Aitken Creek Waterway Values Assessment

Final Project report

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Melbourne Water

Aitken Creek Waterway Values Assessment

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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			

Contents

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.

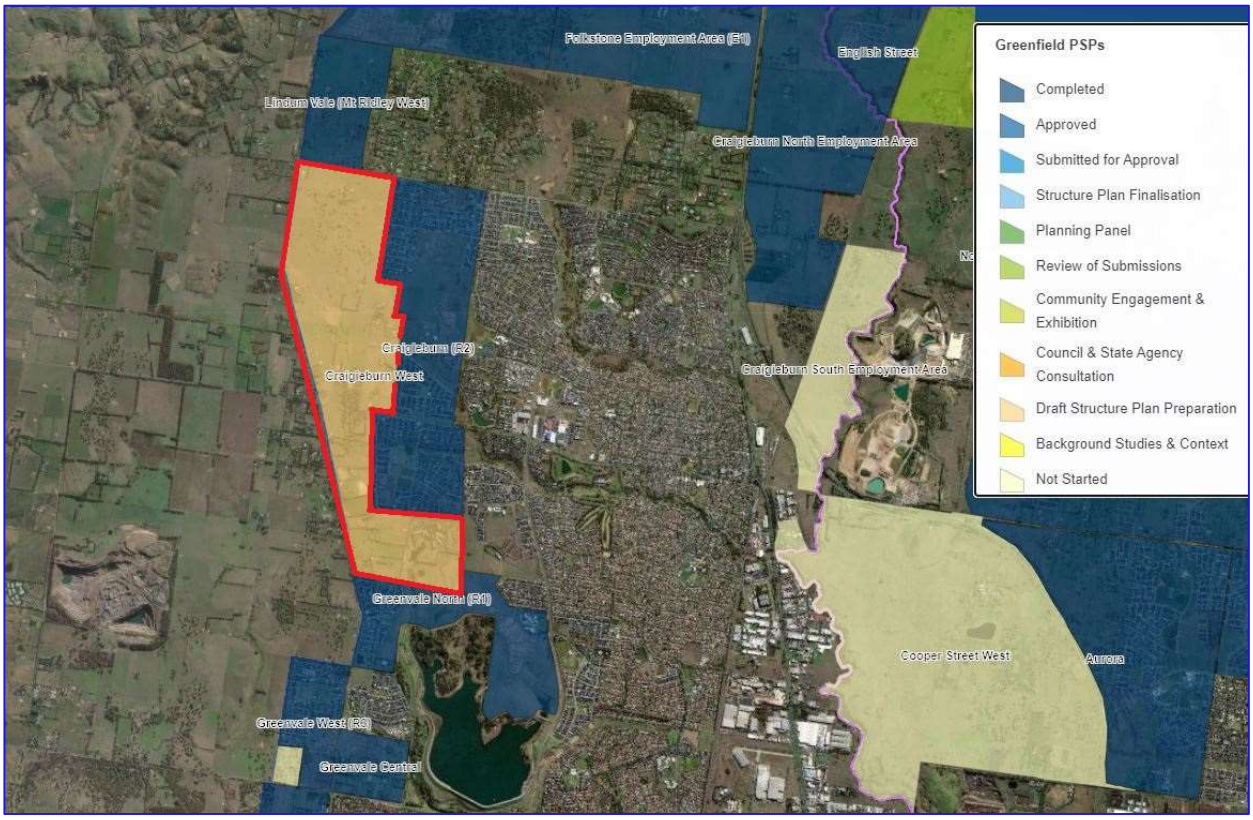

Figure 1-2. Craigieburn West PSP, which Aitken Creek flows through, landscape context (image courtesy of VPA[1]). Craigieburn West PSP outlined in red (our emphasis).

