Exmouth Regional Water Management Report



Prepared for the Shire of Exmouth

By Urbaqua

November 2025

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Acknowledgement

We acknowledge the traditional custodians of the land of Exmouth, the Jinigudera, who are a part of the West Thalanyji people, and pay our respect to their deep ancestral knowledge, their elders past, present and emerging, and their ongoing connection to the skies, waters and lands of Country.

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1 INTRODUCTION

This Regional Water Management Report (WMR) has been prepared to identify water resource constraints and opportunities that will underpin future planning controls within the Shire of Exmouth in the medium to long term (five to thirty plus years) for the northern portion of the Shire, described as the North West Cape, excluding the Cape Range National Park, as far south as the Kailis Site and Charles Knife Road, and shown in Figure 1 (referred to hereafter as the study area).

This WMR implements *State Planning Policy 2.9: Planning for Water* (SPP 2.9) and the *Planning for Water Guidelines* (draft, WAPC, 2021a&b).

1.1 Purpose

This Regional WMR will inform the preparation of the Shire's new local planning strategy and scheme. It provides clear guidance on the management of water resources as part of future land use planning and development in the study area. It identifies current and future pressures on water resources and contains objectives and strategies for the protection and management of the area's water resources which are to be met as part of future land use change and development, in particular the requirements for protection of important water resources, management of flood risk, provision of water for potable and non-potable uses, and the management of wastewater in areas earmarked for future development.

1.2 Water management objectives

The water management objectives for the future planning and development activities occurring within the study area are to:

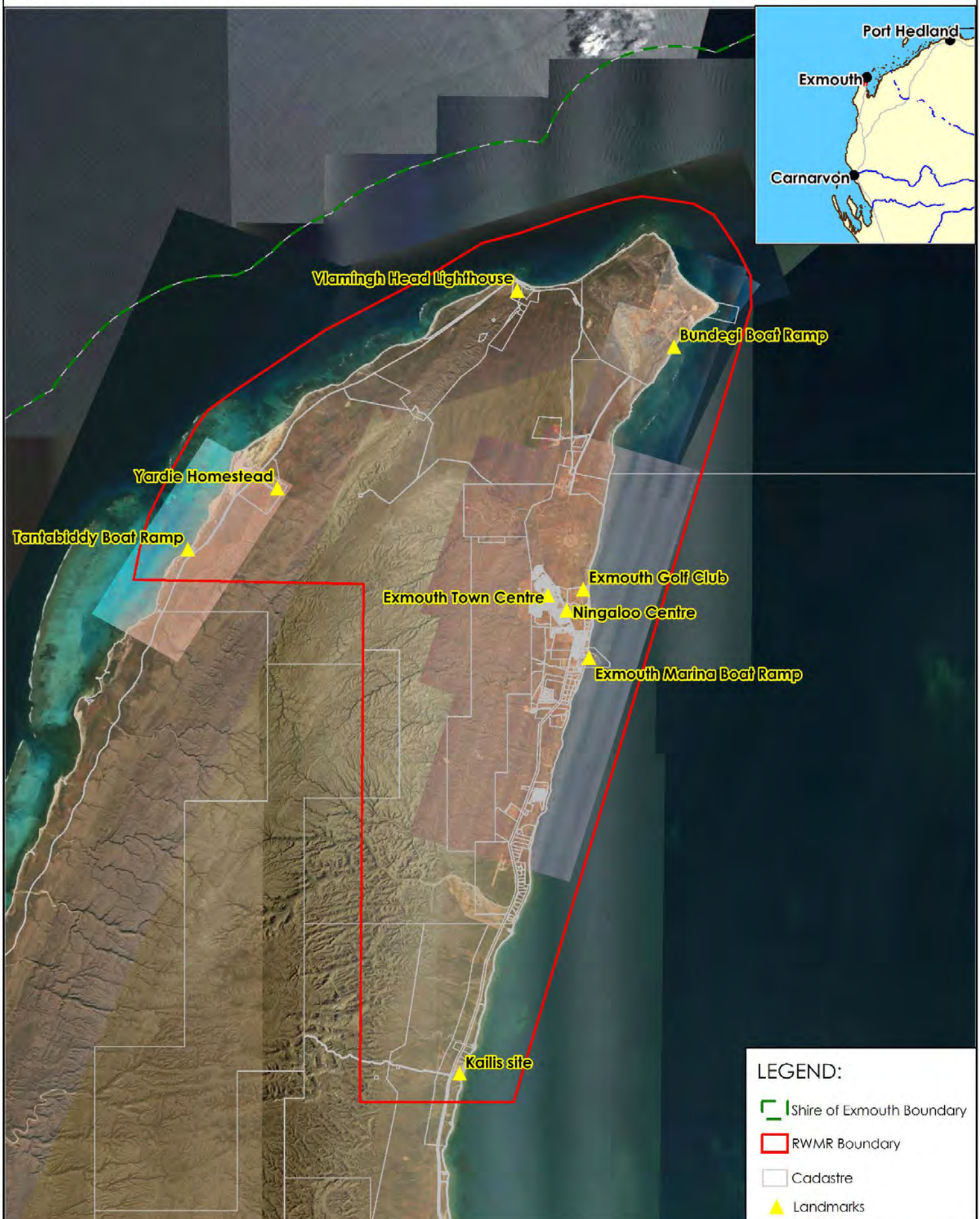
1. Provide a sustainable, local water supply and wastewater system for a growing population that optimises efficient use of all types of available resources.
2. Protect water for cultural and environmental values.
3. Support community health and wellbeing through greening and waterwise development that provides climate resilience.
4. Create a locally responsive approach (low impact) to flood protection and incorporate emergency planning.
5. Support the collaborative delivery of an improved total water cycle solution to achieve objectives 1-4.

1.3 Implementation of the strategy

In accordance with SPP 2.9, implementation of this WMR will be through the land use planning process. Proponents of planning and development proposals are required to develop water management reports at each planning stage to support and inform their proposals, environmental investigations, engineering, landscaping and urban designs, as depicted in Figure 2.

Future water management reports are to be consistent with the requirements of this WMR, aiming to achieve its objectives, through delivery of the relevant strategies consistent with the regional water management principles in section 5. Additional guidance regarding implementation is contained in section 6.

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Figure 1 - Study area



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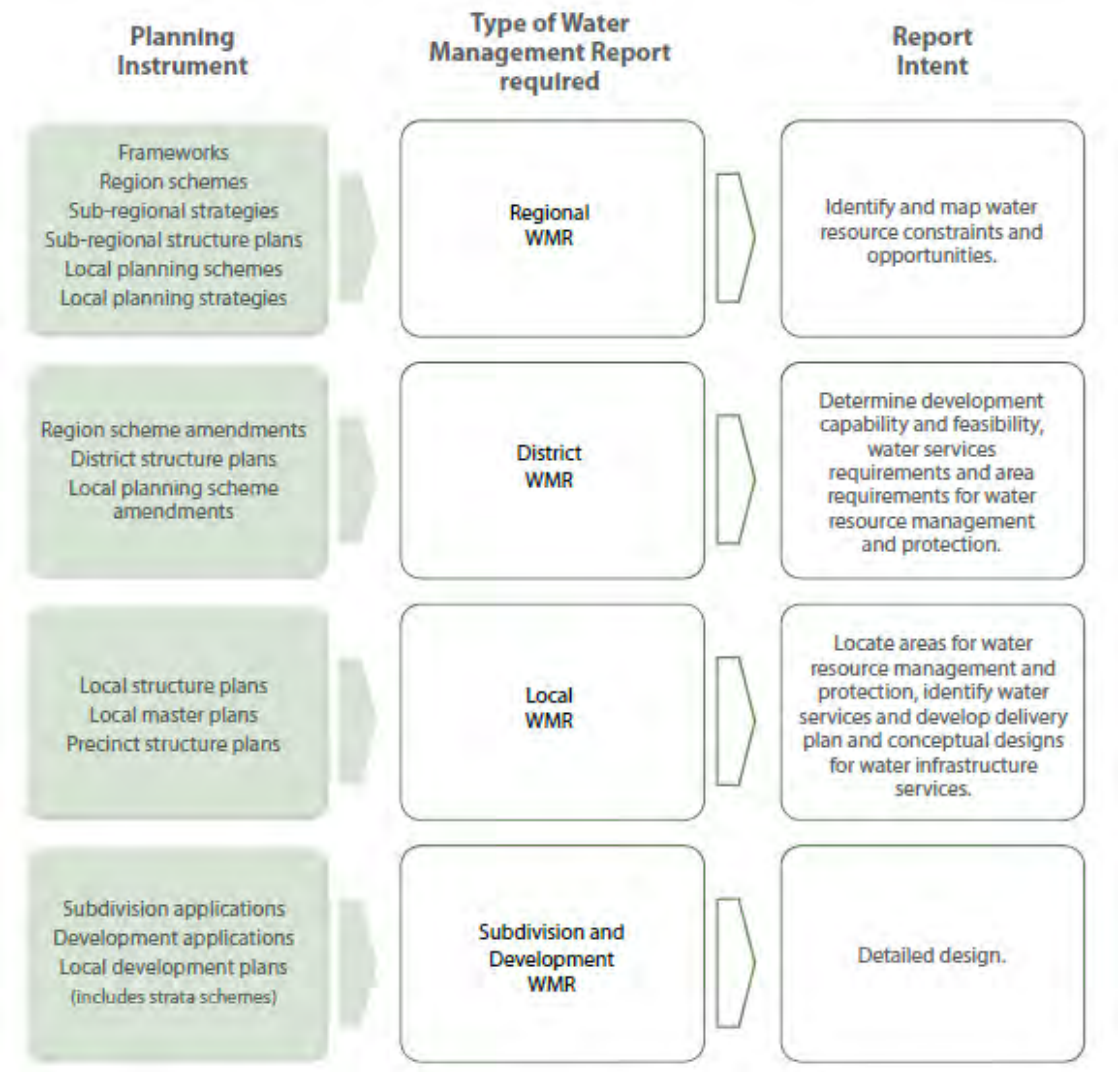


Figure 2: The WMR and planning instrument hierarchy (WAPC, 2021)

1.4 Preparation of report

This WMR has been prepared by the Shire in consultation with the Department of Water and Environmental Regulation (DWER), Department of Planning, Lands and Heritage (DPLH), the Water Corporation and DevelopmentWA. This included preliminary discussions with each agency, as well as a collaborative workshop held at the Shire to discuss the opportunities and constraints and agree on the water management objectives and key strategies.

This collaborative approach has particularly informed the flood modelling methodology and assumptions, protection of and access to groundwater, future capacity of potable water supplies and access to reticulated sewerage, as well as the water management objectives and priority strategies.

It is anticipated that this WMR is referred to DWER for their endorsement prior to inclusion in the local planning strategy.

2 PLANNING AND DEVELOPMENT CONTEXT

The Shire is located 1,270 kilometres north of Perth in the Gascoyne Region, together with the Shires of Carnarvon, Upper Gascoyne and Shark Bay. It is bordered by the Exmouth Gulf and the World Heritage Listed Ningaloo Coast and contains the Cape Range National Park. While the Shire covers an area of 6,261 square kilometres, the study area comprises 360 square kilometres (Figure 1).

The main settlement and key regional centre is the Exmouth townsite, which is located on the western side of the Exmouth Gulf. Outside the Exmouth townsite, notable places include the Lighthouse Caravan Park, Yardie Homestead Caravan Park, Exmouth Limestone and Kailis properties, and properties located within the Ingram Street industrial area and the Wilderness Estate, as well as the pastoral leases for Exmouth Gulf Station and Bullara Station. The Department of Defence also owns and maintains various landholdings which together comprise of the Areas A-C of Naval Communications Station Harold E. Holt; Learmonth RAAF Base; Learmonth Air Weapons Range; and historical or disused Commonwealth landholdings (Shire of Exmouth, 2019).

Originally founded around defence industries, Exmouth has transitioned into a thriving tourist destination, with eco-tourism leading significant growth in the local economy. Other key industries include defence, government services, and support for the offshore oil and gas sector, along with tourism-related services such as hospitality and accommodation, fishing, pastoral activities, aquaculture, light engineering, and construction. During the winter months, the influx of tourists can triple the town's resident population, presenting both challenges and economic opportunities for the Shire (Niche Studio, 2025)).

The ABS Population statistics for the Shire are shown in Table 1.

Table 1: Exmouth population statistics 2016 & 2021

Statistic	2016	2021
Aboriginal and/or Torres Strait Islander persons	2% (55)	2.9% (90)
0-14 years	20.7% (565)	18.1% (560)
15-24 years	9.2% (250)	10.5% (326)
25-44 years	32**%** (874)	33.7% (1042)
45 years +	26.6% (725)	26% (804)
65 years +	11.1% (305)	11.1% (345)
85 years+	0.4% (11)	3.8% (117)
Total	**2,730**	**3,085**

With regard to possible future population, the population growth rate from the Census figures is 2.6%. Should this rate of growth be maintained, the population could exceed 5,400 by 2050. Alternatively, if the State Government's WA Tomorrow 12 population projections are considered (https://www.wa.gov.au/organisation/department-of-planning-lands-and-heritage/western-australia-tomorrow-12-population-forecasts), the Band C population growth rate suggests that the population would be approximately 4,400 by 2050, and the Band E rate would be approximately 5,700 by 2050.

It is noted, however, that in addition to the residential population, Exmouth has a substantial seasonal spike in non-residential population (tourists and seasonal workers) which is currently

estimated at approximately 4,400 people. Tourism WA estimates that in 2024 alone, Exmouth received 134,000[1] overnight international and domestic visitors. The ratio of tourists to residents in Exmouth is among the highest in the state (Niche Planning Studio, 2025), and this places significant strain on the local infrastructure and services required for this influx of population.

The Shire's Local Planning Scheme 4 was gazetted on 12th March 2019. The current local zones, reserves and special control areas (three of which address water resource issues), as shown in Figure 3 are:

- **Zones:** Residential, Urban Development, Commercial (Retail Core C1), Commercial (Mixed Use C2), Commercial (Mixed Business – C3), Tourism, Light Industry, Service Commercial, General Industry, Industrial Development, Rural Residential, Rural, Special Use.
- **Local Reserves:** Civic and Community, Environmental Conservation Area, Public Open Space, Public Purposes, Public Purposes - Medical Services, Public Purposes - Infrastructure Services, Public Purposes - Education, Emergency Services, Public Purposes - Heritage, Public Purposes - Government Services, Public Purposes - Recreational, Public Purposes - Cemetery, Public Purposes - Car Park, Strategic Infrastructure, Primary Distributor Road, District Distributor Road, Local Distributor Road, Local Road, Drainage/Waterway, Foreshore.
- **Special Control Areas:** Exmouth Water Reserve (SCA 1), Exmouth Waste Water Treatment Plant (SCA 2), Exmouth Power Station (SCA 3), Exmouth Aerodrome (SCA 4), Floodplain (SCA 5), Minilya-Exmouth Road (SCA 6).
- Special Use Zones SU1 - SU10.

The study area also contains a number of conservation reserves managed by the Department of Biodiversity, Conservation and Attractions (DBCA). These are shown in Table 2.

Table 2: DBCA managed lands

Protected area name	Reserve type
Bundegi Coastal Park [2]	5(1)(h) Reserve
Cape Range	National Park
Jurabi Coastal Park	5(1)(h) Reserve
Ningaloo	Marine Park

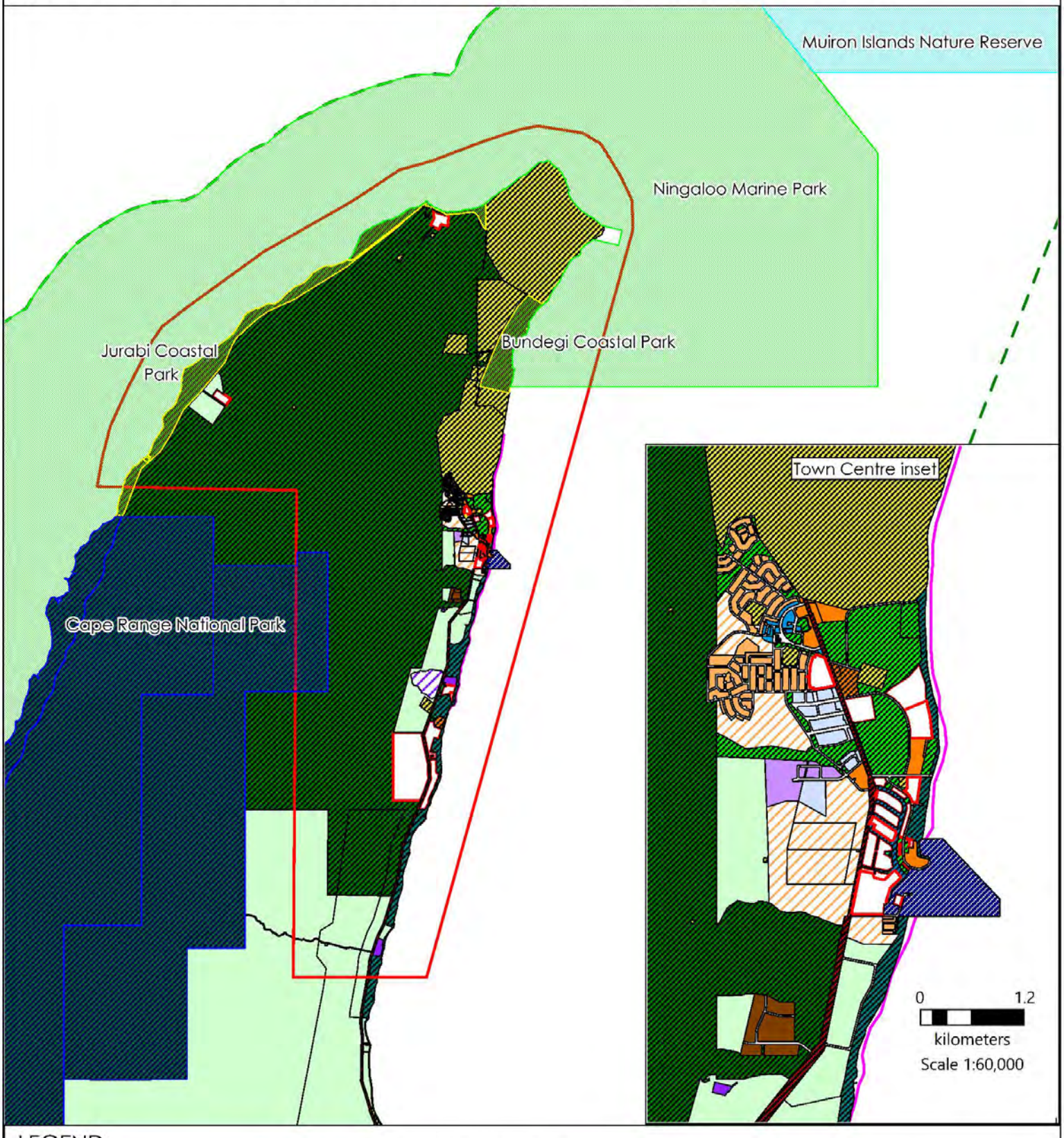
The Shire's Local Planning Strategy was endorsed by the WAPC in April 2019 to provide long-term planning directions and identifies thirty future development areas for the range of land uses as follows:

- Residential (1-7)
- Long term residential (1-4)
- Rural residential (1,2)
- Industry (1-4)
- Tourism (1-13)

These sites are shown in Figure 4 and are a key focus for this WMR. For further information on the characteristics of each site, refer to the Shire's Local Planning Strategy.

[1] Tourism Western Australia, LGA Visitor Factsheet 2023 - Exmouth, 2024.
[2] This reserve is jointly managed by DBCA and the Shire.

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Figure 3 - Shire of Exmouth Local Planning Scheme 4 and DBCA reserves



LEGEND:

- Shire of Exmouth Boundary
- RWMR Boundary

DBCA Managed land

- Marine Park
- National Park
- Section 5(1)(h) Reserve

Local planning scheme zones and reserves

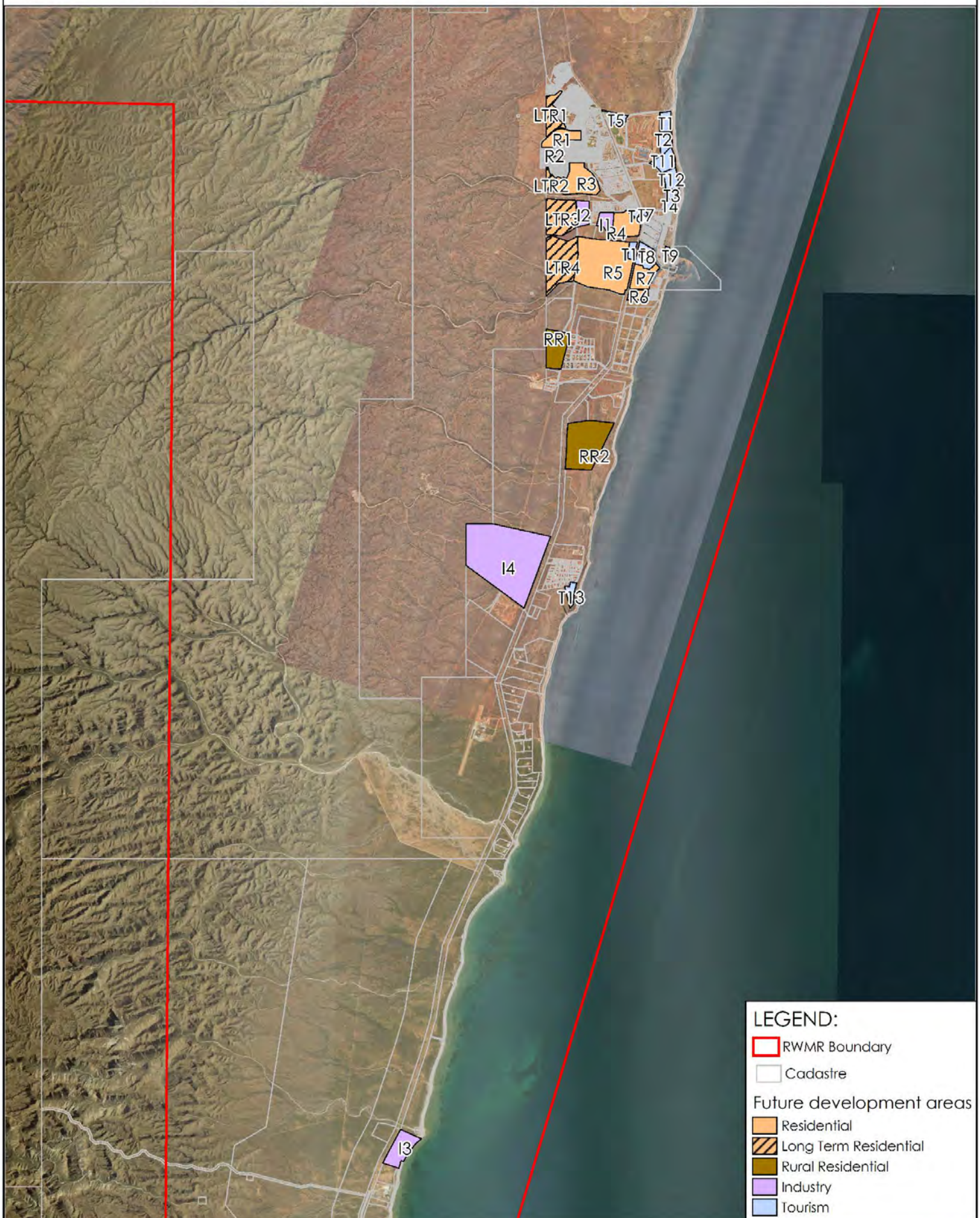
- Civic and community
- Drainage/waterway
- Environmental conservation reserve
- Foreshore
- Local distributor road
- Local road
- Primary distributor road
- Public open space
- Public purposes
- Strategic infrastructure
- Commercial
- General industry
- Industrial development
- Light industry
- Residential
- Rural
- Rural residential
- Service commercial
- Special use
- Tourism
- Urban development

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Figure 4 - Future Development Areas



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2.1 Key relevant guidance

In addition to the Shire's Scheme and Local Planning Strategy described above and as mentioned in Section 1.3, the key policy supporting preparation and implementation of this water management report is *State Planning Policy 2.9: Planning for Water* and the *Planning for Water Guidelines* (draft, WAPC, 2021).

Other relevant guidance includes:

- Strategic Community Plan: Exmouth 2030, which contains action 2.3.1 Lobby government agencies for the provision of better quality water and affordable renewable energy and sustainable use.
- Your Choice Future 2023-2033L Strategic Community Plan and Corporate Business Plan, Shire of Exmouth, 2025, which contains the following strategic priorities:
    - 2.1.1: Improve sustainability and management of energy consumption and water use in Shire operations, industry and the community
    - 2.2.2: Establish Exmouth at the leading edge of green technologies and assist in minimising the effects of air and water pollution and ecological damage
    - 3.2.3: Advocate for telecommunications, water and electricity supply networks that can support growth and renewable developments
- Council Policy OIS003: Verge Maintenance and Enhancement
- Council Policy OIS004: Guidelines and Specifications for Storm Water Drainage

3 ENVIRONMENTAL CONTEXT

3.1 Climate

Exmouth, located on the tip of the North West Cape in Western Australia, experiences a hot semi-arid climate (BSh) under the Köppen–Geiger classification. This climate is characterised by high temperatures year-round and low, irregular rainfall.

The area experiences its highest temperatures between January and March, while rainfall is most likely during the first half of the year, often associated with tropical weather systems. The latter half of the year is markedly drier, with minimal precipitation.

The meteorological recording station is located at Learmonth (No. 005007). Climatic data from this station indicates the mean maximum temperature ranges from 38.0 °C in January to 24.4 °C in July. The mean minimum temperature ranges from 24.1 °C in February to 11.5 °C in July.

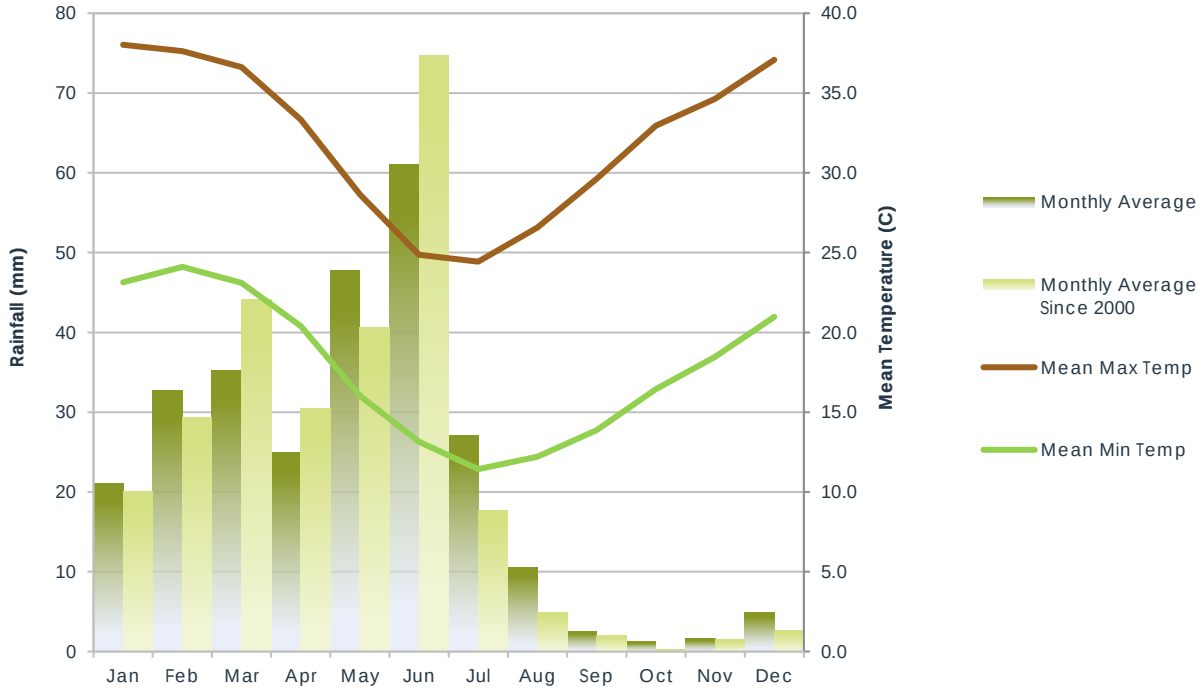


Figure 5: Climate data for Exmouth (Learmonth) (Source: BOM, 2025)

The mean annual rainfall is 284 mm with an average of 32 rain days a year (BoM 2024). The wettest months are typically May and June, while the driest months are September to November, often recording minimal to no rainfall. However, annual rainfall is highly unpredictable and varies with the occurrent of cyclones. The highest recorded rainfall occurred in March 2008, with 479.8mm leading to a yearly average of 641.7mm. In comparison, the lowest year of rainfall, which occurred in 2023, only received 74.8mm (Figure 6).

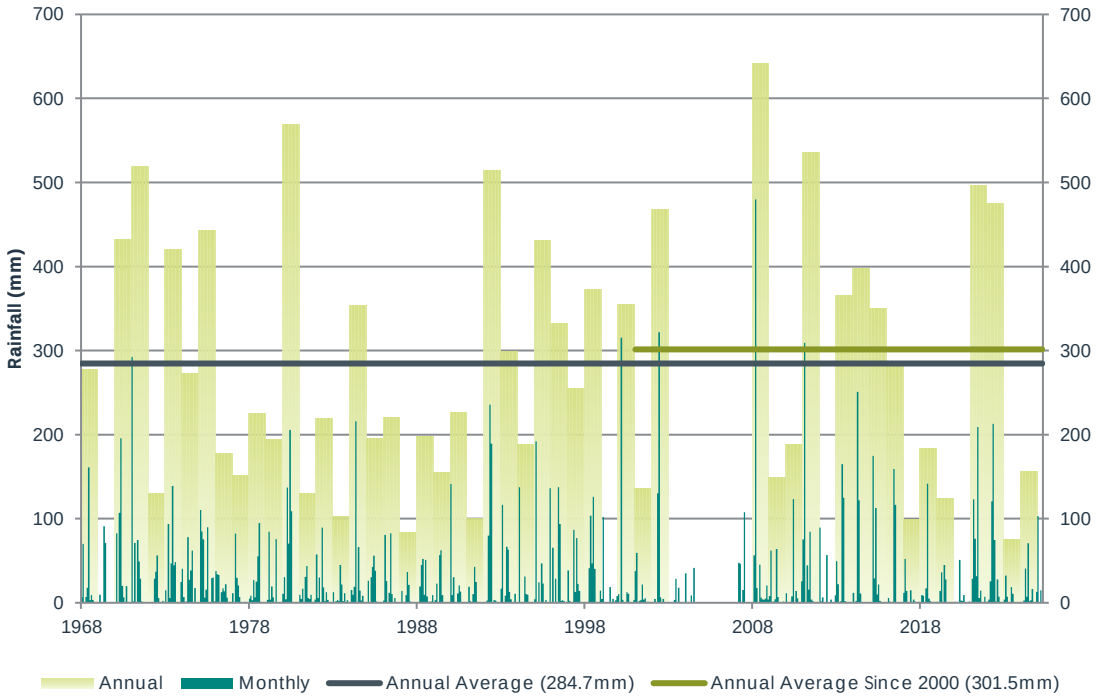


Figure 6: Monthly and annual rainfall since 1968 (Source: BOM 2025)

An analysis of the data suggests that annual rainfall is generally increasing, with the total record (since 1968) annual average of 284.7mm compared to the average since 2000, which is 301.5mm (Figure 6Figure 7). The pattern is highly variable, however, as show in Figure 6.

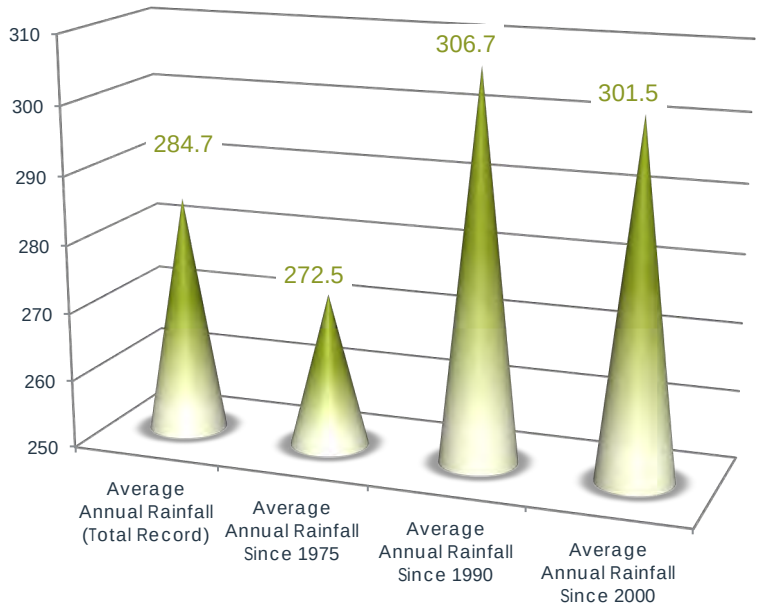


Figure 7: Average rainfall over various periods (Source: BOM, 2025)

3.1.1 Climate change

While there are recent climate scenarios for Australia as a whole, the Climate Change in Australia projections that identified regional differences are dated 2015 (and were produced using the Coupled Model Intercomparison Project Phase 5 (CMIP5)). While these are currently being updated, the available projections for Exmouth, which is part of the Rangelands Sub-cluster (part of the Shire is in Rangelands south and part in Rangelands north), are:

- Average temperatures will continue to increase in all seasons (*very high confidence*).
- More hot days and warm spells are projected with *very high confidence*. DWER notes that by 2090 in Carnarvon, the number of days over 35 degrees will increase from an average of 26 to 66 per year (DWER, 2021). Fewer frosts are projected with *high confidence*.
- Changes to rainfall are predicted to be different for the north and south: in Rangelands north, changes in rainfall are possible but unclear, while in the south, changes to summer rainfall are possible but unclear and winter rainfall is projected to decrease with *high confidence*.
- Increased intensity of extreme rainfall events is projected, with *high confidence*.
- Mean sea level will continue to rise and height of extreme sea-level events will also increase (*very high confidence*).
- For Rangelands north (only): A harsher fire-weather climate in the future (*high confidence*).
- On annual and decadal basis, natural variability in the climate system can act to either mask or enhance any long-term human induced trend, particularly in the next 20 years and for rainfall.

These impacts are likely to be observed through:

- **Marine heatwaves and ecosystem stress -** Exmouth and the surrounding Ningaloo Reef are already experiencing marine heatwaves, which are becoming more frequent and intense due to climate change. A recent event in early 2025 caused the death of over 30,000 fish along the Pilbara coast, with overheated waters threatening the Exmouth Gulf and Ningaloo Reef ecosystems (Australian Marine Conservation Society, 2025). These heatwaves can lead to coral bleaching and loss of biodiversity, declines in fish populations and disruption of local fishing and tourism industries
- **Rising sea temperatures and ocean acidification -** Warmer ocean temperatures and increased CO_2 absorption are expected to stress coral reefs and marine life, alter species distributions and impact the productivity of marine ecosystems that support local livelihoods.
- **Sea level rise and coastal erosion -** Exmouth's low-lying coastal areas may be vulnerable to inundation from rising sea levels, increased erosion and damage to infrastructure and loss of coastal habitats such as mangroves and seagrass beds.
- **Changes in rainfall and increases in extreme weather –** It is likely that there will be a general decline in winter rainfall but increased intensity of heatwaves and bushfires. DWER notes that the north-west coastline between Exmouth and Broome is the most cyclone-prone region of the Australian coast (Bureau of Meteorology n.d.). The frequency of cyclones has remained relatively stable in WA, but it is thought that the intensity has increased. This trend is expected to continue with medium confidence (DWER, 2021).

3.2 Land resources

The Shire of Exmouth's landscape is a product of its complex geological history, featuring sedimentary formations from the Carnarvon Basin, prominent limestone ranges, and dynamic coastal systems. The interplay between geology and geomorphological processes has resulted in a region with diverse landforms and soil types, each influencing the area's ecology and land use practices (Water and Rivers Commission, 1999).

3.2.1 Geology and soils

The Exmouth Province mostly sits over the sedimentary rocks of the Carnarvon Basin. To the west of Exmouth Gulf, the Tertiary limestone of the Cape Range Group is found on top of the Triassic-Jurassic sediments of the Exmouth Sub-basin (Tille, 2006).

The Cape Giralia Coastal Zone is based on the Giralia Anticline geomorphic province and a combination of the Cape Range, Coastal Dunes, Giralia Range and (western) Winning Plains geomorphic districts. The Zone is described as sandy plains, alluvial plains and hills and ranges (with some stony plains) on Cainozoic deposits and marine limestone over sedimentary rocks of the Carnarvon Basin (Tille, 2006).

A unique feature of the Cape Range peninsula is the karst environment. Karst landscapes are terrain with distinctive landforms and drainage patters arising from the high solubility of limestone in natural waters. In the Cape Range area some of the pure and friable limestone has undergone extensive solution with caves and large solution openings having developed (Water and Rivers Commission 1999).

Soils in the Shire of Exmouth are largely derived from the underlying limestone and sandy deposits (Figure 8). They are typically characterised by:

- Calcareous Sands: These are prevalent in coastal areas and are formed from marine shell fragments and coral debris.
- Brownish Sands: Found inland, these sands overlay the limestone formations and are generally shallow, ranging from 60 to 100 cm in depth.

3.2.2 Landform

The landforms within the Shire of Exmouth are diverse, and include:

- Elevated Ranges: The Cape Range is a prominent feature, consisting of folded and faulted limestone ridges running in a north-south direction.
- Karst Topography: The presence of porous limestone has led to the development of karst features such as sinkholes and underground drainage systems.
- Coastal Plains: These are primarily composed of sandy soils and are influenced by marine processes, with some coastal dunes obstructing runoff from the Cape to the Exmouth Gulf.

