaide River, which is a large seasonally-inundated freshwater floodplain, and features a mix of wetland, grass and sedge, and open woodland communities, with pockets of monsoon forest. This floodplain provides breeding habitat for waterbirds, including magpie geese. Mangroves are found in the lower reaches of the Adelaide River as are migratory shorebirds utilising wetlands and mudflats. The floodplain is habitat for threatened species, including the northern quoll (*Dasyurus hallucatus*), plain death adder (*Acanthophis hawkei*) and Gouldian finch (*Erythrura gouldiae*) (Northern Territory Government, 2009).

The Mary catchment features the coastal floodplain of the Mary River, which is a mix of dry and wet habitats that support waterbirds, magpie geese and is a breeding area for barramundi. This floodplain is habitat for threatened species, including the brush-tailed rabbit-rat (*Conilurus penicillatus*) and the bar-tailed godwit (*Limosa lapponica*). There are barrages in place to prevent saltwater intrusion into the freshwater wetland systems (Northern Territory Government, 2009).

The Wildman catchment neighbours and incorporates part of Kakadu National Park, which contains a diversity of wetlands, habitats and species. It is a Ramsar-listed wetland and provides habitat for more than 75 threatened species.
Figure 3-2 Distribution of important wetlands, important bird areas and protected areas within the Darwin catchments

The Adelaide and Mary River coastal floodplain systems are recognised as an important breeding area for waterbirds and crocodiles, and are among the most important breeding sites for magpie geese in Australia (SKM, 2009). About 27% of the Darwin catchments is protected within national parks and reserve systems (Department of Land Resource Management, 2015). Protected areas include Litchfield National Park (Finniss River), Djukbinj National Park (Adelaide River) and Mary River National Park (Mary River). In total, 53% of the catchments are conservation lands or other natural environments.

The Darwin catchments include both highly modified urban and agricultural landscapes and large areas of intact landscapes with a distinctive wet-dry tropical climate, as well as the downstream marine environment to which they are connected. The Darwin catchments discharge into the Arafura and Timor Seas and so their condition influences the ecological and economic values of these marine environments.

Coastal floodplains, mangroves and mudflats are characteristic habitats at the end of the Darwin catchments (Territory Natural Resource Management, 2016). Within the NT, mangroves are
considered to be unusually diverse and extensive (Woinarski, 2004). Important inland habitats throughout the catchments include extensive floodplains, wetlands and inchannel waterholes, riparian zones and groundwater-dependent monsoon forests (Warfe et al., 2010). The extensive floodplain wetlands support aquatic fauna, including waterbirds, fish invertebrates, crocodiles, frogs and turtles (Figure 3-1). Seasonal flooding of the Darwin catchments sustains off-river wetlands and leads to a boom in productivity, while the groundwater baseflow maintains permanent waterholes as important refuge habitat (Warfe et al., 2011). Many permanent waterholes through the river systems are also in part replenished by groundwater, with the waterholes creating refugia in the dry season. Floodplains provide an important source of nutrients for a sub-set of fish species, including those feeding on benthic algae (Douglas et al., 2005). Fish, crayfish, prawns and shrimps access carbon from the floodplain as a source of energy. In turn, these animals are an important food source for large predators, particularly in waterholes during the dry season (Douglas et al., 2005).

The NT has a relatively simple patterning of vegetation over large areas, but with localised variation (Woinarski et al., 2005). Examples of this variation are the highly diverse monsoon forest patches, comprising only a small area (Woinarski et al., 2005). Spring-fed monsoon forests are of high conservation value in the Wildman catchment and are vulnerable to increased use of groundwater resources. Riparian zones are another vegetation variant and are represented as only narrow strips that have high biodiversity and productivity. Riparian zones are rich in birdlife (Woinarski et al., 2000) and are sensitive to changes in both surface water and groundwater regimes (Pusey and Kennard, 2009). Melaleuca forests and woodlands occur in seasonally-inundated areas, especially on the floodplains of the lower reaches of major river systems (Woinarski, 2004).

The Darwin catchments also have a high fish biodiversity. The Finniss River has had 46 fish species recorded, the Adelaide River 44, the Mary River 34 and the Wildman River 22 (Burrows, 2008). With further survey effort, it is anticipated that further species would be found (Burrows, 2008). The Darwin catchments have high fish endemism within northern Australia (Hermoso et al., 2011). There are a number of rare species in the study area including some with disjointed distributions on the tip of Cape York and the Fly River in Papua New Guinea.

Of the rarer Australian species a tongue sole (*Cynglossus heterolepis*) and an eel-tailed tandan (*Porochilus obbesi*) have been found in the Adelaide River; a halfbeak (*Zenarchopterurus spp.*) and a circumpect goby (*Glossogobius circumspectus*) have been recorded from the Finniss River catchment; while a rare rainbowfish (*Melanotaenia exquisita*) is present in the region and is most abundant in the Mary River catchment (Pusey et al., 2017). The Darwin catchments also have the highest Australian records of the nursery fish (*Kurtis gulliveri*), a peculiar animal which has a hook on its head upon which the embryos sit prior to hatching. Lorentz grunter (*Pingalla lorentzi*) is a narrowly distributed freshwater fish in Australia, being found in the Finniss catchment, though it is extremely rare there relative to its populations on Cape York (Pusey et al., 2017). Elasmobranch fauna has not been closely investigated in the Darwin catchments, nevertheless, there are records of freshwater sawfish, freshwater whipray (*Urogymnus dalyensis*) and bull sharks (*Carcharhinus leucas*) (Allen et al., 2002; Last and Stevens, 2009). The Adelaide River is also habitat for the speartooth shark (*Glyphis glyphis*) and the northern river shark (*Glyphis garricki*), which are listed as critically endangered and endangered respectively under the EPBC Act (Burrows, 2008).
Freshwater fishes perform central ecological functions and structure ecological communities within floodplain river ecosystems (Jardine et al., 2012). In the Darwin catchments there are several species of large-bodied diadromous species (species that migrate between freshwater and seawater) that provide the basis for recreational and subsistence fisheries, and are of cultural significance (Bayliss et al., 2014; Close et al., 2014; Ebner et al., 2016). In the absence of definitive local studies of fish ecology in the study area, the movement and migration ecology of the fish fauna is perhaps best inferred from research in the Alligator Rivers region. This research revealed considerable seasonal migration between lowland floodplain and main channel habitats (Bishop et al., 1990). As with fish assemblage studies in all northern Australian river systems since, wet-season related connectivity of aquatic habitats is an important driver of fish assemblage dynamics.

Species such as barramundi, threadfin salmon (*Polydactylus sheridani*) and mudcrab (*Scylla serrata*) are particularly important to commercial and cultural fisheries, and they also support recreational fishing (Bayliss et al., 2014). Other significant fauna in the Darwin catchments include saltwater and freshwater crocodiles, Australian snubfin dolphins (*Orcaella heinsohni*) and the pig-nosed turtle (*Carettochelys insculpta*). The ecology of many of these species is highly dependent on the quality and quantity of water resources, and maintenance of habitat complexity.

The NT has the world’s largest intact savanna (Territory Natural Resource Management, 2016) and about 20% of Australia’s eucalypt forests and woodlands, with low clearing rates (Woinarski, 2004), although there are some areas of clearing in the Darwin catchments (Ziembicki et al., 2014). Dry-season fires are a feature of tropical savannas of northern Australia, with the northern half of the NT being burnt annually or biennially (Williams et al., 1999). Low-frequency, high-intensity fires cause high mortality of trees, unlike low-intensity, high-frequency fires (Williams et al., 1999). The riparian zone is particularly sensitive to fire, far more so than the surrounding savanna (Douglas et al., 2015).

To describe the ecology of the Darwin catchments and discuss the likely impacts of future water resource development on this system, ecological assets have been selected. This chapter considers a key sub-set of assets, as shown in Table 3-1. More information on catchment assets and their distribution is available in the companion technical reports on ecology (Pollino et al., 2018a, 2018b). In Chapter 7, models are used to explore the potential of change to these assets, as a consequence of changes in flow. Please refer to Figure 3-1 for the spatial distribution of important areas for conservation (protected areas and important wetlands).
Table 3-1 Asset types and asset names in the Darwin catchments
All assets listed in this table are detailed in the companion technical reports on ecology (Pollino et al., 2018a, 2018b). Assets are water dependent on either surface water flows or groundwater, resulting in either periodic or sustained inundation. Assets consist of species of significance, functional groups, important habitats or ecosystem processes. An asterisk (*) represents assets included in analysis (see Chapter 7.5). Barramundi and sawfish are considered freshwater assets as the asset analysis only considers the freshwater stage of their life cycle.

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<th>CATEGORY</th>
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3.2.2 CURRENT CONDITION OF THE DARWIN CATCHMENTS

The Darwin catchments reflect enormous diversity, in terms of their landscapes, the ecological and environmental assets that they encompass, the economic enterprises that they support and the nature and extent to which they have been modified by human activity.

The study area includes Darwin, the NT’s largest urban area. Other parts of the catchments have also been modified for agricultural development. While a very large proportion of the Darwin catchments are under conservation reserves in very good environmental condition, the region does face significant environmental threats.
One of the most significant threats to the environment and ecosystems of the Darwin catchments comes from invasive plant species. The northern section of the NT has been subject to invasion by several Weeds of National Significance as well as numerous other recognised weeds. Particularly noteworthy are the invasions of wetlands by olive hymenachne (*Hymenachne amplexicaulis*) and mimosa (*Mimosa pigra*). These, along with para grass (*Urochloa mutica*) and Aleman grass (*Echinochloa polystachya*), have radically altered the composition, structure and function of floodplain environments, especially on the Adelaide River floodplain. Terrestrial environments have also been subject to plant invasions with perhaps the most important being that by gamba grass (*Andropogon gayanus*). This species is continuing to invade woodland environments and radically alter the composition of both the ground and tree layers of the vegetation through sequestration of resources and increasing the intensity of fires.

Feral animals have also had major impacts on the ecosystems of the Darwin catchments. Large numbers of water buffalo (*Bubalus bubalis*) and feral pigs (*Sus scrofa*) have increased levels of physical disturbance in wetlands and monsoon vine forests and, especially in wetlands, the activities have led to changes in the composition, structure and function of the vegetation. Cane toads reached the Darwin region as recently as 2005 with significant negative consequences for native wildlife, particularly native carnivores such as the northern quoll.

Most river systems of the Darwin catchments are largely unregulated. Water supply infrastructure for Darwin includes two dams, the Darwin River Dam on the Darwin River, and Manton Dam, on a tributary of the Adelaide River. Otherwise the region’s water supply comes from groundwater sources and the drawdown from these sources can affect natural springs and waterholes in creeks and rivers. Historical mining activity has resulted in some contamination of water sources, notably in the east branch of the Finniss River as a result of uranium and copper mining at Rum Jungle up until 1971. Saltwater intrusion into formerly freshwater wetlands of the lower Mary River floodplain has been reported since the 1940s, a change attributed to several factors, including overgrazing and other activity by feral water buffalo (Applegate, 1999).

Since the 1970s numerous land resource surveys (e.g. Fogarty, 1980; Fogarty et al., 1979; Lynch and Manning, 1998; Mangion and Parkinson, 2012; Napier and Steen, 2002; Olsen, 1985) covering approximately 70% of the Darwin catchments and undertaken in urban, agricultural, pastoral and conservation lands, have consistently reported concerns over the potential for, and management of, soil erosion. Key concerns include granitic soils in drainage depressions within the lower Finniss catchment, particularly where these soils have been cleared (Hill et al., 2002), yellow earths within the upper Adelaide catchment (Forster and Fogarty, 1975), and coarse granitic sands, fine siltstone ‘bulldust’ earths and sodic soils of the upper Mary River catchment (Napier and Steen, 2002).

### 3.2.3 KEY HABITATS

Northern Australia contains rivers with highly seasonal flow regimes that support a diversity of habitats. These habitats require flows across the flow regime and are key for breeding, supporting juvenile aquatic animals, foraging and refuge. Habitats of significance in the Darwin catchments that can potentially be impacted by agricultural and water resource development are described below.
Waterholes and wetlands

During the dry season, many ephemeral rivers of northern Australia cease to flow but retain water in a series of disconnected instream waterholes (McJannet et al., 2014; Waltham et al., 2013). The waterholes that remain during the dry season are an important cultural resource and provide a range of ecosystem functions (Centre of Excellence in Natural Resource Management, 2010; McJannet et al., 2014). For example, at the landscape scale, the number of waterholes and their connectivity allows for movement of biota across the landscape (Department of Environment and Resource Management, 2010). While at the local scale, the size of waterholes confers water-dependent species a refuge in periods without surface flows (Department of Environment and Resource Management, 2010). Permanent waterholes retain water during the dry season, with some being maintained or supported by groundwater inputs. See Section 2.5 (Figure 2-46) for the distribution of permanent waterholes in the Darwin catchments.

During dry-season low-flow or cease-to-flow periods, the size, quality and connectivity of waterholes remaining within the landscape decreases (Department of Environment and Resource Management, 2010; McJannet et al., 2014). Waterholes are typically surrounded by riparian vegetation, which offer shade and structural diversity, and act as an interface between aquatic and terrestrial ecosystems, supporting high biodiversity. Changes in the flow regime associated with water resource development, surface and groundwater extraction and climate change have the potential to alter the natural filling and drying cycles of waterholes as well as water quality, including turbidity (McJannet et al., 2014; Waltham et al., 2013). Changes in waterhole permanence could have impacts on the plants and animals at a local scale and on habitats across regional landscapes.

The extensive wetlands of northern Australia are highly productive. Aquatic production in tropical rivers is primarily driven by hydrology and the annual flooding that occurs (Pettit et al., 2017) and this cycle influences the availability of nutrients within rivers and the coastal zone (Junk et al., 1989), providing a boost to the overall annual energy budget. In rivers, this supports huge biomasses of fish and invertebrates, and large bird breeding events. Prolonged inundation of wetlands promotes the productivity and biomass of aquatic vegetation (Finlayson, 1991; Pettit et al., 2011; Warfe et al., 2011), which provides important habitat for aquatic fauna.

The floodplains of the Darwin catchments are extensive, with a high density of wetlands (Figure 3-1) including those of national significance in the coastal lower catchments. The NT has some of Australia’s largest and relatively unmodified wetlands (Whitehead et al., 1990). Floodplain wetlands provide extensive habitat for a wide range of aquatic biota during the wet season and refugia habitats for aquatic biota and waterbirds during the dry season (Warfe et al., 2010). They provide habitats for large congregations of birds, including magpie geese (Territory Natural Resource Management, 2016). In a study of the Mary River coastal floodplain wetlands, plant communities were simple, with low species richness, however diversity of wildlife habitats were high (Whitehead et al., 1990). The distribution of plant species across catchments in the NT was similar, but there were some regional variations (Whitehead et al., 1990). Despite being in relatively pristine condition, they are threatened by feral animals and invasive plants.
Mangroves and salt flats

Mangrove communities are assemblages of trees and shrubs that are found fringing most of the coastline of mainland Australia, with the most extensive and diverse communities found along the northern coastline. Mangroves occur extensively across the NT (Woodroffe, 1995), including the coastal floodplains of the Darwin catchments (Figure 3-3). Mangroves support diverse and complex food webs, including crustaceans such as prawns, and a diversity of fish species. While associated with the marine system, mangroves require freshwater input, with many of them living close to their salinity tolerance levels. Changes in flow regimes can potentially affect mangroves.

![Map of Darwin catchments showing distribution of mangroves and salt flats](image)

Figure 3-3 Distribution of mangroves and salt flats in the coastal area of the Darwin catchments

Hydrology of mangroves is complex: tidal inundation, rainfall, groundwater seepage and evaporation all influence soil salinity and have a profound effect on mangrove growth and distribution. Freshwater flows into mangroves reduces salinity, creating favourable conditions. Extraction of water from rivers and subsequent changes to flow regimes can negatively impact the productivity and extent of mangroves (Röderstein et al., 2014). A reduction in the volume of wet-season flow is likely to reduce the productivity (growth) and composition of mangroves, their extent and their connectivity, particularly in the upper reaches of estuaries and in the high...
intertidal zone. Minor reductions in flow regimes have led to massive mortality of mangroves (Blasco et al., 1996). There is a high species richness, with 22 species of mangroves found in a study of the tidal areas of the Adelaide River (Ball, 1998). Darwin Harbour, which represents a broad open embayment, contains the largest single stand of mangroves in the NT (Woodroffe, 1995).

Coastal salt flats or claypans are shallow coastal basins which are only infrequently tidally inundated. They are often found adjacent to coastal mangrove forests. Tropical northern Australia has extensive areas of these salt flats which remain relatively pristine. These low-lying systems are mostly vegetation free, and are coated in a thick salt crust for most of the year. During large rainfall events when overbank flow occurs, or during sustained local rainfall, they may be flooded for extensive periods. Wetting of salt flats results in the release of high concentrations of nutrients and benthic algae, which become a food source for animals, including prawns.