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

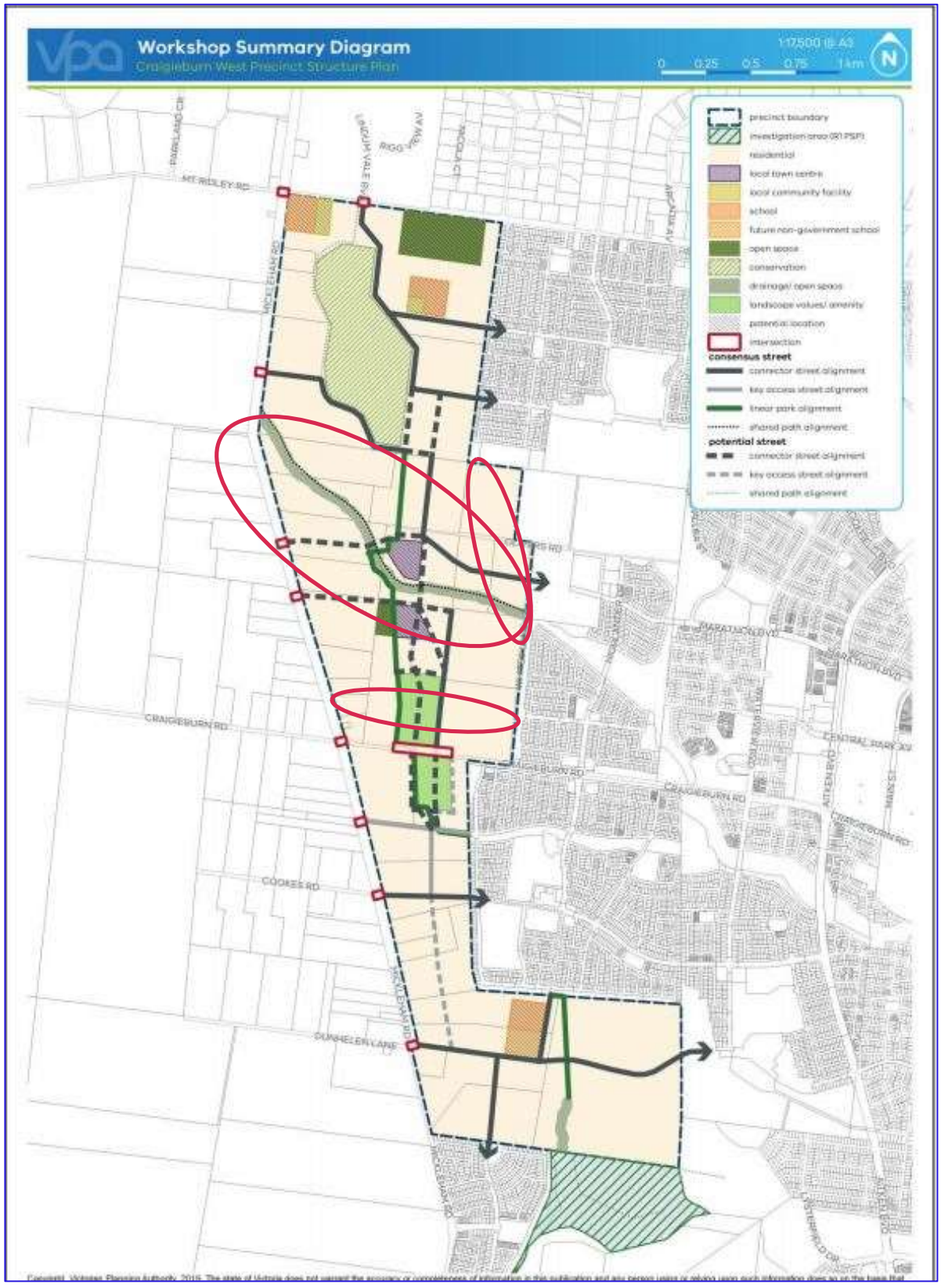

Figure 1-3. Proposed PSP layout in the Craigieburn West PSP Co-Design Workshop. Aitken Creek main channel and tributaries as they pass through the PSP circled in red (our emphasis). Map courtesy of Elton Consulting, 2019.

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).

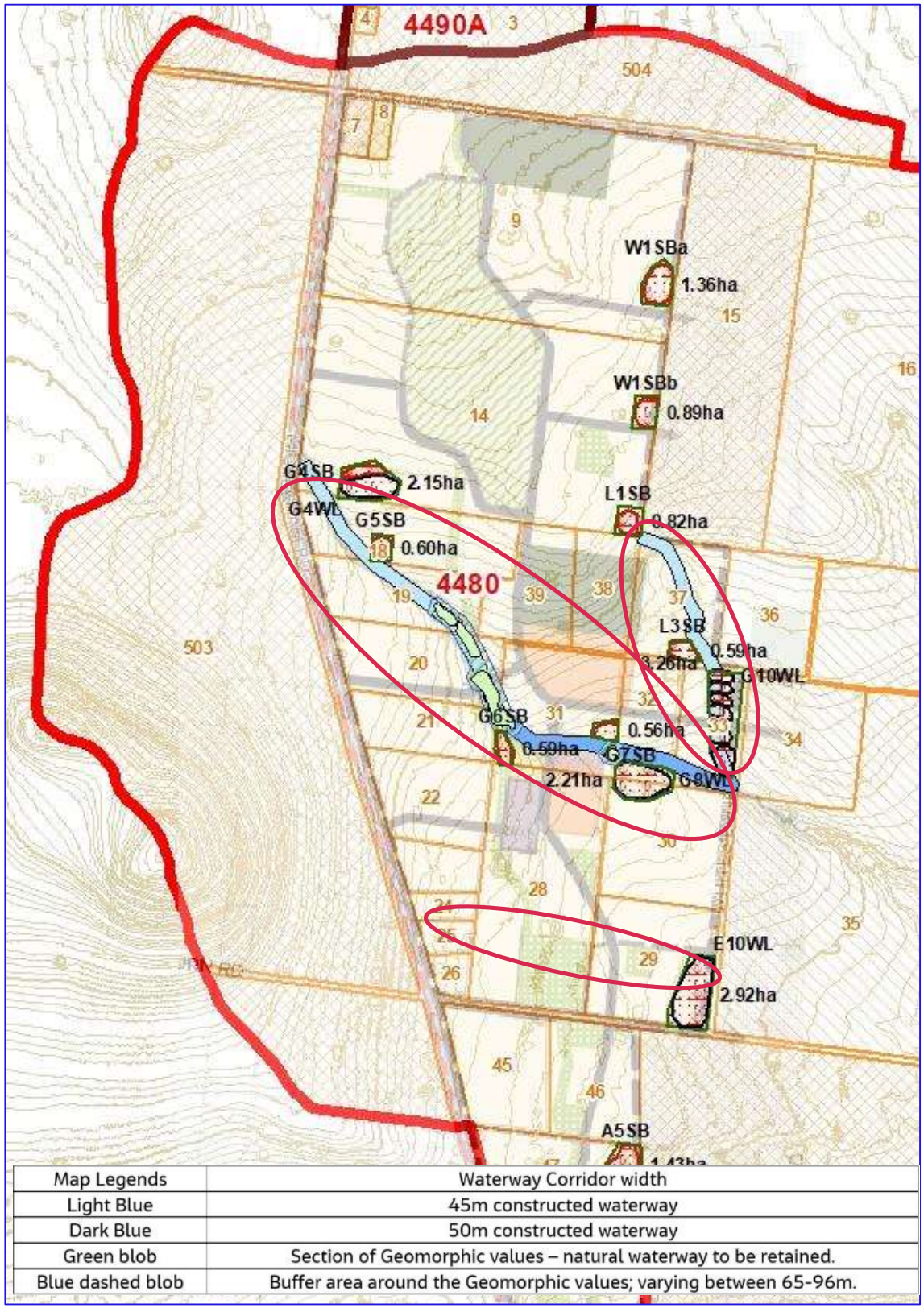

Figure 1-4. Proposed buffer widths and asset locations. Aitken Creek main channel and tributaries as they pass through the PSP circled in red (our emphasis). Asset reference codes link to Table 1 1. Map courtesy of Melbourne Water.