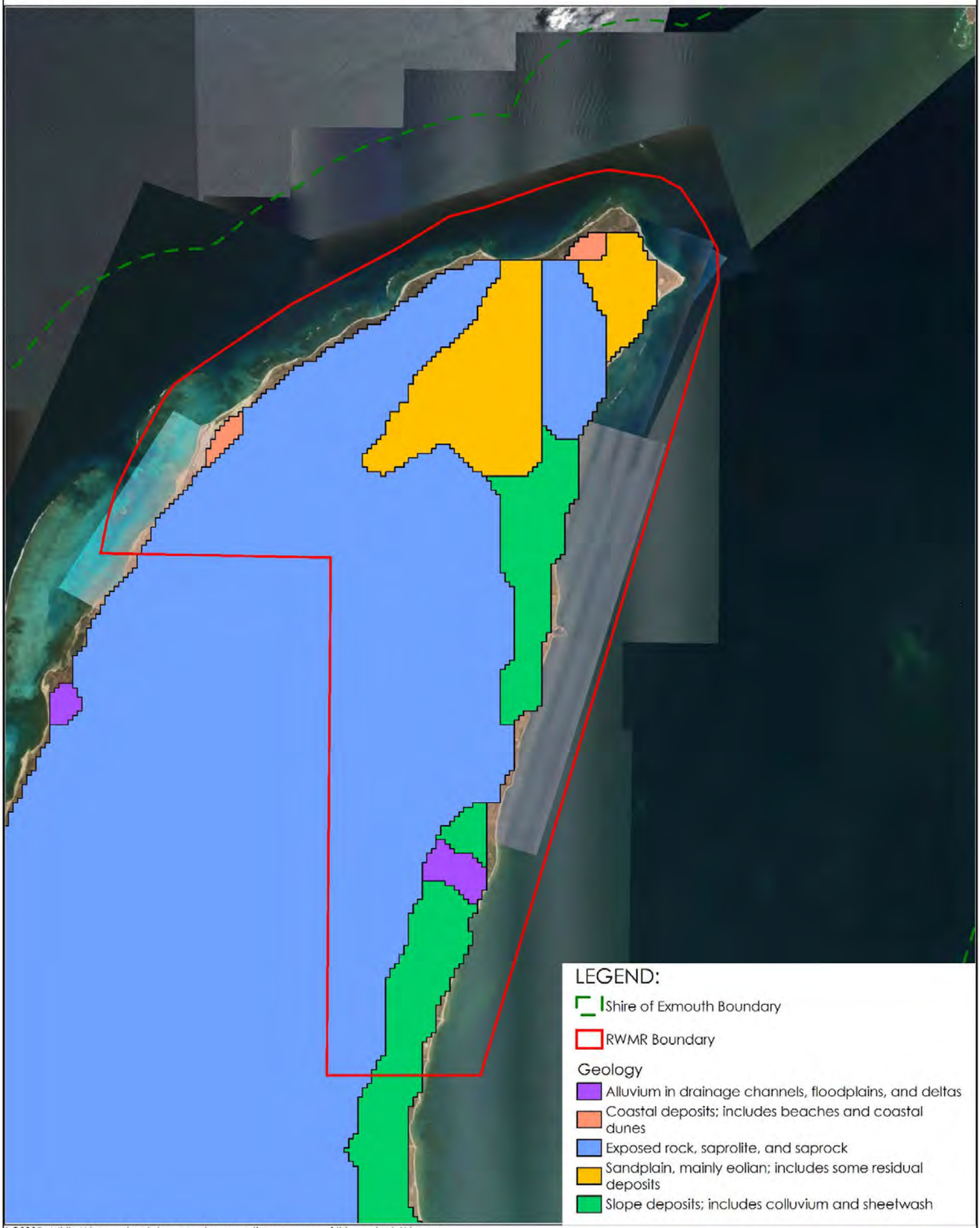
The region's landforms have been shaped by a combination of tectonic uplift, erosion, and sediment deposition. The coastal areas, in particular, are subject to dynamic processes, including cyclonic activity and sea-level changes, which influence sediment distribution and shoreline morphology (Eliot et al, 2012).

Topography ranges from the coastal areas (0mADH) to the top of the Cape Range at approximately 315mAHD (Figure 9).

3.2.3 Acid sulfate soils

The Acid Sulfate Soils Risk Map (Figure 10) shows is a high to moderate risk (Class 1 – red) of acid sulfate soils occurring within 3m of natural soil surface surface in the low lying areas along the coast and a moderate to low risk (Class 2 – orange) of acid sulfate soils occurring within 3 metres of natural soil surface areas subject to riverine processes (creek valleys and flood-prone areas).

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Figure 8 - Geology

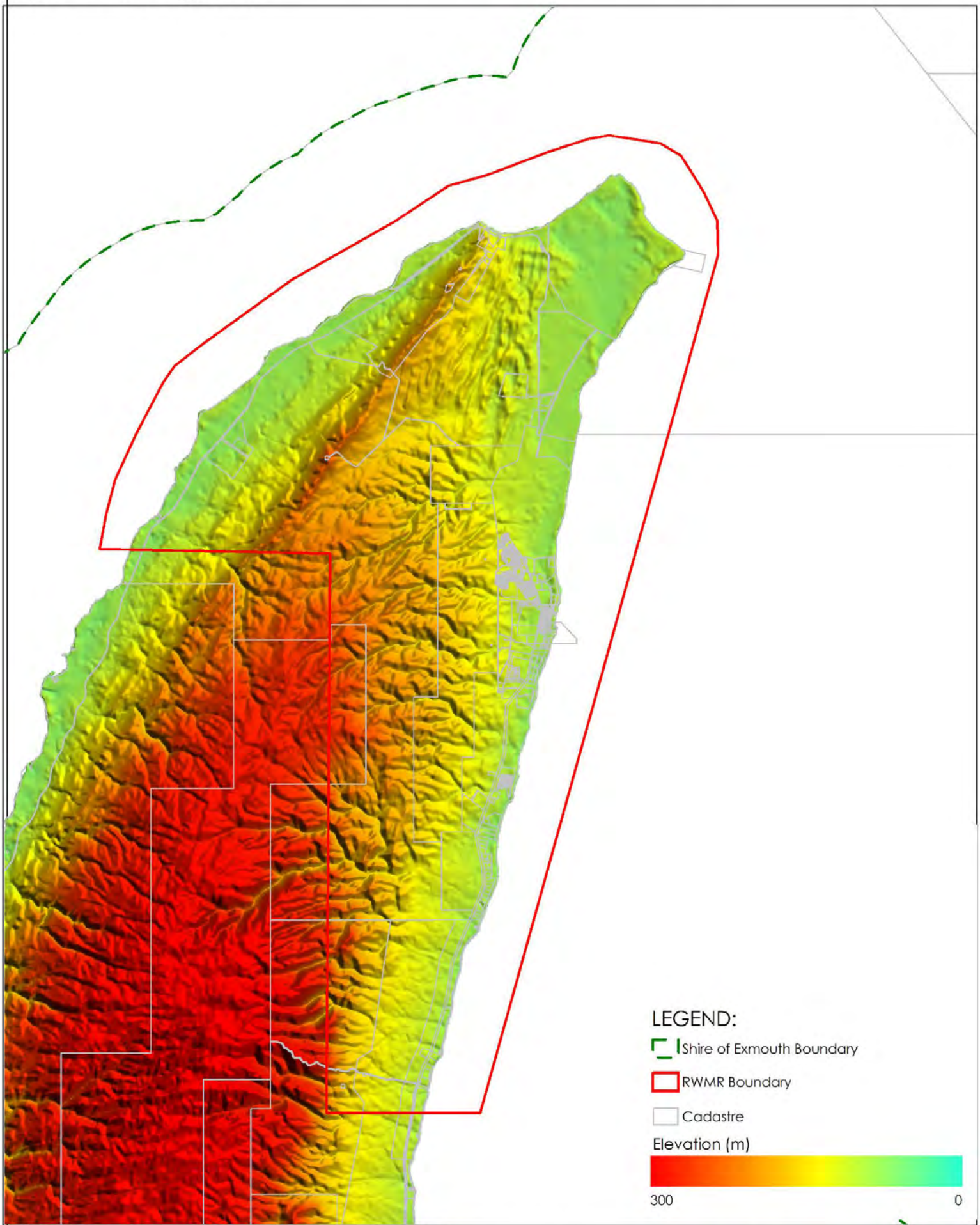


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Figure 9 - Topography

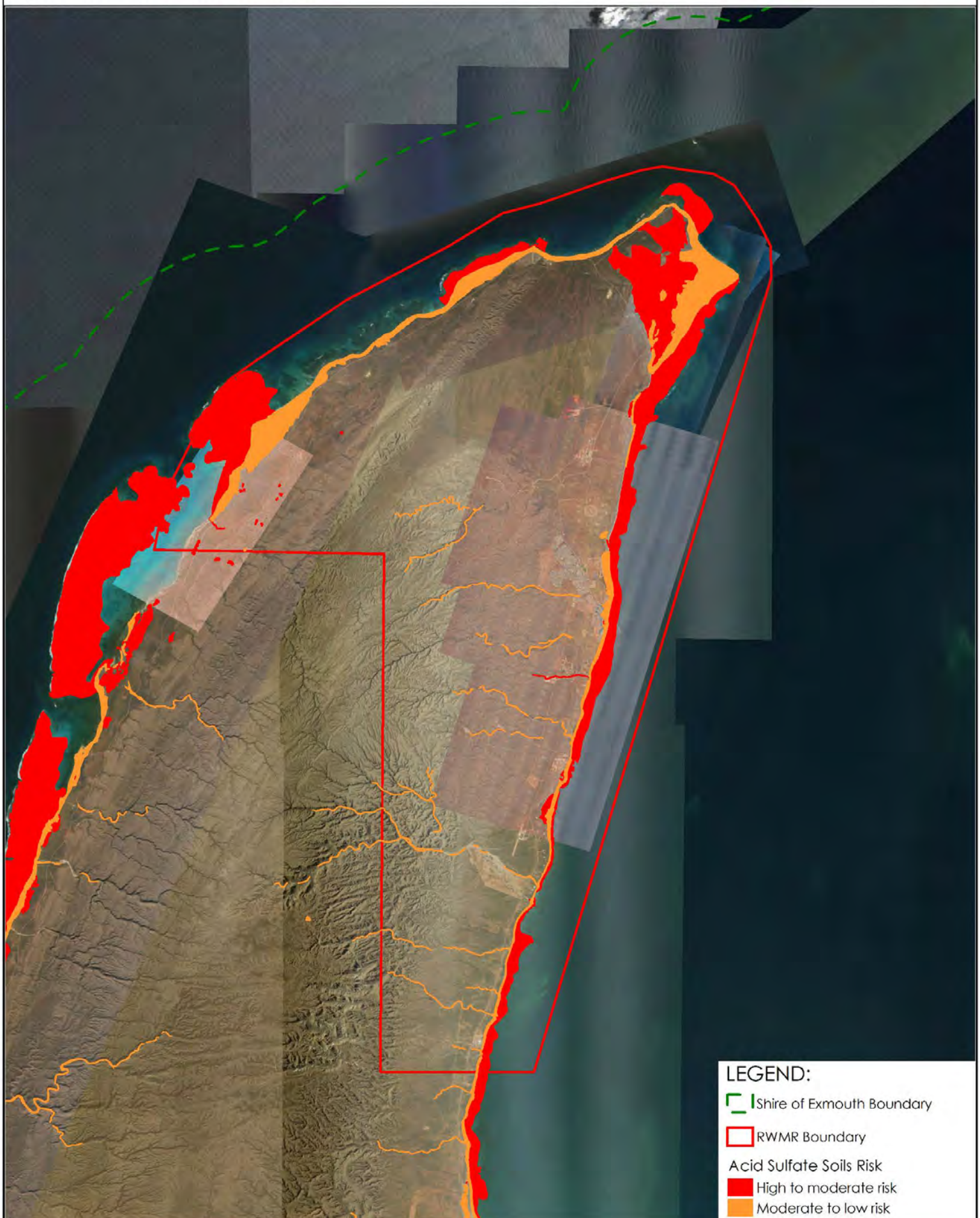


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Figure 10 - Acid sulfate soils



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3.2.4 Contamination

The DWER Contaminated Sites database contains 19 records within the study area. Ten of these have been Remediated for Restricted Use, while nine are classified as "Contamination – Remediation Required". Contaminants include asbestos and hydrocarbons in soils and the groundwater as described in Table 3 and shown on Figure 11.

Table 3: Sites listed in the DWER Contaminated Sites Database

Plan/Lot No	Classification	Nature of contamination	Restrictions on use
Entire Huston Street road reserve	Contaminated - remediation required	Hydrocarbons are present in groundwater beneath the site.	a site-specific health and safety plan is required to address the risks to the health of any workers undertaking intrusive works. Groundwater abstraction is not permitted.
LOT 8 on Plan 209502 (8 Murat Rd Exmouth)	Contaminated - remediation required	Fragments of asbestos-containing material were reported to be present in soils on-site. Groundwater beneath the site is impacted by hydrocarbons.	Groundwater abstraction is not permitted.
LOT 10 on Diagram 71455 (6 Huston St, Exmouth)	Contaminated - remediation required	Hydrocarbons are present in groundwater beneath the site.	A site-specific health and safety plan is required to address the risks to the health of any workers undertaking intrusive works. Groundwater abstraction is not permitted.
LOT 618 on Plan 172623 (4 Huston St Exmouth)	Contaminated - remediation required	Hydrocarbons are present in the groundwater in the northern part of the site	A site-specific health and safety plan is required to address the risks to the health of any workers undertaking intrusive works. The land use of the site is restricted to commercial/industrial use. Groundwater abstraction is not permitted.
LOT 617 on Plan 172623 (26 Nimitz St, Exmouth)	Contaminated - remediation required	Hydrocarbons are present in the soils of the site in the vicinity of the underground storage tanks in the north western corner of the site and in the groundwater.	A site-specific health and safety plan is required to address the risks to the health of any workers undertaking intrusive works. The land use of the site is restricted to commercial/industrial use. Groundwater abstraction is not permitted.
LOT 2 on Plan 209502 (24 Nimitz St, Exmouth)	Contaminated - remediation required	Hydrocarbons present in groundwater beneath the site and extend off site to the road reserve and properties to the east.	A site-specific health and safety plan is required to address the risks to the health of any workers undertaking intrusive works. Groundwater abstraction is not permitted.
LOT 289 on Plan 209502 (16 Christie St, Exmouth)	Contaminated - remediation required	Fragments of asbestos containing material are present within soil at the site.	A site-specific health and safety plan is required to address the risks to the health of any workers undertaking intrusive works.
LOT 300 on Plan 406333 (1 Huston St, Exmouth)	Remediated for restricted use	Hydrocarbons are present in soils and the groundwater, extending off-site to the east.	The Ongoing Site Management Plan is required to be implemented. Groundwater abstraction is not permitted. The land use of the site is restricted to commercial/industrial use.
LOT 301 on Plan 406333 (29 Pelias St, Exmouth)	Remediated for restricted use	Hydrocarbons are present in soils	The Ongoing Site Management Plan is required to be implemented. Groundwater abstraction is not permitted. The land use of the site is restricted to commercial/industrial use.

Plan/Lot No	Classification	Nature of contamination	Restrictions on use
LOT 11 on Diagram 71455 (8 Huston St, Exmouth)	Remediated for restricted use	Hydrocarbons are located on the surface of the groundwater and dissolved in groundwater at this site.	Groundwater abstraction is not permitted.
LOT 43 on Plan 209471 (Harold E. Holt Naval Communication Station)	Remediated for restricted use	Soil impacted with heavy metals, hydrocarbons including fuel oils, asbestos and PCBs	Use restricted to commercial/industrial uses.
Lots 1-7 on Strata Plan 47438 (12 Christie St, Exmouth)	Remediated for restricted use	Cement materials containing asbestos remain in the soils of the Site.	A Site-specific health and safety plan is required to address the risks to the health of any workers undertaking intrusive works and no soil to be disturbed by residential occupants.
LOT 1480 ON DEPOSITED PLAN 38636	Remediated for restricted use	Following remediation, hydrocarbons (such as from diesel) remain in soil and groundwater beneath the site.	The land use of the site is restricted to commercial/industrial use as a fuel depot.

3.2.5 Vegetation, flora and fauna

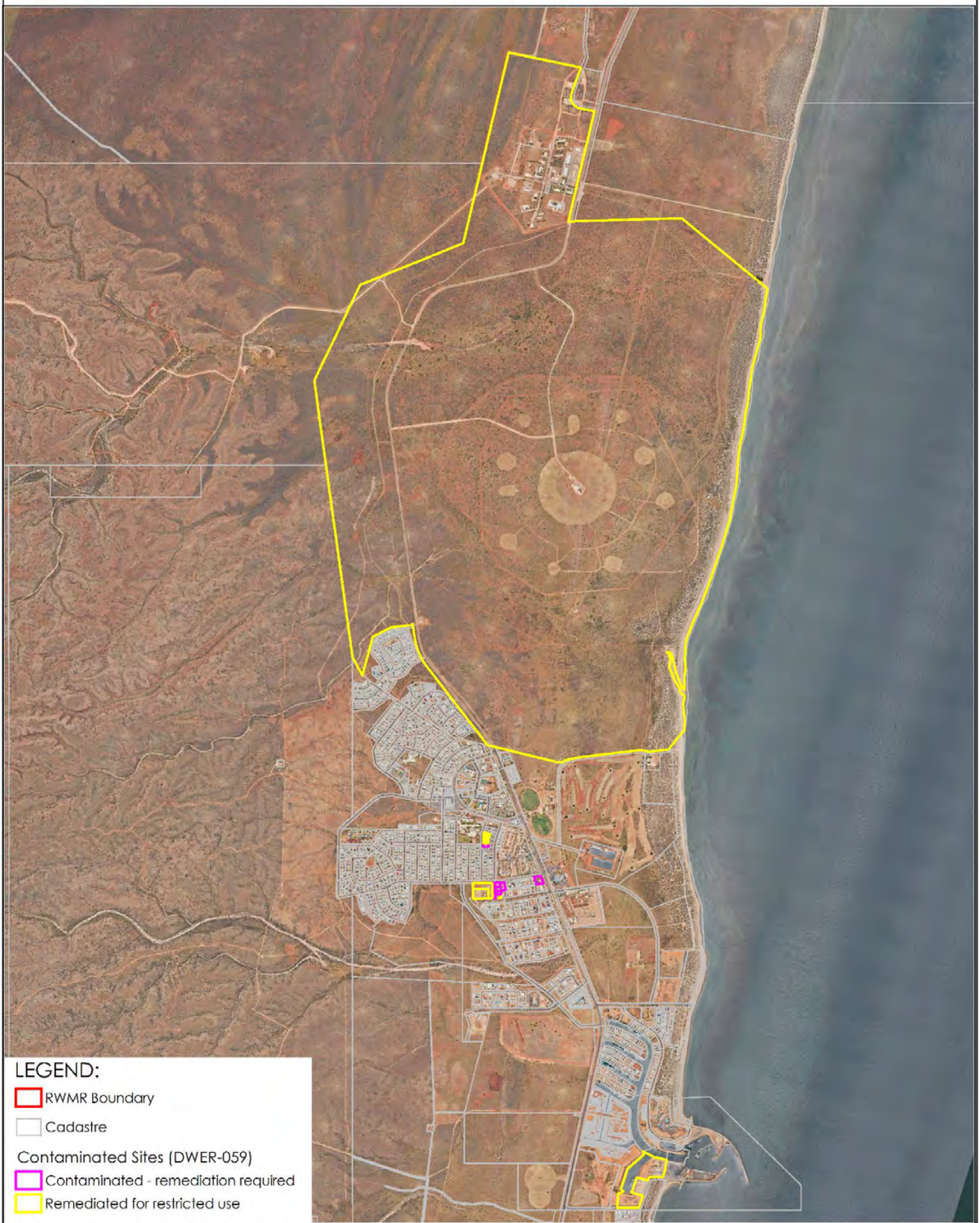
The Shire is located in the Carnarvon bioregion and Cape Range subregion as described by the Interim Biogeographic Regionalisation of Australia (IBRA). The Carnarvon bioregion is composed of quaternary alluvial, aeolian and marine sediments overlying Cretaceous strata. A mosaic of saline alluvial plains with samphire and saltbush low shrublands, Bowgada low woodland on sandy ridges and plains, Snakewood scrub on clay flats, and tree to shrub steppe over hummock grasslands on and between red sand dune fields (Figure 12). Limestone strata with *Acacia stuartii* or *A. bivenosa* shrubland outcrop in the north, where extensive tidal flats in sheltered embayments support mangal (Kendrick and Mau 2002).

As noted in Kendrick and Mau (2002), the Karst System of Cape Range comprises an **"**Elevated limestone range, with deeply dissected rugged topography. Extensive karst features within range, with over 600 karst features described (Darren Brooks, pers. comm.). It contains a large troglobitic fauna of international significance, including both terrestrial and stygofaunal elements. Fauna includes fish (*Ophisternon candidum* and *Milyeringa veritas*), shrimps (*Stygiocaris* spp., ostracods (*Danielopolona*), amphipods (*Liagoceradocus, Halosbaena*), Remipedes (*Lasionectes*), plus many other families and orders of terrestrial and aquatic species.

The Cape Range has a very rich flora for an arid area. The tertiary limestones of Cape Range are vegetated by shrublands comprising *Acacia tetragonophylla*, *A. bivenosa*, *Grevillea variifolia* subsp. *variifolia*, *G. calcicola*, *Melaleuca cardiophylla* (or terraces north of Yardie Creek by *Ipomoea yardiensis*). Hummock grasses of the Cape Range include *Triodia wiseana* and *T. pungens*, and there are a whole suite of less common herbs and shrubs restricted to the community. Yardie Creek represents the northern extent of range for many southern taxa, and the creek system and permanent wetlands in the area provide refugia for these species at the extremities of their ranges (Keighery and Gibson 1993).

The extent of vegetation remaining across the State was measured by DBCA in 2018 (Government of WA 2019). This information suggests that 98% of the extent of pre-European vegetation is considered to remain, however only 7.8% of this is currently protected in secure conservation reserves. Of the 18 vegetation associations contained across the Shire, only eight (8) of those have some protection, while the remainder have no protection.

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Figure 11 - Contaminated sites

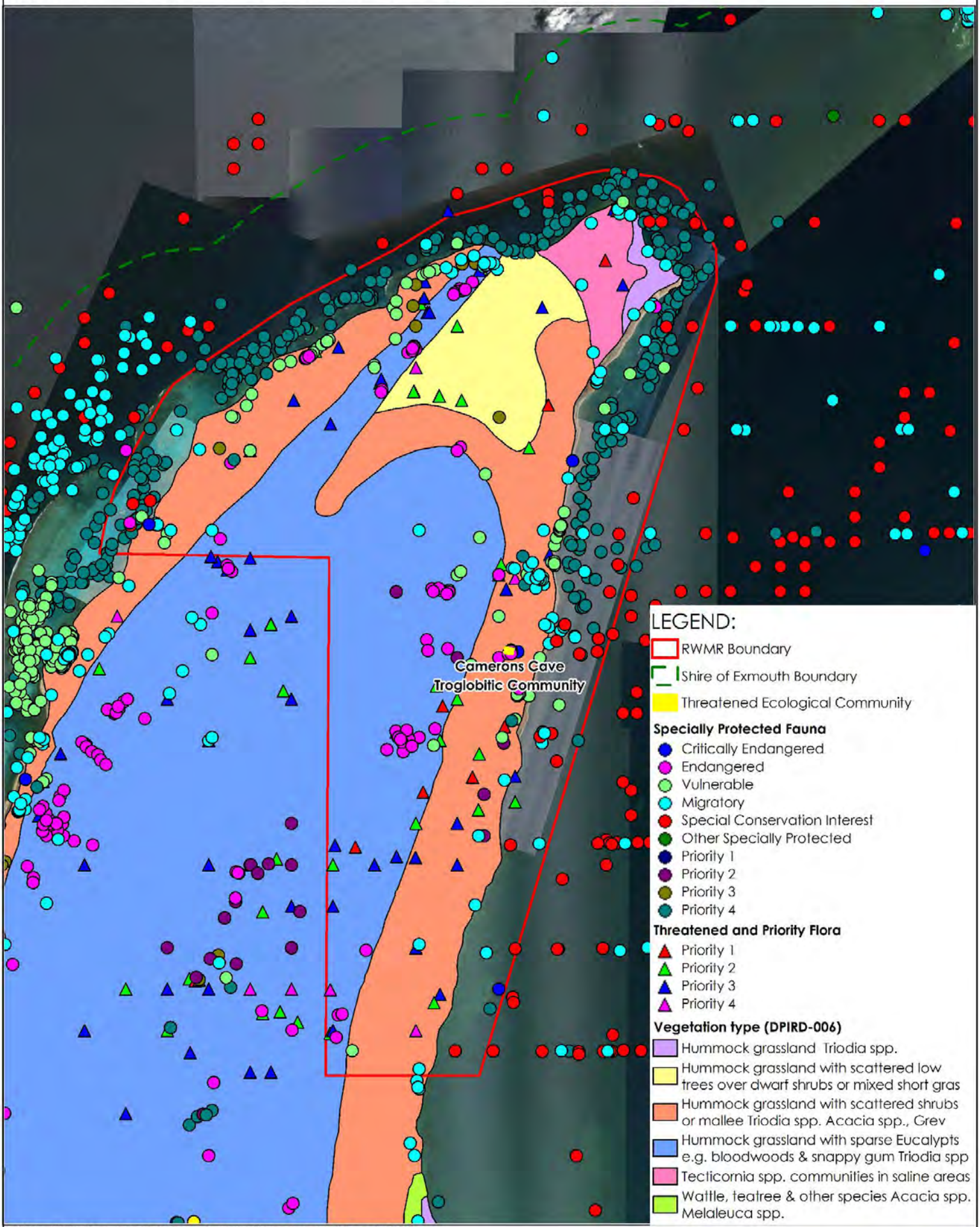


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Figure 12 - Vegetation, flora and fauna



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The majority of the site is an Environmentally sensitive area under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. This will require consideration of vegetation values as part of any planning and development approvals process.

The study area contains a significant number of important flora and fauna. A search of the DBCA's Threatened, Extinct and Specially Protected fauna and fauna database revealed 31 species of protected flora, 120 protected fauna species and one Threatened Ecological Community (TEC). These are shown on Figure 12 and listed in Appendix 1. These plants and animals are protected under the *Biodiversity Conservation Act 2016*. In addition, the area contains federally protected species. A search of the Commonwealth's Matters of National Significance database revealed the presence of 43 listed threatened species and 50 Listed migratory species. These species are protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Critically Endangered TEC is known as the *Cameron's Cave Troglobitic Community* and is known from Camerons Cave on the Cape Range peninsula. The community comprises a unique assemblage of species, at least eight of which are known only from this location. The threatened species *Stygiochiropus peculiaris* (Camerons Cave millipede; critically endangered) and *Indohya damocles* (Camerons Cave pseudoscorpion; critically endangered) (previously Hyella sp. BES 1154.2525, 1546, 2554) are endemic to Camerons Cave. *Milyeringa veritas* (blind gudgeon; vulnerable) and *Draculoides bramstokeri* (Barrow Island draculoides; vulnerable) also occur in the cave (DBCA TEC fact sheet).

3.3 Water resources

3.3.1 Surface water

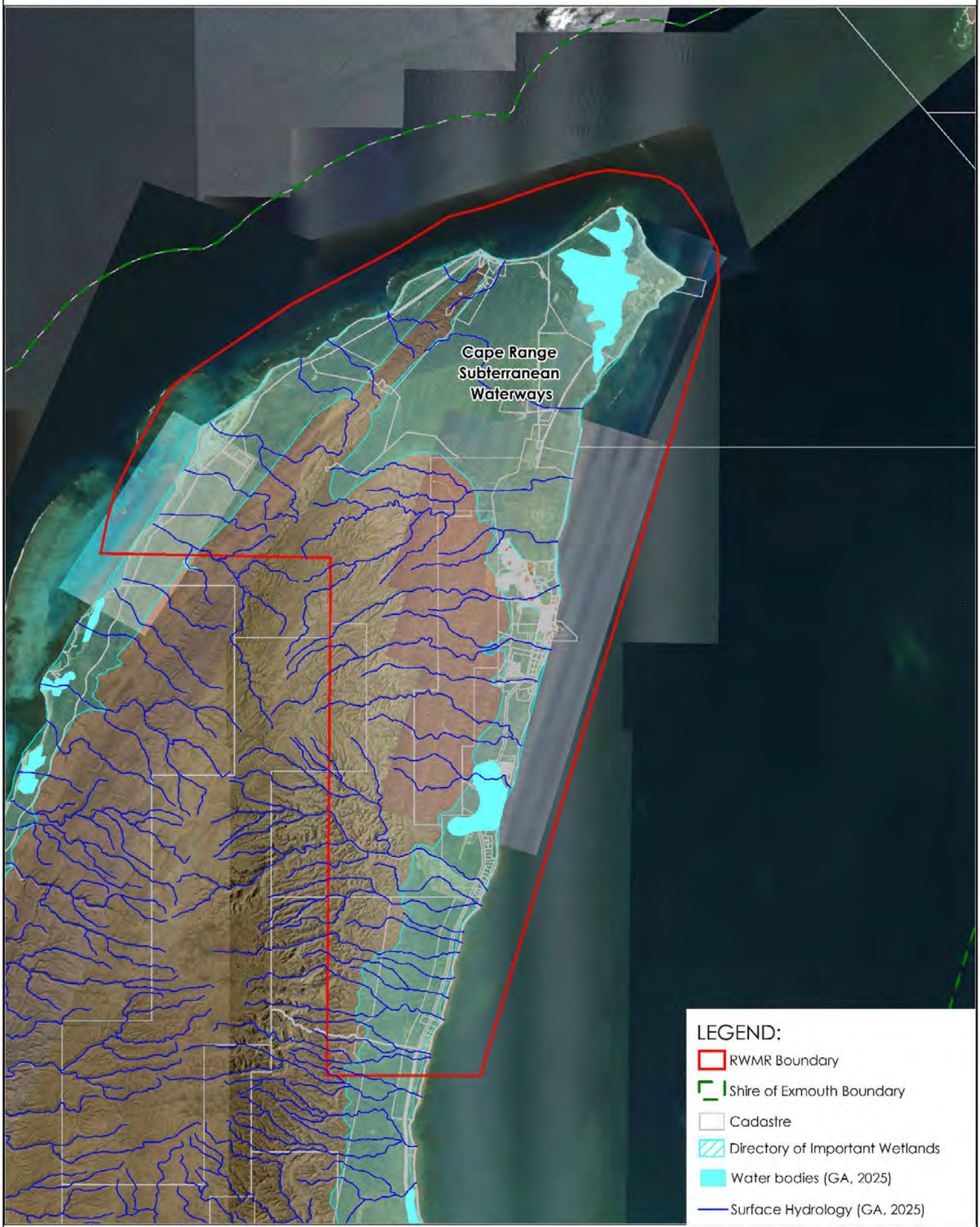
Surface water management in Exmouth is significantly influenced by the landform, geology and patterns of rainfall. Key surface water resources include numerous larger waterways and smaller creeklines which originate in the Cape Range and discharge to the coast (Figure 13).

The unique topography, combined with highly permeable limestone aquifers beneath the Cape Range Peninsula, allows for rapid infiltration of rainfall and surface runoff, which contribute to groundwater recharge, with some coastal dunes obstructing runoff from the Cape to the Exmouth Gulf (DWER, 2025a). Six main creeks flow eastward from the Cape Range through the Exmouth townsite, with the Light Industrial Area (LIA) Creek catchment and Market Street catchment being the largest (Hyde2O, 2014).

The study area is contained within the Pilbara Surface Water Area, which is proclaimed under the *Rights in Water and Irrigation Act 1914* (RIWI Act). There are no areas proclaimed under the *Waterway Conservation Act 1976.*

The study area contains one Nationally Important Wetland, the Cape Range Subterranean Waterways (Figure 13). It is designated as the subterranean waterways, sinkholes, general groundwater and artificial wells (notably Billy, Five Mile, Javis, Kubara, Kudumurra, Milyering, Mowbowra, Pilgramunna, Tantabiddi and Tulki Wells, Tantabiddi and Wobiri Rockholes, Bundera Sinkhole, and caves C-23, C-215, C-452, C-495) of the coastal plain and foothills of Cape Range north of a line between Norwegian Bay, at the foot of the peninsula on the west coast, and the Bay of Rest in Exmouth Gulf (Australian Wetlands Database).

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Figure 13 - Surface water resources



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DCCEEW (2023a) describes the Cape Range Subterranean Waterways as unique because they:

- Support threatened species listed under WA's *Wildlife Conservation Act 1950* and the EPBC Act.
- Meet two Ramsar criteria for possible listing as a wetland of international importance (Jaensch & Watkins 1999), given the system is the only one of its type (apart from Barrow Island) in arid north-western Australia.
- Are the only wetlands listed principally for subterranean aquatic fauna values in the Directory of important wetlands in Australia (DIWA) (Environment Australia 2001).
- Support a rich, entirely endemic (local) subterranean community mostly of relictual marine (Tethys Sea) fauna such as the Blind Gudgeon (*Milyeringa veritas*), the Blind Cave Eel (*Ophisternon candidum*. Many species share similarities with those from similar habitats in the Caribbean and Canary Islands, and the fauna includes the only southern hemisphere representatives of entire classes, orders, families and genera of crustaceans.

DWER notes that the peninsula supports a few persistent and ephemeral creeks and wetlands. Qualing Pool, south of the Exmouth townsite near the mouth of an unnamed creek, is made up of a series of pools that are also considered permanent and groundwater-fed.

Springs are also critically important sources of water, particularly in arid and semi-arid environments, supporting terrestrial fauna, and aquatic and riparian habitat. DWER reports that fresh to brackish springs were known to occur near the coastline and a cluster of submarine springs has been observed offshore at Mangrove Bay, discharging fresh water into the marine environment. In addition, two soaks and a gnamma hole have been mapped in the Mowbowra Creek area and the Mowbowra bore/well to the south of the gnamma holes was known to support stygofauna. The creeks, springs and pools likely represent significant spiritual, cultural and historical heritage values for the Nganhurra Thanardi Garrbu Aboriginal Corporation Traditional Owners (DWER, 2025).

Flood risk

Flood risk on the Exmouth Peninsula is primarily driven by intense rainfall from tropical cyclones and storm surges. Historical events, such as Tropical Cyclone Vance in March 1999 and a significant rainfall event in June 2002, resulted in extensive inundation (SKM, 2007). While a number of previous studies have investigated flood risk to the townsite, there have been recent changes in landform such as the marina development and the addition of fill to support development across the townsite, that, when coupled with the potential future impacts of climate change, support the need for an updated hydrological assessment.

Accordingly, Urbaqua undertook hydrological modelling to review the likely levels of flood risk under different rainfall conditions. The aim was for the model to be capable of defining the extent, depth and velocities of flood flows traversing the land as well as representing changes to local topography following development so that floodways and flood prone areas within the existing townsite and developing areas can be protected, and risks to people, property and infrastructure can be suitably managed for the existing and future community.

It is noted that there are existing flood mitigation measures in place within the townsite, and current modelling has assumed that these critical works remain in place and are properly maintained to ensure functionality into the future. Significant flood mitigation works present in the townsite include:

- Market Street bund.
- Reid Street drainage and floodway levee.
- Warne Street spillway.

In addition, there are numerous floodways across Murat Road with associated signage in place. Progressive upgrades at these locations, to provide new or upgraded culverts and prevent

overtopping of the road have been previously recommended to reduce the risk of road closures preventing access to the townsite and to reduce the frequency of flood damage to the road, which can cause extended periods of isolation (SKM, 2007).

The area selected for hydrological modelling (the model area), is smaller than the study area, in part due to data availability but primarily because the areas of interest for planning and potential future development purposes are in and around the Exmouth Townsite. The only exception to this, is one potential area of industrial development adjacent to the former Kailis prawn processing facility, near the southern boundary of the study area.

A combined a 1/2-dimensional hydrological and hydraulic model was constructed using the InfoWorks Integrated Catchment Model (ICM). The upstream catchments were delineated based on local topography, with consideration of catchments applied in previous modelling (SKM, 2007 and Worley, 2024). Nine principal catchments were defined as feeding into the model area at 21 individual discharge locations.

Model topography was developed from a combination of LiDAR digital terrain model (DTM) prepared in 2024 and provided by the Water Corporation, augmented with small areas of 0.5m resolution Aerial Laser Scanning Survey (ALS) data from the earlier *Exmouth Floodplain Management Study* (SKM, 2007).

The Coastal Boundary condition was generated from the Statewide Coastal Inundation Assessment Phase 2 Report (Seashore Engineering, 2024) to allow consideration of the effect of coastal processes on flood risk.

The analysis then applied ensemble design rainfall analysis consistent with the procedures recommended by Australian Rainfall and Runoff (ARR2019) and with consideration of the following relevant previous modelling and associated studies:

- Exmouth Floodplain Management Study (2 parts): Flood Modelling Report (SKM, 2007) and Floodplain Management Strategy (SKM, 2007)
- Exmouth Hydrological Study (Hyd2O, 2014)
- Statewide Coastal Inundation Assessment Phase 2 Report (Seashore Engineering, 2024)
- Exmouth Desalination Plant Flood Study – Draft Report (Worley Consulting, 2024).

The existing (base) case was represented by current climate conditions (2024), and a joint probability pre-screening assessment was undertaken to determine if coastal or fluvial processes (rainfall/ stormwater) dominate and decide what combinations to use in model simulations (Figure 14). This noted that most of the proposed development sites are located in areas dominated by fluvial processes (green) while most of the tourism sites are mainly dominated by coastal processes (blue). ARR2019 recommends that complete interdependence should be assumed in both situations. In the joint dependence zone (red) some adjustment away from the fluvial flood (one percent annual exceedance probability 1% AEP) event could be justified, however this study has assumed complete interdependence as a worst-case assessment for planning purposes. In future, when more detailed planning is undertaken for these sites, it is recommended that a more detailed joint probability assessment is carried out.

Results from the current climate base scenario are presented in Figure 15 (10% AEP, which includes a coastal boundary condition at Highest Astronomical Tide – 1.47m AHD)) and Figure 16 (1% AEP(which includes a coastal boundary condition at the extreme (1% AEP) inundation level – 3.1 AHD)). Results include presentation of flood hazard for each scenario based on flood hazard regimes for people as outlined in Table 4 which is taken from ARR2019.

