GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

Tributary Foreshore Assessment Report: Helena River (Mandoon)

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Rivers and Estuaries Division

January 2018

GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

Department of Biodiversity, Conservation and Attractions
Locked Bag 104
Bentley Delivery Centre WA 6983
Phone: (08) 9219 9000
Fax: (08) 9334 0498

www.dbca.wa.gov.au

This report was prepared by Alison McGilvray and Kim Sylva, Rivers and Estuaries Division, DBCA.

Questions regarding the use of this material should be directed to:
Alison McGilvray
Rivers and Estuaries Division
Department of Biodiversity, Conservation and Attractions
Locked Bag 104
Bentley Delivery Centre WA 6983
Phone: 08 9278 0906
Email: alison.mcgilvray@dbca.wa.gov.au

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Front cover: Helena River pool, Beelu National Park. Photo – Alison McGilvray/DBCA

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Acknowledgments

Ngala kaaditj Noongar moort keyen kaadak nidja boodja

We acknowledge the Noongar people as the original custodians of this land. We also acknowledge the Whadjuk people as the traditional owners of the lands and waters of Mandoon, the Helena River.

The field assessment of the Helena River was carried out by the following Department of Biodiversity, Conservation and Attractions (DBCA) staff – Alison McGilvray, Michelle Crow, Debbie Besch, Kim Sylva, Christie Atkinson and Mark Cugley. Joy McGilvray also assisted as a volunteer.

Patrick Maslen and Leah Botten from DBCA set up the data collection system and Patrick has provided data management, mapping and general GIS support for the assessment.

The Helena River Catchment Group (HRCG), Katharine Street River Gang, Lower Helena Association, and DBCA volunteer Peter Day carry out a significant amount of restoration works on the river, particularly in Darlington, Helena Valley, Woodbridge and Guildford, and have provided input and feedback into this report. Penny Hussey from HRCG assisted with weed and native species identification.

The Eastern Metropolitan Regional Council (EMRC) and local government authorities have provided input and feedback into this report.

Perth NRM supplied GIS files and information on the location of restoration works along the Helena River and within the eastern NRM subregion.

Water Corporation and Department of Water and Environmental Regulation have provided input and feedback into the content of this report.

DBCA's Perth Hills District has provided input into this report. DBCA's Species and Communities Branch supplied GIS shapefiles of threatened flora, fauna and community records adjacent to the river. DBCA's Aboriginal Heritage Unit provided feedback on the cultural values section of this report.

A workshop was held on 26 October 2017 in which the findings of the draft report were presented, with an opportunity for feedback from participants. Participants represented local government, catchment groups, EMRC and DBCA. Recommendations that were workshopped have been included in this final report.

Summary

The Helena River is a major contributor to the Swan and Canning river system. It provides a significant water source to the Goldfields region and eastern Wheatbelt region from two major dam structures – Mundaring Weir and the Lower Helena Pumpback Dam. The river flows from east of Mount Dale in the Shire of York to its confluence with the Swan River in Guildford. It forms a biodiversity corridor along a transition between the Darling Range, Darling escarpment and the Swan Coastal Plain. The area of the Helena River from Mundaring Weir downstream to its confluence with the Swan River was selected by the Department of Biodiversity, Conservation and Attractions (DBCA) for assessment of the quality and condition of the riparian vegetation, and river bank condition and stability.

Two previous assessments have been conducted: by the former Water and Rivers Commission (WRC) in 1999 and by the former Department of Water in 2006. Data from these assessments have enabled a comparison of riparian quality and health over this 17-year period. Within this period Perth has undergone a rapid expansion in population and resulting infrastructure, housing and industrial development. In the Helena River system, this is evident in the lower reaches through Helena Valley, Bellevue, Hazelmere and Midland. The significant reduction in rainfall and stream flows in the south-west of WA since the 1970s has continued over this 17-year period.

DBCA works with Perth NRM and the Eastern Region Catchment Management Program (ERCMP), which facilitates environmental protection and restoration projects with community and local governments in the East NRM subregion. The Helena River Catchment Group (HRCG), Katharine Street River Gang and the Lower Helena Association work within the lower Helena catchments and have carried out restoration, revegetation and weed control projects adjacent to the Helena River.

A 10-year Eastern Catchment Management Plan was developed by ERCMP in 2012 which reviewed existing works and set direction to coordinate future action and a vision for catchment management in the East subregion. This plan includes the Swan Canning Tributary Assessment Project as an activity to implement and lists several other actions which align with the objectives of this assessment.

The field assessment was conducted from September to November 2016. Field data were analysed from December 2016 to March 2017. The riverbank was split into 44 segments based on vegetation structure, bank type and substantial changes in land use. Segments were assigned a category for management action based on their ecological value and condition, and prioritised for protection or rehabilitation. Recommendations for each segment were identified and are included in this report. This report also identifies potential project areas in addition to existing restoration works. The Helena River was divided into three sections (east, central and west) to reflect major changes in landform (the Darling Scarp to the Swan Coastal Plain), land use and the area of operation of active catchment groups.

The following major observations were made:

East – Mundaring Weir to Lower Helena Pumpback Dam

This section had the longest length of riverbank with intact vegetation, and the majority of riverbank had moderate weed coverage. Bank stability was mostly good with only a small area rating average. Banks were mostly vegetated with remnant vegetation including good understorey. A stretch just below Mundaring Weir and another midway through the section that has been cleared were in poorer condition.

The overall condition of this section was better than in the downstream sections, due to the protection offered by Beelu National Park. The major pressures facing this section are the presence of the dam and reduced flow, also caused by a declining rainfall, reduced flow from other tributaries and weed coverage.

Pen and Scott grades ranged from A3 to C2, with the majority of segments at B3 or above. Segments fit into prioritisation categories 1 to 6 out of the possible 0 to 8.

Central – Lower Helena Pumpback Dam to Scott Street

Vegetation condition, weed coverage and bank stability of the riverbank within the Beelu National Park was in better condition than areas downstream that are within private property.

Vegetation condition was mostly average but weed cover was extensive. Bank stability was mostly average with some areas good. The pressure of reduced flow is added to with the pressures of having the river running through private properties, increasing weed coverage from clearing and gardens, water extraction from the river and livestock accessing the river.

Pen and Scott grades ranged from A3 to C1, however less than half as much as the East section was in the A3 grade with the largest portion in C1 and prioritisation categories 2 and 3.

West – Scott Street to Swan River confluence

Bank stability was average over most of this section with a few areas in good condition and a small area with poor bank stability. Vegetation condition was graded average to poor. Weed cover was extensive along most of the riverbank. Understorey was either absent or only found in very limited areas with weeds dominating understorey and mid-storey. Riverbank with moderate or minimal weed coverage was undergoing active rehabilitation.

The pressures increase from moderate to extensive downstream of the Scott Street crossing with a narrow riparian zone and cleared floodplain providing little buffer between the neighbouring residential estates and industrial areas.

Pen and Scott grades for segments in this section ranged from B1 to D3, with over 95% of the section falling into the C1 to D3 grades. Prioritisation categories ranged from 3 to 8.

1 Introduction

1.1 Area description

The Helena River is a major tributary of the Swan Canning river system. The river flows from east of Mount Dale in the Shire of York to its confluence with the Swan River in Guildford. It is dammed at Mundaring Weir and together with the Lower Helena Pumpback Dam (the Pumpback Dam), it provides a significant water source for the eastern Wheatbelt and Goldfields region (WAPC 2010).

This assessment was limited to the section of the river from Mundaring Weir downstream to the confluence with the Swan River (Figure 1). This section is comprised of the Middle Helena Catchment, from Mundaring Weir to the Pumpback Dam, approximately 12 km, and the Lower Helena Catchment, from the Pumpback Dam to the Swan River (EHCMP 2014), which extends for approximately 16 km.

The Helena River flows through the Darling Plateau and Darling Scarp in the East NRM subregion, where it is mostly located within Beelu National Park. The river enters the Swan Coastal Plain in Helena Valley. Crown reserve, private residential and industrial properties are adjacent to the river in the suburbs of Helena Valley, Bellevue and Hazelmere downstream of the Pumpback Dam.

This section of the Helena River flows through two Interim Biogeographic Regionalisation for Australia (IBRA) regions – Jarrah Forest and the Swan Coastal Plain - and forms a biodiversity corridor along a transition from the Darling Range, through the Darling escarpment, to the Swan Coastal Plain. Steep sloped river valleys are in the section between Mundaring Weir and the Pumpback Dam (WAPC 2010) and as the river flows on the Swan Coastal Plain, the flood plain becomes wider and flatter, with several anabranches remaining along sections of the lower Helena River.

Figure 1: Extent of the Helena River assessment, Interim Biogeographic Regionalisation for Australia (IBRA), Perth NRM subregions, and Swan River Trust Development Control Area (DCA).

1.2 Historical context

The Helena River and its adjacent valleys and floodplain are highly significant to Aboriginal people. A brief discussion of its cultural significance is included in Section 1.3.

Mundaring Weir was the second dam to be built for water supply in Western Australia, and it was built during a wetter climate. Construction began in 1889 and was completed in 1903. After several years of low stream flow, more than 5,000ha of native woodland adjacent to the weir was ringbarked to reduce evapotranspiration and increase stream flow. Whilst the scheme was deemed successful for increasing streamflow, salinity and turbidity also increased, with a 300% increase in salinity reported in 1909 (Batini and Selkirk 1978). The dam wall was raised in 1951 and again in 1959 (Batini and Selkirk 1978). The weir last overflowed in 1996.

The Pumpback Dam was constructed in 1971 to collect runoff from the Middle Helena Catchment area and supplement Mundaring Weir via the pumpback pipeline (Smith *et al*. 2007). The Lower Helena Main Trunk (water pipe) between the Pumpback Dam and Mundaring Weir was upgraded in the mid 2000s and watsonia control near the Pumpback Dam was conducted through an environmental offset.

A long-term resident of Woodbridge explained that the northern channel in the section of river from Military Road in Bellevue to Water Street in Guildford was the original river alignment, and that a southern channel was cut in the 1960s to encourage fast water flow and prevent pooling which was believed led to large mosquito populations. However, we could not find reference to this in other reports.

Early post European settlement land uses adjacent to the Helena River included State forest, horticulture and agriculture. On the Swan Coastal Plain, dairy and olive farming and clay extraction was common. Housing developments in Helena Valley and South Guildford were originally cleared for grazing (Chalmers 1997).

In the early 1980s the Environmental Protection Authority (EPA) recommended that the banks and parts of the adjacent floodplain of the Helena River from Darlington to the confluence with the Swan River be reserved for Parks and Recreation as a linear park under the Metropolitan Regional Scheme (EPA 1983). The area between Mundaring Weir and the Pumpback Dam was of high significance for the preservation of water quality and conservation of flora and fauna. Much of the immediate catchment area of Mundaring Weir and the Pumpback Dam was reserved as State Forest in the early 1900s and Beelu National Park was gazetted in 1995.

1.3 Cultural values

Noongar people are the traditional owners of the south-west of WA, and the Whadjuk language group are the custodians of country for the area of Perth associated with the Swan Coastal Plain and Jarrah Forest (EHCMP 2012). The land between the Swan and the Canning Rivers is known as Beeloo (river dwellers), the territory of

Munday's people (Chalmers 1997). The Helena River is probably known by several names, including Mandoon (Green 1984).

Water is central to Aboriginal tradition and the close social, spiritual and cultural tie between Aboriginal people and water carries an obligation to protect this resource for the future (Langton, 2006). Culture, identity, spirituality and history are intertwined with water.

The length of the Helena River from its source to the confluence with the Swan River is a registered site with the Department of Aboriginal Affairs for its ceremonial and mythological significance (DAA n.d.). There are several other registered sites near the Helena River where this assessment was undertaken, including sites of artefact scatters and special significance, and there are likely to be many other culturally significant areas which are not registered (Figure 2).

Prior to and during early European colonisation of Perth, Whadjuk people lived on the river systems which provided freshwater and food resources (Amergin Consulting 2013). The river and the surrounding floodplain environment provided for hunting and gathering bush foods and medicine. Whadjuk people participated in cultural ceremonies and rituals along the river. The construction of Mundaring Weir and the resulting flooding of river and creek valleys caused significant disruption to special cultural sites (O'Connor and Bennell 1987) and the movement of people along the river. Despite this, Mandoon continues to hold special significance for Whadjuk people whose culture is still practiced along the river today.

1.4 Natural values

The Helena River forms a biodiversity corridor with relatively intact vegetation through the Darling Range and escarpment, particularly through Beelu National Park. It is the only major valley close to Perth which is in a relatively natural state with large areas of remnant vegetation and no major traffic arteries through it, and is regionally significant open space (EPA 1983). The section of the Helena River assessed traverses two Interim Biogeographic Regionalisation for Australia (IBRA) regions – Jarrah Forest and Swan Coastal Plain.

The Directory of Important Wetlands in Australia identifies wetlands which are deemed to be of national significance. The only recognised nationally important wetland near the Helena River is the Swan-Canning Estuary, which extends from the mouth of the Swan River upstream to just north of the Guildford Road Bridge. It is therefore only the lower section of the Helena River adjacent to a nationally important wetland. However, a series of deep river pools occur along the river, providing refuge and critical habitat to native fish and other aquatic organisms particularly during dry summer months.

Vegetation complexes were originally mapped by Heddle *et al*. (1980) and represent vegetation within the context of landform, soils and climatic conditions. Complexes adjacent to the Helena River include the Helena and Swan complexes and small areas of the Darling Scarp, Forrestfield, Southern River and Guildford complexes

(Figure 3). The Helena complex is dominated by *Eucalyptus wandoo* woodlands on valley floors and slopes, vegetation associated with granite outcrops, and marri and jarrah woodlands. The Swan complex is dominated by woodland of flooded gum (*Eucalyptus rudis)* and swamp paperbark (*Melaleuca rhaphiophylla)*, with localised occurrences of *Casuarina obesa* and *Melaleuca cuticularis.*

The Darling Scarp complex is largely dominated by *Eucalyptus wandoo* with some marri, and includes heath and vegetation associated with granite outcrops. The Forrestfield complex is dominated by open forests of marri-wandoo-jarrah on heavier gravelly soils and jarrah-marri-sheoak on sandier soils, while rivers support fringing woodlands of flooded gum and swamp paperbark. The Southern River complex is dominated by open woodlands of marri, jarrah and *Banksia* species with fringing woodlands of flooded gum and swamp paperbark along creek beds. The Guildford complex is a mixture of open forests of marri, wandoo and jarrah, wandoo woodlands, and minor occurrences of flooded gum and swamp paperbark (DEP 2000; Appendix 1).

There is one registered Priority Ecological Community (PEC) along the stretch of the Helena River in the Jarrah Forest IBRA - the *Central Northern Darling Scarp Granite Shrubland Community* (Priority 4). On the Swan Coastal Plain IBRA there are several Threatened Ecological Communities (TECs) within 500m to 1km of the watercourse. These include *Shrublands and woodlands of the eastern side of the Swan Coastal Plain* (Critically Endangered), Banksia attenuata *woodlands over species rich dense shrublands* (Endangered) and Corymbia calophylla - Xanthorrhoea preissii *woodlands and shrublands, Swan Coastal Plain* (Critically Endangered). The Banksia *Woodlands of the Swan Coastal Plain* is a Commonwealth *Environment Protection and Biodiversity Conservation Act*-listed TEC between 500m and 1km of the Helena River.

Ten threatened and priority terrestrial flora species are known to occur within a 500-metre buffer of the Helena River. These include one endangered and two vulnerable species, five Priority 3 (poorly known species in need of further survey) and two Priority 4 (rare, near threatened and other species in need of further monitoring) species (Figures 4-6; Appendix 2).

Thirteen species of specially protected fauna are recorded within a 500-metre buffer of the Helena River, including three species of black cockatoo, chuditch, numbat, quenda and Carter's freshwater mussel (Figures 4-6; Appendix 2). Rakali, the water rat, was also likely to have been common on the riverbanks (Dundas and Mills 2011). From observations of community groups, it is no longer found. There are also several freshwater fish species occurring in the Middle Helena River, including western minnow, freshwater cobbler, nightfish, western pygmy perch and the hardyhead (Close *et al*. 2014; WAPC 2010). Natural freshwater pools through the Helena River system provide critical habitat for these species and other aquatic organisms, particularly during dry summer months.

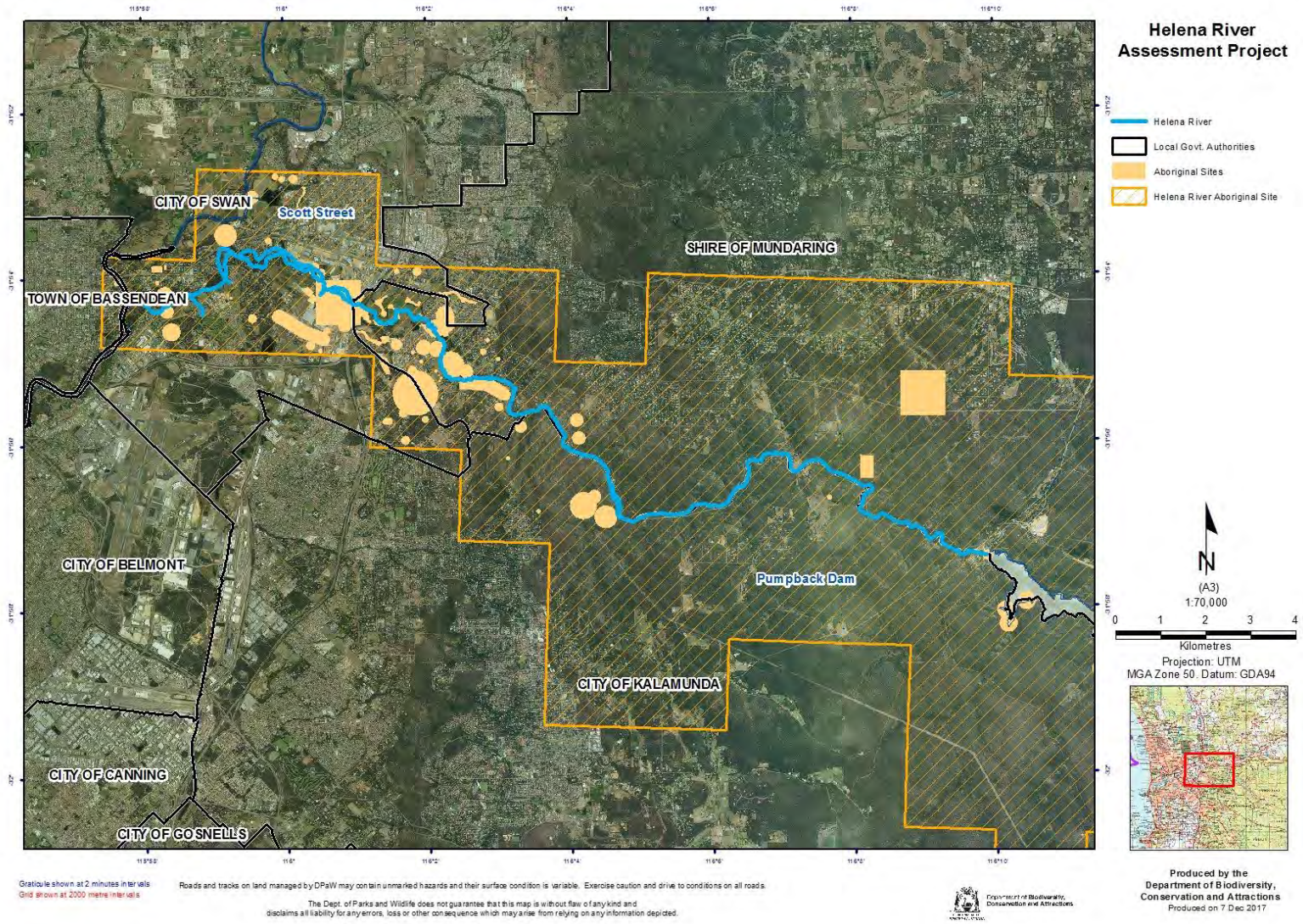


Figure 2: Registered Aboriginal sites within a 500m buffer of the Helena River.

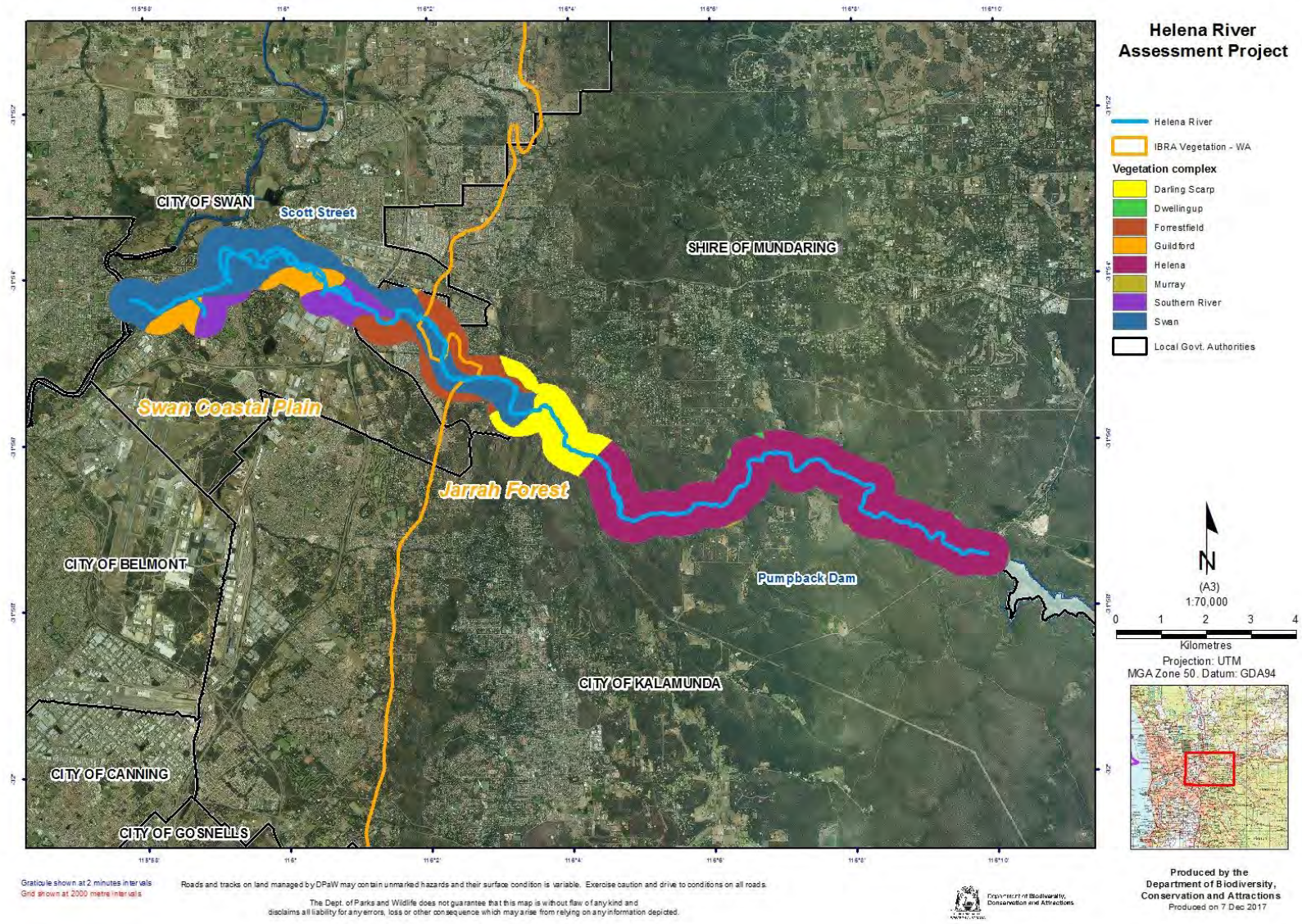


Figure 3: Vegetation complexes and IBRA regions within a 500m buffer of the Helena River.

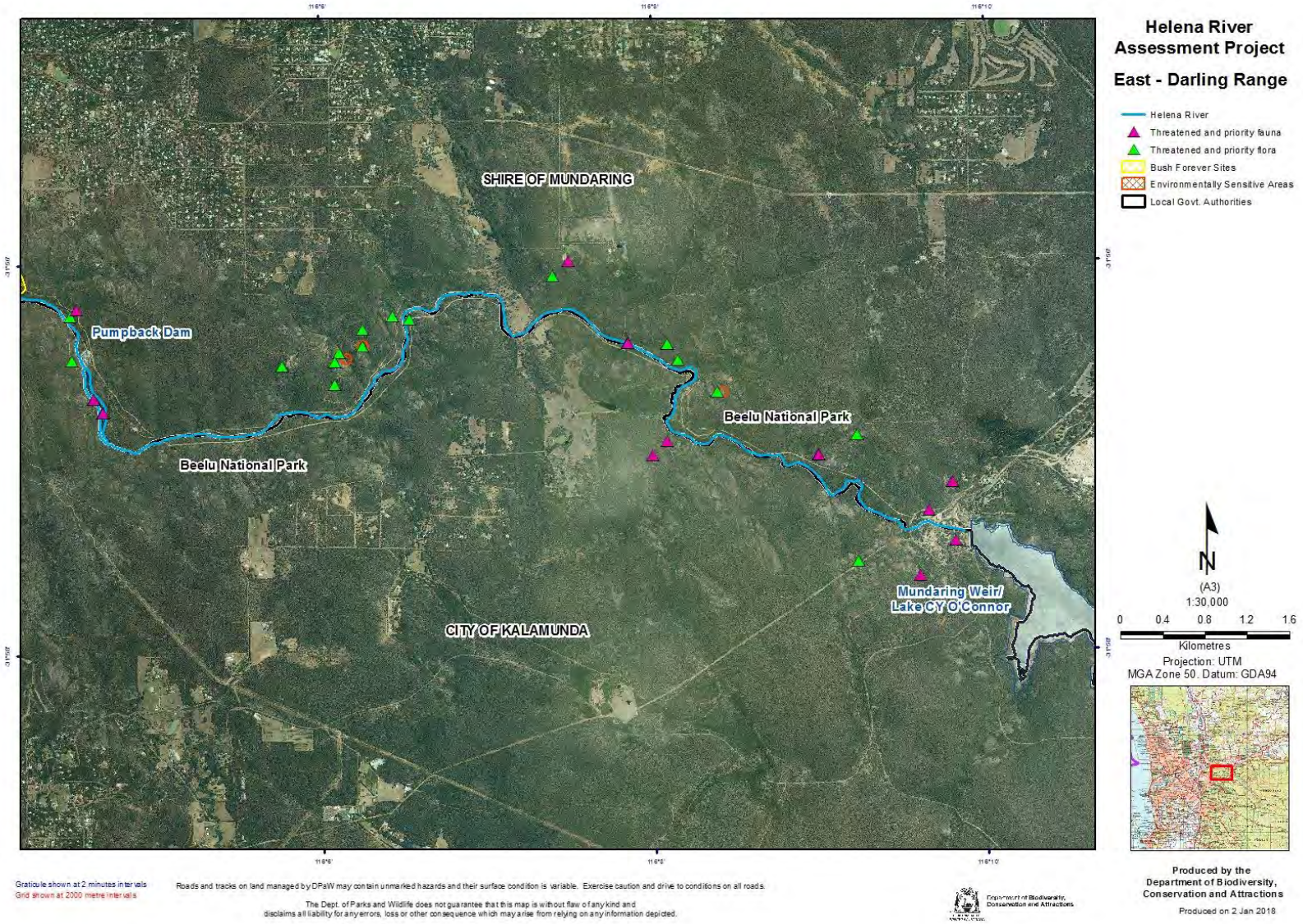


Figure 4: Recorded natural values within a 500m buffer of the Helena River, Mundaring Weir to Pumpback Dam.

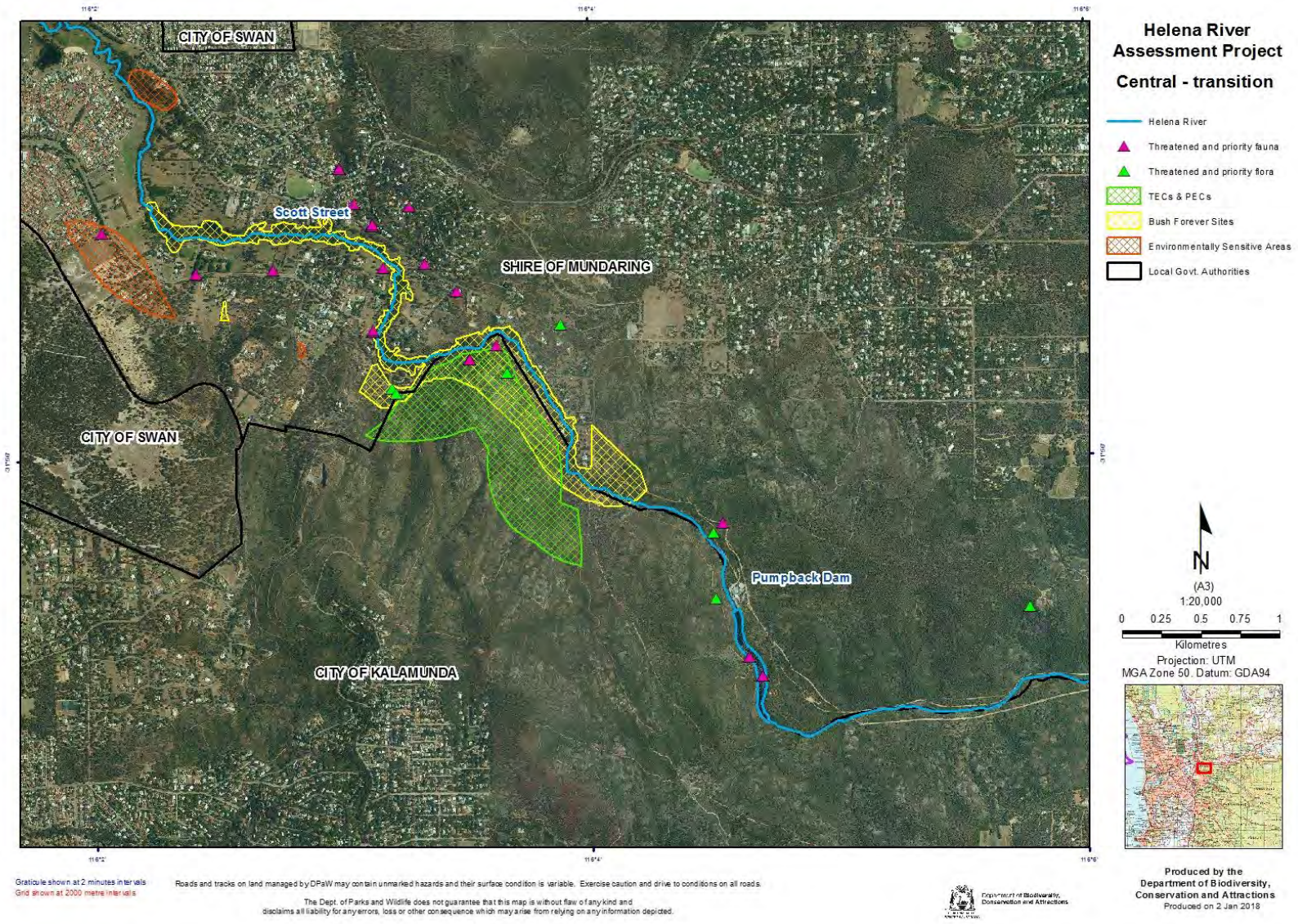


Figure 5: Recorded natural values within a 500m buffer of the Helena River, Pumpback Dam to Scott Street.

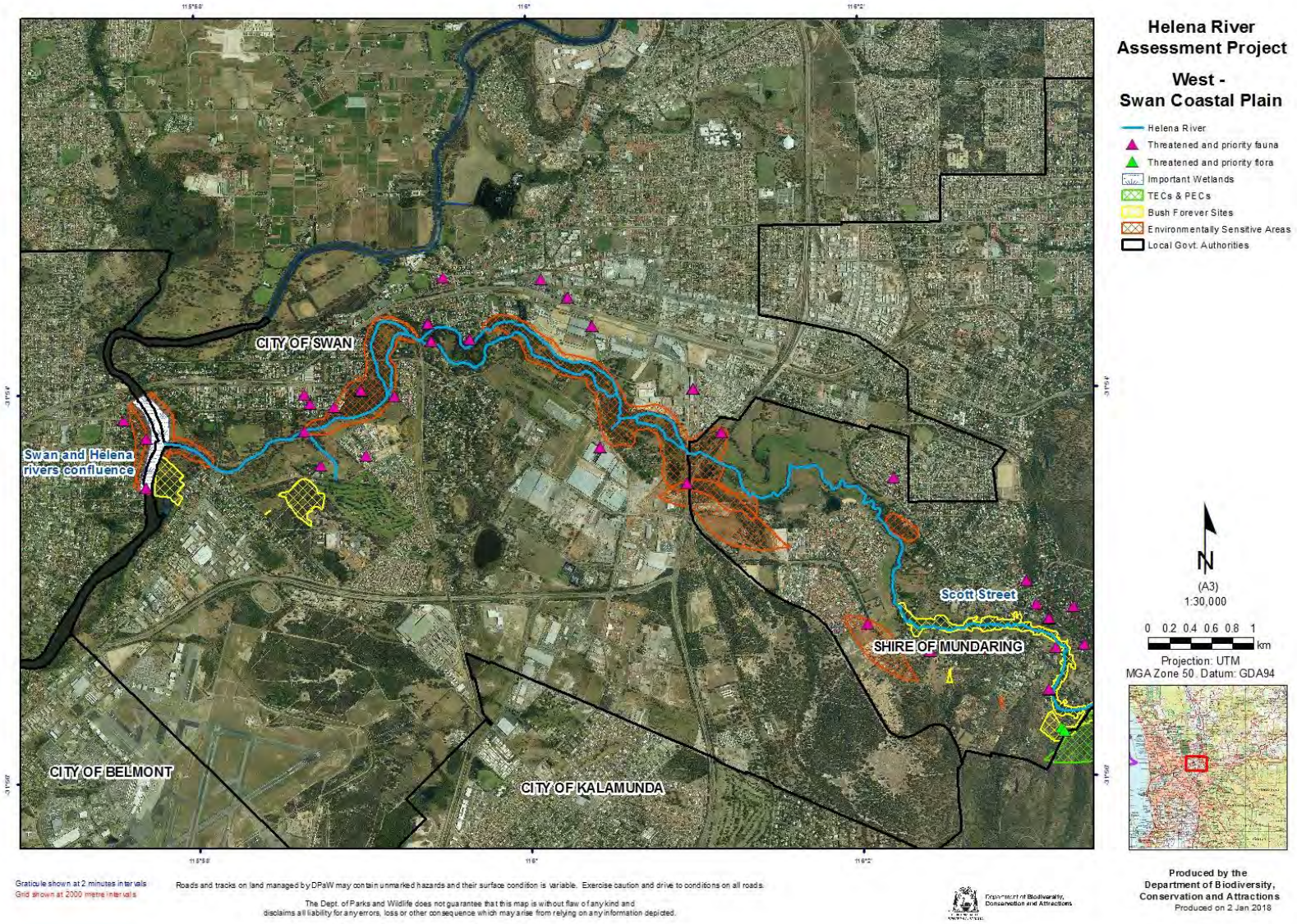


Figure 6: Recorded natural values within a 500m buffer of the Helena River, Scott Street to the confluence with the Swan River.

