

# TOWN PLANNERS

## CLEMENT—STONE SINCE 1989

18 December 2020

Victorian Planning Authority

c/- Craigieburn West PSP

Via email: [amendments@vpa.vic.gov.au](mailto:amendments@vpa.vic.gov.au)

**RE: Craigieburn West Precinct Structure Plan (PSP)**  
**Submissions made on behalf of [REDACTED] Whites Lane, Yuroke (Mickleham)**  
**PSP property ID 16**

Dear Sir/Madam,

1. We act on behalf of the registered landowner [REDACTED] Whites Lane, Yuroke (Mickleham). Our client's site is identified as PSP property ID 16 within the PSP.
2. The draft PSP proposes a land take of 4.55 hectares (44.75%) of our client's 8.23 hectare site for waterway and drainage reserve. The PSP outlines the drainage asset will comprise of wetland (ACWL-02) equating to 1.46 hectares (3.26 ha total, 1.8 ha included waterway corridor).
3. A waterway crossing/bridge/culvert (BR-03) is also proposed within our client's property in a north-south direction along the east-west Connector Street road across the Aitken Creek main channel.
4. In short, our client is seeking for any assets proposed within her land to be **minimised**, particularly along the eastern portion of the site, given the significant land take currently proposed as part of the PSP, and on the basis of the following key considerations:
  - 4.1. The blunt application of the minimum corridor widths in the absence of a robust site specific assessment does not represent a sophisticated solution for this section of the north-eastern tributary as it relates to our client's site;
  - 4.2. This section of the north-eastern tributary has been assessed to have limited ecological values;
  - 4.3. No presence of significant vegetation (such as River Red Gums) is located along this section of the north-eastern tributary;
  - 4.4. No rare or threatened flora and fauna was found (or likely to be found) along this section of the north-eastern tributary;
  - 4.5. There is merit in considering an 'online' stormwater treatment in lieu of the proposed 'offline' treatment for the north-eastern tributary given the steep topography, and therefore opportunity to reduce the minimum corridor widths associated with the proposed asset – e.g. the existing online treatment successfully utilised at Flax Lily Creek to the south of Craigieburn Road;

- 4.6. The infrastructure assets (connector road and bridge) are proposed to cut across the waterway along this section of the north-eastern tributary which does not represent an economically sound solution based on the excessively wide corridor widths proposed and potential impacts upon Net Developable Area of the precinct.
5. In providing these submissions, we have reviewed the following documents, as relevant to our client's site:
  - 5.1. Craigieburn West PSP Draft for Public Consultation, Victorian Planning Authority, November 2020
  - 5.2. Craigieburn West PSP Integrated Water Management Issues and Opportunities, Alluvium, March 2019
  - 5.3. Craigieburn West PSP Services Investigation Report, Taylors, March 2019
  - 5.4. Craigieburn R2 Precinct Structure Plan, Victorian Planning Authority, September 2010 amended November 2020
  - 5.5. Craigieburn West PSP Co-Design Workshop – Outcomes Report, Elton Consulting, 7 November 2019
6. We have also discussed the PSP with Melbourne Water (Katy Marriott – Environmental Planner, Schemes) who provided a copy of the following documents to aid with our assessment:
  - 6.1. Aitken Creek Waterway Values Assessment, Jacobs, 8 December 2020
  - 6.2. Waterway Corridors – Guidelines for Greenfield Development Areas within the Port Phillip and Westernport Region, Melbourne Water, October 2013

#### **Our client's site**

7. Our client's site (also known as Lot 1 on Title Plan 558734B) is located to the south-west of Whites Lane and Olivers Road.
8. The Aitken Creek north-eastern tributary transverses the eastern boundary of the site, and the Aitken Creek Main Channel transverses the southern portion of the site.



Figure 1 Extract of aerial map (Nearmap, 2020) – subject site dashed red

9. Our client's site is located towards the eastern perimeter of the Craigieburn West PSP boundary, and has a direct interface with the existing urban development on the opposite side of Whites Lane (land identified within the Craigieburn R2 PSP).
10. The site is currently zoned Farming – Schedule 13 (FZ3) within the Hume Planning Scheme. The PSP proposes this area for residential development, with drainage and waterways located along the eastern and southern portions of the site.
11. The PSP proposes a number of assets to be located on our client's site including waterway/drainage, connector road, bridge, and possible public transport/pedestrian linkages.



Figure 2 Extract of Transport Map - draft CW PSP, pg. 18 – subject site dashed red



Figure 3 Extract of Integrated Water Management Plan - draft CW PSP, pg. 21 – subject site dashed red

## Submissions

12. The Aitken Creek Development Services Scheme (DSS) was originally prepared in August 2000, and it is understood that Melbourne Water are currently undertaking revisions to cater for the Craigieburn West PSP.
13. As part of the revision process, waterway corridor widths and drainage asset locations have been proposed by Melbourne Water as per the below figures, as relevant to our client's site.

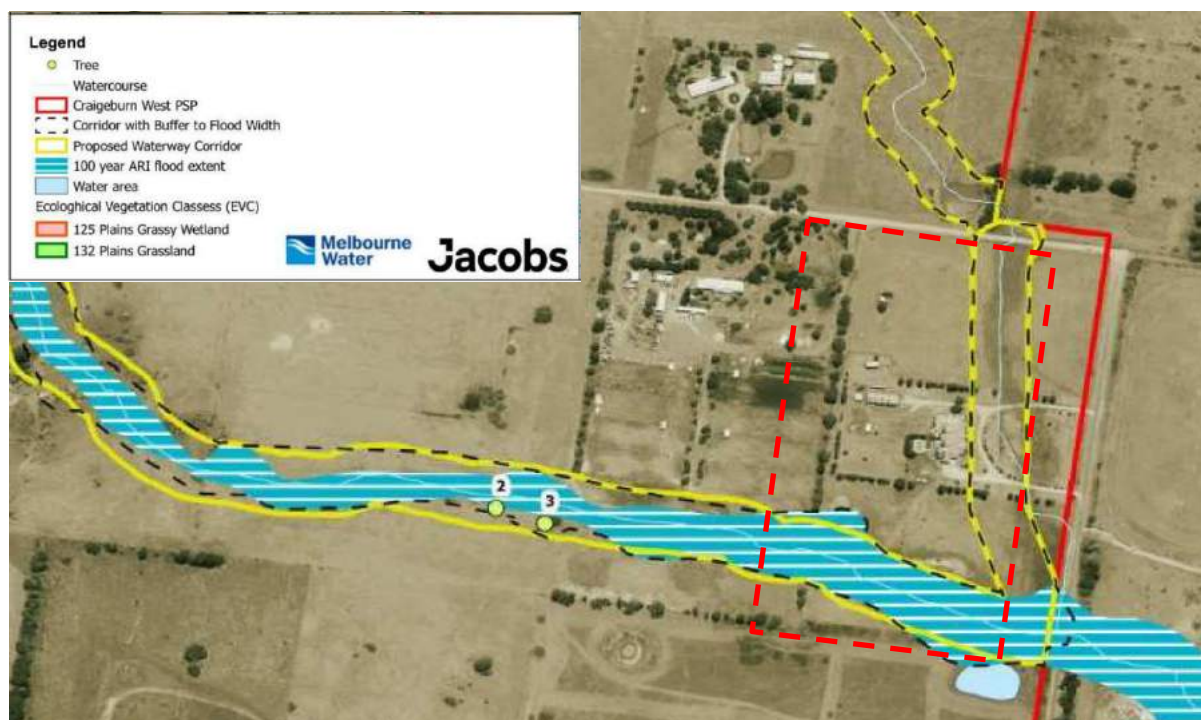


Figure 4 Proposed waterway corridor - Aitken Creek Waterway Values Assessment, December 2020 – subject site dashed red

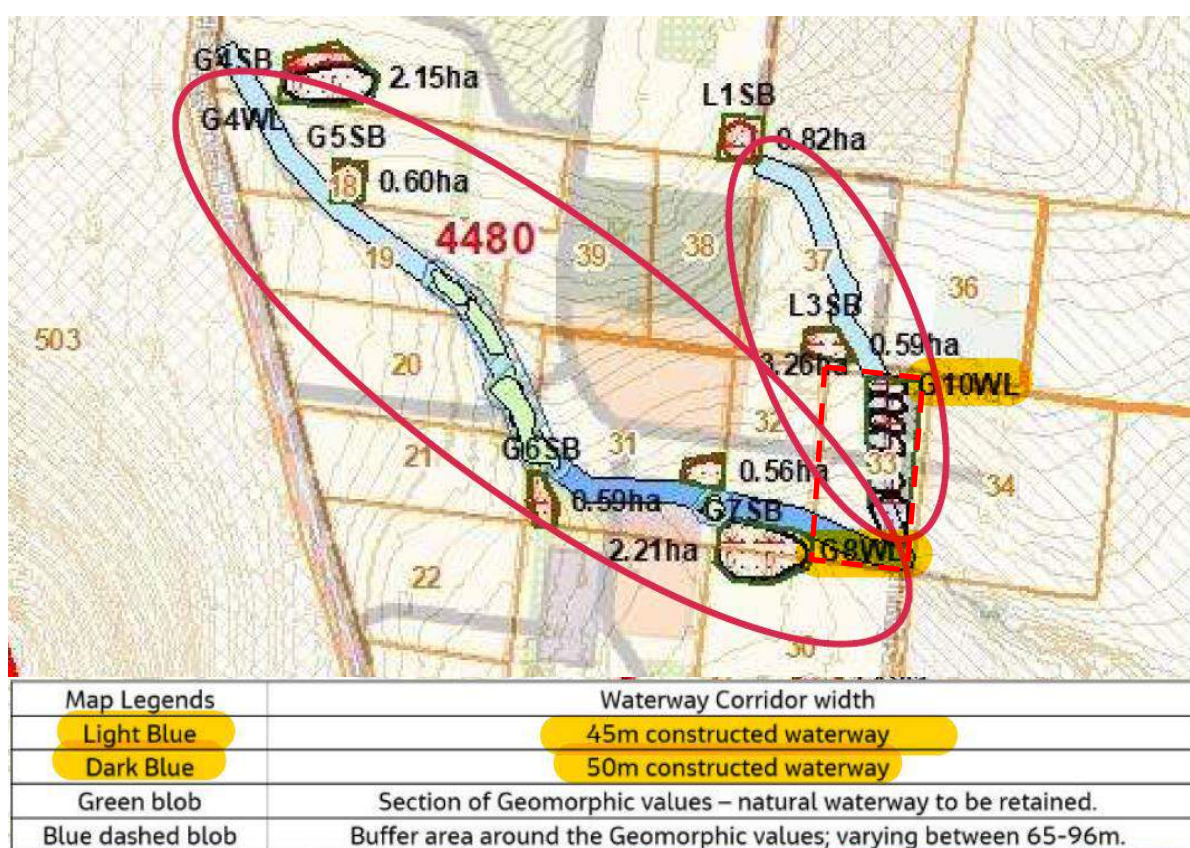


Figure 5 Proposed buffer widths and locations - Aitken Creek Waterway Values Assessment, December 2020 – subject site dashed red

14. The proposed asset (G10WL – wetland) along the eastern portion of our clients site equates to a catchment area of 88.9 ha, with 0.7 ha surface area and a footprint area of 3.26 ha (including 1.8 ha within the waterway corridor).
15. The proposed asset (G8WL – wetland) along the southern portion of our clients site equates to a catchment area of 30 ha, with 0.5 ha surface area and a footprint area of 2.21 ha.<sup>1</sup>
16. While it is understood that Melbourne Water have based its proposed corridor widths on the minimum standard setback widths and the Strahler stream ordering system, it is noted that the *Waterway Corridors Guidelines*<sup>2</sup> contemplate **narrower setbacks can be considered if it can be conclusively demonstrated that the objectives of waterway corridors will still be met.**
17. The minimum corridor width is currently proposed at a minimum 20 m setback along each bank, and assuming a waterway width of 5-10 m, this would lead to a baseline corridor width of 45-50 m.<sup>3</sup> We say the blunt application of the minimum setback widths in the absence of a robust and site specific assessment of this section of the north-eastern tributary (noting no field work was undertaken on our client's site) does not represent a sophisticated solution.
18. When considering the **site specific factors**, as required by the *Waterway Corridors Guidelines*, it is submitted that there is opportunity to reduce the setback widths to the proposed asset (wetland) which transverses along the eastern boundary of our client's site (Aitken Creek north-eastern tributary), as follows:
  - 18.1. **Geomorphic values** – The north-eastern tributary has been assessed to have been extensively modified through agricultural development, with insignificant values and geomorphic features in poor condition. While it is understood that the north-eastern tributary remains as an important headwater area in the overall drainage network, a proper assessment in determining the minimum corridor width requires a full and robust assessment of this section of the reach within our client's site.
  - 18.2. **Ecological values** – No ecological vegetation classes (EVCs) were recorded along the north-eastern tributary. This differentiates it from the main channel and southern tributary where two EVCs were recorded.
  - 18.3. **Significant trees** – No significant vegetation is located along this section of the north-eastern tributary. This differentiates it from the main channel and southern tributary where significant River Red Gums are present.
  - 18.4. **Rare or threatened flora and fauna** – Neither rare or threatened flora and fauna species were recorded along this section of the north-eastern tributary. No presence of rare or threatened flora and fauna was detected generally, however the *Jacobs* assessment indicated

<sup>1</sup> Table 1-1, Aitken Creek Waterway Values Assessment, Jacobs, 8 December 2020, pg. 11

<sup>2</sup> *Waterway Corridors – Guidelines for Greenfield Development Areas within the Port Phillip and Westernport Region*, Melbourne Water, October 2013, pg. 7

<sup>3</sup> Section 4.3.1 Waterway buffer width, Aitken Creek Waterway Values Assessment, Jacobs, 8 December 2020, pg. 42

a high likelihood for such flora/fauna to be present along the main channel and southern tributary.

- 18.5. **Stormwater treatment assets and erodible soils** – There is merit in considering an ‘online’ stormwater treatment for this section of the north-eastern tributary, which is generally adopted by Melbourne Water for areas which exhibit steep topography. An online stormwater treatment would allow for the built assets to be accommodated within the waterway, in lieu of extensive works and excavation required to situate the required ponds etc along the steep banks – which would ultimately result in a preferred outcome for areas exhibiting erodible soils. An online stormwater treatment has been successfully implemented at Flax Lily Creek to the south of Craigieburn Road (see below figure).

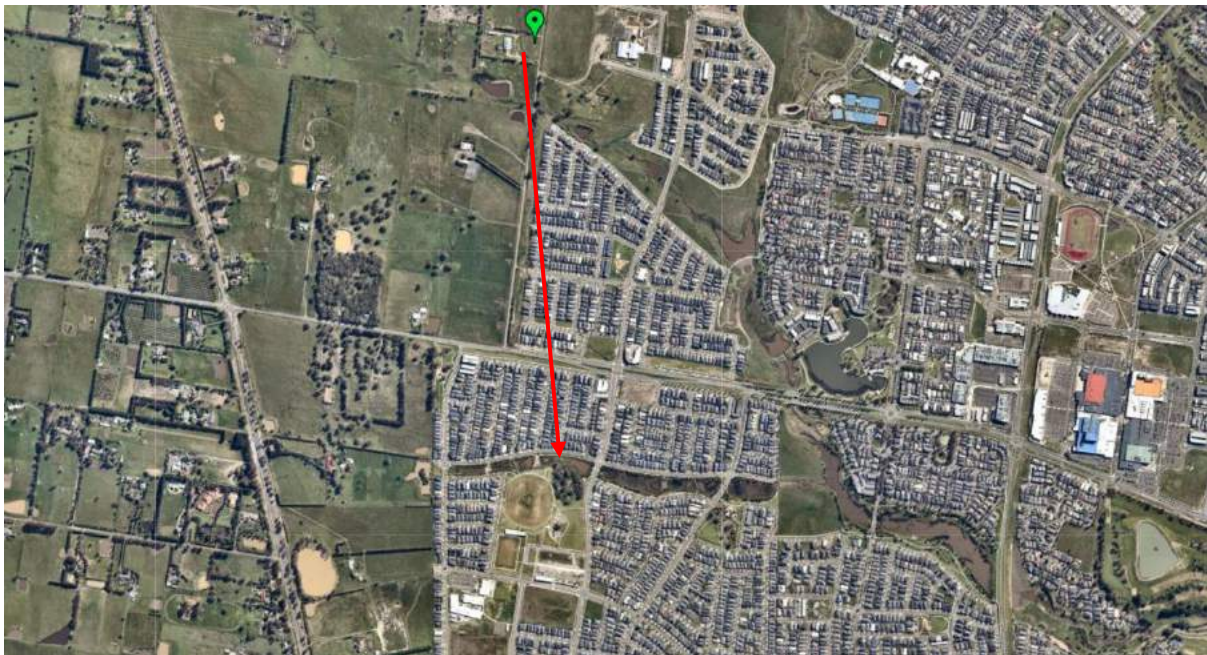


Figure 6 Aerial map of Flax Lily Creek and proximity to our client's site (Nearmap, 2020)

19. In addition, it is noted that the PSP proposes a connector road to the southern portion of our client's site to adjoin the existing urban development to the east of Whites Road (Marathon Boulevard). This connector road has been earmarked as a potential future public transport corridor. In addition to the road, a waterway bridge and shared path is proposed to cut through the proposed wetland. Given the excessive width of the waterway corridor currently proposed, this would not result in an economically sound solution due to potential impacts onto the Net Developable Area of the precinct.

## Conclusion

20. For the foregoing reasons, it is submitted that a more robust and detailed assessment is required in order to ensure the proposed land take as it relates to our client's relatively small site is reasonable, and achieves the objectives of the PSP. A blunt application of the minimum corridor widths is not appropriate based solely on the Strahler stream ordering system, particularly in the context of the site specific factors outlined above.
21. It is clear from the various expert reports exhibited as part of the public consultation process that the north-eastern tributary is not considered to hold significant environmental/ecological values, and is considered to be a cut drain only.
22. We say that there is merit in considering a reduced corridor width along this section of our client's site, and that alternative solutions such as the application of an online stormwater treatment may be a more appropriate outcome for this section of the Aitken Creek north-eastern tributary.
23. We are available to engage with the relevant experts to carefully consider the required stormwater and infrastructure modelling for the precinct in consultation with the VPA as part of the PSP process.

We are grateful for the opportunity to provide these submissions on behalf of our client, and look forward to the continued engagement with the VPA, relevant authorities and stakeholders through the PSP process.

Please contact me on [am@townplanners.com.au](mailto:am@townplanners.com.au) or (03) 933 2060 should you have any questions, or to discuss.

Yours Faithfully,



**Angela Mok** BE nvs (UrbDesign&Plan), MPIA, MVPELA  
**Associate** | Clement-Stone Town Planners

On behalf of [REDACTED] Whites Lane, Yuroke (Mickleham)

## **Appendix**

1. Aitken Creek Waterway Values Assessment, Jacobs, 8 December 2020
2. Waterway Corridors – Guidelines for Greenfield Development Areas within the Port Phillip and Westernport Region, Melbourne Water, October 2013



## **Aitken Creek Waterway Values Assessment**

**Final Project report**

December 2020

**Melbourne Water**



**Aitken Creek Waterway Values Assessment**

Project No: IA5000BS  
Document Title: DRAFT Project report  
Date: 8<sup>th</sup> December 2020  
Client Name: Melbourne Water  
Project Manager: Bron Gwyther  
Author: Bron Gwyther, Peter Sandercock, John Kershaw  
File Name: Aitken Creek Waterway Values Assessment\_DRAFT FINAL

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**Document history and status**

Revision	Date	Description	Author	Checked	Reviewed	Approved
V1	28/9/20	Draft report for client review	Bron Gwyther John Kershaw Peter Sandercock Simon Treadwell	Fiona Gilbert	Sarah Hale	
Final	8/12/20	Final report, incorporating client comments.	Bron Gwyther			

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## Executive Summary

### *Project context*

Aitken Creek is an ephemeral headwater stream located within the City of Hume, approximately 32 km north of the Melbourne CBD. It rises in an agricultural landscape at the edge of the Urban Growth Boundary and flows in a south easterly direction, joining small tributaries before flowing through the suburban areas of Craigieburn and meeting Merri Creek.

The main channel and two tributaries of Aitken Creek flow through the Craigieburn West Precinct Structure Plan (PSP) area which is currently in the Council & State Agency Consultation phase of development. To ensure that new developments in greenfield areas are effectively supported by water infrastructure, Melbourne Water prepares Development Services Schemes (DSS), effectively master plans for drainage in a catchment. The Aitken Creek DSS was originally prepared in August 2000. Revisions are currently being made to the DSS to cater for the new Craigieburn West PSP. Since development of the original DSS, knowledge regarding the impacts of development of waterways and their amelioration has improved, best practice standards for stormwater management have been updated and community expectations for the protection and management of waterways has increased markedly.

### *Project objective and method*

This project has been undertaken on behalf of Melbourne Water to inform the revision of the Aitken Creek DSS and consultation with the VPA regarding appropriate waterway buffers and asset locations in the Craigieburn West PSP. As part of the DSS revision process, waterway corridor widths and drainage asset locations have been proposed for the DSS by Melbourne Water.

This project involved desktop and field investigations into the flora, fauna and geomorphic values of Aitken Creek, an assessment of the sensitivity of these values to hydrological change and high level review and recommendations regarding the suitability of proposed buffers and potential management interventions to protect these values.

### *Geomorphic values*

The Aitken Creek Main Channel, Southern Tributary and North Eastern tributary were mapped using the Melbourne Water Geomorphic River Styles fieldsheet. All reaches were mapped as Valley fill intact – urban future according to the Healthy Waterways Visions typology. This is a common stream form across the study area, in poor condition and located within an agricultural landscape. The soils are Sodosols with a strong texture contrast. Sand to clay loamy surface horizons and dense and coarsely structured subsoil horizons that are sodic and dispersive. In several reaches there is likely to have been alteration of the stream form through the relocation of basalt boulders and the construction of dams. While the Southern Tributary does not have a defined channel, it is a mapped waterway and at the time of survey was saturated with large areas of standing water.

While the streams do not contain any significant geomorphic features, their current form provides critical ecological functions as headwater streams.

### *Ecological values*

The majority of vegetation within the project area comprised exotic grassland dominated by a number of ubiquitous perennial grass species. A small suite of indigenous species - mostly grasses and graminoids - was common within this vegetation. Scattered patches of native vegetation referable to two threatened Ecological Vegetation Classes (EVCs) were recorded within Aitken Creek Main Channel and Aitken Creek Southern Tributary. While not surveyed, a brief inspection of the grasslands adjacent to the north west end of Aitken Creek within 1760 Mickleham Road indicated that this area is likely to be dominated by native grassland.

A total of 90 vascular plant species were recorded within the project area as part of desktop and field survey, of which 34 species (38%) are indigenous and 56 (62%) are exotic.

Patches of native vegetation recorded comprised four Habitat Zones of two EVCs (EVC 132 61 Heavier soils and Plains Grassland EVC 125 Plains Grassy Wetland). Habitat condition scores ranged from 16% to 46% of pre-European condition. During field investigations for this project, eleven scattered trees were recorded along Aitken creek, eight of which were large.

### *Summary*

While Aitken Creek as it passes through the Aitken Creek DSS has been degraded by channel form modification in places and by widespread grazing, it continues to support state and federally listed species and communities, significant trees and, as headwater streams, to provide the important functions of infiltration, reduction in peak flows and nutrient retention. Aitken Creek is also a waterway particularly at risk of erosion and incision due to the underlying sodic soils. Proposed asset locations, waterway corridor widths and form and stormwater treatments in the catchment should be considered in light of these values and functions.

Particular risks include:

- Narrow waterway corridors requiring channelization of the waterway into the underlying sodic soils, increasing shear stress, construction costs, failure risk and long term maintenance.
- Channelisation of the waterways leading to hydrological connection to the underlying groundwater with associated increase to flows in channel and lowering of groundwater level (and associated risks to adjacent groundwater dependent ecosystems).
- Direct loss of significant native vegetation communities and mature trees through construction of the waterway and drainage assets.
- Indirect loss of mature trees due to changed hydrology (shift from an ephemeral to permanent flow regime due to increased stormwater as well as risks to groundwater levels).
- Risks to downstream ecological values and drainage assets from increased flows and nutrients from stormwater and potential groundwater connection.

The desktop and field investigations undertaken by Jacobs support the corridor widths proposed by Melbourne Water to enable the retention of a shallow, wide waterway that reduces the risk of channelization into sodic subsoils and associated erosion and groundwater risks. This also provides opportunities to retain some infiltration functions within the corridor either through stream form or WSUD treatments.

We recommend the following principles for consideration during design:

- Retention of mature trees along the waterway wherever possible.
- Where waterways are to be constructed, review whether the channel can avoid existing mature trees to prevent these being located in standing water as the flow regime changes.
- Retention of areas of Plains Grassland and Plains Grassy Wetland in the Aitken Creek Main Channel as natural waterway, rather than constructed waterway (particularly at the north west end of the Main Channel, where it links to existing high value grassland and immediately to the north of the area proposed to be retained as a natural channel).
- Review options for stream form that provide infiltration and nutrient retention within waterway buffers (e.g. chain of ponds), this may require additional buffer width.
- Maintain wide buffers wherever possible to support shallow waterway channels and avoid channelization into sodic subsoils. Expansion of the corridor to encompass the 100-year ARI flood extent in areas beyond those outlined above could be considered to enable this, particularly around the mapped area of Plains Grassy Wetland in the Main Channel.
- Relocation of the proposed 2.15 ha wetland (G4WL) to an area of lower ecological value.

- Relocation of the proposed 2.92 ha wetland (E10WL) in the Southern tributary to an area of lower ecological value.
- Harvesting of stormwater runoff from the newly created impervious catchment areas and/or redirection of stormwater to outfalls located downstream of this reach to protect stream form.

Further targeted field investigations should be undertaken to confirm the presence of two threatened flora species and additional modelling of how the hydrology will change in these waterway corridors and if the existing channel form would remain stable under developed flow conditions would be required to inform detailed analysis of potential changes. This would also inform whether further mitigation measures are required.

We note that the Healthy Waterways Strategy has a performance objective of putting in place protection mechanisms for headwaters to ensure that they are retained as features in the landscape for environmental, social, cultural and economic benefits and that Melbourne Water is currently developing policy for the protection of headwater streams under development scenarios. The HWS also sets ambitious targets for stormwater infiltration in developing catchments. With this strategy, Melbourne Water and its co-design partners have put forward a vision for a higher standard of waterway protection both through on ground management and management of catchment hydrology. Innovative IWM solutions to stormwater management challenges are also supported by a wide range of strategies from agencies that will be involved in the management of the area as it is developed, including from Hume City Council, Yarra Valley Water and DELWP.

The Aitken Creek DSS review and development of the Craigieburn West PSP provides an opportunity to test innovative management actions to protect headwater streams in an evolving policy space and retain these valuable environmental assets and the services they provide in the catchment and downstream.

## **Important note about your report**

*The sole purpose of this report and the associated services performed by Jacobs is to undertake a risk assessment of waterway values in the context of development within the Aitken Creek Development Services Scheme in accordance with the scope of services set out in the contract between Jacobs and the Client (Melbourne Water). That scope of services, as described in this report, was developed with input from Melbourne Water.*

*In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.*

*Jacobs derived the data in this report from information sourced from Melbourne Water as well as information available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.*

*Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.*

*This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context. This report has been prepared on behalf of, and for the exclusive use of, Melbourne Water, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and Melbourne Water. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.*

## **1. Introduction**

### **1.1 Aitken Creek**

Aitken Creek is an ephemeral headwater stream located within the City of Hume, approximately 32 km north of the Melbourne CBD (Figure 1-1). It rises in an agricultural landscape and flows in a south easterly direction, joining small tributaries before flowing through the suburban areas of Craigieburn and the Craigieburn Golf Course, and meeting Merri Creek approximately 5 km downstream of the project boundary, at the Craigieburn Grassland Nature Reserve. This confluence is approximately 1.8km downstream of the Malcolm Creek and Merri Creek confluence, and ~35 km upstream of where the Merri Creek meets the Yarra River.