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Figure 14 - Joint probability - pre-screening analysis



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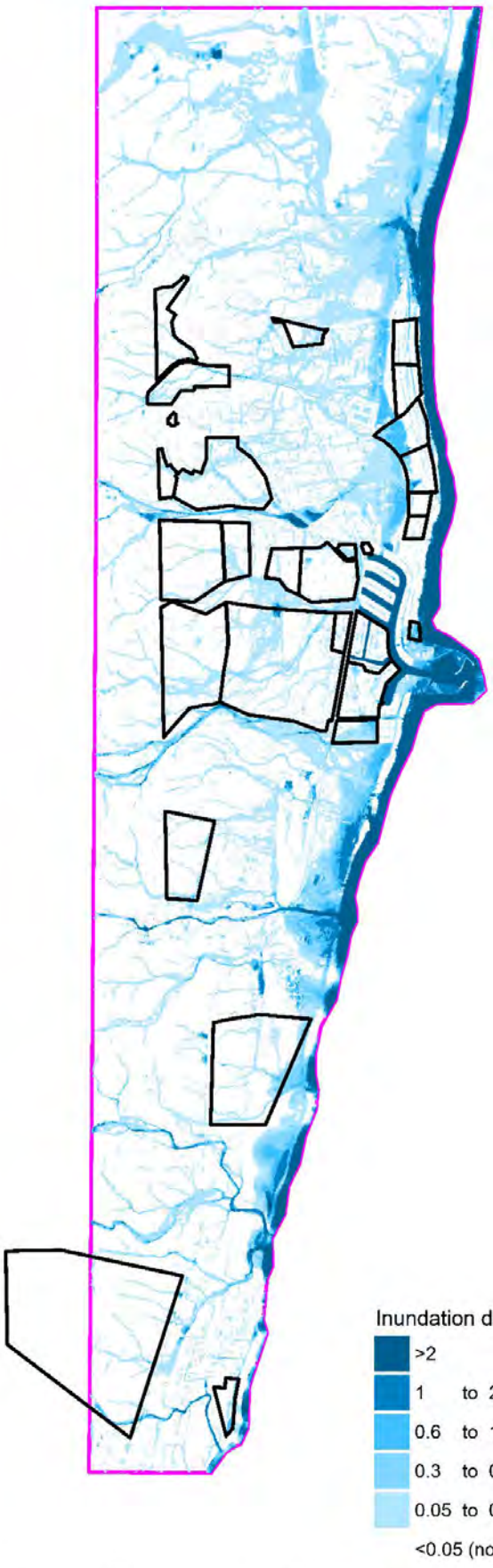
- Model Boundary (2D)
- Potential development sites
- Joint dependence zone
- Complete independence zone (Coastal dominance)
- Complete independence zone (Fluvial dominance)

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Figure 15 - 10% AEP model results (base scenario)





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Figure 16 - 1% AEP model results (base scenario)



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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Table 4: Flood hazard regimes for people (ARR2019)

Depth x velocity	Children	Adults
0	Safe	Safe
0-0.4	Low hazard if depth<0.5m and velocity <3m/s otherwise Extreme Hazard	Low hazard if depth<1.2m and velocity <3m/s otherwise Extreme Hazard
0.4-0.6	Significant hazard; dangerous to most if depth<0.5m and velocity <3m/s otherwise Extreme Hazard	
0.6-0.8	Extreme Hazard; dangerous to all	Moderate hazard; dangerous to some if depth<1.2m and velocity <3m/s otherwise Extreme Hazard
0.8-1.2		Significant hazard; dangerous to most if depth<1.2m and velocity <3m/s otherwise Extreme Hazard
>1.2		Extreme Hazard; dangerous to all

For this study, two climate change scenarios were selected as follows:

- Medium term (2070) – SSP2-4.5: Selected as the principal 'design scenario'
- Long term (2120) – SSP3-7.0: Selected as a 'stress-test' scenario.

For these scenarios, the extreme inundation level plus allowances for sea level rise has been applied as the downstream boundary condition in 1% AEP events. The highest astronomical tide has been applied in the 10% AEP event scenarios, plus allowances for sea level rise. Sea level rise allowances of 0.4m and 0.9m have been applied respectively to medium-term design scenarios and long-term stress test scenarios.

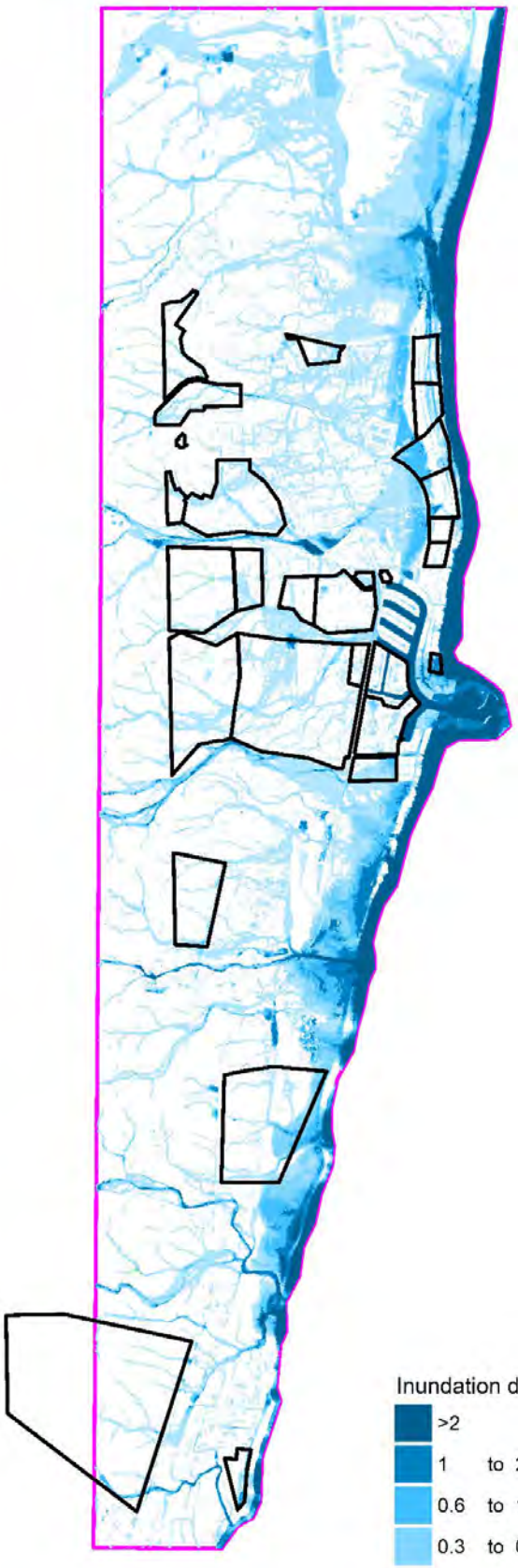
Climate change design scenario results with existing land uses and the existing digital terrain model are presented in Figure 17 and Figure 18. The results of the long term climate stress test are provided in Appendix 2.

Development scenario modelling is also provided in Appendix 2. For this modelling, a revised digital terrain model was adopted with all proposed development sites filled to prevent flooding in the 1 % AEP event. An assessment of afflux in areas surrounding the proposed development areas caused by filling of the land has also been undertaken and the results are provided in Appendix 2.

The implications of these results for future development are discussed in Section 4.

The hydrological modelling report is provided at Appendix 2.

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Figure 17 - 10% AEP model results (climate change 'design scenario')



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



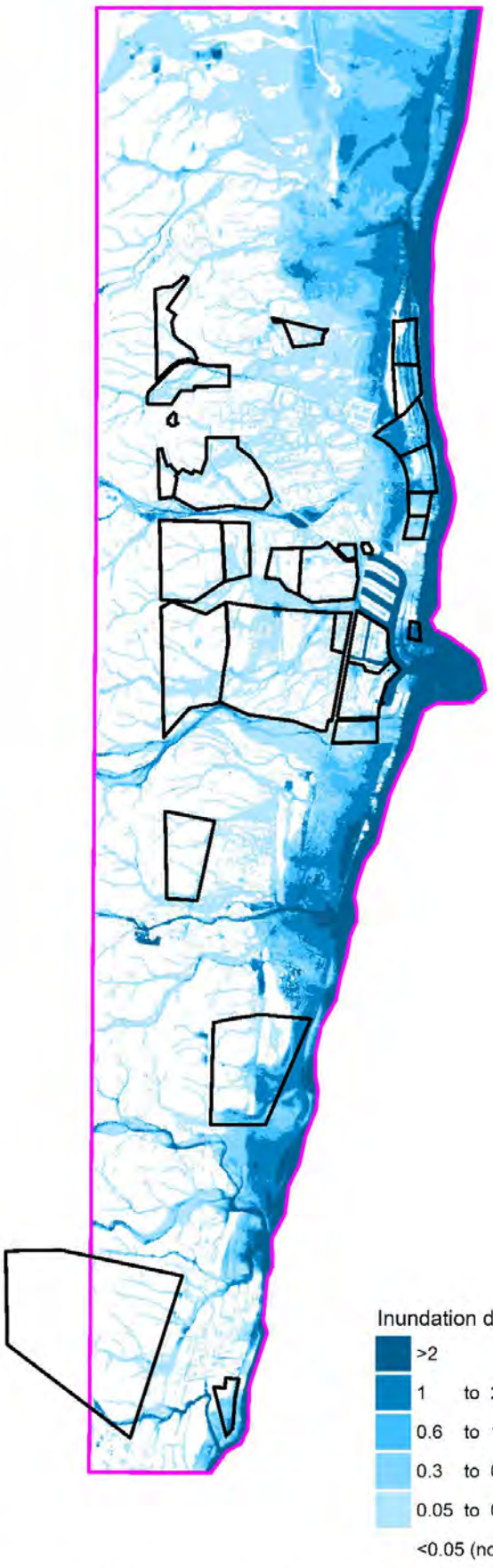
Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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Figure 18 - 1% AEP model results (climate change 'design scenario')



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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3.3.2 Groundwater

The study area is underlain by the Cape Range Group (unconfined) and Birdrong Sandstone (confined) aquifers. The Cape Range Group comprises the Trealla, Tulki and Mandu Limestone karst environment. The aquifer has a thin freshwater lens contained in the limestone over saline water (Figure 19). Groundwater levels are only marginally above sea level and flow direction is from the Cape Range anticline out to the sea, from west to east on the eastern side of the range (Water and Rivers Commission 1999).

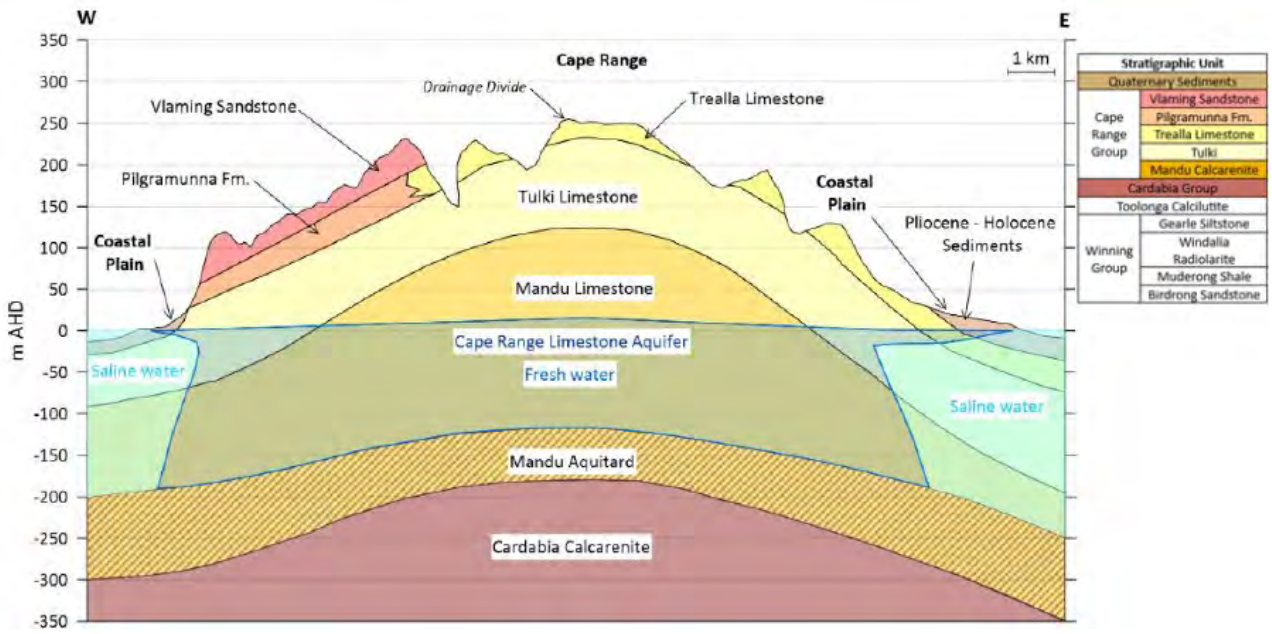


Figure 19: Conceptual cross-section of the Exmouth Peninsula's aquifer system showing a west (left) to east (right) transect through the Cape Range and coastal plains (Source: DWER, 2025)

The Cape Range Limestone aquifer has variable but generally high hydraulic conductivity (water flows easily and rapidly) as it has extensive and well-developed karstic features (Forth 1973, as reported in DWER, 2025). Recharge to the unconfined aquifer is mainly by direct infiltration of rainfall. Indirect recharge occurs through the beds of ephemeral streams which carry storm runoff from the Cape Range. Groundwater is discharged by abstraction from the wellfield, by evapotranspiration from vegetation on the coastal plain and by flow to the ocean and several springs along the coast (Water and Rivers Commission 1999).

The Birdrong Sandstone aquifer is a fine to coarse friable sandstone about 30 m thick. The aquifer is found at depths of 1000 m or greater and contains saline water (Water and Rivers Commission 1999).

Groundwater salinity varies from 600 to 1,500 mg/L total dissolved solids (TDS) concentrations (fresh to marginal water quality/salinity). Bores located within the Exmouth township typically yield more marginal water due to the limited lens thickness on the coastal plain (DWER, 2025).

DWER notes that towards the coast, the Cape Range Limestone resource presents as a thinner lens of fresh groundwater overlying seawater (Figure 19 and Figure 20). As such, it is susceptible to the upward migration of saline water if bores are screened too deep or pumping rates are too high.

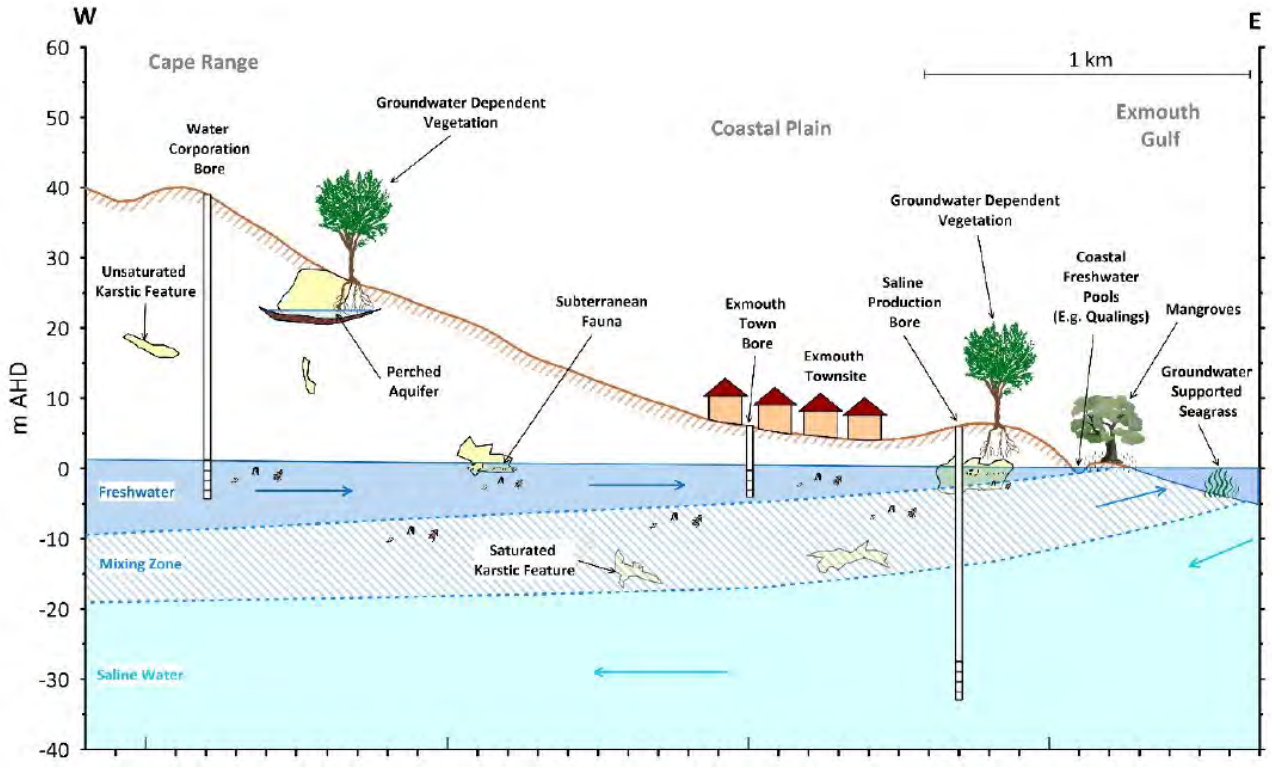


Figure 20: Conceptual hydrogeological cross-section showing how groundwater, water use, and groundwater-dependent ecosystems interact on the peninsula's eastern side (the west coast of Exmouth Gulf) (Source: DWER, 2025)

Groundwater dependent values

The Cape Range Limestone aquifer supports a range of groundwater-dependent ecosystem types both above and below the ground. The terrestrial values supported by groundwater (as discussed previously) include wetland ecosystems (creeklines and pools), springs and vegetation.

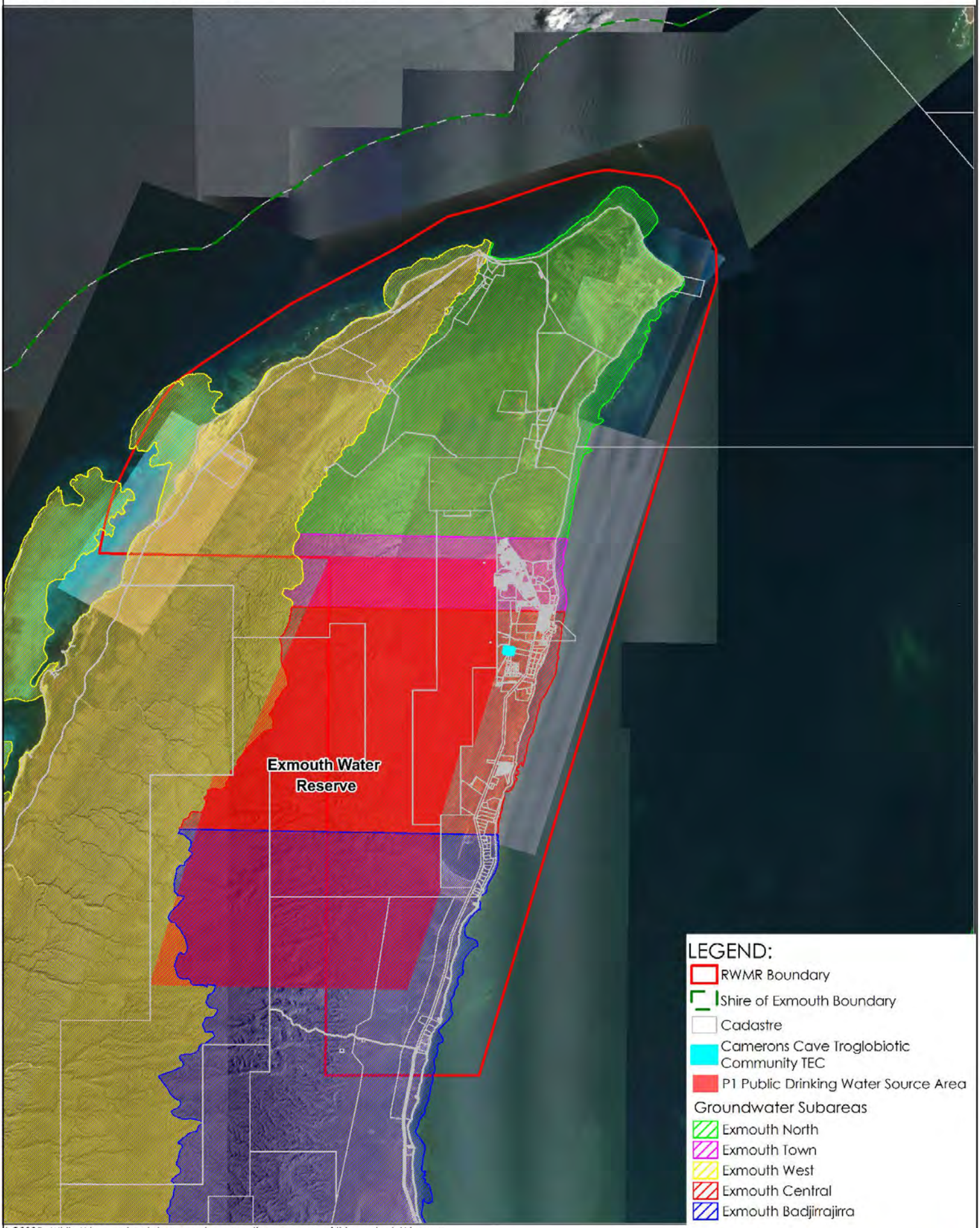
Other important groundwater-dependent ecosystem types are subterranean and aquifer ecosystems (freshwater and mixing zone) and nearshore marine ecosystems (mangroves, seagrass communities).

Subterranean and aquifer ecosystems support an array of fauna that spend their entire lives below the Earth's surface. Stygofauna live in the groundwater and troglofauna breathe air and live in voids, and accordingly, the maintenance of particular groundwater conditions and regimes is critical to their survival. While most species are macroinvertebrates, the blind gudgeon (*Milyeringa veritasi*) and blind cave eel (*Ophisternon candidum*) are also found in the waterways (Humphreys 1999, as cited in DWER, 2025).

As noted previously, the Camerons Cave Troglobiotic Community TEC is listed under the *Biodiversity Conservation Act* (Figure 21). This community contains a unique assemblage of troglofauna, of which at least eight species are only found in this cave and are likely dependent on the humidity from groundwater at the base of the cave. Parts of the cave extend below the watertable, believed to be the unconfined Cape Range Limestone aquifer (DEC 2012, as cited in DWER, 2025).

DWER have also noted that submarine groundwater discharge likely plays a vital role in maintaining the diversity and richness of nearshore and marine ecosystems, including mangroves and seagrass communities, which are a critical element of the World Heritage listed Ningaloo Marine Park.

Shire of Exmouth - Exmouth Regional Water Management Report
Figure 21 - Groundwater resources



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Public Drinking Water Source Area

A Public Drinking Water Source Area (PDWSA) is a collective term used for the description of Water Reserves, Catchment Areas and Underground Pollution Control Areas declared (gazetted) under the provisions of the *Metropolitan Water Supply, Sewage and Drainage Act 1909* or the *Country Area Water Supply Act 1947* (CAWS Act).

PDWSAs are managed with different priority source protection areas (P1, P2, P3) and well-head protection zones, which define strict limitations or guidelines on land use to prevent contamination. The Exmouth Water Reserve is a Priority 1 (P1) area, which aims for the highest quality public drinking water with minimal degradation. The P1 area is shown on Figure 21. It has been incorporated into the Shire of Exmouth Local Planning Scheme No 4 via Special Control Area 1, which provides additional provisions for consideration of land use and development.

Groundwater allocation

The Exmouth Peninsula is proclaimed as part of the Gascoyne groundwater area under the RIWI Act. Accordingly, a licence is required to legally take groundwater in the study area.

DWER has recently reviewed and updated the groundwater allocation limits for the Exmouth Peninsula, last set in the *Exmouth groundwater subareas allocation plan* (WRC 1999). The *Exmouth groundwater subareas allocation limits review* (DWER, 2025) contains updated water allocation limits and guidance to support sustainable groundwater use and environmental outcomes to ensure the long-term viability of subterranean water resources.

The review by DWER has resulted in a change to the groundwater management subareas, with the former Exmouth South subarea being replaced by two new subareas – Badjirrajirra and Exmouth Saltflats to reflect the water features of Badjirrajirra Creek north of Learmonth, and the coastal mangroves and salt flats of the Exmouth Gulf (DWER, 2025).

In addition, the main aquifer has been divided into two resources in each subarea:

- The Cape Range Limestone resource is the freshwater portion of the aquifer within each subarea, which supplies water for the town of Exmouth and its surrounding industries.
- The saline resource is the saline portion of the aquifer within each subarea, which has been targeted to supply water for aquaculture, dust suppression and desalination purposes.

The Birdrong Sandstone aquifer was not included in the DWER review, as it is considered unlikely to be targeted for use (DWER, 2025).

The Shire of Exmouth was re-issued a Licence to take groundwater in 2022. The licence (GWL47592(8)) provides an annual water entitlement of 27,000kL from the Gascoyne resource: Carnarvon - Cape Range Limestone for the irrigation of up to 155 ha of recreation areas in:

- Maidstone Cr Exmouth - Federation Park bore
- Willersdorf Rd Exmouth - Sanctuary bore
- Truscott Cr Exmouth - Visitor's Centre bore
- Exmouth - Pattersons bore

DWER has allocated 500,000 kL from the Badjirrajirra sub-area as public water reserve. This volume is approximately 9.5 per cent of groundwater recharge, allowing the majority of groundwater recharge to remain in the aquifer to protect groundwater-dependent values at a low level of risk (DWER, 2025). It is anticipated that the Water Corporation will apply for this allocation to assist with current capacity constraints to public water supply.

The Department of Defence also uses groundwater to supply the Learmonth Airbase and Harold E. Holt facilities, which are exempt from licensing but which the allocation limits take account of (DWER, 2025).

The revised allocation levels and limits are contained in Table 5. This suggests that some groundwater is available for allocation in the Exmouth North, West and Badjirrajirra sub areas, although it is noted that there is likely to be limited access to the groundwater in the Exmouth West subarea due to national park tenure.

Table 5: Groundwater allocation and limits, 2025

Resource	Number of licenses	Allocated amount	Allocation limit	Status of water availability for licencing
Exmouth North	**3**	**77,220**		
Carnarvon - Cape Range Limestone	0		27,400	Yes
Saline Resource	3	77,220	Not set	Case by case
Exmouth Town	**8**	**679,150**		
Carnarvon - Cape Range Limestone	7	279,150	279,700	Very limited
Saline Resource	1	400,000	Not set	Case by case
Exmouth West	**3**	**33,800**		
Carnarvon - Cape Range Limestone	3	33,800	50,000	Yes
Saline Resource		0	Not set	Case by case
Exmouth Central	**4**	**2,340,898**		
Carnarvon - Cape Range Limestone	3	840,898	840,898	No
Saline Resource	1	1,500,000	Not set	Case by case
Exmouth Badjirrajirra	**0**	**0**		
Carnarvon - Cape Range Limestone	0	0	818,050	Yes
Saline Resource	0	0	Not set	Case by case

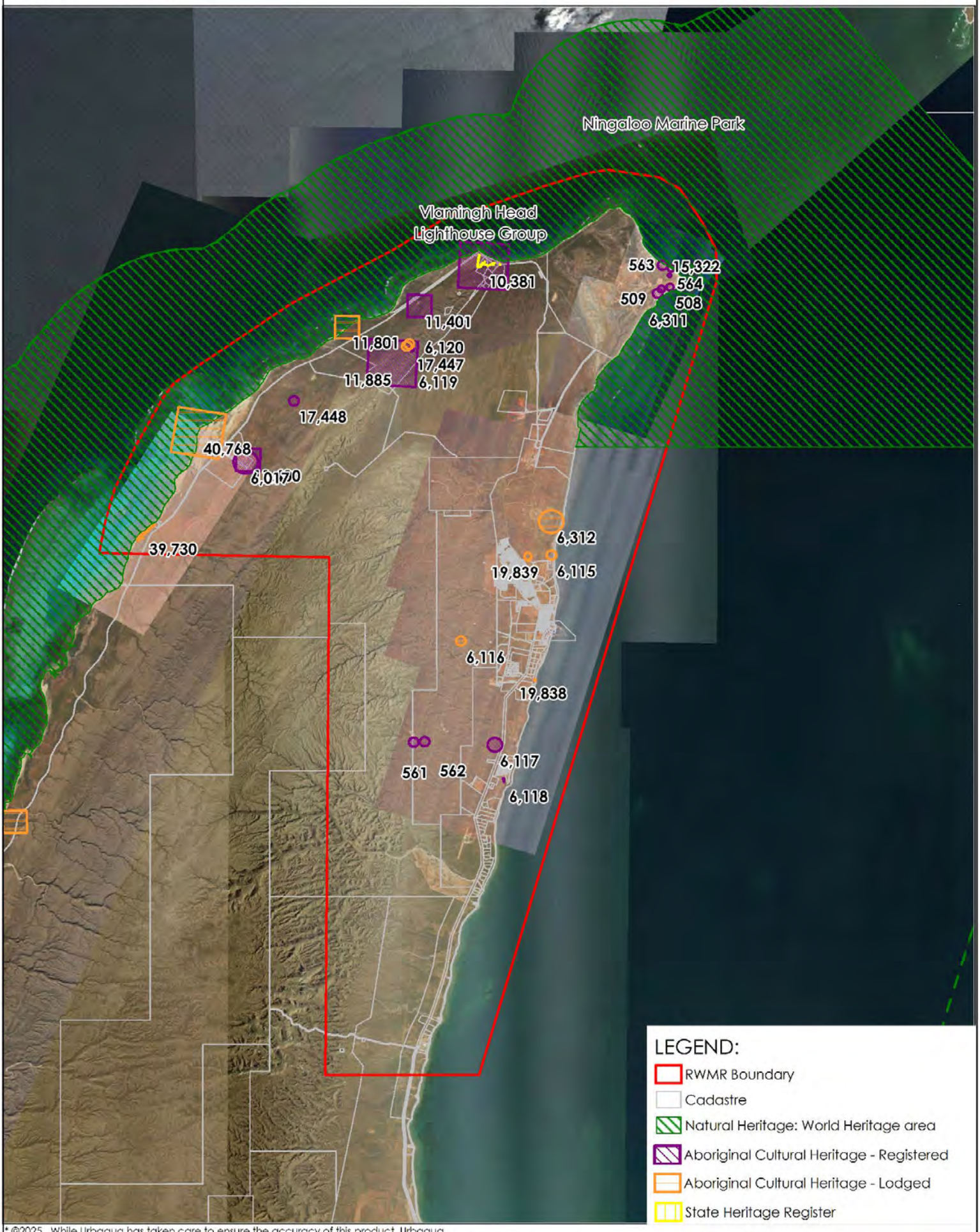
3.4 Heritage

3.4.1 Natural heritage

Inscribed in 2011, the Ningaloo Coast World Heritage Area encompasses both the Ningaloo Marine Park and Cape Range National Park, as shown in Figure 22. This designation recognises the area's outstanding universal value, including:

- Biodiversity: the region supports a diverse range of species, including whale sharks, humpback whales, and numerous marine invertebrates.
- Geological features: Cape Range National Park is characterised by rugged limestone ranges, deep canyons, and over 700 caves, contributing to its unique landscape.
- Ecological processes: the juxtaposition of arid land and rich marine environments creates a dynamic ecological interface supporting diverse habitats.

Shire of Exmouth - Exmouth Regional Water Management Report
Figure 22 - Heritage



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These attributes collectively contribute to the area's recognition as a site of exceptional natural significance.

Management of the area is a collaborative effort between the DBCA and the Traditional Owners, represented by the Nganhurra Tharnardi Garrbu Aboriginal Corporation, under an Indigenous Land Use Agreement.

3.4.2 Aboriginal heritage

The Yinigudera people (also known as Jinigudira), who are part of the broader West Thalanyji people, are the Traditional Owners of the Exmouth region, with a cultural heritage that extends back at least 36,000 years. Other groups from the area, including the Baiyungu and Thalanyji tribes, are also recognised as traditional custodians of the surrounding area including the Ningaloo region. Evidence from rock shelters and caves on the Cape Range Peninsula indicates long-standing Aboriginal presence and utilisation of marine resources.

The Gnulli native title claim was determined in December 2019 and gave recognition to the Baiyungu, Yinnigurrura and/or Thalanyji people over a 71,354 km2 area of the Mid West–Gascoyne region, including the Exmouth Peninsula. The Gnulli people, represented by the Nganhurra Thanardi Garrbu Aboriginal Corporation (NTGAC), have a deep cultural connection with water and there are cultural sites across the Exmouth Peninsula. The cultural heritage, spiritual and religious values of the Exmouth Peninsula and its surrounding environment are of paramount importance to the Traditional Owners. Under traditional lore (law), the Baiyungu and Yinnigurrura people have responsibilities to care for Country and keep culture strong. Based on the cultural importance of water, DWER assumes that all freshwater places have some cultural value, unless otherwise advised by the Traditional Custodians of that place (DWER, 2025a).

The area contains numerous sites of Aboriginal cultural heritage, including rock shelters, middens, and ceremonial sites. Many sites are associated with creeks and contain artefacts, scatter, middens and/or rock shelters. Some pools are also listed as campsites, while grinding patches/grooves are found at Mowbowra Pool only. Other recognised Aboriginal cultural heritage sites within the study area include Qualing Pool, the unnamed creek south of the townsite, Mowbowra Creek, a waterhole, and a skeletal material/burial site on the coast. The Exmouth townsite is also within the Warnangura (Cape Range) cultural precinct. The precinct is listed because it has artefacts/scatter, ceremonial importance, engravings, middens/scatter, mythological significance, rock shelters, named places and water sources.

The Aboriginal cultural heritage sites protected under the *Aboriginal Heritage Act 1972* within the study area are shown on Figure 22 and the registered sites are listed in Table 6. There are also a number of lodged sites (ten) that include additional waterholes, middens, rock shelters and burial sites as shown on Figure 22.

Table 6: Aboriginal Cultural Heritage registered sites

Id	Name	Place type
11401	5 Mile Well (Cape Range)	Sub surface cultural material; Artefacts / Scatter; Engraving; Painting; Quarry
10381	Vlaming Head	Ritual / Ceremonial; Creation / Dreaming Narrative
11400	Yardie Creek Station	Engraving
508, 509, 563, 564	Point Murat	Burial; Artefacts / Scatter; Camp; Midden; Other

Id	Name	Place type
6117	Mowbowra Pool.	Camp; Grinding areas / Grooves; Other
561, 562	Mowbowra Creek	Artefacts / Scatter
6118	Qualing Pool	Water Source
11885	Padjari Manu Cave (Formerly Bunbury Cave)	Sub surface cultural material; Artefacts / Scatter; Ritual / Ceremonial; Engraving; Painting; Water Source
15322	Point Murat/White Opal	Artefacts / Scatter; Midden
17448	Chugori Rockhole	Ritual / Ceremonial; Creation / Dreaming Narrative; Grinding areas / Grooves; Traditional Structure; Water Source
17447	Pap Hill Ochre	Ritual / Ceremonial; Grinding areas / Grooves; Ochre; Rock Shelter
6017	Yardie Creek Caravan	Burial

3.4.3 Local and built heritage

There are four European heritage sites on the State Heritage Register. All are associated with the Vlamingh Head lighthouse, which was a significant feature of the peninsula's northwest coast for 50 years until 1967 (Heritage Council 2025). The sites have aesthetic, historic, social, scientific and cultural heritage significance and are notable pieces of architecture in a very remote location.

There are also a number of places of local heritage identified by the Shire of Exmouth. These include Cape Range no. 1 oil well, the first trees planted in Exmouth and buildings of historic significance as listed in Table 7.

Table 7: Heritage places in the study area

Place No	Place Name	Statutory and other listings
261	Naval Communications Station (Harold E Holt)	Register of the National Estate 2002, Commonwealth Heritage List (Nominated)
837	Vlamingh Head Lighthouse Group	State Heritage Register, 2007, Classified by the National Trust 1976, Register of the National Estate
839	Yardie Creek Homestead	Register of the National Estate 1978, Classified by the National Trust 1976
10615	Bundegi-Cape Well	Municipal Inventory (Shire of Exmouth)
10617	Cape Range No. 1 Oil Well	Municipal Inventory (Shire of Exmouth)
10620	Charles Knife Road	Municipal Inventory (Shire of Exmouth)
10622	First Trees planted in Exmouth	Municipal Inventory (Shire of Exmouth)
10624	F J Reddy's Grave	Municipal Inventory (Shire of Exmouth)
10629	Pier - Pt Murat	Municipal Inventory (Shire of Exmouth)
10632	Shire Library	Municipal Inventory (Shire of Exmouth)
10636	Shothole Canyon and Road	Municipal Inventory (Shire of Exmouth)
10637	Staff House	Municipal Inventory (Shire of Exmouth)
10639	Transit House	Municipal Inventory (Shire of Exmouth)

Place No	Place Name	Statutory and other listings
10640	Vlamingh Head Radar	State Register, Municipal Inventory (Shire of Exmouth)
10641	VLF Towers, Harold E Holt Naval Communication Stn	Municipal Inventory (Shire of Exmouth)
17339	Exmouth Police Station, Lockup & Quarters	Municipal Inventory (Shire of Exmouth)
23799	Vlamingh Head Lighthouse Quarters	State Heritage Register, Municipal Inventory (Shire of Exmouth)
24419	Vlamingh Head Lighthouse	State Heritage Register, Municipal Inventory (Shire of Exmouth)

3.5 Servicing

3.5.1 Water supply – potable

Exmouth's drinking water is sourced from a series of 34 production bores tapping into the freshwater lens overlaying saline groundwater beneath the Cape Range within the P1 PDWSA (Figure 23). These bores are distributed across the Exmouth Town and Central Groundwater Subareas. The extracted water undergoes treatment processes, including chlorination and fluoridation, before distribution to consumers.

Water Corporation manages the Exmouth town water supply scheme and has obligations under Ministerial Statement 459 to manage impacts to stygofauna and report on performance compliance. The existing borefield, spanning over 10km, is designed and operated to abstract water at low flow rates to mitigate saline intrusion and maintain conditions to support stygofauna habitat across the borefield (DWER, 2025b).