Salt flats contribute significantly to primary production in coastal areas (Burford et al., 2016). Reduced flows can impact salt flats through reduced inundation, affecting the growth of primary producers that form the base of the food web, with impacts potentially extending into coastal areas (Burford et al., 2016).

Riparian vegetation

The interface between land and rivers is the riparian zone, which provides an important link between aquatic and terrestrial communities. Riparian zones are regarded as highly diverse, dynamic and complex habitats (Naiman and Decamps, 1997) that act as a thermal buffer to streams. They also influence a number of environmental processes such as instream primary production; nutrient interception, storage and release; enhancement of bank stability; the provision of coarse woody material as habitat and substrate for fish, invertebrates and microalgae; channel morphology and habitat diversity (Pusey and Arthington, 2003). Riparian vegetation is important for providing bank stability, terrestrial and instream habitat and food resources, as well as acting as corridors for wildlife movement and the movement of sediment, carbon and nutrients into rivers. Riparian zones are often more fertile and productive than surrounding terrestrial vegetation. The timing and quantity of water available to the riparian zone is critical for determining its structure, function and resilience, such that all aspects of the flow regime (i.e. precipitation, runoff and evapotranspiration) exert some control over how riparian vegetation access water (Tabacchi et al., 1998). Change to the flooding regime or reduced access to groundwater as a consequence of water resource development can lead to deterioration of the condition of the vegetation of riparian zone, and over longer timespans, affect the extent and diversity of riparian zones. There have only been a few systematic studies of riparian vegetation in the NT (Woinarski, 2004). Within the riparian zone of the nearby Daly catchment, 40 tree species were identified, of which many were highly groundwater dependent (O’Grady et al., 2006).

The ecological integrity of riparian zones across northern Australia is threatened by a range of existing processes, including land clearing, weed invasions and disturbance by livestock (Woinarski et al., 2000). Unlike other parts of Australia, NT riparian zones are largely unmodified (Woinarski, 2004). They provide important habitat for birds including waterfowl, especially in the dry season (Woinarski et al., 2000), likewise for flying foxes, invertebrates and frogs (Woinarski, 2004).
Monsoon vine forest

The monsoon rainforest patches of northern Australia (also known as monsoon vine forests) are an example of groundwater-dependent forests that rely on year-round availability of water. They are associated with areas in the landscape where the water is trapped or the watertable is close to the surface and so occur around the coastline, springs, watercourses and deep rocky gullies, or areas that are naturally fire protected by topographic features such as steeper, rockier terrain (dry monsoon vine forests comprising deciduous species) and especially sheltered gorges or areas with moist substrate (Bowman, 2000). The monsoon vine forests stand out from the sparsely wooded eucalypt savanna that covers much of northern Australia, and are most common in the Darwin catchments (Figure 3-4) (Russell-Smith, 2001).

![Figure 3-4 Distribution of monsoon vine forest in the Darwin catchments](image)

Although there is about 2700 km² of this habitat in the NT, it only accounts for 0.2% of the total land area. The monsoon vine forests in the NT are made up of 15,000 patches ranging from 1 to 4000 ha with a median size of 3.6 ha (Northern Territory Department of Land Resource Management, 2010; Price et al., 1999). They contain very small populations of mostly less than 50 plants (Russell-Smith and Lee, 1992). Access to water is critical to the type and functioning of
tropical tree stands. Even with the monsoonal wet season, many trees must survive primarily on soil water (1 to 2 m of soil (Liedloff and Cook, 2007)). As plant roots can access groundwater throughout an otherwise long, rain-free dry season, these forests support dense stands of tall trees, palms and vine thickets.

Bowman and Panton (1993) found that the monsoon rainforest patches of the Darwin area are susceptible to development, fire, weed invasion and cyclones, with a 60% reduction in cover of pre-1945 monsoon rainforest extent; while Russell-Smith and Bowman (1992) also found impacts from introduced cattle and buffalo, pigs and flood damage on the rainforest patches. These moist, heavily shaded habitats and their concentration of fleshy, fruit-bearing plant species support a variety of animals dependent upon these forests, especially the fruit-eating birds (Price et al., 1999) and bats. Birds move between monsoonal vine forest patches and require many patches over a large area to maintain their populations (Price et al., 1999).

3.2.4 KEY BIOTA

Native fish

Freshwater fish are an important component of the aquatic biodiversity in northern Australia (Pusey et al., 2017). Fishes comprise the dominant aquatic-vertebrate group in terms of species richness in tropical freshwater catchments of northern Australia. In a recent synthesis of a range of information sources from northern Australia, Pusey et al. (2017) mapped the distribution of 111 freshwater and 42 estuarine fishes, not including those that are elasmobranchs (sharks, rays and skates). An earlier publication documented 176 species of bony fish and six species of elasmobranch recorded in northern Australia (Pusey, 2011). A total of 86 of these species reside exclusively in freshwaters and 90 out of 176 require access to marine or estuarine waters for part of their life cycle (Pusey, 2011).

Many northern Australian freshwater fish reproduce during the wet season, when initial flooding increases the area and diversity of available aquatic habitats, as well as increasing plankton and other foods (Bishop et al., 1990). In a synthesis of information on fish in the Alligator Rivers of the NT, it was found that the lowland backflow billabongs were important spawning habitat (Bishop et al., 1990). In a study of the intermittent (seasonal) Fergusson River in the NT, it was concluded that the persistence of refugial waterholes of sufficient size were essential for maintaining freshwater biodiversity, particularly fish, as these waterholes provided suitable habitat (Pusey et al., 2018). The size of the waterholes was determined by the hydrology of the previous year. Each of the rivers within the Darwin catchments have extensive floodplain areas, particularly in their lower reaches. For example, the Mary River dissipates into a distributed floodplain, with extensive floodplains above the estuary, making it an ideal nursery for fish (Erskine et al., 2005). There are few local studies of fish ecology in the Darwin catchments.

A fish group vulnerable to inchannel barriers and changes to flows are freshwater migratory fishes. Migratory fish are distributed throughout the Darwin catchments (Figure 3-5) and include species with populations or subpopulations which undertake large-scale movement during their life cycle. While there are many species in this group, a range of species are distributed through freshwater habitats including inchannel and offchannel environments, as well as upper and lower catchment areas, such as barramundi, freshwater sawfish, bull shark, black catfish (Neosilurus ater) and Hyrtl’s tandan (Neosilurus hyrtlii), sooty grunter (Hephaestus fugilinosus and H. jenkinsi),
freshwater longtom (*Strongylura kreffti*) and spangled perch (*Leiopotherapon unicolor*). These migrations may be required for reproductive purposes or exploiting available habitat and food resources. Movement and migration of fishes in the Darwin catchments is critical. Species can move over the floodplain for weeks to months during the wet season but be confined to the main channel and distributary refugia during the dry season. The distributary refugia are in streams branching off and flowing away from the main stream channel. In the dry season, inundated habitats play a critical role in providing resilience for fish.

Another important group of fish are the stable flow spawners. While they are distributed throughout the Darwin catchments, this group is more prominent in the upper parts of the catchments (Figure 3-6).

![Figure 3-5 Distribution of focal migratory freshwater fishes in the Darwin catchments](image)
This group includes a large number of species, including the freshwater longtom, mouth almighty (*Glossamia aprion*), bony bream (*Nematalosa erebi*), barred grunter (*Amniataba percoideis*), flyspecked (*Craterocephalus stercusmuscarum*) and freckled hardyhead (*Craterocephalus lentiginosus*) and the eastern (*Melanotaenia splendida splendida*), chequered (*Melanotaenia splendida inornata*) and western (*Melanotaenia australis*) rainbowfish.

**Threatened and endangered fish species**

**Freshwater sawfish**

The threatened freshwater sawfish currently occupies the Darwin catchments (Figure 3-7) (Morgan et al., 2004). It is listed as vulnerable under the EPBC Act and as critically endangered by the International Union for Conservation of Nature (IUCN). Given the EPBC Act listing, any proposed action that is likely to have a significant impact on their populations or on their habitat may need an environmental impact assessment. The freshwater sawfish is distributed throughout the Darwin catchments (Figure 3-7; Figure 3-8), although there are limited records, reflecting the
limited fish studies in this area. Historically this species has been distributed across the west coast of Australia, in the NT and in Queensland.

The prospect of inchannel barriers along migration routes and in the lowlands of the Darwin catchments poses a threat to the passage of migratory fishes, including the freshwater sawfish. The freshwater sawfish has a marine adult phase while the juvenile phase is in freshwater or saline environments (Morgan et al., 2016; Peverell, 2005). Pupping occurs in estuaries and river mouths (Last and Stevens, 1994), and juveniles and adults occupy large pools and waterholes mostly in the main channel of larger rivers (Morgan et al., 2004; Peverell, 2005). Occasionally they are also found in larger offchannel habitat. Juveniles enter the river in the wet season (January to April) with higher survival or recruitment correlating with years with high, late wet-season flows (Centre of Excellence in Natural Resource Management, 2010).

![Figure 3-7 The freshwater sawfish (*Pristis pristis*)](image)

Species of sawfish can attain very large sizes (5–7 m total length) and live in tropical and subtropical coastal marine waters as adults (Last and Stevens, 1994). A key feature of the group is the tooth-lined rostrum (or saw) which is a flattened extension of the snout. The saw is important in the specialist, stealth feeding strategies of these species, being used to sense and in some cases strike and impale prey, including prawns and fish (Morgan et al., 2016). The freshwater sawfish is a top predator that feeds on fishes and crustaceans (Thorburn et al., 2014).
Barramundi is a large fish that occurs throughout northern Australia in rivers, lagoons, swamps and estuaries. It is a voracious predator and arguably the most important fish species to cultural, recreational and commercial fisheries throughout wet-dry tropical Australia. The species makes up a substantial component of the total commercial fish catch in northern Australia (Savage and Hobsbawn, 2015). In 2015 the commercial barramundi catch in the NT alone was 344.2 tonnes. Barramundi is also a fish of cultural significance, as well as being an important food source for Indigenous populations (Jackson et al., 2012; Toussaint et al., 2005). Barramundi is found extensively throughout the Darwin catchments (Figure 3-9).
The barramundi is impacted by changes in the flow regimes of rivers and via infrastructure impacting movement of fish. Spawning occurs in the estuary at the beginning of the wet season and young male fish move into floodplain and freshwater habitats when suitable flows provide access (Russell and Garrett, 1985). Recent work has proposed three primary life cycle strategies employed by barramundi (Crook et al., 2017), whereby some male adults return to the estuary to spawn after spending up to several years in freshwater habitats, while some may delay downstream spawning migrations for several years until they have undergone the transition to females in freshwater habitats. Migrations are thought to be triggered by variation in the flow regime (Crook et al., 2017), making the species particularly vulnerable to water resource development. Barramundi can be caught throughout all four fishing seasons, but higher catch rates occur during the build-up and wet season, as barramundi becomes more active with warmer temperatures.

**White banana prawn**

The white banana prawn (*Fenneropenaeus merguiensis*), is a short-lived, fast-growing crustacean species that is an important major commercial fishery resource across tropical Australia (see...
White banana prawns complete their life cycle within a year and can be wild-harvested annually. Their stock is tied to key environmental drivers, particularly annual flood flow (Staples and Vance, 1986; Vance et al., 1985). Each year’s catch of banana prawns is highly variable, being dependent on temporal cycles of monsoonal rainfall and river flows. In addition to forming a major constituent of a high value fishery, white banana prawns are an important ecological species and a key component of marine and estuarine food webs. They provide a significant food source for a myriad of commercially and recreationally valuable fish species in the coastal ecosystem.

A significant body of research has investigated the life cycle, growth, behaviour, and habitat use of the white banana prawn across multiple life stages to help inform the management of the Northern Prawn Fishery (NPF) (Vance et al., 1996; Wang and Haywood, 1999). The NPF is a very well-managed fishery of high economic value. Larger flow events increase prawn catch through greater juvenile emigration from estuaries to offshore habitats where growth is enhanced and mortality is lower for the sub-adult and adult phases (Robins et al., 2005). Recent studies suggest that nutrients exported during the flood flows support enhanced growth and survival and enhanced food availability through primary and secondary production in near-shore habitats (Burford et al., 2010). Assessing the potential impact of water resource development on the NPF is a critical issue, especially for white banana prawns, whose life cycles are intrinsically linked to natural flow regimes.

**Species of significance**

**Magpie goose**

The magpie goose is an iconic waterfowl and wildlife species with significant socio-economic value. Magpie geese are harvested annually and important to cultural practice (Pusey and Kennard, 2009). They are widespread and abundant across the coastal floodplains of northern Australia, with an estimated population size of 3.5 million in the NT alone (Figure 3-10) (Traill et al., 2009). The magpie goose occurs within sub-coastal wetlands across tropical northern Australia. During the wet season, magpie geese make nests from vegetation including sedges and grasses (Colley, 1999). During the dry season magpie geese gather on floodplains in large numbers and feed on the tubers of the sedge *Eleocharis dulcis* (Traill and Brook, 2011). These birds move between river systems in response to seasonal rainfall to find breeding and foraging sites (Traill et al., 2010; Wilson, 1997). The timing of rainfall and monsoonal flooding provide cues for nesting and hatching in magpie geese (Warfe et al., 2011). Flooding triggers dramatic changes in the composition and biomass of floodplain vegetation and, hence, the availability of magpie goose nesting habitat and food (Pusey and Kennard, 2009).
Once prevalent throughout south-east Australia, the distribution of the magpie goose has largely contracted to northern Australia in association with threatening processes including habitat loss, invasive species (e.g. mimosa, para grass, olive hymenachne and pigs) and drought (Traill and Brook, 2011). Recent information suggests that the numbers of magpie geese are on a downward trend, with successive poor wet seasons affecting breeding in the NT (Burton, 2017). Changes to the flooding regime or wetland persistence is likely to impact magpie geese (Pusey and Kennard, 2009).

3.2.5 TERRESTRIAL SYSTEMS

The northern section of the NT has the world’s largest intact savanna and is one of the few remaining natural areas of its kind on Earth (Kutt et al., 2009; Territory Natural Resource Management, 2016). The monsoonal climate controls the ecology of terrestrial, freshwater and coastal systems of northern Australia’s plant and animal species (Figure 3-11). Annual fluctuations in resources dictating migration, dispersal patterns, and fruiting, seeding and flowering are synchronised with this highly seasonal pattern of rainfall (Woinarski et al., 2005).
Intensive agricultural development can cause habitat fragmentation as a consequence of land clearing but the extent of this is dependent on the scale and type of development and the extent to which it is contiguous or in a mosaic. Habitat fragmentation is a critical issue for biodiversity conservation. Fragment size, isolation and the impact of livestock, feral predators and weeds all affect conservation outcomes (Hobbs, 2001). In developing agricultural landscapes in northern Australia, lessons from fragmentation studies are critical. For savanna species, subtle landscape variations provide critical resources for wildlife, and the loss of this variation can lead to local extinctions (Woinarski et al., 2005). For example, for fruit-eating birds, the loss of some of the rainforest or monsoon forest patches within a region is likely to lead to the extinction of many species (Price et al., 1999).

Fragmented habitats in northern Australia are likely to be under extreme pressure from introduced weeds, altered fire regimes and altered hydrology. Taking those issues into account along with the subtle, complex and largely unknown spatial and temporal fluctuations in critical resources required for many vertebrates presents a considerable challenge.

### 3.2.6 ENVIRONMENTAL PROTECTION

There are a number of both aquatic and terrestrial species in the Darwin catchments currently listed as critically endangered, endangered and vulnerable under the EPBC Act and by the Northern Territory Government’s wildlife classification system, which is based on the IUCN Red List categories and criteria (Figure 3-12).