### **1.2 PSP development**

The main channel and two tributaries of Aitken Creek flow through the Craigieburn West Precinct Structure Plan (PSP) area which is currently in the Council & State Agency Consultation phase of development. This PSP abuts the western edge of the Urban Growth Boundary (UGB) and is itself bounded by current or planned development on three sides (Craigieburn PSP to the east, Greenvale North PSP to the south, Lindum Vale PSP to the north) with a rural landscape to the west (Figure 1-2).

The majority of the Craigieburn West PSP has been proposed for residential development, with a corridor currently only set aside for the main channel of Aitken Creek (Figure 1-3).



Figure 1-1. Aitken Creek.

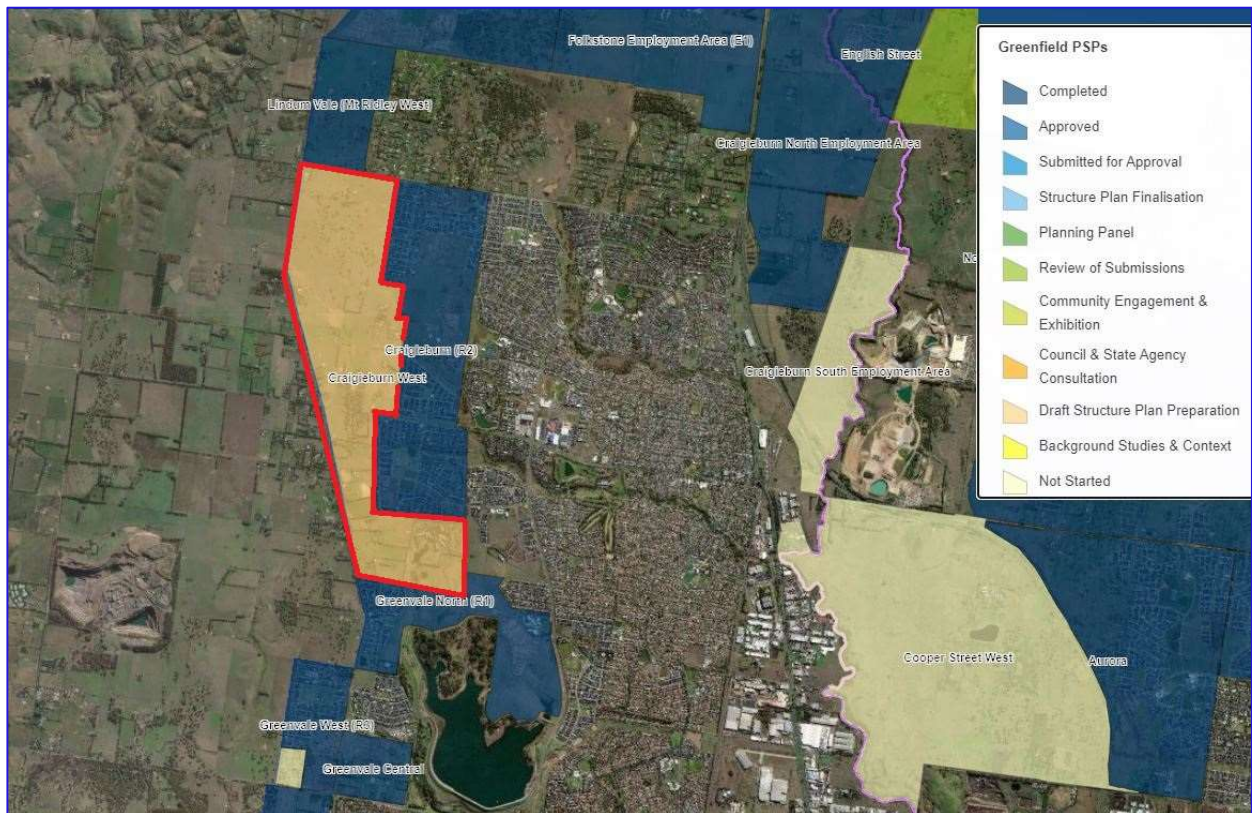
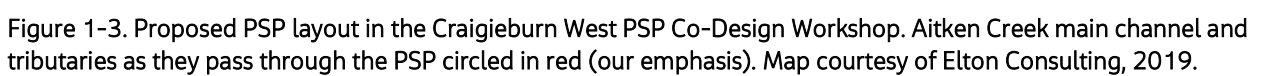


Figure 1-2. Craigieburn West PSP, which Aitken Creek flows through, landscape context (image courtesy of VPA<sup>1</sup>). Craigieburn West PSP outlined in red (our emphasis).

<sup>1</sup> Victorian Planning Authority, (n.d.) Interactive Status Map. <https://vpa.vic.gov.au/greenfield/interactive-status-map/>. Accessed 23 September 2020.



### **1.3 Aitken Creek Development Services Scheme**

To ensure that new developments in greenfield areas are effectively supported by water infrastructure, Melbourne Water prepares Development Services Schemes (DSS), effectively master plans for drainage in a catchment. DSS are used to ensure that appropriate outfall pipelines, open waterways and other drainage infrastructure (e.g. retarding basins, wetlands, sediment ponds and litter traps) are established as development occurs, and that these meet appropriate standards for flood protection, water quality, waterway health and amenity.

The Aitken Creek DSS was originally prepared in August 2000. Revisions are currently being made to the DSS to cater for the new Craigieburn West PSP being prepared by the Victorian Planning Authority (VPA). Since development of the original DSS in 2000, knowledge regarding the impacts of development of waterways and their amelioration has improved, best practice standards for stormwater management have been updated and community expectations for the protection and management of waterways has increased markedly.

Through this revised DSS, Melbourne Water's Development Services team is working to embed greater alignment of best practice standards for the protection of Aitken Creek and its tributaries, as well as with other relevant strategies, such as Melbourne Water's Healthy Waterways Strategy (HWS). The revision process is also an opportunity to expand protections for significant ecological and geomorphological values into the DSS, particularly through waterway buffers and improved siting of drainage infrastructure.

As part of the DSS revision process, waterway corridor widths and drainage asset locations have been proposed for the DSS by Melbourne Water (Figure 1-4 and Table 1-1).

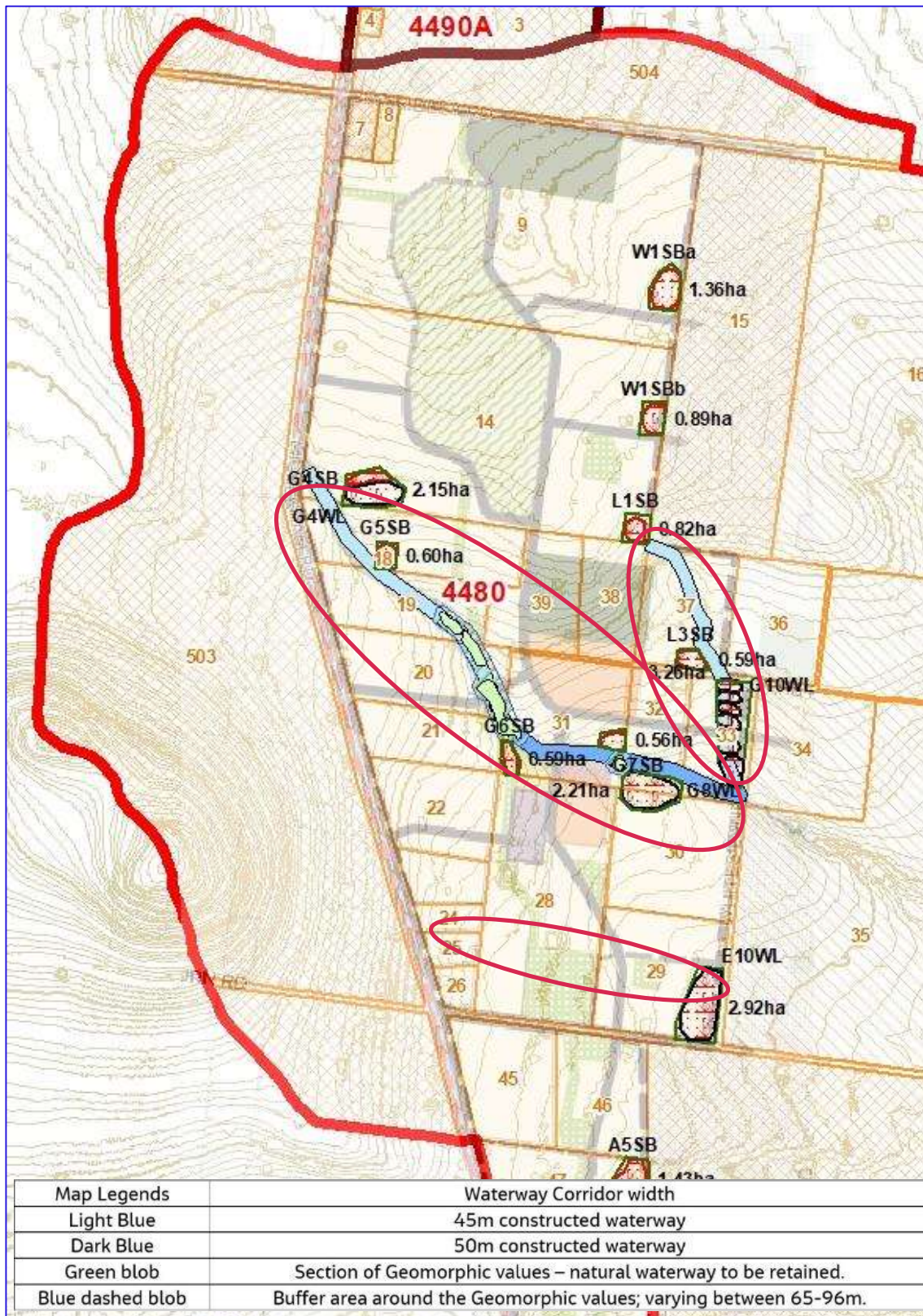


Figure 1-4. Proposed buffer widths and asset locations. Aitken Creek main channel and tributaries as they pass through the PSP circled in red (our emphasis). Asset reference codes link to Table 1 1. Map courtesy of Melbourne Water.

Table 1-1. Description of drainage assets in Figure 1-4. Provided by Melbourne Water 5 August 2020.

Reference code	Asset Type	Catchment Area (ha)	Potential Asset Owner	Surface Area (ha)	Footprint Area (ha)
A5SB	Sediment Basin	39.8	Council	0.5	1.43
W1SBa	Sediment Basin	41.6	Council	0.6	0.89
W1SBb	Sediment Basin	31.7	Council	0.35	1.36
L1SB	Sediment Basin	34	Council	0.2	0.82
L3SB	Sediment Basin	29.8	Council	0.2	0.59
G10WL	Wetland	88.9	MW	0.7	3.26 (including 1.8ha within waterway corridor)
G4WL	Wetland	33.7	MW/Council	0.76	2.15
G5SB	Sediment Basin	32.7	Council	0.16	0.6
G6SB	Sediment Basin	29.9	Council	0.16	0.59
G7SB	Sediment Basin	30	Council	0.16	0.56
G8WL	Wetland	30	MW/Council	0.5	2.21
E10WL	Wetland	79	MW	1.4	2.92
<b>Total</b>				<b>5.7</b>	<b>17.4 (including 1.8ha within waterway corridor)</b>

## 1.4 Project scope

To inform the revision of the Aitken Creek DSS and consultation with the VPA regarding appropriate waterway buffers and asset locations in the Craigieburn West PSP, Melbourne Water commissioned Jacobs to undertake desktop and field assessments of waterway values of Aitken Creek as it flows through the Aitken Creek DSS.

The scope of this assessment included:

- Confirmation of the presence and condition of the ecological (flora and fauna) and geomorphic values of Aitken Creek and its tributaries as they flow through the DSS, including:
  - **flora and fauna:** assessment of extent, condition and ecological significance of native vegetation, listed species and vegetation communities; identification of potential habitat for threatened species; identification of any implications under National, State & local legislation and policy & relevant Melbourne Water strategies (e.g. HWS)
  - **geomorphic:** form, condition, value & current trajectory of target areas.
- Evaluation of the sufficiency of the currently proposed buffers.
- High level assessment of whether and how current waterway form (and associated values) could be maintained under a post-development hydrological regime, particularly through the design of the DSS.
- Advice on how significant native trees (particularly River Red Gums) along the waterways could be retained and supported during and post development of the surrounding catchment (including the development of constructed waterways) particularly through management of hydrological threats and location of drainage assets.

The spatial extent of the desktop and field assessment included (see Figure 1-1):

- Aitken Creek Main Channel
- Aitken Creek tributary #4485 (North Eastern tributary)
- Aitken Creek tributary #4483 (Southern Tributary), eastern end.

- Adjacent ecological values linked to these tributaries.

However only the Southern Tributary and Main Channel were able to be accessed in the field.

## 2. Methodology

The development of the Aitken Creek Waterway Values Assessment involved an initial desktop assessment, a field assessment and subsequent synthesis of findings, including a hydrological sensitivity assessment, as outlined below.

### 2.1 Desktop assessment

Jacobs undertook a desktop review of existing information regarding geomorphic and ecological (flora, fauna and wetland) values in the study area, based on available literature, reports, data and research. The key focus of this assessment was the preliminary identification of native vegetation, listed species, vegetation communities and potential threatened species habitat and the compilation of existing information on the extent, condition, ecological significance and legislative and policy ramifications of these.

The outputs from the desktop assessment were used to inform the location, extent and methodology of field investigations and form the basis of a preliminary assessment of reaches of high value and priority for protection<sup>2</sup>.

#### 2.1.1 Geomorphic values desktop assessment

A desktop assessment was undertaken and a summary prepared outlining geomorphic values in the PSP area. This included a collation and review of existing research, data and mapping, as follows:

- Catchment areas, stream network and valley topography.
- River Style™ mapping and HWS 2030 Geomorphic Templates.
- Sites of Geological and Geomorphological Significance.

#### 2.1.2 Flora and fauna values desktop assessment

Identification of flora and fauna species, vegetation communities and wetlands which have previously been recorded or are considered likely to be present within the proposed target area, based on review of available information sources:

- **Commonwealth data:**
  - Protected Matters Search Tool (PMST): The PMST highlights any Matters of National Environmental Significance (MNES) relevant to the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that are likely to occur within an area. Records from within 5 km of the PSP area have been assessed for this report (Commonwealth Department of Agriculture, Water and the Environment, n.d.).
  - Groundwater Dependent Ecosystems (GDE) Atlas: aquatic and terrestrial GDEs within the PSP and surrounding area (Australian Bureau of Meteorology, n.d.).
- **Victorian Department of Environment, Land, Water and Planning Biodiversity Data:**
  - Victorian Biodiversity Atlas (VBA): this database comprises historical records of flora and fauna species from across the state. Records are added opportunistically, as flora and fauna surveys are conducted within Victoria for a variety of purposes. Records from within 5 km of the PSP area have been assessed for this report (NatureKit).
  - Modelled Victorian Ecological Vegetation Classes (EVCs) (DELWP, n.d.).
  - Current Wetland, 1994 wetland and Pre-European wetland layers (DELWP, n.d.).
- **Melbourne Water data:**

<sup>2</sup> Desktop findings are summarised in Jacobs 2020, Aitken Creek Waterway Assessment Desktop assessment and methodology statement memo. Unpublished memo to Melbourne Water.

- Melbourne Water's "Waterbodies\_integrated" layer. An extensive spatial layer of natural and artificial waterbodies in the Melbourne Water region.
- Aerial imagery (Spring 2019 10 cm).
- Review of DSS layouts, proposed asset locations and waterway corridor widths.

Site specific reports relevant to the area were also reviewed, as cited throughout this report.

## 2.2 Field assessment

Geomorphic and ecological investigations were undertaken along Aitken Creek by John Kershaw and Peter Sandercock on the 20<sup>th</sup> August 2020. A walk over was completed of waterway reaches where access was approved. For reaches that could not be accessed, a visual inspection of the waterway was completed at points that were accessible (i.e. roadside reserves, property boundary/fence lines).

Areas assessed included:

- Aitken Creek Main Channel (except for 1720 Mickleham Road);
- Aitken Creek tributary #4483 (southern tributary), eastern end; and
- Brief assessment of grasslands adjacent to the north west end of Aitken Creek within 1760 Mickleham Road (though no vegetation mapping was conducted).

As no access was available for Aitken Creek tributary #4485 (north eastern tributary)<sup>3</sup>, these areas were viewed from Whites Lane and Olivers Road to get an indication of likely values. A map of areas not able to be accessed during the site visit is provided in Appendix A.

### 2.2.1 Geomorphic assessment

The purpose of the geomorphic field assessments was to undertake reach-scale assessments documenting the nature of processes influencing a reach's stability and trajectory and how these in turn are impacting on flora, fauna and geomorphology values. The Geomorphology Pro forma as supplied by Melbourne Water was used in the field to document the assessment of waterways in a tabulated format. A summary of the information collected in the pro formas is provided in Table 2-1, the ranking scheme used to assess the overall condition of geomorphic values is outlined in Table 2-2 and the populated pro formas are provided in Appendix B.

Table 2-1. Geomorphology Pro forma – Information collected for waterway reaches.

ASSET_NAME	e.g. Aitken Creek
Date of Site visit	When site assessment was completed or if it wasn't why not (i.e. no access, desktop assessment)
DSS	[Provided by Melbourne Water]
COMPKEY	[Provided by Melbourne Water]
UNITID	[Provided by Melbourne Water]
UNITID2 (if applicable)	[Provided by Melbourne Water]
HWVisions_Stream_Form	[Provided by Melbourne Water]
GEOMORPHIC CHARACTER	
Values	Whether geomorphic features are present that trigger one or more of the categories of: Rarity(uniqueness), naturalness (condition), diversity (richness), intactness, representativeness
Valley-setting	Confined, partly-confined, laterally-unconfined
Channel planform	Sinuosity (do qualitatively, not quantitatively)
Upstream catchment area	[Note – This only required for each waterway under consideration, not for each reach]

<sup>3</sup> 225 Olivers Road, 220 Olivers Road and 125 Whites Lane.

Land use	Existing land use surrounding the waterway
Geomorphic units / In stream habitat features	Within-channel – get simplified info at broad scale, e.g. not topo survey (pools, riffles, glides, benches, bars, vegetated islands, large wood) Floodplain - (backchannels, flood channels, palaeochannels, terraces, swamp)
Bed	<ul style="list-style-type: none"> <li>• Slope</li> <li>• Sediment (substrate type and load)</li> <li>• Parent material, origin and classification</li> <li>• Soil Type - Cohesiveness and dispersiveness (i.e. erodibility)</li> </ul>
Vegetation associations	Riparian vegetation – THIS TO LINK IN WITH F&F ASSESSMENT
Process zone	Incision, Aggradation or Sediment Transfer
In stream works	Note the presence and condition of any previous in stream works and modifications to the channel, including straightening, channelization, rock armouring, presence of stormwater outlets, bridge crossings, culverts etc.
<b>WATERWAY BEHAVIOUR – PROCESSES &amp; TRAJECTORY</b>	
Waterway Process Trajectory (under current and PSP development conditions)	<ul style="list-style-type: none"> <li>• Waterway trajectory</li> <li>• Potential for bed adjustment</li> <li>• Types of bank erosion</li> <li>• Form &amp; reworking of instream units</li> </ul>
<b>WATERWAY CONDITION AND RISK</b>	
Condition	Waterway physical condition/value of reach as compared to a rating methodology.
Risk	Net outcome of the trajectory of the waterway on physical (geomorphic) assets and adjacent socio-economic assets (e.g. services, bridges, roads)
Trajectory (existing conditions)	Stream Form Vision (existing conditions and land management)
Trajectory (post development)	Stream Form Vision (with no mitigation activities). This will then inform DSS design on what, if any mitigating measures are needed (e.g. waterway corridor widths, RBs)

Table 2-2. Ranking scheme to assess overall condition of geomorphic values.

Level	Significance	Geomorphic value/condition
1	Insignificant	Common stream form across the study area and geomorphic features in poor condition
2	Low	Relatively common stream form across the study area and geomorphic features in moderate condition
3	Moderate	Unique/rare stream form and geomorphic features of regional significance in relatively good condition
4	High	Unique/rare and relatively intact stream form and geomorphic features of state significance
5	Very high	Unique/rare and intact stream form and geomorphic features of national or international significance

### 2.2.2 Ecological assessment

The purpose of the ecological field assessment was to identify the location and quality of native vegetation and fauna habitat along Aitken Creek, for areas that could be accessed. Mapping of the vegetation was undertaken using ArcGIS Collector. Native vegetation was mapped in accordance with the Guidelines for the removal, destruction or lopping of native vegetation (DELWP 2017) as either:

#### Patch:

- An area of vegetation where at least 25 per cent of the total perennial understorey plant cover is native, or
- Any area with three or more native canopy trees where the drip line of each tree touches the drip line of at least one other tree, forming a continuous canopy, or
- Any mapped wetland included in the Current wetlands map, available in DELWP systems and tools (DELWP 2017), is considered native vegetation according to the Guidelines (DELWP 2017).

### Scattered tree:

- A native canopy tree that does not form part of a remnant patch. A native canopy tree is a mature tree (i.e. is capable of flowering) that is greater than 3m in height and is normally found in the upper layer of the relevant vegetation type.

Patches of native vegetation were subsequently assigned to the applicable EVC and assessed against EPBC Act-listed vegetation community condition thresholds as detailed in listing Conservation Advice. Indicative quality of the vegetation was recorded using the Habitat Hectares method (DSE, 2004). A list of flora species observed during fieldwork was also recorded.

#### 2.2.2.1 Likelihood of occurrence assessment

An assessment of the likelihood of relevant rare and threatened species and threatened ecological communities occurring within the investigation area was undertaken. This assessment was based on the known preferred habitats in comparison to the habitat available in the investigation area, and the frequency, timing and location of previous recordings. A summary of the likelihood of occurrence assessment is provided in Section 3.

The criteria used for assessing likelihood of occurrence are described in Table 2-3 and Table 2-4.

Table 2-3. Criteria for determining the likelihood of threatened species occurring in the investigation area.

Likelihood	Criteria
High	<ul style="list-style-type: none"> <li>▪ Recent records of species from DELWP databases</li> <li>▪ Review of aerial photography indicates potential habitat on site</li> <li>▪ Review of habitat and distribution literature indicates the site is appropriate for this species.</li> </ul>
Moderate	<ul style="list-style-type: none"> <li>▪ Historic records of species from DELWP databases</li> <li>▪ Review of habitat distribution literature indicates the site is appropriate for this species</li> <li>▪ Review of aerial photography indicates limited habitat on site.</li> </ul>
Low	<ul style="list-style-type: none"> <li>▪ Species has not been previously recorded within DELWP database</li> <li>▪ Review of aerial photography indicates that no available habitat is present on site</li> <li>▪ Review of literature regarding habitat and distribution indicates the site is unlikely to be utilised by this species.</li> </ul>
Negligible	<ul style="list-style-type: none"> <li>▪ Conditions within the project area are incongruous with requirements of the species (e.g. marine pelagic species could not occur in a terrestrial project area; or a highly degraded environment lacking in habitat features required for species), and/or</li> <li>▪ The species has been deemed absent after sufficient survey effort (criterion generally reserved for particularly conspicuous species).</li> </ul>
N/A	<ul style="list-style-type: none"> <li>▪ Legislation protecting threatened species does not apply to the species within the project area, as: <ul style="list-style-type: none"> <li>- The project area is outside the natural range of the species, and</li> <li>- The species is present for non-conservation purposes (e.g., planted for amenity, or has become naturalised in the area).</li> </ul> </li> </ul>

Table 2-4. Criteria for determining the likelihood of threatened ecological communities occurring in the investigation area

Likelihood	Criteria
High	<ul style="list-style-type: none"> <li>▪ Mapping by DELWP indicates the EVCs likely to be present at the site are of a similar composition to the threatened ecological community</li> <li>▪ Review of aerial photography indicates that native vegetation is likely to be present at the site</li> <li>▪ Review of literature and general knowledge of vegetation in the area indicates the site is appropriate for this threatened ecological community.</li> </ul>

Likelihood	Criteria
Moderate	<ul style="list-style-type: none"> <li>Mapping by DELWP indicates the EVCs likely to be present at the site are of a similar composition to the threatened ecological community</li> <li>It is difficult to determine from aerial photography whether the community is present, such as grassland communities</li> <li>Review of literature and general knowledge of vegetation in the area indicates the site is suitable for this threatened ecological community.</li> </ul>
Low	<ul style="list-style-type: none"> <li>Mapping by DELWP indicates the EVCs likely to be present at the site are not of similar composition to the threatened ecological community</li> <li>Review of aerial photography indicates that no native vegetation is likely present</li> <li>Review of literature and general knowledge of vegetation in the area indicates that the threatened ecological community is unlikely to be present at the site.</li> </ul>

### 2.2.2.2 Limitations

Targeted surveys for threatened flora and fauna species were not conducted. In addition, two threatened flora species that are likely to occur in the area, Matted Flax-lily and River Swamp Wallaby-grass, were assessed outside of the flowering time of both of these species which is November through March. Targeted follow up surveys would be required to confirm their occurrence.

Information from the desktop assessment is only as reliable as the data available and, in the case of the VBA the number of surveys previously undertaken (i.e. an area where many surveys have been taken in the past, will, most likely, have a more extensive list of species than areas where very little survey work has been undertaken). The accuracy of past surveys is also variable and point locations can be out by up to 1 km.

In addition to the number of previous surveys undertaken, there are other reasons why species, including threatened species, may not have previously been recorded. For example, at the time of historical site visits some plant species may not have been visible above the ground or flowering and therefore not identified as being present within the area surveyed. Also, the data collected is likely to consist of opportunistic observations only, and, therefore, listed fauna species moving in and out of the area may not have been observed or recorded. Similarly, many fauna species are cryptic, nocturnal and well-hidden such that their presence can only be detected through detailed targeted assessment methods. Hence, species that can be readily identified at that time, heard, or have distinctive signs, such as tracks, scats, diggings are those most likely to be recorded.

Several properties were not able to be visited during fieldwork due to access not being granted by landowners, particularly in the North Eastern Tributary. This includes:

- 1720 Mickleham Road
- 220 Olivers Road
- 225 Olivers Road
- 125 Whites Lane.

These are displayed spatially in Appendix A.

## 2.3 Hydrological sensitivity analysis

This section describes the methods used to assess the sensitivity of the waterway reaches in the study region to hydrological change as a result of urbanisation and the need for management intervention.

### 2.3.1 Overview of risk framework

A risk-based framework was used to assess the risk that hydrological changes pose to geomorphology, flora and fauna values. To do this we applied our understanding of the current condition of the channel reaches and their values, together with hydrological changes to assess the severity of risks.

With respect to hydrological analysis, the likely rate and magnitude of stream form adjustment due to the probable magnitude of hydrologic change (pre- and post-development) was considered. All elements of the hydrological regime, including potential changes to low flows and the frequency of high-disturbance events were considered. These changes can impact on values such as chain of ponds morphology, some types of riparian vegetation and a range of instream fauna (e.g. Growling Grass frogs) that are adapted to an intermittent flow regime.

The steps to completing this assessment of risk were as follows:

- Step 1 Determine the severity of the **consequences** (magnitude of the hydrological change).
- Step 2 Determine the **likelihood** that waterway processes and trajectory will threaten geomorphology, flora and fauna values (sensitivity of values to hydrological change).
- Step 3 Analyse the unmitigated risk profile.

### 2.3.2 Consequence assessment

Our analysis of risk considered the severity of the consequences (magnitude of the hydrological change) occurring. The magnitude of hydrological change influences the resulting environmental impact. The criteria in Table 2-5 were used to rate the magnitude of hydrological change.

Table 2-5. Consequence criteria for assessing the magnitude of the hydrological change.

Rating		Description
3	High	High magnitude of hydrological change (i.e. shift from an ephemeral to a perennial flow regime, persistent low flows and frequent high-disturbance events).
2	Moderate	Moderate magnitude of hydrological change (i.e. shift from ephemeral pre-development flows, notable increase in the duration of low flows and frequency of high-disturbance events).
1	Low	Low magnitude of hydrological change (i.e. ephemeral pre-development flow regime with existing catchment conditions maintained).

These consequence criteria could be further refined with reference to hydrological models of existing and developed catchment conditions and analysis of changes in flow. This would involve analysis of changes in flow rates for a selection of AEP flows.

