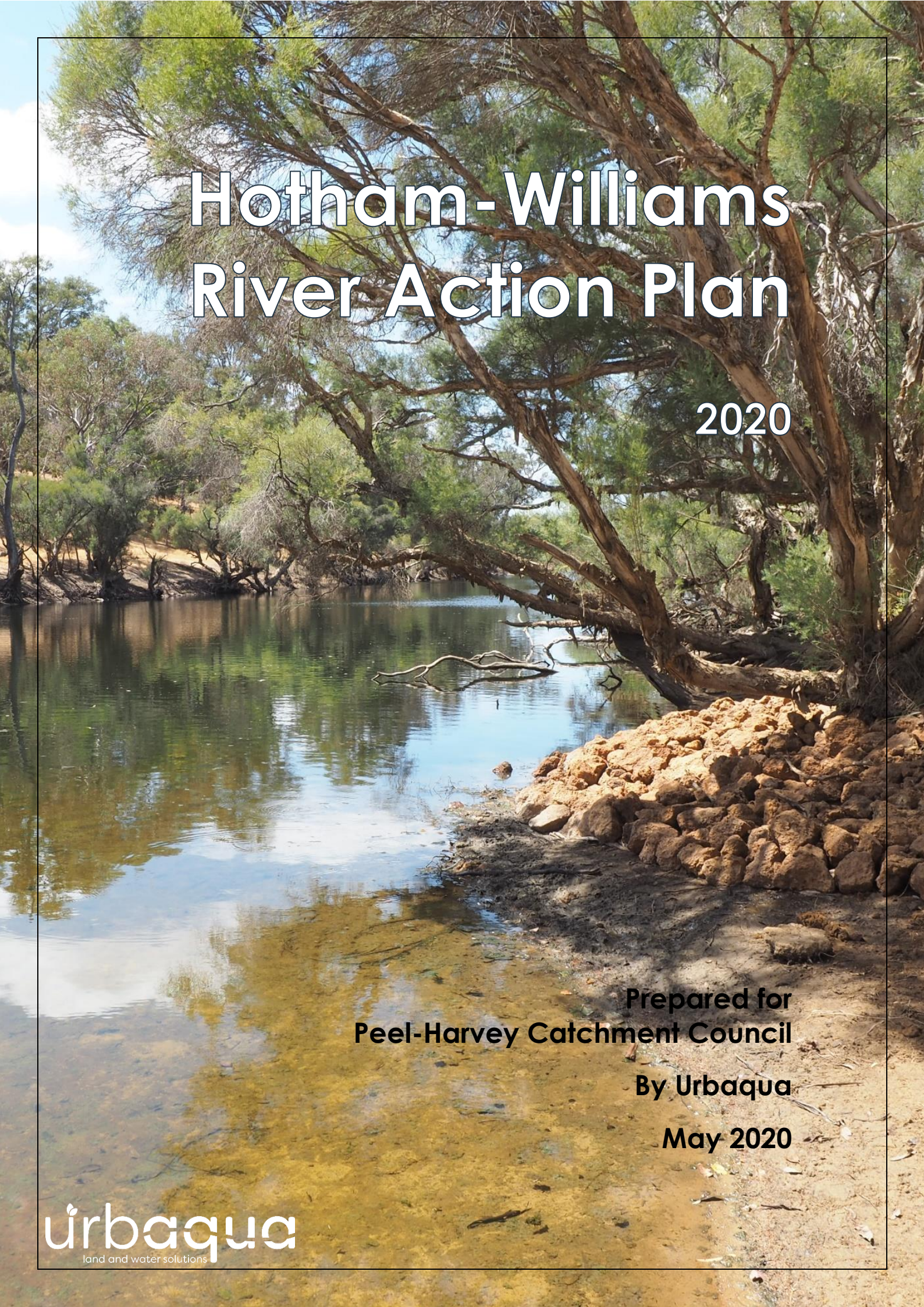

Hotham-Williams River Action Plan

2020

Prepared for
Peel-Harvey Catchment Council

By Urbaqua

May 2020

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1. Peel-Harvey Catchment Council;
2. Newmont Boddington (for funding, use of aerial imagery and in-kind support);
3. Department of Water and Environmental Regulation;
4. Shire of Cuballing (for funding towards the Yornaning Dam field assessment); and
5. South32 Worsley Alumina (for use of aerial imagery)

EXECUTIVE SUMMARY

The Hotham and Williams Rivers are the two major rivers which feed into the Murray River, one of the three main rivers feeding the Peel-Harvey Estuary. As with most rivers in the south west of Western Australia, the Hotham-Williams catchment has been subject to significant disturbances since European settlement from agriculture, mining and urban development. Along with these past and current pressures, the Hotham-Williams Catchment also faces threats from the impacts of projected declines in rainfall.

The Hotham-Williams River Action Plan (RAP) has been prepared to provide a basis for rehabilitation works and a summary of baseline conditions to monitor the effects of future on-ground works. The document was prepared in partnership between the Peel-Harvey Catchment Council (PHCC) and Urbaqua, with funding provided by Newmont Boddington. The RAP is a key component of the PHCC and Newmont Community Partnership Agreement entitled *Hotham-Williams Rivers and Tributaries' Natural Resource Management and Conservation Project*. Additional funding has been provided by the Shire of Cuballing for the Yornaning Dam reach assessment.

A significant part of the RAP has been to investigate eight (8) reaches on the Hotham and Williams Rivers, all of which have significant environmental values and were identified by the PHCC through a process of prioritisation. The identified reaches are:

- Yornaning Dam, creeklines of the Hotham River (Shire of Cuballing);
- Popanyinning townsite, Hotham River (Shire of Cuballing);
- Hotham River Nature Reserve, Hotham River (Shire of Cuballing);
- Pumphreys Bridge, Hotham River (Shire of Pingelly, Shire of Cuballing & Shire of Wandering);
- Ranford (Darminning) Pool, Hotham River (Shire of Boddington);
- Williams townsite, Williams River (Shire of Williams);
- Boraning Reserve, Williams River (Shire of Williams); and
- Quindanning, Williams River (Shire of Williams & Shire of Boddington).

The RAP was prepared based on assessments of the waterways at a number of scales. Detailed field inspections were carried out for the above reaches, and the catchment as a whole was assessed using desktop analysis of aerial imagery, and consideration of previous investigations. Each field reach was assessed in accordance with the Department of Water and Environmental Regulation's *River Restoration Manual* (WRC, 1999), specifically the Pen-Scott method that grades foreshore between grades A (pristine) and D (degraded). Scoring of the foreshore condition allowed for determination of priority areas for rehabilitation.

The majority of the Rivers demonstrated the impacts of land use pressures, including historical clearing for agriculture and residential development. Based on the Pen-Scott scoring, the condition of channels varied from degraded and weed infested to eroded, with the majority of reaches assessed as erosion-prone with the soil exposed. Reaches included in the field investigation demonstrated degraded vegetation, particularly the loss of understorey and extensive exotic ground cover. The majority of reaches had an almost continuous tree cover near the river, but otherwise limited fringing vegetation owing to adjacent crops, agriculture and residential areas.

Throughout the catchment, cleared vegetation has led to accelerated erosion and sedimentation in the rivers and tributaries. Areas of sedimentation within the river were noted at the Hotham River Nature Reserve, upstream of Ranford Pool, Pumphreys Bridge, Williams, and

Boraning Reserve. Erosion and channel instability have also been exacerbated by stock access and the community utilising the river for recreation, particularly at Pumphreys Bridge. Recent work to stabilise the banks and control community access at Ranford Pool offers a template for addressing these issues elsewhere in the catchment.

Another common theme from the field assessments was evidence of poor water quality, either through algae in stagnant water or oil flecks and sheens. The water quality is indicative of the wider catchment management practices that require attention.

Common themes for management of the rivers emerged from the field and desktop assessments, consistent with the objectives of the *Hotham Williams NRM Plan 2015-2025*. A summary of these recommendations is provided in Table 1, with opportunities to restore the ecological condition of the river and for engagement with the community to increase knowledge and appreciation of the environmental values of the Hotham-Williams catchment.

Table 1: Hotham and Williams Rivers Actions and Recommendations Summary

Priority	Location	Action
a. Degraded areas are actively managed to restore natural functions, and production where appropriate		
Short-term	Popanyinning Boraning Reserve Williams Townsite	Remove litter from the river, including, oil drums at Popanyinning, general litter in Williams and investigate the sources of oil flecks and sheen observed at Boraning.
Short-term	Ranford Pool Pumphreys Bridge Williams Townsite	Undertake annual bathymetry surveys (depth of the channel, including underwater) of channel/pool capacity to assess the impact of upstream erosion and sedimentation and guide future remediation works.
Short-term	Pumphreys Bridge Quindanning Yornaning Dam Popanyinning Ranford Pool	Provide further measures to prevent stock access (fences, crossings) and control community access.
Short-term	Popanyinning Yornaning Dam Williams Townsite	Install bank protection measures (rock pitching, geo-fabric) to prevent erosion where there is potential for collapse of healthy trees and damage to infrastructure.
Short-term	Pumphreys Bridge Yornaning Dam Hotham River Nature Reserve	Investigate causes of dying trees downstream of Pumphreys Bridge, within Hotham River Nature Reserve and at Yornaning Dam.
Short-term / long-term	Priority sub-catchments (desktop assessment)	Undertake further desktop (recent aerial imagery) and initial field investigations to characterise the conditions of the channels and vegetation in these areas, and determine community and environmental values.
Short-term / long-term	Fourteen Mile Brook North-East Hotham Catchment (desktop assessment)	Further investigate reaches in sub-catchments that are identified by desktop assessment as having poor riparian vegetation widths and coverage, including assessment of the quality and extent of riparian and fringing vegetation, extent of erosion and habitat diversity.
Short-term / long-term	Hotham River Nature Reserve Popanyinning Pumphreys Bridge	Remove and/or redesign structures within the rivers that present a risk to channel stability, including the existing weir structure within Hotham River Nature Reserve (priority), private crossing at the north end of Popanyinning and investigate stabilisation options of the old Pumphreys Bridge to prevent erosion of the river bank.
Long-term	Ranford Pool	Monitor and document the success and failures of the remediation works at Ranford Pool as a template for other sites in the catchment.

Priority	Location	Action
Long-term	Ranford Pool	Extend remediation works in the Ranford Pool reserve to banks upstream and downstream to stabilise additional areas.
Long-term	Ranford Pool	Consider floodplain risk (via mapping) in the design of infrastructure and rehabilitation works.
b. Rivers and creeks are actively restored and managed for their water supply, ecological, landscape, social and cultural values		
Short-term	Pumphreys Bridge	Consider controlled access points for recreation (similar to Ranford Pool) using rock pitching and/or steps to prevent bank erosion.
Short-term	Pumphreys Bridge	Investigate the origins and usage of the diversion channel/pool and consider closing this feature.
Short-term / long Term	Williams Townsite Quindanning Popanyinning Hotham River Nature Reserve	Work with local landholders to improve riparian vegetation along the entire Williams reach, near the Quindanning townsite, conservation areas in Popanyinning and in Hotham River Nature Reserve (long term, following the stabilisation of the channel form).
Short-term / long Term	All	Document stories and narratives of the importance of the watercourses to Noongar culture, and the stories linked to the rivers.
Short-term / long Term	All	Develop case studies of remediation projects including the issues that needed to be overcome and projects outcomes.
Long-term	Pumphreys Bridge	Improve camping facilities to prevent litter and fires near the channel, and improve riparian vegetation.
Long-term	Yornaning Dam	Investigate a functional and natural form for the minor channel that provides valuable habitats.
c. Focused management of sub-catchments is encouraged to restore river and creek water quality for water supply, ecological, landscape social and cultural values		
Short-term	Hotham River Nature Reserve Boraning Reserve Yornaning Dam	Undertake feral animal control programs within the Hotham River Nature Reserve, Boraning Reserve and Yornaning Dam.
Short-term	Ranford Pool Popanyinning Yornaning Dam	Provide resources to private landholders to identify and eradicate weeds, such as fact sheets.
Short-term	Pumphreys Bridge	Work with the landholder to ensure the existing private quarry is suitably managed to reduce runoff and subsequent sedimentation.
Short-term / long-term	Hotham River Nature Reserve Quindanning Williams Boraning Reserve	Investigate opportunities to increase fringing vegetation, including on private land at Hotham River Nature Reserve, within the reserves on the eastern side of Pinjarra-Williams Road at Quindanning, downstream of Albany Hwy in Williams and on the eastern side of the river at Boraning.
Short-term / long-term	Williams TownsiteHotham River Nature Reserve	Investigate sources of sediment in Williams and work with landholders to improve land management practices (priority). In the long term, investigate channel instability in tributaries and upstream of Williams and prepare a sediment budget for Hotham River Nature Reserve upstream to Popanyinning.
Long-term	Ranford Pool Pumphreys Bridge Williams Townsite	Install / update signage to provide community education regarding the wider catchment at prominent recreation areas including Ranford Pool, Pumphreys Bridge camping area and the bridge construction laydown area at Williams.
Long-term	Popanyinning	Continue to protect the existing conservation area, including fencing and gates to restrict access.
Long-term	Popanyinning	Work with rural residential and residential landholders to reduce nutrient inputs near the river.

Priority	Location	Action
d. Management of stormwater supported and improved, including townsite stormwater management		
Short-term	Popanyinning	Modify local drains (e.g. south of the conservation area) to reduce flow speed and prevent local bank erosion.
Long-term	Ranford Pool	Investigate the water quality in the major tributary from the south and consider modification and planting to improve nutrient and sediment removal.
Long-term	Williams Townsite	Work with developers to ensure zoned land south of Growse Street implements water sensitive urban design and appropriate sediment controls during construction to prevent damage to the adjacent channel.

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

The Hotham-Williams River Action Plan (RAP) has been prepared to assess the current state of the Rivers and guide future restoration actions. Conservation and restoration of the Hotham and Williams Rivers (Figure 1) is paramount to protecting the environmental, economic, social and heritage values of the Rivers and the Peel-Harvey Estuary. The Rivers have been assessed in the field at key locations throughout the catchment, identified as areas of high priority in an ecological and social context. The document outlines the findings of these field inspections and desktop data review of the entire Hotham-Williams subcatchment and presents recommendations for on-ground works to implement the RAP.

The RAP is prepared through funding provided by Newmont Boddington and is a key component of the *Hotham-Williams Rivers and Tributaries' Natural Resource Management and Conservation Project* (a partnership project between Peel-Harvey Catchment Council (PHCC) and Newmont Boddington). Additional funding has been provided by the Shire of Cuballing for the Yornaning Dam reach assessment.

1.1 Project Aims

The RAP has been prepared consistent with the PHCC's vision for the catchment:

The Peel-Harvey catchment is once again a flourishing network of interconnected, productive landscapes, with diverse, healthy and resilient ecosystems, globally and locally recognised, acknowledged and embraced for its environmental significance. It is wisely managed by a community that values it – people working together for a healthy environment.

PHCC Strategic Directions 2019-2026 (PHCC, 2019) provides the goals that guide the RAP, namely;

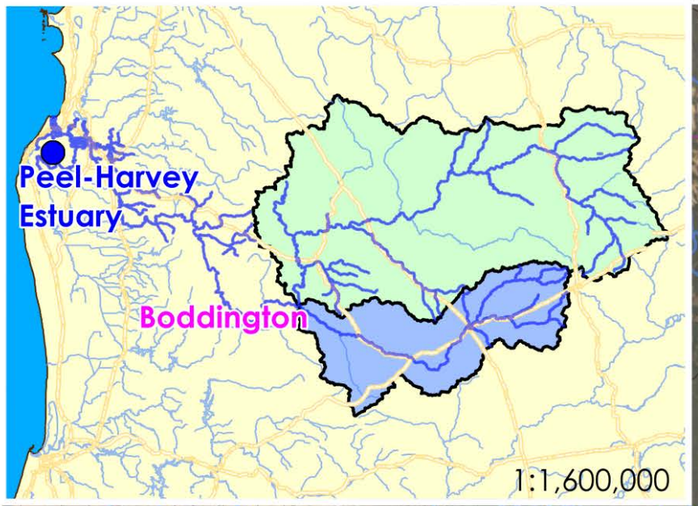
- Influence key decision-makers for better governance;
- Facilitate collaborative adaptive management;
- Deliver quality environmental outcomes; and
- Engage and enable individuals and communities.

Goal 2 of the *Hotham-Williams NRM Plan 2025* (PHCC, 2015a) states that *rivers, creeks, valley floors and sub-catchments are managed and restored*, with the following objectives:

a. Degraded areas are actively managed to restore natural functions, and production where appropriate;
b. Rivers and creeks are actively restored and managed for their water supply, ecological, landscape, social and cultural values;
c. Focused management of sub-catchments is encouraged to restore river and creek water quality for water supply, ecological, landscape social and cultural values; and
d. Management of stormwater is supported and improved, including townsite stormwater management.

The principal aim of the RAP is to identify assets, attributes and threats to the health of the Rivers from which priority actions can be identified and projects developed. In turn, this will protect the ecosystem health and function of the Rivers and their riparian zones. The on-ground projects will need to be undertaken with relevant cultural and environmental approvals (i.e. through the *Aboriginal Heritage Act 1972 (WA)* and the *Rights in Water and Irrigation Act 1914 (WA)*).

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 1 - Hotham-Williams River catchment



SHIRE OF PINGELLY
SHIRE OF WANDERING
SHIRE OF BODDINGTON
SHIRE OF WILLIAMS
SHIRE OF CUBALLING
SHIRE OF NARROGIN
WANDERING
BANNISTER
BODDINGTON
LOWER HOTHAM
POPANYINNING
CUBALLING
MINIGIN
QUINDANNING
WILLIAMS
Albany Hwy
Boyagin Rd
Davis Rd
Tanners Rd
Bunmulling Rd
Reid Rd
Gold Mine Rd
Yornaning West Rd
York - Williams Rd
Fourteen Mile Brook
Harvey - Quindanning Rd
Zilko Rd
Pinjarra Williams Rd
Piesseville - Tarwonga Rd
Hotham River North
Hotham River
Calcoran Brook
Wandering Brook
Bannister River
Dam D4
Murray River
Junction Brook
Geeralying Brook
Williams River

Hotham River and tributaries
Williams River and tributaries
Local Government
Hotham Catchment
Williams Catchment

Data source: PHCC, SLIP, DWER, Created by:YY Projection: MGA: zone 50.

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kilometers
Scale 1:400,000 @ A3

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The RAP has been prepared to address these aims through a combination of field inspections and desktop review of existing datasets. Specifically, the RAP provides a summary of the river condition to determine priority sites for future restoration actions. The RAP also acts as a reference document outlining baseline conditions. The methodology used to assess the river condition is replicable and the condition should be reassessed at regular intervals (minimum of 5 years to a maximum of 10 years) to review the performance of restoration works and identify any new threats that require intervention. The results of the RAP will be incorporated into a baseline assessment of the catchment under Department of Water and Environmental Regulation's *South West Index of River Condition* (SWIRC) that will allow for comparison of river condition at a national level. The SWIRC assessment considers seven ecological themes; physical form, water and sediment, aquatic biota, fringing zone, hydrology, aquatic habitat and land use (DoW, 2011). River health assessments were also being planned within the priority reaches and will provide water quality and aquatic biota data in the field. This work is being conducted by Wetland Research and Management through funding provided by Newmont Boddington and the Department of Water and Environmental Regulation. Surveys were planned for spring 2019 and autumn 2020. Results from the river health assessments will be combined with results from this RAP to complete the SWIRC assessment. This further work will be coordinated by the PHCC.

In 2018-19 the process of rehabilitating and restoring Ranford (Darminning) Pool, based on a concept design by Urbaqua, was instigated with funding from South32 Worsley Alumina and these works were completed at the time of the condition assessments for the RAP. The Ranford Pool restoration project is a partnership between Friends of the Reserves – Boddington (Inc.), the Shire of Boddington, South32 Worsley Alumina and the PHCC.

1.2 Preparation of the RAP

Preparation of the Hotham-Williams RAP included a review of existing studies and available data sets supported by field assessments of selected reaches and desktop analysis of the wider catchment.

1.2.1 Existing studies

The Hotham-Williams RAP has been prepared having considered a number of existing studies as outlined below. These documents have been used for guidance and reference to ensure the Hotham-Williams community priorities and recommendations are taken into consideration during the preparation of the RAP. Key considerations included existing land use, landform and vegetation. A detailed literature review is provided in Appendix 1.

- Avon Hotham Catchment Appraisal (Department of Agriculture and Food, 2005);
- The Framework for the Assessment of River and Wetland Health (FARWH) for flowing rivers (Department of Water (DoW), 2011a);
- Hotham-Williams NRM Plan 2025 (PHCC, 2015a);
- Binjareb Boojda Landscapes 2025 (PHCC, 2015b); and
- Hotham-Williams River Health Assessment (Wetlands Research Management, 2020).

1.2.2 Field Assessment

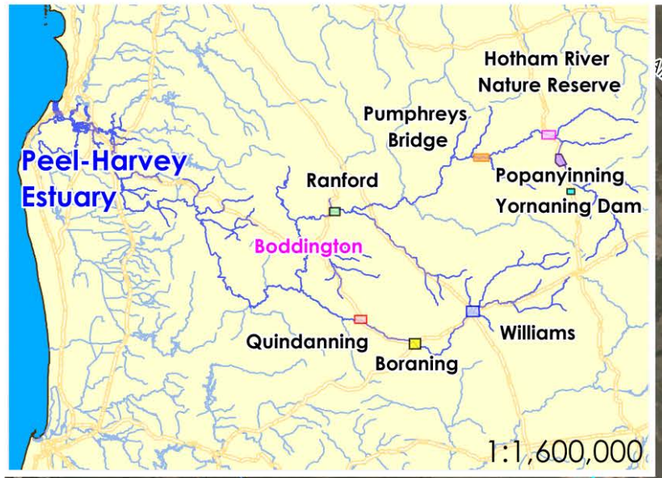
The collection of data in the field was completed for eight (8) defined reaches consistent with Department of Water and Environmental Regulation's (DWER's) *River Restoration Manual* (WRC, 1999), specifically using the Penn-Scott Foreshore Condition Assessment (see Figure 3). The reach descriptions are provided in Table 2 and shown in Figure 2. The methodology is consistent with the

Foreshore condition assessment in farming areas of south-west Western Australia (WRC, 1999) that results in sub-categories for foreshore condition of grades A1 (pristine) to D3 (Drain – weed dominated) (Figure 3). Further detail on the assessment methodology and rating system is provided in Appendix 2 and Appendix 3 to allow for the methodology to be replicated in the future. Field investigations were supported by desktop assessment of data sets including aerial imagery, and regional mapping.

This approach was taken to ensure that methods were standardised at each site to enable direct comparison of data between reaches and future assessment and monitoring of their ecological condition. Note, that while the DWER River Restoration assessment is aimed at small reaches of 100m, the reaches surveyed and scored in this project were approximately 300 m – 400 m in length.

Section 3.2 provides a detailed assessment of each reach, including a description of the conditions and recommended actions for rehabilitation and restoration. Supporting maps depicting foreshore condition assessment, elevation and land tenure have also been prepared for each reach.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 2 - Field Assessment Sites



Data source: PHCC, SLIP, DWER, Created by:YY Projection: MGA: zone 50.

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Table 2: Priority Reach Descriptions

Reach	Upstream (GDA94, Zone 50)	Downstream (GDA94, Zone 50)	Sub-Catchment	Local Government	Length	Characteristics	Page Ref
Yornaning Dam	E515287 N6377034	E514983 N6377340	Hotham River	Shire of Cuballing	1.2 km	Two small watercourses flow into Yornaning Dam. Both have degraded riparian vegetation.	20
Popanyinning	E512619 N6384967	E511767 N6387044	Hotham River	Shire of Cuballing	2.8 km	The River meanders near the townsite to a wider area of permanent water. The River is influenced by a number of private and public crossings.	27
Hotham River Nature Reserve	E509634 N6391992	E507594 N6392763	Hotham River	Shire of Cuballing	2.6 km	Highly active meandering channel with eroding, retreating banks and sediment within the channel.	34
Pumphreys Bridge	E492349 N6386159	E489318 N6386667	Hotham River	Shire of Pingelly; Shire of Cuballing; & Shire of Wandering	3.5 km	Meandering channel with a large pool. The channel is influenced by the surrounding rural land uses and the informal campground near the bridge.	41
Ranford (Darminning) Pool	E453433 N6371984	E451833 N6371952	Hotham River	Shire of Boddington	1.8 km	Ranford (Darminning) Pool is an area of high ecological and recreational value. It features a permanent pool with meandering channels upstream and downstream.	48
Williams Townsite	E489772 N6346531	E487759 N6345080	Williams River	Shire of Williams	3.4 km	The River flows near the townsite forming large meanders and a series of pools, mostly with degraded riparian vegetation and eroding banks.	55
Boraning Reserve	E474137 N6336756	E473839 N6337395	Williams River	Shire of Williams	0.7 km	The small reach assessed adjacent to the Reserve featured multiple small channels that were actively eroding.	62
Quindanning	E460417 N6343010	E458751 N6343343	Williams River	Shire of Williams & Shire of Boddington	2.3 km	The most downstream reach of the Williams River assessed included large meanders with a variety of channel forms including wide pools.	69

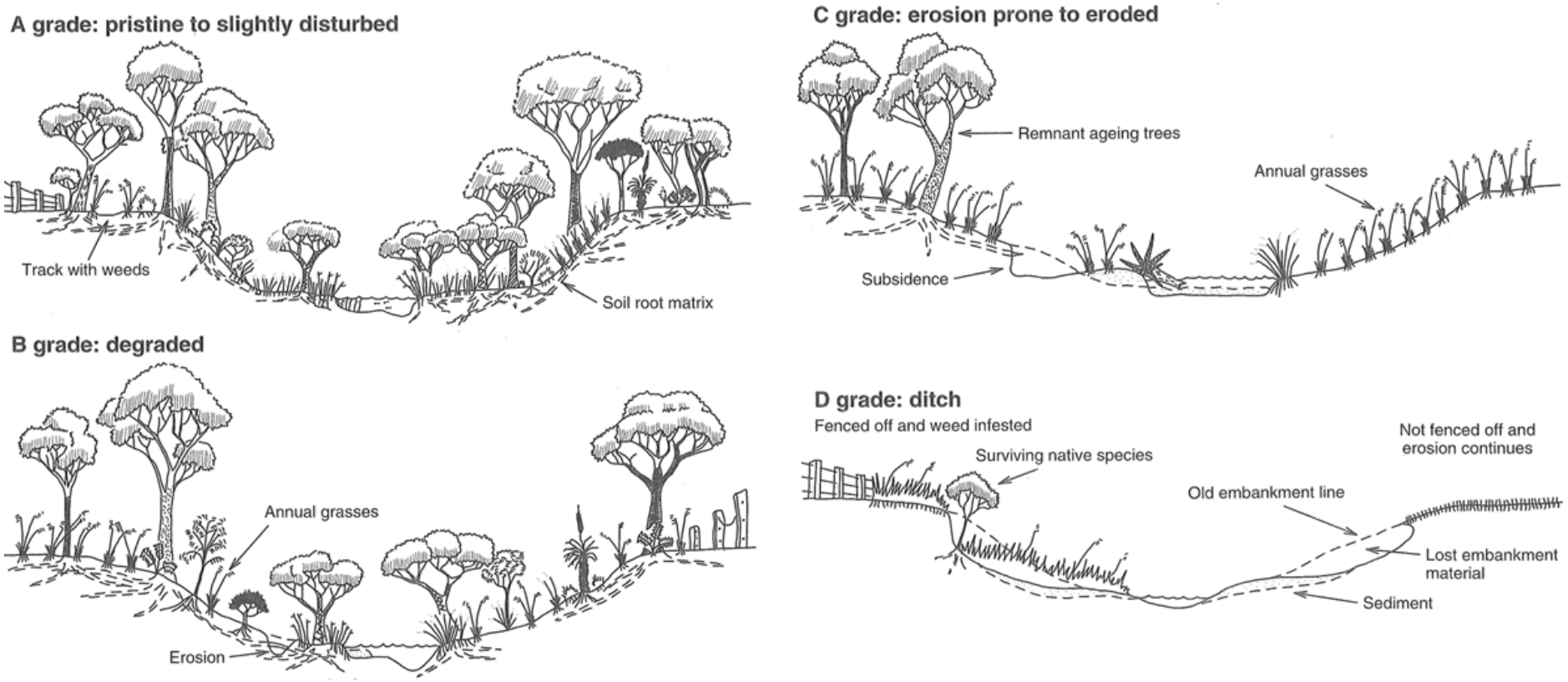


Figure 3: Pen-Scott Foreshore Condition Assessment (Pen & Scott, 1995)

A Grade Foreshore

A1: Pristine
The river embankments and floodway are entirely vegetated with native species, and there is no evidence of human presence or livestock damage.

A2: Near pristine
Native vegetation dominates. Some introduced weeds may be present in the understorey, but not to the extent that they displace native species. Otherwise there is no evidence of human impact. A river valley in this condition is as good as will be found today.

A3: Slightly disturbed
Native vegetation dominates, but there are some areas of human disturbance where soil may be exposed and weeds are relatively dense (such as along tracks). The native vegetation would quickly recolonise the disturbed areas if human activity declined.

B Grade Foreshore

B1: Degraded - weed infested
Weeds have become a significant component of the understorey vegetation. Although native species are dominant, a few have been replaced by weeds.

B2: Degraded - heavily weed infested
In the understorey, weeds are about as abundant as native species. The regeneration of some tree and large shrub species may have declined.

B3: Degraded - weed dominated
Weeds dominate the understorey, but many native species remain. Some trees and large shrub species may have declined or disappeared altogether.

C Grade Foreshore

C1: Erosion prone
Trees remain, and possibly some large shrubs or tree grasses, but the understorey consists entirely of weeds, mainly annual grasses. The trees are generally resilient or long lived species but there is little or no evidence of regeneration. The shallow-rooted weedy understorey provides no support to the soil, and only a small increase in physical disturbance will expose the soil and make the river embankments and floodway vulnerable to erosion.

C2: Soil exposed
Older trees remain, but the ground is virtually bare. Annual grasses and other weeds have been removed by livestock trampling or grazing, or through over use by humans. Low-level soil erosion has begun, by the action of either wind or water.

C3: Eroded
Soil is washed away from between tree roots, trees are being undermined and unsupported embankments are subsiding into the river valley.

D Grade Foreshore

D1: Ditch - eroding
There is not enough fringing vegetation to control erosion. Some trees and shrubs remain and act to retard erosion in certain spots, but are doomed to be undermined eventually.

D2: Ditch - freely eroding
No significant fringing vegetation remains and erosion is completely out of control. Undermined and subsided embankments are common, and large sediment plumes are visible along the river channel.

D3: Drain - weed dominated
The highly eroded river valley has been fenced off, preventing control of weeds by stock. Perennial (long-lived) weeds have become established. The river has become a simple drain, similar or identical to a typical major urban drain.

1.2.3 Desktop Assessment

A desktop based assessment of the Hotham-Williams catchment was completed to determine its health and condition on a large scale. This allowed for a high level assessment of the entire catchment relatively quickly compared to the field assessments which were resource intensive and not feasible across the entire catchment due to its size, with over 2,900km of mapped watercourses. The information gathered from the desktop assessment is able to be used for baseline monitoring and to identify sub-catchments for further field investigation and on-ground actions.

The desktop analysis was carried out using available datasets and generally based on the methods outlined in the *Framework for the Assessment of River and Wetland Health (FARWH) for flowing rivers of the south-west Western Australia* (DoW, 2011a). Regional datasets are used to score reaches within the catchment with the aims of being easily repeatable (with updated datasets) and cost effective. The key datasets used for this assessment are provided in Table 3.

Table 3: Desktop Analysis Datasets

Theme	Data Components	Source	Data-Period
Catchment Disturbance	Land use	DoW, 2011b	2011
Physical Form	River crossings (roads and rail) Catchment gradients	Main Roads WA Landgate	2012
Fringing Zone	Extent of fringing vegetation Native vegetation	Desktop analysis PHCC	2019

The FARWH method has been modified for this project based on the available datasets and previous investigations. Each reach (between 5 km and 10 km) was scored based on the criteria shown in Table 4, considering impacts of surrounding land use, connectivity, vegetation, topography and soils. The detailed FARWH methodology and scoring is provided in Appendix 4.

Table 4: Desktop Analysis Scoring

Total Score	Description
1.00	Catchment is 100% conservation with native vegetation and un-impacted channel or fringe vegetation.
0.75	Catchment is 50% conservation with minimal impact on channel form or fringe vegetation
0.50	Catchment is 50% conservation with reduced fringe vegetation and/or channel disturbance
0.25	Minimal conservation areas with exotic species and limited fringing vegetation
0.00	No conservation areas within the catchment and no fringing vegetation

The limitation of this approach is the ability of regional datasets to capture small scale changes within the catchment. For example, the rehabilitation project at Ranford (Darminning) Pool which included bank protection works and planting of riparian vegetation occurred along 150 m of the River and at a reach scale would not be discernible in the regional datasets. Similarly the analysis is limited by the frequency of the datasets being updated, which in the case of the land use within the catchment is relatively infrequent. The results of the analysis are therefore suitable in providing reference conditions and site selection for further works. Pre and post field assessments should be considered to determine the success of rehabilitation projects within the catchment.

2 THE HOTHAM AND WILLIAMS RIVERS

The Hotham and Williams Rivers are the two major rivers which feed into the Murray River, one of three main rivers feeding the Ramsar listed Peel-Harvey Estuary. The Murray River is notable as the only major river feeding the Peel-Harvey Estuary that is not dammed (DoW, 2011b). The Hotham-Williams catchment covers an area of 5,730 km^2 (PHCC, 2015a), approximately 60% of the total Peel-Harvey catchment (9,560 km^2). A summary of the environmental and historical factors that influence the current condition of the Rivers is provided below.

2.1 River System and Catchments

The confluence of the Hotham and Williams Rivers is west of Quindanning, near the eastern boundary of the Lane Poole Reserve. The respective catchments upstream contain 2,910 km of mapped watercourses extending east to Cuballing (Figure 1). Approximately only 7% of these waterways are in good (or near-pristine condition) (PHCC, 2015b), though the community place a high importance on the management of rivers and creeks (PHCC, 2015a).

The Hotham River catchment is the northern sub-catchment, extending from Cuballing to Lane Poole Reserve, flowing through the towns of Popanyinning and Boddington. The catchment includes a number of significant tributaries including Bannister River, Crossman River, Fourteen Mile Brook, Thirty-four Mile Brook, and Wandering Brook (Figure 2). The River largely maintains its natural form without large dams or modification, and features a meandering system with a series of pools. Local changes to the River have occurred since European settlement, with examples described from field assessments. Five (5) of the field assessment sites are within the Hotham catchment, including four (4) on the main channel itself.

The Williams River catchment is the southern sub-catchment, extending east beyond the Williams townsite. The major tributaries of the Williams River are Junction Brook and MacDermott Brook that join the main channel within the Williams townsite. The channel features a number of pools within its meandering form. Three (3) field assessment sites are located on the Williams River, including Williams townsite, Boraning Reserve and Quindanning.

The dominant land use in both catchments is cropping, grazing and other agricultural activities, totalling approximately 3,870 km^2 (PHCC, 2015b). Cereal crops are the main product in the region. The other key industry in the catchment is mining in the western portion including gold (Newmont Boddington) and bauxite (South32 Worsley Alumina).

Approximately 1,866 km^2 of the Hotham-Williams catchment contains native vegetation, with 1,120 km^2 in dedicated conservation areas, including the Dryandra Woodland, one of the most significant conservation areas in the Wheatbelt (managed by the Department of Biodiversity, Conservation and Attractions (DBCA)). The Dryandra Woodlands consist of 17 discrete blocks of ownership totalling 281 km^2 that contain diverse flora and fauna, including many threatened fauna species such as Western Australia's fauna emblem, the Numbat (*Myrmecobius fasciatus*).

2.2 Climate

The Hotham-Williams Catchment is characterised by a temperate climate with distinct dry (and hot) summers and mild winters based on the Köppen Climate Classification. The dominant rainfall mechanisms are frontal systems caused by cold fronts associated with low pressure systems that extend across southern Australia between May and October. During the summer months,

thunderstorms and ex-tropical cyclones can bring intense rainfall, however most flows occur over winter.

The rainfall varies across the catchment, with inland areas generally receiving reduced precipitation. Annual average rainfall in the west of the catchment, near Boddington, measures on average 600 mm – 700 mm, while eastern areas of the catchment, near Cuballing, receive around 500 mm – 550 mm of rain each year (Bureau of Meteorology, 2019).

In the south-west of Western Australia, there has been a significant decline in winter rainfall, a result of weakened and less frequent frontal systems. Climatologic modelling strongly suggests a general increase in temperature and decrease in rainfall from weakened and less frequent frontal systems, attributed to large scale changes in the southern hemisphere circulation patterns (DoW, 2014). Since 1975, there has been an 11% decrease in annual rainfall at the Marradong station (BoM Station No.9575) and an 8% decrease at the Narrogin station (BoM Station No.10614) near the eastern edge of the catchment.

2.3 European Heritage

The catchment has undergone significant changes since European settlement with the clearing of native vegetation for agriculture, mining, urban development and infrastructure. Land clearing for agricultural purposes started in the 1890s throughout the catchment. Jarrah forests on the scarp have been protected by the State's *Forests Act 1918*, however extensive clearing has occurred in Wheatbelt areas. Clearing of this vegetation is estimated to have increased annual streamflow from the Hotham and Williams Rivers by 190 GL and 100 GL respectively, though this has since decreased with the drying climate (Section 2.2) (DoW, 2011b).

Clearing of vegetation has also led to compounding issues including dryland salinity, higher groundwater levels and accelerated erosion and sedimentation in the catchment. The salinity issue is highlighted by the Murray River being considered too saline for a drinking water source. Additional sediment delivery to the creeks and rivers in the catchment contributes to filling of pools and loss of habitat, with channels and instability in the banks and beds.

Furthermore, arrival of European settlement and clearing of native vegetation has coincided with a proliferation of weeds and feral animals within the catchment (PHCC, 2015b). Vegetation remains along the river and creek channels, though quality and extent vary considerably, particularly associated with previous clearing, weed invasion and impacts from salinity.

The Hotham-Williams catchment is comprised of eight (8) Local Government Areas (LGAs) and several towns. One of these being Boddington which was gazetted in 1912 during the construction of the Hotham Valley Railway, to meet the demand created by the local timber industry within the scarp. Bauxite mining operations commenced near Boddington in 1979, followed by gold mining operations in 1987 (Shire of Boddington, 2019).

The Shire of Williams was first explored in 1831 but was not settled until 1836. Originally, the town was on the Albany side of the River, however it was relocated following floods caused by intensive clearing and farming practices (Shire of Williams, 2019). Pingelly was established when a lease for grazing was granted for 4,000 acres around the Moorumbine Spring in 1846 (Landgate, 2019; Shire of Pingelly, 2019).

Since the 1960s, eutrophication of the Peel-Harvey Estuary has been a significant environmental problem, particularly associated with the introduction of trace element fertilisers in the 1950s (DoW, 2011b). Given its size and land use history, the Hotham-Williams Catchment is one of the sources of the nutrients contributing to this issue.

2.4 Aboriginal Heritage

The Hotham River and its major tributaries are collectively registered as a site of aboriginal significance (site number 27935) commencing near Pumphreys Bridge, and is specifically identified as having mythological status by the Department of Planning, Lands and Heritage "Aboriginal Heritage Inquiry System". The *Aboriginal Heritage Act 1972 (WA)*, protects all Aboriginal Heritage sites in Western Australia whether they are registered with the Department or not. Before undertaking any work On Country, officers will consult and engage with the delegated local Noongar Elders, Traditional Owners and/or Representatives. Noongar Elders and Representatives will provide knowledge and advice on each site. Officers will follow the draft PHCC Noongar Consultation and Engagement Guidelines. If the on-ground actions are deemed likely to have an impact on the significant site, the consent of the Minister must be sought under the Act.

2.5 Key issues

Previous investigations and reports have identified the following key issues for the Hotham-Williams catchment that required consideration during field assessments and formulation of management recommendations:

- Since 1975 there has been a **decline in rainfall** of more than 10% in the western catchment and 8% in the eastern catchment, with associated decreases in flows;
- **Compromising** of key natural assets, including Dryandra Woodlands and other unique ecosystems that require intervention and management to conserve native flora and fauna;
- The **clearing of native vegetation** has led to dryland salinity through the catchment, resulting in reduced water quality and degraded remnant vegetation;
- Coinciding with the loss of native vegetation, **invasive weeds** are a problem throughout the catchment including in the riparian areas;
- **Proliferation of feral animals** such as the red fox, European rabbit, feral cat and feral pig which impact on flora and fauna;
- Land uses within the catchment contribute to **elevated nutrient loads** exported to the Murray River and the Peel-Harvey Estuary; and,
- Since the establishment of agriculture there has been **accelerated erosion and sedimentation** in the catchment, contributing to channel instability.

3 FIELD REACH ASSESSMENT

The field reach assessment was undertaken on eight (8) defined reaches within the catchment, which have significant environmental values and were identified by the PHCC through a process of prioritisation. These reaches were assessed to provide a detailed summary of the key issues and considerations for future management. A summary of the methodology and results are provided below. Further detail is provided in Appendix 2 and 3.

3.1 Methodology

The methodology for collating and assessing the data is adapted from *River Restoration – Foreshore condition assessment in farming areas of south-west Western Australia* (WRC, 1999). Assigning a category is generally a subjective exercise, matching observation with descriptions for each category. In order to provide a more objective, repeatable approach, key parameters are assessed and scored based on the data breakdown provided below. Table 5 (WRC, 1999) provides a scoring system to calculate overall stream health and has been adapted to score foreshore condition. For the Hotham-Williams RAP, each bank within each sub-reach has been assessed with this scoring system, noting that habitat diversity refers to condition within the channel, and therefore is the same for both banks.

Table 5: Stream Health Scoring (WRC, 1999)

	Floodway and bank vegetation	Verge vegetation	Stream Cover	Bank Stability and Erosion	Habitat Diversity
Excellent	- Healthy undisturbed native vegetation - No Weeds **(15 points)**	- Healthy undisturbed native vegetation - Verges more than 20m wide **(8 points)**	-Abundant cover: shade, overhanging vegetation - Snags, leaf litter, rocks and/or aquatic vegetation in stream **(8 points)**	- No erosion or subsidence or sediment deposits - Dense vegetation cover on banks and verge - No disturbance **(8 points)**	- Three or more habitat types - Some permanent water **(6 points)**
Good	- Mainly healthy undisturbed native vegetation - Some weeds - No recent disturbances **(12 points)**	- Mainly healthy undisturbed native vegetation - Verges less than 20m wide **(6 points)**	- Abundant shade and overhanging vegetation - Some cover in the stream **(6 points)**	- No significant erosion, subsidence or sediment deposits in floodway or on lower banks - May be some soil exposure and vegetation thinning on upper bank and verge **(6 points)**	- Two habitat types - Some permanent water **(4 points)**
Moderate	- Good vegetation cover but a mixture of native and exotic species - Localised clearing - Little recent disturbance **(6 points)**	- Good vegetation cover but a mixture of native and exotic species - Verges 20m wide or more **(4 points)**	- Some permanent shade and overhanging vegetation - Some instream cover **(4 points)**	- Good vegetation cover - Only localised erosion, bank collapse and sediment heaps - Verges may have sparse vegetation cover **(4 points)**	- Mainly one habitat type with permanent water, or a range of habitats with no permanent water **(2 points)**
Poor	- Mainly exotic ground cover - Obvious site disturbance **(3 points)**	- Narrow verges only (<20m wide) - Mainly exotic vegetation **(2 points)**	- Channel mainly clear - Little permanent shade or instream cover **(2 points)**	- Extensive active erosion and sediment heaps - Bare banks and verges common - Banks may be collapsing **(2 points)**	- Mainly one habitat type with no permanent water **(1 points)**
Very Poor	- Mostly bare ground or exotic ground cover (i.e. pasture gardens or weeds but no trees) **(0 points)**	- Mostly bare ground or exotic ground cover (i.e. pasture gardens or weeds but no trees) **(0 points)**	- Virtually no shade or instream cover **(0 points)**	- Almost continuous erosion - Over 50% of banks collapsing - Sediment heaps line or fill much of the floodway - Little or no vegetation cover **(0 points)**	- Stream channelised - No pools, riffles or meanders - The stream forms a continuous channel **(0 points)**

Scores from each bank were determined from an analysis of key categories listed in Table 6. The categories are adapted from *River Restoration – Foreshore condition assessment in farming areas of south-west Western Australia* (WRC, 1999) and represent a collection of items that were assessed during the field assessment. As demonstrated in Table 5, categories are weighted based on their importance, with floodway and bank vegetation considered the most significant category of foreshore condition, whereas habitat diversity is the least significant. Further details of each of the categories, including the full list of the key indicators and considerations are outlined in Appendix 2.