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
Total				**5.7**	**17.4 (including 1.8ha within waterway corridor)**

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[2].

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 Meterology, 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:**

[2] 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 20th 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)[3], 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]

[3] 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	• Slope • Sediment (substrate type and load) • Parent material, origin and classification • Soil Type - Cohesiveness and dispersiveness (i.e. erodibility)
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.
WATERWAY BEHAVIOUR – PROCESSES & TRAJECTORY	
Waterway Process Trajectory (under current and PSP development conditions)	• Waterway trajectory • Potential for bed adjustment • Types of bank erosion • Form & reworking of instream units
WATERWAY CONDITION AND RISK	
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)	Steam 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	▪ Recent records of species from DELWP databases ▪ Review of aerial photography indicates potential habitat on site ▪ Review of habitat and distribution literature indicates the site is appropriate for this species.
Moderate	▪ Historic records of species from DELWP databases ▪ Review of habitat distribution literature indicates the site is appropriate for this species ▪ Review of aerial photography indicates limited habitat on site.
Low	▪ Species has not been previously recorded within DELWP database ▪ Review of aerial photography indicates that no available habitat is present on site ▪ Review of literature regarding habitat and distribution indicates the site is unlikely to be utilised by this species.
Negligible	▪ 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 ▪ The species has been deemed absent after sufficient survey effort (criterion generally reserved for particularly conspicuous species).
N/A	▪ Legislation protecting threatened species does not apply to the species within the project area, as: - The project area is outside the natural range of the species, and - The species is present for non-conservation purposes (e.g., planted for amenity, or has become naturalised in the area).

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

Likelihood	Criteria
High	▪ Mapping by DELWP indicates the EVCs likely to be present at the site are of a similar composition to the threatened ecological community ▪ Review of aerial photography indicates that native vegetation is likely to be present at the site ▪ Review of literature and general knowledge of vegetation in the area indicates the site is appropriate for this threatened ecological community.

Likelihood	Criteria
Moderate	▪ Mapping by DELWP indicates the EVCs likely to be present at the site are of a similar composition to the threatened ecological community ▪ It is difficult to determine from aerial photography whether the community is present, such as grassland communities ▪ Review of literature and general knowledge of vegetation in the area indicates the site is suitable for this threatened ecological community.
Low	▪ Mapping by DELWP indicates the EVCs likely to be present at the site are not of similar composition to the threatened ecological community ▪ Review of aerial photography indicates that no native vegetation is likely present ▪ 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.

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	• Highly specialised habitat and water regime requirements • 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 • Individual species have specific water regime requirements within a narrow range of variability. • EPBC /FFG listed community or species located within 1% AEP flood event extent • Waterway intersects or immediately adjacent to named Biosite • Unable to move/migrate to new locations
2	Moderate	• Individual species have some specific requirements but are able to cope with moderate variability. • Moderate change (+/- 60%) in frequency or duration of inundation events needed before community composition changes • Mobile species that can move around local region to take advantage of shifting habitat
1	Low	• Generalist habitat requirements. • Individuals are adapted to a range of conditions with no specific regime requirements. • Large change (+/- 80%) in frequency or duration of inundation events needed before community composition changes. • Very mobile species that can move between regions • Species able to rapidly colonise disturbed habitats

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.

	Consequence - Magnitude of Hydrological Change		
Likelihood - Sensitivity	**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 larva flows and incision of larva 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).

Drained section of Aitken Creek Main Channel east of Mickleham Road.

Partly confined channel with basalt boulder riffle.

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 contributary 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.

Broad drainage depression/valley fill north of Olivers Road

Broad drainage depression/valley fill south of Olivers Road

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 contributary 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.

Broad saturated plain/wetland

Waterlogged soils and standing water

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* (Kneed 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
	Total	**75**	**32.64**	**34**	**12.24**	**27.2**
Landscape Context	Patch size	10	8	1	1	1
	Neighbourhood	10	1	0	0	0
	Distance to Core	5	4	3	3	3
	Total	25	13	4	4	4
Habitat Score		**100**	**45.64**	**38**	**16.24**	**31.2**
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	*Eucalyptus ovata* var. *ovata*	74	Small	No	30-70%	
2	*Eucalyptus ovata* var. *ovata*	75	Small	No	30-70%	DBH estimated
3	*Allocasuarina verticillata*	50	Small		>70%	DBH estimated. Species may not technically comprise a scattered tree in this part of landscape.
4	*Eucalyptus camaldulensis*	185	Large	Yes	>70%	
5	*Eucalyptus camaldulensis*	84	Large		>70%	
6	*Eucalyptus camaldulensis*	168	Large	Yes	>70%	
7	*Eucalyptus camaldulensis*	92	Large	Yes	>70%	
8	*Eucalyptus camaldulensis*	130	Large	Yes	>70%	DBH estimated
9	*Eucalyptus camaldulensis*	140	Large	Yes	>70%	DBH estimated
10	*Eucalyptus camaldulensis*	110	Large		>70%	DBH estimated
11	*Eucalyptus ovata* var. *ovata*	83	Large		<30%	

Tree 1

Tree 2

Tree 11

Tree 3

Trees 4 to 10

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).