### 2.3.3 Likelihood assessment

The likelihood that waterway processes and trajectory will threaten geomorphology, flora and fauna values is a function of the sensitivity of the values to hydrological change. Criteria in Table 2-6 and Table 2-7 were used to rank the sensitivity of values to hydrological changes for geomorphology and ecology values respectively.

Table 2-6. Likelihood criteria for assessing the sensitivity of geomorphology (stream form) values to hydrological change.

Rating		Description
3	High	High potential for erosion and stream form adjustment (incision and widening). Surface is comprised of fine-grained sediments, with highly erodible soils (sodosols).
2	Moderate	Moderate potential for erosion and stream form adjustment (incision and widening). Surface is comprised of a mixture of fine-grained sediments, cobbles and gravel.
1	Low	Low potential for erosion and stream form adjustment (incision and widening). Surface is comprised of a mixture of fine-grained sediments, cobbles and gravel. Bedrock and boulders also present and form a highly resistant boundary.

Table 2-7. Likelihood criteria for assessing the sensitivity of flora and fauna values to hydrological change.

Rating		Description
3	High	<ul style="list-style-type: none"> <li>Highly specialised habitat and water regime requirements</li> <li>Very small change (+/- 20%) in the frequency or duration of inundation events likely to result in change in community composition and loss of sensitive species</li> <li>Individual species have specific water regime requirements within a narrow range of variability.</li> <li>EPBC /FFG listed community or species located within 1% AEP flood event extent</li> <li>Waterway intersects or immediately adjacent to named Biosite</li> <li>Unable to move/migrate to new locations</li> </ul>
2	Moderate	<ul style="list-style-type: none"> <li>Individual species have some specific requirements but are able to cope with moderate variability.</li> <li>Moderate change (+/- 60%) in frequency or duration of inundation events needed before community composition changes</li> <li>Mobile species that can move around local region to take advantage of shifting habitat</li> </ul>
1	Low	<ul style="list-style-type: none"> <li>Generalist habitat requirements.</li> <li>Individuals are adapted to a range of conditions with no specific regime requirements.</li> <li>Large change (+/- 80%) in frequency or duration of inundation events needed before community composition changes.</li> <li>Very mobile species that can move between regions</li> <li>Species able to rapidly colonise disturbed habitats</li> </ul>

### 2.3.4 Risk rating and evaluation

The consequence (magnitude of hydrological change) and likelihood (sensitivity of values to hydrological change) were then used to determine the risk rating of either low, medium or high. The matrix in Table 2-8 can be used to provide a visual method of categorising risks based on their risk rating.

To determine the risk rating, the Magnitude of Hydrological Change rating was multiplied (x) by the Sensitivity rating. The multiplication of the two numbers produces a number from 1 through to 9.

For example, Magnitude of Hydrological Change **3** x Sensitivity **2** = **6** which is a **High** risk rating.

Table 2-8. Risk Rating Matrix.

Likelihood - Sensitivity	Consequence - Magnitude of Hydrological Change		
	Low (1)	Moderate (2)	High (3)
High (3)	Medium (3)	High (6)	High (9)
Moderate (2)	Low (2)	Medium (4)	High (6)
Low (1)	Low (1)	Low (2)	Medium (3)

The purpose of risk evaluation is to make decisions based on the outcomes of the risk analysis. This includes:

- Identifying which reaches and values are most at risk (i.e. high magnitude of hydrological change, high value, high sensitivity)
- Considering what management interventions would be required to minimise hydrological changes and protect riparian values.

### 3. Results

#### 3.1 Geomorphic values

##### 3.1.1 Overview

Aitken Creek and its tributaries drain a volcanic landscape. The geomorphology and topography has been influenced by lava flows and incision of lava by Aitken Creek (Streamline Research, 1997). Appendix B shows our reach scale assessment of current 2020 Stream Form Templates for waterways within the study region. All reaches were assessed as having a 'Valley Fill Intact' Stream Form. No listed geological or geomorphological features of significance have been identified in the study area. All reaches were assessed as having insignificant values, with reaches having a common stream form across the study area and geomorphic features in poor condition.

##### 3.1.2 Aitken Creek Main Channel

The main channel of Aitken Creek was assessed as having a 'Valley Fill Intact' stream form with insignificant values and geomorphic features in poor condition. Whilst we have assessed the stream form as 'Valley Fill Intact', the form and condition of the creek has been significantly altered as a result of agricultural development. The valley in sections has been drained (Figure 3-1). There has also been extensive alteration of topography through the removal and relocation of basalt boulders and the excavation of farm dams/water storages. Basalt boulder riffles are present in some sections (Figure 3-1).



Figure 3-1. Selected photographs of 'Valley Fill Intact' Stream Form along Aitken Creek – main channel.

Despite the assessment of the reach as having insignificant values and geomorphic features in poor condition, it does still provide an important function as a headwater stream. Depressions along the channel and adjacent low-lying areas would experience seasonal inundation. Headwater streams have been shown to provide an important role in regulating the flow of water, sediment and nutrients in the catchment (Jacobs, 2016).

These waterways are generally considered to be stable under existing conditions, however increased runoff arising from development has the potential to scour the channel. The soils in the study area are sodosols (Beveridge Williams, 2018) and as such are considered highly susceptible to erosion. With development there is a concern that traditional stormwater management (drainage and outfalls to creek) would result in increased flows along the waterways, potentially leading to scour and ongoing problems of erosion.

In order to retain the existing stream form post development, harvesting of stormwater runoff from the upstream contributory areas and/or redirection of stormwater to outfalls further downstream are likely to be

required. It is recognised that under a business as usual development scenario, the hydrology of the catchment post development is likely to result in a shift from an ephemeral to a perennial flow regime, and as such areas which are currently seasonally wet, may remain wet and pond water throughout the year. There may be opportunities within the waterway corridor to vary the stream form, so as to create a series of wetlands that hold water throughout the year separated by drier vegetated swales/rocky riffles.

### 3.1.3 Aitken Creek Tributary #4485 (North Eastern Tributary)

Inspection of this reach was from the roadside due to access restrictions (Figure 3-2). This reach is likely to have been extensively modified through agricultural development. It was assessed as having a 'Valley Fill Intact' stream form with insignificant values and geomorphic features in poor condition, however these reaches do still provide an important function as a headwater stream. These areas would experience seasonal inundation and play an important role in regulating the flow of water, sediment and nutrients in the catchment.



Figure 3-2. Selected photographs of 'Valley Fill Intact' Stream Form along Aitken Creek – north east tributary (left) and north east extension (right).

The trajectory of this reach is that it is likely to remain stable as a 'Valley-Fill Intact' stream form under existing conditions and post development, although it is noted that the current PSP does not allow for the protection of the reach. The proposed layout of the residential area would need to be modified so as to include an allowance for a waterway corridor to enable this.

Even with the provision of a waterway corridor, to retain the existing 'Valley-Fill Intact' stream form is likely to require harvesting of stormwater runoff from upstream contributory areas and/or redirection of stormwater to outfalls located downstream of this reach. It is recognised that under a business as usual development scenario, the hydrology of the catchment post development is likely to result in a shift from an ephemeral to a perennial flow regime, and as such areas which are currently seasonally wet, may remain wet and pond water throughout the year. There may be opportunities within the waterway corridor to vary the stream form, so as to create a series of wetlands that hold water throughout the year separated by drier vegetated swales/rocky riffles.

### 3.1.4 Aitken Creek Tributary #4483 (Southern Tributary), eastern end

The southern tributary of Aitken Creek (#4483) is assessed as having an 'Intact Valley Fill' stream form with insignificant geomorphology values and geomorphic features in poor condition. Topography and drainage patterns are likely to have been significantly modified through agricultural development. The area is very flat, with little drainage, is prone to seasonal inundation and waterlogging.(Figure 3-3).

A wetland is currently proposed for this reach (Asset E10WL). The current PSP does not allow for the protection of this reach. No waterway buffer width has been proposed by Melbourne Water for this reach, however it was noted at the time of field survey that ground conditions across the entire property (Scheme property 29) were

saturated with large areas of standing water. Presumably a large proportion of this property will be developed in the future. A suitable drainage scheme will need to be designed to accommodate anticipated changes in hydrology (increased runoff), reduction in the area of potential inundation (smaller constructed wetland) relative to existing conditions (ponding of water across the entire property) and also retention of ecological features such as EVCs and mature native trees.



Figure 3-3. Selected photographs of 'Valley Fill Intact' Stream Form along Aitken Creek – south east tributary.

## 3.2 Ecological values

The majority of vegetation within the project area comprised exotic grassland dominated by a number of ubiquitous perennial grass species, including *\*Agrostis capillaris* var. *capillaris* (Brown-top Bent), *\*Dactylis glomerata* (Cocksfoot) and *\*Nassella neesiana* (Chilean Needle-grass). A small suite of indigenous species - mostly grasses and graminoids - was common within this vegetation. Scattered patches of native vegetation referable to two EVCs were recorded within Aitken Creek Main Channel and Aitken Creek Southern Tributary. While not surveyed, a brief inspection of the grasslands adjacent to the north west end of Aitken Creek within 1760 Mickleham Road indicated that this area is likely to be dominated by native grassland.

A total of 90 vascular plant species were recorded within the project area as part of desktop and field survey, of which 34 species (38%) are indigenous and 56 (62%) are exotic (a full species list is provided in Appendix C).

### 3.2.1 Ecological Vegetation Classes (EVCs)

Two EVCs were recorded within the project area and are discussed below.

#### 3.2.1.1 EVC 132\_61 Heavier-soils Plains Grassland (Endangered)

Plains Grassland mapped within the project area ranged from moderately intact in the northern end of the Main Channel (adjacent to the grasslands within 1760 Mickleham Road), to highly modified in Aitken Creek Southern Tributary. Native species were largely restricted to the following grass species: *Themeda triandra* (Kangaroo Grass), *Austrostipa bigeniculata* (Knead Spear-grass), *Microlaena stipoides* var. *stipoides* (Weeping Grass) and *Rytidosperma* spp. (Wallaby-grasses). A small suite of native forbs and graminoids were present in the better-quality patches, though with low overall cover. Weed cover was high and was dominated by high-threat perennial grass species such as Chilean Needle-grass.

Four patches of Plains Grassland ranging in size from 0.02 ha to 0.13 ha were recorded, three of which were in Aitken Creek Main Channel and one in Aitken Creek Southern Tributary. It is also expected that the grasslands

within 1760 Mickleham Road supports large areas of this EVC. Two habitat zones of Plains Grassland were mapped and are detailed in Section 3.2.2 below.

### 3.2.1.2 EVC 125 Plains Grassy Wetland (Endangered)

The allocation of Plains Grassy Wetland for this vegetation is a 'best fit' scenario; much of the vegetation in question was highly modified, associated with dams, and often dominated by rushes (*Juncus* spp.). Commonly occurring native species included *Amphibromus nervosus* (Common Swamp Wallaby-grass), *Eleocharis acuta* (Common Spike-sedge), *Juncus* spp. (Rushes), *Rytidosperma duttonianum* (Brown-back Wallaby-grass) and *Schoenus apogon* (Common Bog-sedge).

Five patches of Plains Grassy Wetland ranging in size from 0.02 ha to 0.28 were recorded, three of which were in Aitken Creek Main Channel and one in Aitken Creek Southern Tributary. Two habitat zones of Plains Grassy Wetland were mapped and are detailed in Section 3.2.2 below.

### 3.2.2 Vegetation Quality Assessment

Patches of native vegetation recorded comprised four Habitat Zones of two EVCs (EVC 132\_61 Heavier soils Plains Grassland EVC 125 Plains Grassy Wetland) (Table 3-1 and Figure 3-4). Habitat condition scores ranged from 16% to 46% of pre-European condition.

Table 3-1. Vegetation Quality Assessment results

Habitat Zone			1	2	3	4
Bioregion			VVP	VVP	VVP	VVP
EVC #: Name			132_61:PG	125:PGW	132:PG	125:PGW
EVC Conservation Status		Max Score	Endangered	Endangered	Endangered	Endangered
Site Condition	Large Old Trees	10	na	na	na	na
	Canopy Cover	5	na	na	na	na
	Understorey	25	15	10	5	5
	Lack of Weeds	15	4	7	0	7
	Recruitment	10	0	3	0	3
	Organic Litter	5	5	5	4	5
	Logs	5	na	na	na	na
	Standardiser	n/a	1.36	1.36	1.36	1.36
	<b>Total</b>	<b>75</b>	<b>32.64</b>	<b>34</b>	<b>12.24</b>	<b>27.2</b>
Landscape Context	Patch size	10	8	1	1	1
	Neighbourhood	10	1	0	0	0
	Distance to Core	5	4	3	3	3
	<b>Total</b>	<b>25</b>	<b>13</b>	<b>4</b>	<b>4</b>	<b>4</b>
<b>Habitat Score</b>		<b>100</b>	<b>45.64</b>	<b>38</b>	<b>16.24</b>	<b>31.2</b>
Habitat points = #/100		1	0.46	0.38	0.16	0.31
Habitat Zone area (ha)			0.13	0.18	0.05	0.06
Habitat Hectares			0.059	0.068	0.008	0.019

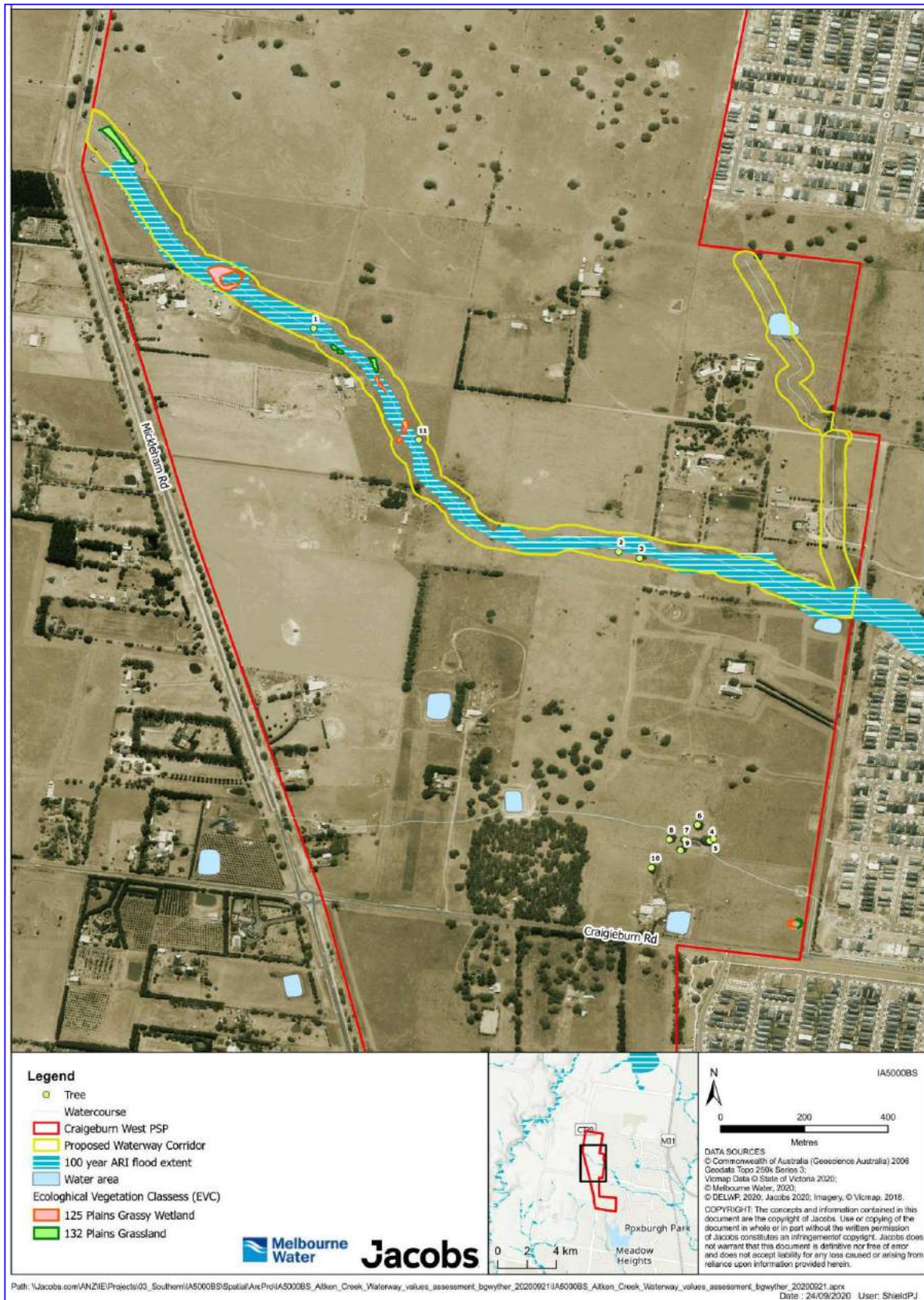


Figure 3-4. Location of ecological values mapped within Aitken Creek Main Channel.

### 3.2.3 Mature trees

During field investigations for this project, eleven scattered trees were recorded along Aitken creek, eight of which were large and three small (Figure 3-4 and Figure 3-5).

While much of the DSS landscape is open grassland with scattered mature trees, there is a dense stand of River Red Gums (RRGs) in the south of the DSS. The northern section of the block supports numerous large mature RRGs, with high retention value (see Figure 3-6 and Figure 3-7). The southern section is comprised of hundreds of semi-mature to mature RRGs in a dense cluster of similar age, condition and life expectancy. While this area was not assessed during Jacobs field work, it has been reviewed as part of previous arboricultural assessments and has been noted for its arboricultural and ecological value (Treetec, 2018). Aerial imagery from the 1950s shows the the patterns of trees in the landscape 70 years prior to present day (Figure 3-8).

Table 3-2. Scattered trees recorded within Aitken Creek Main Channel and Aitken Creek Southern Tributary (photos provided in Figure 3-5).

Number	Species	Diameter at breast height (cm)	Size	Hollow Bearing	Canopy Health	Comment
1	<i>Eucalyptus ovata</i> var. <i>ovata</i>	74	Small	No	30-70%	
2	<i>Eucalyptus ovata</i> var. <i>ovata</i>	75	Small	No	30-70%	DBH estimated
3	<i>Allocasuarina verticillata</i>	50	Small		>70%	DBH estimated. Species may not technically comprise a scattered tree in this part of landscape.
4	<i>Eucalyptus camaldulensis</i>	185	Large	Yes	>70%	
5	<i>Eucalyptus camaldulensis</i>	84	Large		>70%	
6	<i>Eucalyptus camaldulensis</i>	168	Large	Yes	>70%	
7	<i>Eucalyptus camaldulensis</i>	92	Large	Yes	>70%	
8	<i>Eucalyptus camaldulensis</i>	130	Large	Yes	>70%	DBH estimated
9	<i>Eucalyptus camaldulensis</i>	140	Large	Yes	>70%	DBH estimated
10	<i>Eucalyptus camaldulensis</i>	110	Large		>70%	DBH estimated
11	<i>Eucalyptus ovata</i> var. <i>ovata</i>	83	Large		<30%	



Tree 1



Tree 2



Tree 11



Tree 3



Figure 3-5. Mature trees along Aitken Creek. Photos taken during fieldwork in August 2020. Identification numbers refer to Table 3-2 .



Figure 3-6. Pictures of the RRG stand, from the south of the block looking north (top left); from the north of the block looking east (top right); facing west from the north of the block (bottom left); facing east into the block from the west (bottom right) (Ecology and Heritage Partners, 2018).

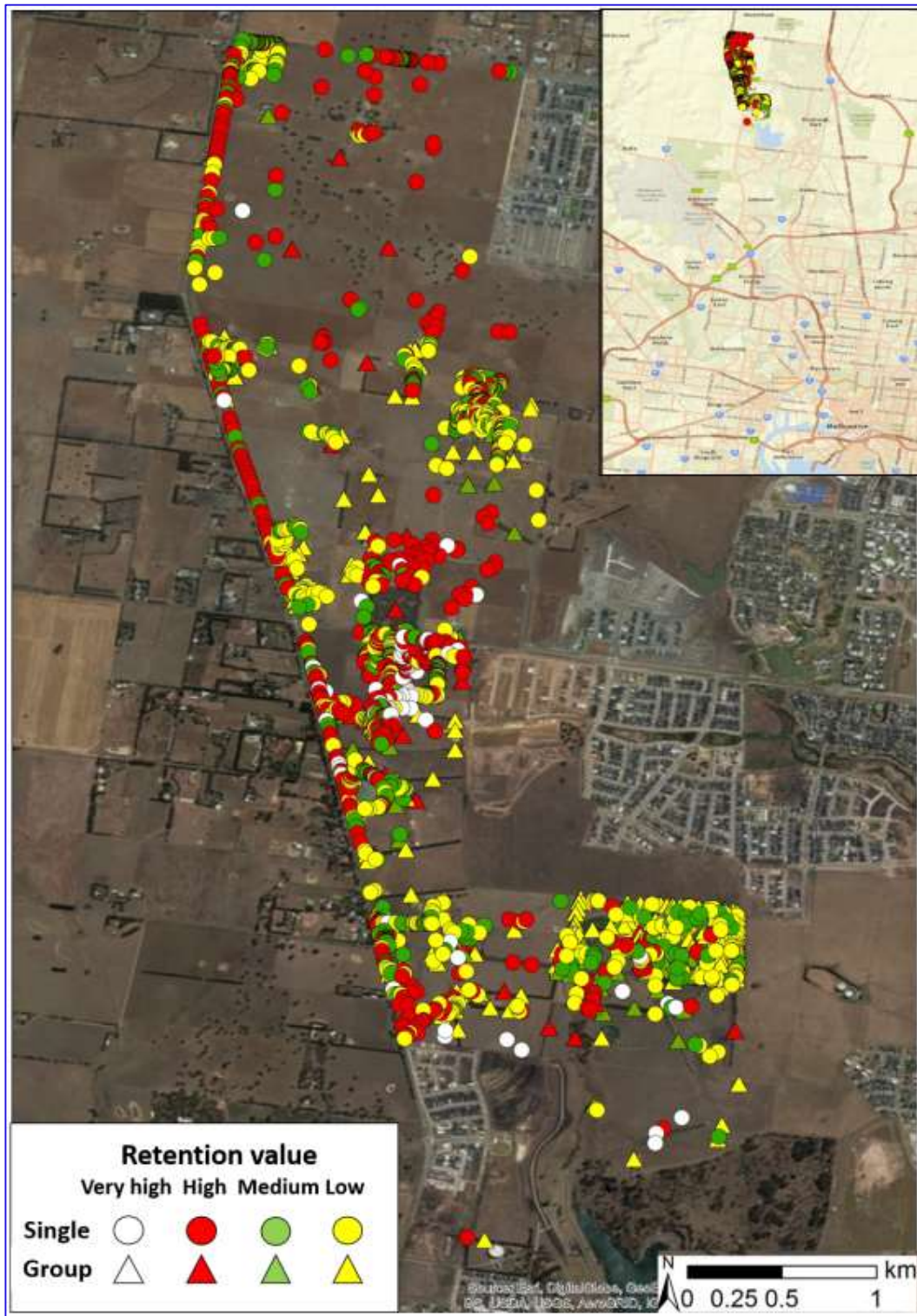


Figure 3-7. Retention value of mature trees in the DSS (Tretec, 2018).



Figure 3-8. 1951 aerial image of the DSS (Source: Land Victoria Historic Aerial Photos, cited in (Ecology and Heritage Partners, 2018).

#### 3.2.4 Wetlands

There are no wetlands mapped within the DSS on the following spatial layers:

- Current wetland (2018 version)
- 1994 wetland
- Pre European wetland
- Ramsar Convention
- Directory of Important Wetlands in Australia (DELWP, n.d.).

The Melbourne Water “Waterbodies\_integrated” spatial layer shows several waterbodies classed as natural within or adjacent to the Area of Investigation and many more artificial (farm dams). Seven wetlands were recorded onsite during field investigations, four within Aitken Creek Main Channel and three within Aitken Creek Southern Tributary. While two (#10657 and #10752) was mapped as natural by the “Waterbodies\_integrated” spatial layer, all appeared to be constructed. While they all supported scattered indigenous wetland plant species, only two (#56777 and #10657) contained significant enough areas of native vegetation to be mapped as an EVC (Plains Grassy Wetland).

### 3.2.5 Groundwater dependence

Aitken Creek is mapped as having a high potential to be an aquatic groundwater dependent ecosystem (GDE) as part of a national assessment of GDE potential (Australian Bureau of Meteorology, n.d.). In addition, the Stand of River Red Gums is mapped as having a high potential to be a terrestrial GDE (circled in red in Figure 3-9) and vegetation at the north west end of Aitken Creek is mapped as having a moderate potential to be a GDE (circled in orange). There are other scattered patches mapped as potential terrestrial GDEs (Australian Bureau of Meteorology, n.d.).

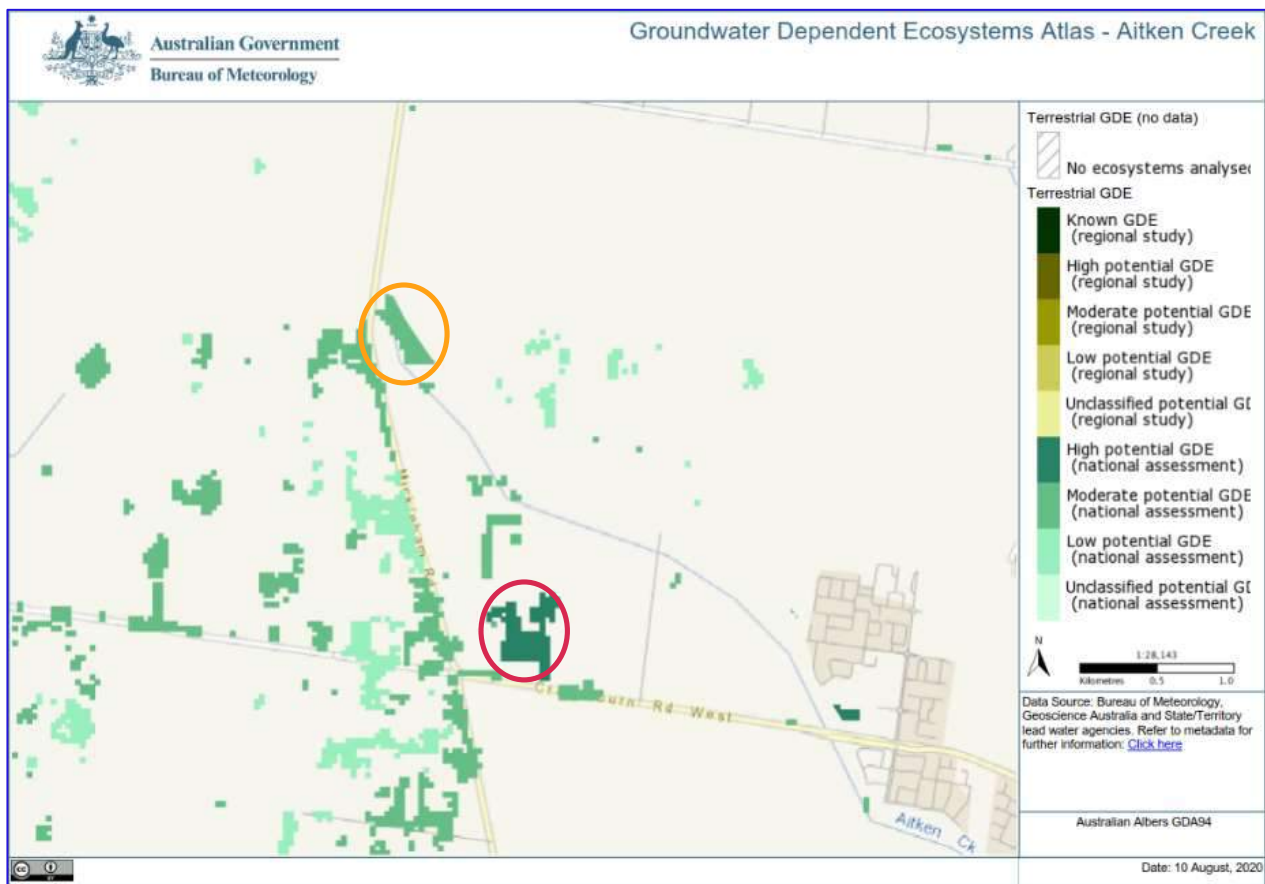


Figure 3-9. Modelled groundwater dependent terrestrial ecosystems. The stand of River Red Gums is circled in red, vegetation at the north west end of Aitken Creek is circled in orange.