Table 6: Foreshore assessment categories

Category	Score Range	Description	Key Indicators	Other Considerations
Floodway and bank vegetation	0 – 15	Vegetation that grows either on the bank of the river or within the floodway, providing canopy cover, plant roots that stabilise banks and stems and foliage in the river dissipate the energy of flows to reduce the risk of erosion.	- Vegetation type (e.g. bare ground, shrubs, trees) - Exotic vegetation percentage	- Riparian layer vegetation type - Width of riparian zone - Dominant riparian species - Exotic tree percentage
Verge vegetation	0 – 8	Vegetation located adjacent to the floodway and bank, extending to the floodplain. The condition and extent influences the banks stability, habitat and health of the riparian ecosystem.	- Dominant vegetation type (e.g. weeds/grasses/crops, remnant, plantation) 10 – 49 m, from floodway - Dominant vegetation type 50 – 99 m, from floodway	- Dominant vegetation type >100 m, from floodway
Stream Cover	0 – 8	Stream cover is important for fish, animals and other aquatic organisms that depend on the river. Snags, leaf litter and rocks provide shelter, and overhanging and emergent vegetation provides shade during summer.	- Percentage of vegetation overhanging bank - Percentage of trees overhanging water - Percentage aquatic plant cover - Proportion of emergent and submerged vegetation - Woody debris	- Bank vegetation draped in water - Percentage of trees overhanging water - Stream width - Percentage of shrubs overhanging water
Bank Stability and Erosion	0 – 8	Erosion (removal of sediment by water, observed as scouring, slumping or bare surfaces) is a natural process for river systems, but accelerated or wide-spread erosion is indicative of an unstable system that will continue to degrade.	- Erosion percentage - Erosion severity	- Bank shape - Bank slope - Bank depth
Habitat Diversity	0 – 8	Aquatic habitat is an indicator as stream sections that have a range of habitat types and can support a greater variety of species. Limited habitat variety (and a lower score) is therefore associated with degraded rivers.	- Percentage of habitat type (channel, riffle, pool, reach)	- Water odours and oils - Turbidity - Tanning, staining - Algae in water column and on substrates - Sediment (plumes, oils and odours)

The scores from this analysis were then equated to the foreshore condition, based on the scoring system outlined in Table 7. The sum of all the parameter scores within a reach gives a rating which falls under a category ranging from A1 (pristine) to D3 (drain – weed dominated) (described further in Section 1.2.2 and Appendix 2), allowing for sub-categories (e.g. B1-B2). Manual adjustments of scores were applied based on secondary parameters and a review of field photography, water quality data and other data sets.

Table 7: Foreshore category scoring

	Score					
Rating	Floodway and Bank Veg	Verge Vegetation	Stream Cover	Bank Stability and Erosion	Habitat Diversity	Total Score
A1	15	8	8	8	6	45
A2	12	8	8	8	6	42
A3	12	6	8	6	4	36
B1	12	4	6	6	4	32
B1-B2	-	-	-	-	-	28
B2	6	4	4	6	4	24
B2-B3	-	-	-	-	-	20.5
B3	3	2	4	6	2	17
B3-C1	-	-	-	-	-	16
C1	3	4	2	4	2	15
C1-C2	-	-	-	-	-	13
C2	3	2	2	2	2	11
C2-C3	-	-	-	-	-	9
C3	3	0	0	2	2	7
D1	3	2	0	0	0	5
D2	3	0	0	0	0	3
D3	0	0	0	0	0	0

3.2 Results

Results of the field assessments for the 8 defined reaches are provided in this section, along with management recommendations to improve identified issues. The data and information is provided for each reach in the format outlined in Table 8.

Table 8: Reach Assessment Data Format

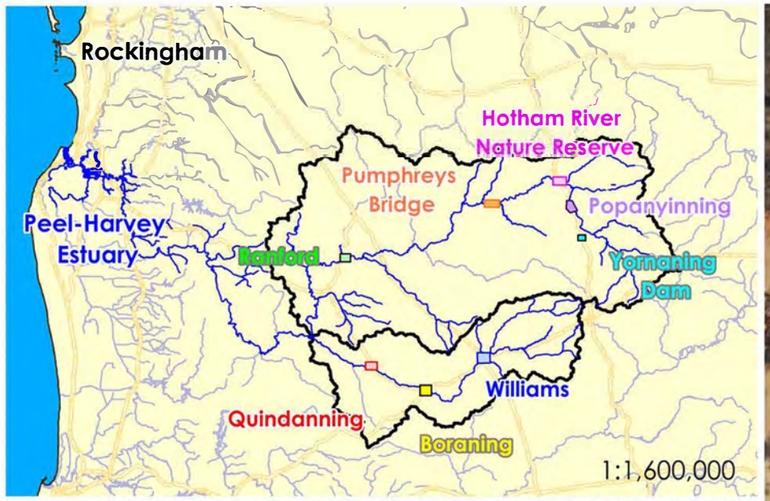
Item	Format	Title	Notes
1	Figure	Reach Location Map	Reach, tributaries and surrounding features
2	Figure	Reach Elevation Map	Floodplain and catchment elevation contours
3	Figure	Land Use Map	Surrounding land uses
4	Table	Description and Conditions	Summary of the characteristics of each reach and description of assessment scores
5	Table	Management Actions and Recommendations	Recommendations to improve the reach based on condition assessment and notable features
6	Figure	Condition Assessment	Assessment scores for each sub-reach with points of interest including infrastructure, weeds and significant erosion

The detailed scoring for each sub-reach and bank is provided in Appendix 3 based on the methodology outlined in Appendix 2 (example in Figure 4).

		Left Bank						
Reach	Subreach	Floodway and Bank Veg	Verge Vegetation	Stream Cover	Bank Stability and Erosion	Habitat Diversity	Total Score	Rating
Pumphreys Bridge	2	3	4	2.50	4	4	**17.50**	**B2-B3**
	3	2	1.5	2.50	2	3.5	**11.50**	**C1-C2**
	5	1.5	2	2.00	4	3	**12.50**	**C1-C2**
	6	1	2	1.50	3	1	**8.50**	**C2-C3**
	7	2	3	1.50	2	2	**10.50**	**C2**
	8	3	3	2.00	2	3.5	**13.50**	**C1**
	9	5	2.5	2.50	2	2	**14.00**	**C1**
	10	4	2	3.86	1	2	**12.86**	**C1-C2**

Figure 4: Reach Scoring Example

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 5 - Yornaning Dam Location Map



Yornaning Dam
Major Channel
4
CBH Facilities
Great Southern Hwy
6
3
Minor Channel
Railway
2
5
1
SHIRE OF CUBALLING

Start/End Points
Creek
Reach Division Line
Local Government

Data source: PHCC. Created by:YY Projection: MGA: zone 50.

0 300
meters
Scale 1:3,000 @ A3

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land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 6 - Yornaning Dam Elevation Map

Data source: PHCC, SLIP, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:3,000 @ A3

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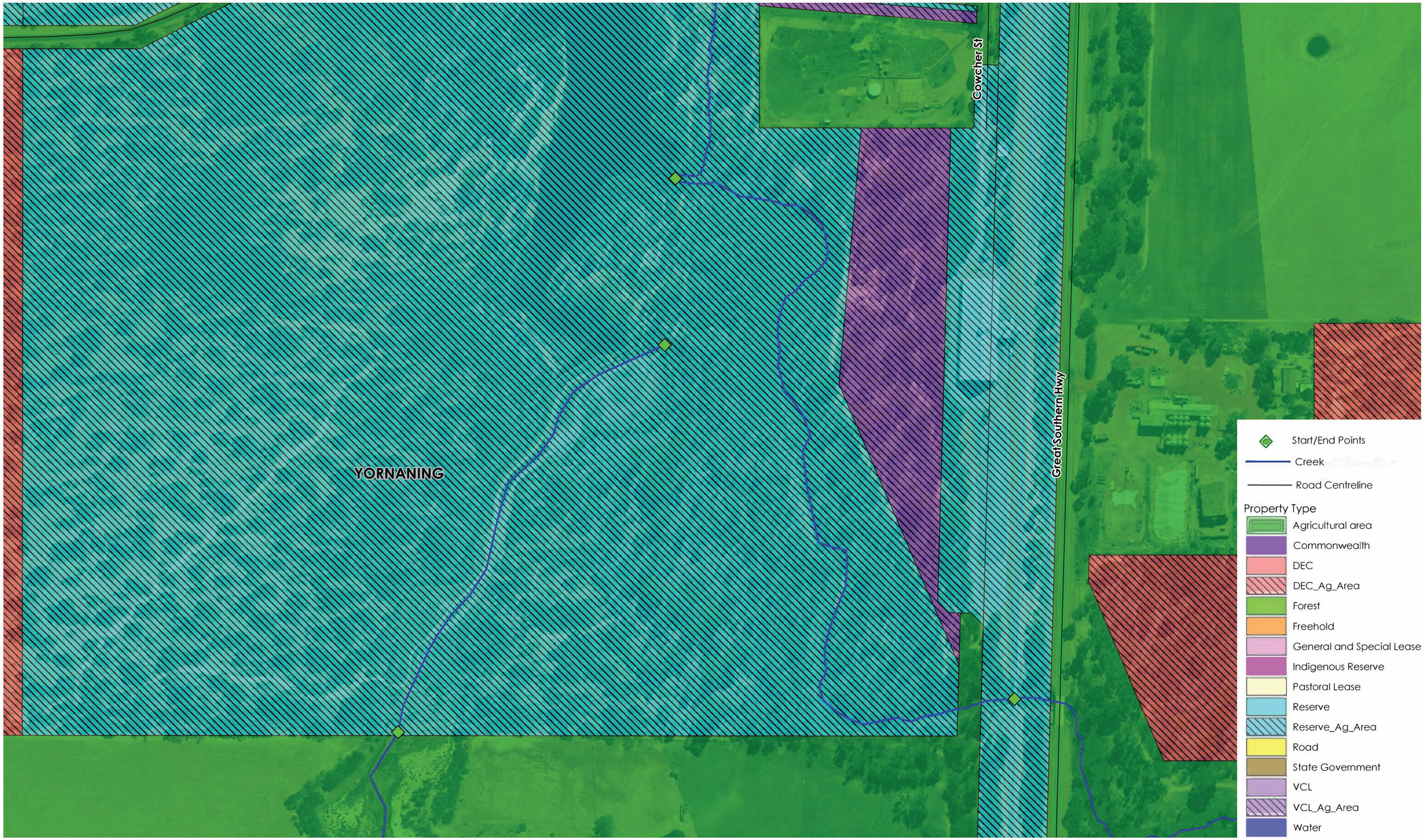
land and water solutions

Peel Harvey Catchment Council-Hotham-Williams River Action Plan
Figure 7 - Yornaning Dam Land Use Map



Data source: PHCC, SLIP, DWER, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:3,000 @ A3

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land and water solutions

3.2.1 Yornaning Dam

The Yornaning Dam reach includes two creeks that flow into the Dam, covering a total distance of 1.2 km as shown in Figure 5. Assessment of this reach included the definition of 6 sub-reaches, each being approximately 200 m in length. Characteristics of the creeks at this site, defined by results of the field assessment and desktop review are provided in Table 9, with management recommendations provided in Table 10.

Plate 5: Yornaning Dam Site Photos

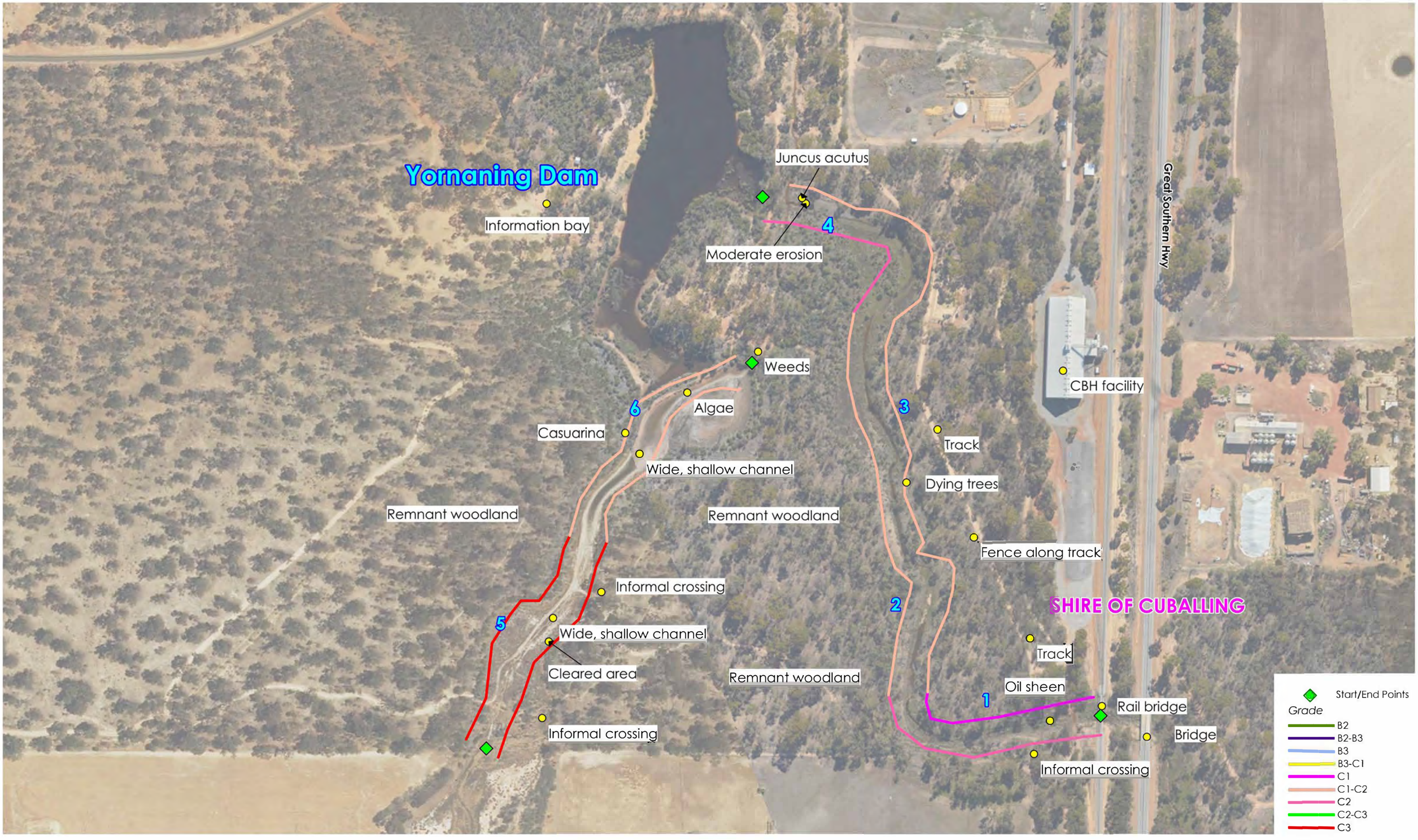
Table 9: Yornaning Dam Description and Conditions

Feature	Comments
Land use	The dam and assessed reaches are within areas of remnant vegetation that are part of the Yornaning Dam Reserve. There is rural land south and north-east of the reserve, along with the CBH facilities near the railway line.
Fencing and Infrastructure	The dam is used for recreation by the community and there are vehicle tracks throughout the site including one crossing near the railway bridge (upstream end of the assessed reaches). Fencing is largely offset from the channel, either on the boundary of the rural property to the south or along the tracks within the reserve (east of the main channel). Fencing was rated as in good condition, and there was no evidence of stock access, though dog tracks were noted near the minor channel.
Channel Form	There are two channels that flow into the dam, a major channel flowing under the Great Southern Highway and a minor channel that collects drainage from the adjacent rural property, west of the major channel (Figure 5). The major channel is relatively narrow (2-3 m) and features a meandering profile and shallow banks. The minor channel is an ephemeral system with no distinguishable banks and has been heavily modified from a natural state.
General Foreshore Condition	The major channel was scored between C1 (erosion prone) and C2 (soil exposed), reflecting the poor vegetation condition, limited stream cover and lack of habitat diversity. The minor channel, upstream near the rural property, was scored as C3 associated with the lack of riparian vegetation cover. Closer to the dam, the minor channel was similar to the major channel (C1-C2).
Vegetation Cover and Stream Health	Both channels featured heavily reduced or absent riparian vegetation apart from exotic ground covers. Many dying trees were noted throughout the reach, both near the creeks and within the adjacent reserve. This could be attributed to a number of factors including insect attack, Phytophthora dieback, salinity and drought stress. Healthy trees included Wandoo, Marri and Casuarina sp., but they offered no stream shading. Samphire and salt bush were also recorded within these reaches.
Weeds	Common weeds within these reaches were *Juncus acutus*, Bridal Creeper, Cape Tulip, Cape Weed, Wild Oats, Blowfly Grass, Prickly Lettuce, Yellow Button Clover, and Purple Guildford grass.
Erosion	Erosion was recorded along both channels, but it was largely insignificant as the banks were generally shallow. Undercutting was only observed near the dam, but was relatively isolated. The major channel featured large quantities of sediment deposits.
Other Issues	Poor water quality was observed in the major channel, including oil at the upstream end (near the railway bridge) and algae in the remainder, associated with stagnant water (Appendix 7). Dissolved oxygen (DO) concentration varied along the channel. At reaches 1 – 4, DO ranged from 1.35 mg/L to 11.23 mg/L which is within the expected range for a low flowing channel. Reach 5 was dry and reach 6 recorded a very high DO concentration (14.19 mg/L or 175.1%) which is often observed in shallow water with dense algal growth. Electrical conductivity (EC) was generally high across all the sampling sites. Reach 6 recorded an exceedingly high EC which is most likely reflective of the lack of flow at the site.
Cultural and Community Heritage	The Aboriginal Heritage Act 1972 (WA), protects all Aboriginal Heritage sites in Western Australia whether they are registered with the Department of Planning, Lands and Heritage or not. Noongar Elders and Representatives will provide specific knowledge and advice about cultural significance and values at the Yornaning Dam. Please refer to section 2.4 of this document to ensure all processes and procedures are followed. The Dam has a long history of providing fresh water supply for the rail industry and towns. Today it is saline and used for recreational purposes, with a dedicated picnic and playground area and 1.5 km nature walk.

Table 10: Yornaning Dam Management Actions and Recommendations

Prioritised management actions recommended
• Reduce recreational access through the reserve, including closure of tracks along the minor channel and/or fencing; • As with other areas in the catchment, confirm the causes of tree death in the reserve prior to any remediation works; • Focus rehabilitation works including revegetation, on the major channel as it has a better chance of reaching a natural form and improved habitat value; • Undertake works to remove/control weeds and feral animals in the reserve; and • Install bank protection measures (rock pitching, geo-fabric) at the downstream end of the major channel to prevent bank retreat and mobilisation of sediment.
Long term management actions recommended
• Investigate a functional and natural form for the minor channel that provides valuable habitats.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 8 - Yornaning Dam Condition Map



Data source: PHCC, Created by:YY Projection: MGA: zone 50.

0 300
meters
Scale 1:3,000 @ A3

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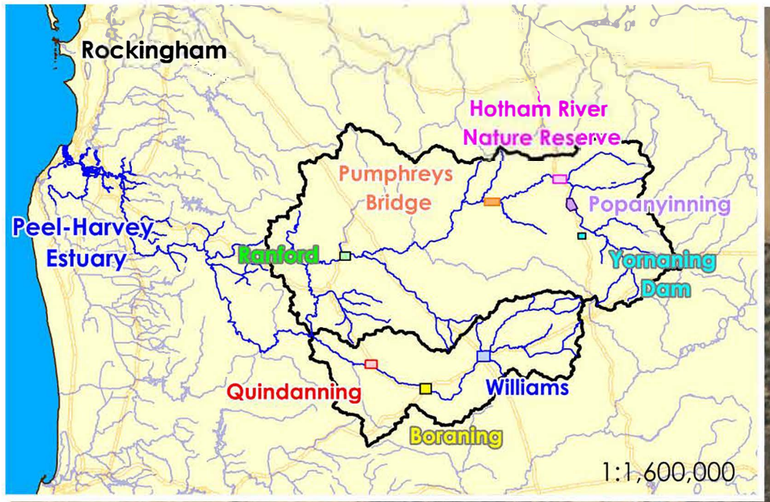
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 9 - Popanyinning Location Map



Popanyinning

Dowling St

Great Southern Hwy

Hotham River

SHIRE OF CUBALLING

Great Southern Hwy

Railway

Popanyinning West Rd

Bunmulling Rd

Hotham River

1 2 3 4 5 6 7 8

Start/End Points
Hotham River
Reach Division Line
Local Government

Data source: PHCC, SLIP., Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:10,000 @ A3

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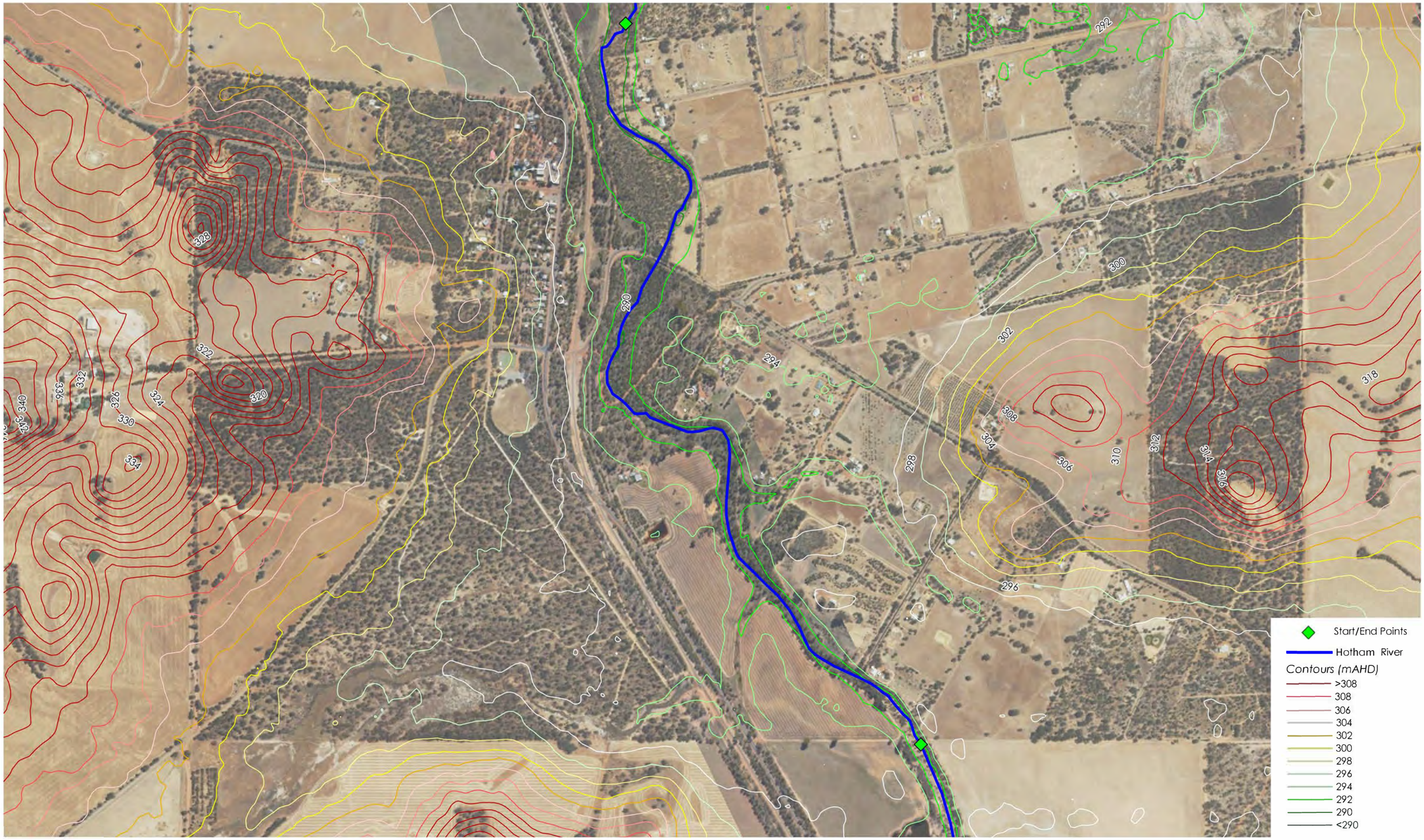
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 10 - Popanyinning Elevation Map



Data source: PHCC, SLIP, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:10,000 @ A3

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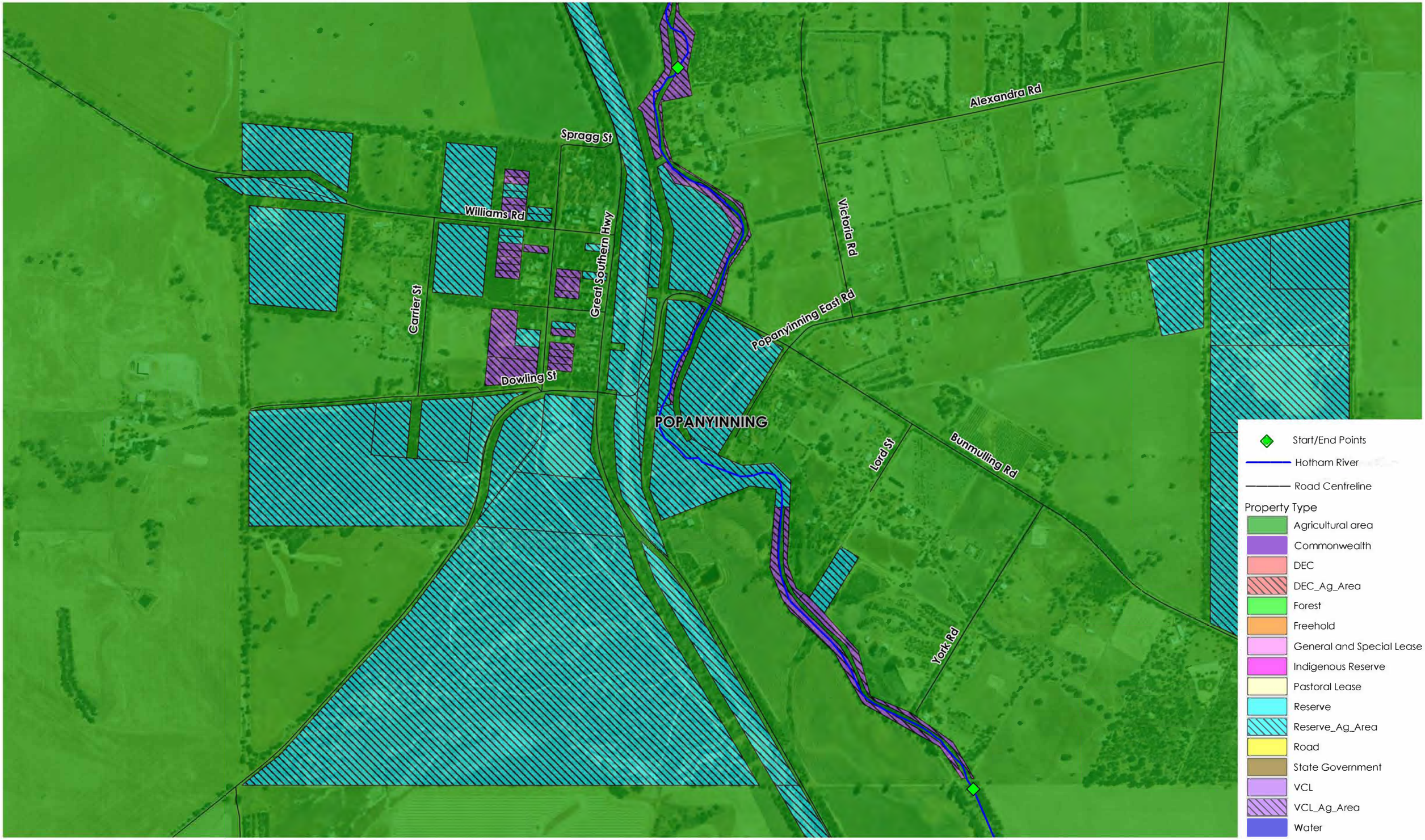
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 11 - Popanyinning Land Use Map



Data source: PHCC, SLIP, DWER. Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:10,000 @ A3

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land and water solutions

3.2.2 *Popanyinning*

The Popanyinning reach of the Hotham River is east of the townsite, Great Southern Highway and rail line, covering approximately 2.8 km as shown in Figure 9. Assessment of this reach included the definition of 8 sub-reaches, each being approximately 400 m in length (Figure 9). Characteristics of the River, defined by results of the field assessment and desktop review are provided in Table 11, with management recommendations provided in Table 12.

Plate 4: Popanyinning Site Photos

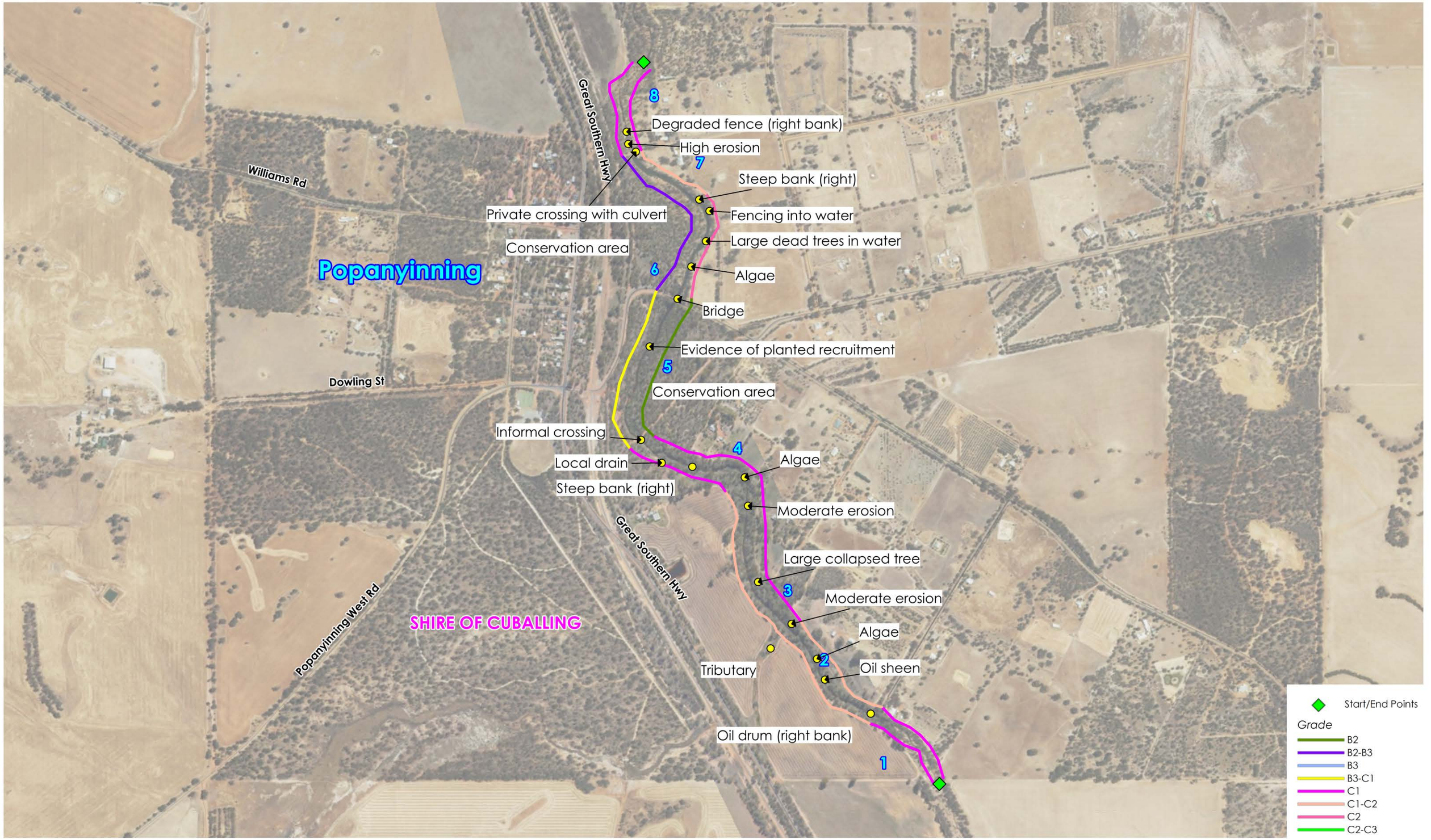
Table 11: Popanyinning Description and Conditions

Feature	Comments
Land use	The upstream and downstream parts of the reach are surrounded by rural and rural residential (small landholding) lots. The middle parts of this reach are surrounded by conservation areas, particularly from west of the River to the railway line.
Fencing and Infrastructure	Fencing was generally limited to private properties beyond the River. These fences were rated between poor and average, though there was no stock access evidence south of Bunmulling Road. Vegetation damage, manure and tracks on the property north of Bunmulling Road indicate stock access (sheep) along with old fencing leading to the River. The significant infrastructure along this reach is the Bunmulling Road bridge and two crossings. The southern crossing is a track through the conservation area and the northern crossing leads to a private property. This crossing forms a small weir with a backwater area.
Channel Form	The channel generally has a narrow, meandering form approximately 10 m wide. North of Bunmulling Road the River is wider, up to 20m, including erosion on the eastern bank that has extended beyond now submerged large trees. Banks are generally shallow apart from the outside of large meander bends where they are steeper.
General Foreshore Condition	Assessment of the foreshore conditions ranges from relatively good (B2-B3 – degraded) to erosion prone (C2 – soil exposed). Middle reaches surrounded by conservation areas have higher scores, and lowest scores are associated with areas of bare ground, limited shrub layers and high bank instability. Where the River is surrounded by private landholdings, the typical score was C1, suggesting the River is eroding and native vegetation has been degraded.
Vegetation Cover and Stream Health	The vegetation along this reach consists of scattered trees (Sheoak and Eucalyptus sp.), exotic and native grasses with a variable shrub layer (Callistemon and Acacia sp.). *Juncus acutus* was observed in middle and downstream reaches, particularly in conservations areas. Samphire was also noted in upstream and middle reaches. There were a considerable number of dead trees throughout the reach, and stream cover and shading was limited.
Weeds	Exotic grasses (Guildford, Veldt and Blowfly) were common throughout the reach. Other dominant species include Bridal Creeper, Watsonia, Cape Tulip, Wild Oats and *Juncus acutus*.
Erosion	Bank instability occurred throughout the reach on both sides though generally minor with little structural impact. Major erosion is associated with the outside of meander bends, or where other factors such as local runoff and/or human and stock access have caused bank slumping and retreat.
Other Issues	Algae was noted consistently throughout the reach, suggesting stagnant water and high nutrient concentrations. A rusted (empty) drum was found at the upstream end of the reach, with oil observed in the water further downstream.
Cultural and Community Heritage	The Aboriginal Heritage Act 1972 (WA), protects all Aboriginal Heritage sites in Western Australia whether they are registered with the Department of Planning, Lands and Heritage or not. Noongar Elders and Representatives will provide specific knowledge and advice about cultural significance and values at the Popanyinning town site. Please refer to section 2.4 of this document to ensure all processes and procedures are followed. The River at this site is greatly valued by the community, with the local Progress Association carrying out projects within the riparian area adjacent to Bunmulling Rd and establishing the Popanyinning Nature Trail of which the "Qujo Trail" section runs adjacent to the Hotham River. The 'Popanyinning Pool' has historically been used by the locals, including a flying fox that used to span the River.

Table 12: Popanyinning Management Actions and Recommendations

Prioritised management actions recommended
• The priority action is to clean up oil drums and any oil remaining in the channel. Clean up should include other inappropriate litter within the channel; • Work with the landholder north of Bunmulling Road to improve fencing, prevent stock access and work to stabilise the banks, particularly on steep banks with significant trees; • Improve the outlet of the local drain (south of the conservation area) into the River to slow flows and prevent local erosion; • Undertake weed removal and control, particularly in the conservation area; • Work with local landholders south of the conservation area to improve riparian and fringing vegetation along these reaches; and • Reinforce banks surrounding the river crossing in the conservation area or consider closure altogether.
Long term management actions recommended
• Continue to protect the conservation area, including fencing and gates to restrict access; • Work with the landholder to redesign the private crossing to prevent stagnant water and algae growth within the channel; and • Work with rural residential and residential landholders to reduce nutrient inputs into the River.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 12 - Popanyinning Condition Map



Data source: PHCC, SLIP., Created by:YY Projection: MGA: zone 50.

0 1,000
meters
Scale 1:10,000 @ A3

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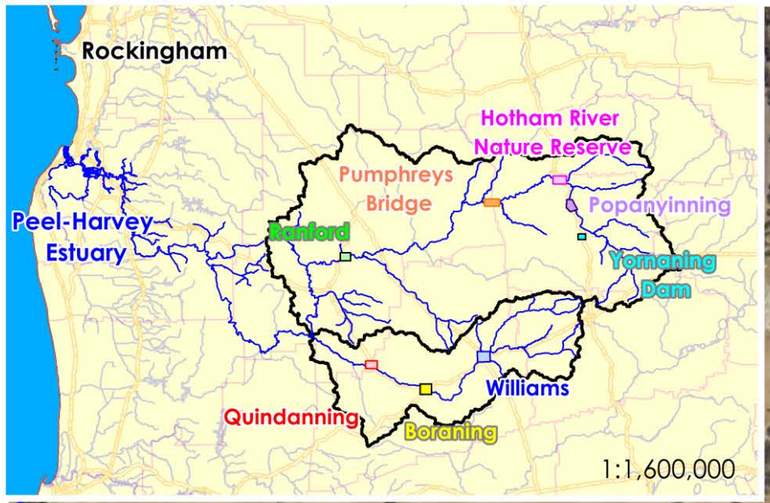
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 13 - Hotham River Nature Reserve Location Map



Hotham River
Great Southern Hwy
Karping Rd
SHIRE OF CUBALLING
8
7
6
5
4
3
2
Hotham River Nature Reserve
Hotham River North
Hotham River
Great Southern Hwy

Start/End Points
Hotham River
Reach Division Line
Local Government

Data source: PHCC, SLIP, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:10,000 @ A3

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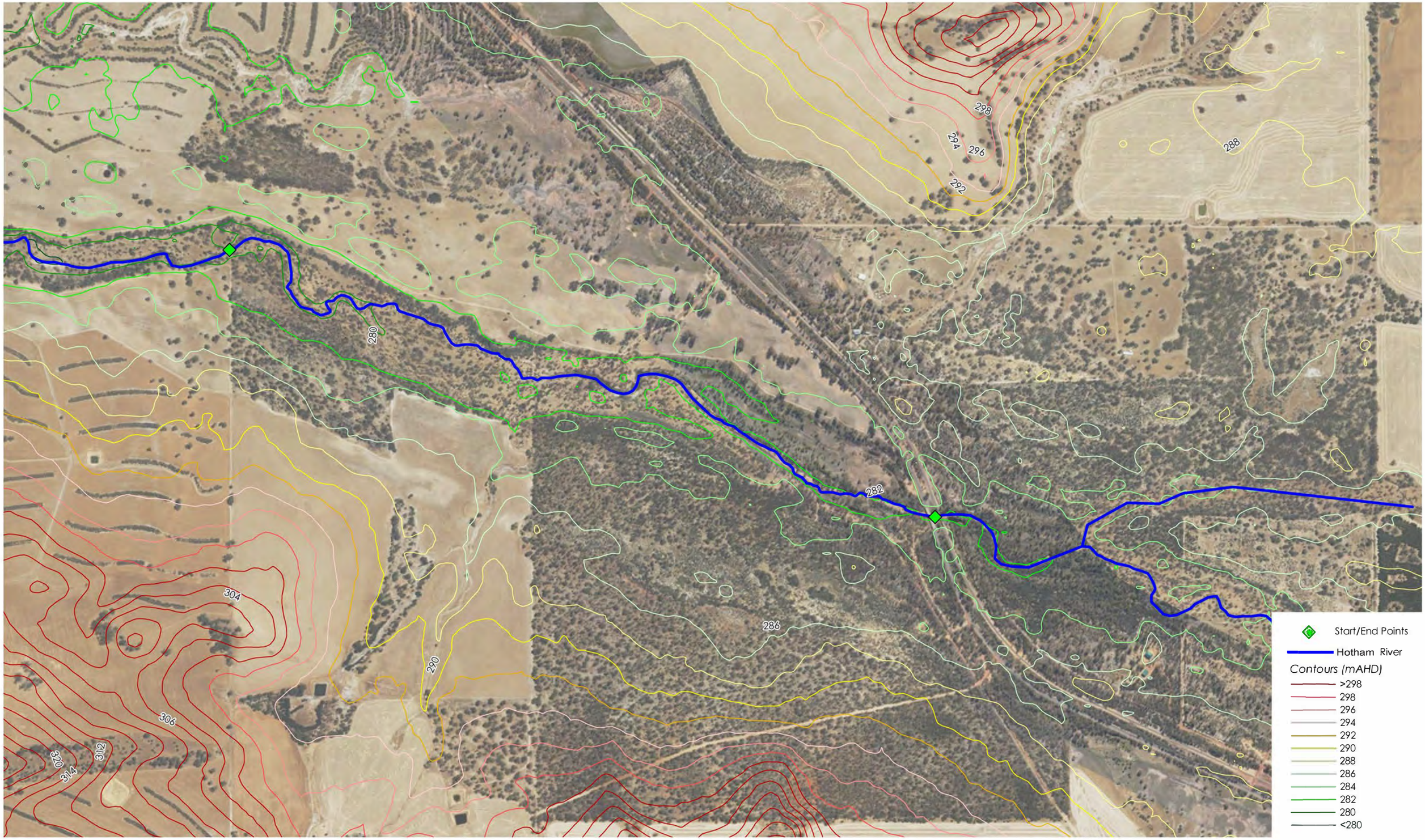
Peel Harvey Catchment Council - Hotham-Williams River Action Plan

Figure 14 - Hotham River Nature Reserve Elevation Map



Data source: PHCC, SLIP. Created by:YY Projection: MGA: zone 50.

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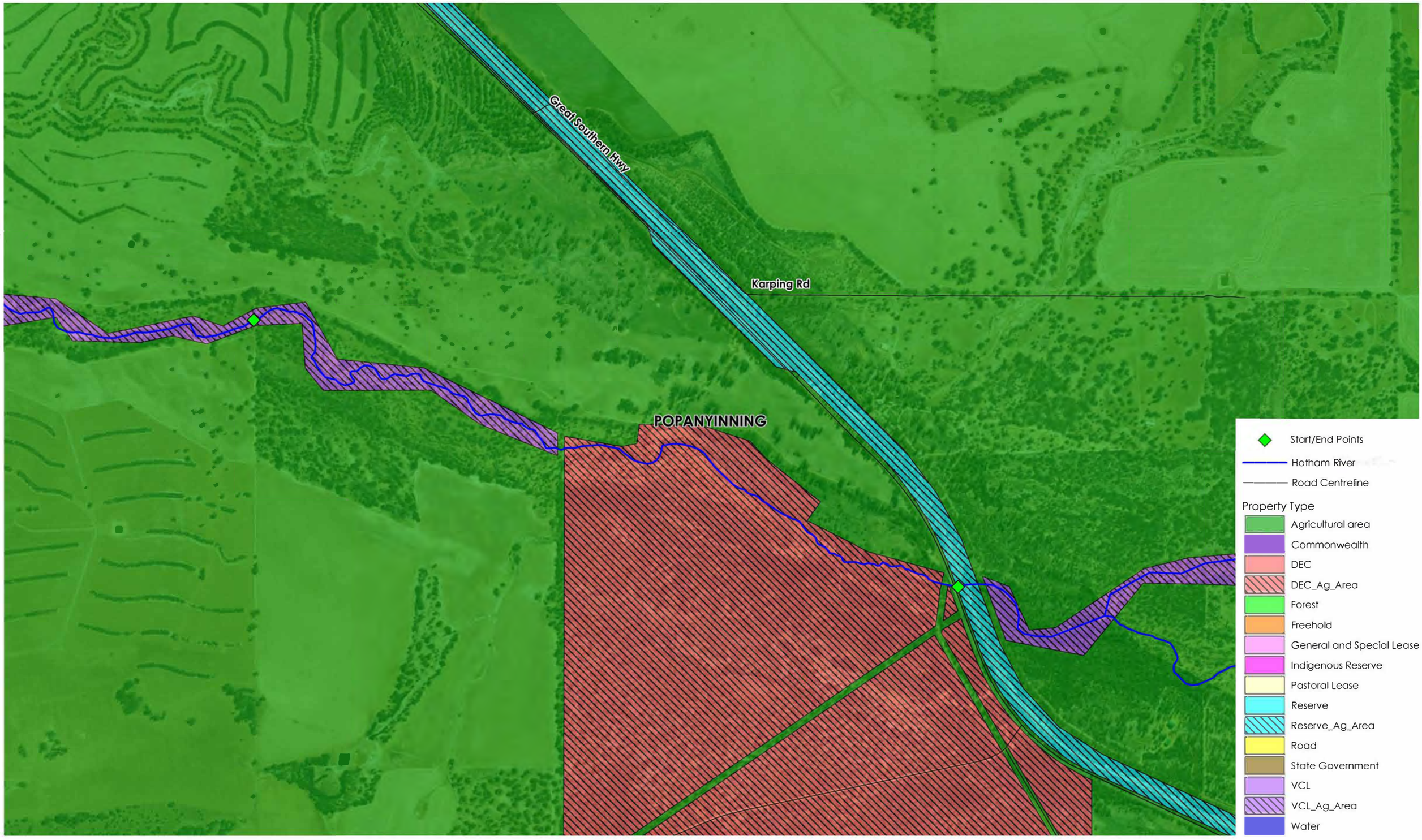
Scale 1:10,000 @ A3

urbaqua land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 15 - Hotham Nature Reserve Land Use Map



Data source: PHCC, SLIP, DWER. Created by:YY Projection: MGA: zone 50.