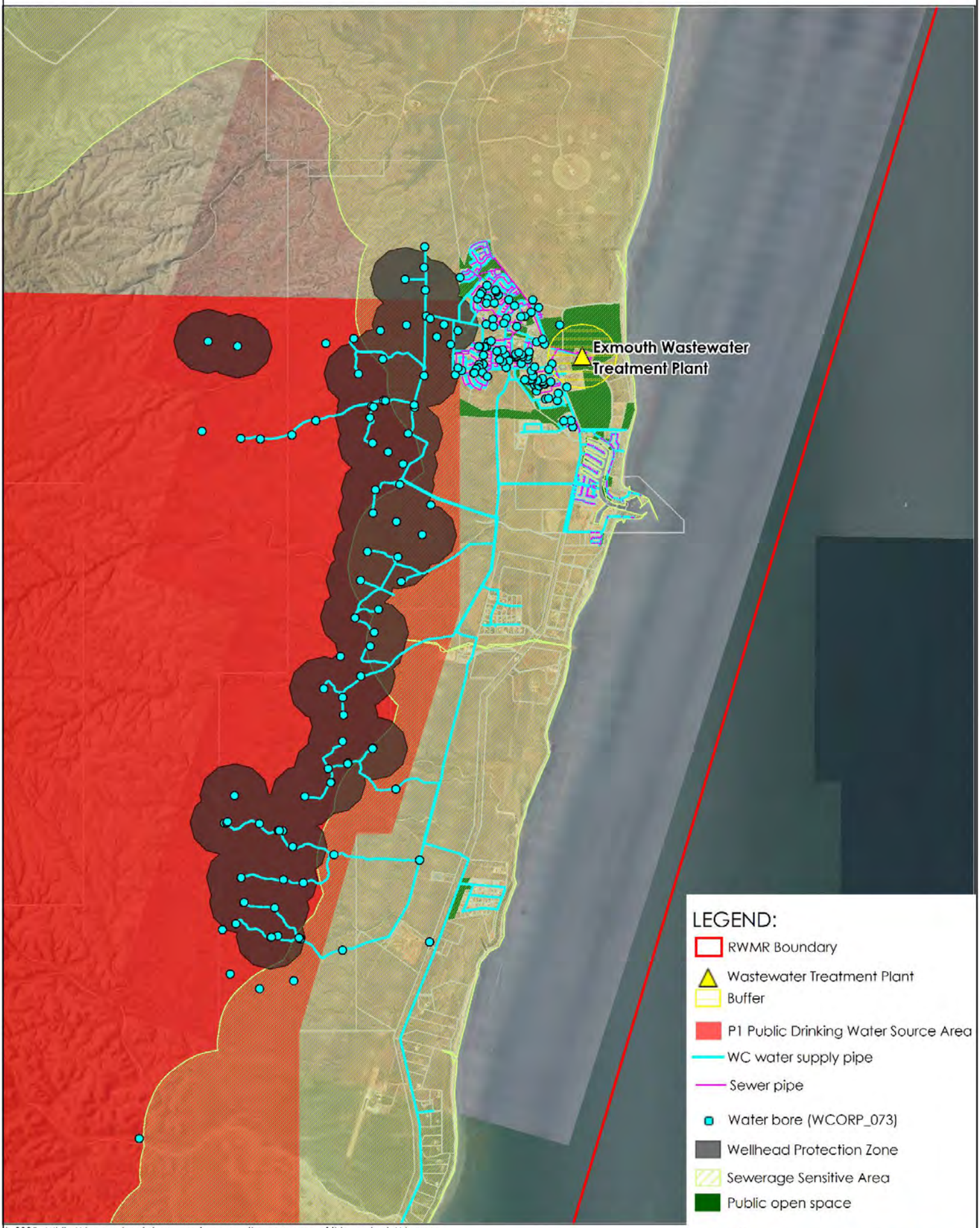
The Water Corporation has advised that the "existing water supply facility is able to manage additional small connections (standard residential-sized water services, i.e. a 20mm water meter) until a new water source is online. Pending government and environmental approvals, delivery of a new water source is expected to be completed within five years. Major proposals for new water connections are reviewed on a case-by-case basis as they are submitted to the Water Corporation's Development Services team. However, DWER has noted that "with the scheme often operating at close to capacity, groundwater from the current scheme will not meet anticipated medium- to long-term demand, with up to a further 1 GL per year required" (DWER, 2025b).

The Water Corporation is also working to increase water conservation within the community and promotes the Showerhead Swap program and other waterwise campaigns.

3.5.2 Wastewater management

The Exmouth townsite is serviced by a reticulated sewerage system managed by the Water Corporation. The wastewater treatment plant is located between the townsite and the coast and its 500m buffer is a significant constraint to development (Figure 23). Treated wastewater from the wastewater treatment plant is used to irrigate the Shire's public open space, as explained further below.

Shire of Exmouth - Exmouth Regional Water Management Report
Figure 23 - Water-related services and sewerage sensitive area



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The Shire of Exmouth's local planning strategy (Shire of Exmouth, 2019) notes "there are existing and proposed sensitive land uses located within the 500m buffer and it is understood that under certain weather/climatic conditions odour issues are experienced and occasionally during the use of recycled water on the town's irrigated ovals." It also notes that the ability of the system to have capacity to support additional development is contingent on the Shire of Exmouth's re-use system being operated at a high level of performance. However, recent advice from the Shire suggests that the system is not operating optimally, with the Shire being unable to use the recycled water, diminishing the capacity of the system to meet increased wastewater demands.

The relocation of the wastewater treatment plant was recommended by the *Exmouth Structure Plan* in 2004, and a preferred site was shown in the *Exmouth Townsite Structure Plan* in 2011. The Water Corporation has commenced detailed planning for the relocation of the wastewater treatment plant that will include negotiations with the Department of Defence to enable the facility to be relocated on Commonwealth Land immediately to the north of the townsite (Shire of Exmouth, 2019).

The Water Corporation has also recently advised that "the existing Wastewater Resource Recycling Facility is able to manage additional small connections (standard residential-sized wastewater services, i.e. a 100mm sewer junction) until future upgrades are delivered. Major proposals for connection to sewer are reviewed on a case-by-case basis as they are submitted to the Development Services team."

Areas outside the Water Corporation's sewerage network rely on on-site wastewater treatment systems, including septic tanks and alternative treatment units to manage their wastewater. The installation and operation of these systems are regulated under the *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974*. Property owners must obtain approval from the Shire of Exmouth and/or the WA Department of Health before installing such systems. Additionally, greywater reuse systems can be implemented for garden irrigation, subject to similar approval processes.

It is noted that the coastal portion of the Shire is designated as a Sewerage Sensitive Area under the Government Sewerage Policy (Figure 23). This is due to the proximity (1km) to the Exmouth Gulf and Ningaloo World Heritage Area. Additional areas are designated in proximity to Threatened and Priority Flora and Fauna. In this area, unsewered development will need to comply with additional requirements which include the need for additional water quality treatment performance and a 1ha minimum lot size.

3.5.3 Public open space irrigation

As noted above, treated wastewater from the Water Corporation's wastewater treatment plant is used to irrigate the Shire's public open space and the Exmouth Golf Couse. The Water Corporation supples treated wastewater to the Shire who then provides the Golf Course with a portion of the available volume.

The volume of available water is determined by the inflow to the wastewater facility. Water corporation closely manage their treatment pond levels though the peak inflow period (winter tourist seasons) to manage the risk of overtopping (overflow from ponds. Through the winter months, the Shire aims to dispose of 900,000 litres per night, which is distributed across Talanjee (1.8ha) and Koobaroo (1.7ha) Ovals, half of the golf course fairways, and street trees on Murat Rd and Maidstone Cr. During the summer months when the wastewater volumes are down, there is often only capacity to water the ovals and street trees and the Shire is unable to provide water to the golf course fairways. If water levels become too low, the Shire will only water Talanjee Oval which is still used for some sport in the summer months.

It is expected that as the inflows to the new wastewater treatment plant increase, there will be a greater volume of treated wastewater available for future irrigation use . The Water Corporation has proposed that the irrigated area at the golf course is increased (from the 6 ha currently irrigated with treated wastewater) in proportion to the inflows to the wastewater treatment plant. The increased usage could occur at locations where there are existing Department of Health approvals for irrigation with treated water from the wastewater facility, which includes the Golf Course (approximately 18 ha of potential irrigation area). It is not expected that there will be additional volume of treated wastewater in excess to the irrigation needs of the total area of the Shire's ovals and the golf course within the next 25 years, however.

Due to the uncertain and low volume of treated wastewater currently available for irrigation, the Shire uses scheme water to irrigate additional areas of public open space and support the public's access to drinking water. The Shire's records suggest that scheme water is currently used at the following locations:

- Krait St Park (Lockwood St) – grass, vegetation and drinking fountain
- Snapper Loop – vegetation and drink fountain
- Falls St Park – grass plus drinking fountain
- Lefroy Park (Bonefish St) – grass, vegetation and ablutions
- Kennedy St – car park vegetation and ablutions (possibly also garden beds in the mall)
- Town Centre Bottom Car Park – car park vegetation.
- Federation Park – grass, vegetation and ablutions
- Swimming Pool & Surrounds
- Payne St Memorial – grass and vegetation
- Town Beach – foreshore reserve and ablutions
- Crevalle Way Foreshore – grass, vegetation and street trees on Mortiss St

The amount of scheme water used for irrigation and public access over the last three years is summarised in Table 8. It is assumed that this varies in response to climate change and public use.

Table 8: Scheme water used for irrigation of public open space (kL)

Year	Scheme water used for irrigation of public open space (kL)
2022	34,635
2023	29,004
2024	37,294

The Shire also has access to local groundwater resources (as noted in section 3.3.2) for the irrigation of public open space. The Shire has advised that in 2024, they used 11,864kL of groundwater (noting the allocation is 27,000kL), however it was noted that the Sanctuary bore is no longer in use and there were issues with the bore at the Visitor's Centre, which was operating sub-optimally from January to April. It is also noted that that the resource may be saline, as the bore water at the Visitors Centre and other areas is mixed with scheme water in tanks for irrigation use.

3.5.4 Drainage

The Shire manages drainage predominantly via overland flows which are connected to the natural creeklines. Due to the flood risk associated with the regional climate and landform as described previously, the areas provided for drainage are a significant part of the urban landscape. Accordingly, the Shire promotes the use of natural drainage lines as a movement corridor asset through landscape maintenance, planting, lighting and safe pedestrian and cyclist access, as well

as landscaping upgrades, particularly to Town Creek and associated drainage lines within the Town Centre, to improve ecological habitat values and drainage functionality.

The Shire's guidelines for stormwater drainage require the design and management of stormwater to be in accordance with Sate Government policy (including SPP 2.9), DWER's Stormwater Management Manual for WA and the Local Government Guidelines for Subdivisional Development released by the Institute of Public Works Engineering Australia WA Division.

4 KEY WATER ISSUES

The key water issues requiring consideration as part of future planning and development within the study area are:

- Limitations of existing water and wastewater infrastructure including buffers
- Managing flood risk
- Protecting important ecological and cultural values
- Water for open space irrigation, amenity and urban cooling
- Coastal vulnerability and inundation
- Wastewater disposal in unsewered areas
- Climate and climate change impacts
- Managing karst environments, contamination and acid sulfate soils

These are outlined in more detail below.

4.1 Limitations of existing water and wastewater infrastructure

Exmouth's existing potable water supply relies on a sensitive freshwater lens within the Cape Range Limestone aquifer, accessed through numerous production bores located in a Priority 1 Public Drinking Water Source Area (P1 PDWSA). While the borefield is managed by the Water Corporation to minimise saline intrusion and protect unique stygofauna habitats, the current supply system is operating close to its maximum capacity. This poses a significant challenge, as projections indicate that the current scheme will be insufficient to meet anticipated medium- to long-term demand, with an additional 1 gigalitre per year potentially required.

Similarly, the town's reticulated sewerage system and its wastewater treatment plant are facing capacity constraints. The wastewater treatment plant's current location near the coast, including the required 500-metre buffer, restricts development and has led to occasional odour issues. Furthermore, the Shire's ability to effectively reuse treated wastewater for public open space irrigation is currently suboptimal, reducing the system's overall capacity to manage increasing wastewater volumes.

Considerations for planning and development

Future planning by the Water Corporation must prioritise substantial upgrades to both potable water supply and wastewater treatment infrastructure. This includes exploring new water sources or advanced treatment methods to augment supply, and planning for the relocation of the wastewater treatment plant to a more suitable site to alleviate development constraints and improve operational efficiency.

It is crucial that this planning avoids a 'least cost' approach. Protecting the sensitive receiving environments, including groundwater, underground karst systems, and the nearshore marine environment, presents a unique opportunity to develop an integrated water management solution. This solution should involve high-quality wastewater treatment, ensuring that safe and clean water of appropriate quality is consistently available for irrigating the Shire's open spaces and enhancing community amenity throughout all seasons. This initiative could serve as a flagship project, demonstrating the Government's commitment to sustainability and fostering the adoption of industry-leading technologies and solutions.

To achieve this, the Water Corporation must collaborate closely with the Shire to gain a deeper understanding of their irrigation and urban greening requirements, including how to address

seasonal variations and optimise delivery systems. Furthermore, demand management strategies, such as enhanced water conservation programs, will be vital. These programs should aim to increase the community's water awareness and knowledge, while also recognising the importance of engaging the diverse visitor population, who may come from various demographic and cultural backgrounds.

4.2 Managing flood risk

The Exmouth Peninsula is highly susceptible to significant flooding, primarily driven by intense rainfall events associated with tropical cyclones and storm surges. Historical records confirm that such events have led to widespread inundation across the region. Recent alterations to the landform, including marina developments and extensive land infill for urban expansion, have further complicated flood dynamics. These changes, combined with the projected impacts of climate change, necessitate continuous and updated hydrological assessments to accurately understand and mitigate flood risks.

Urbaqua undertook hydrological modelling using InfoWorks Integrated Catchment Model (ICM) to identify flood prone areas guide management of the risk of flooding to people, property and infrastructure. This included the review of flood risk levels under different rainfall conditions. The model defines the extent, depth, and velocities of flood flows and accounts for topographical changes due to development, aiming to protect existing and future floodways and flood prone areas and manage risks to people, property and infrastructure.

The modelling area focused on the Exmouth Townsite and surrounding potential development areas, with the coastal boundary condition generated from the Statewide Coastal Inundation Assessment Phase 2 Report.

Ensemble design rainfall analysis consistent with Australian Rainfall and Runoff (ARR2019) was applied. A joint probability pre-screening assessment determined that most proposed development sites are dominated by fluvial processes (rainfall/stormwater), while most tourism sites are dominated by coastal processes. The study assumed complete interdependence for a worst-case assessment, recommending more detailed joint probability assessments for future planning. Two climate change scenarios were applied: a medium-term (2070) design scenario (SSP2-4.5) and a long-term (2120) stress-test scenario (SSP3-7.0), incorporating sea level rise allowances (0.4m and 0.9m respectively) as downstream boundary conditions for 1% AEP events.

Flood modelling demonstrates that the nature of flood routing in Exmouth features extensive networks of poorly defined ephemeral creeks and a significant tendency for large overland breakout flows. Breakout flows occur where extreme event runoff cannot be contained within the banks of the many shallow creeks and these flows traverse the landscape to rejoin the same or another nearby creek further downstream.

A second notable feature of flooding in Exmouth is the significant storage of floodwaters behind linear sand dunes along the coast. This results in large areas of inundation where the depth and duration of flooding is dominated by coastal processes. This means that these areas may experience particularly long periods of time where safe access and egress will be limited or non-existent until coastal inundation recedes and inland floodwaters can dissipate.

In each of the climate change scenarios presented, the extent, depth and consequent hazard of flooding in Exmouth is increased. This is particularly evident in response to sea level rise and will further exacerbate the issue of long durations without safe access and egress noted above.

To provide a preliminary understanding of the development potential in each of the indicative development sites, development scenario modelling was undertaken and is provided in Appendix 2.

For these scenarios, a revised digital terrain model was adopted, with proposed development sites filled to prevent flooding in the 1% AEP event. The extent and depth of fill applied in these scenarios is not intended to represent an actual development outcome but rather considers an approach that applies broadscale fill to the development area whilst maintaining all major flood paths, including significant breakout flows.

It is important to note that broadscale filling of land involves the mining, transportation and use of substantial quantities of basic raw materials and limits the ability to retain natural landform or existing vegetation and trees. Therefore, it is recommended that future planning and development proposals consider alternative built-form approaches to manage flood risk to properties and infrastructure and minimise the use of fill.

However, if filling of land is proposed, this has the potential to result in an increased risk of flooding adjacent to the filled area. An assessment of "afflux," the rise in water level caused by obstructions, has therefore also been undertaken based on modelling of preliminary filled development footprints and is presented in Appendix 2. This assessment indicates minimal afflux in most cases, due to the maintenance of all significant flood paths. It should be noted that, where increased areas of fill are applied to obstruct or divert breakout flood flows, additional afflux is likely to occur. It is therefore critical that an assessment of afflux, including consideration of potential breakout flows originating upstream of the site, is undertaken to support any proposals to fill the land in and around Exmouth. These detailed modelling results are crucial for informing future development decisions and ensuring flood resilience.

Considerations for planning and development

Traditionally, flood risk management in Western Australia has involved importing significant amounts of fill to elevate sites, ensuring habitable floor heights are above the identified flood levels indicated in the *Decision Process for Stormwater Management in WA* (DWER, 2017) as outlined below:

> *"Protect people and property from flooding by constructing residential, commercial and industrial building habitable floor levels with the following minimum clearances above the 1 per cent annual exceedance probability (AEP) flood level:*
>
> - *road drainage systems: 0.3 m*
> - *terminal retention or detention areas with no overflow relief: 0.5 m*
> - *major drainage system and waterways: 0.5 m.*
>
> *We recommend that critical infrastructure and important community facilities (such as hospitals) have a higher level of flood protection. We recommend a risk-based approach is used to determine the acceptable level of flood protection for these facilities and their access routes, to ensure they remain operable during major flood events. See Australian emergency management handbook series: Handbook 7: Managing the floodplain: a guide to best practice in flood risk management in Australia (Attorney-General's Department 2013)."*

However, notwithstanding the critical importance of protecting people and property from flooding, the conventional approach of filling entire development areas substantially lowers the sustainability of development due to the environmental impacts associated with sourcing and transporting the fill, as well as the effects on the development area itself, including clearing of native vegetation, erosion, sedimentation, and downstream impacts to waterways and coastal environments.

Alternative strategies for mitigating flood risk should be explored. These include implementing diverse building forms and typologies, carefully considering appropriate land uses within flood-prone areas, and enhancing community education and emergency management practices.

Future development must integrate robust flood risk management strategies. This includes strict adherence to a principal of avoiding or protecting natural floodways and breakout flow paths predicted by modelling presented in this WMR.

All development proposals should be supported by detailed flood risk assessments including assessment of the potential "afflux" (rise in water level) caused by land infill, ensuring that development does not exacerbate flooding in surrounding areas, whilst minimising the use of fill.

Where proposals include modification or diversion of a predicted natural floodway, it is critical that the supporting flood risk assessment includes a sufficiently large study area to ensure that the potential upstream and downstream implications of the proposed strategy are fully addressed.

Flood risk assessments should include assessment of the combined effects of the 1% AEP fluvial flood event combined with the predicted extreme (1% AEP) coastal inundation level from the most recent available assessment and an appropriate sea level rise consistent with up-to-date state government guidance. Where it is proposed to deviate from this combination of effects, the assessment must include a detailed joint probability assessment, demonstrating selection of an appropriate combination of fluvial and coastal flood risks, for site-specific planning.

Development proposals should include consideration of evacuation potential and isolation risk due to flooding. This consideration should include an assessment of the potential duration of limited or restricted access and egress associated with flooding and coastal processes over extended periods.

Comprehensive flood-resilient design principles should be mandated for all new construction, particularly in areas identified as high-risk. This should include a hierarchy of approaches that start with finding alternative approaches to the use of fill to manage flood risk.

4.3 Protecting important ecological and cultural values

The Exmouth region is globally recognised for its exceptional natural and cultural heritage, which demands stringent protection. Ecologically, it is home to the Nationally Important Cape Range Subterranean Waterways, a unique wetland supporting a critically endangered troglobitic community with endemic species, all highly dependent on stable groundwater conditions.

The broader Ningaloo Coast, a World Heritage Area encompassing the Ningaloo Marine Park and Cape Range National Park, is celebrated for its rich biodiversity, distinctive geological features, and dynamic ecological processes. This area also contains numerous protected flora and fauna species, including federally protected and migratory species, underscoring its immense ecological value.

From a cultural perspective, the Gnulli people, the Traditional Owners, possess a deep and enduring connection to the land and water, with numerous Aboriginal cultural heritage sites—including rock shelters, middens, ceremonial grounds, and vital water sources—scattered across the peninsula. There are also a number of local heritage sites that celebrate the region's past.

Considerations for planning and development

Any future planning and development proposal should include rigorous environmental and cultural heritage assessments to identify and mitigate potential impacts on these invaluable assets. This includes establishing appropriate buffer zones around sensitive ecological areas and heritage sites, and implementing detailed cultural heritage management plans developed in close consultation with the Nganhurra Thanardi Garrbu Aboriginal Corporation Traditional Owners. Development should actively seek to enhance, rather than detract from, the outstanding universal value of the World Heritage Area and the cultural significance of Aboriginal sites.

4.4 Water for open space irrigation, amenity and urban cooling

Access to reliable and sustainable water sources for irrigating public open spaces is crucial for maintaining amenity and mitigating urban heat in Exmouth's hot climate. Currently, the Shire relies on a combination of treated wastewater from the wastewater treatment plant, groundwater and scheme water for this purpose. However, the volume of available treated wastewater is inconsistent and often insufficient, particularly during off-peak tourism months, leading to a reliance on potable scheme water to irrigate many public areas. While the Shire holds a licence for local groundwater, it is under-utilised, possibly due to the quality of the water and/or the infrastructure. The high level of dependency on potable water for irrigation is unsustainable in the long term, given projected population growth and climate change impacts.

Considerations for planning and development

Future planning must prioritise the identification and development of alternative, sustainable water sources for public open space irrigation, such as fit-for-purpose recycled water. As stated above, this should be ensured through a relocated and upgraded wastewater treatment plant, that delivers water of an appropriate quality and sufficient volume for ongoing use within a partnership approach between the Shire and the Water Corporation. Until this facility is established, the Shire should seek to work in closer partnership with the Water Corporation to secure necessary upgrades to plant and delivery infrastructure to optimise operation of the treatment plant while providing a source of water of an appropriate quality that results in clear community benefits.

It is also recommended that the Shire undertake an audit of their groundwater use to determine the opportunity to optimise the use of this resource. This may require improvements to metering and irrigation infrastructure, as well as a better understanding of the areas of application and the areas of need. It is also noted that some allocation remains in both the Exmouth North and West subareas so consideration should be given to the opportunity to access this resource if an appropriate location is identified.

Waterwise development principles should be integrated into all new projects, promoting efficient irrigation systems and drought-tolerant landscaping. Strategic investment in green infrastructure, including increased tree canopy cover and permeable surfaces, will be essential for urban cooling and enhancing liveability, reducing the demand for intensive irrigation.

4.5 Coastal vulnerability and inundation

Exmouth's coastal areas are inherently vulnerable to the impacts of a changing climate, particularly rising sea levels and the increased intensity of extreme weather events like tropical cyclones and associated storm surges. These factors significantly elevate the risk of coastal inundation and erosion, which can threaten existing infrastructure, coastal habitats such as mangroves and seagrass beds, and the overall integrity of the shoreline. The dynamic interplay between marine processes and the low-lying coastal topography, particularly in areas with coastal dunes that obstruct runoff from the Cape Range, means that even minor increases in sea level or storm intensity can have substantial and widespread consequences.

As noted in Section 4.2, and demonstrated by flood modelling presented in this WMR, coastal inundation and sea level rise have a significant relationship to the extent, depth and consequent hazard of inland flooding. This is particularly critical in the consideration of emergency response planning where the combination of inland flooding and coastal inundation may result in long durations without safe access and egress from developed and developing parts of Exmouth.

The recently prepared *Coastal Hazard Risk and Adaptation Management Plan: Exmouth Townsite* (*Exmouth Townsite CHRMAP*) (Seashore Engineering, 2025) outlines strategies for assessing and

managing coastal hazards and risks to community assets. The *Exmouth Townsite CHRMAP* aims to address coastal hazards such as erosion and inundation while aligning local planning with state policies, focusing on a 5km length from Exmouth golf course to McLeod Street. Whilst the principal focus of the *Exmouth Townsite CHRMAP* is identification of mitigation and management strategies for existing assets and values at risk, the document also provides information and advice that is relevant to planning for future development.

Considerations for planning and development

Planning for coastal areas must incorporate robust coastal hazard mapping and assessment, with consideration of the *Exmouth Townsite CHRMAP* (Seashore Engineering, 2025) to inform the establishment of appropriate setback provisions for new development or provide clear instructions for temporary uses via statutory foreshore management plans which include triggers for contingency planning and/or removal of development.

Infrastructure in vulnerable coastal zones should be designed to be climate-resilient, considering future sea level rise projections. Strategies for coastal protection, including natural and engineered solutions, should be explored and implemented where necessary to safeguard both natural assets and built environments.

Development proposals should include consideration of evacuation potential and isolation risk due to coastal processes. This consideration should include an assessment of the potential duration of limited or restricted access and egress over extended periods in combination with fluvial flooding events as outlined in Section 4.2 of this WMR.

4.6 Wastewater disposal in unsewered areas

For areas within the Shire of Exmouth that are not connected to the reticulated sewerage network, wastewater disposal relies on on-site treatment systems, including septic tanks and alternative treatment units. The installation and operation of these systems are subject to strict regulations and require approval from the Shire and/or the Department of Health.

A significant challenge arises in areas designated as Sewerage Sensitive Areas, particularly those in close proximity (within 1 kilometre) to the Exmouth Gulf and the Ningaloo World Heritage Area. In these sensitive zones, unsewered development faces additional, more stringent requirements, including the need for enhanced water quality treatment performance from on-site systems and a minimum lot size of 1 hectare.

Considerations for planning and development

Future planning for unsewered areas must ensure strict compliance with all relevant health and environmental regulations including draft State Planning Policy 2.9 which incorporates the Government Sewerage Policy.

Developers are required to demonstrate that proposed on-site wastewater treatment systems are appropriate for the specific site conditions and meet the necessary requirements, especially in Sewerage Sensitive Areas. The imposition of minimum lot sizes in these vulnerable zones is critical to ensure adequate land for effluent disposal and minimise environmental contamination risks to sensitive marine and coastal ecosystems.

4.7 Climate and climate change impacts

Exmouth's inherent hot semi-arid climate is projected to undergo significant shifts due to climate change, intensifying existing environmental pressures. Average temperatures are expected to continue rising, leading to more frequent and prolonged heatwaves, which will place increased stress on both natural ecosystems and human populations. While annual rainfall patterns remain highly variable, there is a clear projection for increased intensity of extreme rainfall events, contributing directly to heightened flood risks.

The particular impacts of climate change in relation to flood risk, and coastal vulnerability and inundation have already been discussed in sections 4.2 and 4. 5. In addition, in the marine environment, the Ningaloo Reef and surrounding waters are already experiencing more frequent and intense marine heatwaves, resulting in coral bleaching, a decline in biodiversity, and adverse impacts on local fishing and tourism industries. Furthermore, rising sea temperatures and increased oceanic absorption of carbon dioxide are expected to stress coral reefs and marine life, altering species distributions and affecting ecosystem productivity.

Considerations for planning and development

Planning for Exmouth's future must proactively integrate climate change adaptation strategies. This involves promoting water-sensitive urban design principles that enhance resilience to extreme weather events and heat. Development should encourage green infrastructure and tree canopy cover to mitigate urban heat island effects and reduce energy consumption, however the current constraint of access to water for irrigation is noted.

Consideration should also be given to the form and function of future public open space so that it is reflective of the climate conditions and needs of the Exmouth community. While the need for shade, preferentially provided by large canopy trees should be prioritised, consideration will also need to be given to the chosen species to ensure they are appropriate for the future climate including occurrence of cyclones. It is also recommended that the Shire prepare a future recreation strategy, to allow consideration of forms of active recreation that do not require large, grassed playing fields or sport to be played during the day. This should be translated into guidance for future open space planning and delivery.

Long-term planning should also consider the broader ecological shifts and socio-economic impacts resulting from a changing climate and develop strategies that foster a more resilient community and economy.

4.8 Managing karst environments, contamination and acid sulfate soils

Exmouth's unique geological setting presents specific land resource management challenges. The Cape Range peninsula is characterised by a sensitive karst environment, where porous limestone has led to the development of extensive caves, sinkholes, and underground drainage systems. Development in these areas carries a high risk of impacting the integrity of these formations and their associated subterranean ecosystems.

Additionally, the presence of acid sulfate soils, particularly in low-lying coastal areas and riverine floodplains, poses a significant environmental hazard. If disturbed, these soils can oxidise and release sulfuric acid, leading to acidification of soils and water bodies, with detrimental effects on ecosystems and infrastructure. Furthermore, the study area contains 19 identified contaminated sites, with nine still requiring remediation, where contaminants like asbestos and hydrocarbons are present in soils and groundwater.

Considerations for planning and development

Future planning must be accompanied by detailed site investigations for any proposed development in areas identified with karst features, acid sulfate soils, or potential contamination. Specialised management plans, developed by qualified professionals, will be required to mitigate risks associated with disturbing these environments. This includes specific construction methodologies for karst areas, acid sulfate soil management plans to prevent acidification, and remediation strategies for contaminated sites. In high-risk areas, avoidance of development or strict land use restrictions may be the most appropriate planning response to safeguard environmental and human health.

4.9 Assessment of future development sites

More detailed mapping of water related issues relevant to the future development areas identified in the 2019 Shire of Exmouth Local Planning Strategy has been prepared. The issues considered for each site have been identified through a desk top assessment of available spatial data which includes:

- Flood risk (1% AEP event) inundation depth (m) and flood heights (mAHD) with current terrain and medium term (2070) SSP2-4.5 climate scenario plus highest astronomical tide, plus 0.4m allowance for sea level rise.
- Protected flora, fauna and ecological communities
- Important waterways and wetlands
- Public drinking water source areas and well-head protection zones
- Registered and lodged sites of Aboriginal cultural heritage
- Sewerage sensitive areas
- Acid sulfate soil risk
- Registered contaminated sites
- Water and wastewater services

Where any of the above issues are not relevant, they are not shown on the mapping.

The mapping and text below provides guidance on the key relevant water-related issues that will need to be addressed in any future district, local, subdivision or development WMR, consistent with *State Planning Policy 2.9: Planning for Water* and *the Planning for Water Guidelines* (draft, WAPC, 2021) and this Regional WMR (including the objectives and strategies in Section 5). The identified issues are not listed in any order of priority and have been drawn from the issues described previously in this section. It is expected that a more detailed site-specific assessment will be undertaken to clarify the critical pre and post development water resource issues faced by each site at the next phase of planning.

4.9.1 Future residential area 1

Area 1 comprises Lot 5000 (UCL) Learmonth Street and Reserve 27484 (Church Site) Kennedy Street and is located immediately south west of the Exmouth Town Centre. It is approximately 12.8ha in size and includes Town creek.

Area 1 is partially zoned Residential R20 correlating with an approved subdivision layout obtaining access from Sargent Street. The approved subdivision was supported by the Town Centre Creek Flood Study, Lot 5000 Learmonth Street (EXM05), Exmouth, undertaken by JDA for LandCorp in 2011. This defined the flood levels for the approved subdivision.

The remainder of the site is zoned “Urban Development” and accordingly, a local structure plan and Local WMR would be required for this portion of the land.

Issues affecting the site that require further consideration in a WMR are shown in Figure 24 and include:

- Flood risk
- Well-head protection zone
- Adjacent to a Priority 1 Public drinking water source area
- Potential to contain priority flora and fauna
- Adjacent to an environmentally sensitive area
- Within a Sewerage Sensitive Area
- Nationally Important Wetland: potential to be underlain by important karst features

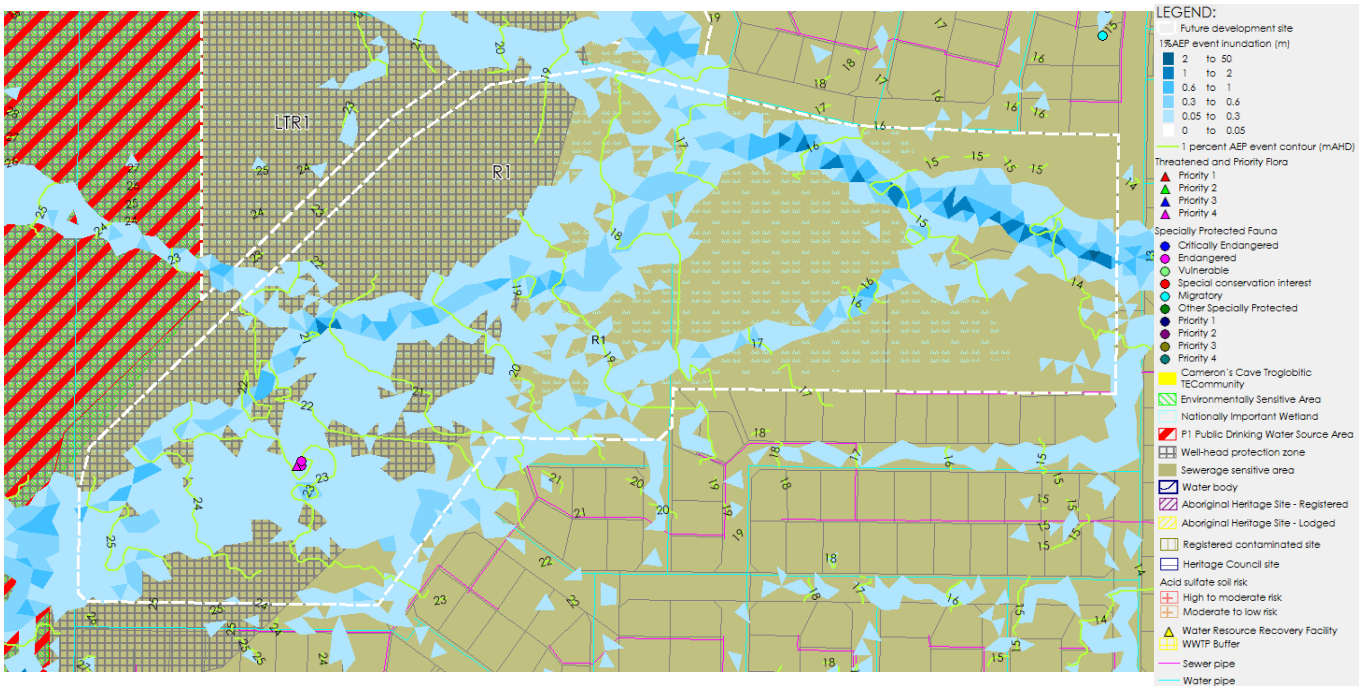


Figure 24: Future residential area 1 (existing terrain)

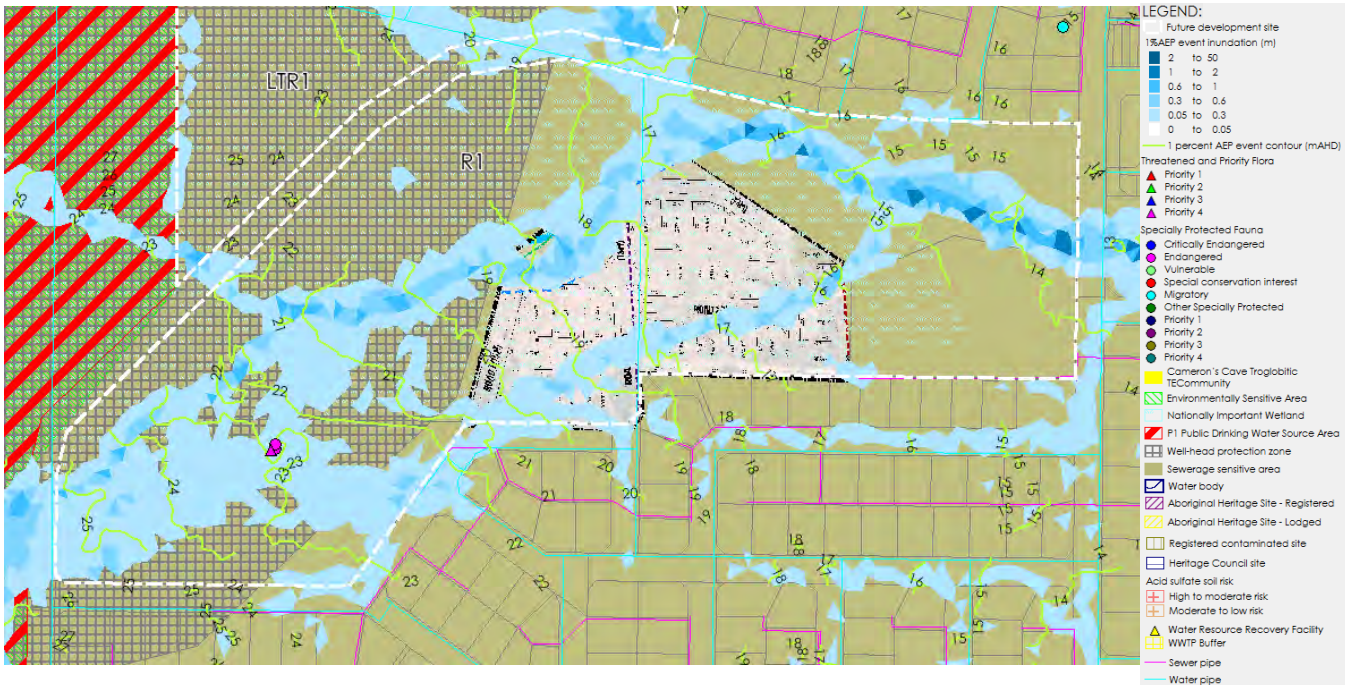


Figure 25: Future residential area 1 post development scenario (filling of the site excluding major flowpaths)

While no further structure planning is required over the zoned portion of Area 1 (unless the current subdivision approval expires), the results of the post development modelling scenario shown in Figure 25 suggest that insufficient land may have been provided for flood protection and that the site may be affected by a breakout further upstream. Accordingly, it is recommended that this subdivision design is reviewed in greater detail prior to development commencing.

4.9.2 Future residential area 2

Area 2 (Lot 300 King Place) is located south-west of the Town Centre and is surrounded by an existing built up residential precinct. The site is currently vacant unallocated crown land and is located at the junction of King, Jones and Tonge Places. It comprises 0.63 ha land zoned Residential (R20).

As shown in the top left of Figure 26 development of the site is not likely to impact on or be impacted by water resources and accordingly a WMR is not likely to be required to accompany the subdivision and/or development application.