### 3.2.6 Threatened species and communities

#### 3.2.6.1 Rare or threatened flora

The likelihood of rare and threatened flora species previously recorded with 5km of the project area or identified by the PMST as having potential to occur in the project area is provided in Appendix D. These determinations are based on the location, number and age of previous records, as well as modelled habitat within the project area. A total of 30 rare or threatened flora species was identified within 5 km of project area.

Of the 30 rare or threatened flora species three are considered to have a high likelihood of occurrence, four a moderate likelihood, nine a low-moderate likelihood and nine a low likelihood. Five species were not considered further as their occurrence within the Project area is presumed to be as planted or naturalised specimens.

The two threatened species determined to have a high likelihood of occurrence within the Project area are detailed in Table 3-3 below. The remaining species considered likely to occur—*Convolvulus angustissimus*

subsp. *Omnigracilis* (Slender Bindweed)—is only listed as 'poorly known' under the Victorian Advisory List and is not considered any further.

Table 3-3. Rare or threatened flora species with a high likelihood of occurrence within the Project area.

Species	Conservation status	Notes
<i>Amphibromus fluitans</i> (River Swamp Wallaby-grass)	EPBC - Vulnerable	<p>Three records within the 5km data review area with most recent record from 2017. No River Swamp Wallaby-Grass was recorded within the project area, however at least one <i>Amphibromus</i> species was present within most wetland habitats assessed. Formal identification of this species could not be undertaken given the general absence of fertile material, however from what flowering material could be found it appears many of these plants are likely to be <i>A. nervosus</i> (Common Swamp Wallaby-grass).</p> <p>While no River Swamp Wallaby-Grass was detected, most wetland habitats in the project area are considered to support potential habitat for this species, and given known populations within less than a kilometre downstream on Aitken Creek there is considered to be a high likelihood of this species being present within the project area. This is reinforced by the ability for this species to persist within heavily grazed habitats, as well as artificial waterbodies within the landscape.</p> <p>It is recommended that a survey is undertaken for River Swamp Wallaby-Grass within wetland habitats in the project area during its flowering period (November–March).</p>
<i>Dianella amoena</i> (Matted Flax-lily)	EPBC – Endangered FFG – Listed VicAdv – endangered	<p>23 records within the 5km data review area with most recent record from 2020. No plants of Matted Flax-lily were recorded within the project area during the current assessment. This species is known to persist and/or establish within degraded grassland vegetation within the landscape, and while no plants were recorded there remains a likelihood of occurrence for this species within the grassland at 1760 Mickleham Road and upstream area of Aitken Creek Main Channel.</p> <p>It is recommended that Matted Flax-lily is surveyed for in the vicinity of Plains Grassland vegetation mapped on Aitken Creek Main Channel. If works are to be undertaken within the Northwest Grasslands it is recommended that Matted Flax-lily is surveyed for, and if located, due consideration is given to avoiding or minimizing impacts to this species.</p>

### 3.2.6.2 Threatened fauna

The likelihood of threatened fauna species previously recorded with 5km of the project area or identified by the PMST as having potential to occur in the project area is provided in Appendix D. These determinations are based on the location, number and age of previous records, as well as available habitat within the project area. A total of 44 threatened fauna species was identified within 5 km of project area.

Of these 44 threatened fauna species, one is considered to have a high likelihood of occurrence (Golden Sun Moth), 16 a moderate likelihood (including Growling Grass Frog), 26 a low likelihood, and one a negligible likelihood of occurrence within the Project area. Species determined to have a high likelihood of occurrence within the Project area are detailed in Table 3-4 below.

Additional to the threatened fauna detailed above, a suite of listed migratory bird species has been identified by the PMST as having the potential to occur within the Project area. These species are provided in Appendix D and are not considered likely to be significantly impacted by development of the PSP due to the small amount of wetland habitat in the DSS.

Table 3-4. Threatened fauna species with a high likelihood of occurrence within the Project area.

Species	Conservation status	Notes
<i>Synemon plana</i> (Golden Sun Moth)	EPBC – Critically Endangered FFG – Listed VicAdv – critically endangered	305 records within the 5km data review area with most recent record from 2019. There are numerous records from 2010-11 in the immediate vicinity of Aitken Creek Main Channel within 1720 Mickleham Road. Additional records located within the surrounding grassland area.  This species is likely to occur within Plains Grassland vegetation and *Chilean Needle-grass dominated vegetation in the upstream areas of Aitken Creek Main Channel within the Project area.

### 3.2.6.3 Threatened ecological communities

#### EPBC Act

Two threatened ecological communities listed under the EPBC Act have a high likelihood of occurring within the Northwest Grasslands. All EPBC listed communities have criteria that must be met to be classified as a threatened community and a field assessment would be required to confirm whether these criteria are met.

- Natural Temperate Grassland of the Victorian Volcanic Plain (Critically Endangered)
  - The northernmost patch of Plains Grassland recorded within Aitken Creek Main Channel may comprise part of this community. This is similarly the case for native grassland vegetation within 1760 Mickleham Road.
- Grassy Eucalypt Woodland of the Victorian Volcanic Plain (Critically Endangered)
  - Native woodland, and potentially grassland, vegetation within the Northwest Grasslands may comprise part of this community.

#### FFG Act

One threatened floristic community listed under the FFG Act was recorded within the project and a second has a high likelihood of occurring within the Northwest Grasslands. FFG communities do not have defined criteria that are required to be met, but constituent species and geographic occurrence must match the description of the communities.

- Western (Basalt) Plains Grasslands Community
  - All patches of Plains Grassland mapped within the project area comprise part of the threatened community Western (Basalt) Plains Grasslands Community.
- Western Basalt Plains (River Red Gum) Grassy Woodland Community
  - Native woodland vegetation within the Northwest Grasslands is likely to comprise part of this community.

## 3.3 Legislative, strategic and policy implications

### 3.3.1 Melbourne Strategic Assessment

The DSS is covered by the Melbourne Strategic Assessment (MSA). No further approvals are required under the EPBC Act for urban development in these areas, as long as development follows the Program Report and the conditions of the approvals which ensure that urban development proceeds in a way that protects matters of national environmental significance. An Environment Mitigation Levy may be required to offset the removal of native vegetation and threatened species habitat within the project area. The liability to pay a levy is triggered when a levy event occurs within the levy area; the only levy event relevant to this project is the construction of utility infrastructure on Crown land.

### 3.3.2 Healthy Waterways Strategy

The Healthy Waterways Strategy 2018-2028 is the regional co-designed strategy for waterway management in the Port Phillip and Western Port region. It contains a series of regional targets relevant to Aitken Creek, in particular:

- Regional Performance Objective-16 Protection mechanisms are in place for headwaters to ensure that they are retained as features in the landscape for environmental, social, cultural and economic benefits.
- Regional Performance Objective -14. Standards, tools and guidelines are in place and implemented to enable re-use and infiltration of excess stormwater and protect and/or restore urban waterways.

The HWS also recognises the importance of headwater streams: *“As well as altering stream flows and water quality, ongoing greenfield and infill development has historically impacted waterways where small natural streams have been converted into underground pipes or enlarged, rock-lined channels. These small, headwater streams play an important role in the protection of waterway health, for example: reducing flooding, filtering excess nutrients and sediment, processing organic matter, supporting unique species, and decreasing downstream erosion”* (Melbourne Water, 2018a p. 37). We also note that Melbourne Water is currently developing policy for the protection of headwater streams under development scenarios, and that this is an evolving policy space.

The strategy also highlights a number of objectives for the sub-catchment including to:

- Identify and implement opportunities to maintain or improve the flow regime.
- Establish a continuous riparian vegetated buffer, and maintain existing vegetation along priority reaches.
- Maintain or achieve high and very high-quality vegetation and protection of endangered EVCs.
- Improve stormwater condition through directly connected imperviousness, stormwater harvesting and infiltration targets.
- Mitigate threats to physical form and other high values.
- Increase access to and along waterways.
- Promote access and participation.
- Manage sedimentation from construction activities.
- Indigenous co-design - Share connection to country and active respect for the river (Alluvium, 2019; Melbourne Water, 2018b).

### 3.3.3 Craigieburn West PSP Integrated Water Management Issues and Opportunities

The Craigieburn West PSP Integrated Water Management Issues and Opportunities report was developed on behalf of the VPA and involved a stakeholder consultation workshop attended by Hume City Council, Yarra Valley Water, Melbourne Water, DEWLP and the Victorian Planning Authority (Alluvium, 2019). Workshop aims included discussing and agreeing on Integrated Water Management (IWM) objectives for the Craigieburn West PSP and identify opportunities to implement IWM in development of the PSP. A range of actions relevant to Aitken Creek were developed during the workshop against the following objectives:

- Stormwater management goes beyond best practice:
  - VPA to become involved in the Upper Merri Sub-catchment IWM Plan process.
  - Include stormwater harvesting as part of the 'alternative' water supply mix for Craigieburn West PSP.
  - In collaboration with the Upper Merri project, investigate the benefits of combining recycled water and rainwater tanks in contributing to the HWS targets.
  - Quantify the impact stormwater diversion to the west of Mickleham Road will have on achieving HWS targets.
  - Council to collaborate with VPA and designers to specify WSUD asset and maintenance requirements.

- A desktop investigation to understand the feasibility of managed aquifer recharge (MAR) in this location.
- To reduce mains water use through the use of fit-for-purpose alternative water supply:
  - Further work is required between Council, Melbourne Water and Yarra Valley Water (and the EPA and Department of Health) to understand the potential for stormwater (and rainwater) harvesting in the context of a recycled water, third pipe network. This may be investigated as part of the Upper Merri IWM Plan.
  - A cost benefit analysis on the inclusion of smart tanks can be undertaken if this is supported by the developer. The benefits assessed should include how these tanks contribute to Healthy Waterways Strategy targets.
- Rethink the use and function of public and open spaces:
  - A stand-alone opportunity for Council, Melbourne Water, the VPA and the land developer to investigate how the PSP could be reconfigured to contribute to the Healthy Waterways Strategy targets
  - Confirm the in-principle acceptance of passive irrigation of street trees within the PSP by Council.
  - Craigieburn PSP should implement the finding of the ongoing report to ensure that the hydrologic regime of the River Red Gum is maintained to support their continued survival.

There was also a broad agreement that to meet the stormwater infiltration targets in the strategy would require "going beyond best practice" and "could not be achieved by business as usual practices". It was also noted that while Craigieburn West (and Aitken Creek within it) was not a 'Priority Stormwater Area', this does not imply that stormwater condition is not important in this area. Rather it suggests that specific modelling has not yet undertaken and it is fair to assume in this context that the targets within the broader sub-catchment should be considered for this area as well (Alluvium, 2019).

### 3.3.4 Other strategic alignment

Innovative IWM solutions to stormwater management challenges are also supported by a wide range of strategies from agencies that will be involved in the management of the area as it is developed, including from Hume City Council, Yarra Valley Water and the State Government.

- Hume City Council IWM Plan 2014-2017 (currently being updated):
  - GOAL 1: Excellence in Integrated Water Management including - Council aims to demonstrate excellence in integrated water management by implementing projects and programs that progress towards the achievement of long-term targets.
  - GOAL 3: Influence and Advocate - Influence the actions of external organisations and advocate for improved support and the regulatory environment that supports integrated water management (Hume City Council, 2020).
- Hume City Land and Biodiversity Plan 2015-2019
  - GOAL 1: The City's natural heritage, environment and rural spaces are protected, enhanced, maintained and valued.
  - GOAL 3: Suburbs are leafier with increased canopy cover (Hume City Council, 2015).
- Yarra Valley Water People, Planet, Prosperity Report:
  - IWM commitments include: participating in Integrated Water Management (IWM) forums to maximise water-related amenity and making optimal use of alternative water sources (Yarra Valley Water, 2019).
- Water for Victoria Plan: Chapter 5 – Resilient and liveable cities and towns
  - Five key outcomes to achieve 'Resilient and Liveable Cities and Towns' including efficient and affordable water and sewerage services, effective stormwater management to protect the urban

environment, healthy and valued landscapes and community values reflected in place-based planning (Victorian Department of Environment, Land, Water and Planning, 2016).

- Stormwater Ministerial Advisory Council (MAC) (2018):
  - The stormwater MAC reviewed the regulation of stormwater management in Victoria and delivered a series of recommendations in September of 2018. The first stage (planning reforms) have been gazetted and is embedded into the Victorian Planning Policy Framework. This extends the range of developments that are required to meet Clause 56 best practice environmental management (BPEM) pollution reduction targets beyond residential subdivisions to include commercial subdivisions and developments, industrial subdivisions and developments, public-use developments and multi-dwelling residential subdivisions and developments.
- Integrated Water Management Framework for Victoria (2017):
  - Designed to help local governments, water corporations, Catchment Management Authorities, Traditional Owners and other organisations collaborate to ensure the water cycle efficiently contributes to the liveability of the region, with enhanced benefits for communities and the environment (DELWP, 2017).

## **4. Discussion and recommendations**

This section provides a synthesis of the waterway values within Aitken Creek as well as an assessment of the risks from hydrological change during development of the area and recommendations for protection.

### **4.1 Waterway values and priorities for protection**

#### **4.1.1 Geomorphology**

The Aitken Creek reaches assessed can be broadly classified as headwater streams – small flow lines (swales/wetlands), creeks and streams that are closely linked to adjacent slopes. Headwater streams may only flow or have ponds of water periodically following rainfall events, however they do play an important role in retaining and temporarily storing water in the landscape (Jacobs, 2016). This ability slows down the rate of flow over the land and assists in regulating flows and reducing downstream flood peaks. The infiltration of surface water in headwater streams into the local groundwater system also plays an important role in providing recharge to groundwater. Groundwater is thought to maintain base flows in many headwater streams, and the BOM GDE mapping indicates a high potential for groundwater interaction with Aitken Creek (see Section 3.2.5). If small headwater streams are destroyed because of urbanisation there is an increase in the number of high flows to downstream reaches. These high flow events can cause bed and bank erosion that significantly degrades community and environmental values (Bond & Cottingham, 2008).

Headwater streams make up a significant proportion of the stream network and collect the majority of the runoff and dissolved nutrients from a catchment. Nutrient cycling and retention in headwater streams can significantly reduce nutrient exports to downstream reaches, estuaries and bays. This is because headwater streams provide the ideal mix of shallow depths, high surface-to-volume ratios, water-sediment exchange and biotic communities required for nutrient cycling (Peterson et al., 2001). If the nutrient processing capacity of headwater streams is diminished (for example through changed flows or the clearing of riparian vegetation), or lost altogether (e.g. through drainage and urbanisation), then more nutrients are delivered to downstream reaches (Jacobs, 2016).

With urban development, many headwater streams are converted into stormwater drains and these modified drainage courses become a key driver in the degradation of downstream reaches. This is a high risk for Aitken Creek through the DSS. Downstream reaches naturally have a lower capacity to process nutrients, and if the amount of nutrients exported from headwater reaches exceeds the processing capacity of these downstream reaches this results in a net increase in the amount of nutrients that are exported to receiving waters such as estuaries and bays (SKM, 2013). Excessive erosion of downstream waterways is caused by increased flow and decreased sediment supply that results from urbanisation in headwater streams. The increased flow and pollutant load from conventional stormwater drainage networks greatly reduces the nutrient retention capacity of downstream waters through the multiple impacts of urbanisation (Vietz et al. 2014, Walsh et al., 2005) and in the case of Aitken Creek, will have impacts to downstream reaches of the Merri Creek and Yarra River. Increased loads of nutrients from the surrounding catchments are recognised as one of the major threats to environmental health, and community and recreational values, and also to the economic productivity of Port Phillip Bay (CSIRO & Melbourne Water 1996).

While the Aitken Creek and its tributaries have been assessed as having low geomorphic values, they are however important headwater areas in the drainage network and should be protected as they help to regulate the flow of water and nutrients in the catchment. Headwater streams such as these can capture and temporarily store large volume of water in the landscape, by virtue of the large surface area that at present is essentially grassed agricultural fields and broad drainage depressions. This attenuates flow to downstream reaches and helps retain nutrients in the upper catchments rather than those nutrients being exported to downstream reaches and Port Phillip Bay.

#### **4.1.2 Ecology**

Given the general lack of native vegetation in the vicinity of the DSS it is recommended that wherever possible areas of Plains Grassland and Scattered Trees identified in Section 3.2 are retained. Of particular note are the stand of large River Red Gums located within the Aitken Creek Southern Tributary and Plains Grassland in the north western end of Aitken Creek Main Channel (within and adjoining the Grassland at 1760 Mickleham Road).

Where mature trees are planned for retention within the vicinity of works, it is recommended that an arboriculture assessment be prepared to address potential impacts to trees pre, during and post-construction.

The ecology findings of this report in isolation do not warrant a change from the corridor widths proposed by Melbourne Water; though it is recommended that corridors be configured in a manner that will allow for the greatest retention of extant flora and fauna values.

If threatened species are identified within the DSS during follow up survey it is recommended that due consideration is given to avoiding or minimising impacts to these species during the design phase.

### **4.2 Hydrological sensitivity analysis**

The risk that hydrological changes associated with the development of the PSP pose to waterway values has been assessed with reference to the magnitude of hydrological change and sensitivity criteria outlined in Section 2.3. The outcomes of the risk assessment are provided below.

#### **4.2.1 Magnitude of hydrological changes**

The magnitude of hydrological changes occurring in a reach is related to the amount of change in fraction imperviousness with developed catchment conditions and the influence this has on the magnitude and frequency of flows. Urbanisation dramatically changes natural hydrologic cycles due to the increased impervious areas which in turn increases overland flow and stormwater runoff volumes and peaks, with increased frequency of small to medium flows.

For the project study areas, we have assessed the magnitude of hydrological changes as high rating:

- the headwaters of Aitken Creek are assessed as likely to experience a high magnitude of hydrological change given that the development area within the PSP will impact on the majority of the catchment area for this creek (see Figure 1-3). Increased runoff from development areas under a conventional/business as usual drainage scenario has the potential to result in a shift from an ephemeral to a perennial flow regime, with persistent low flows and frequent high-disturbance events. Changes in hydrology within the headwaters of Aitken Creek catchment as it flows through the PSP area will also contribute to the cumulative impact of catchment development to Aitken Creek downstream.

#### **4.2.2 Sensitivity of values to hydrological changes**

##### **4.2.2.1 Geomorphology**

All reaches are assessed as having a high sensitivity for erosion and stream form adjustment (incision and widening). This is largely attributed to the surface of the waterways being comprised of very fine-grained sediments, with highly erodible soils (sodosols) distributed throughout the catchment area.

##### **4.2.2.2 Ecology**

The risk to significant ecological values within Aitken Creek are summarised in Table 4-1 along with the relevant water regime requirements, and their sensitivity to changes in hydrology. These ecological values/potential ecological values are used to inform a preliminary summary ecological rating for each reach of the creek, and a sensitivity rating to indicate sensitivity to being negatively impacted by the proposed hydrological change (see Section 2.3 for method).

Table 4-1. Summary of significant ecological values within Aitken Creek, their water regime requirement, and their sensitivity to a changed hydrological regime due to urbanisation.

Species/community	Water source / water regime requirement	Sensitivity within Aitken Creek to increased flows from urbanisation
Mature <i>Eucalyptus Camaldulensis</i> - River Red Gums	Preferred inundation regime for River Red Gums: Flood frequency 1-4 years, duration up to 7 months, timing of winter to summer (Roberts and Marston 2011).  Can be tolerant of prolonged periods without inundation.  Some individuals may be able to access groundwater.	High  A shift towards more frequent and longer duration inundation may be tolerable for the trees, within limits. Inundation for long periods beyond tolerable limits would lead to slow health decline and death  Particularly in cases where trees are within the channel of the waterway.
EVC 132_61 Heavier-soils Plains Grassland (Endangered)	Occupies cracking basalt soils prone to seasonal waterlogging.  Source of water: Local surface runoff that generates seasonal waterlogging.	High  Sensitive to hydrological change and other disturbance.  Urbanisation that results in a change in runoff and drainage patterns across the landscape will likely result in an increase in the runoff to these areas which could result in a shift towards vegetation community suited to more frequent and longer duration inundation.
EVC 125: Plains Grassy Wetland (endangered)	Shallow seasonal wetlands, grassland grading into wetland and typically treeless or with sparse River Red Gum canopy on heavy clay soils. Periodically wet for several months per year in winter/spring and dry over summer.	High  Changes in inundation from intermittent inflows to permanent (or reduction in inundation depending on catchment and topographical changes) is likely to result in a change to flora composition and reduced diversity of native plants.
<i>Amphibromus fluitans</i> - River Swamp Wallaby Grass	Grows in ephemeral pools and creeklines, around the edges of dams.	Moderate  While existing populations (if confirmed to be present) may be impacted by changed hydrology, most wetlands in the DSS could support potential habitat and the species can persist within artificial waterbodies such as dams. There are source populations within 1 km downstream that could support recolonization.  While flow regimes in wetland habitats may be altered or lost through development, the species may be able to colonise new wetland habitat created.
Threatened flora in grasslands e.g. <i>Dianella amoena</i> (Matted Flax-lily)	Grows in grassland and grassy woodland habitats, on well drained to seasonally wet clay soils.	High  Urbanisation that results in a change in runoff and drainage patterns across the landscape will likely result in an increase in the runoff to these grassland areas which could result in a shift towards vegetation community suited to more frequent and longer duration inundation.
<i>Litoria raniformis</i> - Growling Grass Frog EPBC Act listed	Permanently flooded wetlands, or access to permanent water (eg. river channels or farms dams) if seasonal wetlands dry out. Requires several localised habitats to form meta-populations	Moderate (could be positive or negative)  A reduction in the frequency and duration of inundation of seasonal wetlands, especially if isolated from permanent refuge habitat (river channels or farm dams) will result in a reduction of suitable habitat.

Species/community	Water source / water regime requirement	Sensitivity within Aitken Creek to increased flows from urbanisation
		Increased permanency of ephemeral waterways may increase refuge areas and dispersal opportunities, although high velocity associated with more frequent flows and reduced water quality will limit suitability of this habitat.
Golden Sun Moth ( <i>Synemon plana</i> ) in grasslands adjacent to creek EPBC Act listed	Studies show a broader tolerance for other species compositions, including degraded grasslands dominated by exotic Chilean Needlegrass.	High  Habitat likely to be reduced. Urbanisation that results in a change in runoff and drainage patterns across the landscape will likely result in an increase in the runoff to these areas which could flood out native fauna and result in a shift towards vegetation community suited to more frequent and longer duration inundation, reducing available habitat.

#### 4.2.3 Unmitigated risk assessment

The unmitigated risk is the product of the magnitude of hydrological change (A) and the sensitivity score (B). The distribution of unmitigated risk scores across the study region is shown in Table 4-2.

Table 4-2. Summary table outlining results of unmitigated risk assessment.

Name	Values				Unmitigated Risk Profile								Priority Values		
					Magnitude (A)		Sensitivity (B)		Risk Rating (AxB)						
	Ecology		Geomorphology				Ecology		Geomorphology						
Aitken Creek - Main Channel	2	Medium - high	1	Insignificant	3	High	3	High	3	High	9	High	9	High	<ul style="list-style-type: none"><li>▪ Mature <i>Eucalyptus Camaldulensis</i> - River Red Gums</li><li>▪ EVC 132_61 Heavier-soils Plains Grassland (Endangered)</li><li>▪ EVC 125: Plains Grassy Wetland (endangered)</li></ul> Presence not confirmed: <ul style="list-style-type: none"><li>▪ <i>Amphibromus fluitans</i> -River Swamp Wallaby Grass</li><li>▪ Golden Sun Moth (<i>Synemon plana</i>) in grasslands adjacent to creek</li><li>▪ <i>Litoria raniformis</i> - Growling Grass Frog</li><li>▪ <i>Dianella amoena</i> - Matted Flax Lily</li></ul>
Aitken Creek – Southern Tributary	2	Medium - high	1	Insignificant	3	High	3	High	3	High	9	High	9	High	<ul style="list-style-type: none"><li>▪ Mature <i>Eucalyptus Camaldulensis</i> - River Red Gums</li><li>▪ EVC 132_61 Heavier-soils Plains Grassland (Endangered)</li><li>▪ EVC 125: Plains Grassy Wetland (endangered)</li></ul> Presence not confirmed: <ul style="list-style-type: none"><li>▪ <i>Amphibromus fluitans</i> -River Swamp Wallaby Grass</li><li>▪ <i>Litoria raniformis</i> - Growling Grass Frog</li><li>▪ <i>Dianella amoena</i> - Matted Flax Lily</li></ul>

#### 4.2.4 Feasibility of maintaining waterways with minimal intervention

Under the current landuse the trajectory of Aitken Creek within the study area is likely to be relatively stable, however the underlying soil type makes these reaches at high risk of alteration under a development scenario, particularly where the surface soil is removed and subsoils exposed. Risks include erosion, incision, scour, and bank failures due to changing hydrology and channel alteration. It is likely that a business as usual development scenario in the Aitken Creek catchment will result in a shift from an ephemeral to perennial flow regime, with areas that are currently only seasonally wet remaining wet with ponding of water throughout the year.

If development in the surrounding catchment area adopts a conventional drainage system – that is, a pit and pipe network in combination with stormwater treatment measures to meet the *Urban Stormwater – Best Practice Environmental Management (BPEM) Guidelines* (Victorian Stormwater Committee 1999) – maintenance of existing waterway values is unlikely to be feasible. This is because the guidelines largely focus on pollutant load reductions and don't address the hydrological changes that result from urban development such as increases in the duration of low flows and the frequency of high-disturbance events. The rapid increases (and high variability) in flow volume in a single day in developed areas can scour pools, increase erosion and dislodge macroinvertebrates. Stream heights can also change rapidly in response to urbanisation with impacts to vegetation stability and establishment and erosion.

Ecological and geomorphic degradation of waterways due to hydrological changes can be detected at very low levels of urban development (~0.5% directly connected imperviousness, DCI<sup>4</sup>, a commonly used indicator of urban density) and the window for protecting waterways is generally accepted as 2-5% DCI (Vietz, Sammonds et al. 2014, Walsh and Webb 2016). It becomes increasingly less feasible beyond this point to protect or restore waterways due to the extent of works required to intercept stormwater. In the context of this study area with its highly erodible soils, geomorphic condition is particularly at risk and it is expected that bed and bank erosion is a major threat. Without interventions to mitigate hydrological change, it is expected that bed and bank stabilisation works (e.g. rock chutes, rocked beds) would be required to prevent exposure and accelerated erosion of underlying sodic soils.

Failure to address changes to the hydrologic regime may also negatively impact the health of the River Red Gums that occur along Aitken Creek within the DSS. The long-term protection of River Red Gums under urban development is an ongoing challenge throughout the urban growth boundary of Melbourne, as conventional/business as usual urban development brings increased impervious areas and changed flow regimes which impact on the water regime requirements of this species. Urban development is likely to shift the ephemeral nature of the stream towards a more perennial flow regime in Aitken Creek. Increased incidence or duration of waterlogging of trees within or adjacent to the channel of the creek has the potential to contribute to declining tree health, as has been observed in Malcolm Creek, Craigieburn (Jacobs 2018). The PSP arboricultural report recommends designing the subdivision to minimise runoff and maintain groundwater recharge (Treetec, 2018).

More detailed modelling would be required to provide a more explicit description and understanding of how Aitken Creek and its tributaries would respond to additional stormwater flows associated with development of the PSP and upstream catchments (see 4.3.4).

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<sup>4</sup> The proportion of impervious area within a catchment that is directly connected to a receiving water via the stormwater drainage system

### 4.3 Options for waterway protection

Protection of waterway values in Aitken Creek under a development scenario will require both physical protection through waterway buffers that enable a more natural stream form to be retained and maintain function as well as hydrological protection through stormwater harvesting in the catchment.