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3.2.3 Hotham River Nature Reserve

The assessment reach of the Hotham River within the Hotham Nature reserve extends from the Great Southern Highway to approximately 2.6 km downstream. Assessment of this reach included the definition of 7 sub-reaches, each being approximately 300 m in length (Figure 13). Characteristics of the River, defined by results of the field assessment and desktop review are provided in Table 13, with management recommendations provided in Table 14 .

Plate 3: Hotham River Nature Reserve Site Photos

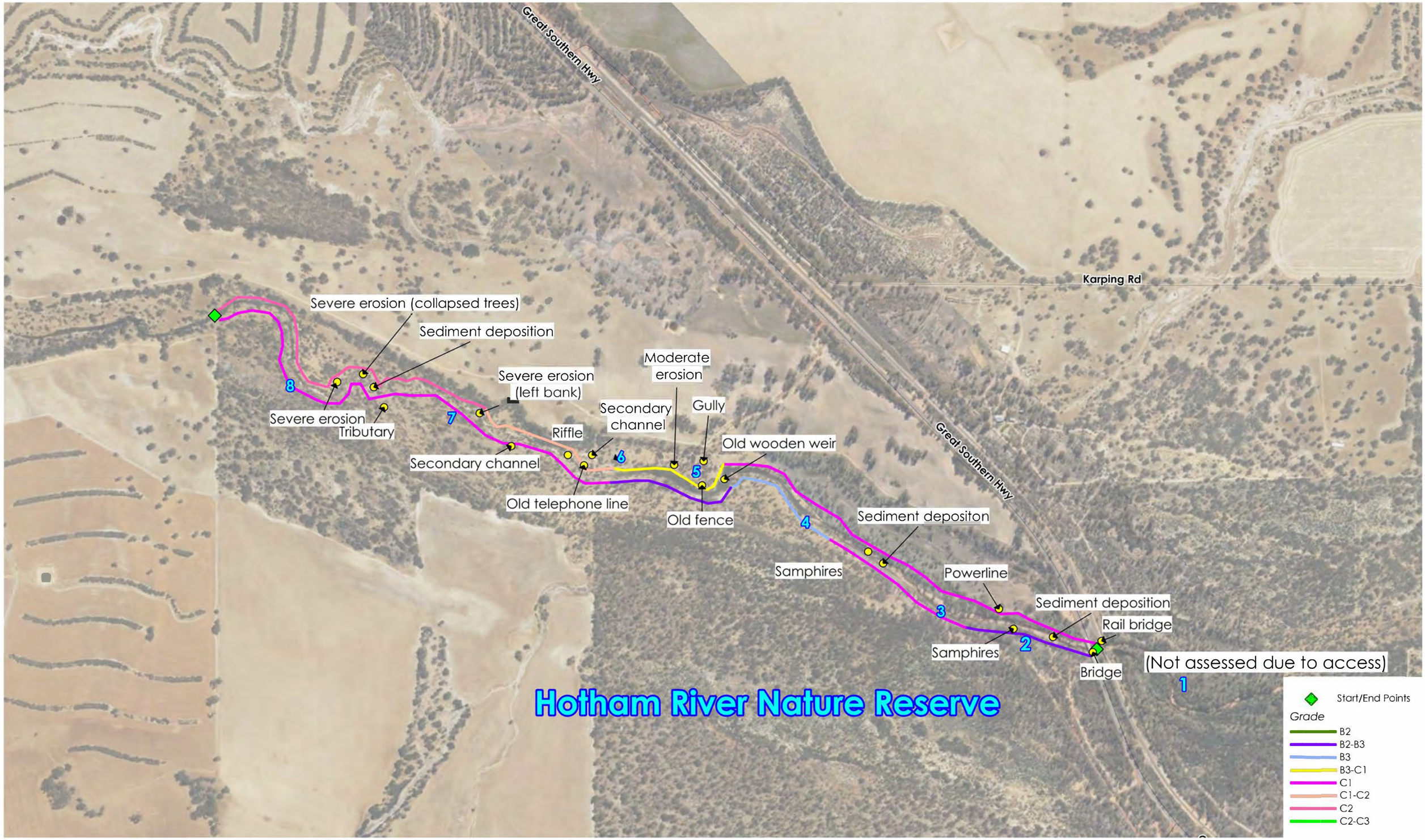
Table 13: Hotham River Nature Reserve Description and Conditions

Feature	Comments
Land use	The reach is within the northern portion of the Hotham River Nature Reserve, a 148 ha DBCA managed reserve for the conservation of flora and fauna. North of the River and south (beyond the reserve) is rural land.
Fencing and Infrastructure	Fencing along the River is set back from the banks and generally aligns with the firebreaks in the adjacent paddocks. No livestock was observed within the channel, but tracks and prints from kangaroos, dogs and cats were noted. There is a wooden weir within the channel (Figure 16) that is heavily damaged, but still inhibits flows in this reach.
Channel Form	The channel has a meandering form with varying width between 8 and 25 m. The meandering and sediment deposition within the channel has formed cut-offs and secondary channels creating a variety of habitats. There is also an abundance of woody debris throughout the channel.
General Foreshore Condition	Assessment of the foreshore condition ranges from average (B2-B3 – degraded) to erosion prone (C2 – soil exposed). The general trend is decreasing condition downstream away from the Hotham River Nature Reserve, associated with reduced verge vegetation condition and increased bank instability. Riparian vegetation and stream cover were generally poor throughout the reach.
Vegetation Cover and Stream Health	Riparian vegetation is dominated by scattered trees and exotic ground cover. The vegetation is degraded throughout the reach, with minimal shrub layers and dying trees limiting the shading of the River. In many cases, the verge vegetation in the Reserve is in better condition than on the banks, which could be attributed to a number of factors including erosion, Phytophthora dieback, insect attack, salinity and drought stress. Samphire was noted in several locations within this reach.
Weeds	Weeds were observed throughout the reach, including extensive exotic grasses within the riparian zone. Bridal Creeper, Wild Oats, Guildford Grass and Cape Weed were noted throughout the reach, including within the Reserve.
Erosion	The upstream, wider areas of the reach feature generally shallow banks with minor erosion, however there is a considerable sediment (sand) deposit within the channel. High and severe erosion was noted in meandering sections downstream, where the channel narrows. Bank undercutting on the outside of meander bends is pronounced, including the collapse of large trees.
Other Issues	Field inspections noted the presence of algae in the water column and substrate consistently throughout the reach, particularly in stagnant pools.
Cultural and Community Heritage	The Aboriginal Heritage Act 1972 (WA), protects all Aboriginal Heritage sites in Western Australia whether they are registered with the Department of Planning, Lands and Heritage or not. Noongar Elders and Representatives will provide specific knowledge and advice about cultural significance and values at the Hotham River Nature Reserve. Please refer to section 2.4 of this document to ensure all processes and procedures are followed. This part of the River was originally the Pingelly town water supply and a swimming hole was located close to the Great Southern Highway Bridge. The reserve is currently under the management of the Department of Biodiversity, Conservation and Attractions and community access is now somewhat limited.

Table 14: Hotham River Nature Reserve Management Actions and Recommendations

Prioritised management actions recommended
• Investigate the causes of dying trees along this reach to guide future rehabilitation works, noting the presence of samphire indicates that salinity may be the key factor; • Improve the condition of fringe vegetation (away from the River) including the eradication of significant weeds and revegetation to improve tree density and understorey; • Investigate local sources of sediment, and work with landholders to improve land management practices; • Undertake feral animal control programs within the reserve; and • Remove the existing weir structure (with relevant approvals) to prevent standing water and monitor the channel response (erosion and meandering upstream and downstream).
Long term management actions recommended
• Once the channel achieves a more stable form, particularly the downstream reaches, undertake planting to consolidate banks and connect riparian vegetation with fringing vegetation; • Prepare a sediment budget (sources and stores of sediment) for this area and investigate tributaries and the main channel upstream to Popanyinning to understand the sediment sources and potential for sediment mobilisation to downstream pools; and • Investigate opportunities to increase fringing vegetation at the downstream reaches, including on private rural land.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 16 - Hotham River Nature Reserve Condition Map



Data source: PHCC, SLIP, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:8,000 @ A3

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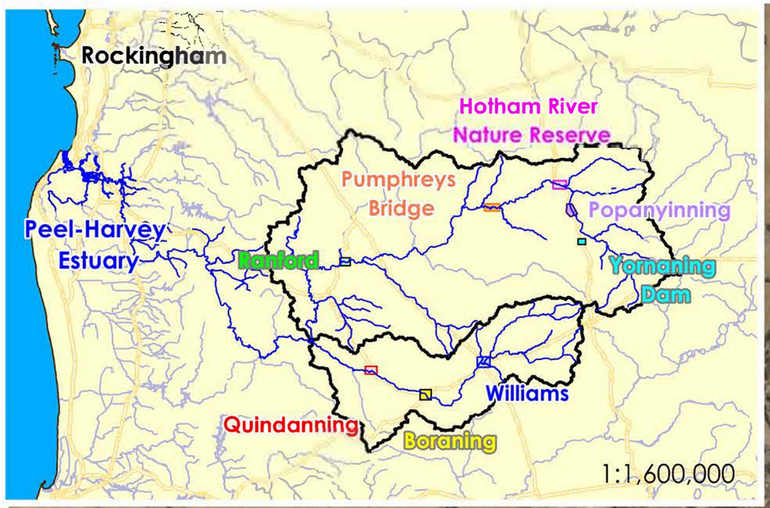
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 17 - Pumphreys Bridge Location Map



Data source: PHCC, Created by:YY Projection: MGA: zone 50.

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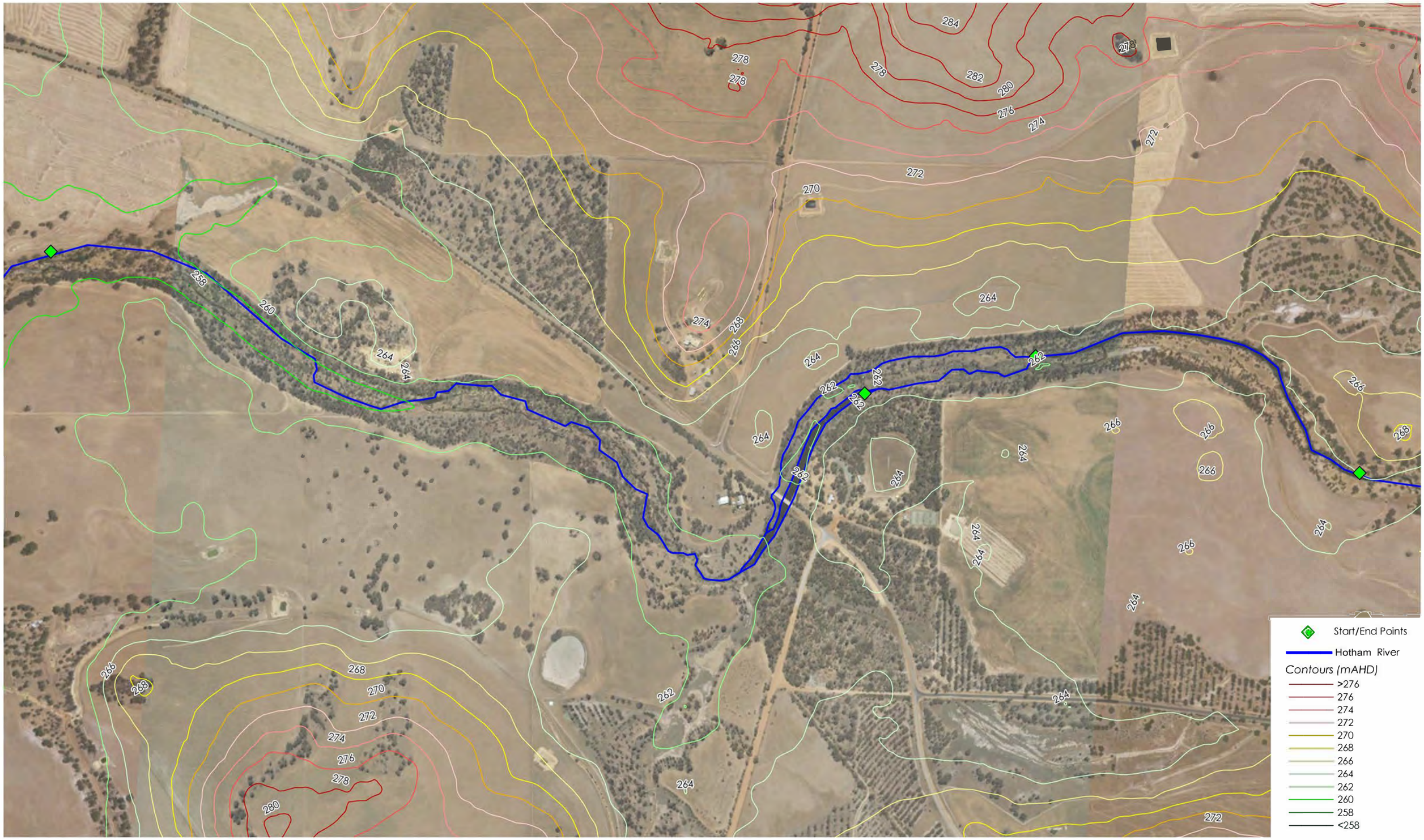
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 18 - Pumphreys Bridge Elevation Map



Data source: PHCC, SLIP, Created by:YY Projection: MGA: zone 50.

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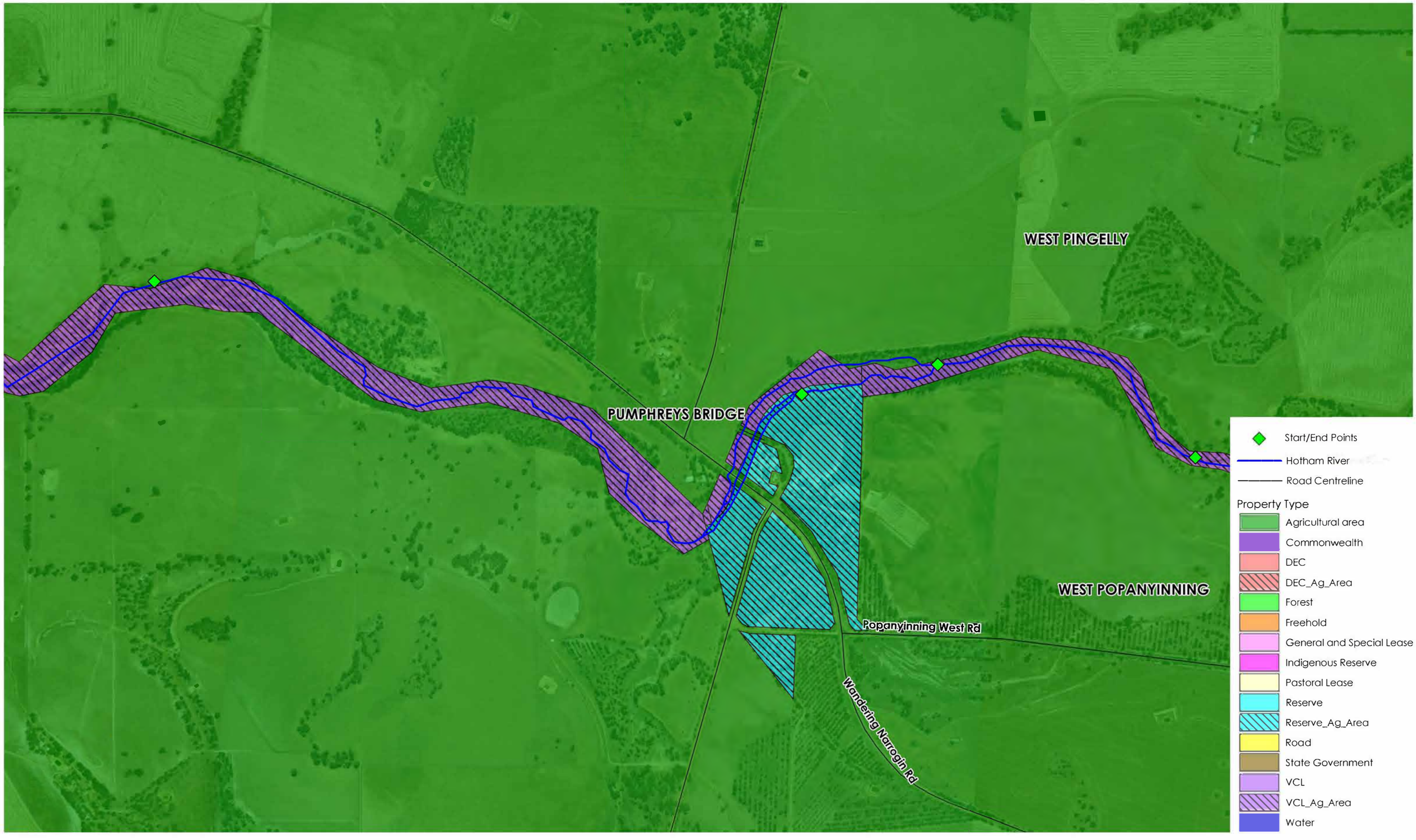
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 19 - Pumphreys Bridge Land Use Map



Data source: PHCC, SLIP, DWER. Created by:YY Projection: MGA: zone 50.

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3.2.4 Pumphreys Bridge

The assessment reach of the Hotham River at Pumphreys Bridge extends either side of current bridge (Wandering-Narrogin Road) covering approximately 3.5 km. Assessment of this reach included the definition of 9 sub-reaches (one sub-reach was not assessed due to safety concerns), each being approximately 400 m in length (Figure 17). Characteristics of the River, defined by results of the field assessment and desktop review are provided in Table 15, with management recommendations provided in Table 16.

Plate 2: Pumphreys Bridge Site Photos

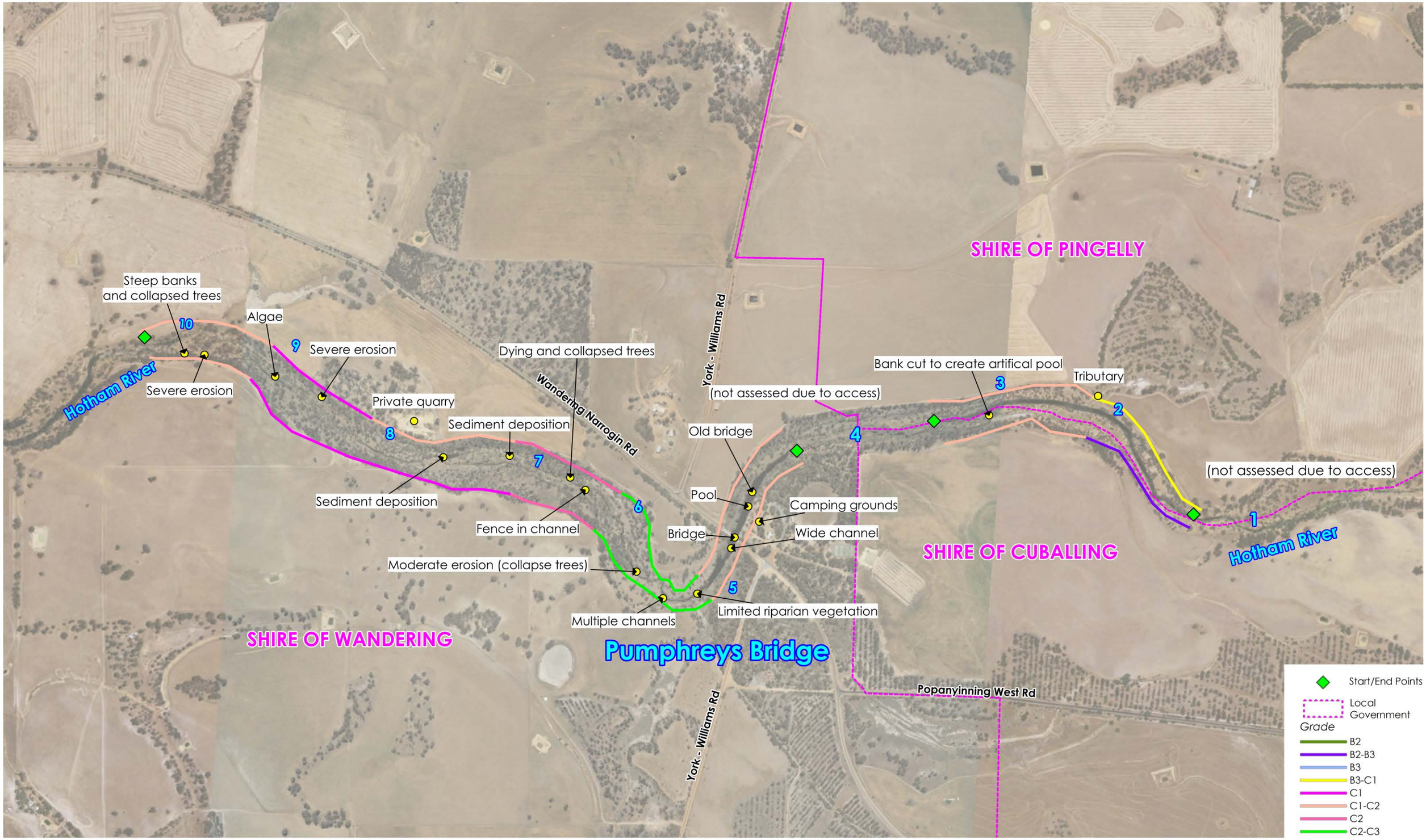
Table 15: Pumphreys Bridge Description and Conditions

Feature	Comments
Land use	The majority of the reach is surrounded by rural land use. The informal Pumphreys Bridge camp ground is located on the eastern side of the River upstream of the bridge along with a community hall. The closest dwelling to the River is on the southern side of the bridge, approximately 80 m from the River. There is a small private quarry on the northern side of the River, adjacent to the riparian vegetation downstream from the bridge. The other notable feature is the sporting ground upstream from the bridge, surrounded by remnant vegetation.
Fencing and Infrastructure	Fencing condition was noted as average along the River where it was visible during the assessment. Damage from stock access (sheep) was observed through the reach including minor vegetation damage, tracks and pugging. Significant structures along the River include the new bridge (Wandering-Narrogin Road) and the old wooden bridge (York-Williams Road). An informal River crossing structure was also observed downstream of the assessment area.
Channel Form	The River has a meandering form with two wider pools at, and upstream of the bridge. These pools are approximately 20 m wide in contrast to the remainder of the channel which is typically 2 m wide. A cut/diversion in the channel was noted in the upstream area, potentially acting to provide water for stock access.
General Foreshore Condition	Foreshore condition varies from B2-B3 (degraded) to C2-C3 (eroded and soil exposed), though the majority of the reach is graded C1 (erosion prone) associated with degraded vegetation and limited stream cover. The lowest graded areas are located in the middle of the reach, downstream of the bridge, where riparian vegetation is highly degraded and erosion has created small meanders.
Vegetation Cover and Stream Health	Riparian vegetation along this reach is broadly characterised by exotic ground cover and scattered trees (Flooded Gum, Wandoo and York Gum) providing limited stream cover. Riparian vegetation has been damaged by stock access and direct clearing (for the camp grounds) and verge vegetation is generally limited by the rural land use.
Weeds	The exotic ground cover through the reach includes Couch, Wild Oats, Guildford Grass, Cape Weed, Bridal Creeper and Brome Grass.
Erosion	Erosion was common along the reach, though generally noted as minor to moderate. Upstream of the bridge the banks are shallow and erosion results in bare ground or exposed sediment. Downstream from the bridge, erosion has caused bank and tree collapse and large sediment deposits colonised with exotic grasses.
Other Issues	Algae was isolated to one sub-reach at the downstream end of the assessment area.
Cultural and Community Heritage	The Hotham River and its major tributaries are a registered aboriginal site and are considered of mythological importance. Noongar Elders and Representatives will provide specific knowledge and advice about cultural significance and values at Pumphreys Bridge. Please refer to section 2.4 of this document to ensure all processes and procedures are followed. The informal camp ground is the site of long term use by the local community spanning many decades. The River at this location has been valued and used as a swimming, camping and fishing spot dating back to early settlement. Adjacent to the River is the historic Country Women's Association Hall and Pumphreys bridge tennis club and football oval.

Table 16: Pumphreys Bridge Management Actions and Recommendations

Prioritised management actions recommended
• Similar to restoration works at Ranford Pool, consider installing controlled access points for recreation using rock pitching and/or steps to prevent bank erosion; • Work with the landholder downstream of the bridge to limit stock access through improved fencing and constructed, defined crossings; • Work with the landholder to ensure the quarry is suitably managed and wind and water actions do not bring excessive sediment into the channel; • Investigate the origins and usage of the diversion channel/pool (see Figure 20) and consider closing this feature; and • Investigate causes of dying trees downstream of bridge, and undertake planting and rehabilitation in this area to stabilise the channel.
Long term management actions recommended
• Work with the Shire of Wandering to improve camping facilities to prevent litter and fires near the channel, and improve riparian vegetation; • The camping grounds are a prominent public location on the River and educational signage should be considered here; • Consider stabilisation works for the old bridge to ensure it does not contribute to debris downstream; and • Consider bathymetric surveys of the pool near the bridge to examine capacity and sedimentation processes.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 20 - Pumphreys Bridge Condition Map



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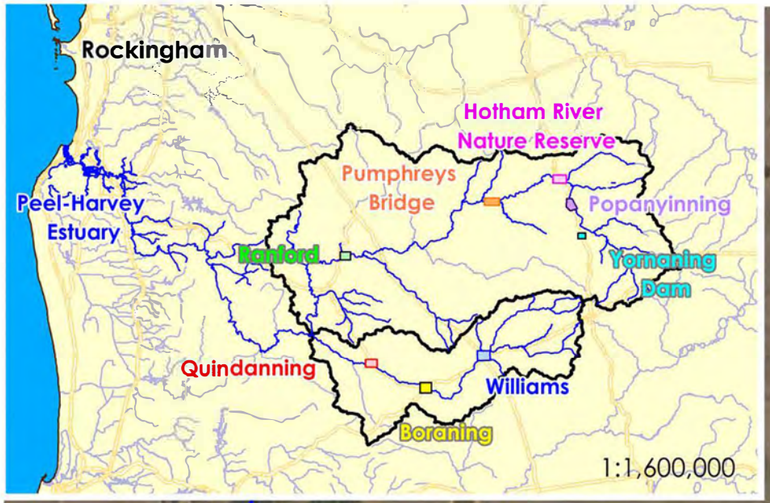
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 21 - Ranford (Darminning) Pool Location Map



Ranford Pool

Hotham River

Bannister River

Castlerock Rd

Ranford Pool Reserve

5

4

6

3

2

River Rd

Bannister Marradong Rd

SHIRE OF BODDINGTON

Crossman Rd

Crossman Rd

Ranford Rd

Start/End Points

Hotham River

Reach Division Line

Local Government

Data source: PHCC, SLIP, DWER. Created by:YY Projection: MGA: zone 50.

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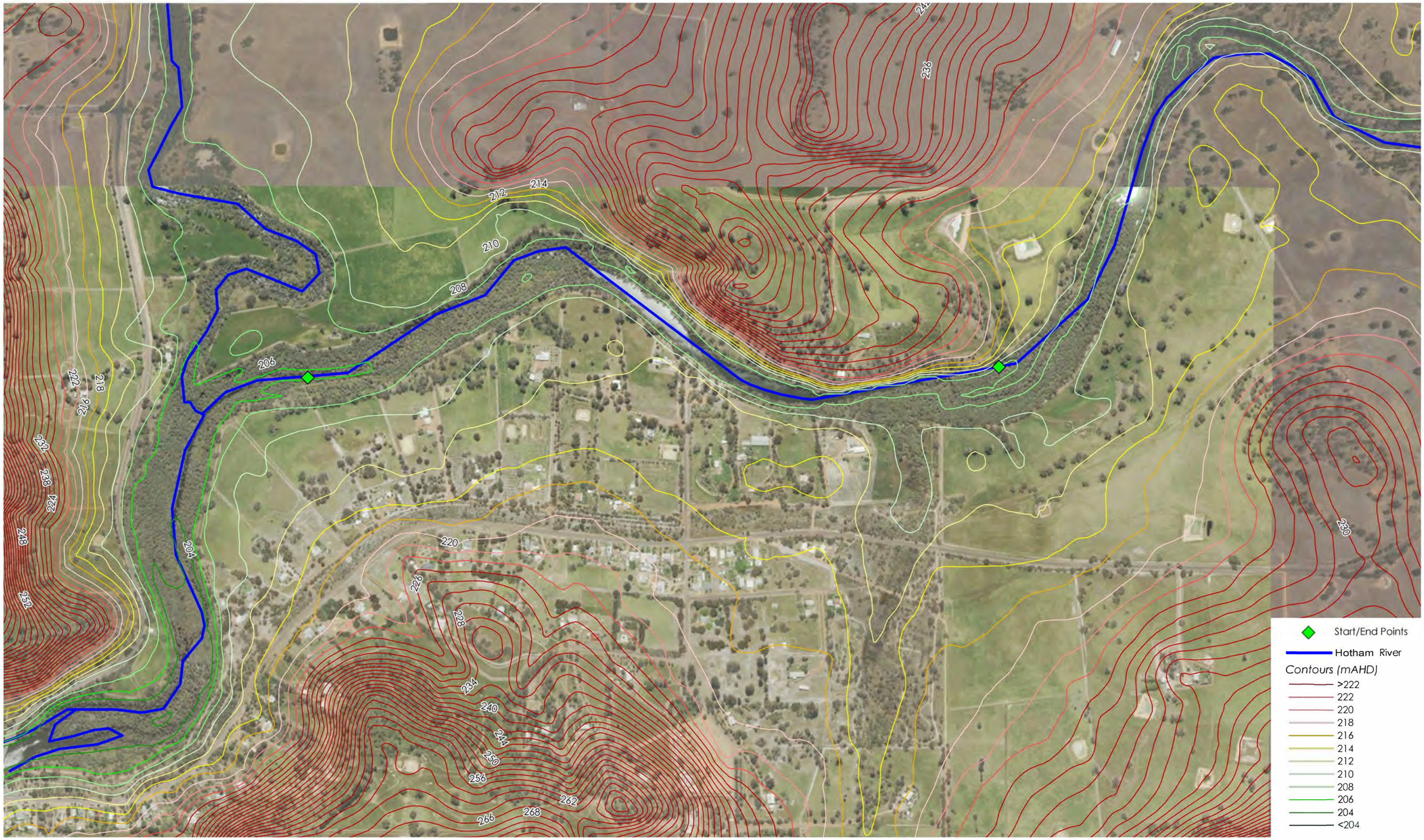
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 22 - Ranford (Darminning) Pool Elevation Map



Data source: PHCC, SLIP. Created by:YY Projection: MGA: zone 50.

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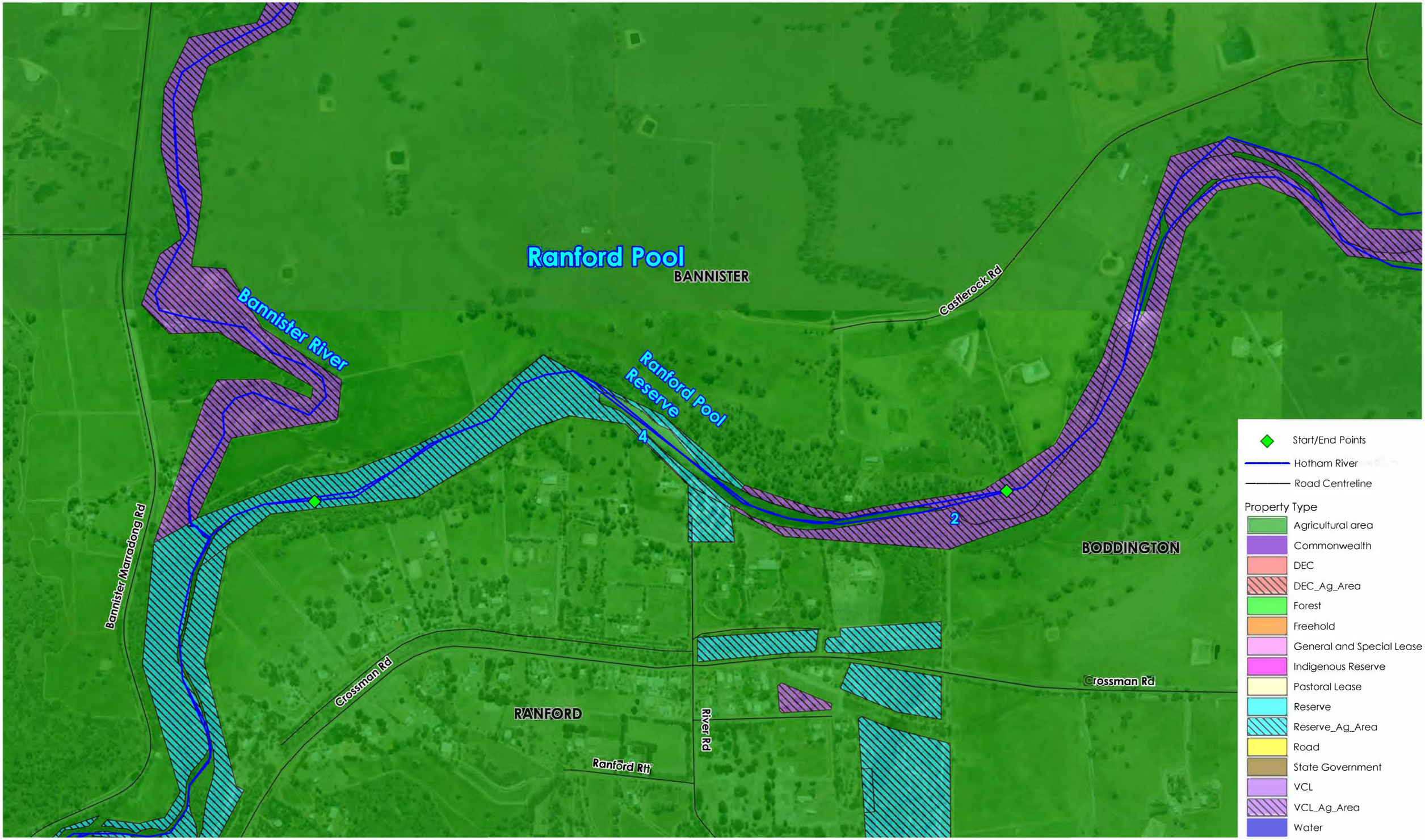
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 23 - Ranford (Darminning) Pool Land Use Map



Data source: PHCC, SLIP, DWER. Created by:YY Projection: MGA: zone 50.

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3.2.5 Ranford (Darminning) Pool

The assessment of the Ranford Pool reach includes the pool and channel upstream and downstream, covering approximately 1.8 km. Assessment of this reach included the definition of 5 sub-reaches, each being approximately 400 m in length (Figure 21). Characteristics of the River, defined by results of the field assessment and desktop review are provided in Table 17, with management recommendations provided in Table 18.

Plate 1: Ranford Pool Site Photos

Table 17: Ranford (Darminning) Pool Description and Conditions

Feature	Comments
Land use	This reach is located upstream from Boddington and the confluence with the Bannister River in Ranford. Land use north and south of the river is rural and rural residential and Ranford Pool itself is contained within a reserve. Ranford Pool is a popular recreation site as it is a permanent pool in summer months.
Fencing and Infrastructure	Fencing on the southern side of the river was rated good downstream from Ranford Pool. Upstream, the fencing was noted as average to good, with the presence of sheep recorded on both sides of the river. Around the Ranford Pool reserve, restoration works have been conducted in the past 12 months, including the installation of timber steps (to control access), rock pitching and plantings (bank stabilisation). On the southern bank there is infrastructure associated with a Tannery Extracts Factory (closed in the 1960s).
Channel Form	The channel is divided into three forms: a narrow upstream channel <10 m wide; Ranford Pool is a deep permanent water body, approximately 700 m long, 50 m wide and up to 2 m deep; and a narrow meandering downstream channel <10 m wide.
General Foreshore Condition	Scoring of the channel condition was generally consistent along the reach, with the southern bank ranging from B2 to B2-B3 (degraded and weed infested) and the northern bank ranging from B2 (degraded) to C1 (erosion prone). Variation on the northern bank is attributed to the varying riparian and verge vegetation quality, with degradation and absence of the shrub layer particularly evident with the rural land use along Ranford Pool. Vegetation and erosion along the southern bank was consistently degraded along the entire reach.
Vegetation Cover and Stream Health	Vegetation cover in this reach is generally dominated by tree cover (Eucalyptus sp. including Flooded Gums; and Melaleuca sp.) with a limited understorey and exotic grasses. The shrub layer has been reduced from stock access (northern bank) or human (southern bank, associated with Ranford Pool reserve and the presence of a track from the Boddington townsite). Vegetation cover improves downstream from Ranford Pool, which is attributed to greater canopy cover at this location.
Weeds	The ground cover along the reach generally consists of exotic species. The field investigations noted common weeds along the reach including Bridal Creeper, Wild Oats, Cape Weed, Cape Tulip, Fiddle Dock, Guildford Grass and Rye Grass.
Erosion	Banks along this reach are susceptible to erosion from flows and runoff, and damage from human and stock access. Erosion was noted almost continuously on the northern bank though generally only low to moderate with the risk of tree collapse. Similar erosion was observed on the southern bank, though rehabilitation works at Ranford Pool are aimed at stabilising the damage. Large sediment (sand) deposits were visible upstream and downstream of the pool, suggesting the pool is likely to contain sediment.
Other Issues	This reach was covered by the Boddington Flood Modelling Report (SKM, 2009) that determined the floodplain for a major flood event (100 yr ARI) is approximately 300 m wide in the downstream areas. Mapping for the 10 yr and 25 yr ARI events is also provided and any remediation works should consider the risk from flooding.
Cultural and Community Heritage	The Hotham River and its major tributaries are a registered aboriginal site and are considered of mythological importance. Noongar Elders and Representatives will provide specific knowledge and advice about cultural significance and values at Ranford (Darminning) Pool. Please refer to section 2.4 of this document to ensure all processes and procedures are followed. A tannin extracts factory was operating adjacent to Ranford Pool from 1937 to 1964 which extracted water from and discharged water into the river as part of its operations. The Pool has been used by the local community for decades as a swimming and fishing spot. These activities along with

Feature	Comments
	kayaking are still popular, and the dedicated walking track facilitates ongoing enjoyment of the natural area by the local community. Recent rehabilitation works have stabilised the banks and provided dedicated access points to the River.

Table 18: Ranford (Darminning) Pool Management Actions and Recommendations

Prioritised management actions recommended
• Undertake a baseline bathymetry survey of Ranford Pool to understand the current topography and capacity of the channel and banks. Annual surveys should be undertaken to measure changes in the pool volume and to consider intervention measures; • Work with the landholders on the northern side of the river to improve fencing and limit stock access; • Consider localised bank protection to prevent erosion near significant, healthy, native trees and/or adjacent to the track on the southern side of the river for safety; and • Provide resources such as fact sheets, to adjacent landholders to identify and eradicate significant weeds.
Long term management actions recommended
• Monitor and document the success and failures of the remediation works at Ranford Pool as a template for other sites in the catchment; • Extend remediation works in the Ranford Pool reserve to banks upstream and downstream to stabilise additional areas; • Update signage within the reserve for community education regarding the wider catchment; • Investigate the water quality in the tributary south of the site and consider modification and planting to improve nutrient and sediment removal; • Provide safe access to the river and formal walk tracks from the townsite that are not susceptible to erosion and collapse; and • Consider floodplain risks (available mapping) in future infrastructure and rehabilitation works.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 24 - Ranford (Darminning) Pool Condition Map

Bannister Marradong Rd
Hotham River
Ranford Pool
Bannister River
Castlerock Rd
Multiple channels
Paperbark trees
Sediment deposition
Rope swing
Ranford Pool Reserve
Moderate Erosion
Restoration work
Pool
Community facilities
Moderate erosion
Sediment deposition
(Not assessed due to access)
Narrow, confined channel
Old pump
Tributary
River Rd
Bannister Marradong Rd
SHIRE OF BODDINGTON
Crossman Rd
Crossman Rd
Ranford Rtt
1
2
3
4
5
6
Start/End Points
Grade
B2
B2-B3
B3
B3-C1
C1
C1-C2
C2
C2-C3

Data source: PHCC, SLIP, DWER, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:8,000 @ A3

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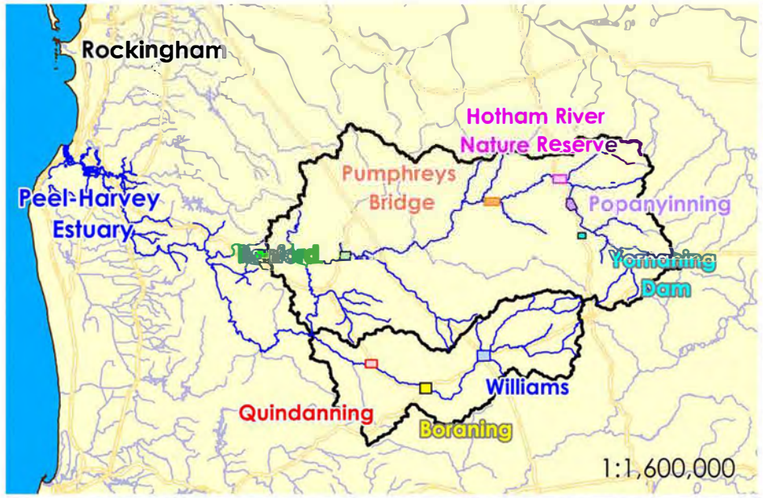
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 25 - Williams Location Map



Murrihoola Rd
Richmond St
Piesse St
Coalling Brook
Albany Hwy
SHIRE OF WILLIAMS
Williams River
Williams
Brooking St
Narrogin Rd
MacDermott Brook
Williams Town
Pool
Millbrook Pl
Millpond Rd
1
2
3
4
5
6
7
8
9

Start/End Points
Williams River
Reach Division Line
Local Government

Data source: PHCC, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:7,000 @ A3

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Peel Harvey Catchment Council-Hotham-Williams River Action Plan
Figure 26 - Williams Elevation Map

Data source: PHCC, SLIP, Created by:YY Projection: MGA: zone 50.