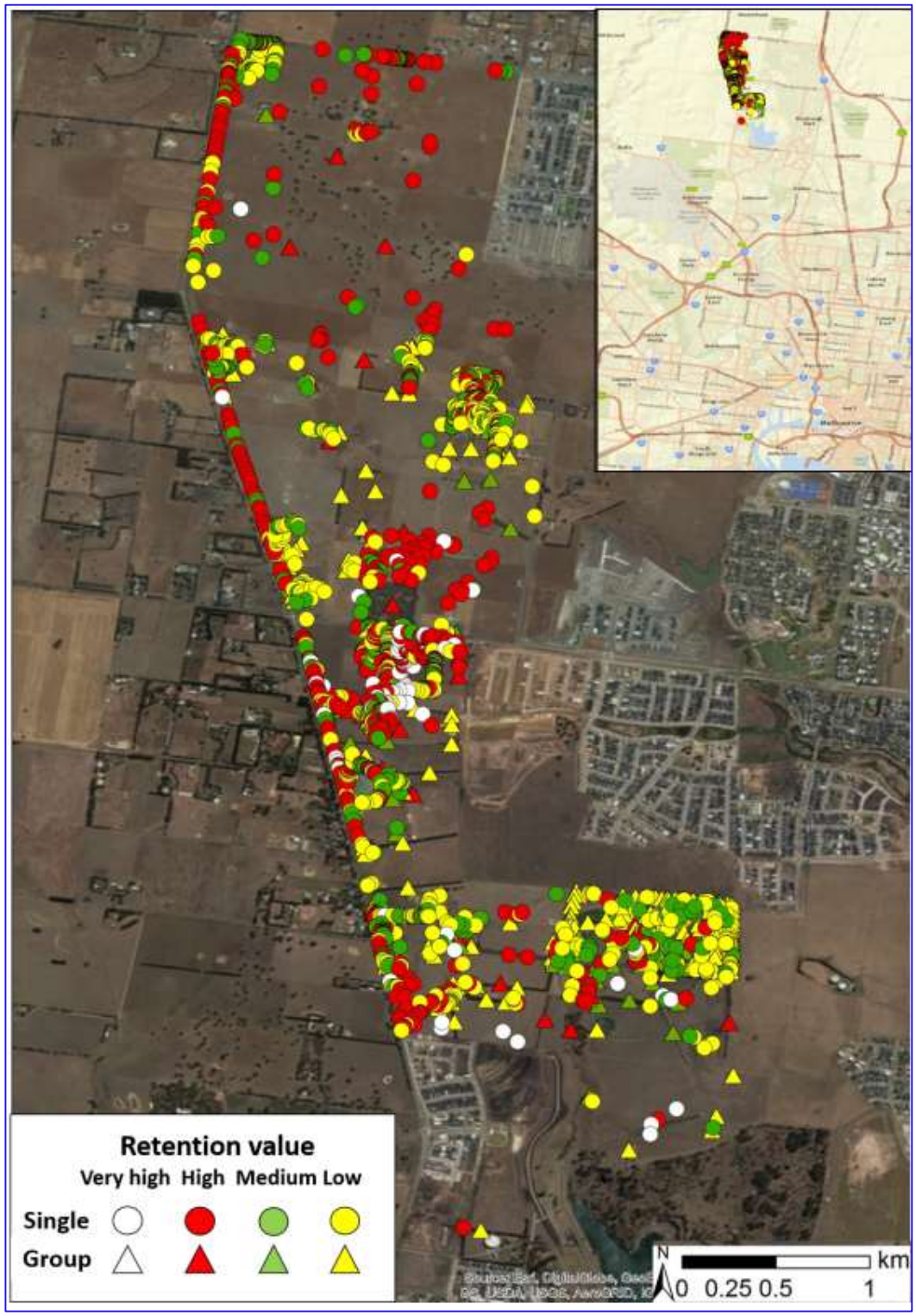

Figure 3-7. Retention value of mature trees in the DSS (Treetec, 2018).

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 Meterology, 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 Meterology, n.d.).