#### 4.3.1 Waterway buffer width

Melbourne Water has developed a draft waterway corridor width for Aitken Creek within the DSS of roughly 60 m wide, with isolated areas of up to 85 m to support existing landscape features (shown in yellow outline in Figure 4-1).

Melbourne Water's Waterway Corridors Guidelines for Greenfield Development Areas Within the Port Phillip and Westernport Region (the Guidelines) (Melbourne Water, 2013) defines minimum standards for waterway corridor widths for the protection of riparian and instream values, to enable passive recreation and some stormwater treatment elements. Minimum width is assigned according to waterway characteristics and can be increased to reflect site specific factors.

Stream order (Strahler classification) is used to define the minimum setback (as per Section 7 of the Guidelines). Aitken Creek at this point in the landscape is a first order stream, so would be assigned a minimum 20 m setback on each bank. Assuming a waterway width of 5-10 m (noting that waterway width varies throughout the area) would lead to a baseline corridor width of 45-50 m.

The guidelines also note that: *"in situations where the standard waterway corridor width – as specified in these guidelines – is less than the width of the post development 1 in 100 year ARI flood extent, the waterway corridor will be extended to include the entire 100 year ARI flood extent i.e. the 100 year ARI line becomes the waterway corridor boundary"*. A similar approach was put forward for Olive Grove (Alluvium, 2014) for a similarly low relief channels, whereby land beyond the standard corridor width within the 100 year flood extent was retained to support the retention of intact form. In light of the significant ecological services provided by headwater streams, consideration could be given to the extension of the corridor where the 100-year ARI flood extent is beyond this area (shown in dotted black outline in Figure 4-1). In practice, this would result in an extension of buffer to approximately 105 m around an existing naturally wet area (which currently contains a dam), a mapped area of Plains Grassy Wetland as well as minor extensions in the south eastern end of the Main Channel.

Buffer widths that are wider than the standard for this stream order and consideration of appropriate waterway form (e.g. wider, shallower, and/or chain of ponds to slow flows) can support the valuable functions provided by headwater streams (i.e. infiltration, nutrient cycling and reduction of peak flows) and reduce risks to downstream ecological and built assets. In addition, considered location of drainage assets can be used to minimize the direct loss of significant vegetation and fauna habitat.

Setbacks from the waterway can also be varied in response to site specific factors (as per Section 9 of the Guidelines) (see Table 4-3).



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#### 4.3.2 Waterway form

In addition to buffer width, stream form can also be varied to slow flows and retain infiltration and nutrient retention. As part of review of the Aitken Creek DSS there are opportunities within the waterway corridor to vary the stream form, so as to create a series of wetlands that hold water throughout the year separated by dryer vegetated swales/rocky riffles. This will slow the export of flows out of the catchment and enable some infiltration and nutrient processing to occur. It may also provide habitat for inundation dependent species such as *Amphibromus fluitans* (River Swamp Wallaby Grass). This approach has been successfully applied in another tributary of Aitken Creek (#4482) as part of earlier development in the Craigieburn PSP.

There are also opportunities to retain a more natural corridor rather than a constructed one in sections (as proposed for the mid section of Aitken Creek Main Channel – see Figure 1-4) to protect existing values.

#### 4.3.3 Proposed locations of other assets

Desktop and field investigations for this project have found significant ecological values within areas proposed for drainage assets as part of the initial Aitken Creek DSS, in particular:

- High likelihood of high value areas of grassland (that are likely to support *Synemon plana* (Golden Sun Moth) habitat) located within the footprint of a proposed 2.15 ha wetland (G4WL) and
- Small patches of Plains Grassy Wetland and Plains Grassland within the footprint of a proposed 2.92 ha wetland (E10WL).

The potential to move these assets to lower ecological value areas should be investigated.

A summary of site specific factors in Aitken Creek that should be considered in regards to waterway corridor width, form and asset locations along Aitken Creek is provided in Table 4-3.

Table 4-3. Relevance of site specific factors to waterway corridor width, form and asset locations along Aitken Creek.

Factor outlined in guidelines	Relevance to Aitken Creek	Notes
High value species or communities may require increased setbacks to protect habitat for these species	Potential for River Swamp Wallaby Grass to be present within wetland habitats	<ul style="list-style-type: none"> <li>Follow up targeted surveys in the flowering period (November to March) would be required to confirm locations.</li> <li>If present, consider wider buffer on wetlands to protect core habitat (the guidelines note that natural wetlands that fall within a waterway corridor may have requirements beyond those listed.).</li> <li>River Swamp Wallaby Grass could also colonise constructed wetland habitat, consider providing appropriate watering regimes and revegetating with the species.</li> <li>Retention of a more natural waterway form in the upstream end of the Aitken Creek Main Channel, rather than a constructed waterway.</li> </ul>
	Potential for Matted Flax-lily to be present within the main channel of Aitken Creek (in the vicinity of Plains Grassland vegetation) and in the Grasslands at 1760 Mickelham Road.	
	The patch of Plains Grassland adjoining the Grasslands at 1760 Mickelham Road (within the Aitken Creek main channel) may comprise part of the nationally threatened community Natural Temperate Grassland of the Victorian Volcanic Plain. This is similarly the case for much of the vegetation within the Grasslands at 1760 Mickelham Road.	
	All patches of Plains Grassland mapped within the project area comprise part of the threatened community Western (Basalt) Plains Grasslands Community.	
Where the site forms an important part of an existing, or potential high value habitat corridor	There are known Growling Grass Frog populations downstream of the site, it is possible that there is suitable wetland habitat within the area. This section of Aitken Creek provides a link from inside the urban growth boundary (UGB) to the rural land	<ul style="list-style-type: none"> <li>There are small patches of Plains Grassy Wetland and Plains Grassland within the footprint of a proposed 2.92 ha wetland (E10WL) in the Southern tributary. Consider whether the asset can be relocated or whether the vegetation communities can be incorporated into the design.</li> <li>There are small patches of Plains Grassy Wetland and Plains Grassland within the Aitken Creek main channel. These are almost entirely contained within the currently proposed waterway corridor width (though there may be a small area that extends just outside the corridor – see Figure 3-4). Several of these patches are contained within the area proposed as retention as a natural waterway and buffer. Consider slightly extending this section if possible, to include the mapped Plains Grassland immediately upstream of the end of the proposed natural waterway and give consideration to how these communities can be maintained in landscaping design.</li> <li>Consider whether a wider corridor is required to support Growling Grass Frog habitat and movement. Revegetation principles often denote two separate standards for both permanent wetland habitat, which maintains populations, and the terrestrial habitat within 100 m of a waterbody, where the species forages (DELWP, 2017).</li> </ul>

Factor outlined in guidelines	Relevance to Aitken Creek	Notes
	outside it (the UGB is at the western edge of the site). The waterway corridor could therefore be a key movement corridor for fauna from high value areas downstream (such as the Craigieburn Grassland Nature Conservation Reserve) as well as from adjacent conservation areas within the Craigieburn West PSP out to the rural landscape to the west.	<ul style="list-style-type: none"> <li>Corridor widths, buffers from high use areas, permanent wetlands and landscaping should also consider the value of the waterway for faunal movement into and out of the UGB.</li> </ul>
Where the site contains high value geomorphic features or assemblages that may be negatively affected by setting inadequate waterway corridor widths (e.g. backwaters, rocky outcrops or escarpments)	There are no areas mapped as high value geomorphic features per se, however headwater streams play an outsized role in infiltration and nutrient cycling in the catchment. In addition, existing stream form is at high risk of incision and erosion if stormwater harvesting measures in the catchment are insufficient.	<ul style="list-style-type: none"> <li>Consideration should be given to whether infiltration can be supported within the catchment and waterway corridor (e.g. through corridor width) to support these essential functions, to prevent the export of nutrients and additional flows into downstream waterways.</li> <li>There may be opportunities within the waterway corridor to vary the stream form, so as to create a series of wetlands that hold water throughout the year separated by drier vegetated swales/rocky riffles. This would support infiltration, nutrient retention and habitat creation.</li> <li>To retain existing stream form is likely to require harvesting of stormwater runoff from upstream contributory areas and/or redirection of stormwater to outfalls located downstream of this reach.</li> </ul>
Where a site has been determined by Melbourne Water to contain significant local or regional waterway values	There are trees of significant age that are of value for retention and are threatened by the changed hydrology associated with the development of the catchment as well as by the development footprint in the PSP.	<ul style="list-style-type: none"> <li>Mature trees within the Aitken Creek channel are at high risk of long term decline due to changed hydrology due to development (i.e. shift from ephemeral to perennial flow regime) (Clifton et al., 2017). Consider whether the current intermittent flow regime can be maintained within these sections through waterway design (e.g. chain of ponds or channel alignment ensuring that RRG are not sitting within the channel, or wider and shallower waterways).</li> <li>There is currently no waterway corridor proposed for the Southern Tributary. This area is currently a swampy plain, with large areas of standing water present during fieldwork. It is likely that this area is significantly contributing to groundwater recharge and nutrient retention. It also currently supports trees considered significant in the landscape and should be considered for a waterway corridor, with opportunities for infiltration of stormwater.</li> <li>The stand of River Red Gums to the south of the Southern Tributary has been mapped as a high potential to be a groundwater dependent ecosystem (see Figure 3-9). Consideration should be given to retention of infiltration ability where impervious surfaces are planned. This can include permeable pavements, rain gardens and other water sensitive urban design treatments.</li> </ul>
Where built assets require protection from	High erodible sodic subsoils are present and present a high risk of erosion and incision. No	<ul style="list-style-type: none"> <li>Narrow buffers should be avoided on these sodic subsoils as they require channelization of the waterway, digging down into the highly dispersive subsoil. This is likely to lead to higher shear stresses on the waterway (due to increased depth</li> </ul>

Factor outlined in guidelines	Relevance to Aitken Creek	Notes
potential future channel migration (especially in areas with highly erodible soils)	assets are present as yet, but are proposed as part of development (e.g. constructed waterway and wetlands).	<p>of flow and gradient), associated increased costs of construction (i.e. stable clay liners and more rock protection of bed and banks to stabilise the waterway), increased risk of failure and increased maintenance costs long term. A wider buffer allows a shallower, wider waterway to be maintained or constructed with reduced risk and costs over the life of the asset and reduced risk to downstream ecological values and constructed assets by maintaining infiltration and nutrient retention in the upper catchment.</p> <ul style="list-style-type: none"> <li>Channelisation of Aitken Creek poses a risk to groundwater in the area due to the likelihood of groundwater being close to the surface. Channelisation and incision of the waterway could result in a hydrological connection being made between the waterway and the groundwater, leading to discharge of the groundwater to the creek. As well as increasing flows (with risks to the waterway and downstream ecological and drainage assets), this could have the impact of lowering groundwater levels to the stand of River Red Gums that have been marked for protection from development, leading to their long term decline and loss).</li> </ul>
Where a waterway reach requires greater levels of protection to ensure significant upstream or downstream values are protected	Downstream values include significant populations of River Swamp Wallaby Grass and Growling Grass Frog, the Craigieburn Grassland Nature Conservation Reserve at the confluence of Aitken and Merri Creeks, the Merri Creek, Yarra and Port Phillip Bay that will receive the additional nutrients exported from the catchment due to development.	<ul style="list-style-type: none"> <li>Headwater streams play a significant role in attenuating flows and nutrient cycling. This helps to protect downstream values (including the Merri Creek, Yarra River and Port Phillip Bay). Where wider buffer widths can be provided, these can be used to support infiltration and retain nutrients and additional flows in this part of the catchment.</li> <li>The ability of stormwater treatment assets to accommodate increased flows and altered flow regime from development of this PSP should also be considered.</li> </ul>

The desktop and field investigations undertaken by Jacobs support the corridor widths proposed by Melbourne Water to enable the retention of a shallow, wide waterway that reduces the risk of channelisation into sodic subsoils and associated erosion and groundwater risks. This also provides opportunities to retain some infiltration functions within the corridor either through stream form or WSUD treatments.

We recommend the following principles for consideration during design:

- Retention of mature trees along the waterway wherever possible (in particular, trees 4-10 around the Southern Tributary).
- Retention of areas of Plains Grassland and Plains Grassy Wetland in the Aitken Creek Main Channel as natural waterway, rather than constructed waterway (particularly at the north west end of the Main Channel, where it links to existing high value grassland and immediately to the north of the area proposed to be retained as a natural channel).
- Review options for stream form that provide infiltration and nutrient retention within waterway buffers (e.g. chain of ponds), this may require additional buffer width.
- Maintain wide buffers wherever possible to support shallow waterway channels and avoid channelization into sodic subsoils. Expansion of the corridor to encompass the 100-year ARI flood extent in areas beyond those outlined above could be considered to enable this, particularly around the mapped area of Plains Grassy Wetland in the Main Channel.
- Where waterways are to be constructed, review whether the channel can avoid existing mature trees to prevent these being located in standing water as the flow regime changes.
- Relocation of the proposed 2.15 ha wetland (G4WL) to an area of lower ecological value.
- Relocation of the proposed 2.92 ha wetland (E10WL) in the Southern tributary to an area of lower ecological value.

#### **4.3.3.1 Catchment interventions (stormwater harvesting)**

To retain existing stream form is also likely to require harvesting of stormwater runoff from the newly created impervious catchment areas and/or redirection of stormwater to outfalls located downstream of this reach. Without stormwater interventions that go beyond meeting the BPEM guidelines, there is little prospect of avoiding channel erosion in these highly dispersive soils nor a shift from an ephemeral to a perennial streamflow regime. Retaining ecological and geomorphic values requires maintaining a water balance that is close to natural and this can only be achieved if almost all the additional surface runoff generated by urbanisation is prevented from entering the waterways (Duncan, Fletcher et al. 2014, Duncan, Fletcher et al. 2016). This would require extensive stormwater harvesting, which is likely to have practical challenges, such as lack of demand in the catchment or the cost associated with storage infrastructure if there is a mismatch in the timing of supply and demand. However, there are several opportunities to address stormwater flows within the Aitken Creek catchment. These could be implemented at a range of scales, including:

- Collecting roofwater at the property-scale for onsite use, coupled with implementation of ground-level stormwater treatment and infiltration measures to manage runoff from roads, driveways, etc.
- Collecting stormwater at the DSS/PSP scale and:
  - Supplying it to non-potable demands within the PSP area through a secondary water supply pipe
  - Applying advanced treatment for full integration with the potable supply.

Innovative and extensive integrated water management solutions to stormwater management challenges are supported in principle by the Healthy Waterways Strategy as well as by a wide range of strategies from agencies that will be involved in the management of the area as it is developed, including from Hume City Council, Yarra Valley Water and DELWP.

#### **4.3.4 Further survey and modelling**

Additional modelling of how the hydrology will change in these waterway corridors and if the existing channel form would remain stable under developed flow conditions would be required to inform detailed analysis of potential changes. This would also inform whether further mitigation measures are required. We assume that this modelling will be part of Melbourne Water's DSS review. From a physical form perspective, factors of interest would include: changes to the duration, magnitude and frequency of flows, how that equates with changes in shear stress and whether this exceeds thresholds expected for scour of vegetated surfaces. Post development flows and flood extent would also be of use in refining buffer widths.

While not a legislative requirement (given the occurrence of the DSS within the Melbourne Strategic Assessment area), it is recommended that targeted flora surveys are undertaken for:

- River Swamp Wallaby Grass within wetland habitats in the Project area (November–March).
- Matted Flax-lily (November–January) in the vicinity of Plains Grassland vegetation mapped on Aitken Creek Main Channel, and within any areas of proposed disturbance within the grasslands at 1760 Mickleham Road.

This will allow these values to be retained and managed for within the landscape and/or to provide new habitats for these threatened species.

## 5. Summary

While Aitken Creek as it passes through the Aitken Creek DSS has been degraded by channel form modification in places and by widespread grazing, it continues to support state and federally listed species and communities, significant trees and, as headwater streams, to provide the important functions of infiltration, reduction in peak flows and nutrient retention. Aitken Creek is also a waterway particularly at risk of erosion and incision due to the underlying sodic soils. Proposed asset locations, waterway corridor widths and form and stormwater treatments in the catchment should be reviewed in light of these values and functions.

Particular risks include:

- Narrow waterway corridors requiring channelization of the waterway into the underlying sodic soils, increasing shear stress, construction costs, failure risk and long term maintenance.
- Channelisation of the waterways leading to hydrological connection to the underlying groundwater with associated increase to flows in channel and lowering of groundwater level (and associated risks to adjacent groundwater dependent ecosystems).
- Direct loss of significant native vegetation communities and mature trees through construction of the waterway and drainage assets.
- Indirect loss of mature trees due to changed hydrology (shift from an ephemeral to permanent flow regime due to increased stormwater as well as risks to groundwater levels).
- Risks to downstream ecological values and drainage assets from increased flows and nutrients from stormwater and potential groundwater connection.

The desktop and field investigations undertaken by Jacobs support the corridor widths proposed by Melbourne Water to enable the retention of a shallow, wide waterway that reduces the risk of channelization into sodic subsoils and associated erosion and groundwater risks. This also provides opportunities to retain some infiltration functions within the corridor either through stream form or WSUD treatments.

We recommend the following principles for consideration during design:

- Retention of mature trees along the waterway wherever possible (in particular, trees 4-10 around the Southern Tributary).
- Retention of areas of Plains Grassland and Plains Grassy Wetland in the Aitken Creek Main Channel as natural waterway, rather than constructed waterway (particularly at the north west end of the Main Channel, where it links to existing high value grassland and immediately to the north of the area proposed to be retained as a natural channel).
- Review options for stream form that provide infiltration and nutrient retention within waterway buffers (e.g. chain of ponds), this may require additional buffer width.
- Maintain wide buffers wherever possible to support shallow waterway channels and avoid channelization into sodic subsoils. Expansion of the corridor to encompass the 100-year ARI flood extent in areas beyond those outlined above could be considered to enable this, particularly around the mapped area of Plains Grassy Wetland in the Main Channel.
- Where waterways are to be constructed, review whether the channel can avoid existing mature trees to prevent these being located in standing water as the flow regime changes.
- Relocation of the proposed 2.15 ha wetland (G4WL) to an area of lower ecological value.
- Relocation of the proposed 2.92 ha wetland (E10WL) in the Southern tributary to an area of lower ecological value.

To retain existing stream form is also likely to require harvesting of stormwater runoff from the newly created impervious catchment areas and/or redirection of stormwater to outfalls located downstream of this reach. Without stormwater interventions that go beyond meeting the BPEM guidelines, there is little prospect of

avoiding channel erosion in these highly dispersive soils nor a shift from an ephemeral to a perennial streamflow regime.

Further targeted field investigations should be undertaken to confirm the presence of two threatened flora species and additional modelling of how the hydrology will change in these waterway corridors and if the existing channel form would remain stable under developed flow conditions would be required to inform detailed analysis of potential changes. This would also inform whether further mitigation measures are required.

We note that the Healthy Waterways Strategy has a performance objective of putting in place protection mechanisms for headwaters to ensure that they are retained as features in the landscape for environmental, social, cultural and economic benefits and that Melbourne Water is currently developing policy for the protection of headwater streams under development scenarios. The HWS also sets ambitious targets for stormwater infiltration in developing catchments. With this strategy, Melbourne Water and its co-design partners have put forward a vision for a higher standard of waterway protection both through on ground management and management of catchment hydrology. Innovative IWM solutions to stormwater management challenges are also supported by a wide range of strategies from agencies that will be involved in the management of the area as it is developed, including from Hume City Council, Yarra Valley Water and DELWP.

The Aitken Creek DSS review and development of the Craigieburn West PSP provides an opportunity to test innovative management actions to protect headwater streams in an evolving policy space and retain these valuable environmental assets and the services they provide in the catchment and downstream.

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## Appendix A. Properties not able to be accessed during fieldwork



## **Appendix B. Stream form template for each reach**

ASSET_NAME	AITKEN CREEK
Date of Site visit	20 August 2020
DSS	Aitken Creek
COMPKEY	133979
UNITID	[To be provided by Melbourne Water]
UNITID2 (if applicable)	[To be provided by Melbourne Water]
HWVisions_Stream_Form	Valley fill intact – Urban future

GEOMORPHIC CHARACTER	
Values	Common stream form across the study area and geomorphic features in poor condition
Valley-setting	Partly confined by valley sides (stony rises).
Channel planform	Low sinuosity – 1.1 (from Physical Form Dataset)
Upstream catchment area	3.17 km <sup>2</sup> (from Physical Form Dataset)
Land use	Agricultural land
Geomorphic units / In stream habitat features	Within-channel - Seasonal pools and wetlands in valley floor, basalt boulder riffles. Water storages/farm dams are also present within-channel. Floodplain – wetlands in valley floor
Bed	<ul style="list-style-type: none"> <li>Average Streambed Slope = 3.9% (from Physical Form Dataset)</li> <li>Sediment - Silty to fine sandy clay loams (fines when entrained contribute to suspended sediment load)</li> <li>Parent material, origin and classification - Basalt, Newer Volcanic Group</li> <li>Soil Type – Sodosols, strong texture contrast, with sand to clay loamy surface horizons and dense and coarsely structured subsoil horizons that are sodic and dispersive. Sodosols are susceptible to problems of waterlogging and erosion. Erosion risk is increased in circumstances where the surface soil has been removed and subsoils are then exposed.</li> </ul>
Vegetation associations	Sedges (Juncus) are present in wetter channel and floodplain areas.
Process zone	Incision, Sediment Transfer and Aggradation within reach
In stream works	Valley in section has been drained. There has also been extensive alteration of topography through the removal and relocation of basalt boulders and excavation of farm dams/water storages.

WATERWAY BEHAVIOUR – PROCESSES & TRAJECTORY	
Waterway Process Trajectory (under current and PSP development conditions)	<p>Current conditions:</p> <ul style="list-style-type: none"> <li>Waterway trajectory – Relatively stable under existing landuse, maintenance of vegetation cover.</li> <li>Potential for bed adjustment – Higher potential for incision in areas where basalt boulders have been removed, valley has been drained and creek forms a narrow drainage channel.</li> <li>Types of bank erosion – Dispersion and fretting of banks</li> <li>Form &amp; reworking of instream units – Further incision of valley fill.</li> </ul> <p>PSP development conditions</p> <ul style="list-style-type: none"> <li>Waterway trajectory – Increased runoff has potential to scour channel</li> </ul>

	<ul style="list-style-type: none"> <li>• Potential for bed adjustment – High, particularly if upper soil horizon is disturbed.</li> <li>• Types of bank erosion – Slow fretting of banks as clays become dispersed under saturation, bank failures may also occur as bank height increases.</li> <li>• Form &amp; reworking of instream units – Further incision of valley fill.</li> </ul>
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WATERWAY CONDITION AND RISK	
Condition	Level 1, Insignificant Significance - Common stream form across the study area and geomorphic features in poor condition
Risk	High. Potential for erosion and incision is considered high particularly in response to future urban development, based on anticipated increase in flows (stormwater runoff) and the nature of the soils in the area.
Trajectory (existing conditions)	VALLEY FILL INTACT Likely to remain relatively intact under existing conditions. Some further localised degradation of stream form is possible in section of the creek that have been drained.
Trajectory (post development)	VALLEY FILL INTACT To retain existing stream form is likely to require harvesting of stormwater runoff from upstream contributory areas and/or redirection of stormwater to outfalls located downstream of this reach. It is recognised that the hydrology of the catchment post development is likely to result in a shift from an ephemeral to a perennial flow regime, and as such areas which are currently seasonally wet, may remain wet and pond water throughout the year. There may be opportunities within the waterway corridor to vary the stream form, so as to create a series of wetlands that hold water throughout the year separated by dryer vegetated swales/rocky riffles.



Figure 1 Scheme Property 14 – Drained creek (left) and farm dam (right).



Figure 2 Scheme Property 19 – Farm dam (left) and downstream creek/drainage depression traversing valley fill (right).



Figure 3 Scheme Property 20 – Partly confined channel with exposed basalt boulders.



Figure 4 Scheme Property 21 – Raised boulder surfaces along waterway corridor and remnants of quarry (left) and basalt boulder/riffle (right).



Figure 5 Scheme Property 31 – Drained creek (left) and onstream watering point for cattle (right).

ASSET_NAME	TRIB OF AITKEN CREEK (AITKEN CK NORTH EAST TRIBUTARY)
Date of Site visit	20 August 2020
DSS	Aitken Creek
COMPKEY	135092
UNITID	[To be provided by Melbourne Water]
UNITID2 (if applicable)	[To be provided by Melbourne Water]
HWVisions_Stream_Form	Valley fill intact – Urban future

GEOMORPHIC CHARACTER	
Values	Common stream form across the study area and geomorphic features in poor condition
Valley-setting	Partly confined by valley sides (stony rises).
Channel planform	Low sinuosity – 1.1 (from Physical Form Dataset)
Upstream catchment area	3.17 km <sup>2</sup> (from Physical Form Dataset)
Land use	Agricultural land
Geomorphic units / In stream habitat features	Within-channel - Seasonal wetlands in valley floor. Water storages/farm dams are also present. Floodplain – wetlands in valley floor
Bed	<ul style="list-style-type: none"> <li>Average Streambed Slope = 3.1% (from Physical Form Dataset)</li> <li>Sediment - Silty to fine sandy clay loams (fines when entrained contribute to suspended sediment load)</li> <li>Parent material, origin and classification - Basalt, Newer Volcanic Group</li> <li>Soil Type – Sodosols, strong texture contrast, with sand to clay loamy surface horizons and dense and coarsely structured subsoil horizons that are sodic and dispersive. Sodosols are susceptible to problems of waterlogging and erosion. Erosion risk is increased in circumstances where the surface soil has been removed and subsoils are then exposed.</li> </ul>
Vegetation associations	Sedges (Juncus) are present in wetter channel and floodplain areas.
Process zone	Aggradation within reach
In stream works	None evident. Likely to have been extensive alteration of topography through the removal and relocation of basalt boulders and excavation of farm dams/water storages.

WATERWAY BEHAVIOUR – PROCESSES & TRAJECTORY	
Waterway Process Trajectory (under current and PSP development conditions)	<p>Current conditions:</p> <ul style="list-style-type: none"> <li>Waterway trajectory – Relatively stable under existing landuse, maintenance of vegetation cover.</li> <li>Potential for bed adjustment – Higher potential for incision in areas where basalt boulders have been removed, valley has been drained and creek forms a narrow drainage channel.</li> <li>Types of bank erosion – None observed but noted turbid water in farm dams, which is an indicator of dispersion of sodic subsoils.</li> <li>Form &amp; reworking of instream units – Further incision of valley fill.</li> </ul> <p>PSP development conditions</p> <ul style="list-style-type: none"> <li>Waterway trajectory – Increased runoff has potential to scour channel</li> </ul>

	<ul style="list-style-type: none"> <li>• Potential for bed adjustment – High, particularly if upper soil horizon is disturbed.</li> <li>• Types of bank erosion – Slow fretting of banks as clays become dispersed under saturation, bank failures may also occur as bank height increases.</li> <li>• Form &amp; reworking of instream units – Further incision of valley fill.</li> </ul>
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#### WATERWAY CONDITION AND RISK

Condition	Level 1, Insignificant Significance - Common stream form across the study area and geomorphic features in poor condition
Risk	High. Potential for erosion and incision is considered high particularly in response to future urban development, based on anticipated increase in flows (stormwater runoff) and the nature of the soils in the area.
Trajectory (existing conditions)	VALLEY FILL INTACT Likely to remain relatively intact under existing conditions.
Trajectory (post development)	VALLEY FILL INTACT To retain existing stream form is likely to require harvesting of stormwater runoff from upstream contributory areas and/or redirection of stormwater to outfalls located downstream of this reach. It is recognised that the hydrology of the catchment post development is likely to result in a shift from an ephemeral to a perennial flow regime, and as such areas which are currently seasonally wet, may remain wet and pond water throughout the year. There may be opportunities within the waterway corridor to vary the stream form, so as to create a series of wetlands that hold water throughout the year separated by dryer vegetated swales/rocky riffles.



Figure 1 Scheme Property 37 – Broad drainage depression/valley fill (left) and farm dam (right).