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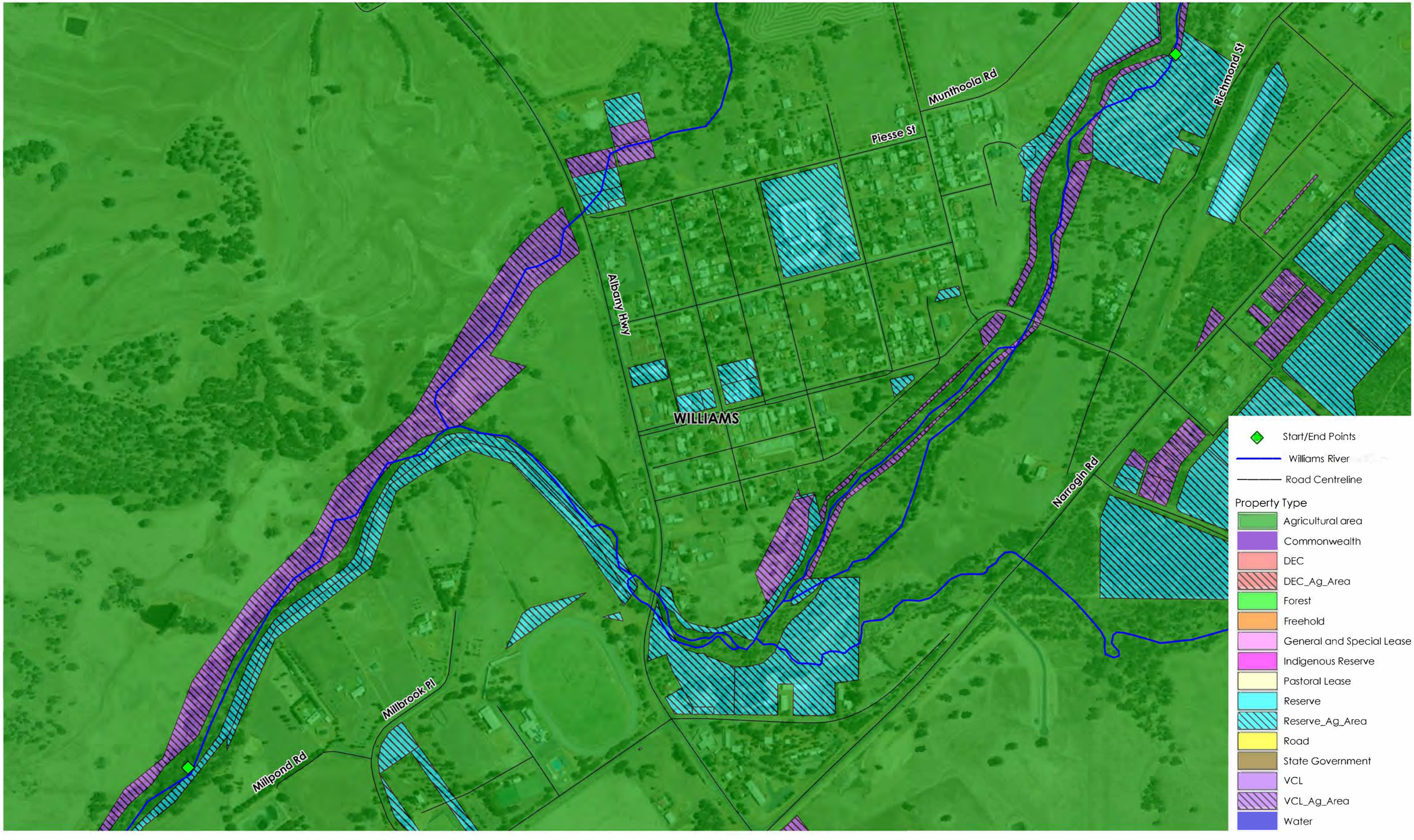
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 27 - Williams Land Use Map



Data source: PHCC, SLIP, DWER. Created by:YY Projection: MGA: zone 50.

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land and water solutions

3.2.6 *Williams*

The assessment reach of the Williams River with the Williams townsite extends upstream and downstream of Albany Highway covering approximately 3.4 km. Assessment of this reach included the definition of 9 sub-reaches, each being approximately 400 m in length (Figure 25). Characteristics of the river, defined by results of the field assessment and desktop review are provided in Table 19, with management recommendations provided in Table 20.

Plate 6: Williams Site Photos

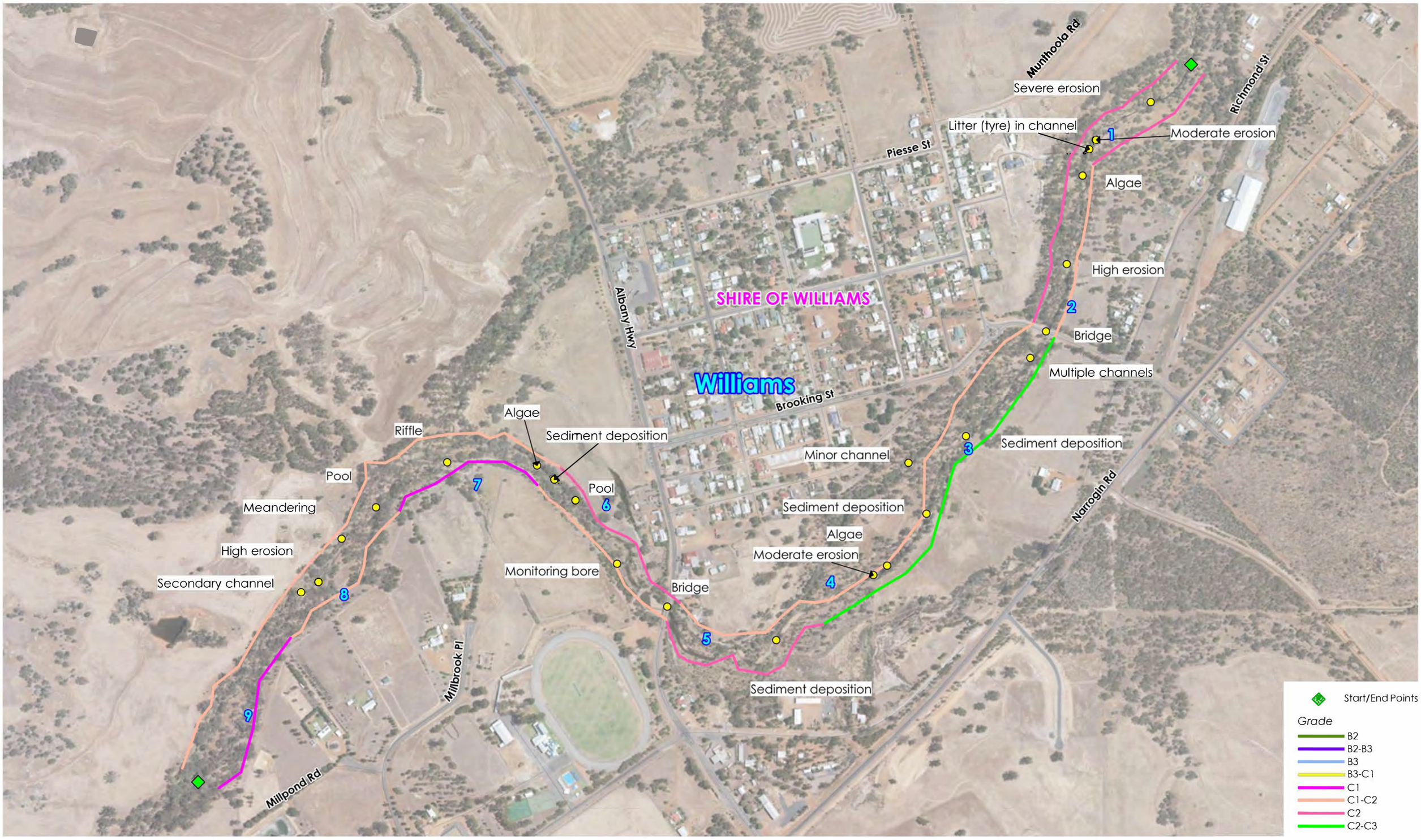
Table 19: Williams Description and Conditions

Feature	Comments
Land use	The Williams River flows through the Williams townsite. The river is bounded by a variety of land uses including reserves, industrial, residential (within the townsite), rural and rural residential (upstream and downstream of the townsite). Land east of Albany Highway (behind the roadhouse) is zoned residential, but has not been developed.
Fencing and Infrastructure	Fencing was of mixed quality through the reach, with poor or missing fencing in the upstream areas. Downstream of the confluence with Coalling Brook, the fencing was rated as average. There are two bridges across the river: Brooking Street and Albany Highway. The Albany Highway bridge was recently upgraded and consequently there are exposed banks upstream and downstream, with some rock protection. Upstream of Albany Highway there is a path along the river.
Channel Form	The channel has a meandering form in this reach, with a series of pools in the river. Water levels during the field inspection were low and many of the pools appeared as smaller, parallel channels. The majority of the reach has channel widths between 4 m and 8 m, however pools (particularly the Williams Town Pool downstream of Albany Highway) are up to 30 m wide.
General Foreshore Condition	Channel condition is relatively consistent along the reach, varying only between C1 (erosion prone) and C2-C3 (soil exposed – eroded). The poor rating is associated with high levels of erosion and sedimentation within the channel, reduced riparian vegetation and clearing for surrounding land uses.
Vegetation Cover and Stream Health	Vegetation cover was typical of other reaches in the catchment with a near continuous tree cover, limited understorey and a high proportion of exotic ground cover. The common trees and shrubs along the reach are Eucalyptus sp., Sheoak and Melaleuca sp. Stream shading and tree overhang were generally poor. Vegetation conditions were consistent along the reach, though shrub layers were improved in parts downstream of Albany Highway. Upstream of the highway is an area of revegetation works.
Weeds	The proportion of exotic ground cover was consistently recorded as >75%. Common weeds were African Love Grass, Bridal Creeper, Wild Oats, Cape Tulip, Dock/Sorrel, Kikuyu, Couch, Fleabane, and Veldt grass. A small Olive tree was recorded at the upstream end of the reach. Watsonia was also noted on the northern upstream reaches.
Erosion	The channel was relatively active (in comparison with other reaches), with high/severe erosion in many locations and significant amounts of sediment within the channel. The instability was associated with the meander bends, both small and large (for example upstream of Albany Highway). Erosion has caused bank retreat, slumping and tree collapse.
Other Issues	Owing to the location near the townsite, litter was identified in the river, including a tyre in the channel.
Cultural and Community Heritage	The Aboriginal Heritage Act 1972 (WA), protects all Aboriginal Heritage sites in Western Australia whether they are registered with the Department of Planning, Lands and Heritage or not. Noongar Elders and Representatives will provide specific knowledge and advice about cultural significance and values of the Williams River where it runs through the Williams town site. Please refer to section 2.4 of this document to ensure all processes and procedures are followed. The River at this location is used by the community for recreational purposes, such as the weir, picnic areas and the recently re-developed Lions Park which includes a nature playground and an iconic giant Numbat sculpture. Some revegetation has been carried out by the community in the past to improve habitat.

Table 20: Williams Management Actions and Recommendations

Prioritised management actions recommended
• Remove bulky litter from the river and encourage community events to remove other smaller items of litter; • Improve vegetation (weed control and planting) along the entire reach, with priority areas immediately downstream of Albany Highway and south of Cornwall Terrace, utilising community volunteers where possible; • Acquire available topography and bathymetry survey data from MRWA regarding the new bridge design and construction, and investigate whether this can be continued to monitor sediment within the town pool; and, • Install bank protection measures (rock pitching, geo-fabric) at key locations, including upstream of Albany highway (to protect rehabilitation areas) and the reach upstream of the confluence with MacDermott Brook.
Long term management actions recommended
• Work with developers to ensure zoned land south of Growse Street implements water sensitive urban design (including water quality protection) and appropriate sediment controls during construction to prevent damage to the adjacent channel; • Investigate opportunities to increase fringing vegetation downstream of Albany Highway and east of the river between Williams Street and Brooking Road; • Investigate channel instability in tributaries and upstream of the townsite to determine the sources of sediment; and • Install signage within the bridge construction laydown for community education regarding the Williams River and the wider catchment.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 28 - Williams Condition Map



Data source: PHCC. Created by:YY Projection: MGA: zone 50.

0 500
meters
Scale 1:7,000 @ A3

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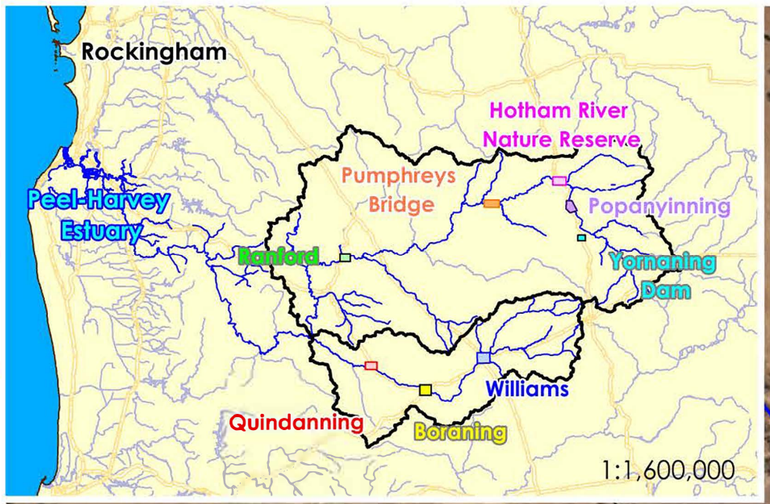
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 29 - Boraning Reserve Location Map



Chapman Rd
Pinjarra Williams Rd
Williams River
SHIRE OF WILLIAMS
Pinjarra Williams Rd
3
2
Collie Williams Rd
Cubbin - Boraning Rd
Boraning
Reserve

Start/End Points
Williams River
Reach Division Lines
Local Government

Data source: PHCC, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:10,000 @ A3

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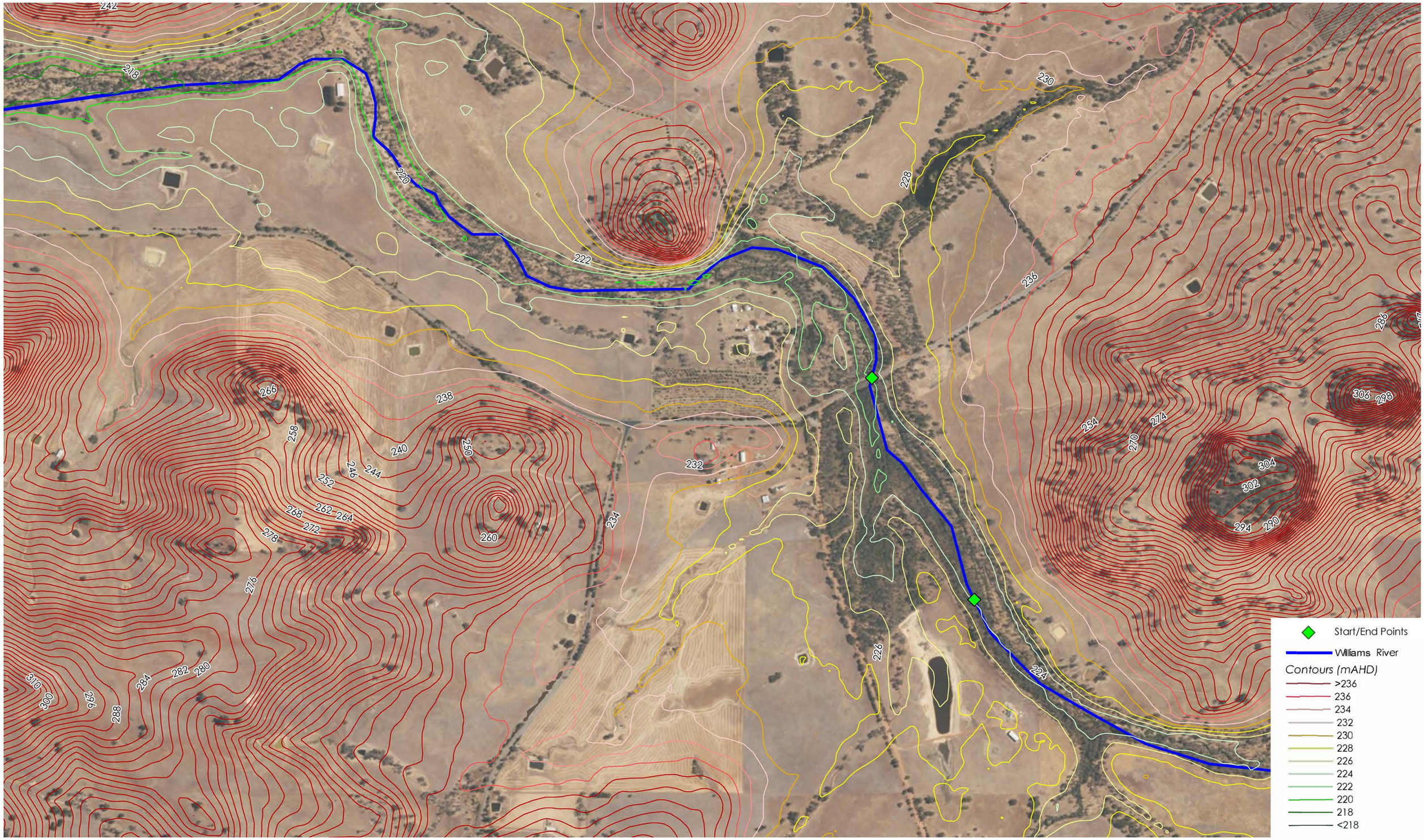
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 30 - Boraning Reserve Elevation Map



Data source: PHCC, SLIP. Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:10,000 @ A3

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Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 31 - Boraning Reserve Land Use Map

Data source: PHCC, SLIP, DWER. Created by:YY Projection: MGA: zone 50.

0 1,000
meters
Scale 1:10,000 @ A3

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3.2.7 Boraning Reserve

The Boraning Reserve reach of the Williams River is approximately halfway between Williams and Quindanning. Only 0.7 km of the river at Boraning Reserve reach was assessed, with 2 sub-reaches defined upstream of the Pinjarra-Williams Road Bridge (Figure 29). Characteristics of the river, defined by results of the field assessment and desktop review are provided in Table 21, with management recommendations provided in Table 22.

Plate 7: Boraning Site Photos

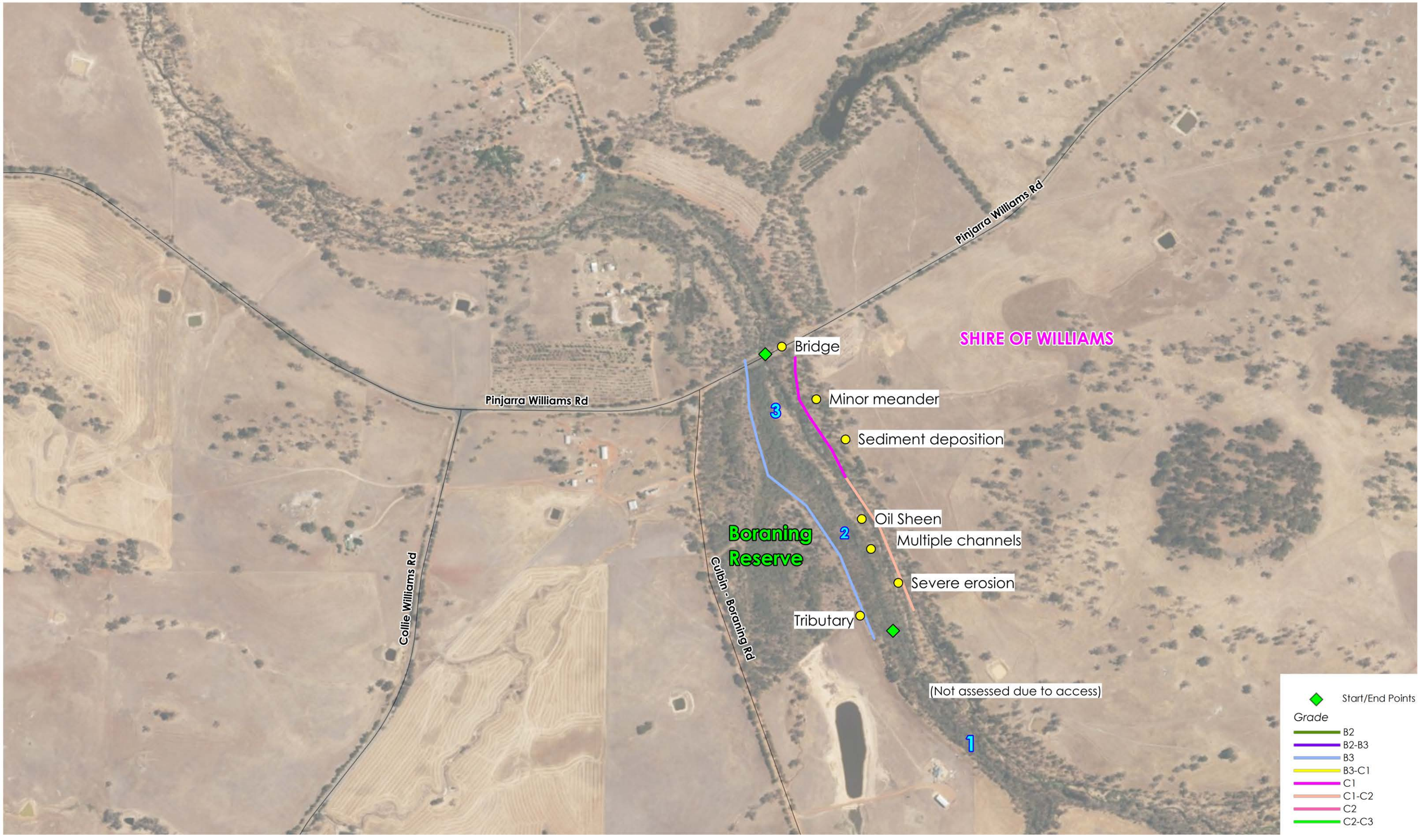
Table 21: Boraning Reserve Description and Conditions

Feature	Comments
Land use	The river is surrounded by rural land use to the east, and the Boraning Reserve to the west, containing remnant vegetation connecting to the road reserve.
Fencing and Infrastructure	Fencing on the rural side of the river was rated between average and good, and no evidence of stock access was observed. There was no fencing on the western (reserve) side near the river.
Channel Form	The river transitions from multiple, parallel channels into a single channel with minor meanders towards the Bridge. The main channel features banks up to 2 m deep with a steep profile. The low flow channel was approximately 4 m wide.
General Foreshore Condition	The channel ratings varied between B3 (degraded – weed dominated) and C1/C1-C2 (eroded – soil exposed) on the western and eastern banks respectively. The key difference between the two sides of the river is the condition of the verge vegetation and the remnant vegetation in the reserve offering improved habitat and buffers for the river. Riparian vegetation and erosion conditions within the channel were generally consistent.
Vegetation Cover and Stream Health	Riparian vegetation is dominated by species of Melaleuca shrubs and scattered trees (Eucalyptus sp.) resulting in limited stream shading. Ground cover was largely exotic, including turf grass (couch) that has colonised sediment deposits within the main channel.
Weeds	Key weeds identified in this reach include Wild Oats, Fleabane, Cape Tulip, Dock, Cape Weed, Guildford Grass, Couch Grass and Dandelion.
Erosion	Erosion was generally low to moderate and not extensive through the reach. An area of high erosion (undercutting) and bank retreat was noted on the eastern upstream bank. There is considerable sedimentation within the channel, including areas that are covered with (exotic) grass.
Cultural and Community Heritage	The Aboriginal Heritage Act 1972 (WA), protects all Aboriginal Heritage sites in Western Australia whether they are registered with the Department of Planning, Lands and Heritage or not. Noongar Elders and Representatives will provide specific knowledge and advice about cultural significance and values of the Williams River at the Boraning Reserve. Please refer to section 2.4 of this document to ensure all processes and procedures are followed. The River at this location contains a pool to the north of the study reach, which would have been used by the community, with the historic Boraning Homestead nearby as well as the site of the original Williamsburg town site.

Table 22: Boraning Reserve Management Actions and Recommendations

Prioritised management actions recommended
• Undertake feral animal and weed control within the reserve; and • Investigate sources of oil flecks and sheen observed in the reach.
Long term management actions recommended
• Work with the landholder to increase the fringing vegetation on the eastern side of the river.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 32 - Boraning Reserve Condition Map



Data source: PHCC, Created by:YY Projection: MGA: zone 50.

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Scale 1:8,000 @ A3

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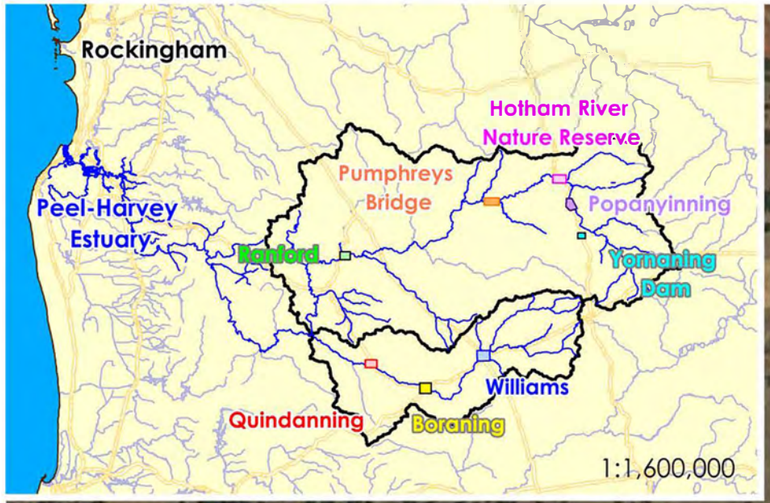
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 33 - Quindanning Location Map



Quindanning
Pinjarra Williams Rd
SHIRE OF WILLIAMS
Williams River
4
3
Quindanning Pool
2
1
6
5
Harvey - Quindanning Rd
SHIRE OF BODDINGTON
Waldock Rd
Pinjarra Williams Rd
Williams River

Start/End Points
Williams River
Reach Division Lines
Local Government

Data source: PHCC, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:15,000 @ A3

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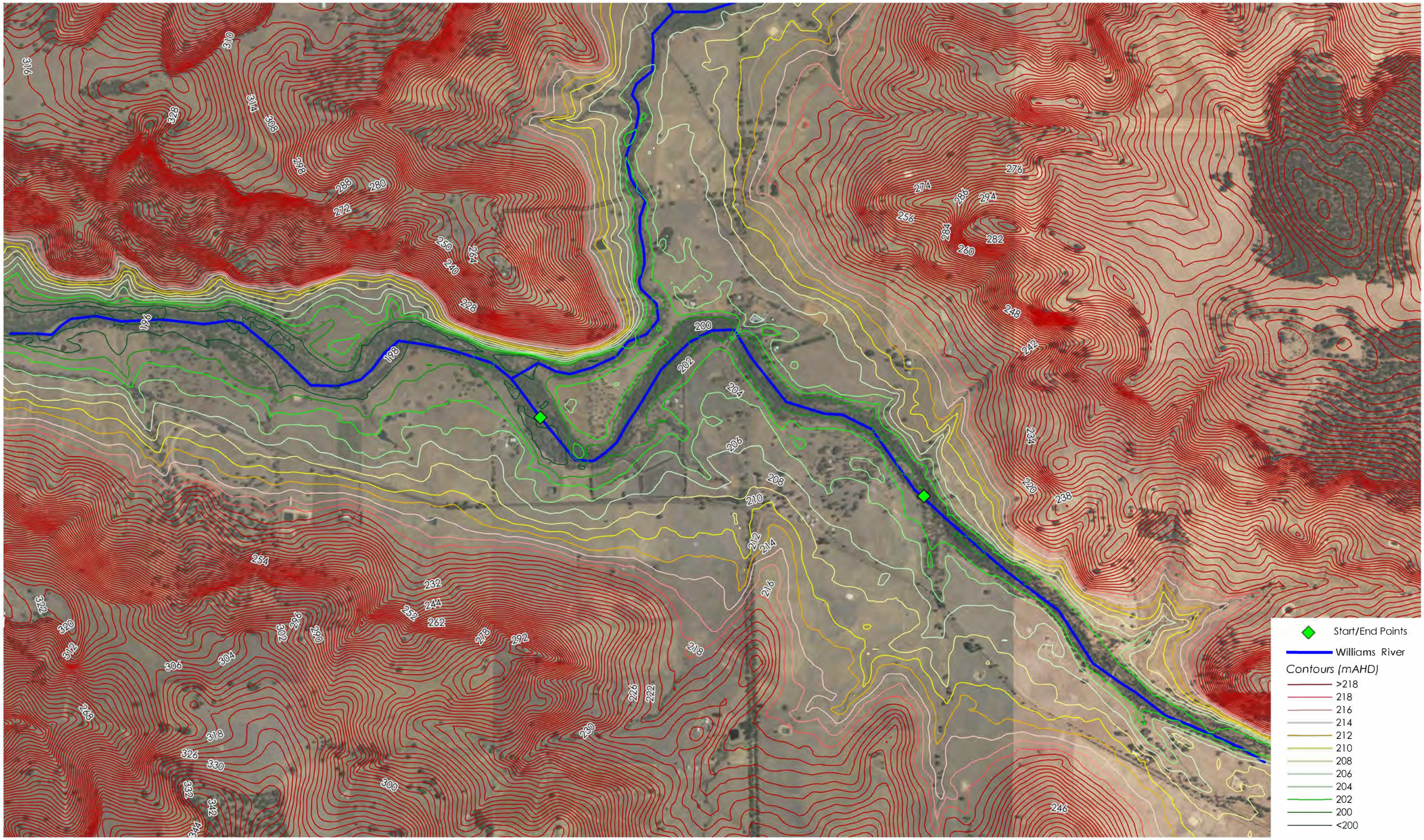
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 34 - Quindanning Elevation Map



Data source: PHCC, SLIP, Created by:YY Projection: MGA: zone 50.

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Scale 1:15,000 @ A3

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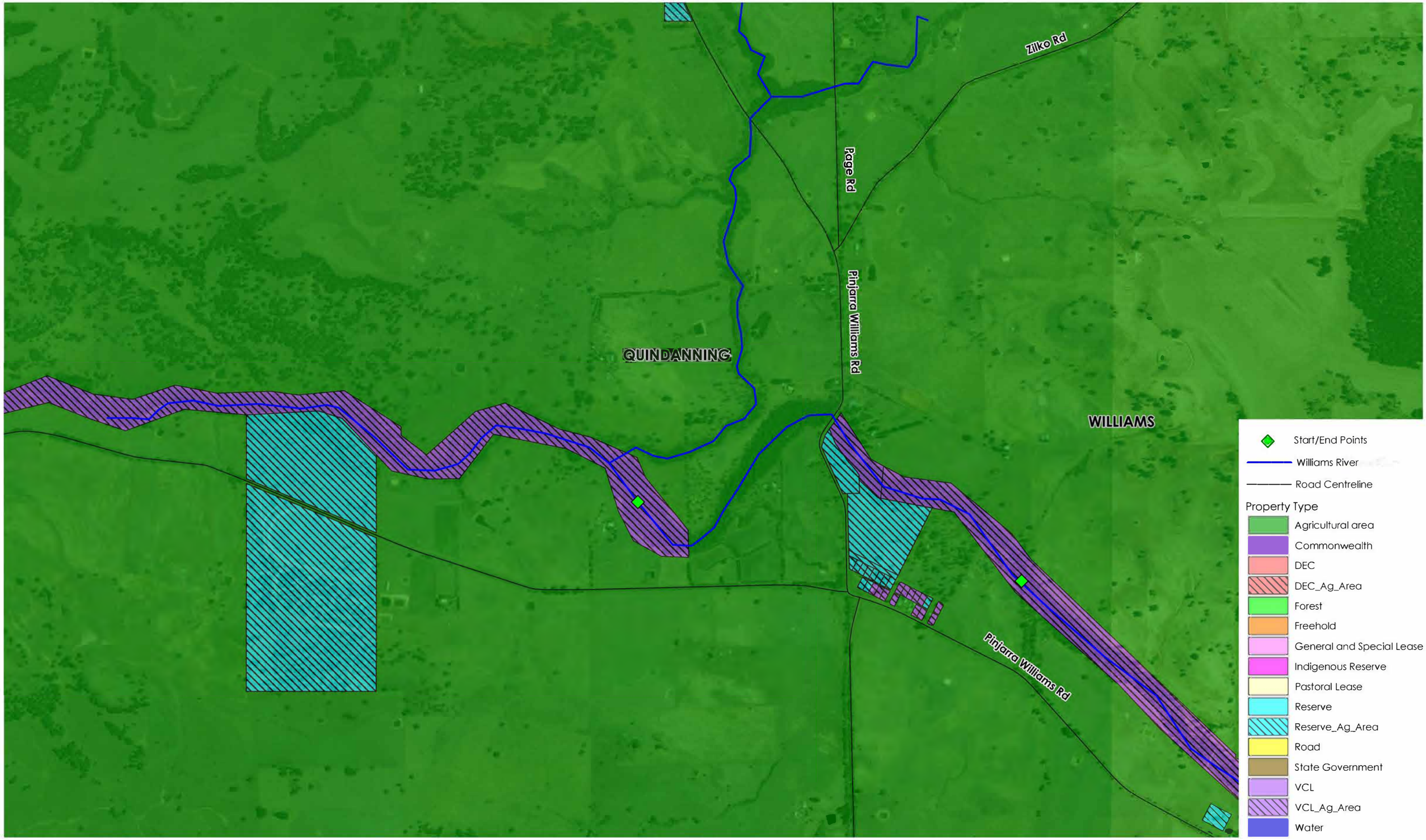
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 35 - Quindanning Land Use Map



Data source: PHCC, SLIP, DWER. Created by:YY Projection: MGA: zone 50.

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Scale 1:15,000 @ A3

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3.2.8 Quindanning

The Quindanning reach of the Williams River is south of the Quindanning townsite, covering approximately 2.3 km upstream and downstream of the Pinjarra-Williams Road Bridge as shown in Figure 33. Assessment of this reach included the definition of 6 sub-reaches, each being approximately 400 m in length. Characteristics of the River, defined by results of the field assessment and desktop review are provided in Table 23, with management recommendations provided in Table 24.

Plate 8: Quindanning Site Photos

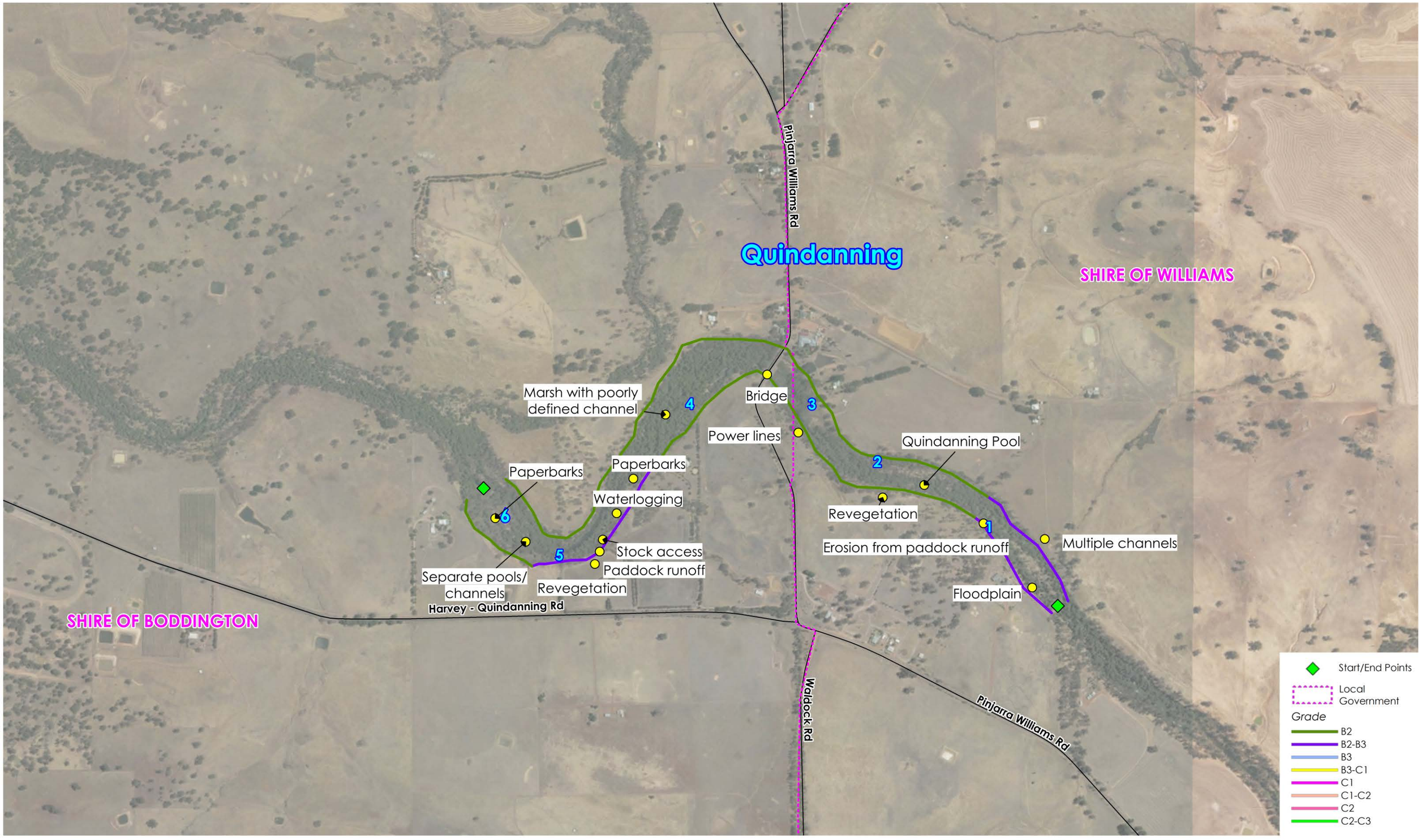
Table 23: Quindanning Description and Conditions

Feature	Comments
Land use	The reach is south of the Quindanning townsite, surrounded by rural and small landholdings with associated clearing.
Fencing and Infrastructure	Fencing was consistently rated as average along the reach, with evidence of stock access limited to the downstream parts of the reach (pugging observed in low–lying waterlogged areas). In this area a corrugated fence (suspended approximately 1.0 m above the channel bed) was observed. The key infrastructure along the reach is the Pinjarra-Williams Road Bridge.
Channel Form	The channel features significant (400 m) meanders with pools at and downstream of the bridge. The channel varies from multiple, small low-flow channels (approximately 3m wide, banks up to 1.5 m) and the Quindanning Pool, to a wider system with gentle banks up to 30 m wide. The floodplain at the downstream end was generally flat and waterlogged.
General Foreshore Condition	Channel ratings are very consistent with the majority of sites scores as B2 (degraded – weed infested), with the three sub-reaches scored at B2-B3 (degraded – weed infested/dominated). Scores were relatively high compared with other reaches in the catchment, owing to the minor and insignificant erosion along the reach. The channels also offered a variety of habitats and good stream shading.
Vegetation Cover and Stream Health	Tree and shrub cover (Eucalyptus sp. and Melaleuca sp.) is nearly continuous along the reach, apart from a reduced area on the northern bank near the townsite. This canopy provides a high proportion of stream cover. Understorey is heavily reduced and exotic grasses were noted. There are two areas of revegetation, one upstream of the bridge and one downstream, where waterlogged areas were noted. Dying trees were also observed along the reach.
Weeds	Weeds were abundant along the reach, including Wild Oats, Cape Weed, Cape Tulip, Bridal Creeper, Dock, African Love Grass, Rye Grass, Couch Grass and several unidentified grasses.
Erosion	Erosion and sedimentation were not prominent along the reach, with minimal examples of exposed tree roots. Visible erosion was minor and presented no threat of collapse or retreat.
Cultural and Community Heritage	The Aboriginal Heritage Act 1972 (WA), protects all Aboriginal Heritage sites in Western Australia whether they are registered with the Department of Planning, Lands and Heritage or not. Noongar Elders and Representatives will provide specific knowledge and advice about cultural significance and values of the Williams River at the Quindanning town site. Please refer to section 2.4 of this document to ensure all processes and procedures are followed. The pools in the Williams River are significant for both the Aboriginal people, and the early settlers and the wider community. Nearby recreational points today include the Quindanning Hall, Quindanning Tavern, and cricket grounds adjacent to the River.

Table 24: Quindanning Reserve Management Actions and Recommendations

Prioritised management actions recommended
• Work with landholders downstream of the bridge to improve fencing and limit stock access to the River; • Work with landholders to expand revegetation work along the reach; and • Improve riparian vegetation near the townsite, including areas of broken canopy.
Long term management actions recommended
• Utilise the reserves on the eastern side of Pinjarra-Williams Road to improve fringing vegetation.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 36 - Quindanning Condition Map



Data source: PHCC, Created by:YY Projection: MGA: zone 50.

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meters
Scale 1:10,000 @ A3

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4 SUB-CATCHMENT DESKTOP ASSESSMENT

The purpose of the desktop assessment of the Hotham-Williams catchment is to provide an overview of waterway condition on a catchment scale. This provides both a snapshot in time and a baseline for monitoring and evaluation of on-ground projects. The desktop assessment process also identifies areas for more detailed field investigations in the future, following the methodology used in the priority reaches carried out during the development of the RAP. The following sections provide an explanation of the indicators that have been used in the desktop assessment of the Hotham-Williams Catchment, along with the assessment results. Further details is provided in Appendix 4 and 5.

4.1 Methodology

The *Framework for the Assessment of River and Wetland Health (FARWH) for flowing rivers of the south-west of Western Australia* (Department of Water, 2011a) provides a basis for desktop and field analysis. For the latter, the Hotham-Williams catchment was divided into 102 sub-catchments and available desktop data used to determine baseline river and wetland conditions consistent with the National Water Initiative benchmarks (Figure 37). For the Hotham-Williams RAP, the detailed field data has been collected in 8 priority reaches, the results of which are outlined in Section 3. Table 25 provides the complete set of indicators for sub-catchment health for the FARWH assessment adapted by the DWER in the south-west of Western Australia.

Table 25: Sub-Catchment Indicators for the South West FARHW (DoW, 2011c)

Indicator	Components	Data Source	Scale	Recommended Sampling Frequency
Catchment Disturbance	Infrastructure	Desktop	Reach	5 years
	Land Cover Change	Desktop	Reach	5 years
	Land Use	Desktop	Reach	5 years
Physical Form	Longitudinal Connectivity			
	- Major Dams	Desktop	Reach	5 years
	- Minor Dams	Desktop	Reach	5 years
	- Gauging Stations	Desktop	Reach	5 years
	- Road-rail crossings	Desktop	Reach	5 years
	Artificial Channels	Desktop	Reach	5 years
	Erosion			
	- Erosion extent	Field	Site	Annual
	- Bank Stabilisation	Field	Site	Annual
Fringing Zone	Extent of Fringing Zone			
	- Fringing veg length	Desktop	Reach	5 years
	- Fringing veg width	Desktop	Reach	5 years
	Nativeness	Field	Site	Annual
Hydrological Change	Flow Stress Ranking			
	- Low Flow	Desktop	Reach	5 years
	- High Flow	Desktop	Reach	5 years
	- Proportion of zero flow	Desktop	Reach	5 years
	- Monthly variation	Desktop	Reach	5 years
	- Seasonal period	Desktop	Reach	5 years
Water Quality	Total Nitrogen	Field	Site	Annual
	Total Phosphorus	Field	Site	Annual
	Turbidity	Field	Site	Annual
	Salinity	Field	Site	Annual

Indicator	Components	Data Source	Scale	Recommended Sampling Frequency
	Dissolved Oxygen	Field	Site	Annual
	Temperature	Field	Site	Annual
Aquatic Biota	Fish/crayfish			
	- Expectedness	Field	Site	Bi-annual
	- Nativeness	Field	Site	Bi-annual
	Macroinvertebrates	Field	Site	Annual in spring

The methodology has been adapted further for the Hotham-Williams Catchment, according to the components that have available and measurable datasets via desktop assessment. For example, the Hydrological Change components have not been included in the desktop assessment due to the lack of data available and inadequate area covered by the active gauging stations. Available desktop data used in the FARWH desktop assessment includes the themes and components listed in Table 26. A number of Indicators have not been included in the Hotham-Williams desktop assessment but form part of the data collected in the field at the priority reaches for both the RAP (refer to Section 3) and the planned river health assessments (refer to Section 1.1).