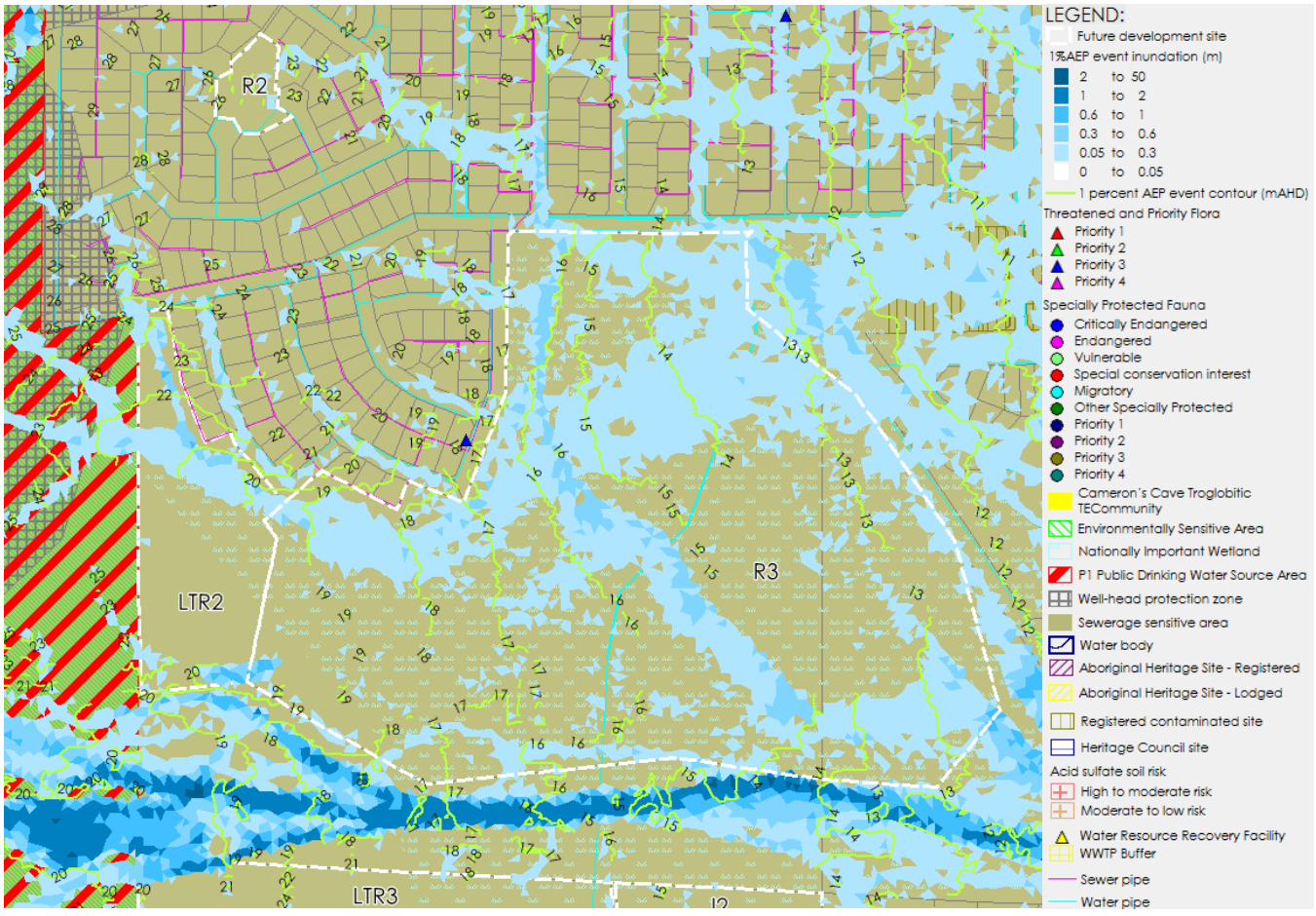


Figure 26: Future residential areas 2 and 3, and Long-term residential area 2

4.9.3 Future residential area 3

Area 3 comprises land generally bound by Reid Street to the east, Nimitz Street to the north, Cameron Street to the west and Public Open Space Reserve to the south which comprises the LIA creek. The site is situated approximately 500m directly south of the Town Centre via Kennedy Street and is zoned Residential Development.

The majority of the site is subject to an approved Outline Development Plan (ODP) adopted by the Shire and endorsed by the WAPC. The Nimitz St Urban Development, Exmouth Local Water Management Strategy was prepared by JDA for LandCorp in September 2012 to support the ODP. Any future development must meet he design criteria specified in the local water management strategy. The WAPC has granted conditional subdivisional approval to Stages 1, 2 and 3.

As shown in the post-development scenario modelling in Figure 27 (based on the assumption that the development site excluding major flow paths is filled), while the ODP has made provision for the management of flood risk in some areas of the development, there is a significant breakout flowpath traversing the site that has not been provided for. In this case, due to the downstream flooding caused by this breakout, it may be preferable to provide for this flow to join the creek to the south of the development area via long-term residential area 2. It is therefore recommended that flood management for this site is reviewed in light of the recent modelling and it is demonstrated that flood flows are able to be adequately accommodated by the design.

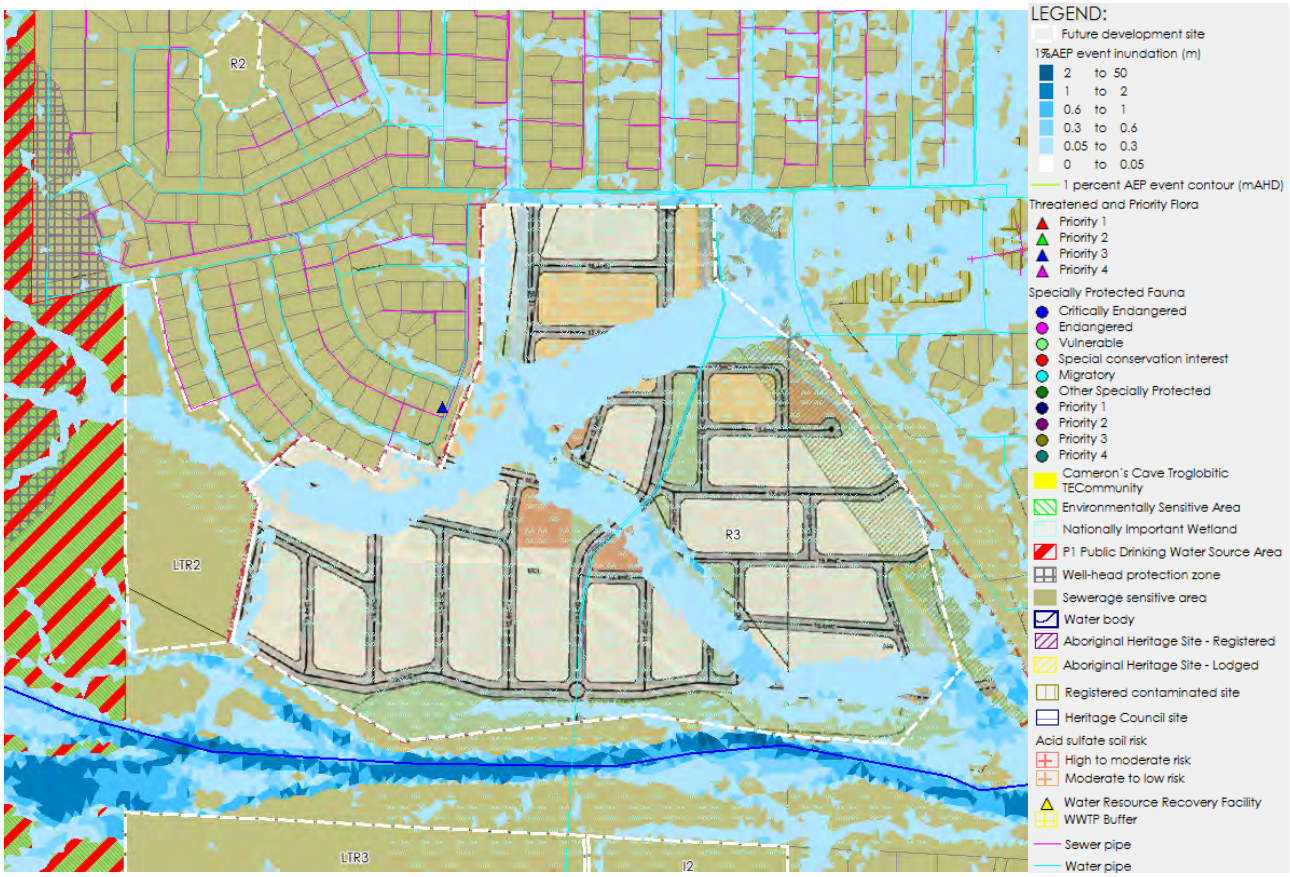


Figure 27: Future residential area 2: Post development scenario

4.9.4 Future residential area 4

Area 4 (UCL Lot 1391) is bounded by Murat Road, Welch and Reid Streets and is located immediately to the east of the Exmouth Power Station and west of the Exmouth Marina. Area 4 comprises approximately 23ha and is currently vacant unallocated Crown Land.

The Shire's local planning strategy notes that "Site levels over the full extent of the area have been raised due to the import of excess fill during the construction phase of Exmouth Marina, with exception of land within the low flood hazard floodplain of the Marina Creek. The western portion of the site has been previously used for waste disposal activity and may be subject to site contamination. The site has been subject to Native Title Agreement."

The site is zoned for 'Residential Development' and accordingly, any future development will need to be supported by a local structure plan. The structure plan will need to be accompanied by a local WMR, consistent with draft SPP 2.9 and this Regional WMR Issues affecting the site that require further consideration in the WMR are show in Figure 28 include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths.
- Within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

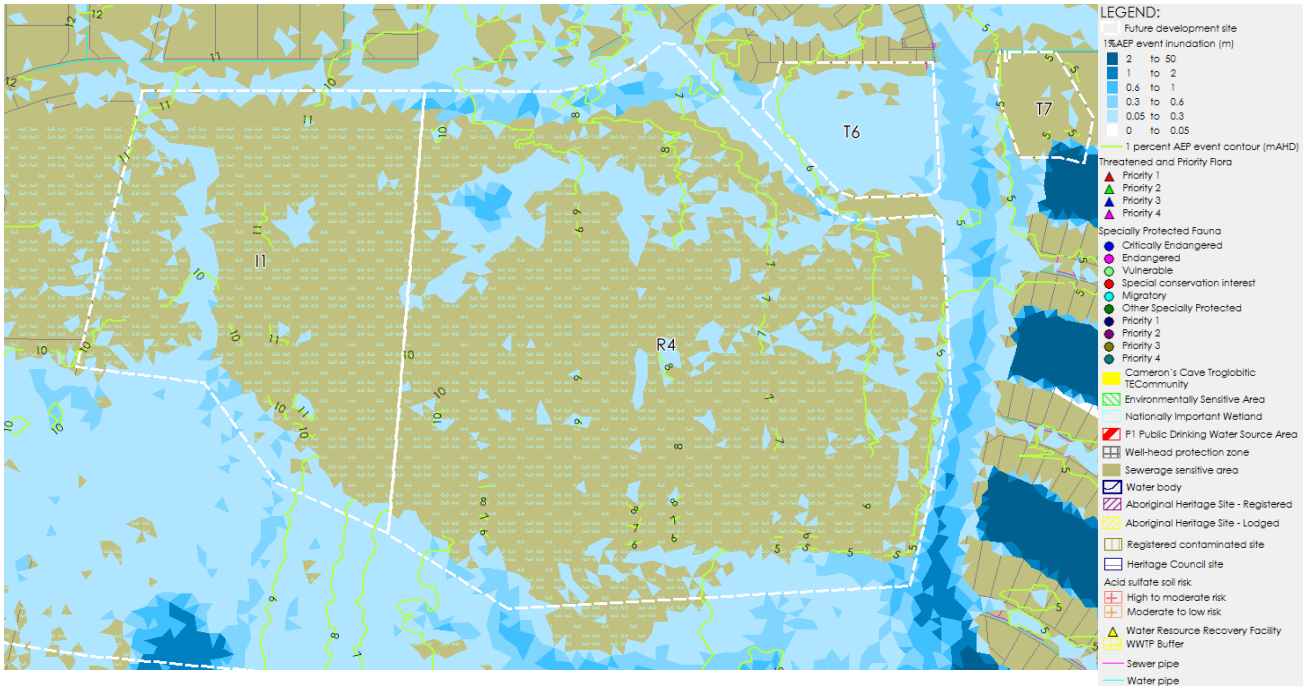


Figure 28: Future residential area 4, Industrial area 1 and Tourism areas 6 and 7 (existing terrain)

It is critical to note that the minimal flooding shown in Figure 28 for this development site results from the presence of a significant flood protection bund which prevents breakout flows from the Market Street Creek to the south (see Figure 29). The geotechnical status of this bund is unknown, and it is recommended that the sensitivity of flooding to a possible failure of this bund is considered. The safe passage of floodwaters through this area in the event of a failure of the bund (and/or event larger than the bunds design flow) should be considered in future planning. The Water Corporation in collaboration with DWER have released a guidance note for proposed development adjacent to structures of this nature (see spoil bank guidance).

4.9.5 Future residential area 5

Area 5 is bounded by Marina Creek to the north, Murat Road to the east and Market Street creek to the south, which is protected by the Environmental Conservation Reserve. The western boundary is generally defined by the existing north-south access track.

The site is zoned for 'Residential Development' and accordingly, any future development will need to be supported by a local structure plan. The structure plan will need to be accompanied by a local WMR, consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are shown in Figure 29 and include:

- Flood risk– noting that the flood extent and levels shown are pre-development and assumes the Market Street Bund (shown in Figure 29) remains intact, to provide an understanding of the extent of predicted floodways and overland flowpaths.
- Contains part of an environmentally sensitive area (associated with the Camerons Cave Troglobitic TEC).
- Within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

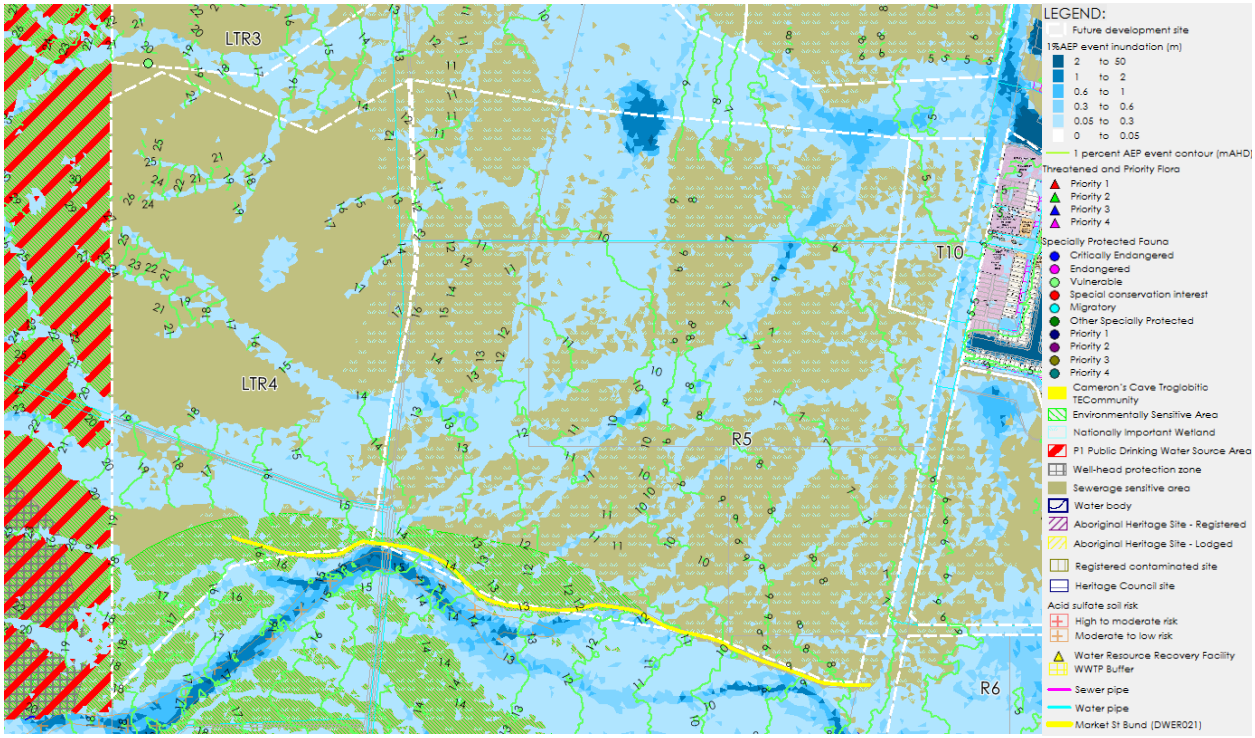


Figure 29: Future residential area 5, Long term residential area 4 and Tourism area 10 (existing terrain)

Similarly to Area 4, it is critical to note the presence of a significant flood protection bund which prevents breakout flows from the Market Street Creek to the south. The geotechnical status of this bund is unknown, and it is recommended that the sensitivity of flooding to a possible failure of this bund is considered. The safe passage of floodwaters through this area in the event of a failure of the bund (and/or event larger than the bunds design flow) should be considered in future planning. The Water Corporation in collaboration with DWER have released a guidance note for proposed development adjacent to structures of this nature (see spoil bank guidance).

4.9.6 Future residential area 6

Future Residential Area 6 is located immediately south of the Exmouth Marina bounded by Mortiss Street to the north, Murat Road to the west and the extension of the Market Street bund to the south. The site is located to the west of the Seaside residential precinct.

The site is zoned 'Residential Development' and accordingly, any future development will need to be supported by a local structure plan. The structure plan will need to be accompanied by a local WMR, consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR as shown in Figure 30 include:

- Flood risk – a significant portion of the site is affected, noting that the flood extent and levels shown are pre-development and assume the Market Street Bund (shown in Figure 28) remains intact, to provide an understanding of the extent of predicted floodways and overland flowpaths.

- Within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

In addition, consideration could be given to the potential for the future planning and development of this site to mitigate the flood risk affecting the already developed land to the east.

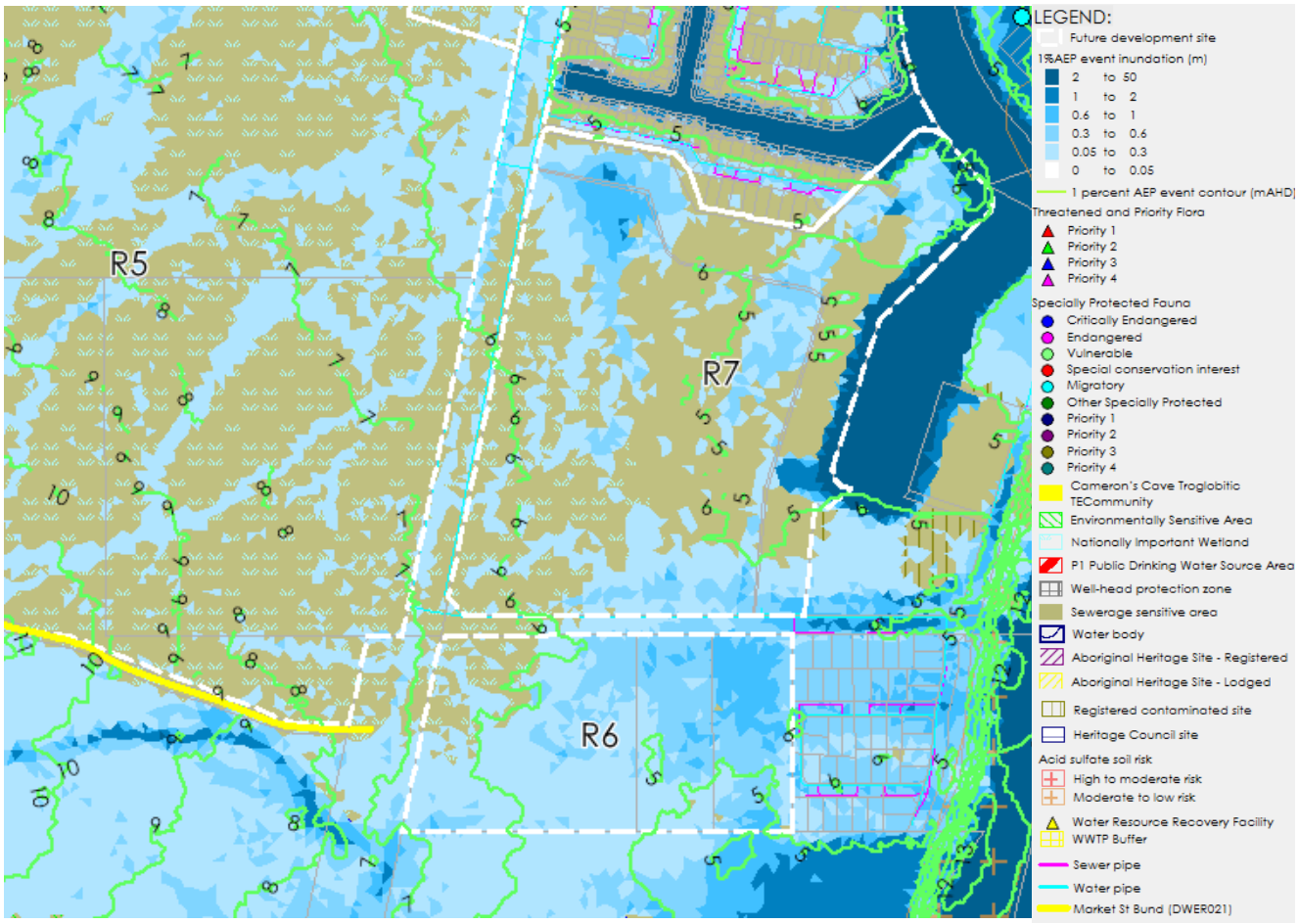


Figure 30: Future residential areas 6 and 7 (existing terrain)

4.9.7 Future residential area 7

Future residential area 7 is located within the southern portion of the Exmouth Marina Village Outline Development Plan area, bounded by Murat Road to the west, Mortiss Street to south, industrial canal waterway and Exmouth Boat Harbour to the east and residential/mixed use development to the north. The site is zoned Special Use and subject to the Exmouth Marina Village Outline Development Plan and Broad Design Guidelines, and is identified as Precinct D.

The flood risk shown in Figure 30 has been noted by DevelopmentWA, as indicated in the Lot 9510 Murat Road (Superlot D), Exmouth Assessment of Flood Risk Mitigation Options by JDA Consultant Hydrologists, dated May 2023. This advice recommends that flood risk is mitigated by:

- Importation of fill,
- Construction of a levee or bund, or
- Use of an alternative built form.

It is therefore anticipated that a local WMR is prepared to address the issues shown in Figure 30 which include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths.
- Within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

It should also be noted that, due to the proximity of this site to the Exmouth Gulf, it is also recommended that best practice stormwater management is utilised to mitigate any risk of loss of sediment or other pollutants from the site during construction and after development.

4.9.8 Future residential (long term) area 1

Long term residential area 1 is located on the western boundary of Exmouth townsite abutting the Exmouth Water Reserve. The southern portion of the site is zoned for Urban Development and the remaining part is reserved for Public Open Space.

Any future development will need to be supported by a local structure plan and local WMR, consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are shown in Figure 31 and include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths
- Well-head protection zone
- Adjacent to a Priority 1 Public drinking water source area
- Potential to contain priority flora and fauna
- Adjacent to an environmentally sensitive area
- Within a Sewerage Sensitive Area
- Nationally Important Wetland: potential to be underlain by important karst features

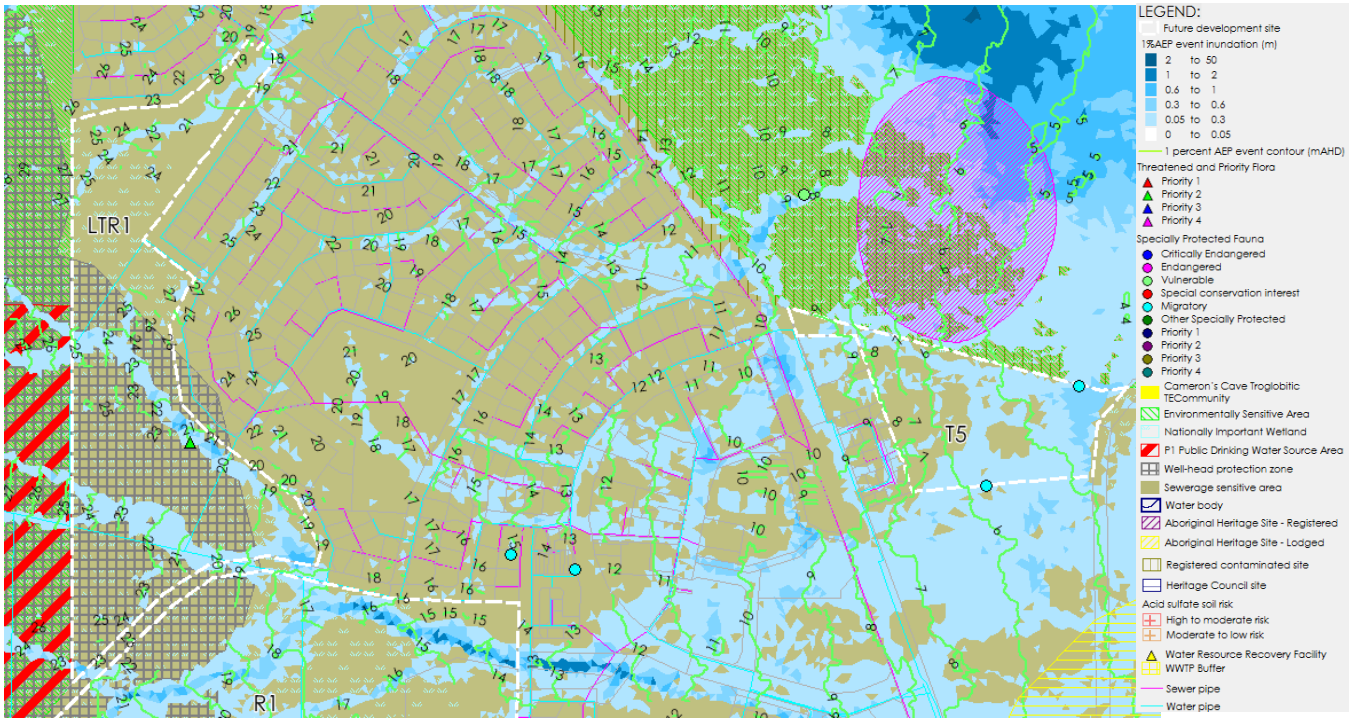


Figure 31: Long term residential area 1 and Tourism area 5 (existing terrain)

4.9.9 Future residential (long term) area 2

Long term residential area 2 is located west of the Nimitz Street ODP Area abutting the Exmouth Water Reserve (Figure 26). The majority of the site is zoned for Urban Development with a small portion in along the southern boundary reserved for Public Open Space.

Any future development will need to be supported by a local structure plan and local WMR, consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are shown in Figure 26 and include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths
- Adjacent to a Priority 1 Public drinking water source area
- Adjacent to an environmentally sensitive area
- Within a Sewerage Sensitive Area
- Nationally Important Wetland: potential to be underlain by important karst features

4.9.10 Future residential (long term) area 3

Long term residential area 3 is located to the west of the power station abutting the Exmouth Water Reserve. It is currently zoned Rural.

The site will require rezoning for residential development, and this should be accompanied by a District WMR consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are shown in Figure 32 and include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths
- Potential to contain priority flora and fauna
- Adjacent to a Priority 1 Public drinking water source area
- Adjacent to an environmentally sensitive area
- Within a Sewerage Sensitive Area
- Nationally Important Wetland: potential to be underlain by important karst features

4.9.11 Future residential (long term) area 4

Long term residential area 4 is located to the west of Residential Area 5 abutting the Exmouth Water Reserve (Figure 29). It is currently zoned Rural with a small portion of Environmental Conservation Reserve along the southern boundary, in recognition of the buffer for the Camerons Cave Troglobitic Community and Market Street creek.

The site will require rezoning for residential development and this should be accompanied by a District WMR consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are shown in Figure 29 and include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths.
- Contains part of an environmentally sensitive area (associated with the Camerons Cave Troglobitic TEC).
- Within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

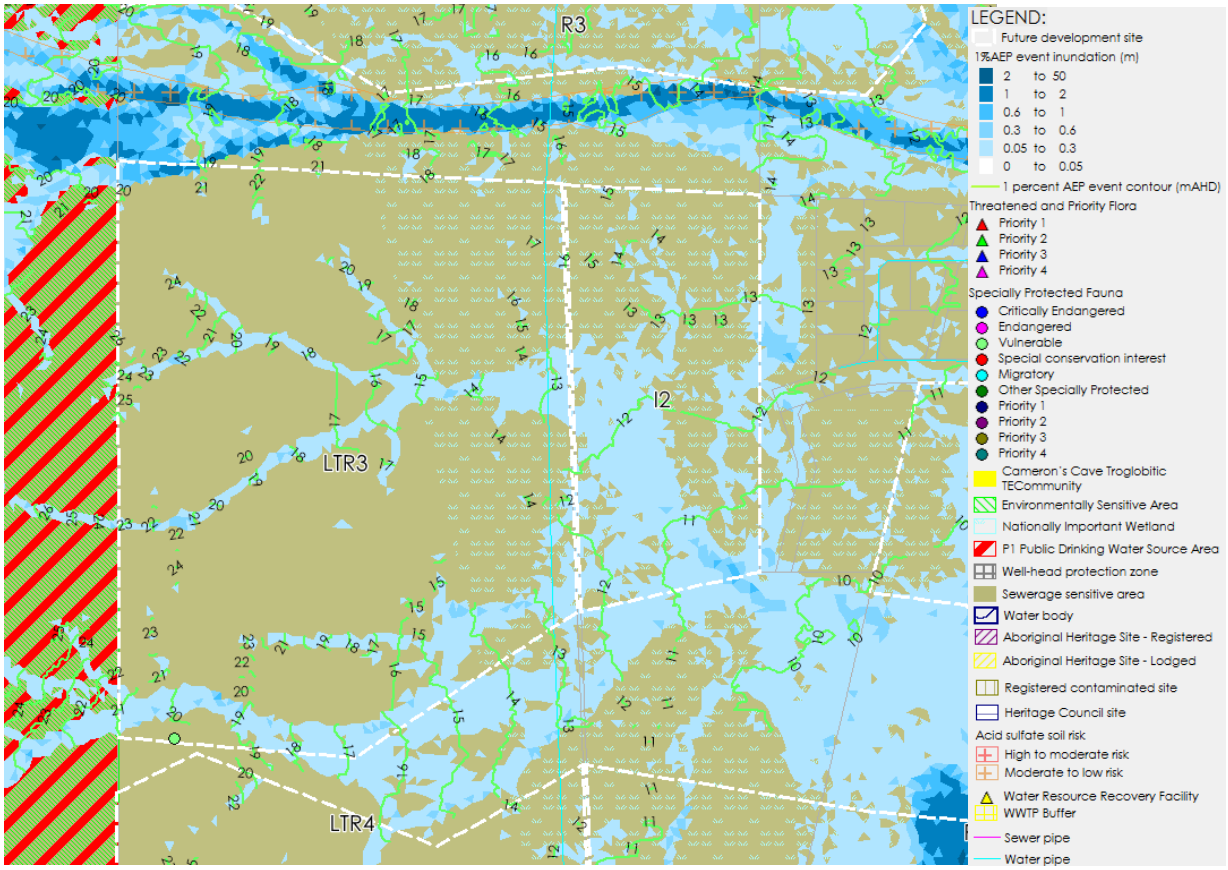


Figure 32: Long term residential area 3 and Industrial area 2 (existing terrain)

4.9.12 Future rural residential area 1

Future Rural Residential Area 1 is to the east of the existing Preston Street rural residential area on the southern boundary of Exmouth townsite. It represents an extension of the existing Preston Street rural residential area where a minimum 1ha lot size applies.

The Shire's Local Planning Strategy notes that 'the site is traversed by power infrastructure and excavation and environmental constraints may be anticipated due to karst landform. Area 1 has the potential to be connected to water and power with on-site effluent disposal. The northern boundary of Area 1 abuts the 500m buffer of Cameron's Cave limiting the northern extension of this precinct."

The site is currently zoned Rural with a small portion along the southern boundary reserved for 'Recreation and Open Space. It currently has access to reticulated water but not sewer.

The site will require rezoning for rural residential development and this should be accompanied by a District WMR consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are shown in Figure 33 and include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths.
- Adjacent to a Priority 1 Public drinking water source area.
- Contains part of an environmentally sensitive area (associated with the Camerons Cave Troglobitic TEC).
- No connection to reticulated sewer and is within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

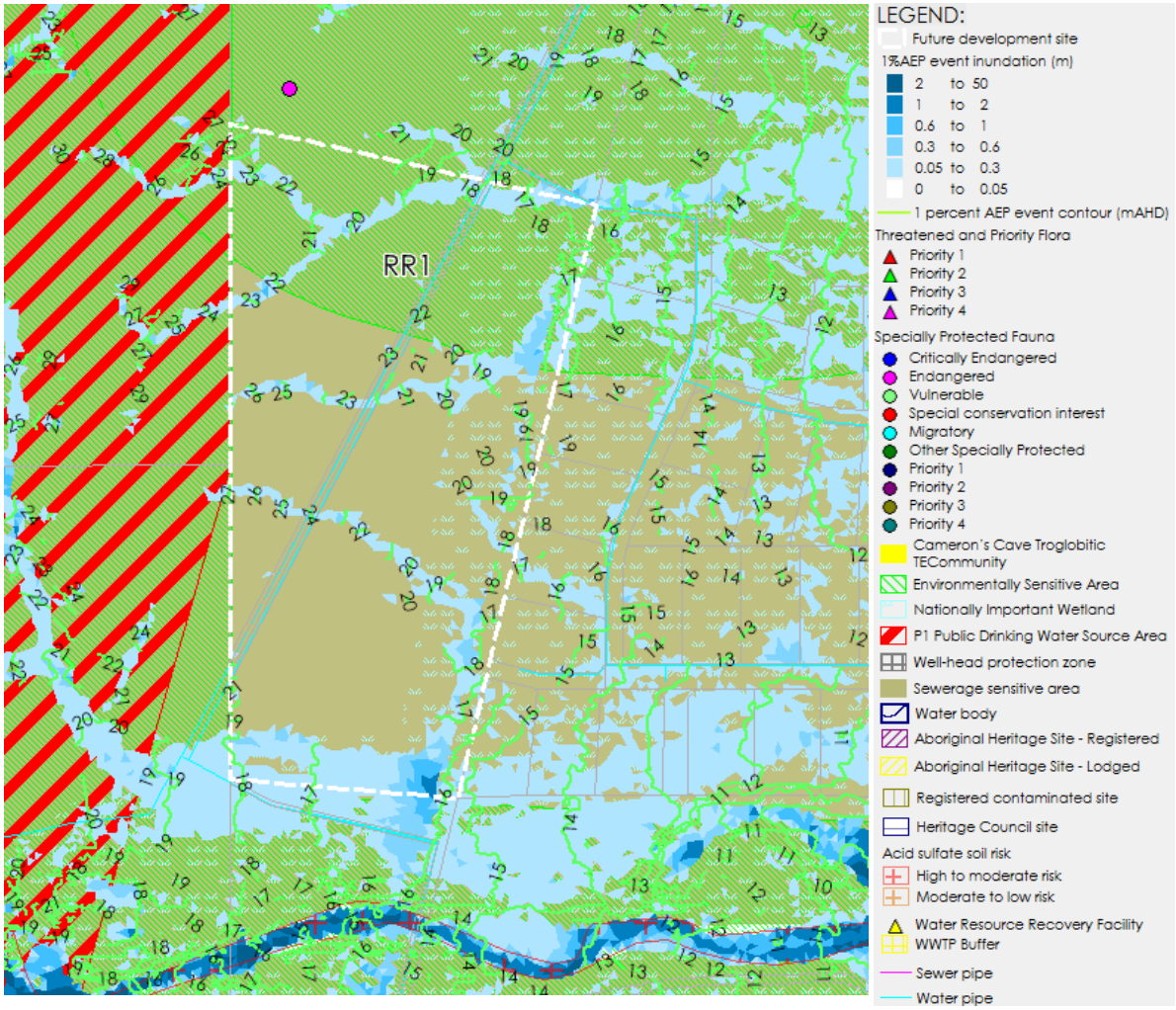


Figure 33: Future rural residential area 1 (existing terrain)

4.9.13 Future rural residential area 2

Future Rural Residential Area 2 is located south of Exmouth townsite and north of Mowbowra Creek between Minilya- Exmouth Road and Exmouth Gulf. The site is zoned Rural, with a small area of Foreshore Reserve on the eastern and southern edge. The site has access to reticulated water but not sewer.

The Shire's Local Planning Strategy (2019) notes that the "site is vacant UCL comprising approximately 51 ha. The landscape is relatively flat and vegetated comprising interdunal depressions and intermittent tracks. Portion of the site is affected by the high and low hazard floodplain. A greater portion of the site has uninterrupted views through to Exmouth Gulf."

The site will require rezoning for rural residential development, and this should be accompanied by a District WMR consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are shown in Figure 34 and include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths.
- Known protected fauna.
- Within an environmentally sensitive area.
- No connection to reticulated sewer and is within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

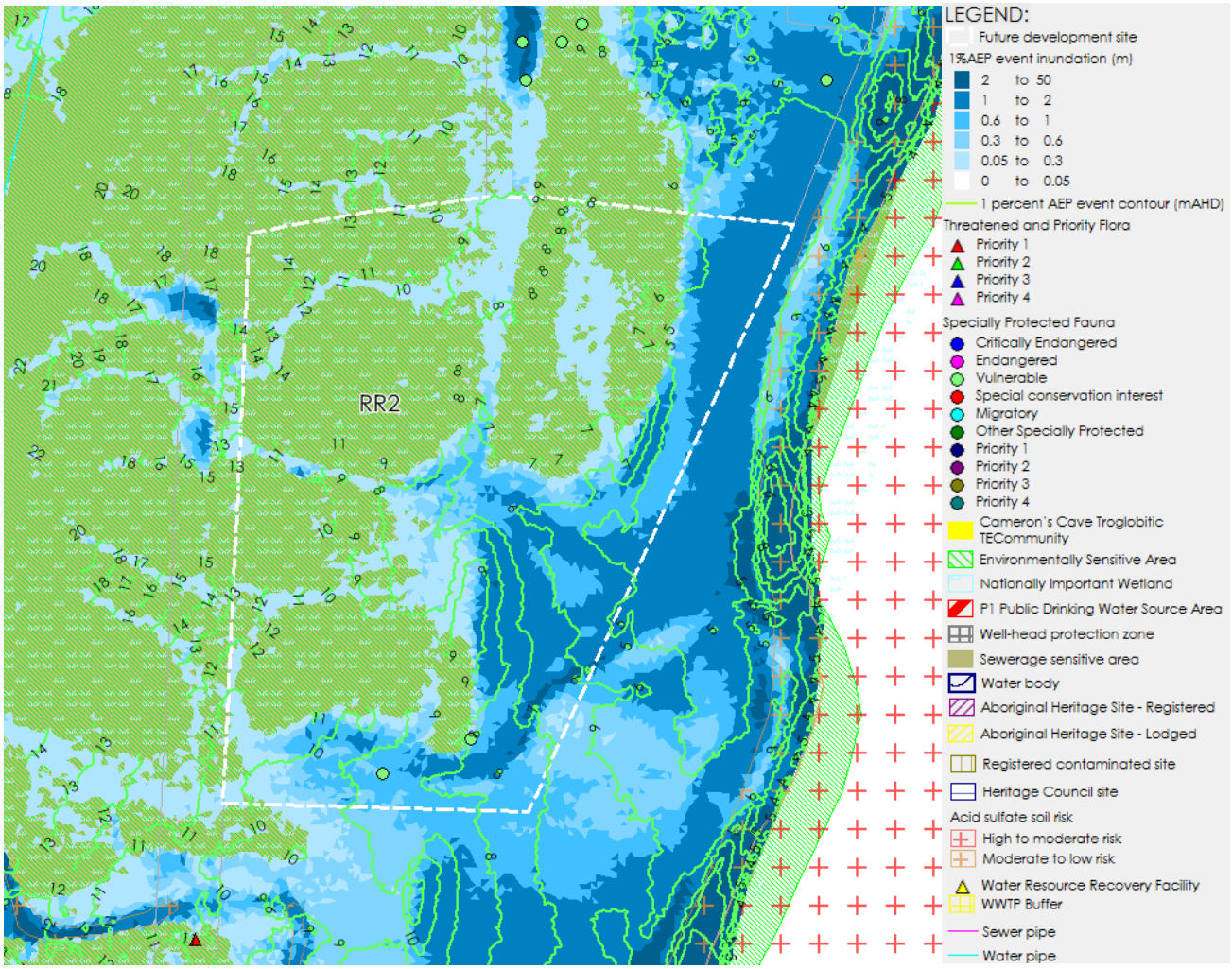


Figure 34: Future rural residential area 2 (existing terrain)

4.9.14 Future Industry (Service) Area 1

Future Industry (Service) Area 1 is currently zoned Service Commercial and is located immediately south of the existing Welch Street Light Industrial area and east of the Exmouth Power Station. The southern boundary of the site abuts the floodplain of Marina Creek.