ASSET_NAME	TRIB OF AITKEN CREEK (AITKEN CK SOUTHERN TRIBUTARY)
Date of Site visit	20 August 2020
DSS	Aitken Creek
COMPKEY	135092
UNITID	[To be provided by Melbourne Water]
UNITID2 (if applicable)	[To be provided by Melbourne Water]
HWVisions_Stream_Form	Valley fill intact – Urban future

GEOMORPHIC CHARACTER	
Values	Common stream form across the study area and geomorphic features in poor condition
Valley-setting	Partly confined by valley sides (stony rises).
Channel planform	Low sinuosity – 1.16 (from Physical Form Dataset)
Upstream catchment area	Unknown
Land use	Agricultural land
Geomorphic units / In stream habitat features	Within-channel - Seasonal wetlands in valley floor (absence of clearly defined channel). Floodplain – wetlands in valley floor
Bed	<ul style="list-style-type: none"> <li>Average Streambed Slope = 2.8% (from Physical Form Dataset)</li> <li>Sediment - Silty to fine sandy clay loams (fines when entrained contribute to suspended sediment load)</li> <li>Parent material, origin and classification - Basalt, Newer Volcanic Group</li> <li>Soil Type – Sodosols, strong texture contrast, with sand to clay loamy surface horizons and dense and coarsely structured subsoil horizons that are sodic and dispersive. Sodosols are susceptible to problems of waterlogging and erosion. Erosion risk is increased in circumstances where the surface soil has been removed and subsoils are then exposed.</li> </ul>
Vegetation associations	Sedges (Juncus) are present in wetter channel and floodplain areas.
Process zone	Aggradation within reach
In stream works	None evident. Likely to have been extensive alteration of topography through the removal and relocation of basalt boulders and excavation of farm dams/water storages.

WATERWAY BEHAVIOUR – PROCESSES & TRAJECTORY	
Waterway Process Trajectory (under current and PSP development conditions)	<p>Current conditions:</p> <ul style="list-style-type: none"> <li>Waterway trajectory – Relatively stable under existing landuse, maintenance of vegetation cover.</li> <li>Potential for bed adjustment – Relatively low given current conditions.</li> <li>Types of bank erosion – None observed.</li> <li>Form &amp; reworking of instream units – Further incision of valley fill.</li> </ul> <p>PSP development conditions</p> <ul style="list-style-type: none"> <li>Waterway trajectory – Increased runoff has potential to scour channel</li> <li>Potential for bed adjustment – High, particularly if upper soil horizon is disturbed.</li> </ul>

	<ul style="list-style-type: none"> <li>Types of bank erosion – Slow fretting of banks as clays become dispersed under saturation, bank failures may also occur as bank height increases.</li> <li>Form &amp; reworking of instream units – Further incision of valley fill.</li> </ul>
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WATERWAY CONDITION AND RISK	
Condition	Level 1, Insignificant Significance - Common stream form across the study area and geomorphic features in poor condition
Risk	High. Potential for erosion and incision is considered high particularly in response to future urban development, based on anticipated increase in flows (stormwater runoff) and the nature of the soils in the area.
Trajectory (existing conditions)	<b>VALLEY FILL INTACT</b> Likely to remain relatively intact under existing conditions.
Trajectory (post development)	<b>VALLEY FILL INTACT</b> A wetland is currently proposed for this reach (Asset E10WL). No waterway buffer width has been proposed for this Reach, however it was noted at the time of field survey that ground conditions across the entire property (Scheme property 29) were saturated with large areas of standing water. Presumably a large proportion of this property will be developed in the future. A suitable drainage scheme will need to be designed to accommodate anticipated changes in hydrology (increased runoff) and also reduction in the area of potential inundation (smaller constructed wetland) relative to existing conditions (ponding of water across the entire property).



Figure 1 Scheme Property 29 – Broad saturated plain/wetland.



Figure 2 Scheme Property 29 – Saturated fields (left) and large tree adjacent to farm dam (right).

## Appendix C. Vascular plant species recorded within the project area during fieldwork

Introduced	Scientific name	Common name
*	<i>Agrostis capillaris</i> var. <i>capillaris</i>	Brown-top Bent
	<i>Allocasuarina verticillata</i>	Drooping Sheoak
	<i>Amphibromus nervosus</i>	Common Swamp Wallaby-grass
	<i>Anthosachne scabra</i> s.s.	Common Wheat-grass
*	<i>Anthoxanthum odoratum</i>	Sweet Vernal-grass
*	<i>Arctotheca calendula</i>	Cape Weed
	<i>Atriplex semibaccata</i>	Berry Saltbush
	<i>Austrostipa bigeniculata</i>	Knead Spear-grass
*	<i>Avena fatua</i>	Wild Oat
*	<i>Avena</i> spp.	Oat
*	<i>Briza maxima</i>	Large Quaking-grass
*	<i>Bromus catharticus</i>	Prairie Grass
*	<i>Bromus diandrus</i>	Great Brome
*	<i>Bromus hordeaceus</i>	Soft Brome
*	<i>Callitriche stagnalis</i>	Common Water-starwort
	<i>Carex inversa</i>	Knob Sedge
	<i>Carex tereticaulis</i>	Poong'ort
*	<i>Cassinia sifton</i>	Drooping Cassinia
*	<i>Cenchrus clandestinus</i>	Kikuyu
	<i>Centella cordifolia</i>	Centella
*	<i>Chenopodium murale</i>	Sowbane
	<i>Chloris truncata</i>	Windmill Grass
*	<i>Cirsium vulgare</i>	Spear Thistle
	<i>Crassula</i> sp.	Crassula
*	<i>Cynara cardunculus</i> subsp. <i>flavescens</i>	Artichoke Thistle
*	<i>Cynodon dactylon</i> var. <i>dactylon</i>	Couch
*	<i>Cyperus eragrostis</i>	Drain Flat-sedge
*	<i>Dactylis glomerata</i>	Cocksfoot
*	<i>Echium plantagineum</i>	Paterson's Curse
*	<i>Ehrharta erecta</i>	Panic Veldt-grass
*	<i>Ehrharta longiflora</i>	Annual Veldt-grass
	<i>Eleocharis acuta</i>	Common Spike-sedge
	<i>Epilobium billardiereum</i>	Variable Willow-herb
*	<i>Erigeron</i> spp.	Fleabane
*	<i>Erodium botrys</i>	Big Heron's-bill
	<i>Eucalyptus camaldulensis</i> subsp. <i>camaldulensis</i>	River Red-gum
	<i>Eucalyptus ovata</i> subsp. <i>ovata</i>	Swamp Gum
*	<i>Fraxinus angustifolia</i> subsp. <i>angustifolia</i>	Desert Ash
	<i>Geranium</i> spp.	Crane's Bill

*	<i>Helminthotheca echioides</i>	Ox-tongue
*	<i>Holcus lanatus</i>	Yorkshire Fog
*	<i>Hordeum spp.</i>	Barley Grass
*	<i>Hypochaeris radicata</i>	Flatweed
	<i>Juncus amabilis</i>	Hollow Rush
	<i>Juncus australis</i>	Austral Rush
	<i>Juncus pallidus</i>	Pale Rush
	<i>Juncus procerus</i>	Tall Rush
	<i>Juncus spp.</i>	Rush
	<i>Lachnagrostis filiformis s.s.</i>	Common Blown-grass
*	<i>Lepidium africanum</i>	Common Peppergrass
*	<i>Lolium spp.</i>	Rye Grass
*	<i>Lotus spp. (naturalised)</i>	Trefoil
*	<i>Lycium ferocissimum</i>	African Box-thorn
	<i>Lythrum hyssopifolia</i>	Small Loosestrife
*	<i>Malva parviflora</i>	Small-flower Mallow
*	<i>Marrubium vulgare</i>	Horehound
	<i>Melicytus dentatus s.s.</i>	Tree Violet
	<i>Microlaena stipoides var. stipoides</i>	Weeping Grass
*	<i>Modiola caroliniana</i>	Red-flower Mallow
*	<i>Nassella neesiana</i>	Chilean Needle-grass
*	<i>Nassella trichotoma</i>	Serrated Tussock
*	<i>Oxalis pes-caprae</i>	Sour sob
	<i>Oxalis spp.</i>	Wood Sorrel
*	<i>Paspalum dilatatum</i>	Paspalum
*	<i>Paspalum distichum</i>	Water Couch
	<i>Persicaria prostrata</i>	Creeping Knotweed
*	<i>Plantago lanceolata</i>	Ribwort
*	<i>Plantago major</i>	Greater Plantain
*	<i>Poa annua s.l.</i>	Annual Meadow-grass
	<i>Poa labillardierei var. labillardierei</i>	Common Tussock-grass
*	<i>Romulea rosea</i>	Onion Grass
*	<i>Rosa rubiginosa</i>	Sweet Briar
*	<i>Rubus fruticosus spp. agg.</i>	Blackberry
	<i>Rumex brownii</i>	Slender Dock
*	<i>Rumex crispus</i>	Curled Dock
	<i>Rytidosperma caespitosum</i>	Common Wallaby-grass
	<i>Rytidosperma duttonianum</i>	Brown-back Wallaby-grass
	<i>Rytidosperma racemosum var. racemosum</i>	Slender Wallaby-grass
	<i>Rytidosperma setaceum var. setaceum</i>	Bristly Wallaby-grass
	<i>Schoenus apogon</i>	Common Bog-sedge
*	<i>Solanum nigrum s.s.</i>	Black Nightshade

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*	<i>Sonchus asper</i> s.s.	Rough Sow-thistle
*	<i>Sonchus oleraceus</i>	Common Sow-thistle
*	<i>Sporobolus africanus</i>	Rat-tail Grass
	<i>Themeda triandra</i>	Kangaroo Grass
*	<i>Trifolium angustifolium</i> var. <i>angustifolium</i>	Narrow-leaf Clover
*	<i>Trifolium repens</i> var. <i>repens</i>	White Clover
*	<i>Urtica urens</i>	Small Nettle
*	<i>Vicia sativa</i> subsp. <i>sativa</i>	Common Vetch
*	<i>Vulpia</i> spp.	Fescue

## Appendix D. Likelihood of occurrence of rare and threatened species

Key	
Status under the EPBC Act	
CR	Critically Endangered
EN	Endangered
VU	Vulnerable
Mig	Migratory
Mar	Marine
Status under the FFG Act	
L	Listed
Status on the VicAdv list	
cr	Critically Endangered
e	Endangered
v	Vulnerable
nt	Near Threatened
r	Rare
k	Poorly known

## D.1.1 Rare or threatened flora

EPBC	FFG	VicAdv	Taxon	Habitat/distribution	PMST	Last record	No. recs	Likelihood occurrence
VU	R		<i>Amphibromus fluitans</i> (River Swamp Wallaby Grass)	Largely confined to permanent swamps, principally along the Murray River between Wodonga and Echuca, uncommon to rare in the south (e.g. Casterton, Moe, Yarram), probably due to historic drainage of wetlands {RBGV, 2016 #65}. Largely restricted in greater Melbourne to seasonal wetlands and mudflats of River Red Gum swamps of the Lower Yarra and Plenty/Merri volcanic plains north of Melbourne.		6/12/2017	3	High
	L	en	<i>Amphibromus pithogastrus</i> (Plump Swamp Wallaby-grass)	Known only from swampy depressions in black volcanic clay soils north of Craigieburn.		21/12/1992	2	Low-Moderate
		k	<i>Caesia parviflora</i> var. <i>vittata</i> (Pale Grass-lily)	Lowland grassland and grassy woodland. Flowers mainly in spring.		21/12/1992	1	Low-Moderate
	R	r	<i>Callitriche umbonata</i> (Winged Water-starwort)	Scattered and uncommon. Mainly in inland parts of Victoria in damp and swampy places. Flowers Aug-Dec.		10/10/2012	1	Low-Moderate
		k	<i>Convolvulus angustissimus</i> subsp. <i>omnigracilis</i> (Slender Bindweed)	Mostly in grassland, grassy woodland. Flowers mainly in Spring, Summer (but spasmodically throughout the year).		6/09/2018	12	High
		vu	<i>Corymbia maculata</i> (Spotted Gum)	Grows naturally only in far east Gippsland within Victoria - Commonly planted street tree. Flowers Jul.-Sep.		1/09/2017	2	NA
	L	en	<i>Cullen tenax</i> (Tough Scurf-pea)	Generally grows in drier parts of Victoria in grassland and grassy woodland on heavy soils.		1/11/2017	1	Low-Moderate
		k	<i>Desmodium varians</i> (Slender Tick-trefoil)	An uncommon species mostly from inland parts of eastern Victoria where found mainly in woodland and open-forest.		19/12/2018	4	Low-Moderate
EN	L	en	<i>Dianella amoena</i> (Matted Flax-lily)	Largely confined to drier grassy woodland and grassland communities south of the Dividing Range and now much depleted through its range.		3/03/2020	23	High
		vu	<i>Dianella longifolia</i> var. <i>grandis</i> (Flax-lily)	Occurs in lowland plains grassland and grassy woodlands (e.g. Volcanic Plain and Riverina) as well as around rocky outcrops at higher altitudes than the var. <i>longifolia</i> . Flowers Nov.-Dec.		6/12/2017	3	Low-Moderate
VU		vu	<i>Dodonaea procumbens</i> (Trailing Hop-bush)	Grows in low-lying, often winter-wet areas in woodland, low open-forest and grassland on sands and clays.	PMST			Low
		r	<i>Eucalyptus kitsoniana</i> (Bog Gum)	Occurring on coastal lowlands from Yarram, west to Cape Otway and Mt. Richmond near Portland. Flowers Aug-Mar.		5/12/2017	1	Low
	L	en	<i>Eucalyptus leucoxylon</i> subsp. <i>megalocarpa</i> (Large-fruit Yellow-gum)	Coastal, from Robe to south of Mt. Gambier. Flowers May-Dec.		5/12/2017	2	NA

EPBC	FFG	VicAdv	Taxon	Habitat/distribution	PMST	Last record	No. recs	Likelihood occurrence
		r	<i>Eucalyptus sideroxylon</i> subsp. <i>sideroxylon</i> (Mugga)	In Victoria confined to the Chiltern area, northern Warby Range and south of Winton, while the other ironbark, <i>Eucalyptus tricarpa</i> , with its 3-budded inflorescences and larger fruit is widespread		5/12/2017	1	NA
		vu	<i>Geranium solanderi</i> var. <i>solanderi</i> s.s. (Austral Crane's-bill)	An uncommon species occurring in damp to dryish, sheltered sites of grassy woodlands, often along drainage lines or seepage areas.		3/03/2020	14	Moderate
		r	<i>Geranium</i> sp. 3 (Pale-flower Crane's-bill)	Found in open, grassy areas of dry woodland forest. Flowers Sep.-Jan.		6/10/2016	2	Moderate
VU	L	vu	<i>Glycine latrobeana</i> (Clover Glycine)	Widespread but of sporadic occurrence and rarely encountered. Grows mainly in grasslands and grassy woodlands.	PMST			Low
		k	<i>Kunzea leptospermoides</i> (Yarra Burgan)	Thought to be restricted to the upper Yarra Valley and areas to the west of Melbourne around Meredith and Durididwarrah, where it is restricted to riparian areas and damp forest.		23/11/2017	2	Moderate
EN	L	vu	<i>Lachnagrostis adamsonii</i> (Adamson's Blown-grass)	Occurs in and around saline depressions on the Volcanic Plain where recorded from Portalington west almost to the South Australian border.	PMST			Low
EN	L	en	<i>Lepidium hyssopifolium</i> s.s. (Basalt Peppergrass)	Collected from scattered sites on the volcanic plain, but now much reduced from its former range and recorded recently only from e.g. Moorabool, Winchelsea, Bacchus Marsh, Woodend, Trentham. Most recent collections are from disturbed, rather weedy sites. One collection from near Port Fairy is noteworthy for its occurrence in a slightly saline estuary amongst saltmarsh and fringing sedgeland. Flowers mostly summer-autumn.		21/05/2018	1	Low-Moderate
EN	L	en	<i>Leucochrysum albicans</i> subsp. <i>tricolor</i> (White Sunray)	Very rare in Victoria, the only recent collections from volcanic grassland remnants in the Wickliffe, Willaura, Streatham, Inverleigh and Creswick districts. All other Victorian collections were made last century, from e.g. Mt Cole, the Grampians and the Port Fairy district. Collections from the Victorian alps have been attributed to this subspecies, but they may be the result of hybridisation between <i>Leucochrysum alpinum</i> and <i>Leucochrysum albicans</i> subsp. <i>albicans</i> . Flowers Nov.-Dec.	PMST			Low
		r	<i>Melaleuca armillaris</i> subsp. <i>armillaris</i> (Giant Honey-myrtle)	Mainly confined to near-coastal sandy heaths, scrubs slightly raised above saltmarsh, riparian scrubs, rocky coastlines and foothill outcrops eastwards from about Marlo. Occurrences to the west are naturalized from cultivated stock. Commonly grown for ornament across Victoria, as a windbreak or street tree and sometimes giving rise to seedlings, particularly after fire.		29/11/2017	4	NA
		k	<i>Pauridia vaginata</i> var. <i>brevistigmata</i> (Yellow Star)	#N/A		11/10/1992	1	Low-Moderate
CR	L	en	<i>Pimelea spinescens</i> subsp. <i>spinescens</i> (Spiny Rice-flower)	Grows in grassland, open shrubland and occasionally woodland, often on basalt-derived soils. Mostly west of Melbourne (to near Horsham), but extending as far north as Echuca.	PMST			Low

EPBC	FFG	VicAdv	Taxon	Habitat/distribution	PMST	Last record	No. recs	Likelihood occurrence
		k	<i>Poa labillardierei</i> var. (Volcanic Plains) (Basalt Tussock-grass)	The common tussock grass of streamsides and alluvial flats through most of the State, but a distinctive form with completely glabrous lemmas, lacking a web, occurs near drainage lines of the Volcanic Plain. It is often more robust than typical forms of the variety which may grow in association with it.		6/12/2017	10	Moderate
EN	L	en	<i>Prasophyllum frenchii</i> (Maroon Leek-orchid)	Widespread across southern Victoria, but rare. Occurs in grassland, heathland and open forest on well-drained or water-retentive sand or clay loams.	PMST			Low
		r	<i>Rhagodia parabolica</i> (Fragrant Saltbush)	Confined to rocky slopes and broad ridges between Sunbury and Geelong - but locally common where present. Flowers, not foliage are fragrant. Flowers mostly Sep-Jan.		15/12/2017	5	NA
EN	L	en	<i>Rutidosia leptorhynchoides</i> (Button Wrinklewort)	In Victoria confined to basaltic grasslands between Rokewood and Melbourne where endangered due to loss of habitat (formerly occurring as far west as Casterton, and on the Gippsland Plain near Newry).	PMST			Low
VU		vu	<i>Senecio psilocarpus</i> (Swamp Fireweed)	Rare, restricted in Victoria to a few herb-rich winter-wet swamps throughout the south of the state, west from Sale, growing on volcanic clays or peaty soils.	PMST			Low
		r	<i>Tripogonella loliiformis</i> (Rye Beetle-grass)	An uncommon grass of scattered occurrence throughout the state, including rocky areas and the Basalt Plain.		13/11/2015	1	Low-Moderate

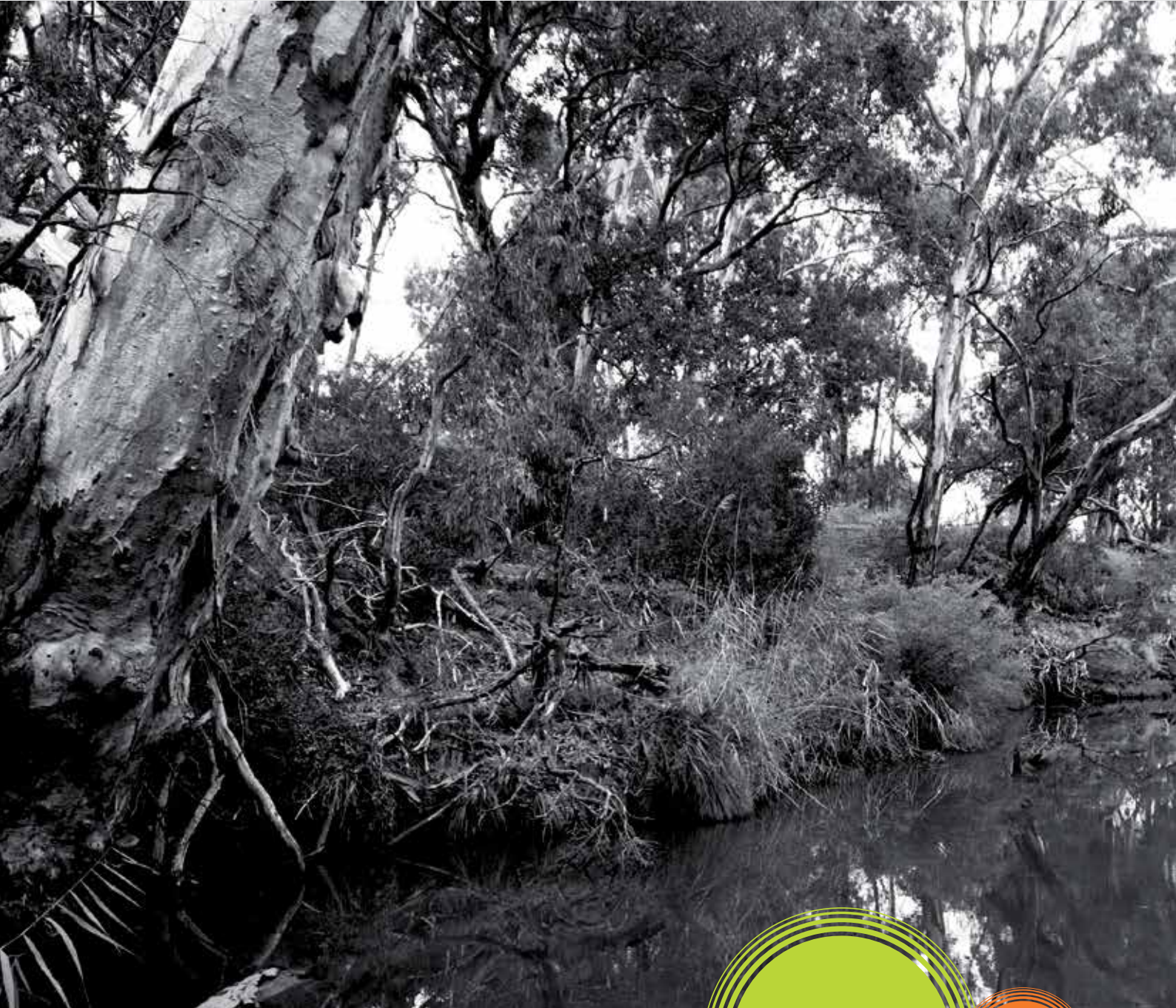
## D.1.2 Threatened fauna

EPBC	FFG	VicAdv	Taxon	Habitat/distribution	PMST	Last record	No. recs	Likelihood occurrence
		vu	<i>Actitis hypoleucos</i> (Common Sandpiper)	Shallow, pebbly, muddy or sandy edges of rivers and streams, coastal to far inland; dams, lakes, sewage ponds; margins of tidal rivers; waterways in mangroves or saltmarsh; mudflats; rocky or sandy beaches; causeways, riverside lawns, drains, street gutters {Pizzey, 2012 #16}.		1/12/1980	1	Low
CR	L	cr	<i>Anthochaera phrygia</i> (Regent Honeyeater)	Dry open forest, woodlands, or red ironbark, yellow box, white and yellow gum, mistletoe on river she-oaks, trees in farmlands, streets, gardens {Pizzey, 2012 #16}.	PMST			Low
	L	vu	<i>Ardea alba</i> (Great Egret)	Shallows of rivers, estuaries, tidal mudflats, freshwater wetlands; sewage ponds, irrigation areas, larger dams etc {Pizzey, 2012 #16}.		1/05/2015	12	Moderate
	L	en	<i>Ardea intermedia plumifera</i> (Plumed Egret)	Freshwater wetlands, pastures and croplands, tidal mudflats, floodplains {Pizzey, 2012 #16}.		1/03/1980	1	Low
		vu	<i>Aythya australis</i> (Hardhead)	Deep, permanent wetlands, large open waters, brackish coastal swamps, farm dams, ornamental lakes, sewage ponds {Pizzey, 2012 #16}.		5/12/2018	32	Moderate
		vu	<i>Biziura lobata</i> (Musk Duck)	Well-vegetated swamps, wetlands, both brackish and fresh, lakes, reservoirs, shallow bays, inlets; occasionally at sea {Pizzey, 2012 #16}.		19/06/2010	40	Moderate
EN	L	en	<i>Botaurus poiciloptilus</i> (Australasian Bittern)	Narrow habitat preferences, preferring shallow, vegetated freshwater or brackish swamps {Pizzey, 2012 #16}.	PMST			Low
CR	L	en	<i>Calidris ferruginea</i> (Curlew Sandpiper)	Tidal mudflats; saltmarsh, saltfields; fresh, brackish or saline wetlands; sewage ponds {Pizzey, 2012 #16}.	PMST			Low
		dd	<i>Chelodina longicollis</i> (Eastern Snake-necked Turtle)	Typical inhabitant of swamps, oxbow lakes and billabongs, or slow-moving rivers. Sometimes extensive overland migrations occur in summer. Feeds on a variety of aquatic organisms - molluscs, crustaceans, tadpoles and small fishes. Lays eggs in banks, usual {Cogger, 2014 #10}.		31/05/1991	1	Moderate
		nt	<i>Chlidonias hybrida</i> (Whiskered Tern)	Vegetated and open wetlands; brackish, saline lakes; saltfields, irrigated lands, sewage ponds; occasionally offshore {Pizzey, 2012 #16}.		28/10/2006	4	Moderate

EPBC	FFG	VicAdv	Taxon	Habitat/distribution	PMST	Last record	No. recs	Likelihood occurrence
		nt	<i>Circus assimilis</i> (Spotted Harrier)	Grassy plains, crops and stubblefields; bluebush, saltbush, spinifex associations; scrublands, mallee, heathlands; open, grassy woodlands.		10/01/1989	2	Low
EN	L	en	<i>Dasyurus maculatus maculatus</i> (Spot-tailed Quoll)	Has a wide range of habitats, including rainforest, open forest, woodland, coastal heathland and inland riparian forest.	PMST			Negligible
		nt	<i>Dromaius novaehollandiae</i> (Emu)	Found in plains, scrublands, open woodlands, coastal heaths, alpine pastures, semi-deserts, margins of lakes, pastoral and cereal growing areas. Mostly absent from closely settled parts, common in pastoral and cropping regions, state forests and national parks.		5/09/2014	3	Low
	L	en	<i>Egretta garzetta</i> (Little Egret)	Tidal mudflats, saltmarshes, mangroves, freshwater wetlands, sewage ponds.		1/01/1986	4	Low
	L	en	<i>Falco hypoleucos</i> (Grey Falcon)	Lightly treed inland plains, gibber deserts, sandridges, pastoral lands, timber watercourses; seldom in driest deserts.	PMST			Low
	L	vu	<i>Falco subniger</i> (Black Falcon)	Plains, grasslands, foothills, timbered watercourses, wetland environs; crops; occasionally over towns and cities.		21/05/2005	3	Moderate
VU	L	en	<i>Galaxiella pusilla</i> (Dwarf Galaxias)	In streams, burrow in moist soil, in yabby burrows, ground water and underground streams.	PMST			Low
		nt	<i>Gallinago hardwickii</i> (Latham's Snipe)	Freshwater or brackish wetlands, preferring to be close to protective vegetation cover.		14/12/2004	1	Low
VU	L	vu	<i>Grantiella picta</i> (Painted Honeyeater)	Mistletoes in eucalypt forests/woodlands; black box on watercourses; box-ironbark-yellow gum woodlands; paperbarks, Casuarinas; mulga, other acacias; trees on farmland; gardens.	PMST			Low
VU	L	vu	<i>Hirundapus caudacutus</i> (White-throated Needletail)	Airspace over forests, woodlands, farmlands, plains, lakes, coasts, towns, feeding companies frequency patrol back and forward along favoured hilltops and timbered ranges.		1/03/1981	4	Low
	L	nt	<i>Hydroprogne caspia</i> (Caspian Tern)	Coastal, offshore waters, beaches, mudflats, estuaries, larger rivers, reservoirs and lakes.		1/12/1980	2	Low
	L	vu	<i>Jalmenus icilius</i> (Amethyst Hairstreak Butterfly)	Found in all mainland states of Australia, where It is generally common except in the south-eastern end of its range in central and western Victoria, where it is now very scarce.		24/11/2015	1	Moderate