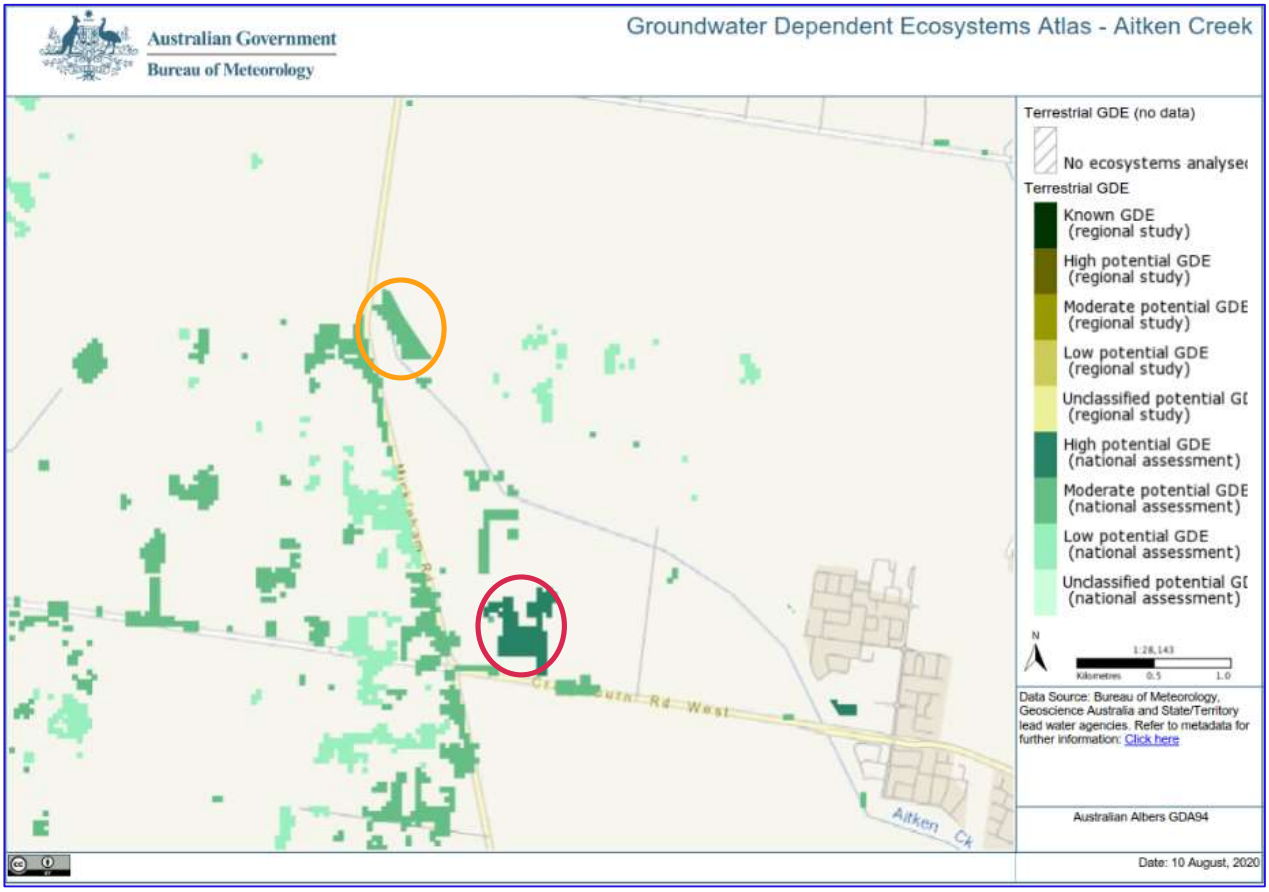

Figure 3-9. Modelled groundwater dependent terrestrial ecosystems. The stand of River Red Gums is circled in red, vegetation at the north west end of Aitken Creek is circled in orange.

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
Amphibromus fluitans (River Swamp Wallaby-grass)	EPBC - Vulnerable	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 *Amphibromus* 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 *A. nervosus* (Common Swamp Wallaby-grass). 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. 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).
Dianella amoena (Matted Flax-lily)	EPBC – Endangered FFG – Listed VicAdv – endangered	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. 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.

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
Synemon plana (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 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 *Eucalyptus Camaldulensis* - 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 spare 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.
Amphibromus fluitans - 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. *Dianella amoena* (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.
Litoria raniformis - 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 (*Synemon plana*) 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
	Ecology		Geomorphology		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	▪ Mature *Eucalyptus Camaldulensis* - River Red Gums ▪ EVC 132_61 Heavier-soils Plains Grassland (Endangered) ▪ EVC 125: Plains Grassy Wetland (endangered) Presence not confirmed: ▪ *Amphibromus fluitans* -River Swamp Wallaby Grass ▪ Golden Sun Moth (*Synemon plana*) in grasslands adjacent to creek ▪ *Litoria raniformis* - Growling Grass Frog ▪ *Dianella amoena* - Matted Flax Lily
Aitken Creek – Southern Tributary	2	Medium - high	1	Insignificant	3	High	3	High	3	High	9	High	9	High	▪ Mature *Eucalyptus Camaldulensis* - River Red Gums ▪ EVC 132_61 Heavier-soils Plains Grassland (Endangered) ▪ EVC 125: Plains Grassy Wetland (endangered) Presence not confirmed: ▪ *Amphibromus fluitans* -River Swamp Wallaby Grass ▪ *Litoria raniformis* - Growling Grass Frog ▪ *Dianella amoena* - Matted Flax Lily

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[4], 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).

[4] 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).