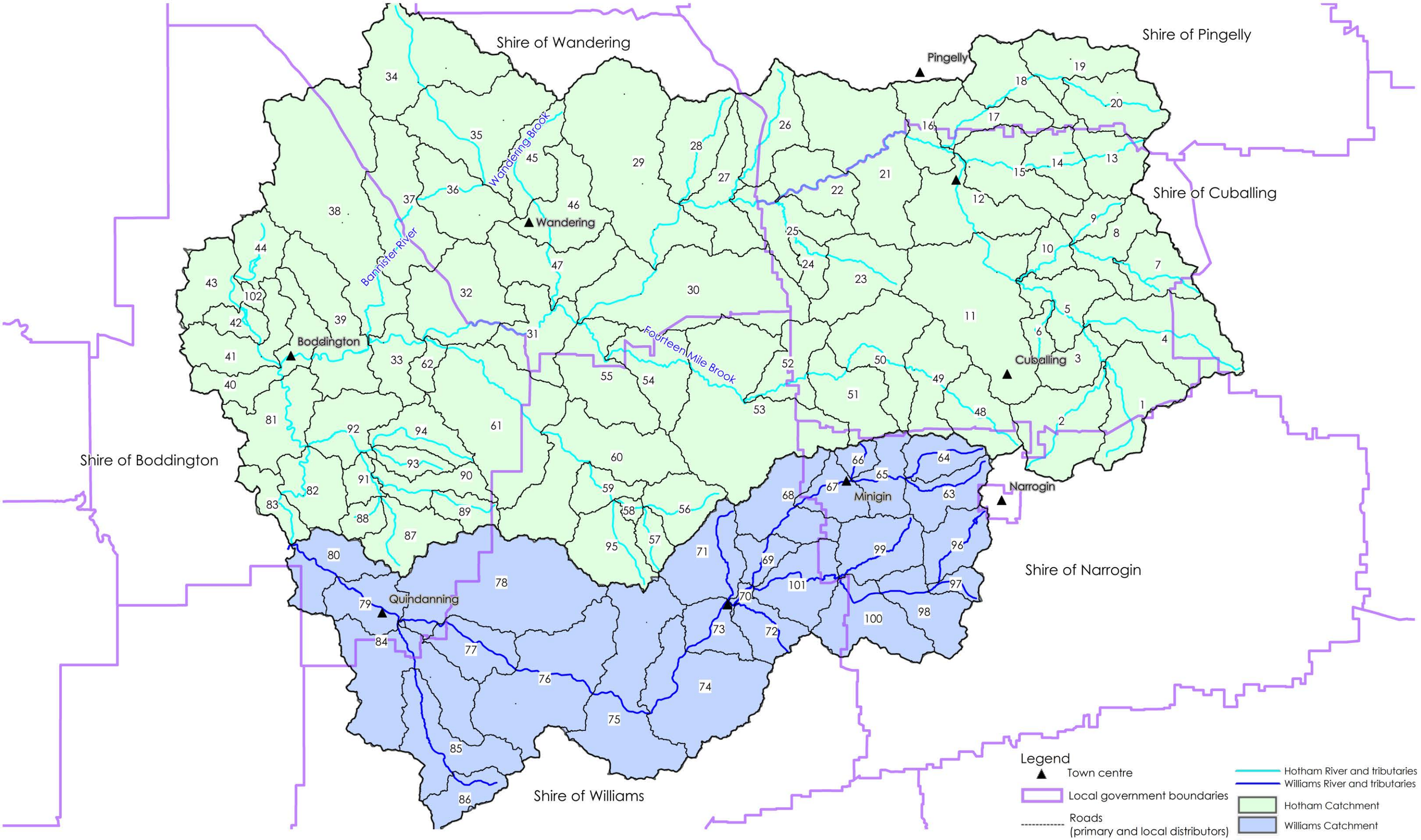
Table 26: Indicators Chosen for the Hotham-Williams Desktop Sub-Catchment Assessment

Indicator	Components	Data Source	Scale	Recommended Sampling Frequency
Catchment Disturbance	Infrastructure	Desktop	Reach	5 years
	Land Use	Desktop	Reach	5 years
		Desktop	Reach	5 years
Physical Form	Longitudinal Connectivity			
	- Major Dams	Desktop	Reach	5 years
	- Minor Dams	Desktop	Reach	5 years
	- Gauging Stations	Desktop	Reach	5 years
	- Road-rail crossings	Desktop	Reach	5 years
	Erosion			
	- Catchment topography (erosion risk)	Desktop	Reach	5 years
Fringing Zone	Extent of Fringing Zone			
	- Fringing veg length	Desktop	Reach	5 years
	- Fringing veg width	Desktop	Reach	5 years
	Nativeness	Desktop	Reach	5 years

4.1.1 Catchment Disturbance

The physical characteristics of a catchment provide controls on the hydrology, sediment delivery and chemistry within the river system and the Catchment Disturbance theme provides information on the causes of river health issues and potential future impacts (DoW, 2011a). The FARWH approach suggests the use of three sub-indices: *land use, land cover change* and *infrastructure*. As this assessment is determining base line conditions, the *land cover change* was excluded and can be considered in future. The weighting for each *land use* component is provided in Table 27, based on disturbance to the catchment (i.e. higher disturbance, higher score). The final score for the sub-catchment is based on *1.0 minus the percentage of each land use within each sub-catchment multiplied by the land use weighting*. A sub-catchment with minimal disturbance will have a score close to 1, whereas a sub-catchment that is entirely intensive and irrigated agriculture will have a score of 0.3.

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 37 - Sub-Catchment Reference Map



Data source: PHCC, SLIP, DWER, Created by:AT Projection: MGA2020: zone 50.

Table 27: Land use weighting (adapted from DoW, 2011a)

Land use	Weighting	Land use	Weighting
Urban	0.66	Plantation forestry	0.23
Intensive and irrigated agriculture	0.70	Managed resources	0.08
Dryland cropping	0.51	Conservation	0
Grazing	0.34		

The *infrastructure* sub-indicator was identified as generally insensitive to catchment conditions or change, due to the requirement for high proportions of the catchment to contain infrastructure. Therefore it has not been included within this analysis. However, infrastructure such as unsealed roads can be a significant source of sediment and nutrients by altering natural flows. Therefore unsealed road crossings have been considered in the Physical Form theme.

4.1.2 Physical Form

The Physical Form theme is assessed to determine the state of local habitat and its ability to support aquatic life (DoW, 2011a). Specific components of the river habitat include bed substrate, large woody debris, macrophytes, variance in channel form (pools, riffles and runs), flooded zones and connectivity of the channel (absence of any physical barriers). These components were assessed in detail as part of the Pen-Scott field based methods (Appendix 1). The recommended approach for assessment at a reach scale is the use of sub-indices: *longitudinal connectivity*, *artificial channel* and *erosion*.

Longitudinal Connectivity considers the impacts from anthropogenic barriers within each reach, including structures such as weirs, gauging stations and roads/railways. The scoring for each reach is provided in Table 28, with the final score for each reach dependent on the number of structures per type within the reach.

Table 28: Connectivity scoring (adapted from DoW, 2011a)

Score	Major Dam Component (weighting = 1.0)	Minor Dam Component (weighting = 0.75)	Gauging Station Component (weighting = 0.5)	Road and Rail Crossing Component (weighting = 0.25)
0.00	Present on reach			Not applicable
0.25	Present within 5 km of start/end of reach			>2 /km (high density)
0.50	Present between 5 and 20 km of start/end of reach			1 – 2 /km (moderate)
0.75	Present between 20 and 40 km of start/end of reach			>0 – 1 /km (low)
1.00	Present >40 km of start/end of reach			0 /km

The presence of *artificial channels* (trained or modified) reduces available habitats and identifying these locations can assist in determining areas of poor ecological condition. In the Hotham-Williams catchment, channel modifications are generally restricted to the local site scale rather than sub-catchment scale, so these sites cannot be determined from desktop analysis.

The other category assessed is the *erosion and sedimentation* within the reach. Erosion and sedimentation occur naturally, however accelerated erosion and sedimentation can cause turbidity in the water column, interfere with filter-feeding and reduce habitat diversity. Ideally erosion assessments are field based, accessing the extent and severity of erosion along a reach. This was carried out in the field reach assessment component of the RAP, detailed in section 3. For the desktop based approach, catchment topography and fringing zone vegetation conditions were used as indicators. The Avon Hotham Catchment Appraisal (Department of Agriculture and Food, 2005) considered catchment slope and the likelihood of erosion in the context of determining the risks and impacts to agricultural production and natural resources and providing recommendations for management of surface water

(Appendix 1). The erosion categories have been adapted for the Hotham-Williams catchment as shown in Table 29.

Table 29: Catchment erosion risk scoring (adapted from DAF, 2005)

Slope	Description	Score
0 – 1%	Low gradients, poorly drained	1.0
1 – 3%	Potential for erosion. Waterlogging possible on clayey and duplex soils	0.70
3 – 10%	High risk of water erosion	0.30
>10%	Very high risk of water erosion	0

Catchment slope cannot be considered in isolation from the vegetation present within the channel, and the width and nature of the fringing zone should be considered in the final scoring, as discussed further below. Similarly, human and livestock access were noted as major causes of erosion during field inspection. Therefore land use and the quality of fencing also require consideration.

4.1.3 Fringing Zone

The Fringing Zone theme assesses the health and quality of vegetation either side of rivers within the catchment. This vegetation is significant in providing stream shading, increasing bank stability, providing habitat and acting as a buffer to prevent human and stock access (DoW, 2011a). The two sub-indices considered in the FARWH approach are the *extent of the fringing zone* and *nativeness* (extent of exotic species) of the vegetation.

The extent of *fringing vegetation* considers both the length (continuity) and width of vegetation along a reach (defined as the main river channel in the sub-catchment). For this assessment, an average score for the entire reach was estimated by reviewing aerial imagery and scored based on Table 30.

Table 30: Fringing zone width scoring (adapted from DoW, 2011a)

Average Distance	Score
0 m	0.0
12.5 m	0.25
25 m	0.50
37.5 m	0.75
50 m	1.0

Determining the nativeness of vegetation is carried out through field assessments, particularly owing to the ability to assess weeds and the health of native ground cover and shrubs. In the absence of field assessments for the sub-catchments assessed via desktop, the Native Vegetation (reserve) mapping provided by Peel-Harvey Catchment Council was utilised. Where reaches are located within reserves, a score of 1.0 was assigned, otherwise reaches were scored 0.0.

4.1.4 Other Indicators

The other key indicators for the South West FARHW (DoW, 2011c) are *hydrological change*, *water quality* and *aquatic biota*. As mentioned above, there is insufficient data for these indicators in the Hotham-Williams Catchment for them to be adequately assessed. Proposed river health studies are being conducted separately to this RAP which will be assessing water quality and aquatic biota in the field as explained in Section 1.1. Further information on these indicators is provided in Appendix 4.

4.1.5 Total Score

To simplify the sub-catchments reach ratings, a total score was determined to identify priorities for further investigation. The FARWH approach provides a summary score for each theme rather than a total score which allows for comparison of systems with different physical settings and catchment conditions. For the RAP, a total score is adopted due to the available data and common issues and conditions identified within the Hotham-Williams catchment.

The total score is calculated based on the various indicators outlined above. Recognising that the indicators are not of equal importance, a weight for each is applied. Table 31 outlines the respective weightings for the indicators that have been adapted for the RAP. Catchment disturbance (*land use*) received the highest weighting as land use within the sub-catchment was considered to be the main factor that influences river condition. Fringing vegetation was also weighted marginally higher than other indicators as the extent of vegetation near the river can also influence physical form (*erosion*) as it may stabilise the banks.

Table 31: Total score weighting

Indicator	Land Use	Connectivity	Slope	Fringing Zone Length	Fringing Zone Width	Native Vegetation
Theme	Catchment Disturbance	Physical Form	Physical Form	Fringing Zone	Fringing Zone	Fringing Zone
Weighting	0.40	0.10	0.10	0.15	0.15	0.10
Reference	Table 27	Table 28	Table 29	-	Table 30	-

Scores from each of the indicators is then multiplied by the respective weightings and combined for a total score between 0 (completely degraded) and 1 (undisturbed) as shown in Table 32. Priority catchments can therefore be determined by two approaches. Firstly, setting a target score and capturing all sub-catchments under that number. For example, any sub-catchment with a score under 0.50 (reduced fringing vegetation and channel disturbance) may be considered a priority. The alternative approach, adopted for the RAP, is to prioritise the lowest scoring sub-catchments in areas where multiple sub-catchments have scored lowly and there are significant waterways. This is discussed further in Section 4.2, along with the results and recommendations. A more detailed breakdown of the scoring is presented in Appendix 5.

Table 32: Total score description

Total Score	Description
1.00	Catchment is 100% conservation with native vegetation and un-impacted channel or fringe vegetation.
0.75	Catchment is 50% conservation with minimal impact on channel form or fringe vegetation
0.50	Catchment is 50% conservation with reduced fringe vegetation and/or channel disturbance
0.25	Minimal conservation areas with exotic species and limited fringing vegetation
0.00	No conservation areas within the catchment and no fringing vegetation

4.2 Results

The Hotham-Williams catchment was divided into 102 sub-catchments as shown in Figure 37, with the numbering beginning in the upper (eastern) part of the Hotham River catchment. Of these sub-catchments, 101 were assessed as one sub-catchment (number 102) contained mining facilities

and no significant waterways. The results of the assessment are provided in this Section, along with assessment scoring maps that are provided in Figures 39 to 44. All sub-catchment scores are provided in Appendix 5.

The five lowest scoring sub-catchments are provided in Table 33. These sub-catchments, as shown in Figure 37, are generally located at the top of catchment with waterways that are either smaller, ephemeral or poorly defined (where tributaries commence).

Table 33: Lowest scoring sub-catchment scores

Catchment number	Land Use *(w: 0.40)*	Connectivity *(w: 0.10)*	Slope *(w: 0.10)*	Fringing Zone Width *(w: 0.15)*	Fringing Zone Length *(w: 0.15)*	Native Vegetation *(w: 0.1)*	Total Score
6	0.57	0.75	0.7	0.20	0.20	1.0	**0.53**
89	0.62	0.75	0.7	0.30	0.20	1.0	**0.57**
57	0.56	0.75	0.7	0.50	0.20	1.0	**0.57**
24	0.60	0.75	1.0	0.20	0.20	1.0	**0.58**
7	0.57	0.75	1.0	0.25	0.30	1.0	**0.59**

w = weighting

Of the lowest scoring sub-catchments, the three below require further investigation:

- North east of Cuballing, score 0.53 associated with poor fringing vegetation (Shire of Cuballing, Figure 42);
- North west of Williams, score of 0.57, associated with poor fringing vegetation width (Shire of Williams, Figure 43); and
- South east of Boddington, score of 0.57, associated with poor fringing vegetation width (Shire of Boddington, Figure 39).

These areas warrant further investigation, including analysis of recent aerial imagery and field-based assessments to characterise the condition of the channels. Assessments of the relative environmental and community value of these reaches are also required to confirm the associated benefits of rehabilitation efforts, though they are not anticipated to be significant. If these reaches are deemed unsuitable for further investigation, the next lowest scored sub-catchments should be considered.

Along the larger waterways, there are two areas that warrant field investigations to further determine river condition, community value and suitability for rehabilitation works. The first area spans 11 sub-catchments in the north-east reaches of the Hotham River to the east of Popanyinning. The second area is the sub-catchments along Fourteen Mile Brook, south of the main block of the Dryandra Woodlands.

4.2.1 North-East Hotham River

The sub-catchments east (and north east) of Popanyinning (Figure 42) generally feature scores less than 0.65, making them amongst the lowest 20 (out of 102) scored sub-catchments (Table 34). The scores are associated with poor riparian vegetation widths and coverage along the waterway. These areas have previously been identified as a potential source of the sediment noted in field work carried out in the Hotham River Nature Reserve (Section 3.2.3). The desktop findings support the recommendation to further investigate these reaches including desktop assessment (aerial imagery) and preliminary field assessments (site walkovers) followed by detailed reach assessments similar to Section 3 (if required).

Investigations should determine the quality and extent of riparian and fringing vegetation, extent of erosion and habitat diversity. Where significant issues are identified, and there are community and ecological benefits, rehabilitation projects should be established.

Table 34: North east Hotham River sub-catchment scores (see Figure 42)

Catchment number	Land Use *(w: 0.40)*	Connectivity *(w: 0.10)*	Slope *(w: 0.10)*	Fringing Zone Width *(w: 0.15)*	Fringing Zone Length *(w: 0.15)*	Native Vegetation *(w: 0.1)*	Total Score
7	0.57	0.75	1.0	0.25	0.30	1.0	**0.59**
8	0.55	0.75	1.0	0.50	0.50	1.0	**0.64**
9	0.55	0.75	1.0	0.70	0.75	1.0	**0.71**
10	0.58	0.75	1.0	0.40	0.50	1.0	**0.64**
12	0.58	0.75	1.0	0.80	0.35	1.0	**0.68**
13	0.59	0.75	0.7	0.50	0.20	1.0	**0.59**
14	0.59	0.75	1.0	0.45	0.30	1.0	**0.62**
15	0.57	0.75	1.0	0.30	0.60	1.0	**0.64**
18	0.54	1.00	1.0	0.50	0.75	1.0	**0.70**
20	0.58	1.00	1.0	0.40	0.40	1.0	**0.65**

w = weighting

4.2.2 *Fourteen Mile Brook*

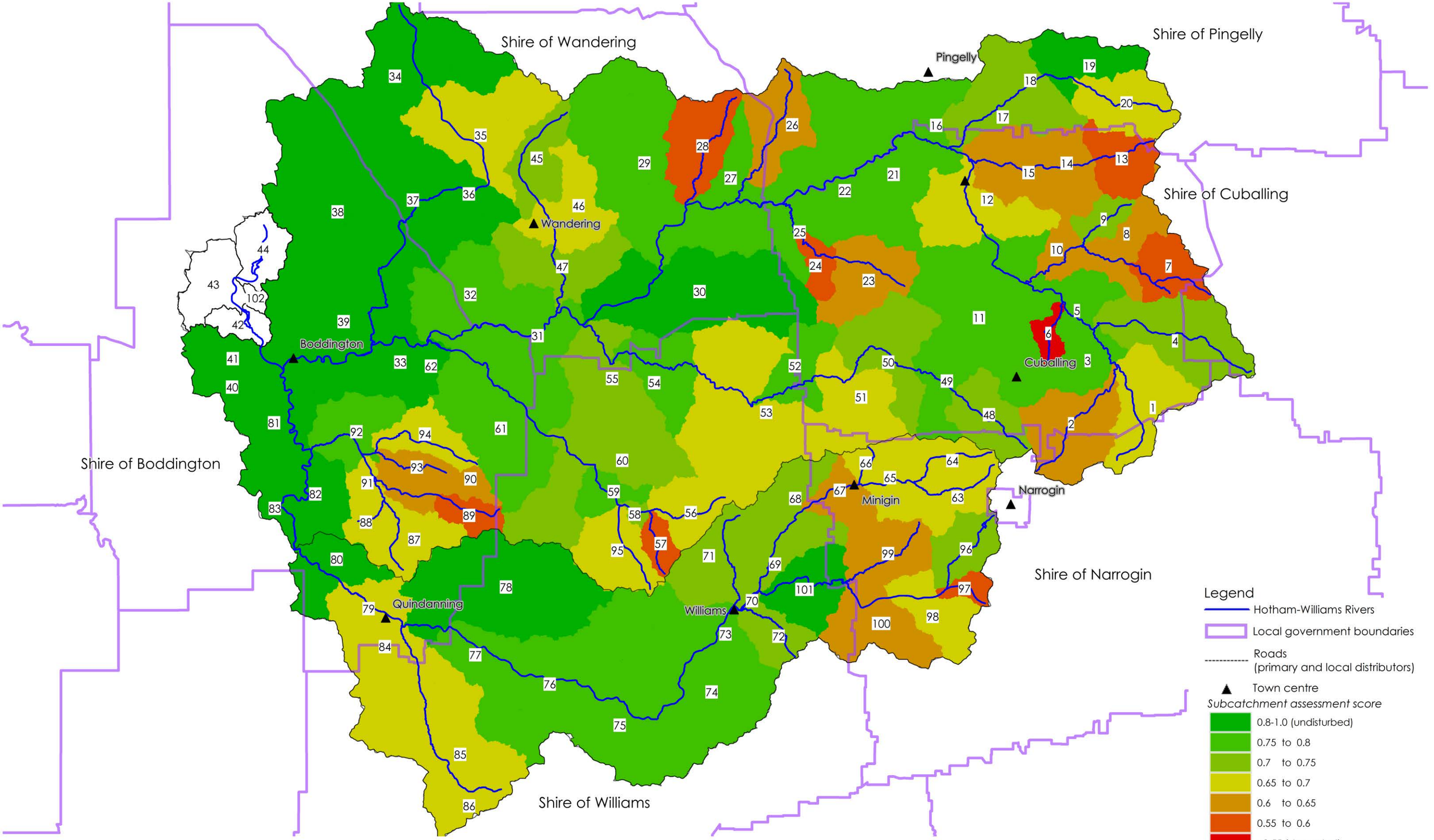
Fourteen Mile Brook flows through agricultural land in close proximity to the Dryandra Woodlands in the Shire of Cuballing (Figure 42) and the Shire of Williams (Figure 43). The woodlands include 17 discrete blocks of land on either side of Fourteen Mile Brook and its tributaries. The desktop assessment identifies these areas with scores in the range of 0.65 – 0.70 (Table 35). These scores are reflective of the limited riparian vegetation, particularly the width of the vegetation. Between the Dryandra Woodlands and Fourteen Mile Brook, the land is mostly cleared for agriculture, limiting ecological connectivity between conservation areas and to the River. Consequently these areas warrant further investigation, commencing with desktop and preliminary field assessments (similar to North-East Hotham River) and supported by detailed field assessment to determine potential rehabilitation works and to improve riparian and fringing vegetation and ecological connectivity.

Table 35: Fourteen Mile Brook sub-catchment scores (see Figure 42 and Figure 43)

Catchment number	Land Use *(w: 0.40)*	Connectivity *(w: 0.10)*	Slope *(w: 0.10)*	Fringing Zone Width *(w: 0.15)*	Fringing Zone Length *(w: 0.15)*	Native Vegetation *(w: 0.1)*	Total Score
23	0.63	0.75	1.0	0.40	0.35	1.0	**0.64**
24	0.60	0.75	1.0	0.20	0.20	1.0	**0.58**
50	0.71	0.75	1.0	0.70	0.25	1.0	**0.70**
51	0.66	0.75	1.0	0.60	0.20	1.0	**0.66**
52	0.80	1.00	1.0	0.70	0.30	1.0	**0.77**
53	0.71	0.75	1.0	0.50	0.40	1.0	**0.69**

w = weighting

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 38 - Catchment Reach Assessment



Data source: PHCC, SLIP, DWER, Created by:AT Projection: MGA2020: zone 50.

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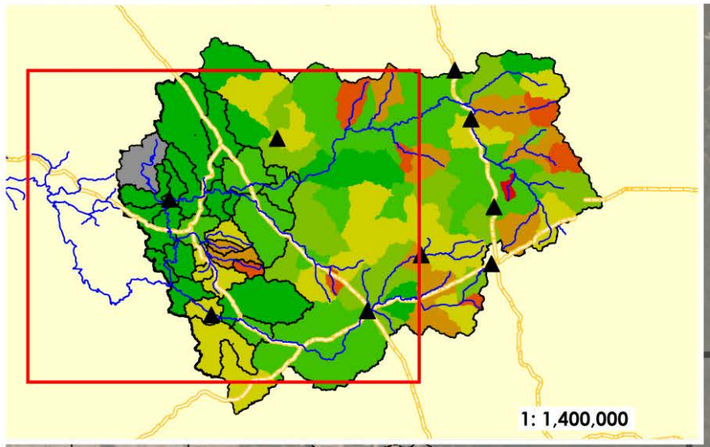
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 39 - Shire of Boddington Reach Assessment



Bannister River
Shire of Wandering
Wandering
Hotham River
Pingelly
Dryandra Woodlands
Fourteen Mile Brook
Fourteen Mile Brook
Minigin
Boddington
Shire of Boddington
Quindanning
Williams
Williams River
38
37
32
39
31
41
33
62
40
92
94
61
93
91
90
82
83
89
88
87
80
78
79
84
77

Legend
- Hotham-Williams Rivers
- Local government boundaries
- Roads (primary and local distributors)
- Town centre

Subcatchment assessment score
- 0.8-1.0 (undisturbed)
- 0.75 - 0.8
- 0.7 - 0.75
- 0.65 - 0.7
- 0.6 - 0.65
- 0.55 - 0.6
- <0.55 (degraded)
- Mine site

Data source: PHCC, SLIP, DWER, Created by:AT Projection: MGA2020: zone 50.

0 20
kilometers
Scale 1:300,000 @ A3

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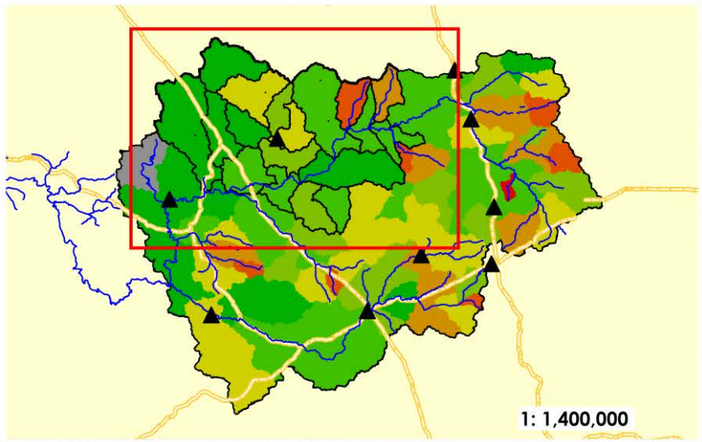
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 40 - Shire of Wandering Reach Assessment



Shire of Pingelly
Pingelly
Bannister River
Hotham River
Shire of Wandering
Wandering
Shire of Boddington
Boddington
Dryandra Woodlands
Fourteen Mile Brook
Minig
34
35
36
37
38
26
27
28
25
47
30
32
31
55
54

Legend

- Hotham-Williams Rivers
- Local government boundaries
- Roads (primary and local distributors)
- Town centre

Subcatchment assessment score

- 0.8-1.0 (undisturbed)
- 0.75 - 0.8
- 0.7 - 0.75
- 0.65 - 0.7
- 0.6 - 0.65
- 0.55 - 0.6
- <0.55 (degraded)
- Mine site

Data source: PHCC, SLIP, DWER, Created by:AT Projection: MGA2020: zone 50.

0 20
kilometers
Scale 1:250,000 @ A3

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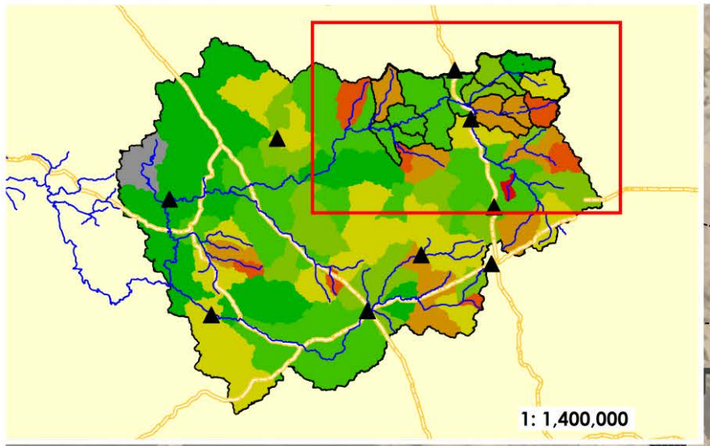
land and water solutions

Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 41 - Shire of Pingelly Reach Assessment



Shire of Pingelly
Pingelly
Shire of Wandering
Wandering
Dryandra Woodlands
Cuballing
Hotham River
Hotham River
Hotham River
Fourteen Mile Brook
Fourteen Mile Brook
26
25
16
17
18
19
20
15
14
13

Legend
- Hotham-Williams Rivers
- Local government boundaries
- Roads (primary and local distributors)
- Town centre

Subcatchment assessment score
- 0.8-1.0 (undisturbed)
- 0.75 - 0.8
- 0.7 - 0.75
- 0.65 - 0.7
- 0.6 - 0.65
- 0.55 - 0.6
- <0.55 (degraded)
- Mine site

Data source: PHCC, SLIP, DWER, Created by:AT Projection: MGA2020: zone 50.

0 20
kilometers
Scale 1:250,000 @ A3

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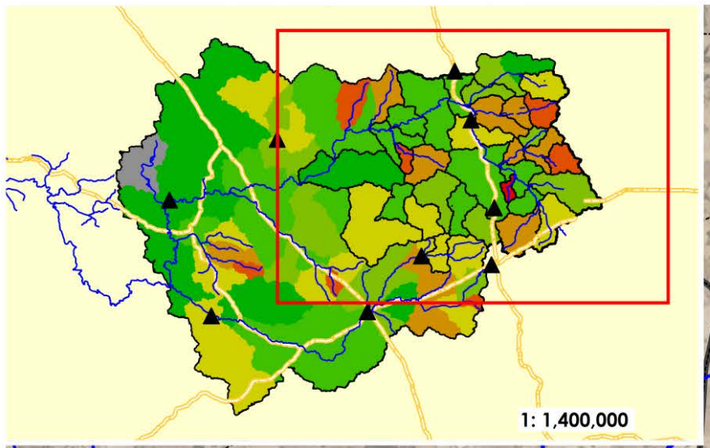
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 42 - Shire of Cuballing Reach Assessment



Shire of Pingelly
Pingelly
Hotham River
Wandering
Shire of Cuballing
Cuballing
Hotham River
Fourteen Mile Brook
Fourteen Mile Brook
Hotham River
Narrogin
Shire of Narrogin
16
17
20
15
14
13
12
9
10
8
7
25
24
23
30
6
4
3
52
50
51
53
48
1
65

Legend
- Hotham-Williams Rivers
- Local government boundaries
- Roads (primary and local distributors)
- Town centre

Subcatchment assessment score
- 0.8-1.0 (undisturbed)
- 0.75 - 0.8
- 0.7 - 0.75
- 0.65 - 0.7
- 0.6 - 0.65
- 0.55 - 0.6
- <0.55 (degraded)
- Mine site

Data source: PHCC, SLIP, DWER, Created by:AT Projection: MGA2020: zone 50.

0 20
kilometers
Scale 1:250,000 @ A3

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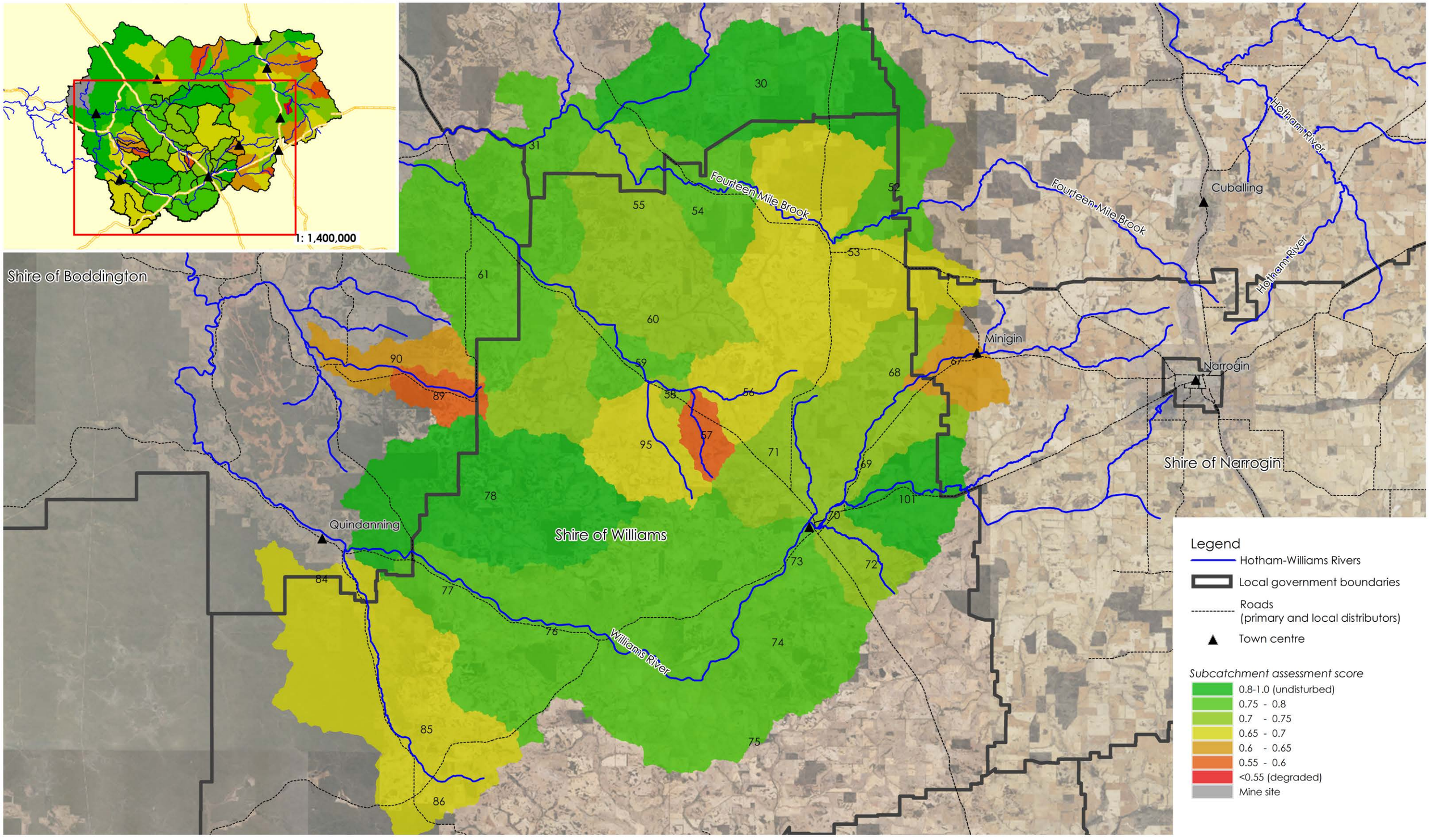
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 43 - Shire of Williams Reach Assessment



Data source: PHCC, SLIP, DWER, Created by:AT Projection: MGA2020: zone 50.

0 20
kilometers
Scale 1:250,000 @ A3

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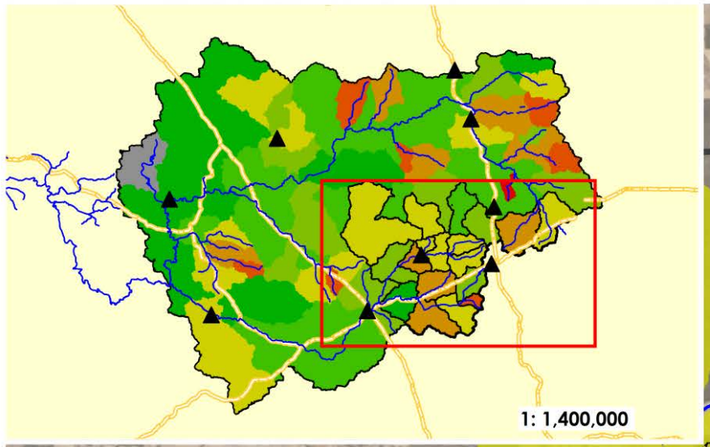
Peel Harvey Catchment Council - Hotham-Williams River Action Plan
Figure 44 - Shire of Narrogin Reach Assessment



Hotham River
Fourteen Mile Brook
Cuballing
Hotham River
51
53
48
1
66
64
Minigin
65
67
68
63
Narrogin
99
96
Shire of Narrogin
101
97
Williams
98
100
Williams River

Legend

- Hotham-Williams Rivers
- Local government boundaries
- Roads (primary and local distributors)
- Town centre

Subcatchment assessment score

- 0.8-1.0 (undisturbed)
- 0.75 - 0.8
- 0.7 - 0.75
- 0.65 - 0.7
- 0.6 - 0.65
- 0.55 - 0.6
- <0.55 (degraded)
- Mine site

Data source: PHCC, SLIP, DWER, Created by:AT Projection: MGA2020: zone 50.

0 20
kilometers
Scale 1:200,000 @ A3

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5 RECOMMENDATIONS

A summary of the recommended actions is provided in Table 36, grouped to address the objectives of Goal 2 of the *Hotham-Williams NRM Plan 2025* (PHCC, 2015a) that *rivers, creeks, valley floors and sub-catchments are managed and restored*. It is envisioned that these actions are adapted based on findings from further investigations, identification of other issues and threats, or following remediation work. On-ground projects can be planned using these recommendations and will need to be discussed with the relevant land owners and managers during the project development stage for consultation and approval. This RAP can be used as a supporting document for funding applications to implement proposed projects and achieve the objectives of the Hotham-Williams NRM Plan.

All restoration works which occur in the future should adhere to the guidelines for revegetation, stream stabilisation, planning and management set out in *A Guide to the Nature, Protection, Rehabilitation and Long-Term Management of Waterways in Western Australia* (WRC, 2000). The chapters of the series collectively form the River Restoration Manual. The manual is based on the teachings of the successful river restoration courses, which have been run for river managers in the past (between 1996 and 2010).

Broader recommendations for the catchment include documentation of culture and remediation efforts. Stories of Noongar culture on the rivers in the Hotham-Williams Catchment have been recorded to some extent, though further documentation is necessary. This may be in the form of voice and/or video recordings, publications, maps or public presentations. Documentation of already commenced or completed works in the Hotham-Williams Catchment are useful case studies for similar sites and to demonstrate accomplishments for the community. The Revitalisation of Ranford (Darminning) Pool is an example of a project which would provide guidance for future on-ground proposals.

A further underlying principle of the recommendations is that climate change should be considered when planning any future works. As outlined in Section 2.2, there has been a decline in winter rainfall, including an 8 to 11% decrease in annual rainfall across the catchment since 1975. Consideration should include vegetation species selection (drought resistant) and reduced flows within the river.

Additional outcomes were determined in the review of existing literature for the catchment provided in Appendix A. The outcomes outlined in these documents are consistent with the recommendations of the RAP, however further site specific investigations should refer to these documents.

Abbreviations for the various agencies in Table 36 are provided below:

- CPC: Conservation and Parks Commission
- DBCA: Department of Biodiversity, Conservation and Attractions
- DPLH: Department of Planning, Lands and Heritage
- DWER: Department of Water and Environmental Regulation
- UCL: Unallocated Crown Land
- WA: Western Australia

Abbreviations for the sites in Table 36 are provided below:

- B: Boraning
- H: Hotham River Nature Reserve
- P: Popanyinning,
- PB: Pumphreys Bridge
- Q: Quindanning,
- RP: Ranford Pool,
- W: Williams,
- Y: Yornaning.

Numbers in brackets after the site name indicate the reach number, i.e. *Popanyinning (1)* is *Reach 1 at Popanyinning site*.