EPBC	FFG	VicAdv	Taxon	Habitat/distribution	PMST	Last record	No. recs	Likelihood occurrence
CR	L	en	<i>Lathamus discolor</i> (Swift Parrot)	Open grassy woodland, with dead trees, near permanent water and forested hills, coastal heaths, pastures with exotic grasses, weeds, roadsides, orchards.		29/05/1990	1	Low
VU	L	en	<i>Litoria raniformis</i> (Growling Grass Frog)	A largely aquatic species found among vegetation within or at the edges of permanent water – streams, swamps, lagoons, farm dams and ornamental ponds. Often found under debris on low, often flooded river flats. Frequently active by day.		16/08/2013	3	Moderate
VU	L	vu	<i>Maccullochella peelii</i> (Murray Cod)	Slow flowing turbid water of rivers and streams at low elevations. Also fast-moving clear, rocky upland streams. Favours deeper water around boulders, longs, undercut banks and overhanging vegetation.	PMST			Low
	L	nt	<i>Melanodryas cucullata</i> (Hooded Robin)	Drier Eucalypt forests, woodlands, scrubs with fallen logs, debris, mallee, Casuarina, cypress pine, mulga, cleared paddocks, Banksia dominated coastal scrubs.		29/05/1990	1	Low
	L	vu	<i>Miniopterus schreibersii oceanensis</i> (Common Bent-wing Bat (eastern ssp.))	Commonly found by day in caves, old mines, stormwater channels and comparable structures including occasional buildings. Typically found in well timbered valleys where it forages, above the tree canopy.		11/10/2013	2	Moderate
CR	L	vu	<i>Numenius madagascariensis</i> (Eastern Curlew)	Estuaries, tidal mudflats, sandspits, saltmarshes, mangroves; occasionally fresh or brackish lakes; bare grasslands near water.	PMST			Low
		nt	<i>Nycticorax caledonicus</i> (Nankeen Night-Heron)	Shallow margins of rivers, wetlands, mangrove-lined estuaries, offshore islands, floodwaters, garden trees.		22/03/2017	10	Moderate
	L	en	<i>Oxyura australis</i> (Blue-billed Duck)	Found on temperate, fresh to saline, terrestrial wetlands including sewerage ponds, rivers, salt lakes and salt pans. Preferring deep, permanent open water within or near dense vegetation.		5/12/2018	15	Moderate
CR	L	cr	<i>Pedionomus torquatus</i> (Plains-wanderer)	Sparse, treeless, lightly grazed native grasslands/herbfields with bare ground, old cereal crops, short Lucerne, sparse saltbush, low shrubland.		1/01/1989	1	Low
		nt	<i>Phalacrocorax varius</i> (Pied Cormorant)	Coastal waters with sloping shorelines; estuaries, bays, tidal inlets, large inland lakes and rivers, irrigation ponds, coastal mangroves and offshore islands.		15/04/2016	6	Moderate

EPBC	FFG	VicAdv	Taxon	Habitat/distribution	PMST	Last record	No. recs	Likelihood occurrence
		nt	<i>Platalea regia</i> (Royal Spoonbill)	Larger shallow waters, inland and coastal, well-vegetated shallow freshwater wetlands, saltfields, mangroves, islands, farm dams occasionally.		3/11/2017	5	Moderate
VU	L	vu	<i>Prototroctes maraena</i> (Australian Grayling)	Predominately a freshwater fish but is considered diadromous because the fry have a marine phase. The majority of its life is spent in freshwater, inhabiting rivers and streams, usually in cool (5-26°C), clear waters with a gravel substrate and alternating pool and riffle zones but it has also been recorded to occur in turbid water with muddy-bottomed, heavily silted habitat as well. Grayling can penetrate well inland, and have been reported over 100 km upstream from the sea, provided there are no barriers to movement.	PMST			Low
		vu	<i>Pseudemoia pagenstecheri</i> (Tussock Skink)	Tussock grasslands with few or no trees from highlands in ne Victoria to low-altitude basalt plains of Southern Victoria.		13/10/2015	5	Moderate
	L	en	<i>Pseudophryne bibronii</i> (Brown Toadlet)	Found below rocks in logs in wet and dry sclerophyll forest, in proximity to seasonally inundated areas.		23/05/1990	6	Moderate
VU	L	vu	<i>Pteropus poliocephalus</i> (Grey-headed Flying-fox)	Camps of this species are found in gullies, typically not far from water and usually in vegetation with a dense canopy.	PMST			Moderate
	L	vu	<i>Pyrrholaemus sagittatus</i> (Speckled Warbler)	Drier woodlands with tussocks, branches and rocks.		1/06/1978	3	Low
EN	L	cr	<i>Rostratula australis</i> (Australian Painted-snipe)	Well-vegetated shallows and margins of wetlands, dams, sewage ponds; wet pastures, marshy areas, irrigation systems, lignum, tea-tree scrub, open timber.	PMST			Low
		nt	<i>Sminthopsis crassicaudata</i> (Fat-tailed Dunnart)	Open woodland, low shrublands of saltbush and bluebush, tussock grasslands on clay or sandy soils, gibber plain and farmlands.		18/12/1989	1	Low
		vu	<i>Spatula rhynchotis</i> (Australasian Shoveler)	Larger waters, fresh and saline lakes, well-vegetated freshwater wetlands, coastal inlets, sewage ponds, floodwaters.		29/01/2000	1	Low
	L	nt	<i>Stagonopleura guttata</i> (Diamond Firetail)	Open Eucalypt forests/woodlands; River Red Gum, Mallee, Buloke, Cypress Pine.		1/09/1977	1	Low
	L	en	<i>Stictonetta naevosa</i> (Freckled Duck)	Large, well vegetated swamps; in dry periods moves to open lakes.		18/07/2004	1	Low
CR	L	cr	<i>Synemon plana</i> (Golden Sun Moth)	Native temperate grassland and open grassy woodlands, may also be found in degraded grasslands dominated by exotic Chilean Needlegrass.		20/12/2019	305	High



# Waterway Corridors

Guidelines for greenfield development  
areas within the Port Phillip  
and Westernport Region





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*Front Cover: Lower Werribee River; an example of the waterway values present on many of the waterways within the urban growth boundary that these guidelines will help to protect.*





# 1 Introduction

Melbourne Water is the caretaker of river health for the 8,400 kilometres of waterway in the Port Phillip and Westernport region. As part of its role, Melbourne Water has a duty of care to establish and maintain riparian zones along all our waterways to improve waterway health.

The waterways of the Port Phillip and Westernport region are major environmental and social assets, which are highly valued by the community and hold particularly high levels of cultural heritage significance. Waterways are important reserves of biodiversity and provide valuable habitat and corridors for native fish, birds, amphibians and mammals such as platypus, and provide, in many cases, a setting for recreational activities. In combination, these attributes (and others) are referred to as *river health*.

There has been significant improvement in river health in the Port Phillip and Westernport region over recent decades, and some waterways in the region are in excellent condition (in terms of river health). However, nearly half are in poor or very poor condition, and more than 200 kilometres of waterways need to be carefully managed as urban development spreads into currently undeveloped areas.

Urban development represents both a great challenge and a great opportunity for river health. The preservation, rehabilitation and restoration of appropriate riparian zones<sup>1</sup> in urban developments is essential if the river health objectives as defined in the Healthy Waterways Strategy<sup>2</sup> are to be met. The size and condition of the riparian zone is important for channel bed and bank stability, water quality, and aquatic and riparian biodiversity, which are all cornerstones of a healthy waterway and catchment system.

1 The area immediately adjacent to the waterway is referred to as the 'riparian zone'; the waterway (bed and banks) and riparian zones on both banks are collectively defined as the 'waterway corridor'.  
2 Melbourne Water 2012, 'Healthy Waterways Strategy (draft)'.

## 2 Purpose of the guidelines

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These guidelines have been developed to provide a consistent, strategic approach to the management of riparian zones in greenfield developments.

They define minimum standards for *waterway corridor widths*, vegetation quality, infrastructure and activities permitted within waterway corridors.

As caretaker of waterway health in the Port Phillip and Westernport region, Melbourne Water has an obligation to ensure that appropriate provisions are made to ensure waterway resilience and function in the face of environmental pressures such

as urban development. These guidelines will facilitate a consistent and strategic approach for government authorities, local government and developers to create environmentally and socially sustainable waterway corridors in new developments.

These guidelines do not remove the need for detailed environmental assessment of waterways and their surrounding environs prior to development occurring.

## 3 What is a waterway corridor?

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A waterway corridor is defined (for the purposes of these guidelines) as the waterway channel and its associated riparian zones.

Assigning a waterway corridor preserves areas of the riparian zone that protect or enhance native vegetation, river health and biodiversity in some cases, the waterway corridor may also be able to support a level of passive recreational use or some stormwater treatment elements.

The waterway corridor is the area of land that is required to help ensure a resilient waterway system – both ecologically and socially – that can effectively absorb and/or recover from damaging processes without losing core functionality.

In greenfield development sites waterway corridors are created through the modification of title boundaries during the subdivision process to preserve the waterway corridor for specified purposes. Melbourne Water is a statutory referral agency in this process and provides comment on planning permit applications as referred by the Responsible Authority and has the power under the Water Act 1989 to require reserves and/or easements for the purpose of drainage

and waterway management. Ultimately, the waterway corridor may be considered non-developable for either, or both, of these management requirements.

The width of waterway corridor required to meet the objectives of the corridors varies depending on the type of waterway (physical morphology, vegetation type, geologic setting etc). You can find more detailed information in Sections 5 and 6. These corridors establish the optimum balance between river health, biodiversity, social amenity, asset protection and developable land requirements. The minimum waterway corridor widths specified in these guidelines are based on the best available science, are compatible with current legislation and comparable to waterway corridor management in other jurisdictions.

The approach to calculating the waterway corridor width at a particular location depends on whether the waterway is an existing waterway or an artificial waterway that will be constructed as part of urban development, as well as considering any site specific factors such as environmental values, recreation uses or landscape characteristics.

In existing waterways the waterway corridor is defined by setbacks from the waterway that specify the minimum distance from the waterway on each side of the channel to urban development features such as roads and subdivisional lots. For new or existing

constructed channels the standard waterway corridor is defined as the sum of the width of the waterway channel and the setbacks on both banks, as described in Section 7.

In constructed waterways, an alternative approach is used to define waterway corridor widths, as there is no pre-existing waterway channel from which to define setbacks. Waterway corridor widths in constructed waterways are scaled according to the hydraulic width of the constructed waterway. The hydraulic width concept (as described in detail in Section 8) is a well understood variable in constructed waterway design across the development industry.

For both constructed and existing waterways there are a number of other factors (described in Section 6) that may require urban development to be located further from the waterway than specified by the minimum waterway corridor width (e.g. flood protection or the presence of highly sensitive flora and fauna).

In addition to the width of waterway corridors, these guidelines also specify controlled activities and infrastructure within the waterway corridors, and riparian zone management requirements. These requirements are described for existing waterways (Section 7) and constructed waterways (Section 8).



## 4 Scope of the guidelines

The guidelines apply only to greenfield development areas, which are defined as areas identified for urban development (residential, commercial or industrial) by state and/or local government, located on or beyond the boundaries of existing urban development.

Melbourne Water prepares Development Services Schemes or strategies for greenfield development areas that determine the surface water management infrastructure requirements within each catchment.

**The guidelines do not apply to:**

- Redevelopment zones, i.e. sites that are being redeveloped from some previous development use (e.g. development of a factory into a housing estate)
- Infill development, i.e. sites that may not have been previously developed but are surrounded by existing development.
- Rural waterways in forested and agricultural catchments that are not subject to urban development.
- Wetland systems, both natural and man made. Protection and management of these systems require considerations in addition to those covered in these guidelines, especially when they are managed for biodiversity purposes.

These guidelines focus on regional drainage assets, which can be perennial (always flowing) and ephemeral (flowing sometimes) rivers and/or creeks with catchments greater than 60 hectares. They also provide recommendations for local waterways/drainage lines that are commonly managed by organisations other than Melbourne Water. Please see section 7.2 for more information regarding smaller, local drainage assets.

The guidelines apply to all subdivisions of two lots or more.

Note: these guidelines do apply to parcels of land that may be surrounded by development within existing Development Services Schemes.



# 5 Objectives for waterway corridors in greenfield development areas

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## The objectives for waterway corridors in greenfield development areas of the Port Phillip and Westernport are:

- To protect, enhance or restore river health and biodiversity
- To enable some complementary use of waterways for recreational purposes and infrastructure (if appropriate) while maintaining primary river health, flood protection and biodiversity functions
- To provide effective flood protection.

### Waterway corridors and associated riparian vegetation provide a range of river health functions, including:

- Provision of food and habitat for aquatic fauna
- Provision of breeding, feeding and habitat for terrestrial fauna
- Provision of corridors for fauna movement up and down the waterway
- Provision of fauna refugia in developed landscapes and enhancing links between remaining habitats that would otherwise remain fragmented
- Stabilisation of channel banks against erosion
- Shading and maintenance of natural temperatures within waterways
- Reducing sediments and pollutants that reach waterways through overland flow
- Maintenance and improved water quality through filtering and nutrient cycling within the riparian zone and vegetated buffer zone
- Allowance for inclusion of some stormwater treatment systems within vegetation buffer zones if appropriate
- Allow space for natural migration of the waterway channel, especially in areas with highly erosive soil types
- Recruiting large woody debris into the stream and for riparian habitat over the long term.

Riparian zones differ from terrestrial lands in several ways: they often have more fertile soils, higher moisture levels and different plant species. Due to these factors, riparian zones provide the habitat features needed by a diverse range of wildlife species.

Riparian zones may also provide space for recreation and social activities. They provide an interface between urban development and waterways and visual amenity. Although Melbourne Water is the caretaker of waterways and has a primary objective of protecting and enhancing the health of waterways, we recognise the benefits of healthy, accessible riparian zones to communities and the importance of engaging the community with waterways and river health. This document is intended to provide clarity for the creation of waterway corridors that will balance the needs of the environment and the community in urban developments.

Waterways are also an extremely important component of the landscape in terms of indigenous cultural heritage as reflected in the Aboriginal Heritage Act 2006 and Regulations 2007. These list the land within 200m of a named waterway as being 'culturally significant'. By protecting and enhancing riparian areas, we can assist in preserving and in some cases, enhancing, cultural heritage values.

The objectives for waterway corridors were used to identify optimum waterway corridor widths, riparian vegetation zones, and permitted activities and infrastructure.



## 6 Principles underlying the guidelines

The development of the guidelines is underpinned by a number of principles:

- The minimum waterway corridor widths and riparian vegetation zoning required to meet the river health / biodiversity and social objectives described above are based on the best available science and riparian management practice in Australia and worldwide
- The minimum waterway corridor widths also take into account the scale of vegetation required to provide robust and self-sustaining riparian vegetation communities over the long-term. Narrow waterway corridors require high levels of maintenance and plant replacement to prevent weed invasion, and do not provide the minimum spacing requirements for riparian trees (which are generally required components of healthy riparian vegetation communities in urban developments)
- The minimum required waterway corridor width varies dependant on stream order, which increases with distance downstream of headwater streams. Smaller waterways in the headwaters of catchments will have smaller riparian zone widths and large waterways in the downstream area of a catchment will have wider riparian zones. This ensures that waterway corridors are at an appropriate spatial scale for the size of the waterway in any given location
- Waterways do not need to have 'permanent' or 'flowing' water to be considered waterways under the Water Act 1989. Therefore ephemeral waterways are also considered 'waterways' for the purpose of these guidelines
- Two distinct riparian sub-zones are identified within the waterway corridor: a core riparian zone (CRZ) of high quality native vegetation immediately adjacent to the waterway to provide the greatest biodiversity benefit; and, a robust vegetated buffer (VB) between the core riparian zone and the edge of the waterway corridor to protect the high value vegetation in the core riparian zone from 'edge effects'
- While Melbourne Water is supportive of community interaction and use of waterway corridors, infrastructure and recreational activities will be limited in the high value 'core riparian zone' to protect river health and biodiversity values. There is more flexibility in locating public open space assets (such as shared pathways) in the 'vegetated buffer'. It should be noted that a development's Public Open Space contribution is a council requirement and is determined/ approved separately to Melbourne Water's waterway corridor requirements.



The waterway corridor widths or setback widths in these guidelines are minimum widths, which may be increased to reflect site specific factors, as described below:

- Where high value species and/or communities are present, especially those listed as key values in the Healthy Waterways Strategy, Waterway Corridor width may be increased to protect or enhance habitat for these species. High value species may be – but are not limited to – those listed under the Environment Protection and Biodiversity Conservation Act or Flora and Fauna Guarantee Act
- Where the site forms an important part of an existing, or potential high value habitat corridor
- Where a fuel break is required 'by relevant authorities' to mitigate fire risk
- Where a site has been determined by Melbourne Water to contain significant local or regional waterway values
- Where a waterway reach requires greater levels of protection to ensure significant upstream or downstream values are protected
- Where the site contains high value geomorphic features or assemblages

that may be negatively affected by adopting inadequate setbacks e.g. escarpments or chain of ponds

- If there is risk of significant channel migration in the future (presence of highly erodible soils)
- Where biodiversity conservation or stormwater quality assets are required within the waterway corridor
- Where substantial recreation based assets are proposed to be placed within the waterway corridor
- Natural wetlands that fall within a waterway corridor may have requirements beyond those listed in these guidelines. Likewise, waterway corridors may need to be expanded to include wetlands associated with the system or modified to provide an adequate connectivity between the wetland and the waterway corridor
- Where cultural heritage sites of significance have been identified.

In situations where the standard waterway corridor width – as specified in these guidelines – is less than the width of the post development 1 in 100 year ARI flood<sup>3</sup> extent, the waterway corridor will be extended to include the entire 100 year ARI flood extent i.e. the 100 year ARI line becomes the waterway corridor boundary. Under these circumstances, the corridor

width required in excess of the 'minimum setback width' will be treated as 'vegetated buffer'.

It should be noted that in rare instances, the required waterway setback may be narrower than standard (minimum) width. Narrower setbacks will only be considered if it can be conclusively demonstrated that the objectives of waterway corridors (as outlined in these guidelines) will still be met.



3 Average Recurrence Interval is the expected time period between flood events of a given size. A 100 year ARI flood can also be thought of as a flood with a 1% chance of occurring in any year.



# 7 Waterway corridors for existing waterways

Existing waterways are typically well-defined channels, which may flow permanently or only during the wetter months of the year.

They will generally require only localised modification such as bank re-profiling, strengthening and/or revegetation as part of urban development. The condition of existing waterways in greenfield development areas is variable, but they are important environmental and social assets.

The approach to defining waterway corridor widths and riparian zones in existing waterways is based on the application of setback widths, as described in the following sections.

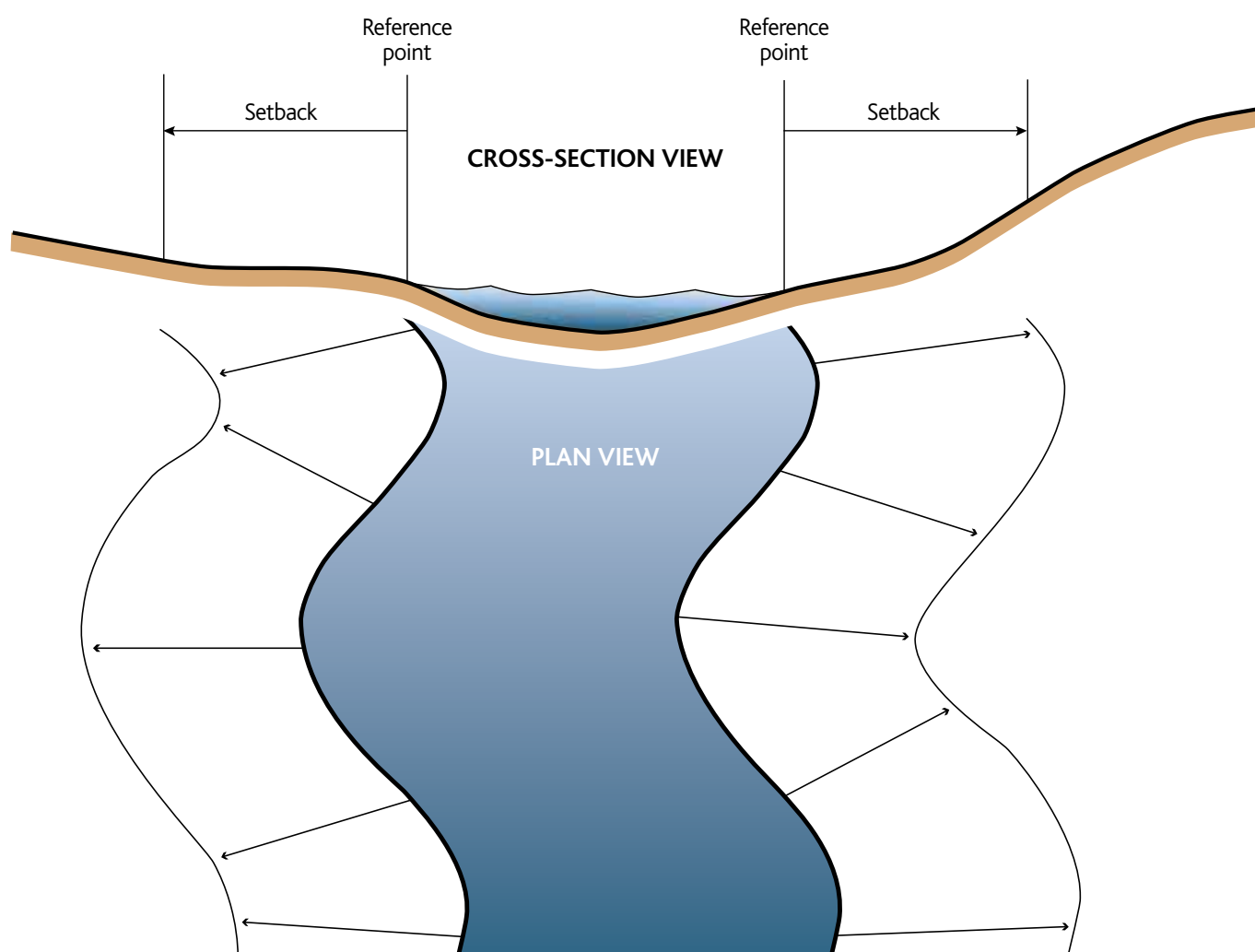
## 7.1 Minimum standard setback widths

Three standard setback widths apply to existing waterways in the Port Phillip and Westernport region: 20 m, 30 m and 50 m. These setback widths have been defined following a comprehensive review of waterway management science in Australia and worldwide. They provide a balance between achieving river health and biodiversity objectives, providing for recreation and visual amenity and maximising developable land.

The setback widths apply to both banks and are measured from a setback reference point as shown in Figure 1 (below).

The reference point is generally the Top of Bank (break of slope from the river bank to surrounding land) of the waterway. In some cases top of bank may not be easily defined, and an alternative reference point such as a hydraulic measurement may be required instead. Melbourne Water will provide further direction on how to determine and locate the reference point at specific sites as required. Please contact Melbourne Water on 131722 to request this information.

Figure 1. Schematic illustration of setback from waterway





## 7.2 How do setbacks vary with position in the catchment?

The setback that applies to a waterway at a particular location depends on the position of the site in the stream channel network. The underlying principle is that smaller waterways require a smaller setback to meet waterway health objectives, larger streams require a larger setback and major waterways require the largest setback.

The Strahler stream ordering system<sup>4</sup> is used to define a particular location in the stream channel network. The Strahler stream order is a simple method of defining stream size based on a hierarchy of tributaries. A small stream with no tributaries is defined as a first order stream. When two first order streams come together, they form a second order stream. When two second order streams come together, they form

a third order stream. Streams of lower order joining a higher order stream do not change the order of the higher stream, so if a first order stream joins a second order stream, it remains a second order stream. The Strahler stream order concept is illustrated schematically in Figure 2.



4 Strahler, AN, 1953 'Hypsometric (area altitude) analysis of erosional topology'. Geological Society of America Bulletin, 63(11), 1117 – 1142.

## Figure 2. Strahler stream order network

The stream order is used to define the setback that applies to a development site in a particular location in the Port Phillip and Westernport stream channel network. The three categories of setback width are assigned to stream orders as follows:

1. First and second order streams have a minimum 20 m setback on both banks
2. Third order streams have a minimum 30 m setback on both banks
3. Fourth order and greater streams have a minimum 50 m setback on both banks.

Once the setback width at a site has been determined from the stream order of the waterway at that site, the application and integration of the setbacks into the urban design process can be finalised, as described in the sections below.

Please note: for the purpose of these guidelines the calculation of the stream order begins at the 60 hectare catchment size i.e. if a waterway/stream of 60 hectare catchment size has one or more drainage lines flowing into it, its stream order is still classified as one.

### Streams less than 60ha catchment size

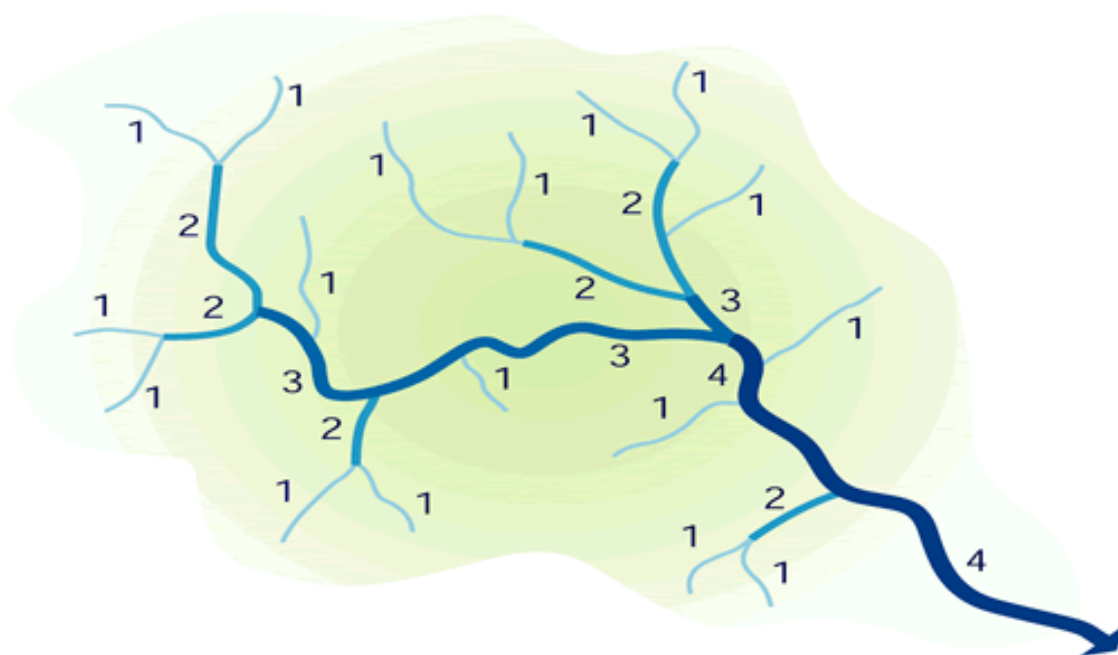
Generally, local government has a lead role in management of waterways with catchments less than 60 hectares; however, Melbourne Water recognises the important role these smaller streams play in regulating the health of the broader waterway system and the implicit values they hold in their own right. For example, minor waterways:

- are key habitat for vast numbers of flora and fauna species
- have an important role in regulating flows
- can be major sources of sediment and nutrient inputs if not appropriately managed.

The responsibility for managing these small, local waterways has traditionally fallen to local government. Under the Water Act 1989, Melbourne Water has the power to intervene with management of any 'waterway' within the Port Phillip and Westernport region, regardless of its catchment size, provided that it fits the description of a 'waterway' provided in the Act.