1.5 Major threats

The south-west of WA has experienced a 10-20% reduction in the dominant cool season rainfall since the 1970s (CSIRO and BOM 2015) and in some parts of the south-west by up 40% in the past 50 years (CSIRO 2012). In the far south-west of Australia streamflow has declined by more than 50% since the 1970s (CSIRO and BOM 2016).

Mundaring Weir and the Pumpback Dam have also resulted in a major change to the Helena River. The river contributes less than 1% to the average flow of the Swan River due to water extraction schemes (WAPC 2010). River pools no longer receive the intake from upstream or the catchment to remain permanent during summer, nor receive high volume flows which help to maintain river pools. The dams are also an artificial barrier to migration of native fish during their breeding cycle (WRM 2010).

Large areas of the floodplain on the Swan Coastal Plain have been cleared or subjected to grazing, removing or degrading the native understorey. In many areas only a narrow band of riparian vegetation remains to protect the banks from erosion and provide habitat. Land clearing and changed land practices have also caused the invasion of many weed species, displacing native vegetation and reducing its diversity and structural complexity (Swan River Trust 1999).

Agricultural practices as well as land clearing has led to salinization and increased levels of nutrients, heavy metals and other contaminants entering the river system (WAPC 2003). Industrial developments and urbanisation on the Swan Coastal Plain have also resulted in increased sedimentation and runoff of contaminants.

Phytophthora dieback is an introduced soil-borne pathogen which threatens about 40% of the flora species of south-west WA (CALM 2004). Dieback is present in the Darling Range and along the Helena River and has resulted in the deaths of susceptible species, in some areas causing notable change to vegetation structure, complexity and habitat value (WAPC 2003).

Other major threats to the Helena River include changed fire regimes and an increased risk of severe bushfires, trampling and contamination by feral pigs and predation of native fauna by feral cats and foxes.

1.6 Management structure

The Department of Biodiversity, Conservation and Attractions (DBCA) is concerned with catchment management, water quality and river health of the Swan-Canning river system. Along the Helena River, the Swan River Trust Development Control Area extends from the Pumpback Dam to the confluence of the Swan and Helena rivers. Within this area land use planning and development is subject to approval processes under the *Swan and Canning Rivers Management Act 2006* and the *Swan and Canning Rivers Management Regulations 2007*.

The Swan Canning Riverpark includes the waterways and public reserves adjacent to the river and is managed by DBCA and riverbank land managers, including local governments and other state government agencies.

Land tenure along the Helena River includes Beelu National Park, crown reserve vested in local government, unallocated crown land and private property (Figures 7-9). There is currently no management plan for the National Park, but the area is managed for conservation and recreation by DBCA. DBCA's Perth Hills District conducts prescribed burns within the National Park, including the riparian zone, on a rotational basis. The District also undertakes weed management.

Local government authorities for this part of the Helena River are the Cities of Swan and Kalamunda, and the Shire of Mundaring. Local government supports Friends and other environmental restoration groups operating within their jurisdiction and plays a role in controlling and managing developments adjacent to the river through local planning schemes.

Perth Region NRM (Perth NRM) is the natural resource management body for the Swan Region which includes the East sub region. The Eastern Region Catchment Management Program (ERCMP) is a partnership between Eastern Metropolitan Regional Council (EMRC), DBCA, Cities of Swan and Kalamunda, Shire of Mundaring and Perth NRM. A 10-year Eastern Catchment Management Plan was developed by ERCMP in 2012 which reviewed existing work and set direction to coordinate future action and a vision for catchment management. The EMRC has also developed a Swan and Helena River Management Framework (Hassell 2007) to guide the ongoing management of the eastern reaches of the Swan and Helena rivers.

Several community groups operate within the middle and lower Helena catchments - the Helena River Catchment Group (HRCG), Katharine Street River Gang and the Lower Helena Association. HRCG operates from the Pumpback Dam to the Scott Street Bridge, the Katharine Street Gang work in Bellevue and the Lower Helena Association operates from Military Road in Midland to the confluence with the Swan River. DBCA volunteer Peter Day also conducts regular weed control on the north side of the river below the Pumpback Dam. These groups have carried out restoration, revegetation and weed control projects along the Helena River, and play an advocacy role in protecting the river. The Friends of Piesse Brook play a key role in the restoration of Piesse Brook, a major tributary to the Helena River entering upstream of the Pumpback Dam. These groups operate primarily through volunteers and funds from various sources, including the Swan Alcoa Landcare Program. The HRCG Action Plan proposes practical management actions to guide rehabilitation activities and forms a supporting document for grant funding (EHCMP 2014).

DBCA has initiated an environmental flows program in collaboration with the Department of Water and Environmental Regulation (DWER) and Water Corporation to provide some water flow to downstream river pools over the summer months. This helps to maintain water quality, viable refuge and critical habitat for aquatic organisms. Water quality monitoring is undertaken monthly and the results trigger water releases from the Pumpback Dam to supplement the downstream pools. There are no environmental flows from Mundaring Weir, and there is currently no infrastructure available for releases to be made.

Figure 7: Land ownership within a 500m buffer of the Helena River, Mundaring Weir to Pumpback Dam.

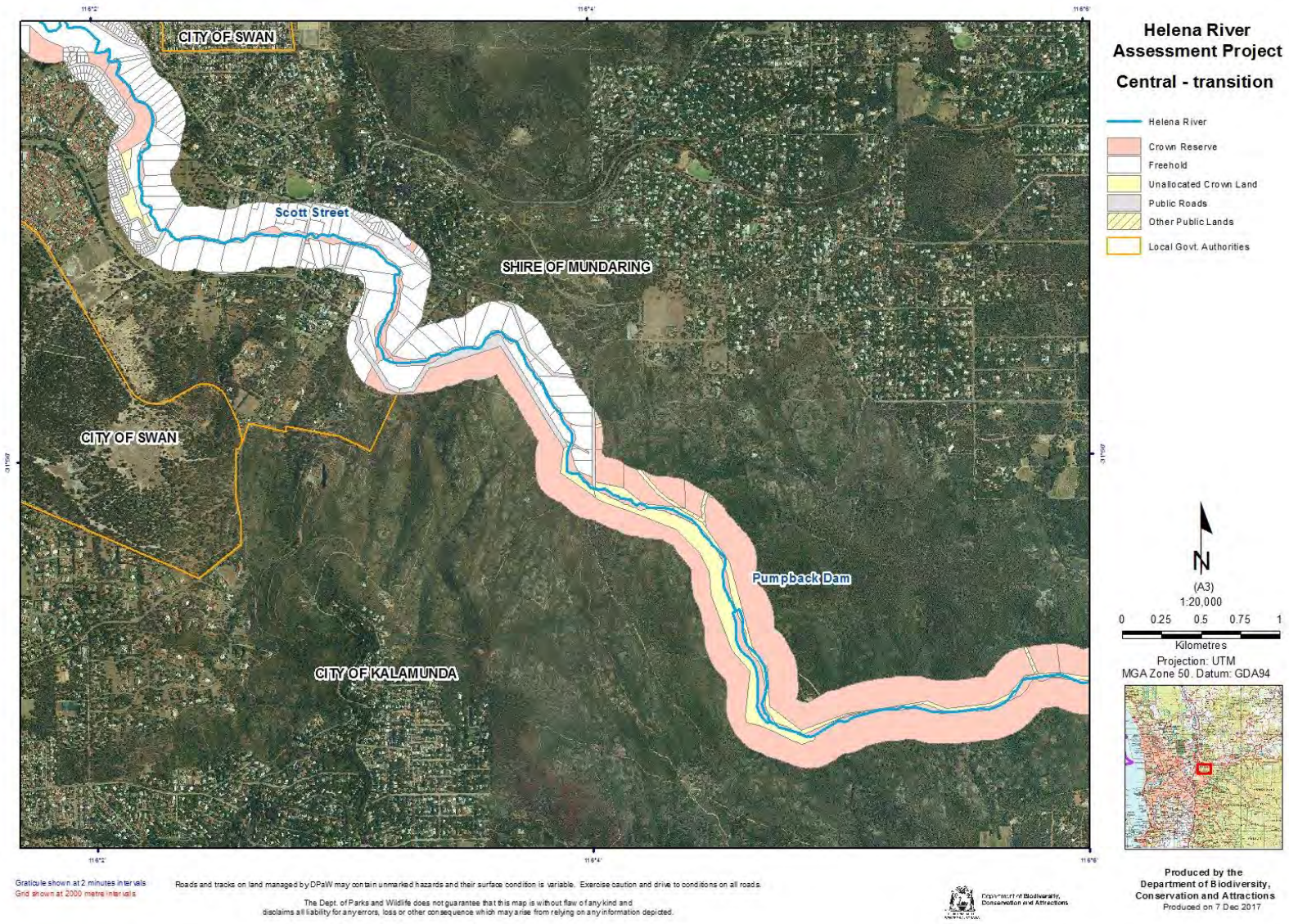


Figure 8: Land ownership within a 500m buffer of the Helena River, Pumpback Dam to Scott Street.

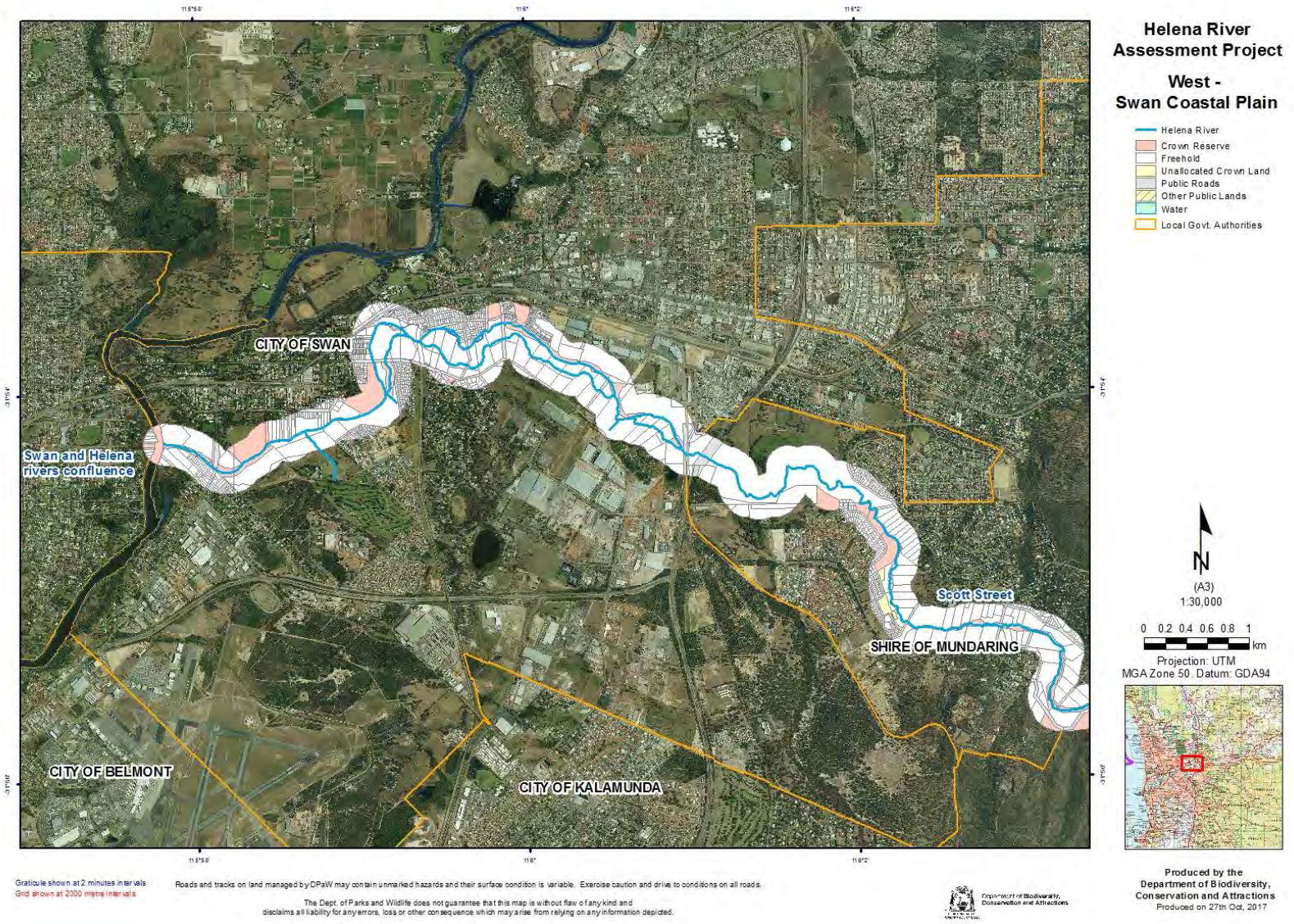


Figure 9: Land ownership within a 500m buffer of the Helena River, Scott Street to the confluence with the Swan River.

1.7 Previous assessments

The former Water and Rivers Commission (WRC) funded a foreshore assessment of parts of the Helena River Catchment in mid-1999 (Siemon 2001). The Foreshore Condition Assessment Form developed by WRC (Pen and Scott 1999) for community groups to assess foreshore condition in urban and semi-rural areas was used. Sections of the Helena River assessed were 5.5km from Kidman Avenue (Swan River confluence) to Stirling Crescent, and upstream of Scott Street for 600m.

The Department of Water and Environmental Regulation (DWER) (formerly DoW), DBCA (formerly Swan River Trust) and the Ellen Brockman Integrated Catchment Group undertook foreshore assessments of 37 tributaries in the Swan Canning Catchment between 2006 and 2007 (SRT 2008b). The Helena River assessment was conducted by DWER in 2006. The assessment extended from Mundaring Weir downstream to the confluence with the Swan River and included tributaries to the Helena River including Piesse Brook and Kadina Brook. The Swan River Trust ran a prioritisation process for all tributaries, including the Helena River. These results are included in Section 3.

The Swan River Trust undertook a comprehensive foreshore condition assessment from 2004 to 2007 of the Development Control Area (SRT 2008a). Riparian vegetation along the Helena River from the Pumpback Dam to the confluence with the Swan River was assessed in 2006, and shoreline condition from East Street in Guildford to the Swan River confluence (the estuarine section of the Helena River) was assessed in 2007.

1.8 Major land use changes since 2006 and major proposals

Perth has undergone rapid population growth in the previous decade, and several major residential expansions have occurred adjacent to the Helena River in this time. These include expansion of the Helena Valley Estate, land releases and subdivisions adjacent to the Midland Railway Workshops and development of the Rosehill Waters estate in South Guildford.

The Shire of Mundaring has developed the *Draft Helena Valley Urban Expansion Strategy* for future urban growth in Helena Valley (Shire of Mundaring 2016). It identifies the potential for urban development for the long-term to meet the expectation that Perth's population will reach 3.5 million by 2050. Several environmental, social and economic opportunities were identified, including rezoning options for low, medium to high density housing and parks and recreation reserve. The strategy was open for public comment in 2017. Impacts to the Helena River that may result from implementation of the strategy include clearing of riparian vegetation at proposed road crossings at Fyfe Street, Samson Street and/or Katharine Street and upgrade of the Scott Street crossing; possible nutrient and other contaminant runoff from proposed recreation grounds, and urban runoff and sedimentation from increased housing density.

Belle View Estate is a proposed residential development from the Katharine Street footbridge crossing in Bellevue to the Roe Highway crossing. A restoration program is planned for the Helena River riverbank in this area including a series of constructed wetlands that will form part of a living stream to treat drainage water from the suburb of Bellevue. DBCA and DWER have been consulted in the development of a local water management strategy and a constructed lakes and wetlands management plan, which have been prepared by Coterra Environment (Hopkirk 2015).

At the time the most recent land use strategy was published (2010), no future industrial development in the area from Mundaring Weir to the Pumpback Dam was anticipated (WAPC 2010).

1.9 Objectives

For the section of the Helena River from Mundaring Weir downstream to the confluence with the Swan River, objectives of this assessment are to:

- determine riparian vegetation condition;
- identify significant points of erosion;
- identify management issues including uncontrolled access, weed incursion and vegetation loss;
- determine recommendations for intermediate to longer-term management;
- identify management works that could be undertaken and achieved in the short-term; and
- compare the current condition to that determined in 1999 and 2006 assessments.

2 Method

2.1 Previous assessments

2.1.1 Water and Rivers Commission

Siemon (2001) adopted the Foreshore Condition Assessment Form (Pen and Scott 1999) for assessment of the Helena River, from the Swan River confluence upstream for 5.5km to Stirling Crescent, and upstream of Scott Street for 600m. An overall stream condition index was determined by using the following indicators of foreshore condition:

- bank stability;
- foreshore vegetation;
- stream cover; and
- habitat diversity.

A colour-coded system was used to summarise the condition of each parameter based on a scale from Excellent to Very Poor for homogenous sections of vegetation, and each condition category contained a score. The condition values were summed for all parameters to give an overall stream condition index, also ranked on a scale from Excellent to Very Poor (Appendix 10).

2.1.2 Department of Water and Environmental Regulation (DWER) 2006

The foreshore assessment conducted by DWER in June 2006 used a methodology based on Pen and Scott's (1995) grading of foreshore condition, and was carried out from Mundaring Weir downstream to the confluence with the Swan River. Sections of the river were split into 'segments', fairly homogenous sections of the river based on vegetation condition and bank stability (DoW n.d.). These were surveyed by foot, or by vehicle at access points where complete access to the segment was not possible due to land tenure or terrain.

Vegetation was assessed within each segment based on Keighery's (1994) scale of condition, including growth form, dominant species and crown cover. Data were also collected for weed percentage cover, drains, infrastructure, management pressures and management responses, adapted from the Swan River Trust's methodology for the Foreshore Assessment and Management Strategy (2008a).

Bank stability, terrestrial and instream habitat and land use, and suggestions for management were adapted from the Foreshore Condition Assessment Form (Pen and Scott 1999).

The Swan River Trust categorised segments based on Rutherford *et al*. (2000a and 2000b) which ranks segments based on several parameters, described in Section 2.2.4. This prioritisation method was also used by DBCA in the current assessment to enable comparison with the earlier survey.

2.1.3 Swan River Trust 2004 - 2007

The Swan River Trust's foreshore condition assessment of the Swan-Canning river system was based on a pressure-state-response framework, and management issues and recommendations were identified.

It included an assessment of shoreline structures and their stability (mostly relevant to lower stretches of the Swan and Canning rivers where built structures have been constructed for public amenity and to support other infrastructure), shoreline stability and erosion risk, and a vegetation classification and condition assessment (Swan River Trust 2008a).

Shoreline stability and condition of the Helena River was assessed from the confluence with the Swan River upstream for approximately 2km, the estuarine section of the Helena River.

Vegetation was mapped from the confluence with the Swan River to the Pumpback Dam into similar units based on assessment of aerial photography. These units were ground-truthed and a vegetation description for each unit was provided, dominant weed species were identified and other indicators related to vegetation condition were assessed.

2.2 Current assessment

DWER's methodology was adopted for the current assessment to enable a relatively reliable comparison as it covered the same stretch of river. The riverbank was split into segments based on vegetation structure, bank type and land tenure. The segments were similar to those defined by DWER, but were modified where land use had changed or other attributes had altered significantly since 2006.

2.2.1 Desktop assessment

A brief desktop assessment was undertaken to note the recorded natural and cultural values adjacent to the Helena River. A 500m buffer to the river's alignment was applied and a search for the following data was conducted:

- Nationally Important Wetlands;
- Bush Forever sites;
- Environmentally Sensitive Areas declared under the *Environmental Protection Act 1986*;
- known populations of rare or priority flora and fauna;
- State and nationally listed threatened ecological communities (TECs); and
- registered Aboriginal sites.

Perth NRM provided a summary shapefile of restoration projects funded by the Swan Alcoa Landcare Program (SALP) and other programs from 2007 to 2016. Sites that were adjacent to the river were cross-checked with the field assessment to determine whether restoration works were still evident and had aided in the rehabilitation of the area.

2.2.2 Data collection

The ArcGIS *GIS Collector* application was used to collect field data on an Apple iPad. Shapefiles and a base map were created for viewing in the web version *GIS Online* and the phone/tablet application *GIS Collector*. Field data were automatically uploaded to the Cloud and were checked at the end of each field day to ensure data had been accurately captured.

The alignment of the Helena River was accurately digitised from aerial photography and was viewed in the field in *GIS Collector*. The start point of each segment was marked in GIS Collector. A number of attributes were recorded in the field which were linked to each segment point (see Section 2.2.3).

2.2.3 Field surveys

Field surveys were undertaken from September to November 2016. DBCA conducted the surveys on foot where access to the riparian zone was possible, and by vehicle viewing the river at access points where the full length of segments was not accessible due to land tenure or terrain.

The Helena River was assessed in a downstream direction. Left and right banks were determined when facing downstream.

The riverbank was split into segments based on vegetation structure, bank type and substantial changes in land use. Both sides of the river were assessed as one segment. Attributes were then assigned to the left and right banks.

The following attributes were collected:

- Segment details – date, field officers, river name
- Summary comment – key issues of note
- Height and slope of the left and right banks
- Land use of the left and right banks: agriculture, parkland, rural, residential, commercial/industrial, remnant bush/reserve and/or recreation
- Fencing of the riparian zone of the left or right banks
- Vegetation type description
- Dominant native species – from each of the prominent vegetation layers
- Condition:
    - Bank stability/erosion (good, average, poor)
    - Vegetation (good, average, poor)
    - Weed cover (minimal, moderate, extensive)
    - Level of pressure (minimal, moderate, extensive)
    - Pen and Scott's foreshore condition assessment grading (A to D grade)
- Management issues:
    - Weed species (a full list of weeds noted in the field)
    - Erosion and siltation presence, through natural means or by disturbance
    - Type of erosion present; including undermining, large silt deposits, incised scour, slumped bank, embayment retreat, exposed tree roots

    - Vegetation loss; through trampling, grazing (current and historic if known), displacement by weeds, clearing, erosion
    - Uncontrolled access; by vehicles, people (including private property owners where gardens encroached the shoreline and fences were not constructed) or stock (only included stock where sighted or evidence of current presence of stock was evident and the river was not fenced to limit their access to the water)
    - Other management issues; comment field to note other issues of significance
- Trajectory (stable/improving, deteriorating)
- 'Hope' for the segment if the current level of management was maintained
- Ease of rehabilitation, and factors affecting likely rehabilitation success
- Rehabilitation recommendations, including weed control and priority species for control, fencing required, erosion control, species for revegetation, silt management and water quality management

See Appendix 7 for a further definition of attributes.

2.2.4 Categorisation of segments

We followed a similar method to DoW (n.d.) and the Swan River Trust (2008c) to categorise river segments, which was based on the Cooperative Research Centre (CRC) of Catchment Hydrology's framework (Rutherfurd *et al*., 2000a and 2000b). The CRC developed a 'reach priority shuffle' method (Appendix 9) to rank segments or reaches according to five parameters:

- rarity or conservation value (rare/nationally or regionally significant);
- condition (good-poor);
- trajectory (deteriorating-improving) and hope (with hope-without hope);
- proximity to good reaches, and
- ease of rehabilitation (easy-hard).

See Appendix 8 for a description of these parameters and their application to this assessment.

Each segment was assigned a category for recommended restoration strategies (Table 1). This enabled prioritisation of segments and highlighted areas of riverbank for restoration activities to be planned. Once these areas were highlighted we then considered whether there was existing or potential for community interest in the area and multiple benefits possible (eg. educational, recreational).

Table 1: Criteria for assigning a category to a segment and the suggested management strategy for each category.

Category	Criteria and management strategy
0	**Condition and pressures** Pen and Scott grade = A1; Level of pressure = Minimal; and none of the following issues were recorded for the segment: o Access – vehicle, people, stock, or 'other' o Loss of vegetation – through trampling, grazing, displacement by weeds, clearing, erosion o Erosion – undermining, large deposits, incised scour, scarps/vertical shears, slumped banks, embayment retreat, exposed tree/shrub roots o Other management issues **Strategy: Only requires monitoring for the emergence of new threats in the future**
1	**Rarity or conservation value** Segments intersect with or are within 500m of one or more of the following: o Nationally Important Wetland o Bush Forever site o Environmentally Sensitive Area o Known populations of rare or priority flora and fauna o State or nationally listed threatened ecological community **Strategy: Protection or minor restoration to maintain conservation value and condition**
2	**Condition** Pen and Scott grade = A1, A2 or A3 but segment does not meet criteria for Category 1 **Strategy: Protection or minor restoration to maintain good condition**
3	**Condition and trajectory** Pen and Scott grade = B1, B2, B3, C1 or C2 and Trajectory = Deteriorating **Strategy: Restoration to prevent further deterioration**

4	**Condition, trajectory and proximity to good reaches** Pen and Scott grade = B1, B2, B3, C1 or C2; Trajectory = Stable / improving, and the segment abuts another segment that meets Pen and Scott grade A1, A2 or A3 **Strategy: Expansion of good quality segments by restoring abutting segments in poorer condition**
5	**Condition, trajectory, proximity to good reaches and ease of rehabilitation** Pen and Scott grade = B1, B2, B3, C1 or C2; Trajectory = Stable / improving; the segment does not abut another segment that meets Pen and Scott grade A1, A2 or A3, and Ease of rehabilitation = Easy **Strategy: A small investment in restoration works to stimulate natural recovery**
6	**Condition, trajectory, proximity to good reaches and ease of rehabilitation** Pen and Scott grade = B1, B2, B3, C1 or C2; Trajectory = Stable / improving; the segment does not abut another segment that meets Pen and Scott grade A1, A2 or A3, and Ease of rehabilitation = Hard **Strategy: Restoration is a lower priority as investment of resources is likely to be high, although there is a potential for recovery**
7	**Condition and hope** Pen and Scott grade = C3, D1, D2 or D3 and Hope = without hope **Strategy: Low priority for restoration as these areas are likely to be expensive and difficult to rehabilitate**
8	**Condition and hope** Pen and Scott grade = C3, D1, D2 or D3 and Hope = with hope **Strategy: Lowest priority for restoration as these areas are likely to be expensive and difficult to rehabilitate, and there is some chance of natural recovery if no action is undertaken**

3 Assessment results

The Helena River was divided into three sections (East, Central, West) to reflect major changes in landform (the Darling Scarp to the Swan Coastal Plain), land use and the area of operation of two active catchment groups.

From Mundaring Weir to the confluence with the Swan River, the Helena River was divided into 44 segments based on variation in landform features, vegetation and bank type. Two open stormwater drains and a short channel from a small wetland below an industrial site were assessed and are included in this figure. Segments ranged from 90m to 3.2km, with an average length of nearly 800m (Table 2).

DWER's 2006 assessment covered the same area of the Helena River to this assessment and its dataset is most comparable. Segments are not identical to DWER's; generally the 2016 assessment divided the riverbank into shorter segments. In the West section DWER included a short drainage channel of 25m that we did not assess. In 2006, the East section was assessed as a single segment by DWER, while we split it into 14 segments to pick up variation in landform and riverbank condition. Comparison of values for this section is therefore difficult as features were averaged across the whole section in 2006.

Parts of DWER's dataset that have been included in this report to assess change since 2006 are bank stability, vegetation condition, level of pressure and Pen and Scott grades. Weed cover was not recorded by DWER but their list of dominant weed species enables some comparison of changes in weed structure.

The East section was not assessed as part of the Swan River Trust's or WRC's foreshore assessments.

Table 2: Number of segments and average segment length for each section of the Helena River

Section	Section length (km)	Average segment length 2016	Number of segments 2016	Number of segments 2006
East – Mundaring Weir to Pumpback Dam	24.5	0.933	15	1
Central – Pumpback Dam to Scott Street crossing	9.63	0.688	7	6
West - Scott Street crossing to confluence with Swan River	33.97	0.739	23	24
Total	**68.1**	**0.792**	**45**	**31**

Several features and condition ratings were different for the left and right banks, and the figures in Tables 2-13 reflect the lengths for both banks, effectively doubling the distance of the river. In the West section there are two alignments to the river and the length recorded in Table 2 includes the distance of both alignments. Proportions of the distance of features and condition ratings for the river sections are therefore also included to enable a more effective comparison.

3.1 Land use

The primary land use of most segments in the East section is remnant bush reserve, with only the three segments immediately below Mundaring Weir used as a day-use recreation area. The Munda Biddi Trail, a long-distance cycling trail, runs along the eastern part of this section near Mundaring Weir Road. The Water Corporation's pipeline access track is open to management vehicles only and most walking trails within Beelu National Park are located away from the watercourse. There is also a narrow section of cleared paddocks about half way along this section, now within the national park.

Multiple land use is more common in the Central section. Remnant bush reserve is still the dominant land use, particularly as a large part of this section is within Beelu National Park. Walking trails are present on the left bank of the river through the national park. Rural and residential land uses are common immediately adjacent to the river reserve through Helena Valley. Although the river is reserved, it is difficult to access as property boundaries in many places are within 10-20m of the watercourse.

Multiple land use is also common in the West section. Rural, residential and remnant bush reserve occurs through Helena Valley and Bellevue, although much of the river is inaccessible due to the proximity of private property. There is a significant area of private property immediately east of Roe Highway in Bellevue which is proposed for a residential development. Within the development proposal the river is planned for reservation and there are plans to convert a tributary drain into a living stream providing some treatment to stormwater before it enters the Helena River. Industrial land use is common through Hazelmere and Midland. The Western Australian Planning Commission (WAPC) owns a significant portion of land in this area as well as through Woodbridge, where much of the area is semi-rural. Through Guildford most of the land adjacent to the river is owned by WAPC or vested in the City of Swan, and managed as parkland or remnant bush reserve.

Table 3: Land uses over the length of the Helena River assessed.

Landuse	Section of Helena River							
	East		Central		West		Overall	
	Km	%	Km	%	Km	%	Km	%
Agriculture	0.99	4	0	0	4.66	13.7	5.65	8.3
Parkland	0	0	0	0	6.29	18.5	6.29	9.2
Rural	0	0	3.76	39	20.87	61.4	24.63	36.2
Residential	0	0	6.1	63.3	19.16	56.4	25.26	37.1
Commercial/ industrial	0.93	3.8	0.87	9	4.88	14.4	6.68	9.8
Remnant bush/ reserve	22.83	93.2	5.88	61.1	12.04	35.4	40.75	59.8
Recreation	4.96	20.2	1.75	18.2	1.12	3.3	7.83	11.5
Total	**29.71**	**121.2**	**18.36**	**190.6**	**69.02**	**203.1**	**117.09**	**171.9**

More than one land use may be recorded for each segment, therefore total percentage is greater than 100.

3.2 Bank height, slope and stability

The Helena River is impacted by the lack of flow caused by the presence of Mundaring Weir and the Pumpback Dam, declining rainfall and reduced streamflow from its tributaries. In many areas this has led to siltation of the watercourse and in-filling of pools with organic material (WRM 2010).

East section

Banks are mostly medium (31-60 degrees) slope with a height of 0.5-1m or 1-2m. Immediately below Mundaring Weir the banks are steep (>60 degrees), concreted and higher than 2m. The banks are shallow (0-30 degrees) in three segments only - near Mundaring Weir infrastructure downstream of the concreted area, in a segment where granite dominates the watercourse, and where a ford on the pipeline access track causes localised flooding (Figure 10).

Bank stability is mostly good, with an average rating in only two segments. The banks are largely vegetated with remnant vegetation and a dense understorey, helping to protect and secure the bank. The vesting of the surrounding land in national park and water catchment has meant that the riparian vegetation is mostly intact through the river valley and it joins with dryland vegetation further up slope. Where cleared paddocks intersect with the watercourse, the bank sediment appears less stable. The floodway of the Pumpback Dam also has evidence of fluctuating water levels, localised flooding and bank destabilisation. There are no environmental water releases from Mundaring Weir.

Erosion was recorded immediately downstream of the bridge on Mundaring Weir Road where 4WDs and off-road bikes crossing the river have caused localised erosion, and downstream of O'Connor Road (a closed road) where vehicle traffic crossing the river has caused localised erosion and exposed banks.

No developments or changes to the bank alignment have occurred since 2006. The values given for bank stability in 2006 and 2016 suggest an improvement in bank stability, in that nearly all the length of bank is now considered good, up from average in 2006.

Figure 10: Localised flooding occurs above this small ford.
Figure 11: Steep banks above the Pumpback Dam.

Figure 12: Localised erosion downstream of Mundaring Weir Road.

Central section

The banks are mostly medium slope and 0.5-1m or 1-2m in height. A steep bank occurs on a river bend on private property near Clayton Road in Helena Valley, where the bank is eroding and there is little vegetation behind it to stabilise the soil and prevent further retreat. A shallow, low bank is located at the gravel carpark near Craignish Gauging Station in Helena Valley. Four wheel drives are driven across the river, illegally accessing the area below the Pumpback Dam which is closed to the public.

From the Pumpback Dam through Beelu National Park bank stability is considered good. The understorey and mid-storey holds the bank together, and in places there is a narrow band of sedges helping provide a dense matting in the top soil. Granite is a common feature of the watercourse in this area, also providing a solid foundation and limited opportunity for sediment to be washed away. Through private property to

the Scott Street crossing bank stability is average. The native mid and understorey has largely been removed and replaced by weedy grasses and herbs. Localised erosion is evident in some areas.

Since DWER's assessment in 2006 an improvement in bank stability is indicated. No segments were considered to have good stability in 2006, while most segments are now considered good.

Siemon (2001) found localised occurrences of erosion and slumping in the 600m assessed upstream of Scott Street, especially on the outside of river bends. Bank stability was considered poor. We could not access all 600m assessed by WRC on foot, but viewed the river from a point 1.5km upstream of the Scott Street bridge and at the bridge where bank stability is now considered average.

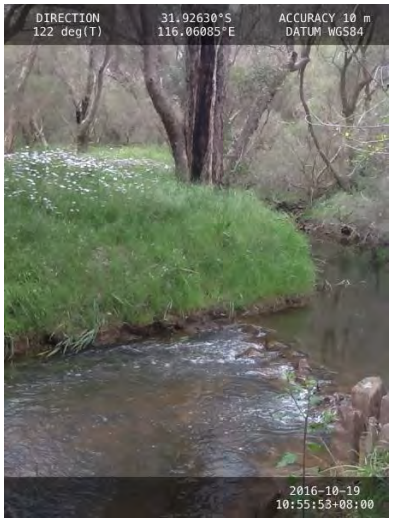


Figure 13: 1-2m medium sloped bank in Helena Valley.
Figure 14: 1-2m steep sloped bank in Helena Valley.