Table 36: Priority Actions and Recommendations Based on Field Assessments

Item	Priority	Location	Action	Owner	Manager	Stakeholders
a. Degraded areas are actively managed to restore natural functions, and production where appropriate						
a-i.	Short-term	Popanyinning (1) Boraning Reserve (2) Williams (1)	Litter and bulky waste material should be removed from the river, including: - Oil drums at Popanyinning - General and bulky litter in Williams Investigate sources of oil flecks and sheen observed at Boraning.	(P1) UCL, DWER	(P1) DPLH, DWER	Shire of Cuballing, Private landholders
				(B2) UCL, State of WA, DPLH	(B2) DPLH, Shire of Williams	Shire of Williams, Private landholders
				(W1) UCL, State of WA, DPLH, DWER	(W1) DPLH, DWER	Shire of Williams, Private landholders
a-ii	Short-term	Ranford Pool (3-4) Pumphreys Bridge (5) Williams (5-6)	Annual bathymetry surveys of channel capacity should be undertaken to assess the impact of upstream erosion and sedimentation. Surveys of the following should be undertaken: - Ranford Pool - Pumphreys Bridge, around the current bridge - Williams town pool, utilising MRWA survey information if available Survey information should guide future remediation works.	(RP3-4) UCL, State of WA, DWER	(RP3-4) DPLH, DWER, Shire of Boddington	Shire of Boddington, Private landholders
				(PB5) State of WA, UCL	(PB5) DPLH, Shire of Wandering	Shire of Wandering, Private landholders
				(W5) State of WA, DPLH, DWER (W6) State of WA, DPLH, DWER, Private landholders	(W5) DPLH, DWER, Shire of Williams (W6) DPLH, DWER, Private landholders, Shire of Williams	Shire of Williams, Private landholders
a-iii	Short-term	Pumphreys Bridge (7-8) Quindanning (4-6) Yornaning Dam (5) Popanyinning (7-8) Ranford Pool (2-6)	Provide further measures to prevent stock access and control community access. Significant access points include: - Private land downstream of Pumphreys Bridge with poor fencing and uncontrolled stock crossings - Private land downstream of the bridge at Quindanning with uncontrolled stock access - Reduce recreation and vehicle access through the reserve at Yornaning Dam, including the river crossing - Private land at Popanyinning north of Bunmulling Road with limited fencing and stock access - North side of the river at Ranford Pool	(PB7-8) UCL	(PB7-8) DPLH	Shire of Wandering, Private landholders
				(Q4) DWER (Q5) DWER, UCL (Q6) UCL, State of WA, DPLH	(Q4) DWER (Q5) DWER, DPLH (Q6) DPLH	Shire of Boddington, Private landholders
				(Y5) State of WA, DPLH	(Y5) Shire of Cuballing	Shire of Cuballing, Private landholders
				(P7) UCL, DWER, State of WA (P8) UCL, DWER	(P7-8) DPLH, DWER	Shire of Cuballing, Private landholders
				(RP2) UCL	(RP2) DPLH	Shire of Boddington,

Item	Priority	Location	Action	Owner	Manager	Stakeholders
				(RP3) UCL, DWER, State of WA (RP4) UCL, DWER, State of WA (RP5) State of WA (RP6) State of WA	(RP3) DPLH, DWER, Shire of Boddington (RP4) DPLH, DWER, Shire of Boddington (RP5) DPLH, Shire of Boddington (RP6) DPLH, Shire of Boddington	Private landholders
a-iv	Short-term	Popanyinning (5-7) Williams (5) Yornaning Dam (4) Ranford Pool (3)	Implement localised bank protection (rock pitching, geo-fabric) to prevent erosion where there is potential for collapse of healthy trees. Sites include: - Conservation areas at Popanyinning - Large trees on private land north of Bunmulling Road at Popanyinning - Upstream of Albany Hwy at Williams near rehabilitation areas and the confluence with MacDermott Brook - Downstream end of the major channel at Yornaning Dam - On the southern side of Ranford Pool along the track.	(P5) State of WA, DWER (P6-7) UCL, DWER, State of WA	(P5-7) DPLH, DWER	Shire of Cuballing, Private landholders
				(W5) State of WA, DPLH, DWER	(W5) DPLH, DWER, Shire of Williams	Shire of Williams, Private landholders
				(Y4) State of WA, DPLH	(Y4) Shire of Cuballing	Shire of Cuballing, Private landholders
				(RP3) UCL, DWER, State of WA	(RP3) DPLH, DWER, Shire of Boddington	Shire of Boddington, Private landholders
a-v	Short-term	Pumphreys Bridge (6-7) Hotham River Nature Reserve (5-6) Yornaning Dam (5-6)	Investigate causes of dying trees, including the potential for dieback, along the following reaches: - Downstream of Pumphreys Bridge - Within Hotham River Nature Reserve - Within Yornaning Dam Dieback disease mapping should also be considered over-time to determine the considerations for revegetation and/or impacts on recreation activities.	(PB6-7) UCL	(PB6-7) DPLH	Shire of Wandering, Private landholders
				(H5) State of WA, DBCA (H6) UCL	(H5) CPC (H6) DPLH	Shire of Cuballing, Private landholders
				(Y5-6) State of WA, DPLH	(Y5-6) Shire of Cuballing	Shire of Cuballing, Private landholders
a-vi	Short-term	Sub-catchments identified in desktop assessment	Undertake further desktop (recent aerial imagery) and initial field investigations to characterise the conditions of the channels and vegetation, and community and environmental values of: - Sub-catchment #6 (north-east of Cuballing) - Sub-catchment #89 (north-west of Williams) - Sub-catchment #57 (south-east of Boddington)	Determined during further investigations	Determined during further investigations	Shire of Cuballing, Shire of Williams, Shire of Boddington, Private landholders
a-vii	Short-term /	North-east	Further investigate reaches in sub-catchments that are identified	Determined during	Determined during	Shire of Cuballing,

Item	Priority	Location	Action	Owner	Manager	Stakeholders
	long-term	Hotham River Catchment Fourteen Mile Brook	by desktop assessment as having poor riparian vegetation widths and coverage. Investigations should determine the quality and extent of riparian and fringing vegetation, extent of erosion and habitat diversity.	further investigations	further investigations	Shire of Williams, Private landholders
a-viii	Short-term / long-term	Hotham River Nature Reserve (5) Popanyinning (8) Pumphreys Bridge (5)	Remove and/or redesign structures within the rivers that present a risk. These include: - Existing weir structure within Hotham River Nature Reserve (priority) - Private crossing at the north end of Popanyinning could be redesigned to prevent stagnant water and algae growth - Investigate risk and options of the old Pumphreys Bridge and consider stabilisation work Channel response to removal of these structures should be monitored.	(H5) DBCA, State of WA	(H5) CPC	Shire of Cuballing, Private landholders
				(P8) UCL, DWER	(P8) DPLH, DWER	Shire of Cuballing, Private landholders
				(PB5) State of WA, UCL	(PB5) Shire of Wandering, DPLH,	Shire of Wandering, Private landholders
a-ix	Long-term	Ranford Pool (4)	Monitor and document the success and failures of the remediation works at Ranford Pool as a template for other sites in the catchment.	(RP4) UCL, DWER, State of WA	(RP4) DPLH, DWER Shire of Boddington	Shire of Boddington, Private landholders
a-x	Long-term	Ranford Pool (3-5)	Extend remediation works in the Ranford Pool reserve to banks upstream and downstream to stabilise additional areas. Consider floodplain risk (via mapping) in the design of infrastructure and rehabilitation works.	(RP3-4) UCL, DWER, State of WA (RP5) State of WA	(RP3-4) DPLH, DWER, Shire of Boddington (RP5) DPLH, Shire of Boddington	Shire of Boddington, Private landholders
b. Rivers and creeks are actively restored and managed for their water supply, ecological, landscape, social and cultural values						
b-i	Short-term	Pumphreys Bridge (5 – Upstream of bridge)	Similar to restoration works at Ranford Pool, consider installing controlled access points for recreation using rock pitching and/or steps to prevent bank erosion.	(PB5) State of WA, UCL	(PB5) DPLH, Shire of Wandering	Shire of Wandering, Private landholders
b-ii	Short-term	Pumphreys Bridge (3)	Investigate the origins and usage of the diversion channel/pool and consider closing this feature.	(PB3) UCL	(PB3) DPLH	Shire of Pingelly, Shire of Cuballing, Private landholders
b-iii	Short-term / long-term	Williams (3-6) Quindanning (3) Popanyinning (5-6)	Work with local landholders to improve riparian vegetation in the following areas: - The entire Williams reach, with priority areas downstream of Albany Hwy and south of Cornwell Terrace - Quindanning, including near the townsite - Conservation areas in Popanyinning	(W3) UCL, State of WA, DWER, Private landholders (W4) Private landholders, State of	(W3) Private landholders, DPLH, DWER (W4) Private landholders, Shire of	Shire of Williams, Private landholders

Item	Priority	Location	Action	Owner	Manager	Stakeholders
		Hotham River Nature Reserve (5-8)	- Hotham River Nature Reserve (long term), following the stabilisation of the channel form.	WA, DWER (W5) State of WA, DPLH, DWER (W6) State of WA, DPLH, Private landholders, DWER	Williams, DWER (W5) DPLH, Shire of Williams, DWER (W6) DPLH, Shire of Williams, Private landholders, DWER	
				(Q3) UCL, State of WA, DPLH	(Q3) DPLH, Shire of Williams	Shire of Williams, Shire of Boddington, Private landholders
				(P5) State of WA (P6) UCL, State of WA, DWER	(P5) DPLH, DWER (P6) DPLH, DWER	Shire of Cuballing, Private landholders
				(H5) DBCA, State of WA (H6-8) UCL	(H5) CPC (H6-8) DPLH	Shire of Cuballing, Private landholders
b-iv	Short-term / long-term	All	Increase the catalogue of resources by documenting stories and narratives of the importance of the watercourses to Noongar culture, and the stories linked to the rivers.	All	All	All
b-v	Short-term / long-term	All	Case studies should be generated detailing the actions of implemented projects, issues that needed to be overcome and outcomes of the projects.	All	All	All
b-vi	Long-term	Pumphreys Bridge (5)	Work with the Shire of Wandering to improve camping facilities to prevent litter and fires near the channel, and improve riparian vegetation.	(PB5) UCL, State of WA	(PB5) DPLH, Shire of Wandering	Shire of Wandering, Private landholders, Local community
b-vii	Long-term	Yornaning Dam (5-6)	Investigate a functional and more natural form for the minor channel to provide habitat for aquatic species.	(Y5-6) State of WA, DPLH	Shire of Cuballing	Shire of Cuballing, Private landholders
c. Focused management of sub-catchments is encouraged to restore river and creek water quality for water supply, ecological, landscape social and cultural values						
c-i	Short-term	Hotham River Nature Reserve (All) Boraning Reserve (All) Yornaning	Undertake feral animal control programs within the Hotham River Nature Reserve, Boraning Reserve and Yornaning Dam Reserve.	(H2-8) UCL, DBCA, State of WA	(H2-8) CPC, DPLH	Shire of Cuballing, Private landholders
				(B1-3) UCL, State of WA, DPLH	(B1-3) DPLH, Shire of Williams	Shire of Williams, Private landholders
				(Y1-6) UCL, State of	(Y1-6) Shire of	Shire of Cuballing,

Item	Priority	Location	Action	Owner	Manager	Stakeholders
		Dam (All)		WA, DPLH	Cuballing	Private landholders
c-ii	Short-term	Ranford Pool (All) Popanyinning (All) Yornaning Dam (All)	Provide resources to private landholders to identify and eradicate weeds, including fact sheets to identify significant weeds and advice on removal, particularly at: - The conservation area at Popanyinning - Along Ranford Pool, including upstream and downstream areas - Yornaning Dam Reserve	(RP1-6) UCL, State of WA, DWER	(RP1-6) DPLH, Shire of Boddington, DWER	Shire of Boddington, Private landholders
				(P1-8) UCL, DWER, State of WA	(P1-8) DPLH, DWER, Shire of Cuballing	Shire of Cuballing, Private landholders
				(Y1-6) UCL, State of WA, DPLH	(Y1-6) Shire of Cuballing	Shire of Cuballing, Private landholders
c-iii	Short-term	Pumphreys Bridge (8)	Work with the landholder to ensure the existing quarry is suitably managed and wind and water actions do not bring excessive sediment into the channel.	(PB8) UCL	(PB8) DPLH	Shire of Wandering, Private landholders
c-iv	Short-term / long-term	Hotham River Nature Reserve (6-7) Quindanning (3) Williams (3-5) Boraning Reserve (2-3)	Investigate opportunities to increase fringing native vegetation (including control of weeds) at: - Hotham River Nature Reserve, including on private rural land - Within the reserves on the eastern side of Pinjarra-Williams Road in Quindanning - Work with landholders downstream of Albany Hwy and east of the river between Williams Street and Brooking Street - On the eastern side of the river at Boraning.	(H6-7) UCL	(H6-7) DPLH	Shire of Cuballing, Private landholders
				(Q3) UCL, State of WA, DPLH	(Q3) DPLH, Shire of Williams	Shire of Williams, Shire of Boddington, Private landholders
				(W3) State of WA, DWER, UCL, Private landholders (W4) State of WA, DWER, Private landholders (W5) State of WA, DPLH, DWER	(W3) DPLH, DWER, Private landholders (W4) DWER, Shire of Williams, Private landholders (W5) DPLH, DWER, Shire of Williams	Shire of Williams, Private landholders
				(B2-3) UCL, State of WA, DPLH	(B2-3) DPLH, Shire of Williams	Shire of Williams, Private landholders
c-v	Long-term	Ranford Pool (4) Pumphreys Bridge (5) Williams (6)	Install / update signage to provide community education regarding the wider catchment. Suggested locations are: - Ranford Pool - Pumphreys Bridge camping area - The bridge construction laydown area at Williams	(RP4) UCL, State of WA	(RP4) DPLH, Shire of Boddington, DWER	Shire of Boddington, Private landholders
				(PB5) UCL, State of WA	(PB5) DPLH, Shire of Wandering	Shire of Wandering, Private landholders
				(W6) State of WA, DPLH, Private landholders	(W6) DPLH, Shire of Williams, Private landholders, DWER	Shire of Williams, Private landholders

Item	Priority	Location	Action	Owner	Manager	Stakeholders
c-vi	Long-term	Popanyinning (5-6)	Continue to protect the conservation area, including fencing and gates to restrict access.	(P5-6) UCL, State of WA, DWER	(P5-6) DPLH, DWER	Shire of Cuballing, Private landholders
c-vii	Short-term / long-term	Williams (1-2) Hotham River Nature Reserve (All)	Investigate local sources of sediment at Williams, and work with landholders to improve land management practices (priority). In the long term, investigate the following with regards to sedimentation to guide improved land use management: - Channel instability in tributaries and upstream of the Williams townsite to determine the sources of sediment - Prepare a sediment budget from the Hotham River Nature Reserve upstream to Popanyinning, to understand the potential for sediment mobilisation.	(W1-2) UCL, State of WA, DPLH, DWER	(W1-2) DPLH, DWER	Shire of Williams, Private landholders
				(H2-8) UCL, DBCA, State of WA	(H2-8) CPC, DPLH	Shire of Cuballing, Private landholders
c-viii	Long-term	Popanyinning (1-4 & 7-8)	Work with rural residential and residential landholders to reduce nutrient inputs near the river.	(P1-2) UCL, DWER (P3) UCL, State of WA, DWER (P4) State of WA (P7) UCL, State of WA, DWER (P8) UCL, DWER	(P1-2) DPLH, DWER (P3) DPLH, Shire of Cuballing (P4) DPLH, Shire of Cuballing (P7) DPLH, DWER (P8) DPLH, DWER	Shire of Cuballing, Private landholders
d. Management of stormwater supported and improved, including townsite stormwater management						
d-i	Short-term	Popanyinning (4)	Modify local drains (e.g. south of the conservation area) to reduce flow speed and prevent local bank erosion.	(P4) State of WA	(P4) DPLH, Shire of Cuballing	Shire of Cuballing, Private landholders
d-ii	Long-term	Ranford Pool (2)	Investigate the water quality in the major tributary from the south, and consider modification and planting to improve nutrient and sediment removal.	(RP2) UCL	(RP2) DPLH	Shire of Boddington, Private landholders
d-iii	Long-term	Williams (4)	Work with developers to ensure zoned land south of Growse Street implements water sensitive urban design and appropriate sediment controls during construction to prevent damage to the adjacent channel.	(W4) Private landholders, State of WA, DWER	(W4) Private landholders, Shire of Williams, DWER	Shire of Williams

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APPENDIX 1: LITERATURE REVIEW

PHCC Working Together
Peel-Harvey Catchment Council

Literature Review

December 2019

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We acknowledge the Noongar people as Traditional Custodians of this land and pay our respects to all Elders past and present

Contents

1.0 Introduction

There have been numerous studies carried out in the Peel-Harvey Catchment on the condition of natural resources and methods of protecting and enhancing them. This literature review will focus on the Hotham-Williams Catchment, specifically previous studies and projects that have implemented assessment of, and improvement in the health of the sub-catchments and waterways. The existing literature will provide data, guidelines and methodology for the development of the Hotham-Williams River Action Plan (RAP) and projects thereafter, and identify gaps that exist for further research and collaboration with relevant organisations.

In 2015, the Hotham-Williams Natural Resource (NRM) Plan (the Plan) was prepared to guide future NRM work in the Hotham-Williams sub-catchment of the Peel Harvey Catchment (*Del Marco A, 2015)*. During community consultation for the Plan, the importance of rivers and creeks for their social and ecological values and management of river corridors was frequently raised as an issue of concern. To guide future NRM investment, Goal 2 of the Plan states that:

Rivers, creeks, valley floors and sub-catchments are managed and restored

a) Degraded areas are actively managed to restore natural functions, and production where appropriate;

b) Rivers and creeks are actively restored and managed for their water supply, ecological, landscape, social and cultural values;

c) Focused management of sub-catchments is encouraged to restore river and creek water quality for water supply, ecological, landscape social and cultural values;

d) Management of stormwater supported and improved, including town site stormwater management."

Nine prospective projects were outlined in the Plan to achieve these objectives. Projects 2.2, 2.3 and 2.8 aim to provide a current picture of overall river health of the Hotham and Williams Rivers and are outlined in Table 1.

As recommended in Project 2.2 *Assessing river condition and health*, this Literature Review aims to summarise the historical significance and management of the major rivers as well as existing studies of the watercourses in the Hotham-Williams Catchment. This in turn will provide a contextual background to the Hotham-Williams River Action Plan (Project 2.3) and provide additional data to present an overview of the catchment and recommendations for future field assessment in areas where field work is unable to be conducted. This Literature Review is to be considered a "living document" that is continually updated as additional data and resources are discovered.

The existing literature is arranged into common themes where the publications will be outlined and related to the scope of the River Action Plan. The common themes that make up this review are methodology, hydrology, aquatic fauna, flora, heritage, agriculture and research. Previous studies will also provide a basis to define the need for further investigations, case studies and future on-ground works.

Table 1: Prospective projects 2.2, 2.3 and 2.8 of the Hotham-Williams NRM Plan – Rivers, creeks and valley floors

	Project name	Project aims	Project Description	Project Rationale	Geographic coverage	Target Groups
2.2	Assessing river condition and health (selected river reaches)	Conduct field and desktop assessments to determine the health and condition of the Catchment's major Rivers, or selected river reaches. Findings are to guide River Action Plans and river restoration works.	Use existing river studies by industry, government and community to frame study objectives. (e.g. use of biological indicators of river health). Establish baselines to identify the 'what' and 'where' of river condition and health.	The condition of the Catchment's major river systems is of concern to the community. There is no recent study which presents an accurate picture of overall river health. Friends of the Reserves – Boddington has quarterly water test results of up to 17 sampling locations between Matchbrook Rd and Albany Highway, Crossman from April 2001 to present (ongoing activity). Test results cover water body temperature, pH, EC & NTU.	Major Rivers	PHCC, community, research organisations, industry, local Govt., DWER and Water Corporation.
2.3	Prepare River Action Plans for key river reaches	Create plans that are implementable, scientifically based and supported by the community.	River Action Plans identify key areas where restoration works are required. Use results of Project 2.2 (above) to guide the Plans	River Action Plan will ensure that resources to improve river health are allocated to the most effective works and activities	Major Rivers	All stakeholders

	Project name	Project aims	Project Description	Project Rationale	Geographic coverage	Target Groups
2.8	Focused sub-catchment restoration program	Improve water quality in selected sub-catchments.	Identify 1-3 sub-catchments where water quality improvement is a priority for farmers and land managers. Establish water quality improvement goals. Determine specific actions. Co-fund implementation	Past Landcare work has demonstrated that water quality improvement is achievable in small sub-catchments (e.g. saline water has been made fresh enough for farm use).	To be determined	All land manager sectors

2.0 Methodology and Guidelines

The condition of rivers and creeks is symptomatic of how water and land are managed throughout the catchment (Del Marco, 2015). In response to this, the PHCC is working in partnership with Urbaqua to develop the Hotham-Williams River Action Plan (RAP) through funding from Newmont Boddington. The principal aim of the RAP is to identify assets, attributes and threats to the health of the Rivers from which priority actions can be identified, and projects developed to help protect the ecosystem health and function of the Hotham and Williams Rivers and respective riparian zones.

There are a number of documents that provide a template for action planning and methods for data collection and these will be used to guide the development of the Hotham-Williams RAP.

2.1 Peel-Harvey Catchment Council (2015) Middle Murray River Action Plan. Reviewed and Updated 2015

The Hotham-Williams River Action Plan will be modelled on a working example of a RAP in the Peel-Harvey Catchment, the *Middle Murray River Action Plan*. *(Peel-Harvey Catchment Council, 2015)*. This document provides a summary of the Middle Murray River foreshore condition and weed presence, so that future works can be more focused on identified management priorities and issues. The condition of the foreshore assessments will be carried out using the Pen-Scott Method (*Pen and Scott, 1995).*

2.2 Pen, L.J. and Scott, M. (1995) Stream Foreshore Assessment in Farming areas. Blackwood Catchment Co-ordinating Group, Western Australia

The Pen-Scott method is a standardised rating technique that allows the user to classify foreshore areas along a gradient from pristine (A grade) through to highly degraded (D grade). This assessment system was developed for south west Western Australia so that it could be used by members of the local community, supported by state government agencies, to enable the production of maps and tables describing foreshore condition over large areas.

The Pen-Scott method has been included in the Water and Rivers Commission's River Restoration Manual *A Guide to the Nature, Protection, Rehabilitation and Long-Term Management of Waterways in Western Australia (2000),* a series of guidelines to determine the nature, rehabilitation and long-term management of waterways in Western Australia. It can be used both to prioritise and plan protection and rehabilitation works and to monitor the results of these works.

With 2,912km of mapped watercourses in the Hotham-Williams Catchment including the Hotham, Williams, Bannister and Crossman Rivers and their tributaries (Del Marco, 2015), eight priority sites were identified for field assessments on the Hotham and Williams Rivers using the Pen-Scott method. Reaches of the Rivers that are not field assessed due to scale and cost restraints will be evaluated via desktop using existing datasets and information to provide an overview of the catchment and recommendations for future field assessments. The sites identified were Quindanning and Williams town sites on the Williams River, and Ranford (Darminning) Pool, Pumphreys Bridge, Popanyinning town site and Hotham River Nature Reserve on the Hotham River. An additional site, Boraning, on the Williams River was also identified for field assessment due to disturbance in the Williams town site during construction of a new bridge on the Williams River. Yornaning Dam was also added to the list

of sites to be assessed in the field, which was requested by the Shire of Cuballing who provided additional funding.

2.3 Department of Water (2017) South West Index of River Condition (SWIRC)

The SWIRC is a suite of standardised methods for collecting field and desktop data and protocols for analysing it, including a standardised system for scoring river condition. This standardised process allows results to be compared between river systems. Furthermore, the scoring system complies with the national Framework for the Assessment of River and Wetland Health (FARWH).

The scoring protocols are based on a reference condition approach. Each score provides a measure of the departure of the observed values from expected values. The expected values are those typically anticipated under minimal disturbance conditions, and can be derived from historical data, data from minimally disturbed sites or expert opinion. SWIRC scores are divided into Condition Bands ranging from 'largely unmodified' to 'severely modified'.

SWIRC consists of several themes, sub-themes and components, including catchment disturbance, hydrological change, the fringing zone, the physical form, water and sediment quality and aquatic biota.

In addition to the Pen-Scott method, the eight priority sites on the Hotham and Williams Rivers that were assessed for the RAP were also surveyed following the DWER South West Index of River Condition (SWIRC) protocols. Importantly, this approach will ensure that methods are standardised at each site to enable direct comparison of data between sites, and enable comparison with future assessment and monitoring of their ecological condition. An interpretive report summarising the condition of each site will include standardised scores for each of the indicators measured and arranged into condition bands, relative to the condition of the reference site.

2.4 Peel-Harvey Catchment Council (2015) Binjareb Boodja Landscapes 2025: A Strategy for Natural Resource Management in the Peel-Harvey Region, A Report to the Peel-Harvey Catchment Council, Jane O'Malley & Andrew Del Marco (eds) Mandurah, Western Australia.

The Strategy has been compiled by the Peel-Harvey Catchment Council as the Region's first official natural resource management (NRM) Strategy. It provides a road map for how the Peel-Harvey community plans to repair and care for the natural resources of the Region over the next 10 years to reach a 100 year vision. There are 2,912 km of mapped watercourses in the Hotham-Williams Catchment. Only 7% of these watercourse reaches have been assessed to be in good or better condition. The community's priorities in the Hotham-Williams sub-catchment include implementing catchment management to improve water quality.

The following is of particular relevance in terms of threats and issues that will be addressed, and goals of the NRM Strategy achieved, through the development and implementation of the Hotham-Williams RAP:

- Section 5.2.5 of the NRM Strategy *Water Resources, Water Quality, Wetlands and Waterways* states that all of the waterways of the Hotham-Williams catchments, once fresh, are now salty due to extensive clearing of native vegetation;
- Goal B1.2 Improve the condition of wetlands and watercourses

    - Activity B1.2.1 Prepare and implement action plans to restore the natural function of wetlands and watercourses;
    - Activity B1.2.2 Prepare and implement action plans to manage drains for multiple benefits;
    - Activity B1.2.3 Manage issues such as erosion, sediment and monosulphidic black ooze to improve/protect condition of wetlands and watercourses;
- Goal B1.3 Protect wetlands and watercourses
    - Activity B1.3.1 Influence land-use planning to afford protection to wetland and watercourse values;
    - Activity B1.3.2 Encourage implementation of management plans and ongoing maintenance in accordance with planning conditions;
- Goal B1.4 Protect groundwater quality and quantity as hydrological inputs to wetlands and watercourses
    - Activity B1.4.1 Ensure environmental water provisions are adequate for maintenance of ecosystem health;
    - Activity B1.4.2 Ensure groundwater monitoring is sufficient to measure and assess environmental water provision adequacy.

2.5 Del Marco, A (2015) Hotham-Williams NRM Plan, A report to the communities of the Hotham-Williams Catchment and the Peel-Harvey Catchment Council, Western Australia, July 2015, Perth.

This report was prepared to guide coordinated natural resource management and landcare activities in the Hotham-Williams Catchment. It was prepared through a process of community consultation, review of technical documents and professional analysis. The Plan works on a number of levels, in particular to:

- Propose a long-term vision and objectives for natural resource management that is broadly supported by the community;
- Outline possible future NRM programs and projects, based on ideas that have been put forward by community members or area recommendations of past projects and studies;
- Provide a framework by which the community can consider how they wish to coordinate future NRM programs and works.

Goal 2 of the Hotham-Williams NRM Plan, that *rivers, creeks, valley floors and sub-catchments are managed and restored* provides four broad objectives on which the River Action Plan recommendations will be based.

2.6 MacGregor, C., Cook, B., Farrell, C. and Mazzella, L. (2011). Assessment framework for prioritising waterways for management in Western Australia, Centre of Excellence in Natural Resource Management, University of Western Australia, Albany.

The framework provides a consistent and transparent approach to setting priorities for management. It ranks waterways in terms of their ecological, social and economic values and also according to their level of threat. Based on these rankings, waterways are classified into broad categories and appropriate management responses for each of these categories are proposed. The framework can be used at scales ranging from whole catchments down to individual reaches of a waterway.

The assessment approach is based on a framework of values, criteria, indicators and measures. Three broad categories of values are proposed – ecological, social (including cultural) and economic. For each of these values, a number of criteria are defined. For each of these criteria, a number of indicators are proposed, and for each indicator, a number of possible measures are suggested.

This document recommends criteria to use, GIS databases and other sources of information to rank management priorities for waterways.

2.7 Water and Rivers Commission (2000) A Guide to the Nature, Protection, Rehabilitation and Long-Term Management of Waterways in Western Australia. Water and Rivers Commission.

This series of guidelines provides a guide to the nature, rehabilitation and long-term management of waterways in Western Australia. The chapters of the series collectively form the River Restoration Manual. The manual is split into sections under the following topics:

1. Introduction;
2. Catchment Processes;
3. Stream Channel Processes;
4. Stream Channel Analysis;
5. Stream Ecology;
6. Revegetation;
7. Stream Stabilisation;
8. Planning and Management.

Of particular note is the section on Planning and Management. It includes seven reports outlining foreshore condition assessment in different landuse environments, planning for waterways management, determining foreshore reserves and guidelines for preparing a regional strategy Water Management Plan, and River Action Plan. The reports most relevant to the development of the Hotham-Williams River Action Plan are outlined below.

2.8 Water and Rivers Commission (2000), Planning and Management: Foreshore condition assessment in farming areas of south-west Western Australia. Report No RR 3. Water and Rivers Commission.

This report was developed for farming areas in south-west WA and is a revised version of Pen, L.J. and Scott, M. (1995) Stream Foreshore Assessment in Farming areas. It includes how to conduct a foreshore assessment in Farming areas and how to complete the assessment using the survey form.

2.9 Water and Rivers Commission (1999), Planning and Management: Foreshore condition assessment in urban and semi-rural areas of south-west Western Australia. Water and Rivers Commission River Restoration Report No. RR2.

This report was developed for urban and semi-rural areas in south-west WA based on the methods developed by Pen and Scott in 1995. The document includes how to conduct a foreshore condition assessment in urban and semi-rural areas and how to complete the assessment using the survey form.

2.10 Water and Rivers Commission (2001) Planning for Waterways Management: Guidelines for Preparing a River Action Plan. Water and Rivers Commission, River Restoration Report No. RR 14.

This report is a guide to preparing a River Action Plan (RAP) and has been prepared for community groups and people who are involved in on-ground river restoration activities. The purpose of a RAP is to provide an integrated and coordinated approach to on-ground management of waterways on a local scale. There are five key steps to the RAP planning process:

1. Community and stakeholder consultation;
2. Information collection;
3. Strategic outline;
4. Establishing management actions;
5. Gaining approval.

It is important to gain an understanding of the current situation of the catchment by compiling information on the ecological condition of the waterways, pressures exerted on the waterways, the extent and severity of the impacts resulting from the pressures, the response to the pressures, the history of the waterways, past management practices and landuses. This can be achieved by reviewing reports, data sets, other Action Plans and texts, as well as carrying out RAP foreshore condition assessments (on-ground and desktop). For the purpose of this literature review, documents relevant to the Hotham-Williams River Action Plan have been summarised under the categories of Hydrology, aquatic fauna, flora, heritage, agriculture and research.

3.0 Hydrology, Surface Water Management and Groundwater Management

3.1 Joyce, Leonie Rose (2007) The Hydrological Impacts of Climate Change and Variability in the Murray Hotham Catchment, Western Australia. Honours Dissertation School of Environmental Systems Engineering. The University of Western Australia.

This study quantifies how rainfall patterns have changed in the Murray and Hotham Sub-Catchments in the Peel-Harvey Catchment during the last century, and how the landscape has responded hydrologically to this change. It also projects future change in climate characteristics that may influence catchment hydrological processes.

The findings of the study into historical change and the projection of future change in rainfall and runoff response both clearly indicate that, like other areas of the South West of Western Australia, the Murray and Hotham Catchments are becoming drier. Rainfall has decreased, and projections suggest that further decline is probable. The observed and projected surface hydrological response amplifies this rainfall reduction, demonstrating extreme sensitivity to change in inputs. Managers of water and land should consider these and other projections when planning strategies for a water limited future.

The document makes recommendations for improving the statistical analysis of the catchment by improving the modelling software and processes. It is recommended that further research should continue to investigate the impact of projected climate change in the south west of Western Australia including and beyond the small region containing water supply catchments.

3.2 Westrup, T. (2009), Surface water management in the East Yornaning Catchment. Department of Agriculture and Food, Western Australia, Perth. Report 345.

This report documents the results of a surface water risk survey undertaken with landholders in the East Yornaning catchment group during 2008. It includes a description of the catchment, the landholders' interpretation of surface water risks, a field assessment by surface water specialists and suggestions for remedial work.

Landholders were surveyed during 2008 on a range of agriculture related issues which included surface water hazards. These included water supplies, flooding, waterlogging, salinity in dams and water courses, water erosion, phosphorus export and culvert maintenance.

Constructing large dams and grade banks in the shedding landscape to ease peak flow pressure is recommended. Some of the culverts in the receiving landscape need attention, as inappropriate size and installation are currently hampering surface water drainage upstream of the crossings.

3.3 Ghauri, S. (2002) Groundwater Study of the Wandering Town site. Resource Management Technical Report 260. Department of Agriculture. Government of Western Australia.

A groundwater study of Wandering was undertaken as part of the Rural Towns Program Community Bores Project which aimed to provide the technical basis on which towns can develop their salinity management strategies. This report describes the town and its catchment, the hydrogeological investigation characterising groundwater flow systems with the town site, and recommended actions for managing salinity risk

Wandering Shire had concerns over damage to the town site infrastructure, particularly the car park at the community centre. Wandering Shire had already installed a deep closed drain above the car park in an attempt to reduce waterlogging. Other issues were degradation of vegetation south of the town and possibility of leakage from a water supply dam contributing to groundwater problems. To assist in salinity management it was recommended to:

1. Revegetate public areas above and around the car park;
2. Delineate the transmissive zone and devise an economic dewatering strategy;
3. Line water supply dam to prevent leakage;
4. Manage surface water in the catchment;
5. Rejuvenate the main creek to assist in surface drainage;
6. Revegetate areas of dead or dying native vegetation with salt-tolerant trees and shrubs;
7. Reduce recharge on cleared land to the west of the town.

3.4 Raper, G P. (2005), Groundwater study of the Boddington town site. Department of Agriculture and Food, Western Australia, Perth. Report 252

A study of the groundwater beneath the Boddington town site was carried out in April 2002. The aim was to assess the salinity risk to the town site infrastructure and to accelerate the implementation of effective salinity management for the town.

Thirty-one piezometers were installed at 14 sites. This study showed that most of the Boddington town site sits over quartz-rich weathered granitic rocks. This contributes to the high yields of water (up to 2.0 L/s) observed in several piezometers drilled in the town. The study found that groundwater

levels were 4 to 5 m deep under the central business district and that groundwater levels are not rising at significant rates, suggesting that this area of town is not at risk from salinity. Groundwater pressures were above ground level adjacent to two watercourses in Boddington and the surrounding areas already exhibit signs of degradation resulting from salinity and waterlogging. Recommendations for managing the salinity risk to infrastructure in Boddington are:

1. Investigate the development of the potential groundwater resource under the north-western portion of the school sports ground, to replace the bore currently used;
2. Install additional shallow subsurface drains under the school sports ground and investigate the possibility of installing similar drains under the areas to the east of the school buildings;
3. Revegetate watercourses and public open space to minimise the impacts of shallow groundwater in areas adjacent to natural drainage lines that run through the town site;
4. Continue to monitor groundwater levels throughout the town site;
5. Commence monitoring the condition of the drainage line and vegetation in the vicinity of Johnstone St;
6. Implement water conservation and recharge reduction measures in the Boddington town site.

3.5 Water Condition Rating (and Reservoir Condition Rating) (2014) Peel Harvey Catchment Council.

This dataset shows the condition of water in the Peel-Harvey Catchment. As the data was extracted from a hard copy map, no data processing lineage from the original dataset has been captured. The map indicates the data source was "Adapted from Hamilton (2002)" but may be from a report by Hamilton in 2012 which was also not able to be located. It is recommended that Hamilton (2002) is investigated further as its usefulness is not able to be verified without a copy of the original report.

The watercourse condition maps are available as ESRI Shapefile Format. Watercourses range from A2-A3 Near pristine, slightly disturbed to C1-C3 Erosion prone, Eroded. A2 and A3 watercourses occur mostly in Reserves and large areas in the west of the catchment that have not been cleared.

3.6 Department of Water (2009) Rights in Water and Irrigation Act, 1914 Surface Water Proclamation Areas Map. Department of Water, Water Resources Use Division.

This map shows all of the areas in Western Australia that are proclaimed as Surface Water Areas under the Rights in Water and Irrigation Act, 1914 (RIWI Act). The Hotham-Williams Catchment is within the Murray River System which is a proclaimed Surfaced Water Area under the RIWI Act, meaning that it is illegal to take water from a proclaimed watercourse without a licence.

3.7 Department of Water. Hotham-Williams-Murray Rivers Salinity Recovery Projects. Department of Water

Department of Water and Environmental Regulation, previously Department of Water, has recorded water quality data from gauging stations on the Crossman River and 14 Mile Brook. These stations provide computerised measurements of a range of factors including flow levels, pH and salinity levels.

3.8 Hotham-Williams Snapshot Data 2003-2009

A variety of datasets from 81 locations in the Hotham-Williams catchment collected from 2003-2009 are available for analysis. Data available includes EC, Temperature, TDS, pH, TN, TP and TSS. Data for some, if not all of the sites may also exist with the Department of Water, Newmont Boddington,, South 32 Worsley Alumina and community groups such as Friends of the Reserves Boddington. Long term data will give a better picture of the health of the Hotham and Williams River systems and if there is a change in the trends.

3.9 Peel-Harvey Catchment Council (2008) RS01 Hotham Williams Murray River Salinity Recovery Project Report September 2008.

The report is a result of collaboration between PHCC, GHD (Matt Giraudo) and the Dept of Water. It contains:

1. GHD (2008) Preliminary Salinity Situation Statement for the Hotham-Williams-Murray Catchment Part 1: Conceptual Hydrogeological Analysis November 2008;
2. Peel-Harvey Catchment Council (June 2008) Hotham-Williams-Murray River Salinity Recovery Project Community Workshop Dryandra 25th June 2008. (Presentation);
3. Monitoring Data and Site Review Information
    a. Dept. of Water Flow Gauging Station Data;
    b. Peel-Harvey Catchment Council (2004) Sampling and Analysis Plan Hotham-Williams Salinity Snapshot;
    c. Hotham-Williams Snapshot Results 2007;
4. GHD (2008) Report on Preliminary Salinity Situation Statement – Hotham-Williams-Murray Catchment Part 2: LUCICAT Model November 2008.

Gauging Stations were built on the Crossman River and 14 Mile Brook. These stations provide computerised measurements of a range of factors including flow levels, pH and salinity levels. The report provides an understanding of current salinity situation in the upper Peel-Harvey Catchment and the development of mathematical and conceptual hydro-geological model to assist in the development of management responses to salinity in the catchment. It also provides a review of stream-flow and salinity monitoring.

4.0 Aquatic Fauna

4.1 Bunn, S.E. & Davies, P.M. Hydrobiologia (1992) Community structure of the macroinvertebrate fauna and water quality of a saline river system in south-western Australia. 248: 143. https://doi.org/10.1007/BF00006082

The purpose of this paper is to provide a description of the water quality and macroinvertebrate fauna of a salinised river system in the south west of Western Australia.

Two sites on an intermittent stream (Thirty-four Mile Brook) and two sites on a perennial river (Hotham River), above and below the confluence of the two waterways, were sampled on three occasions for benthic macroinvertebrates. Classification and ordination revealed major differences in community structure of the benthic fauna between the Hotham River and its tributary. This was

attributed to differences in the physical nature of the two waterways, particularly substrate characteristics and stream permanence, rather than differences in water quality. Temporal differences in community structure were also apparent, but were more obvious in the Hotham River than in the tributary.

4.2 Wetlands Research & Management (2012). Thirty-Four Mile Brook Ecological Monitoring: Aquatic Fauna sampling September 2010 and August 2011. Unpublished report by Wetland Research & Management to Newmont Boddington Gold Pty Ltd. Final Report August 2012.

Newmont Boddington Pty Ltd has made a commitment to monitor the ecological health of Thirty-Four Mile Brook which traverses their mine lease near Boddington. A snapshot of the condition of the Thirty-four Mile Brook was recorded in September 2010 for that point in time.

4.3 Wetland Research & Management (2012). Acquired Lands Ecological Monitoring: Baseline Aquatic Fauna Sampling August 2011. Unpublished report by Wetland Research & Management to Newmont Boddington Gold. Final Report August 2012.

A snapshot of the condition of Boggy House Brook and Wattle Hollow Brook was recorded in August 2011 for that point in time. During the course of the study, a total of 6 sites were sampled for water quality and aquatic fauna:

- Boggy Brook; three sites upstream of Gold Mine Road: AL1, AL6, and AL8;
- House Brook; two sites upstream of Mine Road: AL3, and AL4;
- Wattle Hollow Brook; one site downstream of Gold Mine Road: WHB1.

4.4 Wetland Research & Management (2012). Gringer Creek - Baseline Aquatic Fauna sampling October 2011. Unpublished report by Wetland Research & Management to Newmont Boddington Pty Ltd. Final Report September 2012

A snapshot of the condition of Gringer Creek (a Tributary of Bannister River) in October 2011 for that point in time. Surveys included sampling for water quality, aquatic macroinvertebrates, crayfish and vertebrate fish. The scope of work for the current study included:

1. Systematic sampling of water quality, benthic macroinvertebrates, crayfish and fish of the Gringer Creek in early spring 2011;
2. Comparison of water quality data against ANZECC/ARMCANZ (2000) guidelines for protection of aquatic ecosystems;
3. Assessment of the conservation status of aquatic fauna recorded;
4. Statistical analysis of species assemblage data.

5.0 Flora

5.1 Greenskills Inc. (2007) Peel Harvey Regional Ecological Linkages Project. South West Catchments Council.

The project identifies Regional Ecological Linkages and local natural area 'stepping-stones' in the eastern Peel Harvey Region, to provide the basis for establishing a sustainable ecological network for the whole Peel Harvey Catchment.

Five datasets were created identifying the location of Ecological Linkages, and priority reserves and remnant vegetation, and displaying regional significant ratings of reserves. Datasets have been entered in GRID .

5.2 L W Sage, L.W., Blankendaal, P.A., Moylett, A., & Agar, K. (2004). The occurrence and impact of Phytophthora cinnamomi in the Central Western Avon Wheatbelt Bioregion of Western Australia. Journal of the Royal Society of Western Australia, 87:15–18, 2004

While there have been numerous studies examining dieback (the expression of the disease caused by *Phytophthora cinnamomi*) in the Jarrah forest, little work has been done on the impact and distribution of the disease in the lower rainfall areas of the South West botanical province. This study in the Narrogin district found four dieback infestations were found out of the 21 Dryandra Woodland blocks, 11 nature reserves and one private property. All infestations were located on water-gaining sites (i.e. along a water course, drain or near a dam) or where there had been high disturbance in areas that were also low in the landscape. 11 susceptible plant species were recorded as dead or dying in association with the dieback infections but other possible causes of death, such as drought, cannot be discounted as contributing factors. There are a number of management recommendations when carrying out field work in natural areas:

1. In winter and spring or under moist soil conditions (where clumps of soil may attach that may carry propagules) vehicles should be cleaned down on entry into reserves and State Forest blocks to remove soil and root material underneath;
2. Road maintenance activities should avoid relocating soil from gullies and water-gaining sites;
3. Vehicle access tracks that cross gullies or areas of muddy sticky soils should be constructed to allow natural drainage. Track running surfaces should remain hard and not conducive to soil adhering to vehicles.

6.0 Heritage: Stories of Place (mythology and community context)

6.1 Indigenous Heritage

6.1.1 Department of Aboriginal Affairs (DAA) Fact Sheet: Reassessment of DAA 27935 (Hotham River) DAA 27935 Hotham River is reported as being associated with a sacred narrative from Pumphreys Bridge near Wandering to where it meets the Murray River.

The purpose of the DAA is to protect Aboriginal heritage within Western Australia, which does not affect property ownership. In relation to the Hotham River, the area which has been associated with a sacred narrative and is classified as having mythological significance, encompasses approximately 30 metres of riverbank. Land owners and managers should seek the advice of DAA if they propose to undertake any activities within the boundary of DAA 27935. DAA provides an online mapping search system that is available at http://maps.dia.wa.gov.au/AHIS2/

6.1.2 Abraham, M (2015) Koompkinning: The Pumphreys Bridge Storybook. Wheatbelt NRM

"Koompkinning: The Pumphreys Bridge Storybook" is a collation of local stories and photographs, containing information on local significant sites, flora and fauna, family groups, and the mysterious falling stones. The story included details of how Pumphreys Bridge looked in the early - mid 20th

Century and how it was part of every Noongar life. There is specific mention of the pool "Koomphinning" meaning plenty of water and spring at Pumphreys Bridge.

6.1.3 Thorne, G & Thorne, E (2017) Interview with Greg and Errol Thorne. Interviewed by Melanie Durack (Peel-Harvey Catchment Council) and Greg Marston (Friends of the Reserves – Boddington (Inc.))

Voice-recorded interviews with local Noongar Elder Greg Thorne and his brother Errol Thorne at Camballing Reserve, Red Hill Reserve and Mooliamans Reserve. Stories include life around Camballing Reserve on the banks of the Hotham River, the "Mooly Man" legend and significant sites in the Hotham and Williams Rivers.

6.1.4 Water and rivers Commission (2002) Water Notes: Safeguarding Aboriginal Heritage. WN30 November 2002.

This Water Note is intended to provide community members and government staff with an understanding of the importance of rivers and wetlands to Aboriginal people and why there is the need for consultation. The Water Note focuses on legal responsibilities under the Aboriginal Heritage Act 1972 and the Native Title Act 1993 and the preferred approach before, and during, river and wetland restoration activities to ensure that sites of heritage or spiritual significance are protected. The note also provides a brief overview of the spiritual significance and history of rivers and wetlands to Aboriginal people. In the context of river restoration, activities that require approval on Aboriginal sites include any digging into or driving any object into a bank or bed of a river, estuary or wetland; and any construction such as gauging stations, erosion control works and river restoration works.

Individuals or groups undertaking on-ground projects are responsible for ensuring that Aboriginal sites of significance are not disturbed and that obligations related to native title ownership of, or claims for the project area are observed. As a general rule it is recommended that in the initial stages of a project, prior to any works being undertaken, all legal and social aspects be identified by contacting the appropriate government agencies.

6.1.5 Kickett, Glenda J & Curtin University of Technology. Centre for Aboriginal Studies (2004). Karla Kuliny -- return to the campfire: the Kickett family of Cuballing, story about country.

This study provides the background experiences, stories, and feelings of one family's connection to and association with country. The research has been conducted and framed from an insider's perspective, based on the Kickett family of Cuballing in the Upper Great Southern region of Western Australia. The study examines the ways in which, despite the impact of colonisation, Noongar peoples' connection to and association with country has been modified to suit their changing cultural, social and economic experiences. The Kickett family property is adjacent (upstream) to Yornaning Dam which is on a tributary of the Hotham River.

6.2 European Heritage

6.2.1 Ebner, Pilica Brito (1994) The Pumphreys journey: the story of a pioneer family.

A historical account of the Pumphrey family and settlement of their homestead at Pumphreys Bridge (Hotham Crossing). Chapter 2-5 and 9-10 have accounts of early white settlement and daily life at Pumphreys Bridge.

6.2.2 Ferrell, John (1992) Becoming Boddington. Shire of Boddington

A history of the Boddington district from 1830 to 1992 including all aspects of community life from pioneer subsistence to development of the Boddington Gold Mine. The collection includes photographs, interviews, biographical notes, correspondence, cuttings, and records of Marradong Road Board.

7.0 Agriculture

7.1 Sharafi, S, Lauk, H, and Galloway, P. (2005), Avon Hotham Catchment Appraisal 2005. Department of Agriculture and Food, Western Australia, Perth. Report 294

This report summarises current information on risks and impacts to agricultural production and natural resources within the Avon Hotham study area. It then identifies suitable options to manage such risks.

The salinity of both the Avon and Hotham Rivers has risen substantially since the clearing of the native vegetation from their catchments. The estimated original salinity of these rivers is between < 100 mS/m and 550 mS/m (fresh to brackish). The Hotham has increased to an average fluctuation of between 400 mS/m and 2,500 mS/m (brackish to saline).

The document outlines recommendations to manage surface water runoff to minimise erosion, groundwater recharge, waterlogging and to conserve water for supply.

8.0 Research and other projects

8.1 Glynn, M. & Marston, G. (2016) Ranford Pool Revitalisation: Project Proposal

The goal of the proposal was to enhance the visitor experience at Ranford (Darminning) Pool by carrying out improvements to the amenities and natural waterscape of the Pool area, promoting responsible recreational use and the restoration and preservation of the natural environment. The project outlined 5 proposed phases:

1. Reduce vehicular access to banks and waterside to improve safety, stop ‘hoon’ driving activity and reduce erosion of banks and tracks;
2. Re-establish a natural back side landscape removing the eroded depressions from vehicular use and install graduated pedestrian access to waterside;
3. Enhance user access to the water and rehabilitate vegetation at the Pool;
4. Provide amenities to users of the Ranford Pool;
5. Enhance water user experience.

The proposal also recommended actions for each of the 5 phases. The Ranford Pool Revitilisation Project was funded by South 32 as a joint project between PHCC, Friends of Reserves Boddington and Shire of Boddington. Urbaqua were consulted to draw up plans for rehabilitation works which were completed in 2019.

8.2 Maesepp, Ella Korine (2002) Assessing the Health of the Yornaning Catchment, South-west Western Australia: Past, Present and Future. Honours Thesis School of Environmental Science. Murdoch University.