![Figure 3-11 Mary River, showing floodplains, wetlands, riparian areas and terrestrial systems](Photo: CSIRO)
If a proposed development is predicted to have a significant impact on a matter of national environmental significance (e.g. the populations of a nationally listed species, communities, migratory species or wetlands of importance) it would require approval to proceed under the EPBC Act (Table 3-2). This approval is required irrespective of local government policies. The Northern Territory Government lists 18 species, most of them as vulnerable, but one as critically endangered.
Table 3-2 Definition of threatened categories under the EPBC Act (Cth) and the Northern Territory wildlife classification system

<table>
<thead>
<tr>
<th>ACT</th>
<th>CATEGORY</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPBC Act (Cth)</td>
<td>Matters of National Environmental Significance</td>
<td>World heritage properties, National Heritage places, wetlands of international importance (listed under the Ramsar Convention), listed threatened species and ecological communities, migratory species protected under international agreements, Commonwealth marine areas, the Great Barrier Reef Marine Park, nuclear actions (including uranium mines), and water resources, in relation to coal seam gas development and large coal mining development</td>
</tr>
<tr>
<td></td>
<td>Critically endangered species</td>
<td>It has undergone, is suspected to, or is likely to undergo very severe reduction in numbers in the immediate future; its geographic distribution is precarious for the survival of the species and is very restricted. The estimated total number of mature individuals is very low and evidence suggests that the number will continue to decline at a very high rate and the probability of its extinction in the wild is at least 50% in the immediate future</td>
</tr>
<tr>
<td></td>
<td>Endangered species</td>
<td>It has undergone, is suspected to, or is likely to undergo severe reduction in numbers in the immediate future; its geographic distribution is precarious for the survival of the species and is restricted. The estimated total number of mature individuals is low and evidence suggests that the number will continue to decline at a high rate and the probability of its extinction in the wild is at least 20% in the near future</td>
</tr>
<tr>
<td></td>
<td>Vulnerable species</td>
<td>It has undergone, is suspected to, or is likely to undergo substantial reduction in numbers in the immediate future; its geographic distribution is precarious for the survival of the species and is limited. The estimated total number of mature individuals is limited and either evidence suggests that the number will continue to decline at a substantial rate and the probability of its extinction in the wild is at least 10% in the medium-term future</td>
</tr>
<tr>
<td>NT wildlife classification†</td>
<td>Critically endangered communities</td>
<td>Extremely high risk of extinction in the next 10 years or three generations of key species</td>
</tr>
<tr>
<td></td>
<td>Endangered communities</td>
<td>Extremely high risk of extinction in the next 20 years or five generations of key species</td>
</tr>
<tr>
<td></td>
<td>Vulnerable communities</td>
<td>Extremely high risk of extinction in the next 50 years or ten generations of key species</td>
</tr>
</tbody>
</table>

†The Northern Territory wildlife classification categories are based on the International Union for the Conservation of Nature Red List categories and criteria. An extract of each category is presented here. For the full definition see https://nt.gov.au/__data/assets/pdf_file/0010/192538/red-list-guidelines.pdf
3.3 Demographic and economic profile

3.3.1 INTRODUCTION

This section describes the current social and economic characteristics of the Darwin catchments including the demographics of local communities (Section 3.3.1), current industries and land use (Section 3.3.2), and the existing infrastructure (transport, supply chains, utilities and community infrastructure) on which any new development would build (Section 3.3.3). Unless stated otherwise material for this section was sourced from the companion technical report on socio-economics (Stokes et al., 2017).

3.3.2 DEMOGRAPHICS

The Darwin catchments encompass all or part of a number of different local government areas, including the municipalities of Darwin, Darwin Waterfront Precinct, Palmerston and Litchfield, the shires of Wagait, Belyuen and Coomalie, and the most western edge of West Arnhem Regional Council. The Darwin catchments also encompass unincorporated areas, which do not form part of any local council. At the territory level, the Darwin catchments include part or all of a number of electoral divisions, including all of Causarina, Wanguri, Nightcliff, Johnston, Sanderson, Karama, Fannie Bay, Hong Lim, Port Darwin, Spillett, Drysdale, Brennan, Blain, Nelson and Goyder, and part of Daly and Arnhem. At the federal level, the Darwin catchments encompass all of the electoral division of Solomon (the region around Darwin) plus a part of the division of Lingiari (which encompasses the remainder of the NT).

The population of the Darwin catchments is concentrated in the Greater Darwin area (ABS ‘Darwin’ SA4 area, population 136,828), comprising Darwin City (population 6464), Howard Springs (population 5132), several smaller population centres (Palmerston, Howard Springs, and McMinns Lagoon), and surrounding suburbs and rural areas. Population centres outside Greater Darwin, such as Belyuen, Batchelor and Adelaide River, all have populations of less than 1000 according to the 2016 Australian Bureau of Statistics (ABS) census (ABS, 2016a). Other towns within the Darwin catchments include Palmerston, Howard Springs, Belyuen, McMinns Lagoon, Batchelor and Adelaide River. With the exception of Howard Springs (population 5132), all of these towns have populations of less than 1000 according to the 2016 census.

The demographic profile of the Darwin catchments, based on data from the 2016 and 2011 censuses, is shown in Table 3-3. The Darwin catchments contain two very different areas: the urban areas including Darwin and the surrounding suburbs, and the remaining rural areas. The population of the urban areas is predominantly younger, with a larger proportion of Indigenous people than is typical compared to the country as a whole. However, the trends suggest these characteristics are moving towards the national average. The population of the rural areas is older and the proportion of males and of Indigenous people are significantly above the national average. Furthermore the trend over time demonstrates these characteristics of the rural areas are strengthening. The median weekly gross household income for both the urban ($2160) and rural ($1965) areas was above the average for Australia in 2016.
Table 3-3 Major demographic indicators for the Darwin catchments
The Darwin catchments are separated into urban and rural areas because the demographics of the two are so different. The overall demographics for the Darwin catchments are given in the ‘combined’ column.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>UNIT</th>
<th>URBAN AREAS</th>
<th>RURAL AREAS</th>
<th>COMBINED (URBAN + RURAL)</th>
<th>NT</th>
<th>AUSTRALIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population, 2016†</td>
<td>number</td>
<td>112,134</td>
<td>26,918</td>
<td>139,052</td>
<td>228,833</td>
<td>23,401,892</td>
</tr>
<tr>
<td>Total population, 2011‡</td>
<td>number</td>
<td>101,136</td>
<td>21,598</td>
<td>122,734</td>
<td>211,943</td>
<td>21,507,719</td>
</tr>
<tr>
<td>% change in population</td>
<td>%</td>
<td>10.9</td>
<td>24.6</td>
<td>13.3</td>
<td>8.0</td>
<td>8.8</td>
</tr>
<tr>
<td>Indigenous population, 2016, as % of total§</td>
<td>%</td>
<td>8.5</td>
<td>11.1</td>
<td>9.0</td>
<td>25.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Indigenous population, 2011, as % of total§</td>
<td>%</td>
<td>9.6</td>
<td>9.3</td>
<td>9.6</td>
<td>26.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Male population, 2016, as % of total†</td>
<td>%</td>
<td>51.0</td>
<td>59.0</td>
<td>52.5</td>
<td>51.8</td>
<td>49.3</td>
</tr>
<tr>
<td>Male population, 2011, as % of total†</td>
<td>%</td>
<td>51.7</td>
<td>54.4</td>
<td>52.2</td>
<td>51.7</td>
<td>49.4</td>
</tr>
<tr>
<td>Population density, 2016†</td>
<td>people/km²</td>
<td>497.2</td>
<td>0.9</td>
<td>4.5</td>
<td>0.2</td>
<td>3.0</td>
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<tr>
<td>Median age, 2016†</td>
<td>years</td>
<td>33</td>
<td>38</td>
<td>34</td>
<td>32</td>
<td>38</td>
</tr>
<tr>
<td>Change in median age, from 2011 to 2016§</td>
<td>years</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Median weekly gross household income, 2016††</td>
<td>$</td>
<td>2,160</td>
<td>1,965</td>
<td>2,130</td>
<td>1,983</td>
<td>1,438</td>
</tr>
<tr>
<td>Change in median household income, from 2011 to 2016††,††</td>
<td>%</td>
<td>20.6</td>
<td>37.3</td>
<td>23.0</td>
<td>18.5</td>
<td>16.5</td>
</tr>
<tr>
<td>Average people per household, 2016†</td>
<td>number</td>
<td>2.5</td>
<td>3.2</td>
<td>2.6</td>
<td>2.9</td>
<td>2.6</td>
</tr>
<tr>
<td>Change in average people per household, from 2011 to 2016§,††</td>
<td>number</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>No change</td>
<td>No change</td>
</tr>
</tbody>
</table>

†Data sourced from ABS (2016c).
‡Data sourced from ABS (2011c).
§Data sourced from ABS (2016a).
*Data sourced from ABS (2011a).
†† Data sourced from ABS (2016b).
‡‡ Data sourced from ABS (2011b).

Socio-Economic Indexes for Areas (SEIFA) scores, which provide measures of socio-economic advantage and disadvantage, indicate that the combined Darwin catchments study area is around the middle or a little higher than the rest of the country (Table 3-4) but with differences between rural and urban areas.

Table 3-4 SEIFA scores of relative socio-economic advantage for the Darwin catchments
Scores are relativised to a national mean of 1000, with higher scores (smaller deciles) indicating greater advantage. The Darwin catchments are separated into urban and rural areas because the demographics of the two are so different. The overall demographics for the Darwin catchments are given in the ‘combined’ column.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>URBAN AREAS</th>
<th>RURAL AREAS</th>
<th>COMBINED (URBAN + RURAL)</th>
<th>NT</th>
<th>AUSTRALIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score (Decile)</td>
<td>Score (Decile)</td>
<td>Score (Decile)</td>
<td>Score (Decile)</td>
<td>Score (Decile)</td>
<td>Score (Decile)</td>
</tr>
<tr>
<td>Index of Relative Socio-economic Advantage and Disadvantage†</td>
<td>1028 (6)</td>
<td>977 (4)</td>
<td>1019 (6)</td>
<td>922 (3)</td>
<td></td>
</tr>
<tr>
<td>Index of Relative Socio-economic Disadvantage§</td>
<td>1021 (6)</td>
<td>973 (4)</td>
<td>1011 (5)</td>
<td>899 (2)</td>
<td></td>
</tr>
<tr>
<td>Index of Economic Resources</td>
<td>999 (5)</td>
<td>1004 (5)</td>
<td>1000 (5)</td>
<td>896 (2)</td>
<td></td>
</tr>
<tr>
<td>Index of Education and Occupation</td>
<td>1025 (7)</td>
<td>965 (4)</td>
<td>1013 (6)</td>
<td>976 (5)</td>
<td></td>
</tr>
</tbody>
</table>

104 | Water resource assessment for the Darwin catchments
3.3.3 CURRENT INDUSTRIES AND LAND USE

New agricultural development could affect current land users and other industries that rely on natural resources. This section describes current agriculture and fisheries industries in the Darwin catchments, and the other land uses and industries that might be impacted by new development projects.

**Employment**

Within both the urban and rural areas of the Darwin catchments, the overall unemployment rate is close to full employment at less than 5% which is noticeably lower than that seen across the NT and the country as a whole (Table 3-5). The low level of unemployment suggests that industries within the study area may struggle to find enough workers to meet their growth needs, which could place upward pressures on wage rates in the study area.

There are noticeable differences in the industries providing the most jobs, both across the Darwin catchments and compared to Australia as a whole. In terms of the ABS-defined major industry categories, ‘Public administration and safety’ is by far the most significant employer in the urban part of the Darwin catchments and the NT, providing around one in five jobs, but does not feature as one of the top five employers in the country as a whole. Within the rural areas of the Darwin catchments, ‘Construction’ is by far the largest employer. These differences may significantly impact the regional economic benefits that could result from development projects initiated within the Darwin catchments (see Section 6.5).

Table 3-5 Key employment data in the Darwin catchments in relation to state and national means

The Darwin catchments are separated into urban and rural areas because the demographics of the two are so different. Employment within ‘Agriculture, forestry and fishing’ was 0.5% in urban areas, 4.6% in rural areas and 1.2% in the combined Darwin catchments study area. Only the top five industries are provided for each location.

<table>
<thead>
<tr>
<th>EMPLOYMENT STATISTIC</th>
<th>URBAN AREAS</th>
<th>RURAL AREAS</th>
<th>COMBINED (RURAL + URBAN)</th>
<th>NT</th>
<th>AUSTRALIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment rate (%), 2016†</td>
<td>4.8</td>
<td>4.6</td>
<td>4.7</td>
<td>7.0</td>
<td>6.9</td>
</tr>
<tr>
<td>Unemployment rate (%), 2011‡</td>
<td>3.7</td>
<td>3.8</td>
<td>3.7</td>
<td>5.3</td>
<td>5.6</td>
</tr>
<tr>
<td>Major industries of employment – top five industries % of employment for each location†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public administration and safety</td>
<td>19.9</td>
<td>17.1</td>
<td>19.4</td>
<td>19.0</td>
<td>na</td>
</tr>
<tr>
<td>Construction</td>
<td>11.1</td>
<td>19.3</td>
<td>12.5</td>
<td>10.6</td>
<td>8.9</td>
</tr>
<tr>
<td>Health care and social assistance</td>
<td>10.8</td>
<td>na</td>
<td>9.9</td>
<td>11.6</td>
<td>13.2</td>
</tr>
<tr>
<td>Education and training</td>
<td>8.7</td>
<td>8.2</td>
<td>8.6</td>
<td>9.7</td>
<td>9.1</td>
</tr>
<tr>
<td>Retail trade</td>
<td>8.0</td>
<td>6.3</td>
<td>7.7</td>
<td>7.6</td>
<td>10.3</td>
</tr>
<tr>
<td>Professional, scientific and technical services</td>
<td>na</td>
<td>7.0</td>
<td>na</td>
<td>na</td>
<td>7.6</td>
</tr>
</tbody>
</table>

na = not applicable.
†Data sourced from ABS (2016b).
‡Data sourced from ABS (2011b).
Land use

Land use in the Darwin catchments is dominated by conservation and protected land (53%), including 7280 km² of national parks and 1163 km² under traditional Indigenous uses (Figure 3-13). A further 7.2% is classified as water and wetlands, most of which is in several large areas on the western and northern boundaries of the Darwin catchments. Most of the remaining area (36.5%) is used for grazing and livestock production. This includes about 15,000 ha of intensive agriculture and 16,000 ha of dryland cropping. Urban areas (2%) make up most of the remainder of the Darwin catchments, and mining has a concentrated footprint (0.3%).

Figure 3-13 Land use classification for the Darwin catchments

Agriculture and fisheries

Agriculture is a significant contributor to the economy of the Darwin region, with the gross value of agricultural production (GVAP) in the Darwin area approximately $136 million (ABS, 2017; NT Farmers Association, 2016). Cropping accounts for about 90% of the GVAP ($123 million), mostly from fruit, vegetables and hay (NT Farmers Association, 2016). Beef cattle contribute around $13 million to GVAP (ABS, 2017). This is mostly from smallholder beef production as there
are very few pastoral stations of any significant size in the Darwin catchments. Agriculture is not a major source of employment in the Darwin catchments (Table 3-5).

**Grazing industry in the Darwin catchments**

The pastoral industry developed mostly in the regions to the south of Darwin, where larger areas of grassy savanna are well-suited to pastoral production. As the live export trade has developed, the Darwin region has become extremely important as an export hub via Darwin Port. Associated with that, in the Darwin region there are properties for holding cattle prior to export and areas of forage production.

**Past and existing irrigation in the Darwin catchments**

Early agricultural interest in the Darwin catchments was in plantation agriculture. During the 1870s and 1880s around 60,000 ha of land was granted to a number of companies for sugarcane production (Hillock, 2005). A modest sugar mill was established at Delissaville (now known as Belyuen). However, much of this early investment in plantation agriculture was speculative and by 1890 all plantations had been abandoned. There were also efforts by Chinese farmers from 1884 onwards to grow rice on the sub-coastal plains of the Adelaide River (Forster, 1961). However, rice as an industry didn’t receive significant investment until after World War II. Territory Rice Limited was established in 1954 and 300,000 ha was to be made available on the sub-coastal plains. However, only a small area of rice (around 1000 ha) was grown before the operation folded in the early 1960s.

These early attempts at large-scale agriculture in the Darwin region relied on rainfall, exploiting the reliable wet seasons. However, the rainy season is short and it proved difficult to grow grain crops, such as rice. Vegetables and fruit were grown locally from an early stage of development, with early production focusing on providing fresh fruit and vegetables to local residents. Pests and diseases during the wet season proved a challenge for larger scale commercial production, as well as the ability to transport products to markets outside of the NT. Over more recent decades transport links and the ability to control pests have improved and the horticultural industry has developed, with a focus on supplying mangoes and Asian vegetables to the Australian market. There is about 4,400 ha of irrigated land in the Darwin catchments.

**Northern Prawn Fishery**

The Northern Prawn Fishery (NPF) spans the northern Australian coast between Cape Londonderry in WA to Cape York in Queensland (Figure 3-14). It is one of the most valuable fisheries in the country and is managed by the Australian Government (via the Australian Fisheries Management Authority) through input controls such as gear restrictions (number of boats and nets, length of nets) and restricted entry. The Darwin catchments flow into the three western NPF regions: the Joseph-Bonaparte Gulf, Fog Bay and Cobourg-Melville (Figure 3-14). Together, these three NPF regions account for about one-fifth of the total annual NPF prawn catch. Like many tropical fisheries, the target species exhibit an inshore-offshore larval life cycle and are dependent on inshore habitats, including estuaries, during the postlarval and juvenile phase (Vance et al., 1998). Monsoon-driven freshwater flood flows cue juvenile prawns to emigrate from estuaries to the fishing grounds and flood magnitude explains 30% to 70% of annual catch variation, depending on catchment region (Buckworth et al., 2014; Vance et al., 2003).
Initially comprising over 200 vessels in the late 1960s, the number of vessels in the NPF has reduced to just 52 trawlers and 19 licensed operators after management initiatives including effort reductions and vessel buy-back programs (Dichmont et al., 2008). Fishing activity for banana and tiger prawns, which constitute 80% of the catch, is also limited to two seasons: a shorter banana prawn season from April to June, and a longer tiger prawn season from August to November. The specific dates of each season are adjusted depending on catch rates. Banana prawns generally form the majority of the annual prawn catch by volume.