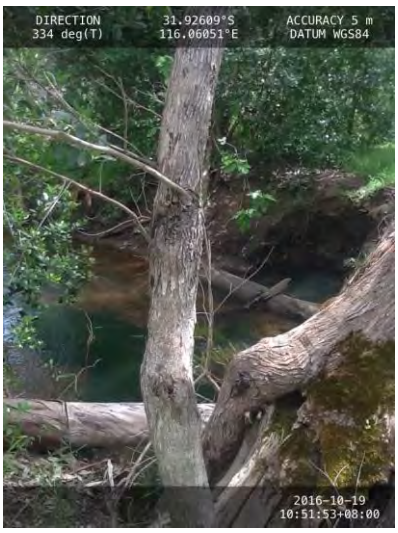


Figure 15: Exposed riverbank near Craignish Gauging Station.
Figure 16: Erosion on a riverbend on private property in Helena Valley.

West section

Most segments have a medium or steeply sloped bank, and in most segments bank stability is average (Table 4).

Erosion and siltation was not noted from Scott Street to Roe Highway, partly as some of this section was not visible due to the proximity of private property to the river, and as the weeds present have inadvertently provided soil stability. Downstream of Roe Highway erosion and siltation was much more common and occurred in 14 of the 20 segments assessed.

Between Roe Highway in Midland and Water Street in Guildford there are two alignments to the river. According to information provided by residents the northern channel is the original alignment of the Helena River and the southern alignment was cut in the 1960s. Since then the river has been subjected to reduced flow due to the construction of the Pumpback Dam, reduced rainfall and streamflow from other tributaries. The northern alignment is very silted and shallow, and only a depth of 0.5-1m in places with little or no surface water present at the time of assessment (October). The southern alignment is much steeper and deeper, with many areas of bank over 2m in height, and there are areas of exposed tree roots and scoured banks. The native understorey in this area was completely absent and only grasses and the upperstorey remains to provide soil stability.

Bank stability is poor in a drain from a small wetland near an industrial property in Midland, where there is erosion and sedimentation downslope from the industrial site. A significant amount of sand has also mobilised down an embankment from another industrial property in Midland, causing both erosion and sedimentation on the floodplain.

Figure 17: Sedimentation downslope from an industrial property in Midland.
Figure 18: Incised bank on grazed floodplain in Midland.

Undermining of the bank has occurred between the rail crossing in Woodbridge and Water Street where the riparian zone appears to have been sprayed and is very

bare. The heavy clay bank has probably prevented wide scale erosion which may have occurred in more mobile sediments.

From Water Street to the confluence with the Swan River the bank slope ranges from medium to steep, and is mostly 1-2m in height. The banks of an open drain outfall near Waterhall Estate are deeply incised and sparsely vegetated. Erosion was not detected further downstream of the drain from the Rosehill Waters estate.

Figure 19: 0.5-1m medium slope bank in South Guildford.
Figure 20: 0.5-1m steep slope bank in Woodbridge.

There is potential for increased discharge of loose substrate from the expansion of the Helena Valley, Woodbridge and Rosehill estates. Currently the density of weedy vegetation in the riparian zone is likely to exclude other weed species that may be found in runoff from the estate.

A significant improvement appears to have occurred since DWER's assessment, with almost the entire length of bank having poor stability in 2006 (Table 5). However, this could be as DWER considered bank stability poor where weeds made up most of the bank cover. We considered it to be good where the bank was stabilised by vegetation: weedy or not.

Siemon (2001) found widespread evidence of erosion with up to 50% of the riverbank from Stirling Crescent to the Swan River affected. Bank destabilisation was attributed to loss of fringing vegetation, weed invasion and uncontrolled stock access. Whilst bare banks are still common, active erosion is not extensive and banks are either bare but stable due to the heavy clay substrate, or vegetated with weedy grasses and herbs, *Bolboschoenus caldwellii* or planted shrubs.

Table 4: Stability of the river bank recorded for each section of the Helena River.

Bank stability	Section of Helena River							
	East		Central		West		Overall	
	Km	%	Km	%	Km	%	Km	%
Good	21.88	89.3	3.5	36.3	5.48	16.1	30.86	45.3
Average	2.61	10.7	6.13	63.7	28.22	83.1	36.96	54.3
Poor	0	0	0	0	0.27	0.8	0.27	0.4
Total	**24.49**	**100**	**9.63**	**100**	**33.97**	**100**	**68.09**	**100**

Table 5: Bank stability, comparison between 2016 and 2006.

Comparative bank stability	Section of Helena River							
	East		Central		West		Overall	
	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006
Good	98.7	0	83.2	0	44.9	0	69.6	0
Average	0	100	5.4	54.3	0	1.1	0.8	43
Poor	1.4	0	11.4	45.7	55.1	98.9	29.6	57
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

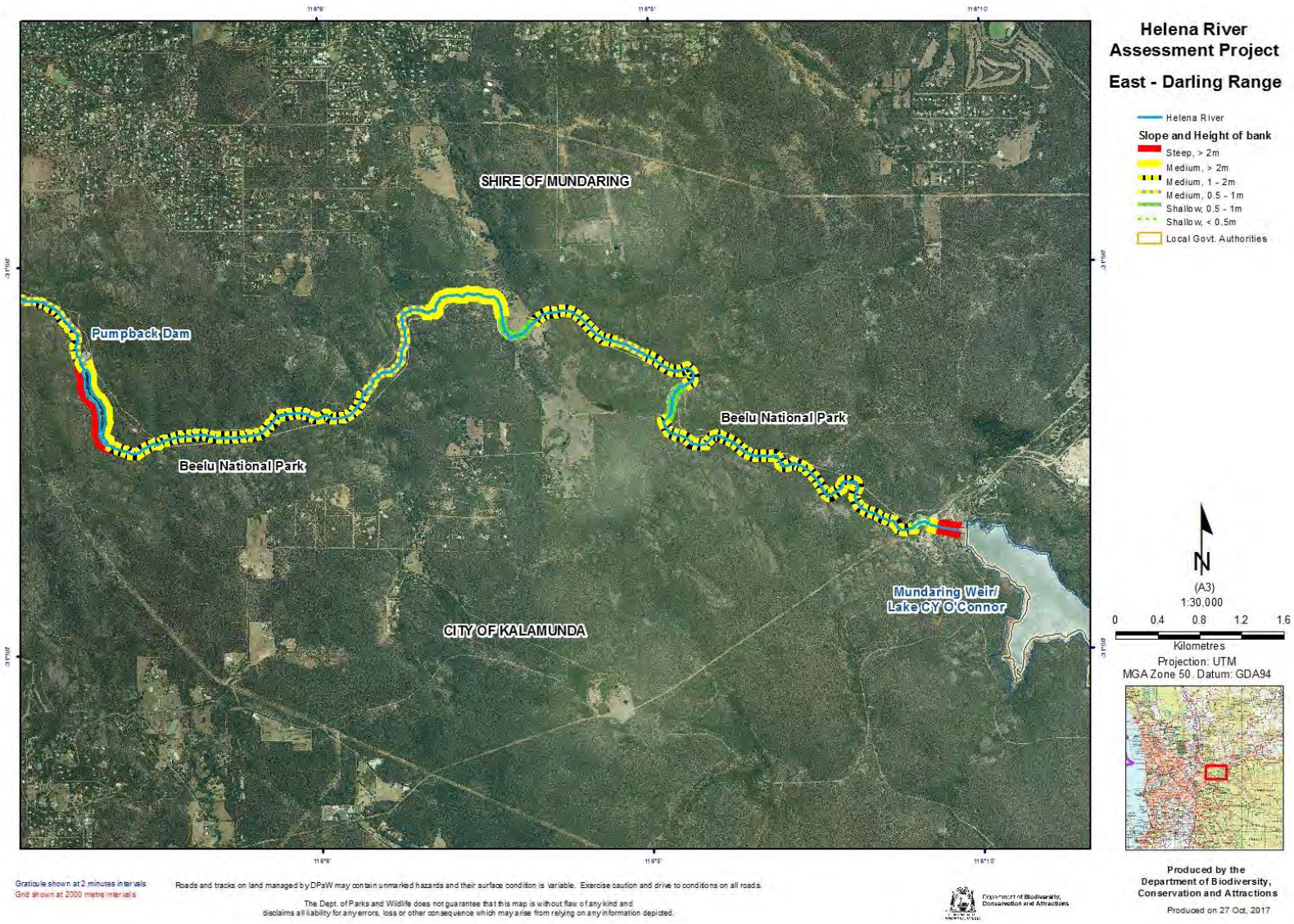


Figure 21: Slope and height of bank, East section.

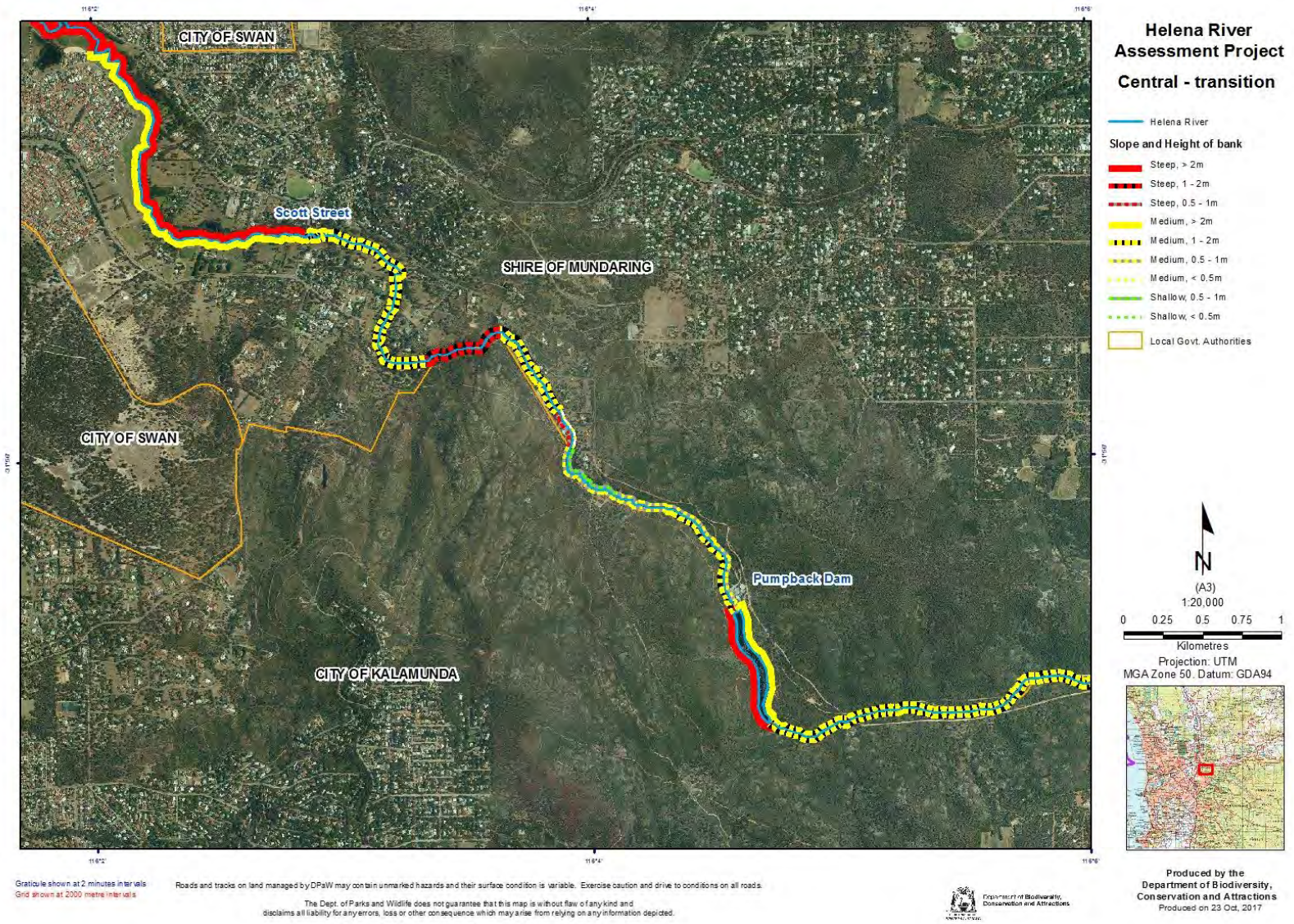


Figure 22: Slope and height of bank, Central section.

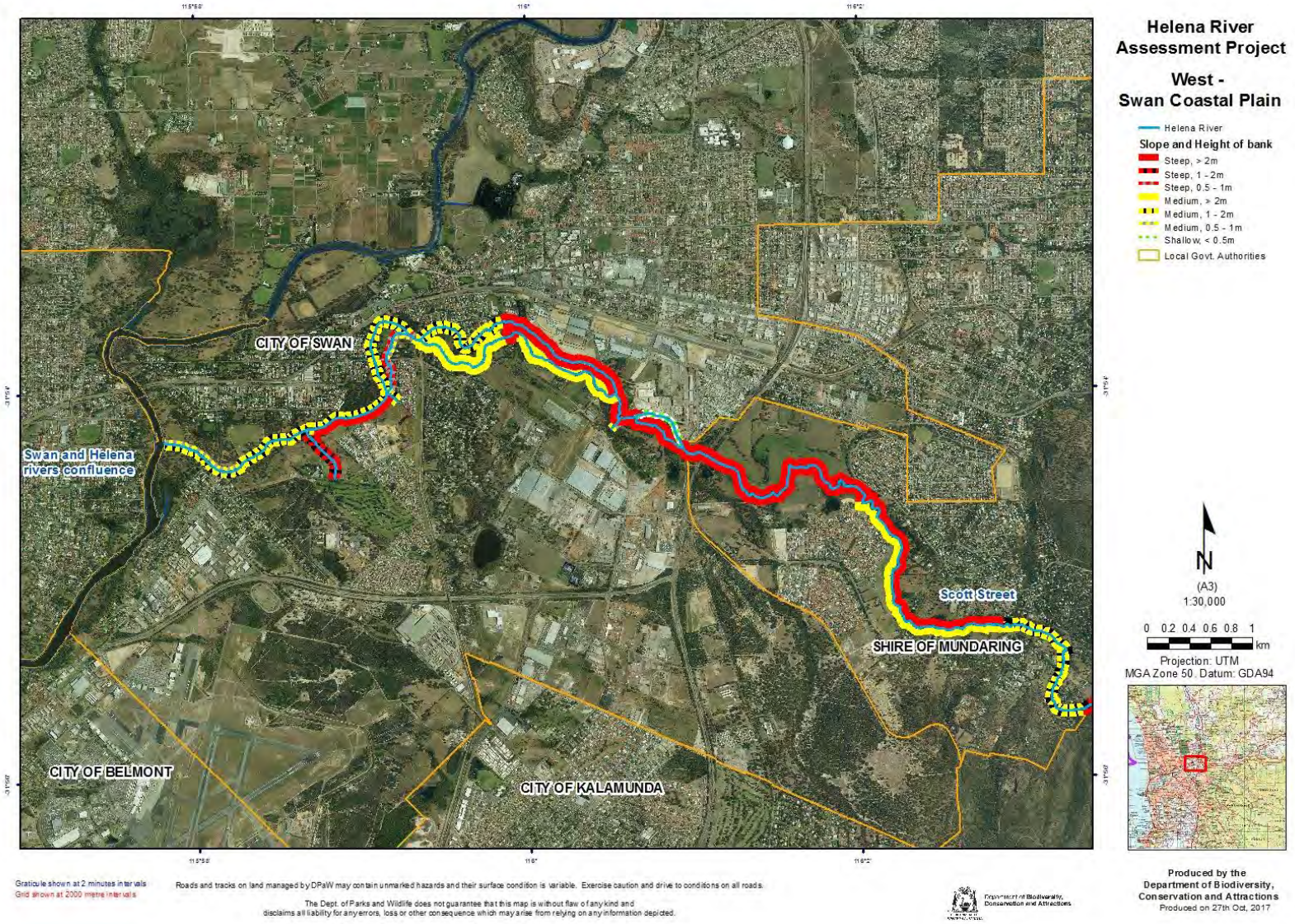


Figure 23: Slope and height of bank, West section.

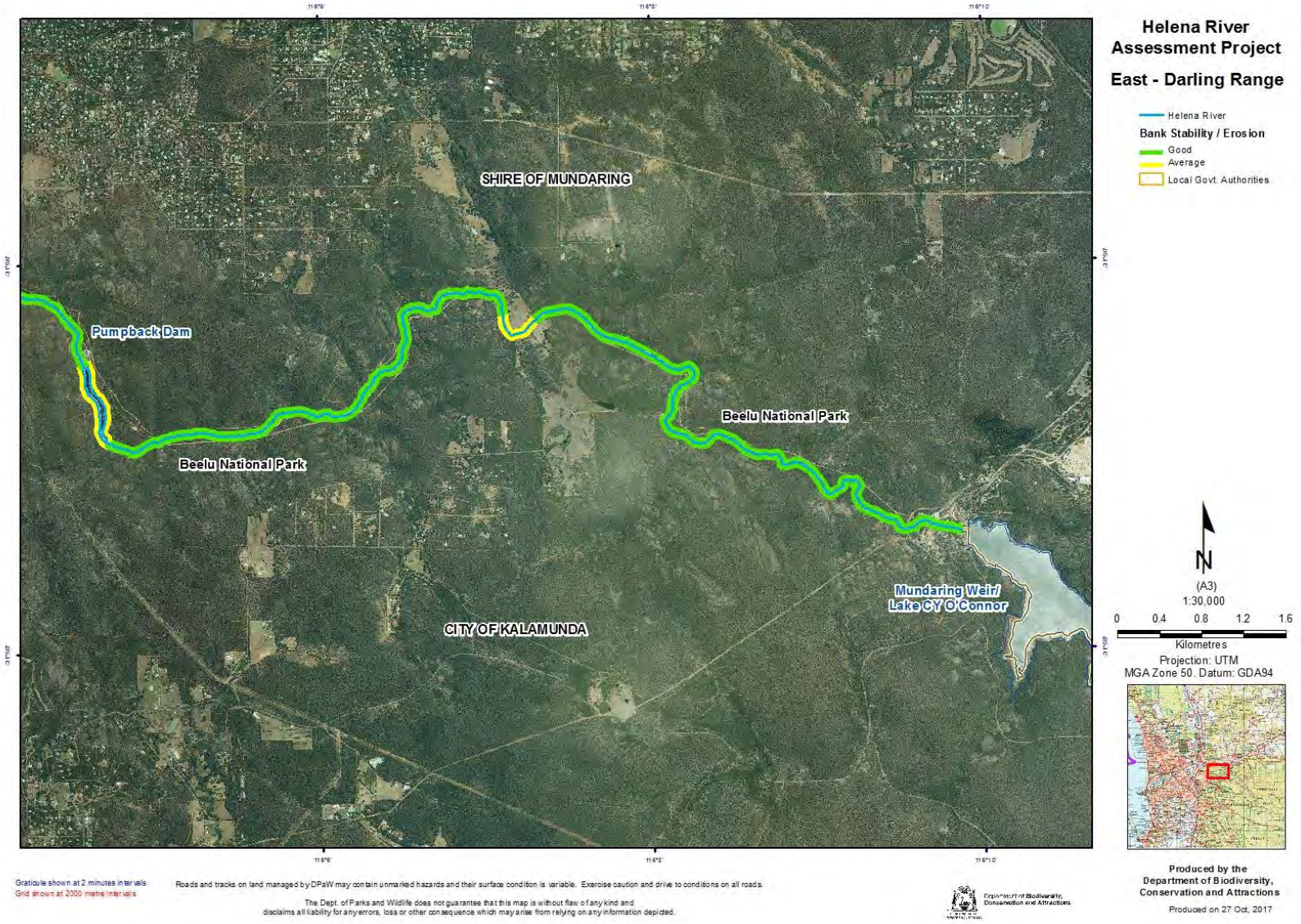


Figure 24: Bank stability, East section.

Figure 25: Bank stability, Central section.

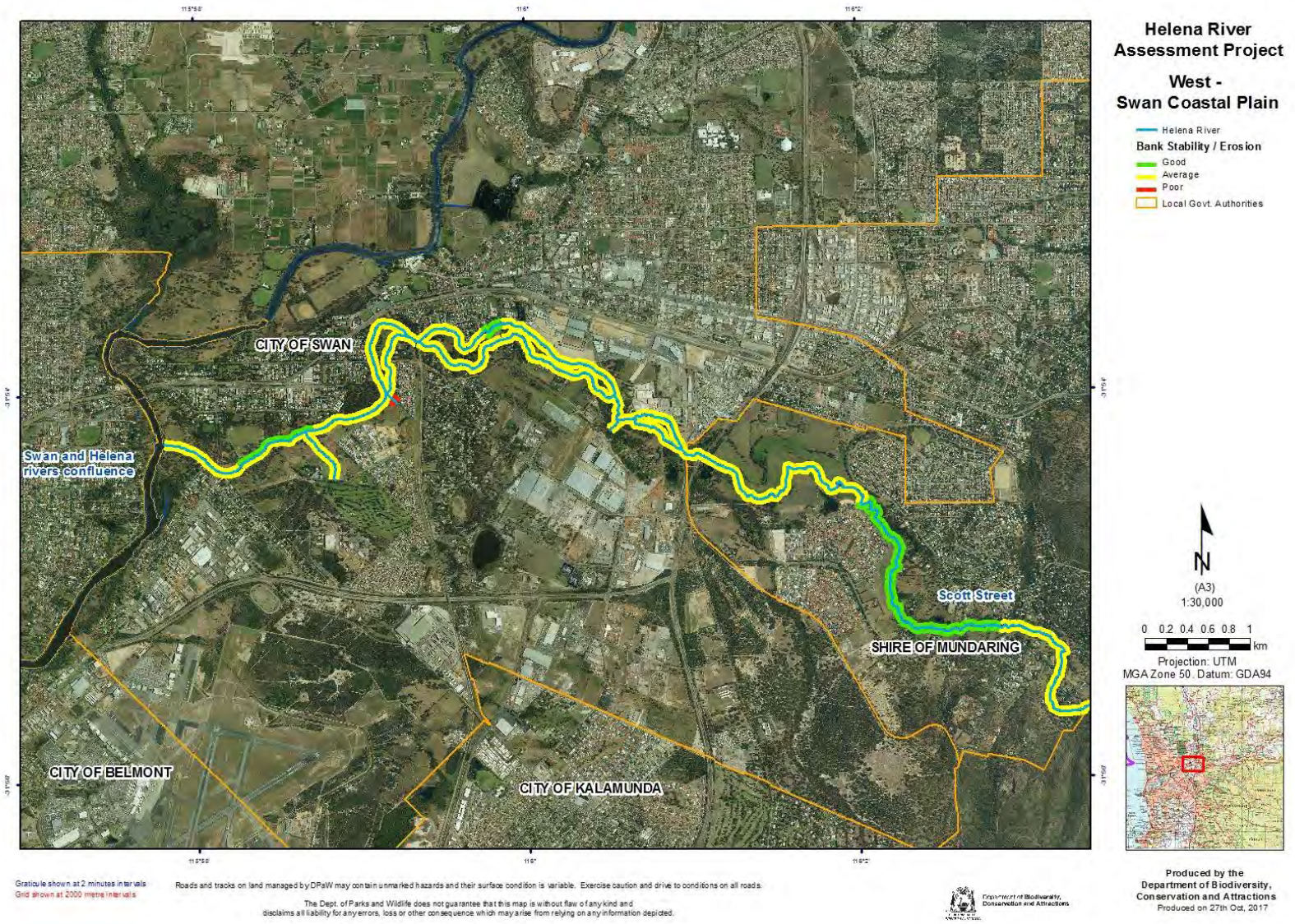


Figure 26: Bank stability, West section.

3.3 Vegetation type and condition

East section

Much of the vegetation from Mundaring Weir to the Pumpback Dam is remnant and contains components of its original structure and composition, although with significant populations of invasive weeds. It has relatively high species diversity and structure within the mid and understorey vegetation.

The dominant upperstorey is *Eucalyptus rudis* (flooded gum) over *Melaleuca rhaphiophylla* (swamp paperbark), or *E*. *rudis* and *E. wandoo* (wandoo) or *Corymbia calophylla* (marri) over *M. rhaphiophylla*. *Trymalium odoratissimum* (karri hazel) dominates the mid-storey in most areas, and other Helena and Darling Scarp complex species are common in the mid and understorey, including *Hypocalymma angustifolium* (white myrtle), *Gastrolobium bilobum* (heart leaf poison), *Grevillea manglesii* (smooth grevillea), *Callistemon phoeniceus* (lesser bottlebrush) and *Calothamnus quadrifidus* (one-sided bottlebrush). Where granite dominates the waterway, species from the transitional zone between the riverbank and dryland are common, including low Melaleucas, Acacias and *Darwinia citriodora* (lemon-scented darwinia). Weedy *Watsonia* spp. are a common part of the understorey in many areas, as are low-growing weedy herb and grass species. There are few areas of sedges along this section of the river and where they do occur they are mostly in a narrow band to the top of the primary bank only.

Vegetation loss from displacement by weeds and historic land clearing is evident. However, vegetation is in good condition in over 55% of this section, and in all segments where vegetation condition is good weed cover is either minimal or moderate. In all segments where granite dominates the watercourse condition is also good. Vegetation is in average condition in 44% of the riverbank; two of these segments were just below Mundaring Weir where there is a high number of weed species and moderate weed cover. Where old cleared paddocks intersect the watercourse weed coverage is notably higher and is also high downstream. Therefore, vegetation condition is deemed to be average from this point to the Pumpback Dam. Vegetation condition is poor in only one segment, about 400m downstream from Mundaring Weir where the original vegetation has been largely cleared. Weed cover in this segment is extensive.

We assessed the section in greater detail than in 2006 and as expected there is more variation in results in 2016. All riparian vegetation was considered average in 2006. Just over half the length of bank vegetation is now considered good, although it is difficult to conclude that the vegetation has improved in condition given the lack of detail in 2006. It is likely that vegetation condition has remained stable, as there have been no major disturbances in the intervening decade. However, several weed species have probably increased in coverage.

Figure 27: Poor condition vegetation immediately downstream of Mundaring Weir.
Figure 28: Granite dominated area with good condition vegetation.

Central section

Vegetation ranges from remnants of its original structure with a distinct upper, mid and understorey in Beelu National Park, to a marked change where private property is close to the waterway. Although the upperstorey of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* is largely intact the middle and understorey is almost entirely made up of weeds. Through Beelu National Park the lower bank is dominated by *E. rudis* over *M*. *rhaphiophylla* and *T*. *odoratissimum*, *Acacia* and *Grevillea* species, while the upper bank is *C. calophylla* over *T. odoratissimum* and *Grevillea* species or mixed low weedy annuals. Where private property borders the river reserve the dominant vegetation type is *E. rudis* over *M. rhaphiophylla* and an understorey of mixed weeds.

Vegetation declines from good condition just below the Pumpback Dam, to average throughout most of the remainder of the section to Scott Street. Where HRCG has controlled watsonia and other weeds immediately downstream of the dam, weed cover is moderate.

Vegetation becomes degraded near the gravel carpark at the Craignish Gauging Station where weedy herbs and grasses are prolific and vegetation is trampled by 4WDs and motorbikes. Where private properties are adjacent to the river reserve in Helena Valley the native mid and understorey is virtually absent and weed cover is extensive. Although there is good upperstorey structure, properties have been partially cleared and there is little connection between the riparian zone and remnant dryland vegetation. Vegetation composition simplifies with a reduced habitat complexity and a general lack of cover for fauna in the understorey as weedy grasses and herbs are dominant. Ground-dwelling species such as quenda are unlikely to have sufficient dense refuge in these areas. There is a grove of dead or dying marris on the upper bank close to Helena Valley Road and many have lost their bark. Marri canker may be the cause but further investigation is needed.

In 2006, approximately 75% of banks were considered to have poor vegetation condition, whilst about 75% of banks are now considered to have average vegetation

condition. Significant weed control and removal of watsonia has occurred in this area, contributing to the improvement in vegetation condition. A reasonable area of the riverbank through Beelu National Park is now also in good condition, whilst none was in 2006.

Siemon (2001) reported that the adjacent land use had a significant impact on the condition of the Helena River, and detrimental impacts of surrounding land use were particularly evident on the section east of Scott Street where semi-rural and residential lots border the river. This resulted in poor quality vegetation and bank stability. We determined vegetation condition to be average, with a noticeable deterioration in native species diversity in the mid and understorey from Beelu National Park to private properties.

Figure 29: Remnant riparian vegetation in Beelu National Park.
Figure 30: Understorey dominated by weedy grasses and herbs, Helena Valley.

West section

Both the upper and understorey is impacted by invasive weed species from Scott Street to Roe Highway. Most of the riparian zone has been cleared except a narrow strip immediately adjacent to the watercourse. Vegetation remaining is *E. rudis* over *M. rhaphiophylla*, *Schinus terebinthifolius* (Brazilian pepper) and *Ficus carica* (fig) with an understorey of *Rubus* sp. (blackberry), *Watsonia* sp. and mixed weedy grasses. From Roe Highway to Amherst Road the upperstorey is relatively intact across the floodplain and dominated by large, old *E. rudis* but the mid-storey has largely disappeared and the understorey is predominantly *Avena barbata* (bearded oats), *Pennisetum clandestinum* (kikuyu) and *Fumaria capreolata* (white fumitory). From Amherst Road to the confluence with the Swan River the upperstorey is dominated by *E. rudis*, with an understorey of mostly *P. clandestinum*, *A. barbata* and *F. capreolata,* with *Bolboschoenus caldwellii* (marsh club-rush*)* in the watercourse, and occasional sites of revegetated native species.

Vegetation condition is good in only one segment, in an area where the Lower Helena Association has restored the original alignment of the Helena River near Amherst Road. There is high species diversity from revegetation over the previous 7-8 years and weeds are controlled. Vegetation condition is average over 21% and

poor over 78% of the remainder of this section. In most parts vegetation condition was the same on both banks; although in one segment it was poor on the left bank and average on the right bank, reflecting weed control and revegetation that had been conducted on the right bank. In almost all areas where vegetation condition was poor, weed cover was extensive. Through much of the area in Midland, Hazelmere, Woodbridge and Guildford the floodplain has been historically grazed and most of the native mid and understorey has been lost, providing limited refuge for ground-dwelling fauna. The upperstorey contains a good canopy of mostly *Eucalyptus rudis*, with some very large old trees forming hollows and roosting sites for birds, insects and arboreal mammals.

Vegetation condition has improved from 2006 to 2016, with the length of foreshore in poor condition reduced and the length in average condition increased. A small area is now in good condition where none had been considered previously. Restoration works are likely to have contributed significantly to the improvement in condition.

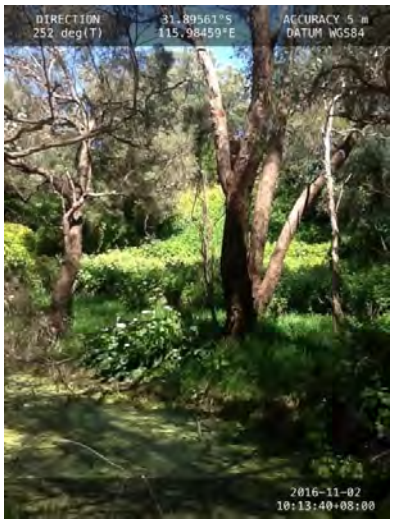


Figure 31: Connected upperstorey of Eucalyptus rudis *in the floodplain in Midland.*
Figure 32: Understorey of arum lily and nasturtium in Guildford.

Table 6: Vegetation condition recorded for each section of the Helena River.

Vegetation condition	Section of Helena River							
	East		Central		West		Overall	
	Km	%	Km	%	Km	%	Km	%
Good	13.37	54.6	1.75	18.2	0.40	1.2	15.52	22.8
Average	10.79	44	7.34	76.1	7.26	21.4	25.39	37.3
Poor	0.34	1.4	0.55	5.7	26.31	77.5	27.20	39.9
Total	**24.5**	**100**	**9.64**	**100**	**33.97**	**100**	**68.11**	**100**

Table 7: Vegetation condition, comparison between 2016 and 2006.

Comparative vegetation condition	Section of Helena River							
	East		Central		West		Overall	
	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006
Good	54.6	0	18.2	0	1.2	0	22.8	0
Average	44.0	100	76.1	25.8	21.4	14.1	37.3	45.5
Poor	1.4	0	5.7	74.2	77.5	85.9	39.9	54.5
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note that the DWER data used to determine condition was 'Variety of vegetation types; Dense protective vegetation; Presence of tree hollows'. In 2016 condition was judged in the field by assessing % cover of natives, species diversity, native regeneration and crown death.