The Shire's Local Planning Strategy (2019) notes that "Site levels over the site have been raised due to the import of excess fill during the construction phase of Exmouth Marina. In addition, portion of the site has been previously used for waste disposal activity and may be subject to site contamination."

Any future development will need to be consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are show in Figure 28 include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths.
- Within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

4.9.15 Future Industry (Light) Area 2

Area 2 is located immediately west of the existing Welch Street Light Industrial area and includes the existing Exmouth Power Station site. This site has already been developed as a solar farm and therefore no planning and/or development is likely to occur in the near future.

4.9.16 Future Industry (General) Areas 3

Future industry area 3 is located 22 kilometres south of the Exmouth townsite at the intersection of Charles Knife Road and immediately south of Badjirrajirra Creek. This site is outside the flood model domain boundary. The area is zoned Rural and abuts the existing Kalis industrial area to the south.

The site will require rezoning for industrial development, and this should be accompanied by a District WMR consistent with draft SPP 2.9 and this Regional WMR. Issues affecting the site that require further consideration in the WMR are shown in Figure 35 and include:

- Flood risk – consider the potential impact from Badjirrajirra Creek.
- Within an environmentally sensitive area.
- Nationally Important Wetland: potential to be underlain by important karst features.
- No connection to reticulated sewer or water and is within a Sewerage Sensitive Area.
- Potential for acid sulfate soils.

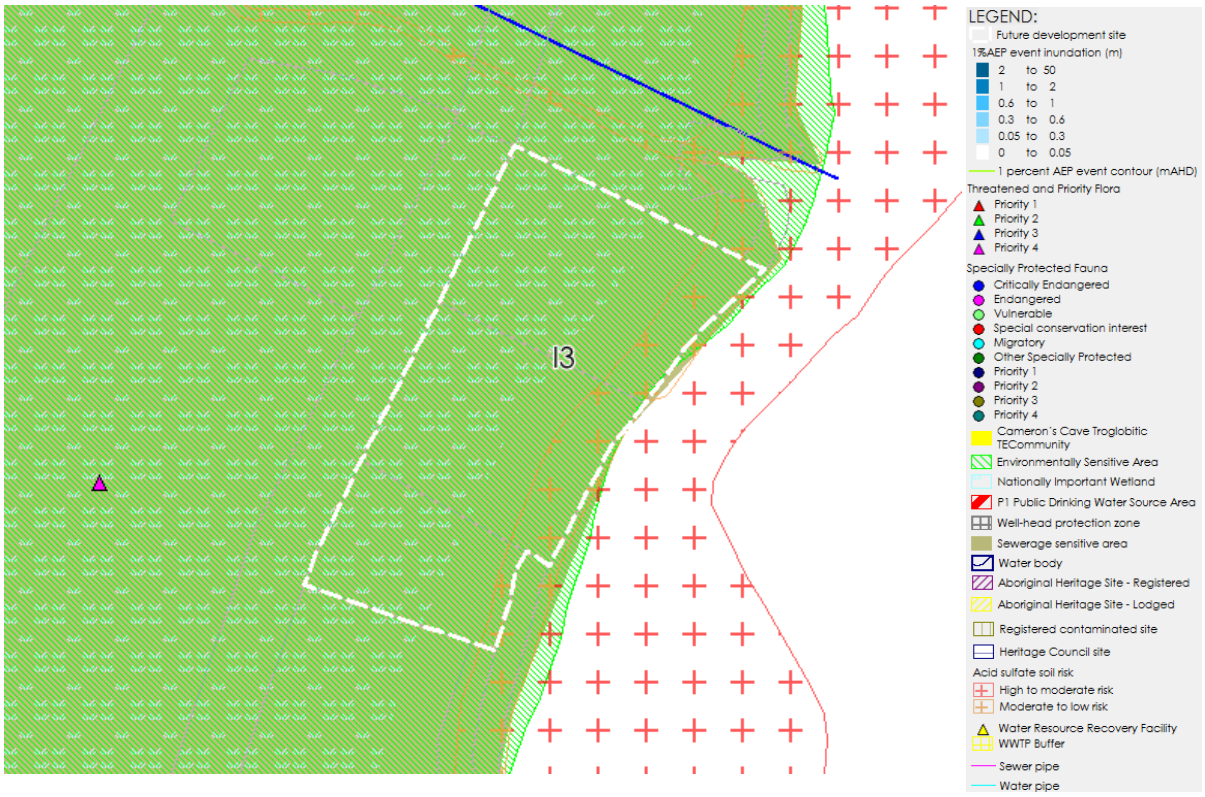


Figure 35: Future industrial area 3 (existing terrain)

4.9.17 Future industry area 4

Future industry area 4 is located immediately west of the Ingram Street Industrial area on Minilya-Exmouth Road, 8 kilometres south of the Exmouth townsite. The majority of the site is zoned Industrial Development, with areas along the northern and southern boundaries zoned Rural. While the site has access to reticulated water supply, there is currently no connection to reticulated sewerage.

Any future development within the area zoned Industrial Development will need to be supported by a local structure plan and local WMR, consistent with draft SPP 2.9 and this Regional WMR. Any industrial development proposed within the Rural area will require rezoning. Issues affecting the site that require further consideration in the WMR are shown in Figure 36 and include:

- Flood risk – noting that the flood extent and levels shown are pre-development, to provide an understanding of the extent of predicted floodways and overland flowpaths.
- Contains a wetland and waterway.
- Known protected flora.
- Aboriginal cultural heritage.
- Adjacent to a Priority 1 Public drinking water source area.
- Contains an environmentally sensitive area.
- No connection to sewer and within a Sewerage Sensitive Area.
- Nationally Important Wetland: potential to be underlain by important karst features.

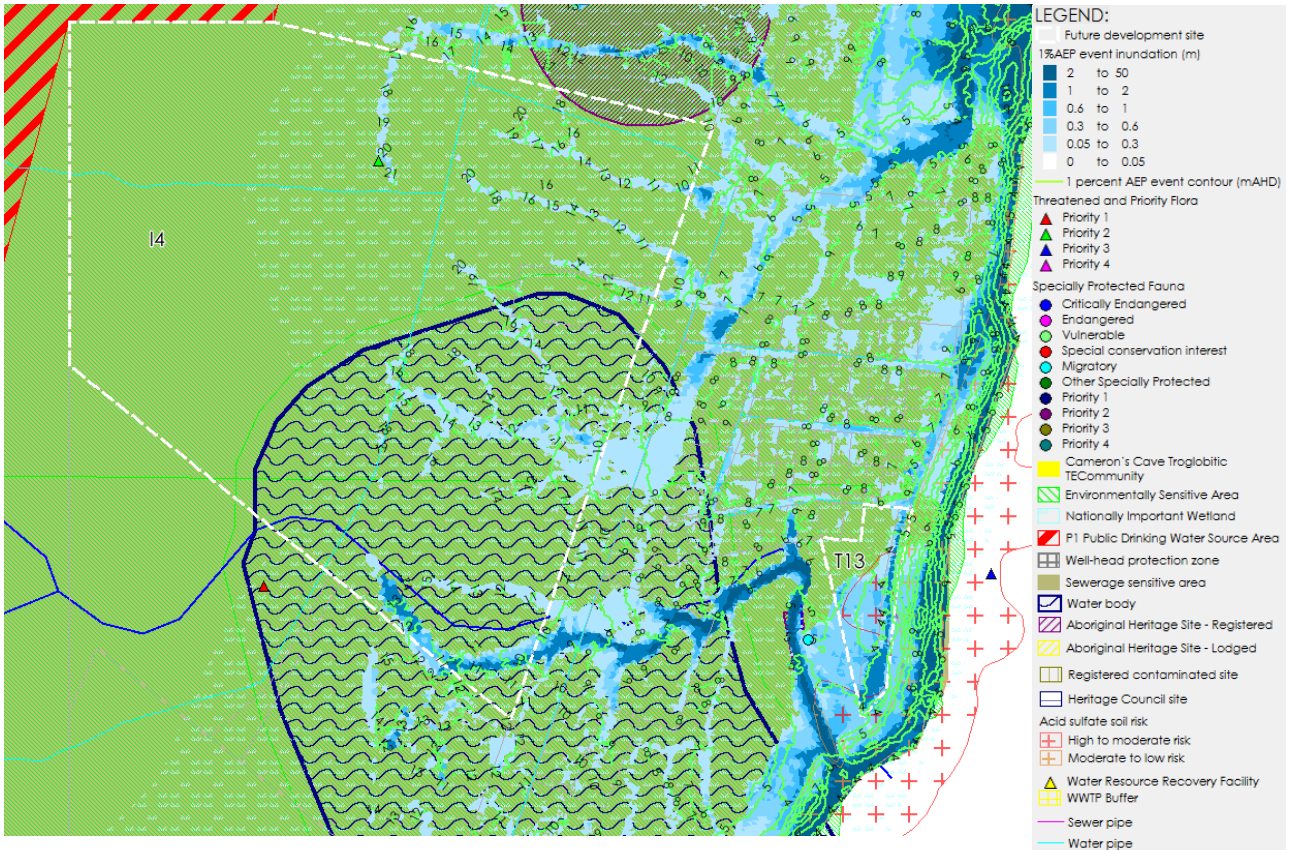


Figure 36: Future industrial area 4 and Tourism site 13 (existing terrain)

4.9.18 Future Tourism

Areas 1 to 12 are identified as future tourism sites within the Shire's Local Planning Strategy (2019). Dependent upon the qualities and attributes of each site, the future tourism areas are categorised as Tourism, Tourism/Residential, Caravan Park and Camping or Nature Based Camping. The following description of future tourism areas is taken from the Shire's Local Planning Strategy (2019).

> *Areas 1 and 2 have been specifically identified for Tourism purposes in which residential use is not supported given the high tourism value of the sites. These areas have been identified to facilitate the longer-term protection of a beachside locality for short stay accommodation purposes. The land use and development parameters required to ensure development can take place when economic conditions are appropriate have been defined.*

Areas 3 to 10 have been identified for Tourism/Residential in which the local government may consider up to 40% of the site being developed for residential purposes where specified criteria has been met, such as: the overall size of the site, the extent to which the area of highest tourism value is protected; maximisation of tourism value through site design having regard to minimising conflict with residential amenity; and the manner in which development is to be staged to retain the primacy of tourism uses.

Areas 11 and 12 have been identified for Caravan Park and Camping in which residential use will be restricted, to protect the intended function of these future sites.

Nature Based Camping will be considered as a discretionary use in managed locations outside of the Exmouth townsite subject to further investigation in accordance with the planning considerations identified.

Where development is proposed in any of these areas, it should be undertaken in accordance with draft SPP 2.9 and this Regional WMR. This will require consideration of the issues identified in Figures 38, 39 and 40 (as well as 29, 30 and 32) and in Table 9. The darker colour in the table indicates a more significant issue.

Table 9: Water management issues relevant to future Tourism areas

Issue/ Site	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
Flood risk													
Coastal hazards													
Known protected flora/fauna													
Aboriginal cultural heritage													
Acid sulfate soils													
Environmentally sensitive area													
Within a Sewerage Sensitive Area													
Nationally Important Wetland: potential to be underlain by important karst features													
Wastewater treatment plant buffer													

It is noted that all of the coastal tourism sites are affected by flooding. In the case of T1-T4, this is largely a result of the nearshore coastal dunes and does not represent a significant fluvial flood flowpath. Therefore, it is anticipated that these sites could be developed for tourism purposes until such time as they become affected by costal processes. Long-term development of these sites is not recommended due to the important values and functions of the dunal landforms.

Similarly, elevated portions of T11 and T12 are affected by interdunal flooding but could be developed for short to medium-term tourism purposes until such time as they become affected by costal processes. However, it should be noted that substantial floodwaters collect on the lower-lying inland portions of these sites and are redirected northwards by the dunes. It is critical that these areas remain unfilled and undeveloped.

T13 is located at the mouth of a creek and flooding here is a complex combination of breakout flow from the creek and floodwaters from lots to the north. The dynamics of sand accretion and erosion at the creek mouth will substantially affect the extent of flooding on this land and this should be a consideration for any development proposed at this site. Again, this site is considered unsuitable for long-term development.

Tourism areas T5, T6 and T10, being somewhat removed from the coast, could potentially be considered for longer-term development (hence they are indicated as not significantly impacted in Table 9) although they are significantly impacted by flooding and coastal inundation and will become increasingly susceptible to coastal processes in future as the sea level rises.

Tourism areas T7, T8 and T9, located on the Exmouth marina and canals, are somewhat protected from the effects of coastal erosion, and could therefore be considered for more substantial development. However, it should be noted that these sites are significantly affected by coastal inundation, the extent and level of which will increase in future due to sea level rise. In addition, site T9 is particularly at risk of potentially long periods of isolation with limited access and egress possible during inundation events.

Development of these sites should be undertaken with consideration of the Exmouth Coastal Hazard Risk and Adaptation Management Plan: Exmouth Townsite (in development) and include an adaptive management strategy that establishes monitoring of coastal impacts to facilitate early detection of change and defines triggers for proactive implementation of specified actions in a timely manner.

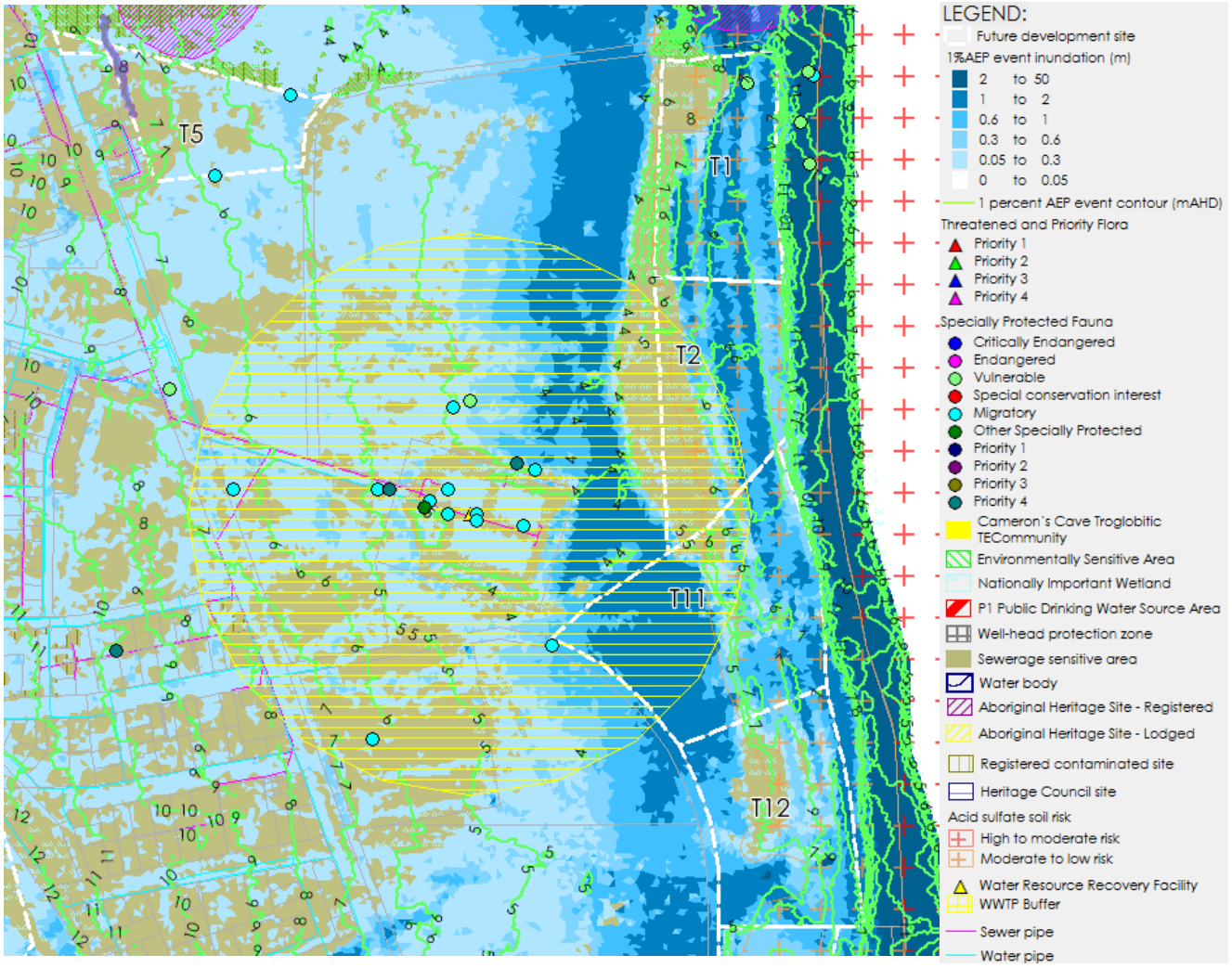


Figure 37: Future Tourism areas 1, 2, 5, 11 and 12 (existing terrain)

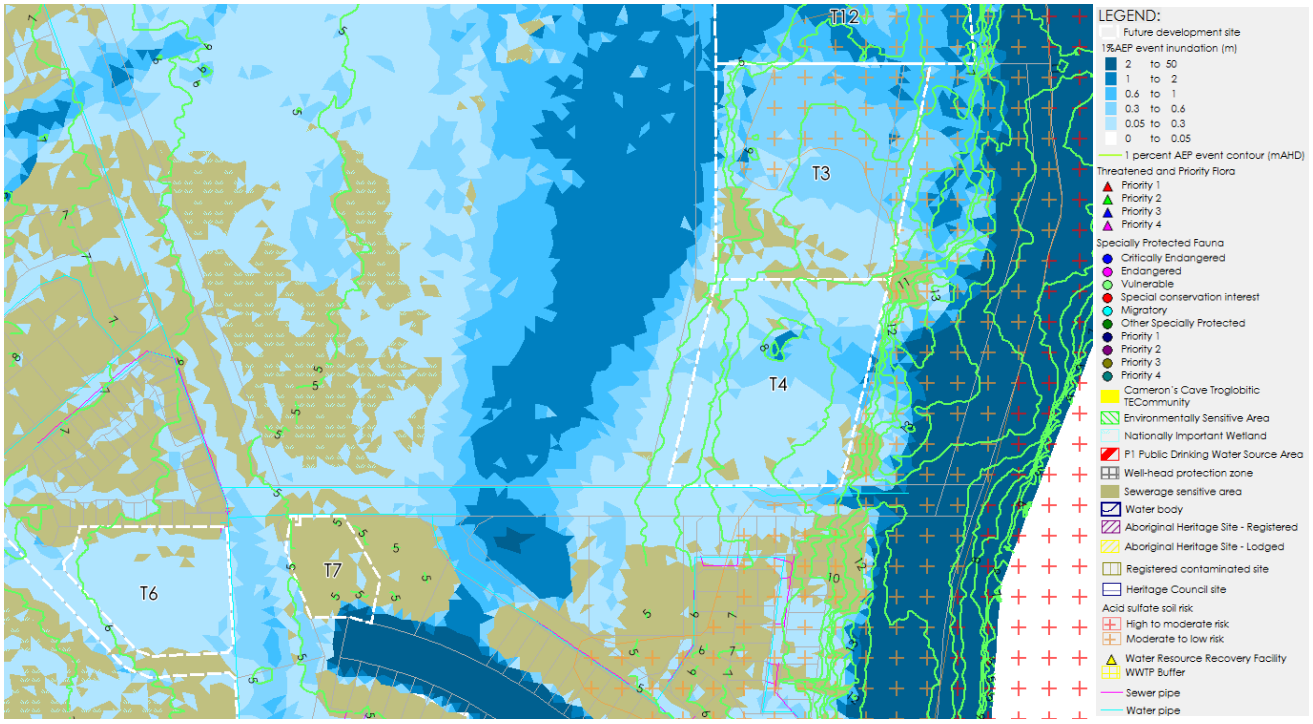


Figure 38: Future Tourism areas 3, 4, 6 and 7 (existing terrain)

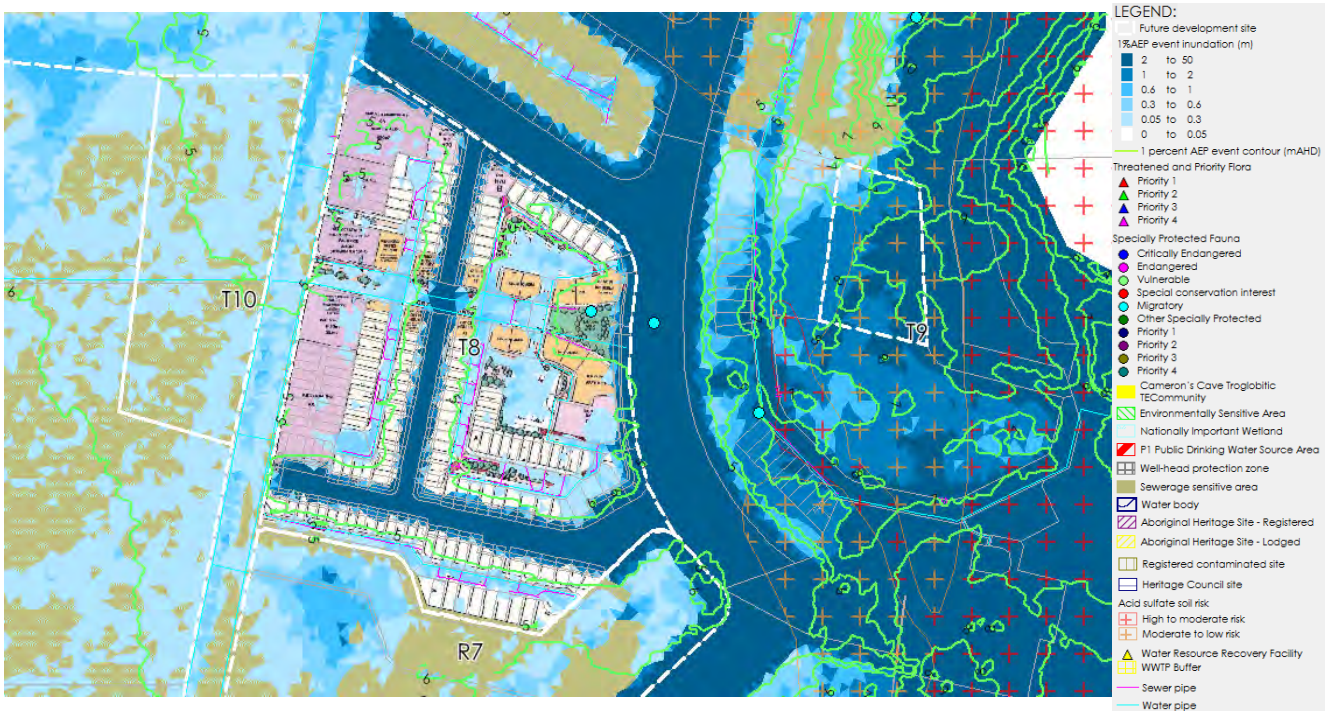


Figure 39: Future Tourism areas 8, 9 and 10 (existing terrain)

5 WATER MANAGEMENT STRATEGY

5.1 Objectives

The objectives of this Regional WMR are to:

1. provide a sustainable, local water supply and wastewater system for a growing population that optimises efficient use of all types of available resources.
2. protect water for cultural and environmental values.
3. support community health and wellbeing through greening and waterwise development that provides climate resilience.
4. create a locally responsive approach (low impact) to flood protection and incorporate emergency planning.
5. support the collaborative delivery of an improved total water cycle solution to achieve objectives 1-4.

5.2 Principles

All land use planning and development proposals should aim to:

- Enhance economic, social and cultural values of water resources, together with community and system resilience, amenity and liveability.
- Mimic natural hydrological processes - design based on local site conditions and minimise changes to hydrology, including retention and protection of natural floodways, and breakout flowpaths, avoiding their obstruction or diversion wherever possible.
- Enhance natural systems - manage, protect and restore wetlands and waterways.
- Provide protection from flooding in 1% annual exceedance probability (AEP) flood event, extreme (1% AEP) coastal inundation levels with appropriate consideration of sea level rise, and surface or groundwater inundation/waterlogging.
- Maximise water use efficiency and facilitate fit-for-purpose water sources including water reuse/recycling.
- Minimise pollution inputs and outputs in flows and in receiving environments.
- Create fit-for purpose, safe and sustainable water management systems that are integrated into the urban form.
- Consider all water resources as early as possible in the process, to integrate water and land use planning, protecting important values and optimise total water cycle outcomes.

5.3 Strategies

In order to meet the objectives of this regional WMR, the following strategies are to be considered as part of the preparation of a new local planning strategy and scheme, and other activities of the Shire and implemented as part of future land use planning and development. Implementation of these strategies must be site specific and address, as a priority, the issues identified in section 4 of this report.

Objective 1: Provide a sustainable, local water supply and wastewater system for a growing population that optimises efficient use of all types of available resources.

1. Work with the Water Corporation to improve access to treated wastewater for non-potable water needs in the short and longer term, accounting for substantial seasonal population fluctuations.
2. Provide support to a coordinated request for funding of essential infrastructure in Exmouth.
3. Work with industry to identify and trial innovative infrastructure solutions, including for temporary or transitional systems.
4. Promote compatible, beneficial uses within the Wastewater Treatment Plant buffer that do not limit future opportunities after relocation.

Objective 2: Protect water for cultural and environmental values

5. Engage with Traditional Owners including the Nganhurra Thanardi Garrbu Aboriginal Corporation in the planning and design of future development.
6. Ensure development sites address stormwater quality in a locally responsive manner that reflects the climate and landscape characteristics. This must include management of erosion and sediment through suitable drainage design, landscaping and site management.
7. Protect important drinking water resources through appropriate land use controls and land management activities in accordance with draft SPP 2.9 and the Planning for Water guidelines.
8. Assist state water agencies in the maintenance of environmental, social and cultural values through advocacy for sustainable water management and protection, including for sustainable use, improved water quality and increased urban biodiversity.

Objective 3: Support community health and wellbeing through greening and waterwise development that provides climate resilience.

9. Develop a public open space strategy to guide the function, design and maintenance of locally appropriate public spaces that integrate water management requirements. Consider use of cash-in-lieu to support the upgrade/maintenance of existing parks where recreational needs are met.
10. Continue to optimise use of treated wastewater for irrigation of public open space including prioritisation of parks, streetscapes and/or drainage swales for use of irrigation to sustain values, improved aesthetics, urban amenity and vegetation, and address urban heat.
11. Support new development that identifies and secures a non-scheme water source for non-potable needs.
12. Ensure Council operations maximise water use efficiency.
13. Increase community education regarding the environmental, social and cultural values of water resources including the need for improved efficiency, fit-for-purpose use and water quality management.

Objective 4: Create a locally responsive, low impact approach to flood protection and incorporate emergency planning.

14. Develop open space, urban and built form typologies that respond to the local climate and landscape conditions, where the use of fill is a 'last resort' approach to achieving required separations from flood level to habitable floor levels. Review existing criteria to make them current, future focussed, and appropriate to the context of different land uses and

development typologies. Prepare local guidance (Local Planning Policy) to support delivery of local variations.

15. Recognise and address flood risk (from stormwater, riverine and coastal systems) as part of future planning and development assessment and decision-making. Retain floodways and overland flow paths and integrate water management requirements into open space supported by locally responsive landscape treatments. Update Special Control Areas in response to outcomes of the modelling.
    a. Apply a risk-based approach, in consultation with the Shire and DWER, to determine the acceptable level of flood protection for proposed land uses where any deviation from criteria specified in the Decision Process for Stormwater Management in WA (DWER, 2017) is proposed.
16. Consider appropriate temporary uses and identify triggers and thresholds for retreat in coastal areas, with sites remaining in public ownership to facilitate emergency evacuation and/or retreat strategies.
17. Enhance emergency management planning for heatwaves, bushfire, flood and cyclones including consideration of potentially long periods of isolation with limited access and egress possible from areas affected by a combination of fluvial flooding and coastal inundation.

Objective 5: Support the collaborative delivery of an improved total water cycle solution to achieve objectives 1-4.

18. Create a shared responsibility for improving the sustainable management of the total water cycle including making treated wastewater available to support liveability.
19. Work with DWER to optimise allocation and use of groundwater
20. Enhance relationships with Gascoyne Development Commission and Infrastructure WA to support development of a business case.

6 IMPLEMENTATION

Implementation of this WMR is via the planning and development approvals process, through actions by the Shire and collaboration with other agencies and industry.

6.1 Future land use planning and development

Any future planning and development shall be undertaken in accordance with draft SPP 2.9 and the Planning for Water Guidelines (WAPC 2021, or most recent version) and the principles and objectives of this WMR. Proponents of development are required to develop a WMR at each planning stage to support and inform their planning proposals, environmental investigations, engineering, landscaping and urban designs as follows.

- A District WMR is required to support the rezoning of land.
- A Local WMR is required to support the preparation of a local structure plan.
- A Subdivision WMR is required to support an application for subdivision.
- A Development WMR is required to support an application for development.

A further WMR is not required if the previously approved WMR specifically states there is sufficient information contained within, and the proposal complies with the previously approved WMR.

Particular attention should be paid to the issues identified for each future development area, as highlighted in Section 4 and depicted on the detailed issues maps.

Proponents of development should demonstrate that their proposals and designs are consistent with the principles, objectives and strategies in section 5, as well as satisfying requirements of other relevant State and local government agencies.

Proposals can be considered where alternative approaches are applied to achievement of flood clearances with reduced reliance on fill, or where it is proposed to modify the clearance criteria, for example where it may be reasonable to accept episodic flooding of a particular land use or building. However, these proposals will need to be supported by a detailed flood risk assessment and emergency planning developed in consultation with the Shire and DWER.

6.1.1 Role of referral agencies

The role of DWER is to provide advice consistent with their role as the manager of water resources. Technical assessment of water management systems and strategies will generally be provided by the Shire. However, some technical assessment may be undertaken by DWER where specifically requested by the Shire or by the proponent.

6.2 Role of the Shire

In supporting proponents to address the requirements of this WMR, the Shire will:

- Develop guidance for local variations to open space, urban form and built form design to deliver more sustainable and climate resilient communities.
- Ensure new development is designed to meet appropriate flood risk criteria.
- Ensure planning applications are supported by an appropriate level of water resource information consistent with SPP 2.9 and this WMR.

- Determine priority areas for emergency planning to adequately manage risks from stormwater and riverine flooding.
- Develop a POS strategy and optimise water supply and irrigation efficiency of parks and public realm.
- Update the special control areas in the local planning scheme to provide guidance on flood risk; appropriate land use controls to protect drinking water sources and buffers for sensitive land uses.
- Incorporate the strategies of this WMR into operational and business planning.

6.3 Fostering partnerships for improved community outcomes

The Shire will work with State Government agencies and other organisations to deliver the objectives of this WMR which includes:

- Working with DWER to provide appropriate guidance for developers proposing alternative approaches to achievement of flood clearances with reduced reliance on fill or considering modified clearances.
- Supporting the Water Corporation to plan for a sustainable, total water cycle approach to the future servicing of the growing Exmouth community.
- Working with the region's Traditional Owners to incorporate traditional knowledge regarding the management of water resources into management practices.
- Working with the Water Corporation in the near future to facilitate innovative, industry led and possibly temporary solutions to servicing.
- Engaging with the community to understand water values and behaviours including attitudes to water reuse and efficiency.
- Promoting water efficiency measures within the community and workplace including behaviour change and installation of more water efficient fittings and fixtures.

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APPENDIX 1: THREATENED, EXTINCT AND SPECIALLY PROTECTED FAUNA OR FLORA IN THE SHIRE OF EXMOUTH

Threatened and Priority Flora

Taxon	Conservation Code
Calytrix sp. Learmonth (S. Fox EMopp 1)	Priority 1
Indigofera oraria	Priority 1
Myoporum sp. Ningaloo (S. Colwill 14)	Priority 1
Sclerolaena stylosa	Priority 1
Abutilon sp. Quobba (H. Demarz 3858)	Priority 2
Acacia ryaniana	Priority 2
Acanthocarpus rupestris	Priority 2
Calandrinia sp. Cape Range (F. Obbens FO 10/18)	Priority 2
Crinum flaccidum	Priority 2
Cucumis sp. Barrow Island (D.W. Goodall 1264)	Priority 2
Daviesia pleurophylla	Priority 2
Eremophila occidens	Priority 2
Harnieria kempeana subsp. rhadinophylla	Priority 2
Tephrosia sp. North West Cape (G. Marsh 81)	Priority 2
Tinospora esiangkara	Priority 2
Verticordia serotina	Priority 2
Acacia alexandri	Priority 3
Acacia startii	Priority 3
Carpobrotus sp. Thevenard Island (M. White 050)	Priority 3
Corchorus congener	Priority 3
Corynotheca flexuosissima	Priority 3
Eremophila forrestii subsp. capensis	Priority 3
Grevillea calcicola	Priority 3
Gymnanthera cunninghamii	Priority 3
Lysiandra fuernrohrii	Priority 3
Stackhousia umbellata	Priority 3
Thryptomene dampieri subsp. capensis	Priority 3
Brachychiton obtusilobus	Priority 4
Eremophila youngii subsp. lepidota	Priority 4
Livistona alfredii	Priority 4
Rhynchosia bungarensis	Priority 4

Specially Protected Fauna

Taxon	Common name	WA Status	EPBC status
BIRD			
Limosa lapponica menzbieri	bar-tailed godwit (northern Siberian)	CR	CR
Calidris ferruginea	curlew sandpiper	CR	CR & MI
Numenius madagascariensis	eastern curlew	CR	CR & MI
Calidris tenuirostris	great knot	CR	CR & MI

Taxon	Common name	WA Status	EPBC status
Puffinus huttoni	Hutton's shearwater	EN	
Charadrius mongolus	lesser sand plover	EN	EN & MI
Calidris canutus	red knot	EN	EN & MI
Zanda sp. 'white-tailed black cockatoo'	white-tailed black cockatoo	EN	EN
Limosa lapponica	bar-tailed godwit	MI	MI
Limosa limosa	black-tailed godwit	MI	MI
Onychoprion anaethetus	bridled tern	MI	MI
Calidris falcinellus	broad-billed sandpiper	MI	MI
Hydroprogne caspia	Caspian tern	MI	MI
Tringa nebularia	common greenshank	MI	MI
Anous stolidus	common noddy	MI	MI
Actitis hypoleucos	common sandpiper	MI	MI
Sterna hirundo	common tern	MI	MI
Thalasseus bergii	crested tern	MI	MI
Plegadis falcinellus	glossy ibis	MI	MI
Pluvialis squatarola	grey plover	MI	MI
Gelochelidon nilotica	gull-billed tern	MI	MI
Fregata ariel	lesser frigatebird	MI	MI
Numenius minutus	little curlew	MI	MI
Sternula albifrons	little tern	MI	MI
Calidris subminuta	long-toed stint	MI	MI
Tringa stagnatilis	marsh sandpiper	MI	MI
Charadrius veredus	oriental plover	MI	MI
Glareola maldivarum	oriental pratincole	MI	MI
Pandion haliaetus	osprey	MI	MI
Pluvialis fulva	Pacific golden plover	MI	MI
Gallinago stenura	pin-tailed snipe	MI	MI
Calidris ruficollis	red-necked stint	MI	MI
Sterna dougallii	roseate tern	MI	MI
Arenaria interpres	ruddy turnstone	MI	MI
Calidris alba	sanderling	MI	MI
Calidris acuminata	sharp-tailed sandpiper	MI	MI
Xenus cinereus	Terek sandpiper	MI	MI
Ardenna pacifica	wedge-tailed shearwater	MI	MI
Numenius phaeopus	whimbrel	MI	MI
Phaethon lepturus	white-tailed tropicbird	MI	MI
Chlidonias leucopterus	white-winged black tern	MI	MI
Oceanites oceanicus	Wilson's storm-petrel	MI	MI
Tringa glareola	wood sandpiper	MI	MI
Falco peregrinus	peregrine falcon	OS	
Amytornis textilis textilis	western grasswren	P4	
Tringa brevipes	grey-tailed tattler	P4 & MI	MI
Phaethon rubricauda	red-tailed tropicbird	P4 & MI	MI
Thalassarche chlororhynchos	Atlantic yellow-nosed albatross	VU	MI
Sternula nereis nereis	fairy tern	VU	VU

Taxon	Common name	WA Status	EPBC status
Charadrius leschenaultii	greater sand plover, large sand plover	VU	VU & MI
Falco hypoleucos	grey falcon	VU	
FISH			
Mobula birostris	giant manta ray	MI	MI
Rhincodon typus	whale shark	MI	VU & MI
Ophisternon candidum	blind cave eel	VU	VU
Milyeringa veritas	blind gudgeon	VU	VU
Milyeringa veritas	cave gudgeon, blind gudgeon	VU	VU
Carcharodon carcharias	great white shark	VU	VU & MI
Pristis zijsron	green sawfish	VU	VU
INVERTEBRATE			
Bunderia misophaga	a copepod (Bundera Sinkhole)	CR	
Stygocyclopia australis	a copepod (Bundera Sinkhole)	CR	
Speleophria bunderae	a copepod (Bundera Sinkhole)	CR	
Prionospio thalanji	Bundera Sinkhole worm	CR	
Stygiochiropus peculiaris	Cameron's Cave millipede	CR	
Indohya damocles	Cameron's Cave pseudoscorpion	CR	
Kumonga exleyi	Cape Range remipede	CR	VU
Welesina kornickeri	Kornicker's Bundera Sinkhole ostracod	CR	
Liagoceradocus branchialis	Cape Range liagoceradocus amphipod	EN	
Bamazomus subsolanus	eastern Cape Range bamazomus	EN	
Draculoides brooksi	northern Cape Range draculoides	EN	
Bamazomus vespertinus	western Cape Range bamazomus	EN	
Draculoides julianneae	western Cape Range draculoides	EN	
Nocticola flabella	Cape Range blind cockroach, Cape Range delicate cockroach	P4	
Stygiocaris stylifera	spear-beaked cave shrimp	P4	
Stygiochiropus isolatus	a stygiochiropus millipede (Cape Range)	VU	
Stygiochiropus sympatricus	a stygiochiropus millipede (Cape Range)	VU	
Stygiocaris lancifera	lance-beaked cave shrimp	VU	
MAMMAL			
Bettongia lesueur graii	boodie (inland), burrowing bettong (inland)	CD	VU
Phascogale calura	red-tailed phascogale, kenngoor	CD	VU
Megaptera novaeangliae	humpback whale	CD & MI	MI
Zyzomys pedunculatus	central rock-rat, antina	CR	CR
Petrogale lateralis lateralis	black-flanked rock-wallaby, black-footed rock-wallaby, moororong	EN	EN
Dasyurus hallucatus	northern quoll	EN	EN
Potorous platyops	broad-faced potoroo	EX	EX
Bettongia lesueur graii	burrowing bettong (inland), boodie (inland)	EX	EX
Leporillus apicalis	lesser stick-nest rat	EX	EX
Balaenoptera bonaerensis	Antarctic minke whale	MI	MI
Dugong dugon	dugong	MI	MI
Tursiops aduncus	Indian Ocean bottlenose dolphin, Indo-Pacific bottlenose dolphin	MI	MI

Taxon	Common name	WA Status	EPBC status
Orcinus orca	killer whale	MI	MI
Sousa sahulensis	Australian humpback dolphin	MI & P4	VU & MI
Orcaella heinsohni	Australian snubfin dolphin	MI & P4	VU & MI
Stenella longirostris	spinner dolphin	MI & P4	MI
Ozimops cobourgianus	northern coastal free-tailed bat	P1	
Dasycercus blythi	brush-tailed mulgara	P4	
Mesembriomys macrurus	golden-backed tree-rat	P4	
Antechinomys longicaudatus	long-tailed dunnart	P4	
Antechinomys longicaudata	long-tailed dunnart	P4	
Leggadina lakedownensis	northern short-tailed mouse, Lakeland Downs mouse, kerakenga	P4	
Pseudomys chapmani	western pebble-mound mouse, ngadji	P4	
Sousa sahulensis	Australian humpback dolphin	P4 & MI	MI
Orcaella heinsohni	Australian snubfin dolphin	P4 & MI	MI
Stenella longirostris roseiventris	dwarf spinner dolphin	P4 & MI	MI
Stenella longirostris	spinner dolphin	P4 & MI	MI
Isoodon auratus barrowensis	Barrow Island golden bandicoot	VU	VU
Macrotis lagotis	bilby, dalgyte, ninu	VU	VU
Macroderma gigas	ghost bat	VU	VU
Isoodon auratus auratus	golden bandicoot (mainland), wintarru	VU	VU
Pseudomys gouldii	Gould's mouse, Shark Bay mouse, djoongari	VU	VU
Rhinonicteris aurantia (Pilbara form)	Pilbara leaf-nosed bat	VU	VU
Pseudomys fieldi	Shark Bay mouse, djoongari	VU	VU
REPTILE			
Aipysurus apraefrontalis	short-nosed seasnake	CR	CR
Caretta caretta	loggerhead turtle	EN	EN & MI
Crenadactylus tuberculatus	Cape Range clawless gecko	P2	
Diplodactylus capensis	Cape Range stone gecko	P2	
Lerista allochira	Cape Range slider	P3	
Aprasia rostrata	Ningaloo worm lizard	P3	
Natator depressus	flatback turtle	VU	VU & MI
Chelonia mydas	green turtle	VU	VU & MI
Eretmochelys imbricata	hawksbill turtle	VU	VU & MI
Dermochelys coriacea	leatherback turtle	VU	EN & MI

APPENDIX 2: HYDROLOGICAL MODELING REPORT

APPENDIX 2: HYDROLOGICAL MODELLING REPORT

Modelling presented in this regional water management strategy is from a combined 1/2-dimensional hydrological and hydraulic model constructed using the InfoWorks Integrated Catchment Model (ICM), applying ensemble design rainfall analysis consistent with the procedures recommended by Australian Rainfall and Runoff (ARR2019) and with consideration of the following relevant previous modelling and associated studies:

- Exmouth Floodplain Management Study (2 parts):
  - Flood Modelling Report (SKM, 2007)
  - Floodplain Management Strategy (SKM, 2007)
- Exmouth Hydrological Study (Hyd_2O, 2014)
- Statewide Coastal Inundation Assessment Phase 2 Report (Seashore Engineering, 2024)
- Exmouth Desalination Plant Flood Study – Draft Report (Worley Consulting, 2024)

Model conceptualisation

The Exmouth RWMS study area, shown in Figure 1, found in the main body of this report, includes eastern and northern portions of the North West Cape, wrapping around the Cape Range National Park from Charles Knife Road in the south east to the National Park pay station in the west.