The catch is often frozen on-board and sold in domestic and export markets. The catch from the NPF was valued at $106.8 million in 2015 by the Australian Fisheries Management Authority (AFMA). Given recent efforts to alleviate fishing pressure in the NPF, there is little opportunity for further expansion of the industry.

**Land-based aquaculture in the Darwin catchments**

There is minimal land-based aquaculture in the Darwin catchments (see companion technical report on aquaculture (Irvin et al., 2018)). A farm near Humpty Doo produces more than 1000 tonnes of barramundi per year. The fish are farmed in ponds, with marine water pumped from the
Adelaide River. The Aquaculture Research Centre in Darwin is conducting research on marine species (black-lipped oysters, giant clams and sea cucumbers) with the engagement of Indigenous communities as a key component. Barramundi and tiger prawns were identified as established species suitable for culture in the Darwin catchments. Potential opportunities for land-based aquaculture in the Darwin catchments are discussed in Chapter 4.

**Tourism**

Tourism contributed $52.9 billion (3.2% of GDP) to the Australian economy in 2015–16 (ABS Tourism satellite accounts, 2015–16). International visitors account for 29% of this total contribution to GDP, with the remainder generated by domestic day and overnight stay visitors. The countries providing the largest numbers of international visitors are New Zealand (NZ), China, the United Kingdom (UK) and United States of America (USA).

Of the 76 regions for which Tourism Research Australia collects data, the ‘Darwin’ and ‘Kakadu Arnhem’ tourism regions are most relevant to the Darwin catchments (Figure 3-15). Some of the data regions can be further broken down into smaller ABS SA2 regions. The relevant region for the Darwin catchments is ‘Alligator’, which lies within the larger Kakadu Arnhem tourism region. The boundaries of the Darwin catchments, tourism regions, and the smaller ABS region of Alligator, are shown in Figure 3-16.

![Figure 3-15 Tourism is a major contributor to the economy of the Darwin catchments](Photo: CSIRO)
More than 1.1 million ‘visitors’ (see Table 3-6 footnote, §§, for definition of a ‘visitor’), both international and domestic) visit the Darwin tourism region annually, and over 0.7 million visit the Kakadu Arnhem tourism region (Table 3-6). However, adding the data together risks double counting because the two regions likely receive many of the same visitors. A larger proportion of international visitors (mostly from the UK and Germany) travel to Darwin compared to the national average, but a smaller proportion visit Kakadu Arnhem. For Darwin, day visitors are less frequent than the national average, probably due to the tourism region’s considerable distance from the major population centres. Accordingly, the average length of stay is longer than that for the whole country, and the average spend per visitor is also higher. In contrast, day visitors are more common in the Kakadu Arnhem tourism region than in the rest of Australia, and overnight visitors stay fewer nights and visitors spend less overall.
Table 3-6 Key 2015 tourism data relevant to the Darwin catchments

The extent of the Darwin and Kakadu Arnhem tourism regions are shown in Figure 3-13.

<table>
<thead>
<tr>
<th>TOURISM STATISTIC</th>
<th>DARWIN</th>
<th>KAKADU ARNHEM</th>
<th>NT</th>
<th>AUSTRALIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitors (thousands)*, §§</td>
<td>1,147</td>
<td>743</td>
<td>2,480</td>
<td>266,874</td>
</tr>
<tr>
<td>International visitors (% visitors)*, §§</td>
<td>11</td>
<td>4</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Domestic day visitors (% visitors)*, §§</td>
<td>39</td>
<td>58</td>
<td>40</td>
<td>66</td>
</tr>
<tr>
<td>Visitor nights (thousands)*</td>
<td>6,378</td>
<td>1,358</td>
<td>12,400</td>
<td>560,116</td>
</tr>
<tr>
<td>International visitors (% visitor nights)*</td>
<td>40</td>
<td>11</td>
<td>35</td>
<td>43</td>
</tr>
<tr>
<td>Average stay per overnight visitor (number of nights)*</td>
<td>9</td>
<td>4</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Spend ($ million)*</td>
<td>$972</td>
<td>$231</td>
<td>$2,032</td>
<td>$99,086</td>
</tr>
<tr>
<td>Average spend per visitor ($)*</td>
<td>$847</td>
<td>$311</td>
<td>$820</td>
<td>$371</td>
</tr>
<tr>
<td>International visitors (% spend)*</td>
<td>16</td>
<td>9</td>
<td>21</td>
<td>23</td>
</tr>
<tr>
<td>Room occupancy rate 2015–16 for hotels, resorts, motels, guest houses and serviced apartments§,‡‡</td>
<td>61.6%</td>
<td>42.6%</td>
<td>60.6%</td>
<td>66.0%</td>
</tr>
<tr>
<td>Top three/four countries of origin for international visitors*†</td>
<td>UK, Germany, USA</td>
<td>UK, Germany, France</td>
<td>NA</td>
<td>NZ, China, UK, USA</td>
</tr>
<tr>
<td>Number of tourism businesses in region††</td>
<td>1,288</td>
<td>95</td>
<td>2,066</td>
<td>273,512</td>
</tr>
</tbody>
</table>

NA = no available data.
§Domestic ‘visitors’ represent the number of trips recorded in the National Visitor Survey†,‡ where trip types include (domestic) overnight trips, (domestic) day trips and outbound (international) trips. Some routine trips, such as same-day journeys to work, are excluded. International ‘visitors’ represents the number of short term travellers to Australia from overseas†,‡.

Low room occupancy rates (even during the peak tourism season from July to September) suggest that there is capacity to accommodate additional visitors to the tourism regions, particularly within Kakadu Arnhem. Visitors are drawn to these tourism regions to pursue both city- and nature-based activities (Stokes et al., 2017). In particular, visitors are drawn to the many protected areas close to the Darwin catchments including the Charles Darwin River, Djukbinj, Litchfield, Mary River, Nitmiluk (Katherine Gorge) and Kakadu National Park, which was listed as a World Heritage Site in 1981 for its outstanding cultural and natural values.

Mining

The NT contributes a small proportion to Australian mining industry jobs and revenue, but within the NT, the contribution made by the Darwin catchments is significant. Based on employment by industry sector in the 2011 census data, the Darwin catchments supplied more than 60% of the workers for the NT mining sector (Table 3-7). Based on 2011 census data, mining was the thirteenth most important industry in the Darwin catchments out of 19 industries.
Table 3-7 Key statistics relating to the mining industry in the Darwin catchments

<table>
<thead>
<tr>
<th>EMPLOYMENT STATISTIC</th>
<th>URBAN AREAS</th>
<th>RURAL AREAS</th>
<th>COMBINED (URBAN + RURAL)</th>
<th>NT</th>
<th>AUSTRALIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers employed in mining, Census 2016†</td>
<td>1,081</td>
<td>422</td>
<td>1,503</td>
<td>2,522</td>
<td>177,640</td>
</tr>
<tr>
<td>Numbers employed in mining, Census 2011‡</td>
<td>1,076</td>
<td>563</td>
<td>1,639</td>
<td>2,694</td>
<td>176,560</td>
</tr>
<tr>
<td>Sales and service income of mining sector*, 2014–15 ($ million)§</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>$4,395</td>
<td>$195,519</td>
</tr>
</tbody>
</table>

% Employment within mining sector:

<table>
<thead>
<tr>
<th></th>
<th>Census 2016†</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.9</td>
<td>3.5</td>
<td>2.2</td>
<td>2.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Census 2011‡</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.0</td>
<td>5.1</td>
<td>2.6</td>
<td>2.8</td>
<td>1.8</td>
</tr>
</tbody>
</table>

* Mining sector is defined as coal mining, oil and gas extraction, metal ore mining, non-metallic mineral mining and quarrying. It does not include exploration and other mining support services.
NA = no available data.
† Data sourced from ABS (2016b).
‡ Data sourced from ABS (2011b).
§ Data sourced from ABS (2015).

The mining industry currently has a footprint covering less than 3.5% of the land within the Darwin catchments. However, there are a number of mining exploration licenses in place, covering just over 43% of the land area, indicating the significant potential for further mining operations in the future (Figure 3-17).

Exploration and mining tenements in the Darwin catchments are closely correlated with the Pine Creek Orogen (Figure 2-2), which underlies much of the study area. The Pine Creek Orogen hosts over a thousand mineral occurrences and is among the most prospective geological regions of Australia. It contains approximately 20% of the world’s total uranium resource and approximately nine million mega ounces of gold have been identified. Considerable resources of other commodities exist, including copper, nickel, cobalt, lead, zinc, silver, platinum, palladium, tin, tantalum, tungsten, iron, magnesite and phosphate (Ahmad and Hollis, 2013).

The most economically important gold is hosted in quartz-reef near Pine Creek (the Spring Hill and Mount Porter gold mines). Alluvial gold was originally discovered at Pine Creek in 1871 by workers digging holes for the telegraph line, triggering a gold rush at the time. However, in recent years the main exploration focus has been on hard rock gold, which uses far less water than that required for processing alluvial gold. Gold mineralisation similar to that at Pine Creek also occurs at Tom’s Gully 115 km to the north-north-west, and exploration for areas of similar mineralisation is taking place regionally.

Alluvial tin was mostly mined in the late 1800s with the majority of historic workings located within a north to south corridor extending south of Darwin and in a broad zone north of Pine Creek. Although there are currently no major tin projects operating in the Darwin catchments, recent exploration has refocussed on the potential for sourcing lithium for battery production from Tin-Tantalum-rich pegmatites in the Finniss area south of Darwin.
Figure 3-17 Mining licences, tenements and major resources in the Darwin catchments
Exploration tenements are parcels of land on which a company has rights to explore for specific resources (e.g. minerals, coal or petroleum (oil and/or gas)).

Large quantities of uranium (including the Jabiluka and Ranger Mines) occur to the east of the Darwin catchments in west Arnhem Land (Lambert et al., 2005). Significant uranium deposits also halo an Archean-aged granite dome (McCready et al., 2004), sitting at the boundary between the Finniss and Adelaide catchments in the vicinity of the Rum Jungle Uranium mine. While Rum Jungle is no longer operational, the nearby Browns base metal project is a major resource. Base metals and uranium should be considered largely restricted to a halo around the Archean embayment.

Onshore and offshore basins to the north and west of the Darwin catchments have been covered by oil and gas tenements in the past and are currently under application for exploration rights. However, the prime areas of interest lie predominantly outside of the study area.
3.3.4 CURRENT INFRASTRUCTURE

Existing infrastructure in the Darwin catchments provides a base from which any future development could build. Current infrastructure is described below in terms of transport, supply chains and processing facilities, energy and water services, and community facilities. Costs of new infrastructure are discussed in Chapter 6.

Transport

Outside the Darwin urban footprint, the study area is characterised by a sparse network of major roads (Figure 3-18) with the Stuart Highway being the main access to Darwin from the south.

Figure 3-18 Road rankings and conditions for the Darwin catchments

Rank 1 = well-maintained highways or other major roads, usually sealed; Rank 2 = secondary ‘state’ roads; Rank 3 = minor routes, usually unsealed local roads.

Other major sealed roads include the Cox Peninsula Road and the 230 km Arnhem Highway that links parts of Kakadu National Park with the Stuart Highway. Despite the proximity to Darwin, there are a large number of unsealed minor roads connecting communities and cattle properties.
in the Darwin catchments. These roads involve several creek crossings with limited or no causeway or bridge infrastructure, and are often inaccessible during the wet season.

Figure 3-19 shows the heavy vehicle access restrictions for roads within the Darwin catchments, as per the National Heavy Vehicle Regulator. Except for urban roads in Darwin and other towns, all roads within the Darwin catchments permit Type 2 road trains, which are vehicles up to 53 m in length (typically a prime mover pulling three 40-foot trailers, Figure 3-20). Darwin Port is also accessible by these road trains. Despite the poor condition of many of the local roads, these large road trains are permitted due to minimal safety issues from low traffic volumes and minimal road infrastructure restrictions (e.g. bridge limits, intersection turning safety). However, drivers would regularly use smaller vehicle configurations on the minor roads due to the difficult terrain, single lane access and during wet conditions.

Figure 3-19 Vehicle access restrictions for the Darwin catchments
Truck classes listed from shortest to longest in legend, as shown in Figure 3-17.
Figure 3-21 shows the speed limits for the road network within the Darwin catchments. These speed limits are usually higher than the average speed achieved for freight vehicles, particularly on unsealed Rank 2 and 3 roads. Heavy vehicles using such unsealed roads would usually achieve average speeds of no more than 60 km/hour, often as low as 20 km/hour when transporting livestock.

![Typical vehicle combinations used for agriculture transport in Australia](image1)

**Figure 3-20 Typical vehicle combinations used for agriculture transport in Australia**

![Road speed restrictions for the Darwin catchments](image2)

**Figure 3-21 Road speed restrictions for the Darwin catchments**
The Stuart Highway is the main route to Darwin Port and to markets in the south. From 2002 to 2013 the highway has been closed a total of 41 days due to impassable flooding and high-clearance only restrictions (NT road closure data). For access to Darwin, road closures are minimal. The Darwin catchments have a good quality standard gauge rail line, providing freight access to the port. From 2000 to 2004 the line was extended from Alice Springs to Darwin Port (East Arm), providing rail access to the southern states. The rail line is primarily used for bulk commodity transport (mostly minerals) to Darwin Port. There are no branch lines in the Darwin catchments, and use of the railway within or near the study area requires road transport to loading points (e.g. Adelaide River).

Supply chains and processing

A large proportion of cattle stations in the Darwin catchments (Figure 3-22) can only be accessed via unsealed Rank 3 local roads. Agricultural production is currently dominated by beef and horticulture, particularly live cattle export.

![Figure 3-22 Agricultural enterprises in the Darwin catchments](image)

Roads are colour-coded to show the number of trailers per year of agricultural produce transported along them.
The road network has high volumes of annual truck movements along the Stuart Highway, mostly to Darwin Port (487,000 head of cattle in 2015) via the cattle export depots. There are also up to 400 head per day transported to the AACo (Australian Agricultural Company) abattoir at Livingstone although AACo announced in May 2018 that this abattoir was to be closed.

Table 3-8 provides volumes of agricultural commodities transported into and out of the Darwin catchments. Live export of cattle is by far the biggest industry in terms of volume (2014 values). Some export depots are located outside of the Darwin catchments, which is why there is significant live export temporarily transported outside the study area en route to the port.

### Table 3-8 Overview of agriculture commodities transported into and out of the Darwin catchments

Prices for horticultural produce can vary substantially over time, which in turn can affect what farmers choose to grow.

<table>
<thead>
<tr>
<th>COMMODITY</th>
<th>DESTINATION</th>
<th>INBOUND</th>
<th>OUTBOUND</th>
<th>INDICATIVE PRICES ($/KG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef (head)</td>
<td>Live export</td>
<td>305,280</td>
<td>215,760</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>Abattoirs</td>
<td>90,240</td>
<td>16,560</td>
<td>2.68</td>
</tr>
<tr>
<td></td>
<td>Property</td>
<td>43,440</td>
<td>23,530</td>
<td>2.15</td>
</tr>
<tr>
<td></td>
<td>Feedlots</td>
<td>0</td>
<td>2,400</td>
<td>2.60</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>0</td>
<td>5,040</td>
<td>NA</td>
</tr>
<tr>
<td>Boxed beef (t)</td>
<td></td>
<td>630</td>
<td>29,884</td>
<td>5.48</td>
</tr>
<tr>
<td>Boxed chicken (t)</td>
<td></td>
<td>330</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Mixed (t)†</td>
<td></td>
<td>19,723</td>
<td>381</td>
<td>NA</td>
</tr>
<tr>
<td>All horticulture (t)</td>
<td></td>
<td>21,573</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Bananas (t)</td>
<td></td>
<td>0</td>
<td>3,206</td>
<td>1.92</td>
</tr>
<tr>
<td>Mango (t)</td>
<td></td>
<td>0</td>
<td>16,455</td>
<td>3.14</td>
</tr>
<tr>
<td>Melons (t)</td>
<td></td>
<td>0</td>
<td>7,776</td>
<td>1.07</td>
</tr>
<tr>
<td>Pumpkins (t)</td>
<td></td>
<td>0</td>
<td>559</td>
<td>0.75</td>
</tr>
<tr>
<td>Onions (t)</td>
<td></td>
<td>0</td>
<td>5</td>
<td>0.45</td>
</tr>
<tr>
<td>Asian vegetables (t)‡</td>
<td></td>
<td>0</td>
<td>8,800</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA = not available.  
†Mixed – mixture of horticulture and cold meat, usually from distribution centres.  
‡Source: NT Farmers (2015).