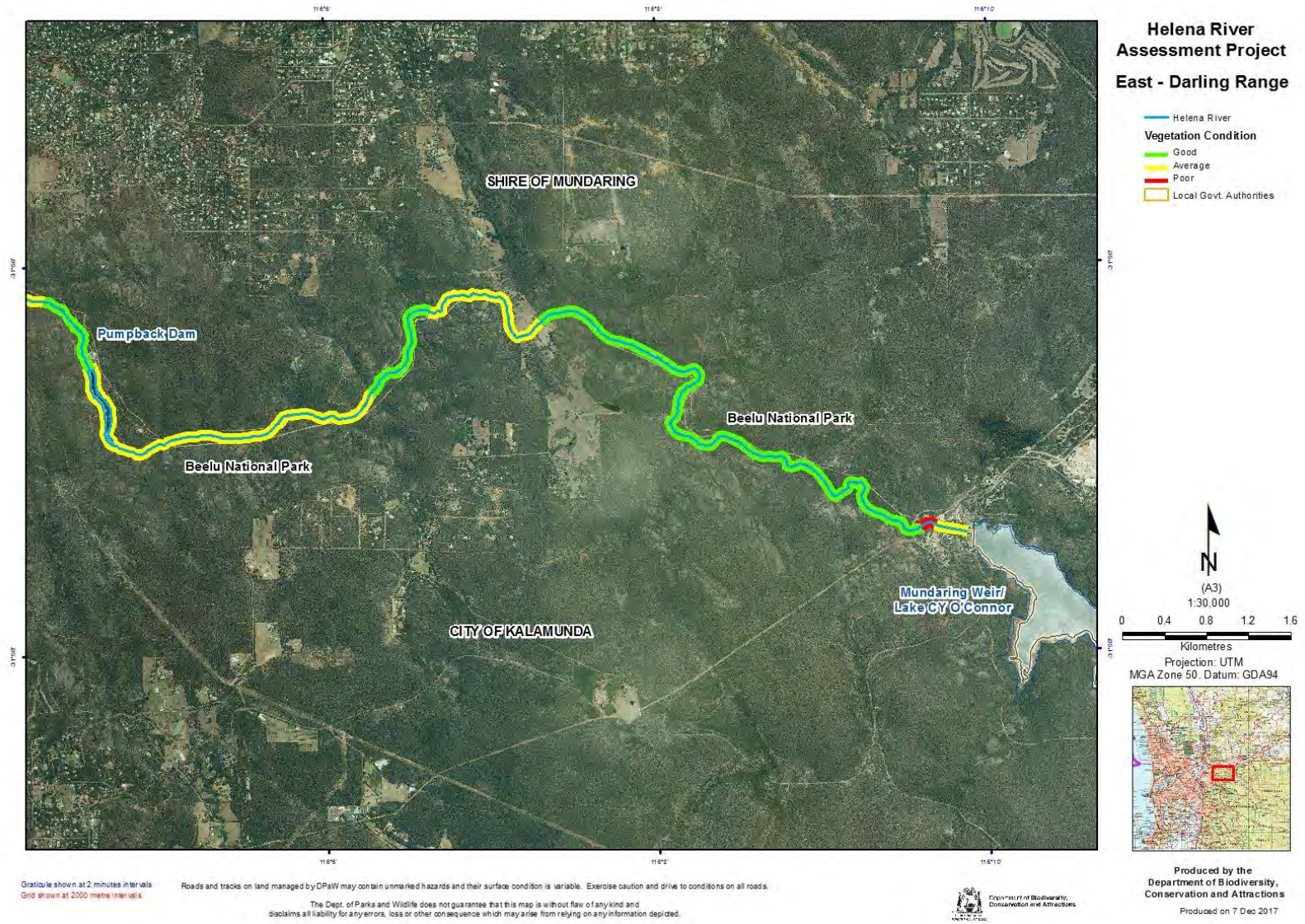


Figure 33: Vegetation condition, East section.

Figure 34: Vegetation condition, Central section.

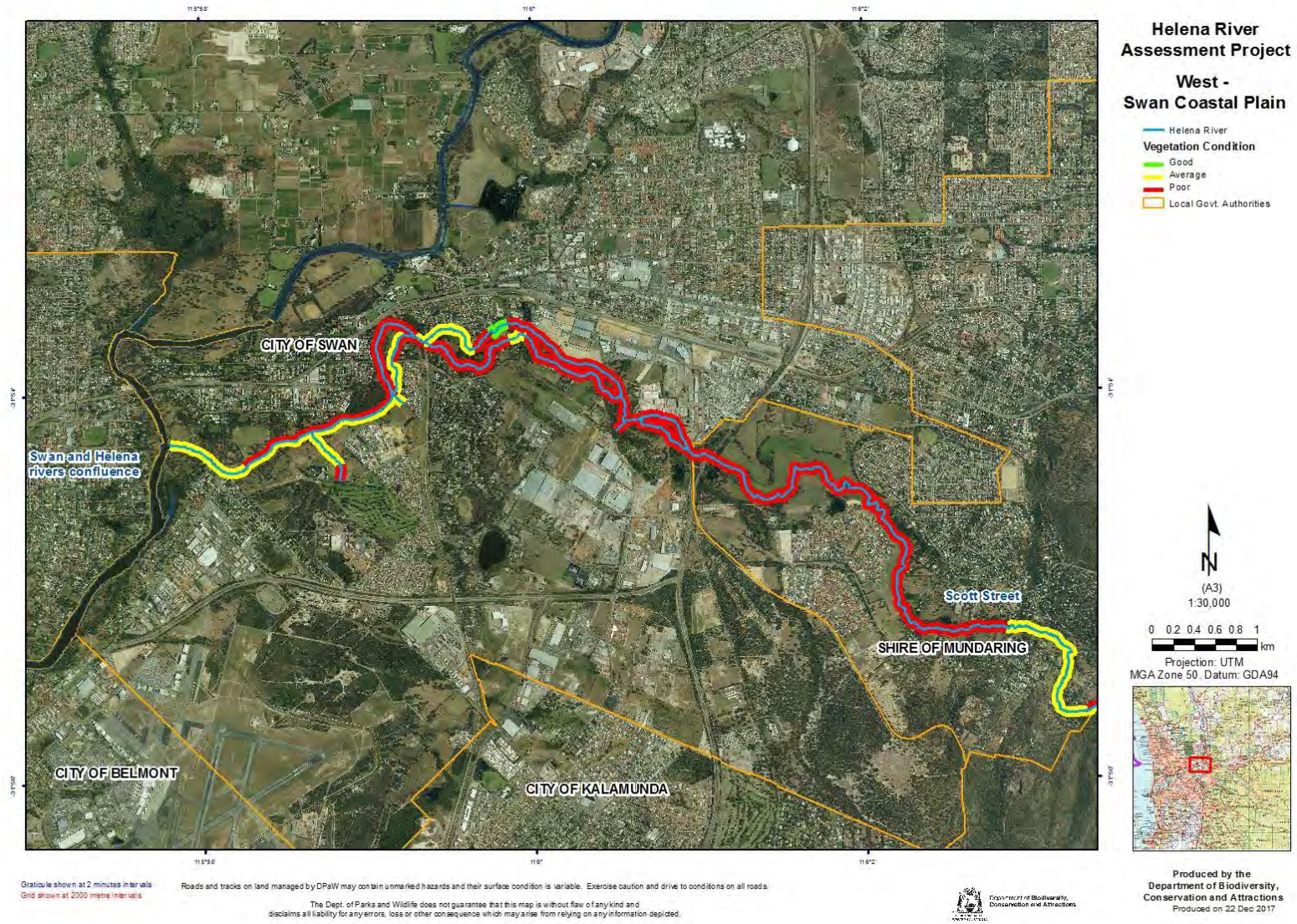


Figure 35: Vegetation condition, West section.

3.4 Weed cover and species

Species found in all three sections of the Helena River were blue pimpernel, giant reed, cape weed, fig, white fumitory, cotton bush, olive, oxalis, Guildford grass, blackberry, watsonia and arum lily. See Appendix 4 for a complete weed list for the three sections.

Two species of *Typha* occur in south-western WA – *Typha domingensis*, which is widely considered native, and *Typha orientalis,* which may have been introduced from the tropics and naturalised in the south-west, or may have occurred naturally in wet ecosystems. Noongar people say the two species (called yanjeb) are native and are opposed to their removal (Dundas and Mills 2011), and other evidence suggests that *T. orientialis* was present in the Swan River at the time of European settlement (Keighery and McCabe 2015). Both species can be prolific on the shallow edges of waterways and harvesting by Noongar people may have kept populations in check. They are also known to hybridise and can be difficult to distinguish. In this assessment, the species were noted as *Typha* sp. and where found were included in the weeds section and in the dominant native species section if dominant. Removal of *Typha* at a site is dependent on the site requirements – it may be left in position or controlled to prevent rapid growth and invasion.

East section

Weed cover ranges from minimal to extensive. 5% of the riverbank has minimal weed cover, and in these areas vegetation has much of its original structure, probably preventing weeds from establishing. Weed cover is moderate in 55% of this section. In four segments weed cover is extensive, and watsonia is the main species in three of these.

Several species currently low in extent are found immediately downstream of Mundaring Weir at the day-use recreation area and would be relatively easy to eradicate, including arum lily (*Zantedeschia aethiopica*), cotton bush (*Gomphocarpus fruticosus*), giant reed (*Arundo donax*) and pampas grass (*Cortaderia selloana*). Excluding arum lily, these species were not sighted again until at least 5.5km downstream. Small patches of dolichos pea (*Dipogon lignosus*) were found near the Mundaring Weir infrastructure, and a large infestation was found about 1km downstream and then not seen again for the length of the Helena River. There is a pool about 3.5km downstream of the weir where large infestations of arum lily and watsonia occur and are likely to be a significant contributor to populations downstream. Where cleared paddocks intersect the river, there is a dramatic increase in the amount of watsonia found in the watercourse, and a recurrence of cotton bush. A dense infestation of cotton bush was noted in the paddock on the left bank and is a priority for removal as this will continue to impact downstream.

Several other species are currently low in number or coverage in this section and are also a priority for removal – including blackberry (*Rubus* sp.), red valerian (*Centranthus ruber*), asparagus (*Asparagus officinalis*), baboon flower (*Babiana angustifolia*), fennel (*Foeniculum vulgare*), olive (*Olea europaea*), morning glory (*Ipomoea* sp.), veldt daisy (*Osteospermum ecklonis*) and lavender (*Lavandula*

stoechas). As watsonia is currently so extensive, the plants at the uppermost extent in the valleys are a priority for control, and in the tributaries feeding into the Helena River where control is likely to be more effective.

In 2006 similar weed species were dominant to those dominant now. It is not possible to determine whether coverage has increased or decreased though it is likely there has not been a significant reduction.

Figure 36: Dolichos pea infestation about 1km downstream of Mundaring Weir.
Figure 37: Dense watsonia infestation above the Pumpbank Dam.

Central section

In this section, watsonia is only a significant part of the understorey immediately below the Pumpback Dam. Weed cover here is moderate, reflecting the ongoing control works undertaken by HRCG. Extensive populations of watsonia exist upstream of the Pumpback Dam and until it is effectively controlled, the area below the dam is likely to require ongoing control.

All other segments in this section of river have extensive weed cover. Most species are less invasive annual grasses and herbs including white fumitory (*Fumaria capreolata*), *Briza maxima* and *B. minor*, bearded oats (*Avena barbata*), three-cornered garlic (*Allium triquetrum*), blue pimpernel (*Anagallis arvensis* var. *caerulea*) and oxalis (*Oxalis pes-caprae*). The following species are only found in this section of river and are a priority for control and/or eradication to prevent incursion downstream - buckthorn (*Rhamnus alaternus*), ivy (*Hedera helix*) and Cootamundra wattle (*Acacia baileyana*).

Several species associated with private properties are just within or on the border of the river reserve and should be monitored – private landholders could be encouraged to remove seedlings or prevent further spread – date palm (*Phoenix dactylifera*), olive (*Olea europaea*), nasturtium (*Tropaeolum majus*) and wonga vine (*Pandorea pandorana)*.

In 2006, watsonia, bridal creeper and blackberry were dominant in this section but are no longer. Siemon (2001) reported a continuous level of cover of the upper, mid

and understorey, with the upperstorey dominated by natives and only a small portion of the mid and understorey natives. Many of the more invasive species are now not present.

West section

More weed species were found in the West section than the East or Central. The natural understorey has largely disappeared and been replaced with exotic grasses and other weeds due to changed land practices since European settlement, including stock grazing, recreational use and current land management practices (Dundas and Mills 2011). From Scott Street to Roe Highway, both the midstorey and the understorey are severely impacted by invasive species. Apart from the *Eucalyptus rudis* upperstorey, the native vegetation has almost all been displaced by fig, Brazilian pepper, watsonia, blackberry and arum lily. These species were also widespread in 2006. Weed cover is extensive, and the riparian vegetation has largely been cleared, now forming only a narrow band along the waterway.

From Roe Highway to Water Street in Guildford the floodplain upperstorey is wider although the understorey is mostly spreading invasive weeds or annual weedy grasses or herbs. In several areas weed control and revegetation is evident and the dominant weeds remaining are bearded oats, kikuyu (*Pennisetum clandestinum*) and white fumitory. There are also large areas where the mid and understorey is dominated by fig, blackberry and castor oil (*Ricinus communis*). In several areas gardens from private properties encroach onto the river reserve and while less invasive than some other species, garden plants in these areas (grape vine, garden fan palm, snake vine, canna lilies, nasturtium and willow) should be monitored by private landholders and further spread be prevented. In 2006, cotton bush and Brazilian pepper were recorded dominant but are not now.

From Water Street to the confluence with the Swan River the remnant floodplain vegetation is generally narrower, but similarly characterised by an upperstorey of *E.rudis* and an understorey of grassy weeds, with several large areas of revegetation. Weed cover ranges from moderate to extensive. Watercress was first found in a drain near the Rosehill Waters estate and then small infestations in each segment downstream, and is a priority for control. From the Johnson Street crossing to the Swan River several species have escaped from adjacent gardens on the south bank, including morning glory, date palm, nasturtium and lippia. From Scott Street to the Swan River there are several olive plantings in or adjacent to the river reserve which should be monitored and seedlings removed to prevent ongoing spread.

For the lowest 5.5km of the river from Stirling Crescent downstream, Siemon (2001) reported poor riparian vegetation, with an upperstorey comprised of olives, figs and Brazilian pepper as well as *Eucalyptus rudis* – these weeds are still present but appear to be less widespread. The middlestorey was largely weed dominated, with castor oil, giant reed and cotton bush particularly abundant. These species are no longer dominant. At least 90% of the understorey was comprised of weeds, including watsonia, dock, blackberry, oxalis and paspalum. From 2001 to 2006, watsonia and blackberry reduced in severity so they were no longer dominant in 2006. They have remained low in coverage since 2006.

Figure 38: Dense watsonia infestation immediately downstream of Scott Street.

Figure 39: Narrow riparian zone of Eucalyptus rudis *and* Ficus carica*.*

Table 8: Weed cover categories recorded for each section of the Helena River.

Weed cover	Section of Helena River							
	East		Central		West		Overall	
	Km	%	Km	%	Km	%	Km	%
Minimal	1.32	5.1	0	0	1.05	3.1	2.37	3.5
Moderate	14.3	54.7	1.75	18.2	4.96	14.6	21.01	30.9
Extensive	8.87	33.9	7.88	81.8	27.96	82.3	44.71	65.7
Total	**24.49**	**100**	**9.63**	**100**	**33.97**	**100**	**68.09**	**100**

Table 9: Weed cover, comparison between 2016 and 2006.

Weed cover	Section of Helena River							
	East		Central		West		Overall	
	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006
Minimal	5.1		0		3.1		3.5	
Moderate	54.7		18.2		14.6		30.9	
Extensive	33.9		81.8		82.3		65.7	
Total	**100**		**100**		**100**		**100**	

Figure 40: Weed cover, East section.

Figure 41: Weed cover, Central section.

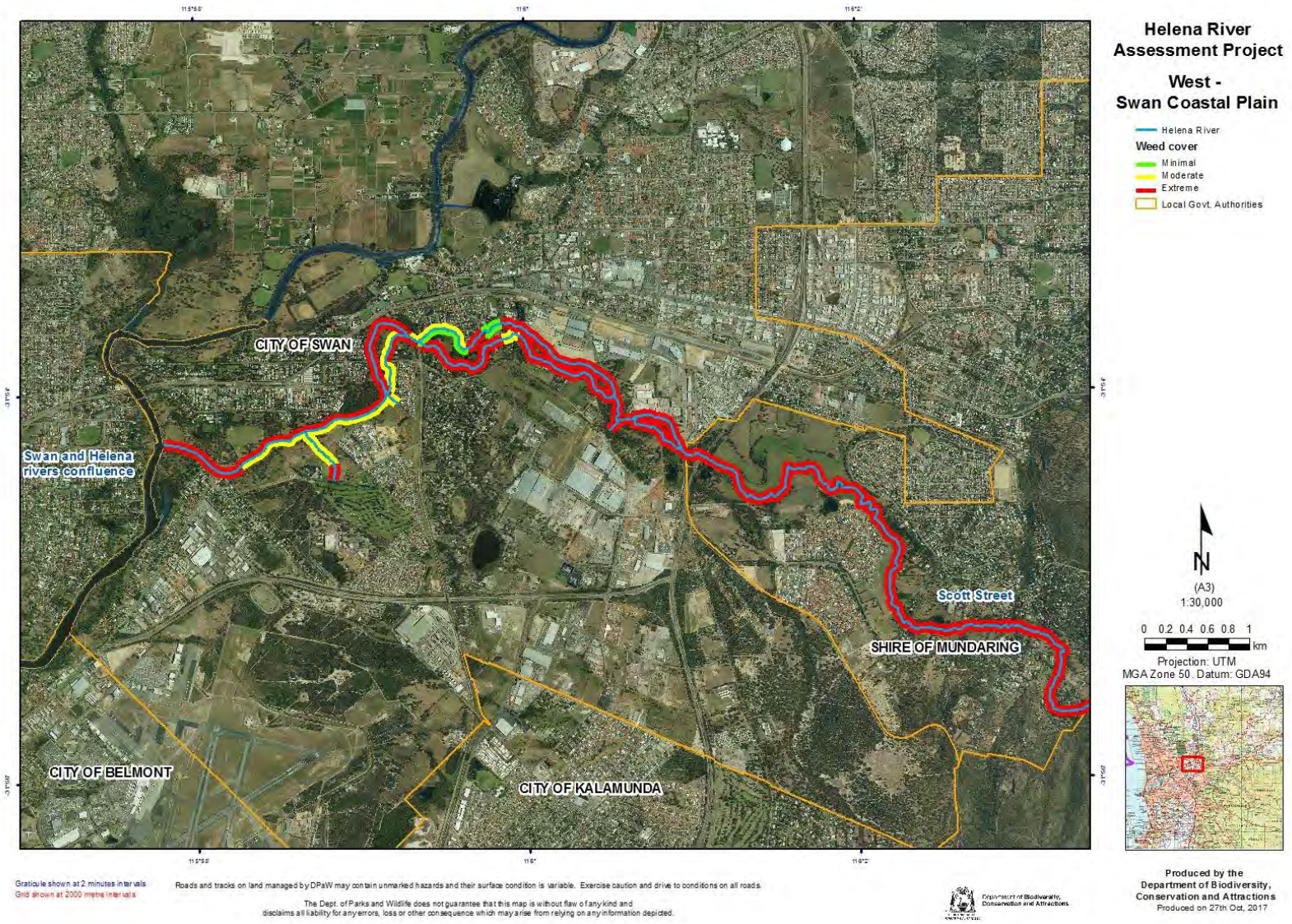


Figure 42: Weed cover, West section.

3.5 Level of pressure

No segments along the Helena River have a minimal level of pressure. This is largely due to the presence of Mundaring Weir and the Pumpback Dam and their contribution, together with a drying climate, on flow and disconnectivity of river pools, and their function as an artificial barrier to instream fauna migration. A lack of flow has led to sedimentation and shallow pools which are not scoured regularly by undisturbed (undammed) patterns of flow during rainfall events. Sedimentation has also been exacerbated by an accumulation of ash and earth from hillsides following fires, and from unlined drainage channels that have been dug to discharge runoff from roadways and urban areas, mainly in the Central section.

We assessed level of pressure at a landscape scale, whilst in 2006 DWER had considered localised pressures on each segment only, such as widening of the channel, erosion and trampled understorey. To enable a comparison, Table 11 shows data for level of pressure calculated in the same way as DWER, and the last paragraph within each section's results below uses these data.

East section

The level of pressure in most segments is moderate. The presence of the weir and weed coverage are the major pressures on this section of river. There were also some localised areas of erosion and evidence of 4WDing near the watercourse. In one segment the level of pressure was extensive, where cleared paddocks intersect the river and contribute a significant weed cover to the watercourse. The presence of Beelu National Park and water catchment has helped to preserve the connectivity of the riparian zone to the dryland landscape and to limit impacts from intense land uses such as industrialisation and urbanisation.

In 2006 the level of pressure over the whole East section was considered minimal. When we applied a comparative level of pressure using only localised impacts, it was also minimal for this section – reflecting that the area is largely protected within national park and water catchment and there has been little change in 10 years.

Central section

In this section 42% of the river has a moderate level of pressure. This is the riverbank in Beelu National Park. From where private properties are adjacent to the river reserve the level of pressure is extensive, due to an increased presence of weeds and a lack of native mid and understorey, water extraction, livestock very close to the river, and the overall impact of Mundaring Weir and the Pumpback Dam and declining rainfall on river flow. Although the assessment was conducted during a relatively wet spring, the water level was low and flow was slow.

When we used a comparative level of pressure score, there was a significant reduction in localised pressures from 2006 to 2016, with fewer management issues recorded now regarding stock grazing and trampled understorey.

West section

Approximately 38% of the river has a moderate level of pressure and 62% an extensive level of pressure. The level of pressure is extensive from Scott Street to Roe Highway, where the remnant riparian vegetation is very narrow and most of the floodplain has been cleared, weed cover is extensive, there is evidence of stock in the watercourse and several housing estates are adjacent. In Midland and Hazelmere several industrial properties are adjacent to the floodplain and erosion and sedimentation is evident downslope of these properties. The understorey has been entirely replaced with weedy grasses and herbs, probably due to historic grazing in this area. Therefore, most segments in this area have an extensive level of pressure. From Amherst Road downstream to the Swan River the level of pressure is moderate, except for part of a drain which runs through Rosehill Waters estate and there is a complete loss of native vegetation – here the level of pressure is extensive.

There was a slight reduction in the comparative level of pressure from 2006 to 2016.

Table 10: Level of pressure (at landscape level) that was recorded for each section of the Helena River assessed.

Level of pressure	Section of Helena River							
	East		Central		West		Overall	
	Km	%	Km	%	Km	%	Km	%
Minimal	0	0	0	0	0	0	0	0
Moderate	23.51	96	4.05	42.1	12.84	37.8	40.4	59.4
Extensive	0.99	4	5.58	57.9	21.1	62.1	27.67	40.6
Total	**24.5**	**100**	**9.63**	**100**	**33.94**	**100**	**68.07**	**100**

Table 11: Localised level of pressure, comparison between 2006 and 2016.

Comparative pressures	Section of Helena River							
	East		Central		West		Overall	
	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006
Minimal	100	100	83.8	0	72.9	61.5	84.2	76.2
Moderate	0	0	10.9	28.7	27.1	30.2	15.1	19.5
Extensive	0	0	5.4	71.3	0	8.3	0.8	4.2
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note that the DWER data fields used to determine level of pressure were 'Presence of incised banks; Presence of widening; Presence of meandering; Evidence of domestic animal grazing; Evident of parking near vegetation; Trampled understorey.' As not all these fields were used in 2016, we used the management issues fields to determine localised level of pressure.

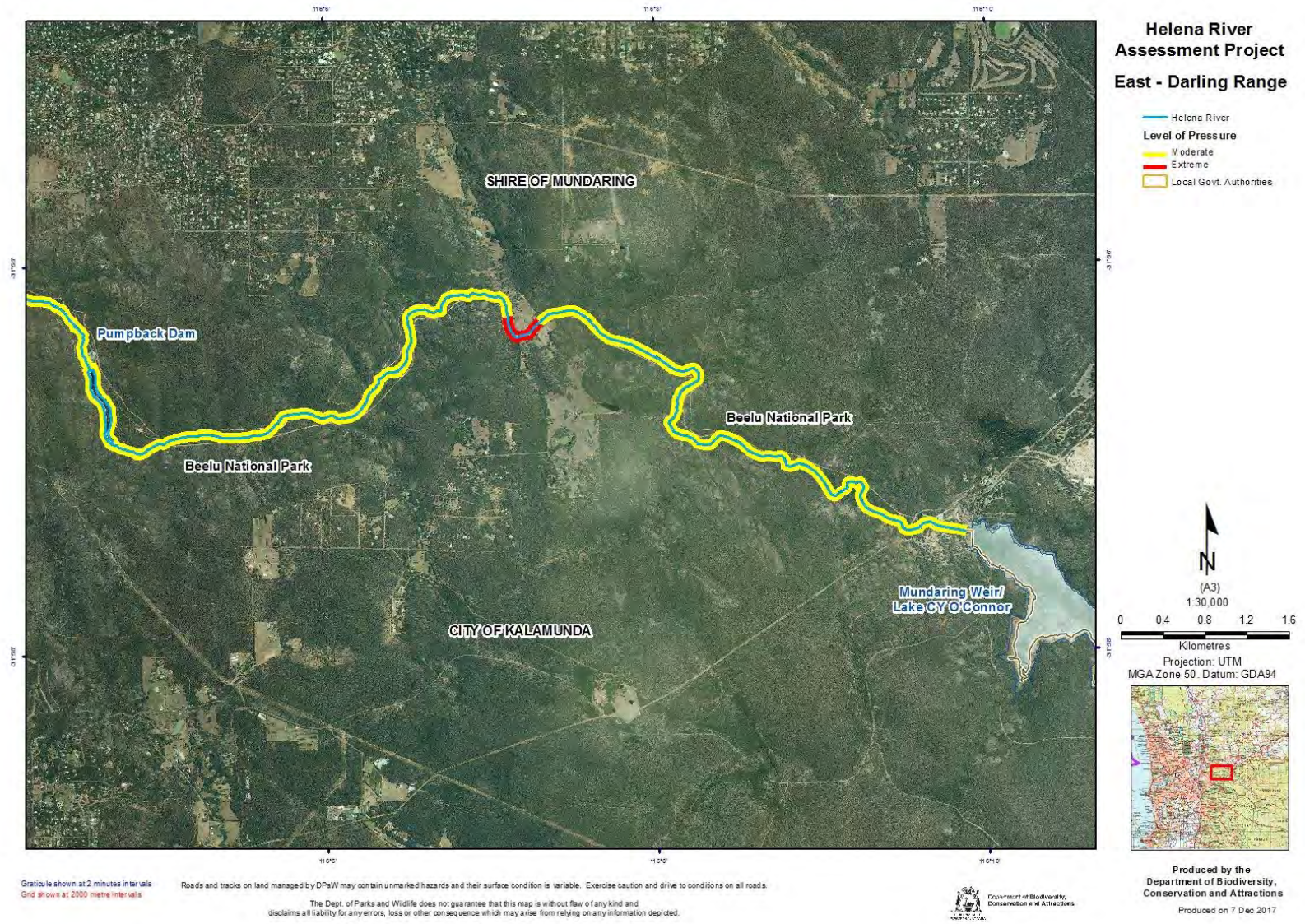


Figure 43: Level of pressure, East section.

Figure 44: Level of pressure, Central section.

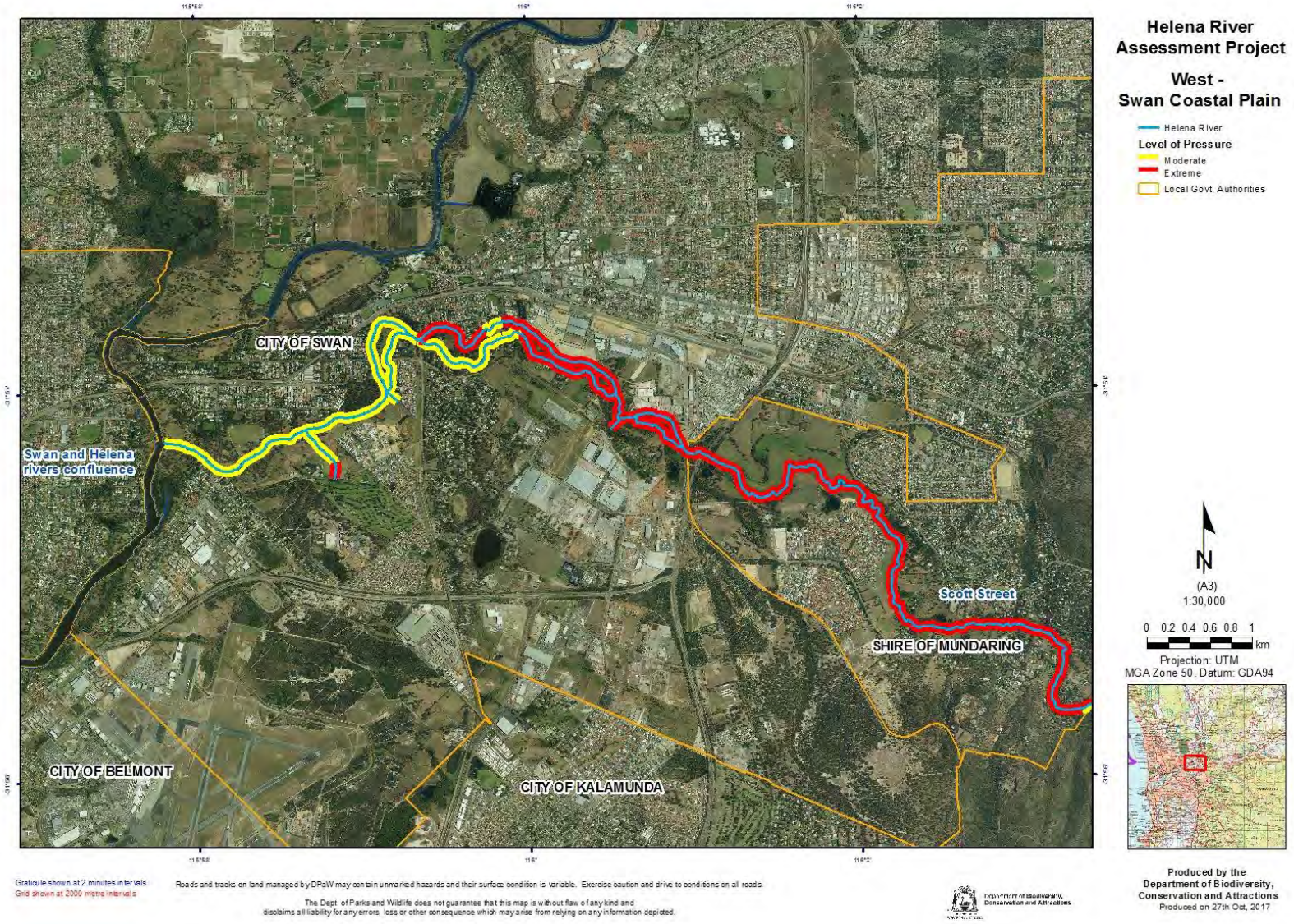


Figure 45: Level of pressure, West section.

3.6 Pen and Scott grade

A description of each grade is provided in Appendix 6.

East section

This section of river has the highest proportion of A grade riverbank. The highest grade is A3 and the lowest is C2. The most common grades are A3 and B1. The segment deemed to be C2 is located about 400m downstream of Mundaring Weir and has been extensively cleared and there is very little coverage of the watercourse, although there is a high regeneration rate of *Astartea* sp. B3 occurs where paddocks intersect the watercourse and a substantial increase in weed cover occurs, and in the two segments upstream of the floodwaters of the Pumpback Dam where watsonia coverage is extensive.

There is more variation in Pen and Scott gradings in 2016 than 2006, as expected due to the more detailed assessment in 2016. It is not possible to determine whether the gradings have improved, although as most of this section is between A3 and B3, and in 2006 it was considered B1, the grading appears similar.

Central section

The highest grade of riverbank is A3 and the lowest is C1. Most segments are C1. The only A3 segment is immediately downstream of the Pumpback Dam where a large effort into the control of watsonia has occurred. The C1 segments are located adjacent to private property through Helena Valley where weed infestations are significant.

In 2006, the most common grading was C1, the same as in 2016. However, the highest grading is now A3, not B1, and the lowest grading is now C1 not C3, indicating an improvement.

West section

This was the only section of river to contain any D grade segments. Most segments are C1. The highest grading is B1 and the lowest is D3. The segment graded B1 is located on the northern alignment of the Helena River immediately west of Amherst Road where a successful restoration program has been implemented. Four segments were in D3 grade and resembled an urban drain. These include a weed-infested drain from the Rosehill Waters estate with virtually no native vegetation, and several segments west of Military Road in Midland and Hazelmere which are bound by industrial properties, and have become very silted and weed infested.

In 2006 the highest grading was B3 while it is now B1. However, the proportion of riverbank in B1 and B2 grades is very small (<5%) and the majority of riverbank in both 2006 and 2016 was C1. A similar proportion of riverbank fell into C3 and the lowest grade of D3, showing that the western section still has the poorest grades and improvement has not been significant. This is reflective of the changed hydrology of the channel and not a lack of restoration work.

Table 12: Pen and Scott grades assigned for each section of the Helena River.

Pen & Scott grade	Section of Helena River							
	East		Central		West		Overall	
	Km	%	Km	%	Km	%	Km	%
A1	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0
A3	9.18	37.5	1.75	18.2	0	0	10.93	16
B1	4.82	19.7	0	0	0.4	1.2	5.22	7.7
B2	1.63	6.7	1.4	14.5	1.23	3.6	4.26	6.3
B3	8.53	34.8	0.9	9.3	0	0	9.43	13.8
C1	0	0	5.58	57.9	22.28	65.6	27.86	40.9
C2	0.34	1.4	0	0	1.29	3.8	1.63	2.4
C3	0	0	0	0	2.22	6.5	2.22	3.3
D1	0	0	0	0	0	0	0	0
D2	0	0	0	0	0	0	0	0
D3	0	0	0	0	6.55	19.3	6.55	9.6
Total	**24.5**	**100**	**9.63**	**100**	**33.97**	**100**	**68.1**	**100**

Table 13: Pen and Scott grade, comparison between 2006 and 2016.