The study area selected for hydrological modelling (the model area), shown in Figure 1 of this appendix, is somewhat smaller than this, in part due to data availability but primarily because the areas of interest for planning and potential future development purposes are in and around the Exmouth Townsite. The only exception to this, is one potential area of industrial development adjacent to the former Kailis prawn processing facility, near the southern boundary of the RWMS study area.

The model area is mainly characterised by relatively flat terrain traversed by a few ephemeral creeks mainly flowing in an easterly direction. The headwaters of these creeks extend into the Cape Range which is characterized by dissected limestone plateaux, hills and ridges with extensive gorges, steep rocky slopes and sparse vegetation.

There are nine principal catchments feeding into the model area at 21 individual discharge locations, as shown in Figure 1.

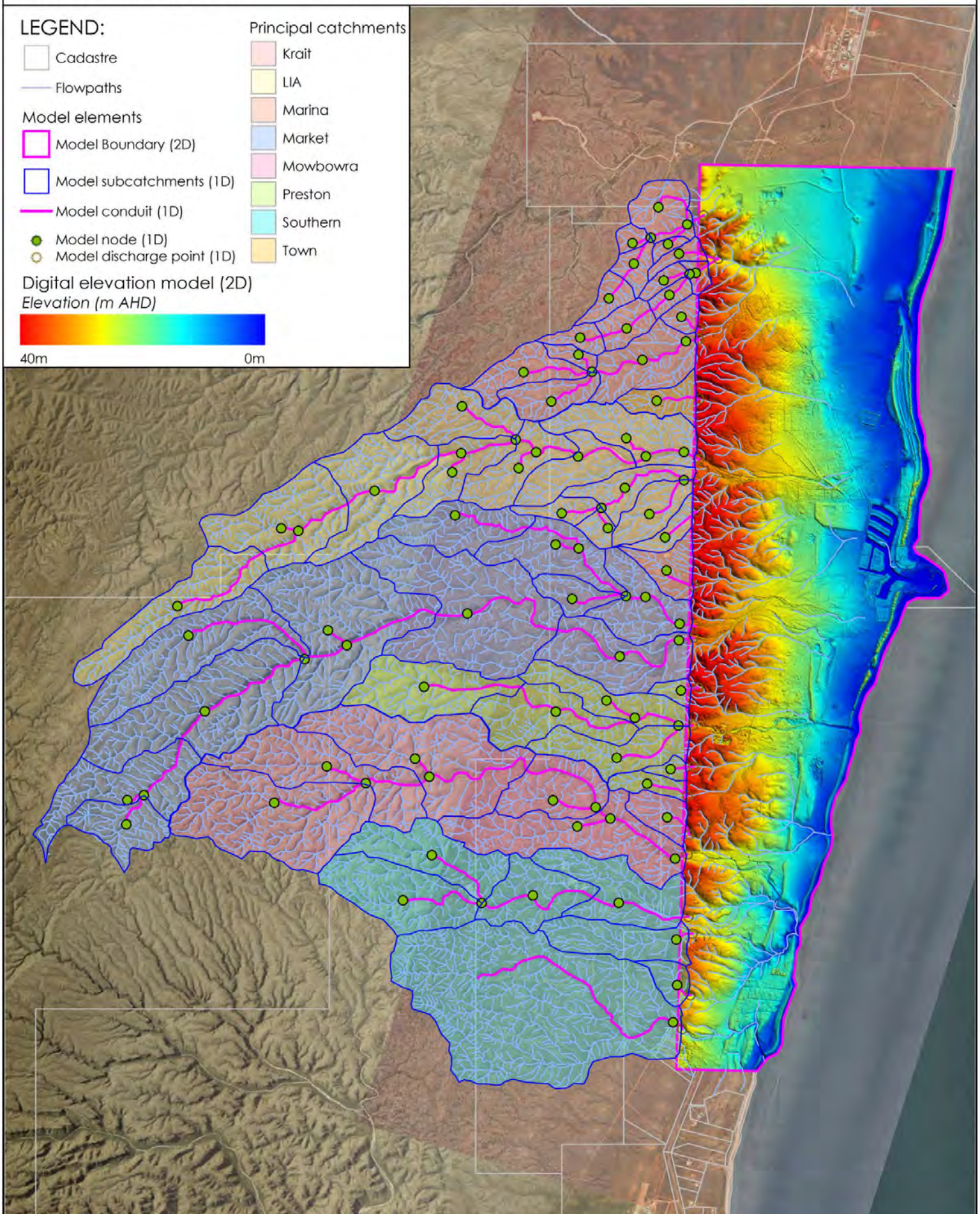
Because of the relatively incised geomorphology of creeks in the upper catchment, inflows to the main study area can be suitably represented by 1-dimensional catchments to generate hydrographs entering the boundary of the model area which is more suitably represented in a 2-dimensional model zone so that overland flows, breakouts and areas of surface storage can be more accurately reflected.

Within the existing townsite and developing areas, it is necessary for the model to be capable of defining the extent, depth and velocities of flood flows traversing the land as well as representing changes to local topography following development so that floodways are protected, and safety risks are suitably managed for the existing and future community.

Within the 2-dimensional model domain, application of direct rain-on-grid is preferred to enable representation of the behaviour of accumulated flows generated within the domain in addition to the larger creek inflows from the upper catchment.

Figure 1 presents an overview of the model layout and construction which is described in the next section.

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Modelling Study Figure 1 - Model Layout



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Model construction

The model construction is discussed below in two components:

- Upstream catchment inflows (1D)
- Model area digital terrain model domain (2D)

Hydrology of upstream catchments

Upstream catchment inflows are represented by 62 1-dimensional subcatchments feeding into the model area along its western boundary.

Catchment delineation

Upstream catchments have been delineated based on local topography, with consideration of catchments applied in previous modelling (SKM, 2007 and Worley, 2024).

Modelled subcatchments are presented in Figure 1 and Table 1 provides a summary of catchment characteristics applied in modelling. RAFTS runoff routing has been applied to upstream catchments.

Table 1: Summary of upstream rural catchment characteristics

Catchment ID	Total area (hectares)	Slope (m/m)
Krait	**520.6**	
KRT_01	60.92	0.093
KRT_02	8.99	0.065
KRT_03	13.30	0.041
KRT_04	25.98	0.041
KRT_05	27.81	0.036
KRT_06	17.69	0.065
KRT_07	12.78	0.103
KRT_08	15.66	0.040
KRT_09	18.05	0.061
KRT_10	37.18	0.046
KRT_11	23.00	0.039
KRT_12	19.54	0.071
KRT_13	103.95	0.050
KRT_14	16.08	0.026
KRT_15	55.88	0.038
KRT_16	63.80	0.040
Town	**42.8**	
TWN_01	42.80	0.061
Marina	**48.9**	
MAR_01	48.91	0.107

Catchment ID	Total area (hectares)	Slope (m/m)
Market	**1,839.4**	
MKT_01	101.45	0.073
MKT_02	41.33	0.047
MKT_03	106.24	0.061
MKT_04	100.91	0.055
MKT_05	146.60	0.074
MKT_06	327.26	0.063
MKT_07	312.45	0.060
MKT_08	209.40	0.051
MKT_09	276.57	0.050
MKT_10	139.32	0.043
MKT_11	77.90	0.041
Preston	**493.7**	
PRS_01	14.20	0.095
PRS_02	27.92	0.035
PRS_03	11.98	0.049
PRS_04	95.44	0.045
PRS_05	85.41	0.052
PRS_06	120.98	0.065
PRS_07	137.82	0.058

Catchment ID	Total area (hectares)	Slope (m/m)
LIA	**1,129.4**	
LIA_01	114.72	0.056
LIA_02	83.04	0.059
LIA_03	85.58	0.068
LIA_04	100.52	0.049
LIA_05	78.42	0.077
LIA_06	164.00	0.050
LIA_07	168.94	0.045
LIA_08	144.47	0.035
LIA_09	26.68	0.092
LIA_10	58.28	0.048
LIA_11	58.36	0.053
LIA_12	18.69	0.037
LIA_13	27.66	0.042

Catchment ID	Total area (hectares)	Slope (m/m)
Mowbowra	**1,064.2**	
MIB_01	41.22	0.059
MIB_02	195.50	0.067
MIB_03	103.26	0.090
MIB_04	269.44	0.066
MIB_05	174.92	0.055
MIB_06	279.83	0.055
Southern	**1,283.1**	
STH_01	94.59	0.033
STH_02	131.87	0.043
STH_03	100.14	0.067
STH_04	125.02	0.059
STH_05	153.83	0.048
STH_06	27.55	0.026
STH_07	650.07	0.045

Runoff parameterisation

Modelling undertaken for the *Exmouth Floodplain Management Study* (SKM, 2007) applied variable runoff coefficients (0.18 (10y ARI) - 0.6 (500y ARI)) with no initial losses.

Current advice, provided in ARR2019 recommends that the Initial Loss/Continuing Loss model is typically the most suitable for design flood estimation and provides spatially distributed recommendations for loss rates in rural catchments. However, for this site, there are no recommendations for design loss information because the prediction equations were developed using data from wetter catchments.

ARR2019 provides some limited guidance including that, for the Pilbara, Flavell and Belstead (1986) recommended IL values of approximately 40 to 50 mm and a CL of 5 mm/h. However, proposed initial and continuing losses proposed in the recent *Exmouth Desalination Plant Flood Study* (Worley, 2024) were validated by applying four rainfall events (March 1999, May 1999, June 2002, June 2021). The following parameters were determined, and have been adopted for this study:

- Initial loss – 20 mm
- Continuing loss – 4.5 mm/hr

Model area 2-dimensional model domain (predevelopment)

The model area 2-dimensional model domain is over 3,350 hectares and is shown in Figure 1.

Model topography

Model topography was developed from a combination of LiDAR digital terrain model (DTM) prepared in 2024 and provided by the Water Corporation, augmented with small areas of 0.5m resolution Aerial Laser Scanning Survey (ALS) data from the earlier *Exmouth Floodplain Management Study* (SKM, 2007). The modelled DTM is presented in Figure 1.

The DTM was used within the model to directly generate the variable mesh elements based on local slope. Heights at the vertices of the generated mesh elements were calculated by interpolation from the DTM.

The model domain is constructed as a Shewchuk Triangle variable mesh with maximum and minimum triangle areas of 5m and 100m respectively. The mesh varies according to the local terrain, resulting in a smaller mesh in steeper parts of the domain. Figure 1 presents the model domain and basic structure. A global eddy viscosity of 0.15 m2/s was applied throughout the model domain.

Rainfall and losses

Within the 2-dimensional model domain, rainfall is applied directly to mesh elements. Initial losses are accounted for through application of initial loss conditions and ongoing infiltration rates that vary by land use. It is noted that rainfall utilised at the beginning of simulations to fill small depressions prior to runoff generation also contributes to initial losses. Therefore, the initial loss conditions applied to the 2-dimensional domain have been moderated to avoid doubling-up on the effective initial loss.

Four infiltration rates were applied within the model in land use zones shown in Figure 2. These were:

- Roads and open water – 0mm initial loss, 0 mm/hr continuing loss
- Undeveloped areas and rural residential lots – 15mm initial loss, 4.3 mm/hr continuing loss
- Developed urban and industrial lots – 5mm initial loss, 4.3 mm/hr continuing loss

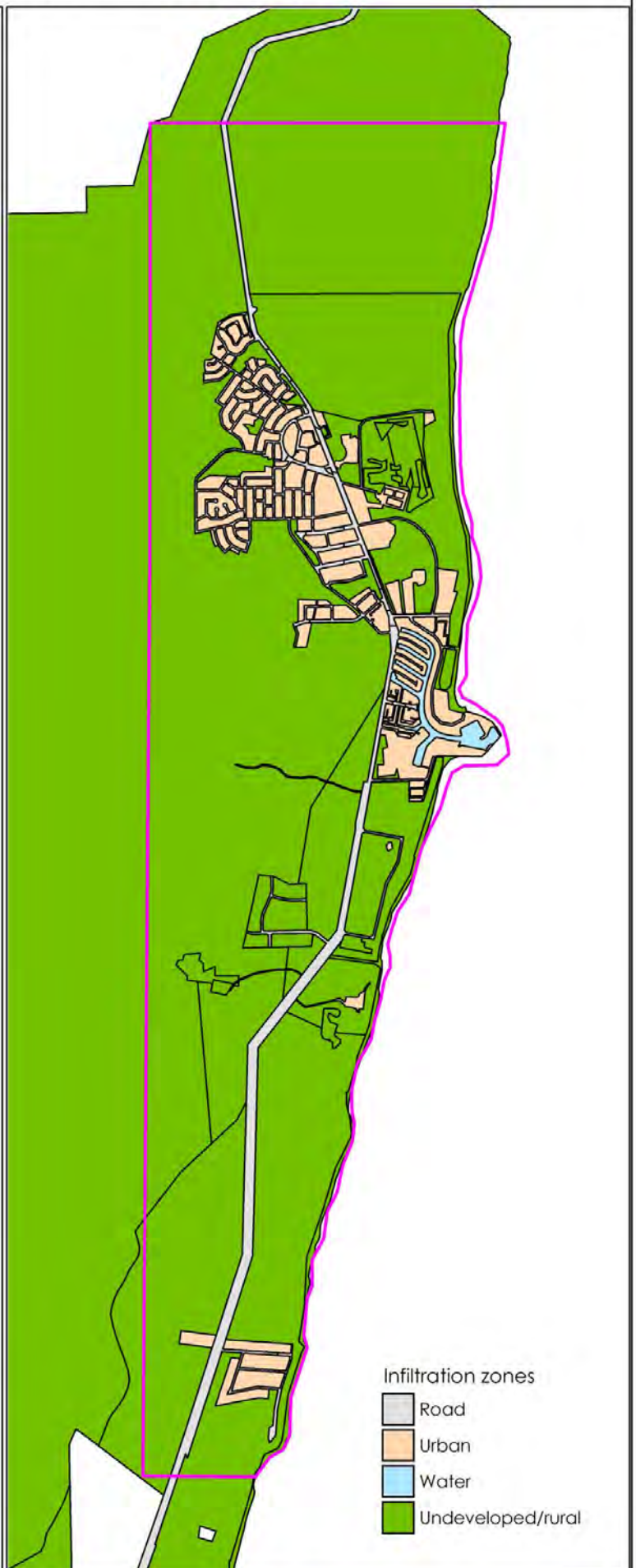
Surface Roughness

After losses have been accounted for, the flow of runoff across the model domain is controlled by slope and surface roughness. Roughness values were applied to the model domain based on an assessment of land use and vegetation cover shown in Figure 2 except for flow depths less than 0.1m where a universal roughness of 0.1 is applied. Seven different roughness rates (Manning's N) have been modelled, which are:

- Roads – 0.020
- Turfed recreation areas – 0.025
- Open water and bare sand – 0.030
- Rural residential areas – 0.035
- Urban and industrial areas (including extractive industries) – 0.040
- Vegetation on rocky slopes – 0.045
- Vegetation with understory – 0.055

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Modelling Study Figure 2 - Model roughness and infiltration zones





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Scenario modelling

Modelling presented in this report includes the following scenarios:

- Existing case (2024 climate) scenarios
- Climate change (2070 and 2120) scenarios

Base (2024 climate) scenarios

Base case scenarios based on the current climate include modelling of existing and proposed land uses. Results are presented as flood depth and hazard mapping across the whole model domain together with analysis of floodplain storage accommodated within proposed development areas.

Rainfall

Rainfall for design events were developed using *Australian Rainfall and Runoff* (ARR2019) and BoM (2016) IFD ensemble methodology resulting in an ensemble of 10 rainfall simulation events for each design storm. Ensembles were generated for 10%, and 1% AEP events of 1hr, 3hr, 6hr, and 12hr durations.

Rainfall factoring to allow for uplift to current climate (2024) has been undertaken as per the recent ARR2019 Book 1 update (September 2024) recommendations, discussed further below in relation to the selected climate change scenarios.

Critical duration events were selected based on a review of the ensemble mean peak discharges from upstream catchment inflows to reduce the number of simulations required to be run with the full 2-dimensional domain in place and these events have been used in subsequent model simulations.

From these initial simulations, the critical duration events by catchment were found to be 1 hour or 6 hours for the 10% AEP event and 1 hour or 3 hours for the 1 % AEP event as shown in Table 2.

Table 2: Catchment critical durations

Catchment ID	10% AEP	1% AEP
Krait	6 hours	1 hour
Town	1 hour	1 hour
Marina	1 hour	1 hour
Mowbowra	6 hours	3 hours
Market	6 hours	1 hour
LIA	6 hours	1 hour
Preston	6 hours	1 hour
Southern	6 hours	1 hour

2D model outflow Boundary Conditions

The 2-dimensional model outflow boundaries are set to 'normal' flow conditions, meaning that it is assumed that slope balances friction forces (normal flow). Depth and velocity are kept constant when water reaches the boundary, so water can flow out of the domain without losses.

Static water levels based on the *Statewide Coastal Inundation Assessment Phase 2 Report* (Seashore Engineering, 2024) have been applied along the eastern boundary of the model domain. Three inundation levels are considered in the report and applied in scenario modelling. These are:

- High Inundation (2.3m AHD): approximately corresponds to a 25-year ARI water level.
- Extreme Inundation (3.1m AHD): approximately corresponds to a 100-year ARI water level.
- Extreme +0.9m Inundation (4m AHD): approximately corresponds to a 100-year ARI water level plus 100-year sea level rise allowance

Research in Australia and internationally has shown that extreme rainfall and storm surge processes are statistically dependent, and therefore their interaction needs to be taken into account for areas affected by both processes (ARR2019).

As recommended by ARR2019, pre-screening analysis has been undertaken using the base (existing) scenario, to determine the areas where various levels of interdependence apply.

For this study, two pre-screening scenarios have been selected for the 1% AEP rainfall AEP event, as shown in Table 4, and water levels have been compared to extreme inundation levels generated by coastal inundation with no rainfall from the *Statewide Coastal Inundation Assessment Phase 2 Report* (Seashore Engineering, 2024).

Table 3: Joint probability pre-screening assessment scenarios

	No rainfall	1% AEP
Highest astronomical tide (1.47m AHD)		✓
Extreme Inundation (3.1m AHD)	✓	✓

The results of this analysis are presented in Figure 4 demonstrating that most of the proposed development sites are located in areas dominated by fluvial processes where ARR2019 recommends that complete interdependence should be assumed.

Three of the potential development sites contain areas of joint dependence. In this study, complete interdependence has also been assumed in these areas, as a worst-case assessment for planning purposes. However, in future when more detailed planning is undertaken for these sites, it is recommended that a more detailed joint probability assessment is carried out.

Based on this analysis the extreme inundation level has been applied as the outflow boundary condition for all current climate 1% AEP event simulations and the highest astronomical tide has been applied for all current climate 10% AEP event simulations.

Sensitivity testing

Sensitivity testing has been conducted by adjusting hydraulic roughness parameters for the base (existing) scenario model in the 1 hour 1% AEP event. The sensitivity test was undertaken using a 25% increase and decrease in roughness and the resulting changes are presented in Table 3 and Figure 4.

As observed, the changes to peak inundation depths are less than 0.2m with less than 5% of inundated areas having afflux greater than 0.01m. Therefore, any uncertainties regarding seasonal or interannual variance in hydraulic roughness are likely able to be managed by a standard design freeboard.

Table 4: Sensitivity testing results

	Roughness + 25%	Roughness – 25%
Maximum inundation depth changes	- 0.144 to + 0.109 m	- 0.161 to + 0.123

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Modelling Study Figure 3 - Joint probability - pre-screening analysis



LEGEND:

- Model Boundary (2D)
- Potential development sites
- Joint dependence zone
- Complete independence zone (Coastal dominance)
- Complete independence zone (Fluvial dominance)

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Modelling Study Figure 4 - Model sensitivity analysis

Sensitivity test 1: Roughness + 25%



Afflux ranges (m)
(model cell count)

0.1	to	1	(3)
0.01	to	0.1	(7,682)
0	to	0.01	(147,689)
-0.01	to	0	(56,074)
-0.1	to	-0.01	(2,703)
-1	to	-0.1	(10)

Sensitivity test 2: Roughness - 25%



Afflux ranges (m)
(model cell count)

0.1	to	1	(8)
0.01	to	0.1	(2,863)
0	to	0.01	(53,199)
-0.01	to	0	(147,561)
-0.1	to	-0.01	(10,511)
-1	to	-0.1	(19)

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Model results – base scenarios

Results from the current climate base scenario are presented in Figure 5 (10% AEP) and Figure 6 (1% AEP). Results include a presentation of flood hazard for each scenario based on flood hazard regimes for people as outlined in Table 5 which is taken from ARR2019.

Table 5: Flood hazard regimes for people (ARR2019)

<table>
<tr><th>Depth x velocity</th><th>Children</th><th>Adults</th></tr>
<tr><td>0</td><td>Safe</td><td>Safe</td></tr>
<tr><td>0-0.4</td><td>Low hazard if depth<0.5m and velocity <3m/s otherwise Extreme Hazard</td><td rowspan="2">Low hazard if depth<1.2m and velocity <3m/s otherwise Extreme Hazard</td></tr>
<tr><td>0.4-0.6</td><td>Significant hazard; dangerous to most if depth<0.5m and velocity <3m/s otherwise Extreme Hazard</td></tr>
<tr><td>0.6-0.8</td><td rowspan="3">Extreme Hazard; dangerous to all</td><td>Moderate hazard; dangerous to some if depth<1.2m and velocity <3m/s otherwise Extreme Hazard</td></tr>
<tr><td>0.8-1.2</td><td>Significant hazard; dangerous to most if depth<1.2m and velocity <3m/s otherwise Extreme Hazard</td></tr>
<tr><td>>1.2</td><td>Extreme Hazard; dangerous to all</td></tr>
</table>

Climate change and development scenarios

The 2022 update to ARR2019 provides guidance for addressing climate change impacts in design flood estimation. The following three major topics are included and discussed further below:

- Rainfall Intensity-Frequency-Duration adjustment
- Loss parameter adjustment
- Sea Levels and Sea Level Interaction

Rainfall Intensity-Frequency-Duration adjustment

ARR2019 recommends factoring of rainfall IFD information to account for predicted future rainfall change aligned to temperature projections from selected Shared Socioeconomic Pathways (SSPs) using the following equation:

$$I_p = I \times (1 + \alpha/100)^{\Delta T}$$

Where:

- I_p = projected (current or future) design rainfall depth or intensity
- α = rate of change
- I = historical design rainfall depth or intensity
- ΔT is the most up-to-date estimate of global (land and ocean) temperature projection for the design period of interest and selected climate scenario relative to a baseline time period.

For this study, two climate change scenarios have been selected as follows:

- Medium term (2070) – SSP2-4.5: Selected as the principal 'design scenario'
- Long term (2120) – SSP3-7.0: Selected as a 'stress-test' scenario

The rainfall factors applied in scenario modelling are presented in Table 5

Table 6: Applied rainfall factors

Event duration	Rate of change (%/°C)	Base scenarios 2024 (SSP2-4.5)	Design scenario 2070 (SSP2-4.5)	Stress test scenario 2120 (SSP3-7.0)
Temperature increase projection:		***1.2***	***2.1***	***3.6***
1 hour	15	1.18	1.33	1.66
3 hour	11.8	1.14	1.26	1.50
6 hour	10.2	1.12	1.22	1.42
12 hour	9	1.11	1.19	1.37

Loss parameter adjustment

In addition to rainfall factoring, ARR2019 also recommends factoring of empirical loss estimates to represent expected drier mean antecedent future climatic conditions. It is noted that loss parameters determined for the *Exmouth Desalination Plant Flood Study* (Worley, 2024) included validation for a recent event in 2021. Therefore, current day (2024) loss estimates have not been factored, with factoring only applied to the 2070 and 2120 future climate estimates.

Based on the recommendations in ARR2019 for the Rangelands West cluster and projected temperature increases for the SSP2-4.5 and SS3-7.0 pathways, the loss values presented in Table 6 have been applied in this study.

Table 7: Applied Loss factors and resulting losses

Event duration	Rate of change (%/°C)	Base scenarios 2024 (SSP2-4.5)	Design scenario 2070 (SSP2-4.5)	Stress test scenario 2120 (SSP3-7.0)
Applied loss factors				
Initial loss	4.5	1.05	1.10	1.17
Continuing loss	5.6	1.07	1.12	1.22
Applied losses				
Initial loss (mm)		20	21.9	23.5
Continuing loss (mm/hr)		4.3	4.8	5.2

Sea Levels and Sea Level Interaction

As discussed previously, pre-screening analysis has determined that a small number of potential development sites contain areas of joint dependence. However, for this study, complete interdependence has been assumed throughout, as a worst-case assessment for planning purposes. In future, when more detailed planning is undertaken for these sites, it is recommended that a more detailed joint probability assessment is carried out.

For climate change scenarios, the extreme inundation level plus allowances for sea level rise has been applied as the downstream boundary condition in 1% AEP events. The highest astronomical tide has been applied in the 10% AEP event scenarios, also plus allowances for sea level rise.

Sea level rise allowances of 0.4m and 0.9m have been applied respectively to medium-term design scenarios and long-term stress test scenarios.

Model results – climate change scenarios (existing land uses)

Climate change design scenario results with existing land uses and the existing digital terrain model are presented in Figure 7 and Figure 8.

Climate change "stress test" scenario results with existing land uses and the existing digital terrain model are presented in Figure 9 and Figure 10.

Proposed development

For development scenario modelling, a revised digital terrain model (shown in Figure 11) was adopted with all proposed development sites filled to prevent flooding in the 1 % AEP event.

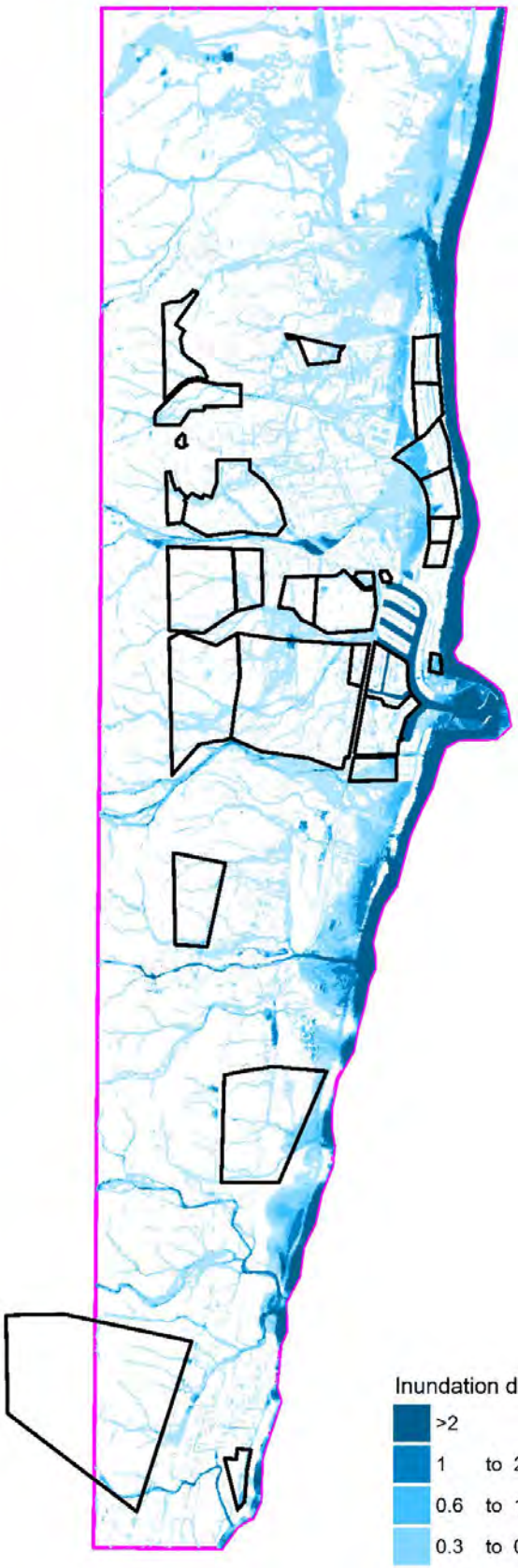
Climate change design scenario results with proposed development and the revised digital terrain model are presented in Figure 12 and Figure 13 and an assessment of afflux in areas surrounding the proposed development areas caused by filling of the land is presented in Figure 14.

Climate change "stress test" scenario results with proposed development and the revised digital terrain model are presented in Figure 15 and Figure 16.

Model performance validation

Worley (2024) conducted limited validation of proposed modelling parameters based on available flood level and debris mark observations from four rainfall events (March 1999, May 1999, June 2002, June 2021). To provide validation of the modelling presented in this report, the current climate 1% AEP flood extent and depths at locations of observed records are compared to those presented in Worley (2024) in Figure 17 to Figure 19.

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Modelling Study Figure 5 - Model results: Base scenario (existing), 10% AEP



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



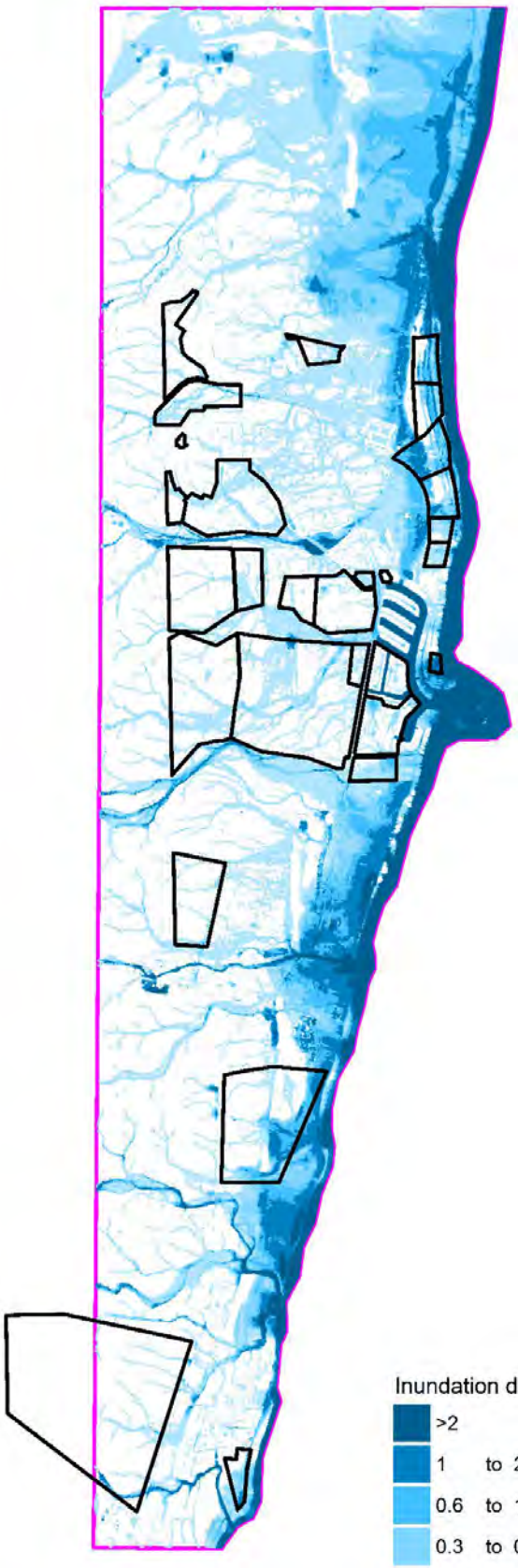
Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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Created by: HB Projection: MGA: zone 50.