Yornaning Dam was engineered for an improvement in water quality following recommendations made in a 1992 study by C.J. Clarke *The Degradation of the Yornaning Dam and its Surroundings: Future Management Strategies.* The 2002 Honours thesis provides the follow-up study of the engineering and an assessment of the health of the Yornaning Catchment as a whole, relative to the baseline data collected in 1992.

Data from 1992-2002 show that the health of the Yornaning Catchment is declining. The EC of the water within the Yornaning Dam and Yornaning Creek is increasing while the flow of the water in the creek is decreasing.

In order to protect the Yornaning Dam from further decline, the amount of water entering the dam must be increased. Recommendations are made in Chapter 6 and 7 as to how this can be achieved.

8.3 Shire of Boddington ICLEI Water Campaign™ Local Action Plan.

Shire of Cuballing ICLEI Water Campaign™ Local Action Plan.

Shire of Wandering ICLEI Water Campaign™ Milestone 3: Corporate and Community Local Action Plan.

The purpose of these documents is to provide a strategic direction and an implementation plan for improved water management. In accordance with the Milestone 3 of the ICLEI Water Campaign, the local action plans include:

1. An outline of the National, State, Regional and Local context of water management;
2. A baseline profile of water consumption and water quality issues within the Shires' boundaries;
3. A statement of water conservation and water quality goals set by the Shires;
4. An outline of council actions and policies implemented by the Shires since the base year;
5. An outline of proposed actions and policies to be implemented by the Shires up until the target year;
6. A commitment to monitoring and review of the local action plan.

9.0 Gaps and Future Opportunities

It is important to note that some recommendations suggested in the reviewed documents are outside PHCC controls and or capabilities.

The Hotham-Williams NRM Plan (2015) identified that assessing river health and the development of the Hotham-Williams River Action Plan were important projects that would help achieve Goal 2 of the NRM Plan which states that 'Rivers, creeks, valley floors and sub-catchments are managed and restored'. *It is recommended that the River Action Plan (RAP) is consistent with other RAPs in the Peel-Harvey Catchment and other Catchments in south west Western Australia.*

The principal aim of the River Action Plan is to identify assets, attributes and threats to the health of the rivers. From this priority action can be identified, and projects developed to help protect the ecosystem health and function of the Hotham and Williams Rivers and respective riparian zones.

It is recommended that the Pen-Scott method, described in the Water and Rivers Commissions River Restoration Manual, is used to assess and rate the condition of the foreshore of the Hotham and Williams Rivers. The Pen-Scott method was developed for the south west of Western Australia and has been used for other River Action Plans in the Peel-Harvey Catchment. This method can be used by members of the community to assess other sites in the Hotham-Williams Catchment in the future.

It is recommended that the health of Hotham and Williams Rivers are assessed using the South West Index of River Condition (SWIRC). Developed by the Department of Water, is a standardised system for collecting and analysing field and desktop data, and scoring river condition. This allows the result to be compared between river systems.

9.1 Data and further investigations

There has been significant decrease in average annual rainfall and consequently runoff in the Hotham-Williams catchment since 1975. Projections suggest that further decline is probable. Managers of water and land should consider these and other projections when planning strategies for a water limited future. *It is recommended by Joyce (2007) that further research should continue to investigate the impact of projected climate change, and the resulting decrease in rainfall, in the south west of Western Australia.* Problems were encountered downscaling the present (1975-2004) modelled rainfall distribution to correctly predict the observed data. If possible, investigations should be carried out for improving the modelling software and processes for better statistical analysis of the catchment

Phytophthora cinnamomi was found at 4 sites in the Narrogin district and may also be present in other low lying, water gaining sites in the Hotham-Williams Catchment. *Further studies could help identify infested sites. When screening for P. cinnamomi it is recommended taking soil and root tissue samples from deep-rooted plants such as Banksia sp.* Higher moisture in roots and soil is likely to be found deeper in the soil profile.

To avoid the spread of Phytophthora cinnamomi, it is advised that under moist soil conditions vehicles should be clean on entry to nature reserves and State Forest blocks, road maintenance works should not move soil from gullies, and that vehicle access tracks across boggy crossings should be avoided or built to provide a hard, all weather running surface.

9.2 Approvals

The Hotham-Williams Catchment is within the Murray River System which is a proclaimed Surface Water Area under the Rights in Water and Irrigation Act, 1914.

DAA 27935 Hotham River and its tributaries is reported as being associated with a sacred narrative, from Pumphreys Bridge near Wandering to where it meets the Murray River.

It is recommended that in the initial stages of a project, prior to any works being undertaken, all legal and social requirements for approval be identified by contacting appropriate government agencies.

9.3 Case Studies

Stories of Noongar culture on the rivers in the Hotham-Williams Catchment have been recorded to some extent*. It is recommended to Increase the catalogue of resources by documenting stories and narratives of the importance of the watercourses to Noongar culture, and the stories linked to the rivers.* This may be in the form of voice and/or video recordings, publications, maps or public presentations.

Works that have already commenced or have been completed in the Hotham-Williams Catchment could be useful case studies for similar sites. *It is recommended that case studies be generated detailing the actions of implemented projects, issues that needed to be overcome and outcomes of the projects.* The Revitalisation of Ranford (Darminning) Pool is an example of a project which would provide a good case study for future on-ground proposals.

9.4 On-Ground Works

In 2002, the Rural Towns Program undertook groundwater studies in the Boddington and Wandering as part of the Community Bores Project, which aimed to provide the technical basis on which towns can develop their salinity management strategies. While many of the recommendations made in these reports were beyond the scope of PHCC, some of the recommendations focused on managing surface water in the catchment and reducing recharge of groundwater on cleared land through revegetation programs. *In particular, it was recommended to:*

1. *Rejuvenate the creeks to assist in surface drainage;*
2. *Revegetate areas of dead or dying native vegetation with salt-tolerant trees and shrubs;*
3. *Revegetate above areas affected by salinity and/rising groundwater;*
4. *Revegetate watercourses and public open space to minimise the impacts of shallow groundwater in areas adjacent to natural drainage lines that run through the town sites;*
5. *Continue to monitor groundwater levels throughout the town sites.*

Watercourse condition in south west of Western Australia, including those in the Hotham-Williams Catchment, were mapped to show the condition of water adapted using information on a previous map created by Hamilton (2002). However, the original dataset, including the metadata, used by Hamilton has not been able to be located to verify the map*. It is recommended that the report by Hamilton (2002) be located to verify the watercourse condition dataset and methodology.*

A variety of water quality data from 81 locations in the Hotham-Williams Catchment was collected from 2003-2009 (*Hotham Williams Snapshot Data 2003-2009).* Further data collection after 2009 is likely to have been carried out by the Department of Water and Environmental Regulation (DWER), Newmont Boddington, South 32 and community Groups such as Friends of Reserves Boddington. *This data should be compiled and analysed to gain a better understanding of the health of the rivers and trends over time.*

Further recommendations will come from the River Action Plan site assessments and River Health Assessments (RHA) are being carried out in late 2019 at 4 Priority sites on the Hotham River and 3 Priority sites on the Williams River (2 sites for the RHA).

10.0 Conclusion

Of the 2,912 km of mapped watercourses in the Hotham-Williams Catchment, only 7% have been assessed to be in good or better condition (Hamilton, 2002; Del Marco, 2015). During community consultation for the Hotham-Williams NRM Plan, the importance of rivers and creeks for their social and ecological values, and management of river corridors was identified as significant (Del Marco 2015). To address these concerns, assessing river condition and health and the subsequent preparation of a River Action Plan were projects identified to achieve Goal 2, that *Rivers, creeks, valley floors and sub-catchments are managed and restored*. Furthermore, the Hotham-Williams RAP will assist the PHCC to seek funding and strategically allocate resources to conduct on-ground activities that achieve successful environmental and community outcomes.

Many studies have been carried out and data collected by research institutions, industry, government departments and community groups on factors affecting the Hotham-River Catchment. Localised studies of hydrology, surface water management, groundwater management, aquatic fauna, and flora have been carried out. However, these studies have either been localised or very broad, and are not always put into the context of the Hotham-Williams Catchment. Projects 2.2, and 2.3 identified in the Hotham-Williams NRM Plan 2015-2025 will inform and enhance most other projects under Goal 2, that *Rivers Creeks, Valley Floors and Sub-catchments are managed and restored.* Furthermore, the studies and data identified in this Literature Review fill gaps in areas where field work is unable to be carried out to present an overview of the health of the waterways in the Hotham-River Catchment. Aboriginal heritage and European settlement stories have also been documented and provide contextual background to the cultural significance of watercourses in the region.

Further work and research continues to be undertaken in the Hotham-Williams Catchment by research institutions, government departments, private industry and other non-government organisations. For this reason, this literature review is considered a 'living document' that is to be updated as additional resources are identified.

11.0 Table of Publications

The following table provides an alphabetised summary of publications and the number assigned to each document corresponds with the sections outlined in the body of the literature review.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
6.1.2	Abraham, M (2015) Koompkinning: The Pumphreys Bridge Storybook. Wheatbelt NRM	A collation of local stories and photographs, containing information on local significant sites, flora and fauna, family groups, and the mysterious falling stones.	Details of how Pumphreys Bridge was used in the early to mid-20th Century and how it was part of every Noongar life. There is specific information on the pool ("Koompkinning" meaning plenty of water) and spring at Pumphreys Bridge.	Electronic and Hardcopy	The historical use of the river by the Noongar community will be acknowledged and on-ground activities that are prioritised by the RAP will take this into account.
4.1	Bunn, S.E. & Davies, P.M. Hydrobiology (1992) Community structure of the macroinvertebrate fauna and water quality of a saline river system in south-western Australia. 248: 143. https://doi.org/10.1007/BF00006082	A description of the water quality and macroinvertebrate fauna of a salinised river system in southwestern Australia.	Two sites on an intermittent stream (Thirty-four Mile Brook) and two sites on a perennial river (Hotham River), above and below the confluence with the above tributary, were sampled on three occasions for benthic macroinvertebrates. Classification and ordination revealed major differences in community structure of the benthic fauna between the Hotham River and its tributary. This was attributed to differences in the physical nature of the two streams, particularly substrate characteristics and stream	Electronic	The findings of this study are site specific and can be referred to during future reach assessments that occur as a result of the RAP.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
			permanence, rather than differences in water quality. Temporal differences in community structure were also apparent, but were more obvious in the Hotham River than in the tributary.		
2.5	Del Marco, A (2015) Hotham-Williams NRM Plan, A report to the communities of the Hotham-Williams Catchment and the Peel-Harvey Catchment Council, Western Australia, July 2015, Perth.	This report was prepared to guide coordinated natural resource management and landcare activities in the Hotham-Williams Catchment. It was prepared through a process of community consultation, review of technical documents and professional analysis.	The Plan works on a number of levels, in particular to: 1. Propose a long-term vision and objectives for natural resource management that is broadly supported by the community; 2. Outline possible future NRM programs and projects, based on ideas that have been put forward by community members or area recommendations of past projects and studies; 3. Provide a framework by which the community can consider how they wish to coordinate future NRM programs and works.	Electronic and Hardcopy	The recommendations made by the RAP will address specific objectives of Goal 2 of the NRM Plan, that R*ivers creeks, valley floors and sub-catchments are managed and restored.*

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
6.1.1	Department of Aboriginal Affairs Fact Sheet: Reassessment of DAA 27935 (Hotham River)	DAA 27935 Hotham River is reported as being associated with a sacred narrative from Pumphreys Bridge near Wandering to where it meets the Murray River.	The purpose of the AHA is to protect Aboriginal heritage within Western Australia, which does not affect property ownership. The area in question relates to approximately 30 metres of riverbank. Land owners should seek the advice of DAA if they propose to undertake any activities within the boundary of DAA 27935.	Electronic	Relevant land owners should seek the advice of DAA if they propose to undertake any activities within the boundary of DAA 27935. DAA provides an online mapping enquiry system that is available at http://maps.dia.wa.gov.au/AHIS2/
3.7	Department of Water. Hotham-Williams-Murray Rivers Salinity Recovery Projects.	Department of Water and Environmental Regulation, previously Department of Water, has recorded water quality data from gauging stations on the Crossman River and 14 Mile Brook.	The gauging stations provide computerised measurements of a range of factors including flow levels, pH and salinity levels.		The data will be considered during the desktop data collection undertaken during the development of the RAP. The data will be useful if site specific investigations occur in the future near the gauging stations.
3.6	Department of Water (2009) Rights in Water and Irrigation Act, 1914 Surface Water Proclamation Areas Map. Department of Water,	This map shows all of the areas in Western Australia that are proclaimed as Surface Water Areas under the *Rights in Water and Irrigation Act, 1914 (RIWI Act)*	This map shows that the Hotham-Williams Catchment is within the Murray River System which is a proclaimed Surfaced Water Area under the RIWI Act.		The RIWI Act will be taken into account when planning on-ground works and seeking appropriate approvals

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
	Water Resources Use Division.				
2.3	Department of Water (2017) South West Index of River Condition. Department of Water. www.water.wa.gov.au	The Department of Water assesses the condition of rivers and estuaries in order to manage these valuable water resources. A range of indicators are used to assess condition. The South West Index of River Condition (SWIRC) brings a large number of these indicators together into a single tool for assessing river condition in south-west Western Australia.	The SWIRC provides: Standardised methods for collecting field and desktop data Protocols for analysing field and desktop data, including a standardised system for scoring river condition. The SWIRC includes six key ecological themes representing ecological integrity: aquatic biota, water quality, fringing zone, physical form, hydrological change and catchment disturbance. Each theme is divided into a series of sub-themes and components. The SWIRC is continually developing and may include additional sub-themes and components in the future.	Electronic http://www.water.wa.gov.au/water-topics/waterways/assessing-waterway-health/south-west-index-of-river-condition	The SWIRC method will be applied to the field and desktop data collection for the RAP.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
6.2.1	Ebner, Pilica Brito (1994) The Pumphreys journey the story of a pioneer family.	A historic account of the Pumphrey family and their settlement of their homestead at Pumphreys Bridge (Hotham Crossing)	Ch 2-5 & 9-10 give accounts of early white settlement and daily life at Pumphreys Bridge.	Hardcopy	The historical use of the river by the local community will be acknowledged and on-ground activities that are prioritised by the RAP will take this into account
6.2.2	Ferrell, John (1992) Becoming Boddington. Shire of Boddington	A history of the Boddington district from 1830 to 1992 including all aspects of community life from pioneer subsistence to development of the Boddington Gold Mine. The collection includes photographs, interviews, biographical notes, correspondence, cuttings, and records of Marradong Road Board.	This book documents the importance of the Hotham River to daily life in Boddington since European settlement. Historical photos depict recreational use of the river near Lions Weir (Boddington Pool) and Ranford (Darminning) Pool, major floods, water drawn from the river by steam pumps, and the construction of infrastructure on the Hotham River.	Hardcopy (Boddington Library)	The historical use of the river by the local community will be acknowledged and on-ground activities that are prioritised by the RAP will take this into account
3.3	Ghauri, S. (2002) Groundwater Study of the Wandering Town site. Resource Management Technical Report 260. Department of Agriculture. Government of Western Australia.	A groundwater study of Wandering was undertaken as part of the Rural Towns Program Community Bores Project which aimed to provide the technical basis on which towns can develop their salinity management strategies.	Wandering Shire had concerns over damage to the town site infrastructure, particularly the car park at the community centre. Wandering Shire had already installed a deep closed drain above the car park in an attempt to reduce waterlogging. Other issue including	Hardcopy	The study provides detailed recommendations to address town site salinity which can be used to guide future projects that take place in and adjacent to the town of Wandering.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
		This report describes the town and its catchment, the hydrogeological investigation characterising groundwater flow systems with the town site, and recommends action for managing salinity risk	degradation of vegetation south of the town and possibility of leakage from a water supply dam contributing to groundwater problems.		
8.1	Glynn, M. & Marston, G. (2016) Ranford Pool Revitilisation: Project Proposal	The goal of the proposal is to enhance community use at Ranford (Darminning) Pool by improving the amenities and natural waterscape of the Pool by promoting responsible recreational use and the preservation of the natural environment.	Funding was granted by South 32 Worsley Alumina in 2017 as a joint project between the PHCC, Friends of the Reserves - Boddington (Inc.) and the Shire of Boddington. The project was carried out in 2019, implementing 5 on-ground phases: 1. Reduce vehicular access to banks and waterside to improve safety, stop hoon driving activity and reduce erosion of banks and tracks; 2. Re-establish a natural back side landscape removing the eroded depressions of vehicular use and facilitate graduation pedestrian access to waterside; 3. Enhance user access to the water	Hardcopy and Electronic	The outcomes of this project could be used as a case study for rehabilitation works at other sites that have high recreation use on the Hotham and Williams Rivers.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
			and rehabilitate vegetation at the Pool; 4. Provide amenities to users of the Ranford Pool; 5. Enhance water user experience.		
5.1	Greenskills Inc (2007) Peel-Harvey Regional Ecological Linkages Project. South West Catchments Council	The project identifies Regional Ecological Linkages and local natural area 'stepping-stones' in the eastern Peel-Harvey Catchment, to provide the basis for establishing a sustainable ecological network.	Five datasets were created identifying the location of Ecological Linkages, priority reserves and remnant vegetation; and displaying regionally significant ratings of reserves.	Electronic datasets have been entered into GRID	The datasets created by this project can be used to guide on-ground activities that involve protection and restoration of native vegetation.
3.8	Hotham Williams Snapshot Data 2003-2009	A variety of data from 81 locations in the Hotham-Williams catchment collected from 2003-2009	Data collected includes EC, Temperature, TDS, pH, TN, TP, TSS. Data for some of the sites may also exist with the Department of Water and Environmental Regulation, Newmont Boddington, South 32 Worsley Alumina and/or community groups such as Friends of the Reserves – Boddington (Inc.).	Electronic	Long term data will give a better picture of the health of the Hotham and Williams River systems and allow for comparison with subsequent monitoring. The data may be useful if site specific investigations occur in the future near the gauging stations.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
3.1	Joyce, Leonie Rose (2007) The Hydrological Impacts of Climate Change and Variability in the Murray Hotham Catchment, Western Australia. School of Environmental Systems Engineering The University of Western Australia	This study aimed to quantify historical changes in rainfall pattern of the Murray Hotham Catchment, and the resulting impact these have had on the hydrological processes in the catchment during the latter part of the 20th century.	There has been a significant decrease in average annual rainfall and consequently run-off in the Hotham-Williams catchment since 1975. Projections suggest that further decline is probable. Managers of water and land should consider these and other projections when planning strategies for a water limited future.	Electronic	It is recommended that the RAP take climate change into account in terms of 'future-proofing' on-ground outcomes.
6.1.5	Kickett, Glenda J & Curtin University of Technology. Centre for Aboriginal Studies (2004).Karla Kuliny - return to the campfire: the Kickett family of Cuballing, story about Country.	This study provides the background experiences, stories, and feelings of one family's connection to and association with Country. The research has been conducted and framed from an insider's perspective, for the study of the Kickett family of Cuballing in the Upper Great Southern region of Western Australia. The study examines the ways in which, despite the impact of colonisation, Noongar people's connection to and association	The Kickett family property is adjacent (upstream) to Yornaning Dam which is located on a tributary of the Hotham River		The historical use of the river by the Noongar community will be acknowledged and on-ground activities that are prioritised by the RAP will take this into account

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
		with Country has been modified to suit their changing cultural, social and economic experiences.			
2.6	MacGregor, C., Cook, B., Farrell, C. and Mazzella, L. (2011). Assessment framework for prioritising waterways for management in Western Australia, Centre of Excellence in Natural Resource Management, University of Western Australia, Albany.	The framework provides a consistent and transparent approach to setting priorities for management of waterways. It ranks them in terms of their ecological, social and economic values and also according to their level of threat. Based on the ranking, the waterways are classified into broad categories. Furthermore, the document proposes appropriate management responses for each of the categories.	The framework can be used at scales ranging from whole catchments down to individual reaches of a waterway. The assessment approach is based on a framework of values, criteria, indicators and measures. Three broad categories of values are proposed – ecological, social (including cultural) and economic. For each of these values, a number of criteria are defined. For each of these criteria, a number of indicators are proposed, and for each indicator, a number of possible measures are suggested.	Electronic	It is recommended that on-ground projects make use of the prioritisation framework and other sources of information such as the GIS database, to rank management priorities for waterways.
8.2	Maesepp, Ella Korine (2002) Assessing the Health of the Yornaning Catchment, South-west Western Australia: Past, Present and Future. Honours Thesis School of	Yornaning Dam was engineered for an improvement in water quality following recommendations made in a 1992 study. This thesis provides the follow-up study of the engineering and an assessment	Data from 1992-2002 show that the health of the Yornaning Catchment is declining. The EC of the water within the Yornaning Dam and Yornaning Creek is increasing while the flow of the water in the creek is decreasing.	Hardcopy	The study outlines a number of on-ground recommendations to protect the Yornaning Dam and downstream waterways from further decline. It is recommended that these

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
	Environmental Science. Murdoch University.	of the health of the Yornaning Catchment as a whole, relative to baseline data collected in 1992.			detailed recommendation be reviewed when developing the Yornaning Dam project proposal for implementation of recommendations by the RAP.
3.9	Peel-Harvey Catchment Council (2008) RS01 Hotham Williams Murray River Salinity Recovery Project Report September 2008.	The report is a result of collaboration between PHCC, GHD (Matt Giraudo) and the Dept of Water. It contains: 1. GHD (2008) Preliminary Salinity Situation Statement for the Hotham-Williams-Murray Catchment Part 1: Conceptual Hydrogeological Analysis November 2008; 2. Peel-Harvey Catchment Council (June 2008) Hotham-Williams-Murray River Salinity Recovery Project Community Workshop Dryandra 25th June 2008. (Presentation); 3. Monitoring Data & Site	Gauging Stations were built on the Crossman River and 14 Mile Brook. These stations provide computerised measurements of a range of factors including flow levels, pH and salinity levels. The report provides an understanding of current salinity situation in the upper Peel-Harvey Catchment & Development of mathematical & a conceptual hydro-geological model to assist in the development of management responses to salinity in the catchment. Also reviews stream-flow & salinity monitoring.	Hard copy and Electronic reports on a CD	The modelling that was developed during this study can be used to guide specific management activities in on-ground projects.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
		Review Information a. Dept. of Water Flow Gauging Station Data; b. Peel-Harvey Catchment Council (2004) Sampling and Analysis Plan Hotham-Williams Salinity Snapshot; c. Hotham-Williams Snapshot Results 2007; 4. GHD (2008) Report on Preliminary Salinity Situation Statement – Hotham-Williams-Murray Catchment Part 2: LUCICAT Model November 2008.			
2.4	Peel-Harvey Catchment Council (2015) Binjareb Boodja Landscapes 2025: A Strategy for Natural Resource Management in the Peel-Harvey Region, A Report to the Peel-Harvey Catchment Council, Jane O'Malley & Andrew Del Marco (eds) Mandurah,	The Strategy has been compiled by the Peel-Harvey Catchment Council as the Region's first official natural resource management (NRM) strategy. It provides a road map for how the Peel-Harvey community plans to repair and care for the natural resources of the Region over the next 10 years to reach	There are 2912 km of mapped watercourses in the Hotham-Williams Catchment. Only 7% have been assessed to be in good or better condition. Community's priorities in the Hotham-Williams sub-catchment include Implementing catchment management to improve water quality. Section 5.2.5 Water Resources, Water Quality, Wetlands	Electronic and Hardcopy	The NRM Strategy is a guiding document for the RAP which will address specific Goals and Activities.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
	Western Australia.	a 100 year vision.	and Waterways states that all of the waterways of the Hotham-Williams catchments, once fresh, are now salty due to extensive clearing of native vegetation.		
2.1	Peel-Harvey Catchment Council (2015) Middle Murray River Action Plan. Reviewed and Updated 2015.	This report provides a summary of Middle Murray River foreshore condition and weed presence so that future works in the area can be more focused on identified management priorities and issues.	This report gives a working example of a River Action Plan in the Peel-Harvey Catchment.	Hardcopy	This report will be used as a template for developing a River Action Plan for the Hotham-Williams Catchment.
3.5	Peel-Harvey Catchment Council (2014) Water Condition Rating (and Reservoir Condition Rating).	This dataset shows the condition of water in the Peel-Harvey Catchment Council Region. As the data was extracted from a hard copy map, no data processing lineage from the original dataset has been captured. The map indicates the data source was "Adapted from Hamilton (2002)".	Available as ESRI Shapefile Format. Watercourses range from A2-A3 – (near pristine to slightly disturbed) and C1-C3 (erosion prone to eroded). The former occur mostly in Reserves and large areas in the west of the catchment that have not been cleared. Correspondence with Peter Nash, Regional NRM Facilitator South West Catchment Council indicates that the Technical Report by Bruce Hamilton may have been an early draft of the	Electronic	The original document is *Hamilton, B. (2002) South West Regional Strategy for Natural Resource Management. Technical Report No. 1. Prepared for the South West Catchments Council, Bunbury.* This document should be located to determine the condition of relevant reaches in 2002.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
			Regional Strategy, and if so, the reference above should be 2012, not 2002. Hamilton wrote the Regional Strategy in 2012 and was not working for the South West Catchment Council in 2002.		
2.2	Pen, L.J. and Scott, M. (1995) Stream Foreshore Assessment in Farming areas. Blackwood Catchment Co-ordinating Group, Western Australia	This assessment system was developed so that it could be used by members of the local community, supported by state government agencies, to enable standardised description of foreshore condition over large areas.	The condition of a section of river foreshore can be assessed using a simple system developed from observations of river system degradation throughout south-west Western Australia. It can be used to prioritise and plan protection and rehabilitation works and to monitor the results.	Hardcopy	The Pen-Scott method will be used to collect data in the field for the development of the RAP.
3.4	Raper, G P. (2005), Groundwater study of the Boddington town site. Department of Agriculture and Food, Western Australia, Perth. Report 252	A study of the groundwater beneath the Boddington town site was carried out in April 2002. The aim was to access the salinity risk to the town site infrastructure and to accelerate the implementation of effective salinity management for the town.	Thirty-one piezometers were installed at 14 sites. This study showed that most of the Boddington town site sits over quartz-rich weathered granitic rocks. This contributes to the high yields of water (up to 2.0 L/s) observed in several piezometers drilled in the town. The study found that groundwater levels were 4 to 5 m deep under the central business	Electronic	The study provides detailed recommendations to address town site salinity which can be used to guide future projects that take place in and adjacent to the town of Boddington.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
			district and that groundwater levels are not rising at significant rates, suggesting that this area of town is not at risk from salinity. Groundwater pressures were above ground level adjacent to two watercourses in Boddington and the surrounding areas already exhibit signs of degradation resulting from salinity and waterlogging.		
5.2	Sage, L.W., Blankendaal, P.A., Moylett, A., & Agar, K. (2004) The occurrence and impact of *Phytophthora cinnamomi* in the Central Western Avon Wheatbelt Bioregion of Western Australia. Journal of the Royal Society of Western Australia, 87:15–18, 2004	There have been very few studies of *Phytophthora cinnamomi* in the lower rainfall (less than 600mm) areas of the South-West botanical province of WA. This survey identified 4 areas with dieback infestations from interpretation of 21 state forest blocks, 11 nature reserves and 1 private property block in the Department of Conservation and Land Management Narrogin operational district.	All infestations were located on water-gaining sites (i.e. along a water course, drain or near a dam) or where there had been high disturbance in areas that were also low in the landscape. Eleven susceptible plant species were recorded as dead or dying in association with the dieback infections, but other possible causes of death, such as drought, cannot be discounted as contributing factors. Previous studies found that the impact of phytophthora dieback is low in inland woodlands and shrub lands due to low rainfall. Three of the four infestations located in the study	Electronic	*P. cinnamomi* may also be present in other low lying, water gaining sites in the Hotham Williams Catchment. Strategic soil and root sampling and testing will identify infested sites and should be incorporated into on-ground recommendations made by the RAP.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
			area supported this finding. However, the fourth site, the Lol Gray infestation, found that the level of impact was high with the granite outcropping possibly being a contributing factor by promoting moisture runoff after rainfall or fog and some under-surface moisture accumulation.		
8.3	Shire of Boddington ICLEI Water Campaign™ Local Action Plan. Shire of Cuballing ICLEI Water Campaign™ Local Action Plan Shire of Wandering ICLEI Water Campaign™ Milestone 3: Corporate and Community Local Action Plan	The purpose of this document is to provide a strategic direction and implementation plan for improved water management.	In accordance with the Water Campaign requirements for Milestone 3, this plan includes: 1. An outline of the National, State, Regional and Local context of water management 2. A baseline profile of water consumption and water quality issues with the Shire's boundaries 3. A statement of water conservation and water quality goals set by the Shire. 4. An outline of council actions and policies implemented by the Shire since the base year. 5. An outline of proposed actions	Hardcopy	Each plan includes an outline of proposed actions and policies to be implemented by the Shires up until the target year and a commitment to monitoring and review of the local action plan. It is recommended that these be reviewed by the relevant Shires.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
			and policies to be implemented by the Shire up until the target year and; 6. A commitment to monitoring and review of the local action plan		
7.1	Sharafi, S, Lauk, H, and Galloway, P. (2005), Avon Hotham catchment appraisal 2005. Department of Agriculture and Food, Western Australia, Perth. Report 294	This report summarises current information on risks and impacts to agricultural production and natural resources within the Avon Hotham study area. It then identifies suitable options to manage such risks.	The salinity of both the Avon and Hotham Rivers has risen substantially since the clearing of the native vegetation from their catchments. The estimated original salinity of these rivers is between < 100 mS/m and 550 mS/m (fresh to brackish). The Hotham has increased to an average fluctuation of between 400 mS/m and 2,500 mS/m (brackish to saline).	Electronic	When formulating on-ground projects, the recommendations of this study should be considered to manage water logging, surface water runoff, minimise erosion and reduce groundwater recharge.
6.1.3	Thorne, G & Thorne, E (2017) Interview with Greg and Errol Thorne. Interviewed by Melanie Durack (Peel-Harvey Catchment Council) and Greg Marston (Friends of the Reserves – Boddington (Inc.)	Voice recorded interviews with local Noongar Elder Greg Thorne and his brother Errol Thorne at Camballing Reserve, Red Hill Reserve and Mooliamans Reserve.	Stories include life around Camballing Reserve on the banks of the Hotham River, the "Mooly Man" legend and its significant sites on the Hotham and Williams Rivers.	Electronic	The historical use of the river by the Noongar community will be acknowledged and on-ground activities that are prioritised by the RAP will take this into account.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
2.7	Water and Rivers Commission (2000) A Guide to the Nature, Protection, Rehabilitation and Long-Term Management of Waterways in Western Australia.	This series of guidelines provides a guide to the nature, rehabilitation and long-term management of waterways in Western Australia. The chapters of the series collectively form the River Restoration Manual. The manual is based on the teachings of the successful river restoration courses, which have been run for river managers in the past (between 1996 and 2010).	The manual currently consists of 18 sections under the following topics: Introduction Catchment Processes Stream Channel Processes Stream Channel Analysis Stream Ecology Revegetation Stream Stabilisation Planning and Management	Electronic and Hardcopy	On-ground recommendations that are included in the RAP will adhere to the guidelines for revegetation, stream stabilisation, planning and management.
2.10	Water and Rivers Commission (2001) Planning for Waterways Management: Guidelines for Preparing a River Action Plan. Water and Rivers Commission, River Restoration Report No. RR 14.	This document is part of the River Restoration Manual. This manual is a guide to preparing a River Action Plan (RAP). It is intended to assist the process of planning river restoration activities at the local level and complementing the technical advice provided through other mechanisms.	There are five key steps to the RAP planning process: 1. Community and stakeholder consultation; 2. Information collection; 3. Strategic outline; 4. Establishing management actions; 5. Gaining approval.	Electronic and Hardcopy	The Hotham-Williams RAP will be developed following the guidelines set out in this document.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
2.8	Water and Rivers Commission. (2000) Planning and Management: Foreshore condition assessment in farming areas of south-west Western Australia. Report No RR 3. Water and Rivers Commission.	This document is part of the River Restoration Manual. It has been developed for farming areas in south-west WA and is a revised version of Pen, L.J. and Scott, M. (1995) Stream Foreshore Assessment in Farming areas.	Using the Pen and Scott method described in this document enable community groups and individuals to conduct foreshore surveys to collect information while ensuring future assessments will record data in a consistent manner.	Electronic and Hardcopy	Methodologies adopted for the RAP for data collection in the field will follow the guidelines for foreshore condition assessment outlined by this document.
2.9	Water and Rivers Commission (1999), Planning and Management: Foreshore condition assessment in urban and semi-rural areas of south-west Western Australia. Water and Rivers Commission River Restoration Report No. RR2.	This document is part of the River Restoration Manual. It has been developed for urban and semi-rural areas in south-west WA based on the methods developed by Scott and Pen in 1995.	Using the Pen and Scott method described in this document enables community groups and individuals to conduct foreshore surveys to collect information while ensuring future assessments will record data in a consistent manner.	Electronic and Hardcopy	Methodologies adopted for the RAP for data collection in the field will follow the guidelines for foreshore condition assessment outlined by this document.
6.1.4	Water and Rivers Commission (2002) Water Notes: Safeguarding Aboriginal Heritage. WN30 November 2002	This Water Note is intended to provide community members and government staff with an understanding of the importance of rivers and	The spiritual significance and history of rivers and wetlands to Aboriginal people and the legal responsibilities of management authorities in seeking the appropriate approvals prior to on-		In the context of river restoration, activities that require approval on Aboriginal sites include: 1. Any digging into or

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
		wetlands to Aboriginal people and why there is need for consultation. The Water Note focuses on legal responsibilities under the Aboriginal Heritage Act 1972 and the Native Title Act 1993 and the preferred approach before and during river and wetland restoration activities, to ensure that sites of heritage or spiritual significance are protected. The note also provides a brief overview of the spiritual significance and history of rivers and wetlands to Aboriginal people.	ground works.		driving any object into a bank or bed of a river, estuary or wetland; 2. Any construction, i.e. gauging stations, erosion control works, river restoration works.

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
3.2	Westrup, T. (2009), Surface water management in the East Yornaning Catchment. Department of Agriculture and Food, Western Australia, Perth. Report 345.	This report documents the results of a surface water risk survey undertaken with landholders in the East Yornaning catchment group during 2008. It includes a description of the catchment, the landholders' interpretation of surface water risks, a field assessment by surface water specialists and suggestions for remedial work.	Landholders were surveyed during 2008 on a range of agriculture-related issues which included surface water hazards. These included water supplies, flooding, waterlogging, salinity in dams and water courses, water erosion, phosphorus export and culvert maintenance.	Electronic	The findings of this study are site specific and can be referred to during future development of a project in the Yornaning Catchment as a result of the RAP.
4.3	WRM (2012). Acquired Lands Ecological Monitoring: Baseline Aquatic Fauna Sampling August 2011. Unpublished report by Wetland Research & Management to Newmont Boddington Gold. Final Report August 2012.	A snapshot of the condition of Boggy House Brook and Wattle Hollow Brook.	During the course of the study, a total of 6 sites were sampled for water quality and aquatic fauna: Boggy Brook; three sites upstream Gold Mine Road: AL1, AL6, and AL8; House Brook; two sites upstream Gold Mine Road: AL3, and AL4; Wattle Hollow Brook; one site downstream Gold Mine Road: WHB1.	Electronic	This report will be used as an information source for the river health assessments in Spring 2019 and Autumn 2020
4.2	WRM (2012). Thirty-Four Mile Brook Ecological Monitoring: Aquatic	Newmont Boddington Gold (NBG) Pty Ltd has made a commitment to monitor the	A snapshot of the condition of the Thirty-four Mile Brook at that point in time.	Electronic	This report will be used as an information source for the river health assessments

Section	Document Reference	Overview	Relevant Information	Electronic/ Hardcopy	Outcomes
	Fauna sampling September 2010 and August 2011. Unpublished report by Wetland Research & Management to Newmont Boddington Gold Pty Ltd. Final Report August 2012.	ecological health of Thirty-Four Mile Brook which traverses their mine lease near Boddington.			in Spring 2019 and Autumn 2020
4.4	WRM (2012). Gringer Creek - Baseline Aquatic Fauna sampling October 2011. Unpublished report by Wetland Research & Management to NBG Pty Ltd. Final Report September 2012.	A snapshot of the condition of Gringer Creek (a Tributary of Bannister River) at that point in time.	Surveys included sampling for water quality, aquatic macroinvertebrates, crayfish and fish. The scope of work for the current study included: Systematic sampling of water quality, benthic macroinvertebrates, crayfish and fish of the Gringer Creek in early spring 2011 Comparison of water quality data against ANZECC/ARMCANZ (2000) guidelines for protection of aquatic ecosystems Assessment of the conservation status of aquatic fauna recorded Statistical analysis of species assemblage data.		This report will be used as an information source for the river health assessments in Spring 2019 and Autumn 2020

APPENDIX 2: FIELD DATA ANALYSIS METHODOLOGY

The methodology for collating and assessing the data is adapted from *River Restoration – Foreshore condition assessment in farming areas of south-west Western Australia* (WRC, 1999). For consistency with previously prepared RAPs, the detailed foreshore criteria was prepared considering grades between A (pristine) and D (ditch)). The detailed assessment allows for 3 sub-categories under each grade with a total of 12 categories. Assigning a category is generally a subjective exercise, matching observation with descriptions for each category.

In order to provide a more objective, repeatable approach, key parameters are assessed and scored based on the data breakdown provided below. Table 37 (WRC, 1999) provides a scoring system to calculate overall stream health and has been adapted to score foreshore conditions. For the Hotham-Williams RAP, each bank within each sub-reach has been assessed with this scoring system, noting that habitat diversity refers to conditions within the channel, and therefore is the same for both banks.

Table 37: Stream Health Scoring (WRC, 1999)

	Floodway and bank vegetation	Verge vegetation	Stream Cover	Bank Stability and Erosion	Habitat Diversity
Excellent	- Healthy undisturbed native vegetation - No Weeds **(15 points)**	- Healthy undisturbed native vegetation - Verges more than 20m wide **(8 points)**	-Abundant cover: shade, overhanging vegetation - Snags, leaf litter, rocks and/or aquatic vegetation in-stream **(8 points)**	- No erosion or subsidence or sediment deposits - Dense vegetation cover on banks and verge - No disturbance **(8 points)**	- Three or more habitat types - Some permanent water **(6 points)**
Good	- Mainly healthy undisturbed native vegetation - Some weeds - No recent disturbances **(12 points)**	- Mainly healthy undisturbed native vegetation - Verges less than 20m wide **(6 points)**	- Abundant shade and overhanging vegetation - Some cover in-stream **(6 points)**	- No significant erosion, subsidence or sediment deposits in floodway or on lower banks - May be some soil exposure and vegetation thinning on upper bank and verge **(6 points)**	- Two habitat types - Some permanent water **(4 points)**
Moderate	- Good vegetation cover but a mixture of native and exotic species - Localised clearing - Little recent disturbance **(6 points)**	- Good vegetation cover but a mixture of native and exotic species - Verges 20m wide or more **(4 points)**	- Some permanent shade and overhanging vegetation - Some in-stream cover **(4 points)**	- Good vegetation cover - Only localised erosion, bank collapse and sediment heaps - Verges may have sparse vegetation cover **(4 points)**	- Mainly one habitat type with permanent water, or a range of habitats with no permanent water **(2 points)**
Poor	- Mainly exotic ground cover - Obvious site disturbance **(3 points)**	- Narrow verges only (<20m wide) - Mainly exotic vegetation **(2 points)**	- Channel mainly clear - Little permanent shade or instream cover **(2 points)**	- Extensive active erosion and sediment heaps - Bare banks and verges common - Banks may be collapsing **(2 points)**	- Mainly one habitat type with no permanent water **(1 points)**
Very Poor	- Mostly bare ground or exotic ground cover (i.e. pasture gardens or weeds but no trees) **(0 points)**	- Mostly bare ground or exotic ground cover (i.e. pasture gardens or weeds but no trees) **(0 points)**	- Virtually no shade or instream cover **(0 points)**	- Almost continuous erosion - Over 50% of banks collapsing - Sediment heaps line or fill much of the floodway - Little or no vegetation cover **(0 points)**	- Stream channelised - No pools, riffles or meanders - The stream forms a continuous channel **(0 points)**

Scores from each bank were determined from an analysis of key parameters, described further below. The scores from this analysis were then equated to the foreshore condition, based on the scoring system outlined in Table 38. The sum of all the parameter scores within a reach gives a rating which falls under a category ranging from A1 (pristine) to D3 (drain – weed dominated). Where a rating falls between two categories, a range is applied. For example, a score of 28 would be assigned B1-B2. Manual adjustments to the final condition category were then applied based on a review of field photography, water quality data and other data sets.

Table 38: Foreshore Category Scoring

	Score					
	Floodway and Bank Veg	Verge Vegetation	Stream Cover	Bank Stability and Erosion	Habitat Diversity	Rating
A1	15	8	8	8	6	45
A2	12	8	8	8	6	42
A3	12	6	8	6	4	36
B1	12	4	6	6	4	32
B1-B2	-	-	-	-	-	28
B2	6	4	4	6	4	24
B2-B3	-	-	-	-	-	20.5
B3	3	2	4	6	2	17
B3-C1	-	-	-	-	-	16
C1	3	4	2	4	2	15
C1-C2	-	-	-	-	-	13
C2	3	2	2	2	2	11
C2-C3	-	-	-	-	-	9
C3	3	0	0	2	2	7
D1	3	2	0	0	0	5
D2	3	0	0	0	0	3
D3	0	0	0	0	0	0

Floodway and Bank Vegetation

Floodway and bank vegetation grows either on the bank of the river or within the floodway, providing canopy cover, plant roots that stabilise banks and stems and foliage in the river dissipate the energy of flows to reduce the risk of erosion (WRC, 1999). The scoring outlined in Table 37 assigns the highest possible score (15) to this category, which demonstrates its significance in relation to the other categories. The key indicators used to determine scores are provided in Table 39. The secondary indicators, listed as other considerations in Table 39, were also considered to manually adjust scores.

Table 39: Floodway and Bank Vegetation Indicators

Key indicators	Other considerations
Streamside Zone Vegetation: Bare Ground	Riparian Layer: Ground Layer (rushes/sedges)
Streamside Zone Vegetation: Turf Grass	Riparian Layer: Shrub Layer
Streamside Zone Vegetation: Ground Cover	Riparian Layer: Tree Layer
Streamside Zone Vegetation: Shrubs	Width of Riparian Zone
Streamside Zone Vegetation: Trees <10 m	Dominant Riparian Species
Streamside Zone Vegetation: Trees >10 m	Riparian Zone Absent or Reduced Factors
Streamside Zone Vegetation: Turf Grass % Exotic	Streamside Zone Vegetation: Trees <10 m % Exotic

Key indicators	Other considerations
Streamside Zone Vegetation: Ground Cover % Exotic	Streamside Zone Vegetation: Trees >10 m % Exotic
Streamside Zone Vegetation: Shrubs % Exotic	

The scoring for the floodway and bank vegetation is outlined in Table 40.

Table 40: Floodway and Bank Vegetation Scoring

Rating	Score	Description	Indicator Assessment
Excellent	15 points	- Healthy undisturbed native vegetation - No Weeds	- No bare ground - No weeds - Shrub or Tree Cover >50%
Good	12 points	- Mainly healthy undisturbed native vegetation - Some weeds - No recent disturbances	- No bare ground - Weeds <10% - Shrub or Tree Cover >50%
Moderate	6 points	- Good vegetation cover but a mixture of native and exotic species - Localised clearing - Little recent disturbance	- Bare ground <10% - Weeds 10%-49% - Shrub and Tree Cover 10-49%
Poor	3 points	- Mainly exotic ground cover - Obvious site disturbance	- Bare ground 10-49% - Exotic Ground Cover 10%-49% - Turf Grass 10-49%
Very Poor	0 points	- Mostly bare ground or exotic ground cover (i.e. pasture gardens or weeds but no trees)	- Bare ground >50% - Exotic Ground Cover >50% - Turf Grass >50%

Verge Vegetation

Verge vegetation is located adjacent to the floodway and bank, extending to the floodplain. The condition and extent of the verge vegetation influences the stability of the banks, provision of habitat and health of the riparian ecosystem. The key indicators used to determine scores and other considerations for adjustment are provided in Table 41.

Table 41: Verge Vegetation Indicators

Key indicators	Other considerations
Beyond the Streamside Zone: Dominant Feature 10-49m	Beyond the Streamside Zone: Dominant Feature >100m
Beyond the Streamside Zone: Dominant Feature 50-99m	

Features selected from the following categories: Minimal vegetation, Weeds/Grasses/Crops, Remnant vegetation, Forest, Plantation or Other.