Horticulture, particularly mangoes, melons and Asian vegetables, also has a significance presence in the Darwin catchments. Inbound horticulture and mixed agriculture represents food transported to supermarkets in Darwin.

### Energy

Electricity in the Darwin catchments is supplied by four main power stations and delivered via the Darwin-Katherine Interconnected System (DKIS), the largest energy grid system in the NT. The DKIS is isolated from other Australian grids such as the east coast National Electricity Market (NEM) grid (EPRI, 2015). Combined generation capacity is 511.3 MW and annual electricity production is in the order of 1547 GWh (Power and Water Corporation, 2015a; Territory Generation, 2017) (Table 3-9). Generation and network infrastructure in the vicinity of Darwin are
centrally managed by the Northern Territory Government-owned entities Territory Generation and the Power and Water Corporation respectively. The largest generation facility is the 310 MW Channel Island Power Station (CIPS), located on the island of the same name across the Darwin Harbour to the south of the central business district (CBD) and connected by road to the mainland. CIPS is the main source of electricity for the Darwin-Katherine grid, and is powered by natural gas with diesel fuel back-up capability. Two smaller power stations are located at Pine Creek (26.6 MW, privately owned by a mining company) and Katherine (34.7 MW, also managed by Territory Generation), and provide supplementary energy to the grid and run on gas with diesel fuel back-up capability. The Power and Water Corporation are also investigating the use of an estimated 30 MW of standby generation from commercial customers in the DKIS, additional generation that may be made available under constrained network conditions (Power and Water Corporation, 2015a).

Table 3-9 Energy generation facilities in the Darwin catchments

<table>
<thead>
<tr>
<th>POWER STATION FACILITY NAME</th>
<th>CAPACITY (MW)</th>
<th>ANNUAL ELECTRICITY PRODUCTION (MWh)</th>
<th>GRID</th>
<th>PRIMARY FUEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Island Power Station</td>
<td>310</td>
<td>1,068,439</td>
<td>DKIS</td>
<td>Natural gas (diesel back-up)</td>
</tr>
<tr>
<td>Weddell Power Station</td>
<td>129</td>
<td>430,558</td>
<td>DKIS</td>
<td>Natural gas</td>
</tr>
<tr>
<td>Pine Creek Power Station</td>
<td>26.6</td>
<td>191,081</td>
<td>DKIS</td>
<td>Natural gas</td>
</tr>
<tr>
<td>Katherine Power Station</td>
<td>34.7</td>
<td>11,247</td>
<td>DKIS</td>
<td>Natural gas (diesel back-up)</td>
</tr>
<tr>
<td>Berrimah Power Station</td>
<td>10</td>
<td>Back-up/standby</td>
<td>DKIS</td>
<td>Natural gas</td>
</tr>
<tr>
<td>Shoal Bay Landfill Gas Facility</td>
<td>1.0</td>
<td>7,688</td>
<td>DKIS</td>
<td>Landfill methane gas</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>511.3</strong></td>
<td><strong>1,709,013</strong></td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

na = not applicable.
DKIS = Darwin-Katherine Interconnected System.

While there is significant potential for renewable energy generation, there currently exists only one renewable energy power station in the Darwin catchments. The 1 MW Shoal Bay Landfill Gas facility is a methane generation plant owned by Darwin City Council. Electricity generated is sold back into the grid through a power purchase agreement with Territory Generation (Territory Generation, 2016). There is also an increasing array of large-scale rooftop solar installations such as those at Darwin Airport and Casuarina Shopping Centre. The NT Government has signalled its intent to increase renewable energy generation to 50% by 2030, and as such the renewable generation component is anticipated to increase (Northern Territory Government, 2016).

The DKIS services Darwin city, Palmerston, suburbs and surrounding rural areas of Darwin, terminating some 300 km south at the township of Katherine and its surrounding rural areas (Figure 3-23). The network operations for the DKIS are managed by the Northern Territory Government-owned Power and Water Corporation and regulated by the Utilities Commission of the NT. The Utilities Commission regulates licences and applies a Guaranteed Service Level Scheme to customers consuming below 160 MWh (Power and Water Corporation, 2015a). The DKIS electrical network operates at transmission voltages of 132 and 66 kV and distribution reticulation at 22 kV and 11 kV.

The Darwin-Katherine Transmission Line (132kV) extends from CIPS to a 132/22 kV substation adjacent to the Katherine Power Station, with a 132/22 kV substation at Manton Dam and a
132/66 kV substation at Pine Creek. South of Darwin, a single 66 kV 15 MVA overhead line extends south-eastward from the Stuart Highway near Humpty Doo and along the Arnhem Highway to the Mary River (Power and Water Corporation, 2015a). This small rural system is not cyclone coded and is being upgraded to provide an alternative supply from the Humpty Doo Zone Substation (Power and Water Corporation, 2015a).

The Northern Territory Government-owned Jacana Energy is the dominant electricity retailer for the majority of residential and light commercial customers in the DKIS. There is competition in the market for major commercial and industrial customers and these customers have a number of retailers (Utilities Commission, 2016).

Water

Darwin River Dam currently supplies 85% of the urban water demand and the McMinns and Howard East Borefields in the DRWCD currently supply on average 15% of urban water demand (Power and Water Corporation, 2015a). Storage capacity of the Darwin River Dam is approximately
265,000 ML, and the borefields can supply a maximum capacity of approximately 23 ML/day under best operating conditions (Power and Water Corporation, 2015b). The utilisation rate for the source water asset is between 71% (based on water licences) and 100% (based on available extraction) and heavily dependent on seasonal water yields (Power and Water Corporation, 2015b). There is no conventional water treatment plant for the Darwin water supply; the water is simply disinfected and fluoridated before provision to customers (Power and Water Corporation, 2015b). The Darwin area requires a new water source to be identified and developed to meet the needs of the projected demand over the next five years (Power and Water Corporation, 2015b). Possible future water supply sites short-listed by Power and Water for future consideration include Adelaide River offstream water storage (AROWS), Upper Adelaide River Dam, Mount Bennett Dam and the Marrakai Dam (DLPE, 2015).

The extent of reticulated water supply in the Greater Darwin area extends from the Darwin CBD in the north, to some 75 km south along the Stuart Highway to the intersection of Manton Dam (Figure 3-24). The easternmost point of the reticulated network extends about 13 km east from the Stuart Highway at Coolalinga to Herbert (Power and Water Corporation, 2017a).

Beyond Manton Dam in the south-west, bulk supply pipeline infrastructure connects the Darwin River Dam (DLPE, 2015). Manton Dam is not currently in service, and will require major infrastructure investment (about $100 million) to return to service (Power and Water Corporation, 2015b).

Outside of the Darwin urban water network, private water supplies rely on groundwater as the dominant form of water supply. Some isolated settlements are also provided with off-grid reticulated water within small residential zones. The satellite residential area of Mandorah, located across the Darwin Harbour from the Darwin CBD, has a local borefield and 12 km of water reticulation network for approximately 200 residential lots (Power and Water Corporation, 2015b, 2017a).

A second isolated water network at Murrumujuk, to the north north-east of the Darwin water grid, consists of 16 km of water reticulation and is 20 km from the nearest link to the Darwin water grid (DLPE, 2015; Power and Water Corporation, 2017a). Two Indigenous communities, Belyuen and Acacia-Larrakia (both with populations under 200) are supplied with isolated public (ground) water and sewerage services with local reticulation by Power and Water Corporation under a community service obligation to the Northern Territory Government (IES, 2016).
Before investigating the potential for new dams in the Darwin catchments it is prudent to first examine existing dams and the extent of regulation and quantities of general and strategic reserves in river systems. Table 3-10 lists existing large dams (>10 GL capacity and >10m wall height) in the Darwin catchments.

Two large dams have been constructed in the Darwin catchments, Darwin River Dam and Manton Dam. Further detail on these existing dams is provided in the companion technical report on surface water storage (Petheram et al., 2017).
Table 3-10 Constructed large dams in the Darwin catchments
Locations in parentheses indicate Australian Water Resource Council catchment.

<table>
<thead>
<tr>
<th>NAME OF DAM</th>
<th>NEAREST TOWN</th>
<th>ORIGINAL OWNER</th>
<th>YEAR CONSTRUCTED</th>
<th>HEIGHT ABOVE BED LEVEL (M)</th>
<th>STORAGE CAPACITY AT FSL (GL)</th>
<th>PRIMARY INTENDED PURPOSE</th>
<th>TYPE OF DAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darwin River Dam</td>
<td>Darwin</td>
<td>NT PWC</td>
<td>1972</td>
<td>27</td>
<td>265</td>
<td>Water supply</td>
<td>Concrete gravity</td>
</tr>
<tr>
<td>Manton Dam</td>
<td>Darwin</td>
<td>NT PWC</td>
<td>1942</td>
<td>24</td>
<td>13</td>
<td>Recreation</td>
<td>Concrete gravity</td>
</tr>
</tbody>
</table>

Source: ANCOLD Register of Large Dams (https://www.ancold.org.au/).

Darwin River Dam

The Darwin River Dam, owned and operated by the Northern Territory Power and Water Corporation, currently provides 85% of Darwin’s water supply (Figure 3-25). The dam was completed in 1972 with a 35 m wide uncontrolled spillway on the left abutment. The spillway was widened in 2002 to 265 m to improve spillway capacity and in 2010, the embankment was upgraded and the spillway crest raised 1.3 m, increasing storage capacity and water yield. There is limited capacity to further increase the storage capacity of the Darwin River Dam.

Figure 3-25 Darwin River Dam looking upstream
Photo: CSIRO

Releases from the dam are made via a pipeline to a pump station downstream of the dam and then via pipeline to a reservoir and transfer station where the supply is blended with the bore
water supply. Environmental flow releases are also made to the river. Power and Water is licensed to extract 49.1 GL from the dam.

**Manton Dam**

Manton Dam was Darwin’s first source of surface water supply (Figure 3-26). Construction was completed in 1942. Supply was conveyed to Darwin via a pump station downstream of the dam and two transmission pipelines (300 mm and 375 mm diameter). Since the completion of the Darwin River Dam in 1972, Manton Dam has not been used as part of the Darwin supply. Releases from the dam can be made to the river through a micro hydro-electric power plant. The dam, which is also managed by the Northern Territory Power and Water Corporation, has in recent years become a popular recreation facility for boating, water sports and fishing.

The Power and Water Corporation intend to return the dam to its water supply service function by about 2025 as a short-term measure to provide additional water supply to Darwin. Consideration has been given to developing larger storage at the site by constructing a higher dam downstream of the existing structure or, alternatively, a higher dam further upstream in the catchment, maintaining the storage level in the existing dam. Consideration has also been given to a raising of the existing dam structure. These options would have major impacts on the existing recreation facilities and only provide a modest increase in the available supply.

![Figure 3-26 Manton Dam looking upstream](Photo: CSIRO)

The return to service of Manton Dam would involve a new intake arrangement, new suction main, pump station and 21 km long 1050 mm diameter delivery main to a proposed new storage and treatment facility at Strauss, south of Darwin city.
Current surface water use and allocation

Surface water allocations have been granted for urban and agricultural use in the Darwin area from various streams. The largest allocation is for public water supply at 56 GL/year, extracting water mainly from Darwin River. Agriculture is the next largest user of fresh surface water with allocations totalling 3.8 GL/year most of which is located in the Adelaide River catchment.

Current groundwater use and allocation

Groundwater allocations are prominent in parts of the Darwin catchments, particularly in the DRWCD in the northern Finniss and Adelaide catchments (Figure 3-27).

![Figure 3-27 Current groundwater allocations for the Darwin catchments](source)

Most of the groundwater allocated comes from the Proterozoic dolostone (Koolpinyah Dolostone, Coomalie Dolostone and the Berry Springs Dolostone) aquifers. The purpose of the allocations from these aquifers is mostly for irrigated agriculture (6.6 GL/year) and to supplement Darwin’s public water supply (8.4 GL/year). An almost equivalent amount of groundwater is also allocated for the purpose of irrigated horticulture and domestic supplies, but the use is unmetered due to the ‘15 litre per second exemption’. This exemption, which excludes bores that pump less than 15 litres per second from having a licensed allocation, has been in place since the commencement of the Water Act in 1992, but has recently been revoked (DENR, 2017). Marsden Jacob Associates
(2012) estimated that in 2012 approximately 10 GL/year of unmetered groundwater use was occurring in the DRWCD from bores using groundwater for irrigated horticulture and domestic purposes under the ‘15 litre per second exemption’. Other major allocations of groundwater are associated with the Coomalie Dolomite aquifer, where approximately 2 GL/year is allocated for the water supply for the town of Batchelor. The only other significant groundwater allocation is for the Koolpinyah Dolostone aquifer in the Wildman catchment. This allocation is approximately 8 GL/year and was for irrigated agriculture which has now ceased and the allocation is now not fully utilised.

Projected urban and industrial water demand

Current annual demand for water in the Greater Darwin region (i.e. between about 40 to 45 GL) is approaching the current water supply system yield. The Power and Water Corporation is currently investigating short and medium-term supply augmentation options. The Darwin River Dam storage level was raised in 2010 as a short-term option at the time. The return to service of Manton Dam to provide additional water supply to Darwin is an additional short-term option. Medium to long-term options include the construction of a new reservoir. At the moment the preferred option of the Power and Water Corporation is the Adelaide River offstream water storage (AROWS).

Darwin’s future annual water demand to 2065 is projected to be between about 50 and 60 GL depending upon assumptions regarding population growth and the success of demand management programs (e.g. Living Water Smart).

Community infrastructure

The availability of community services and facilities can play an important role in attracting or deterring people from living in newly-developed areas in the Darwin catchments. The rural parts of the Darwin catchments are served by 16 schools and total student numbers have risen slightly from 2991 in 2012 to 3308 in 2016. A further 59 schools service the urban parts of the Darwin catchments (Stokes et al., 2017).

Within the Darwin catchments there is one public and one private hospital, both located in Darwin (Table 3-11). A new public hospital in Palmerston is scheduled to come into service in 2018. Each 1000 people in Australia require 4.0 hospital beds served by 28 fulltime equivalent hospital staff and $4.0 million/year funding to maintain current mean national levels of hospital service (AIHW, 2017a).

Recent census data showed that approximately 10% of private dwellings in the Darwin catchments were unoccupied. This is a smaller proportion than the NT and national average (Table 3-12) and suggests that the current pool of housing may have limited capacity to absorb any future increases in population.
Table 3-11 Hospitals servicing the Darwin catchments

<table>
<thead>
<tr>
<th>HOSPITAL NAME</th>
<th>URBAN CENTRE</th>
<th>BEDS</th>
<th>PUBLIC/PRIVATE</th>
<th>EMERGENCY</th>
<th>OTHER SERVICES</th>
<th>PEER GROUP CLASSIFICATION†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darwin Private Hospital</td>
<td>Darwin</td>
<td>100 -199</td>
<td>Private</td>
<td>No</td>
<td>Yes</td>
<td>Private acute group C hospitals</td>
</tr>
<tr>
<td>Royal Darwin Hospital</td>
<td>Darwin</td>
<td>360</td>
<td>Public</td>
<td>Yes</td>
<td>Yes</td>
<td>Principal referral hospitals</td>
</tr>
<tr>
<td>Palmerston Regional Hospital</td>
<td>Palmerston</td>
<td>116</td>
<td>Public</td>
<td>Yes</td>
<td>Yes</td>
<td>(scheduled May 2018)</td>
</tr>
</tbody>
</table>

†Data sourced from AIHW (2015).
Sources: AIHW (2017b), MyHospitals website.

Table 3-12 Number and percentage of unoccupied dwellings and population for the Darwin catchments

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>UNIT</th>
<th>URBAN AREAS</th>
<th>RURAL AREAS</th>
<th>COMBINED (URBAN + RURAL)</th>
<th>NT</th>
<th>AUSTRALIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population, 2016†</td>
<td>Number</td>
<td>112,134</td>
<td>26,918</td>
<td>139,052</td>
<td>228,833</td>
<td>23,401,892</td>
</tr>
<tr>
<td>Total unoccupied private dwellings, 2016‡</td>
<td>Number</td>
<td>4,811</td>
<td>1,073</td>
<td>5,885</td>
<td>10,717</td>
<td>1,039,874</td>
</tr>
<tr>
<td>% private dwellings that are unoccupied‡</td>
<td>%</td>
<td>10.4</td>
<td>10.1</td>
<td>10.3</td>
<td>14.1</td>
<td>11.2</td>
</tr>
</tbody>
</table>

†Data sourced from ABS (2016a).
‡Data sourced from ABS (2016c).