Comparative Pen & Scott grade	Section of Helena River							
	East		Central		West		Overall	
	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006	% 2016	% 2006
A1	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0
A3	37.5	0	18.2	0	0	0	16	0
B1	19.7	100	0	25.8	1.2	0	7.7	38.3
B2	6.7	0	14.5	0	3.6	0	6.3	0
B3	34.8	0	9.3	0	0	4	13.8	2
C1	0	0	57.9	45.5	65.6	67.5	40.9	41
C2	1.4	0	0	0	3.8	0	2.4	0
C3	0	0	0	28.7	6.5	8.3	3.3	8.4
D1	0	0	0	0	0	0	0	0
D2	0	0	0	0	0	0	0	0
D3	0	0	0		19.3	20.3	9.6	10.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

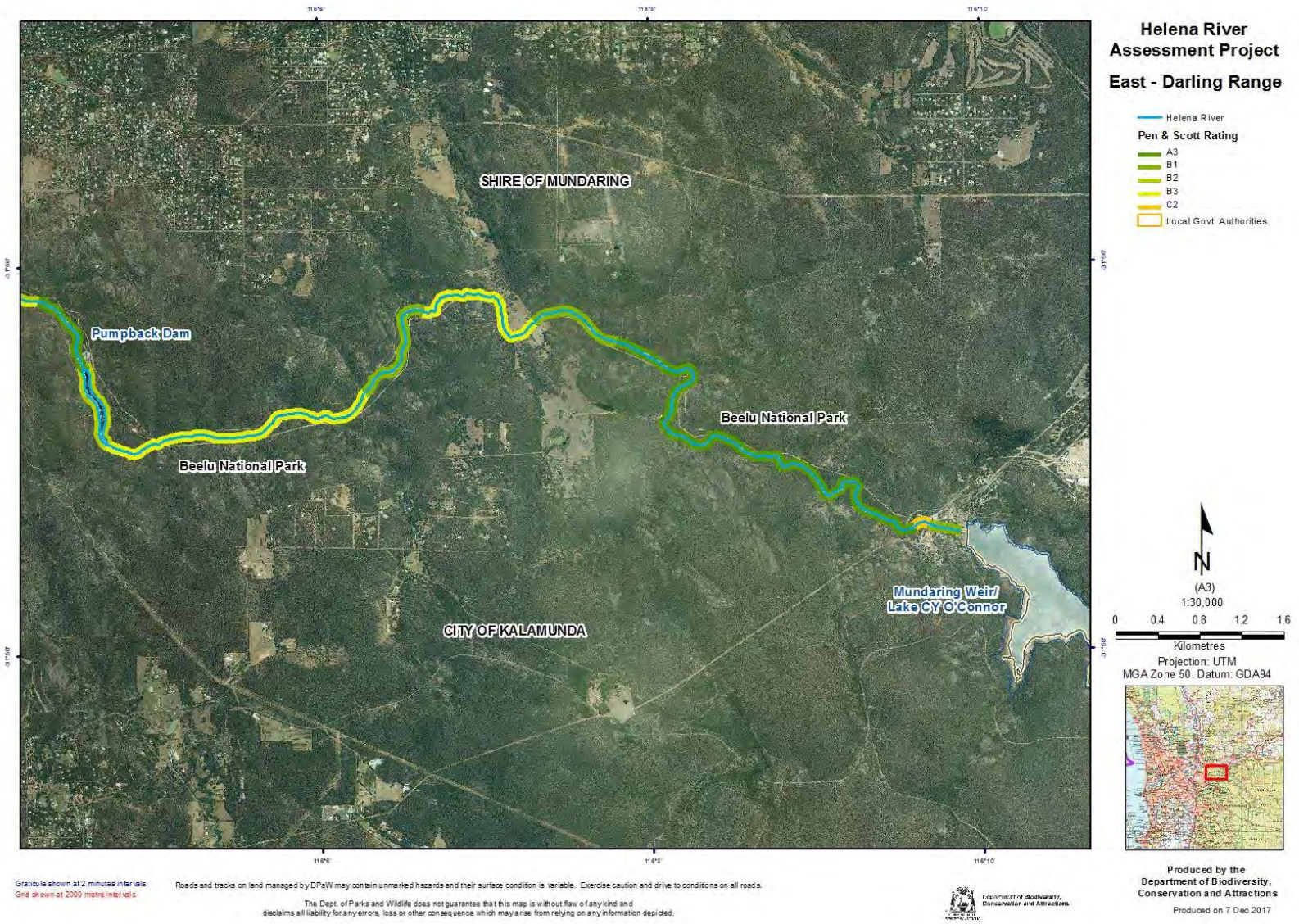


Figure 46: Pen and Scott grading, East section.

Figure 47: Pen and Scott grading, Central section.

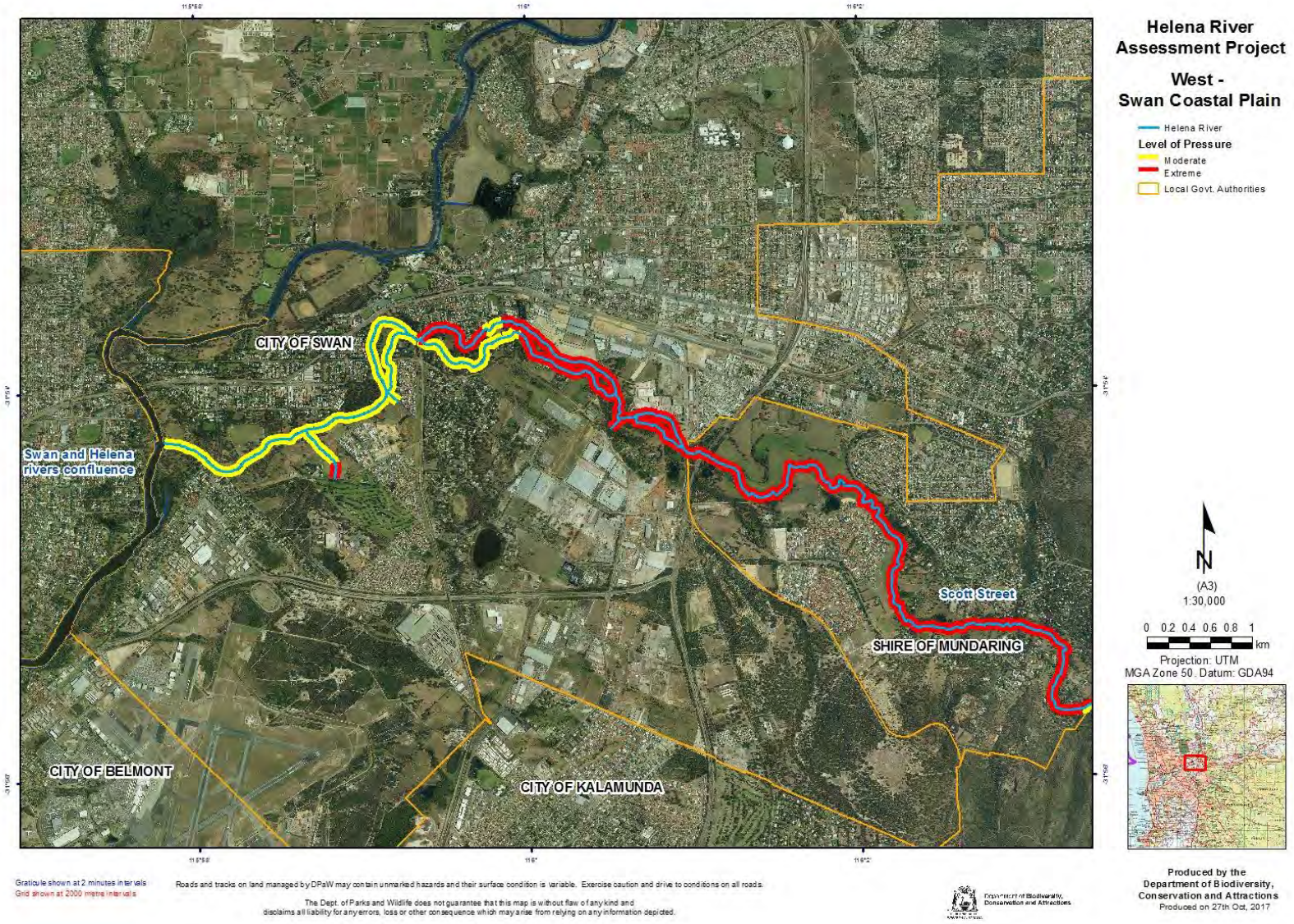


Figure 48: Pen and Scott grading, West section.

3.7 Other management issues

3.7.1 Uncontrolled access to the riverbank

Evidence of vehicles and stock accessing the riverbank were recorded, as well as where activities on private property have impacted the riverbank.

East section

There are few areas where vehicles access the riverbank from Mundaring Weir to the Pumpback Dam due to the management access only track. Some activity by 4WDs and off-road bikes was sighted immediately west of Mundaring Weir Road and O'Connor Road; some drink cans and broken glass were also noted and several trail markers on the Munda Biddi trail appeared to have been pulled out.

There was no evidence of stock access to the river.

Central section

4WD and off-road bike access was apparent in three of the seven segments – all near the western end of Beelu National Park where private property is adjacent to the river reserve. Drink cans, broken glass and small campfires were sighted along the riverbank in the national park in this section and several illegal fauna traps were found near the pipeline and reported to the FishWatch program operated by the Department of Primary Industries and Regional Development. Gates have been installed in the gravel carpark near the Craignish Gauging Station but these have been breached and damaged.

Cattle were sighted in the river just upstream of Roe Highway and the riverbank appears to be actively eroding here.

West section

There were only two segments where uncontrolled vehicle access to the river was apparent – between Roe Highway and Amherst Road - where piles of dumped domestic waste were also common.

Near the Helena Valley housing estate, between Amherst Road and Water Street in Guildford, and from Rosehill Waters to the confluence with the Swan River, private properties and gardens encroach onto the river frontage. The river is unfenced in many of these areas and garden species have established in the riparian zone.

Domestic rubbish was also found near Perth Polo Ground in Guildford and reported to the Pollution Watch Hotline and the City of Swan.

Figure 49: Dumped domestic rubbish in Midland.
Figure 50: Private gardens encroaching onto the watercourse.

3.7.2 Current management concerns

Bare banks were noted in the Woodbridge and Guildford areas where grass has been sprayed to delineate between mown parkland and a narrow strip of riparian vegetation or in preparation for revegetation. In many areas delineation is only 5-10m from the water's edge. This has resulted in the lack of native middle and understorey species, and contributed to a lack of regeneration of trees and shrubs (Dundas and Mills 2011).

The regeneration may also be impacted by the practice of mowing grasses to the base of trees (SRT 2008a). In the Woodbridge area many lower limbs of *Eucalyptus rudis* had been removed, possibly for easy access for the mower.

3.7.3 Other issues

In several areas water quality appeared to be poor, although no physical testing was conducted as part of this assessment. Due to the presence of stock in the riverbed immediately upstream of Roe Highway, water quality testing, stock exclusion and ongoing monitoring is recommended as part of the new Belle View Estate development. Water appeared orange and opaque in parts of the northern alignment of the river between Chatham Road in Woodbridge and Water Street in Guildford. The river was very silted and surface water was shallow and stagnated. Some follow up testing of water quality in this area, and a method of allowing the water to flow, may be required. In an urban drain basin flowing into the river near the Waterhall Estate in South Guildford significant amounts of algae were present and there is good opportunity here for an educational workshop on water quality in this site with residents.

Several water extraction pumps and pipes were found adjacent to private properties in Helena Valley near Beelu National Park.

Some feral pig diggings and prints were found in the segment approximately 1km downstream of Mundaring Weir.

Damaged fencing is located in a drain near Rosehill Waters estate, posing a hazard to birds, and may also impact aquatic fauna if it ends up in the Helena River.

Figure 51: Stagnant water in northern alignment of the Helena River in Woodbridge.
Figure 52: Damaged fencing in drain from Rosehill Estate.

3.8 Current management responses

3.8.1 Restoration works

The HRCG, Katharine Street River Gang, Lower Helena Association and DBCA volunteer Peter Day have contributed a significant effort to the restoration and improvement in condition of the Helena River.

The Swan Alcoa Landcare Program (SALP) has provided grants to support community groups undertaking environmental improvement projects in the Swan Canning Catchment each year since 1999. The grants are funded by the Western Australian Government (through DBCA and previously the Swan River Trust) and Alcoa Australia. Groups working along the Helena River and in its catchment have been among the recipients of these grants and many of the areas with improved vegetation condition are due, at least in part, to SALP grants and the community groups that make use of them.

Most restoration works noted on the riverbank were revegetation and weed control, and erosion control to a much lesser degree. There were few points of erosion noted along the system and many areas, unless bank restoration or removal of weed species is planned, do not require erosion control works.

East section

Some erosion control has been installed at the Munda Biddi Trail crossing over the river just west of Mundaring Weir Road, where coir logs have been placed, though

there is some localised erosion around these and the site would benefit from revegetation with native rushes and sedges.

Weed management was not obvious through this area though DBCA's Perth Hills District was planning watsonia control shortly after the assessment was conducted. During the 2017 growing season, the Perth Hills District contracted regular watsonia control in tributaries flowing into the Helena River.

A small revegetation site is present on the left bank about half way along the East section. Watsonia control was conducted by contractors near the Pumpback Dam in the mid 2000s as part of an environmental offset for an upgrade to the Lower Helena Trunk Main (water pipe), but weed re-incursion has occurred since and watsonia is prolific on the banks of the Pumpback Dam and upslope of the river valley, particularly where small tributaries feed into the dam. Follow up weed control is a priority to consolidate weed control to date. This will also assist control efforts downstream of the dam.

Figure 53: Coir logging in a pool downstream of Mundaring Weir Road.
Figure 54: Small revegetation site requiring maintenance.

Central section

Weed management is evident in the two segments immediately below the Pumpback Dam, through Beelu National Park and upstream of private property in Helena Valley. Watsonia control has been conducted by the HRCG and DBCA volunteer Peter Day using both herbicide application and fire management. This appears very successful, with weed cover being moderate in this segment, while it is extensive in the segments upstream and downstream. HRCG has also controlled buckthorn and olive in the national park and it is a priority to continue this control and prevent further spread of these species. The catchment group has also worked to control watsonia further downstream of the national park, and very few watsonia infestations were found from this point to Scott Street, whereas watsonia had been a dominant part of the understorey when surveyed by WRC in 1999 (Siemon 2001).

Revegetation is evident looking upstream from Scott Street Bridge. Weed control has also occurred in this area, and the sudden presence of dense watsonia

immediately downstream of the bridge indicates the effort undertaken to remove watsonia above the bridge.

Figure 55: Watsonia has been controlled in the valley below the Pumpback Dam.
Figure 56: Weed control and revegetation immediately upstream of Scott Street.

West section

Evidence of weed control and revegetation was common. *Eucalyptus rudis* has been planted near Katharine Street in Bellevue, and upperstorey species (primarily *E.rudis* and *Casuarina obesa*) were planted approximately 10 years ago between Roe Highway and Military Road in Midland, and in the southern alignment of the river just west of Military Road. In the area just west of Military Road there is very little understorey.

Effective weed control and revegetation has been conducted immediately upstream of Amherst Road on the southern alignment of the river on the Men of the Trees property, where recent restoration is ongoing. Similarly, downstream of Amherst Road the Lower Helena Association has restored the original alignment of the Helena River. There is high species diversity from revegetation over the previous 7-8 years and weeds are controlled.

Weed control has been carried out in some areas downstream of Amherst Road on Department of Planning land, where banks appear to have been sprayed from the water mark up to about 5-10m. A noticeable area of weed control is immediately upstream of Water Street on the southern alignment of the river.

Revegetation has also occurred immediately downstream of the rail crossing in Hazelmere and downstream of Water Street in Guildford, both on the southern alignment of the river, although most plants are upperstorey species; the understorey is sparse and there is an absence of sedges or rushes on the riverbank. Two open drains near the Waterhall and Rosehill Waters estates have also been partly revegetated.

The proposed restoration activities and wetland construction associated with the Belle View estate should improve vegetation coverage and bank stability immediately upstream of Roe Highway.

Figure 57: Revegetation site adjacent to the Men of the Trees property in Hazelmere.
Figure 58: Revegetation site near Amherst Road in Woodbridge.

Figure 59: Revegetation site in South Guildford.

Figure 60: Recent weed control was evident in the lower part of the drain from Rosehill Estate.

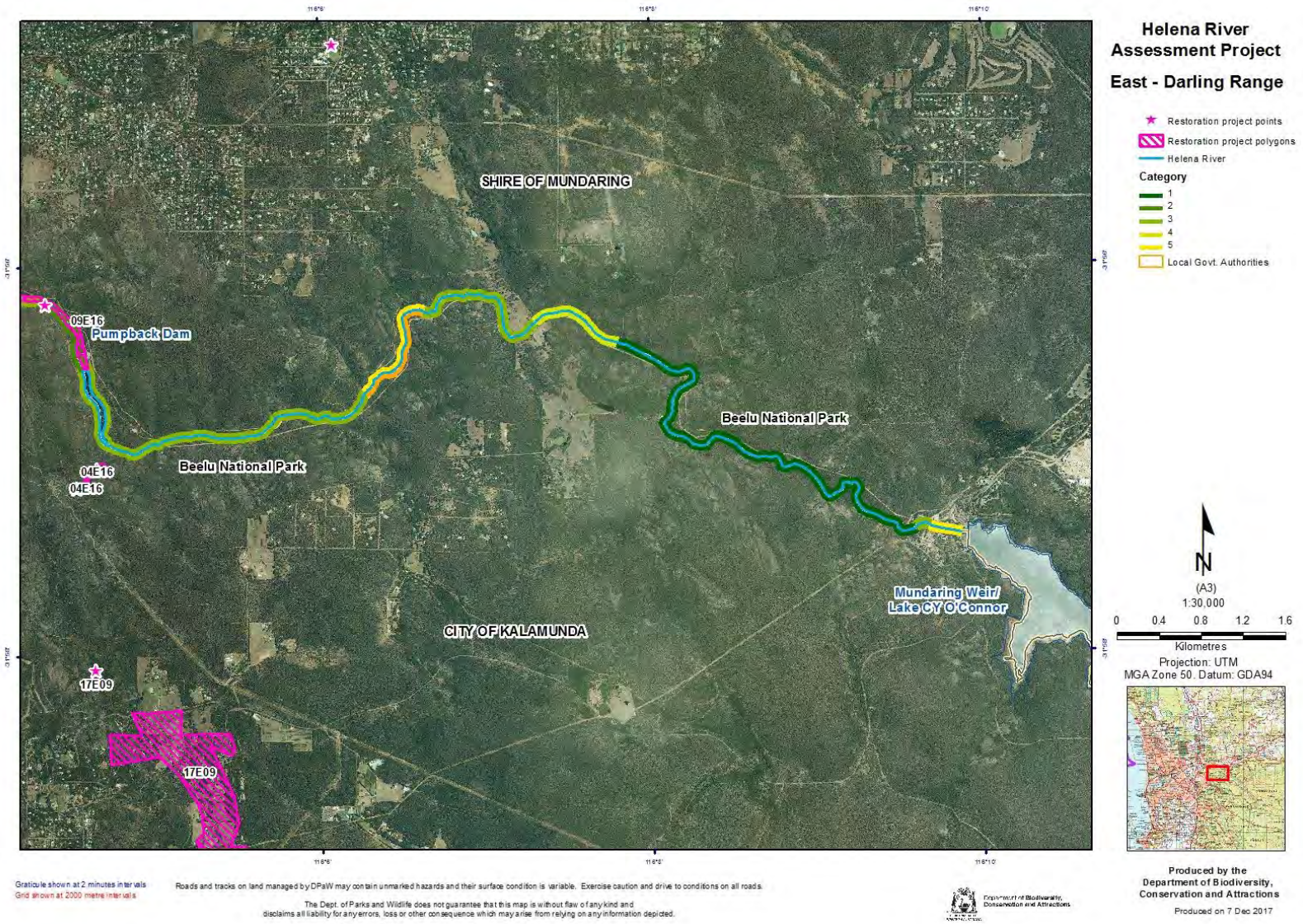


Figure 61: Known restoration project sites over current categories, East section. (Project codes referenced in Appendix 11).

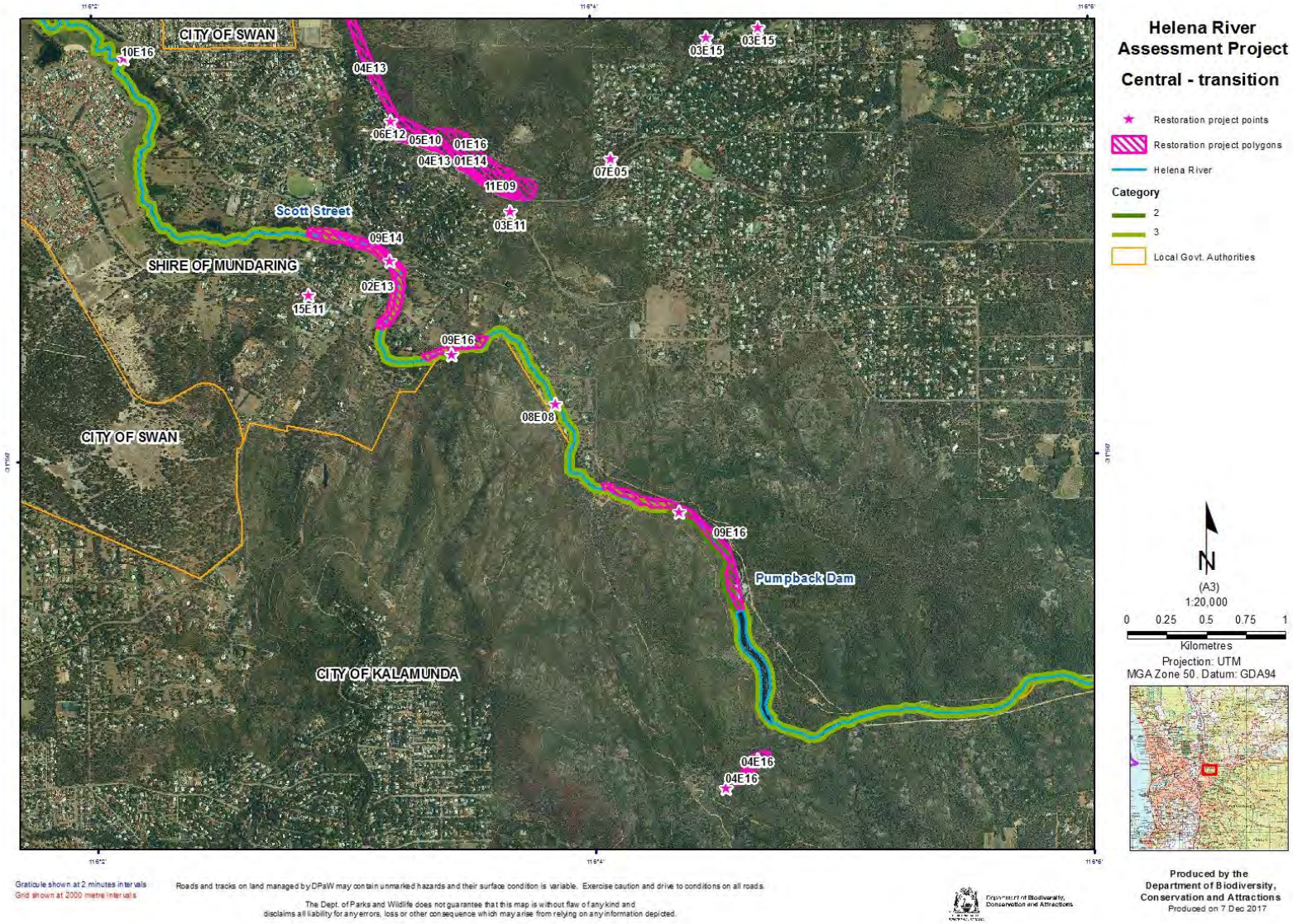


Figure 62: Known restoration project sites over current categories, Central section (Project codes referenced in Appendix 11).

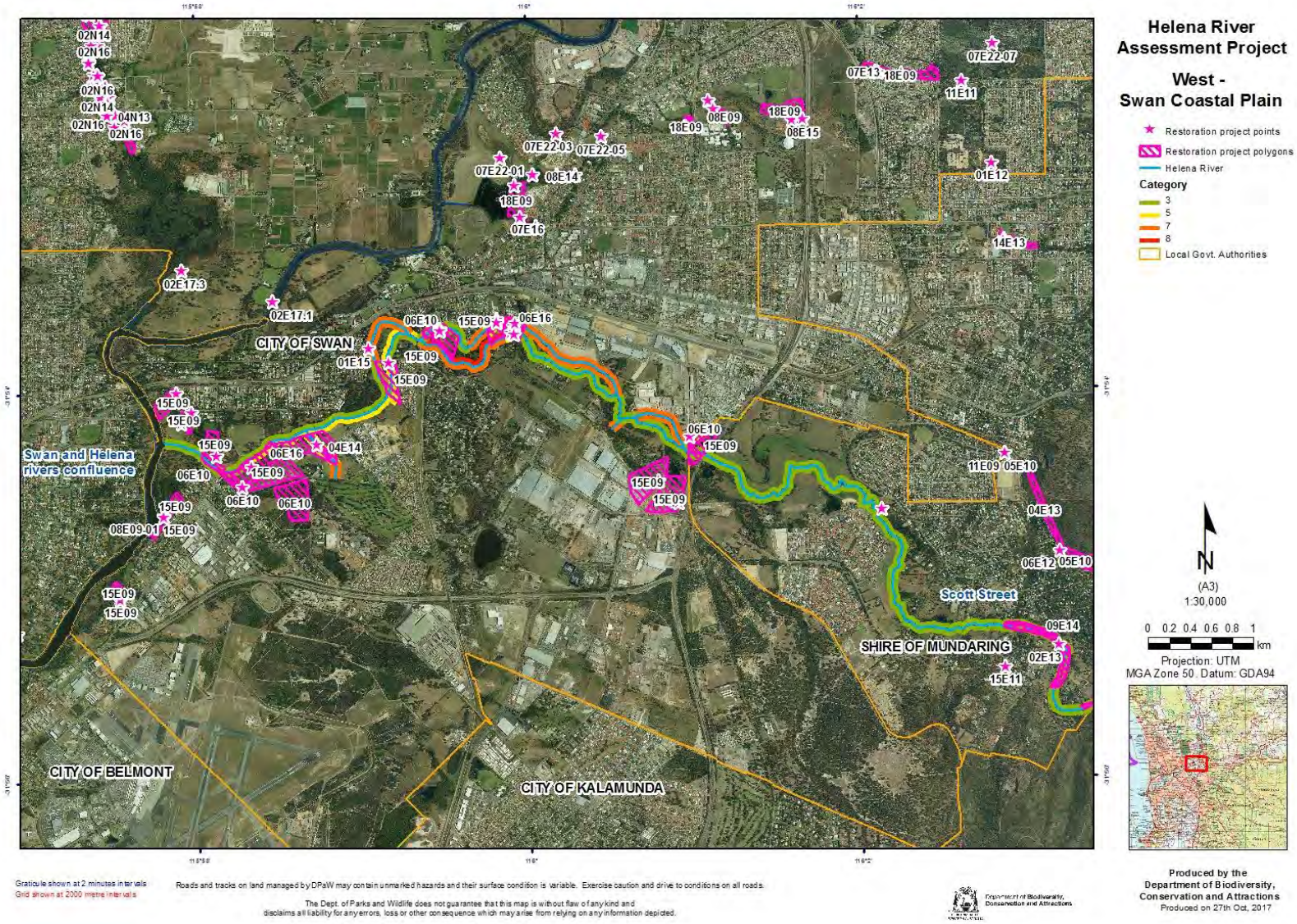


Figure 63: Known restoration project sites over current categories, West section. (Project codes referenced in Appendix 11).

3.8.2 Fencing/stock/human exclusion from watercourse

East section

The day use recreation area downstream of Mundaring Weir is fenced, restricting access to the riverbank. From Mundaring Weir Road downstream to the Pumpback Dam the riverbank is within water catchment and while the area is not fenced, gates are in place and the area is restricted to management vehicle access only. The Munda Biddi Trail runs through part of this section and is clearly marked.

Central section

In Beelu National Park access along the Helena River is restricted to management vehicles only, although 4WDs and off-road bikes do access parts of the river. Much of the river downstream to Scott Street is fenced on the private property boundary adjacent to the river reserve.

West section

We sighted few fenced areas of the river from the Scott Street crossing to Helena Valley estate although we were not able to view much of this area due to the proximity of private property to the river. The river is fenced adjacent to the Helena Valley Estate although fencing is only setback from the river on average about 10m and adjacent to the fence is mown grass.

Fencing on private property upstream of Roe Highway, the site of the planned Belle View Estate, is inadequate and currently stock are accessing the river.

From Roe Highway to Amherst Road the river is fenced along the southern alignment on private property boundaries. Fencing appears setback further away from the watercourse where industrial properties occur. Fences are not necessarily in place to protect the river but effectively form a barrier to the incursion of industrial activity into the river.

From Amherst Road downstream to the confluence with the Swan River rural and residential properties are adjacent to the river reserve or floodplain and most of these properties are fenced. In some instances, gardens encroach into the riparian zone.

4 Strategy and recommendations

4.1 General recommendations

One of the most significant issues facing the Helena River system is the lack of river flow. The reduced river flow is caused by the impacts of a drying climate – a dramatic decline in streamflow across the south-west of WA - and the presence of Mundaring Weir and the Pumpback Dam. The weir was initially constructed to a height of 30.5m and would overtop annually. It was raised to 42m in 1951, and it last overtopped in 1996. The lack of flow over several decades has led to siltation of much of the original alignment of the river through Midland and Hazelmere, loss of instream habitat for aquatic fauna, and poor water quality from stagnation. Siemon (2001) had recommended that the former Water and Rivers Commission be contacted to:

> 'investigate the possibility of diverting the river flow back to the original channel, including an assessment of the hydrology of the entire catchment and main waterway.'

DBCA, DWER and Water Corporation have initiated an environmental flows program from the Pumpback Dam to provide some water flow to downstream river pools over the summer months. It is critical to continue the existing program of environmental water provisions to sustain downstream aquatic ecosystems. There is currently no infrastructure available for releases to be made from Mundaring Weir. We strongly recommend that the relevant organisations work together to enable environmental water provisions to occur in future.

The following overall recommendations are made for the restoration of the Helena River from Mundaring Weir downstream:

- Form a working group to coordinate the delivery of recommendations and restoration effort, including representation from DWER, Department of Planning, Lands and Heritage, Water Corporation, local government, EMRC and DBCA. Items for a potential working group include:
  - Resolve multiple land tenure issues. Reconsider stalled plan to add WAPC land and Unallocated Crown Land to Beelu National Park (north of the river).
  - Partner with stakeholders to leverage funding for restoration works on the Helena River.
  - Consider the management of parts of WAPC land for conservation.
  - Provide strategic direction for on-ground management e.g. staged weed control at a system wide level.
  - Investigate establishment of an on-ground crew (e.g. Aboriginal ranger team) dedicated to work on priorities for the Helena River in conjunction with community and stakeholders.

  - Develop a joint action plan to address illegal 4WD access to the river.
  - Develop a communications plan for land holders.
  - Investigate the possibility of developing a foothills regional or national park linking the Swan Canning Riverpark to Beelu National Park (also recommended in EHCMP 2012).

- Support volunteer groups by undertaking supporting works – for example, controlling major weed species around and upstream of the Pumpback Dam.
- Engage with programs such as Bush Rangers WA, Aboriginal ranger teams, Duke of Edinburgh's International Award, and corporate working bees for restoration activities.
- Engage with the Noongar community in restoration works, and in the joint protection of cultural and natural heritage sites.
- Engage landholders adjacent to the river in protection and weed management. This is particularly important through Helena Valley and Bellevue where the watercourse is within several metres of private property boundaries, and there are water extraction pipes and weedy species. A landholder education program could be established, and also in Guildford and Woodbridge where gardens encroach upon the river reserve.
- Electronically capture knowledge of on-ground staff and volunteers on localised weed infestations in an online tool or map to include in grant applications and enable future evaluation of control programs.
- Remove weeds from the uppermost section of river where they first start appearing.
- Remove weed species that are not currently prevalent in segments.
- As weeds can provide habitat and refuge from predators, stage weed removal to ensure not all habitat is removed at once.
- Investigate successful buckthorn control methods from other states or internationally.
- Manage habitat potential with bushfire risk – identify areas further away from housing where habitat can be a higher priority.
- Wildlife corridors – create connection with Bush Forever sites and TECs and PECs when considering sites for revegetation.
- Promote biodiversity and habitat complexity through planting locally endemic upper, middle and understorey species.

- Engage with the Water Corporation to encourage control of watsonia around the Pumpback Dam and downstream of Mundaring Weir in the day use area where effective weed control can be undertaken at the top of the catchment, and several species can be locally eradicated. Lavender should also be removed from the pipeline access track.
- DBCA to consider undertaking staged control of priority species between Mundaring Weir and the Pumpback Dam, focussing on species that are possible to eradicate or effectively reduce populations – including cotton bush, fennel, dolichos pea, blackberry, red valerian and morning glory. Other species that can be removed from several segments include arum lily, watsonia and olive.
- Remove cotton bush from the paddock on the left bank in Beelu National Park. Other than several plants immediately downstream of Mundaring Weir, this is the most upstream population of cotton bush found.
- Monitor for watsonia, blackberry and cotton bush between the Pumpback Dam and Scott Street and control when and where they appear.
- Increase the width of the riparian zone through Helena Valley where it narrows to almost a single line of *Eucalyptus rudis* where public lands are adjacent to the river reserve. This will require engagement with WAPC and Department of Planning, Lands and Heritage to encourage setting back the existing fence, staged weed removal and revegetation with a diverse mix of upper, middle and understorey species. There is opportunity to link such works into the planned wetland creation and restoration of the river in Belle View estate.
- Set aside some areas for conservation in Woodbridge, Guildford and South Guildford that are not regularly mowed (Dundas and Mills 2011; SRT 2008a). Plan for ‘conservation areas’ as well as ‘maintenance areas’ with each having a distinct and separate program of maintenance.

4.2 Categorisation

Each segment has been assigned a category from 0 to 8 based on its management priority. This was based on a reach priority shuffle method developed by the CRC for Catchment Hydrology (Rutherfurd *et al*., 2000a and 2000b). The categorisation allows prioritisation of segments and highlights areas of riverbank for restoration activities to be conducted.

The East section of the river, Mundaring Weir to Pumpback Dam, was the only section with areas that fit into prioritisation category 1 (37.5 per cent of the East

section fits into category 1). The east section also contained a large portion that fits into category 3, with smaller stretches that fit into categories 4, 5 and 6.

The Central section of the river, Pumpback Dam to Scott Street, was mostly consistent with category 3, with a smaller part falling into category 2.

The West section of the river, Scott Street crossing to the confluence with the Swan River, was mostly category 3, with shorter sections fitting into category 5, 7 and 8.

The categorisation results illustrates the decline in condition from east to west.

Table 14: Length and percentage of the Helena River assigned to each prioritisation category (refer to Table 1 for the criteria used to assign categories).