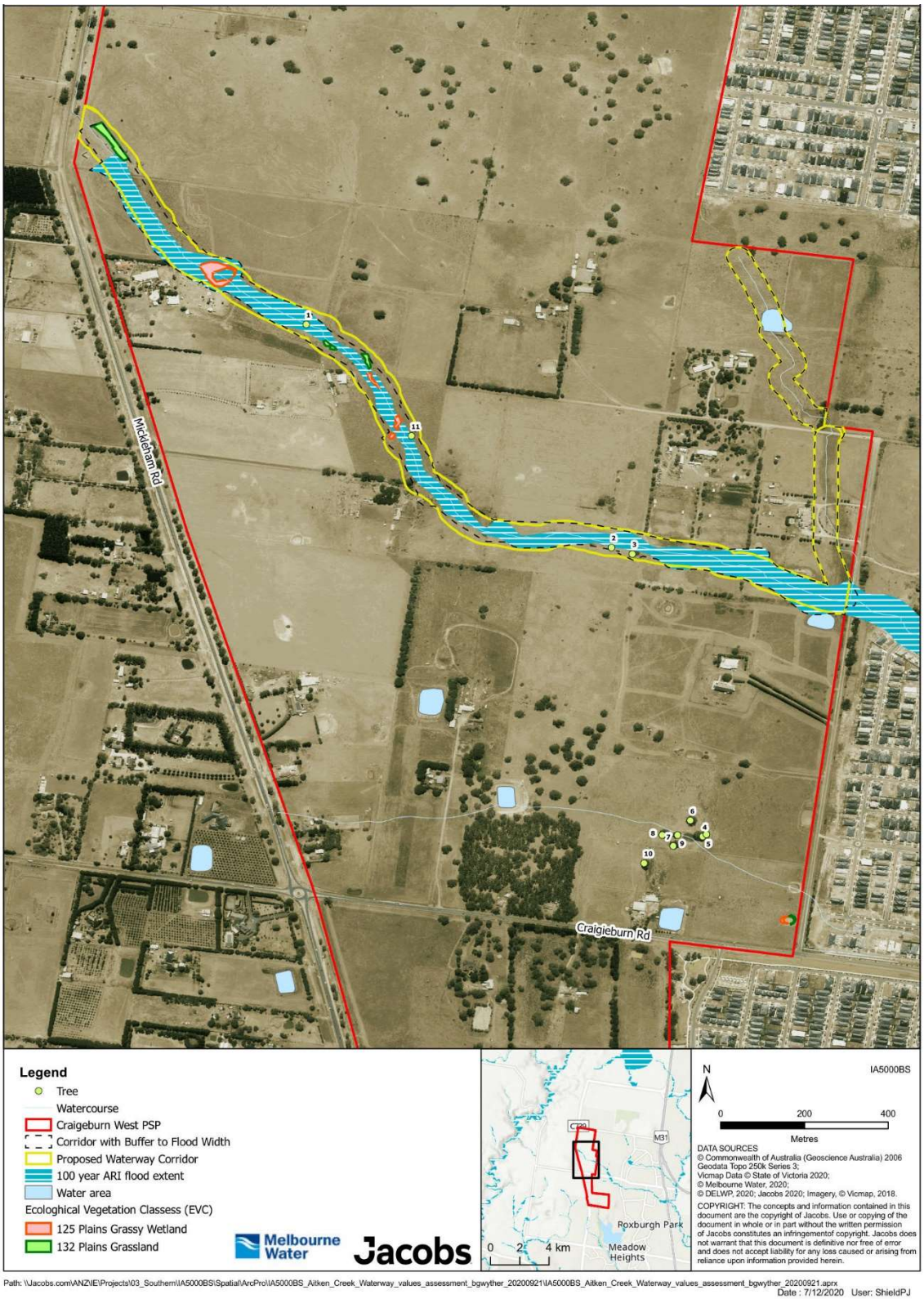

Figure 4-1. Proposed buffer widths for consideration in relation to locations of ecological values.

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 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.	• Follow up targeted surveys in the flowering period (November to March) would be required to confirm locations. • 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.). • River Swamp Wallaby Grass could also colonise constructed wetland habitat, consider providing appropriate watering regimes and revegetating with the species. • Retention of a more natural waterway form in the upstream end of the Aitken Creek Main Channel, rather than a constructed waterway.
	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.	• There are likely to be high value areas of grassland located within a proposed 2.15 ha wetland (G4WL – see Figure 1-4). Earlier investigations have indicated that the area supports Golden Sun Moth habitat and populations. Consider relocating this asset to an area of lower ecological value. • The area of Plains Grassland within the main channel (adjacent to the Grasslands at 1760 Mickelham Road) is proposed to be located within a constructed waterway. Consideration should be given to whether this vegetation community can be maintained as is or incorporated into the waterway design.
	All patches of Plains Grassland mapped within the project area comprise part of the threatened community Western (Basalt) Plains Grasslands Community.	• 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. • 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.
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	• 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).

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.	• 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.
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.	• 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. • 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. • To retain existing stream form is likely to require harvesting of stormwater runoff from upstream contributary areas and/or redirection of stormwater to outfalls located downstream of this reach.
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.	• 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). • 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. • 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.
Where built assets require protection from	High erodible sodic subsoils are present and present a high risk of erosion and incision. No	• 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

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).	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. • 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).
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.	• 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. • The ability of stormwater treatment assets to accommodate increased flows and altered flow regime from development of this PSP should also be considered.

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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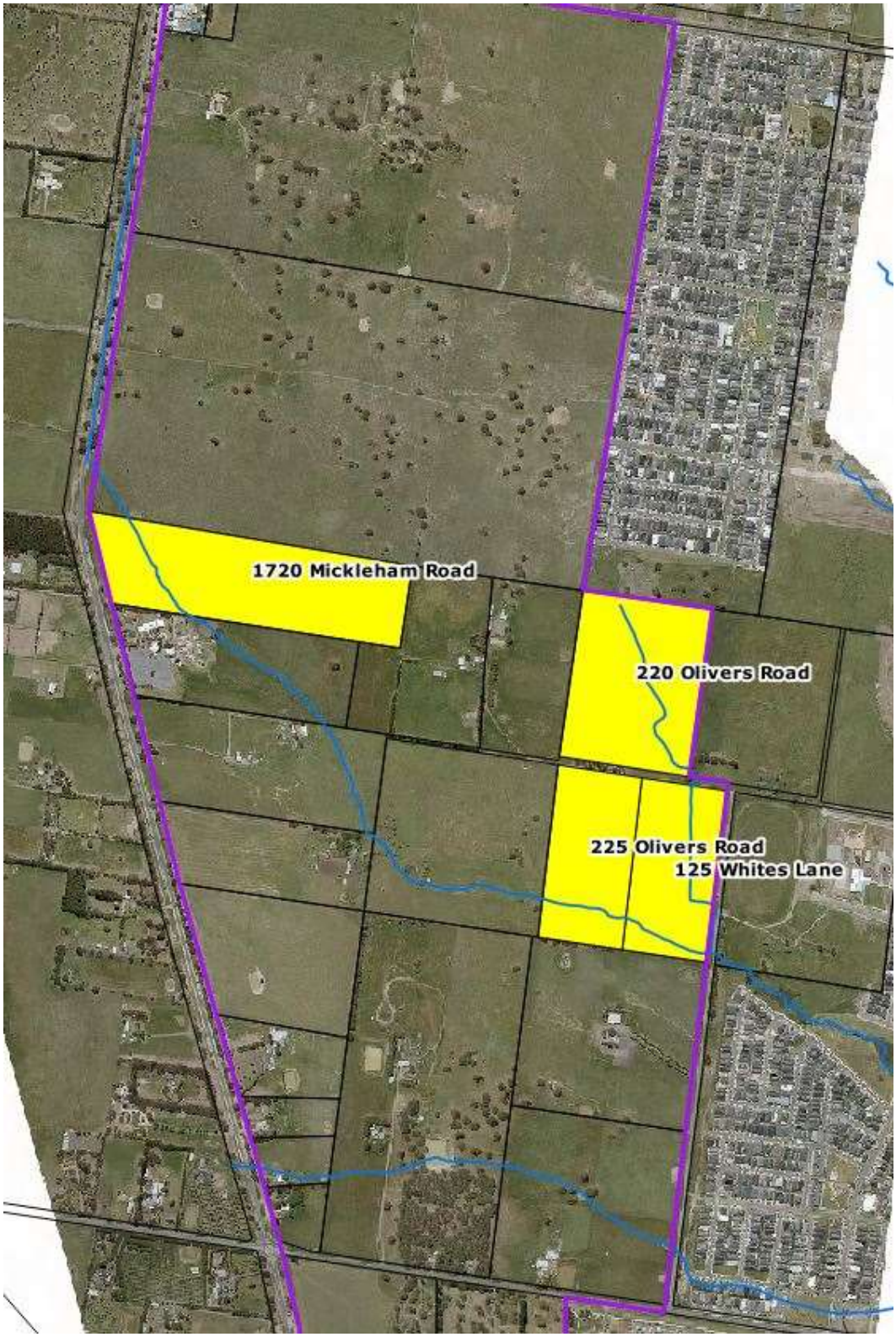
Appendix A. Properties not able to be accessed during fieldwork