3.4 Social and investor values

3.4.1 INTRODUCTION

There are a diverse set of stakeholders with different and sometimes conflicting interests and values relating to the use of water resources and irrigated agricultural development across the Darwin catchments. If greenfield developments were to proceed, the diversity of stakeholder perspectives has implications for the ability of developers to gain and maintain social licence to operate throughout the development process.

3.4.2 STAKEHOLDERS, THEIR VALUES AND POTENTIAL ENGAGEMENT STRATEGIES

Stakeholder analysis and a literature review suggests that northern Australia is highly valued, with the extent and nature of these values shifting through time and between stakeholder groups. For example, from about the late 20th century northern Australia has become increasingly valued for the environmental, aesthetic, cultural and recreational services it provides, rather than its ability to produce agricultural commodities. The rainbow diagram in Figure 3-28 illustrates the diversity of local and national stakeholders in the Darwin catchments, and their likely support for greenfield development of irrigated agriculture. It is important to note that many context-specific factors are missed in this top-down process, and that factors such as the scale of the benefits and to whom benefits may flow may impact support.
Figure 3-28 Rainbow diagram classifying stakeholders according to their likely support of irrigated agriculture in a greenfield site in the Darwin catchments. Stakeholders to the right of the diagram are more likely to be supportive. Internal ring = local stakeholders, external ring = regional, national and international stakeholders, NRM = natural resource management, NT = Northern Territory.
Based on stakeholder analysis and literature review (see Stokes et al., 2017).

Underpinning the likely support, or lack thereof, of stakeholder or interest groups for the potential development of greenfield irrigated agriculture in northern Australia are a set of social values, beliefs, attitudes and norms that are often shared within each group. In general, demographers and commentators note a shift from productivist values (Irving, 2014) centred around the belief that economic productivity and growth are desirable outcomes, towards consumptive (for amenity) and protectionist values in northern Australia (Holmes, 2012). Table 3-13 summarises key stakeholder values that may impact the social licence to operate of development initiatives such as greenfield agriculture. Indigenous-specific values are summarised in Section 3.5.
Table 3-13 Summary of published stakeholder and interest group values relevant to the development of greenfield irrigated agriculture in northern Australia
Ordered least likely to support development through to most likely to support development (as per Figure 3-25). Stakeholder groups who broadly share values related to potential development are combined.

<table>
<thead>
<tr>
<th>STAKEHOLDER</th>
<th>VALUES, ATTITUDES, BELIEFS AND NORMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Inter)national environmental organisations</td>
<td>Want natural environment protected, Indigenous culture valued, sustainability maintained. The ‘real Australia’, utopia, setting for psychological challenges, a ‘proving ground’. Current human geography valued (e.g. few people, poor roads/lack of 2WD access). Valued for nature-based activities, large fish populations, scenic areas and secluded locations. Concern about land clearing, threats to Indigenous values, river diversion, irrigated agriculture, water as a public asset, rivers not dammed, no inter-basin transfer of water or groundwater extraction.</td>
</tr>
<tr>
<td>Four-wheel drivers, retired domestic tourists, international tourists, bushwalkers, safari hunters</td>
<td></td>
</tr>
<tr>
<td>Southern Australians</td>
<td>High value placed upon condition of floodplains, quality of recreational fishing, condition of waterholes. High willingness to pay for rivers to be managed for recreation, cultural and environmental services. Small proportion considers irrigated agriculture important, or wishes it to increase significantly.</td>
</tr>
<tr>
<td>Residents</td>
<td>Passion for rivers, camping, fishing, strong place attachment to rivers and related recreation.</td>
</tr>
<tr>
<td>Amateur fishers and their representatives</td>
<td>Strongly value perceived easy lifestyle (current human geography). Environment and recreation more important than new commercial/retail business and primary industries. Low value placed on income from irrigation agriculture, high value on environmental and cultural assets. Less willing to pay for management of cultural services than southern Australians. Lack of trust in government-driven planning.</td>
</tr>
<tr>
<td>Local shires</td>
<td>Vision: highly productive, innovative, resilient, commercially exciting economy, culturally diverse, dynamic, inclusive communities, relaxed. Value developments that leverage and consider social, economic and environmental assets, impacts. Interest in carbon trading, arts and culture sector, nature and culture-based tourism. Infrastructure, institutions and social capital cited as higher concerns to development than lack of water.</td>
</tr>
<tr>
<td>Regional economic development representatives</td>
<td></td>
</tr>
<tr>
<td>Pastoralists</td>
<td>Occupation as a lifestyle choice and for identity. Environmental stewardship goals and lifestyle goals more important than economic goals Low ability to adapt to change. Free trade, open markets, property rights and private enterprise. Want institutions and infrastructure (largely road networks, but also soft infrastructure) for development.</td>
</tr>
<tr>
<td>Agricultural representatives</td>
<td>Self-identify as innovators, high adaptive capacity, strong motivations towards profitability. Express concern about the environment (including water quality) but not the rhetoric of wilderness.</td>
</tr>
<tr>
<td>Horticulturalists</td>
<td></td>
</tr>
</tbody>
</table>

Stakeholders are also differentiated in terms of their level of interest in, and influence over, an action or change. These differences can help guide engagement strategies, especially when combined with an understanding of stakeholder values like those highlighted in Table 3-13. Interest/influence matrices generated by the Assessment’s stakeholder analysis and literature
review mapped stakeholders into four broad types of appropriate engagement: (i) partner, (ii) involve/engage, (iii) consult, and (iv) inform (Table 3-14). It is important to note that this approach is indicative: a bottom-up stakeholder identification process is a more intensive, rigorous and best-practice approach (Reed et al., 2009) for understanding stakeholders. The approach used by Nolan (2010) for the Howard East Aquifer provides a good example.

Table 3-14 Stakeholder engagement typology for the Darwin catchments, as determined via influence/interest matrices related to the development of irrigated agriculture in a greenfield site.
Partner = High interest, high influence. Involve/engage = Low or moderate interest, high influence. Consult = High interest, low or moderate influence. Inform = Low interest, low influence.

<table>
<thead>
<tr>
<th>SCALE</th>
<th>PARTNER</th>
<th>INVOLVE/ENGAGE</th>
<th>CONSULT</th>
<th>INFORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>–</td>
<td>Amateur fishers</td>
<td>Horticulturalists</td>
<td>Australian Government</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Irrigated foresters</td>
<td>– environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mining interests</td>
<td>– defence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Natural resource management organisations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pastoralists</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Residents</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Traditional Owners</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Traditional Owner corporations</td>
<td></td>
</tr>
<tr>
<td>Regional</td>
<td>Australian Government</td>
<td>Office of Northern Australia</td>
<td>Agricultural representatives (Northern Territory)</td>
<td>Agricultural representatives</td>
</tr>
<tr>
<td></td>
<td>– primary industries</td>
<td>Australian and Southern</td>
<td>Environmental organisations (international and national)</td>
<td>Bushwalkers</td>
</tr>
<tr>
<td></td>
<td>– water</td>
<td>Australians</td>
<td>Indigenous business representatives</td>
<td>Creative industry</td>
</tr>
<tr>
<td></td>
<td>Northern Australia Development Office</td>
<td></td>
<td>Indigenous heritage protection agencies</td>
<td>Australian Government</td>
</tr>
<tr>
<td></td>
<td>NT Government</td>
<td>Northern Australia Development Office</td>
<td>Indigenous Land Councils</td>
<td>– environment</td>
</tr>
<tr>
<td></td>
<td>– environment</td>
<td>NT Government</td>
<td>Indigenous natural resource management organisations</td>
<td>Four-wheel drivers</td>
</tr>
<tr>
<td></td>
<td>– infrastructure, planning, logistics</td>
<td></td>
<td>Regional economic development representatives (regional and national)</td>
<td>Mining interests</td>
</tr>
<tr>
<td></td>
<td>– primary industries</td>
<td>NT Government</td>
<td></td>
<td>Natural resource management organisations</td>
</tr>
<tr>
<td></td>
<td>Utilities provider(s)</td>
<td>NT Government</td>
<td></td>
<td>Safari hunters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NT Government</td>
<td></td>
<td>Tourism industry</td>
</tr>
</tbody>
</table>

Stakeholders in the ‘partner’ section are likely to have a high level of interest and influence related to potential developments in the Darwin catchments. Early, intensive, iterative engagement with these groups, resulting in the co-design of development initiatives, may be most appropriate for these groups. Regular discussions are likely to be appropriate with involve/engage/consult stakeholders. Stakeholders in the ‘inform’ section may accept occasional one-way communication about development in the Darwin catchments.

The results of this analysis suggest that careful thought is needed as to the purpose of development, which ecosystem services may change through the development, how stakeholders are engaged and to whom benefits are intended, as key stakeholder values relate to all of these factors. At scale, development planning and implementation is likely to require a systematic and robust social impact analysis, including an investigation of, and ongoing engagement with, stakeholders and their interests.
3.4.3 POTENTIAL INVESTORS IN IRRIGATED AGRICULTURE

Very little is known about pre-existing or potential investors. To help address this gap, this section provides an initial exploration of potential investors in irrigated agriculture in northern Australia. An initial typology of potential investors across northern Australia highlighted the variety of potential groups and their disparate investor potential, indicated by access to natural and human/financial/social capital. For example, Indigenous landholding/leaseholding corporations have potential access to a significant level of natural capital for development, whereas family trusts may have high levels of human/financial/social capital but little access to natural capital. From this typology, six groups were interviewed (see Section 3.5 for the results of interviews with Indigenous Traditional Owners). Investors or potential investors from international agribusinesses, large companies with agricultural interests and small-scale owner-operator horticulturalist types were also interviewed across northern Australia, with five from the Darwin catchments. These investors perceived similar investment constraints as investors across northern Australia, and there was no difference between investor perspectives and investor type. In order of importance, these perceived constraints were: i) institutional uncertainty, ii) institutional complexity, iii) economy of scale issues, iv) poor infrastructure, and v) training and retaining a skilled workforce. Institutional certainty, simplicity and bureaucratic speed were the key perceived potential enablers of investment in irrigated agriculture. There was less consistency between investors regarding other enablers of irrigated development. Regardless, government support was the most consistently cited enabler of further investment.

The data represents a preliminary sample that acts as a marker of the additional information required to secure investor potential. This is particularly so for small- to medium-scale investors (including local landowners and leaseholders) whose views may not be so effectively represented at higher levels of decision making.

3.5 Indigenous values, rights, interests and development objectives

3.5.1 INTRODUCTION AND RESEARCH SCOPE

Indigenous people represent a substantial and growing proportion of the population across northern Australia, and control significant natural and cultural resource assets, including land, water, and coastlines. They will be crucial owners, partners, investors, and stakeholders in future development. Understanding the past is important to understanding present circumstances and future possibilities. Section 3.5 provides some key background information about the Indigenous Australians of the Darwin catchments and their specific values, rights, interests and objectives in relation to water and irrigated agricultural development. Section 3.5.2 describes the past habitation by Indigenous people, the significance of water in habitation patterns, and the impact of exploration and colonisation processes. Section 3.5.3 reviews the contemporary situation with respect to Indigenous residence, land ownership and access. Section 3.5.4 outlines Indigenous water values and responses to development, and Section 3.5.5 describes Indigenous-generated development objectives.

The material provided here represents a short summary of the research undertaken, and further details regarding this component of the Assessment are contained in the companion technical
Engagement with Indigenous people is a strong aspiration across governments and key industries, but models of engagement can vary considerably and competing understandings of what ‘engagement’ means (consultation, involvement, partnership, etc.) can substantially affect successful outcomes. Standard stakeholder models can also marginalise Indigenous interests, reducing what Indigenous people understand as prior and inalienable ownership rights to a single ‘stake’ equivalent to all others at the table.

Guided by advice from the Northern Land Council (NLC) and from senior Traditional Owners in the study area, the Assessment engaged nominated senior Indigenous decision makers from within the Darwin catchments in one-on-one and small group interviews and in regional NLC meetings to establish a representative range of views regarding water and agricultural development. The companion technical report (Barber, 2018) provides details of this data and is a crucial supporting document for the summary provided here. A small number of comments are replicated in the following sections to show the type of data obtained, complemented by key themes analysed in the data. The Assessment does not provide formal Indigenous group positions about any of the issues raised and does not substitute for formal processes required by cultural heritage, environmental impact assessment, water planning, or other government legislation. Nevertheless, the research undertaken for this component of the Assessment identifies key principles, important issues and potential pathways to provide effective guidance for future planning and for formal negotiations with Indigenous groups.

3.5.2 PRE-COLONIAL AND COLONIAL HISTORY

Pre-colonial Indigenous society

Pre-colonial Indigenous society is distinguished by four primary characteristics: long residence times; detailed knowledge of ecology and food gathering techniques; complex systems of kinship and territorial organisation; and a sophisticated set of religious beliefs, often known as Dreamings. These Indigenous religious cosmologies provided a source of spiritual and emotional connection as well as guidance on identity, language, law, territorial boundaries, and economic relationships (Rose, 2002; Strang, 1997; Williams, 1986). From an Indigenous perspective, ancestral powers are present in the landscape in an ongoing way, intimately connected to people, country, and culture. Those powers must be considered in any action that takes place on the country. Northern Australia contains archaeological evidence of Indigenous habitation stretching back many thousands of years (Clarkson et al., 2017), but there remain gaps in the published archaeological record. Resource-rich riverine habitats were central to Indigenous economies based on seasonally-organised hunting, gathering and fishing. Rivers were also major corridors for social interaction, containing many sites of cultural importance (McIntyre-Tamwoy et al., 2013).
Colonisation

European colonisation resulted in very significant levels of violence towards Indigenous Australians, with consequent negative effects on the structure and function of existing Indigenous societies across the continent. Avoidance, armed defensiveness, and overt violence were all evident in colonial relationships as hostilities occurred as a result of competition for food and water resources, colonial attitudes and cultural misunderstandings. The establishment of pastoralism was a focus for conflict as pastoral homesteads and outstations were sited close to permanent water and the animals grazed fertile plains and river valleys used by Indigenous people for food and other resources (McGrath, 1987). As a consequence, Indigenous attacks on colonial pastoral operations were made both in retaliation for past attacks by colonists and as a response to shortages of food and other resources.

The Darwin area was first colonised in the 1860s and grew quickly following the discovery of gold at Pine Creek soon after. When the *Northern Territory Aboriginals Act 1910* (SA) was passed, it made the Chief Protector of Aborigines in the NT the guardian of all children designated as either Aboriginal or half-caste (Aboriginal people of mixed descent) until they were 18 years old. Movements became restricted and children were forcibly removed. Children continued to be removed under this policy for decades, and some of the participants in the Assessment were people who were removed in this way.

Through the first half of the 20th century, Indigenous people became increasingly employed in the pastoral industry and took positions as stockmen and domestic workers. Extended families resided with their employed kin on the stations and received rations from the station owners, increasing the importance of the stations to Indigenous lives. Stock work also meant that some people were able to access their traditional lands, albeit in a modified way. In the second half of the 20th century, the closure of missions and government reserves, followed by the implementation of the Federal Pastoral Industry Award in 1968 resulted in considerable further social dislocation. Indigenous stockworkers and their families either left, or were evicted from stations and reserves, and the subsequent technological development in pastoralism (helicopters, motorcycles) further reduced the demand for Indigenous labour. Indigenous people from the Darwin catchments retained strong ties to one another and to local cultural landscapes, but were obliged to move into Darwin and into regional towns such as Adelaide River and Batchelor as well as to smaller settlements and encampments.

### 3.5.3 CONTEMPORARY INDIGENOUS OWNERSHIP, MANAGEMENT, RESIDENCE AND REPRESENTATION

Despite the pressures entailed by colonisation, country remained crucial to Indigenous peoples’ lives, sustaining a distinct individual and group identity as well as connections to past ancestors and future descendants. People are connected to places through a combination of genealogical, traditional and residential ties. Only some of these connections are formally recognised by the Australian state.

**Indigenous ownership**

The Indigenous owners of the Darwin catchments include the Makmak Marranungu, Kungarakan, Warai, Limilngan-Wulna, Minitja, and Larrakia peoples. There are also a range of related groups...
and subgroups within these regional ownership descriptors. The Assessment focused on the upstream rural and regional areas of the Darwin catchments and so did not engage the Larrakia people of Darwin itself, but focused on the other named groups. Ownership patterns tend to follow natural landscape features such as rivers and hills, and in some cases formal boundaries between ownership groups have been negotiated. However, in other places the edges of group territory are less distinct and/or there are overlapping claims. Information regarding the identification of potential owners and interest holders is provided by registered organisations such as the NLC and the Aboriginal Areas Protection Authority (AAPA).