Prioritisation category	Section of Helena River							
	East		Central		West		Overall	
	Km	%	Km	%	Km	%	Km	%
0	0	0	0	0	0	0	0	0
1	9.18	37.5	0	0	0	0	9.18	13.5
2	0	0	1.75	18.1	0	0	1.75	2.6
3	10.5	42.9	7.88	81.9	20.48	60.3	38.86	57.1
4	1.82	7.4	0	0	0	0	1.82	2.7
5	1.81	7.4	0	0	4.72	13.9	6.53	9.6
6	1.18	4.8	0	0	0	0	1.18	1.7
7	0	0	0	0	7.66	22.5	7.66	11.2
8	0	0	0	0	1.11	3.3	1.11	1.6
Total	**24.49**	**100**	**9.63**	**100**	**33.97**	**100**	**68.09**	**100**

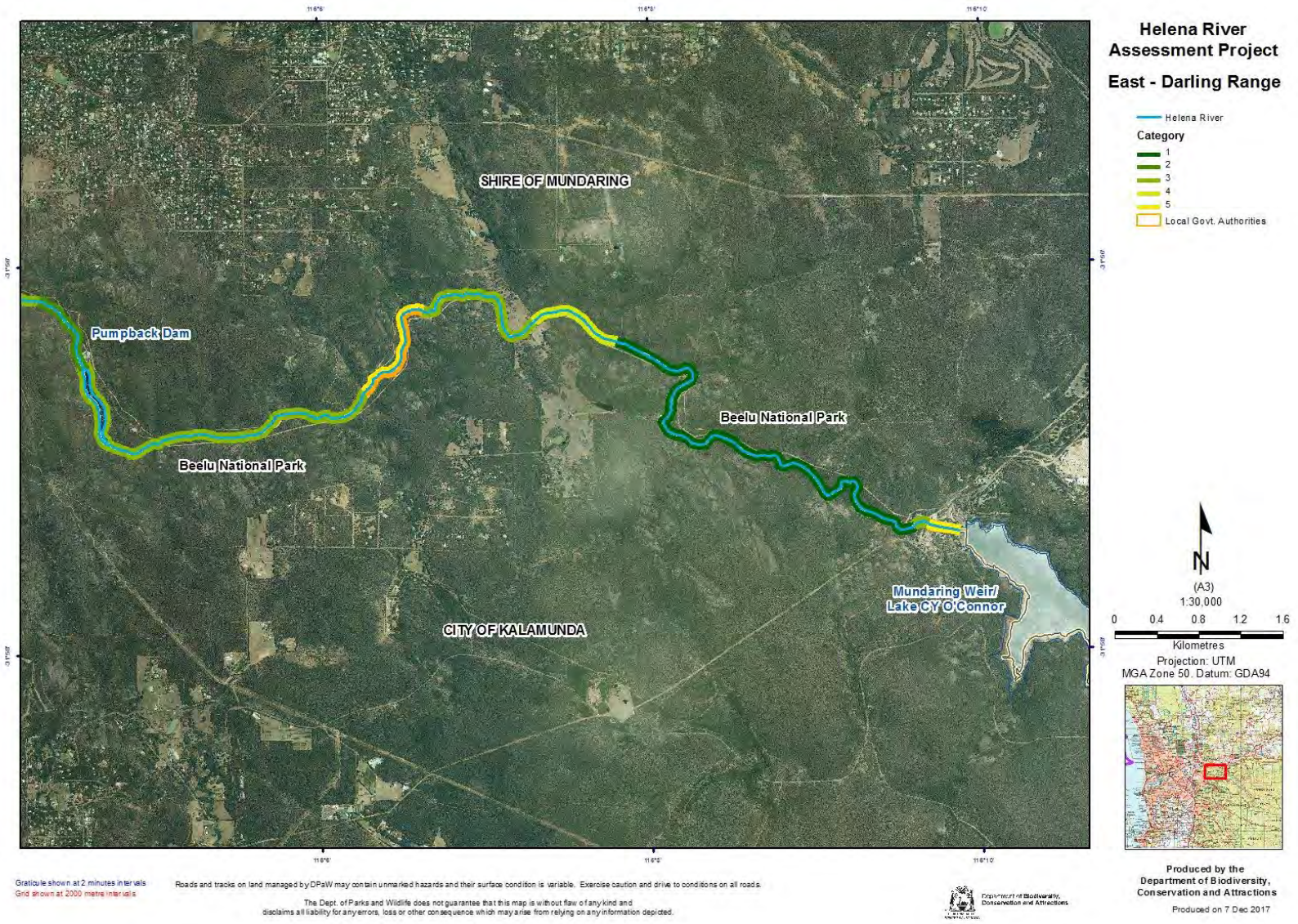


Figure 64: Prioritisation categories assigned to the Helena River, East section (refer to Table 1 for criteria used).

Figure 65: Prioritisation categories assigned to the Helena River, Central section.

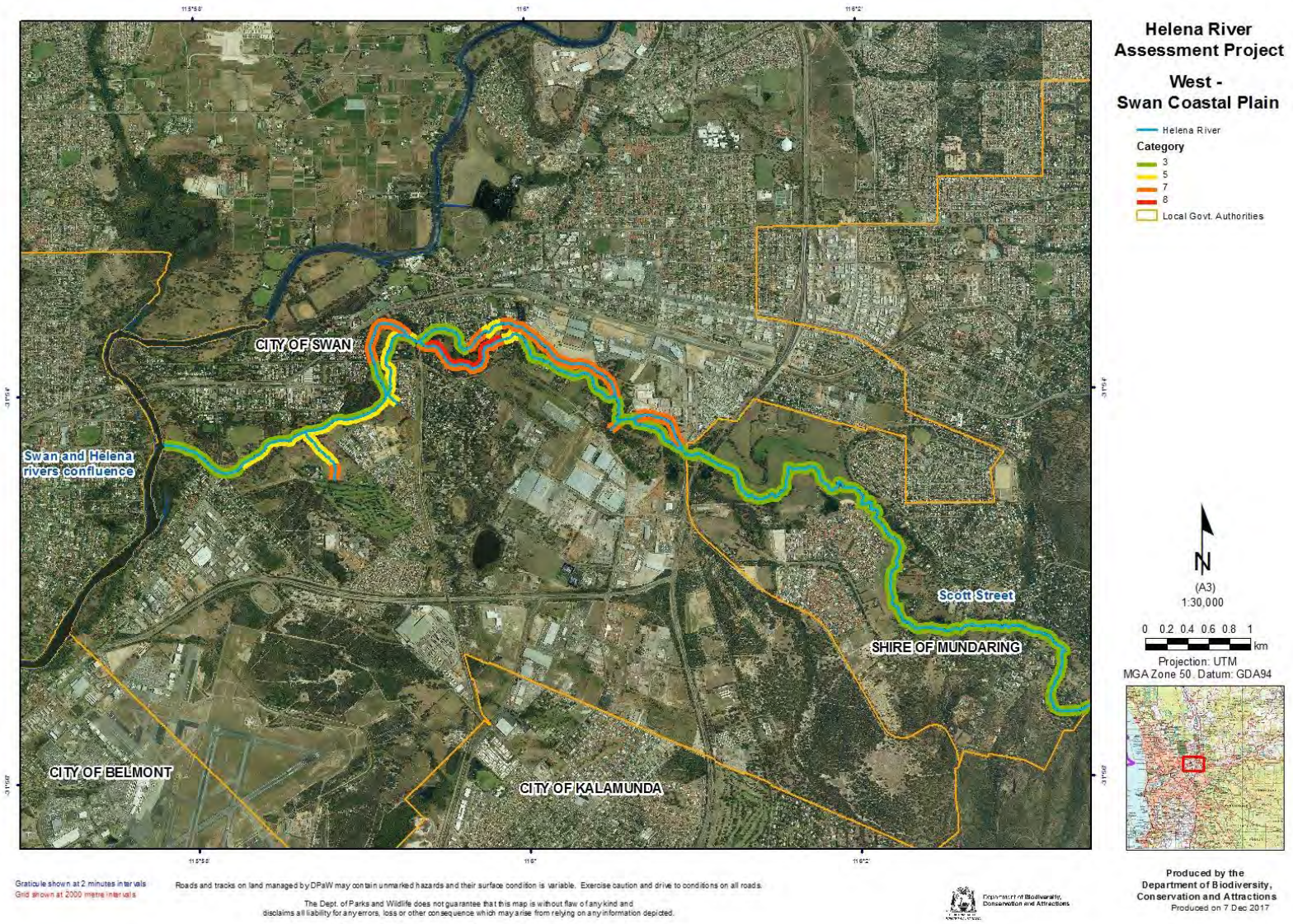


Figure 66: Prioritisation categories assigned to the Helena River, West section.

4.3 Site recommendations

Recommendations that can be achieved in the short to intermediate term have been included for each segment (Table 15). The recommendations include activities such as:

- controlling or locally eradicating weed species that are currently low in coverage and can be removed without a high investment in time or funding;
- addressing issues with uncontrolled access that are impacting on the riverbank;
- infill planting in sites where weeds have been controlled or prior revegetation has taken place; and
- planting behind single lines of trees that remain on the riverbank and are threatened by localised erosion.

In Table 15, recommendations are listed against segment numbers in order of location but can be prioritised based on management category (from 0 to 8). In some instances, there may be high community capacity or landholder ability to undertake works, or recommended works support the actions of already existing projects and their priority may be increased. See Figure 67, Figure 68 and Figure 69 for the segment number that matches to Table 15.

For each segment, recommended species for revegetation are provided by referring to the vegetation complex that the segment is located in, and then the list of native wetland or riparian species for that complex, included in Appendix 5. These species lists have been compiled by referring to the Apace WA website (n.d.). Note that species recommended for Southern River are the same as those for the Guildford complex as the Apace website does not list a specific Southern River complex revegetation catalogue.

Table 15: Recommendations that can be achieved in the short to intermediate term for each segment of the Helena River from Mundaring Weir to the confluence with the Swan River (refer to Figure 67*,* Figure 68 *and* Figure 69 *for segment locations).*

Segment number	River section	Category (LB)	Category (RB)	Short to intermediate term recommendation for management
101	East	5	5	Water Corp managed area. Potential site for weed control and revegetation at the top of the catchment. High visibility and high visitor rate
102	East	5	5	Water Corp managed area. Potential site for weed control and revegetation at the top of the catchment. High visibility and high visitor rate. Remove dolichos pea
103	East	3	3	Water Corp managed area. Potential site for weed control and revegetation at the top of the catchment. High visibility and high visitor rate. Remove dolichos pea
104	East	1	1	Remove wattle and olive both banks, and morning glory, dolichos pea, red valerian

Segment number	River section	Category (LB)	Category (RB)	Short to intermediate term recommendation for management
				and veldt daisy RB. Good seed bank evident and natives are likely to regenerate with removal of weeds
105	East	1	1	Address issues with 4WDs, camping and rubbish. Remove arum lily
106	East	1	1	
107	East	1	1	Remove blackberry patch at west of segment
108	East	4	4	Address issues with 4WD access at O'Connor Rd and localised erosion. Remove blackberry patch at east of segment (O'Connor Rd crossing). Remove plastic bags from >5 year old revegetation LB
109	East	3	3	Remove cotton bush and fig. Check paddock adjacent to LB and remove cotton bush if present
110	East	3	3	Remove cotton bush
111	East	6	5	Check Typha sp and remove if T.orientalis
112	East	3	3	Remove arum lily LB and fennel RB
113	East	3	3	Remove arum lily LB, lavender and olive on pipe access track LB; remove fig; blackberry near crossing; watsonia from tributary near Pumpback Dam RB. Control weeds in Piesse Brook at confluence
114	East	3	3	Remove watsonia from uphill of the vehicle track on south side of river, and from small tributary on north side of the dam
115	Central	2	2	Support volunteer watsonia control. Address slumping issue on Water Corp access track which is impacting vegetation below
116	Central	3	3	Remove buckthorn, olives. Support volunteer watsonia control. Address issues with 4WDs driving into and across riparian zone
117	Central	3	3	Remove fig, buckthorn (mostly north side river) and weedy acacias from informal carpark south side river. Address issues with 4WDs driving into and across riparian zone, and camping and rubbish in carpark
118	Central	3	3	Investigate water extraction in the area. Remove buckthorn, watsonia, cotton bush, palm, olive. Remove any new mango

Segment number	River section	Category (LB)	Category (RB)	Short to intermediate term recommendation for management
				seedlings. Encourage landholders to remove invasive seedlings
119	Central	3	3	Investigate water extraction in the area. Remove arum lily, fig, watsonia, date palm and buckthorn. Encourage landholders to remove invasive seedlings
120	Central	3	3	Remove cotton bush, buckthorn, watsonia and wonga vine. Plant deep rooted natives on bend to reduce erosion risk. Investigate marri deaths south side of river. Encourage removal of invasive seedlings
121	Central	3	3	Monitor for watsonia and remove if found. Remove fig, blackberry, arum lily and date palm. Good potential site for revegetation at the eastern side of Scott St bridge: plant sedges in floodplain
122	West	3	3	Remove arum lily and cotton bush
123	West	3	3	Remove cotton bush, castor oil and fennel. Liaise with WAPC for potential widening of riparian zone and moving fence further back from riverbank
124	West	3	3	Fence could be moved back further from river to prevent stock access. Remove castor oil and Brazilian pepper. Site of proposed subdivision and wetland construction with WAPC
125	West	3	3	Manage bank retreat through revegetation of deep rooted native species. Remove dumped rubbish and consider erecting dumping sign. Protect upperstorey
126	West	7	7	Manage sedimentation from industry and prevent further erosion of sand from vehicle track at top of steep embankment RB
127	West	7	7	Prevent goat access to the river. Remove arum lily and fountain grass. Segment is very degraded and rehab will be difficult. Monitor for and manage sedimentation down embankment from housing development
128	West	7	7	Consider preventing or reducing runoff from industrial property above shallow pool at top of drain
129	West	3	3	Remove arum lily and cotton bush. Remove dumped rubbish and consider erecting dumping sign

Segment number	River section	Category (LB)	Category (RB)	Short to intermediate term recommendation for management
130	West	5	5	Monitor for invasive weeds coming from upstream. Follow up weed control in revegetation area. Infill planting in future if required
131	West	7	8	Monitor olive grove and remove any new seedlings. Support Lower Helena Association revegetation project
132	West	5	5	Support volunteer group in this area; successful weed control and revegetation has been conducted over the last decade
133	West	7	7	Need to get private property owners on board to do any restoration works. Opportunity for landholder education
134	West	3	3	Test water quality as water is very orange. May need to remove silt and allow better flow. Monitor for weed seedlings from private property. Opportunity for landholder education
135	West	3	5	Remove fig and willow LB. Replace sprayed sedges. Support existing weed control
136	West	7	7	Remove arum lily, fig, olive, cotton bush and Patersons curse. Remove weed seedlings coming from adjacent gardens. Opportunity for landholder education
137	West	3	3	Remove arum lily and other weeds to the west of the culvert under Water St
138	West	5	5	Revegetate bank with sedges for stabilisation. Plant understorey in revegetation site
139	West	5	5	Continue weed control and revegetation at the western end of the segment
140	West	5	3	Test water quality in urban drain basin and river. Remove olive and arum lily. Consider workshop with residents in urban drain basin
141	West	5	3	Remove saffron thistle LB, and arum lily, olive and fig RB. Monitor for weed seedlings from adjacent gardens. Opportunity for landholder education
142	West	3	3	Instate a weed buffer between mown grass and riparian vegetation. Remove date palm, watsonia and nasturtium. Suitable area for iconic project to improve access along foreshore and even on water eg.kayak

Segment number	River section	Category (LB)	Category (RB)	Short to intermediate term recommendation for management
143	West	5	5	Continue to hand pull weeds. Manage silt coming through drain from new housing development
144	West	7	7	Remove degraded fence that is a hazard to fauna. Remove lupins. Very degraded, but begin weed control and revegetation to support the works being conducted in the lower part of the drain

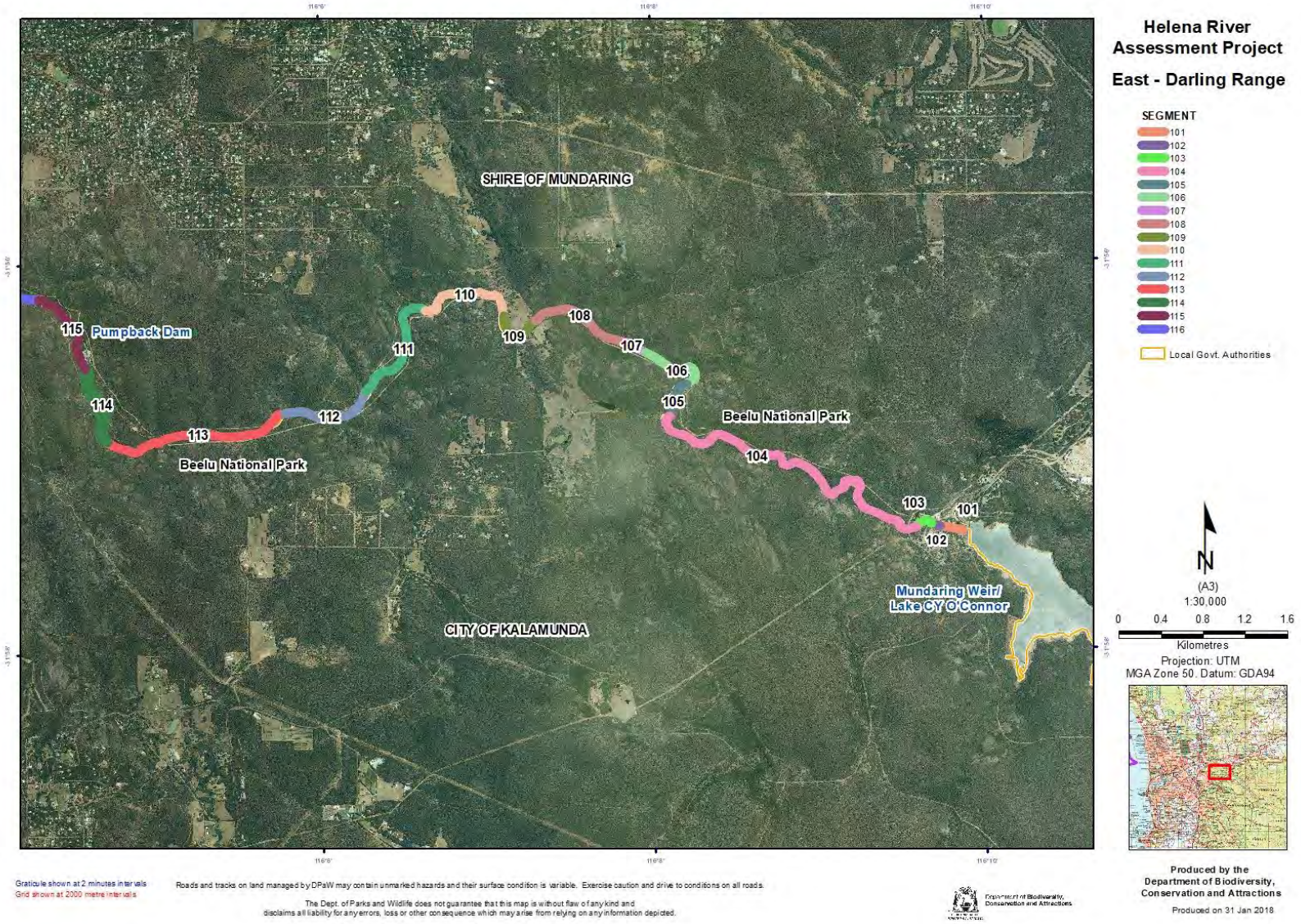


Figure 67: Helena River segment numbers, East section.

Figure 68: Helena River segment numbers, Central section.

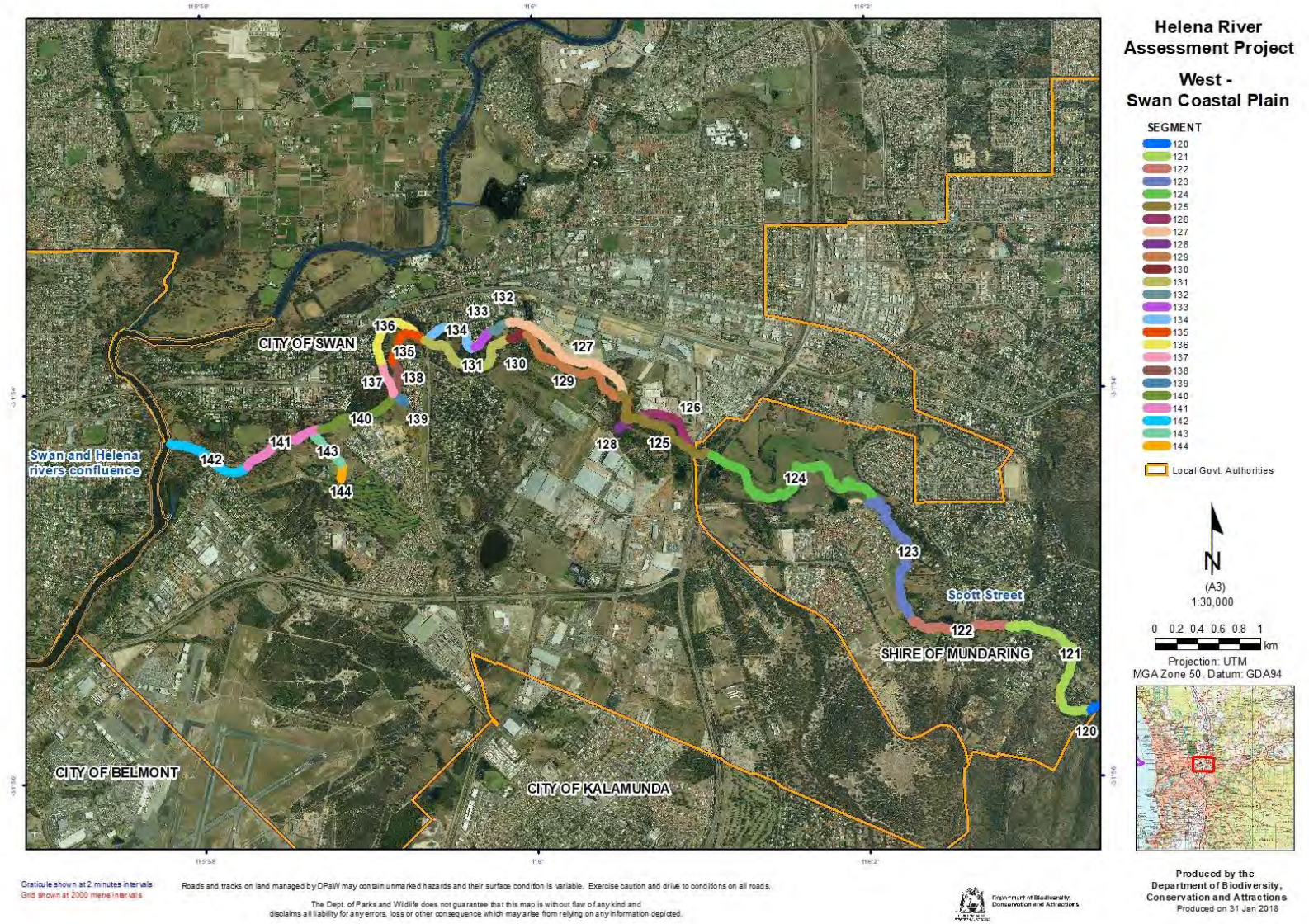


Figure 69: Helena River segment numbers, West section.

5 Assumptions and limitations of the method

The method of assessment used was primarily adopted as it had been used for the previous assessment by DWER in 2006 which enabled us to compare data and change in condition more accurately. The benefits of the assessment technique are that it is rapid, does not require specialist equipment and can be conducted by officers experienced in land management and plant identification.

We were not able to access the entire length of the riverbank due to private property and terrain. It is possible in these segments that areas of erosion, weed species and other management issues were therefore not seen or recorded.

There is some subjectivity with several of the fields in the on-ground survey, for example where assessors needed to make a call between the level of weed cover, vegetation condition, bank stability and level of pressure. We combated this subjectivity by using the same assessor throughout, bringing a degree of consistency across the assessment.

Other fields which were open to subjectivity and some ambiguity were the 'with hope/without hope' and trajectory fields. We used several questions that we asked of each other in the field for a consistent approach - for hope, we asked if there was no intervention and restoration works whether the segment was capable of recovering on its own. For trajectory we asked if the segment would improve or decline in condition based on the current level of management and condition. This was particularly important given that these fields played a significant role in assigning prioritisation categories 3 to 8.

The Pen and Scott grading was originally designed for farming and rural areas so the information relating to grazing and stock access to the river was not relevant for most of the Helena River system. In particular, the C grades were often not relevant as these relate to erosion prone segments where bank vegetation has been cleared by stock. Banks within a segment may have been covered in weeds, and with an absence of stock the weedy understorey was generally intact and the bank therefore not subject to erosion. However, the segment may have otherwise been in poor condition and subject to other pressures (such as adjacent industrial development from which there may be runoff into the segment) but were not listed in this assessment grading system.

Although bank stability could have been considered good, other factors may have been poor – the bank may have been entirely covered in weeds, providing stability, but limited habitat value. Care will need to be taken with any planned weed control works to ensure that large amounts of sediment do not erode during or after restoration. A thick understorey of weeds can also make it difficult to see underlying erosion issues on the bank.

Timing of the survey is an important factor to consider. Season affects which species (both native and weed) are most evident and identifiable at the time of assessment and coverage of grass and herbaceous species can change fairly rapidly. This was not so much an issue during this assessment as it was all

completed in late spring/early summer, but is a factor to consider when comparing the results to the previous assessment, and when comparing to other tributaries that were assessed at a different time of year.

Comparison with previous assessments was challenging as different methods were used for the Swan River Trust and the WRC surveys. The DWER assessment was most closely aligned although in some places the segments lengths were quite different making comparison difficult. For example, DWER had only one segment from Mundaring Weir to the Pumpback Dam, whereas we had distinguished 13 segments that varied in landform and condition. This meant we had more variation and detail in condition indicators whereas the DWER assessment summarised these data over this section of river.

Appendices

Appendix 1 Vegetation complexes within a 500m buffer of the Helena River, from Heddle *et al*. (1980)

Mapping unit	Vegetation complex	Description	Other representative species
Darling Plateau	Darling Scarp	Includes a large variety of flora on a unique geological feature. There is variation of the floristic and structural composition of the vegetation. Dominance of *Eucalyptus wandoo* along the entire length of the Darling Scarp with an admixture of *Corymbia calophylla*. Vegetation ranges from low open woodland of *E. wandoo* with *C. calophylla*, through low open forest of *Allocasuarina huegeliana*, through heath, through herblands of *Borya nitida* to lithic complex on granite rocks	Shrub species include *Thomasia glutinosa, Verticordia acerosa, Hakea incrassata, Hakea stenocarpa, Grevillea bipinnatifida, Hovea pungens, Goodenia fasciculata, Petrophile biloba, Conospermum huegelii* and *Grevillea endlicheriana*
Darling Plateau	Helena, in low to medium rainfall	Vegetation is variable depending on soil depth, and ranges from open-forest to lichens. The distinctive feature is open-woodland of *Eucalyptus wandoo* on the valley slopes and floors. Granite outcrops and associated woodlands, and *Corymbia calophylla* and *Eucalyptus marginata* woodlands, are also features of this complex	Shrub species include *Hakea lissocarpha*, *Hypocalymma angustifolium*, *Leucopogon capitellatus, L. propinquus*, *Phyllanthus calycinus* and *Trymalium ledifolium.* Also *Macrozamia riedlei*.

Mapping unit	Vegetation complex	Description	Other representative species
Swan Coastal Plain	Forrestfield	Dominated by open forest of *Corymbia calophylla-Eucalyptus wandoo-Eucalyptus marginata* on the heavier gravelly soils and *E. marginata – C. calophylla-Alloasuarina fraseriana* on the sandier soils. The complex is dissected by a series of streams which support fringing woodland of *Eucalyptus rudis-Melaleuca rhaphiophylla*	*Banksia grandis, Xylomelum occidentale, Banksia sessilis, Macrozamia riedlei, Xanthorrhoea preisii* and species of *Hibbertia*. On sandier soils common species include *Banksia attenuata, Banksia grandis, Stirlingia latifolia, Mesomelaena tetragona* and *Nuytsia floribunda*
Swan Coastal Plain	Guildford	Dominated by a mixture of open forest, in sections tall open forest, of *Corymbia calophylla-Eucalyptus wandoo-Eucalyptus marginata* and woodland of *E. wandoo*, with minor components including fringing woodland of *Eucalyptus rudis-Melaleuca rhaphiophylla* along streams and the rare *E. lane-poolei*	*Banksia grandis*, *Kingia australis*, *Xanthorrhoea preissii* and *Hardenbergia* and *Hibbertia* species
Swan Coastal Plain	Southern River	Consists of open woodland of *Corymbia calophylla-Eucalyptus marginata -Banksia* species on the elevated areas and fringing woodland of *Eucalyptus rudis-Melaleuca rhaphiophylla* along streams	
Swan Coastal Plain	Swan	Dominated by woodland of *Eucalyptus rudis-Melaleuca rhaphiophylla*, with localised occurrences of low open forest of *Casuarina obesa* and *Melaleuca cuticularis*	*Leptocarpus, Juncus, Cyperus, Schoenus* and *Scirpus* species

Appendix 2 - Recognised natural values adjacent to the Helena River

Note that the Environmentally Sensitive Areas combine datasets for Bush Forever Sites, Ramsar wetlands, World Heritage property, Declared Rare Flora, Swan Coastal Plain geomorphic wetlands, Important Wetlands, TECs or are on the register of National Estate and these sites are covered in the following tables.

Nationally Important Wetlands within a 500-metre buffer of the Helena River

Reference code	Wetland name
WA091	Swan-Canning Estuary

Bush Forever Sites within a 500-metre buffer of the Helena River

Site number	Site name	Landform element
215	Helena River, Helena Valley	Estuaries, rivers and creeks
216	Adelaide Crescent bushland, Helena Valley	Foothills/Pinjarra Plain
311	South Guildford bushland, Hazelmere	Foothills/Pinjarra Plain
491	Swan River backwater, South Guildford	Estuaries, rivers and creeks

Known threatened and priority flora within a 500-metre buffer of the Helena River

Scientific name	Common name	WA *Wildlife Conservation Act 1950* conservation status
Acacia aphylla	Leafless rock wattle	Vulnerable
Acacia oncinophylla subsp. *oncinophylla*		P3

Scientific name	Common name	WA *Wildlife Conservation Act 1950* conservation status
Anthocercis gracilis	Slender tailflower	Vulnerable
Boronia tenuis		P4
Darwinia apiculata	Scarp darwinia	Endangered
Grevillea manglesii subsp. *dissectifolia*		P3
Halgania corymbosa		P3
Pithocarpa corymbulosa		P3
Senecio leucoglossus		P4
Tetratheca sp. Granite (S. Patrick SP1224)		P3

Known threatened and priority fauna within a 500-metre buffer of the Helena River

Scientific name	Common name	WA *Wildlife Conservation Act 1950* conservation status
Ardea modesta	Great egret, white egret	Migratory birds protected under International Agreement
Cacatua pastinator pastinator	Muir's corella	Conservation Dependent
Calyptorhynchus banksii naso	Forest red-tailed black cockatoo	Vulnerable
Calyptorhynchus baudinii	Baudin's cockatoo	Endangered
Calyptorhynchus latirostris	Carnaby's cockatoo	Endangered
Ctenotus delli	Dell's skink	P4
Dasyurus geoffroii	Chuditch	Vulnerable

Falco peregrinus	Peregrine falcon	Other Specially Protected fauna
Isoodon obesulus fusciventer	Quenda	P4
Merops ornatus	Rainbow bee-eater	IA
Myrmecobius fasciatus	Numbat	Endangered
Pseudocheirus occidentalis	Western ringtail possum	Endangered
Westralunio carteri	Carter's freshwater mussel	Vulnerable

Threatened and Priority Ecological Communities within a 500-metre buffer of the Helena River

Community ID code	Community name	Conservation status
SCP20a	*Banksia attenuata* woodlands over species rich dense shrublands	Endangered
SCP20c	Shrublands and woodlands of the eastern side of the Swan Coastal Plain	Critically Endangered
SCP3c	*Corymbia calophylla-Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	Critically Endangered
Central Granite Shrublands (Com 5, Markey)	Central Northern Darling Scarp Granite Shrubland Community	Priority 4
131	Banksia woodlands of the Swan Coastal Plain	EPBC: Endangered

Appendix 3 - Dominant native species

Dominant native species that were recorded for each section of the Helena River

			Section of river		
Abbreviation	**Scientific name**	**Common name**	**East**	**Central**	**West**
Aca den	*Acacia dentifera*	Toothed wattle		■	
Aca pul	*Acacia pulchella*	Prickly moses	■		
Aca sal	*Acacia saligna*	Orange wattle	■		■
Aca sp	*Acacia sp*				■
Ast sp	*Astartea sp*	Probably *A.fascicularis*	■		■
Bau art	*Baumea articulata*	Jointed twigrush		■	
Bau jun	*Baumea juncea*	Bare twigrush	■		
Bau sp	*Baumea sp*	Twigrush	■		
Bau vag	*Baumea vaginalis*	Sheath twigrush	■	■	
Bol cal	*Bolboschoenus caldwellii*	Marsh club-rush			■
Bos spi	*Bossiaea spinescens*		■	■	
Cal pho	*Callistemon phoeniceus*	Lesser bottlebrush	■		
Cal qua	*Calothamnus quadrifidus*	One-sided bottlebrush	■	■	■
Cas obe	*Casuarina obesa*	Swamp sheoak			■
Cen asc	*Centella asciatica*	Centella			■
Cha ari	*Chaetanthus aristatus*		■		■
Cle pub	*Clematis pubescens*	Old man's beard	■		
Cor cal	*Corymbia calophylla*	Marri	■	■	
Cyp N sp	*Cyperaceae sp*	Native sedge	■		
Dar cit	*Darwinia citriodora*	Lemon-scented darwinia	■		
Euc rud	*Eucalyptus rudis*	Flooded gum	■	■	■
Euc wan	*Eucalyptus wandoo*	Wandoo	■		
Gas bil	*Gastrolobium bilobum*	Heart leaf poison	■		
Gas vil	*Gastrolobium villosum*	Crinkled-leaved poison	■		
Gre div	*Grevillea diversifolia*	Variable-leaved grevillea		■	
Gre end	*Grevillea endlicheriana*	Spindly grevillea	■		
Gre man	*Grevillea manglesii*	Smooth grevillea	■	■	
Hak tri	*Hakea trifurcata*	Two-leaf hakea	■		
Hib hyp	*Hibbertia hypericoides*	Yellow buttercup	■		
Hib ser	*Hibbertia serrata*	Serrate leaved guinea flower	■		

Hyp ang	*Hypocalymma angustifolium*	White myrtle
Hyp rob	*Hypocalymma robustum*	Swan River myrtle
Jun pal	*Juncus pallidus*	Pale rush
Jun pau	*Juncus pauciflorus*	Loose flower rush
Jun sp	*Juncus sp*	
Lab lan	*Labichea lanceolata*	Tall labichea
Lep lon	*Lepidosperma longitudinale*	Pithy sword-sedge
Lep sp	*Lepidosperma sp*	Sword sedge
Les bil	*Lechenaultia biloba*	Blue leschenaultia
Mel par	*Melaleuca parviceps*	Rough honeymyrtle
Mel rad	*Melaleuca radula*	Graceful honeymyrtle
Mel rha	*Melaleuca rhaphiophylla*	Swamp paperbark
Ort lax	*Orthrosanthus laxus*	Morning iris
Par lop	*Paraserianthes lophantha*	Albizia
Pim cil	*Pimelea ciliata*	White banjine
Pte esc	*Pteridium esculentum*	Bracken fern
Tho sp	*Thomasia sp*	
Try odo	*Trymalium odoratissimum*	Karri hazel
Typ sp.	*Typha domingensis or T.orientalis**	Typha
Typ dom	*Typha domingensis*	Native bulrush
Vim jun	*Viminaria juncea*	Swishbush
Xan pre	*Xanthorrhoea preissii*	Balga

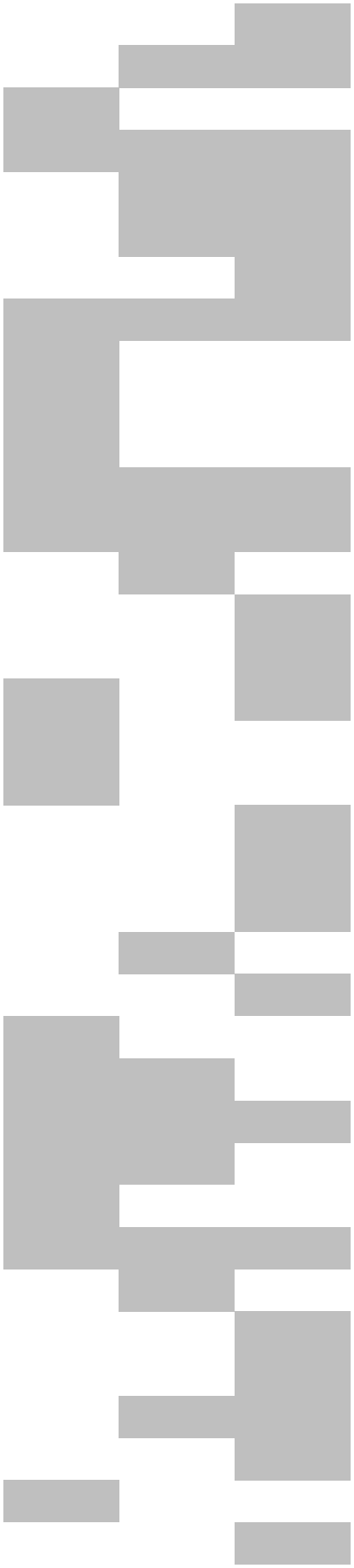
**T.orientalis* is likely to be a native species, but has weedy tendencies (Keighery and McCabe 2015).