The scoring for the floodway and bank vegetation is outlined in Table 42. The average between the 10-49m and 50-99m scores were used for the verge vegetation.

Table 42: Verge Vegetation Scoring

Rating	Score	Description	Indicator Assessment
Excellent	8 points	- Healthy undisturbed native vegetation - Verges more than 20m wide	Forest
Good	6 points	- Mainly healthy undisturbed native vegetation - Verges less than 20m wide	Remnant Vegetation

Rating	Score	Description	Indicator Assessment
Moderate	4 points	- Good vegetation cover but a mixture of native and exotic species - Verges 20m wide or more	Plantation
Poor	2 points	- Narrow verges only (<20m wide) - Mainly exotic vegetation	Weeds/Grasses/Crops
Very Poor	0 points	- Mostly bare ground or exotic ground cover (i.e. pasture gardens or weeds but no trees)	Minimal vegetation

Stream Cover

Stream cover is important for fish and other aquatic organisms that require snags, leaf litter and rocks to shelter from predators and to establish territories (WRC, 1999). Similarly aquatic plants have a direct effect on the available oxygen in the water. Overhanging and emergent vegetation provides shade which is vital for animals during summer. The key indicators are outlined in Table 43, along with the other factors that are considered in the assessment.

Table 43: Stream Cover Indicators

Key indicators	Other considerations
Stream Cover overhanging banks %	Bank vegetation draped in water
Tree overhanging %	Tree overhang
Aquatic plants & macro cover %	Stream width
Emergent proportion %	Shrub overhanging %
Submerged proportion %	
Woody debris	

The scoring for the stream cover is outlined in Table 44. Unlike other categories, the key indicators are generally independent of each other and therefore a weighted approach is undertaken to assign a different importance to each indicator (for example stream over and woody debris are considered more significant than the submerged proportion). Each indicator is scored separately then weighted to provide a final stream cover score.

Table 44: Stream Cover Scoring

Rating	Score	Stream Cover Overhanging banks % (w = 0.29)	Tree Overhanging % (w = 0.14)	Aquatic plants & macro cover % (w = 0.14)	Emergent proportion % (w = 0.14)	Submerged proportion % (w = 0.07)	Woody debris (w = 0.21)
Excellent	8 pts	50-100%	>80%	>50%	>70%	<20%	Dense
Good	6 pts	-	>60%	>30%	>50%	<40%	Moderate
Moderate	4 pts	10-49%	>50%	>20%	>40%	<60%	Sparse
Poor	2 pts	1-9%	>25%	>10%	>25%	<80%	None
Very Poor	0 pts	0%	0%	0%	0%	<100%	-

w = weighting

Bank Stability and Erosion

Whilst erosion (removal of sediment by water, observed as scouring, slumping or bare surfaces) is a natural process for river systems, accelerated or wide-spread erosion is indicative of an

unstable system that will continue to degrade. The key indicators used to determine scores and other considerations for adjustment are provided in Table 45.

Table 45: Bank Stability and Erosion Indicators

Key indicators	Other considerations
Erosion %	Bank Shape
Erosion Severity	Bank Slope
	Bank Depth

The scoring for the bank stability and erosion is outlined in Table 46 and is a combination of erosion extent and the severity of erosion. Bank dimensions are also considered, as steep banks with extensive or severe erosion require intervention more than gentle banks with the same score.

Table 46: Bank Stability and Erosion Scoring

Rating	Score	Description	Indicator Assessment
Excellent	8 points	- No erosion or subsidence or sediment deposits - Dense vegetation cover on banks and verge - No disturbance	- 0-4% erosion & minor rating
Good	6 points	- No significant erosion, subsidence or sediment deposits in floodway or on lower banks - May be some soil exposure and vegetation thinning on upper bank and verge	- 0-4% erosion & low-moderate rating; or - 5-19% erosion & minor rating
Moderate	4 points	- Good vegetation cover - Only localised erosion, bank collapse and sediment heaps - Verges may have sparse vegetation cover	- 0-4% erosion & high to severe rating; or - 5-19% erosion & low-moderate rating
Poor	2 points	- Extensive active erosion and sediment heaps - Bare banks and verges common - Banks may be collapsing	- 5-19% erosion & high to severe rating; or - 20-49% erosion & minor or low-moderate rating
Very Poor	0 points	- Almost continuous erosion - Over 50% of banks collapsing - Sediment heaps line or fill much of the floodway - Little or no vegetation cover	- 20-49% erosion & high to severe rating; or - >50% erosion with any rating

Aquatic Habitat

Aquatic habitat is included as an indicator, as stream sections that have a range of habitat types can support a greater variety of species. Limited habitat variety (and a lower score) is therefore associated with degraded rivers. The habitat score is determined from assessment of the channel itself rather than each bank. Therefore the aquatic habitat score is applied to both the left and right banks for any sub-reach. The key indicators used to determine scores and other considerations for adjustment are provided in Table 47.

Table 47: Aquatic Habitat Indicators

Key indicators	Other considerations
Habitat % Channel	Water Odours

Key indicators	Other considerations
Habitat % Pool	Water Oils
Habitat % Riffle	Turbidity
Habitat % Reach	Tannin Staining
	Algae in Water Column
	Algae on Substrate
	Sediment Plume
	Sediment Oils
	Sediment Odours

The scoring for the aquatic habitat is outlined in Table 48. Diversity in habitat is required for an excellent rating.

Table 48: Aquatic Habitat Scoring

Rating	Score	Description	Indicator Assessment
Excellent	6 points	- Three or more habitat types - Some permanent water	- Pool habitat >20% and Riffle habitat >20%
Good	4 points	- Two habitat types - Some permanent water	- Pool habitat >20% or Riffle habitat >20%
Moderate	2 points	- Mainly one habitat type with permanent water, or a range of habitats with no permanent water	- Pool habitat >10% or Riffle habitat >10%
Poor	1 points	- Mainly one habitat type with no permanent water	- Pool habitat >5% or Riffle habitat >5%
Very Poor	0 points	- Stream channelised - No pools, riffles or meanders - The stream forms a continuous channel	- No Pool or Riffle habitat

APPENDIX 3: FIELD REACH SCORING

Reach	Subreach	Left Bank							Right Bank						
		Floodway and Bank Veg	Verge Vegetation	Stream Cover	Bank Stability and Erosion	Habitat Diversity	Total Score	Rating	Floodway and Bank Veg	Verge Vegetation	Stream Cover	Bank Stability and Erosion	Habitat Diversity	Total Score	Rating
Ranford Pool	2	4	5	3.57	3	2.5	18.07	B2-B3	4	3	3.57	3	2.5	16.07	B3
	3	3.5	2	4.00	5	5	19.50	B2-B3	2	2	3.00	2	5	14.00	C1
	4	3	2	2.50	5	5	17.50	B2-B3	2	2	2.00	3	5	14.00	C1
	5	4	5	5.00	3	4	21.00	B2	4	3	4.00	3	4	18.00	B2-B3
	6	4	3	4.00	4	5	20.00	B2-B3	4	5	5.00	3	5	22.00	B2
Pumphreys Bridge	2	3	4	2.50	4	4	17.50	B2-B3	3	1.5	2.00	5	4	15.50	B3-C1
	3	2	1.5	2.50	2	3.5	11.50	C1-C2	2	1.5	2.50	2.5	3.5	12.00	C1-C2
	5	1.5	2	2.00	4	3	12.50	C1-C2	2.5	1.5	2.00	4	3	13.00	C1-C2
	6	1	2	1.50	3	1	8.50	C2-C3	1	2	1.00	3	1	8.00	C2-C3
	7	2	3	1.50	2	2	10.50	C2	3	2.5	1.50	2	2	11.00	C2
	8	3	3	2.00	2	3.5	13.50	C1	3	2	2.50	2	3.5	13.00	C1-C2
	9	5	2.5	2.50	2	2	14.00	C1	6	3	2.50	1.5	2	15.00	C1
	10	4	2	3.86	1	2	12.86	C1-C2	3.5	3	3.29	1	2	12.79	C1-C2
Hotham River Nature Reserve	2	4	7	2.50	3	1	17.50	B2-B3	3	3.5	2.50	4	1	14.00	C1
	3	2	6	1.50	3	1	13.50	C1	3	3.5	2.00	4	1	13.50	C1
	4	5	6	1.50	3	1	16.50	B3	4	3	2.57	3	1	13.57	C1
	5	4	7	3.00	3	3	20.00	B2-B3	4	3	3.00	3	3	16.00	B3-C1
	6	4	3.5	2.43	1.5	2	13.43	C1	4	2	2.43	1.5	2	11.93	C1-C2
	7	2	7	2.50	1	2	14.50	C1	2.5	2.5	2.50	1	2	10.50	C2
	8	3	6	2.00	1.5	2	14.50	C1	4	2	2.00	1	2	11.00	C2
Popanyinning	1	3.5	2	3.00	3.5	1.5	13.50	C1	3.5	2.5	3.00	3.5	1.5	14.00	C1
	2	2	2	2.57	3.5	1	11.07	C1-C2	2.5	2.5	2.57	4	1	12.57	C1-C2
	3	2.5	2.5	1.71	3.5	1.5	11.71	C1-C2	2.5	4	1.71	5	1.5	14.71	C1
	4	3	5	2.50	2	2	14.50	C1	3	2.5	2.50	4	2	14.00	C1
	5	4	5	2.50	2	2	15.50	B3-C1	6	6	3.00	5	2	22.00	B2
	6	3	6	1.70	6	2.5	19.20	B2-B3	1.5	2	0.86	2.5	2.5	9.36	C2
	7	3.5	6	2.00	6	2.5	20.00	B2-B3	2	2.5	1.43	3	2.5	11.43	C1-C2
	8	3	5	3.00	1.5	2	14.50	C1	3.5	4	3.00	1.5	2	14.00	C1
Yornaning Dam	1	1	2	1.00	6	1	11.00	C2	2	4.5	1.50	6	1	15.00	C1
	2	2	4.5	1.50	4	1	13.00	C1-C2	2	4.5	1.50	4	1	13.00	C1-C2
	3	2.5	3	1.00	4	1.5	12.00	C1-C2	2.5	3.5	1.50	4	1.5	13.00	C1-C2
	4	2	2.5	1.00	3	2	10.50	C2	2.5	2.5	1.50	3	2	11.50	C1-C2
	5	0	3	0.00	4	0	7.00	C3	0	3	0.00	4	0	7.00	C3
	6	3	4	0.50	4	1	12.50	C1-C2	3.5	4	0.50	4	1	13.00	C1-C2
Williams	1	3	4	2.43	1	1.5	11.93	C1-C2	3.5	2	2.43	0.5	1.5	9.93	C2
	2	2	1	2.00	1.5	1.5	8.00	C2-C3	3	2	2.00	1.5	1.5	10.00	C2
	3	3	1	2.00	2.5	1.5	10.00	C2	3.5	3.5	2.00	2.5	1.5	13.00	C1-C2
	4	2	1	1.50	2	2.5	9.00	C2-C3	3	1.5	2.50	3	2.5	12.50	C1-C2
	5	2.5	3	1.43	1	2	9.93	C2	3.5	2	2.00	3	2	12.50	C1-C2
	6	4	2	2.00	2.5	2	12.50	C1-C2	2	1.5	1.43	2.5	2	9.43	C2
	7	4	2.5	2.00	2	3.5	14.00	C1	3.5	2	2.00	1.5	3.5	12.50	C1-C2
	8	3.5	1.5	2.00	2	3	12.00	C1-C2	3.5	2	1.71	1.5	3	11.71	C1-C2
	9	3	2.5	3.00	2	4	14.50	C1	3	1.5	3.00	1.5	4	13.00	C1-C2
Quindanning	1	3	2	3.29	5	5	18.29	B2-B3	3	2	3.29	5	5	18.29	B2-B3
	2	5	2.5	4.00	6	6	23.50	B2	5	2	4.00	4	6	21.00	B2
	3	5	2	4.00	6	5	22.00	B2	5	2.5	4.00	6	5	22.50	B2
	4	4	3	4.00	6	5	22.00	B2	4	3.5	4.00	6	5	22.50	B2
	5	4	2.5	3.30	5	5	19.80	B2-B3	4	2.5	3.30	6	5	20.80	B2
	6	3.5	2.5	4.00	6	5	21.00	B2	4	2	4.00	6	5	21.00	B2
Boraning Reserve	2	4	6	2.50	2	2.5	17.00	B3	3	2.5	1.50	2	2.5	11.50	C1-C2
	3	3	6	2.50	2.5	2.5	16.50	B3	3.5	2.5	2.00	4	2.5	14.50	C1

APPENDIX 4: DESKTOP ANALYSIS METHODOLOGY

The methodology for assessing the desktop data is adapted from *Framework for the Assessment of River and Wetland Health (FARWH) for flowing rivers of the south-west Western Australia* (DoW, 2011a). The FARWH method analyses available desktop (and field) data to determine baseline river and wetland conditions consistent with the National Water Initiative benchmarks. Following trials in south-west Western Australia, DWER noted the following challenges associated with the ephemeral, episodic and seasonal systems and limited data for determining current and historical ecological conditions.

Table 49 below provides the complete data requirements recommended for the FARWH assessment. The method adapted for the Hotham-Williams catchment acknowledges the data limitations and utilises available information to estimate river reach condition based on the recommended theme.

Table 49: Indicators Chosen for the South West FARHW (DoW, 2011c)

Theme	Components	Data Source	Scale	Recommended Sampling Frequency
Catchment Disturbance	Infrastructure	Desktop	Reach	5 years
	Land Cover Change	Desktop	Reach	5 years
	Land Use	**Desktop**	**Reach**	**5 years**
Hydrological Change	Flow Stress Ranking			
	- Low Flow	Desktop	Reach	5 years
	- High Flow	Desktop	Reach	5 years
	- Proportion of zero flow	Desktop	Reach	5 years
	- Monthly variation	Desktop	Reach	5 years
	- Seasonal period	Desktop	Reach	5 years
Water Quality	Total Nitrogen	Field	Site	Annual
	Total Phosphorus	Field	Site	Annual
	Turbidity	Field	Site	Annual
	Salinity	Field	Site	Annual
	Dissolved Oxygen	Field	Site	Annual
	Temperature	Field	Site	Annual
Physical Form	**Longitudinal Connectivity**			
	- **Major Dams**	**Desktop**	**Reach**	**5 years**
	- **Minor Dams**	**Desktop**	**Reach**	**5 years**
	- **Gauging Stations**	**Desktop**	**Reach**	**5 years**
	- **Road-rail crossings**	**Desktop**	**Reach**	**5 years**
	Artificial Channels	Desktop	Reach	5 years
	Erosion			
	- Erosion extent	Field	Site	Annual
	- Bank Stabilisation	Field	Site	Annual
Fringing Zone	**Extent of Fringing Zone**			
	- **Fringing veg length**	**Desktop**	**Reach**	**5 years**
	- **Fringing veg width**	**Desktop**	**Reach**	**5 years**
	Nativeness	**Field**	**Site**	**Annual**
Aquatic Biota	Fish/crayfish			
	- Expectedness	Field	Site	Bi-annual
	- Nativeness	Field	Site	Bi-annual
	Macroinvertebrates	Field	Site	Annual in spring

***BOLD** indicates available datasets, described further below.*

A summary of each of the themes and available data is provided below.

Catchment Disturbance

The physical characteristics of a catchment provide controls on the hydrology, sediment delivery and chemistry within the river system and the Catchment Disturbance theme provides information on the causes of river health issues and potential future impacts (DoW, 2011a). The FARWH approach suggests the use of three sub-indices: *land use, land cover change* and *infrastructure*. As this assessment is determining base line conditions, the *land cover change* was excluded and can be considered in future. The weighting for each *land use* components are provided in Table 50, based on disturbance to the catchment (i.e. higher disturbance, higher score). The final score for the sub-catchment is based on *1.0 minus the percentage of each land use within each sub-catchment multiplied by the land use weighting.* A sub-catchment with minimal disturbance will have a score close to 1, whereas a sub-catchment that is entirely intensive and irrigated agriculture will have a score of 0.3.

Table 50: Land use weighting (adapted from DoW, 2011a)

Land use	Weighting	Land use	Weighting
Urban	0.66	Plantation forestry	0.23
Intensive and irrigated agriculture	0.70	Managed resources	0.08
Dryland cropping	0.51	Conservation	0.00
Grazing	0.34		

The *infrastructure* sub-indicator was identified as generally insensitive to catchment conditions or change, due to the requirement for high proportions of the catchment to contain infrastructure. Therefore it has not been included within this analysis. However, infrastructure such as unsealed roads can be a significant source of sediment and nutrients by altering natural flows. Therefore unsealed road crossings have been considered in the Physical Form theme.

Hydrological Change

The Hydrological Change theme considers the flow regime changes associated with anthropogenic impacts such as land use change and catchment activities. Common alterations throughout south-west Western Australia are dams, diversions, urbanisation, channelisation and groundwater pumping (DoW, 2011a). Extreme or unexpected variations in the flow regime can stress the ecosystem. The FARWH approach includes the assessment of *low flow*, *high flow*, *proportion of zero flow*, *monthly variation* and *seasonal period of flow* based on current monthly flow and un-impacted river flow (assessed from DWER gauging stations). Un-impacted river flows is intended to be a reference condition, with a catchment that is 100% vegetated.

There are nine (9) active gauging stations within the Hotham-Williams catchment, offering limited spatial coverage, particularly in the upper catchments and along the Williams River. A review of the Department of Water WIR database indicates that continuous gauging has only occurred at 5 locations since the year 2000, and only 3 were recorded in 2019. A summary of the available data is provided in Table 51.

Table 51: Available Flow Data (DWER, 2019)

Site	Start Date	End Date	Parameters
614224	15-06-66	15-12-19	Daily discharge max, mean and min
614008	16-06-82	02-05-95	Daily discharge max, mean and min
614011	21-05-75	05-05-98	Daily discharge max, mean and min
614012	30-05-75	05-05-98	Daily discharge max, mean and min
614105	07-06-96	18-03-18	Daily discharge max, mean and min
614125	29-02-08	15-12-19	Daily discharge max, mean and min
614126	19-02-08	18-12-17	Daily discharge max, mean and min
614196	13-06-66	15-12-19	Daily discharge max, mean and min

There is uncertainty in using the limited gauging data for the entire catchment, and establishing reference conditions is difficult. Therefore this theme is not scored as the data will lack sensitivity to distinguish between various reaches within the catchment.

Climate change, declining rainfall and reduced flows are known threats to the catchment and should be considered for reaches, particularly east of the catchment.

Water Quality

The Water Quality theme addresses ecosystem health, particularly with regards to salinisation and eutrophication which have been common since the introduction of European agriculture (DoW, 2011a). Similar to flow data described above, there are limitations in the availability of water quality data through the catchment. A summary of the available water quality data is outlined in Table 52.

Table 52: Available Water Quality Data (DWER, 2019)

	Nutrients				Electrical Conductivity		
Site	Start Date	End Date	No. TN Samples	No. TP Samples	Start Date	End Date	No. of EC Samples
614224	14-10-65	27-10-16	72	142	16-11-00	11-08-19	6777
614008	16-06-82	03-05-95	0	0	-	-	-
614011	21-05-75	02-09-92	0	0	13-06-79	05-05-98	3498
614012	13-02-75	28-08-92	0	0	28-03-79	05-05-98	3419
614105	06-06-96	22-02-16	51	74	27-10-99	29-06-10	3498
614125	09-08-07	27-10-16	2	2	29-02-08	18-03-18	71
614126	09-08-07	27-10-16	3	3	19-02-08	18-12-17	3756
614196	18-05-66	27-10-16	71	136	18-04-00	11-08-19	6796

Owing to the limited data availability, the Water Quality theme has not been scored. The data available is insufficient to distinguish between reaches in the catchment and is not considered in determining priority reaches.

Physical Form

The Physical Form theme is assessed to determine the state of local habitat and its ability to support aquatic life (DoW, 2011a). Specific components of the river habitat include bed substrate, large woody debris, macrophytes, variety in channel form (pools, riffles and runs),

flooded zones and connectivity of the channel (absence of any physical barriers). These components were assessed in detail as part of the Pen-Scott field based methods (Appendix 1). The recommended approach for assessment at a reach scale is the use of sub-indices: *longitudinal connectivity*; and *artificial channel* and *erosion*.

Longitudinal Connectivity (LC) considers the impacts from anthropogenic barriers within each reach, including structures such as weirs, gauging stations and roads/railways. The scoring for each reach is provided in Table 53, with the final score for each reach dependent on the number of structures per type within the reach. The equation of the score is:

$$LC = \frac{(Component_1\ x\ Weighting) + (Component_2\ x\ Weighting) + \cdots - (minimum\ possible\ score)}{(maximum\ possible\ score - minimum\ possible\ score)}$$

Table 53: Connectivity scoring (adapted from DoW, 2011a)

Score	Major Dam Component (weighting = 1.0)	Minor Dam Component (weighting = 0.75)	Gauging Station Component (weighting = 0.5)	Road and Rail Crossing Component (weighting = 0.25)
0.00	Present on reach			Not applicable
0.25	Present within 5 km of start/end of reach			>2 /km (high density)
0.50	Present between 5 and 20 km of start/end of reach			1 – 2 /km (moderate)
0.75	Present between 20 and 40 km of start/end of reach			>0 – 1 /km (low)
1.00	Present >40 km of start/end of reach			0 /km

The presence of artificial channels (trained or modified) reduces available habitats and identifying these locations can assist in determining areas of poor ecological condition. However in the Hotham-Williams catchment, channel modifications are generally restricted to the site scale rather than reach scale, so these sites cannot be determined from desktop analysis.

The other category assessed is the *erosion and sedimentation* within the reach. Erosion and sedimentation occur naturally, however accelerated erosion and sedimentation can cause turbidity in the water column, interfere with filter-feeding and reduce habitat diversity. Ideally erosion assessments are field based, accessing the extent and severity of erosion along a reach. This was carried out in the field reach assessment component of the RAP, detailed in section 3. For the desktop based approach, catchment topography and fringing zone vegetation conditions were used as indicators. The Avon Hotham Catchment Appraisal (Department of Agriculture and Food, 2005) considered catchment slope and the likelihood of erosion in the context of determining the risks and impacts to agricultural production and natural resources and providing recommendations for management of surface water (Appendix 1). The erosion categories have been adapted for the Hotham-Williams catchment as shown in Table 29.

Table 54: Catchment erosion risk scoring (adapted from DAF, 2005)

Slope	Description	Score
0 – 1%	Low gradients, poorly drained	1.0
1 – 3%	Potential for erosion. Waterlogging possible on clayey and duplex soils	0.70
3 – 10%	High risk of water erosion	0.30
>10%	Very high risk of water erosion	0

Catchment slope cannot be considered in isolation from the vegetation present within the channel, and the width and nature of the fringing zone should be considered in the final scoring, as discussed further below. Similarly, human and livestock access were noted as major causes of erosion during field inspection. Therefore land use and the quality of fencing also require consideration.

Fringing Zone

The Fringing Zone theme assesses the health and quality of vegetation either side of rivers within the catchment. This vegetation is significant in providing stream shading, increasing bank stability, providing habitat and acting as a buffer to prevent human and stock access (DoW, 2011a). The two sub-indices considered in the FARWH approach are the *extent of the fringing zone* and *nativeness* (extent of exotic species) of the vegetation.

The extent of fringing vegetation considers both the length (continuity) (FVLC) and width of vegetation along a reach. The length of the fringing zone was scored using the following equation:

$$FVLC = \frac{1}{100} xpercent\ of\ length\ vegetated$$

The width of the fringing zone is determined by measuring the distance of vegetation at 90° from the reach, up to 50 m. Table 55 provides the scores for the respective vegetation widths. The FARWH approach indicates measurements every 50 m along the reach, and an average score determined. For this assessment, an average score for the entire channel within the sub-catchment (reach) was estimated by reviewing aerial imagery.

Table 55: Fringing Zone Width scoring (adapted from DoW, 2011a)

Average Distance	Score
0 m	0.0
12.5 m	0.25
25 m	0.50
37.5 m	0.75
50 m	1.0

Determining the nativeness of vegetation is carried out through field assessments, particularly owing to the ability to assess weeds and the health of native ground cover and shrubs. In the absence of field assessments for the sub-catchments assessed via desktop, the Native Vegetation (reserve) mapping provided by Peel-Harvey Catchment Council was utilised. Where reaches are located within reserves, a score of 1.0 was assigned, otherwise reaches were scored 0.0.

Aquatic Biota

Assessment of the aquatic biota theme provides a summary of the response of biota to changes in aquatic environment, of which the FARWH approach examines sub-indices of fish/crayfish and macroinvertebrates. Data regarding these indicators is limited to site-specific investigations and difficult to implement at a reach scale. Therefore this theme has been excluded from the RAP assessment.

Total Sub-Catchment Condition Score

To simplify the sub-catchments reach ratings, a total score was determined to identify priorities for further investigation. The FARWH approach provides a summary score for each theme rather than a total score which allows for comparison of systems with different physical settings and catchment conditions. For the RAP, a total score is adopted due to the available data and common issues and conditions identified within the Hotham Williams catchment.

The total score is calculated based on the various indicators outlined above. Recognising that the indicators are not of equal importance, a weight for each is applied. Table 56 outlines the respective weightings for the indicators that have been adapted for the RAP. Catchment disturbance (*land use*) received the highest weighting as land use within the sub-catchment was considered to be the main factor that influences river condition. Fringing vegetation was also weighted marginally higher than other indicators as the extent of vegetation near the river can also influence physical form (*erosion*) as it may stabilise the banks.

Table 56: Total score weighting

Indicator	Land Use	Connectivity	Slope	Fringing Zone Length	Fringing Zone Width	Native Vegetation
Theme	Catchment Disturbance	Physical Form	Physical Form	Fringing Zone	Fringing Zone	Fringing Zone
Weighting	0.40	0.10	0.10	0.15	0.15	0.10
Reference	Table 27	Table 28	Table 29	-	Table 30	-

Scores from each of the indicators is then multiplied by the respective weightings and then combined for a total score between 0 (completely degraded) and 1 (undisturbed) as shown in Table 57. Priority catchments can therefore be determined by two approaches. Firstly, setting a target score and capturing all sub-catchments under that number. For example, any sub-catchment with a score under 0.50 (reduced fringing vegetation and channel disturbance) may be considered a priority. The alternative approach, adopted for the RAP, is to prioritise the lowest scoring sub-catchments in areas where multiple sub-catchments have scored lowly and there are significant waterways. This is discussed further in Section 4.2, along with the results and recommendations..

Table 57: Total score description

Total Score	Description
1.00	Catchment is 100% conservation with native vegetation and un-impacted channel or fringe vegetation.
0.75	Catchment is 50% conservation with minimal impact on channel form or fringe vegetation
0.50	Catchment is 50% conservation with reduced fringe vegetation and/or channel disturbance
0.25	Minimal conservation areas with exotic species and limited fringing vegetation
0.00	No conservation areas within the catchment and no fringing vegetation

Scores for all of the sub-catchments are provided in Appendix 5.

APPENDIX 5: DESKTOP SUB-CATCHMENT SCORING

The Hotham Williams catchments were divided into 102 sub-catchments as shown in Figure 37, with the numbering beginning in the upper (eastern) part of the Hotham River catchment. Of these sub-catchments, 101 were assessed as one sub-catchment (number 102) contained mining facilities and no significant waterways. The scoring of the assessment is provided in Table 58 for all sub-catchments. Discussion of the respective weightings is provided in Appendix 4. The 20 lowest scoring sub-catchments are highlighted red and the 20 highest scoring sub-catchments are highlighted green.

Table 58: Sub-catchment assessment

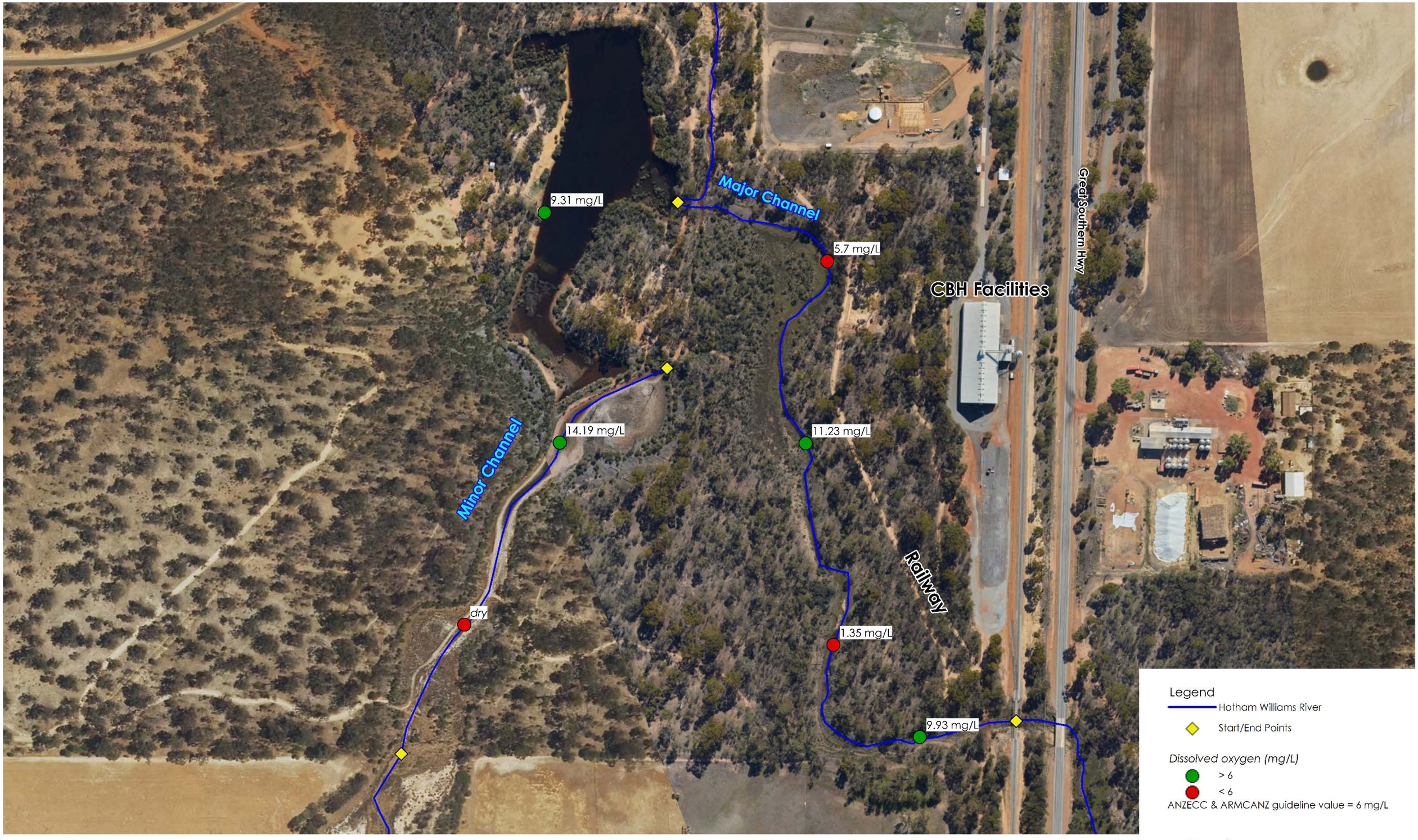
Sub-Catchment	Land Use	Connectivity	Slope	Fringing Zone Length	Fringing Zone Width	Native Vegetation	Total Score
Weighting	**0.40**	**0.10**	**0.10**	**0.15**	**0.15**	**0.10**	
1	0.55	0.75	1.00	0.60	0.60	1.00	**0.68**
2	0.57	0.75	1.00	0.50	0.30	1.00	**0.62**
3	0.60	0.75	1.00	1.00	0.70	1.00	**0.77**
4	0.56	0.75	1.00	0.80	0.65	1.00	**0.72**
5	0.56	0.75	1.00	0.90	0.75	1.00	**0.75**
6	0.57	0.75	0.70	0.20	0.20	1.00	**0.53**
7	0.57	0.75	1.00	0.25	0.30	1.00	**0.59**
8	0.55	0.75	1.00	0.50	0.50	1.00	**0.64**
9	0.55	0.75	1.00	0.70	0.75	1.00	**0.71**
10	0.58	0.75	1.00	0.40	0.50	1.00	**0.64**
11	0.66	0.75	1.00	0.90	0.80	1.00	**0.79**
12	0.58	0.75	1.00	0.80	0.35	1.00	**0.68**
13	0.59	0.75	0.70	0.50	0.20	1.00	**0.59**
14	0.59	0.75	1.00	0.45	0.30	1.00	**0.62**
15	0.57	0.75	1.00	0.30	0.60	1.00	**0.64**
16	0.60	0.75	1.00	1.00	0.80	1.00	**0.79**
17	0.55	0.75	1.00	0.90	0.60	1.00	**0.72**
18	0.54	1.00	1.00	0.50	0.75	1.00	**0.70**
19	0.72	0.75	1.00	0.80	0.80	1.00	**0.80**
20	0.58	1.00	1.00	0.40	0.40	1.00	**0.65**
21	0.58	0.75	1.00	1.00	0.80	1.00	**0.78**
22	0.61	0.75	1.00	1.00	0.75	1.00	**0.78**
23	0.63	0.75	1.00	0.40	0.35	1.00	**0.64**
24	0.60	0.75	1.00	0.20	0.20	1.00	**0.58**
25	0.59	0.75	1.00	0.90	0.90	1.00	**0.78**
26	0.59	0.75	1.00	0.60	0.25	1.00	**0.64**
27	0.59	0.75	1.00	1.00	0.80	1.00	**0.78**
28	0.59	0.75	1.00	0.30	0.25	1.00	**0.59**
29	0.67	0.75	1.00	1.00	0.50	1.00	**0.77**
30	0.66	0.75	1.00	1.00	0.75	1.00	**0.80**
31	0.62	0.75	1.00	1.00	0.80	1.00	**0.79**

Sub-Catchment	Land Use	Connectivity	Slope	Fringing Zone Length	Fringing Zone Width	Native Vegetation	Total Score
Weighting	**0.40**	**0.10**	**0.10**	**0.15**	**0.15**	**0.10**	
32	0.69	0.75	1.00	1.00	0.60	1.00	**0.79**
33	0.75	1.00	1.00	1.00	0.80	1.00	**0.87**
34	0.83	0.75	1.00	0.70	0.80	1.00	**0.83**
35	0.70	0.75	1.00	0.50	0.40	1.00	**0.69**
36	0.70	1.00	1.00	1.00	0.50	1.00	**0.81**
37	0.74	0.75	1.00	0.95	0.65	1.00	**0.81**
38	0.89	0.75	1.00	1.00	0.65	1.00	**0.88**
39	0.85	0.75	1.00	1.00	1.00	1.00	**0.92**
40	0.88	0.75	0.70	1.00	0.80	1.00	**0.87**
41	0.92	1.00	1.00	1.00	0.50	1.00	**0.89**
42	0.74	1.00	1.00	0.05	0.70	1.00	**0.71**
43	0.93	1.00	0.70	0.05	0.70	1.00	**0.76**
44	0.64	1.00	1.00	0.50	0.90	1.00	**0.77**
45	0.69	1.00	1.00	0.80	0.30	1.00	**0.74**
46	0.68	0.75	1.00	0.50	0.30	1.00	**0.67**
47	0.61	0.75	1.00	0.90	0.40	1.00	**0.71**
48	0.57	0.75	1.00	0.90	0.50	1.00	**0.71**
49	0.63	0.75	1.00	0.90	0.75	1.00	**0.77**
50	0.71	0.75	1.00	0.70	0.25	1.00	**0.70**
51	0.66	0.75	1.00	0.60	0.20	1.00	**0.66**
52	0.80	1.00	1.00	0.70	0.30	1.00	**0.77**
53	0.71	0.75	1.00	0.50	0.40	1.00	**0.69**
54	0.66	0.75	1.00	0.90	0.60	1.00	**0.77**
55	0.60	0.75	1.00	0.90	0.50	1.00	**0.73**
56	0.60	0.75	1.00	0.80	0.40	1.00	**0.69**
57	0.56	0.75	0.70	0.50	0.20	1.00	**0.57**
58	0.58	0.75	1.00	0.90	0.50	1.00	**0.72**
59	0.60	1.00	1.00	1.00	0.60	1.00	**0.78**
60	0.60	0.75	1.00	1.00	0.50	1.00	**0.74**
61	0.62	0.75	1.00	1.00	0.80	1.00	**0.79**
62	0.75	0.75	1.00	1.00	0.80	1.00	**0.85**
63	0.56	0.75	1.00	0.75	0.25	1.00	**0.65**
64	0.56	0.75	1.00	0.80	0.40	1.00	**0.68**
65	0.58	0.75	1.00	0.80	0.30	1.00	**0.67**
66	0.66	1.00	0.70	0.60	0.25	1.00	**0.66**
67	0.56	0.75	1.00	0.50	0.30	1.00	**0.62**
68	0.60	1.00	1.00	0.80	0.40	1.00	**0.72**
69	0.61	1.00	1.00	0.70	0.50	1.00	**0.72**
70	0.56	0.75	1.00	0.70	0.75	1.00	**0.71**
71	0.59	0.75	1.00	0.80	0.55	1.00	**0.72**
72	0.62	0.75	1.00	0.80	0.50	1.00	**0.72**
73	0.63	0.75	1.00	0.80	0.75	1.00	**0.76**

Sub-Catchment	Land Use	Connectivity	Slope	Fringing Zone Length	Fringing Zone Width	Native Vegetation	Total Score
Weighting	**0.40**	**0.10**	**0.10**	**0.15**	**0.15**	**0.10**	
74	0.65	0.75	1.00	0.80	0.75	1.00	**0.77**
75	0.60	1.00	1.00	0.80	0.65	1.00	**0.76**
76	0.63	0.75	1.00	0.90	0.60	1.00	**0.75**
77	0.63	0.75	1.00	1.00	0.70	1.00	**0.78**
78	0.67	1.00	1.00	1.00	0.80	1.00	**0.84**
79	0.76	0.75	1.00	0.30	0.25	1.00	**0.66**
80	0.78	0.75	1.00	1.00	0.65	1.00	**0.83**
81	0.82	0.75	1.00	1.00	0.80	1.00	**0.87**
82	0.78	1.00	1.00	1.00	0.70	1.00	**0.87**
83	0.96	1.00	1.00	1.00	0.90	1.00	**0.97**
84	0.84	0.75	1.00	0.30	0.25	1.00	**0.69**
85	0.75	0.75	1.00	0.50	0.20	1.00	**0.68**
86	0.79	0.75	0.70	0.70	0.20	1.00	**0.69**
87	0.70	0.75	1.00	0.60	0.30	1.00	**0.69**
88	0.77	0.75	0.70	0.50	0.30	1.00	**0.67**
89	0.62	0.75	0.70	0.30	0.20	1.00	**0.57**
90	0.62	0.75	1.00	0.40	0.20	1.00	**0.61**
91	0.80	0.75	1.00	0.25	0.25	1.00	**0.67**
92	0.75	0.75	1.00	0.90	0.40	1.00	**0.77**
93	0.67	0.75	0.70	0.45	0.35	1.00	**0.63**
94	0.77	0.75	0.70	0.40	0.30	1.00	**0.66**
95	0.59	0.75	1.00	0.90	0.20	1.00	**0.68**
96	0.63	0.75	1.00	0.85	0.30	1.00	**0.70**
97	0.57	0.75	1.00	0.40	0.20	1.00	**0.59**
98	0.58	0.75	1.00	0.80	0.40	1.00	**0.69**
99	0.59	0.75	1.00	0.50	0.20	1.00	**0.62**
100	0.60	0.75	1.00	0.50	0.30	1.00	**0.63**
101	0.61	1.00	1.00	1.00	0.80	1.00	**0.81**

APPENDIX 6: YORNANING DAM WATER QUALITY MAPPING

Peel Harvey Catchment Council-Hotham-Williams River Action Plan
Figure 45 - Yornaning Dam Dissolved Oxygen



Legend

Hotham Williams River

Start/End Points

Dissolved oxygen (mg/L)

> 6

< 6

ANZECC & ARMCANZ guideline value = 6 mg/L

Data source: PHCC, Created by:AT Projection: MGA2020: zone 50.

0 300

metres

Scale 1:3,000 @ A3

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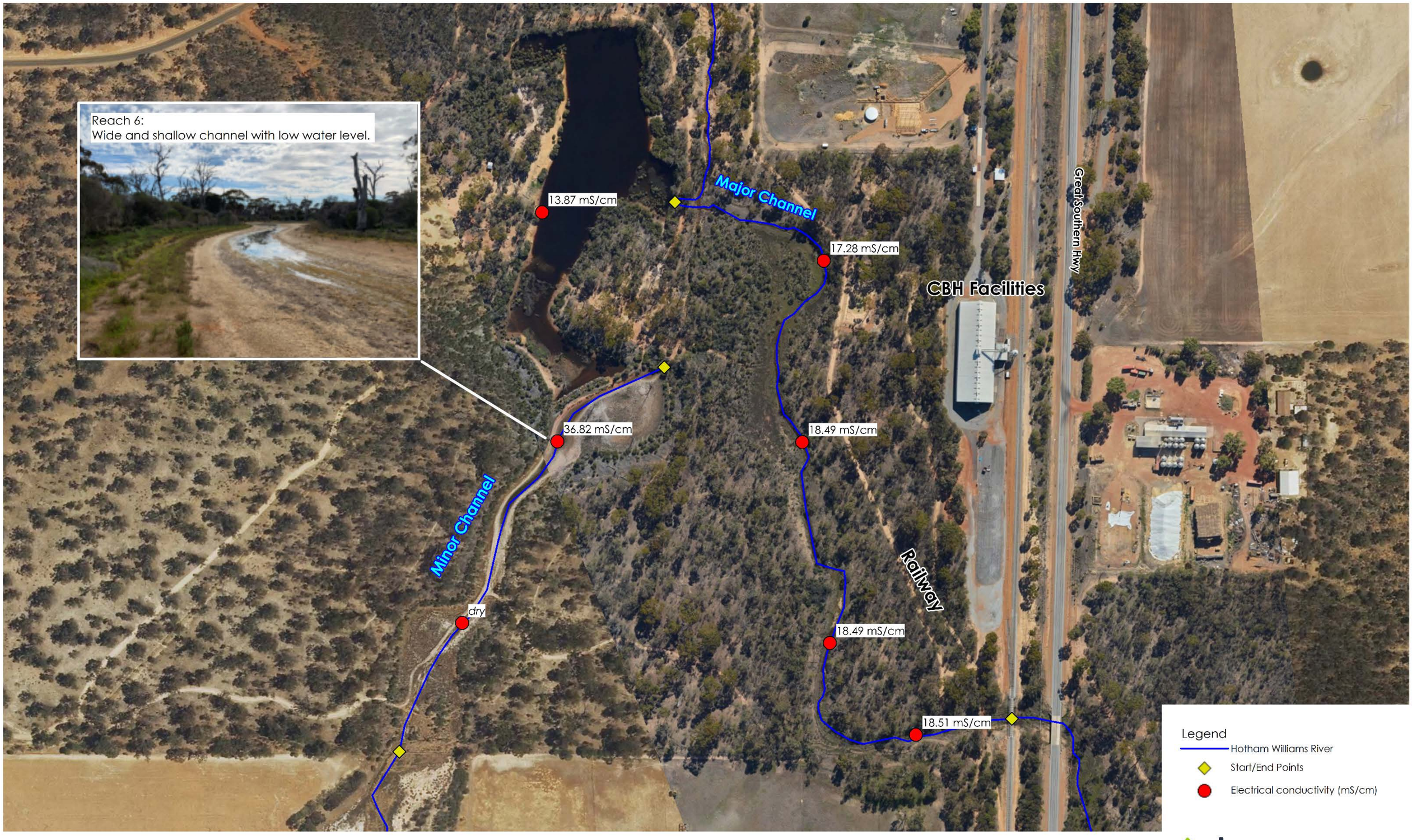
Peel Harvey Catchment Council-Hotham-Williams River Action Plan
Figure 46 - Yornaning Dam Electrical Conductivity



Data source: PHCC, Created by:YY Projection: MGA: zone 50.

0 300
metres
Scale 1:3,000 @ A3

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Client: Peel-Harvey Catchment Council

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
Preliminary draft	V0	RP	HB	Electronic	Jan 2020
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