0 1,200
meters
Scale 1:60,000 @ A4

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Modelling Study Figure 6 - Model results: Base scenario (existing), 1% AEP



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



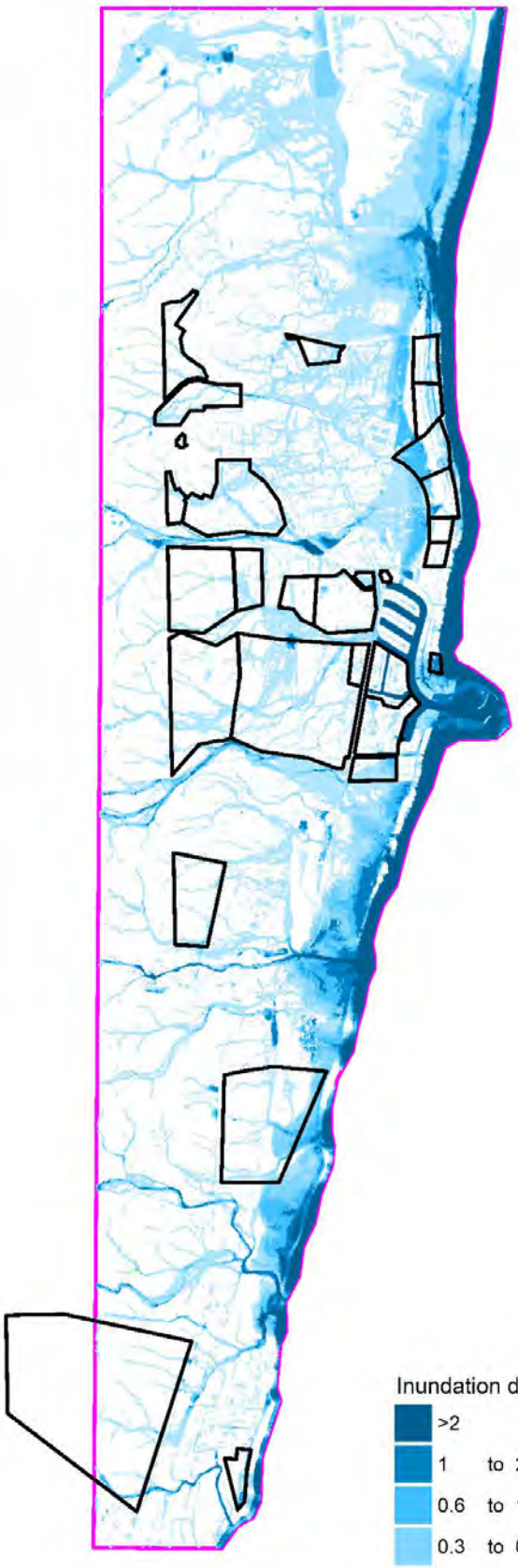
Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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0 1,200
meters
Scale 1:60,000 @ A4

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Modelling Study Figure 7 - Model results: Design climate (existing land use), 10% AEP



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



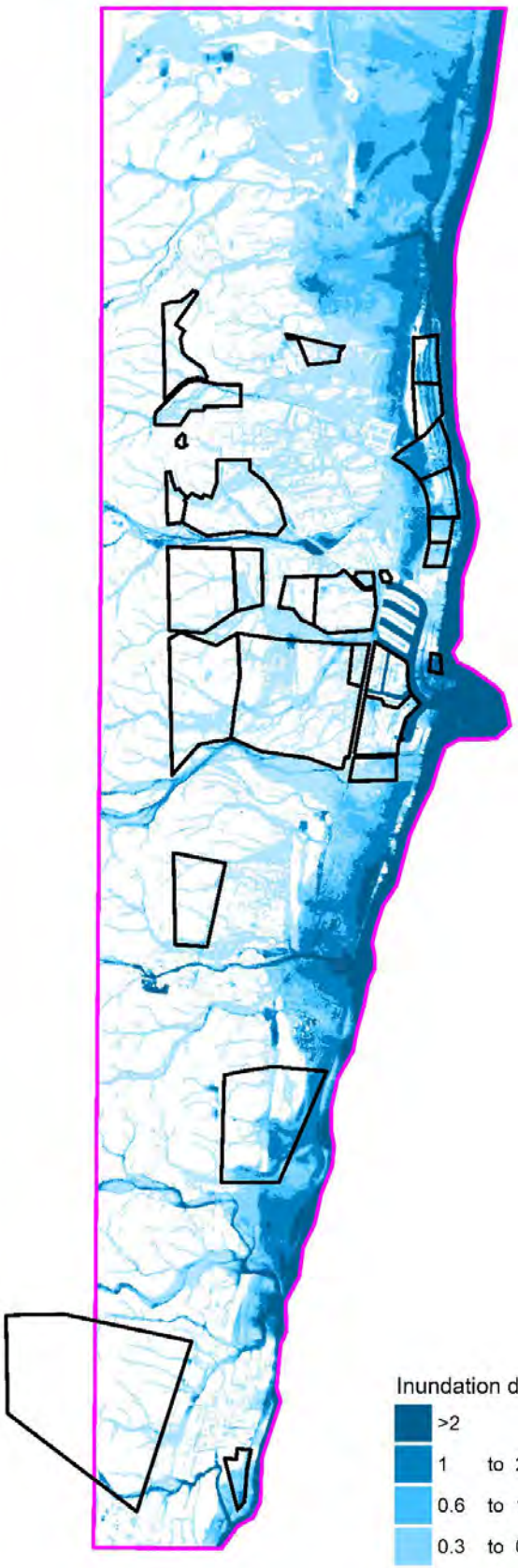
Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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0 1,200
meters
Scale 1:60,000 @ A4

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Modelling Study Figure 8 - Model results: Design climate (existing land use), 1% AEP



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



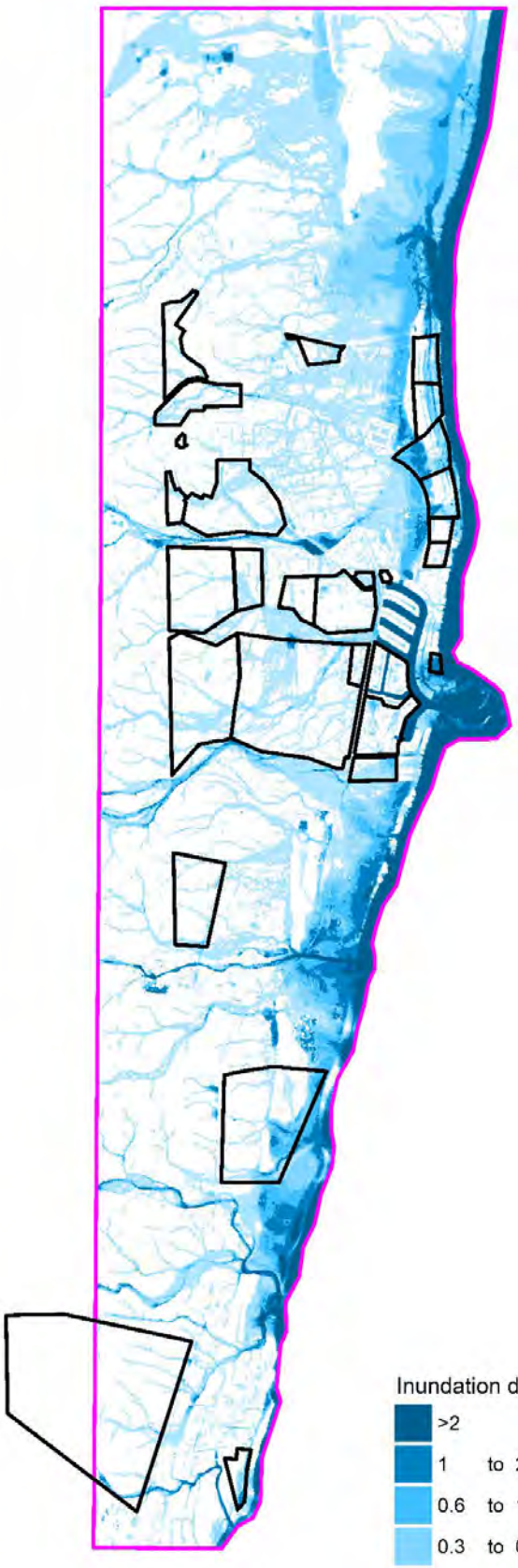
Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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0 1,200
meters
Scale 1:60,000 @ A4

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Modelling Study Figure 9 - Model results: Stress test (existing land use), 10% AEP



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



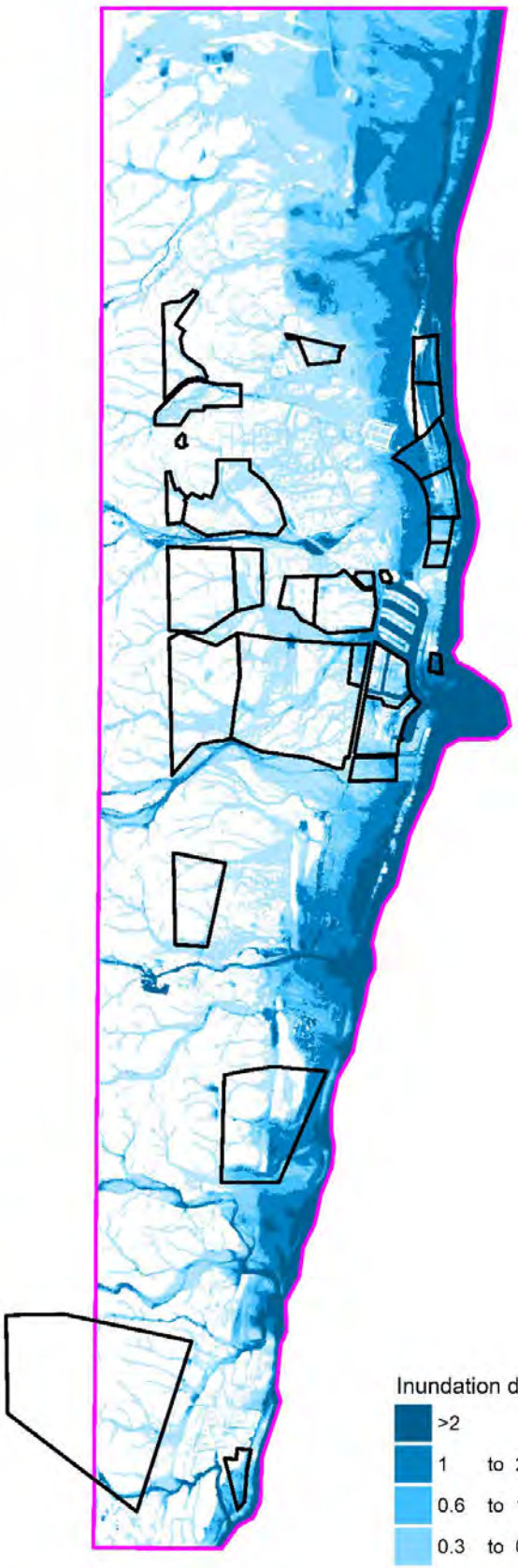
Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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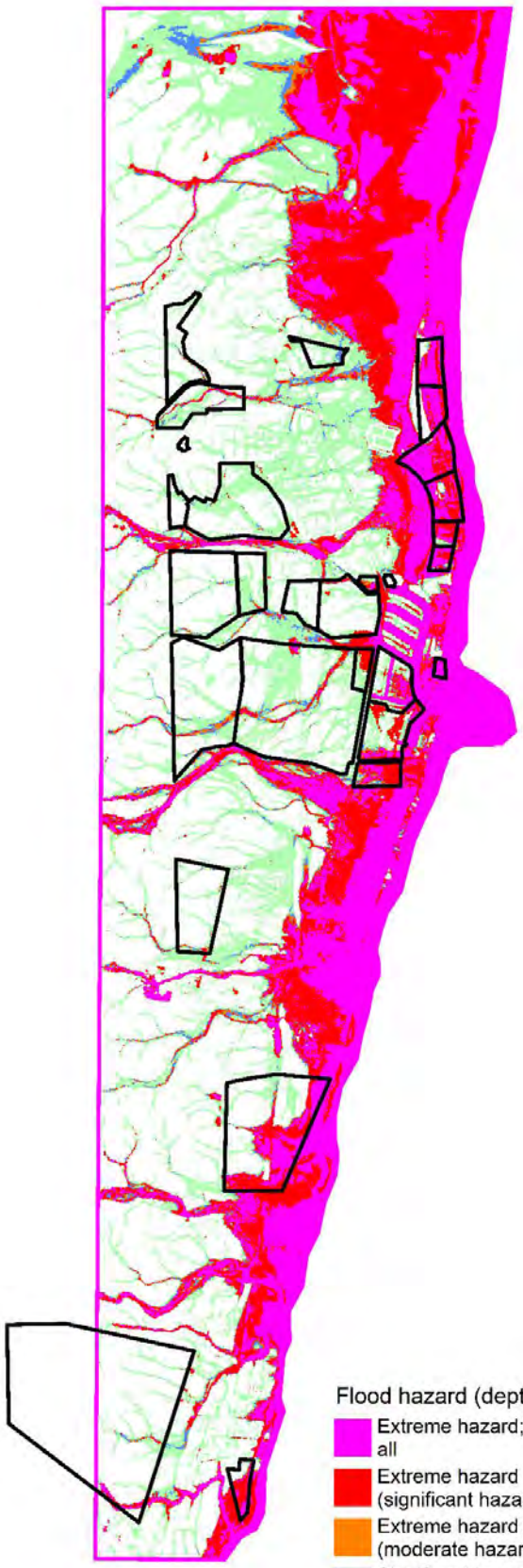
0 1,200
meters
Scale 1:60,000 @ A4

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Modelling Study Figure 10 - Model results: Stress test (existing land use), 1% AEP



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



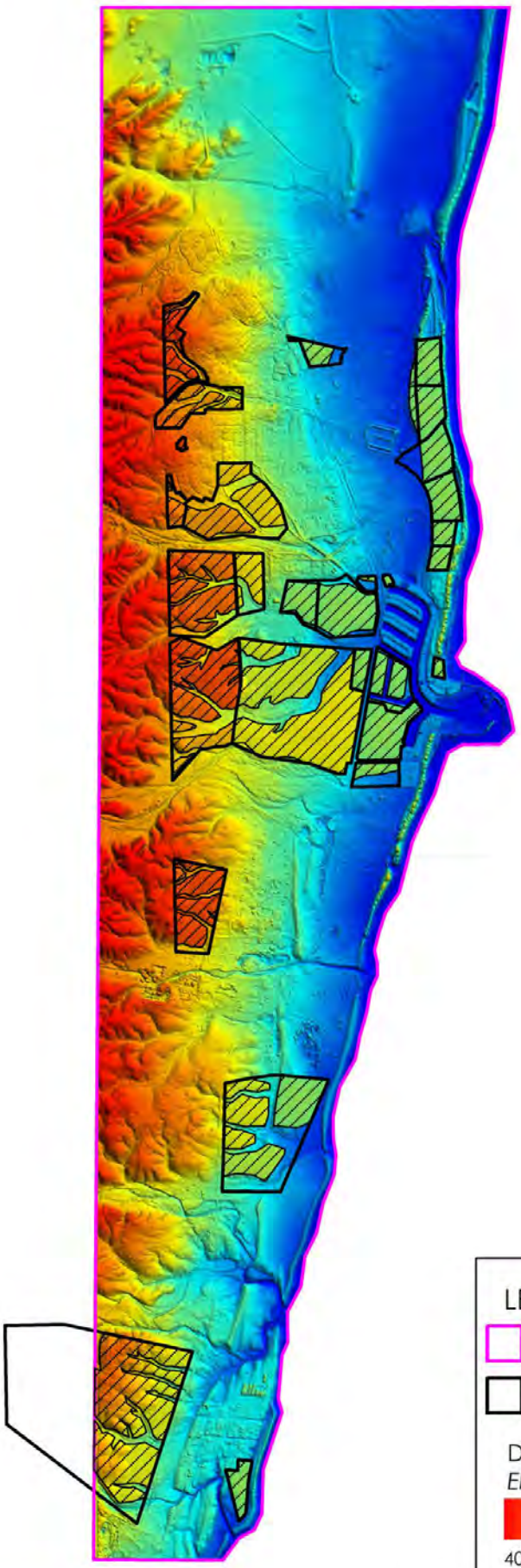
Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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0 1,200
meters
Scale 1:60,000 @ A4

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Modelling Study Figure 11 - Post-development digital terrain model



LEGEND:

- Model Boundary (2D)
- Potential development sites
- Extent of modelled fill

Digital elevation model (2D)
Elevation (m AHD)

40m — 0m

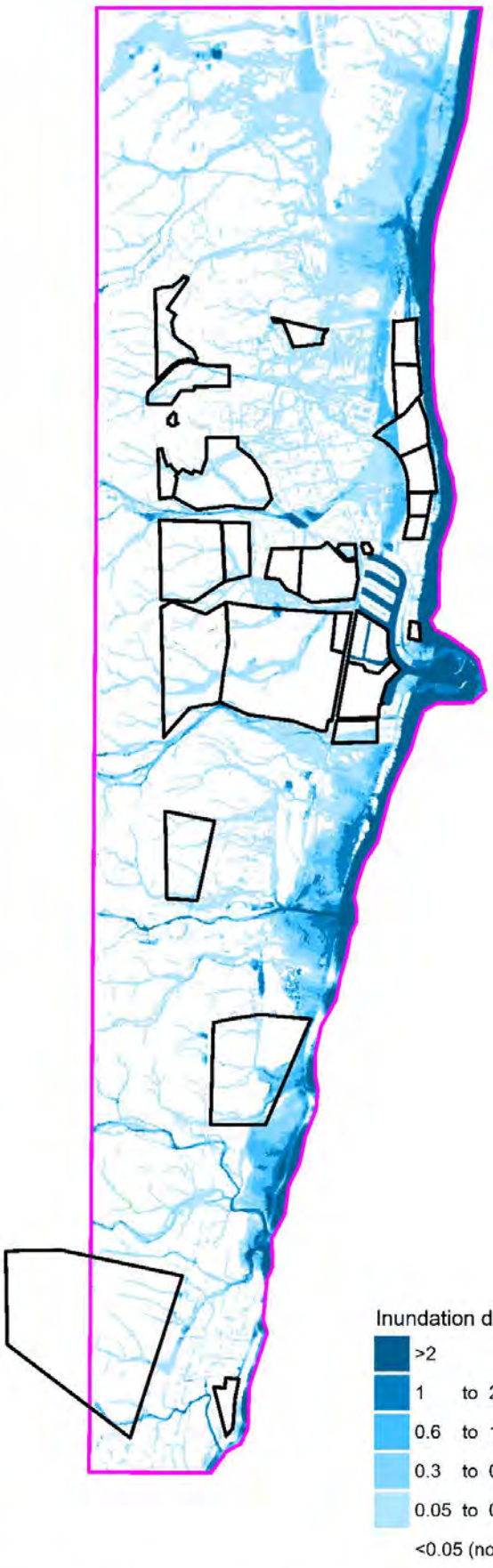
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0 1,000
metres

Scale 1:55,000 @ A4

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Modelling Study Figure 12 - Model results: Design scenario (future land use), 10% AEP





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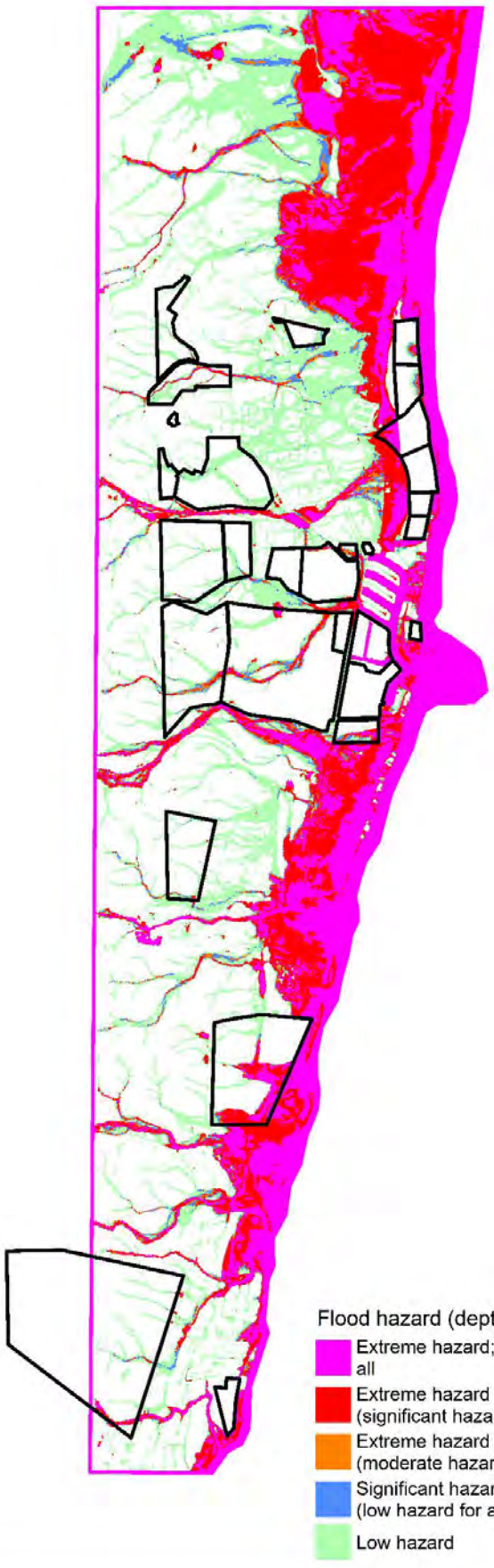
0 1,200
meters
Scale 1:60,000 @ A4

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Modelling Study Figure 13 - Model results: Design scenario (future land use), 1% AEP



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- <0.05 (not shown)



Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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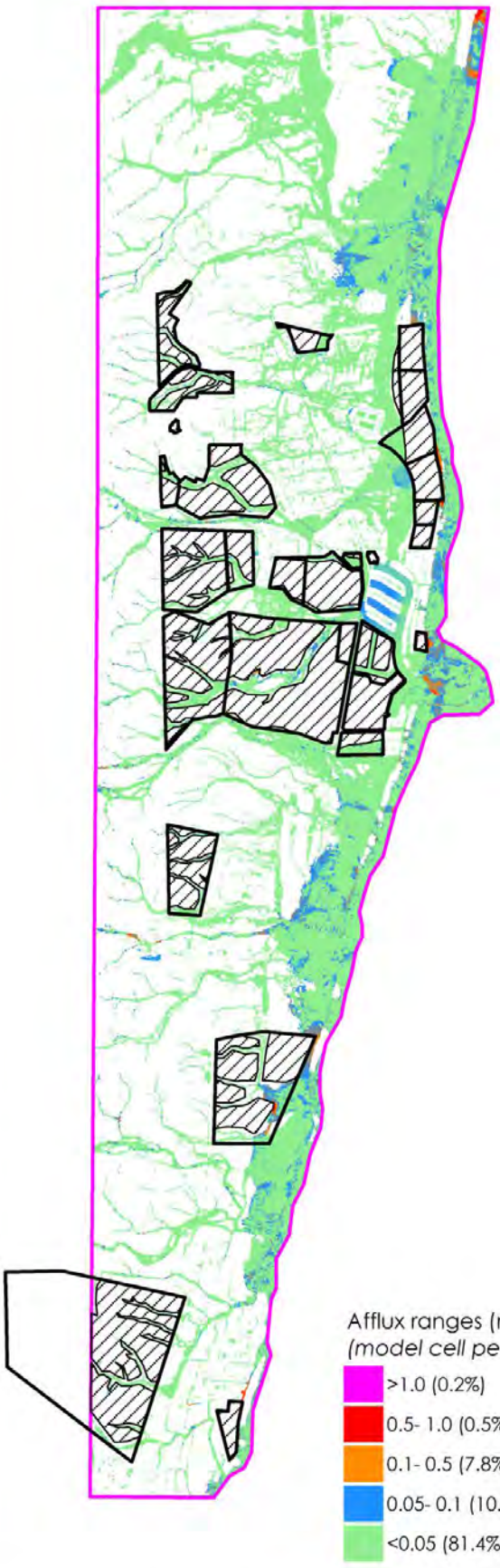
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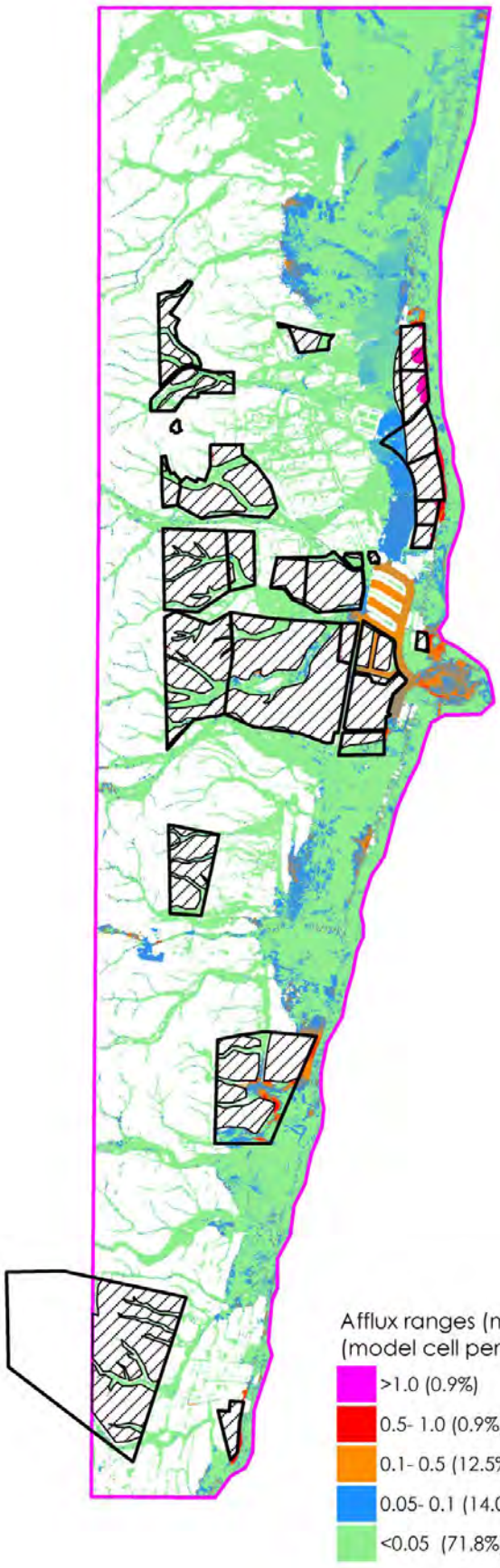
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Modelling Study Figure 14 - Model results: Design scenario afflux



Afflux ranges (m)
(model cell percentage)

- >1.0 (0.2%)
- 0.5- 1.0 (0.5%)
- 0.1- 0.5 (7.8%)
- 0.05- 0.1 (10.1%)
- <0.05 (81.4%)



Afflux ranges (m)
(model cell percentage)

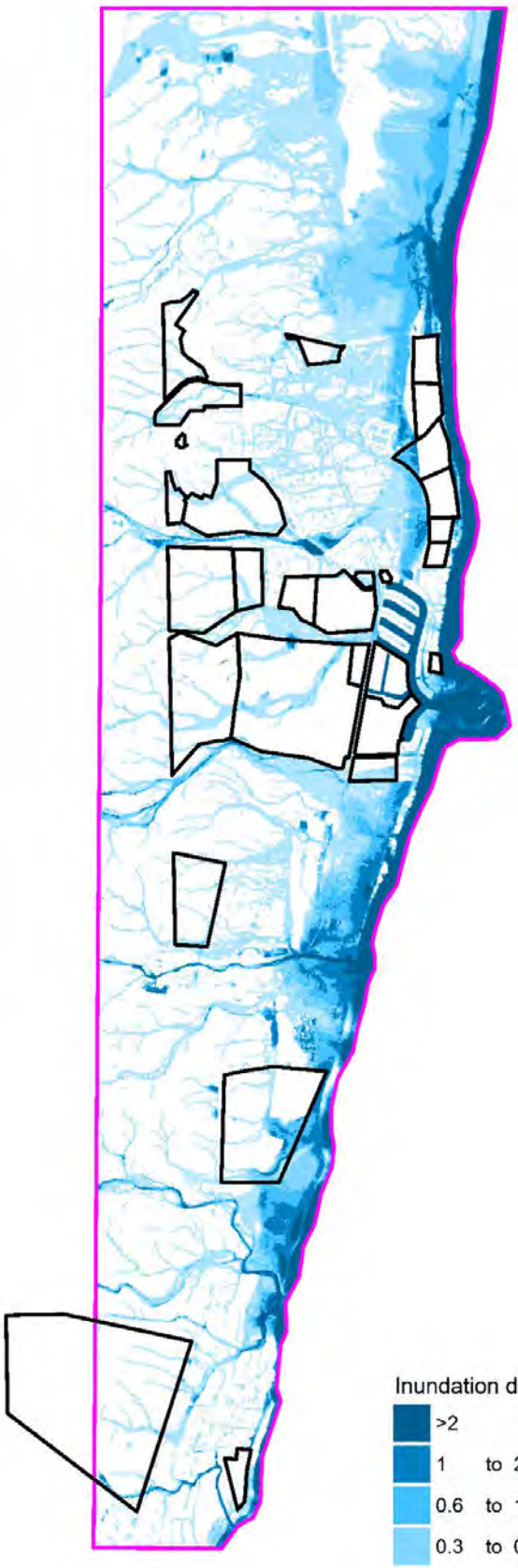
- >1.0 (0.9%)
- 0.5- 1.0 (0.9%)
- 0.1- 0.5 (12.5%)
- 0.05- 0.1 (14.0%)
- <0.05 (71.8%)

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Created by: HB Projection: MGA: zone 50.

0 1,200
metres
Scale 1:60,000 @ A4

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Modelling Study Figure 15 - Model results: Stress test (future land use), 10% AEP



Inundation depth (m)
- >2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- < 0.05 (not shown)



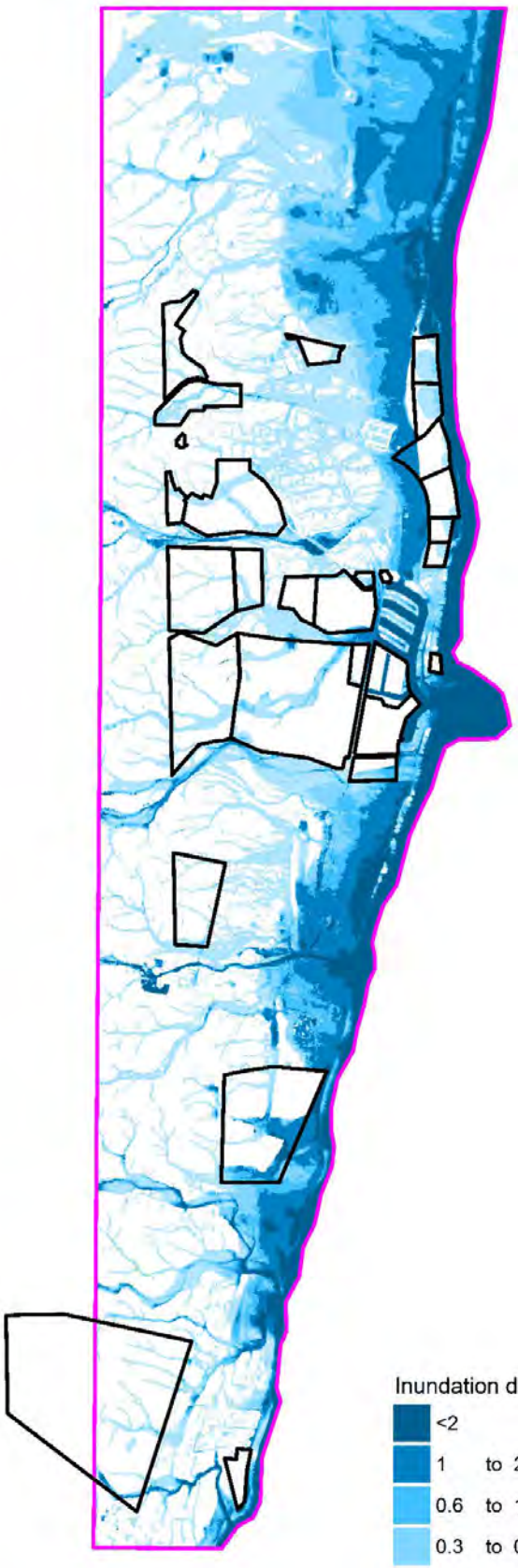
Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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0 1,200
meters
Scale 1:60,000 @ A4

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Modelling Study Figure 16 - Model results: Stress test (future land use), 1% AEP



Inundation depth (m)
- <2
- 1 to 2
- 0.6 to 1
- 0.3 to 0.6
- 0.05 to 0.3
- < 0.05 (not shown)



Flood hazard (depth x velocity)
- Extreme hazard; dangerous to all
- Extreme hazard for children (significant hazard for adults)
- Extreme hazard for children (moderate hazard for adults)
- Significant hazard for children (low hazard for adults)
- Low hazard

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Created by: HB Projection: MGA: zone 50.

0 1,200
meters
Scale 1:60,000 @ A4

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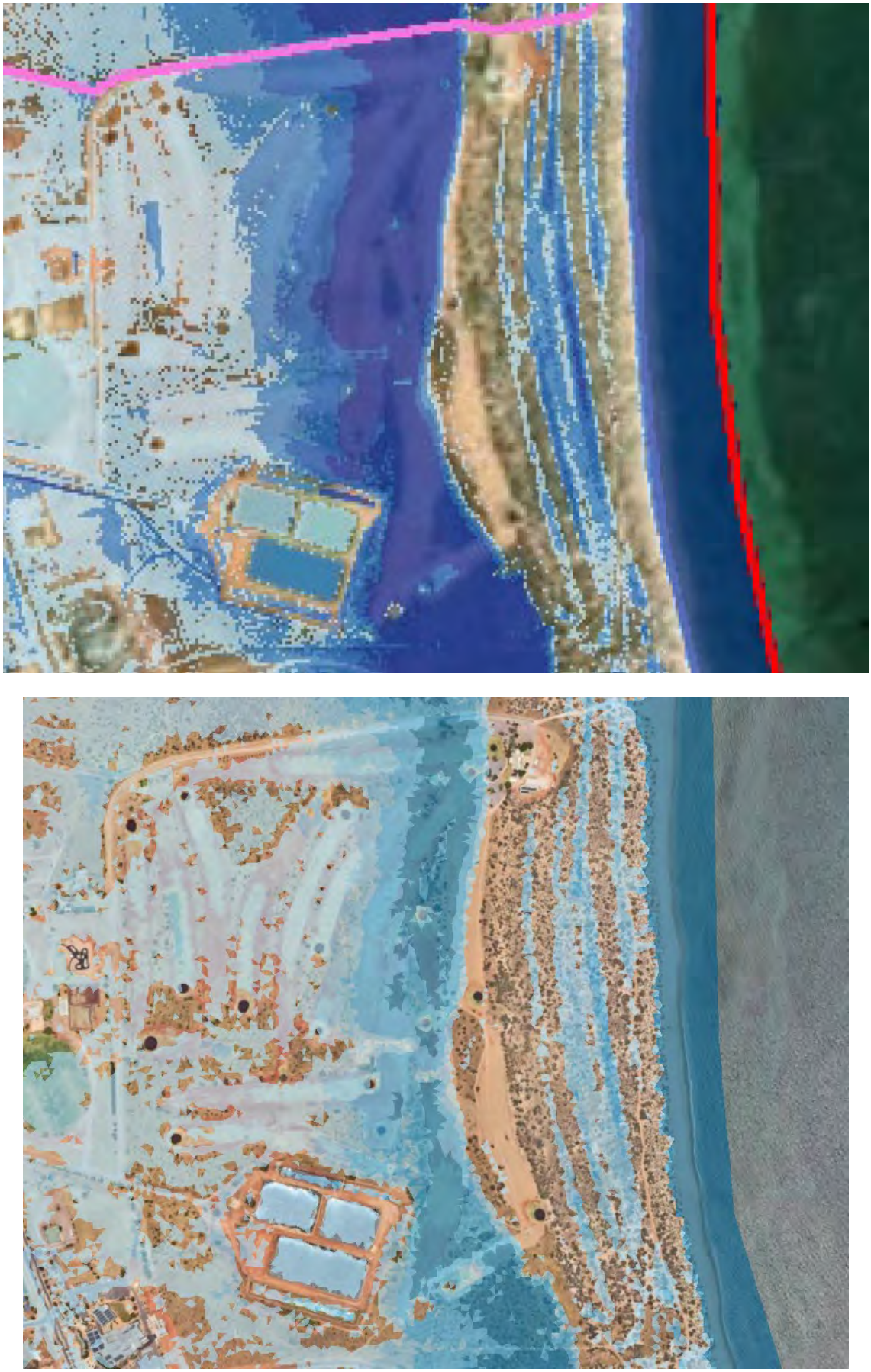


Figure 17: 1% AEP flood model comparison between Worley (2024) (top) and this study (bottom) – site 1



Figure 18: 1% AEP flood model comparison between Worley (2024) (top) and this study (bottom) – site 2



Figure 19: 1% AEP flood model comparison between Worley (2024) (top) and this study (bottom) – site 3

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DWER Feedback and responses

The following feedback was received from Simon Rodgers of DWER following his review of a preliminary version of this Appendix. Various modifications and corrections have been made in response to this feedback, as indicated in the teal text below.

I have reviewed the provided draft Appendix dealing with the Hydrologic modelling for the Exmouth Regional Water Management Strategy and consider the modelling approach outlined is adequate for assessing flood risk to support this level of planning. However, the following comments are provided to improve the usefulness and confidence in model outputs that will support future planning:

- the adopted loss rates are based on a study by Worley (2024) that calibrated these values to observations. However, no information is provided on comparing flow rates (and levels) to demonstrate these rates, as applied to the Urbaqua model, produce similar results in your modelling. While acknowledging the outdated design rainfall estimates it would also be useful to understand how the results compare to the work by SKM (2007).

- Additional information providing a comparison of the predicted flooding to that presented in Worley (2024) and SKM (2007) has been added to the report. However, it has not been possible to provide a direct comparison of catchment flows because this information has not been made available from the Worley modelling at this time.

- In addition, there is some minor differences in the quoted rates for continuing loss. The text on page 4 quotes 4.5 mm/hour from the Worley (2024) study as the adopted rates for this study. However, on page 5 and elsewhere in the report 4.3 mm/hour is quoted.

- Noted, this was an error and has been corrected.

- Was some minor rainfall applied to the model to fill the small depressions in the bathymetry prior to applying the design rainfall? or is this an additional "initial" loss in the 2D model as compared to the application in the 1D model ?

- Initial losses applied within the 2D domain have been reduced to account for additional losses due to filling of small depressions. Validation of the modelled extent of 1% AEP flooding compared to Worley (2024) suggest that the reduced rates applied were reasonable. Application of minor rainfall as a 'hotstart' simulation would result in a similar effect.

- The discussion on outflow boundaries talks about both "normal" flow conditions and static water levels relating to water level in Exmouth Gulf. Is this because the "normal" flow conditions was applied to the downstream boundary of the 1-d model and water level used in the 2 D model?

- The reference to "normal" flow conditions is in relation to the 2-dimensional outflow boundary only. The 1-dimensional and 2-dimensional elements of the model are fully integrated such that the 1-dimensional catchments discharge inside the 2-dimensional domain from 2-dimensional outfall nodes and are not controlled by the 2-dimensional boundary.

- Is the existing Market Street bund (see image below) along the southern boundary of the proposed development area located west of the marina diverting flood flows and providing flood protection to the area north-west? The geotechnical status of this bund is unknown and it is recommended that the sensitivity of flooding to a possible failure of this bund is considered. The safe passage of floodwaters through this area in the event of a failure of the bund (and/or event larger than the bunds design flow) should be considered in future

planning. The Water Corp in collaboration with DWER have released a guidance note for proposed development adjacent to structures of this nature (see spoil bank guidance)

- No analysis of bund failure has been undertaken for this study. Advice in relation to a need for bund failure analysis associated with development of the adjacent development area has been included in the main DWMS report. It is noted that Worley (2024) included some analysis of bund failure but the findings of this analysis have not been made available at this time.

- The evacuation potential and isolation risk should be considered in future planning. For example, the land on dunes north of the marina (east of existing townsite area) will become isolated during major events with floodwaters described as extreme hazard for both relatively frequent (1 in 10 AEP, Figure 9) and larger events (1 in 10 AEP, Fig 10) separating the areas from the remainder of town. It is recommended that information is provided on the period-of-time that land (potential development sites) may be isolated from critical services, including consideration of longer event durations that may result in smaller peak flows but longer isolation risks (particularly for the flood storage areas behind the eastern dunes).

- Advice in relation to a need for consideration of evacuation and emergency management procedures has been included in the main DWMS report. Because the duration of isolation for the most sensitive sites, being those closest to the coast, is likely to be significantly affected by coastal processes, a full analysis of these impacts has not been undertaken at this time. A recommendation for the consideration of isolation durations in future planning has been included.



For further information please contact me on 6364 6923

Regards

Simon Rodgers
Supervising Engineer, Flood Risk Science

Department of Water and Environmental Regulation
Prime House, 8 Davidson Terrace, JOONDALUP WA 6027
Locked Bag 10, Joondalup DC, WA 6919
T: (08) 6364 6923 M: 0429 080 517
E: simon.rodgers@dwer.wa.gov.au |

Client: Shire of Exmouth

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Urbaqua
land & water solutions
Suite 4/226 Carr Place
p: 08 9328 4663 | f: 08 6316 1431
e: info@urbaqua.org.au
www.urbaqua.org.au