Appendix 4 - Weed species sighted

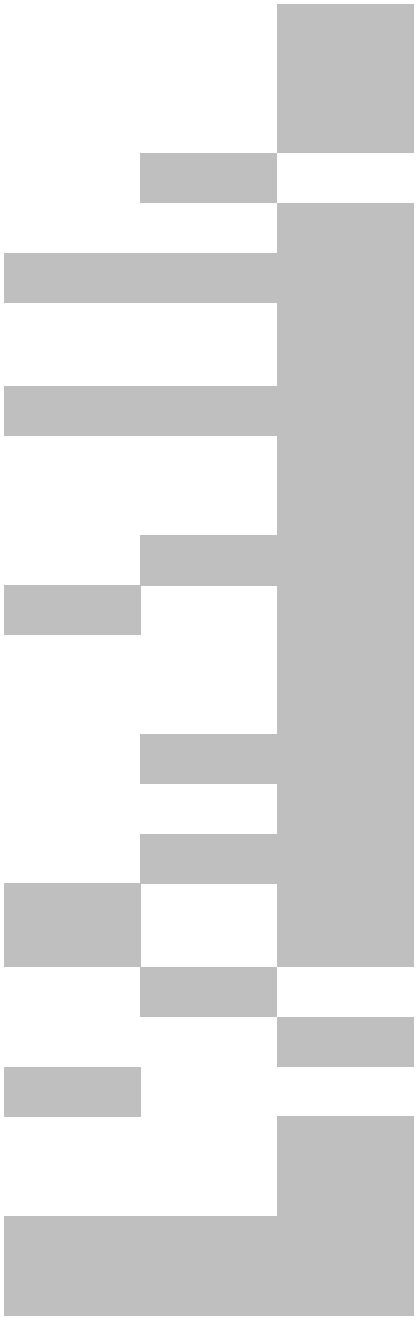
Weed species sighted in the riparian zone for each section of the Helena River. There are likely to be several other species not detected and therefore not recorded

			Section of river		
Abbreviation	**Scientific name**	**Common name**	**East**	**Central**	**West**
Aca bai	*Acacia baileyana*	Cootamundra wattle		■	
Aca dec	*Acacia decurrens*	Early black wattle	■	■	
Aca pod	*Acacia podalyriifolia*	Queensland silver wattle		■	■
Aga pra	*Agapanthus praecox*	Agapanthus	■		
All tri	*Allium triquetrum*	Three-cornered garlic		■	■
Ana arv	*Anagallis arvensis var. arvensis*	Orange pimpernel			■
Ana cae	*Anagallis arvensis var. caerulea*	Blue pimpernel	■	■	■
Arc cal	*Arctotheca calendula*	Cape weed	■	■	■
Aru don	*Arundo donax*	Giant reed	■	■	■
Asp asp	*Asparagus asparagoides*	Bridal creeper	■	■	
Asp off	*Asparagus officinalis*	Asparagus	■		
Ave bar	*Avena barbata*	Bearded oats		■	■
Bab ang	*Babiana angustifolia*	Baboon flower	■		
Bra dis	*Brachypodium distachyon*	False brome			■
Bri max	*Briza maxima*	Blowfly grass		■	■
Bri min	*Briza minor*	Shivery grass		■	■
Bro dia	*Bromus diandrus*	Great brome			■
Bro hor	*Bromus hordeaceus*	Soft brome			■
Cal sp	*Callistemon sp*	Eastern states bottlebrush			■
Can sp	*Canna hybrid*	Canna lilies			■
Cen rub	*Centranthus ruber*	Red valerian	■		
Cen set	*Cenchrus setaceus*	Fountain grass			■
Cha pal	*Chamaecytisus palmensis*	Tree lucerne; Tagasaste	■		
Cha flo	*Chasmanthe floribunda*	African cornflag	■		
Cir vul	*Cirsium vulgare*	Spear thistle			■
Con sp	*Conyza sp*	Fleabane	■		
Cor sel	*Cortaderia selloana*	Pampas	■		

Cyn dac	*Cynodon dactylon*	Couch
Cyp sp	*Cyperus sp*	Cyperus sedge
Dip lig	*Dipogon lignosus*	Dolichos pea
Ech pla	*Echium plantagineum*	Paterson's curse
Ehr cal	*Ehrharta calycina*	Perennial veldt grass
Era cur	*Eragrostis curvula*	African lovegrass
Euc sp	*Eucalyptus sp.*	Eastern state eucalypt
Fic car	*Ficus carica*	Fig
Foe vul	*Foeniculum vulgare*	Fennel
Fra sp	*Fraxinus sp*	Ash
Fre sp	*Freesia sp*	Freesia
Fum cap	*Fumaria capreolata*	White fumitory
Gom fru	*Gomphocarpus fruticosus*	Cotton bush
Hed hel	*Hedera helix*	Ivy
Hib sca	*Hibbertia scandens*	Snake vine
Hyp sp	*Hypochaeris sp*	Catsear or flatweed
Ipo sp	*Ipomoea sp*	Morning glory
Ixi sp	*Ixia sp*	Ixia
Lav sto	*Lavandula stoechas*	Lavender
Lol sp	*Lolium sp*	Ryegrass
Lot ang	*Lotus angustissimus*	Slender birdsfoot trefoil
Lup cos	*Lupinus cosentinii*	Lupin
Man ind	*Mangifera indica*	Mango
Med pol	*Medicago polymorpha*	Burr medic
Mel maj	*Melianthus major*	Honeyflower
Mor fla	*Moraea flaccida*	One leaf cape tulip
Ole eur	*Olea europaea*	Olive
Ost eck	*Osteospermum ecklonis*	Veldt daisy
Oxa inc	*Oxalis incarnata*	White oxalis
Oxa pes	*Oxalis pes-caprae*	Oxalis
Pan pan	*Pandorea pandorana*	Wonga vine
Pen cla	*Pennisetum clandestinum*	Kikuyu
Pha sp	*Phalaris sp.*	Canary grass
Pho dac	*Phoenix dactylifera*	Date palm
Phy nod	*Phyla nodiflora*	Lippia
Pin sp	*Pinus sp*	Pine
Pla lan	*Plantago lanceolata*	Plantain



Pru vul	*Prunella vulgaris*	Self heal
Ran mur	*Ranunculus muricatus*	Sharp buttercup
Rap rap	*Raphanus raphanistrum*	Wild radish
Rha ala	*Rhamnus alaternus*	Buckthorn
Ric com	*Ricinus communis*	Castor oil
Rom ros	*Romulea rosea*	Guildford grass
Ror aqu	*Rorippa nasturtium-aquaticum*	Watercress
Rub sp	*Rubus sp.*	Blackberry
Rum cri	*Rumex crispus*	Curled dock
Sal bab	*Salix babylonica*	Willow
Sch ter	*Schinus terebinthifolius*	Brazilian pepper
Sol nig	*Solanum nigrum*	Black berry nightshade
Sol sol	*Soleirolia soleirolii*	Baby's tears
Son asp	*Sonchus asper*	Prickly sowthistle
Son ole	*Sonchus oleraceus*	Sowthistle
Tri ang	*Trifolium angustifolium*	Narrowleaf clover
Tro maj	*Tropaeolum majus*	Nasturtium
Typ sp.	*Typha domingensis or T.orientalis**	Typha
Val ame	*Vallisneria americana*	Ribbon weed
Vic sat	*Vicia sativa*	Common vetch
Vin maj	*Vinca major*	Blue periwinkle
Vit sp	*Vitis sp*	Grape vine
Was sp	*Washingtonia sp*	Garden fan palm
Wat sp	*Watsonia sp*	Watsonia
Zan aet	*Zantedeschia aethiopica*	Arum lily



T.orientalis is likely to be a native species, but has weedy tendencies (Keighery and McCabe 2015).

Appendix 5 - Suggested revegetation species

Wetland associated species recommended for revegetation in each of the vegetation complexes found on the Helena River, based on Apace WA's (2017) Revegetation Catalogues. All species are available as tubestock.

Soil type/ vegetation complex	Scientific name	Common name	Abbreviation	Growth habit	Height	Area to plant	Season to plant
Darling Scarp	*Acacia alata*	Winged Wattle	Aca ala	Shrub	1-2m	Upper bank or transition	Autumn
Darling Scarp	*Acacia dentifera*		Aca den	Shrub	1-3m	Upper bank or transition	Autumn
Darling Scarp	*Acacia extensa*	Wiry Wattle	Aca ext	Shrub	1-2m	Upper bank or transition	Autumn
Darling Scarp	*Acacia incurva*		Aca inc	Shrub	0.2-0.5m	Upper bank or transition	Autumn
Darling Scarp	*Acacia nervosa*	Rib Wattle	Aca ner	Shrub	0.5m	Upper bank or transition	Autumn
Darling Scarp	*Acacia oncinophylla*		Aca onc	Shrub	1-2m	Upper bank or transition	Autumn
Darling Scarp	*Acacia pulchella*	Prickly Moses	Aca pul	Shrub	1-2m	Upper bank or transition	Autumn
Darling Scarp	*Acacia saligna*	Coojong	Aca sal	Shrub or small tree	2-6m	Upper bank or transition	Autumn
Darling Scarp	*Acacia urophylla*		Aca uro	Shrub	1-5m	Upper bank or transition	Autumn
Darling Scarp	*Actinostrobus acuminatus*	Dwarf Cypress	Act acu	Shrub	0.4m	Upper bank or transition	Autumn
Darling Scarp	*Astartea scoparia*		Ast sco	Shrub	1-2m	Upper bank or transition	Autumn
Darling Scarp	*Banksia nivea*	Couch Honeypot	Ban niv	Shrub	0.3-	Upper bank or	Autumn

					0.7m	transition	
Darling Scarp	*Banksia praemorsa*	Urchin Dryandra	Ban pra	Shrub	2-3m	Upper bank or transition	Autumn
Darling Scarp	*Baumea preissii*	Broad Twig Sedge	Bau pre	Sedge	1.5m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Scarp	*Baumea vaginalis*	Sheath Twig Sedge	Bau vag	Sedge	1.2m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Scarp	*Billardiera floribunda*	White Flowered Billardiera	Bil flo	Climber	0.0m	Upper bank or transition	Autumn
Darling Scarp	*Billardiera fusiformis*	Australian Bluebell	Bil fus	Climber	0.0m	Upper bank or transition	Autumn
Darling Scarp	*Callistemon phoeniceus*	Lesser Bottlebrush	Cal pho	Shrub or tree	1.5-6m	Upper bank or transition	Autumn
Darling Scarp	*Calothamnus quadrifidus*	One-sided Bottlebrush	Cal qua	Shrub	1-2m	Upper bank or transition	Autumn
Darling Scarp	*Calothamnus rupestris*	Cliff Net Bush	Cal rup	Shrub	1-4m	Upper bank or transition	Autumn
Darling Scarp	*Calothamnus sanguineus*	Silky Leaved Blood Flower	Cal san	Shrub	1.2-1.5m	Upper bank or transition	Autumn
Darling Scarp	*Chorizandra multiarticulata*		Cho mul	Sedge	0.5-0.6m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Scarp	*Chorizema cordatum*	Flame Pea	Cho cor	Shrub	0.3-1.5m	Upper bank or transition	Autumn
Darling Scarp	*Conostylis candicans*	Grey Cottonheads	Con can	Grass	0.3-0.4m	Upper bank or transition	Autumn

Darling Scarp	*Dianella revoluta*	Flax Lily, Blueberry Lily	Dia rev	Herb	0.5m	Upper bank or transition	Autumn
Darling Scarp	*Eucalyptus laeliae*	Darling Range Ghost Gum	Euc lae	Tree	6-20m	Upper bank or transition	Autumn
Darling Scarp	*Eucalyptus lane-poolei*	Salmon Gum	Euc lan	Tree	12-15m	Upper bank or transition	Autumn
Darling Scarp	*Eucalyptus marginata*	Jarrah	Euc mar	Tree	10-46m	Upper bank or transition	Autumn
Darling Scarp	*Eucalyptus patens*	Swan River Blackbutt	Euc pat	Tree	10-40m	Upper bank or transition	Autumn
Darling Scarp	*Hakea prostrata*	Harsh Hakea	Hak pro	Shrub	0.3-5m	Upper bank or transition	Autumn
Darling Scarp	*Hakea ruscifolia*	Candle Hakea	Hak rus	Shrub	0.5-3m	Upper bank or transition	Autumn
Darling Scarp	*Hakea undulata*	Wavy-leaved Hakea	Hak und	Shrub	0.8-3m	Upper bank or transition	Autumn
Darling Scarp	*Hakea varia*	Variable Leaved Hakea	Hak var	Shrub	0.5-3m	Upper bank or transition	Autumn
Darling Scarp	*Hypocalymma angustifolium*	White Myrtle	Hyp ang	Shrub	1m	Transition zone	Autumn
Darling Scarp	*Juncus subsecundus*	Finger Rush	Jun sub	Herb	0.3-1m	Transition zone	Autumn
Darling Scarp	*Leptospermum erubescens*	Roadside Tea-tree	Lep eru	Shrub	1-3m	Upper bank or transition	Autumn
Darling Scarp	*Lobelia alata*	Angled Lobelia	Lob ala	Herb	0.1-0.5m	Upper bank or transition	Autumn
Darling Scarp	*Melaleuca lateritia*	Robin Redbreast Bush	Mel lat	Shrub	0.5-2m	Upper bank or transition	Autumn
Darling Scarp	*Melaleuca preissiana*	Modong	Mel pre	Tree	8-10m	Transition zone	Autumn
Darling Scarp	*Melaleuca radula*	Graceful Honey myrtle	Mel red	Shrub	0.3-2.5m	Transition zone	Autumn

Darling Scarp	*Melaleuca rhaphiophylla*	Swamp Paperbark	Mel rha	Tree	7-9m	Upper bank or transition	Autumn
Darling Scarp	*Melaleuca scabra*	Rough Honey Myrtle	Mel sca	Shrub	0.5-1m	Transition zone	Autumn
Darling Scarp	*Melaleuca viminea*	Mohan	Mel vim	Shrub	4-5m	Upper bank or transition	Autumn
Darling Scarp	*Paraserianthes lophantha*	Albizia	Par lop	Shrub or small tree	3-5m	Upper bank or transition	Autumn
Darling Scarp	*Philotheca spicata*	Salt and Pepper	Phi spi	Woody Perennial	0.5-0.6m	Transition zone	Autumn
Darling Scarp	*Sphaerolobium medium*	Globe Pea	Sph med	Shrub	0.4-0.5m	Upper bank or transition	Autumn
Darling Scarp	*Taxandria linearifolia*	Swamp Peppermint	Tax lin	Shrub	2-4m	Transition zone	Autumn
Darling Scarp	*Verticordia acerosa*		Ver ace	Shrub	0.4-1m	Upper bank or transition	Autumn
Darling Scarp	*Verticordia plumosa*	Plumed Feather Flower	Ver plu	Shrub	1-1.5m	Transition zone	Autumn
Darling Scarp	*Villarsia albiflora*		Vil alb	Herb	1m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Scarp	*Xanthorrhoea preissii*	Grass Tree	Xan pre		0.3-3m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Acacia acuminata*	Jam	Aca acu	Tree or shrub	2-5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Acacia alata*	Winged Wattle	Aca ala	Shrub	1-2m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Acacia dentifera*		Aca den	Shrub	1-3m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Acacia extensa*	Wiry Wattle	Aca ext	Shrub	1-2m	Upper bank or transition	Autumn
Darling Valleys	*Acacia incurva*		Aca inc	Shrub	0.2-	Upper bank or	Autumn

(Helena)					0.5m	transition	
Darling Valleys (Helena)	*Acacia nervosa*	Rib Wattle	Aca ner	Shrub	0.5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Acacia oncinophylla*		Aca onc	Shrub	1-2m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Acacia pulchella*	Prickly Moses	Aca pul	Shrub	1-2m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Acacia saligna*	Coojong	Aca sal	Shrub or small tree	2-6m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Acacia urophylla*		Aca uro	Shrub	1-5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Astartea scoparia*		Ast sco	Shrub	1-2m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Banksia littoralis*	Swamp Banksia	Ban lit	Tree	9-10m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Banksia nivea*	Couch Honeypot	Ban niv	Shrub	0.3-0.7m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Banksia praemorsa*	Urchin Dryandra	Ban pra	Shrub	2-3m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Baumea articulata*	Jointed Twig-rush	Bau art	Sedge	2.5m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Valleys (Helena)	*Baumea juncea*	Bare Twig Sedge	Bau jun	Sedge	1-1.2m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Valleys (Helena)	*Baumea preissii*	Broad Twig Sedge	Bau pre	Sedge	1.5m	Lower bank	Spring and summer or winter in seasonally wet areas

Darling Valleys (Helena)	*Billardiera floribunda*	White Flowered Billardiera	Bil flo	Climber	0.0m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Billardiera fusiformis*	Australian Bluebell	Bil fus	Climber	0.0m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Callistachys lanceolata*	Wonnich; Native Willow	Cal lan	Shrub or tree	4-6m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Callistemon phoeniceus*	Lesser Bottlebrush	Cal pho	Shrub or tree	1.5-6m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Calothamnus quadrifidus*	One-sided Bottlebrush	Cal qua	Shrub	1-2m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Calothamnus rupestris*	Cliff Net Bush	Cal rup	Shrub	1-4m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Calothamnus sanguineus*	Silky Leaved Blood Flower	Cal san	Shrub	1.2-1.5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Chorizandra enodis*	Black Bristle-rush	Cho eno	Sedge	0.8-1m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Valleys (Helena)	*Corymbia calophylla*	Marri	Cor cal	Tree	10-20m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Cycnogeton huegelii*	Water Ribbons	Cyc hue	Herb	0.3-2m	In stream	Spring and summer or winter in seasonally wet areas
Darling Valleys (Helena)	*Eucalyptus laeliae*	Darling Range Ghost Gum	Euc lae	Tree	6-20m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Eucalyptus marginata*	Jarrah	Euc mar	Tree	10-46m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Eucalyptus patens*	Swan River Blackbutt	Euc pat	Tree	10-40m	Upper bank or transition	Autumn
Darling Valleys	*Gastrolobium calycinum*	York Road Poison	Gas cal	Shrub	1-1.5m	Transition zone	Autumn

(Helena)							
Darling Valleys (Helena)	*Hakea ceratophylla*	Horned Leaf Hakea	Hak car	Shrub	0.5-2m	Upper bank	Autumn
Darling Valleys (Helena)	*Hakea ruscifolia*	Candle Hakea	Hak rus	Shrub	0.5-3m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Hakea undulata*	Wavy-leaved Hakea	Hak und	Shrub	0.8-3m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Hakea varia*	Variable Leaved Hakea	Hak var	Shrub	0.5-3m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Hypocalymma angustifolium*	White Myrtle	Hyp ang	Shrub	1m	Transition zone	Autumn
Darling Valleys (Helena)	*Juncus pauciflorus*	Loose Flower Rush	Jun pau	Herb	0.3-1m	Transition zone	Autumn
Darling Valleys (Helena)	*Juncus subsecundus*	Finger Rush	Jun sub	Herb	0.3-1m	Transition zone	Autumn
Darling Valleys (Helena)	*Leptocarpus scariosa*	Velvet Rush	Lep sca	Herb	0.6-1.5m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Valleys (Helena)	*Leptospermum erubescens*	Roadside Tea-tree	Lep eru	Shrub	1-3m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Lobelia alata*	Angled Lobelia	Lob ala	Herb	0.1-0.5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Melaleuca incana*	Grey Honeymyrtle	Mel inc	Shrub	2-4m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Melaleuca lateritia*	Robin Redbreast Bush	Mel lat	Shrub	0.5-2m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Melaleuca preissiana*	Modong	Mel pre	Tree	8-10m	Transition zone	Autumn
Darling Valleys (Helena)	*Melaleuca rhaphiophylla*	Swamp Paperbark	Mel rha	Tree	7-9m	Upper bank or transition	Autumn

Darling Valleys (Helena)	*Melaleuca scabra*	Rough Honey Myrtle	Mel sca	Shrub	0.5-1m	Transition zone	Autumn
Darling Valleys (Helena)	*Melaleuca uncinata*	Broom Honeymyrtle	Mel unc	Shrub or small tree	3-5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Melaleuca viminea*	Mohan	Mel vim	Shrub	4-5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Oxylobium lineare*	Narrow-leaved Oxylobium	Oxy lin	Shrub	2-4m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Paraserianthes lophantha*	Albizia	Par lop	Shrub or small tree	3-5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Pericalymma ellipticum*	Swamp Tea Tree	Per ell	Shrub	1m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Philotheca spicata*	Salt and Pepper	Phi spi	Woody Perennial	0.5-0.6m	Transition zone	Autumn
Darling Valleys (Helena)	*Sphaerolobium medium*	Globe Pea	Sph med	Shrub	0.4-0.5m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Taxandria linearifolia*	Swamp Peppermint	Tax lin	Shrub	2-4m	Transition zone	Autumn
Darling Valleys (Helena)	*Verticordia acerosa*		Ver ace	Shrub	0.4-1m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Villarsia albiflora*		Vil alb	Herb	1m	Lower bank	Spring and summer or winter in seasonally wet areas
Darling Valleys (Helena)	*Xanthorrhoea gracilis*	Graceful Grass Tree	Xan gra		1-2m	Upper bank or transition	Autumn
Darling Valleys (Helena)	*Xanthorrhoea preissii*	Grass Tree	Xan pre		0.3-3m	Upper bank or transition	Autumn
Guildford	*Acacia dentifera*		Aca den	Shrub	1-3m	Upper bank or transition	Autumn

Guildford	*Acacia incurva*		Aca inc	Shrub	0.2-0.5m	Upper bank or transition	Autumn
Guildford	*Acacia pulchella*	Prickly Moses	Aca pul	Shrub	1-2m	Upper bank or transition	Autumn
Guildford	*Acacia saligna*	Coojong	Aca sal	Shrub or small tree	2-6m	Upper bank or transition	Autumn
Guildford	*Actinostrobus pyramidalis*	Swamp Cypress	Act pyr	Tree	2.5-3.5m	Upper bank or transition	Autumn
Guildford	*Anigozanthus viridis*	Green Kangaroo Paw	Ani vir	Herbaceous perennial	0.5m	Transition zone	Autumn
Guildford	*Aotus procumbens*		Aot pro	Shrub	0.5m	Upper bank or transition	Autumn
Guildford	*Astartea scoparia*		Ast sco	Shrub	1-2m	Upper bank or transition	Autumn
Guildford	*Banksia littoralis*	Swamp Banksia	Ban lit	Tree	9-10m	Upper bank or transition	Autumn
Guildford	*Banksia telmatiaea*	Swamp Fox Banksia	Ban tel	Shrub	1.5-2m	Upper bank or transition	Autumn
Guildford	*Baumea juncea*	Bare Twig Sedge	Bau jun	Sedge	1-1.2m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Beaufortia elegans*	Elegant Beaufortia	Bea ele	Shrub	0.8-1m	Transition zone	Autumn
Guildford	*Bolboschoenus caldwelii*	Marsh Club-rush	Bol cal	Sedge	0.8-1.2m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Burchardia congesta*	Milkmaids	Bur con	Herbaceous perennial	0.3-0.5m	Transition zone	Autumn
Guildford	*Burchardia multiflora*	Dwarf Burchardia	Bur mul	Herbaceous perennial	0.1-0.3m	Transition zone	Autumn

Guildford	*Calothamnus hirsutus*	Hawkeswood	Cal hir	Shrub	0.3-1.5m	Upper bank or transition	Autumn
Guildford	*Calothamnus lateralis*		Cal lat	Shrub	0.4-1.5m	Upper bank or transition	Autumn
Guildford	*Calothamnus quadrifidus*	One-sided Bottlebrush	Cal qua	Shrub	1-2m	Upper bank or transition	Autumn
Guildford	*Calothamnus sanguineus*	Silky Leaved Blood Flower	Cal san	Shrub	1.2-1.5m	Upper bank or transition	Autumn
Guildford	*Casuarina obesa*	Salt/Swamp Sheoak	Cas obe	Tree	8-10m	Upper bank or transition	Autumn
Guildford	*Centella asiatica*	Centella	Cen asi	Herb	0.2-0.3m	Lower bank to mid bank	Autumn
Guildford	*Chorizandra enodis*	Black Bristle-rush	Cho eno	Sedge	0.8-1m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Conostylis aculeata*	Prickly Conostylis	Con acu	Grass	0.4m	Upper bank	Autumn
Guildford	*Conostylis candicans*	Grey Cottonheads	Con can	Grass	0.3-0.4m	Upper bank or transition	Autumn
Guildford	*Corymbia calophylla*	Marri	Cor cal	Tree	10-20m	Upper bank or transition	Autumn
Guildford	*Cycnogeton huegelii*	Water Ribbons	Cyc hue	Herb	0.3-2m	In stream	Spring and summer or winter in seasonally wet areas
Guildford	*Dampiera trigona*	Angled Stem Dampiera	Dam tri	Herb	0.3-0.5m	Upper bank or transition	Autumn
Guildford	*Dianella revoluta*	Flax Lily, Blueberry Lily	Dia rev	Herb	0.5m	Upper bank or transition	Autumn
Guildford	*Dielsia stenostachya*		Die ste	Herb	0.3-0.6m	Transition zone	Autumn

Guildford	*Eleocharis acuta*	Common Spike-rush	Ele acu	Sedge	0.5-0.7m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Eucalyptus lane-poolei*	Salmon Gum	Euc lan	Tree	12-15m	Upper bank or transition	Autumn
Guildford	*Eucalyptus marginata*	Jarrah	Euc mar	Tree	10-46m	Upper bank or transition	Autumn
Guildford	*Eucalyptus rudis*	Flooded Gum	Euc rud	Tree	5-25m	Upper bank or transition	Autumn
Guildford	*Euchilopsis linearis*	Swamp Pea	Euc lin	Shrub	0.1-1.2m	Upper bank or transition	Autumn
Guildford	*Ficinia nodosa*	Knotted Club Rush	Fic nod	Sedge	0.4-1m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Goodenia filiformis*	Slender Goodenia	Goo fil	Herbaceous perennial	0.4m	Upper bank or transition	Autumn
Guildford	*Haemodorum spicatum*	Mardja	Hae spi	Herb	0.3-2m	Transition zone	Autumn
Guildford	*Hakea ceratophylla*	Horned Leaf Hakea	Hak car	Shrub	0.5-2m	Upper bank	Autumn
Guildford	*Hakea prostrata*	Harsh Hakea	Hak pro	Shrub	0.3-5m	Upper bank or transition	Autumn
Guildford	*Hakea ruscifolia*	Candle Hakea	Hak rus	Shrub	0.5-3m	Upper bank or transition	Autumn
Guildford	*Hakea varia*	Variable Leaved Hakea	Hak var	Shrub	0.5-3m	Upper bank or transition	Autumn
Guildford	*Hypocalymma angustifolium*	White Myrtle	Hyp ang	Shrub	1m	Transition zone	Autumn
Guildford	*Isolepis cernua*	Nodding Club-rush	Iso cer	Sedge	0.2-0.6m	Lower bank	Spring and summer or winter in seasonally wet

							areas
Guildford	*Jacksonia furcellata*	Grey Stinkwood	Jac fur	Shrub	3-4m	Upper bank or transition	Autumn
Guildford	*Jacksonia sternbergiana*	Green Stinkwood	Jac ste	Shrub	3-4m	Upper bank or transition	Autumn
Guildford	*Juncus kraussii*	Sea Rush	Jun kra	Herb	0.3-1.2m	Transition zone	Autumn
Guildford	*Juncus pallidus*	Giant Rush	Jun pal	Herb	0.5-2m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Juncus subsecundus*	Finger Rush	Jun sub	Herb	0.3-1m	Transition zone	Autumn
Guildford	*Kunzea glabrescens*	Spear Wood	Kun gla	Shrub	1.5-4m	Transition zone	Autumn
Guildford	*Kunzea recurva*	Mountain Kunzea	Kun rec	Shrub	0.3-2m	Upper bank or transition	Autumn
Guildford	*Leptocarpus conangustatus*	Velvet Rush	Lep con	Herb	0.5-1.2m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Leptocarpus scariosa*	Velvet Rush	Lep sca	Herb	0.6-1.5m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Lobelia alata*	Angled Lobelia	Lob ala	Herb	0.1-0.5m	Lower bank to mid bank	Autumn
Guildford	*Melaleuca lateritia*	Robin Redbreast Bush	Mel lat	Shrub	0.5-2m	Upper bank or transition	Autumn
Guildford	*Melaleuca preissiana*	Modong	Mel pre	Tree	8-10m	Transition zone	Autumn
Guildford	*Melaleuca radula*	Graceful Honeymyrtle	Mel red	Shrub	0.3-	Transition zone	Autumn

					2.5m		
Guildford	*Melaleuca rhaphiophylla*	Swamp Paperbark	Mel rha	Tree	7-9m	Upper bank or transition	Autumn
Guildford	*Melaleuca scabra*	Rough Honeymyrtle	Mel sca	Shrub	0.5-1m	Transition zone	Autumn
Guildford	*Melaleuca seriata*		Mel ser	Shrub	0.2-1m	Upper bank or transition	Autumn
Guildford	*Melaleuca systena*	Coastal Honeymyrtle	Mel sys	Shrub	0.5-2m	Transition zone	Autumn
Guildford	*Melaleuca teretifolia*	Banbar	Mel ter	Shrub	1.5-5m	Upper bank or transition	Autumn
Guildford	*Melaleuca thymoides*		Mel thy	Shrub	0.4-2m	Upper bank or transition	Autumn
Guildford	*Melaleuca uncinata*	Broom Honeymyrtle	Mel unc	Shrub or small tree	3-5m	Upper bank or transition	Autumn
Guildford	*Melaleuca viminea*	Mohan	Mel vim	Shrub	4-5m	Upper bank or transition	Autumn
Guildford	*Pericalymma ellipticum*	Swamp Tea Tree	Per ell	Shrub	1m	Upper bank or transition	Autumn
Guildford	*Philotheca spicata*	Salt and Pepper	Phi spi	Woody Perennial	0.5-0.6m	Transition zone	Autumn
Guildford	*Regelia ciliata*		Reg cil	Shrub	1.5-2m	Upper bank or transition	Autumn
Guildford	*Regelia inops*		Reg ino	Shrub	2-2.5m	Upper bank or transition	Autumn
Guildford	*Sphaerolobium medium*	Globe Pea	Sph med	Shrub	0.4-0.5m	Upper bank or transition	Autumn
Guildford	*Taxandria linearifolia*	Swamp Peppermint	Tax lin	Shrub	2-4m	Transition zone	Autumn
Guildford	*Verticordia acerosa*		Ver ace	Shrub	0.4-1m	Upper bank or transition	Autumn
Guildford	*Verticordia plumosa*	Plumed Feather Flower	Ver plu	Shrub	1.5m	Upper bank or	Autumn

						transition	
Guildford	*Villarsia albiflora*		Vil alb	Herb	1m	Lower bank	Spring and summer or winter in seasonally wet areas
Guildford	*Viminaria juncea*	Swish Bush	Vim jun	Shrub	2-5m	Transition zone	Autumn
Guildford	*Xanthorrhoea gracilis*	Graceful Grass Tree	Xan gra		1-2m	Upper bank or transition	Autumn
Guildford	*Xanthorrhoea preissii*	Grass Tree	Xan pre		0.3-3m	Upper bank or transition	Autumn
Swan	*Acacia dentifera*		Aca den	Shrub	1-3m	Upper bank or transition	Autumn
Swan	*Acacia extensa*	Wiry Wattle	Aca ext	Shrub	1-2m	Upper bank or transition	Autumn
Swan	*Acacia pulchella*	Prickly Moses	Aca pul	Shrub	1-2m	Upper bank or transition	Autumn
Swan	*Acacia saligna*	Coojong	Aca sal	Shrub or small tree	2-6m	Upper bank or transition	Autumn
Swan	*Agonis flexuosa*	WA Peppermint	Ago fle	Tree	8-12m	Upper bank or transition	Autumn
Swan	*Astartea scoparia*		Ast sco	Shrub	1-2m	Upper bank or transition	Autumn
Swan	*Banksia littoralis*	Swamp Banksia	Ban lit	Tree	9-10m	Upper bank or transition	Autumn
Swan	*Baumea juncea*	Bare Twig Sedge	Bau jun	Sedge	1-1.2m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Baumea preissii*	Broad Twig Sedge	Bau pre	Sedge	1.5m	Lower bank	Spring and summer or winter in seasonally wet

							areas
Swan	*Baumea rubiginosa*	River Twig Sedge	Bau rub	Sedge	1.5m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Billardiera fusiformis*	Australian Bluebell	Bil fus	climber	0.0m	Upper bank or transition	Autumn
Swan	*Bolboschoenus caldwelii*	Marsh Club-rush	Bol cal	Sedge	0.8-1.2m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Carex appressa*	Tall Sedge	Car app	Sedge	1.5-1.8m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Carex tereticaulis*		Car ter	Sedge	0.5-0.7m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Casuarina obesa*	Salt/Swamp Sheoak	Cas obe	Tree	8-10m	Upper bank or transition	Autumn
Swan	*Centella asiatica*	Centella	Cen asi	Herb	0.2-0.3m	Lower bank to mid bank	Autumn
Swan	*Conostylis candicans*	Grey Cottonheads	Con can	Grass	0.3-0.4m	Upper bank or transition	Autumn
Swan	*Corymbia calophylla*	Marri	Cor cal	Tree	10-20m	Upper bank or transition	Autumn
Swan	*Cycnogeton huegelii*	Water Ribbons	Cyc hue	Herb	0.3-2m	In stream	Spring and summer or winter in seasonally wet areas