In the NT jurisdiction there is specific land rights legislation that covers a wide area of the NT, namely the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) (ALRA). This provides a form of collective freehold ownership, and two significant areas of the Finniss catchment are held through this form of ownership (Figure 3-29).

![Figure 3-29 Indigenous freehold (Aboriginal Land) in the Darwin catchments as at July 2017](image)

**Figure 3-29 Indigenous freehold (Aboriginal Land) in the Darwin catchments as at July 2017**

Data source: Northern Land Council (NLC)

Across the whole of Australia, the primary form of recognition for Indigenous interests is native title and associated Indigenous Land Use Agreements (ILUAs). Native title provides a series of
Indigenous native title claims and determinations

- Native title determined not to exist
- Registered applications for native title
- Schedule of native title determination applications
- ILUA registered

Figure 3-30 Indigenous native title claims and determinations in the Darwin catchments as at July 2017
Data sources: National Native Title Tribunal and Northern Land Council

Indigenous population and residence

Indigenous people comprise 9% of the total population in the Darwin catchments (Table 3-3). This includes Indigenous people who are part of the recognised local ownership groups identified above, as well as residents who identify as Indigenous but have their origins elsewhere. For many Traditional Owners, primary residential locations may be outside of the traditional lands to which they have formal ties. These patterns of residence and dispersal reflect a combination of historical involuntary relocation, voluntary movement to seek jobs and other opportunities, and kinship and family links. Indigenous communities in the Darwin catchments face a range of social and
demographic challenges, including significant unemployment, poor health and housing, structural impediments to economic participation, and social and family units under high levels of stress. Assessment participants sought economic and social conditions that would enable more of their people to reside on their own traditional lands as one response to these circumstances.

**Indigenous governance and representation**

Indigenous organisational and political structure within the Darwin catchments is quite diverse. The NLC is the major regional Indigenous representative organisation for the Darwin catchments, representing and acting for Traditional Owners with respect to Indigenous access, participation, partnership and ownership. Local groups in the area are represented through a range of Indigenous corporations and entities. Amongst the Indigenous groups consulted for this study, there were significant variations in existing capacity, resourcing, and ability to participate in natural resource management decision making.

### 3.5.4 INDIGENOUS WATER VALUES AND RESPONSES TO DEVELOPMENT

**Introduction: attachment, ownership, protection**

Indigenous values in relation to their country in the Darwin catchments encompass principles of attachment, ownership, and the responsibility to protect it. These are manifested in practical terms through:

- The assumption of Indigenous ownership of land and water resources.
- The need for formal external recognition of that ownership.
- The role of local histories in establishing local Indigenous connections and authority.
- The ongoing role of religious and spiritual beliefs.
- The existence of ongoing knowledge of group and language boundaries and identities.
- The importance of hunting and fishing activity to Indigenous cultures.
- Inter-generational obligations to both ancestors and descendants to care for the country.
- Regional responsibilities to near neighbours and downstream groups to maintain the integrity of the country.

These principles also apply to Indigenous attitudes to non-Indigenous activities on Indigenous lands. Four frequently highlighted principles include:

- consultation with the relevant owners
- consent for development
- compliance with the terms of policies and agreements, including Traditional Owner employment
- compensation for the access and use of resources.

These principles have clear implications for native title, cultural heritage and environmental impact assessment, as well as for broader issues of sustainable development.

**Cultural heritage**

Indigenous cultural heritage is a crucial manifestation of the principles of attachment, ownership, and protection. Cultural heritage itself has a number of components: archaeological sites; places
associated with traditional stories or traditional knowledge; and places of historical or contemporary importance. Cultural heritage is strongly correlated with permanent water, meaning that riverine and aquatic areas that are the focus of development interest are also likely to contain significant cultural heritage. Figure 3-31 shows the general concentration of Indigenous cultural heritage in the Darwin catchments listed in the Northern Territory Government record. This record is incomplete; the map demonstrates the presence of a layer, not its full extent. Consultations between development proponents and Traditional Owners will be significantly aided by early stage field scoping of cultural heritage issues and requirements.

Contemporary Indigenous water values

In general terms, Indigenous water values emphasise securing sufficient water to maintain healthy landscapes and to support Indigenous needs. Those needs can be defined in multiple ways, and from an economic perspective encompass such activities as art and cultural production, hunting and gathering, and traditional medicine supply, as well as pastoralism, ecotourism, agriculture and
aquaculture. All of these needs depend on natural resources, highlighting the importance of securing and maintaining water supplies. Data from the Assessment clearly demonstrates the overall importance of water for practical hygiene, religious symbolism, and ancestral connection:

_**Water is part of everything, you use it for drinking, washing. Following our tradition it is associated in Dreamtimes when water was created. We have that strong belief in the rainbow serpent it is the creator that makes billabongs and waterways. There is places that you go where the serpent lives under water. All those stories were passed on from one generation to the other, the elders. That is why water is important.***_

*Traditional Owner from the Darwin catchments*

Statements about the importance of water from participants in the Assessment are consistent with broader statements that outline significant Indigenous water rights, values and interests, both in Australia (NAILSMA, 2009) and internationally (World Water Council, 2003).

**Responses to water and irrigation development**

In the Darwin catchments, Indigenous responses to water and irrigation development are interpreted through perceptions of past development, and through observations of ongoing environmental and climate change. Indigenous responses to water development and extraction included considerations of impacts on water quality, on streamflow, and on water-dependent ecosystems and human cultural practices. Large instream dams were not a favoured form of development, and in general, larger scale water and agricultural development was seen as incompatible with contemporary Indigenous values and lifeways. Indigenous concerns about water development also encompassed concerns about the cumulative impacts from other industries, particularly mining.

Awareness of their position as long-term custodians and their marginalised socio-economic and educational status affected Indigenous assessments of the relative risks and benefits associated with development proposals. Noting the above cautions, Indigenous participants also recognised that power imbalances may see large-scale development proceed. In this context, some data on preferences for particular kinds of water development were gathered, and the general trend from most to least favourable was:

1. flood harvesting to supply smaller, offstream storages
2. bore and groundwater extraction
3. smaller instream dams constructed in side tributaries or branches which do not restrict all of the flow
4. large instream dams in major river channels.

Proposals for specific sites may not accord with this general trend, and new information may alter the above order at both local and regional scales. With respect to major water and irrigation development, key Indigenous criteria for evaluation include:

- early and further formal group consultations about options, impacts and preferences
- development that specifically address Indigenous needs (for example, access, education, amenity, and recreational opportunities)
- appropriate cultural heritage surveys of likely areas of impact
• agreements that support Indigenous employment and other benefits during development construction and operation
• the need for ongoing monitoring of impacts that employs Traditional Owners
• support for Indigenous roles in development projects that connect water development with both water planning, wider catchment management and enterprise development.

**Indigenous interests in water planning**

Water planning is understood as one way of managing water development risk, but water planning also has particular challenges. In Australia, the National Water Initiative set the goal that jurisdictionally-based water plans need to recognise Indigenous needs in terms of access and management (Department of Agriculture and Water Resources, 2017). This encompasses Indigenous representation, incorporation of Indigenous social, spiritual and customary objectives, and recognition of native title needs and uses. However, progress in implementing that recognition has been slow due to a lack of knowledge about those interests, competing water demands and the challenges of accommodating Indigenous perspectives in conventional planning frameworks. However, a new water planning initiative has been publicised for Indigenous landowners in the NT. Known as the Strategic Aboriginal Water Reserve (Northern Territory Government, 2017), this initiative provides scope for further Indigenous recognition by creating reserved water allocations for Indigenous people for development purposes.

Based on the data generated during the Assessment, formalising and refining Indigenous water values and water planning issues in the Darwin catchments may require:

• Formal scoping discussions at local and catchment-scales about how best to support Indigenous involvement in water planning.
• Refinement of Indigenous governance rights, roles and responsibilities in water planning.
• Resourcing of Indigenous involvement in water planning, including formal training.
• The reservation of Indigenous-specific water allocations for development purposes.
• Further specification of the impacts on current and potential future native title rights and on cultural heritage.
• Articulating water planning processes with land and development planning.
• Addressing continuing Indigenous water research needs and information priorities.

These principles can also be applied to broader processes of catchment management and associated development planning.

### 3.5.5 INDIGENOUS DEVELOPMENT OBJECTIVES

Indigenous people have a strong desire to be understood as development partners and investors in their own right, and have generated their own development objectives. This stance informs responses to development proposals outlined by others. As a group, Indigenous people are socially and economically disadvantaged, but also custodians of ancient landscapes. They therefore seek to balance short- to medium-term social and economic needs with long-term cultural, historical and religious responsibilities to ancestral lands. Past forums have outlined Indigenous
development agendas that are consistent with Indigenous perspectives in the Darwin catchments (NAILSMA, 2012, 2013). These agendas are informed by two primary goals:

- greater ownership of and/or management control over traditional land and waters
- the sustainable retention and/or resettlement of Indigenous people on their country.

These goals are interrelated, because retention and/or resettlement relies on employment and income generation, and the majority of business opportunities identified by Indigenous people are land- and natural-resource dependent: pastoralism, conservation services, wild and cultivated bush foods and bush products, ecotourism, agriculture, horticulture, and aquaculture. Each group in the Darwin catchments has multiple responsibilities and management roles but, based on geography, residence, assets, governance and/or skills, some may more easily be able to sustain multiple business activities, while others may achieve greater success focusing on a single activity.

**Partnerships and planning**

Indigenous people in the Darwin catchments possess valuable natural and cultural assets and represent a significant potential labour force, but collectively lack business development skills and expertise. Partnerships can address this gap, but there is a need to improve the opportunities for business to understand and invest in Indigenous people and lands in the Darwin catchments. The development of a full business analysis may include the following actions:

- The investigation of the full range of potential business activities and options.
- The production of group and/or catchment plans and prospectuses to coordinate and define collective Indigenous assets and opportunities and to aid communication with potential investors.
- Further information and training for Indigenous people about the opportunities and constraints of partnerships with private industry, including effective use of Indigenous resource rights (land ownership and leaseholding native title, future water allocations, etc.).
- Targeted non-Indigenous community training regarding partnerships with Indigenous people, including models for shared benefit agreements and partnership arrangements, employment and training opportunities, etc.
- Creating incentives for Indigenous involvement in new development initiatives, including relocation and resettlement allowances, pathways from training to jobs, employer incentives to hire and retain Indigenous staff, etc.
- Training for younger Indigenous people about career planning as well as formal job skills.

Indigenous development objectives, and Indigenous development partnerships, are best progressed through locally specific, group and community-based planning and prioritisation processes that are nested in a system of regional coordination. Such planning and coordination can greatly increase the success of business development and of the opportunities for Indigenous employment, retention and resettlement that arise from them. Significant returns on investment may be achievable through well-targeted resourcing to local Indigenous entities, particularly PBCs, to build understanding of business priorities and development objectives, as well as regional coordination processes such as water planning and catchment management.
3.6 Legal and policy environment

3.6.1 INTRODUCTION

This section provides an overview of the legal and policy institutions relevant to water-related development in the Darwin catchments. The term ‘institutions’ is used here to refer to the rules and norms that govern water-related development that stem from international and domestic law and policy. The analysis sheds light on the nature of the rights and interests that are necessary to undertake, and could be affected by, water-related development. Four themes are used to structure the analysis: legal and policy context, interests in land, interests in water, and government approvals.

3.6.2 LEGAL AND POLICY CONTEXT

Government powers and responsibilities concerning the management of land and water resources in the Darwin catchments are shared between the Australian and Northern Territory Governments. While there is a degree of overlap between the powers and responsibilities of these two governments, each perform discrete functions.

**Australian Government**

The Australian Government performs three key functions in the Darwin catchments: oversight of native title, oversight of Aboriginal freehold land, and the implementation of Australia’s obligations under international law. Unlike other types of interests in land, native title and Aboriginal freehold land in the NT are federal responsibilities. Native title is managed under the Native Title Act 1993 (Cth), while Aboriginal freehold land is managed under the Aboriginal Land Rights (Northern Territory) Act 1976 (Cth). Similarly, in relation to international law, the Australian Government is responsible for ensuring Australia meets its international obligations. Under Australian law, international legal obligations have no direct effect on domestic law until and unless they are incorporated into it by an act of parliament. The most relevant federal statutes that give effect to international obligations and responsibilities are the Racial Discrimination Act 1975 (Cth) and Australian Human Rights Commission Act 1986 (Cth), which prohibit discriminatory behaviour, and the EPBC Act, which regulates activities that adversely affect ‘Matters of National Environmental Significance’.

**Northern Territory Government**

The Northern Territory Government is primarily responsible for the management of the land and water resources within the Darwin catchments. It is the ultimate ‘owner’ of most of the land in the NT, is responsible for the NT system of land title, manages Crown lands and reserves, regulates access to and the use of surface and groundwater, and manages the positive and negative externalities associated with development through planning, environmental and heritage regulations.
3.6.3 INTERESTS IN LAND

Proponents of water-related developments will require legal entitlements to access and use the subject land. This could involve the grant or acquisition of a freehold or leasehold interest in the land or the issuance of a licence for a period of time. Freehold and leasehold interests give the holder a legal interest in the land. In contrast, the holder of a licence obtains no property rights in relation to the land. Depending on the nature of the licence, the licensee will either have personal rights of access that are enforceable under contract or the licence will simply make an act lawful that would otherwise be unlawful. For proponents of water-related developments, licences will typically be used for initial exploratory purposes only. To undertake any material development, proponents will usually need to acquire a freehold or leasehold interest in the land from the current landholder, or have a freehold or leasehold interest granted by the state or territory government. Freehold and leasehold interests provide greater security and control than licences, and enable the holder to exclude most third parties from the land and the benefits that stem from its development and use.

Most of the land in the Darwin catchments is held as Crown leasehold land, Crown reserves, unallocated Crown land, freehold land and Aboriginal freehold land.

Crown leasehold land

Crown leasehold land is government owned land held under a lease, typically by a private party. The management of, and issuance of leasehold interests in, Crown land in the NT is governed by the Crown Lands Act (NT), Pastoral Land Act (NT) and Special Purposes Leases Act (NT). There are four main types of Crown leasehold interests that can be issued under these statutes: fixed term leases; perpetual leases; pastoral leases; and special purpose leases. These leases can be subject to restrictions on the use, development and transfer of land. For example, pastoral leasehold land can only be used for pastoral purposes unless a permit authorising a non-pastoral use has been issued by the Pastoral Land Board.

Crown reserves

Crown reserves are government owned land that have been reserved for specific purposes such as nature conservation, travelling stock and Indigenous people. These reserves are usually required to be managed in a manner consistent with the purposes for which they were declared. Generally, people wanting to use a reserve must obtain a licence to do so and there are restrictions on the circumstances in which licences can be issued.

Vacant Crown land

Vacant Crown land is government owned land that has not been reserved for any purpose and in which no interest has been granted. While unallocated, the land is not freely available for the public to use. To occupy or use vacant Crown land, it is necessary to obtain a licence under the Crown Lands Act, which will merely make the relevant activity lawful (rather than conferring a legal interest in the land). Freehold and leasehold estates can also be issued in relation to unallocated Crown land.
Freehold land

Freehold land is land in which a freehold estate has been granted. Freehold estates are the most complete legal interest in land under Australian law. While close to absolute ownership, freehold estates do not give the landholder the right to use the land as they please. The estates are almost always subject to reservations and the use and development of the land is regulated under planning, environment and other similar statutes.

Aboriginal freehold land

Aboriginal freehold land is freehold land held on trust for Indigenous Traditional Owners under the Aboriginal Land Rights (Northern Territory) Act 1976. Under this Act, Aboriginal Land Councils were established to represent and protect the interests of Traditional Owners, with Aboriginal Land Trusts created as the formal legal bodies that hold the freehold estates. There are four Land Councils in the NT: Northern, Central, Tiwi and Anindilyakwa. The Northern Land Council (NLC) covers the Darwin catchments. Like the other Land Councils, the NLC oversees dealings with the land held by the land trusts in its region. There are restrictions on dealings with Aboriginal freehold land under the Aboriginal Land Act (NT), including a prohibition on sale and transfer. The Aboriginal Land Act also makes it an offence for a person to enter onto or remain on Aboriginal land, unless they hold a permit from the Land Council or are an Aboriginal person who is entitled to do so in accordance with Aboriginal tradition.

In addition to the need for a freehold or leasehold interest, or a licence, any water-related development must be consistent with the native title arrangements that apply to the land. A significant proportion of the Darwin catchments to the south and east of the Adelaide River is subject to registered native title claims. Native title is a unique form of property interest under Australian law consisting of a bundle of rights defined by the laws and customs of the relevant Indigenous community. Reflecting its unique status, native title has its own system of determination (through the Federal Court of Australia), registration (at the National Native Title Registry, maintained by the National Native Title Tribunal) and protection (under the Native Title Act).