In instances where a small local waterway (<60ha catchment size) is identified as important to the health of the waterway as a whole, or where the potential exists for degrading processes acting upon it to spread throughout the system, Melbourne Water may take a direct management role. The required setback/corridor width for such waterways will be determined on a 'case by case' basis depending on specific values/threats.

While Melbourne Water does not take direct management responsibility for streams with catchments less than 60ha, we strongly recommend they are retained in a natural state and encourage Councils to provide setbacks that will ensure the values listed above are protected. A recent report by the National Water Commission (The Importance of Headwater Streams<sup>5</sup>) emphasises the difficulty in determining appropriate widths for these small streams, but does note that hydrology and nutrient/sediment/pollutant input may be equally or more important than 'buffer' widths in maintaining their condition. A 10-20m buffer width for each bank is cited as a recommended minimum in several studies listed in this document.



5 L.Barmuta, A.Watson, A.Clarke and A.Clappcott 2009 'The Importance of Headwater Streams' Waterlines Report Series No 25.

### 7.3 Setback sub-zones

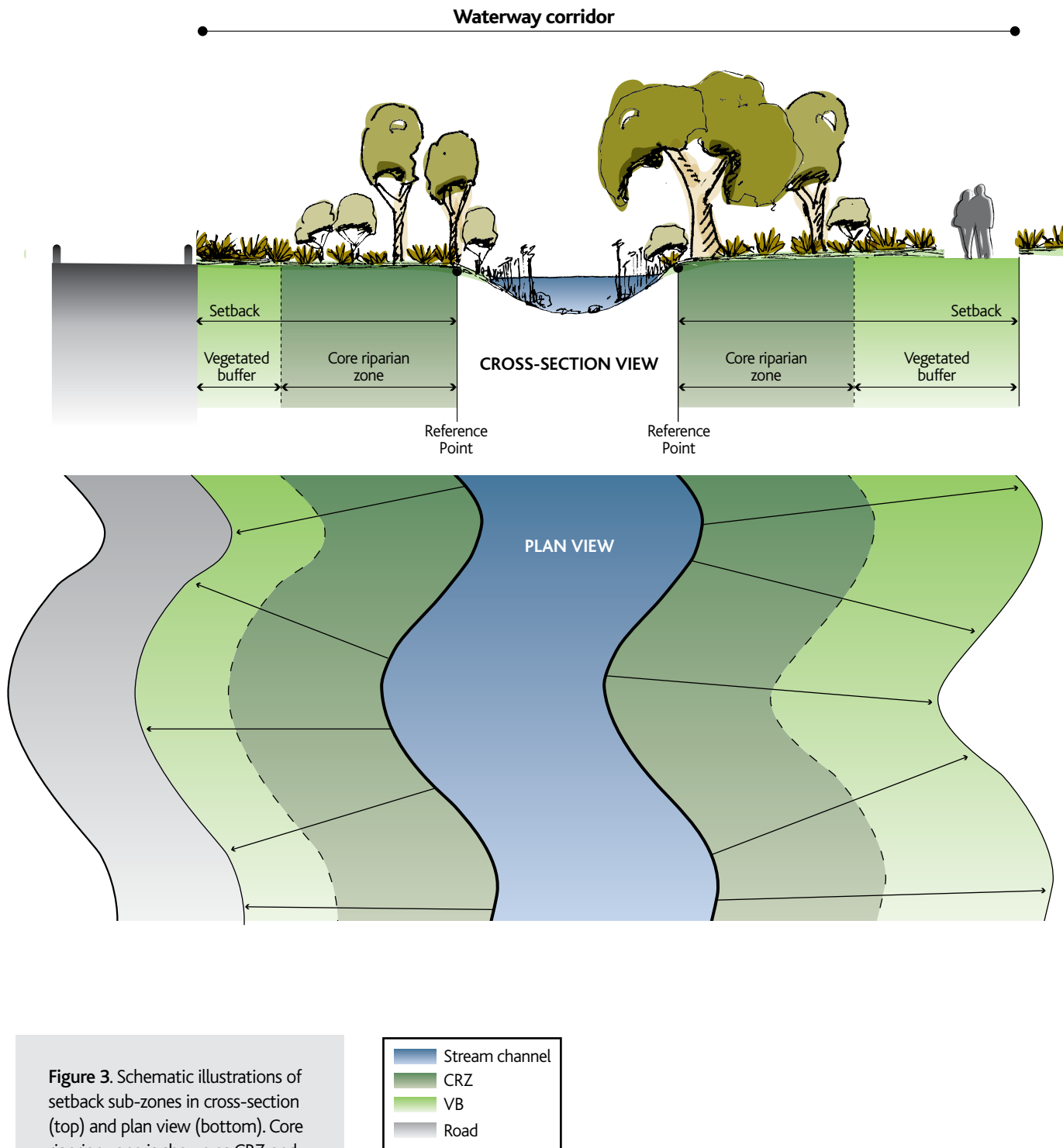
As described earlier, there are two sub-zones within each of the setback widths. The sub-zones have different roles in meeting the overall setback objectives and different activities and infrastructure requirements.

The two sub-zones are:

- the core riparian zone (CRZ)
- the vegetated buffer (VB).

The relationship between these sub-zones is shown in Figure 3

The core riparian zone is fully vegetated with native vegetation selected in accordance with the vegetation component of the Healthy Waterways Visions<sup>6</sup>. Depending on various factors such as geographic location, stream form and current condition, the required vegetation type may vary from



**Figure 3.** Schematic illustrations of setback sub-zones in cross-section (top) and plan view (bottom). Core riparian zone is shown as CRZ and vegetated buffer as VB.

<sup>6</sup> The Healthy Waterways Visions communicate Melbourne Water's longer term aims for the form and function of waterways in the Port Phillip and Westemport region. The visions provide one consistent Melbourne Water view of what the form and function of waterways could be in 20-years and articulate the levels of service that we need to apply to get there.

primarily trees and shrubs through to predominately native grass cover. The core riparian zone provides the main river health and biodiversity functions of the riparian setback. It is the area immediately adjacent to the waterway, and the vegetation in this zone provides the shading, nutrient and wood inputs to the stream required for healthy instream ecosystem function.

The vegetated buffer protects the core riparian zone from edge effects that will impact on vegetation and fauna in the core riparian zone. These edge effects include:

- weed invasion from adjacent areas
- light penetration
- micro-climate changes
- litter/pollution
- trampling

A 10 m wide vegetated buffer running immediately adjacent and parallel to the core riparian zone is required to protect the core riparian zone for all three standard widths. Therefore, although the width of the core riparian zone varies according to stream order, the width of the adjacent vegetated buffer remains constant at 10m (Table 1).

The 'vegetated buffer' vegetation type will vary from site to site, but will need to be designed in such a way that the integrity of the core riparian zone is protected. In many cases this will require this zone having similar vegetation to the core riparian zone. Melbourne Water will provide guidance on a site specific basis regarding the type of vegetation required.

**Table 1. Core riparian zone and vegetated buffer widths for different overall setback widths in existing channels**

OVERALL SETBACK WIDTH (M)	CORE RIPARIAN ZONE WIDTH (M)	VEGETATED BUFFER WIDTH (M)
20 m	10 m	10 m
30 m	20 m	10 m
50 m	40 m	10 m

In order to maintain the river health and biodiversity value of the riparian buffers in the waterway corridors it is necessary to limit the extent to which the vegetated buffer is impacted by services and infrastructure. As described above, riparian buffers provide a corridor through which fauna can travel across the landscape and habitat for fauna that do not migrate, hence optimisation of vegetation quality within this zone will greatly improve the ecological effectiveness of the waterway corridor.

Every effort should be made to locate underground services such as power, water and sewerage outside the core riparian zone to maintain the integrity of waterway function. Similarly, sports ovals, playgrounds, and maintenance tracks should also be located outside the core riparian zone, as they may create a barrier to faunal movement, despite being vegetated.

Wherever possible, shared pathways should also be located outside the core riparian zone and should meet the standards defined in Shared Path Guidelines<sup>7</sup> (available on the Melbourne Water website). While Melbourne Water has a strong preference for the assets and features listed above to be wholly located outside of the core riparian zone, partial placement of assets within this zone will be considered in situations where it is absolutely necessary or where a clear benefit to the community and/or environmental health can be demonstrated.

In some instances, stormwater treatment systems such as constructed wetlands and bio-retention systems may be located within the core riparian zone – subject to Melbourne Water approval – but should form a relatively small proportion of the area of the core riparian zone so as not to degrade its ecological function or put the asset at undue risk from flooding and/or stream migration.

Fire breaks may be required adjacent to areas of vegetation. The Core Riparian Zone and Vegetated Buffer Zone will usually consist of dense vegetation, and should not be included in any fire break. Fire breaks must meet the requirements of relevant public authorities, and will generally require space in addition to the waterway corridor. In some instances roads that are located adjacent to a waterway corridor may suffice as a fire break.

Determining fire break requirements is a shared responsibility between all associated land owners and managers, therefore Melbourne Water recommends developers engage with these agencies early in waterway corridor design process, to determine what requirements will need to be met (both fire break and building design as outlined in AS 3959-2009).



7 Melbourne Water, 2009, Shared Path Guidelines.



## 7.4 Determining waterway corridor width and extent in existing waterways

Three steps are required to determine the standard waterway corridor width at any given site:

1. determine the Strahler Order of the waterway and the associated standard setback
2. identify 'reference point' lines for both sides of the waterway – setbacks are measured from these lines.
3. Consider site specific values and land uses that may require the setbacks in excess of the minimum (see section 6 and section 9.1).

### Strahler orders

Strahler orders have been determined and mapped for all designated waterways with catchment areas equal to or greater than 60Ha in the Port Phillip and Westernport.

Developers should contact Melbourne Water at an early stage in the development process to ascertain the Strahler order and associated standard setback width for the site in question. Where necessary the developer may need to consult with other agencies such as the Department of Environment and Primary Industries, Parks Victoria and/or the relevant council to determine any further requirements associated with the waterway corridor zone (biodiversity protection, open space requirements, stormwater treatment etc).

## 8 Waterway corridors for constructed waterways

Greenfield urban development often requires the construction of artificial waterways to effectively drain stormwater from urban areas. In recent years the approach to designing constructed waterways has moved from being solely or primarily concerned with efficient drainage to a more holistic approach that balances drainage requirements with the need to provide an environmental and social asset for new communities.

Melbourne Water has a responsibility to establish and maintain healthy riparian zones along all its waterways, whether existing or constructed. There is therefore a need to provide waterway corridors for constructed waterways as well as existing 'natural' waterways. However, to set the corridor width, an alternative approach is required because there are significant differences between existing and constructed waterways, the most important for the purpose of these guidelines being, that there is no natural top of bank point in a constructed waterway to use as a setback reference point

The approach to defining constructed waterway corridor widths is founded on the principles outlined in Section 6, and based on the concept of 'hydraulic width', which is defined as the width of the water surface at the 1 in 100 year ARI flow level in the channel.

### 8.1 Constructed waterway corridor widths

Constructed waterways are completely artificial waterways that have been created where either a small existing waterway/drainage line has required expansion or there was no existing waterway/drainage line prior to development. Construction of a waterway may be required to: enhance channel capacity, provide flood conveyance/protection and provide drainage outfall with a stable channel and an aesthetically pleasing landscape with some degree of habitat and ecological function.

The waterway corridor width for constructed waterways is defined as a factor of the hydraulic width of the main channel of the waterway. Hydraulic width is defined as the width of the water surface in metres at the 1 in 100 year ARI post development flow level in the channel.

By scaling the waterway corridor width to the hydraulic width, the resulting waterway corridor widths will be sized according to position in the catchment, which is consistent with the underlying principle that smaller waterways – which carry smaller flows – require a smaller setback to meet the objectives for setbacks, whilst larger streams carry more flow and will require a larger setback and major waterways require the largest setback in order to meet both hydraulic and ecological objectives.

Constructed waterway corridor widths are also classified into the CRZ and VB sub-zones. The sub-zones have different roles in meeting the overall setback objectives and different activities and infrastructure requirements, as described for existing waterways in Section 7.3.



## 8.2 Determining waterway corridor width in constructed waterways

Constructed waterway corridor width is related to the hydraulic width (1 in 100 year ARI flood extent) by a sliding scale, as shown in Table 2.

Table 2. Sliding scale for calculating constructed waterway corridor widths

CRITERIA	RESULTING CORRIDOR WIDTH RANGE
Hydraulic width 5m to 30m	30m-55m
Hydraulic width 35m to 45m	45m-60m
Hydraulic width > 50m	55m-70m

The waterway corridor widths and sub-zone widths for a range of hydraulic widths in constructed waterways are shown in Table 3 and 4. When reading these tables, it should be noted that the Core Riparian Zone and Vegetated Buffer widths are 'total widths' and are not applied as 'setbacks' from the edge of the hydraulic width as is the case with natural channels. The Hydraulic Width falls within and forms a part of, the Core Riparian Zone as shown in Figure 4.

Melbourne Water will require maintenance access to both sides of all waterways. This may be provided in two ways:

- by providing an 'active edge' i.e. a road, that allows access for maintenance vehicles along the length of the waterway
- through the provision of maintenance tracks suitable for vehicular traffic where the waterway does not have an active edge.

Our preference is for the provision of 'active edges', as this has the dual benefit of encouraging positive interaction with the waterway as well as providing continuous maintenance access.

Where detailed information on road or other potential interfaces to the waterway is not available, Table 4 should be used as a starting point. Corridor width requirements can be refined as more detail is available..

Table 3. Sliding scale for calculating constructed waterway corridor widths – assumes active edges (roads) that allow vehicle access along entire corridor length, on both sides of the corridor.

HYDRAULIC WIDTH (M)	CRZ WIDTH (M)	VB WIDTH (M)	CORRIDOR WIDTH (M)
5	20	10	30
10	20	10	30
15	25	15	40
20	25	15	40
25	30	15	45
30	30	15	45
35	30	15	45
40	30	20	50
45	35	20	55
50	35	20	55
55	40	20	60
60	40	20	60
65	40	25	65
70	45	25	70

Table 4. Sliding scale for calculating constructed waterway corridor widths – addition of shared trail/maintenance track either side of channel (within vegetated buffer)

HYDRAULIC WIDTH (M)	CRZ WIDTH (M)	VB WIDTH (M)	CORRIDOR WIDTH (M)
5	20	20	40
10	20	20	40
15	20	25	45
20	25	25	50
25	30	25	55
30	30	25	55
35	30	25	55
40	35	25	60
45	35	25	60
50	35	25	60
55	40	25	65
60	40	25	65
65	40	25	65
70	45	25	70





While 'active edges' need to allow vehicle access along the entire reach of the waterway, this does not mean a 'road' needs to extend the whole length of the waterway. If sections of waterway cannot have 'active edges' but still allow vehicular access to the waterway, the widths in Table 3 can be used as a guide for corridor width.

The pilot channel (conveys regular flows and is typically 3 month ARI capacity) of a constructed waterway may move across the waterway corridor width along its length, but the design should ensure that the channel does not come within 10m of the edge of the corridor.

This will ensure continuity of the riparian zone; while also providing a suitable buffer should channel erosion occur in the future. Likewise, the entire 'waterway corridor' may meander if deemed functionally appropriate during the design phase.

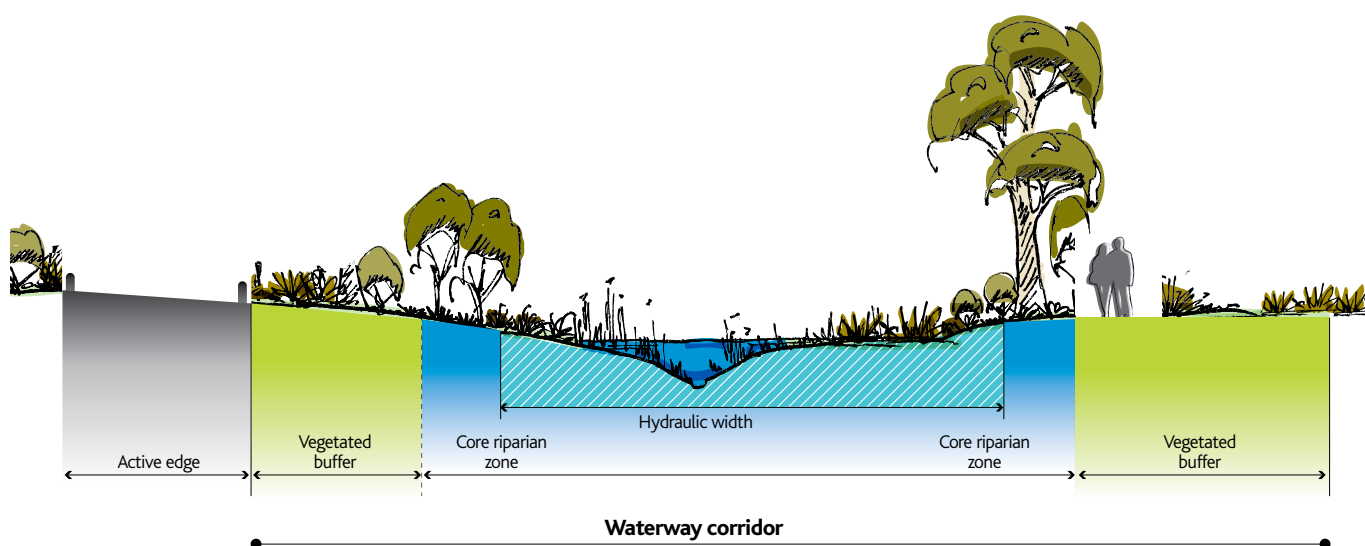
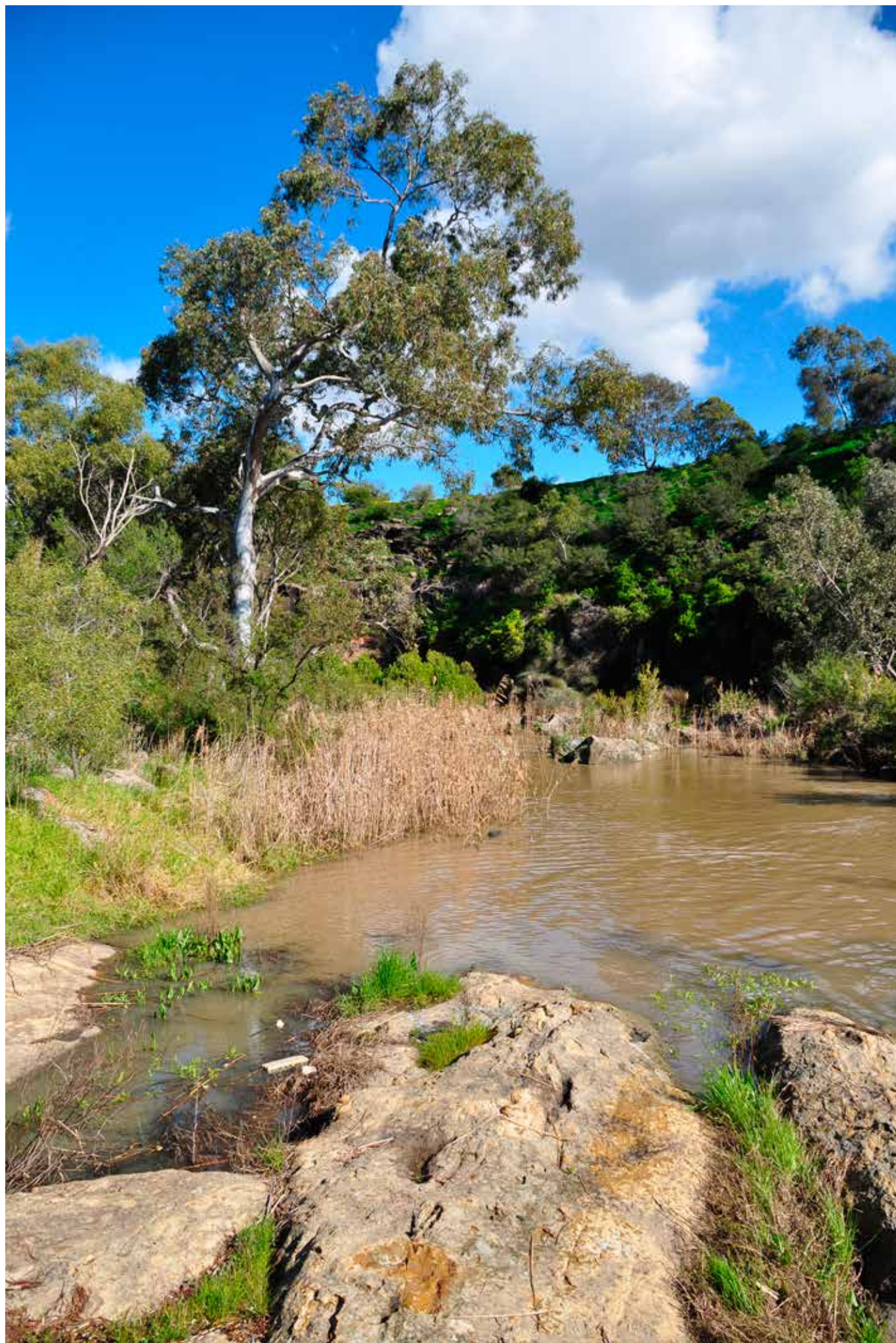


Figure 4. Example of setback sub-zones for constructed waterways



# 9 Incorporating site specific values and urban design elements into waterway corridors

## 9.1 Site specific values

As described in the Section 6, the waterways corridor widths presented in these guidelines are the standard widths to be adopted within greenfield urban developments. Following the definition of the minimum standard waterway corridors for a site (as described in the previous sections) specific investigations should be undertaken to identify factors that may lead to the variation in the waterway corridor widths, i.e. where the setback may need to be greater or narrower to locally account for site values and/or constraints. To recap from Section 6, these factors may include (but not be limited to):

- High value species and/or communities may require increased setbacks to protect habitat for these species
- Where the site forms an important part of an existing, or potential high value habitat corridor
- Where the site contains high value geomorphic features or assemblages that may be negatively affected by setting inadequate waterway corridor widths (e.g. backwaters, rocky outcrops or escarpments)
- Where a site has been determined by Melbourne Water to contain significant local or regional waterway values
- Where built assets require protection from potential future channel migration (especially important in areas with highly erodible soils)

- Where a waterway reach requires greater levels of protection to ensure significant upstream or downstream values are protected
- If the 100 year flood extent exceeds the standard waterway corridor width defined in these guidelines then the setback will be defined by the flood extent.

Where other land uses such as recreation or fire buffers also lead to requirements for land near a waterway, other relevant planning mechanisms will be used to provide for those purposes as required. All expected land uses within and adjacent to the waterway corridor should be considered together as early as possible in the planning process to enable an integrated and efficient corridor plan.

Depending on the shape of the line joining the setback reference points, the overall corridor width may not fit well with the intended subdivisional layout of the development site. It may be possible to adjust the setback line – creating a variable setback width, or in some cases – to fit better with the design of the development, provided built assets/infrastructure are not put at risk and there is no net loss in the total waterway corridor width and waterway functionality.

It will always be Melbourne Water's preference for the corridor width to remain constant, avoiding narrow sections that barriers to fauna movement or negatively affect waterway function i.e. reduction of setbacks on one bank will be compensated with an equal increase in setback on the opposite bank.

Allowing for these types of variations is intended to provide flexibility when fitting the subdivisional layout around the waterway corridor. The final configuration of the waterway corridor in a greenfield site (i.e. the width of the overall setback, core riparian zone and vegetated buffer) must be agreed with Melbourne Water during the planning phase for the development.

### Net Gain

In some instances, vegetation Net Gain offsets may be allowed to be established on land within greenfield development areas that is to be transferred to Melbourne Water; this includes waterway corridors. Please contact the Melbourne Water on 131 722 if you wish to explore options for placement of Net Gain offsets within waterway corridors.



## 9.2 Ownership and ongoing maintenance of the waterway corridor

Once a waterway corridor has been incorporated into the development plan, attention turns to the design and construction of civil and landscaping works that may be required and then to the ongoing maintenance responsibilities for the waterway, the riparian zones and any adjacent open space and associated infrastructure. Waterway corridors are nearly always vested as Reserves in favour of either the local Council or Melbourne Water (the party in whom the land is vested becomes the land owner). Typically, because of the multiple uses of the waterway corridor, the Reserve is vested in favour of Council with a Memorandum of Common Provisions easement created over the Reserve area in favour of Melbourne Water. That way, both parties' interests are accounted for. Accompanying the creation of the Reserve and any easements is a Maintenance Agreement which details the areas and actions that Council and Melbourne Water are responsible for maintaining.

Other options such as singular authority ownership with easements/maintenance agreements in the name of other concerned authorities may also be appropriate; so might involvement of private parties such as Owners Corporations (e.g. Golf Courses). Lastly, service/utility providers may also require an easement in their favour to be created within the waterway corridor Reserve for assets such as power lines, gas mains, water mains, sewerage pipelines, and telephone/internet cables etc.

The following principles should be applied when developing arrangements for ownership and ongoing maintenance of various components of the waterway corridor:

### Ownership of the waterway corridor

- Where there are public use benefits, it is Melbourne Water preference that Council, or DEPI take ownership of the Reserve.
- Where the Reserve is to be managed for the singular purpose of waterway management, Melbourne Water will normally take ownership of the Reserve.
- Where the Reserve is in Council/DEPI ownership, Melbourne Water will require a Memorandum of Common Provisions easement in our favour to be created on the Plan of Subdivision to enable access to undertake the range of maintenance activities included in the Schedule to the Maintenance Agreement.
- Where there are private interests immediately adjacent to the waterway and it is not possible to create a Reserve for the waterway corridor for example, the waterway runs through a golf course, Melbourne Water will require a Memorandum of Common Provisions easement to be created over the waterway on the Plan of Subdivision.

### Maintenance of the waterway corridor

- Melbourne Water assumes responsibility for maintaining vegetation within the channel bed to the edge of ephemeral plantings on the banks, i.e. the regularly 'wetted' areas usually associated with the lower banks and ongoing maintenance of the physical integrity of the bed and banks
- In the absence of public use benefits, Melbourne Water will take responsibility of maintaining vegetation on the bed, banks, core riparian zone and vegetated buffer if this land is to be managed purely for waterway health purposes.
- Council or DEPI/Parks Victoria will assume ongoing maintenance responsibility for any part of the waterway corridor where there is an intended recreational use. In most instances this will be part of, or the entire, vegetated buffer, but may include sections of the core riparian zone where recreational assets such as pedestrian bridges cross through this area. Such areas will be clearly marked on the plan that accompanies the schedule of maintenance activities each party is responsible for.

Where Melbourne Water is responsible for maintaining the waterway corridor, we will do so to Melbourne Water standards; if a higher standard is required then the authority requiring the higher standard will be responsible for any additional works required.

### Involvement of third parties

- Involvement of a party other than, or in addition to, Council on freehold land where Melbourne Water has a waterway management interest, will require the creation of a Section 173 Agreement. The Section 173 Agreement is a legally binding agreement that ensures that the requirements of the accompanying Maintenance Agreement, and Schedule/ Plan of activities that each party is responsible for are maintained in perpetuity. The s173 Agreement is tied to the land upon which the waterway corridor has been created.
- In the case of multiple parties sharing management interests for land vested in the crown, a management agreement of some form (options would need to be explored as to the most appropriate for the particular situation) will need to be entered into to ensure effective delineation of maintenance responsibility.

While Melbourne Water will work with key stakeholders to determine ongoing ownership and maintenance responsibilities as early in the planning process as possible (e.g. Precinct Structure Plans/Conservation Management Plans), it is expected that the ownership and maintenance responsibilities of many waterway corridor Reserves will need to be decided on a case by case basis later in the planning process as information required to assess against the guiding principles listed above become available.



## 10 Waterway Corridor Guideline review process

Recognising the complex and continuously evolving nature of waterway science and town planning theory, Melbourne Water will undertake regular reviews of these guidelines with the intention of providing the very best service to all key customers and stakeholders.

Melbourne Water will conduct an initial review of these guidelines 12 months from the initial launch date, and then conduct subsequent reviews every 24 months.

Melbourne Water welcomes feedback on the guidelines and their implementation success at all times and will endeavour to involve all key stakeholders and customers in the review process. Feedback can be provided via telephone (131 722) or via online submission.



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