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^2 (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	• Average Streambed Slope = 3.9% (from Physical Form Dataset) • Sediment - Silty to fine sandy clay loams (fines when entrained contribute to suspended sediment load) • Parent material, origin and classification - Basalt, Newer Volcanic Group • 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.
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)	Current conditions: • Waterway trajectory – Relatively stable under existing landuse, maintenance of vegetation cover. • 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. • Types of bank erosion – Dispersion and fretting of banks • Form & reworking of instream units – Further incision of valley fill. PSP development conditions • Waterway trajectory – Increased runoff has potential to scour channel

	• Potential for bed adjustment – High, particularly if upper soil horizon is disturbed. • Types of bank erosion – Slow fretting of banks as clays become dispersed under saturation, bank failures may also occur as bank height increases. • Form & reworking of instream units – Further incision of valley fill.

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 contributary 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^2 (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	• Average Streambed Slope = 3.1% (from Physical Form Dataset) • Sediment - Silty to fine sandy clay loams (fines when entrained contribute to suspended sediment load) • Parent material, origin and classification - Basalt, Newer Volcanic Group • 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.
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)	Current conditions: • Waterway trajectory – Relatively stable under existing landuse, maintenance of vegetation cover. • 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. • Types of bank erosion – None observed but noted turbid water in farm dams, which is in indicator of dispersion of sodic subsoils. • Form & reworking of instream units – Further incision of valley fill. PSP development conditions • Waterway trajectory – Increased runoff has potential to scour channel

	• Potential for bed adjustment – High, particularly if upper soil horizon is disturbed. • Types of bank erosion – Slow fretting of banks as clays become dispersed under saturation, bank failures may also occur as bank height increases. • Form & reworking of instream units – Further incision of valley fill.

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 contributary 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	• Average Streambed Slope = 2.8% (from Physical Form Dataset) • Sediment - Silty to fine sandy clay loams (fines when entrained contribute to suspended sediment load) • Parent material, origin and classification - Basalt, Newer Volcanic Group • 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.
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)	Current conditions: • Waterway trajectory – Relatively stable under existing landuse, maintenance of vegetation cover. • Potential for bed adjustment – Relatively low given current conditions. • Types of bank erosion – None observed. • Form & reworking of instream units – Further incision of valley fill. PSP development conditions • Waterway trajectory – Increased runoff has potential to scour channel • Potential for bed adjustment – High, particularly if upper soil horizon is disturbed.

	• Types of bank erosion – Slow fretting of banks as clays become dispersed under saturation, bank failures may also occur as bank height increases. • Form & reworking of instream units – Further incision of valley fill.