Swan	*Cyperus gymnocaulos*	Spiny Flat-sedge	Cyp gym	Sedge	0.3-1m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Dielsia stenostachya*		Die ste	Herb	0.3-0.6m	Transition zone	Autumn
Swan	*Eucalyptus rudis*	Flooded Gum	Euc rud	Tree	5-25m	Upper bank or transition	Autumn
Swan	*Ficinia nodosa*	Knotted Club Rush	Fic nod	Sedge	0.4-1m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Hakea prostrata*	Harsh Hakea	Hak pro	Shrub	0.3-5m	Upper bank or transition	Autumn
Swan	*Hakea varia*	Variable Leaved Hakea	Hak var	Shrub	0.5-3m	Upper bank or transition	Autumn
Swan	*Hypocalymma angustifolium*	White Myrtle	Hyp ang	Shrub	1m	Transition zone	Autumn
Swan	*Jacksonia furcellata*	Grey Stinkwood	Jac fur	Shrub	3-4m	Upper bank or transition	Autumn
Swan	*Jacksonia sternbergiana*	Green Stinkwood	Jac ste	Shrub	3-4m	Upper bank or transition	Autumn
Swan	*Juncus kraussii*	Sea Rush	Jun kra	Herb	0.3-1.2m	Transition zone	Autumn
Swan	*Juncus pallidus*	Giant Rush	Jun pal	Herb	0.5-2m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Juncus pauciflorus*	Loose Flower Rush	Jun pau	Herb	0.3-1m	Transition zone	Autumn
Swan	*Kunzea glabrescens*	Spear Wood	Kun gla	Shrub	1.5-4m	Transition zone	Autumn
Swan	*Kunzea recurva*	Mountain Kunzea	Kun rec	Shrub	0.3-2m	Upper bank or	Autumn

						transition	
Swan	*Leptocarpus scariosa*	Velvet Rush	Lep sca	Herb	0.6-1.5m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Lobelia alata*	Angled Lobelia	Lob ala	Herb	0.1-0.5m	Lower bank to mid bank	Autumn
Swan	*Melaleuca cuticularis*	Saltwater Paperbark	Mel cut	Tree	3-7m	Upper bank or transition	Autumn
Swan	*Melaleuca lateritia*	Robin Redbreast Bush	Mel lat	Shrub	0.5-2m	Upper bank or transition	Autumn
Swan	*Melaleuca preissiana*	Modong	Mel pre	Tree	8-10m	Transition zone	Autumn
Swan	*Melaleuca rhaphiophylla*	Swamp Paperbark	Mel rha	Tree	7-9m	Upper bank or transition	Autumn
Swan	*Melaleuca seriata*		Mel ser	Shrub	0.2-1m	Upper bank or transition	Autumn
Swan	*Melaleuca teretifolia*	Banbar	Mel ter	Shrub	1.5-5m	Upper bank or transition	Autumn
Swan	*Melaleuca viminea*	Mohan	Mel vim	Shrub	4-5m	Upper bank or transition	Autumn
Swan	*Myoporum caprarioides*	Slender Myoporum	Myo cap	Shrub	1.2-2m	Transition zone	Autumn
Swan	*Myriophyllum crispatum*	Milfoil	Myr cri	Herb	0.2-0.6m	Transition zone	Autumn
Swan	*Oxylobium lineare*	Narrow-leaved Oxylobium	Oxy lin	Shrub	2-4m	Upper bank or transition	Autumn
Swan	*Paraserianthes lophantha*	Albizia	Par lop	Shrub or small tree	3-5m	Upper bank or transition	Autumn
Swan	*Pericalymma ellipticum*	Swamp Tea Tree	Per ell	Shrub	1m	Upper bank or transition	Autumn
Swan	*Philotheca spicata*	Salt and Pepper	Phi spi	Woody Perennial	0.5-	Transition zone	Autumn

					0.6m		
Swan	*Regelia ciliata*		Reg cil	Shrub	1.5-2m	Upper bank or transition	Autumn
Swan	*Regelia inops*		Reg ino	Shrub	2-2.5m	Upper bank or transition	Autumn
Swan	*Sarcocornia quinqueflora*	Beaded Samphire	Sar qui	Herb	0.3-0.5m	Upper bank or transition	Autumn
Swan	*Schoenoplectus validus*	Lake Club-rush	Sch val	Sedge	2-3m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Sphaerolobium medium*	Globe Pea	Sph med	Shrub	0.4-0.5m	Upper bank or transition	Autumn
Swan	*Taxandria linearifolia*	Swamp Peppermint	Tax lin	Shrub	2-4m	Transition zone	Autumn
Swan	*Triglochin huegelii*		Tri hue	Herb	0.3-2m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Verticordia acerosa*		Ver ace	Shrub	0.4-1m	Upper bank or transition	Autumn
Swan	*Villarsia albiflora*		Vil alb	Herb	1m	Lower bank	Spring and summer or winter in seasonally wet areas
Swan	*Viminaria juncea*	Swish Bush	Vim jun	Shrub	2-5m	Transition zone	Autumn

Appendix 6 – Pen and Scott foreshore condition grading

(Pen and Scott 1995, pp.4-6)

A-Grade

Foreshore has healthy native bush, similar to that which you would see in most nature reserves, state forests and national parks.

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.
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 if human disturbance declined.

B-Grade

The bush along the stream has been invaded by weeds, mainly grasses, and looks like typical roadside bush.

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 or disappeared altogether.
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

The foreshore supports only trees over weeds or pasture, or just plain pasture, and bank erosion and subsidence may be occurring but only in a few spots.

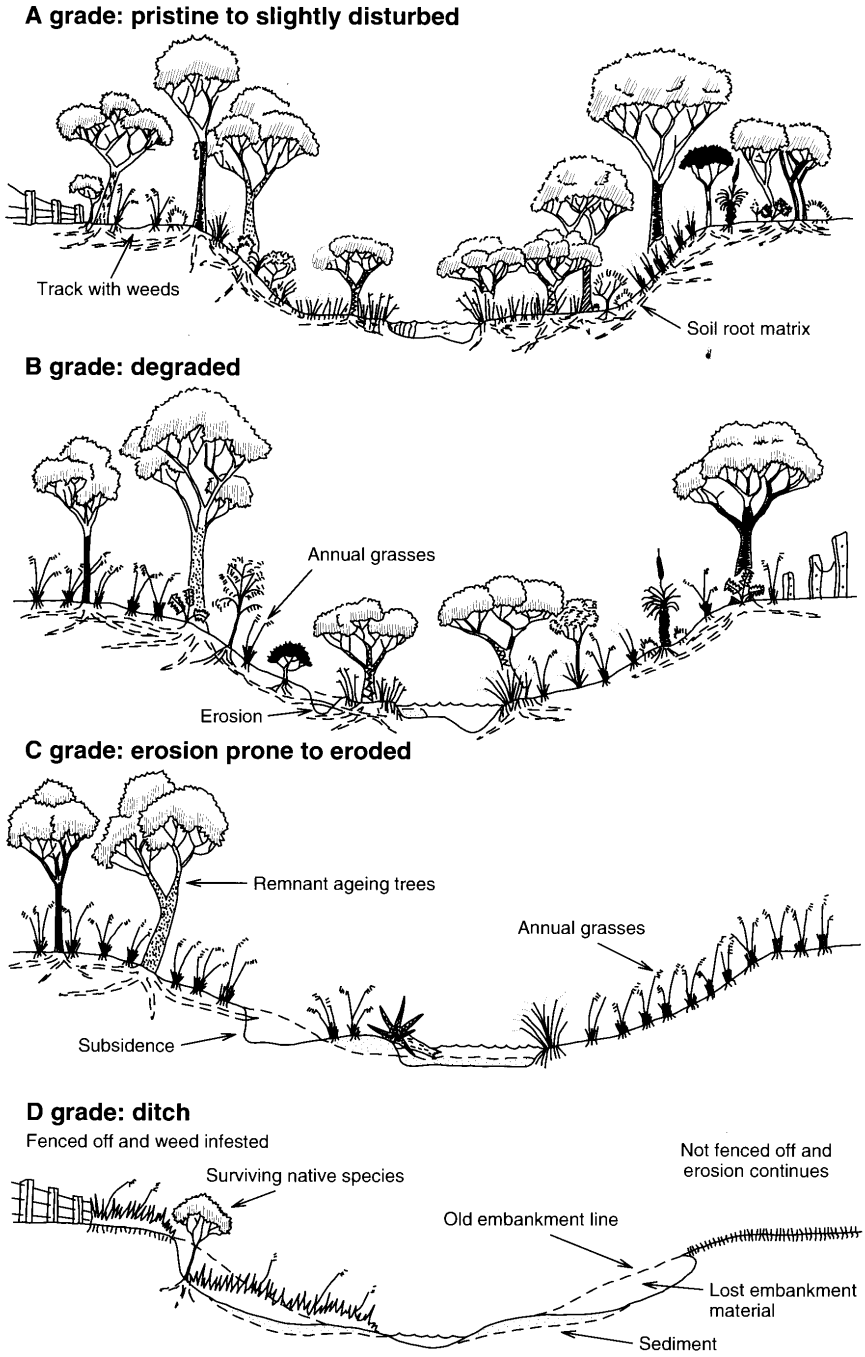
C1. Erosion prone	Trees remain, and possibly some large shrubs or grasses, but the understorey consists entirely of weeds, mainly annual grasses. The trees are generally resilient or long-lived species but there is little or no evidence of regeneration. The shallow-rooted weedy understorey provides no 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

The stream is little more than an eroding ditch or a weed infested drain.

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 weeds have become established. The river has become a simple drain, similar or identical to a typical major urban drain.



Appendix 7 - Data dictionary for field attributes in shapefile Helena_Segments

Attribute	Description
OBJECTID *	Automatically generated unique identifier (within shapefile)
Shape *	Automatically generated geometric coordinates (within shapefile)
Date	Date the segment was assessed
Field Officer	Initials of the field officers who assessed the segment
River	Name of tributary being assessed
Summary comment	Additional observations related to the segment not included elsewhere
MANAGEMENT ISSUES: Dominant weed species	Weed species; a complete list of all weeds sighted on the segment
Dominant Native Species	Dominant native species; a list of the dominant native species from any stratum noted in the segment
MANAGEMENT ISSUES: Erosion and Siltation (L)	Erosion and siltation, Left Bank; whether erosion and siltation pose a management issue
MANAGEMENT ISSUES: Erosion and Siltation (R)	Erosion and siltation, Right Bank; whether erosion and siltation pose a management issue
MANAGEMENT ISSUES - EROSION: Undermining	Erosion, Undermining; whether undermining is present
MANAGEMENT ISSUES - EROSION: Large deposits	Erosion, Large deposits; whether large deposits are present
MANAGEMENT ISSUES - EROSION: Incised scour	Erosion, Incised scour; whether incised scours are present
MANAGEMENT ISSUES - EROSION: Slumped bank	Erosion, Slumped bank; whether slumped banks are present
MANAGEMENT ISSUES - EROSION:	Erosion, Embayment retreat; whether embayment

Embayment retreat	retreat is present
MANAGEMENT ISSUES - EROSION: Exposed tree roots	Erosion, Exposed tree roots; whether exposed tree/shrub roots are present
MANAGEMENT ISSUES - VEG LOSS: Trampling	Vegetation loss, Trampling; whether there is loss of native riparian vegetation through trampling by humans or livestock
MANAGEMENT ISSUES - VEG LOSS: Grazing	Vegetation loss, Grazing; whether there is loss of native riparian vegetation through grazing, including evident historic grazing (note in Mgt Issues Comment that it is historic)
MANAGEMENT ISSUES - VEG LOSS: Displacement by weeds	Vegetation loss, Displacement by weeds; whether there is loss of native vegetation through displacement by weeds
MANAGEMENT ISSUES - VEG LOSS: Clearing	Vegetation loss, Clearing; whether there is loss of native vegetation through clearing, including evident historic clearing (note in Mgt Issues Comment that it is historic)
MANAGEMENT ISSUES - VEG LOSS: Erosion	Vegetation loss, Erosion; whether there is loss of native vegetation through erosion, including evident historic erosion (note in Mgt Issues Comment that it is historic)
MANAGEMENT ISSUES - ACCESS: Vehicles	Access, Vehicles; indicates access by vehicles
MANAGEMENT ISSUES - ACCESS: People	Access, People; indicates access by people off marked trails
MANAGEMENT ISSUES - ACCESS: Stock	Access, Stock; indicates access by stock
MANAGEMENT ISSUES - ACCESS: Other (L)	Access, Other, Left Bank; indicates access by something else to the left bank
MANAGEMENT ISSUES - ACCESS: Other (R)	Access, Other, Right Bank; indicates access by something else to the right bank
MANAGEMENT ISSUES: Comment	Management Issues Comment; any additional information to record on any of the above
Slope of bank (L)	Slope of bank, Left Bank; the average bank slope in metres, from water level to the top of the immediate

	bank
Slope of bank (R)	Slope of bank, Right Bank; the average bank slope in metres, from water level to the top of the immediate bank
Height of bank (L)	Height of bank, Left Bank; The average height of the bank in metres, from water level to the top of the immediate bank
Height of bank (R)	Height of bank, Right Bank; The average height of the bank in metres, from water level to the top of the immediate bank
Fencing	Fencing; whether fencing is present along the riparian zone preventing access by humans or livestock
LAND USE: Agriculture	Agriculture; whether the land surrounding the segment is used for agriculture
LAND USE: Parkland	Parkland; whether the land surrounding the segment is used for parkland
LAND USE: Rural	Rural; whether the land surrounding the segment is used for rural purposes
LAND USE: Residential	Residential; whether the land surrounding the segment is used for residential purposes
LAND USE: Commercial / industrial	Commercial/ industrial; whether the land surrounding the segment is used for commercial/ industrial purposes
LAND USE: Rem Bush / Reserve	Remnant bushland/ reserve; whether the land surrounding the segment is used for remnant bushland/ reserve
LAND USE: Recreation	Recreation; whether the land surrounding the segment is used for recreation, ie walking/running trails or exercise infrastructure is in place
CONDITION: Vegetation (L)	Vegetation, Left Bank; Vegetation condition (ie % cover of natives compared to weeds, native regeneration, crown death etc)
CONDITION: Vegetation (R)	Vegetation, Right Bank; Vegetation condition (ie % cover of natives compared to weeds, native

	regeneration, crown death etc)
CONDITION: Weed cover (L)	Weed cover, Left Bank; weed cover (ie no or low weed % cover=Minimal to weed dominated=Extensive)
CONDITION: Weed cover (R)	Weed cover, Right Bank; weed cover (ie no or low weed % cover=Minimal to weed dominated=Extensive)
CONDITION: Bank stability / erosion (L)	Bank stability, erosion, Left Bank; the stability of the bank (this may not be visible if veg cover is very high & in many cases stability will then be good)
CONDITION: Bank stability / erosion (R)	Bank stability, erosion, Right Bank; the stability of the bank (this may not be visible if veg cover is very high & in many cases stability will then be good)
CONDITION: Pressures (L)	Pressures, Left Bank; Level of pressure (such as pressure from adjacent land uses, dams, weed infestations, uncontrolled stock or human access etc) on a segment
CONDITION: Pressures (R)	Pressures, Right Bank; Level of pressure (such as pressure from adjacent land uses, dams, weed infestations, uncontrolled stock or human access etc) on a segment
Trajectory (L)	Trajectory, Left Bank; whether a segment is stable/ improving or deteriorating in condition based on the current level of management
Trajectory (R)	Trajectory, Right Bank; whether a segment is stable/ improving or deteriorating in condition based on the current level of management
+VE TRAJECTORY: Weed management	Positive trajectory: Weed management; whether weed management is evident and contributing to an improvement in condition
+VE TRAJECTORY: Revegetation	Positive trajectory: Revegetation; whether revegetation is evident and contributing to an improvement in condition
+VE TRAJECTORY: Native species regeneration	Positive trajectory: Native species regeneration; whether regeneration is evident and contributing to an improvement in condition

+VE TRAJECTORY: Controlled access	Positive trajectory: Controlled access; whether access by vehicles, people or stock is controlled and contributing to an improvement in condition
+VE TRAJECTORY: Riffles	Positive trajectory: Riffles; whether riffles have been installed or are naturally occuring and contributing to an improvement in condition
-VE TRAJECTORY: Exotic species regeneration	Negative trajectory: Exotic species regeneration; whether regeneration is evident and and contributing to a decline in condition
-VE TRAJECTORY: Active erosion	Negative trajectory: Active erosion; whether erosion is evident and and contributing to a decline in condition
-VE TRAJECTORY: Loss of native vegetation	Negative trajectory: Loss of native vegetation; whether loss of vegetation is evident and and contributing to a decline in condition
Hope (L)	Hope, Left Bank; whether a segment can improve on its own or if it needs human intervention
Hope (R)	Hope, Right Bank; whether a segment can improve on its own or if it needs human intervention
Ease of Rehab (L)	Rehab, Left Bank; whether a segment would be easy (little work required, low cost) or difficult (large amount of ongoing work required, high cost) to rehabilitate
Ease of Rehab (R)	Rehab, Right Bank; whether a segment would be easy (little work required, low cost) or difficult (large amount of ongoing work required, high cost) to rehabilitate
REHAB EASE FACTOR: Access	Access; an attribute which tells us if we think the segment would be easy to rehabilitate, based on accessibility of the segment (eg vegetation density, steepness of slope, private land etc) (value in attribute table=easy; no value=hard)
REHAB EASE FACTOR: Condition of native vegetation	Condition of native vegetation; an attribute which tells us if we think the segment would be easy to rehabilitate, based on condition of native vegetation (eg healthy with potentially high regeneration or sickly with poor potential for native regeneration)

	(value in attribute table=easy; no value=hard)
REHAB EASE FACTOR: Weed prevalence	Weed prevalence; an attribute which tells us if we think the segment would be easy to rehabilitate, based on weed prevalence (eg few weeds would make rehabilitation easier and many weeds would make it difficult to rehabilitate) (value in attribute table=easy; no value=hard)
REHAB - FENCING: Construct a fence	Fencing, Construct a fence; whether a fence needs to be constructed
REHAB - FENCING: Repair an existing fence	Fencing, Repair an existing fence; whether an existing fence needs repair
REHAB - FENCING: Replace an existing fence	Fencing, Replace an existing fence; whether an existing fence needs to be replaced
REHAB - WEEDS: Identify species	Weeds, Identify species; whether weeds need to be identified
REHAB - WEEDS: Chemical Treatment?	Weeds, Chemical treatment; whether weeds require treatment (herbicide application)
REHAB - WEEDS: Mechanical Removal?	Weeds, Mechanical removal; whether weeds require mechanical removal (plant taken away)
REHAB: Species for replanting (L)	Species for replanting, Left Bank; whether planting is required and a list of suggested species
REHAB: Species for replanting (R)	Species for replanting, Right Bank; whether planting is required and a list of suggested species
REHAB: Erosion control	Erosion control; whether erosion control treatments need to be installed
REHAB - STORMWATER: Silt management required	Stormwater; Silt management required; whether silt management is required. This was only filled out if high levels of sedimentation were evident
REHAB - STORMWATER: Water quality management required	Stormwater; Water quality management required; whether water quality management is required. This was only filled out if water quality was poor by a visual assessment, eg it was a strange colour, smelt badly, high levels of algae were present
REHAB: Comment	Rehab Comment; if any other rehabilitation

	techniques are required, record what they are in this comment field
Survey Method	Survey method; whether the complete length of the segment could be accessed and assessed, or if viewing from access points only was possible
Survey Quality	Survey quality; whether the segment could be assessed with adequate viewing, or if some or much extrapolation was needed and some features of the segment may not have been sighted and recorded
Pen & Scott Rating (L)	Pen & Scott grading, LB; condition grading using the Pen & Scott method from A1 (pristine) to D3 (ditch)
Pen & Scott Rating (R)	Pen & Scott grading, RB; condition grading using the Pen & Scott method from A1 (pristine) to D3 (ditch)
Category (L)	Category, LB; the Rutherfurd matrix priority categories, ranging from protecting and conserving the good areas to improving the average to poor condition areas
Category (R)	Category, RB; the Rutherfurd matrix priority categories, ranging from protecting and conserving the good areas to improving the average to poor condition areas
GlobalID *	Automatically generated unique identifier (within Collector for ArcGIS)
LAT_START	Latitude of segment startpoint
LONG_START	Longitude of segment startpoint
LAT_END	Latitude of segment endpoint
LONG_END	Longitude of segment endpoint
SEGMENT	Sequential numbering of the segments from Mundaring Weir downstream to the Swan River
VegDescription	Vegetation description; structural description and including dominant species in the over, mid and understorey

RiverSection	The river has been divided into three sections for ease of reporting: Mundaring Weir to the Pumpback Dam (East); Pumpback Dam to Scott Street (Central), and Scott Street to the confluence with the Swan River (West)
Shape *	Automatically generated geometric coordinates (within shapefile)
LOCALISED_PRESSURES	Determined in the office, in the same way that the Pressures field had been completed in the 2006 assessment, considering erosion and siltation, vegetation loss and access issues that were recorded for the segment
COMPARATIVE_BANK_STABILITY	Determined in the office, in the same way that the Bank Stability field had been completed in the 2006 assessment, considering Vegetation Condition and Vegetation Loss through Trampling
COMPARATIVE_TRAJECTORY	Determined in the office, in the same way that the Trajectory field had been completed in the 2006 assessment, considering Comparative Bank Stability; Vegetation Condition and Localised Pressures
COMPARATIVE_HOPE	Determined in the office, in the same way that the Hope field had been completed in the 2006 assessment, considering Vegetation Condition, Comparative Bank Stability and Localised Pressures
COMPARATIVE_EASE	Determined in the office, in the same way that the Ease of Rehab field had been completed in the 2006 assessment, considering Vegetation Condition, Comparative Bank Stability and Localised Pressures
COMPARATIVE_CATEGORY	The Rutherfurd matrix priority categories, determined in the same way that it had been in the 2006 assessment
Shape_Length	Length of the segment in metres

Appendix 8 - Parameters used for the categorisation of river segments

Rarity or conservation value

Conservation value was determined from the desktop assessment and the proximity of segments to recognised natural and cultural assets.

Condition

Due to restricted time and to enable comparison to previous studies, this assessment limited condition to:

- vegetation structure and complexity, to give an overall rating of vegetation condition;
- weed cover;
- bank stability, and
- level of pressure from apparent disturbances.

A foreshore condition grade was also determined for each segment from Pen and Scott's (1999) grading system (Appendix 6). Similarly to the previous tributary assessment project, we used the Pen and Scott grading to place segments into an overall good, average or poor condition.

- Good – A1, A2, A3 Pen and Scott grade
- Average – B1, B2, B3, C1 or C2 Pen and Scott grade
- Poor – C3, D1, D2 or D3 Pen and Scott grade

Trajectory and Hope

Trajectory of each segment was determined in the field, and was deemed as stable/improving or deteriorating.

- A segment was determined to be stable/improving if active management was occurring and was successful, such as weed control, erosion control or revegetation, or there were few signs of pressures and threats, and vegetation was in a relatively undisturbed state.
- A segment was determined to be deteriorating if active erosion was present, no active management was occurring, or active management was not successful, vegetation condition was average to poor and exotic species regeneration was characteristic of the segment.

Segments in average condition were divided into those of stable/improving or deteriorating trajectories. Deteriorating segments were prioritised above those which were stable/improving as it is considered more efficient to stabilise deteriorating segments now, rather than remediating them later (Rutherfurd et al. 2000b).

Segments in poor condition were divided into those **without hope**, segments which would not recover without intervention; and those **with hope**, improving reaches which may eventually recover naturally (Rutherfurd et al. 2000b). Segments without

hope are given slightly higher priority than those with hope, as the latter have a smaller chance of recovering independently over time.

Proximity to good segments

As Rutherfurd et al. (2000b) explain, it is more effective to expand upon an area of stream which is already in good condition or has undergone rehabilitation, rather than work on an isolated stretch of the river adjacent to segments in poor condition, particularly where these occur upstream of the segment being considered and could be a continual source of weeds or sediment. This increases the length of the stream community and provides a source of flora and fauna to colonise the newly rehabilitated reach.

In order of priority, Rutherfurd et al. (2000b) recommend working on:

1. Segments with a mix of high-quality assets and some degraded assets;
2. Poor quality segments that link two segments in good condition;
3. Poor quality segments connected by one end to a segment in good condition, then
4. Poor quality segments that are distant from good quality segments.

After the overall condition rating was applied, location of segments in relation to condition were identified using GIS, then ranked based on their proximity to good condition segments.

Ease of rehabilitation

Ease of rehabilitation was determined in the field.

- Segments that were deemed ‘easy’ to rehabilitate were those that were in good condition, with a good vegetation structure and complexity remaining, where weeds were not dominant, and where all that may be needed is short-term weed control and infill planting.
- Segments that were deemed ‘hard’ to rehabilitate were those where native vegetation structure and complexity was largely lost, and which had extensive weed cover, or where erosion was occurring at multiple points along the reach. Rehabilitation required would be wide scale and need to occur over many years to make a long-lasting impact.

Segments were assigned a category value from 0 to 8. Several modifications were made to the process that had been carried out by the Swan River Trust in 2008:

- the buffer width for conservation value was increased from 20m to 500m;
- national parks were not included in the criteria for conservation value, as the area from Mundaring Weir to the Pumpback Dam is all within national park and thus there would be no variation in the conservation value of segments for that area;
- Environmentally Sensitive Areas were added to the criteria for conservation value;
- the level of pressure was determined in the field and included landscape disturbances such as adjacent intensive land uses, dams and modifications to

the river alignment, rather than only the erosion, grazing and trampling issues that were noted in the segment;

- bank stability was assessed in the field and was considered independently of weed coverage (e.g. if no or little erosion was sighted and the banks appeared stable, despite the understorey being weedy, stability was considered ‘good’), rather than using the vegetation condition score and presence or absence of vegetation trampling; and
- trajectory, hope and ease of rehabilitation were determined in the field rather than a combination of bank stability, vegetation condition and pressure scores.

Appendix 9 - Matrix for the categorisation of river segments

Adapted from Cooperative Research Centre (CRC) for Catchment Hydrology (Rutherfurd et al. 2000)

ID segments with high conservation value assets	Pen & Scott = A1 Pressures = Minimal No threats or ideas for management	Intersection with known values Pen & Scott = A1, A2,or A3	Pen & Scott = A1, A2,or A3										
Sort according to condition	Good (Pen & Scott = A1, A2 or A3)			Average (Pen & Scott = B1, B2, B3, C1 or C2)						Poor (Pen & Scott = C3, D1, D2 or D3)			
Sort according to trajectory				(Trajectory = Deteriorating)		(Trajectory = Stable – Improving)				(Hope = Without hope)		(Hope = With hope)	
Sort according to proximity to good segments				(Close) Adjacent segment P&S =A1,A2,A3	(Distant) Adjacent segment P&S ≠A1,A2,A3	(Close) Adjacent segment P&S =A1,A2,A3		(Distant) Adjacent segment P&S ≠A1,A2,A3		(Close) Adjacent segment P&S =A1,A2,A3	(Distant) Adjacent segment P&S ≠A1,A2,A3	(Close) Adjacent segment P&S =A1,A2,A3	(Distant) Adjacent segment P&S ≠A1,A2,A3
Sort according to ease				(Easy)	(Hard)	(Easy)	(Hard)	(Easy)	(Hard)	(Easy)	(Hard)	(Easy)	(Hard)
Priority category	**0**	**1**	**2**	**3**		**4**	**5**	**6**		**7**		**8**	
	Segments in good condition throughout, that are already protected	Protect regional conservation value segments	Protect local conservation value segments	Protect and improve deteriorating segments		Expand good segments	Improve impeded recovery segments (easily fixed segments)	Improve moderately damaged segments (more difficult to fix)		Improve poor segments		Improve poor segments with hope	

Appendix 10 - Ratings for individual parameters of foreshore condition used by Siemon (2001)

	Blue – Excellent 8 points	Green – Good 6 points	Yellow – Moderate 4 points	Red – Poor 2 points	Black - Very poor 0 points
Bank stability	No erosion, slumping or sediment deposits; dense native vegetation cover on banks and verge; no evidence of disturbance or areas of exposed soil.	No significant erosion, slumping or sediment deposits in floodway or on lower banks; good native vegetation cover; only isolated areas of exposed soil or thinning vegetation.	Some localised erosion, slumping and sediment deposits; native vegetation cover on verges may be patchy and interspersed with patches of exposed soil.	Extensive active erosion, slumping and sediment deposition particularly during peak flows; bare banks and verges common.	Almost continuous erosion; over 50% of banks slumping; sediment heaps line or fill much of the floodway; little or no vegetation cover.
Foreshore vegetation	Healthy, undisturbed native vegetation with structure intact and verges more than 20m wide; no weed or signs of disturbance evident.	Vegetation structure dominated by native plants that comprise 80–100% of the total number of species; only scattered weeds or rarely evident in small clusters; nil or minor signs of disturbance (i.e. tracks, rubbish dumping).	Some changes in vegetation structure, native plants comprising 50-80% of the total species composition; little regeneration of trees and shrubs; weeds occurring occasionally; moderate levels of disturbance.	Modified vegetation structure with native plants comprising only 20-50% of the total species composition. Trees remain with only scattered shrubs and an understorey dominated by weeds; high prevalence of disturbance.	Insufficient vegetation to control erosion; natural vegetation structure absent with occasional native trees and shrubs comprising less than 20% of the total species composition; weeds abundant; very high prevalence of disturbance and

					extensive areas of exposed soil.
Stream cover	Abundant stream cover from dense overhanging vegetation providing almost continuous shade; frequent instream cover from aquatic vegetation and/or leaf litter; rocks or logs.	Abundant shade from overhanging vegetation; occasional instream cover from patches of aquatic vegetation and isolated heaps of leaf litter or rocks and logs.	Scattered fringing vegetation with occasional patches of shade; infrequent instream cover with little aquatic vegetation, very infrequent rocks and logs.	Stream channel mainly clear; fringing vegetation almost absent providing very little permanent shade; instream cover almost absent with generally no instream vegetation and very infrequent rocks and logs.	Zero or minimal stream cover with no permanently shaded areas and no instream cover.
Habitat diversity	Excellent water quality with permanent water (i.e. pools and creeks); three or more aquatic and terrestrial habitats including diverse vegetation types, edge waters, instream cascades, riffles, pools and woody debris.	Good water quality and some permanent water; at least three aquatic habitat types; at least one habitat type for terrestrial invertebrates; at least one habitat type for each terrestrial vertebrate category (frogs, reptiles and birds).	No apparent problems with water quality (i.e. muddy or cloudy in winter); at least two aquatic habitat types; at least one habitat type for terrestrial invertebrates; at least one habitat type for any two of the terrestrial vertebrate categories.	Possible seasonal problems with water quality and no permanent water; at least one aquatic habitat type; at least one habitat type for terrestrial invertebrates; at least one habitat type for one of the terrestrial vertebrates.	Poor water quality; almost no healthy habitats available for aquatic and terrestrial organisms.

Sum of individual parameter ratings to give an overall stream condition index (Siemon 2001)

Colour code	Parameter rating	Description
Blue (32 points)	Excellent	All parameters blue
Green (22-30 points)	Good	Three to four parameters rated green or better with only one parameter rated yellow; no red or black ratings
Yellow (14-20 points)	Moderate	Three parameters rated yellow or better with no more than one red; no black
Red (6-12 points)	Poor	Two or three parameters rated red with no more than one black
Black (0-4 points)	Very poor	Two or more parameters rated black

Appendix 11 - Known project sites along the Helena River

Projects are listed in downstream order from Mundaring Weir to the confluence with the Swan River.

Swan Alcoa Landcare Program funded projects

Project code	Group / organisation	Brief description of project
04E16	Friends of Piesse Brook	Revegetation at the Piesse Brook gorge area
09E16	Helena River Catchment Group	Invasive weed control follow-up of Helena River Rehabilitation Project: follow-up watsonia control of Stage 3
08E08	Swan Catchment Council	Helena River Bushland Restoration Project
09E16	Helena River Catchment Group	Invasive weed control follow-up of Helena River Rehabilitation Project: follow-up weed control of Stage 1 targeting buckthorn
02E13	Helena River Catchment Group	Helena River Rehabilitation Project – Stage 4 (Scott Street bridge to Fyfe Street west)
09E14	Helena River Catchment Group	Weed control and planting, Scott Street bridge to Fyfe Street west
10E16	Katharine Street River Gang	River restoration in Helena Valley
15E09	Swan Catchment Council	Lower Helena River Wetland Restoration Project (Midland Road East; Midland Road West; Stirling Crescent; Amherst Riverland; Olive Grove; West Parade)
03E16	Eastern Metropolitan Regional Council	Protecting priority tributaries and preventing the spread of priority weed species

Project code	Group / organisation	Brief description of project
03E13	Lower Helena Association Inc	Lower Helena River Wetland Restoration Project (MRA Foreshore Reserve; Amherst East; Amherst Riverlands; Harridean Wetland Restoration Project)
04E14	Lower Helena Association Inc	Weed control and planting (Amherst East; West Parade)
02E15	Lower Helena Association Inc	Lower Helena River Wetland Restoration Project
06E16	Lower Helena Association Inc	Lower Helena River Wetland Restoration Project (Amherst East; West Parade)
08E09-03	Swan Catchment Council	Amherst Riverland Restoration Project; Harridean Wetland Restoration Project
06E10	Helena River Catchment Group	Revegetate and regenerate 10,000sqm of ephemeral wetland/dampland on the Helena Valley floodplain (Between Pitt Street and Amherst Road; West Parade; Johnson Street bridge)

Eastern Metropolitan Regional Council/Eastern Tributaries projects

Project code	Year funded	Brief description of project
PP1, PP2, PP3	2013	Amherst Riverlands
Unknown	2012	Amherst Riverlands
PP1, PP2, PP3, PP4	2013	Holmesdale Wetland
Unknown	2012	Holmesdale Wetland
Unknown	2012	West Parade

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