Where a native title claim or determined native title exists over an area of land, proponents will be required to engage with relevant Traditional Owners and the federal native title process. Importantly, water-related development in the Darwin catchments could involve ‘future acts’ that could be rendered invalid by the operation of the Native Title Act 1993, or trigger a right to compensation. In this context, relevant ‘future acts’ could consist of special legislation (or legislative amendments) made to facilitate the development, the issuance of property interests and approvals to support or authorise the development, and the conduct of related public works. There are a number of ways of avoiding invalidity of future acts, one of the most notable being entry into ILUAs with Traditional Owners. ILUAs are agreements between native title parties and others about the use of land and waters subject to native title, or over which native title is claimed. Where a determination is made that native title exists, ILUAs can be used to settle arrangements concerning the area and the treatment of native title. Even when native title has not been determined, ILUAs can be used to proactively settle arrangements concerning native title and the use and development of an area with Traditional Owners.
3.6.4 INTERESTS IN WATER

The ‘rights’ to the use, flow and control of all water in the NT are vested in the Northern Territory Government under the Water Act (NT). This legislation contains processes for water planning, the regulation of taking water (with and without government authorisation), and statutory requirements to obtain government approval for works related to water infrastructure (e.g. dams, bores, levies and pipes).

Water planning

The Water Act contains two main legislative mechanisms to support water management and planning: water control district declarations; and water allocation plans. Water control districts are typically in areas where there is a demand for water such that additional controls are required. For declared water control districts, the priority water uses (referred to as ‘beneficial uses’ under the Water Act) are identified and sustaining the beneficial uses forms the basis for the preparation of water allocation plans. Water allocation plans typically describe the total available water resources for an area, current and projected demand and the sustainable water yield and allocation of water to beneficial uses, and strategies for achieving its stated objectives. They also include rules for managing licences and permits, including water trading rules if applicable. The Darwin Rural Water Control District (DRWCD) lies within the Darwin catchments, and there are two relevant water allocation plans within this area: the Berry Springs water allocation plan; and the Howard water allocation plan (which is currently being developed).

Approvals for taking water

Under the Water Act, activities involving taking water are divided into two broad categories: those that can occur without a water licence; and those that can only occur with a water licence. Most water-related developments will require a licence. Licences are typically granted on a ‘first-in-first-serve’ basis, and for a period of up to 10 years. They are not attached to land but specify the land on which the water is to be taken and used. Importantly, the amount of water taken under a licence in any particular year can be limited by an Annual Announced Allocation. Annual Announced Allocations, announced in May each year by the Water Controller, are guided by water allocation plans or default allocation rules.

Water-related works approvals

Permits or licences are generally required under the Water Act to undertake water-related works involving waterways and groundwater. Specifically: (i) a permit is required to construct or alter a dam, water storage or other water control structure in a waterway, or in such a way as to affect the flow or likely flow of water in a waterway; (ii) a permit is required to construct works to take water from groundwater (including the drilling, construction, alternation, lugging, backfilling or sealing of a bore); and (iii) a licence is required to recharge groundwater. Landholders are able to drain their land and capture overland flows by constructing farm dams and other water storages without approval but only if: (a) the works are not in a waterway; and (b) the works do not sensibly diminish or increase the flow or likely flow of water in, or into, a waterway.
3.6.5 GOVERNMENT APPROVALS

In addition to holding the requisite rights and interests to access the land, and to take water, proponents of water-related development must have the necessary privileges to undertake the development. Some of these privileges will come with proponents’ interests in land. However, ownership of an interest in land does not provide the holder with the legal ability to use and develop the land as they please. Government regulations can control the use and development of land and water resources. The most relevant government regulations are those imposed under federal and territory planning, environment and heritage statutes.

**Australian Government regulations**

The Australian Government does not have planning legislation that applies to the Darwin catchments. However, it does have both environmental and heritage regulations that could apply to water-related development in the region. The principal federal environmental statute is the EPBC Act, which regulates actions that have significant impacts on ‘Matters of National Environmental Significance’, the environment on Commonwealth land, and the environment generally where the relevant action is carried out by a Commonwealth agency or on Commonwealth land. There are nine Matters of National Environmental Significance, the most relevant of which are World Heritage areas and National Heritage places (e.g. Kakadu National Park, located in the east of the Darwin catchments), Ramsar wetlands (Kakadu National Park), listed threatened species and ecological communities, and listed migratory species. Water-related development that could have significant adverse impacts on these matters must be referred under the EPBC Act for assessment and approval. Guidelines have been published by the federal environment department to help proponents determine when projects are likely to have significant impacts on matters protected under the Act. Due to the ambiguity associated with determining the significance of potential impacts, proponents should consult with the federal environment department about the need for referrals before undertaking water-related developments. In addition to the regulatory requirements under the EPBC Act, stakeholders interested in water-related development should be aware of the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth) (ATSIHP Act). Declarations can be issued under the ATSIHP Act to protect significant Aboriginal areas and objects from injury or desecration. These declarations are rarely made but they can be powerful, forcing the cessation of projects affecting the relevant area or object. There are a number of other federal regulatory regimes that could apply to proponents involved in water-related development. Foreign investors should take particular note of the federal regulation of foreign investment under the *Foreign Acquisitions and Takeovers Act 1975* (Cth) and *Foreign Acquisitions and Takeovers Fees Imposition Act 2015* (Cth). Under this regulatory regime, the federal Treasurer can impose conditions and even block foreign investment proposals in Australia. Foreign interests in agricultural land are also required to be registered with the Australian Taxation Office under the *Register of Foreign Ownership of Agricultural Land Act 2015* (Cth).
Northern Territory regulations

Planning

Land use planning in the NT is governed by the *Planning Act* (NT). Whether a development permit will be required for water-related development will depend on the zoning that applies to the land under the Northern Territory Planning Scheme. The Northern Territory Planning Scheme applies across the jurisdiction, except where an area is subject to a specific planning scheme (there is currently only one specific scheme, the Jabiru Town Plan). Not all land is zoned in the NT. Where land is unzoned, planning restrictions can still apply to the site. For example, planning restrictions apply to the clearing of native vegetation on unzoned land. For most water-related developments in the Darwin catchments, the consent authority will be the NT planning minister. The Northern Territory Planning Commission may be required to prepare a significant development report if the development is deemed to be a ‘significant development proposal’.

Environment

The main environment protection statute in the NT is the *Environmental Assessment Act* (NT). Projects that could have significant environmental impacts will usually require assessment by the Environmental Protection Authority (EPA) under the Act. The EPA and the NT environment minister are not responsible for approving projects; their role is advisory. The environment minister provides the EPA’s assessment report to the ‘responsible minister’ for decision, with additional comments if they consider they are necessary. In this context, the responsible minister is another minister with statutory decision-making responsibilities in relation to the project (e.g. the planning minister). In addition to the requirements under the Environmental Assessment Act, the *Waste Management and Pollution Control Act* (NT) regulates polluting and waste generating activities. Certain types of water-related developments could require approval under this Act.

Heritage

The two main NT heritage statutes are the *Heritage Act* (NT) and the *Northern Territory Aboriginal Sacred Sites Act* (NT). The *Heritage Act* protects three classes of places and objects: Aboriginal andMacassan archaeological places and objects; places and objects declared to be heritage places and objects under Part 2.2 of the Act; and places and objects declared to be protected classes of places and objects of heritage significance under Part 2.3. Under the Act, it is an offence to knowingly damage a heritage place, to remove something from a heritage place or damage or remove a heritage object, unless one of the exemptions applies. Most relevantly, these exemptions include when the activity is carried out under a work approval issued, or heritage agreement made, under the Act. The Northern Territory Aboriginal Sacred Sites Act protects sites that are sacred to Indigenous people or of significance according to Indigenous tradition. The Act prohibits entry onto sacred sites, the carrying out of work on or use of sacred sites and the desecration of sacred sites, other than in accordance with certificates issued under the Act by the Aboriginal Areas Protection Authority or responsible minister. It is a defence to prosecution if the defendant can prove there were no reasonable grounds for suspecting the site was a sacred site. On Aboriginal land, this defence can only be used if the defendant can also prove they had authority to be on the land and had taken reasonable steps to ascertain the location and extent of sacred sites on the land.
Major projects

The Northern Territory Government has a policy, the Major Project Status Policy Framework, that is intended to help major project proponents navigate government approval requirements. Under the policy, major project status is awarded to developments by the Northern Territory Government having regard to six main criteria: project significance (e.g. capital expenditure, employment); strategic impact (e.g. flow on benefits to other industries); complexity (government approval requirements and environmental, economic and social impacts beyond the project footprint); project feasibility; proponent’s capacity to deliver the project; and ancillary (covering the need for government support and local industry participation, local workforce development and social impacts on the community). While these criteria are used as a guide, ultimately, decisions on major project status are made at the discretion of the Northern Territory Government. If major project status is awarded, the proponent receives assistance with the identification of relevant government approval processes, whole of government coordination and facilitation of the project and project-related government approvals, and a dedicated government project case manager who works as a single point of contact on the project.

3.6.6 DURATION OF GOVERNMENT ASSESSMENT AND APPROVAL TIMES

Proponents of water-related developments should be aware that government assessment and approval processes can be resource intensive and time consuming. To illustrate this, an analysis was undertaken of the length of environmental assessments under the *Environmental Assessment Act* (NT) and the EPBC Act. The NT analysis covered all completed assessments under the *Environmental Assessment Act* since June 2006, while the EPBC Act analysis covered all projects located in the NT that were approved over the period 2010 to 2018.

Figure 3-32 shows the median length of each stage of the environmental assessment process for the sampled projects under the *Environmental Assessment Act*. The results are presented by industry and for the entire sample of 36 projects. There are four main stages in the process (not all of which are mandatory for all projects): i) screening (where the EPA determines whether the project requires formal assessment), ii) scoping (where the EPA determines the scope of, or Terms of Reference for, the environmental assessment), iii) assessment documentation (where the proponent prepares the assessment documentation), and iv) EPA report (where the EPA prepares its advice on the project).

The aggregate of the median length of each stage was 494 days, with the longest part of the process being the preparation of the assessment documentation (328 days). The median total assessment time was 517 days, with an average of 784 days. While these results are noteworthy, the length of the process varied considerably between projects and project types. For example, 22% of assessments took under 365 days, while 36% took longer than 730 days. The variability in assessment times reflects the flexibility of the process and the factors that influence its length, including the size and complexity of the proposals, the nature, magnitude and likelihood of relevant economic, social and environmental impacts, resource constraints within the EPA, and the speed with which proponents are able to produce relevant assessment information.
Figure 3-32 Median length of each stage of the assessment process under the Environmental Assessment Act (NT), 2006–2018

Industry codes: AG = agriculture; AQ = aquaculture; MAN = manufacturing; MNC = mining (non-coal); OG = oil and gas; RC = residential and commercial; TR = transport; WD = water resource development; Oth = other. The number of projects in each industry code is provided in parentheses.
Source: Northern Territory EPA

The federal EPBC Act assessment and approval process often runs in parallel with state and territory processes, meaning it does not necessarily add to project delays. Further, under the EPBC Act, assessments are frequently undertaken through relevant state and territory processes. For example, where a project requires Northern Territory Government approval under the Planning Act and Australian Government approval under the EPBC Act, the assessment carried out under the Environmental Assessment Act that guides and informs the Planning Act approval will often also cover, and be used for, the federal approval process. While the EPBC Act process has been designed to minimise duplication and delays, it can still be time consuming, particularly where state and federal approvals are sought sequentially.

Figure 3-33 shows the median length of the three main stages of the EPBC Act assessment and approval process (screening, assessment and approval) for the eight Northern Territory projects approved over the period 2010 to 2018. Again, the results are presented by industry and for the entire sample.

Figure 3-33 Median length of each stage of the assessment and approval process under the EPBC Act, all projects in the Northern Territory over the period 2010-2018
Source: Department of the Environment and Energy

The aggregate of the median length of each stage was 511 days. The assessment phase accounted for almost 80% of that time, highlighting the importance of proponents ensuring assessment
information is provided in a timely manner. Similar to the results from the *Environmental Assessment Act* analysis, the length of the EPBC Act assessment and approval process was variable, ranging from 340 to 826 days (Figure 3-34).

![Figure 3-34 Total length of EPBC Act assessment and approval process, Northern Territory projects from 2010-2018, by industry and length of process](image)

*Source: Department of the Environment and Energy*

The potential for government assessment and approval processes to cause delays, and the measures available to reduce regulatory timelines and uncertainty, are illustrated by the two aquaculture projects assessed under the *Environmental Assessment Act* over the period 2006 to March 2018. Both of these projects concerned Project Sea Dragon, a proposed large-scale, integrated prawn aquaculture project involving six major components located across the NT and WA.

The first major component of the project is a Stage 1 Grow-out Facility on Legune Station in the NT. The Stage 1 Facility consists of three farms and associated infrastructure, with each farm comprising 36-40 production ponds, for a total of 1120 ha of grow-out ponds. The project will impact on a further area of approximately 7,500 ha for associated infrastructure including water storage, recirculation ponds, water access channels, an intake channel, an environmental protection zone, and roads. The site is located on the Legune Coastal Floodplain; an area of conservation significance. The project will involve broad-scale vegetation clearing, and may impact on the habitat of threatened and migratory species. There are also a number of Aboriginal sacred sites located on the station.

Because of the regional economic significance of the project, and its potential environmental and heritage impacts, the project was given ‘Major Project Status’ under the Northern Territory Major Project Status Policy Framework. This enabled the proponent to receive assistance from the Northern Territory Department of the Chief Minister to navigate NT approval processes, and to engage with the Australian Government. The project was also granted ‘Major Project Facilitation’ status through the Australian Government Department of Infrastructure and Regional Development, which provided it with a single entry point for all necessary federal approvals.

A notice of intent concerning the Stage 1 Facility was submitted to the EPA in July 2015. Simultaneously, the proponent also referred the project under the EPBC Act. In late August 2015, the federal environment minister determined that the project was a controlled action due to its potential impacts on Matters of National Environmental Significance (listed threatened species and ecological communities, and listed migratory species), meaning it would require formal
assessment and approval under the Act. Soon after, on 14 September, the NT EPA determined the project would be assessed under the *Environmental Assessment Act* by way of an environmental impact statement (EIS).

To reduce duplication, the EPBC Act assessment was done under the terms of the bilateral assessment agreement between the Australian and Northern Territory Governments. This meant the EIS prepared under the *Environmental Assessment Act* served the purposes of the EPBC Act and the NT approval processes.

The EPA assessment took a total of 609 days, with the final EPA assessment report issued in March 2017. At the NT level, the EPA assessment report does not constitute an approval in its own right. The EIS and EPA assessment report are used to inform decisions on the grant of required Northern Territory Government approvals, including an aquaculture licence under the *Fisheries Act* (NT), a native vegetation clearing permit under the *Pastoral Land Act* (NT), and an environmental protection approval and environmental protection licence under the *Waste Management and Pollution Control Act* (NT).

At the federal level, the EIS was used to inform the grant of the EPBC Act approval, which was provided in May 2017. While the EPBC Act assessment and approval process took 659 days, much of that time overlapped with the *Environmental Assessment Act* assessment, meaning the additional delays associated with the EPBC Act were negligible. This demonstrates how regulatory delays and costs can be reduced by ensuring federal, state and territory approvals are sought in parallel and allowing assessments to serve dual purposes.

The second major component of Project Sea Dragon is a core breeding centre and broodstock maturation centre proposed to be located at Point Ceylon, on the southern side of Bynoe Harbour. At the core breeding centre, high performing prawn stock will be developed and produced, and the best performing individuals will then be transferred to the broodstock maturation centre. In the broodstock maturation centre, the selected prawns are grown and bred to produce commercial numbers of broodstock for use in a hatchery. The combined site area of the two centres at completion is 152 ha.

A notice of intent for the project was sent to the EPA in February 2016. Due to the potential impacts of the discharge of prawn farm effluent into a local waterway (Wheatley Creek), the management requirements concerning solid and liquid wastes, the risks associated with securing fresh water for the project and the high level of public interest in the project, the EPA decided to assess it by way of another EIS. However, this decision was not made until August, six months after the submission of the notice of intent. Part of the reason for the delay was the EPA required further information from the proponent to inform its approach. In total, the assessment took 402 days, with the final EPA assessment report issued in late March 2017.

In contrast to the assessment of the project under the *Environmental Assessment Act*, the EPBC Act process was short. The project was referred on 10 June 2016 and, in mid-September, it was declared not to be a controlled action, meaning it was allowed to proceed without further assessment and approval under the EPBC Act.

The *Environmental Assessment Act* and EPBC Act will not apply to all water-related developments in the Darwin catchments. Proponents should seek advice on the government approvals required
for their projects well in advance of commencement, including on the likely cost and duration of
the processes.

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