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

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

*	*Sonchus asper s.s.*	Rough Sow-thistle
*	*Sonchus oleraceus*	Common Sow-thistle
*	*Sporobolus africanus*	Rat-tail Grass
	Themeda triandra	Kangaroo Grass
*	*Trifolium angustifolium var. angustifolium*	Narrow-leaf Clover
*	*Trifolium repens var. repens*	White Clover
*	*Urtica urens*	Small Nettle
*	*Vicia sativa subsp. sativa*	Common Vetch
*	*Vulpia 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		*Amphibromus fluitans* (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	*Amphibromus pithogastrus* (Plump Swamp Wallaby-grass)	Known only from swampy depressions in black volcanic clay soils north of Craigieburn.		21/12/1992	2	Low-Moderate
		k	*Caesia parviflora* var. *vittata* (Pale Grass-lily)	Lowland grassland and grassy woodland. Flowers mainly in spring.		21/12/1992	1	Low-Moderate
	R	r	*Callitriche umbonata* (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	*Convolvulus angustissimus* subsp. *omnigracilis* (Slender Bindweed)	Mostly in grassland, grassy woodland. Flowers mainly in Spring, Summer (but spasmodically throughout the year).		6/09/2018	12	High
		vu	*Corymbia maculata* (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	*Cullen tenax* (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	*Desmodium varians* (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	*Dianella amoena* (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	*Dianella longifolia* var. *grandis* (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. longifolia. Flowers Nov.–Dec.		6/12/2017	3	Low-Moderate
VU		vu	*Dodonaea procumbens* (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	*Eucalyptus kitsoniana* (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	*Eucalyptus leucoxylon* subsp. *megalocarpa* (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	*Eucalyptus sideroxylon* subsp. *sideroxylon* (Mugga)	In Victoria confined to the Chiltern area, northern Warby Range and south of Winton, while the other ironbark, Eucalyptus tricarpa, with its 3-budded inflorescences and larger fruit is widespread		5/12/2017	1	NA
		vu	*Geranium solanderi* var. *solanderi* 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	*Geranium* 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	*Glycine latrobeana* (Clover Glycine)	Widespread but of sporadic occurrence and rarely encountered. Grows mainly in grasslands and grassy woodlands.	PMST			Low
		k	*Kunzea leptospermoides* (Yarra Burgan)	Thought to be restricted to the upper Yarra Valley and areas to the west of Melbourne around Meredith and Duridiwarrah, where it is restricted to riparian areas and damp forest.		23/11/2017	2	Moderate
EN	L	vu	*Lachnagrostis adamsonii* (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	*Lepidium hyssopifolium* s.s. (Basalt Peppercress)	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	*Leucochrysum albicans* subsp. *tricolor* (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 Leucochrysum alpinum and Leucochrysum albicans subsp. albicans. Flowers Nov.-Dec.	PMST			Low
		r	*Melaleuca armillaris* subsp. *armillaris* (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	*Pauridia vaginata* var. *brevistigmata* (Yellow Star)	#N/A		11/10/1992	1	Low-Moderate
CR	L	en	*Pimelea spinescens* subsp. *spinescens* (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	*Poa labillardierei* 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	*Prasophyllum frenchii* (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	*Rhagodia parabolica* (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	*Rutidosis leptorhynchoides* (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	*Senecio psilocarpus* (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	*Tripogonella loliiformis* (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	*Actitis hypoleucos* (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	*Anthochaera phrygia* (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	*Ardea alba* (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	*Ardea intermedia plumifera* (Plumed Egret)	Freshwater wetlands, pastures and croplands, tidal mudflats, floodplains {Pizzey, 2012 #16}.		1/03/1980	1	Low
		vu	*Aythya australis* (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	*Biziura lobata* (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	*Botaurus poiciloptilus* (Australasian Bittern)	Narrow habitat preferences, preferring shallow, vegetated freshwater or brackish swamps {Pizzey, 2012 #16}.	PMST			Low
CR	L	en	*Calidris ferruginea* (Curlew Sandpiper)	Tidal mudlfats; saltmarsh, saltfields; fresh, brackish or saline wetlands; sewage ponds {Pizzey, 2012 #16}.	PMST			Low
		dd	*Chelodina longicollis* (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	*Chlidonias hybrida* (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	*Circus assimilis* (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	*Dasyurus maculatus maculatus* (Spot-tailed Quoll)	Has a wide range of habitats, including rainforest, open forest, woodland, coastal heathland and inland riparian forest.	PMST			Negligible
		nt	*Dromaius novaehollandiae* (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	*Egretta garzetta* (Little Egret)	Tidal mudflats, saltmarshes, mangroves, freshwater wetlands, sewage ponds.		1/01/1986	4	Low
	L	en	*Falco hypoleucos* (Grey Falcon)	Lightly treed inland plains, gibber deserts, sandridges, pastoral lands, timber watercourses; seldom in driest deserts.	PMST			Low
	L	vu	*Falco subniger* (Black Falcon)	Plains, grasslands, foothills, timbered watercourses, wetland environs; crops; occasionally over towns and cities.		21/05/2005	3	Moderate
VU	L	en	*Galaxiella pusilla* (Dwarf Galaxias)	In streams, burrow in moist soil, in yabby burrows, ground water and underground streams.	PMST			Low
		nt	*Gallinago hardwickii* (Latham's Snipe)	Freshwater or brackish wetlands, preferring to be close to protective vegetation cover.		14/12/2004	1	Low
VU	L	vu	*Grantiella picta* (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	*Hirundapus caudacutus* (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	*Hydroprogne caspia* (Caspian Tern)	Coastal, offshore waters, beaches, mudflats, estuaries, larger rivers, reservoirs and lakes.		1/12/1980	2	Low
	L	vu	*Jalmenus icilius* (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	*Lathamus discolor* (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	*Litoria raniformis* (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	*Maccullochella peelii* (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	*Melanodryas cucullata* (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	*Miniopterus schreibersii oceanensis* (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	*Numenius madagascariensis* (Eastern Curlew)	Estuaries, tidal mudflats, sandspits, saltmarshes, mangroves; occasionally fresh or brackish lakes; bare grasslands near water.	PMST			Low
		nt	*Nycticorax caledonicus* (Nankeen Night-Heron)	Shallow margins of rivers, wetlands, mangrove-lined estuaries, offshore islands, floodwaters, garden trees.		22/03/2017	10	Moderate
	L	en	*Oxyura australis* (Blue-billed Duck)	Found on temperate, fresh to saline, terrestrial wetlands including sewerage ponds, rivers, salt lakes and saltpans. Preferring deep, permanent open water within or near dense vegetation.		5/12/2018	15	Moderate
CR	L	cr	*Pedionomus torquatus* (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	*Phalacrocorax varius* (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	*Platalea regia* (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	*Prototroctes maraena* (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	*Pseudemoia pagenstecheri* (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	*Pseudophryne bibronii* (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	*Pteropus poliocephalus* (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	*Pyrrholaemus sagittatus* (Speckled Warbler)	Drier woodlands with tussocks, branches and rocks.		1/06/1978	3	Low
EN	L	cr	*Rostratula australis* (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	*Sminthopsis crassicaudata* (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	*Spatula rhynchotis* (Australasian Shoveler)	Larger waters, fresh and saline lakes, well-vegetated freshwater wetlands, coastal inlets, sewage ponds, floodwaters.		29/01/2000	1	Low
	L	nt	*Stagonopleura guttata* (Diamond Firetail)	Open Eucalypt forests/woodlands; River Red Gum, Mallee, Buloke, Cypress Pine.		1/09/1977	1	Low
	L	en	*Stictonetta naevosa* (Freckled Duck)	Large, well vegetated swamps; in dry periods moves to open lakes.		18/07/2004	1	Low
CR	L	cr	*Synemon plana* (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